SUPPORT / INFILL HOUSING
and
OPEN BUILDING

Papers on Principles and Practice

Volume 1 Principles, Methods and Studies

Volume 2 Support / Infill Projects and Commentary

Volume 3 Open Building Principles and Practice

edited by
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<u>Volume 2</u>

Support / Infill Projects and Commentary

Introduction

These three volumes contain a selection of papers, articles and reports on the subject of Support / Infill housing and Open Building. They date from the early 1960's and include discussion of principles and methods, projects and products. Most of the projects shown and discussed are European. The volumes are:

Volume 1 Principles, Methods and Studies
Volume 2 Support / Infill Projects and Commentary
Volume 3 Open Building Principles and Practice

A separate document exists on Developments toward Open Building in Japan (Kendall, 1995). It discusses 24 built projects or planned developments and products in the period 1989 - 95 in Japan. Much work preceeded that period and is unfortunately not well documented in English.

The intent of the selection is to make available in one place a body of work to give those interested in further developments in practice a good grounding in what has been done to date. It does not intend to offer specific guidance in methods in the design of supports or infill systems. The book to study for the design of supports is Variations: The Systematic Design of Supports (Habaken) (MIT Press, 1976). No specific text exists to guide developers in the design and manufacturer of infill systems. However, the work of the OBOM group at TU Delft, while mostly in the Dutch language, provides useful background. Some is included in this collection.

Excluded from this collection is the extensive work on the subject of TISSUES. While Support / Infill concerns the level of buildings and their (mostly interior) infill or fit-out, TISSUES concern the larger context of the urban fabric: the form and space "rules" within which individual buildings can be realized by different parties while still offering a stable, coherent context.

No effort is made to present studies related to Tissues/Support/Infill in developing countries, of which there are many. These can be found most readily in the journal Open House International.

Further, in the sphere of professional education, few published articles exist and those that do are not presented here.

<u>Volume 2</u>
Support / Infill Projects and Commentary

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14. "Berkendamp: A Low-Cost Support - Infill Project of 253 Dwellings for Rent in Enschede, the Netherlands" (van der Werf) (1987)

15. "Management Lessons in Housing Variety" (Kendall) *Journal of Property Management* (1988)

16. "An Efficient Response to User's Individual Preferences" (Habraken) Housing Design 2000 Conference, Singapore (1992)

17. "Open Building Strategies in Post War Housing Estates" (Kapteijns & Cuperus) *Open House International* (1993)

18. "Build-out When You Lease: Marketing and Cost-Deferral Benefits of Just-in-Time Units" (Kendall) Units - National Apartment Association (1993)

19. "Open Stock" (Kendall) *The Construction Specifier* (1993)

20. "Open Building for Housing" (Kendall) *Progressive Architecture* (1993)

21. "Support and Infill: Design and Implementation" (Habraken) Housing Seminar, National Cheng-Kung University, Taiwan (1994)

22. "The Entangled American House" (Kendall) Blueprints - National Building Museum (1994)

23. "Open Building for Housing Rehabilitation" (Dekker and Kendall) *Proceedings, Future Visions of Urban Public Housing*, Cincinnati (1994)

24. "Open Building: A New Approach to Multifamily Architecture, Interior Design and Construction" (Kendall) International Society of Interior Designers Grant (1994)

25. "NEXT 21 in the Open Building Perspective" (Habraken) SD Number 25, Tokyo (1994)

26. "Open Building in Japan and China" (Kendall) proposal to the AIA College of Fellows Grants Program (1995)

27. "The Potential for Residential Open Building in the United States" (Kendall) Journal of Southeast University, Nanjing, China (1995)

28. "Europe's 'Matura Infill System' Quickly Routes Utilities for Custom Remodeling". (Kendall) *Automated Builder* (1996)

Housing, Participation,

Decision Making, Design Solutions, Diversity, Modular Coordination, Non-Load Bearing Elements, Procedures(Methods), Roles(Missions), Space Allocation, Structures(Construction), Users,

Articles., Dirisamer., Industrialization Forum., Kuzmich., Uhl., Voss., Weber., Year 1976.,

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Project "Dwelling of Tomorrow", Hollabrunn, Austria.

R. Dirisamer, F. Kuzmich, O. Uhl, W. Voss and J.P. Weber.

The project, which won a competition in 1971, applies the S.A.R. methodology to offer maximum choice and scope for participation by the users, while respecting cost limits and conventional technology. Start of participation coincided with start of construction; most occupants were fully able to design their own dwellings (the architect subsequently adjusting them to meet e.g. code requirements), leading to a remarkable variety of plans and elevations. On average, each participant changed his plan 2 ½ times and consulted with the architect 35 times (additional fees were necessary). Post-occupancy evaluation will start in 1979.

The project is located near the Czechoslovakian border in Austria, near the town of Hollabrunn. The S.A.R. methodology has been used throughout, to assist in the planning-design-construction-delivery process and also to provide a means of communication for re-defining the role of politicians, financiers and professionals in a structured discourse with the users who were encouraged to participate in all the phases of the project.

Competition.

In 1971 the team entered a competition announced by the Austrian Ministry of Housing and Technology; its entry was subsequently awarded the first prize.

The problem to be solved by the competitors was stated in the title of the competition: "Design Without Information" (meaning: how to design for future anonymous clients, without knowing their exact needs). This led to a proposal which decided to utilize Habraken's S.A.R. methodology as a general planning strategy for the design of a "support-detachable" project, characterized by "open" zones within a general "support" structure (fig. 1) to accomodate user-determined layouts of various types, sizes and materials, including variable facade treatment (fig. 2).

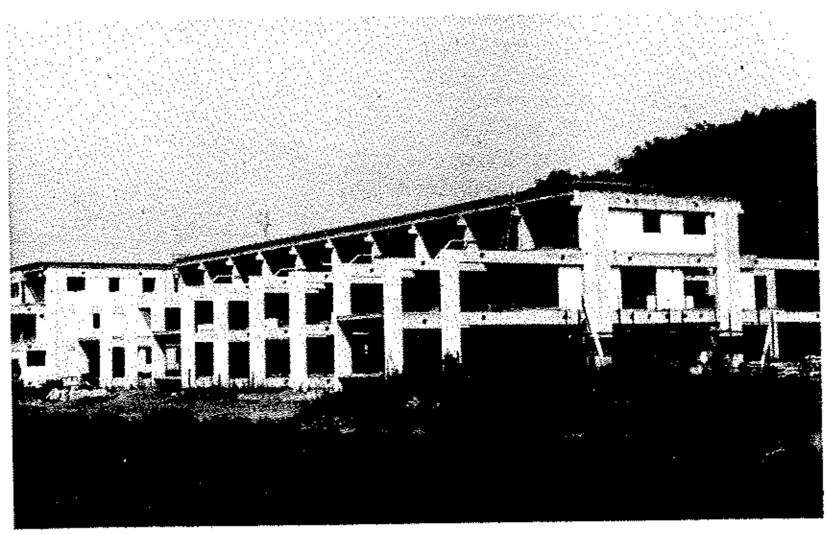

Figure 1. View of support structure.

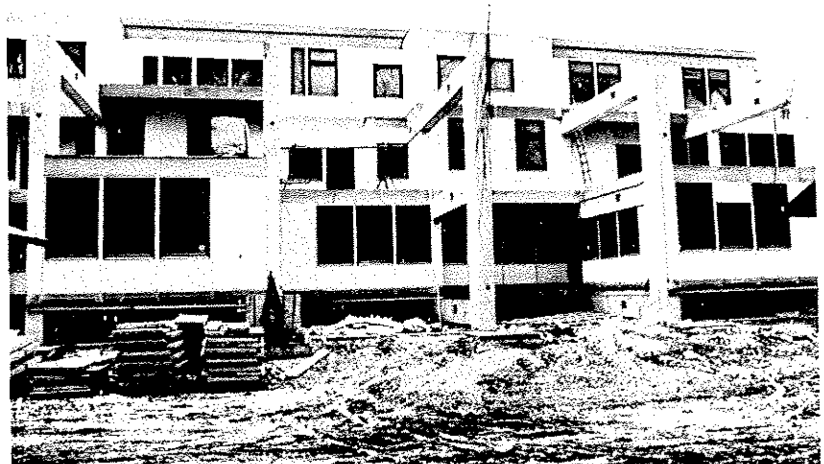

Figure 2. Facade infill elements.

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Conceptual Considerations.

1. Adapt the project to special site conditions, with maximum consideration given to communication links to the town, preservation of topographical features, provision for recreation, education and sports facilities;
2. Include in the design those dwelling types requested by the competition brief, without necessarily forcing the future users to accept these solutions. The stipulated types were: ground floor apartments with private yards, conventional first and second floor apartments, and maisonettes with roof terraces, all designed in such a way as to allow for maximum choice and variation in layout.

Project Parameters.

1. Cost limits as stipulated by project program;
2. Construction type had to be consistent with current conventional building practice and conventional construction materials (brick, concrete, Leca etc.).

In other words, the competition asked for innovation within the limits of conventional construction practices in Austria.

Realization.

In July 1972, the team was given the commission by the local housing cooperative to produce construction documents for the first phase of the project, comprising 60 dwellings or approximately one fifth of the total number planned.

At the same time the team was charged with the task of conducting research into the possibility of full user participation, by using the project as a case study for planning, testing and evaluation of the design and construction of the "Dwelling of Tomorrow."

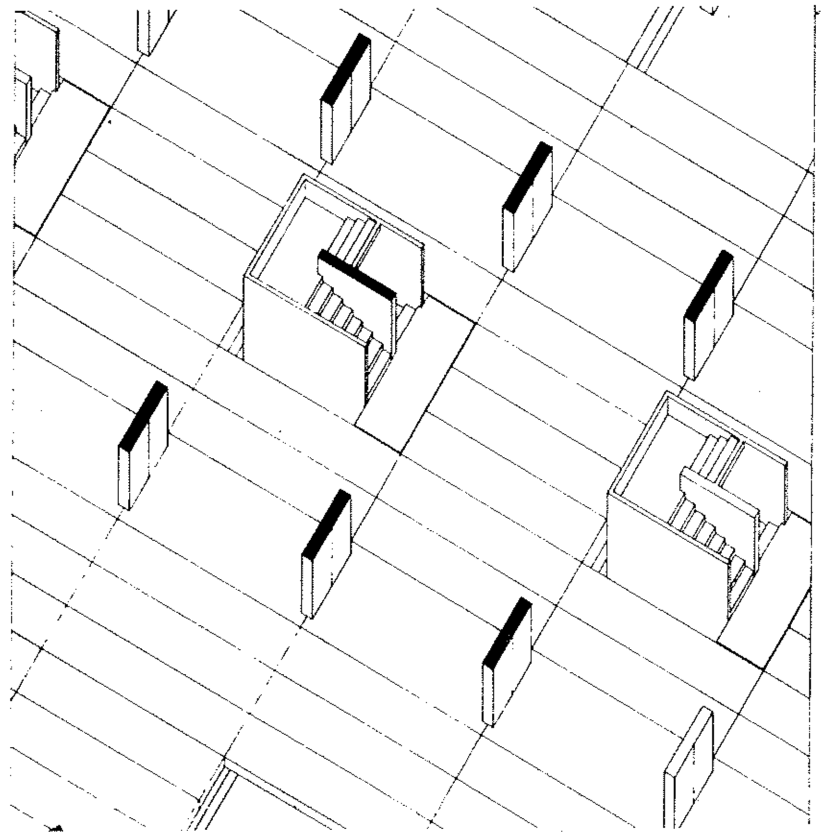


Figure 3. Primary support structure.

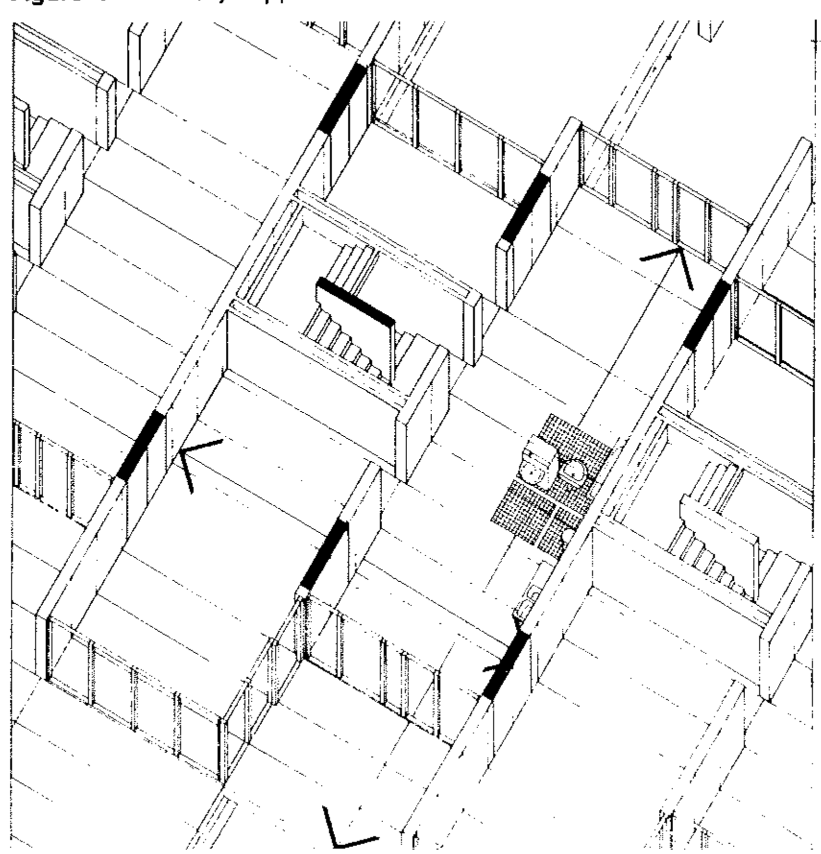


Figure 4. Dwelling size as determined by fixed support elements.

Figure 5. Sizes of rooms as a function of the support elements.

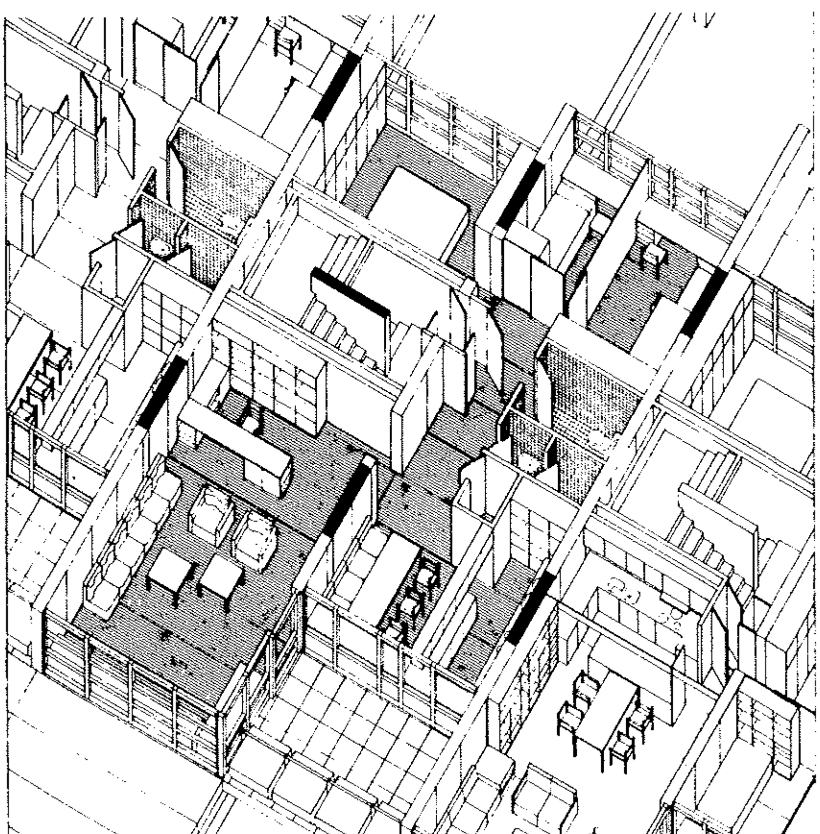


Figure 6. Furnishings: possible arrangements.

In order to provide a methodological framework for the anticipated participation process, it was decided to use the S.A.R. methodology developed in Eindhoven, Holland under the direction of N.J. Habraken. The reasons for this decision were the following (see figs. 3 to 6):

— The basic feature of separating the supports (i.e., the primary structure) from the infill (i.e., the secondary elements) has definite implications on the development of autonomous but compatible production capabilities and on compatible public-private decision-making in housing;

— The tartan grid (modular coordination system) developed by S.A.R. is based on the commonly accepted European 30 cm modular standard, but — in addition — allows for free placement of materials and spaces in alternating 10/20 cm bands (see fig. 7);

— The concept of zones, margins, sectors etc., is used for analysis and evaluation of dwelling layout variants by means of a clear and comprehensive graphic notation system.

Thus, the methodology has both the capacity for open planning and the means for technical implementation, without being tied to any particular construction system or any particular material. Finally, the methodology did not require any radical departure from the original competition requirements, such as the suggested 510/960 cm concrete panel system.

Participation.

Financed and supported by the Ministry, the participation process was officially initiated in June 1973 under the title: "Dwelling of Tomorrow." As a first step, a meeting of prospective interested dwellers was arranged, during which the whole program was explained in detail. In subsequent meetings, different dwelling styles and types were discussed, along with the presentation of sociological comments and explanations concerning the nature of the communications that would be necessary to make the process effective and productive.

January 1974 marked the beginning of the actual participation phase as such, which also coincided with the beginning of construction. Regular meetings were held in Hollabrunn, which were attended by the users, the architects and representatives of the housing cooperative. During the meetings, detailed information material was distributed to all participants, such as documents concerning dwelling size, dwelling type, layout possibilities, costs, construction schedules etc., as well as "blank" floor plans to be taken home by the people for discussion with their families and friends (only the structure and the location of vertical service elements was shown in these "blanks"; examples of actual floor plans were given to discussion participants *only if they expressly asked for them*). Aside from that, a 1:200 scale model of the project was put on display and kept 'up to date' to show construction and occupancy progress (see fig. 8). This allowed the participants to see themselves in the context of everyone else's decisions and to visualize their own decisions better (see figs. 9 to 10).

Interestingly, even during preliminary discussions, most users had already formed strong and divergent feelings about such matters as sun, light, location, view etc. For example, locations 1.0G (fig. 12) and 2.0G were considered most desirable, as were locations providing a good unobstructed view. To have other dwellings, or even trees, in front of windows was considered less desirable.

In October 1974, consultations were under way concerning finalization of floor plans and deci-

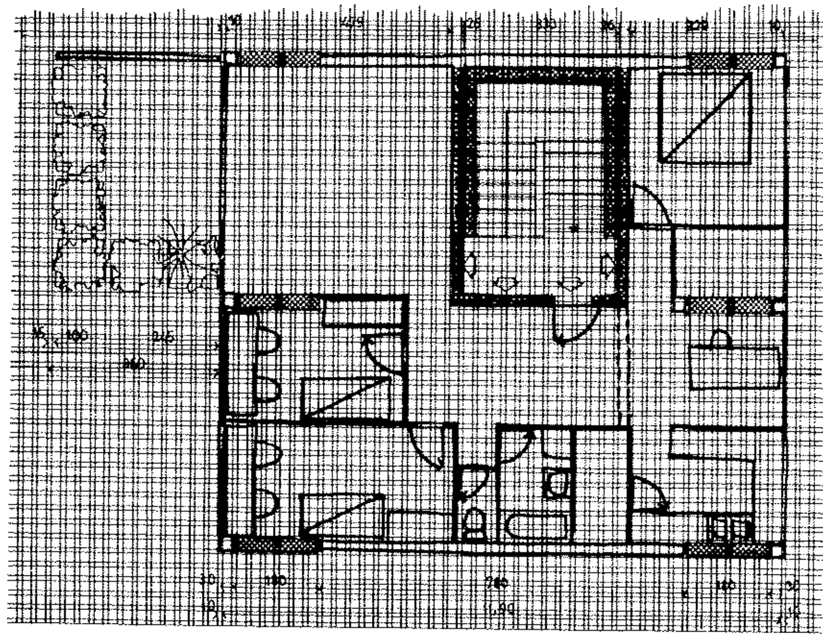


Figure 7. Plan drawn by a user over the 10/20 tartan grid.

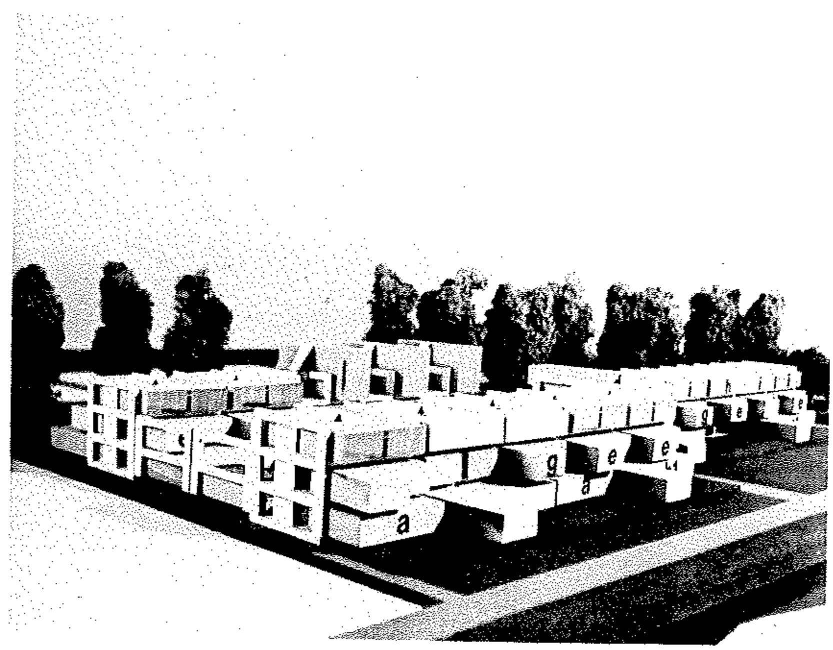


Figure 8. 1:200 scale model of the project, showing construction and occupancy progress.

Figure 9. Model with arrangement designed by user.

Figure 10. Exemple of facade designed by user.

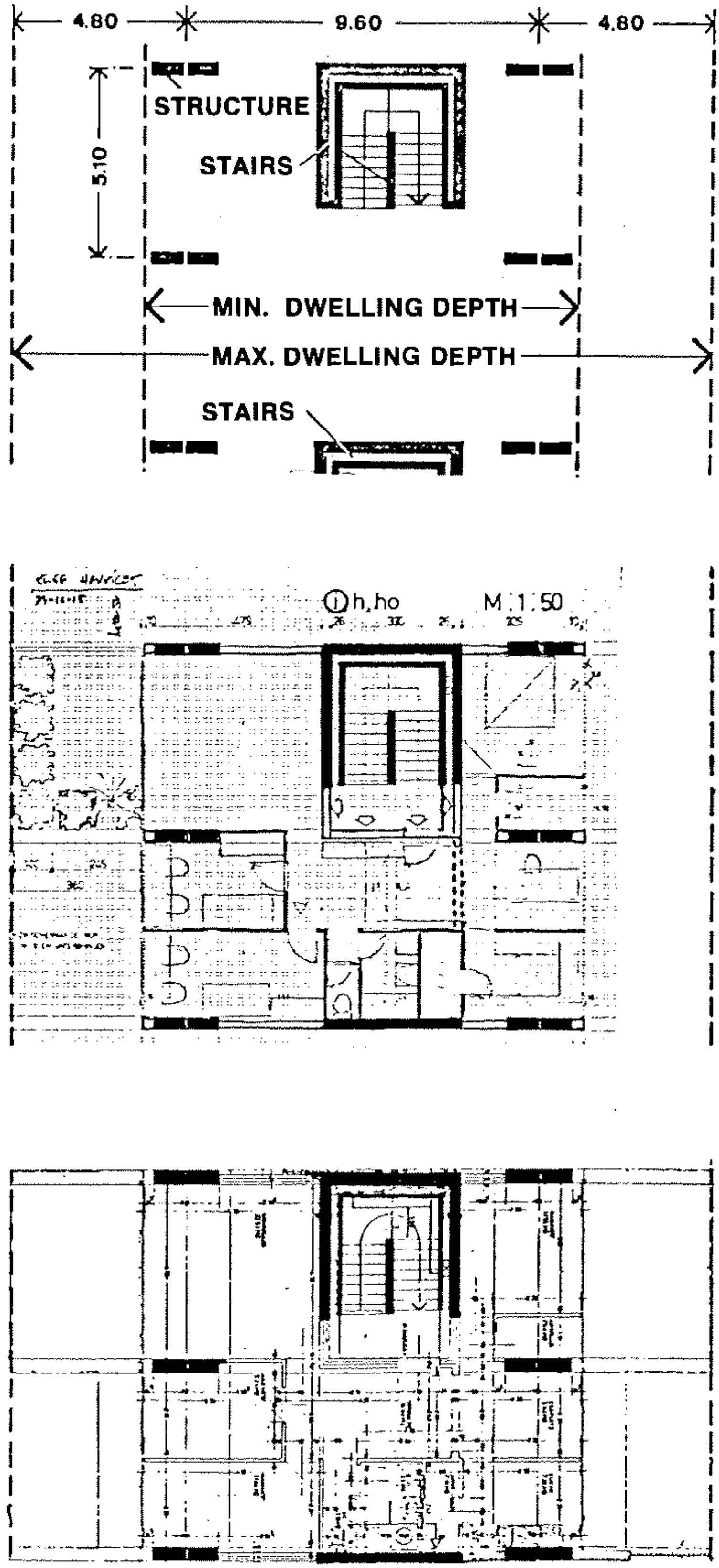


Figure 11. a: Zones and primary support elements; b: floor plan developed by user during meeting; c: same floor plan "adjusted" by architect for construction purposes.

sions on facade treatment, interiors and communal service facilities. Plans had to be brought up to code requirements and adjusted to actual conditions within the support structure (fig. 11c).

Some of the participants not only designed their own layouts but also criticized the plans provided by the architects as examples, and offered suggestions for future improvements. The majority managed to solve all their problems during the general consultation sessions or in individual sessions with the architects. It is truly remarkable that almost none of the participants gave up their right to determine the layout of their own dwelling, except for those who planned to rent their dwelling to someone else. Only in very few cases was participation seen as a burden or an unpleasant duty.

Conclusions.

The inherent openness of the support structure was utilized quite efficiently by the users, while at the same time achieving floor plans responding to their own needs and desires. This has been borne out by the fact that all the plans and facade elements are actually different from each other (see fig. 12). The variety of interiors, in terms of equipment and finishes, is truly astounding and has surpassed all expectations of the design-planning team. It is also interesting to note that for reasons of heating economy, the majority of users opted for smaller window sizes than those suggested by the architects in the original competition scheme.

Additional design fees were incurred due to the need to frequently update construction documents, to include the changes developed during the construction-planning process. On the average, each user changed his or her plan about 2½ times, one way or the other, before deciding on a final scheme.

The number of contacts between users and architects (including face to face consultations, telephone conversations and correspondence) ranged from 20 to 40, with 35 contacts as an average.

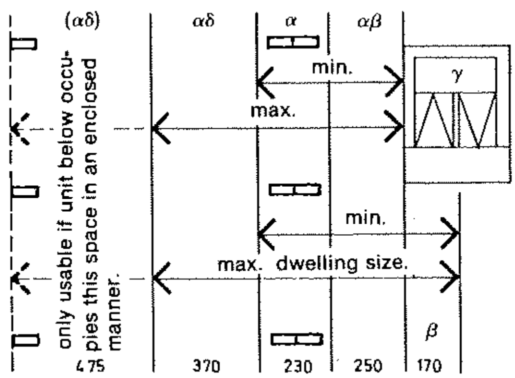
The final evaluation of the project will be completed in 1979, i.e., three years after full occupancy. During that period, the dwellers will be questioned about their experiences, feelings and reactions to the whole process of participation and use.

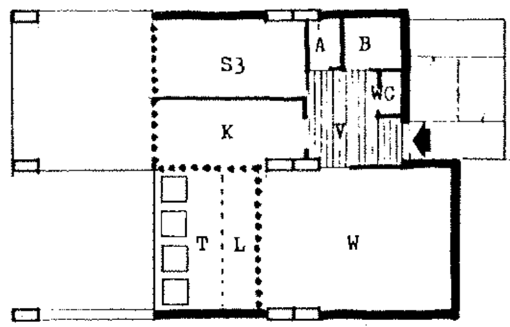
The experience gained by the team, and the results achieved, should provide a good point of departure for future projects in that direction, proving not only the practical (and technical) feasibility of participation but also its social, political, economic and broadly humanistic superiority over current modes of planning and design of mass-housing projects.

Acknowledgements:

Architecture, Urban Planning and Coordination office: Prof. O. Uhl and Prof. J. P. Weber, Architects.

DWELLING TYPE e





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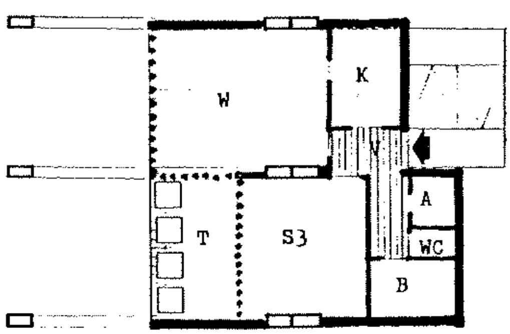
variant: — | axis: 2-4
basic variant: 6 | orientation: W



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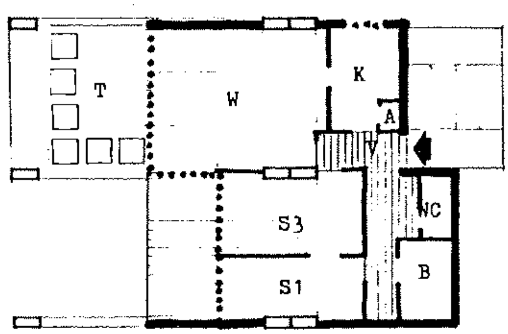

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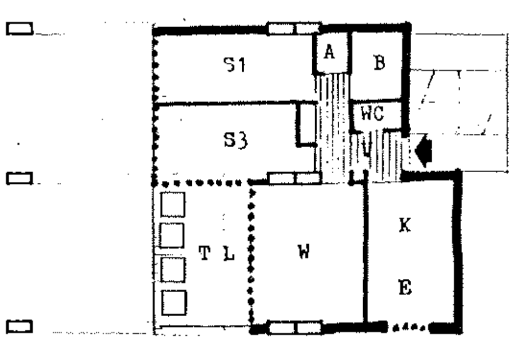
type of unit: e | floor: 1.0G
variant: — | axis: 8-10
basic variant: 1 | orientation: W,N



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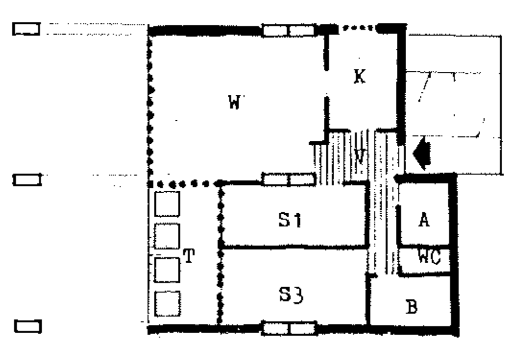

Size of unit (m²): 76.9 | block: II
type of unit: e | floor: 1.0G
variant: — | axis: 8-10
basic variant: 1 | orientation: W,N

Figure 12. Examples of floor plans designed by the users.

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odular Coordination,
Non-Load Bearing Elements, Rationalization, Space Allocation,
Structures(Construction), Student Residences,

Articles., Froyen., Industrialization Forum., Year 1976.,

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Structures and Infills in Practice — Four Recent Projects.

Hubert-Paul Froyen.

It is important to see how principles that involve not only a new approach to technology, but also a set of modified relationships between participants, can be applied in practice. This article brings together short illustrated descriptions of four adaptable housing projects, applying the SAR (Stichting Architekten Research) principles of structure and adaptable infill.

The Social Sector of the University of Louvain, designed with active participation by the students, includes housing for 210 students — 90 of whom chose a regular and egalitarian form of building, whereas 120 of whom opted for a modifiable, varied building. This is built with flat plate construction on the 10/20 grid, with adaptable partitions and external cladding. The PSSHAK, in London, has been used for two projects, in which the assembly principle has been partially utilized. Construction is largely traditional, with rationalized services and adaptable partitions; simple arrangements allow for changes in the overall dwelling sizes. CASCO Shell housing in Delft also is based on cross-wall construction, with suitable provisions for subsequent changes in interior arrangements or extensions. The shells are immediately habitable, and assembly kits are available for fitting them out. The Elementa 72 project near Bonn uses prefabricated, standardized components, within the SAR preferred dimensions and grid, to provide for adaptability. Due to the lack of subsequent market, costs on this project were high.

Introduction.

The four projects that are presented here tackle the problem of adaptability — and controlling that adaptability — in four different countries, and in four significantly different ways.

Construction technology may be part traditional (for the structure) part innovative (for the infill) or more totally innovative; there may be a thourough use of "clip-fit" components or a subtle blending of durable materials to selected demands of adaptability. However, in all cases, a disciplined approach to dimensions, coupled with a rational hierarchy of permanence (both fundamental to the SAR principles) have enabled more adaptable buildings to be built with more participation by the user than is usually the case.

Though their designers might not always wish to admit it, these projects are really prototypes — prototypes of a new kind of technology, a new separation of fixed from adaptable, a new distinction between purpose-built (structure — public) from mass-produced (infill — private). They are, moreover, even more exactly prototypes, when we remember that the whole building decision process is radically affected; who decides the public parts? How can we "avoid" making decisions about the private parts — without falling into the trap of creating so much uncertainty that nothing happens at all?

The comments and illustrations that follow, show that buildings that embody the SAR principle are actually being built and used. They give some indications about the contributions of the occupants to the decision process (or, at least, about the potential that was established for a contribution...). However, we must necessarily supply our own information when we seek to answer — as we should — the next question, which is: how could we adopt this approach here, now...

Ed.

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About the Author:

Mr Hubert-Paul Froyen is Assistant Professor at the Institute of Architecture, Hasselt, Belgium, where he is teaching the S.A.R. philosophy and methodology. Mr Froyen holds a degree in Architecture from the Institute of Architecture, Hasselt; he is also working with the Stichting Architekten Research at Eindhoven, the Netherlands, where he is a Research Associate, with special concern for real world applications of the S.A.R. methodology and for participation in general.

Social Sector — Catholic University of Louvain.

Brussels, Belgium; Designers: The Lucien Kroll Office of Architecture and Urbanism.

Prehistory and Facts.

The project for the Social Sector of the Faculty of Medecine is being built on a 10 acre site; it comprises a built area of 430 000 sq.ft., and includes:

- student residences ("La Mémé" and "Les Fachistes"),
- a restaurant,
- student residences ("Les Pharmaciens") with religeous facilities and a theater at the lower levels,
- married student quarters,
- a primary school.

Construction.

Student dwellings in the "Mémé" building.

The apparent disorder of the building is, in fact, very carefully organized; it is the product of a very strict discipline, based on modular coordination using the 10 cm module with a 30 cm preferred multiple, forming the SAR 10/20 grid. As long as load bearing elements and fixed equipment is installed in the 20 cm spaces, and partitions in the 10 cm spaces, there are no problems.

The structure is based on the use of flat slab construction; the ceiling is flat so that the partitions can be located freely (respecting, of course, the SAR grid). The flat slab is of slightly increased thickness, so that electrical conduits, plumbing and heating pipes etc. can be included in it.

The columns are not randomly located, but are centered on multiples of 90 cm. They form a "mosaic" of square or rectangular "mushrooms" which touch each other and cantilever out to the perimeter of the building.

The architects suggest that "the irregularly spaced columns stimulate the imagination... since the distances between them vary in both direction, without even repeating the same motive, the plan of each room will be lively."

The movable partitions are formed of gypsum boards, glued to a core of bakelized mineral wool; these composite laminates form panels which are self-supporting, without the need for posts. Jacks hold the panels against the ceiling. They can be erected and dismantled rapidly by "amateurs".

On the outside, all windows are multiples of 30 cm (including their framing); they meet up with the partitions which lie within a compatible grid. The use of adjustment components is allowed for. The window frames are of different colors, in order to accentuate the specific identities of the various components.

Sanitary equipment and kitchens are grouped and are fixed.

Guard rails on the decks are replaced by square planter boxes which are randomly positioned and can be rearranged and planted as desired.

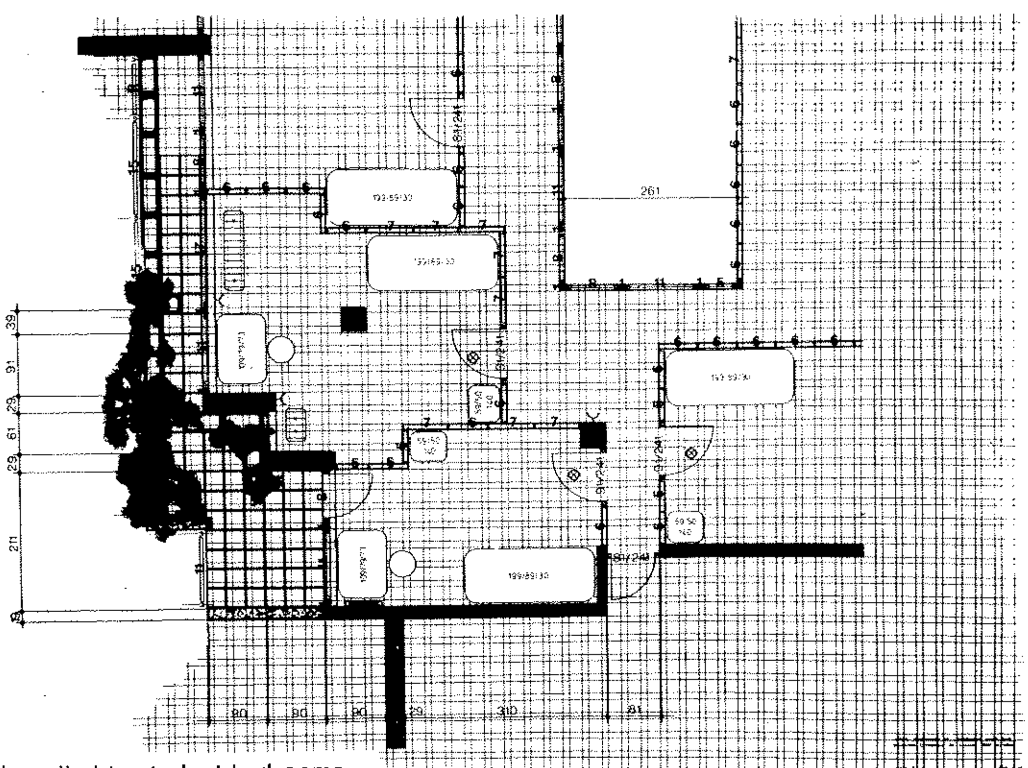


Figure 1. SAR grid applied to student bedrooms.

Figure 2. East elevation of "la Mémé"; arrangement of components reflects the arrangement of the rooms.

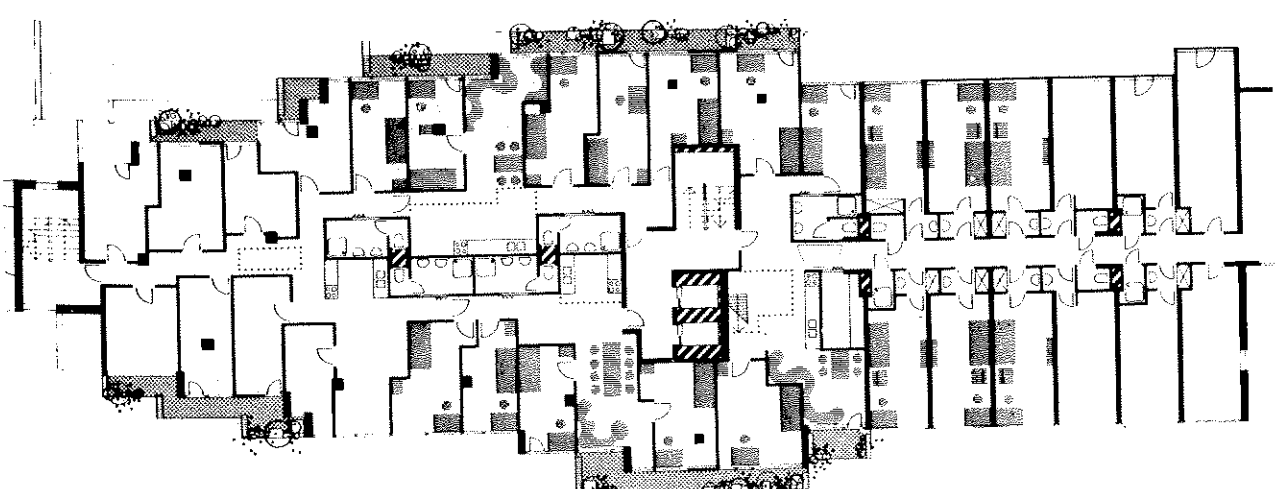


Figure 3. Plan of "la Mémé" (left) and "les Fachistes" (right).

"PSSHAK" Primary Support Structure and Housing Assembly Kits.

GLC (Greater London Council), Department of Architecture and Civic Design, London, Great Britain, Nabs Hamdi and N. Wilkinson.

Prehistory and Facts.

Based on SAR (Stichting Architekten Research group in Eindhoven, Holland) principles and methodology, Hamdi and Wilkinson have developed the PSSHAK method in the "Housing and Town Development Branch" of the GLC's Architect's Department. Two PSSHAK experiments are under way at the present: PSSHAK 1 at "Stamford Hill", Hackney, London, and PSSHAK 2 at "Adelaide Road", Camden, London.

Construction.

PSSHAK "Stamford Hill".

On a site of 2.2 acres, a total of 65 dwellings are under construction, together with an experimental PSSHAK block, consisting of 12 apartments.

The basic PSSHAK structure consists of brick cross walls, pierced with door-sized openings in the appropriate places and filled with a demountable party wall system to provide for long-term adaptation of the dwelling mix.

The "assembly kit" principle is only partially employed: bathrooms, kitchens, the position of windows and ducts are fixed items. The partitioning is being supplied by two British firms whose systems employ different fastening methods:

— Type A: a system first employed in Scandinavia. It has no fasteners to walls, floors, and ceilings, but is held in position by a spring-loaded jack.

— Type B: the use of an expanding sole plate and adjustable head enables the partition to accommodate normal variations in the floor-to-ceiling height of rooms and also accommodates any other movements of the element throughout its life.

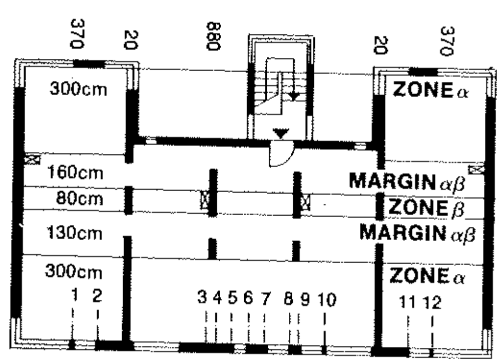
The PSSHAK block has a built-in integral electrical system to accommodate mix variations along with an internal distribution network for plan variations.

The difference in costs between building with PSSHAK and building with traditional methods is relatively small (+2%).

PSSHAK "Adelaide Road".

The second GLC scheme to be designed by the PSSHAK method should be started on-site early in 1976, on the basis of a 15-months contract. It is difficult to say how many dwellings will be built; 44 are planned as of now, i.e., 17 two-person units for old people; 12 two-person units; 9 four-person maisonettes; 4 six-person houses and 2 eight-person houses. "Adelaide Road" is more developed than the earlier "Stamford Hill" scheme. At "Adelaide Rd." the basic structure allows for larger units (compared to "Stamford Hill" with only apartments), including two- and three-storey houses and duplexes, and thus a much greater variety of dwelling types is possible through the use of "penetrable parts" in the slab (these can house either internal staircases or be spanned by a timber floor panel).

A complete set of industrially produced "Detachable Units", based on the SAR methodology, will be provided by a Dutch firm. Complete kits of bathrooms, kitchens, ductwork, walls, doors, etc., will provide a complete break between the shell and the "infill".



Key:

black line denotes support structure,

hatched line denotes demountable party wall,

open line denotes "kit" (infill components),

numbers (1,2,3...12) indicate possible positions of partitions.

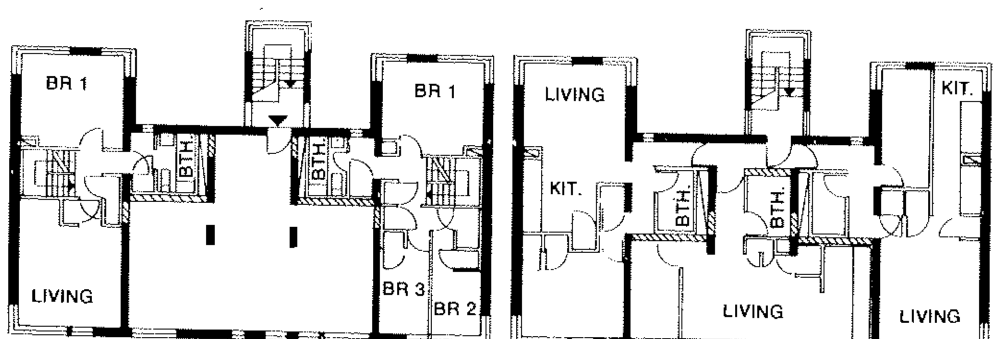


Figure 4. Adelaide Road: plan of the support structure (above) and two sample plans of the second floor (below).

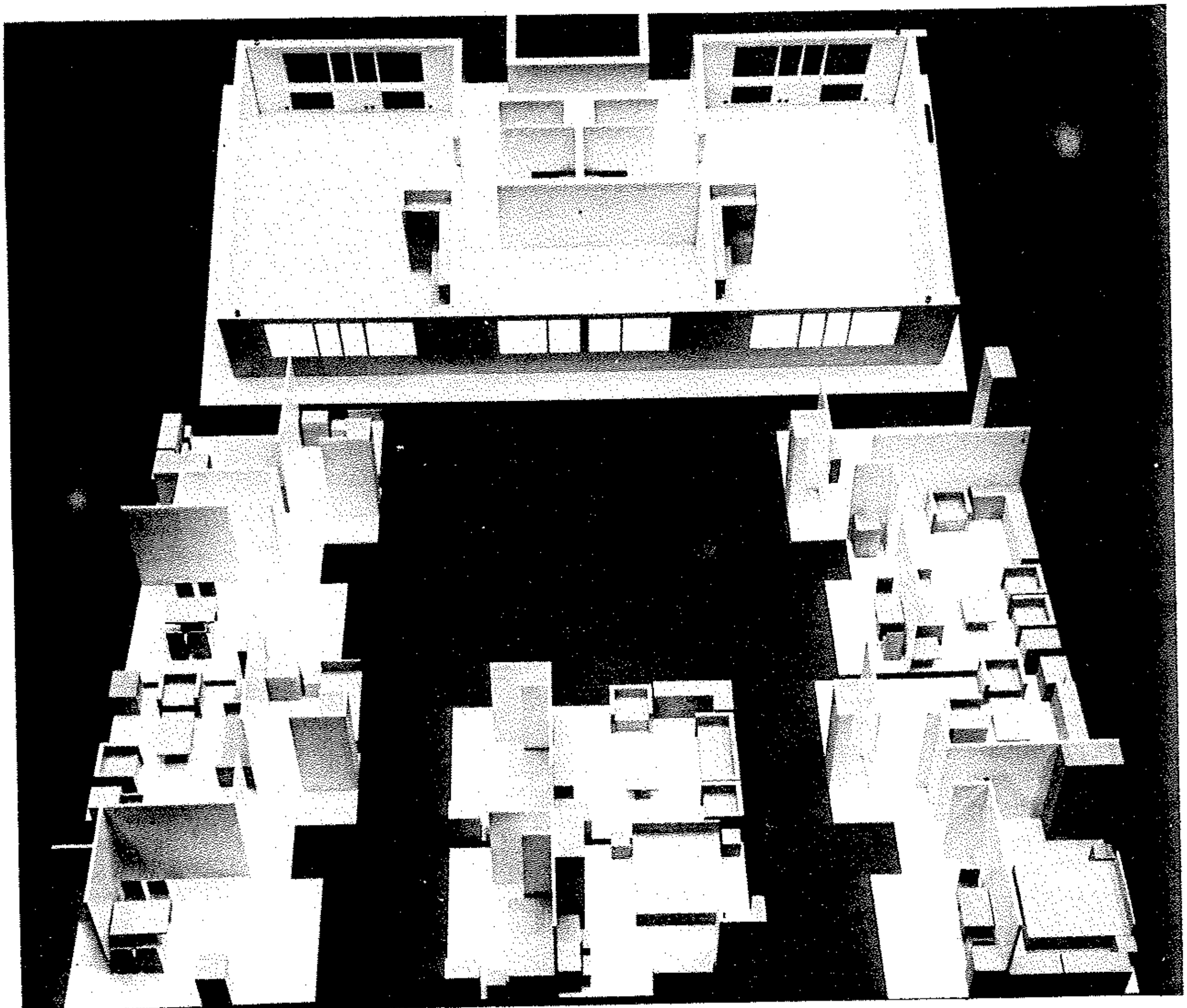


Figure 5. Models of alternative arrangements proposed by tenants (two samples for each apartment are shown).

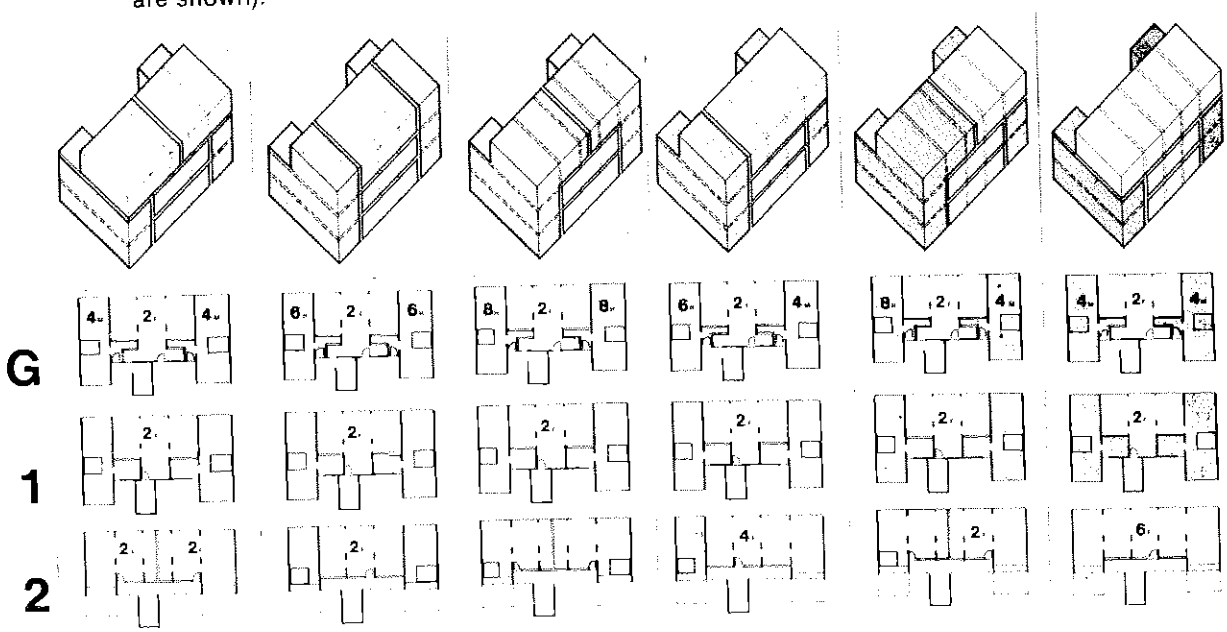


Figure 6. Sketches and plans showing alternative dwelling size possibilities within the standard three storey block.

"CASCO"; Shell Housing and Housing Environment Project.

Delft, The Netherlands, Arch. Sijrk Haaksma.

Prehistory and Facts.

The "Housing and Housing Environment Project" of the Provincial Planning Bureau (P.P.D.) was initiated by the provincial government of South-Holland, with the aim to improve standards of housing and its surrounding environment in the province. In addition to the province, four of its municipalities (including Delft) have participated in this project. Architect Sijrk Haaksma was commissioned by the Municipality of Delft to make a study of low-cost housing that would be adaptable to the perceived needs and requirements of the occupants. This led to the study of "Shell"-housing, made in collaboration with a multi-disciplinary team of advisers, including SAR. The Municipality eventually handed the project over to an Association of Housing Corporations in Delft.

About 120 "shell"-units (50% owner-occupied; 50% rentals) will be built in 4 phases of 30 units, from 1978 onwards, in the "Tanthof" district of Delft. Two experimental "Shell"-units are soon to be built: one will be permanently occupied and evaluated from the users point of view; the other will be permanently used as a testing ground for technical experiments by different firms producing "Detachable Units".

Construction.

The structure consists of:

- Cross wall construction; 540 cm (17'-8") between centers.
- Floor slabs in the α-zone; 270 + 10 cm (8'-8" + 4") or 330 + 10 cm (10'-8" + 4") in front of the house and 230 + 10 (7'-8" + 4") back of the house.
- An open β-zone of 240 cm. (8'-0") width.

Foundations were reinforced because of the low bearing capacity of the soil in this specific area and as a provision for future extensions.

Ducts and services are located adjacent to the cross walls and near the open β-zone. There are 4 holes in the floor slabs, each filled with a "soft" material, which can be easily removed to make way for additional services, either initially or in the future.

The "Shell" is immediately habitable, since all essential features and utilities are provided, including facade, bathroom, toilet, staircase, heating system, electricity, water supply, and finished roof.

Detachable units consist of:

- A "Basic Assembly Kit" (B.A.K.) is included in the price (up to fl.2000 maximum — $750 — in 1976) and consists of: movable partitions, doors, closets, kitchen elements etc. The occupant can make a choice, based on his or her specific needs or wants.
- A "Surplus Assembly Kit" (S.A.K.) may be purchased and consists of: a second toilet, attic windows, bay windows, extra partition elements and closers, a second staircase and other elements to be added by the occupants. Occupants may sell their S.A.K. elements to the next occupier or to the owner (or take them away).

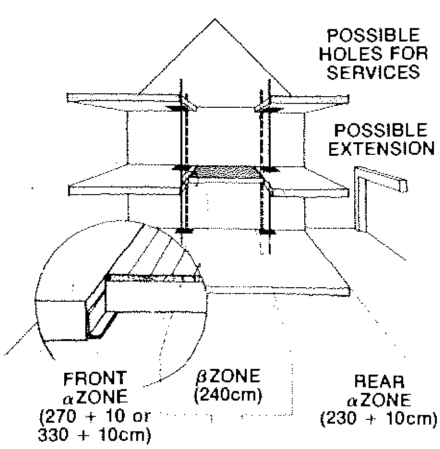


Figure 8. Application of zone principle, showing drop-in floor in β zone.

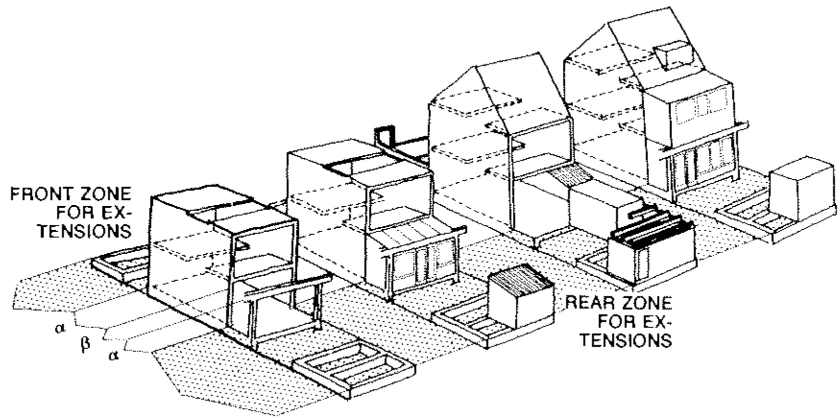


Figure 7. Basic idea of shell housing: possible evolution and variations.

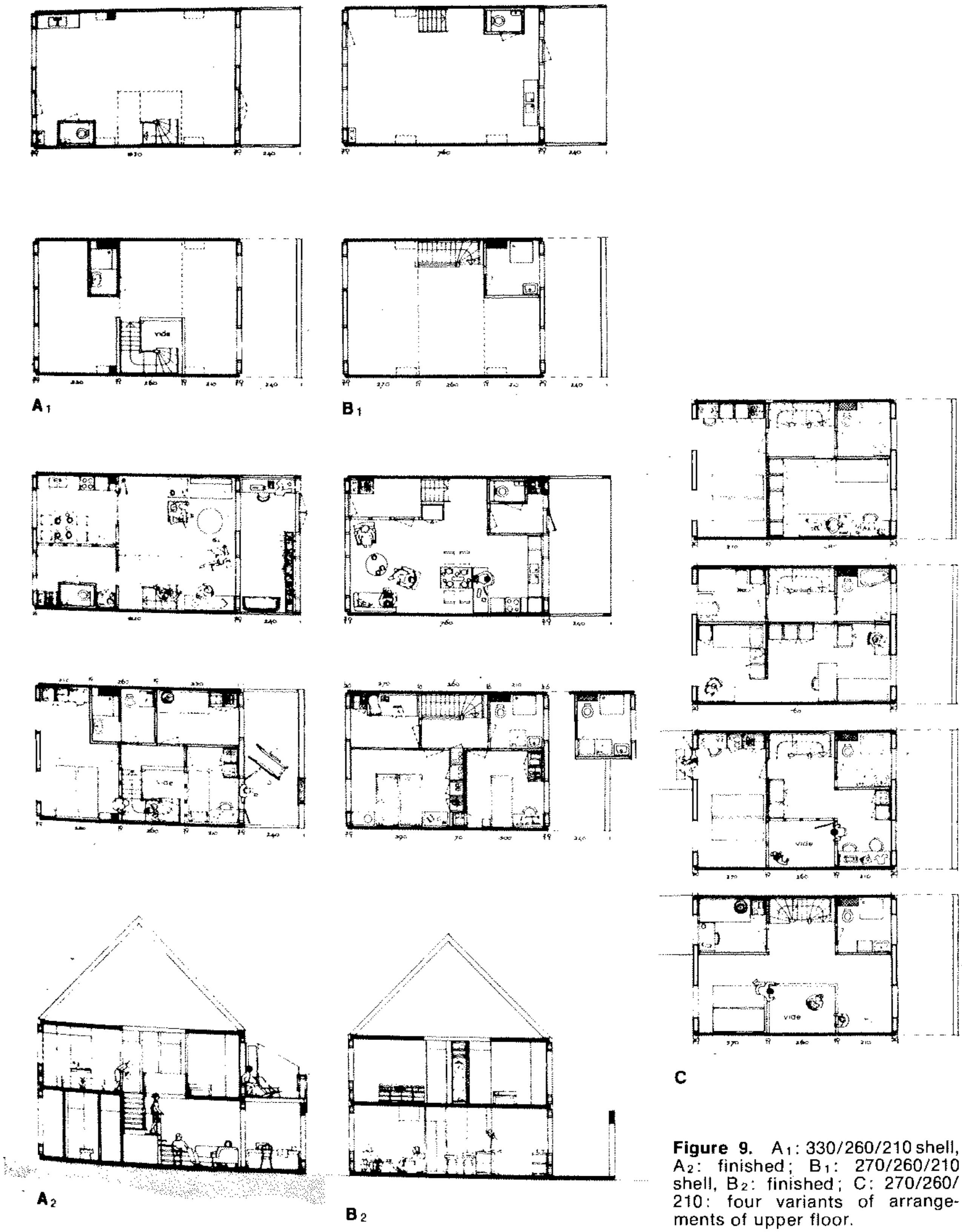


Figure 9. A_1: 330/260/210 shell, A_2: finished; B_1: 270/260/210 shell, B_2: finished; C: 270/260/210: four variants of arrangements of upper floor.

Elementa '72.

Hardtberg, Bonn, West Germany; Designers: Offenbach and P.A.S. — Projektgruppe Architecture und Städtebau/J. Jourdan and B. Müller.

Prehistory and Facts.

In 1972, the Federal Ministry for Urban Development and Housing (Bundesministeriums für Städtebau und Wohnungsbau) launched an architectural competition for housing. A system of prefabricated components was called for, allowing the greatest possible number of building types and dwelling plans.

Two offices teamed up to enter the competition, which they won with a system based integrally on the SAR 65 principles. This project has how been built; it contains 54 dwellings for one to five people, with areas ranging from 44 to 99 m² (475 to 1065 sq. ft.).

Using the SAR 10/20 grid, two construction modules — both multiples of 30 cm — have been developed; they are 270 and 540 cm (8'-8" and 17'-4"). Two special dimensions are also used for the extensions — they are 90 and 180 cm (3'-0" and 6'-0").

Within the zoning principle, two special zones are included: (a) an "exterior" zone which allows for external spaces (gardens, galleries, stairs, extensions to (or subtractions from) the dwelling and (b) a "wet" zone which contains all the piping and connections and allows for changes of level.

Construction.

The load bearing structure is reinforced concrete; it is a mixed system of columns and thin walls which support the other construction components. The floor slabs are 20 cm. thick and exist in two sizes: 270 × 270 and 270 × 540, (in practice, 80% of the slabs were cast in-situ). There are also two triangular slabs for corner extensions. The beams are 20 × 45, with spans of 270 or 540. Columns are storey high, cruci-

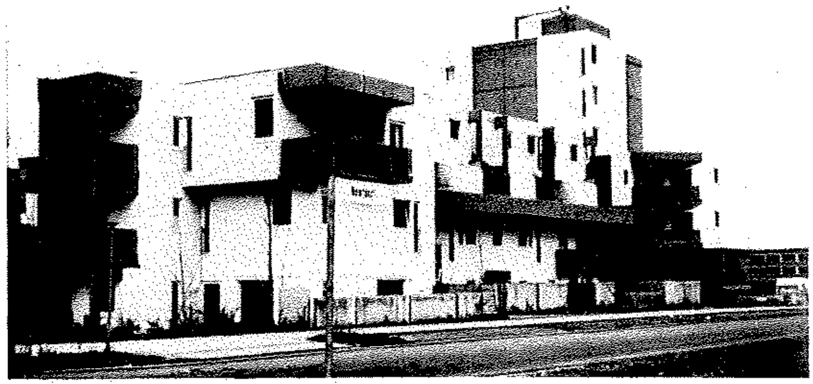


Figure 10. General view from Newtonstr.

Figure 11. Elevation onto courtyards.

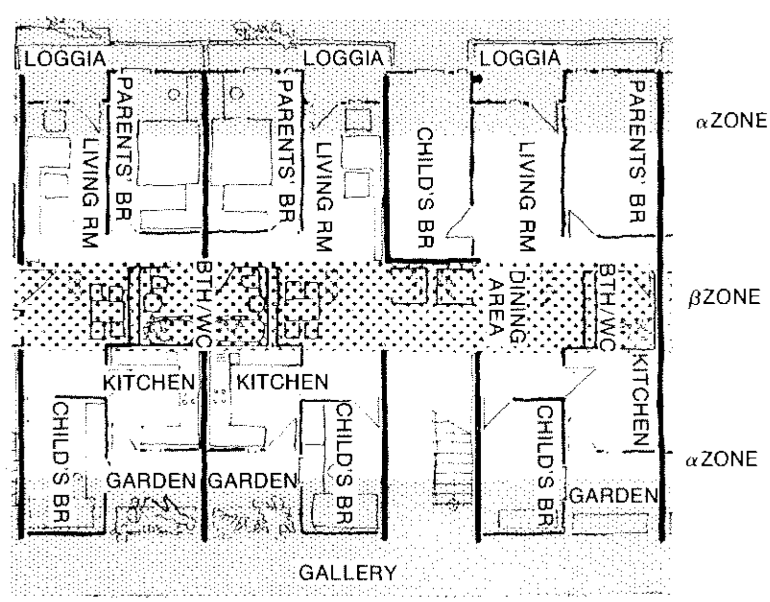


Figure 12. Example of zoning system.

form section lying within dimensions of 30 × 30. The column heads have brackets to receive the beams and cantilevers to hold up the extension components.

The façade components have wooden frames, clad on the outside with plastics and inside with gypsum boards. They can easily be taken down and moved to another position.

Some special components are integrated into the structural system: steel stairs (which can be changed), landings, stair well and elevator shaft enclosures, balustrades and special access-gallery slabs with parapets.

The partitions are made from two panels of pressed wood, 3 cm thick, with a 4 cm. cavity. The cavity can be filled with an insulating material.

There are three types of prefabricated toilet units: 180 (× 240, × 180 or × 120) × 240 cm high. Each type has variants for the internal arrangement of the fixtures. These units are connected to prefabricated vertical plumbing trees.

Hot water central heating is incorporated in the floors. Electrical conduits run in the base boards and in the cavities of partition and façade components.

The building costs between 40 and 50% more than was estimated, because the investment in industrialization had to be written off on this one building. Also, there were some special components which further added to the cost. Coordination was not good, and no prototype dwelling was prepared.

Figure 13. Isometric view of competition project.

Participation.

Louvain.

Through exceptional circumstances, the students were able to choose their architect themselves and to commission him to build their dwellings. Kroll started by consulting the students, with meetings taking place between October 1971 and February 1972; construction started in July 1972. As Christopher Hunziker writes: "The students were far from being unanimous. Some would have preferred that the Mémé building (nickname given to the medical house, for members of the association of medical students) be regular, repetitively divided so that each person would have the same rights to the same amount of space as anyone else.

"Other students wanted rooms that could be changed to suit the students' choices — both initially and subsequently. These two contrary opinions were built — side by side; the one ("Mémé") — neutral, adaptable, for 120 students, the other ("Fachistes") — regular, for about 90 students"[1].

1. *Christopher Hunziker in:* Architecture d'Aujourd'hui, *No. 183, 1976.*

PSSHAK

A participation program with the prospective tenants, prior to their moving in, is intended to go into operation. The tenants will be provided with complete information about the scheme, and will have the use of a scale model to help them in planning the layout of their flat. Both projects are seen as stages in a long-term development program, which will concentrate on all the building and management aspects of flexibility and adaptability, as well as on the tenant participation process.

CASCO

The industrially produced "CASCO" or "Shell" system has been designed to provide both economy and simplicity in terms of shape and dimensions, which enables the occupant to assemble the parts into a complete house with ease and at low cost, while at the same time meeting his or her special requirements.

The areas where the individual occupant has a direct input in terms of self-help or decision-making are:
— the interior of the house,
— the immediate surroundings of the dwelling,
— the transition area between interior and exterior, where expansion and addition is made possible, e.g. with a glazed veranda, bay windows, attic windows etc.

Through their own input, occupants will be involved in their house and in the neighborhood, which should result in greater care and responsibility for both.

Elementa.

The future tenants were not able to intervene during design nor during construction. However, the inhabitants profit from the freedom they have to modify some of the components of their dwelling, thanks to the concept of "constructive flexibility". This freedom encourages on-going self-renewal within the building.

Over the last year or two, the inhabitants have taken to meeting together; they have founded a tenants' association which has adapted a space as an adults club, and also has taken charge of children.

Participation, Users,

Adaptability, Building Sub-Systems, Decision Making, Internal Subdivisions, Procedures(Methods), Space Allocation, Structures(Construction),

Articles., Industrialization Forum., Vernez-Moudon., Year 1976.,

2879

Les Marelles: Lessons in Dwelling Design.

Anne Vernez-Moudon.

This article discusses questions and problems associated with user participation, referring specifically to the experience of Les Marelles, a housing project near Paris designed by Georges Maurios and his colleagues.

The project consists of three multi-family structures where prospective dwellers are encouraged to design their own units according to their own needs. Professional decisions cover the design and construction process of the various building parts, while dwellers' decisions relate to the configuration and arrangement of some of the parts. The dwellers' design process is built into the promotion and sales procedures; widely differing arrangements have resulted, leading one to query the conventional reliance on standards and norms. Difficulties arise in the promotion — which inevitably has to differ from the promotion of traditional housing. Possibly too much flexibility is offered, and a more detailed prior study would be wiser — using for example the S.A.R. methodology. Also the project is not particularly adapted to its suburban location, suggesting a less "generalized" approach to the support structures.

About the Author:

Anne Vernez-Moudon is Assistant Professor of Architecture at the Massachusetts Institute of Technology. She was involved in research for the development of self-help housing programs in the United States. She spent time In Europe visiting housing projects based on user participation and studying the S.A.R. methods and their practical applications. She holds a B. Arch. from the University of California at Berkeley where she taught design and technology between 1973 and 1975.

Acknowledgements:

Gratitude is expressed to Georges Maurios and Hubert-Paul Froyen for providing some of the graphic material and information on the project.

A Different Housing Approach.

Environments created without, or despite, professional involvement have been the subject of much study and some controversy. While they are generally based on a low utilization of resources, they have been shown to generate richness and variety, as well as user satisfaction. Though impressed and influenced by these various schemes and developments, I have been disconcerted by the fact that the vast majority of examples have been restricted to pre-industrial cultures and developing societies, or to what can essentially be considered as rural situations[1]. The literature generally excludes industrial or post-industrial urban contexts as examples of environments where residents have an opportunity to participate directly in planning and building activities.

Clearly, structural and institutional *constraints* and controls posed by the Western urban culture present phenomenal barriers to non-professional involvement at all levels of land development. Clearly also, the simple abolition of these constraints and controls does ot constitute a feasible alternative, and would only re-introduce many of the now forgotten plights of urban life: lack of light and open space, insanitary conditions favorable to the propagation of epidemics, congested public thoroughfares and many other problems caused by an uncontrolled competition for urban land. The question is, then, whether there is a paradox in the possibility for laymen involvement and for the self-determination of urban residents: do the complexities of the urban environment preclude such participatory models?

The project of Les Marelles embodies ideas to the contrary and indeed shows that it is possible to permit layman involvement in high density residential developments; Les Marelles begins to provide an operational model for positive interaction between professionals and urban dwellers.

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Figure 1. Communal open space.

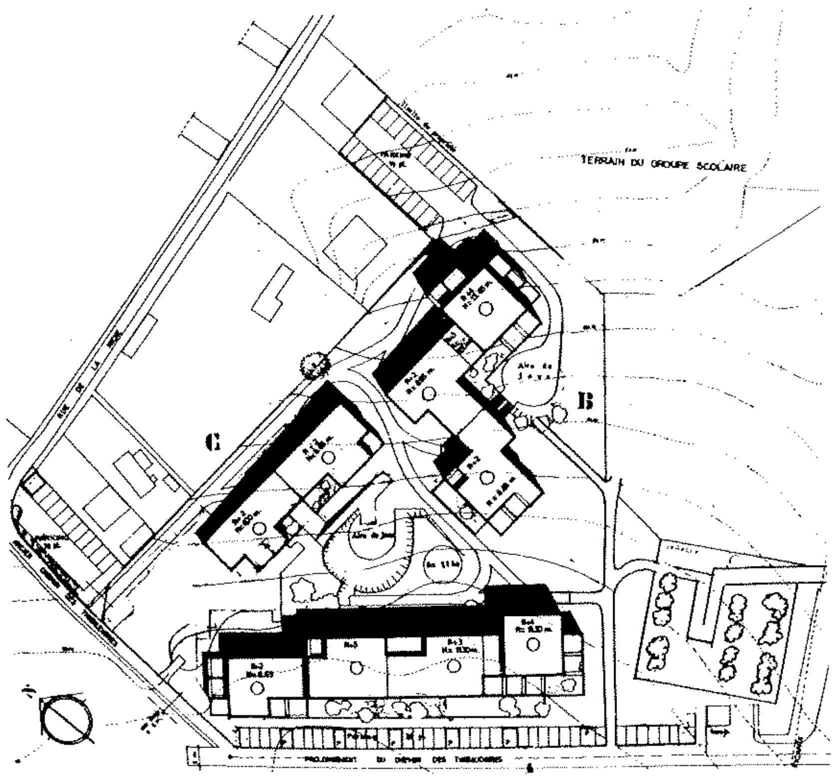


Figure 2. Site plan.

Les Marelles have had their share of publicity and coverage in France and in England, but this literature emphasizes the design and production aspects of the project and only alludes to questions such as the roles assumed by architects, developer, producer and dwellers[2]. It is these aspects which are, to my mind, most innovative and represent the real contribution of the project. Consequently, this article will only briefly describe the project — its history and physical characteristics, referring the reader to the existing literature for more detailed information — and will concentrate on the interactive process that took place between dwellers and professionals.

The Distinction Between Professional and Dwellers Decisions.

Les Marelles lie outside of Paris in the Val d'Yerres near the towns of Evry and La Grande Borne. When compared to the architectural processes exhibited by both these new towns, Les Marelles look like a conservative middle-income housing project. While the technologies used are relatively conventional by European standards, the *processes* corresponding to their selection and use are not: *a clear distinction is made between professional and dwellers decisions.*

Generally, professional decisions pertain to the communal aspects of the project and provide a contextual framework within which individual dwellers decisions can be made. The former decisions cover the design and construction processes of the various building parts, while the latter relate to the configuration or arrangement of *some* of the building parts. Thus the professional essentially provides a kit of parts and a few rules as to how these parts fit together and can be manipulated by the dweller.

However, the hardware system

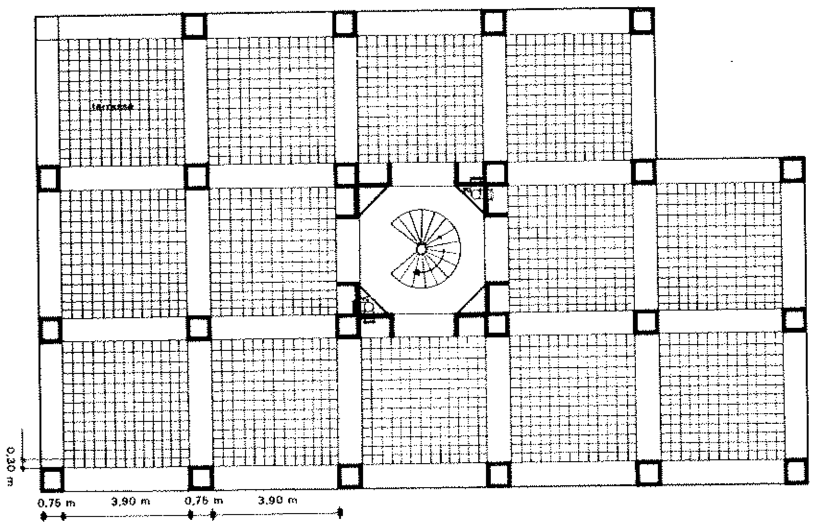


Figure 3. Support structure and access stair.

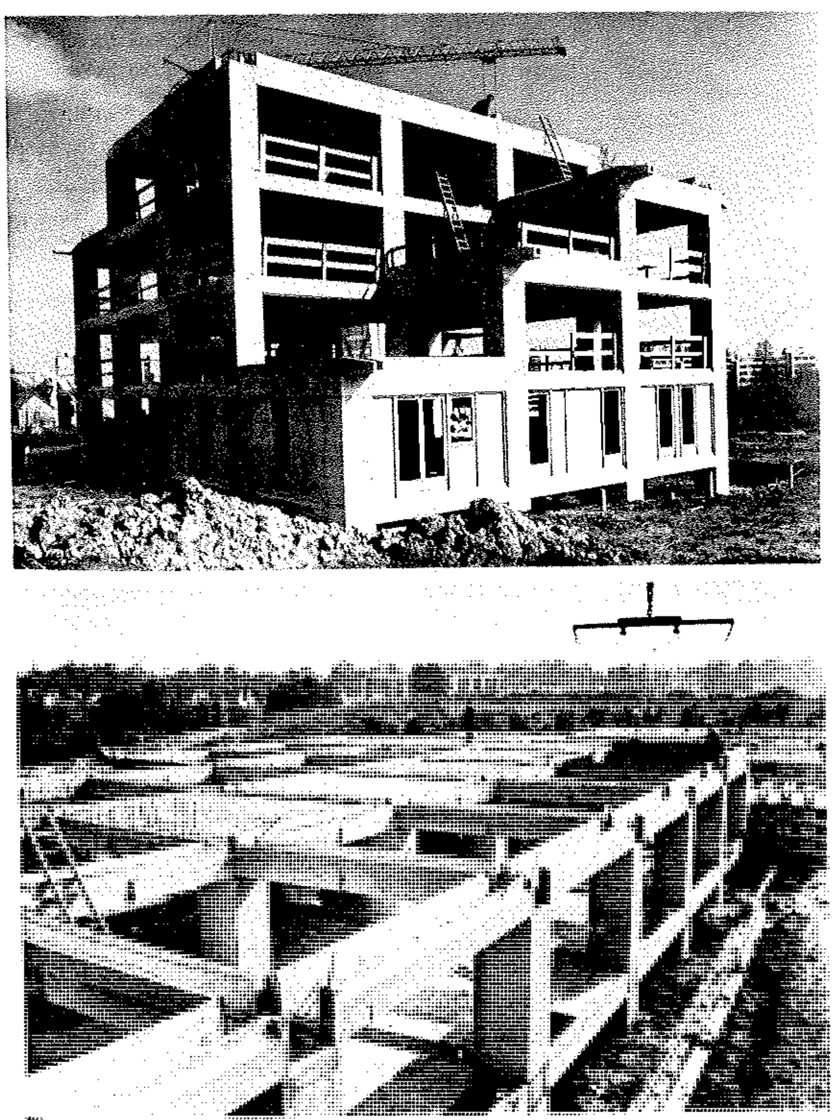


Figure 4. Structural system and interchangeable cladding.

is not what makes Les Marelles a more innovative solution than, for example, the Techbuilt houses or the Neal Mitchell system. The novelty stems from the fact that an actual building structure is built prior to any dweller's involvement. This support structure, as Habraken would call it, internalizes most of the constraints generated by urban communal living and thereby facilitates subsequent non-professional action. In order to achieve this, architect Georges Maurios and his colleagues have had to work some fifteen years to develop the prototype design, to obtain jointly with a local contractor/manufacturer a patent for the structural system, and to find a developer willing to back an experimental project.

Professional Decisions — and Related Handware.

The structural elements are put together without user input to form three buildings capable of housing a maximum of 116 dwellings. The buildings are arranged to enclose a communal open space (figs. 1 and 2). They are a maximum of four stories high, stepping down to one or two stories to provide large roof-top terraces around much of the building's perimeter. Each building is centrally accessed by skylit staircases, with potentially four apartment entry points per floor (fig. 3).

The structural system is the only building part that is entirely controlled by professional decisions. It consists of a moment frame of 3.90M clear span, and three prefabricated concrete elements: slabs, columns, and beams (fig. 4). Both beams and columns are hollow to contain the necessary services. Half of the hollow columns house the plumbing system and the other half the mechanical ventilation system, arranged diagonally. Hollow beams act as horizontal routes for these services (fig. 5). The integration of the three systems is meant to provide a variety

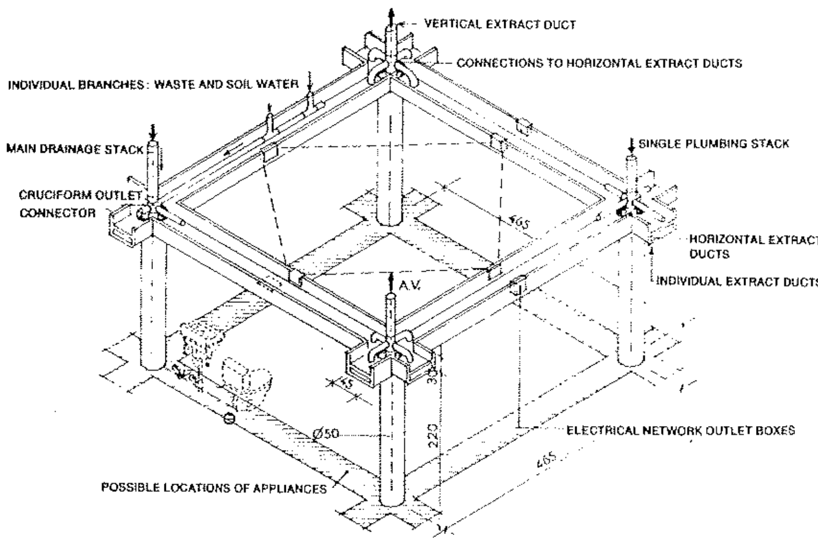


Figure 5. Integration of structure and service systems.

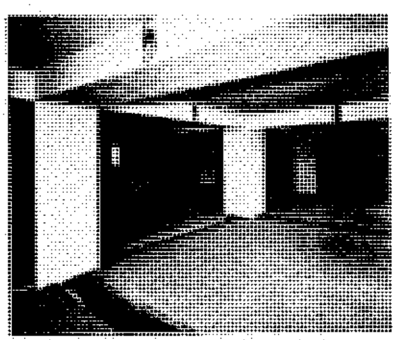


Figure 6. "Raw" interior space.

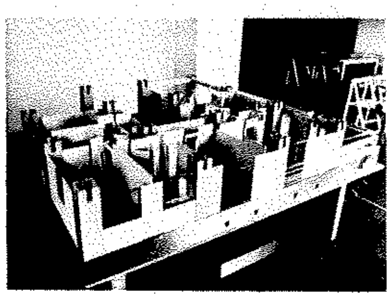


Figure 7. The 1:10 scale model.

of choices in the position and extent of the service systems, without further implications as to the qualities of interior spaces.

Partition systems are divided into party walls (which are essentially a sturdy version of the U.S. drywall) and 50 mm thick panels fitted between structural elements by small built-in jacks. Exterior wall systems are non-load bearing wood frames with interchangeable glass and enamelled asbestos infill panels. Sanitary cells and interior finishes are of conventional in-situ construction.

Dwellers Decisions.

The building elements described above provide a basic dwelling design vocabulary for dwellers to make the following decisions:

- locational choice within the project, in terms of building, story height and orientation;
- size of dwelling, including inside and outside spaces;
- dwelling layout, including the number, size and relationships between rooms;
- level of services, including the size of kitchen and bathrooms(s), the number and type of appliances and fixtures;
- openings within the outside wall, including their size and number, on a per room basis;
- the level and type of interior finishes, including kitchen and bathroom finishes.

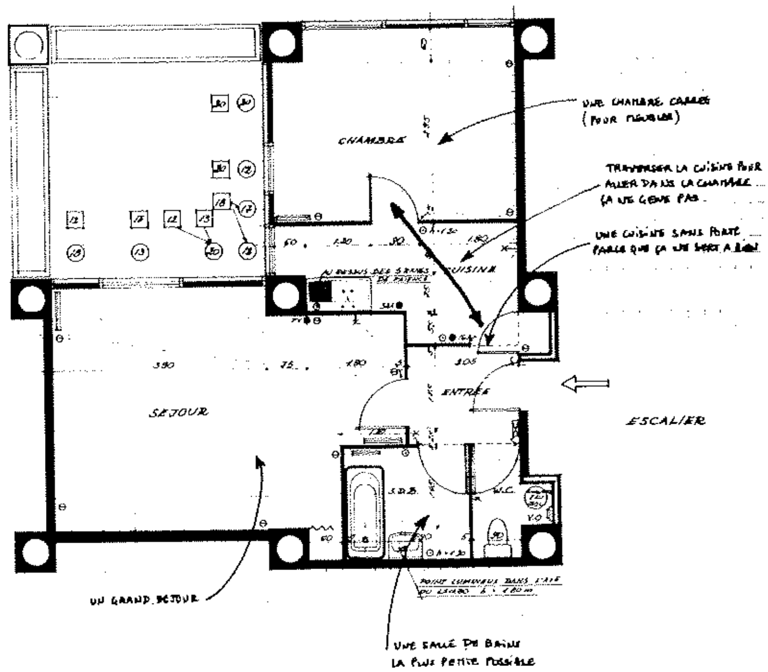
Dwellers Design Process.

While Maurios and his colleagues carefully prepare a setting within which dwellers can operate independently, an important series of steps are undertaken by prospective dwellers that can be summarized as follows:

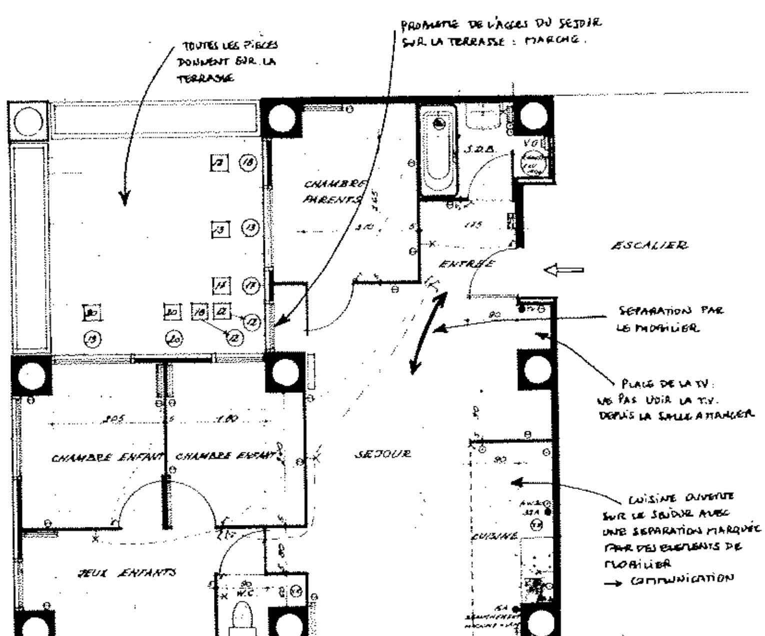
1. Local newspapers and various commercial exhibits advertise the sale of "logements sur mesure" or custom-made dwellings.

2. Prospective dwellers are encouraged to visit the site where they find the buildings enclosed and of finished appearance (fig. 1). The outside spaces are landscaped in a simple fashion, but the inside of the buildings is left unfinished as shown in fig. 6. Potential dwellers are brought to the sales offices which occupy a few bays of one of the buildings. There, the dwelling design development process is explained to them as essentially consisting of: a) putting an option on a part of the buildings, as would be done on a piece of land, and b) designing the actual dwelling layout and determining the types of finishes desired. The option on a part of the buildings requires estimates as to the overall dwelling size and a choice as to its location within the complex. The price of raw space is fixed and based on various spatial increments. The dweller's option is accompanied by a small downpayment, valid for a period of four weeks, during which time the dwelling design can be finalized. The initial decisions with respect to dwelling size and location can be reversed or modified, if deemed necessary after the detailed design process has been completed.

3. To this point architects have not had the opportunity to interact with the prospective dwellers, nor will they be able to until the very end of the design process. Sociologists and psychologists assist the dwellers in the determination of their needs and fulfillment of their expectations. They are aided by a series of tools that facilitate the design process:
   - a 1:10 scale model of several structural bays, complete with magnet-based partitions, doors, furniture, service fixtures, windows and exterior wall panels (fig. 7);
   - a video tape system record-



A.



C.

Figure 8.1. Plans of apartments: A: for a young couple (teacher and student); C: for a couple (employees) with 2 young children.

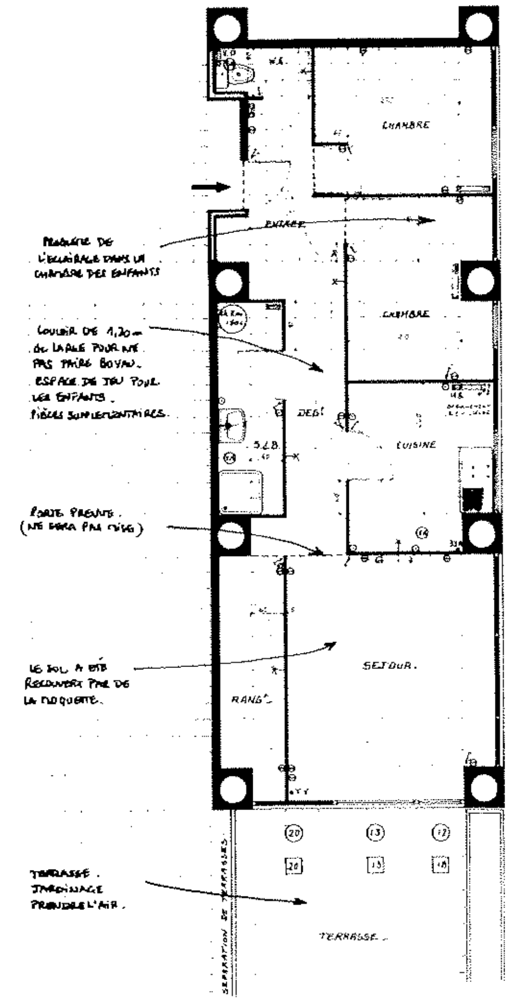
ing every step in the design and enabling dwellers to return to and check earlier solutions;

— a price information package, where all prices are unit, on the basis of building systems or building elements considered, such as electrical installations, plumbing and related fixtures, finishes per type of surface, partitions, doors etc. With this information, the dwellers can almost instantaneously make trade-offs between costs and amenities.

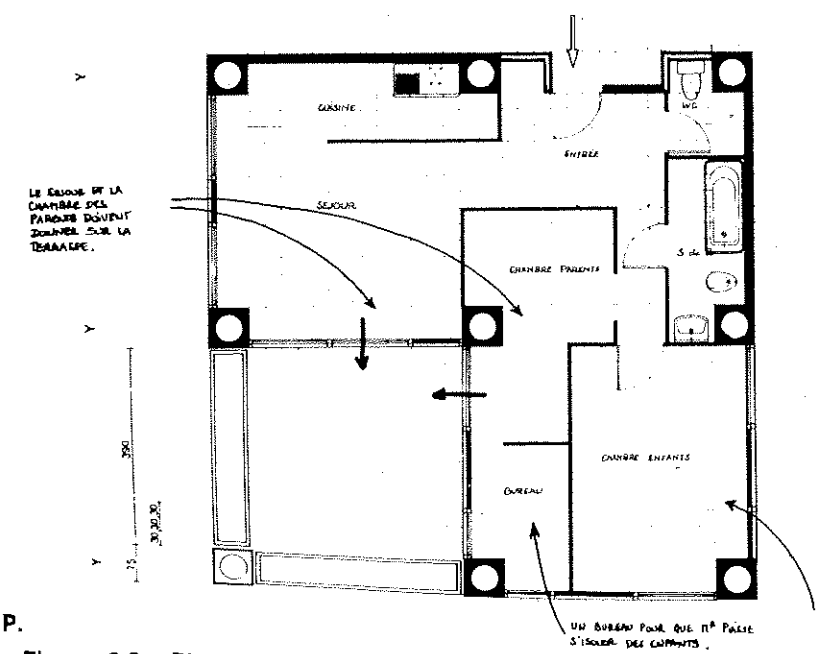
The design process is carried through several iterations, if necessary. Plans and related costs are recorded on sheets where the basic framework or support structure is already drawn as a reference. Costs can be manipulated by varying the level of finishes and services delivered with the dwelling.

Figure 8 exhibits some of the unit layouts at Les Marelles, along with comments made by dwellers as to some of their design objectives and concepts. These drawings are organized on the basis of unit size and several configurations are shown for both four and six structural bay dwellings.

It was mentioned that architects do not intervene until the dwellers are sure that their design is final. A case in point is Apartment B, designed by a family of five. The lady of the family was amused by my questions regarding the dining room — kitchen — den arrangement, and proceeded to explain that she had had "problems" with architects with respect to this particular area of the dwelling. It was important to her that the family had a formal dining room for occasional guests (the display of furniture as shown in Figure 10 reinforces her statement). Correspondingly, the family needed a separate dining area (fig. 9), and both formal and informal dining

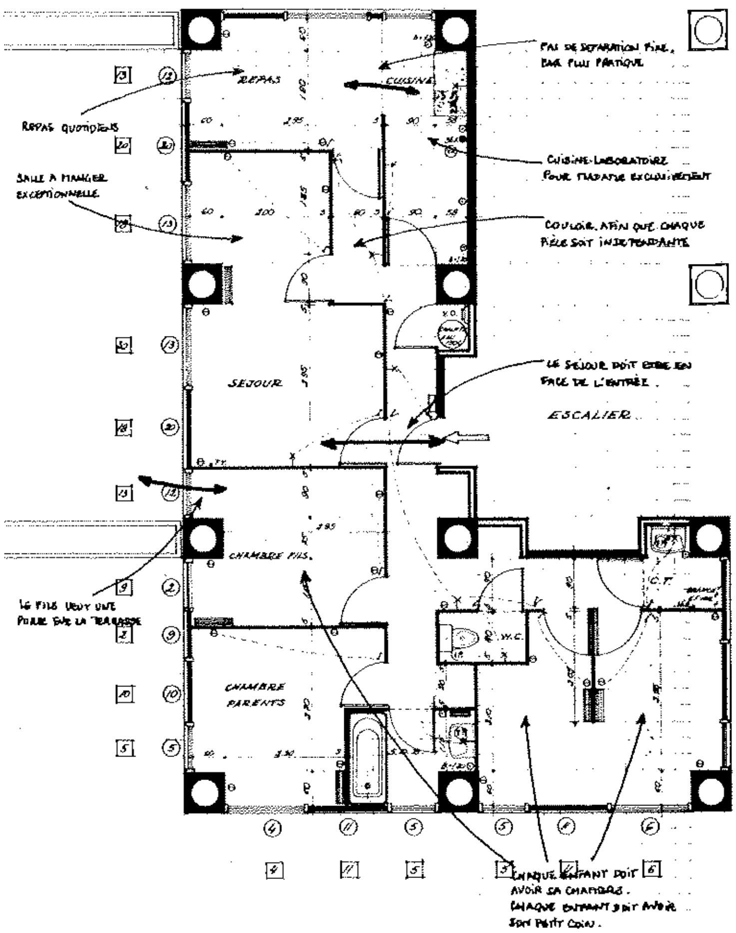


H.

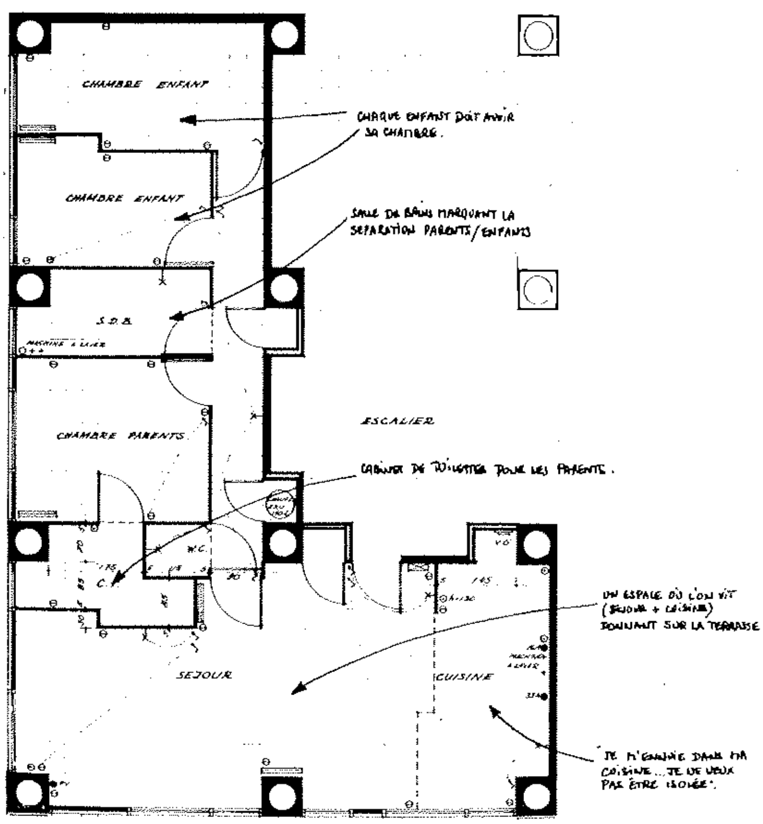


P.

Figure 8.2. Plans of apartments: H: for a couple (salesman) with 2 teenage children; P: for a couple (executives) with no children.



B.



M.

Figure 8.3. Plans of apartments: B: for a couple (technician) with 3 infants; M: for a couple (technicians) with 2 young children.

had to be adjacent to the terrace. Finally, it was also important that the kitchen be inconspicious and off the main circulation paths of both dining areas. The final spatial arrangement, as seen on the plan and the photographs, was entirely satisfactory to the family.

The same family deliberately decided that space was a priority over both services and finishes, as the children were growing up. As a result, both were kept minimum, to be upgraded as the family's financial situation improved, and floor and wall surfaces were to be finished as time was available.

Issues and Lessons.

The differences between these dwelling units and the ones built conventionally are evident and the contrasts between the two types are alarming; indeed these differences catch most of the architectural profession off guard and raise serious questions about the direction taken to-date by architectural education. The superiority of the dwellings in Les Marelles over standard units seems difficult to question in view of the fact that the former have been organized and designed by people that will eventually occupy them. The need for giving these kinds of projects the attention and the study that they deserve is urgent, if collective housing is to become more then the mere provision of "shells and services".

Les Marelles shows that, given a chance for self-expression, the urban dweller is as imaginative and as personal in his formulation of space as his rural or pre-industrial counterparts. The lesson then for professionals and others who are presently controlling the housing process is to realize that there are limitations to their expertise and predictive capabilities. Few would disagree today on the need for inputs on the part of users in the buliding process, but at the same time, the

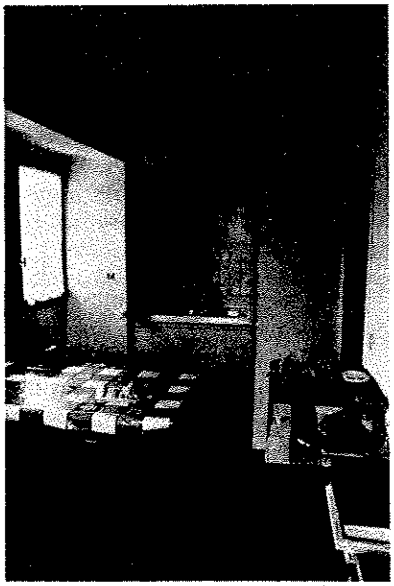


Figure 9. Apartment B: view to the kitchen from the informal dining area.

Figure 10. Apartment B: view into formal dining area from living area.

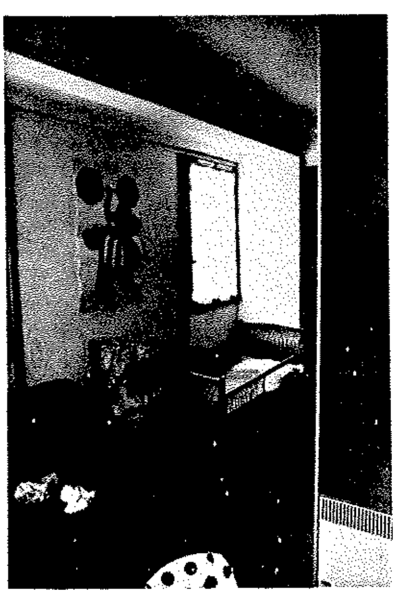


Figure 11. Apartment B: view into children's room.

restrictions of professional knowledge are perceived with more difficulty, and the possible relationships between professional and laymen inputs are totally obscured.

Maurios' abnegation of a know-how which he is conventionally "entitled to", is examplary and provides a convincing model of what professional services can actually be. He rejects unilateral decision making and modifies successful models of relationships between professionals and users (as found traditionally in the design of single family houses) to retain as much self-determination on the part of the user as possible within the changed conditions of collective housing. He proposes a framework which assumes the complexities of urban communal living, and which, in turn, offers a simplified context within which the user can operate on the basis of his skills. The options presented to the dwellers are clearly spelled out and, as mentioned earlier, the available trade-offs are made explicit and measurable in monetary terms.

A second lesson from Les Marelles concerns the issue of housing standards. The broad differences found in dwellings that could be considered as belonging to the same conventional categories are striking; for example, the four apartments averaging 117 gross square meters (including the terrace space), cover a range of one to three bedrooms. Within this sample, the sizes and types of kitchens, their relationship to eating and living spaces are so varied that they defy generalization and point to the actual variety of needs, tastes and values prevailing in so-called homogeneous segments of the housing market. On the basis of these examples one must seriously question the established norms and standards that are widely applied in housing today.

Standards based on minimum room size, as currently used, appear to restrict the use of (and even to often waste) valuable space because they exclude the manipulation of possible relationships between rooms as seen fit by the various users. For example, apartment B exhibits a two-children room (fig. 11), dividable by a moveable partition to form two minuscule spaces whenever privacy is required. In apartment C, the children' playroom acts as an extension of each individual child's room, an arrangement that was obviously preferred to the larger, but shared bedroom. Further studies of the implications of user-designed dwellings on the establishment of standards seem urgently needed, but it appears already that minimum standards fixing square feet per person, rather than on a per room basis, may be more appropriate (or at least less restrictive) in their utilization of the overall dwelling space.

Finally, Les Marelles raise the issue of fixing service and finish standards at levels that a) far exceed minimum health and welfare objectives, b) are often beyond the means of the inhabitants, and c) appear not essential in the eyes of the dwellers themselves. They suggest that standards be reviewed to become performance-based and possibly actuated on time-based increments. In such a case, a minimum level for finishes and services could be established as thresholds of habitability, possibly on condition that they be upgraded over time.

Regardless of the possible interpretations of the lessons taught by Les Marelles, they clearly point to the fact that standards have evolved from being a necessary means of protecting the health and welfare of the urban population to becoming unwelcome restrictions on the life styles of that same population. Reasons behind this evolution have been efforts to facilitate the control of the application of the standards; the results however, are such that the price paid by individuals is enormous, particularly as the opportunity for accomodating their own inputs into the housing process is annihilated. A return to the original objectives of standards would be timely, to restore or retain the basic health and safety standards but to abstain from imposing values on individuals where the public welfare is not at stake.

Problems and Possibilities of Les Marelles.

There are three aspects of the project that appear to be problematic and to warrant further consideration.

The first aspect is the fact that the success of the promotional campaign has been mitigated. Some twenty units have been sold in the six months that Les Marelles has been ready for occupancy. A sluggish market may probably account for these difficulties, but it may be worthwhile venturing other possible reasons which are intrinsic to the project.

Two major roadblocks appear to impede the introduction of prospective dwellers to the project, the first of which is the more than trivial question of attracting dwellers' attention through advertising. In the conventional market place, prices and amenities are always associated with the number of rooms within the dwelling. At Les Marelles, prices need to be shown as a function of square-feet of dwelling, and many dwellers have voiced their initial incredulity as to the economic feasibility of custom-made units compared to standard ones. Thus, for advertising purposes, explicit exhibits of possible dwelling layouts and corresponding costs may need to be used extensively.

The second roadblock to promotional activities may reside in the fact that those potential dwellers who do visit the project, are faced by "raw" space — which may not help trigger the right images of what their future home could be. With the exception of the real estate offices and the design model display rooms, all buildings are totally unfinished, as shown in Figure 6. Again, these surroundings lack explicit suggestions as to what the dwellings might eventually look like. One can't help but comparing such promotional techniques with those used be developers in the United States, where full-scale models carefully display a range of spatial arrangements and finishing styles. In Les Marelles, such models would be particularly appropriate, as they could be accepted, rejected or modified by eventual buyers.

The second aspect of Les Marelles worthy of further scrutiny deals with the design of the support structure. The degree of flexibility offered by the system may exceed by far the actual need for flexibility. Is it really necessary to have half of the structural columns capable of holding the plumbing equipment? Correspondingly, are the relatively large structural columns and beams occupying too excessive a percentage of the usable space? What is the actual impact of the structural module on possible spatial arrangements within the dwelling units? The dwelling configurations proposed by the architects seem to indicate a need for a better understanding of the limitations to the flexibility offered by the system. Such an understanding would give a certain leverage in controlling the costs of the support structure and the related amenities. Methods such as the ones developed by S.A.R. aim at facilitating the evaluation of the capabilities of such systems, and in this case, their application would be particularly easy, because of the strict distinction made between professional and dwellers' responsibilities. Sector analyses would establish the range of basic alternative dwelling configurations, which could serve as a basis for evaluating the dimensional characteristics of the systems as well as their potential for flexibility in the location of services.

A third and final aspect of Les Marelles deals with the general character of the project. I have praised the project for making a case in favor of user self-expression in an urban high density situation. The fact is, however, that the project location in the Val d'Yerres does not warrant a particularly urban architectural solution, which then forces us to look at Les Marelles as a prototype for a more urban context. Like many prototypes, the project is not site-specific, and unfortunately, its conservative physical characteristics may ultimately negate the introduction of innovative processes. By retaining the organizational format used for high-rise housing, Les Marelles is missing an opportunity for introducing new ideas with respect to the territorial identity of individual dwellers. For instance, while the extensive network of terraces begins to suggest new types of relationships between the inside and the outside of the dwellings, their relationship with the land on the first floor of the buildings is not treated seriously. Ground floor units give out to a communal open space which seems difficult to fence off for privacy. Similarly, the relationships established between the built and the open spaces lacks in intention and hence in organization.

These remarks step beyond the original intent of this paper, but it seems important to point to aspects of the project which may indirectly influence the successful integration of the user in the housing process. The prototypical character of the project appears also to cover the levels of flexibility provided by the system. There would be a need for more specificity in the decisions made to fit the particular market and the particular location. Such specificity would begin to introduce custom-made support structures to correspond to the custom-made dwellings.

Conclusion.

Maurios is now beginning to work on a second project using the same system as Les Marelles, but in the context of rental units. Only through time and experience can some of the problems mentioned above be dealt with. In the meantime, it is important to reflect upon the message set forth by such projects. As data on user generated dwelling designs accumulate, professional designers, building technologists, sociologists, housing authorities and others need to consider seriously the new information and to incorporate it into their programs.

Notes:

1. *Specific reference is made to the literature on squatter settlements in the Third World, aided self-help programs in the United States, and writings such as Rudofsky's* Architecture Without Architects *(Museum of Modern Art, 1965), and Turner's and Fichter's* Freedom To Build *(The Macmillan Co., 1972). The author is aware of the few urban homesteading projects in some of the more depressed urban areas of the U.S., and considers them to remain unfortunately exceptions to the general trend of housing policy today. While some of the English and French literature addresses the issue of housing flexibility, varying and changing needs in housing, and related necessary hard-ware systems, processes to involve user participation have rarely gone beyond initial theoretical developments for urban situations.*

2. *See, Rabineck, Andrew, D. Sheppard and P. Town, "Housing Flexibility",* Architectural Design, *November 1973, p. 107, and Rabineck, Andrew, "Adaptable Housing by Georges Maurios",* Architectural Design, *October 1975, pp. 567-570. Other articles in the French press and technical reviews include:* Architecture d'Aujourd'hui, *July 1969 and December 1972,* L'Expresse *#992, 13-19 July 1970,* Elle, *August 24 and December 7, 1970, January 25, 1971 and January 24, 1972.*

MOLENVLIET

Support housing for the rented sector recently completed in Papendrecht, Holland.

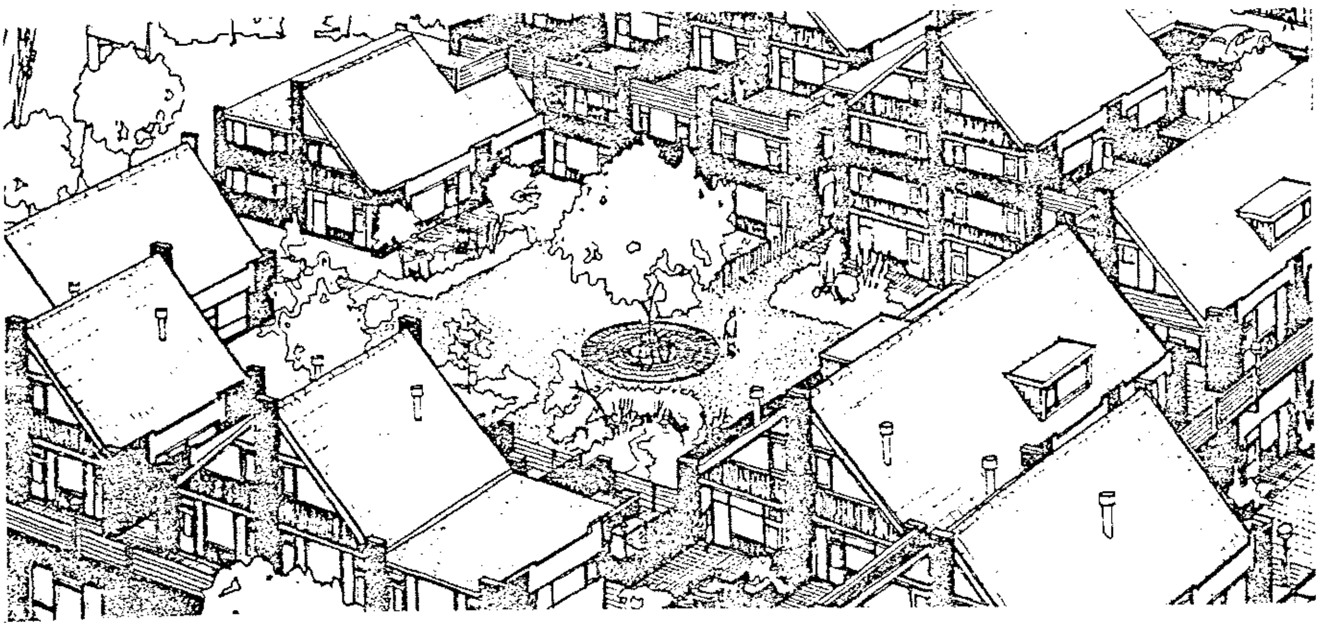
Ton van Rooij.

Project designed by:
Werkgroep KOKON
Stationsplein 45
Rotterdam
Tel.: 010 - 119642

1. Introduction

Habraken wrote in 1961, "a support is a structure in which a number of dwellings can be built up, and which permits construction, modification or demolition of each dwelling separately, without involvement of the other dwellings in the same support". It may be stated that up to now no such structure has yet been realized. Of course, many developments in the course of the last 17 years have helped to bring Habraken's ideas out of the realm of fantasy. The realization of the support project Molenvliet by architect Frans v.d. Werf represents an important milestone in this direction

This project involved 123 dwellings which incorporated many of the ideas put forward first by Habraken and later by the SAR. The right of the occupants to have a say in the arrangement and finishing of their dwellings was the starting point of the design. This implied the design of a support within which every occupant could arrange the assembly kit as he wanted, within the range of possibilities provided by the design. And there were plenty of possibilities; thanks to the tireless efforts of v.d.Werf this project broke through limitations which normally have such a restrictive influence on the building of dwellings in the Netherlands. In particular, it proved possible to apply the rules laid down by the Ministry of Housing and Town Planning in a very flexible manner. It goes without saying that this represents an important precedent for new projects of the same type; and this was all the result of tireless work on the development of an idea which arose as a reaction to the highly unpopular mass housing projects of post-war years.



2. Description of the project

The space around the dwellings

The above illustration gives a bird's-eye view of part of the project. The most striking feature is the recurrence of squares measuring from 23 x 23 m to 27 x 31 m, surrounded by buildings from 1 to 4 stories high. Apart from these clearly concentric spaces, there are two other types of spaces which together with the buildings form the theme of the tissue. These are the traffic streets, with ample space for parking at the side and the paths joining these streets, which are specifically intended for pedestrians. The designer has described the relationship between these various spaces and the buildings with the aid of C. Alexander's pattern method. We shall now give a brief description of the three basic spatial patterns: the square, the path and the traffic street.

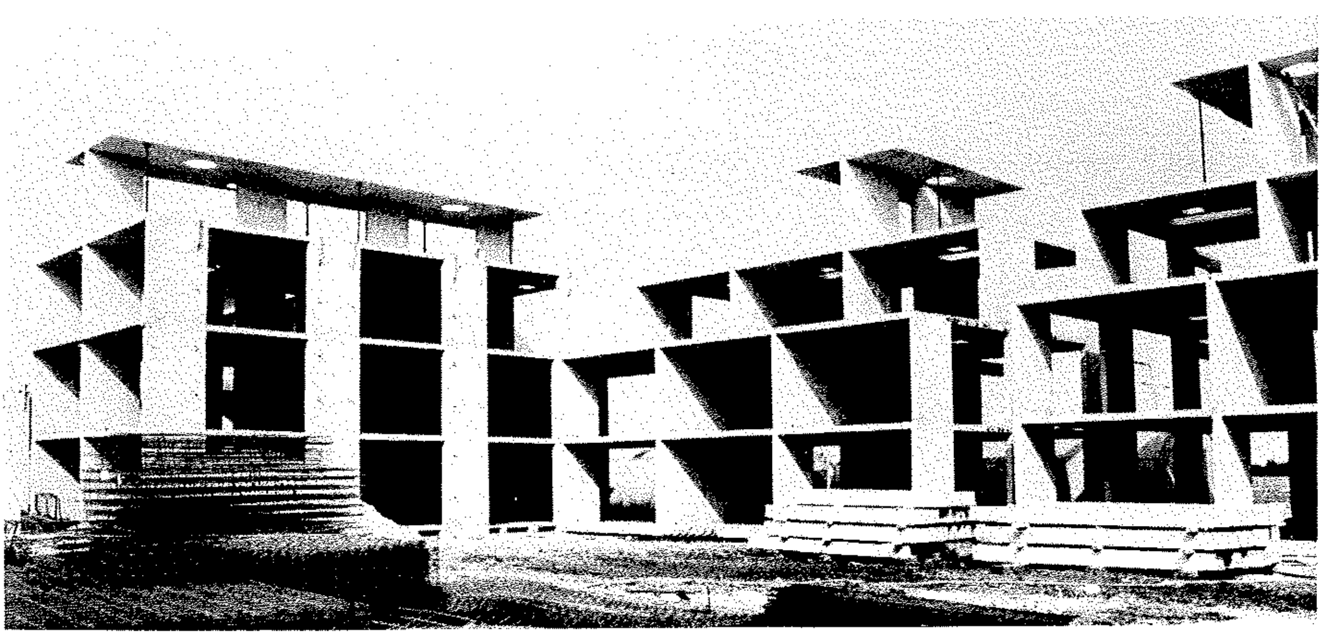
The square is a space which meets the need for activity in the direct vicinity of the dwelling. Children can play and the space also facilitates contacts between neighbours. This domain must provide facilities for activities which are not possible in the dwelling, in a community centre or the town centre, or outside the town. These activities demand well defined spaces with a character of their own, in which people of various ages can spend much of their time.
The solution to this problem is provided by the square, surrounded by between 20 and 30 dwellings which generally have their front doors facing on to the courtyard.

This is a space for pedestrians, enclosed, sheltered and free from motorized traffic. The enclosed nature of the space and its limited area (about 25 m square) will stimulate the occupants to assume collective responsibility for it, and make it easier for them to do so.
Apart from courtyards whose main function is to give access to the houses, there are others which are partly or completely filled by private gardens.

The paths provide connections between the courtyards, and between the traffic streets, for pedestrians. They also provide facilities for taking a walk (alone or with the dog) and for cycling. They further make it possible for services such as the fire brigade, ambulance, milkman and postman to reach the courtyards. By way of contrast with the relatively large courtyards, the paths are narrow (about 5m wide) and generally covered over. They form pleasant, stimulating routes for circulation of pedestrians and cyclists.

There must be a place for the motor car in the neighbourhood - and this place should be chosen so as to involve the minimum risk and nuisance for children and other people. Apart from the risk of accidents, cars take up a lot of space and give rise to noise and unpleasant smells. Nevertheless, many people want to have their car near the home. The solution chosen in Molenvliet was the traffic street, where cars can be driven and parked. Situation of the parking spaces along the roadsides saves a lot of space, as the street itself forms the access to the parking space. People who live along the traffic streets can park their cars in front of the door. Thanks to these measures, the courtyards remain free of traffic.

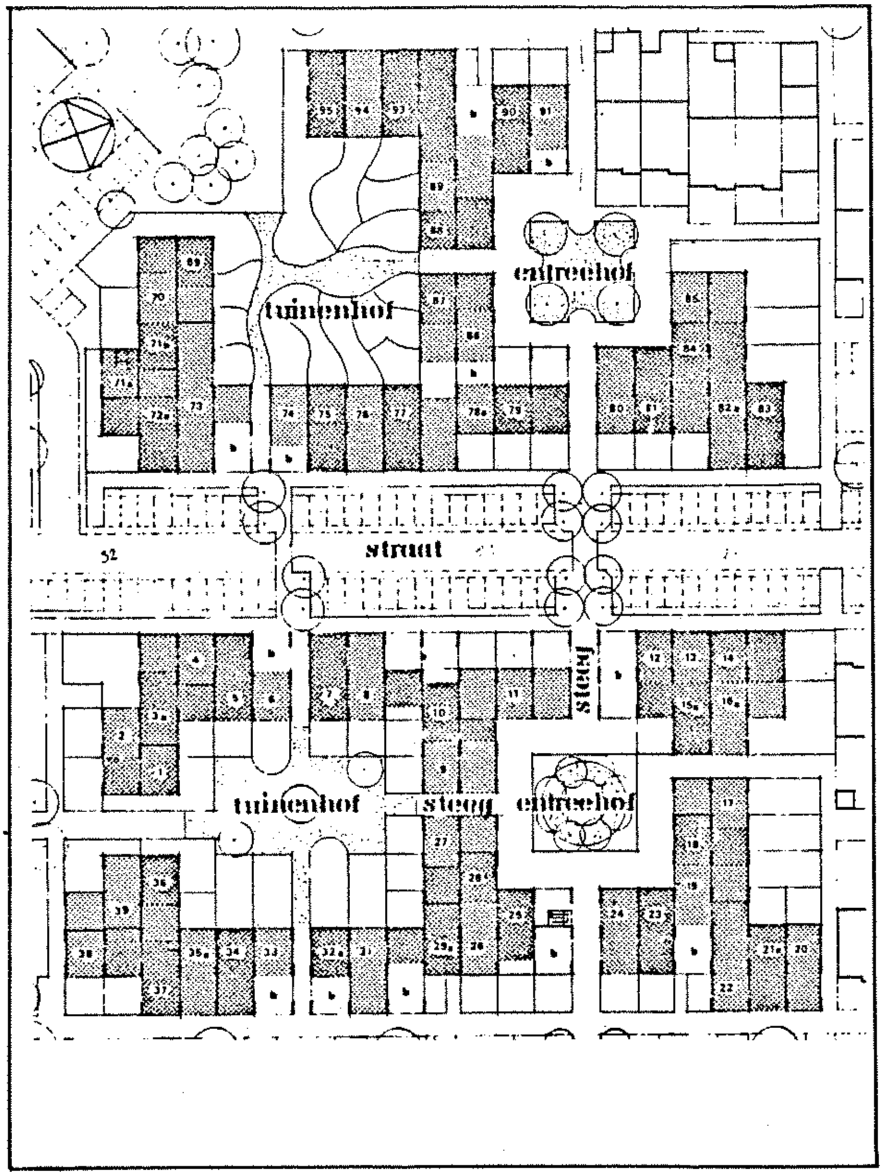
These patterns form the basis for the external functioning of the surroundings of the dwellings.

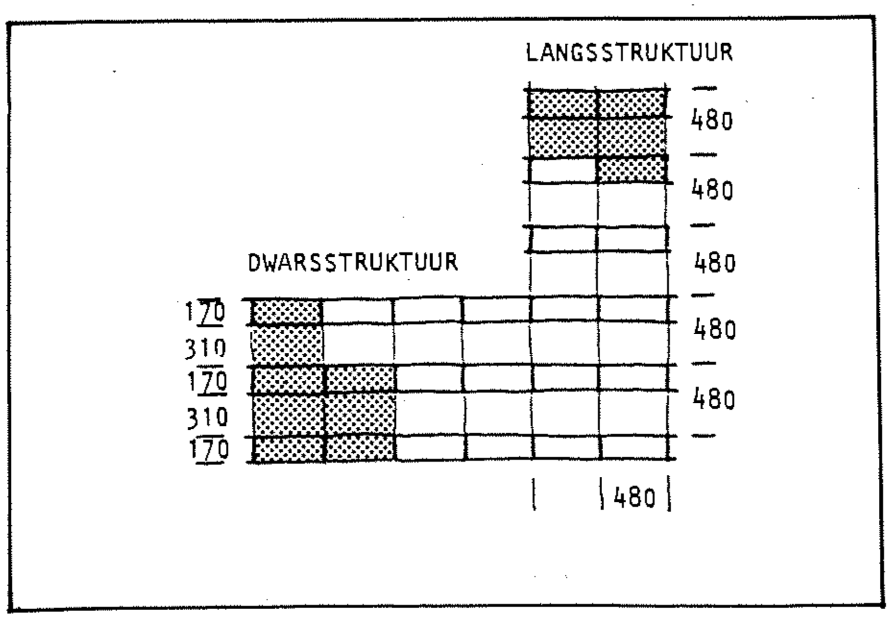


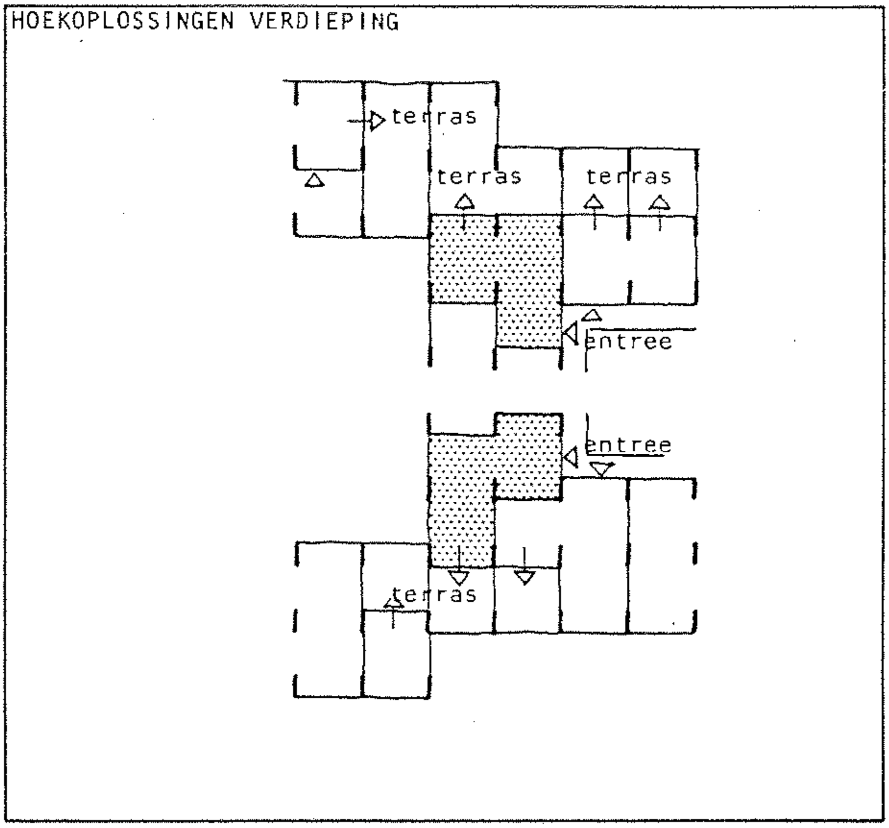
The buildings

As already mentioned, the dwellings in this project were built up of support and infill. The support consists of a reinforced concrete skeleton with wall sections measuring 20 x 170 cm, separated by 310 cm spaces; the entire system is based on a grid dimension of 4.80 m. The wall sections are all aligned in the same direction; this gives two types of support structure, depending on the orientation of the dwellings. The blocks which run in a north-south direction have a transverse structure, while those which run east-west have a longitudinal structure. The depth of the building is 11.30 m and 9.60 m respectively in the two cases.
This basic principle permits construction of the buildings along the sides of the squares. There were of course a number of other principles which helped to give the project as a whole its final form. One of the most important of these was the principle that the height of the buildings should depend on sunlight angles: for this reason, buildings on the south side of a square were never more than 1 story high (+ roof).
The support space was initially parcelled out by the architect on the basis of data on housing requirements from the municipal council. This led to a total number of 108 dwellings with from 2 to 5 rooms each. This arrangement was later modified somewhat in consultation with the future occupants (see next section) to give a final total of 123 dwellings.

Once the arrangement of the dwellings within the support had been decided, the discussion with the future occupants concerning the choice of infill could start.



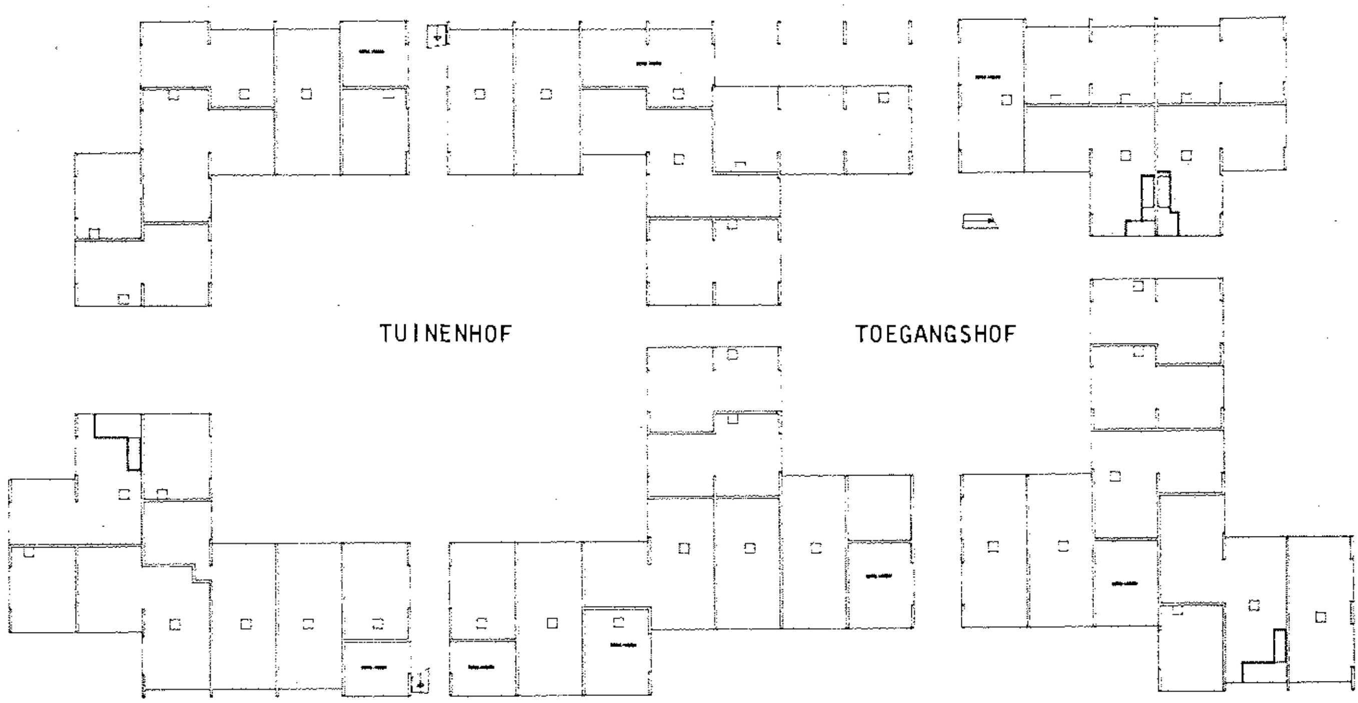




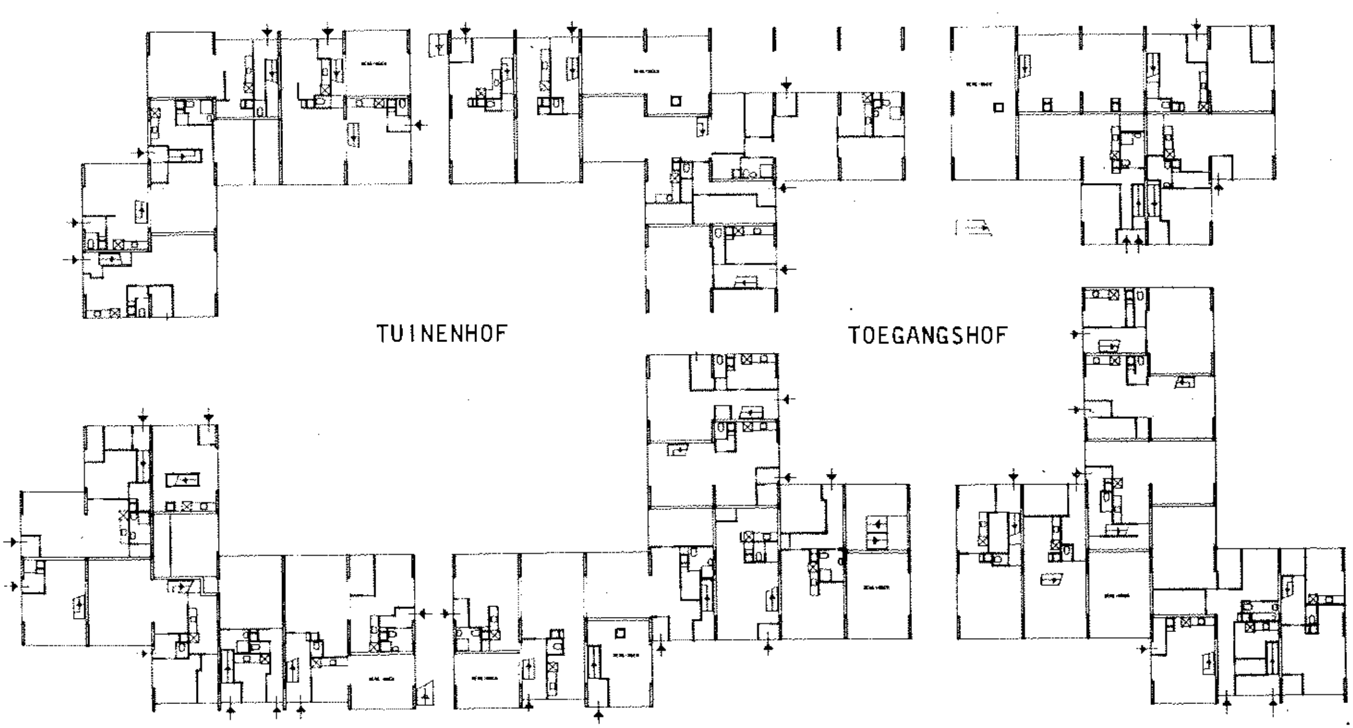
They were free to choose the position of the inside walls, the type of facade, the arrangement of the services and the positioning of the sanitary and central-heating installations. The colours of the wall panels and facade elements could also be chosen from a range of 6 matching colours.

The parcelling out of the support led to the creation of a large number of different dwelling types. Some dwellings were ground-floor only, some had 2 or more stories, while there were also maisonette-type dwellings with the upper level situated along a gallery. The architect also took as one of his starting points that each dwelling should have ample private outdoor space (terraces of about 20 m^2) even on the first and second floors. The creation of terraces with all kinds of different aspects gave the development as a whole a very lively appearance.

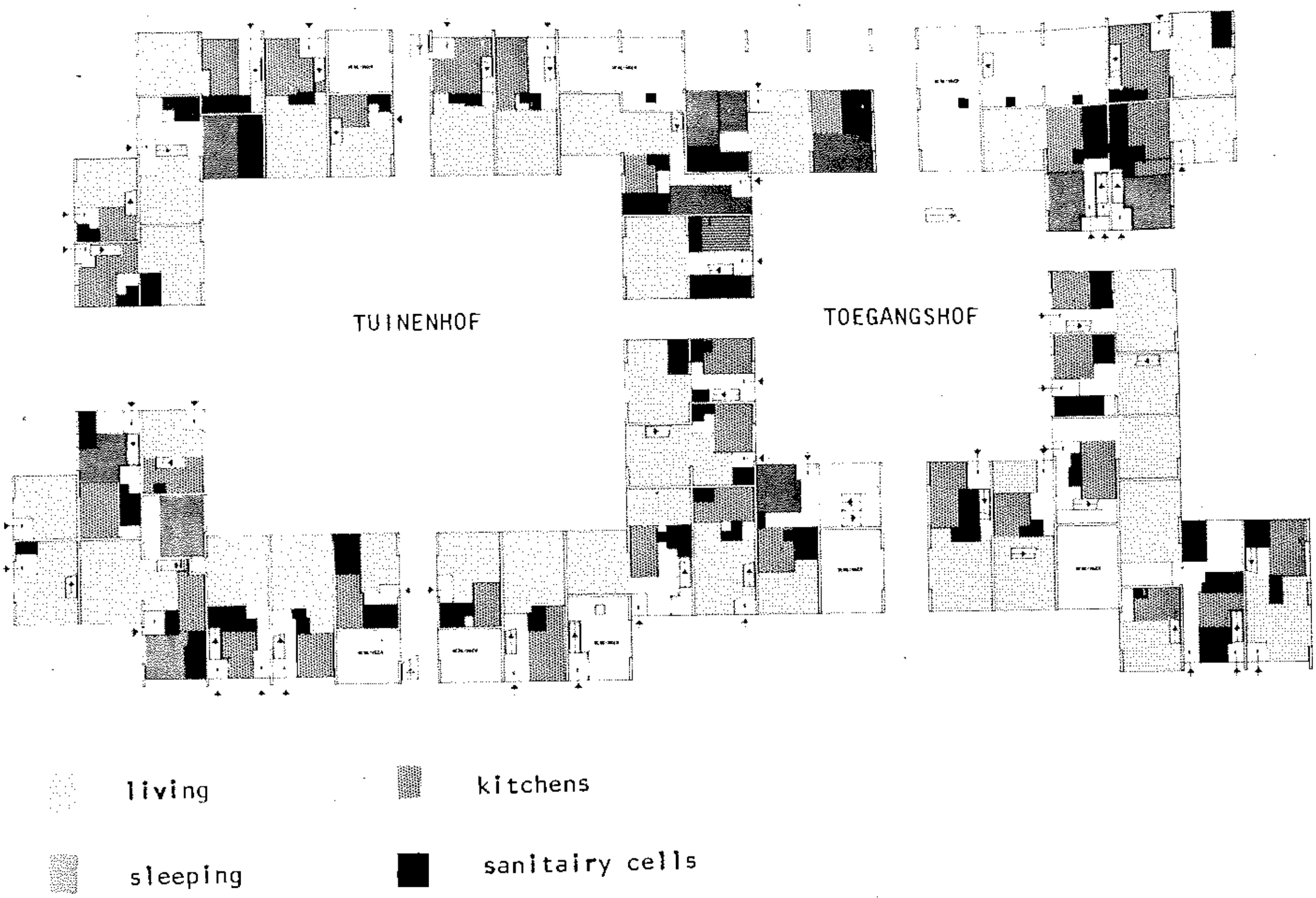
SUPPORT STRUCTURE GROUND LEVEL (east side)



INFILL GROUND LEVEL (east side)



FUNCTIONS GROUND LEVEL (east side)

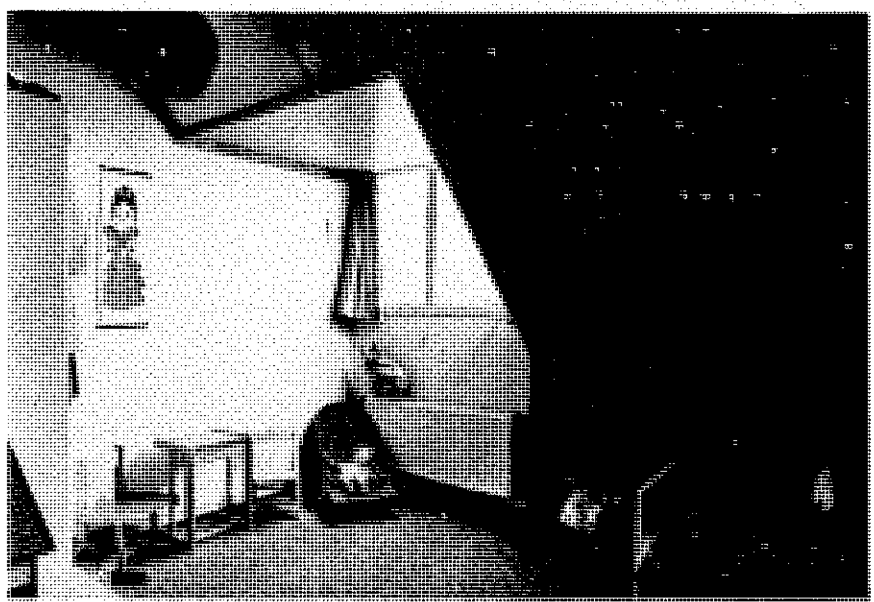


3. Participation

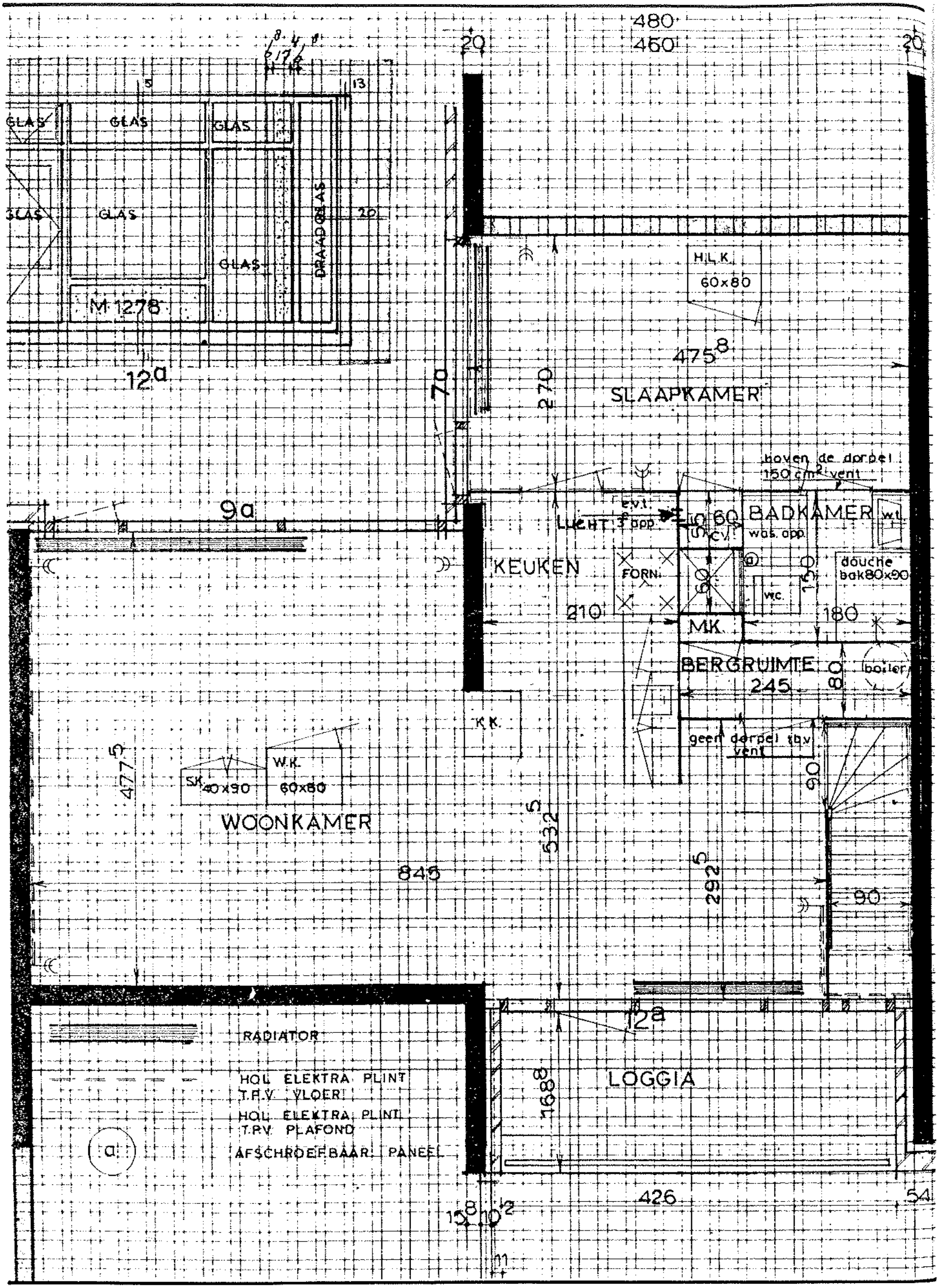
After official approval of the project design (which in connection with the granting of housing subsidies was based on a fictitious division of the support space into dwellings), construction of the support could be started. During the construction process, discussion with future occupants selected by the client (the Papendrecht housing association) started up.

The flexible approach of the authorities to this project has already been mentioned in the introduction. This was particularly marked in the treatment of the design as regards the future arrangement of the dwellings. In fact the subsidies for the project were granted on the basis of the most favourable (hypothetical) arrangement of the dwellings within the support. In the Netherlands, housing subsidies are based on a points system, per room, per dwelling; this is determined by the number of rooms and their size. The architect determined the (hypothetical) arrangement of the dwellings for the purposes of the application for subsidy. This arrangement was taken as basis for the discussions with the future occupants; however, it proved possible to modify the arrangement subsequently. What were the future occupants free to choose in the arrangement of their dwellings? It is perhaps simpler to start by mentioning a number of points which they were not free to choose, which were connected with features shared by more than one dwelling such as party walls and central service ducts (two different dwellings situated one above the other shared a common service duct). These features, and the position of the stairs were fixed in the plans pre-

sented to the future occupants, as without this standardisation it would have been impossible to build the support independently of the infill.
After the position of all the dwellings in the support had been fixed in consultation with the housing association and the future occupants, the architect could talk with the individual occupants about the lay-out of their dwelling. He had two consultations with each occupant, about two weeks apart. The occupants were provided with a basic design sheet (scale 1:20) on which they could choose the layout of the dwelling as their imagination dictated; this design was then discussed and evaluated together with the architect. The use of the 10-20 grid in this basic design sheet was of great assistance in giving the occupant a quick insight into the possibilities of the spaces at his disposal.



After these discussions were completed, finished drawings were made from the rough design sketches. These drawings were sent to the various subcontractors so that the positioning of the infill, including services (electricity, gas, sanitary, central heating, etc.) could be determined. When this was completed, the installation of the infill could begin.
At a certain stage during the participation process, it was decided to split a number of bigger dwellings up into smaller ones. This raised the number of dwellings from 108 to 122.
One space initially destined for business purposes was further changed into a dwelling, giving the final total of 123 dwellings as mentioned above. Every dwelling was different, reflecting the individual desires of the future occupants. Nevertheless, these differences had little or no effect on the course of the building process.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150 cm² vent
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was. app.
douche
bak80x90
KEUKEN
FORN.
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M.K.
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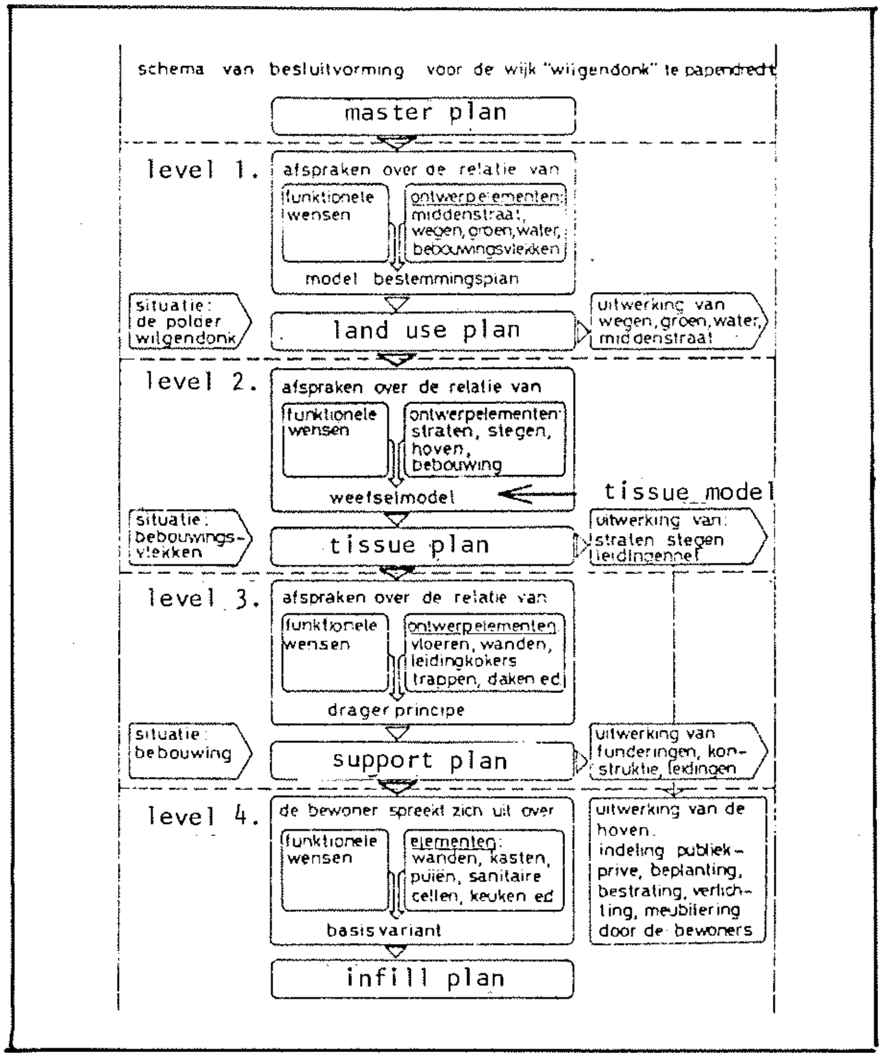


4. Summary and conclusions

Summing up, what can we say about the participation process as a whole? To what extent was the future occupant involved in the design of the project? We are not too far from the truth if we claim that the occupant really only started to count at the stage where the arrangement of the infill had to be determined. He had a lot of say in the disposition of the assembly kit; but he had hardly any say in the support design and the tissue plan. Despite the fact that the architect clearly distinguished three phases in the over-all design process - tissue, support and infill - participation only played an appreciable role in the final phase. The tissue plan and the support design were made by the architect alone (with the exceptions mentioned above). Only the infill plan was determined in consultation with the future occupants. Even this is unique in the history of rented council dwellings in the Netherlands. Another aspect of the support design is that it permits later rearrangement of the dwellings (making one dwelling larger or changing its shape at the expense of neighbouring dwellings) without excessive financial or social sacrifices. These are the positive points of the use of a support-infill design, which are hardly appreciated at present but which will obviate almost insoluble renovation problems in the future.
Our final conclusion concerning this project is that it can really be regarded as a worthy experimental project which will doubtless influence important aspects of housing development and participation in the future. It shows us the fantastic prospects open to (council) housing in the future, once we have mastered the necessary approaches and skills. It tells us a lot about the nature of these necessary approaches and skills; and it indicates some of the pitfalls we shall have to look out for.

Ton van Rooij

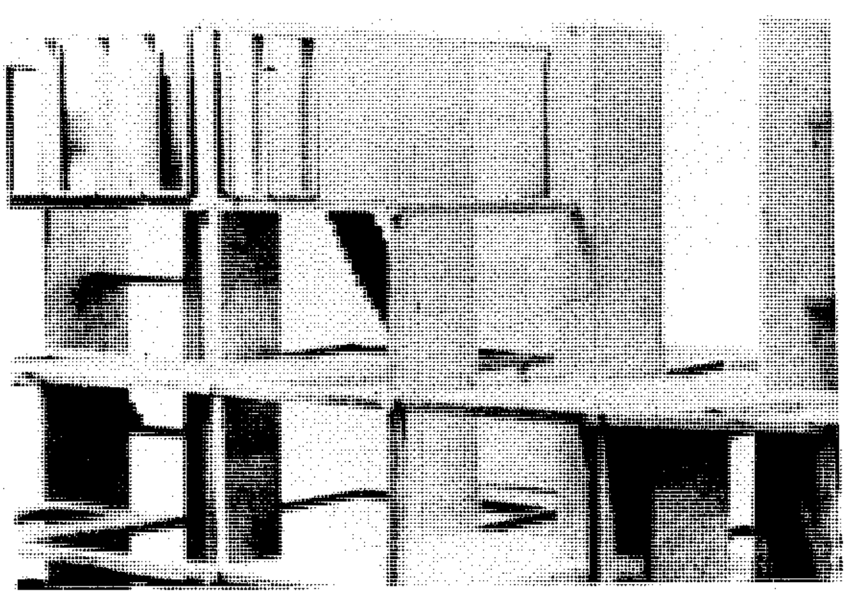
PSSHAK

Adelaide Road London.

Nabeel Hamdi.

Just over 10 years ago discussions took place at the Architectural Association School of Architecture, London, concerning the book by Prof. N.J. Habraken "Supports - an alternative to Mass Housing". A short time later the design methodology (SAR 65) had become an indispensible tool in the communication of an important message. The idea of "supports" became a reality and reinforced the philosophy giving rise to a single objective, namely, to build the idea. As a result members of the housing ministry, profession and industry were invited to attend a series of informal presentations, at different intevals over a period of 6 months. Only after many questions and answers had been made and given did the initiative emerge to undertake an experimental support project.
Because of the time and energy spent in persuading the different parties that their different problems would not minimise their similar aims, namely, to provide social housing within the various constraints and regulations, this project represents a milestone in the development of housing and the move towards a better balance in the sharing of decisions in the housing process.
The following article deals with some of the major issues of the initial development phase and describes the project up to its completion in July 1978.

I. BACKGROUND

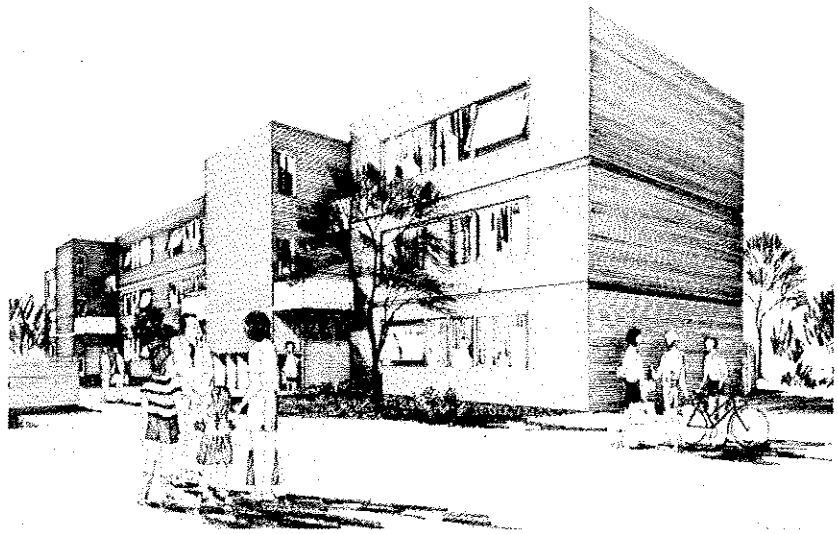


What is PSSHAK?

PSSHAK, which stands for Primary System Support and Housing Assembly Kits, seeks to offer an alternative to the standard forms of housing by proposing an adaptable and flexible approach which will fit the needs of tenants more closely than is normally possible.

Based on the theories developed in Holland by N.J. Habraken, the principal idea involves the separation of the main structure of the building (support structure) from the internal fittings of the dwelling (assembly kit) so that the range of dwelling sizes and of dwelling mix can be varied as circumstances demand.

The impact of this basic concept will be felt by occupants, housing management and the building industry alike.



a. PSSHAK Mark I: a 3 storey block of 12 flats at Stamford Hill, Hackney

How has PSSHAK developed?

PSSHAK methods are currently being used on two GLC housing schemes: at Stamford Hill in Hackney, and at Adelaide Road in Camden.

1967 Experimental programme launched in consultation with Stichting Architecten Research Eindhoven, Holland.

1971 Report presented to Anthony Greenwood, then Minister of Housing and to the GLC. GLC agreed to undertake a pilot scheme.

1972 Work began on Stamford Hill, the GLC's first PSSHAK project. GLC's housing development committee approved the scheme.

1974 Stamford Hill scheme started on site.

1975 GLC's housing development committee approved second PSSHAK scheme at Adelaide Road.

1976 Adelaide Road scheme starts on site. Stamford Hill scheme due for completion.

1977 Adelaide Road scheme due for completion.

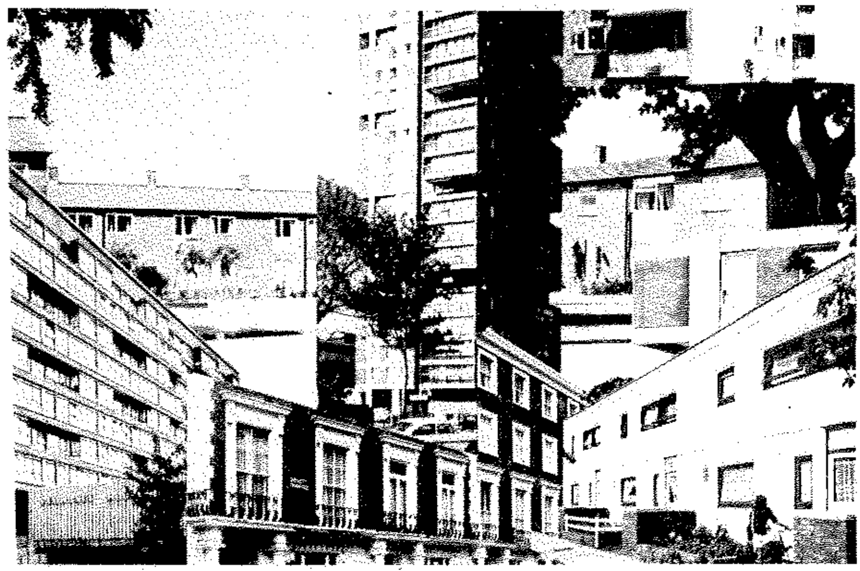
b. PSSHAK Mark II: storey blocks at Adelaide Road, Camden. In spite of the planning innovations developed internally, externally both schemes retain a fairly "traditional" image.

What is the standard approach to housing?

An inherent drawback shared by many current housing methods is an inability either to suit the particular living requirements of individual households or to respond adequately to meet changing social needs. This is largely because the real user i.e. the tenant, normally plays only a minimal role in the housing process.

Although in recent years the problem of meeting user needs has been ameliorated by extending the range of housing mixes to cater for a wider selection of family sizes, dwelling plans and the mix of dwelling types both still tend to be based on the estimated needs of the mythical average family rather than on those of specific families. This can lead to considerable management difficulties in matching household size to dwelling size.

a



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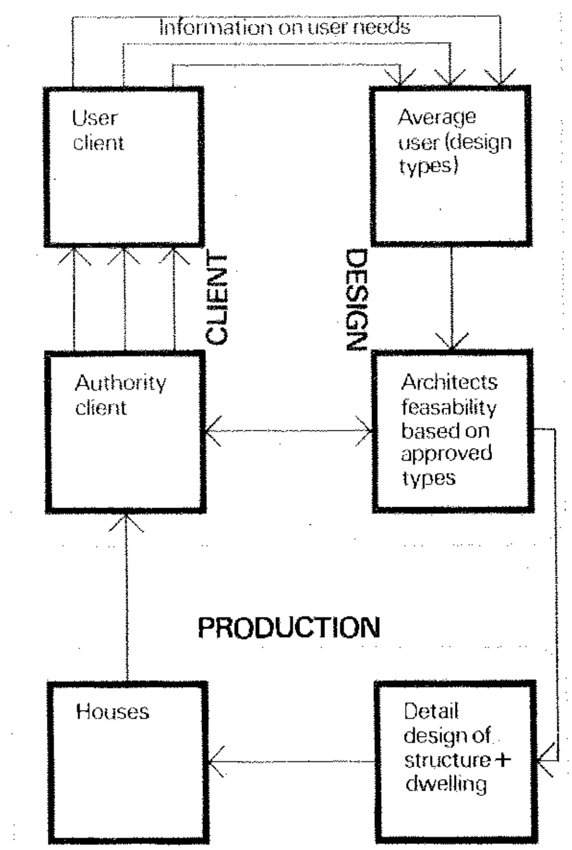


a. Some typical housing types. It is proving increasingly uneconomic to design a wide variety of different housing types especially on small sites. The more uniform type of structural methods proposed by PSSHAK could be a way of overcoming this problem which would also simultaneously increase the number of dwelling possibilities internally

b. The standard housing process, detailed user needs are inadequately defined. This tends to cause inefficiencies in the design process and delays in the eventual letting of dwellings.

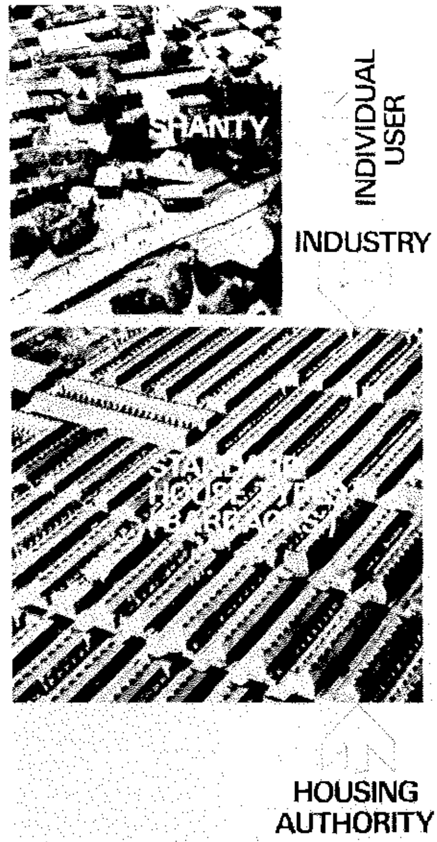
a

What is the PSSHAK approach to housing? What does it mean for the occupants?

In order to meet tenants needs more exactly, the approach redefines the responsibilities of those involved in the housing process giving the user an active and central role to play.

PSSHAK provides a direct method of assessing user needs, and affords the user himself the opportunity to define his own living requirements by means of a questionnaire, which is used to ascertain the particular space requirements of prospective tenants.

a

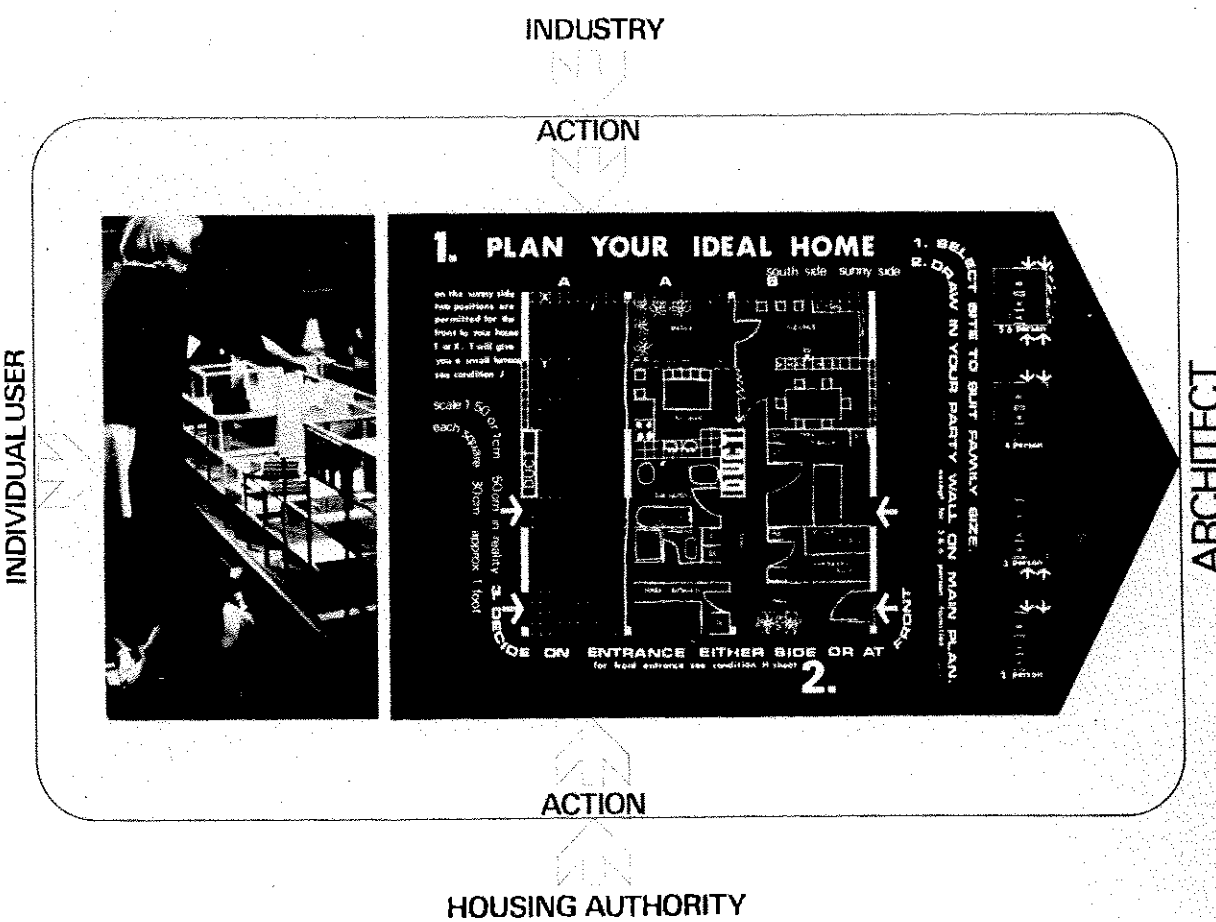


a. At one extreme, action on the part of the individual can result in shanties, and at the other, joint action by industry and housing authorities can result in barrack like sprawl. PSSHAK attempts to solve the impass by coordinating the functions of the different participants in the housing process.

b. A model will be available to help prospective tenants plan their homes in accordance with the ages and interests of their families

Internal house layout drawn up by prospective tenant to suit specific family needs

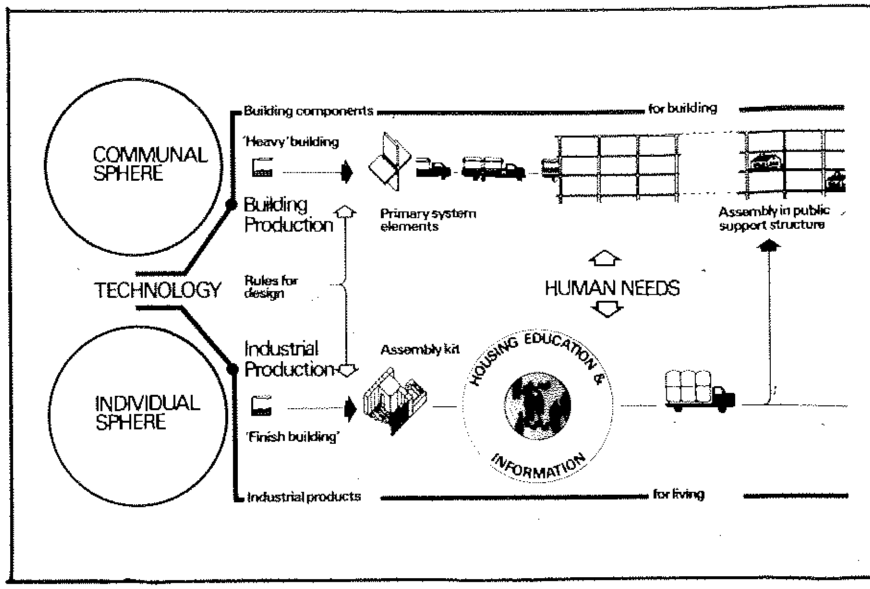
b



What does PSSHAK mean in terms of building?

The two facets of the construction method reflect the importance placed on the function of the user in the housing process.

While the "support structure" i.e. the basic service structure of the building, is designed for the community, the "assembly kit", i.e. the collection of components which forms the internal space-dividing elements and finishings of the dwelling units, is intended for the individual user.



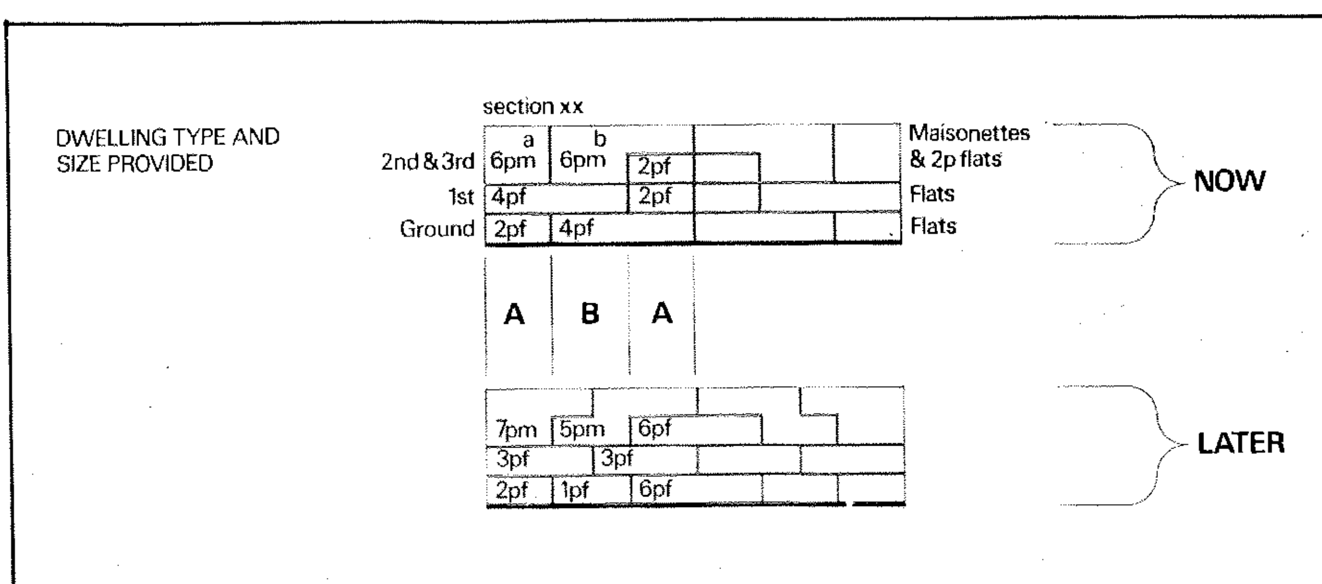
The separation of the building structure from the internal fittings enables a certain amount of flexibility in the planning of the layout of individual dwellings and of the overall housing mix.

The erection of the assembly kit is an entirely dry process, and the finishing procedure using the kit, including joinery, electrical fittings, and decoration should be simple and result in an overall reduction in the average man-hours per dwelling.

The difference in cost between building with PSSHAK and building with traditional methods is minimal. Nevertheless, there are savings in design and construction time due to simplification of pre-contract and construction procedures. In assessing the overall economics of the system, it is also necessary to take into account any savings which might be made in future modernisation programmes. These savings should be substantial, compared with the current high cost of modernisation.

What does PSSHAK mean for housing authorities?

With the use of the adjustable parts of the assembly kit and the organisation of the support structure, the number and sizes of rooms in a dwelling can be modified to suit the requirements of each individual family. Longer term conversion and modernisation to meet waiting list requirements, changing family circumstances and possible future changes in housing standards then becomes less of a problem.



Housing authorities using PSSHAK will be able to make late stage modifications to their briefs, and need not finalise the dwelling mix until the development reaches a fairly advanced phase.

The inbuilt flexibility of the PSSHAK housing structure allows the incorporation of a greater selection of housing mix alternatives than usual, providing a range of dwelling sizes from 1-8 person units, and enabling housing authorities to house a greater range of household types.

Managing PSSHAK

Whether or not the flexibility offered by PSSHAK is anything more than an architects game will be decided in the last analysis by housing management, who are committed to examining its full implications.

At Stamford Hill, for example, the variety of plan types available may be compromised severely unless a coherent participation programme with prospective tenants is put into operation.

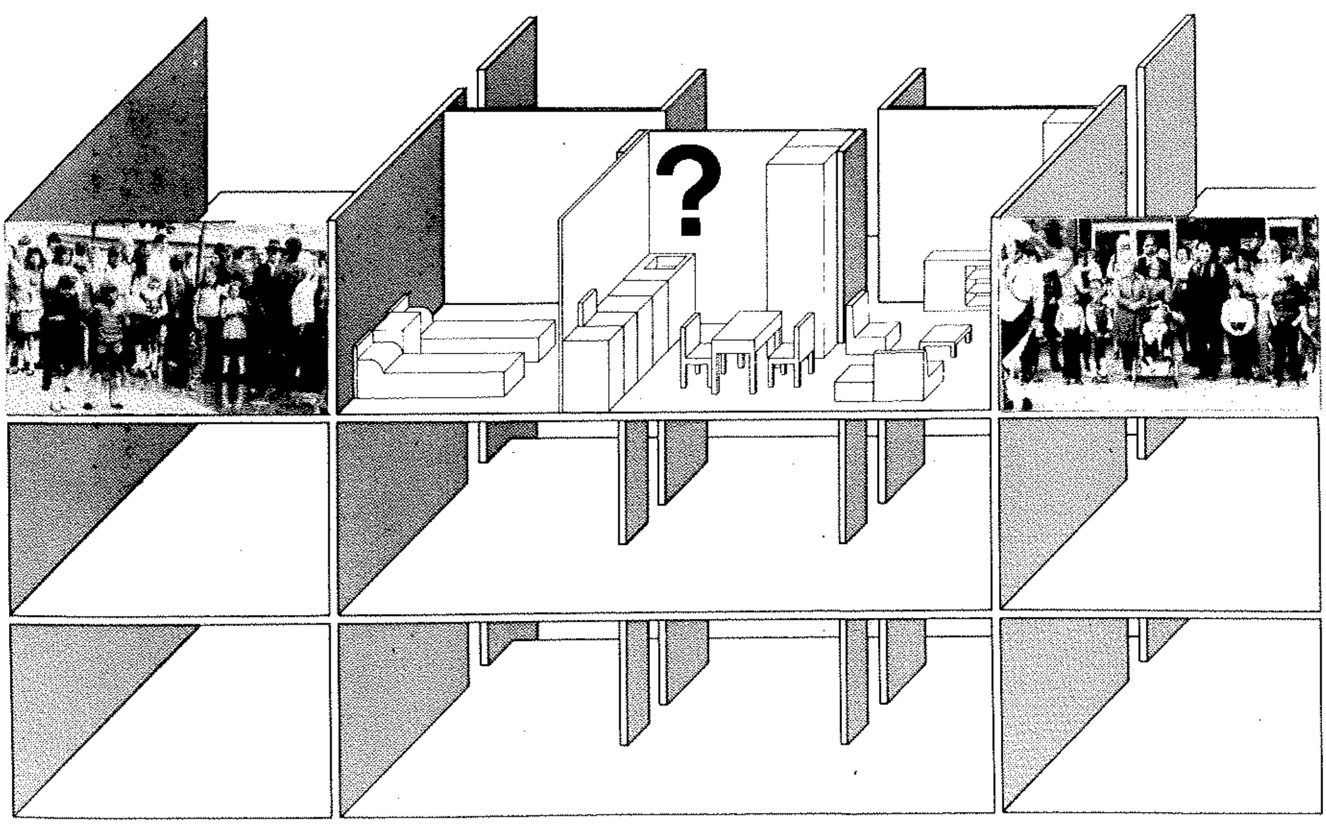
This programme will have to tackle a number of fundamental issues. How will the scheme be explained to future tenants? When do the tenants need to be identified? Where will space components be stored and how will an exchange facility for future modifications to dwellings be organised? Who will make these future adjustments? How will the maintenance and transport of components be financed?

PSSHAK: what does the future hold?

Decisions concerning the future viability of PSSHAK within the Council's housing programme will hinge on feedback from the Stamford Hill and Adelaide Road experiments.

At present the greatest number of unknowns are associated with the assembly kit and the participation programme, and while research into these two areas is in progress, further development probably will concentrate on the support structure.

Once the full financial implications of the structure have been established its potential use for small "infill" sites will be investigated. But until the practical lessons of the first two schemes are apparent, such plans must remain tentative. Their success will decide PSSHAK's future.



II. ADELAIDE ROAD PROJECT

Adelaide Road represents the second stage in the development of the PSSHAK concept of housing. The scheme represents a comprehensive investigation of the significance of PSSHAK housing methods in terms of design, production and constructional advantages, social consequences and financial implications.

The Site

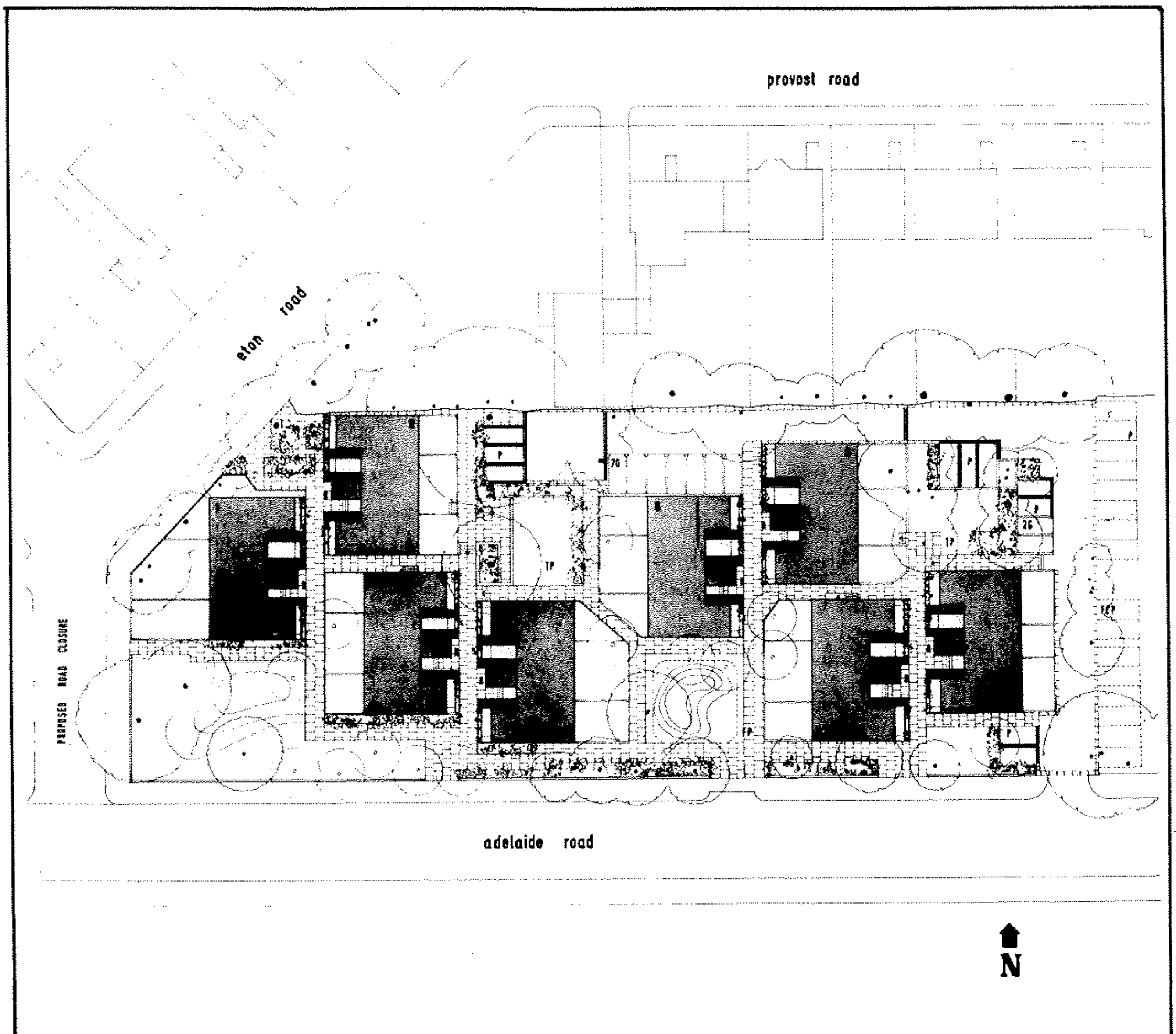
The 1.395 acre (0.565 hectare) Adelaide Road site has become available for housing redevelopment as a result of the abandonment of the North Cross route, and is zoned for residential development at a density of 100 p.p.a. (247 p.p. ha.).

The site is at present vacant, and is bounded to the north by the four and five storey houses of the Eton Villas conservation area. To the south is Adelaide Road, and beyond is the Primrose Hill railway complex, set in a cutting. An existing GLC housing estate lies to the east of the site; to the west is Eton Road.

The site is conveniently located for transport facilities, with a bus stop immediately adjacent, and Chalk Farm underground station situated at a distance of approximately 300m at the junction of Adelaide Road and Haverstock Hill. Bus routes run along both these roads. Near to the station there is a small number of shops, and not far from the site are the open spaces of Primrose Hill.

Accommodation Requirements

The scheme can accommodate a maximum of 64 dwellings (1



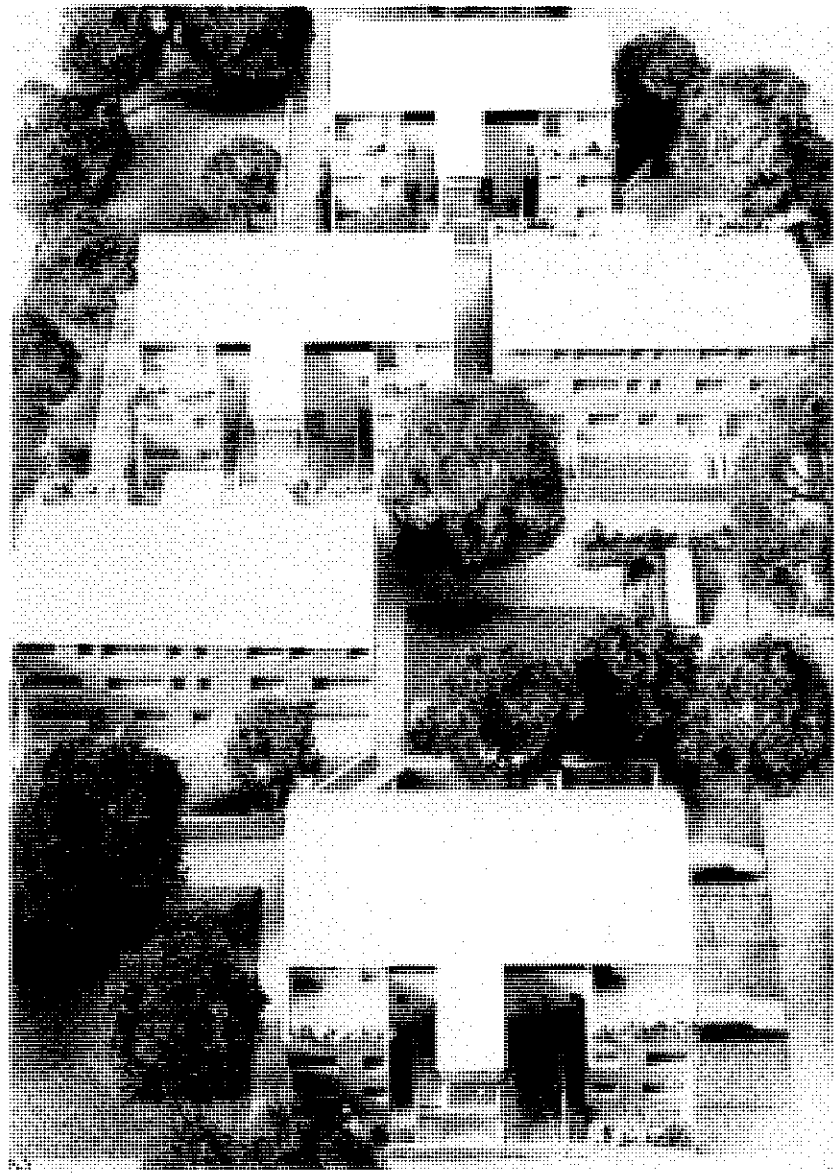
and 2 person flats) and a minimum of 32 dwellings (8 person houses and 2 person flats) in 8 three storey blocks. The accommodation is broken down into the following unit mix, as required in the revised brief:

1 person flats (O.P.)	2
2 person flats (O.P.)	15
2 person flats	13
3/4 person maisonettes	9
3/4 person flats	1
5/6 person houses	4
7/8 person houses	1
Total No. of dwellings	45

To begin with 26 parking spaces will be provided, but there will ultimately be a total of 35 parking spaces, 18 of which will be provided on the ajoining GLC Constable housing estate.

The brief also calls for an old persons' common room.

District heating by central gas-fired boilers will heat individual radiators in all dwellings.



Site Layout and Design

The nature and location of the site have given rise to a number of specific requirements which have been treated as fundamental objectives in the layout and design of the estate. It was considered important that the scheme should relate sympathetically to the scale of building in the surrounding area, particularly to the Eton Villas conservation area. The design of the scheme also aimed at safeguarding the privacy, daylight and prospect from the rear of the existing buildings in nearby Provost Road, and has managed to preserve a good number of the existing hardwood trees on the site.

Another major priority was for as many dwellings as possible to be provided with either private gardens or balconies, with individual front doors to all dwellings at ground level, and with a prospect away from the noise of Adelaide Road.

In view of the lack of parking facilities on the adjoining GLC housing estate it was necessary to provide extra parking spaces in both the proposed and the existing developments. Parking has been planned off the series of open squares around which the blocks of dwellings are grouped, and the layout of both walkways and access roads ensures that pedestrians will not be required to cross the roads at any point. The layout of walkways in the scheme has also been designed to facilitate the surveillance by residents of each part of the estate and of the approaches to the individual dwelling.

Play areas and open spaces have been sheltered from Adelaide Road, and there are special facilities for a toddlers' play area.

Construction

1. Construction Details

External walls at Adelaide Road will be of brick/block cavity construction, with Redland/Ockley 2nd hardstock facing brick. The pitched roofs will have blue/black roof slates, and windows will be of a softwood horizontal pivot type.

The screening and orientation of the blocks should shield them from the noise of Adelaide Road, but as an extra precaution, there will be plate glass fixed along the Adelaide Road elevations.

Due to the construction method being used for this development, it is anticipated that the contract period should be 15 months. Work on site began during the first quarter of 1976.

III SUPPORT & ASSEMBLY KIT

Objections, Questions and Answers

A brief detailed description of the practicability of Supports and Assembly Kits, as well as the design methods devised to produce and evaluate their potential use.

A statement of objectives - theoretical and practical including: increasing the range and quality of choice, satisfying individual user needs, encouraging phased renewal and adaptation, catering with late stage modifications to the design brief, maintaining the benefits of standardisation for building and increasing the efficiency of design, production and building operations. Identifying the range of objections raised.

These include:

- The Support could still over dominate the range of choice, if the user is not involved with its development.
- The Support will remain a tool in the hands of authorities, to manipulate tenants persuading them to accept a range of choice deemed reasonable by the authority.
- The whole idea has middle-class connotations, since one needs to be already well housed to accept the lenghty process of participation - to afford the time.
- In the longer term, management will be over-burdened with having to implement and budget for, the continuing process of adapatation.
- The Assembly Kit idea, by encouraging the process of industrialisation, proliferates the consummerist approach to housing.
- To make the production of the Assembly Kit viable, economically, the idea depends on large scale operations. The tendancy today is away from the universal solution.

Questions include

How does the Support change the stigma of the council house, its image, when tenants have no control over the external appearance of the Support?
If they are involved in deciding the external appearance, how do we control the overall aesthetic and harmony of the built environment?
How is the line of balance, between what the authority decides and where the user is involved, actually defined?
Would it not be easier to issue alternative plans, already drawn up for tenants to select the one which comes closest to satisfying their needs?
What 'reserve' is being inbuilt in order to increase the range of choice to families and to meet future demands for adaptation as requirements change? What does this cost and is it a worthwhile investment?
Who adapts and who pays for adaptation?
Will dwellings, tailor made to the needs of particular households, be difficult to let when the tennancy changes?
Does the process of participation imply an extended contract period?

Support Structure

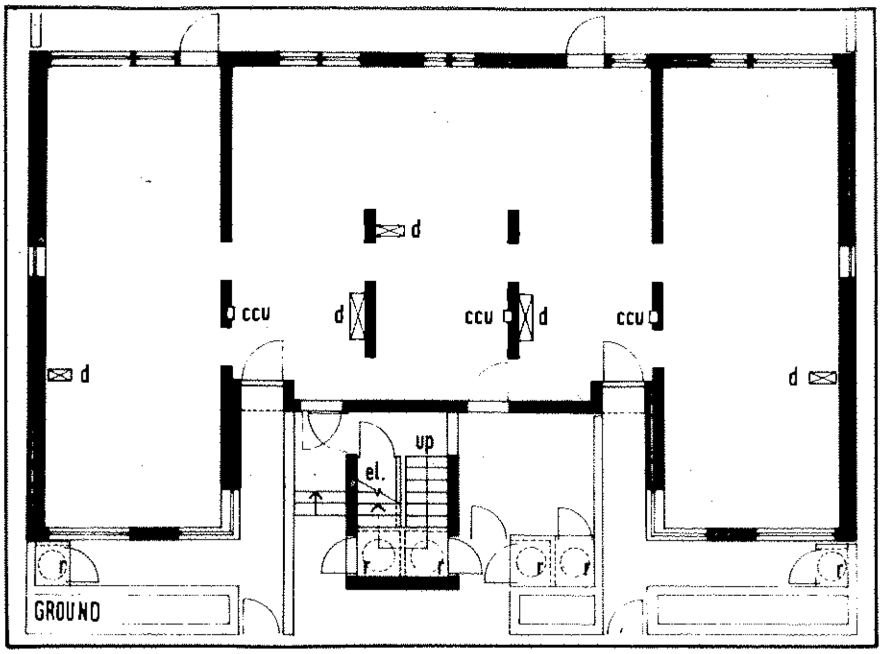
The first stage of the building process involves the construction of the basic structural shell or 'support structure' with load bearing cross walls and reinforced concrete floors pierces in the appropriate places to allow for long term adaptation. The shell includes primary mechanical and electrical service points.

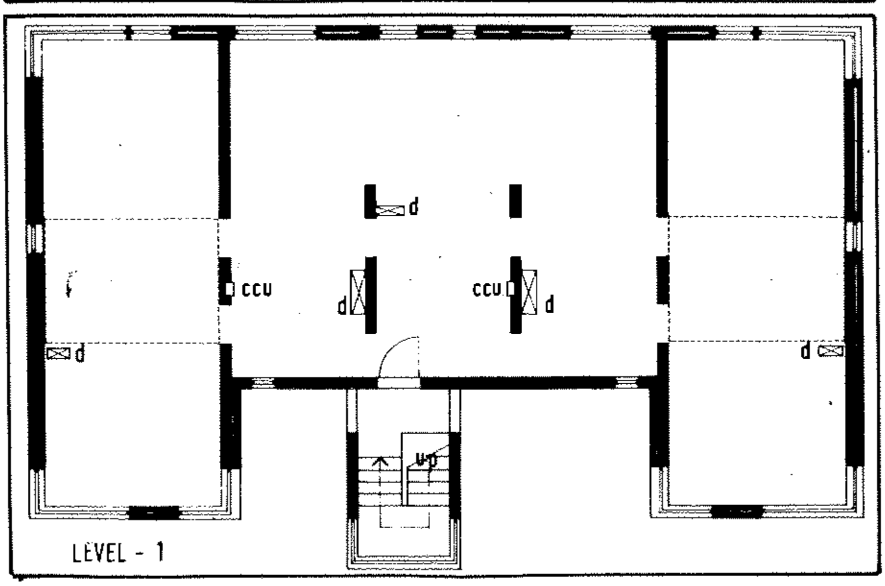
Once the structure is complete the dwellings have been let and detailed requirements are known, work can start on the second stage, which entails the installation of the assembly kits.

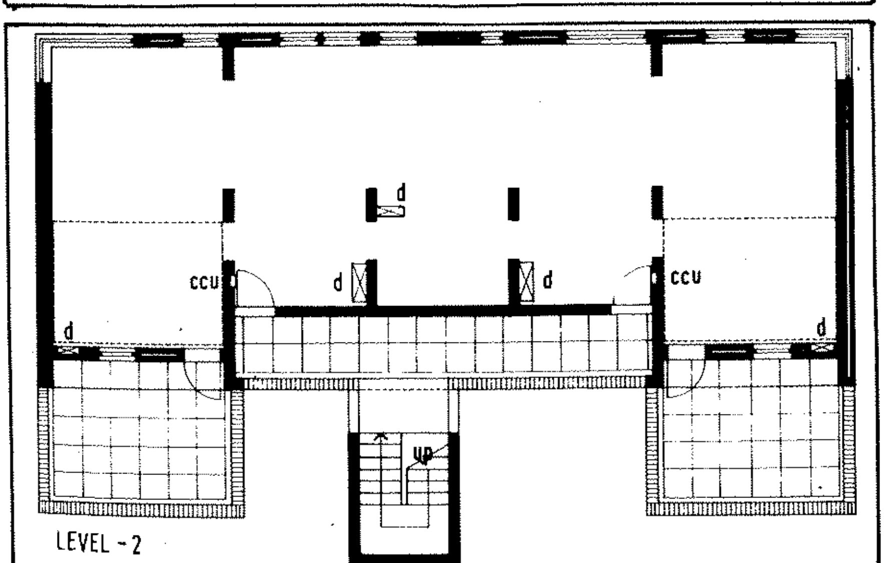
The components which form the assembly kits are completely independent from the support structure. Decisions on the internal layout will involve no modifications to the basic structure and similarly, changes in dwelling mix will not be inhibited at a later stage.

The kits being used at Adelaide Road are being employed more fully than at Stamford Hill where they consisted only of flexible partition systems. The Adelaide Road kit is being supplied by the Dutch firm of Bruynzeel,who

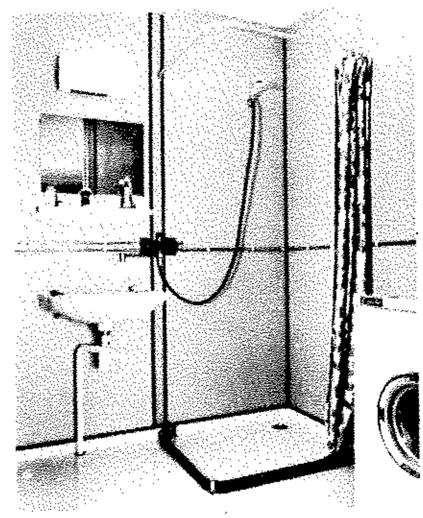
Support Structure

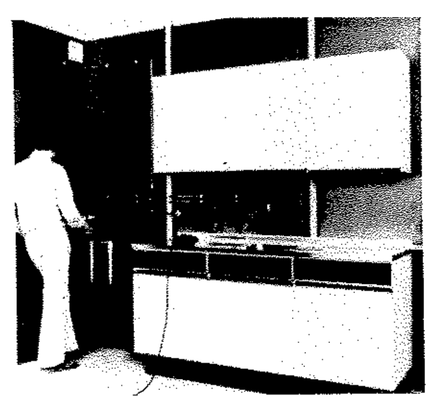


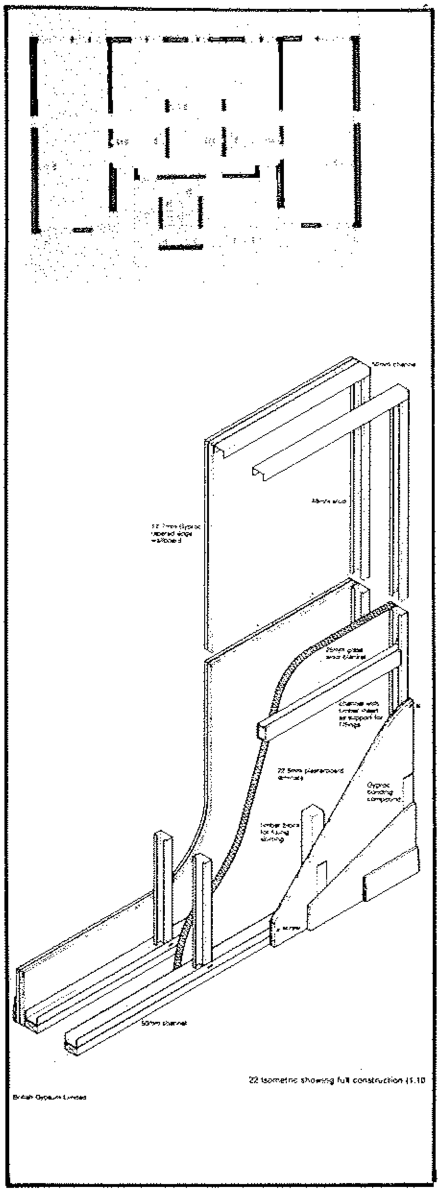


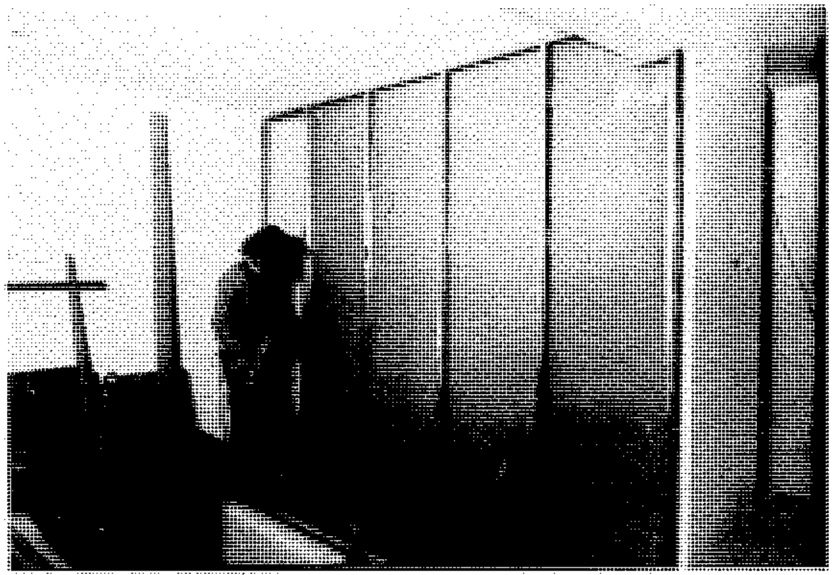


Assembly Kit

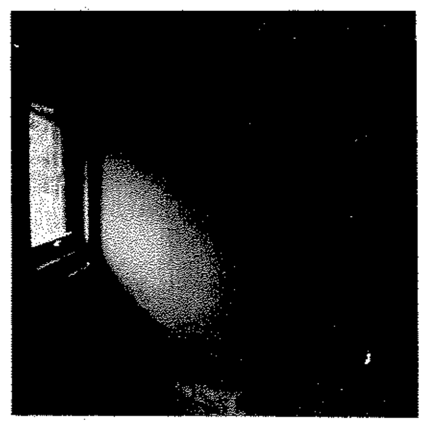


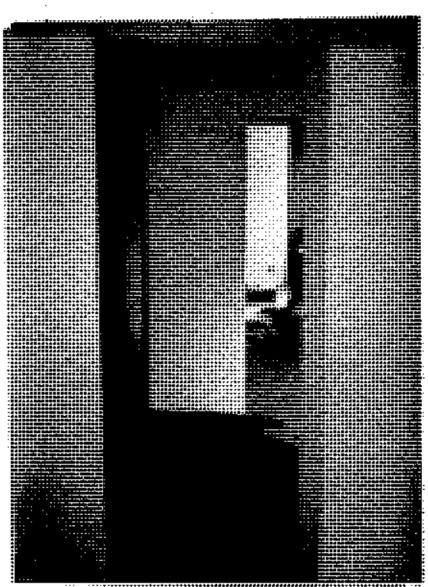




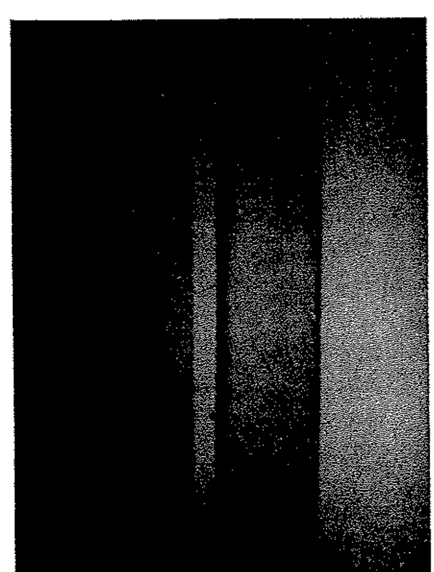


An infill party wall system (British Crypsum Ltd.) is used for filling in the storey-high gaps in the support structure to make the number and size of dwellings required. Future alterations (long term) to the dwelling mix can be made per floor without hinderance to the inhabitants in the remaining dwellings in the block. Photo, middle right, shows the completed infill party wall before a finishing paint is applied.



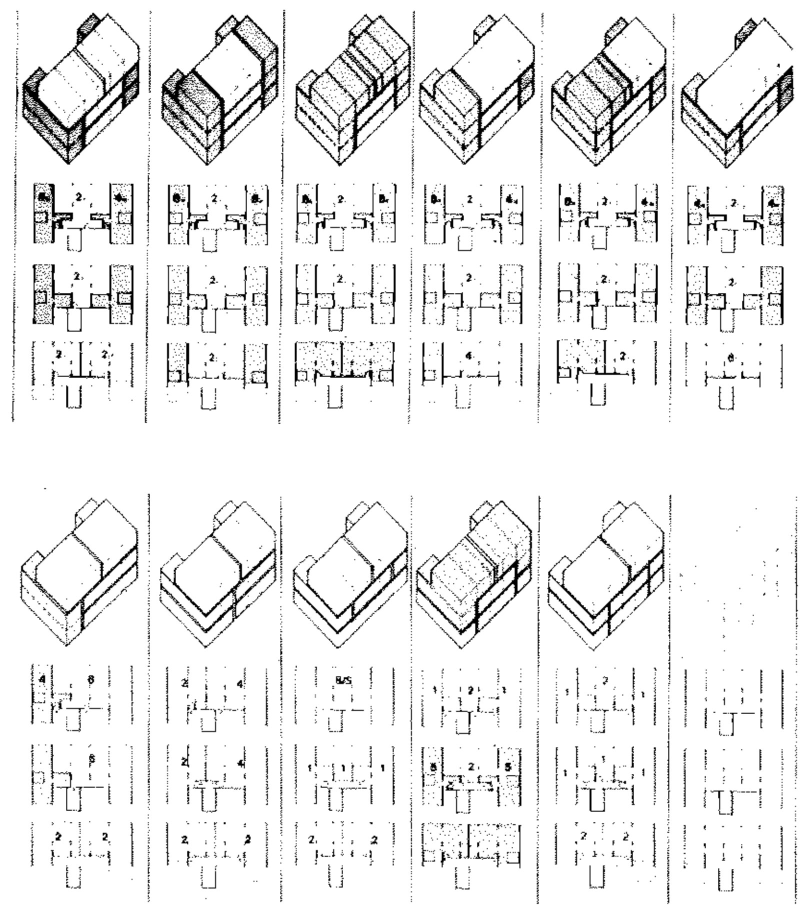


Within each dwelling a number of gaps remain open. (Photo left). These are either used as the doorway connection to the rooms of the dwelling or where not required are filled in with an assembly kit partion (photo right). Future alterations (short term) to the dwelling plan can be made by opening or closing the openings.



are providing vertical service ducts, partitions, doors, cupboards, bathrooms and w.c.'s as consultants on the installation of components and the sequence of operations.

All partitions in the Bruynzeel system are of a softwood frame covered with 16mm thick panels, ready for decoration. Within bathrooms and w.c.'s the frame is faced with 16 mm waterproofed chipboard with a melamine finish. Door frames are of a high impact PVC. Cupboards are made of standard partition elements, with PVC door frames and 18mm thick doors. The inner panels have prepositioned holes to enable shelving and hanging rails to be installed where required.



A selection of possible alternative dwelling mixes which can be accomodated in the 3 storey blocks. The numbers refer to the number of occupants in each unit.

Planning possibilities

The added flexibility of the support structure together with the assembly kits allows sufficient adaptability for each of the eight 3 storey blocks to offer a wide variety of possible flat, maisonette and house plans, ranging in sieze from single person bedsits to eight person houses.
Each block can house a maximum of six dwellings (1p and 2p flats) and a minimum of four dwellings (8p houses and 2p flats).

The inclusion of single person accomodation is particularly pertinent, as is borne out by a recent DoE circular:

More than half the households in Britain now consist of only one or two people. These small households include people of all ages in a wide range of domestic circumstances. Many are in housing need, for instance young single people who need to move frequently because of the nature of their work; young recently married couples; single parent families; those recently separated or divorced; and older single people who wish to settle on their own.

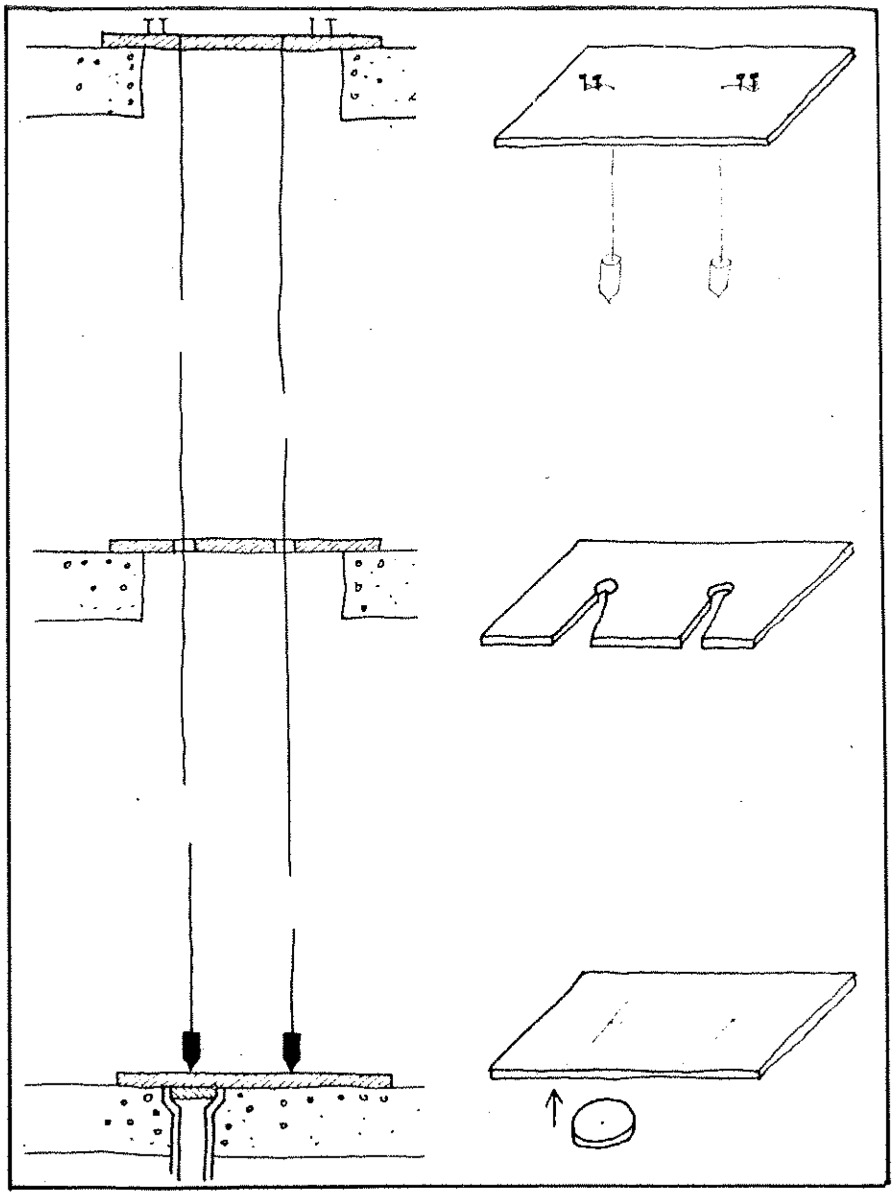
DoE Circular 24/75

Duct and Partition Assembly

Because the assembled ducts are not so easy to manage the duct base plates are used for aligning the ducts.
For the alignment 2 plumbs are dropped through the centres of 2 openings in the base plates.

Due to the fact that the clay soil pipe is cast into the slab of the ground floor the positioning tolerance of the duct soilpipe at groundfloor level is reduced to zero.
The plumb should be dropped in the centre of the clay pipe socket (though some slight variation is possible just because the clay pipe is ending with a socket). Therefore a template should be laid over the clay soilpipe with 2 centreholes for the soilpipe and ventilation pipe.
When the templates are positioned the aligning can take place. From the 2nd floor 2

plumbs are dropped through the holes and fixed on the duct base plate of the 2nd floor. By moving the base plates on all floors the position can be found, whereby the plumb is dropping as near as possible through the centres. At the same time the consequences for the position of the cills can be checked. When an acceptable situation is achieved we can go on with the next activity.



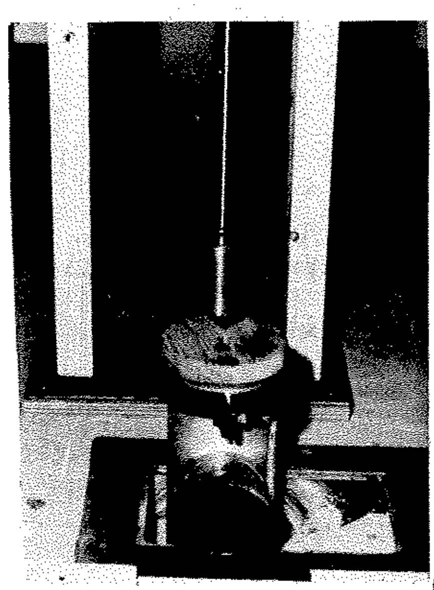
Fixing cills and temporarily fixing of duct base plates

When all base plates are aligned they must be temporarily nailfixed in the corners in such a way that they can be removed when erecting the service ducts.
The cills can be nailfixed to the floors, preventing undesirable moving. The partitions can be put up without further measuring.

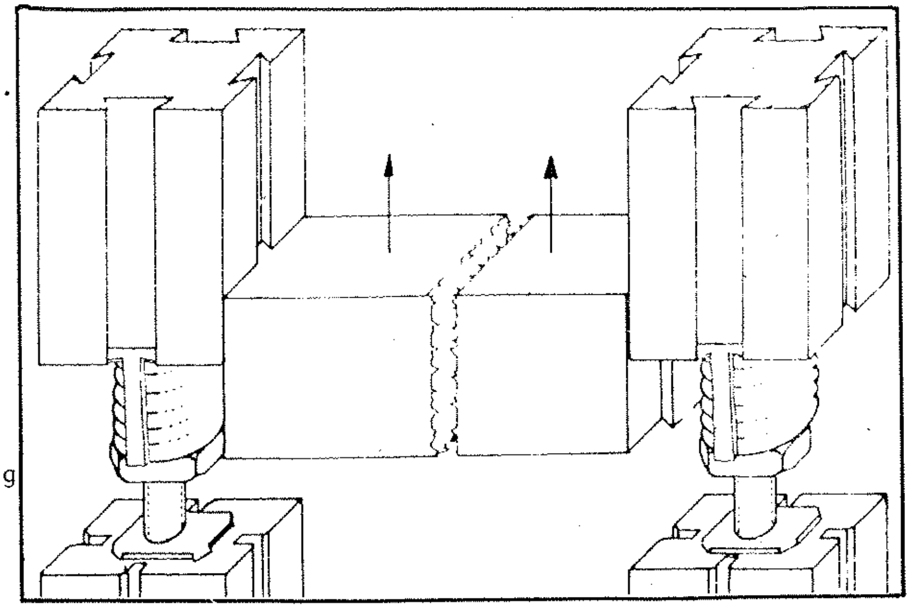
The assembled service duct is now erected. Some pipework will protrude through the duct aperture on the first floor. Soilpipe piece S3 is put above soilpipe branch Ø 75.
Soilpipes are connected with rubber insert collards and coupling collars.
On the first floor the base plate is pushed over the protruding copper pipework and will be held in place by nails in the corners, thus positioning the duct.

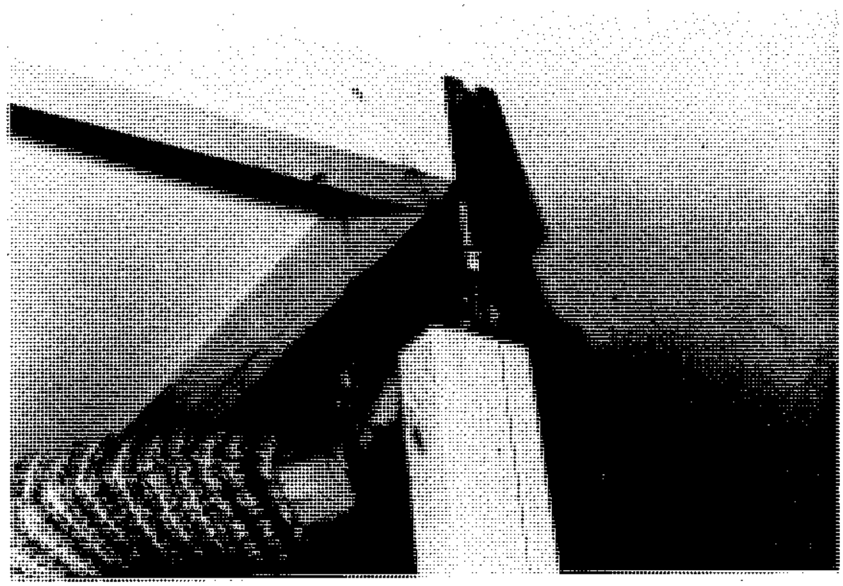
Erecting 4 partitions of a bathroom.

Each post has a hole at its bottom in which the dowel of the post base piece fits.
On top of the post is another hole in which first a threaded rod with nut, spring and a fixing plate are inserted.
On top of this threaded rod assembly, a post top coupling



piece is slid on. Then the post can be plumbed and tightened between floor and ceiling.





The fixing plate has 2 lips. As soon as the flat spanner touches one of these lips the post is tightened enough.

The mounting of the cell is as described below:

One post is erected in one of the corners of the cell, plumbed and tightened. Good care should be taken that the fixing plate is turned in such a way that the dovetail opening of the post top coupling piece is free in the direction where the partition is erected.
After this a second post must be erected and the fixing plate must leave the dovetail opening free into the direction of the first post.
Between these posts a framehead is slid in into the left dovetail openings. The fixing plates can be turned now in such a way that the framehead is secured and the dovetail openings are set free into the erection direction. Every post is fixed in this way as well as the frameheads.
Before all posts are definitely tightened check the alignment with a long jointing rule.

Although the latest phase in the development of the kit has continued along fairly sophisticated product-oriented lines, this is not necessarily the only answer. According to the context of the development, the kit could take the form of a variety of different design options, and instead of concentrating on the design of an actual product for instance, could incorporate a range of off-the-peg components.

IV PARTICIPATION PROCESS

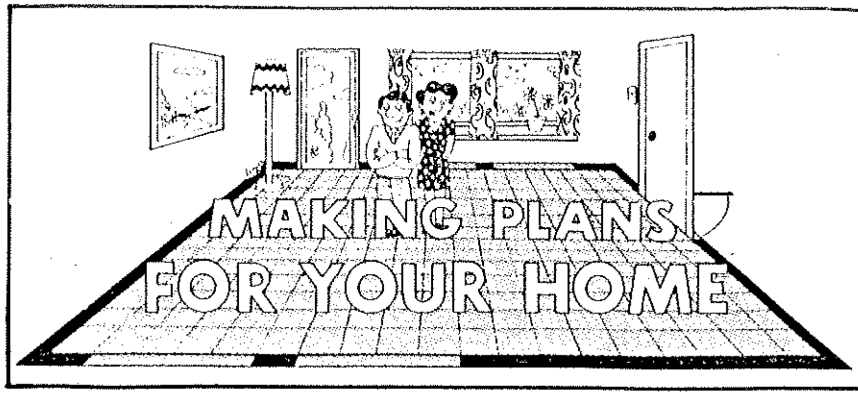
The intention of the general meetings, where these were held, each with a group of approximately 12 families, was to introduce the idea, discuss details of the project and layout and to explain the tenants manual. Various general questions were raised, including rents, ability to park cars close to dwellings, keeping pets, etc.
Tenants were asked to read the manual carefully and to return the relevant sections i.e. the checklists and where possible the plans. In order not to raise expectations it was pointed out that there would be very specific constraints to the planning of the dwellings, due both to the physical nature of the support and also the building regulations. These were to be further explained during the detail planning process on site.
Following the meeting the tenants were asked to return the information within a week and an appointment would be made with each family to visit the site, to view and work with the models and to visit their shell. A short slide presentation was made and general information given on nearest shops, bus stops and recreation facilities.

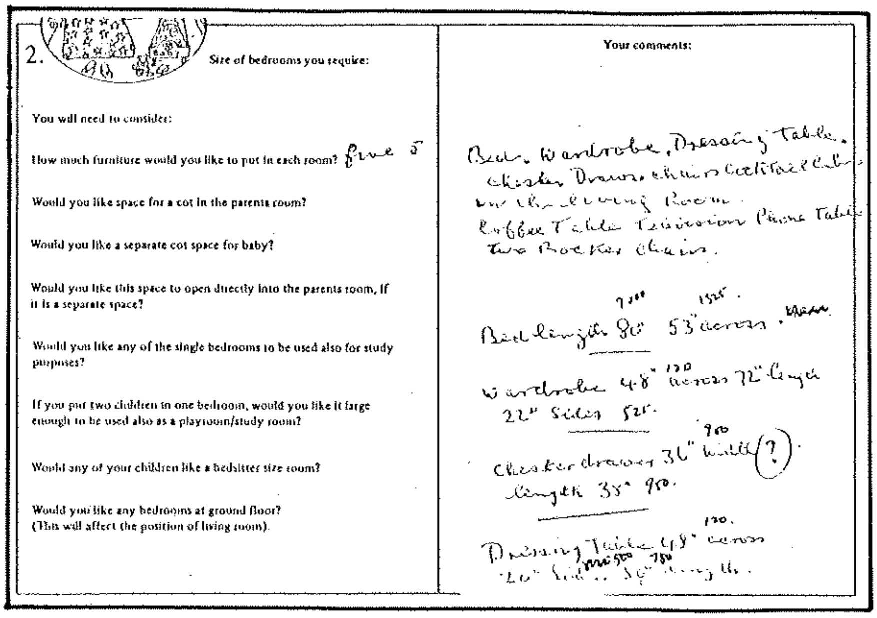
Tenants manual

This manual has been prepared to give you a general description of the major features of your home and estate, to enable you to use and enjoy what is provided to its maximum. In particular it will:

1. Help you to plan your own home, according to your particular preferences and to enable you to make adjustments in the future to your home, should your requirement change. This is included in Part 1 of the Manual.

2. Help to explain how some of the small day to day items of maintenance that can be carried out by you, to help keep down ever increasing maintenance costs and to help hard pressed Management Staff. There are hints on how to divide each area to give more room, how to enlarge rooms, to add storage, to adjust position of doors for suitable furniture arrangements etc. This is included in Part 2 of the Manual.





2. Size of bedrooms you require:

You will need to consider:

How much furniture would you like to put in each room? five 5

Would you like space for a cot in the parents room?

Would you like a separate cot space for baby?

Would you like this space to open directly into the parents room, if it is a separate space?

Would you like any of the single bedrooms to be used also for study purposes?

If you put two children in one bedroom, would you like it large enough to be used also as a playroom/study room?

Would any of your children like a bedsitter size room?

Would you like any bedrooms at ground floor?
(This will affect the position of living room).

Your comments:

Bed, Wardrobe, Dressing Table, Chester Drawers, chairs
in the living Room.
Coffee Table Television Phone Table
Two Rocker Chairs.

Bed length 80" 53" across.

Wardrobe 48" across 72" length
22" sides

Chester drawers 36" width (?)
length 35"

Dressing Table 48" across
20" sides 50" length.

The site accommodates some 45 dwellings of different sizes. All family dwellings are at ground floor level, with a small front and back garden. The front gardens look onto the walkways. Planting these gardens will greatly enhance the appearance of the estate as a whole and will also, in time, give you greater privacy from passers by. A section is included in Part 2 of the Manual on types of plants and shrubs, best suited to the soil in your gardens.

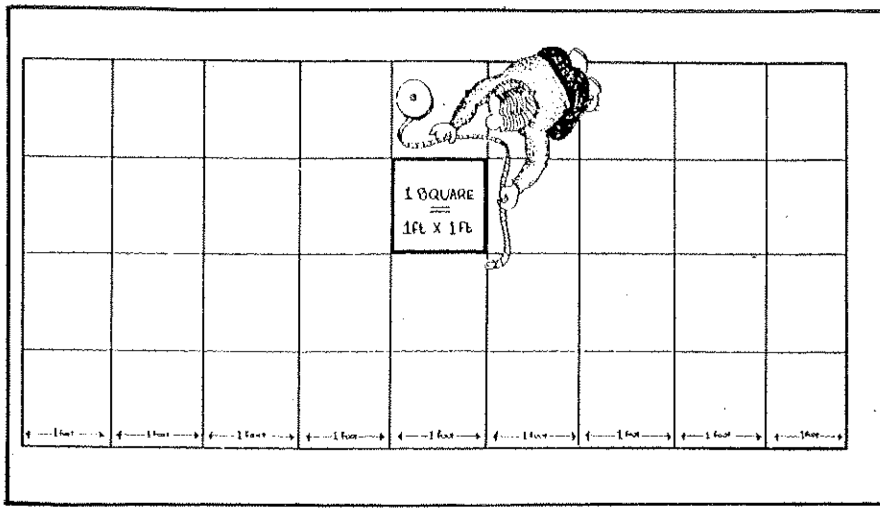
A common room will also be provided. Although this will be primarily for the use of the elderly, you may wish, through your resident's association, to arrange Nursery Mornings for Children, or the like.

In this and other respects, it may be helpful, in consultation with the other residents, to form a residents' association. This will help to maintain a standard for the estate, which you as a community will decide.

There are two parts to the 'Plan Making' procedure. The first is the checklist which ensures that you have considered all the major issues, which will influence your plans. The second is the actual planning of your dwelling. The aim of both these parts together, is to get your requirements for your dwelling. It is therefore more essential that you complete the checklist than to arrive at a detailed plan drawing. If you find difficulty therefore in the drawing, this can be completed at your interview with the Architect, where we shall have a Model and where you will be able to see the actual area of your home. However, with the drawings, you should attempt to discover how best to use the available space to meet your requirements. You may like to draw a series of alternative plans, which you can discuss with the Architect at your interview. The information sheets which follow, should first be read carefully.

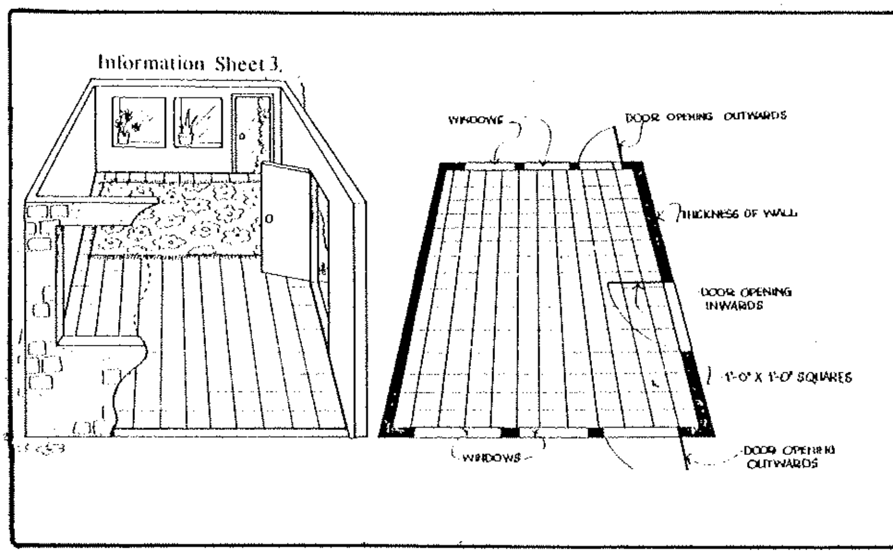
Information Sheet 1.

You will see that your plan has a grid marked on it, which will help you to measure the size of rooms as you draw them. This grid is made up of strips, running in two directions, vertically and horizontally. Each one square is 1 ft x 1 ft so you can get a general idea of how large rooms are, by counting the grid lines.
Once you have moved in, a useful system of measurement are the plastic tiles which you will find laid on the floors. Each of these are 9 in x 9 in.



Information Sheet 3

This drawing shows the basic shell OF A ROOM WITH windows and doors. To help you UNDERSTAND the Plans you will be working on, you can see how a plan looks when the walls are taken away.



Information Sheet 6
Ground Floor

The grid and Location of Walls

Here you see the grid marked on the plan. In general, WALLS can be placed anywhere, following the grid lines. DO not draw walls coming up directly to windows.

Making Rooms

Draw the rooms you require at each side of the house, on all floors, following the grid lines. When you have drawn each room, check to see that you can fit in all the furniture which you want to put in this room. Standard furniture sizes are given at the end of this brochure. For example, a single bed is about 3 squares wide, and 6 sqàres long. Some useful room sizes are given at the end of this Manual.

Hall Door

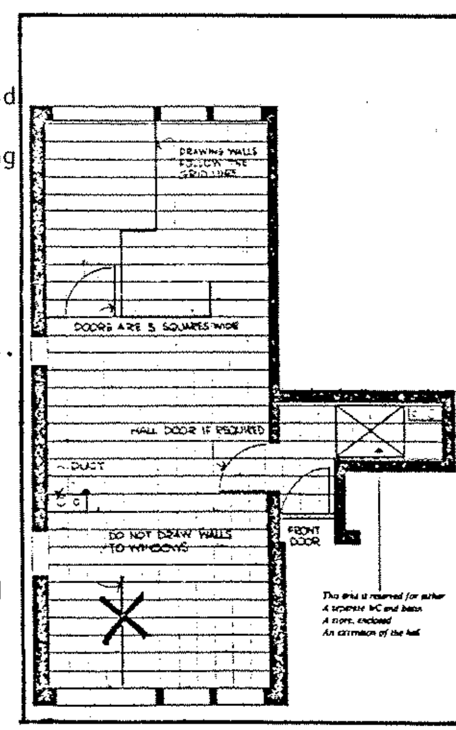
For houses you may like to add a door as shown to isolate your hall from the main living area.

Doors in general

These can be located at will, but there will be a limit to the number which you can have. A door is 3 squares wide.

Ducts

Ducts are for carrying pipes such as hot and cold water, waste and soil. The duct at point X is primarily reserved for kitchens. When deciding the position of your kitchen therefore, one part should always touch this duct.



Recorded interview

Following a description of procedure to tenants, a discussion of the families own plans and requirements, already listed on their manual, the discussions turned to the details of their plan arrangements. Those present included the Director of Housing (D.H.) the Architect (A) the Lettings Officer (L.O.) the Manufacturer (M) and the Tenant (T). The discussions covered a wide range of both general and detailed subjects and lasted approximately 3 hours. These included: overall planning, sizing of rooms, size and arrangement of furniture, detail arrangement and colour of kitchens, storage, number and position of plugs and lights.
The inter-relationship of the various actors is crucial to understanding the real level of choice available, and will best be illustrated in the form of an edited transcript of tapes.

A. I have one problem with your requirement for 2 double and 1 single bedroom. You've managed to fit it all in on your plan, because you've forgotten the stairs at the second level.

T. I'm sorry i haven't been very helpful with my drawings.

A. You could have the single bedroom if you accepted it at ground level, next to the living room. It would mean reducing the size of the living room, and even then the bedroom would still be very small.

T. Oh no, I can't have that. You see I really want it as a spare room. We often have visitors to stay.

A. Well, we need to establish your priorities. Its a bit like a game, your house size is fixed, so your going to have to trade one area off against another. More bedrooms will mean a smaller living room. Large living room will mean a smaller kitchen/diner and so on. We could have two single bedrooms and make one large enough to sleep two so that if someone comes to stay, then your kids can double up for the night.

T. Yes, but he's got a double bed. We can get rid of it. Would it fit into the larger single bedroom?

A. Just about, but there would hardly be enough room to walk round it.

T. No, don't worry, I think we'll get rid of it. How large is the largest single bedroom?

A. We could make it, say 15' long by 6' wide. That would make the other bedroom 12' long by 6' wide.

T. Thats a bit small. I'd like that a bit bigger. Couldn't we have it like this.

A. You could, and both rooms would then be the same size 15' deep. But it would mean going through I bedroom to get to the other. We've had one family who haven't minded that.

T. No they would like that. Before I forget, can I have a handrail in the bathroom by the bath.

DH. Have you made that provision for old persons?

A. No.

DH. We can put it under provisions for old persons:

....

T. Is the living room square, ours is about 30 sq. yards at the moment.

A. What do you mean by square.

T. I mean straight walls, no L shapes.

A. Yes, as you've got it on your plan, but you could build in recesses for shelves, tables and so on.

T. Is that a wall there by the stairs?

A. Yes.

T. I've shown it on my plan as open plan with the stairs and living room as one. Can't I have that?

A. I have to show it to satisfy the building regulations. You have to be able to escape from your bedroom to the outside without going through your living room and kitchen. But once your in you can take it down. We'll be giving you a manual which shows how you can do that.

T. I would prefer to do without it.

DH. That O.K., but we have to put it in for now.

A. If we add a door here to enclose your hallway, then when you take it down you won't be walking straight into your living-room.

....

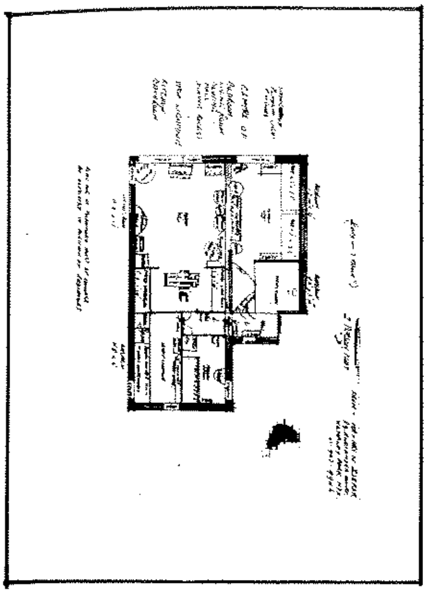
T. I've always liked the idea of a dining recess separate to the kitchen area - but I couldn't fit it in.

A. You could subdivide your kitchen/diner like this, which will give a working kitchen of 6' wide by 11' deep and a dining area of the same size.

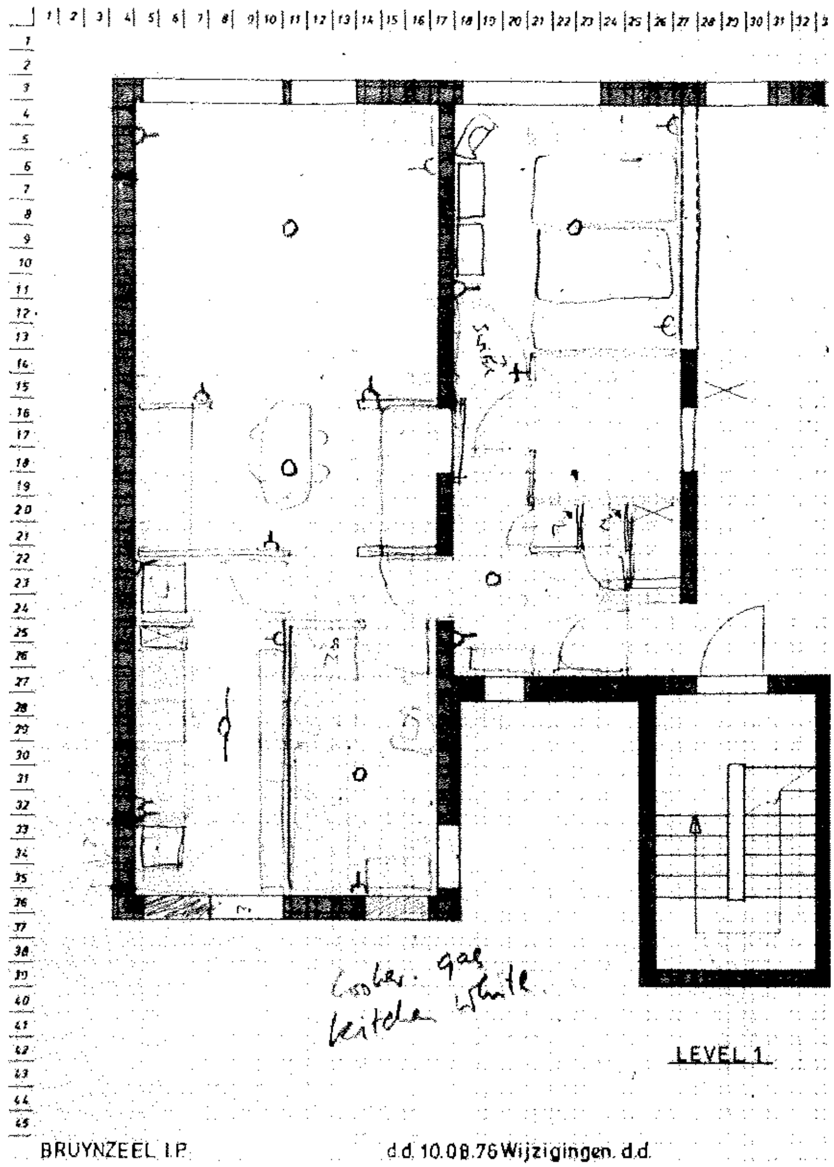
T. No - I've got to have the larger kitchen, the way we are at the moment. I could make a recess here, part of the living room, but it would make the living area so small.

A. Don't forget you will be taking down that wall.

T. Oh yes, well that would probably work nicely.



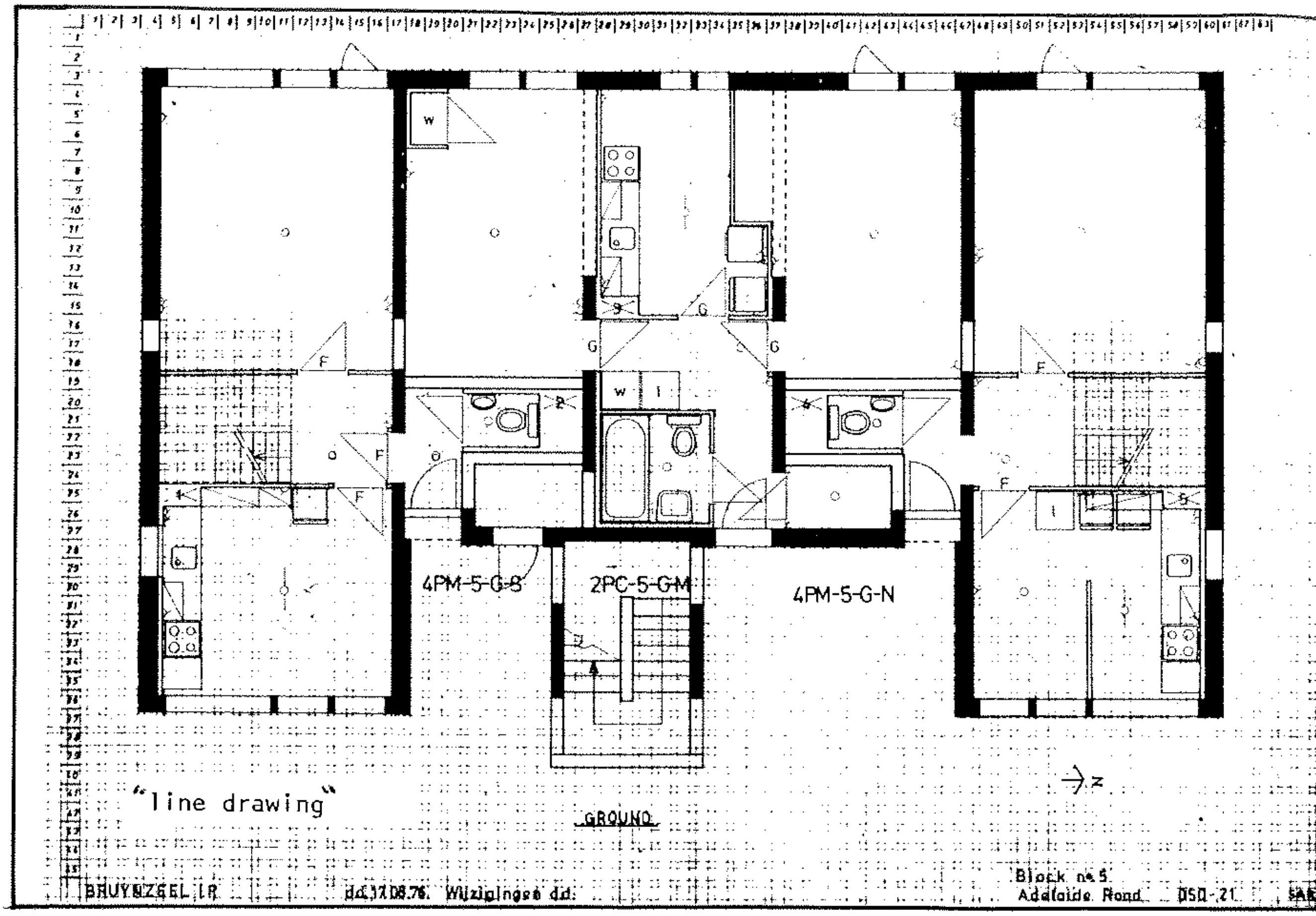
Top left: plan sketch made by tenant and returned to Architect for practical assessment.

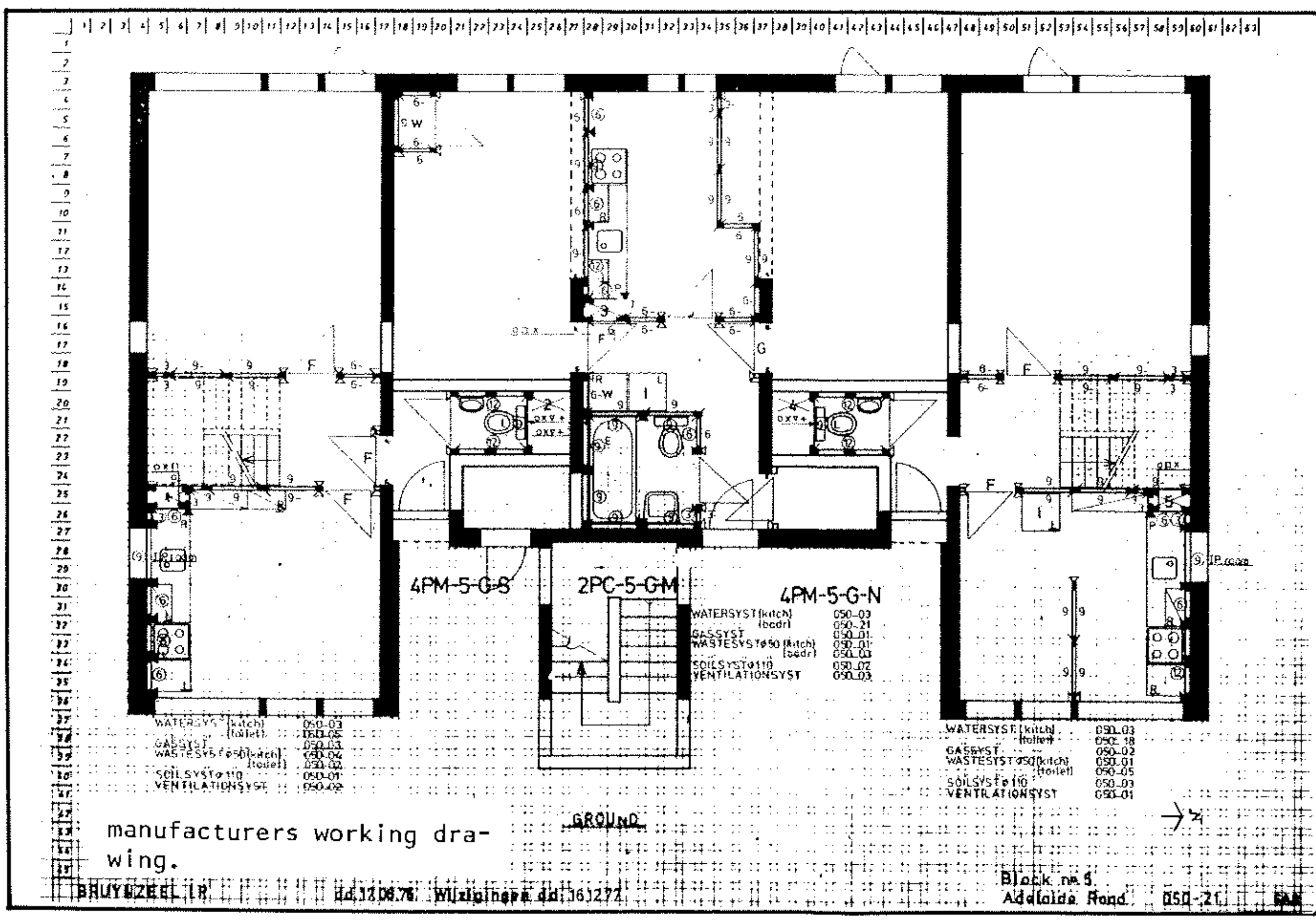


Top right/bottom left:
One week later site meeting arranged with Architect to finalise plan. Tenants could use model and visit the space in the support structure.

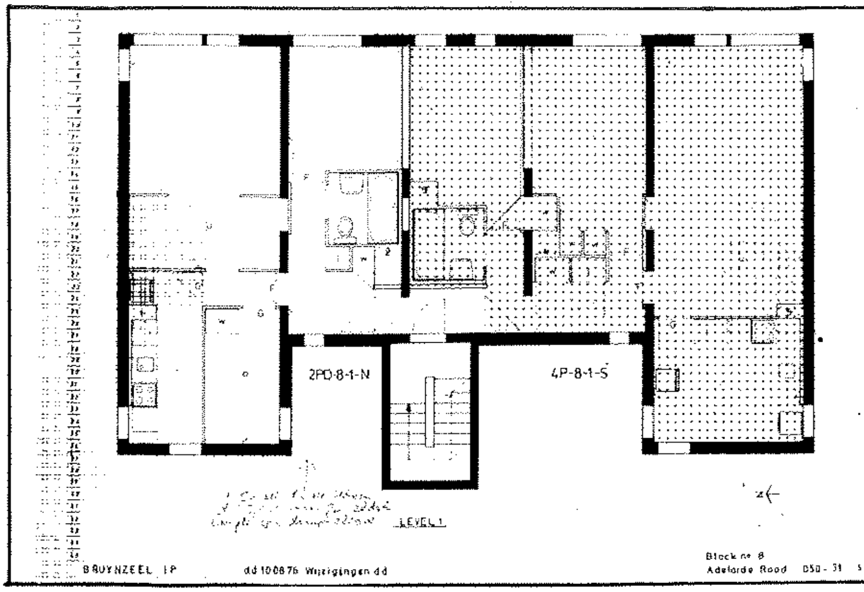
Following the site interview and discussions between Architect and tenant, a "line drawing" was made by Bruynzeel in order to assess the quantity of material and costs in comparison with the original estimate. If the costs exceeded the estimate the tenant was informed and the necessary adjustments were made. The period of time involved between the interview/sketch plan stage and the final plan was one month. see over: top

Final production drawing for detailing and coding the components and elements of the assembly kit for delivery and installation in the support structure. see over: bottom

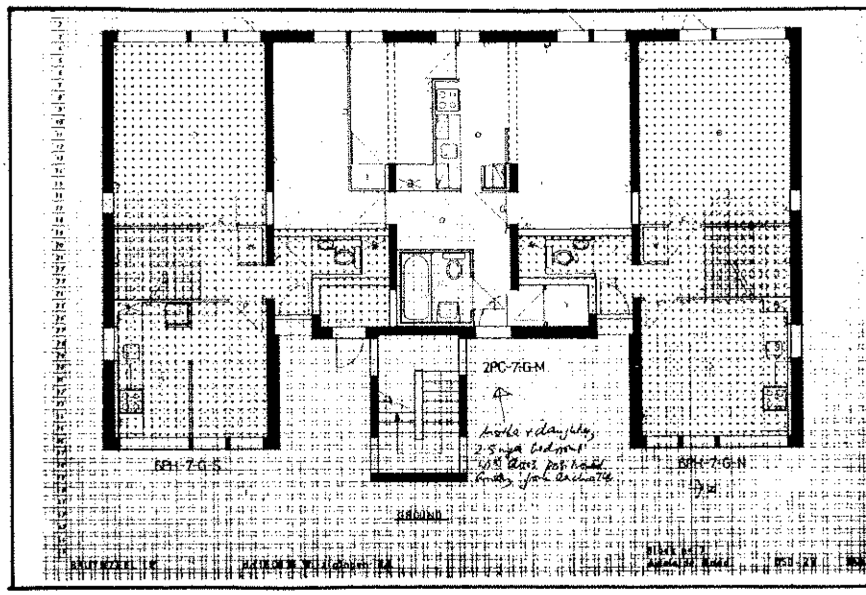

4PM-5-G-S
2PC-5-GM
4PM-5-G-N
"line drawing"
GROUND
Block nr.5
Adelaide Road
050-21


4PM-5-G-S
2PC-5-GM
4PM-5-G-N
GROUND
manufacturers working drawing.
Block nr.5
Adelaide Road
050-21

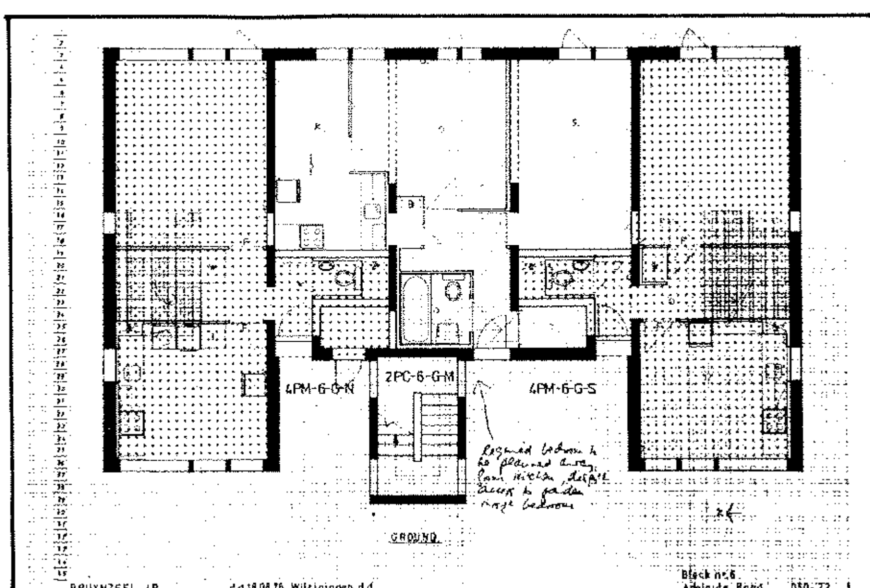
1. Small double bedroom and one spare room for elderly couple; with dining alcove.



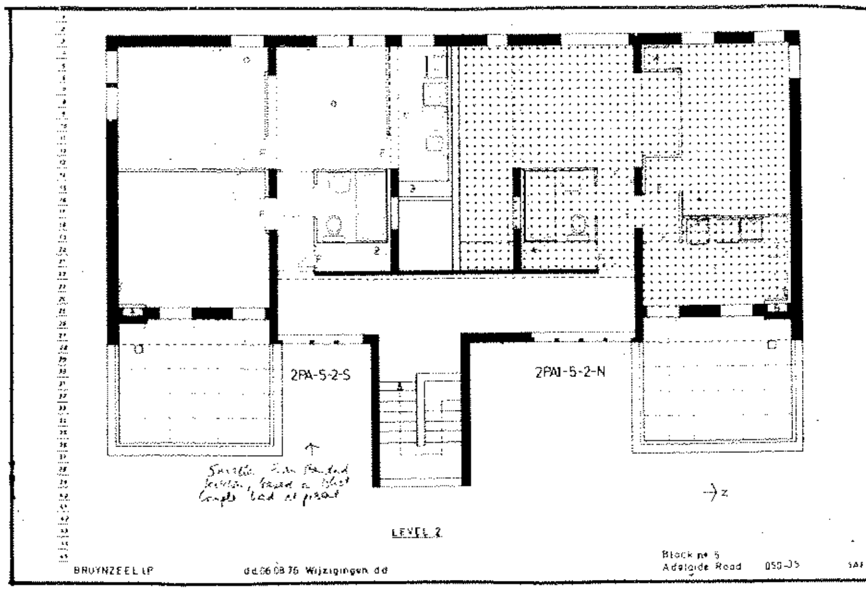
2. 2 Person unit for mother and daughter. Two single bedrooms with doors positioned away from each other.



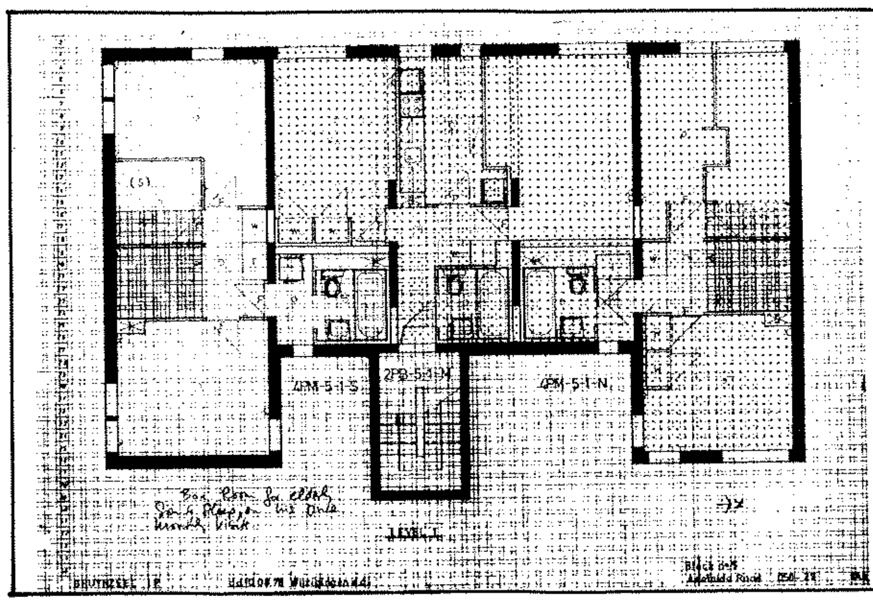
3. Tenant wanted his bedroom to be separated from the kitchen by means of an intermediary room despite the resulting access to garden through bedroom.



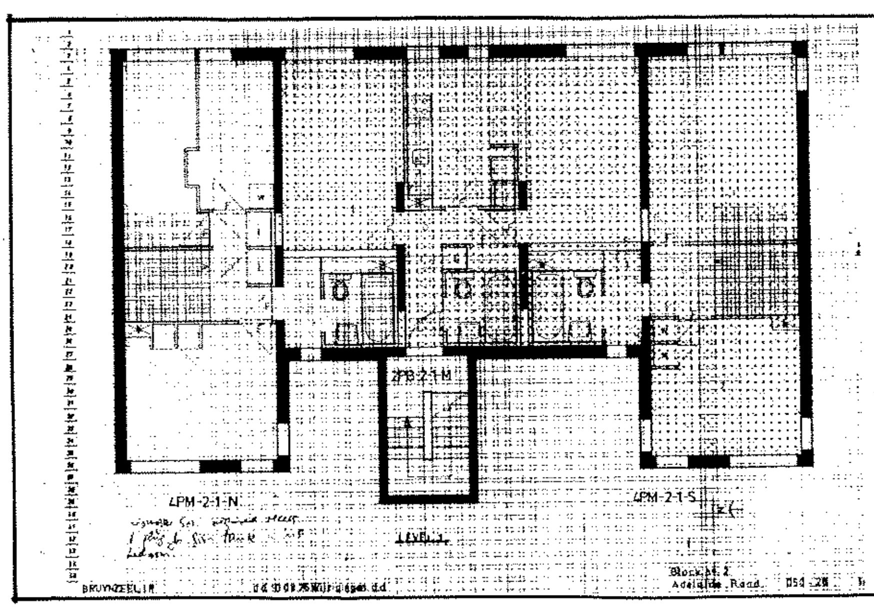
4. Kitchen width less than standard of 1.80 m; based on the tenants present kitchen.

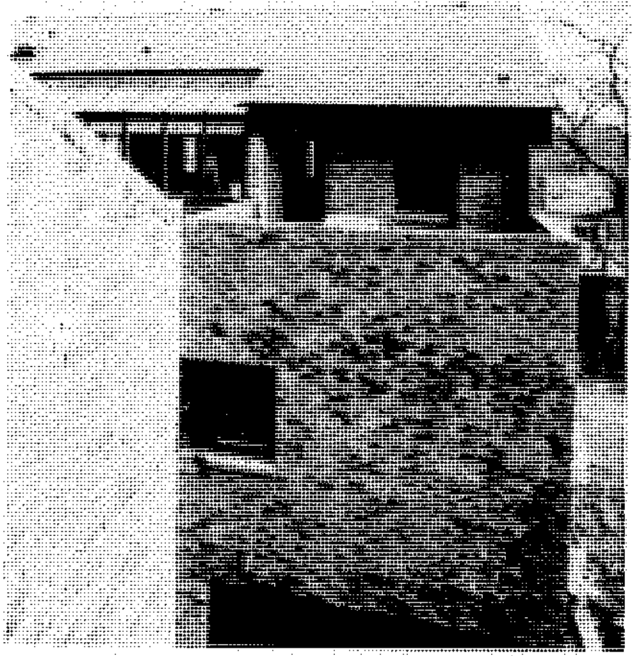


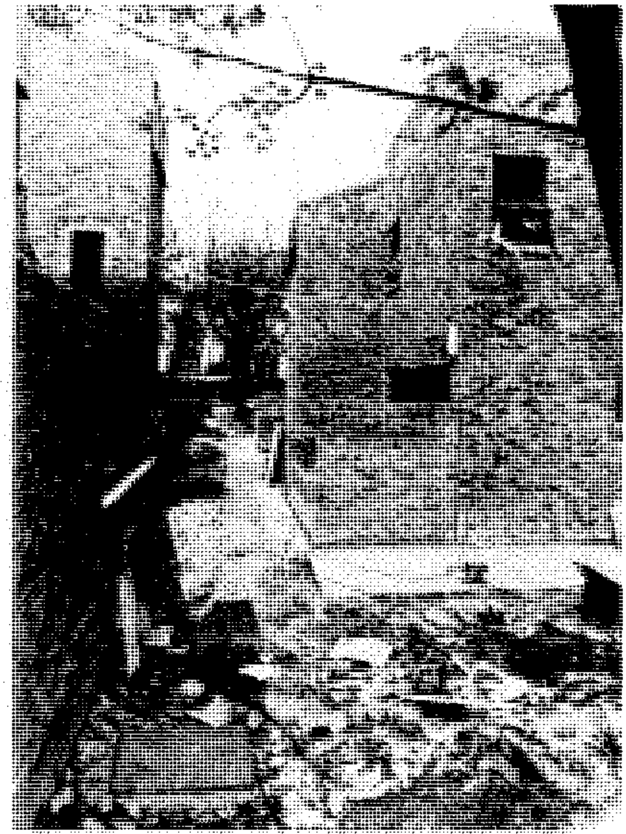
5. Box room (no windows) for elderly son to sleep on his once monthly visits.

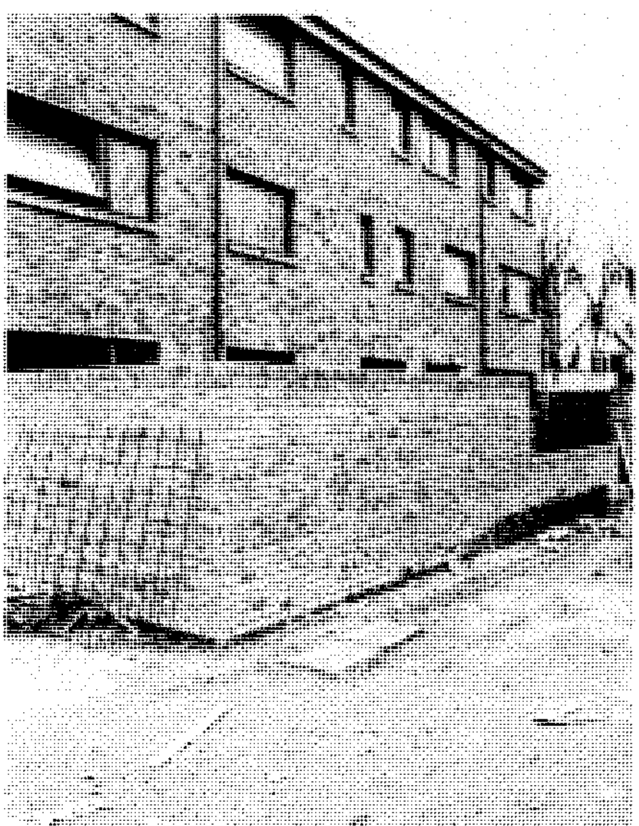


8. Younger son required recess and plug for aquarium in his bedroom.

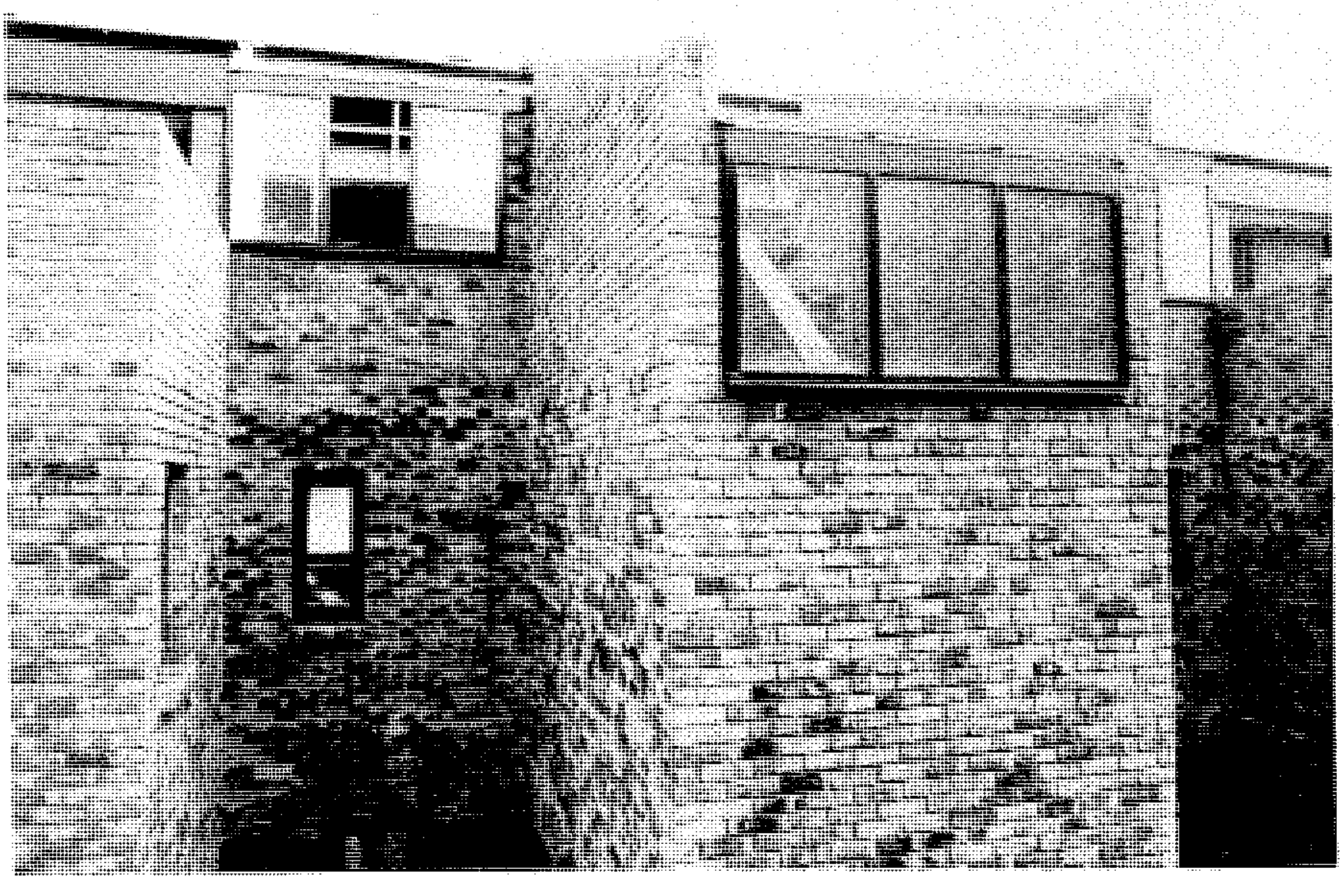








Illustrations of the scheme show the project nearing completion July '78)



V. THE COOPERATIVE

> The Government believes that the development of co-operative housing is essential to a sound social and housing policy...
>
> DoE Circular 8/76

Adelaide Road is now in the procedure of forming a residents cooperative. This is seen as an essential extension of the user control programme in order to allow residents (tenants) to manage and determine the estate environ as a whole. A number of meetings have been held at the County Hall London with all the prospective residents of Adelaide Road to explain the ideas and principles of the Co-operative.

Harold Campbell, Director of the Greater London Secondary Housing Association (GLSHA) explained, briefly, what a Cooperative Housing Association is and how it works.
He emphasised that when your Co-op has been established you will be running your own affairs and making all the decisions about how your estate is to be managed. There will be plenty of time for you all to get to know one another and to learn about the Co-op. Nobody wants to rush you into quick decisions before you are ready for them. In any case, when the Co-op is established, it will operate for a trial period of eighteen months and then you will be able to decide - with this experience behind you - whether you want to go on with it, or revert to being council tenants in the old way.
From now on, Regular Newsletters would be circulated to all residents, to inform them of meetings and progress.
In simple terms the formation of a housing co-operative means the introduction of a sympathetic environment whereby residents can through co-operative schemes participate collectively in decisions which affect their daily life. Generating a strong sense of community and enabling residents to exercise real control over their living conditions (through the co-operative approach) will reduce some of the problems too often encountered, such as social isolation and remote housing management.

There is a variety of alternatives associated with co-operative housing and DoE Circular 8/76 distinguished the main groups as follows:

Management Co-operatives in which associations of residents have collective responsibility for some or all of the management functions but do not own or lease the property.

Non-equity Co-operative in which residents collectively own or lease the property but have either no individual stake in the equity or a stake limited to a share (normally £ 1) repayable on leaving at its original 'par' value.

Co-ownership in which residents collectively own and manage the property and share in the equity through a leasehold interest or an entitlement to payments on leaving.

Co-operative housing may be created through the formation of a Residents' Co-operative Association which may be formed when:

- co-operative ownership or management is to replace a traditional landlord and tenant relationship without physical change to the property
- co-operative ownership or management forms the future basis of tenure for new-build projects or rehabilitation and conversion schemes

It follows therefore that the formation and development of the many forms of housing co-operatives has wide appeal and equally concerns:

- local authorities and their tenants
- housing associations and their tenants
- private landlords and their tenants.

It has been recommended by the DoE that the initial step should be to encourage Management Co-operatives.

There are three kinds of resident involvement within the scope of management co-operatives:

- consultation before decisions are taken
- participation by residents in the actual decision making
- management by residents within agreed limits

> Residents and local authorities must choose between the alternative approaches.
> Co-operatives cannot, by their nature, be imposed from above and their success depends on genuine enthusiasm among the tenants concerned and a realisation by them of the responsibilities involved.
>
> DoE Circular 8/76

The DoE Circular 8/76 states:

> Whatever kind of scheme is adopted it is essential that it should not be seen simply as a means of relinquishing responsibility for problem estates or for functions which are proving troublesome.

Co-operatives are likely to succeed only where a local authority prepares the ground thoroughly and provides the necessary support.

It is similarly essential that the creation of a co-operative is not imposed on the tenants.

From the outset there should be a clear understanding as to which responsibilities are being transferred, retained or shared between landlord and tenant. If residents are not to be quickly disillusioned there must be an early and effective transfer of control over relatively local, day-to-day, issues.

Co-operatives can be established in either houses or flats and it is considered that they will work better where the properties are closely integrated as in the case of a block of flats, a complete street or a total neighbourhood.

In scattered areas the residents may also be able to form a co-operative provided that a strong community spirit exists. Co-operatives may be formed in either existing or new development. In the case of existing buildings an early task of a co-operative may be to become involved in prior consultations and briefing related to modernisation and improvement programmes.

There can be no firm rules over the size of a co-operative but it is important that its size does not create an unwieldly or undemocratic situation with a danger that control may fall into the hands of a small minority. It is likely that the size of a co-operative will lie somewhere between 150 and 200 households, bearing in mind the difference between high density estates and more scattered property.

It may occur that more people in a neighbourhood may wish to partake than is desirable for a single co-operative: two or more co-operatives will then be set up.

Of prime importance is that the residents themselves should have the necessary commitment to the principles involved and a full understanding of the responsibilities they are undertaking.

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GREATER LONDON COUNCIL

The Adelaide Road scheme was designed in the Department of Architecture and Civic Design.

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Housing Architect, Housing and Town Development Branch	Gordon Wigglesworth, AA.Dip, RIBA
Divisional Architect	J. Bancroft
Group Leader	D. Parris
Job Architect	N. Hamdi
Assistant	N. Bird
Quantity Surveyor	H.S. Page
Structural Engineer	E.W. Bunn
Department of Mechanical and Electrical Engineering	P.C. Hoare
Housing Engineer	R.P. Manning-Coe
Landscape	J.C. Kennedy

REFERENCES

For a detailed list of references on PSSHAK, see Access Information Package 1, available from Room N70.

All Enquiries about the work of the Architect's Department should be addressed to:

The Information Office
Department of Architecture and
Civic Design
Greater London Council
The County Hall, S.E. 1

or by telephone to 01-633 8526

EXPERIMENTAL HOUSING

Haeselderveld, Geleen, Holland

Bart Wauben

Government housing policies in the Netherlands have been the subject of a good deal of criticism, both from people concerned professionally with these matters (such as civil servants, administrators, designers and builders) and from the (future) occupants to the dwellings themselves. There is an increasing current of opinion reflecting the view that an end must be made to the throwing up of dull, depressing dwellings and neighbourhoods.

This criticism is aimed not only at the huge blocks of flats, which as a result of their lack of scale and inflexible facade finishings look more like human warehouses than dwellings, but also at the houses, which have hardly any character of their own as regards structure and lay-out. The main point in all these matters is that the initiative of the individual - the occupant - is stifled at birth in the sphere of (public) housing.

During the '60s, the SAR developed a point of view which revealed the basic paradox underlying current mass housing ideas.

The SAR analysis may be devided into two main parts:

Relation between mass housing and occupants

Once upon a time, when people needed a house the problem would be tackled on an individual basis; there are some parts of the world where this is still the case today.

Long ago, when someone needed a roof over his head he would go and build it; or, as higher demands were made on building quality and building methods became more complicated, he would get a group of craftsmen to build it for him. However, the contact between the future occupant and the builders was still so close that the finished dwelling was a faithful reflection of the occupant's wishes. In today's society, only a favoured few still find themselves in this agreeable position. Most people have to put up with "mass housing".

According to the mass housing system, which has slowly grown up over the years, huge complexes of dwellings are erected in accordance with a generalized set of norms aimed at providing suitable housing for the "average individual" or the "average family" - whoever that may be; and it is considered that this procedure in fact makes it possible to produce suitable housing for a large group of individuals. However, this conclusion is a bit premature.

Each individual is different, has different desires, different dwelling habits, and probably different priorities in life. When such widely differing individuals are put into standardized dwellings, the level of dwelling satisfaction cannot be very high.

This conclusion is supported by the results of experiments in which people are allowed to sketch the plans of the dwellings they want; in the Papendrecht project for example, 122 dwellings produced 122 different plans.

Relations between mass housing and industry.

If a dwelling, or part of it, is to be made by a completely mechanized process, vast quantities will have to be made if the production process is to be economically feasible.
However, people reject the idea of excessive "monocultures" as being dull and depressing. As a result, only limited series of a given type of dwelling can be made; this manner of production cannot be optimum from the producer's point of view; while on the other hand the series made may still be too large to give the variety the occupants want. The compromise reached in this way is thus unsatisfactory for both parties.

Flexible dwellings

Of course, one basic question in this context is whether dwellings should be made so that the occupant can modify his dwelling fairly easily when his dwelling style changes, or whether he should move to a new dwelling under these conditions.
Our answer to this question will be based on the conviction that dwelling can only be optimum when it reflects the individual's own character. Now different people have different habits, different life styles, different approaches to life; and all these differences will find expression in the way the various rooms in the dwelling are situated, related and furnished. It takes time to grow into a dwelling; when people move to a new dwelling, it cannot be expected to reflect their personality immediately; the adaptation to the individual takes time, both in the dwelling itself and in the immediate dwelling environment.
There are other factors which, while of importance here, are difficult to quantify, such as the social links with the neighbourhood, the "dwelling inertia" (disinclination to move to a new dwelling), over-all moving costs, etc.
The above factors tend to oppose moving, while there are some factors which stimulate people to move, e.g. a move to another place of work, desire for variety, etc.
However, present-day dwellings are not generally built to facilitate either of the above-mentioned approaches; whether people move often, or modify their dwellings to meet changing life styles, it should be possible to modify the layout and finishings of a dwelling fairly easily, to meet the changing wishes of the old occupant, or the new wishes of the new occupant.
One of the basic wishes people have in connection with their dwelling is that it should be the right size to meet their current needs - which may change with time. There is thus a need to design houses so that they can "expand" or "shrink" in the course of time.
One possible way of doing this is to build bits on to the dwelling, or break bits off, as desired. An alternative solution is to annex bits of the dwelling next door - or the whole dwelling or to give up parts of one's own dwelling to the neighbours. Since however it is rare that the need for expansion or contraction on the part of the occupant of a given dwelling coincides with complementary wishes on the part of his neighbours, the latter solution is rarely practicable except in the case of large-scale urban renovation projects.
This leaves us with the solution, in SAR terms, of designing the support as a basic zone corresponding to the "minimum dwelling", together with "margins" where expansion is possible. The position of these margins should be chosen so that possible expansion or contraction of the dwelling does not interfere unduly with the design of the over-all dwelling environment.
We see that the SAR proposal of splitting the dwelling into support and infill yields an adaptable dwelling with many advantages for change to meet individual wishes and needs.

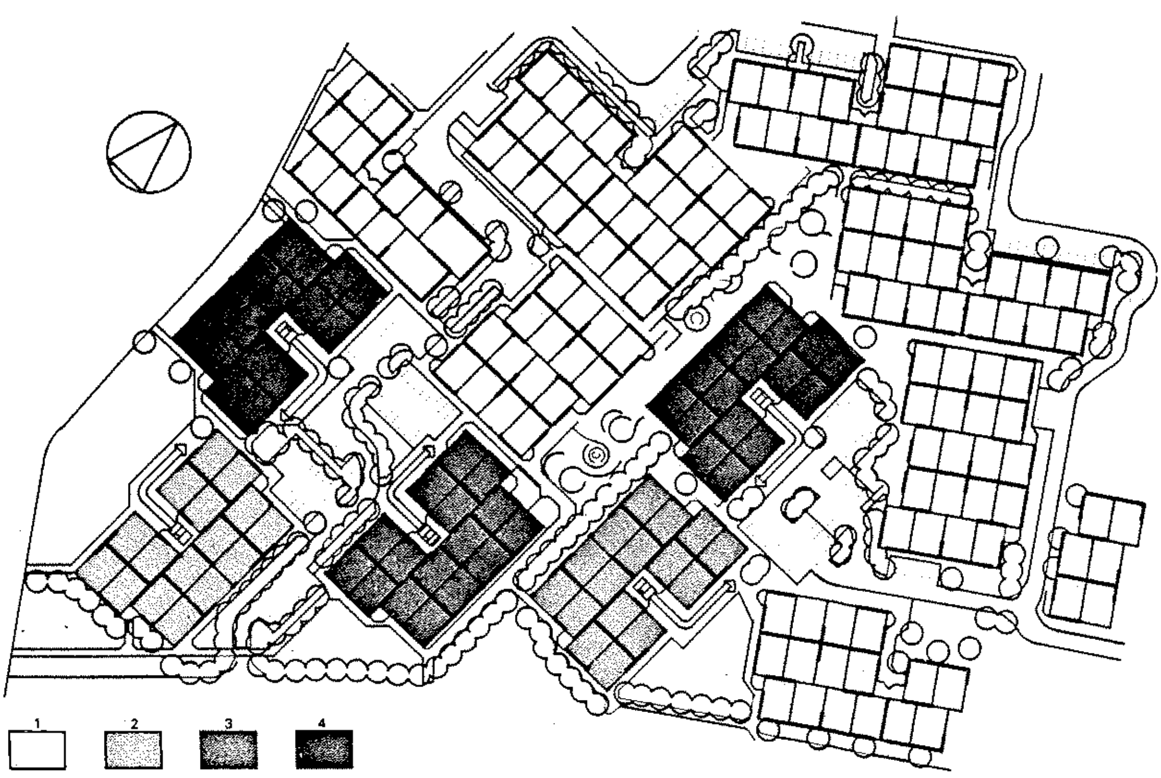
The Geleen experiment

The project was started in 1977 and completed in 1979 and was planned with two main aims in mind:

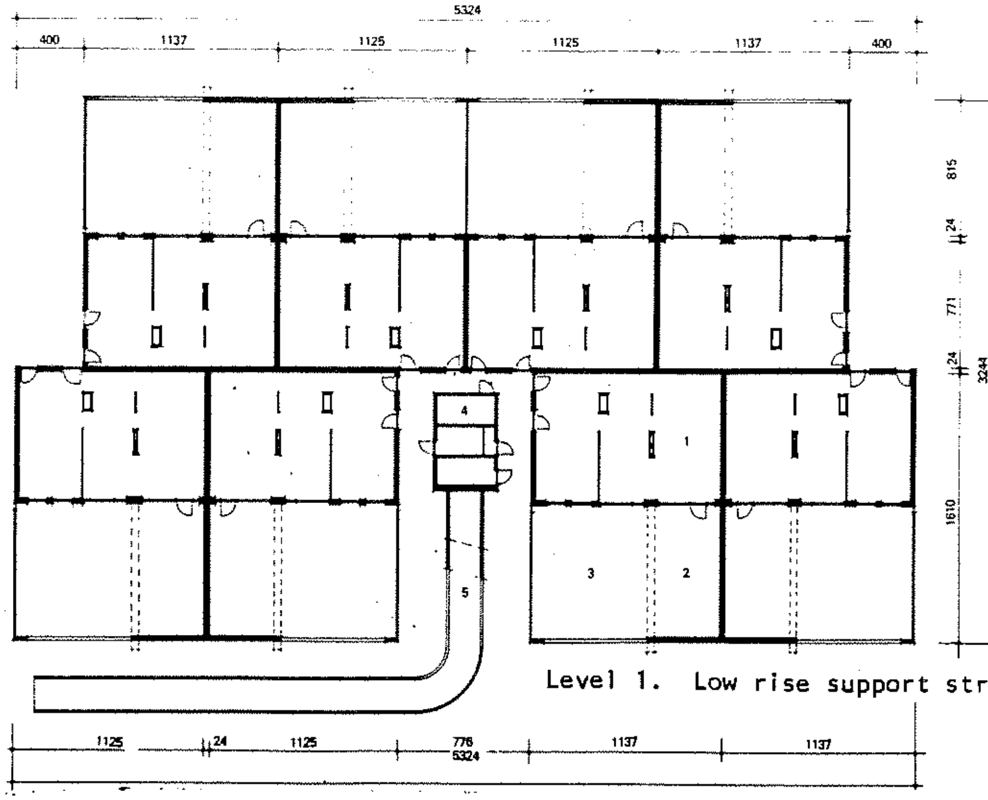
- to realize dwellings with internal and external flexibility, in accordance with SAR ideas;
- to realize dwellings and a dwelling environment of above-average quality.

The project design was inspired by a study of the physical planning of Pompeii (Italy) by B. Wauben of the University of Technology, Eindhoven (1973).
As readers will be well aware, Pompeii

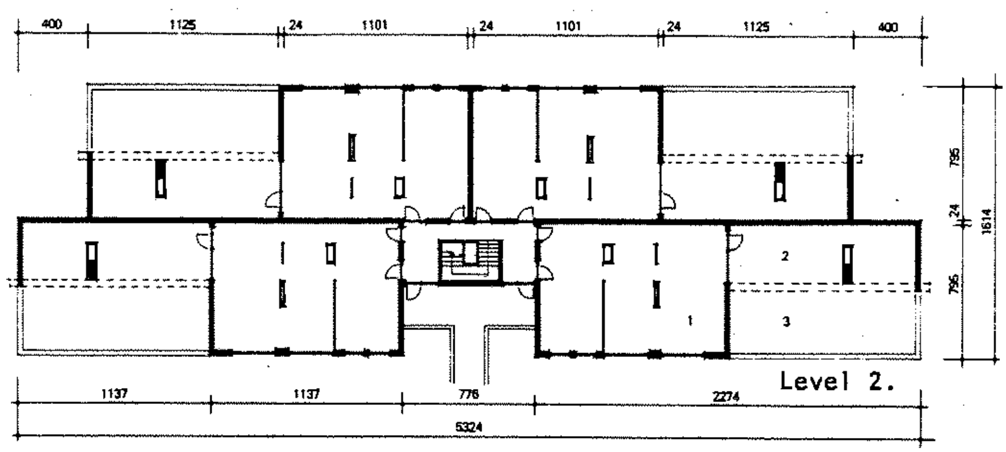
was covered in a layer of lave som 6-7 m thick in the year 79 A.D., while systematic excavation of the town did not start until 1750. Although about two-fifths of the town still are under the lava, the excavations so far give us a unique picture of life in a Roman town nearly two thousands years ago.
The dwellings in Pompeii have by and large an introvert character.
Narrow passages ("fauces") lead to sometimes luxuriously finished dwellings, where the main rooms were arranged round a sort of patio ("atrium" or "peristylium").
The same basic motif, translated into modern terms, has been used in Geleen to give dwelling structures designed in a single constructional layer, in the form of a patio bungalow.
The access to the dwelling is from the public space, while the main rooms (such as living room and bedrooms) are grouped round a patio to give a high degree of privacy. The patio also provides the "margin" for possible expansion of the dwelling.
Different "minimum dwelling" variants are available in the plan: with 1, 2 or 3 bedrooms; a linear, L-shaped or Z-shaped living room; open or enclosed kitchen, etc. Different lay-outs are also possible in the expanded dwelling, giving a total of 64 possible variants to choose from.
These patio bungalows are built in groups with a staggered arrangement - to provide an alternative to traditional terraced housing - with a total of 71 dwellings per block. The dwellings (together with patios and expansion margins) can further be stacked in 2, 3 or four layers. The access to the dwellings on the second level is via a ramp, so that the occupants of only 11 of the 71 dwellings in a given block need to climb stairs to get home.
The over-all lay-out of the project is as follows: There is a green zone, including play facilities for children, in the middle of the neighbourhood.
A large proportion of the dwellings is situated immediately round this green zone. The remaining dwellings are situated in various courts and a restricted-traffic precinct, each of which is connected to the central green zone by pedestrian passageways.



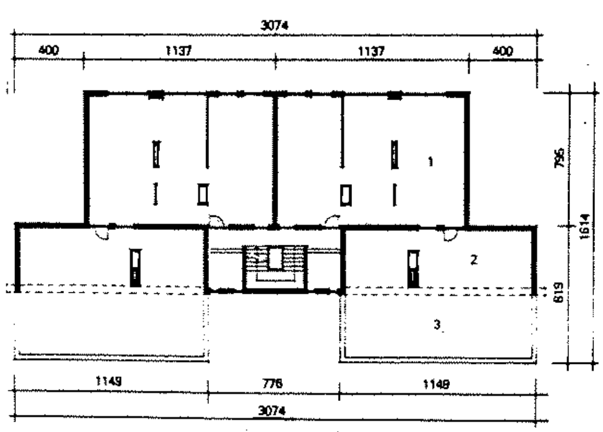
situation



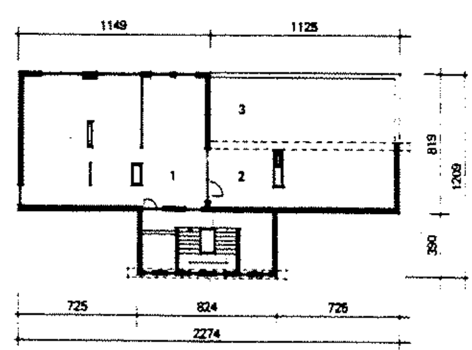
Level 1. Low rise support structure.



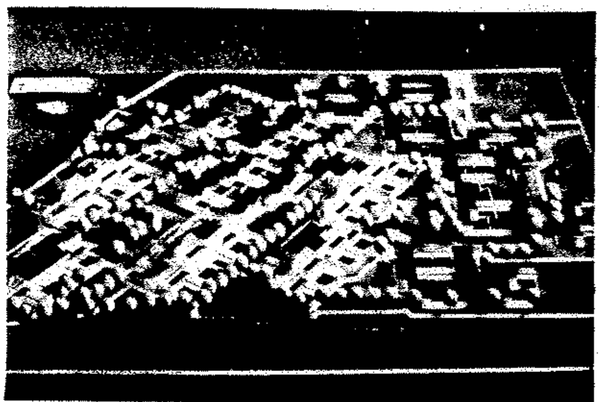
Level 2.

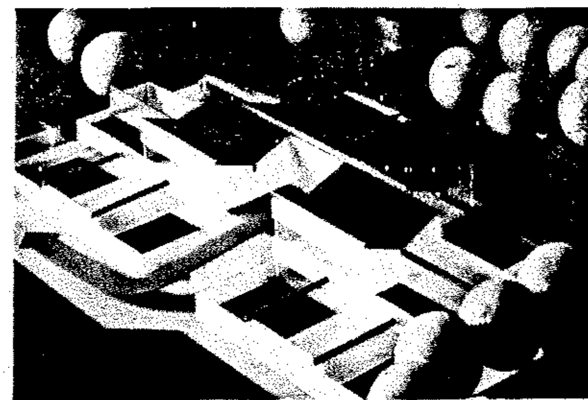


Level 3.

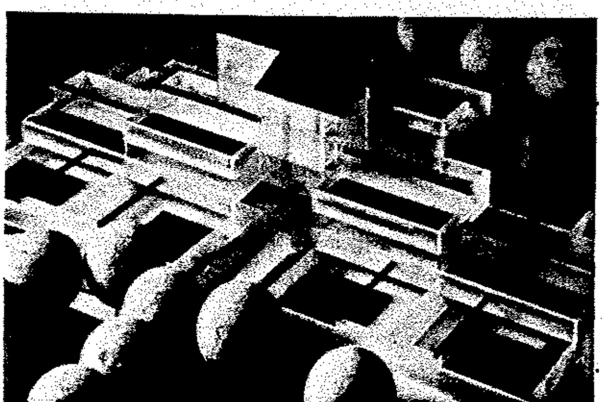


Level 4.

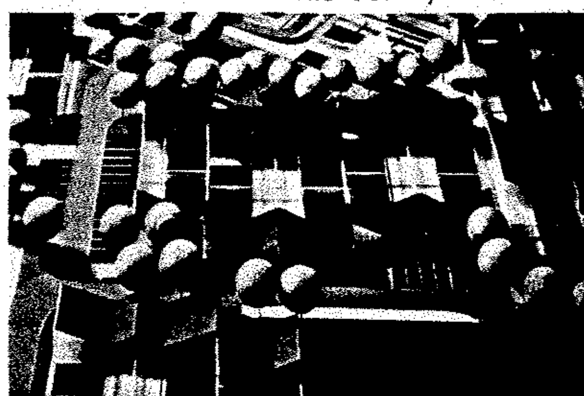




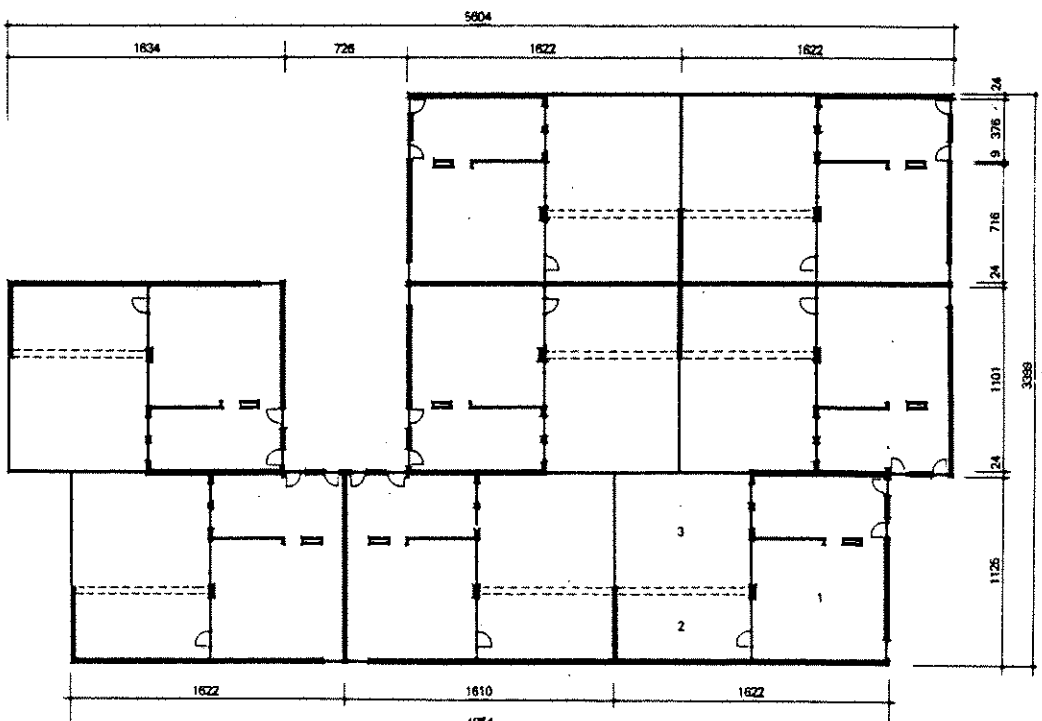
Two storey structure.



Four storey structure.



Tissue detail singly storey structure.



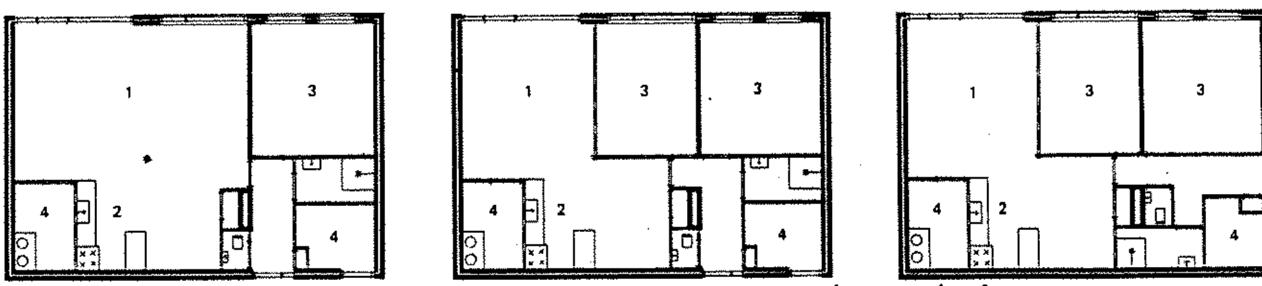
singly storey structure.

Thanks to these various features, this project gives:

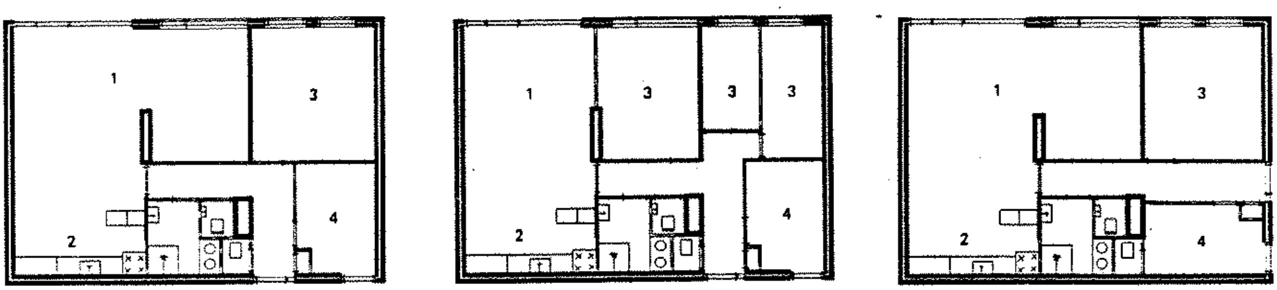
- a pedestrian circuit in two different directions through the neighbourhood
- a place for children to play near their home
- matching of traffic speed to the dwelling environment
- greater intimacy and recognizability of the dwelling environment, thanks to the application of physical planning features such as ample green zones, courts and restricted-traffic precincts.

Despite all these advantages, this project still achieves a higher dwelling density than in traditional plans.

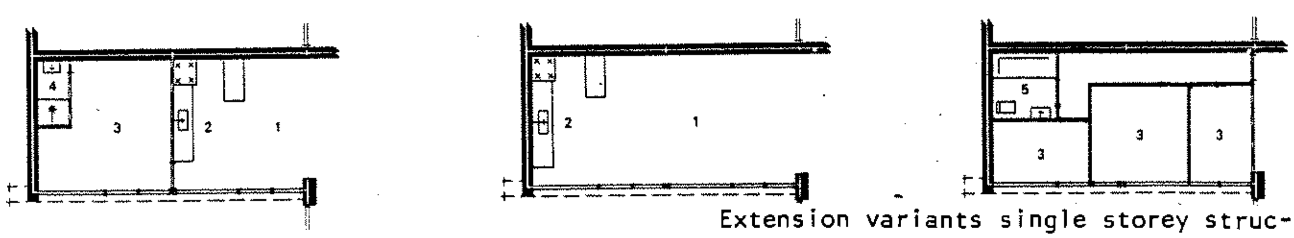
It was not the author's intention in this article to be merely critical about current public housing policies; the Dutch public housing programme can certainly stand comparison with that of neighbouring countries.
However, now that quantitative housing problem is by and large giving way to a qualitative housing problem, it is time we all got together round tha bargaining table to make up our minds which direction we want to take for the future.
The Geleen experiment gives one example of how modern methods can be used to create dwellings and a dwelling environment capable of meeting modern dwelling requirements - and, we hope, future ones too.



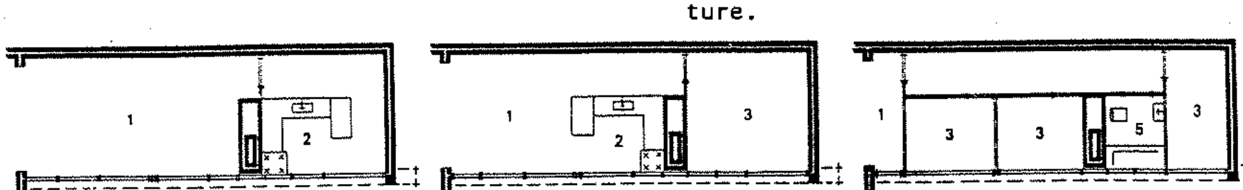
Plan variants single storey structure.



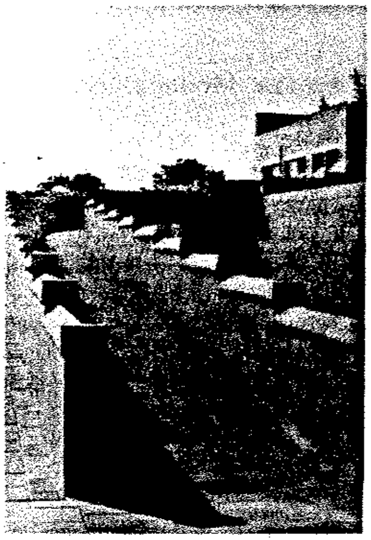
Plan variant low rise structure.

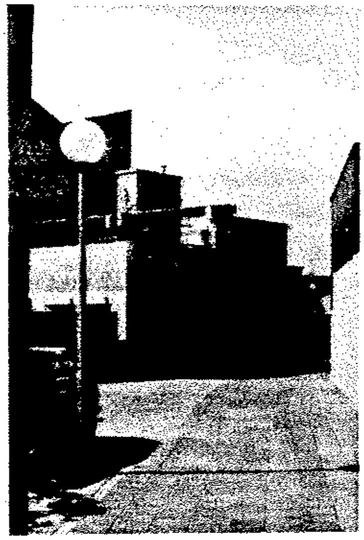


Extension variants single storey structure.



Extension variants low rise structure.


Access for handicapped. Low rise structure.

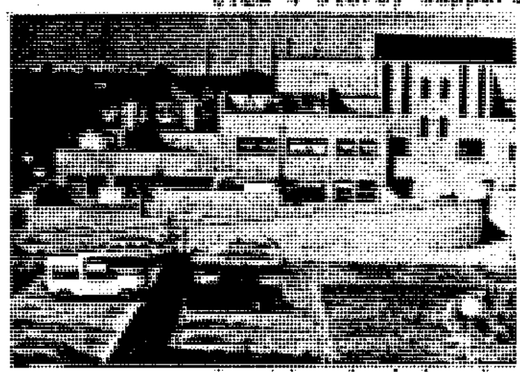

Axis change in the tissue.


Parking lots for one storey support.


View 4 storey support


Connection public open space to buildings.

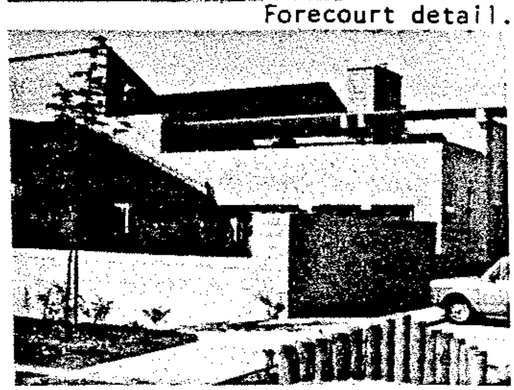

Small alley.


Stacking in 4 levels.


Forecourt detail.


Arch. B. Wauben.


Interior


Extension zone fully used.

BUILD FOR PEOPLE, A QUESTION OF ARCHITECTURAL IDEAS

James Codrington Forsyth.
Sten Andersson.

This is the second of a series of articles, which we hope can make a contribution to a much-needed debate on the built environment as an end or a means.

Building must be founded on a new basis of ideas. We can no longer go on producing artificial and over-simplified reality.

The impoverished, functionally-separated "estates" which we build instead of building communities are reflections of an equally impoverished design process.

We no longer need "ready-made solutions".

We must take a couple of paces back and look at our planning ritual, by now almost regarded as one of the laws of nature. Do we really want to carry it with us into the 'nineties?

For nearly half a century, architectural conformity has been the dominating feature of the Swedish building scene. Hardly anywhere else have the ideas behind functionalism ("modernism") been applied so uncompromisingly as here. We desecrated the city and raped the countryside. Lacking, perhaps, a deep-rooted urban tradition, we did not regard the crime as particularly serious. What we got were buildings evenly spaced in town and country, anxiously crouching behind windswept bushes symbolising the countryside which had been carted away.

People felt more and more estranged in these kite-marked environments which satisfied virtually every physical need. But what had happened to other needs?

The crisis which followed was not entirely home-made; it exists all over the western world. We have, perhaps, denied it and ignored it longer than in other countries. We have perhaps now reached the point where we realise that our planning tools have become blunter with the passage of time and have created bigger problems than those which they attempted to solve; problems which must be tackled with even harsher methods, and so on and so on.

THE ARCHITECT'S IDENTITY CRISIS

Today, the usefulness of planning is under discussion and even architects are dubious about the value of architecture. We seem to have been gripped by an unparalleled identity crisis. This must not lead to an architect's role which is - in the absence of anything better - that of the myopic fuel-saver, the unsuspecting computer operator or (which would be equally unbearable) the painter of stage sets.

It is in this void that various types of fascistoid architecture now appear. Post-modernisms elitism and open contempt of people is easiest to see through. The inhumanism which often thrives under the cloak of energy saving is not so obvious. In the same way, the present computerization of our field of activity can mean that dialogue and democracy are stifled as irrational and time-consuming - if the process is dominated by technical administrators. We must put our house in order. This is, of course, in no sense a denial of the fact that computers, properly used, open up enormous possibilities.

We have reached the point where a change of paradigm is necessary. We must base our work on an idea-complex which embraces all the questions which are topical now and all those which may be added in the course of time. Only if we embrace a new idea-complex which is overall and unifying instead of separating and fragmentating can we arrest the trend to ever-growing alienation between people and the built environment.

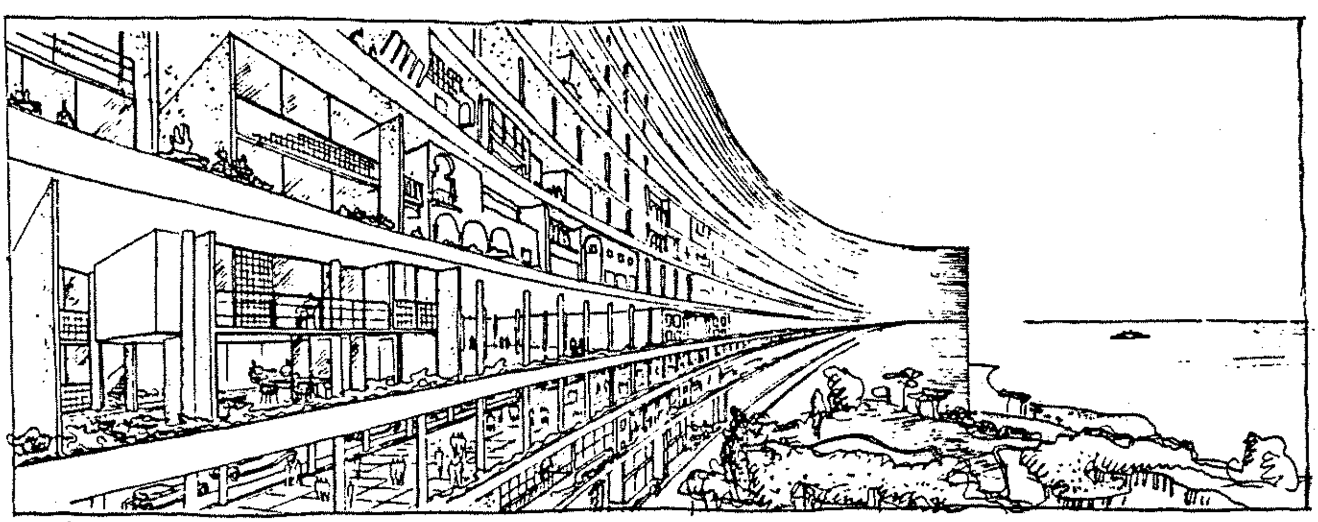
Great pains are taken today to vindicate and legitimize architecture as an independent art. This is presumably necessary, but one can have misgivings about some of the contributions to the international debate. One of the most striking of these is Charles Jencks' as yet unpublished but often-quoted book "Current Architecture", in which he sorts out the isms in the manner of a stamp collection. The vacillating architect in search of a new platform must be rather confused by it all. This is artistic science rather than architectural ideology. If we demand an overall explanatory model there is only one logical step beyond functionalism.

STRUCTURALISM AS A LOGICAL CONTINUATION OF FUNCTIONALISM

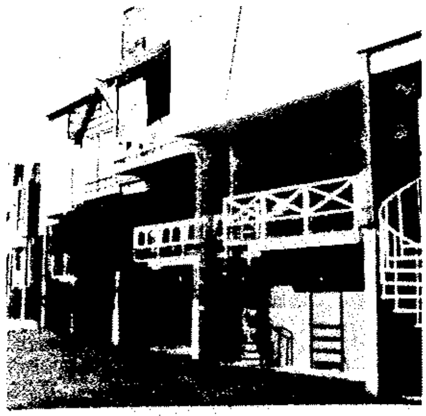
This logical step is to be found in the broader view offered by structuralism. Structuralism brings to the fore the relationship between the part and the whole; it sets up hierarchical systems of dependence. Decisions can be taken in the form of logical, successive outline decisions. Only in this way can we find a stable base for variation, replaceability and user participation. Though these ideas are by no means new they are little-known and sometimes totally misunderstood. Structuralism has its roots in, and has developed from, functionalism's triumphs and failures. Even if there are differences between the two points of view it is not a matter of thesis and antithesis.

It was only at the Otterlo meeting in 1959 that structuralism's theoretical base emerged; the idea of changeable architecture is, however, much older. Among some of the pioneers of functionalism there are projects which clearly foresee the idea of differences in time and space. We find it in an early scheme by Adolf Loos which provides for variation and self-build. Le Corbusier himself has fallen into structuralism on at least one occasion - the Fort l'Empereur project in Algiers (1931-34) which was designed at a time when his houses in Pessac had stood empty and unsold for three years. In Algiers, everyone would have been free to create his own dwelling - Moorish, Louis XVI or modern - within the framework of a massive infrastructure which provided sunshine, water supply, lifts and a stupendous view. Gropius, too, in his housing scheme at Tiki Beach, Galveston, provides an example of "deviationism".

We can, if we wish, go further back in history. In the rich store of vernacular architecture there are many examples of structuralist thinking and open-systems technique, sired by a shortage of resources. Both the log cabin and the half-timbered building,



Everyone would be free to create his own dwelling - Moorish, Louis XIV or modern - within the framework of a massive infrastructure which provided sunshine, water supply, lifts and a stupendous view. Le Courbusier's Fort L'Empereur, Algiers.



Gropius the deviationist at Tiki Beach, Texas.

spread in great numbers throughout northern Europe, are in their several ways splendid examples of technical refinement. They could be built up; extended; taken down and moved, and then re-erected for another purpose on another site.

It is therefore totally incorrect to regard structuralism as an expression of technical optimism and the demands of consumption inherent in an affluent society. It is for diametrically opposite reasons that we should build in this way today.

Half-timbered buildings could be built up, extended, taken down and moved; and then re-erected for another purpose on another site. Illustration from Matoko Suzuki's book Holzhauser in Europa.

Functionalism cut off the bands leading back to this quantitively dominant type of building which today only seems to be of interest to ethnologists. Functionalism, as it developed during its wartime exile on the North American continent and with us among the outposts of European culture, makes it easier to recognize the repressive features and the links with the pre-democratic era which functionalism was supposed to have done away with. The mass building of the 'sixties often seems to be directly descended from the fortification-building of older times (malicious!).

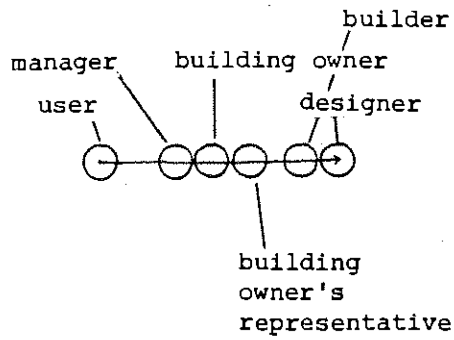
The world war which intervened and the changed political conditions which resulted probably contributed to the fact that development did not turn out as intended. Without the war, the simple-minded analysis and its equally simple-minded addition of parts to form equally simple-minded wholes would have been abandoned much earlier.

When the time came to rebuild Europe after the war it was the means of production rather than the theoretical basis of building that developed. Mass building became possible, and with it came macro-scale planning. There was, quite simply, no other alternative.

Functionalism had given us a scientific method for reducing reality to an abstract, uniform model. The process of abstraction-generalization-regulation-standardization involves the cutting off of all protruberances in the form of irrational (but human) differences. Unfortunately, we also succeeded in transforming this extremely simplified model into reality. The examples are all too numerous and all too well-known to be mentioned here.

THE USER AS A PASSIVE CONSUMER

The concept of functionalism also provided the basis for a modus vivendi between society and the forces of production, which made the "million programme" (the building of over a million dwellings in ten years, 1965-1974) possible. Olof Eriksson has described this perspective in his book "Teknik och byggnadsskick - Makt, energi, form inför 80-talet" (Technique and building types - Power, energy, form on the threshold of the 'eighties). The picture seems absurd. The user is regarded as an absent, passive consumer left far from any chance of meaningful participation. Government proposition 100:1967 confirms this, couched as it is in the passive form (!), a point of view which commanded total unity "the entire population shall be provided with healthy, spacious, well-planned and functionally-equipped dwellings of good quality and at a reasonable price".



The chain of communication between user and designer can be a long one. From Olof Eriksson's report Power, Energy and Form into the Eighties.

Comprehensive regulation of building was to serve as a further cementing of the planning process for a long time to come. It is important to realise that the planning ritual, by now elevated almost to the status of a law of nature, must be reviewed if we are to democratize planning so that it comes in phase with society as a whole. Power relationships must change.

Power must be taken away from someone in order to distribute it to the users. The participation projects which do not start from this obvious fact are doomed.

User participation and housing are however only a couple of facets (albeit important ones) of a new planning ideologi which must take over in the 'eighties. Future building must be characterized by the integration of different activities and by an active relationship between people and the built environment. Only then can we win back our cities.

In countries lacking our deep involvement with functionalism, the turning-point has already been reached. Projects where the user plays an active role are no longer curious, one-off exceptions. The ideas have been tested in practice long ago.

Must we, just as when functionalism was introduced, wait anxiously in the doorway and rush to the lead when the procession comes by?

THE SECONDARY ECONOMY MUST COME TO THE FOREFRONT

No, we cannot afford to wait any longer. Too much of our resources continues to be bound up by erroneous building. This means an indefensible waste of - above all - social chances and a burdensome inheritance for future generations. We shall be forced to admit, painful though it may be, to the bankruptcy of our planning system if we do not realise in time that our present idea base cannot solve new and newly-discovered problems. It is impossible with present methods to achieve a tough resource-conservation policy and to develop direct democracy. We shall no longer be able to afford to let people live as passive guests in their homes, only to keep them entertained with harmless - but costly - therapy. The secondary economy must be brought forward and assigned a respectable position within the overall framework of the built environment. In certain respects, the future is likely to involve a reduction in the division of labour.

We must now once again look out over the clumps of reeds which hem in our duck-pond and try to see what is happening in the world outside. In several European countries, a radical change of direction can be discerned. Naturally, developments follow different lines in different countries; that is in the nature of things. It seems, however, that these eruptions have caused nothing more than ripples on our shores.

RESEARCH IN THE NETHERLANDS

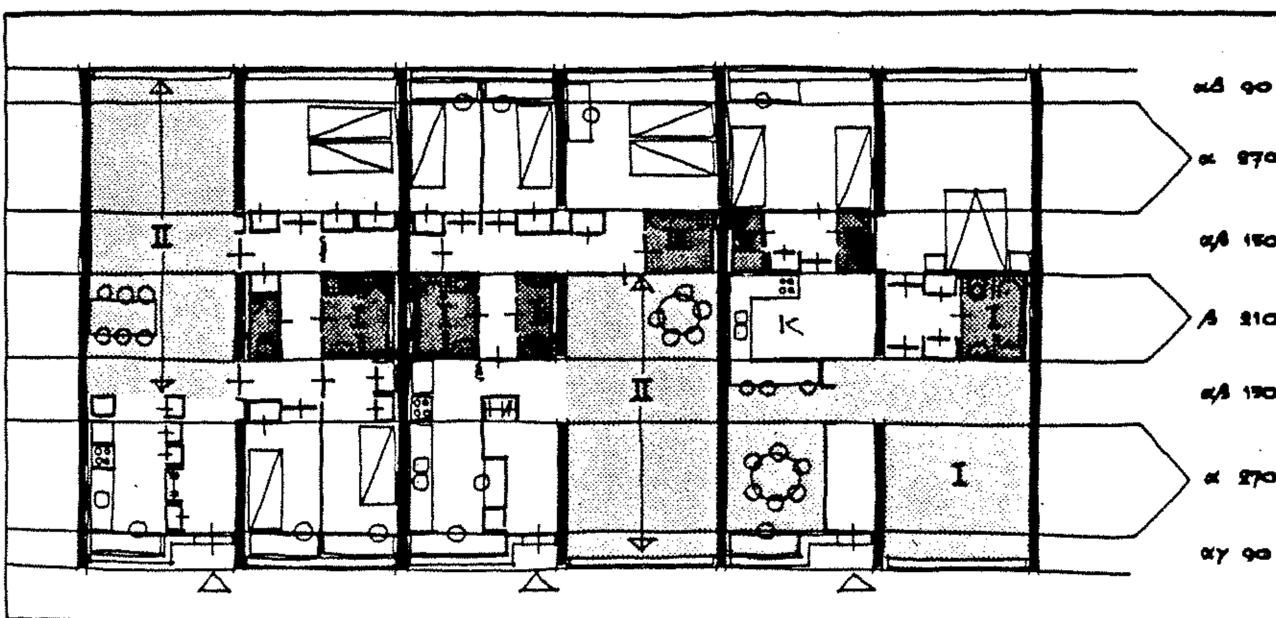
In Holland, a comprehensive research and development programme on structural thinking and user participation has been carried out at Stichting Architecten Research (SAR) since the mid-'sixties. The work is now supported by some sixty sponsors. One of the founders was John Habraken, now at MIT; in his book "Supports: an alternative to mass housing" (Architectural Press 1972) he formulated the theory of supports and detachable units. Here are the first consistent beginnings of usable planning tools based on the new view of the built environment. Instead of standardising flats and whole buildings, Habraken argued for a standardization of components. He views the building process from a system-theoretical standpoint and asserts that variation and intimacy of scale can only occur as a result of a changed power-relationship. This involves giving the non-professional real power with the help of a language and means of communication.

Some of the numerous publications produced by Stichting Architecten Research in Eindhoven.

SAR has published a large amount of literature during the time it has been in existence. Where in Sweden can this be found today? Both in Holland and in other countries, the research being carried out is quickly put into practice. There is now a long series of completed and ongoing projects in various places which can be studied. How many Swedish planners, architects and decision-makers have followed it up?

Lunetten in Utrecht is a current project. For the first time, the structure or support (that which the inhabitants cannot influence) and the detachable units (windows, doors, cabinets, walls etc.) form separate contracts. An interesting detail is that housing loans have been granted on the basis of standard plans within a given area; these can then be varied as desired when the actual building operations take place.

In the first part of the scheme, a courtyard surrounded by three- and four-storey blocks, the support structure is now complete. It will contain three-storey terrace houses, maisonettes and ordinary gallery-access flats. Each family has planned its own dwelling. This has been done at a meeting with the architects (1¼ hours), a visit to the full-size laboratory where this plan has been built as a mock-up (1 hour) and a final meeting with the architects where possible faults in the mock-up have been ironed out (1 hour). The difference between a standardized dwelling and one designed specifically for its inhabitants is a mere three or four hours! It is easy to imagine how computerization, properly



The Support method makes it possible to plan different dwellings within the same structure. Three examples are shown here. Illustration from the book Variations, by N J Habraken and others, published by SAR, Eindhoven and MIT.

used, can be of service here. It is as easy for a computer to keep track of a hundred different "packages" of components as it was to keep track of a hundred similar ones manually. It is hardly a coincidence that the theme of the Swedish Building Standards Institution's annual meeting was Computerization in building.

All this is of course a result of investments made in the new process and a considerable running-in period. A new Dutch standard, NEN 2883, giving unambiguous rules for modular co-ordination which are a necessity, has been put into operation.

OTHER EXAMPLES IN EUROPE

In France, too, similar ideas can be seen. Within the framework of large-scale social housing, open systems ("systèmes constructifs") have been developed. An early breakthrough is anticipated.

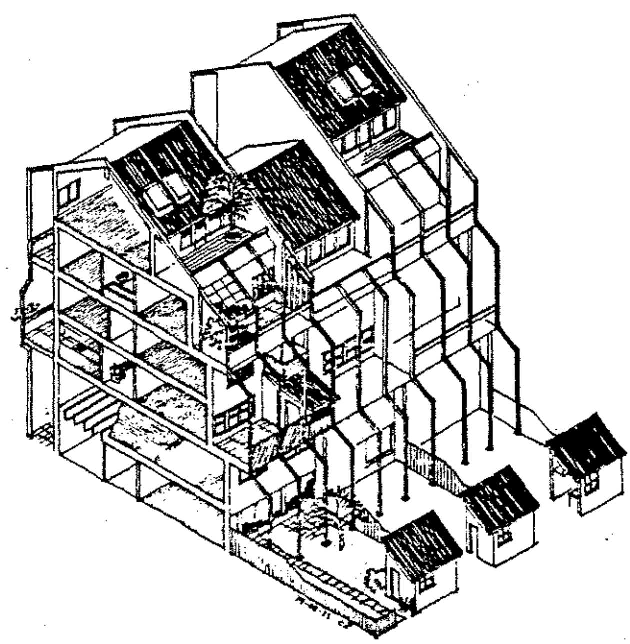
We can hardly omit Belgium and Lucien Kroll with his fantastic creation for the Faculty of Medicine at the Catholic University at Louvain. Don't try and say that this isn't architecture!

The present radicalization going on in the German-speaking world is equally interesting. The waves of debate are high. Self-build and self-management are coming along fast. The West German public will soon be adapting itself to a new situation. It is worth noting that the venerable Deutscher Werkbund has in various ways backed up this development just as it did when functionalism was in its infancy. Is Germany once again to become a powerhouse of ideas?

SOME SWEDISH EXAMPLES

Back to Sweden! Are there really no Swedish examples of similar projects? Yes there are! Despite a parsimonious attitude on the part of the authorities, development goes on thanks to the initiative of individual architects. The problem is, as we have said earlier, not only that we want to introduce a new architectural language but also that we want to change the process. We want to get away from the search for the perfect solution and the short-term view extending no further than the building construction period. Experience shows that it is an uphill struggle to introduce a new scheme of things with new roles for the participants. It sometimes feels like trying to force a piece of Lego into a jigsaw puzzle.

Lucien Kroll's fantastic work - the Medical Faculty at the University of Louvain, Brussels.

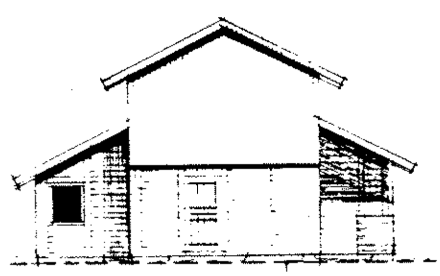


Axonometeric of Olle Volny's proposal for self-build flats at Skarpnack, Stockholm. From the report Sjalvbyggda flerfamiljshus (Self-build flats), KTH Stockholm 1979.

Olle Volny's exciting Skarpnäck project for self-build flats shows some of the perils along the way. It is always possible to raise a thousand (fictitious) objections. Who is going to pay if it turns out too expensive? What if people choose outlandish plans? People can't build themselves. It's going to be ugly. Aren't my four years of architectural training worth anything? And so on, and so on. Most of these "objections" bear witness to nothing more than the narrow-mindedness of their authors. We are however quite convinced that this is the road which we must take.

There is at least one place in Sweden where it has been shown possible to work in the way we have suggested, provided one controls more than one step in the process. Husbyggarna (The Housebuilders) in Köping have succeeded in realizing the idea people first - buildings later. They do it with the aid of a building system which is a development of Peter Broberg's and the Landskrona Group's "Stolpahus" and "Skifteshus", designed in the mid-seventies. This gives a degree of freedom which is unparalleled today. It is surprising that there are still no copiers. It should be particularly interesting for firms starting to take an interest in foreign markets to start thinking in terms of open systems in order to deliver components (rather than whole buildings) and to communicate with markets whose requirements are little-known.

The basic idea behind Husbyggarnas system (for houses and flats) is simple. A building envelope with a standardized section is chosen in the length required, and can be extended with lean-tos at the sides as needed.



End elevation of one of Husbyggarnas' houses in Koping, showing the main body of the house, standardized in section, and available in the length desired; and the lean-tos, also standardized in section and applied in the lengths desired (or not at all).

The plan is worked out in much the same way as in the Dutch example, which of course gives individualized elevations. Let us illustrate this with an example - four houses of roughly equal size, in a group at Ullvi Backar, Köping.

HOUSE D. 138 m²

Marianne Wahlgren is 27 and Bengt Wahlgren 26. They have a daughter of two. The family chose a two-storey house mainly because they liked the exterior and the fact that the sleeping quarters are separated from the daytime area.

They demanded an open plan with a dining area in the kitchen. The playroom is placed so that Marianne can see and hear what is going on there while cooking or doing the washing.

HOUSE E. 141 m²

Gun Risberg is 30 and Göran Isacsson 31. They have boys 4 and 7. They chose the two-storey house because it was roomier than one storey.

A large, enclosed kitchen with dining area was a requirement. Others were a laundry off the kitchen, an L-shaped living room, a front door with porch/veranda, and four bedrooms plus an all-purpose room upstairs. After a certain amount of sketching, the family declared that they were satisfied with the plan and they feel that their dreams of a house are coming true.

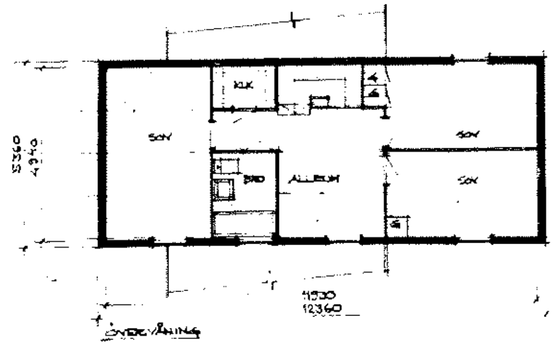
HOUSE G. 134 m²

Marita Nålberg is 25 and Åke Nilsson 36. No children. Fell for what is virtually the sketch plan in the prospectus. Important factors were the desire for an open plan and dining area in the kitchen. They have always wanted a two-storey house.

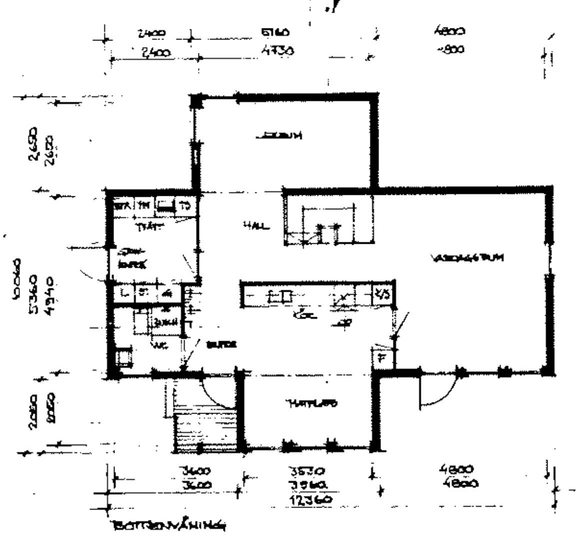
HOUSE A. 142 m²

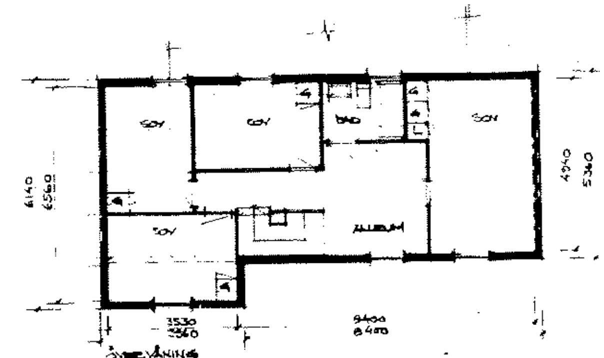
Leila Kauppi is 48 and Rafael Kauppi 47. A 15-year old son lives at home. Their other four children are married and live elsewhere. They wanted a 2-storey house because it took up relatively little space on the site. In other words a bigger garden.

The bedrooms are separated from each other on the first floor so that the son doesn't disturb his parents. His

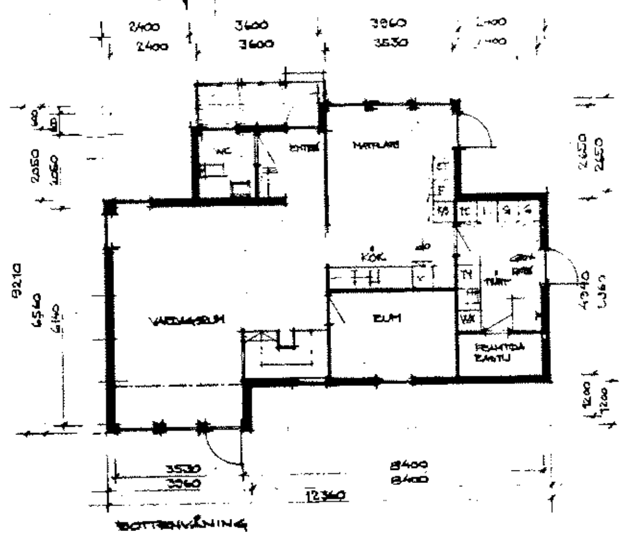


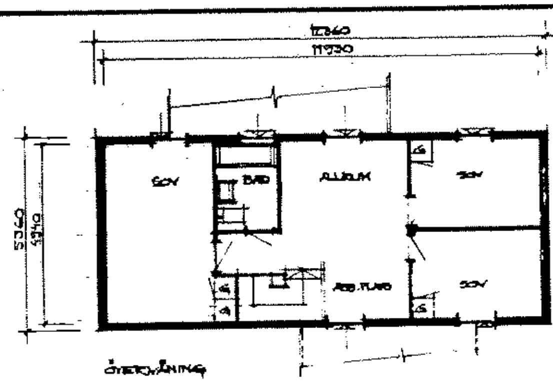
House D



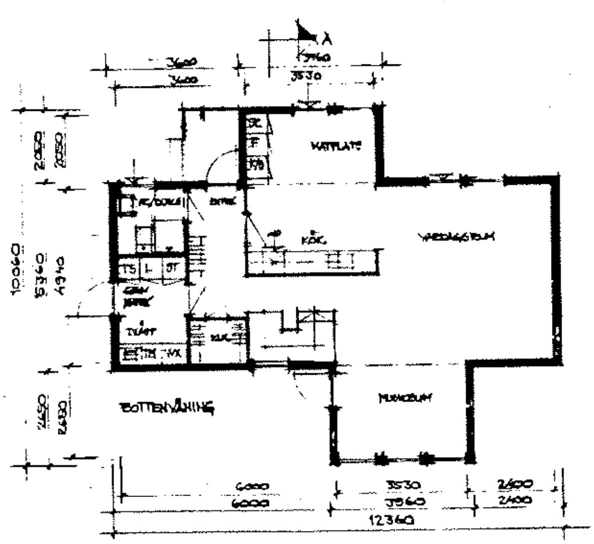


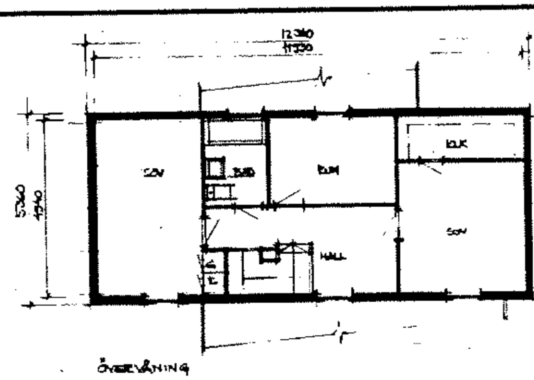
House E



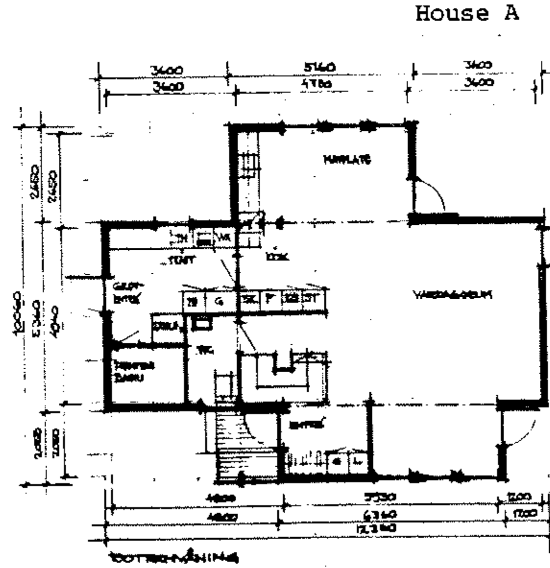


House G





House A



room, which also serves as his workroom (hence the size) faces west.

The large floorspace in the kitchen provides room for children and grand-children when they come visiting. The "dirty" entrance, laundry and sauna were considered very important and a great deal of attention was paid to their planning.

The family is convinced that they are going to enjoy living in the house as it is planned to suit them perfectly. Happiness will be complete if they can paint it yellow with white trim.

The above example can also serve to refute statements like "We know what people want", which even highly respected colleagues can be heard to utter. We feel there are good reasons for rejecting this know-all attitude.

With well-deserved modesty we may ask "How can we contribute to this development when other countries have obviously come a long way?" The way to a new, comprehensive planning concept is long. Much remains to be done. We are only at the beginning of a long period of development. There does seem to be room for a "Swedish Way" combining the two parallel lines of development which can be discerned abroad, one technically orientated and the other socially orientated.

The new planning logic will demand a new rationality, requiring control systems different from those of today. Here are some random examples -

> The creative process must also be an integrative social process aimed at building up congruent technical and social structures, amongst other things as a basis for self-management
>
> Planning decisions must be in the form of hierarchical outline decisions, with a successive transfer of responsibility to the user.
>
> Changeability and addability mean that you only need build that which is needed now. Successive adaptation to new needs can take place as necessary.
>
> The parts of the building are hierachically arranged according to their functional life-spans. For long-life parts, durability and generality are important; for short-lived parts, re-use and recycling.

Architects have many parts to plan in the future. The perspective outlined here offers considerably more than today. What are waiting for?

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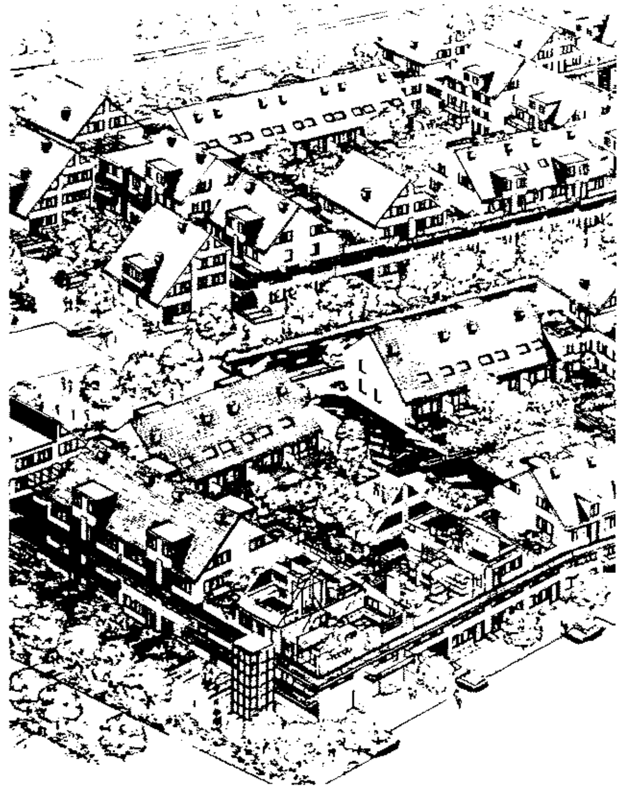
A WORLD OF EXPERIENCES.

support – infill in practice.

John Carp.
Marc Monroy.



0. INTRODUCTION

In the district of "LUNETTEN", a newly developed area of Utrecht, a support project has been realized called 4D.

This name does not refer to an extra dimension that has been added to the plan, it only indicates the section of the landuse plan it occupies. Neverthe-less, the plan really is quite signif-icant. It is not without reason that it received a special award from the Advisory Commission on experimental housing. To mention just a few chara-cteristics of the project: The adjust-ment to the urban plan has been carried out with the aid of the "Tissue Method" developed by SAR. The support that was developed can be allotted into differ-ent dwelling sizes, even though the structure is based on only one span. In the project much use has been made of Modular coordination. An industrially produced infill system has been applied, allowing a flexible dwelling lay-out. Last, but not least, the future tenants have been invited to determine their own floorplan in a number of consulting sessions. They could make use of a full scale mock-up system. It is a project, where one can learn an awful lot about the consequ-ence of the support-infill idea. No wonder that the members of the building team felt, at a certain instance, the need for a first evaluation.

As originator of the support-infill idea, the SAR then organized two ses-sions. The discussion was laid down in a report of which this article is a short version. The following parties took part in the sessions:

- the client: Lunetten B.V.
- the architect: working group Kokon B.V.
- the quantity surveyor: ARO consulting
- the contractor: Wilma Oost
- the manufacturer of the infill system: Bruynzeel.

It was remarkable and very gratifying as well to observe how versed the participants had become in handling the support-infill idea. This idea was not carried by just one of the participants leaving the others only watching from the slideline, no, everyone was equally motivated and knowledgeable.

The support-infill separation had become more meaningful to them as the process went along.

The discussions made clear as well that the support-infill idea supplies a common basis for the generation of solutions. It brought the disciplines closer together without obscuring their specific points of view, and let the participants speak for themselves.

1. THE CONSEQUENCES FOR THE AUTHORITIES

1.1 The public works department

The first subject that was discussed, concerned the consequences for the authorities. The contractor concluded that the activities of the public works department could have started earlier and could have been carried out faster, because of the efficient and clean finishing process. The manufacturer of the infill added, that he would have welcomed the streets already finished before the start of the infill process. This would have enabled the containers with the infill packages to come as close as possible to the front doors, saving hours per dwelling. The infill system had been specifically designed to be brought into the dwelling through the front door, i.e. after the dwelling shell had been made wind and waterproof.

Even though a separate delivery procedure has not been considered in this project, this observation would indicate this as the logical consequence of the support-infill idea. This would also decide on a distinct moment for completing the public works, e.g. the streets, pavement, etc., simultaneously with the completion of the support.

1.2 The public utilities departments

The consequences for the public utilities departments were discussed aswell.

The biggest problem has been how to get the civil servants of these departments to participate in solving the problems. As yet it is impossible to get the public utilities of a support approved, when the distribution of these utilities in the infill plan is not known.

To overcome this problem, the architect had to design reference lay-out plans, even though it was clear from the outset, that the future occupants would come up with different solutions. But even the reference-layout plans present a problem for the public utilities departments. They simply cannot understand that the utilities travel first from the metercupboard to the service duct and only then to e.g. the kitchen sink. They would have preferred a direct connection between metercupboard and sink. They have difficulty in seeing the reference-layout plan as only one solution in many, using the same service duct. Most of all it was the client who put a lot of energy in opening the eyes of these civil servants. They had to unlearn thinking in just one floorplan with just one solution for the distribution of services. The manufacturer of the infill system had another problem with the public utilities departments, the infill system can be put together entirely using dry assembly techniques, preferably in a space that has been dried as well. When the central heating is part of the support, as is usually the case, this can be realized easily. However, this does require that water and gas should already be supplied before the total utilities system has been executed. This is very difficult for the civil servants to accept, but also in this case Lunetten 4D acted as a precedent, especially on the strength of being an officially approved experimental project.
The members of the building team would welcome such precedents to become generally accepted.

1.3 The building department

Next, the experiences with the building department were discussed. The plan evaluation related to the subsidy yardstick was carried out on the basis of the reference-layout plans. These plans acted as proof that the support can contain dwellings that comply with the official standards. However, as the building department wanted to see the eventual floorplans as well, that were to be realized with the involvement of the future tenants, they had to limit their evaluation to aspects of safety, such as fire-escape routes, and hygienics, such as natural ventilation and access of daylight. "For the rest the occupants have been accepted as the authority" as the client delicately describes this new phenomenon. The building department certainly acted according to the spirit and not the letter of the building code. But also in this case this attitude was due to the official status of being an experimental project.

2. PLAN CHANGES

The manufacturer of the infill subsequently put the plan changes to the discussion. Each user floorplan was drafted out and calculated on the number and type of elements. A separate package was prepared for each dwelling. The period between the approval of the plan and its realisation proved to be a danger zone for the manufacturer, because then many requests for changes came forward. This played havoc with the organization.

In future the manufacturer will take up a more formal attitude. The client put forward that more often than not changes were necessary because certain aspects had been overlooked in the design phase, mainly due to the enormous complexity of the project. People had the unjustified idea that all is possible with an infill system. However, this is not the case and the manufacturer will have to check up on the drawings of the support if he wants to avoid unpleasant surprises. At any rate, the distinction of support and infill makes it possible to establish clearly the different responsibilities.

3. THE INFILL

Next, a discussion got started on the degree of finishing the infill system should have. Did not a number of the organizational problems arise because the wall panels of kitchen and bathroom had already received a finishing and a

Photo's
H.J. Stuvel, Leidschendam

number of boreholes? Is it not better to apply finishing and boreholes in-situ? Could this not be left for the user to carry-out?

Would not a simple basic system be sufficient, possibly even without the kitchenblock? This would make the infill a lot cheaper as well! The manufacturer countered these observations, saying that this would reduce the degree of industrialization. It would mean many more operations on site with all their accompanying disturbances of the building process, their messiness, etc. It is an open question what will be cheaper. However, as an other option, it should certainly be considered.

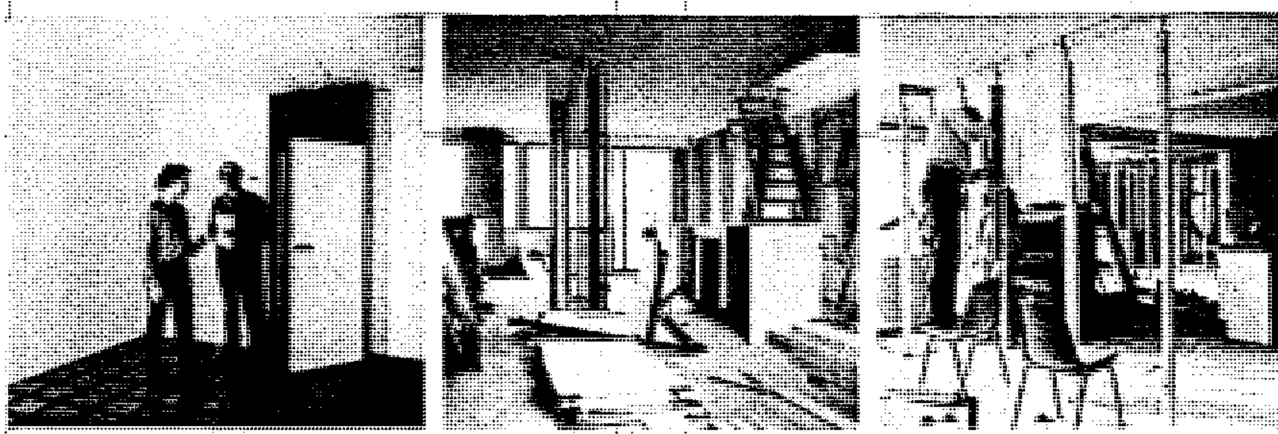
The quantity surveyor put forward the idea of a basic package with a large choice of accessories. Everyone agreed that more options within the infill system, concerning its finishing as well as its style would be a good thing.

4. THE FACADE

After all the contractor would have preferred a more closed facade. This would have greatly facilitated the linking up of the separations.

Now, many styles were necessary which led to a great number of different window frame types, with all its consequences for the building costs. A facade consisting of window openings interrupted by mullions would have been cheaper, as well as providing more surface for linking up the separations. The architect explained that the large window openings had been chosen to let the occupants choose the degree of daylight and ventilation themselves.

This would enable every occupant to answer the requirements of the layout plan to the maximum. The quantity surveyor recalled that the completely flexible facade had been cancelled for cost reasons, with the result that a number of styles received a fixed position. However, he is in doubt of the validity of a completely flexible facade anyway, for the reason that the big question is, - at what moment must the decision concerning the facade be made? It has been put forward earlier that a wind and waterproof facade is a prerequisite for the infill system. This can be an argument for letting the facade be part of the support or for carrying it out with a temporary closure of the openings. The client as well as the contractor consider the first option in contradiction with the



support-infill philosophy: the facade should consist of a fixed and variable part, whereby the variable part should be adapted to the dwelling layout plans.

But the quantity surveyor wishes to consider this as just one of the elaborations of the philosophy. There are other elaborations possible that do not allow any user control of the facade. After all the facade constitutes the face of the building as a whole. In most cases user-influence will be the highest degree of participation exercised on the facade.

Summarizing: Everyone agrees that the support-infill distinction leads to extra complications in the facade. "Completely variable" is equally in conflict with the philosophy as "completely fixed". A realistic compromise is the "openings- and -mullions" facade with variable infill of the openings. The openings should allow for a temporary closure, by frames covered with plastic foil.

5. SERVICE DUCT AND STAIRWELL

After the facade the service duct and the stairwell were discussed. The client stated that afterall the service duct would have been better moved 3M to a position in symmetry with the stairwell. Opposite the 24M stairwell the arrangement of door-duct-door (9M-6M-9M) would then have been possible, which would have provided the most efficient corridors. This would have avoided the many unusable corners in the floor plans.

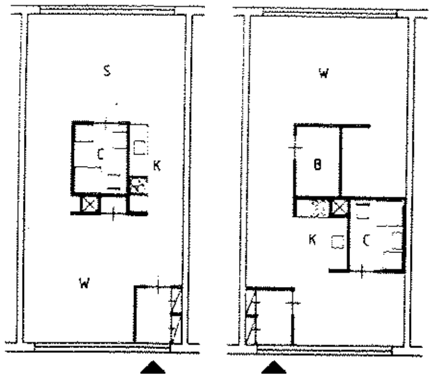
The architect agreed with this, but he remarked that the unfavourable position of the duct resulted exclusively from the need to score points in the value-units system of the subsidy yardstick. However, the quantity surveyor expected a symmetrical position of the duct opposite the stairs to have given the same score, but with the awkward solutions appearing in the subsidy-reference floor plan. If the evaluating authorities will keep to their task and will not have the ambition to play the architect, there will be no problem.

6. THE STAIRS

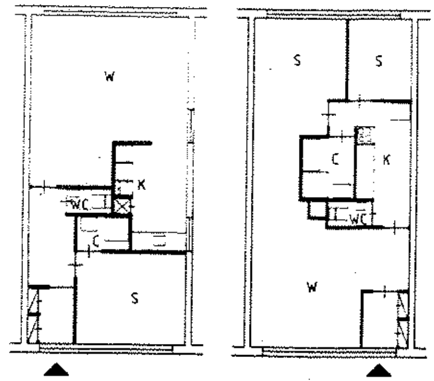
For the time being, the contractor as well as the manufacturer see the stairs as part of the support. The others do not agree with this point of view. In their opinion, the stairs should reflect the requirements of the different floorplans and should therefore belong to the infill. In future the stairs should be as independent as possible from the support and be realized as a free standing unit. In the resulting box a cupboard could be installed, a solution that has already been chosen by the majority of the occupants of 4D.

7. MODULAR COORDINATION

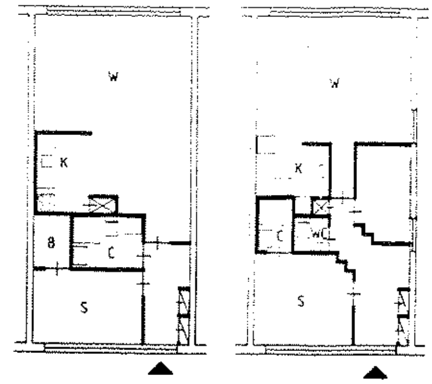
The problem of how to link-up the stairs to the support (gaps occurred that had to be covered up) brought the discussion on to modular coordination. The manufacturer: We are not so concerned with the thicknesses of support walls and floors, but we insist that the agreements, as they are laid down on drawing, are adhered to. This applies to the various connections as well. Much time was spent in checking the measurements of the support. It must be clear who is responsible for what. For this purpose the documents



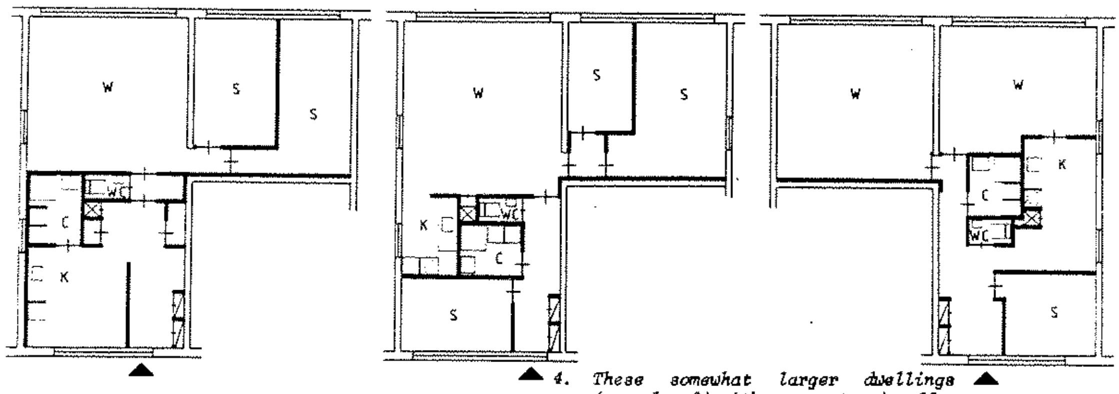
1. *Example of flats which can be situated on the ground floor as well as the upper floors. The total area is 55 m^2 of clear space and freely divisable.*



2. *These flats consist of two sectors. Each sector has a service duct and part of a facade.*



3. *The above plans show how varied different solutions are, each one made by the families themselves.*



4. *These somewhat larger dwellings (one level) (three sectors) offer more subdividing possibilities (82½ m^2)*

and drawings of the support were too general, because they did not mention the tolerances.

The representative of the SAR asked whether the increment of 3M had posed any problems. This had not been the case. However, the contractor had felt the need for further rules concerning the detailing. During the design stage of 4D, the new modular standard NEN 2883 had not yet been brought out. This meant, one had to anticipate the rules.

8. THE SUPPORT DESIGN

Concerning the design of the support a debate got going on the increment in floor area. The bay used in Lunetten 4D measures 5.40 x 10.80 m. Dwelling sizes can be increased in floor area by half a bay, i.e. by 25 m^2.

This increment is rather coarse compared with the increment in floor area that follows from the subsidy yardstick. In the opinion of the contractor the costs of a plan have no direct relationship with the floor areas. If the plan is efficient, excess area has no great consequences. But the quantity surveyor added that the support could very well have received a more complex structure, without becoming more costly. With a rhythm of bays of different widths, there would have been no question of excess floor area. The support may be complex if only it can be built efficiently.

The client introduced a related point of discussion by pointing out that the subsidy yardstick itself leads to excess floor areas as well. Because the yardstick is based on the average user, larger spaces are required than is necessary for the individual user. The individual user knows to set priorities: he or she is quite prepared to have a small sleeping area in order to gain a large living area, or vice versa. This has been proved by the user consulting sessions. The architect: more often than not the dwelling designed together with the user turns out smaller than the standard dwelling. This is a very interesting conclusion!

9. THE COSTS

Finally the crucial aspect of the costs came on the table. The architect: This project would not have been feasible without the startingpoint of support-infill. This conclusion was specified by the quantity surveyor who pointed out that traditional building-techniques would have led to many more disruptions and to a much longer building time. So the support-infill distinction does require a highly efficient building method. On the other hand, this itself is furthered by the support-infill distinction. In the opinion of the contractor the project certainly has not been more costly than a traditional project. The balance credit, that enabled making good the extra costs due to the enormous dwelling variety, consists of many small advantages. E.g. it cost less to clear up the site and the dwellings, there was less involvement of machinery, there were less disruptions of the building process and the building time was shorter. At first glance these are only minor advantages, but added up they amount to a large sum of money. Apart from this the whole process runs more smoothly and can be kept under control more easily, which means that construction risks can be mittigated.

The quantity surveyor would welcome the contractor giving a detailed insight into those aspects which have been cheaper and which more expensive.

The manufacturer of the infill would have liked to have been involved in the project at an earlier stage. He also would have preferred to have worked with an open estimate. Because the manufacturer, in this project, had the role of a sub-contractor, many costs arising from deviations from the principle were rolled off onto him. This occurred especially in the beginning, when the participants were not yet in tune with oneanother.

The client: This is a point, which makes it meaningful to consider a split contract in future. The manufacturer agrees with this; the contractor has his doubts. In his opinion the importance of expertise in building coordination should not be underrated. But the architect considers building the support and realizing the infill to be two worlds apart, which really makes a separation of responsibilities quite obvious.

10. CONCLUSION

The representative of the SAR concluded by pointing out that with this elaboration it should not be different from all other elaborations of the support-infill idea: There is no best solution; there only are appropriate solutions, solutions that fit certain circumstances and priorities. In this respect, however, it becomes obvious that more experiments will take place in split contracting. The reason is, that this elaboration of the idea runs parallel to an option for economizing on housing costs, an option that could well be very interesting for the Ministry of Housing: By leaving the realization of the infill to the user the authorities can concentrate in a better way on those aspects of the building that should comply with the general quality requirements, i.e. the support. Hopefully this will help these qualities to be maintained. This is very necessary because these qualities are currently under threat.

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PREFACE FOR THE ENGLISH TRANSLATION

The Dutch Architects Yearbook of 1982 focussed on housing issues and policy. Of five articles, three were specifically about the design and construction of Supports and the realization of a variety of dwelling plans in them by means of infill packages utilized according to the preferences of the user.

One of these articles dealt with issues of costs relative to the Support idea and presented a specific method for budgeting Support projects. It has often been argued that Supports inevitably will lead to high costs at the short term although they admittedly will have their economic advantages at the long term. Karel Dekker argues that careful planning and design may lead to short term advantages as well that may balance the extra costs for adaptability. He reports on a number of projects that have been completed recently in the Netherlands. The article reflects the specific Dutch conditions in which these projects have been implemented and it is clear that conditions in other countries call for their own design strategies in the Support concept to find the most advantageous solution.

However, this is for the first time that a serious and detailed study is published on the economic aspects of Support implementation. Karel Dekker's work sets an example that may lead to similar studies in other countries by other experts.

The author, who was trained as an engineer and architect, is senior partner in ARO—consultants for cost management and project planning in building. He is a member of the board of SAR, the architects research foundation in Eindhoven, the Netherlands, that initiated the methodology and philosophy for Support housing.

INTRODUCTION

In this article we will examine how the separation of Support and Infill creates the opportunity for a better control of costs during the design phase and for short term and long term cost effectiveness.

These are cost reductions that do not influence the quality of the product. Moreover, they will be effective during the lifetime of the building.

On the basis of experience in practice we will examine to what extent it is already possible today to build Support/Infill projects that are competitive. Subsequently we will discuss a study by ARO about possible cost reductions due to the Support Infill approach at the short term and we will make a prognosis for long term cost effectiveness. In the chapter on *process control* we deal with the opportunities offered by the separation of Support and Infill for better cost-control during the design phase.

The extra costs necessary for Supports that allow for free choice of dwelling size and change of dwelling size will be discussed briefly at the end of this article.

COST

First approach by contractor	
Estimate complete dwelling (basis type)	± 57,500
Less: interior partitioning, sanitary equipment, electrical circuits, mechanical ventillation	± 9,000
Costs infill package(prefab)	± 16,000
Difference	± 7,000
Conclusion: Not feasible	

Second approach	
Estimate support Structural facades, roof, partywalls, etc. central heating ducts finished support	± 45,000
Infill package(prefab)	± 16,000
Total per dwelling	61,000
Traditional	57,000
Difference	3,000
Advantages, less interest and insurance	± 1,500
Extra costs	± 2,000
(approximate figures)	

FIGURE 1. (from De Architect no. 10-1980)

EXPERIENCE FROM PRACTICE

As a consultant for costing and as coordinator, ARO has been involved with a number of projects in which the Separatative Support Infill was applied. A report on our experiences will be given here. These experiences relate mainly to cost reduction and process control.

STERRENBURG III, DORDRECHT

In the city of Dordrecht, the project called Sterrenburg III contains 279 units built according to the Support Infill principle with application of Bruynzeel infill packages. The cost effectiveness of the infill package gave great difficulties in the planning stage of this project, which was designed by architects De Jong, Van Olphen, Bax. The builders had estimated costs based on a traditional way of finishing. The costs for "finishing" in this budget were considered to be the sum available for the infill package. The result was a large price difference: about dfl. 7000 – per dwelling. (see fig. 1.)

In a later phase, however, a separate cost estimate for the Support was made to be combined with the costs for the infill package. This combination, when compared with the costs of the traditional alternative, showed a significantly smaller price difference. Still, in this case, certain advantages of Support/Infill were not calculated: for instance, the electric circuit was mainly incorporated in the Support. In addition, there was no experience with this way of building. The comparison therefore was not entirely valid; it was clear that a correct budgeting procedure is essential for an understanding of the feasibility of a Support/Infill project.

In retrospect it can be concluded from the 279 units in the Sterrenburg III project that in 1977 the Support/Infill with an "industrialized" infill package was more expensive than a traditional project. Neither was it financially feasible to build a support without any electrical circuitry: the costs of such a circuit that was left outside the concrete structural walls were too high compared to the traditional way of installing the electrical circuit. Only in 1979 an ARO study would show that the cost reductions of building a support were significant enough to pay for the extra costs of the infill. (fig. 2)

LUNETTEN PARTIAL PROJECT 4D, UTRECHT

A Support/Infill project is in execution within the Lunetten development project. It is designed by Arch. Frans Van der Werff of "Werkgroep Kokon" (see figs. 4, 5, and 6) The 4D project is in fact a continuation of the

Concrete structure

- *no ducts in structure*
- *standardised openings*
- *maximum use of forms*
- *no disturbing of structural work by subcontractors*
- *less repair, less openings*
- *no changes in formwork details*
- *larger continious series*

} *direct costs*

Administrative costs

- *less cost for project preparation*
- *less cost calculation*
- *less cost for on-site office*

} *overhead costs*

On-site costs

- *less transportation of materials on site*
- *less storage on site*
- *shorter construction time*
- *less personnel needed for coordination*
- *less drafting work needed for execution*
- *faster start of construction*
- *less help to subcontractors*

} *on-site costs*

General

- *less borrowing costs on land and construction expenses*
- *less expense for risk coverage*

} *clients cost reductions*

FIGURE 2. ADVANTAGES AS DISCUSSED IN 1977 PROJECT TEAM

			per dwelling
- extra costs support because of six different building locations		dfl	2,400
- extra cost for space to facilitate flexibility		dfl	1,700
- extra cost to connect bays for variety in dwelling size, as specified:			
central heating system	dfl 1,000		
adaptable facade elements	dfl 600		
extra cost ducts	dfl 200		
openings in walls	dfl 200		
	subtotal :	dfl	2,000
- costs for participation of user		dfl	400
	TOTAL :	dfl	6,500 -/per dwelling

FIGURE 3. EXTRA COSTS FOR PLAN 4D, LUNNETTEN.

experimental project Molenvliet in Papendrecht, completed in 1977. At the beginning of our activities in January 1979, the bidding procedure of the project had been a failure. (The figure submitted by the lowest bidder had been considerably higher than the architect's estimate.)

An attempt was made to arrive at a better price by consultation with the lowest bidder. As this builder did not "believe" in the advantages of the Support/Infill approach it looked as if the project had to be done the traditional way. However, in that case an extra subsidy for experimental projects would be withdrawn. After this initial failure in 1979 a new start was made with another builder (de Waal Co., a subsidiary of the Wilma Co.) The design of the support was adapted to allow for more efficient building execution in close consultation between architect, builder and cost-consultants. Particularly the corners of the building were changed to make continuous undisturbed construction possible, utilizing "tunnel" formwork. The use of Modular Coordination principles according to N.2883 (the new Dutch norms for modular coordination in housing) yielded a cost reduction; now four tunnel forms could do the work of six in the same time span. This was achieved because of the standard floor height of 2.7 meters (previously norms requested different heights for ground floor and bedroom floor spaces.), and because the variation in dwelling sizes and dwelling types in a support structure does not influence formwork sizes or details.

In this way the costs of the "expensive" support could be substantially reduced. This reduction balanced the extra costs needed to make "re-alottment" of the support possible (e.g., the permanent possibility to change dwelling size within the support). This, in turn, allowed the client to react to the changing demands of the market by increasing the number of dwellings even just before the execution of the project without any change of the support design. In this "experimental" project the users were free to decide the layout of their dwellings. They did not have to adhere to current space standards. The result is that no two dwellings are the same whereas the impact of this variety on costs was limited.

Conclusions that can be drawn from this project are:

- It is very important that the support design be closely related to the advantages of the chosen building system to utilize as much as possible the supports potential for continuous and uninterrupted execution.
- The support design should not increase building volume to achieve the desired flexibility.

It is particularly important that the structural module is small enough to relate closely to the increments of dwelling size. Otherwise the increments of dwelling size offered by the support will be too large for the programmatic increments of dwelling sizes. In this particular project the bays of 5.40 x 10.80 meters made for too large increments.

SCHIEDAM INNER CITY

This is a project of 100 units being the first phase of an inner city project by architect A. Kuypers of the office of Treffers & Polgar. Our study on "Costs of Support/Infill" had already shown that the separation of Support and Infill was particularly advantageous in smaller projects. In addition, this particular project had such a short planning time that the "traditional" procedure of design and building execution could not be followed. Following ARO's advice the municipality of Schiedam agreed to the use of the Support Infill approach and of Modular Coordination. ARO was hired to coordinate the team of architects and builders in its capacity of cost-consultant and consultant for Support/Infill and Modular Coordination. This opened the way to use to a maximum the advantages of Support/Infill in combination with Modular Coordination.

a. Procedure

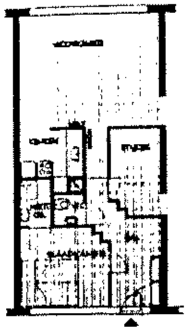
The preliminary design of the architect was completed in January, 1981. The client (municipality) demanded that construction begin in mid-summer. Now, the procedure for approval of an inner city renovation project takes at best a year, which made the time frame virtually impossible.

To gain time the following steps were taken:

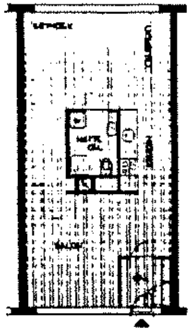
- An accelerated bid-procedure based on separate bidding on Support and Infill.
- Parallel design of the space plan, the infill and the parking garage under one of the buildings.
- ARO determined beforehand what would be Support and what Infill. It was known that an "industrial" infill system would be utilized. The distinction between Infill and Support was also observed in the specification document.
- A consultant for mechanical equipment (plumbing, electricity, heating), who had experience in the Support Infill approach in several previous projects, was hired.
- The plans to be submitted for government approval were budgeted three ways by ARO: on the basis of the program, the dwelling variety as required and the capacity of the Support.
- A building team contract was put together with the builder for the support and the separate contractor for the infill. In this document, a number of cost related issues were specified such as: overhead costs, profit and risks, and on-site costs as related to the very short construction time possible in this approach.
- The specification for the infill was submitted by the infill contractor.
- The specification for the Support was done separately.

b. Budgeting in the Programming phase.

The budgeting in the programming phase was done in the way usual for the municipality



EXAMPLE OF
MAXIMUM INFILL



EXAMPLE OF
MINIMUM INFILL

FIGURE 4.

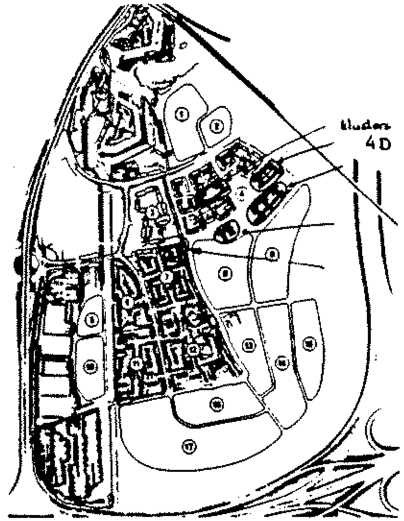


FIGURE 5. OVERVIEW
TOTAL LUNETTEN PROJECT

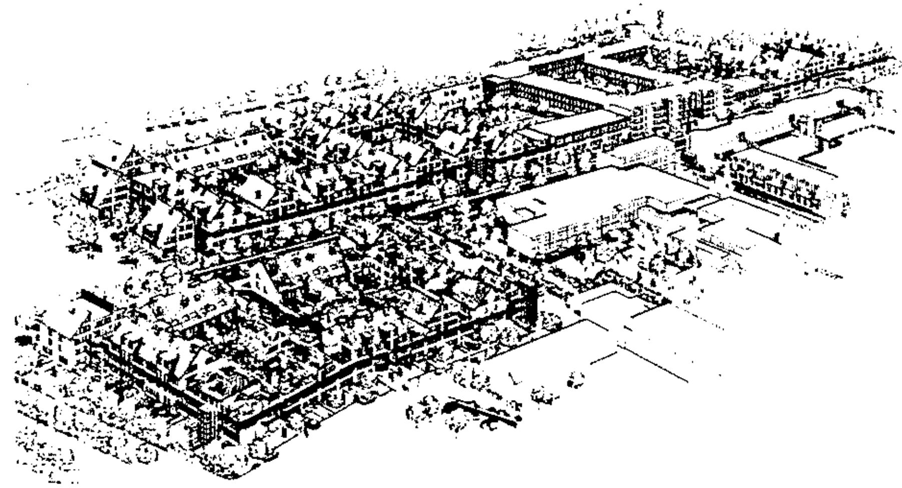


FIGURE 6. PLAN 4D (WITH PITCHED ROOFS) IN LUNETTEN PROJECT

of Schiedam (as developed previously by ARO).

c. Estimating costs in the design phase.

The Support design was evaluated on the basis of the minimum floor space required by the program as applied to the support and expressed in the VE's (VE is a unit in which space capacity is expressed: e.g., a living room = 1 1/2 VE, so is a master bedroom, but a 1 person bedroom is 1/2 VE, etc.). This evaluation showed that the programmed variation of dwelling sizes fitted very well in the support. Evaluation on construction efficiency showed that the design, in spite of the complex program, could be built efficiently (thanks to modular coordination and Support/Infill separation). This gave extra capacity in the budget which was used almost completely for some architectural and site specific "qualities" like bay windows, etc. In addition an extra Dfl. 3000.00 per unit was used for energy saving devices.

d. Budgeting in the Specification phase

Based on the evaluation as described under (c), the final program was decided upon, and the available budget was determined accordingly. At the same time, cost estimates were worked out for the final design to check its possibility within the available budget. The estimates used the information now available in working drawings and specifications. The builders made an estimation for the support. The producer of the infill package made a bid on the infill. After negotiations with both parties it turned out that costs of Support and Infill were within the budget estimate. In the meantime, to gain time, the budget estimate had been the basis for the formal request for cost allocation to the client.

e. Contracts

The building procedure being concluded, contracts were made up with the Support builder and the Infill contractor.

f. Conclusions to be drawn

The use of modular coordination and the Support/Infill approach can yield important gains in construction time. It has to be taken in account in this example that only a few of the participants were familiar with the Support/Infill approach and with modular coordination. If all parties have experience with these methods the project time can be reduced even more.

The calculation of so called excessive costs was made for the "traditional" way of building for the same design for reasons of comparison. This showed that the disturbances would be such that the costs per dwelling would be much higher. (See fig. 9)

The start of the project was finally retarded because of a complaint filed by local groups against the municipality. This only shows that there are plenty of difficulties remaining that slow down the process and that cannot be overcome by modular coordination or support/infill separation.

CASE STUDY SUPPORT INFILL

ARO has done a study about the short term implications of complete separation of Support and an industrialized infill package. This study shows that there are some immediate cost reductions because a number of operations can be dropped with the construction of a support. The most significant cost reductions, however, are the result of the shorter construction time. This yields advantages in terms of indirect costs as well as costs of on-site organization. The acceleration of construction time, as indicated in the study, is particularly significant for the point in time where the first unit is finished. Because this construction time advantage remains independent of the size of the project, it is clear that the relative gain is largest for the smaller project. The average construction time of 100 dwelling units can be reduced from 10.5 months to 7.5 months. This means a reduction of about 30% for a variety of time-related items such as interest, etc. For a large project, the impact of construction time reduction will be relatively less.

LONG TERM COST REDUCTIONS

In an article by W. Bakens, the long term cost implications of Support/Infill are discussed. Mr. Bakens states that measures that improve productivity are particularly important for long term gains. Large scale implementation of the Support/Infill approach together with modular coordination can increase productivity. How much gain in productivity can be achieved this way is impossible to say without a serious study. However, it would be interesting to see what results from a productivity gain of 2-4% a year can be expected for future project costs. When it is assumed that productivity will increase from ~0.5% today to 2% in the next five years and 4% in the second five year period, project cost after those ten years will be 20% less as compared to the continuation of today's building practice, by a constant quality level of the dwelling unit.

The impact of increasing energy costs on building costs is significant. It is therefore extremely important that the energy related component of building costs be reduced as much as possible. To what extent Support/Infill separation can contribute to this cannot be estimated in the context of this article. Building costs are only a part of project costs. The influence of reduced construction time on additional project costs like interest payments, will remain sufficiently advantageous that a 20% reduction of project costs must be possible. (See fig. 13)

When the separation of support and infill will also be seen as a separation of financing modes, shifts will occur in the proportion of public costs to costs for the user. We can

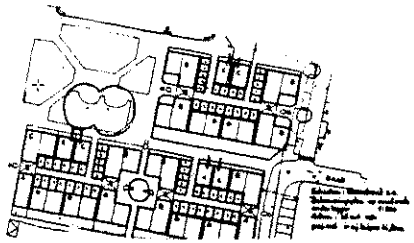


FIGURE 7. SCHIEDAM INNER CITY PROJECT

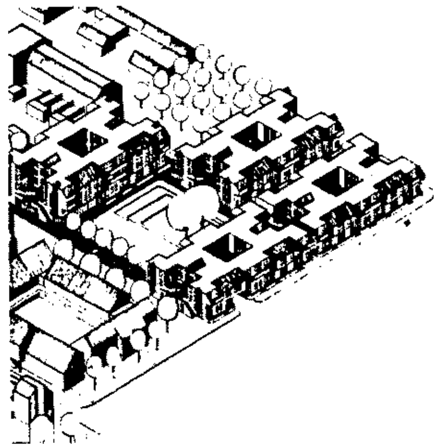


FIGURE 8. SCHIEDAM INNER CITY PROJECT

DIFFERENCES IN 'EXESSIVE COSTS' WHEN THE SCHIEDAM PROJECT WOULD HAVE BEEN EXECUTED 'TRADITIONALLY' PER DWELLING UNIT.

- very large variety: 45 man hour/dwelling	dfl	200
- extra transportation on site	dfl	455
- extra crane time	dfl	330
- precario	dfl	1,000
- guarding	dfl	450
- extra control for half of construction time	dfl	192
- extra costs for water, power	dfl	232
Total extra costs compared to Support/Infill	dfl	4,659

Note: "exessive costs" are the costs above and beyond a normal, uniform, standard housing scheme

FIGURE 9.

consider new management models that become possible, for instance: that support space is rented but the infill is bought. The effect could be calculated in the same way as has been done recently for the calculation of the change of rental units to units for sale by the Institute for Research for Government Finances in the report, "Implications of the Government Budget for Rental Dwelling Units and Dwelling Units for Sale."

COST CONTROL, THE ARO METHOD.

Cost control in relation to the design process in today's practice involves the application of advanced estimating techniques. These techniques, however, are seldom integrated with the design activity nor is cost-control related to the phases before and after the design (that is: the programming phase and the bidding and construction phase.) Hence the important discussion in the programming phase about what is socially acceptable or what quality level and what cost level is desirable, is not touched by cost-control methods. It is only after the social and political decisions are made that the job is done with sophisticated tools to control the relations between costs and quality in the project. As the process goes along the possibility to influence cost levels reduces rapidly. This, at least, is the consensus of most experts.

Before going into the possibilities offered by the Support/Infill approach for better process planning, I will sketch a form of cost planning as applied by ARO consulting. The method is developed in answer to a need to assess in each phase of the planning process the consequences of decisions and design choices in relation to a pre-determined budget. The method is best described by way of a chart that relates planning phases and costs. (fig. 14)

The following aspects of cost planning are involved:

- Budgeting in the program phase
- Estimates in the design phase
- Calculation and evaluation of bids

Budgeting takes place in the program phase. The importance of the determination of a budget before the design phase finds gradually general acceptance. It is characteristic of budgeting that it is done *without* a design. This means that we must use experience from projects in the past as well as facts about local conditions. A budget has several functions in the project development:

- It serves as a basis for agreements or contracts among clients, government, architects and users about financial and quantitative limits within which the projects must be done.
- It serves to estimate in advance the inevitable extra costs related to local conditions, the urban design context, the building program, etc.
- It is a frame of reference to evaluate designs, specifications and cost estimates.

In order to be useful in this way in the development process budgets must fulfill certain conditions:

- It is important that budgets are determined on the basis of detailed calculations.
- It is important that cost data are seriously verified.
- Finally, the budget as determined as well as the quality level that is implied with it must be understood and accepted by all parties.

For the budgeting of building costs in the program phase the ARO-method uses a so-called "theoretical reference dwelling unit."

This is a fictional, simple average dwelling that satisfies the formal minimum standards of the state government for space norms and technical quality. This assures that building quality and use quality are reasonable. This reference dwelling is in fact a set of dwellings of different sizes expressed in VE's (ranging from 2 to 6 VE), (see part A in fig. 14). Hence the minimum solution - that we assume to be unrealistic but theoretically determinable - is, in a given site, the sum of a theoretical model, based on theoretical reference units, plus the influence of local conditions. Local conditions may be:

- Conditions of the labor market and the materials market.
- Conditions of soil.

This sum gives the minimal building costs as related to the given program (fig. 14, column 3, A + B). The range A + B is therefore *independent of the design*. The range C + D in the chart of fig. 14, indicated by the term "margin" gives in fact "losses" that result from additional requirements in the program and from design activities that inevitably will lead to a figure beyond the theoretical minimum. This range may include elements that incur minimal or no losses, but the total of C + D will never be zero.

The theoretical minimum, applied within local conditions, and increased with the margin (C + D) gives the maximum acceptable building budget.

Items for which the margin can be used:

- Difference between theory and practice: A series of dwelling types to be developed within a same support will not be possible without some concessions relative to the minimum.
- The reduction of building sizes, that is to say influence from the urban design.
- Dwelling dimensions may have their impact (floor area, facade area, roof area, bay size.)
- Special additions to the minimum dwelling: (cantilevers, balconies, bay windows, etc.).
- Extra amenities or extra finishes or equipment in the units.
- Other aspects, such as investments to

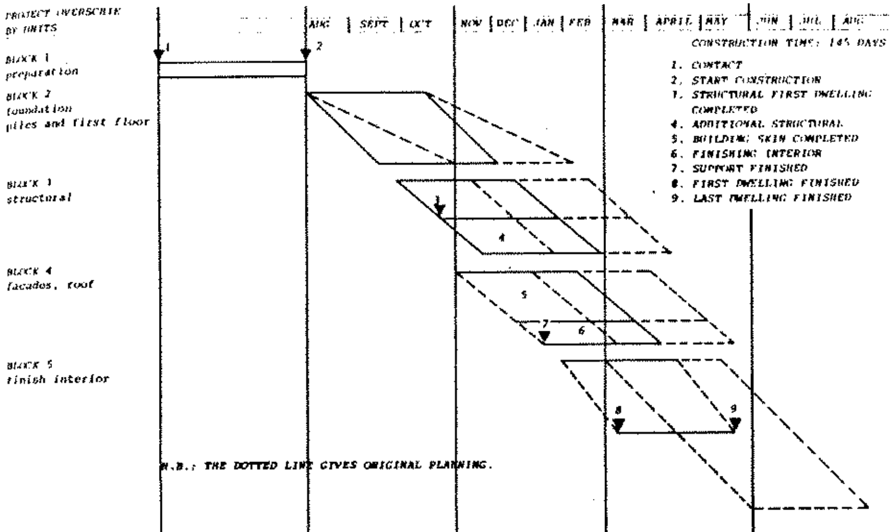


FIGURE 10. PLANNING FOR CONSTRUCTION WITH PREFAB INFILL PACKAGE

minimize future maintenance.

Deviations from efficient building methods. The steps one to six given in fig. 14 can be briefly described as follows:

Step 1

Determination of budget based on theoretical minimum requirements. Calculation of impact of special local conditions like market, soil conditions, project size, the budgets for building costs are completed in this phase with budgets for all other additional building costs.

Step 2

Evaluation of the detailed program for extras as compared to the theoretical minimum (these extras may already take a part of the margin.)

Step 3

Evaluation of the preliminary design against the following aspects:

- Relation between chosen load bearing structure, size, building skin, bay size on the one hand and theoretical minima on the other.
- Relation between urban design aspects and the theoretical assumptions about minimum building block size and staggering of facades.
- Relation between the preliminary design and the optimal construction assumptions that served as a basis for the theoretical minimum such as:

  Maximum use of foundations and piles
  Efficient structural design (use of form work, standardization)
  Efficient configuration of the building skin (angles, facade composition, roof form, etc.)
  Efficient mechanical installations
  Efficient finishing (wall area, number of doors, sizes of sanitary cells, etc.)

After step 3 it can already be determined whether the design is feasible within the budget, although based on assumptions about further detailing.

Step 4

After the final design the layouts are exactly known and can be compared to the assumptions of Step 3.

Step 5

Cost estimations can take place after the design process has yielded specifications and principal working drawings and after the selection of a contractor has led to the determination of the building method. (We will, in the context of this article, not dwell on the methods used for the selection of the contractor nor will I describe the subsequent negotiations within the building team.)

COST COMPARISON - BY DWELLING UNITS - PROJECT DE OVERSCHIE - DATE OF ESTIMATION: 12/31/1979.
ALL FIGURES ARE IN DFL

ITEM	("TRADITIONAL") ORIGINALLY	WITH INDUSTRIAL INFILL SYSTEM, SUBCONTRACTOR IS SUPPORT CONTRACTOR	WITH INDUSTRIAL INFILL SYSTEM, SEPERATE CONTRACTOR
1. CONSTRUCTION COSTS WITHOUT OVERHEAD, PROFIT AND VAT REDUCTIONS:	66,000	66,000	66,000
2. FINISHING		15,095	15,095
3. REDUCTION DIRECT COSTS(SUPPORT)		342	342
4. REDUCTION INDIRECT COSTS(SUPPORT)		2,150	2,650
5. NET COSTS SUPPORT		48,414	47,914
6. COSTS INFILL SYSTEM(SUBCONTRACTOR)		17,117	
7. NET CONSTRUCTION COSTS	66,000	65,531	47,914
8. OVERHEAD (5%)	3,000	3,277	2,396
9. PROFIT AND RISKS (4%)	2,772	2,752	2,012
10. COMPLETE CONSTRUCTION COSTS INCLUDING VAT	85,045	84,441	61,740
11. COSTS OF INFILL SYSTEM(SEPERATE BID)			17,117
12. ON-SITE COSTS FOR INFILL			856
13. 18% OVER INFILL			3,325
14. COMPLETE COSTRUCTION COST SUPPORT/INFILL	85,045	84,441	82,948
15. LAND COSTS INCLUDING VAT	15,000	15,000	15,000
16. INTEREST ON LAND COSTS	1,375	1,029	1,029
17. ADDITIONAL LAND COSTS(NOT CHANGING)	5,200	5,200	5,200
18. ADDITIONAL LAND COSTS(CHANGING)			
19. INTERESTS DURING CONSTRUCTION TIME	3,896	2,896	2,847
20. CONTROL	900	700	700
21. PARTICIPATION	400	650	650
22. RISK PREMIUM FOR HOUSING COSTS	4,675	4,002	4,002
23. COMPLETE PROJECT COSTS	116,491	113,918	112,376
24. DIFFERENCE WITH POINT OF DEPARTURE	-	- 2,573	- 4,115

EXPLANATION:

1. EXTRA COSTS (LINE 1) ARE BASED ON ACCEPTED BID FOR 64 DWELLINGS, OVERSCHIE.
2. THE SUBTRACTION OF FINISHING COSTS (LINE 2) IS BASED ON THE FINISHING ITEMS THAT ARE REPLACED BY THE INFILL SYSTEM, AS SPECIFIED IN THE BID FOR THE ABOVE PROJECT.
3. THE REDUCTION COST (LINES 3 AND 4) ARE DERIVED FROM DIRECT AND INDIRECT COSTS AS SPECIFIED IN BID FOR ABOVE PROJECT.
4. ON-SITE STORAGE COSTS HAVE NOT BEEN CHANGED SINCE NO FIRM CONCLUSION COULD BE DRAWN FROM POSSIBLE ASPECTS FOR REDUCTION BY USE OF SUPPORT/INFILL.
5. FURTHER DIFFERENCES IN ADDITIONAL COSTS ARE SPECIFIED IN LINES 18 THROUGH 22.
6. THE NOMINAL FIGURES FOR ADDITIONAL COSTS AS RELATED TO THE ORIGINAL PROJECT SITUATION HAVE BEEN DETERMINED ON THE BASIS OF AVERAGE FIGURES FOR PROJECTS IN THAT REGION.
7. COSTS FOR INTEREST PAYMENTS DURING CONSTRUCTION TIME HAVE BEEN CALCULATED OVER 11 MONTHS FOR THE ORIGINAL PROJECT AND 8.23 MONTHS BY APPLICATION OF THE BRUYNZEEL INFILL SYSTEM.

FIGURE 11. OVERVIEW

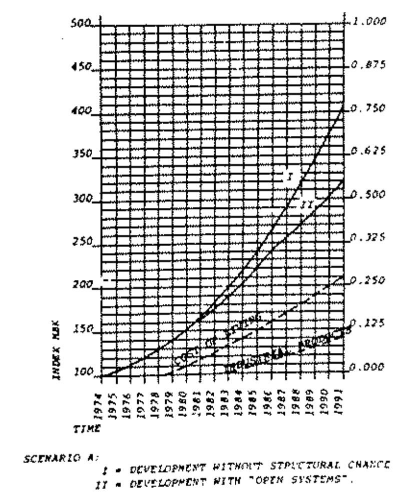


FIGURE 12. GRAPH: LONG TERM COST INCREASE

	1980		1991 TRADITIONAL		1991 SUPPORT/INFILL	
	COSTS	INDEX	COSTS	INDEX	COSTS	INDEX
2.1 LOAD BEARING STRUCTURE	16,250	154	42,208	400	34,505	327
2.2 BUILDING SHELL	33,140	154	91,027	423	77,900	362
2.3 MECHANICAL	11,000	145	27,669	340	20,833	256
2.4 INFILL	11,00	156	32,147	425	25,945	343
2.5 ON-SITE ORGANIZATION	7,320	162	20,830	463	17,968	287
2.6 OVERHEAD	4,030	153	9,824	373	6,743	256
2.7 PROFIT PLUS RISKS 4%	3,390	153	8,948	404	7,156	320
TOTAL	88,000	153	232,653	404	186,050	320

FIGURE 13. OVERVIEW COST DEVELOPMENTS PER BUILDING PHASE

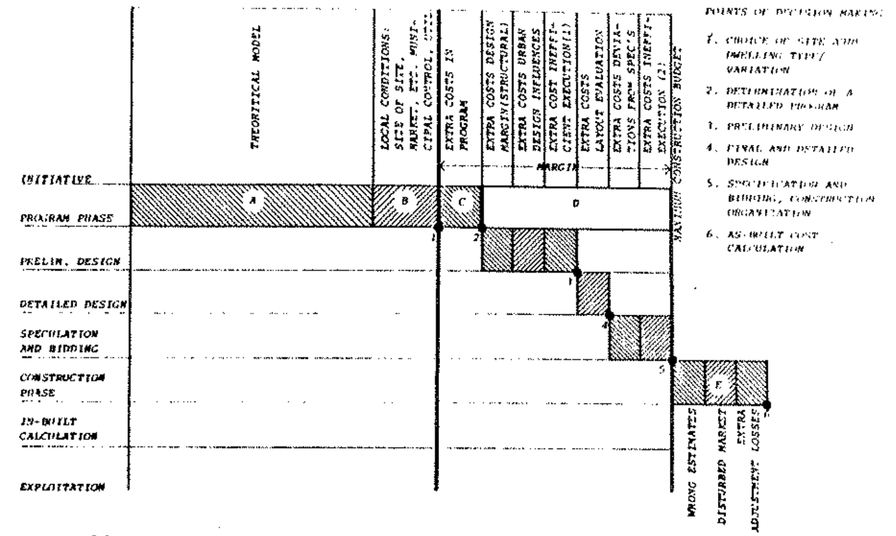


FIGURE 14. BUILDING COST COMPOSITION--PLANNING PROCESS

The subsequent way of working relating to cost estimation may be described as follows:

1. Based on the final design the partial budgets will be decided upon taking into account the final dwelling variation within the project.
2. The budget estimate will be made final. This is also done on the basis of the final design. Principal working details and specifications will be related to the assumptions mentioned in Step 3. This budget estimate gives a reasonable indication for the sum that would be needed to build the project. This budget estimate is still based on the partial budgets for building parts as incorporated in this method.
3. Comparison of the budget estimate with the maximum budget gives an indication of the difference between the real costs and the available resources.
4. The price of the project is finally determined on the basis of a calculation made by the builder.
   - With the selection of the contractor agreements have already been made about overhead, profit and risks percentages, on-site costs, and maximum construction time. An estimate of costs is calculated by the builder taking into account these agreements. The subsequent negotiations about this estimate can be divided in primary discussions about the amounts of material and labor needed and a secondary discussion about unit prices and norms.
   Architect and cost-constultant should be knowledgeable about unit prices, norms and on-site organization to be able to negotiate on an equal basis with the builders.
   The contract price that is the result of the negotiation is compared with the budget and the budget estimate (step 5.2).
   When agreement has been reached about the detailed costs the detailed builder's estimate becomes the basis for further negotiations if the costs exceed the initial budget or when the government authorities demand lower budgets or lower rents. Our experience is that it is often necessary during the negotiations to find (in details) more efficient and cheaper solutions. However, this period of negotiations need not last longer than six weeks after receipt of the builder's detailed estimate and we found it always possible to reach a final costs figure that came very close to our final budget estimate.

When we incorporate the separation of Support and Infill in this method a new firmly delineated future design process can be projected, using the same phases A through E as described above. This future design process is illustrated in fig. 15.

SUPPORT, INFILL AND COST CONTROL

What changes take place in the procedure and what possibilities come available in cost planning and cost-control when the separation of Support and Infill take place? There are no solutions available yet but the method described earlier is beautifully compatible with the separation of Support and Infill. Following the schematic description of the project planning process as described by W. Bakens in the architects yearbook, 1981, we will see what steps may be indicated and what evaluations may take place (fig. 15).

Step 1
Budgeting
Based on space use programs the "theoretical minimal dwelling" units are determined. These units, combined with a specific quality level description, give a cost figure. Additional costs relative to the local market and the local soil conditions are determined. A financial margin is added to arrive at the maximum budgets per dwelling program.

These maximum budgets relate to the complete dwelling units in the "traditional" way or to the sum of support and infill.

Separate budgets for Support and Infill

Particularly when separate bids are asked for support and infill, separate budgets will be needed. There are, basically, two possibilities:

1. In a "description of levels" a specification is given as to which parts of the building will belong to the support and which to the infill. For a few parts the decision may be left open because for choice to be made only in a later stage of the process. Taking the "theoretical minimum dwelling" as a point of departure, costs are estimated for the infill and the unallocated parts. The budget for the support will then be the sum for the total budget minus the infill costs, the costs of the unallocated parts and a part of the financial margin related to infill. Finally this support budget is reduced by the expected economies of construction costs due to a shorter construction time, etc. In this way, the total budget is divided in a support budget, a budget for the unallocated parts and a budget for the infill.

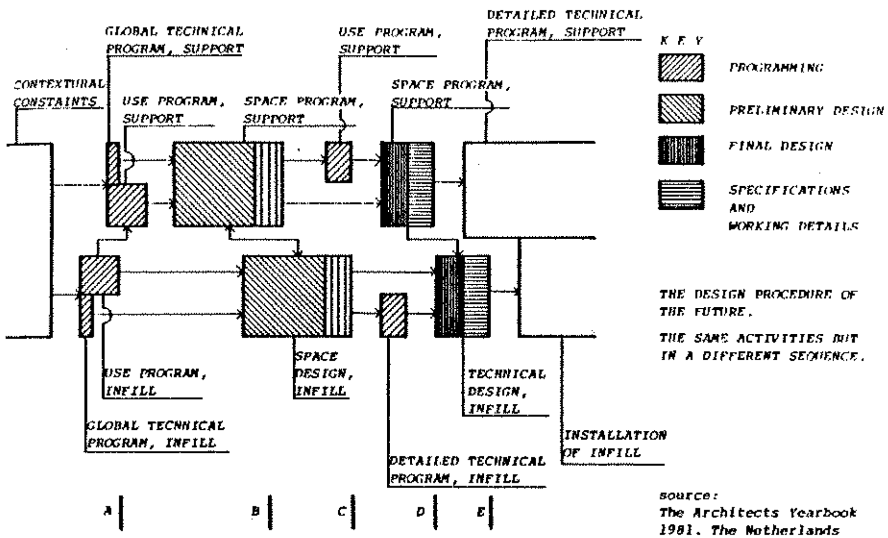


FIGURE 15.

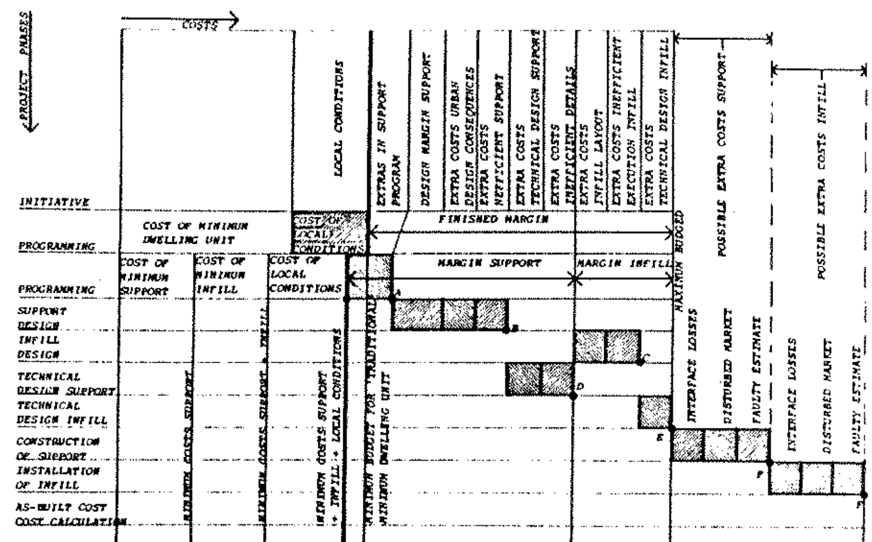


FIGURE 16.

2. After the separation of the building parts in support and infill categories, cost estimates are made for the support as well as the infill, based on the "theoretical minimum dwelling". For those parts that have not yet been allocated separate budgets are made. The margin available between the sum of these budgets and the total available budget is then distributed among the three separate budgets.

Step 2
Evaluation point A
The support program as well as the infill program are scrutinized for extra costs as compared to the points of departure. This happens in evaluation point A as indicated in the chart (fig. 16). These extra costs may already use part of the margin available in the partial budgets.

Step 3
Evaluation point B
There will be a "space design" of the support with layout examples to demonstrate that the space program does fit into the support. The support will be compared to the "theoretical reference units" of similar type and size relative to floor area, facade area, bay dimensions, etc., as discussed in the previous chapter on the ARO method.
The comparison between design and theoretical dwelling units will indicate to what extent the designer has succeeded to accomodate the support to the use program without "losses" (the design margin in the support). In addition the space design will be evaluated for its impact on the building process and the urban design. Compared with the available financial margin for the support this will give an indication of the feasibility of the design. (a correction must also be made for support walls that serve as partitioning within the dwellings.)

Step 4
Evaluation point C
The space design for the infill is final at this stage. Its costs can be assessed as compared to those of the theoretical dwelling unit. This is a simple process concerning total area for partitioning, number of doors, sizes of wet cells, etc. A correction must be made where support elements serve as partitioning. This evaluation will show how much of the financial margin for infill is used. There are today costing methods for infill packages that allow for a rapid estimation of infill variations.

Step 5
Evaluation point D
Specification and technical design of supports are final:
The evaluation is done as follows:
- Determination of final budgets for support based on dwelling layout. Budget estimates for the support and comparison with final budgets.
- Evaluation of support contractors estimate and price negotiations.

Step 6
Evaluation point E
Now the infill is final as well
- Calculation of final budget for completed ("traditional") dwelling
- Calculation of final budget infill
- Budget estimate for infill
- Evaluation of "contractors estimate" for infill and cost negotiations.
- Evaluation of costs for support and infill compared to final budgets for completed ("traditional") dwelling.
- Evaluation of separate costs for support and infill as compared to separate budgets.

Evaluation point F
The contractor for the support and the contractor for the infill will find after completion of the job whether a profit has been made or not. If profits were larger than expected the experience will not necessarily lead to lower prices in the next project. Losses, however, always lead to higher bids in the next project.
The chart of fig. 16 gives the relations between the cost elements and the project phases. The evaluation points have been indicated.

PARCELLING OF SUPPORTS

The capacity of the support to allow for alternative distributions of units of variable sizes may be available in the design phase only. This offers the opportunity to re-distribute dwelling units in the design until the project planning process is completed and bidding begins. However, the capacity for variable distributions may remain in the actual support building. When this is the case we speak of a support that can be parcelled. In that case it is possible to change dwelling sizes in the future. To build a support that can be parcelled demands extra costs. These costs are in fact an investment intended to avoid costs in the future; they consist of facilities in walls and floors such as:
- Openings in walls temporarily closed with removable materials
- Floors that can be partially opened to accomodate stairs
- Openings in floors that allow for future vertical ducts
- Extra joints in the supports basic drainage system to allow for later connections of additional drains.

The costs for these facilities usually imply an extra, but modest, budget of about Dfl. 1500.00 per dwelling unit; this figure is very little compared to the future savings it makes possible.

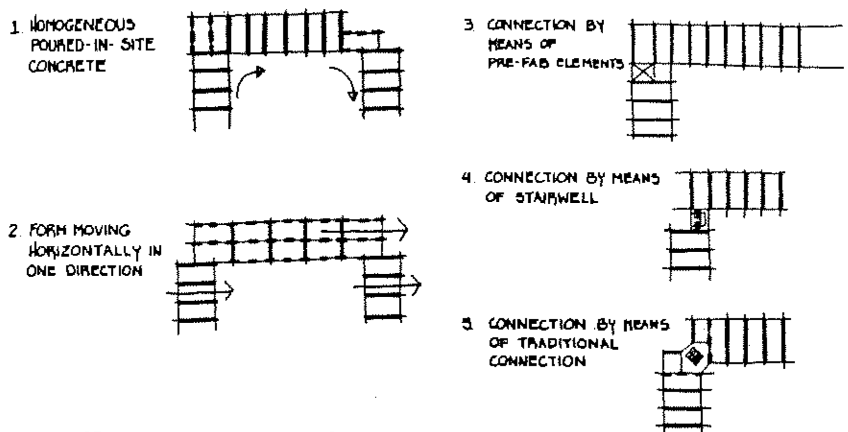


FIGURE 17. CORNER SOLUTIONS; 5 TYPES

The choice of the support type is perhaps the most important design decision.

For this choice, two points are important:

- The support must accomodate the variety of dwelling programs without using a significant amount of extra floor area: there must be a tight fit.
  The support must allow for an efficient construction method.

The first point means that excess floor area for the sake of adaptability and variety must be avoided. With the little slack available in today's economoy this is understandable. It appears that the design of supports that can be parcelled tends to lead to more generous floor areas. This must be weighed against the considerable advantage of future adaptability.

In case of future change the cost to rearrange the infill for a given floor area of a support area is insignificant compared to the costs needed to rehabilitate that same area in a non-adaptable building.

As to the second point, the optimal use of the chosen building system is perhaps equally important in terms of cost as the matter of excess floor area.

ISSUES OF SUPPORT DESIGN

To design is to choose. The choices made can influence costs in an important way.

Consider what *building system* is adequate for the implementation of the design. Size of the project as well as type of support determine what is the best building system.

Influences on the load-bearing structure:

- Standardize major dimensions like bay widths and depths.
- Choose fixed and uniform openings for stairs and vertical ducts.
- Determine fixed and uniform positions for metering of utilities: water, gas, electricity.
- Make uniform floor heights.
- The way the system "changes direction" (see fig. 17) is important: this should interrupt the work as little as possible.
  If the support contains ducts, these must be distributed in a uniform and regular manner and be kept independent of the infill.
- The use of cranes should be kept in mind: all parts must be within easy reach.

Influences on the building skin.

- Roofs to be composed of a standardized set of roof elements.
- Reduce the number of ways in which roof and facade connect.
- Try to standardize the connection of roof and facade, floor and facade, and floor and roof (see Nen 2883. Dutch norms for coordination of building elements in housing).
- Elements heavier than 60 kg should be part of the structure, not of the envelope (exceptions are acceptable for the first 10 feet above ground level).
- Staggering of the facade should be in logic relation with all related parts (roof, floors).
- No masonry on top of pitched roofs.
- When prefabricated concrete elements are used the reduction of element types is extremely important. Cost may vary between Dfl. 800 to Dfl. 1500 per cubic meter due to the number of element types done.
- The position of the central heating unit has an impact on distribution of ducts and costs for ventilation ducts.

Influences on on-site organization.

- Shorter construction time and less use of cranes are important to reduce costs.

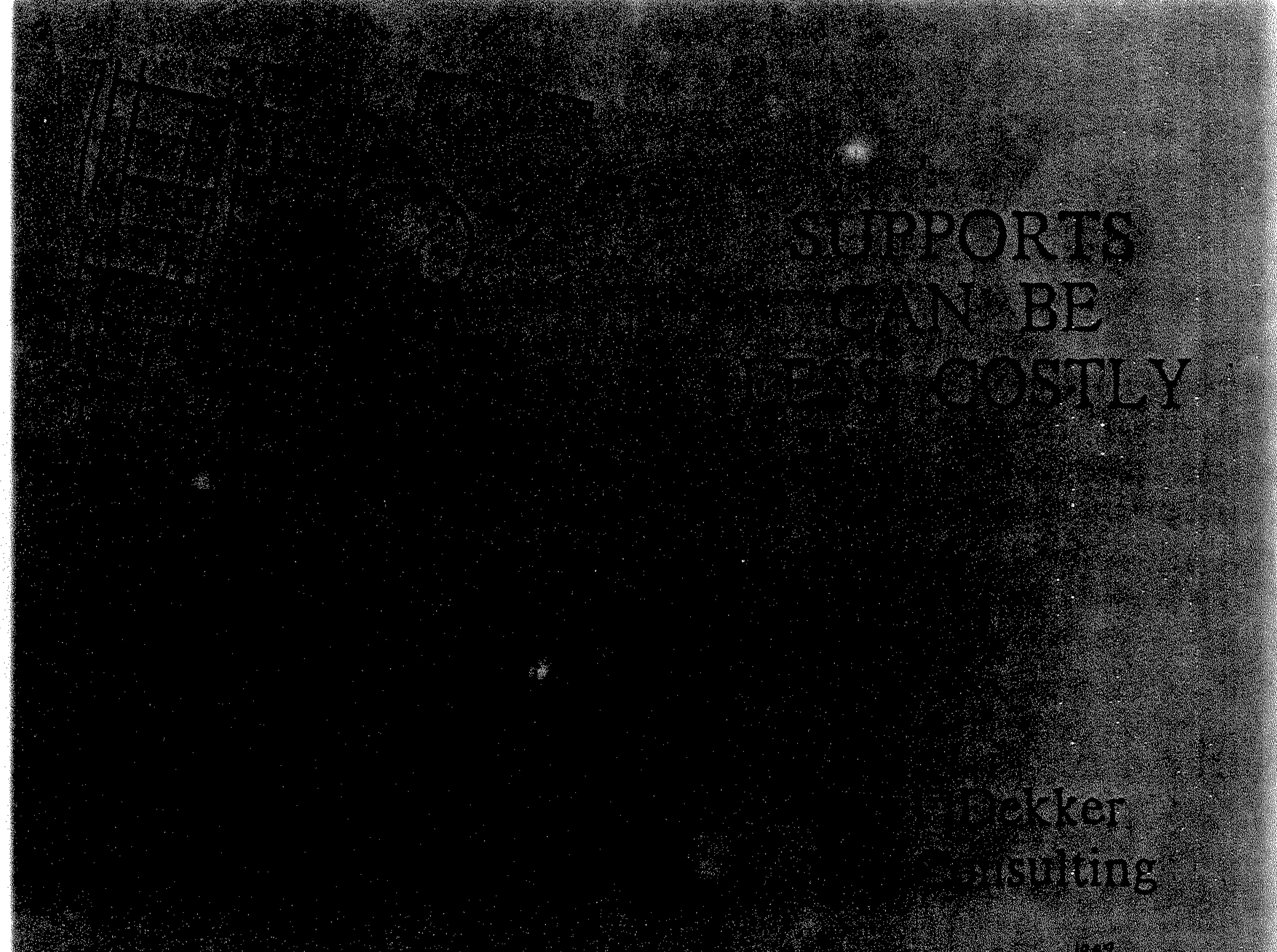
To find extra costs incurred relative to the "theoretical minimum" in the construction phase a checklist is available that is also used in the evaluation of Step 3 in "Support, Infill and Cost Control."

SUMMARY

Separation of Support and Infill can be successful and competitive on the short term on condition that the design of the support does not give too much extra floor area compared to the theoretical minimum floor area for dwelling unit types, and that the support can be built efficiently.

In the long run, large scale application of the support/infill approach can lead to significant improvement of productivity. This may become an important contribution to our attempts to keep housing financially feasible for those who need it most. It may also increase quality.

The project planning process can be accelerted significantly by means of separation of support and infill and cost control can be greatly improved.



SUPPORTS CAN BE LESS COSTLY

Dekker Consulting

1982

PREFACE FOR THE ENGLISH TRANSLATION

The Dutch Architects Yearbook of 1982 focussed on housing issues and policy. Of five articles, three were specifically about the design and construction of Supports and the realization of a variety of dwelling plans in them by means of infill packages utilized according to the preferences of the user.

One of these articles dealt with issues of costs relative to the Support idea and presented a specific method for budgeting Support projects. It has often been argued that Supports inevitably will lead to high costs at the short term although they admittedly will have their economic advantages at the long term. Karel Dekker argues that careful planning and design may lead to short term advantages as well that may balance the extra costs for adaptability. He reports on a number of projects that have been completed recently in the Netherlands. The article reflects the specific Dutch conditions in which these projects have been implemented and it is clear that conditions in other countries call for their own design strategies in the Support concept to find the most advantageous solution.

However, this is for the first time that a serious and detailed study is published on the economic aspects of Support implementation. Karel Dekker's work sets an example that may lead to similar studies in other countries by other experts.

The author, who was trained as an engineer and architect, is senior partner in ARO—consultants for cost management and project planning in building. He is a member of the board of SAR, the architects research foundation in Eindhoven, the Netherlands, that initiated the methodology and philosophy for Support housing.

INTRODUCTION

In this article we will examine how the separation of Support and Infill creates the opportunity for a better control of costs during the design phase and for short term and long term cost effectiveness.

These are cost reductions that do not influence the quality of the product. Moreover, they will be effective during the lifetime of the building.

On the basis of experience in practice we will examine to what extent it is already possible today to build Support/Infill projects that are competitive. Subsequently we will discuss a study by ARO about possible cost reductions due to the Support Infill approach at the short term and we will make a prognosis for long term cost effectiveness. In the chapter on *process control* we deal with the opportunities offered by the separation of Support and Infill for better cost-control during the design phase.

The extra costs necessary for Supports that allow for free choice of dwelling size and change of dwelling size will be discussed briefly at the end of this article.

First approach by contractor	
Estimate complete dwelling (basis type)	*± 57,500*
Less: interior partitioning sanitary equipment electrical circuits mechanical ventillation	*± 9,000*
Costs infill package(prefab)	*± 16,000*
Difference	*± 7,000*
Conclusion: Not feasible	

Second approach	
Estimate support Structural facades, roof, partywalls, etc. central heating ducts finished support	*± 45,000*
Infill package(prefab)	*± 16,000*
Total per dwelling	*61,000*
Traditional	*57,000*
Difference	*3,000*
Advantages, less interest and insurance	*± 1,500*
Extra costs	*± 2,000*
(approximate figures)	

FIGURE 1. (from De Architect no. 10-1980)

EXPERIENCE FROM PRACTICE

As a consultant for costing and as coordinator, ARO has been involved with a number of projects in which the Separatative Support Infill was applied. A report on our experiences will be given here. These experiences relate mainly to cost reduction and process control.

STERRENBURG III, DORDRECHT

In the city of Dordrecht, the project called Sterrenburg III contains 279 units built according to the Support Infill principle with application of Bruynzeel infill packages. The cost effectiveness of the infill package gave great difficulties in the planning stage of this project, which was designed by architects De Jong, Van Olphen, Bax. The builders had estimated costs based on a traditional way of finishing. The costs for "finishing" in this budget were considered to be the sum available for the infill package. The result was a large price difference: about dfl. 7000 - per dwelling. (see fig. 1.)

In a later phase, however, a separate cost estimate for the Support was made to be combined with the costs for the infill package. This combination, when compared with the costs of the traditional alternative, showed a significantly smaller price difference. Still, in this case, certain advantages of Support/Infill were not calculated: for instance, the electric circuit was mainly incorporated in the Support. In addition, there was no experience with this way of building. The comparison therefore was not entirely valid: it was clear that a correct budgeting procedure is essential for an understanding of the feasibility of a Support/Infill project.

In retrospect it can be concluded from the 279 units in the Sterrenburg III project that in 1977 the Support/Infill with an "industrialized" infill package was more expensive than a traditional project. Neither was it financially feasible to build a support without any electrical circuitry: the costs of such a circuit that was left outside the concrete structural walls were too high compared to the traditional way of installing the electrical circuit. Only in 1979 an ARO study would show that the cost reductions of building a support were significant enough to pay for the extra costs of the infill. (fig. 2)

LUNETTEN PARTIAL PROJECT 4D, UTRECHT

A Support/Infill project is in execution within the Lunetten development project. It is designed by Arch. Frans Van der Werff of "Werkgroep Kokon" (see figs. 4, 5, and 6) The 4D project is in fact a continuation of the

Concrete structure

- *no ducts in structure*
- *standardised openings*
- *maximum use of forms*
- *no disturbing of structural work by subcontractors*
- *less repair, less openings*
- *no changes in formwork details*
- *larger continious series*

} *direct costs*

Administrative costs

- *less cost for project preparation*
- *less cost calculation*
- *less cost for on-site office*

} *overhead costs*

On-site costs

- *less transportation of materials on site*
- *less storage on site*
- *shorter construction time*
- *less personnel needed for coordination*
- *less drafting work needed for execution*
- *faster start of construction*
- *less help to subcontractors*

} *on-site costs*

General

- *less borrowing costs on land and construction expenses*
- *less expense for risk coverage*

} *clients cost reductions*

FIGURE 2. ADVANTAGES AS DISCUSSED IN 1977 PROJECT TEAM

		per dwelling
- extra costs support because of six different building locations		dfl 2,400
- extra cost for space to facilitate flexibility		dfl 1,700
- extra cost to connect bays for variety in dwelling size, as specified:		
central heating system	dfl 1,000	
adaptable facade elements	dfl 600	
extra cost ducts	dfl 200	
openings in walls	dfl 200	
	subtotal :	dfl 2,000
- costs for participation of user		dfl 400
	TOTAL :	dfl 6,500 -/per dwelling

FIGURE 3. EXTRA COSTS FOR PLAN 4D, LUNNETTEN.

experimental project Molenvliet in Papendrecht, completed in 1977. At the beginning of our activities in January 1979, the bidding procedure of the project had been a failure. (The figure submitted by the lowest bidder had been considerably higher than the architect's estimate.)

An attempt was made to arrive at a better price by consultation with the lowest bidder. As this builder did not "believe" in the advantages of the Support/Infill approach it looked as if the project had to be done the traditional way. However, in that case an extra subsidy for experimental projects would be withdrawn. After this initial failure in 1979 a new start was made with another builder (de Waal Co., a subsidiary of the Wilma Co.) The design of the support was adapted to allow for more efficient building execution in close consultation between architect, builder and cost-consultants. Particularly the corners of the building were changed to make continuous undisturbed construction possible, utilizing "tunnel" formwork. The use of Modular Coordination principles according to N.2883 (the new Dutch norms for modular coordination in housing) yielded a cost reduction; now four tunnel forms could do the work of six in the same time span. This was achieved because of the standard floor height of 2.7 meters (previously norms requested different heights for ground floor and bedroom floor spaces.), and because the variation in dwelling sizes and dwelling types in a support structure does not influence formwork sizes or details.

In this way the costs of the "expensive" support could be substantially reduced. This reduction balanced the extra costs needed to make "re-alottment" of the support possible (e.g., the permanent possibility to change dwelling size within the support). This, in turn, allowed the client to react to the changing demands of the market by increasing the number of dwellings even just before the execution of the project without any change of the support design. In this "experimental" project the users were free to decide the layout of their dwellings. They did not have to adhere to current space standards. The result is that no two dwellings are the same whereas the impact of this variety on costs was limited.

Conclusions that can be drawn from this project are:

- It is very important that the support design be closely related to the advantages of the chosen building system to utilize as much as possible the supports potential for continuous and uninterrupted execution.
- The support design should not increase building volume to achieve the desired flexibility.

It is particularly important that the structural module is small enough to relate closely to the increments of dwelling size. Otherwise the increments of dwelling size offered by the support will be too large for the programmatic increments of dwelling sizes. In this particular project the bays of 5.40 x 10.80 meters made for too large increments.

SCHIEDAM INNER CITY

This is a project of 100 units being the first phase of an inner city project by architect A. Kuypers of the office of Treffers & Polgar. Our study on "Costs of Support/Infill" had already shown that the separation of Support and Infill was particularly advantageous in smaller projects. In addition, this particular project had such a short planning time that the "traditional" procedure of design and building execution could not be followed. Following ARO's advice the municipality of Schiedam agreed to the use of the Support Infill approach and of Modular Coordination. ARO was hired to coordinate the team of architects and builders in its capacity of cost-consultant and consultant for Support/Infill and Modular Coordination. This opened the way to use to a maximum the advantages of Support/Infill in combination with Modular Coordination.

a. Procedure

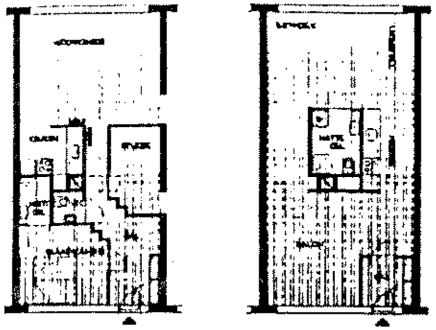
The preliminary design of the architect was completed in January, 1981. The client (municipality) demanded that construction begin in mid-summer. Now, the procedure for approval of an inner city renovation project takes at best a year, which made the time frame virtually impossible.

To gain time the following steps were taken:

- An accelerated bid-procedure based on separate bidding on Support and Infill.
- Parallel design of the space plan, the infill and the parking garage under one of the buildings.
- ARO determined beforehand what would be Support and what Infill. It was known that an "industrial" infill system would be utilized. The distinction between Infill and Support was also observed in the specification document.
- A consultant for mechanical equipment (plumbing, electricity, heating), who had experience in the Support Infill approach in several previous projects, was hired.
- The plans to be submitted for government approval were budgeted three ways by ARO: on the basis of the program, the dwelling variety as required and the capacity of the Support.
- A building team contract was put together with the builder for the support and the separate contractor for the infill. In this document, a number of cost related issues were specified such as: overhead costs, profit and risks, and on-site costs as related to the very short construction time possible in this approach.
- The specification for the infill was submitted by the infill contractor.
- The specification for the Support was done separately.

b. Budgeting in the Programming phase.

The budgeting in the programming phase was done in the way usual for the municipality



EXAMPLE OF MAXIMUM INFILL

EXAMPLE OF MINIMUM INFILL

FIGURE 4.

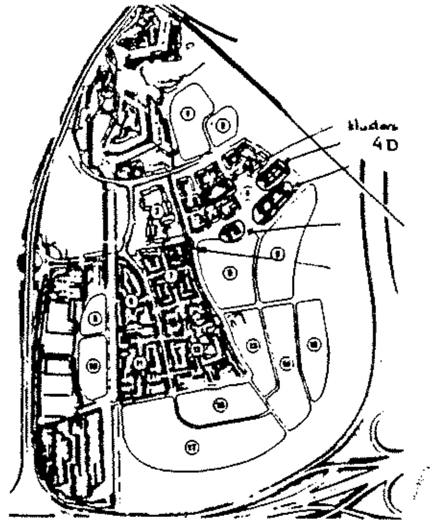


FIGURE 5. OVERVIEW
TOTAL LUNETTEN PROJECT

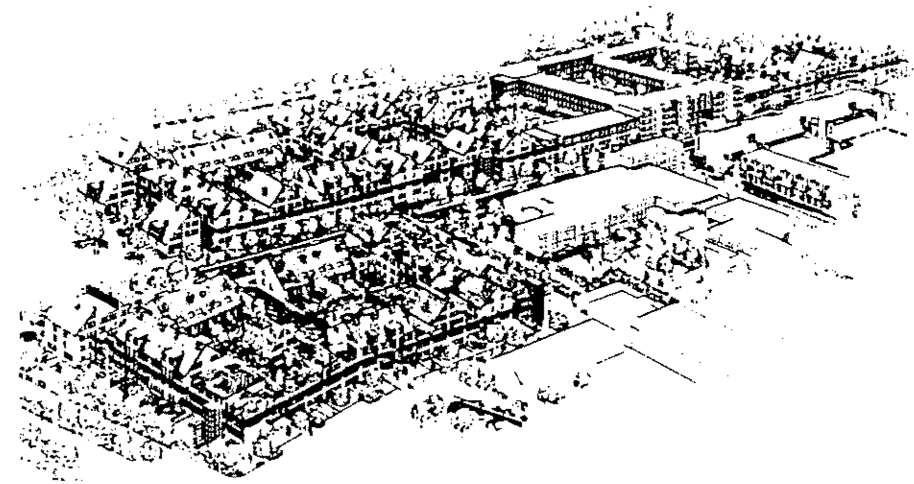


FIGURE 6. PLAN 4D (WITH PITCHED ROOFS) IN LUNETTEN PROJECT

of Schiedam (as developed previously by ARO).

c. Estimating costs in the design phase.

The Support design was evaluated on the basis of the minimum floor space required by the program as applied to the support and expressed in the VE's (VE is a unit in which space capacity is expressed: e.g., a living room = 1 1/2 VE. so is a master bedroom, but a 1 person bedroom is 1/2 VE. etc.). This evaluation showed that the programmed variation of dwelling sizes fitted very well in the support. Evaluation on construction efficiency showed that the design, in spite of the complex program, could be built efficiently (thanks to modular coordination and Support/Infill separation). This gave extra capacity in the budget which was used almost completely for some architectural and site specific "qualities" like bay windows, etc. In addition an extra Dfl. 3000.00 per unit was used for energy saving devices.

d. Budgeting in the Specification phase

Based on the evaluation as described under (c), the final program was decided upon, and the available budget was determined accordingly. At the same time, cost estimates were worked out for the final design to check its possibility within the available budget. The estimates used the information now available in working drawings and specifications. The builders made an estimation for the support. The producer of the infill package made a bid on the infill. After negotiations with both parties it turned out that costs of Support and Infill were within the budget estimate. In the meantime, to gain time, the budget estimate had been the basis for the formal request for cost allocation to the client.

e. Contracts

The building procedure being concluded, contracts were made up with the Support builder and the Infill contractor.

f. Conclusions to be drawn

The use of modular coordination and the Support/Infill approach can yield important gains in construction time. It has to be taken in account in this example that only a few of the participants were familiar with the Support/Infill approach and with modular coordination. If all parties have experience with these methods the project time can be reduced even more.

The calculation of so called excessive costs was made for the "traditional" way of building for the same design for reasons of comparison. This showed that the disturbances would be such that the costs per dwelling would be much higher. (See fig. 9)

The start of the project was finally retarded because of a complaint filed by local groups against the municipality. This only shows that there are plenty of difficulties remaining that slow down the process and that cannot be overcome by modular coordination or support/infill separation.

CASE STUDY SUPPORT INFILL

ARO has done a study about the short term implications of complete separation of Support and an industrialized infill package. This study shows that there are some immediate cost reductions because a number of operations can be dropped with the construction of a support. The most significant cost reductions, however, are the result of the shorter construction time. This yields advantages in terms of indirect costs as well as costs of on-site organization. The acceleration of construction time, as indicated in the study, is particularly significant for the point in time where the first unit is finished. Because this construction time advantage remains independent of the size of the project, it is clear that the relative gain is largest for the smaller project. The average construction time of 100 dwelling units can be reduced from 10.5 months to 7.5 months. This means a reduction of about 30% for a variety of time-related items such as interest, etc. For a large project, the impact of construction time reduction will be relatively less.

LONG TERM COST REDUCTIONS

In an article by W. Bakens, the long term cost implications of Support/Infill are discussed. Mr. Bakens states that measures that improve productivity are particularly important for long term gains. Large scale implementation of the Support/Infill approach together with modular coordination can increase productivity. How much gain in productivity can be achieved this way is impossible to say without a serious study. However, it would be interesting to see what results from a productivity gain of 2-4% a year can be expected for future project costs. When it is assumed that productivity will increase from -0.5% today to 2% in the next five years and 4% in the second five year period, project cost after those ten years will be 20% less as compared to the continuation of today's building practice, by a constant quality level of the dwelling unit.

The impact of increasing energy costs on building costs is significant. It is therefore extremely important that the energy related component of building costs be reduced as much as possible. To what extent Support/Infill separation can contribute to this cannot be estimated in the context of this article. Building costs are only a part of project costs. The influence of reduced construction time on additional project costs like interest payments, will remain sufficiently advantageous that a 20% reduction of project costs must be possible. (See fig. 13)

When the separation of support and infill will also be seen as a separation of financing modes, shifts will occur in the proportion of public costs to costs for the user. We can

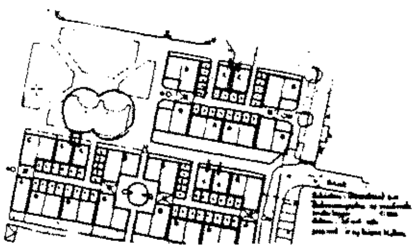


FIGURE 7. SCHIEDAM INNER CITY PROJECT

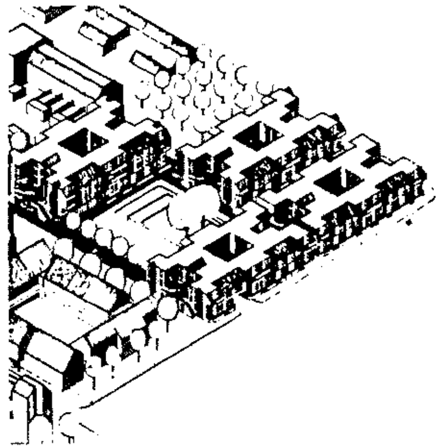


FIGURE 8. SCHIEDAM INNER CITY PROJECT

DIFFERENCES IN 'EXESSIVE COSTS' WHEN THE SCHIEDAM PROJECT WOULD HAVE BEEN EXECUTED 'TRADITIONALLY' PER DWELLING UNIT.

- very large variety: 45 man hour/dwelling	dfl	200
- extra transportation on site	dfl	455
- extra crane time	dfl	330
- precario	dfl	1,000
- guarding	dfl	450
- extra control for half of construction time	dfl	192
- extra costs for water, power	dfl	232
Total extra costs compared to Support/Infill	dfl	4,659

Note: "exessive costs" are the costs above and beyond a normal, uniform, standard housing scheme

FIGURE 9.

consider new management models that become possible, for instance: that support space is rented but the infill is bought. The effect could be calculated in the same way as has been done recently for the calculation of the change of rental units to units for sale by the Institute for Research for Government Finances in the report, "Implications of the Government Budget for Rental Dwelling Units and Dwelling Units for Sale."

COST CONTROL, THE ARO METHOD.

Cost control in relation to the design process in today's practice involves the application of advanced estimating techniques. These techniques, however, are seldom integrated with the design activity nor is cost-control related to the phases before and after the design (that is: the programming phase and the bidding and construction phase.) Hence the important discussion in the programming phase about what is socially acceptable or what quality level and what cost level is desirable, is not touched by cost-control methods. It is only after the social and political decisions are made that the job is done with sophisticated tools to control the relations between costs and quality in the project. As the process goes along the possibility to influence cost levels reduces rapidly. This, at least, is the consensus of most experts.

Before going into the possibilities offered by the Support/Infill approach for better process planning, I will sketch a form of cost planning as applied by ARO consulting. The method is developed in answer to a need to assess in each phase of the planning process the consequences of decisions and design choices in relation to a pre-determined budget. The method is best described by way of a chart that relates planning phases and costs. (fig. 14)

The following aspects of cost planning are involved:

- Budgeting in the program phase
- Estimates in the design phase
- Calculation and evaluation of bids

Budgeting takes place in the program phase. The importance of the determination of a budget before the design phase finds gradually general acceptance. It is characteristic of budgeting that it is done *without* a design. This means that we must use experience from projects in the past as well as facts about local conditions. A budget has several functions in the project development:

- It serves as a basis for agreements or contracts among clients, government, architects and users about financial and quantitative limits within which the projects must be done.
- It serves to estimate in advance the inevitable extra costs related to local conditions, the urban design context, the building program, etc.
- It is a frame of reference to evaluate designs, specifications and cost estimates.

In order to be useful in this way in the development process budgets must fulfill certain conditions:

- It is important that budgets are determined on the basis of detailed calculations.
- It is important that cost data are seriously verified.
- Finally, the budget as determined as well as the quality level that is implied with it must be understood and accepted by all parties.

For the budgeting of building costs in the program phase the ARO-method uses a so-called "theoretical reference dwelling unit."

This is a fictional, simple average dwelling that satisfies the formal minimum standards of the state government for space norms and technical quality. This assures that building quality and use quality are reasonable. This reference dwelling is in fact a set of dwellings of different sizes expressed in VE's (ranging from 2 to 6 VE), (see part A in fig. 14). Hence the minimum solution - that we assume to be unrealistic but theoretically determinable - is, in a given site, the sum of a theoretical model, based on theoretical reference units, plus the influence of local conditions. Local conditions may be:

- Conditions of the labor market and the materials market.
- Conditions of soil.

This sum gives the minimal building costs as related to the given program (fig. 14, column 3, A + B). The range A + B is therefore *independent of the design*. The range C + D in the chart of fig. 14, indicated by the term "margin" gives in fact "losses" that result from additional requirements in the program and from design activities that inevitably will lead to a figure beyond the theoretical minimum. This range may include elements that incur minimal or no losses, but the total of C + D will never be zero.

The theoretical minimum, applied within local conditions, and increased with the margin (C + D) gives the maximum acceptable building budget.

Items for which the margin can be used:

- Difference between theory and practice: A series of dwelling types to be developed within a same support will not be possible without some concessions relative to the minimum.
- The reduction of building sizes, that is to say influence from the urban design.
- Dwelling dimensions may have their impact (floor area, facade area, roof area, bay size.)
- Special additions to the minimum dwelling: (cantilevers, balconies, bay windows, etc.).
- Extra amenities or extra finishes or equipment in the units.
- Other aspects, such as investments to

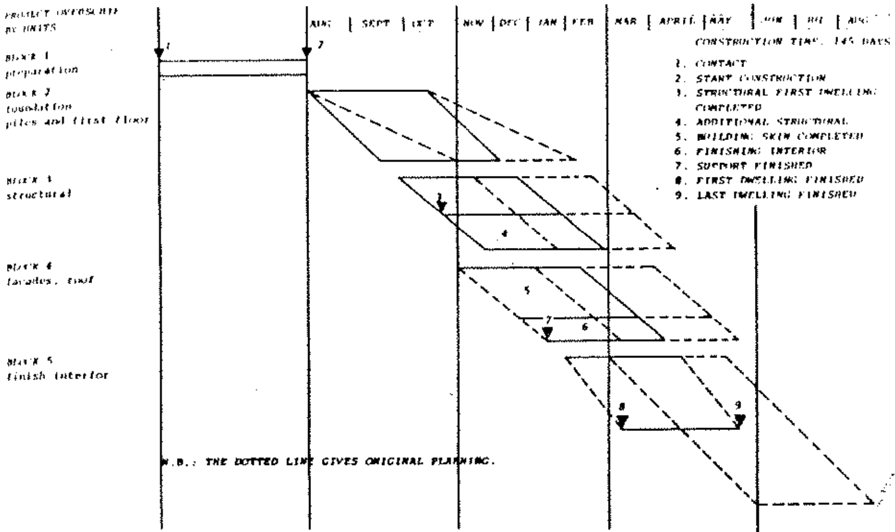


FIGURE 10. PLANNING FOR CONSTRUCTION WITH PREFAB INFILL PACKAGE

minimize future maintenance.

Deviations from efficient building methods. The steps one to six given in fig. 14 can be briefly described as follows:

Step 1

Determination of budget based on theoretical minimum requirements. Calculation of impact of special local conditions like market, soil conditions, project size, the budgets for building costs are completed in this phase with budgets for all other additional building costs.

Step 2

Evaluation of the detailed program for extras as compared to the theoretical minimum (these extras may already take a part of the margin.)

Step 3

Evaluation of the preliminary design against the following aspects:

- Relation between chosen load bearing structure, size, building skin, bay size on the one hand and theoretical minima on the other.
- Relation between urban design aspects and the theoretical assumptions about minimum building block size and staggering of facades.
- Relation between the preliminary design and the optimal construction assumptions that served as a basis for the theoretical minimum such as:
  - Maximum use of foundations and piles
  - Efficient structural design (use of form work, standardization)
  - Efficient configuration of the building skin (angles, facade composition, roof form, etc.)
  - Efficient mechanical installations
  - Efficient finishing (wall area, number of doors, sizes of sanitary cells, etc.)

After step 3 it can already be determined whether the design is feasible within the budget, although based on assumptions about further detailing.

Step 4

After the final design the layouts are exactly known and can be compared to the assumptions of Step 3.

Step 5

Cost estimations can take place after the design process has yielded specifications and principal working drawings and after the selection of a contractor has led to the determination of the building method. (We will, in the context of this article, not dwell on the methods used for the selection of the contractor nor will I describe the subsequent negotiations within the building team.)

COST COMPARISON - BY DWELLING UNITS - PROJECT DE OVERSCHIE - DATE OF ESTIMATION: 12/31/1979.
ALL FIGURES ARE IN DFL

ITEM	("TRADITIONAL") ORIGINALLY	WITH INDUSTRIAL INFILL SYSTEM, SUBCONTRACTOR IS SUPPORT CONTRACTOR	WITH INDUSTRIAL INFILL SYSTEM, SEPERATE CONTRACTOR
1. CONSTRUCTION COSTS WITHOUT OVERHEAD, PROFIT AND VAT REDUCTIONS:	66,000	66,000	66,000
2. FINISHING		15,095	15,095
3. REDUCTION DIRECT COSTS(SUPPORT)		342	342
4. REDUCTION INDIRECT COSTS(SUPPORT)		2,150	2,650
5. NET COSTS SUPPORT		48,414	47,914
6. COSTS INFILL SYSTEM(SUBCONTRACTOR)		17,117	
7. NET CONSTRUCTION COSTS	66,000	65,531	47,914
8. OVERHEAD (5%)	3,300	3,277	2,396
9. PROFIT AND RISKS (4%)	2,772	2,752	2,012
10. COMPLETE CONSTRUCTION COSTS INCLUDING VAT	85,045	84,441	61,740
11. COSTS OF INFILL SYSTEM(SEPERATE BID)			17,117
12. ON-SITE COSTS FOR INFILL			856
13. 18% OVER INFILL			1,325
14. COMPLETE COSTRUCTION COST SUPPORT/INFILL	85,045	84,441	82,948
15. LAND COSTS INCLUDING VAT	15,000	15,000	15,000
16. INTEREST ON LAND COSTS	1,375	1,029	1,029
17. ADDITIONAL LAND COSTS(NOT CHANGING)	5,200	5,200	5,200
18. ADDITIONAL LAND COSTS(CHANGING)			
19. INTERESTS DURING CONSTRUCTION TIME	3,896	2,896	2,847
20. CONTROL	900	700	700
21. PARTICIPATION	400	650	650
22. RISK PREMIUM FOR HOUSING COSTS	4,675	4,002	4,002
23. COMPLETE PROJECT COSTS	116,491	113,918	112,376
24. DIFFERENCE WITH POINT OF DEPARTURE	-	- 2,573	- 4,115

EXPLANATION:

1. EXTRA COSTS (LINE 1) ARE BASED ON ACCEPTED BID FOR 64 DWELLINGS, OVERSCHIE.
2. THE SUBTRACTION OF FINISHING COSTS (LINE 2) IS BASED ON THE FINISHING ITEMS THAT ARE REPLACED BY THE INFILL SYSTEM, AS SPECIFIED IN THE BID FOR THE ABOVE PROJECT.
3. THE REDUCTION COST (LINES 3 AND 4) ARE DERIVED FROM DIRECT AND INDIRECT COSTS AS SPECIFIED IN BID FOR ABOVE PROJECT.
4. ON-SITE STORAGE COSTS HAVE NOT BEEN CHANGED SINCE NO FIRM CONCLUSION COULD BE DRAWN FROM POSSIBLE ASPECTS FOR REDUCTION BY USE OF SUPPORT/INFILL.
5. FURTHER DIFFERENCES IN ADDITIONAL COSTS ARE SPECIFIED IN LINES 18 THROUGH 22.
6. THE NOMINAL FIGURES FOR ADDITIONAL COSTS AS RELATED TO THE ORIGINAL PROJECT SITUATION HAVE BEEN DETERMINED ON THE BASIS OF AVERAGE FIGURES FOR PROJECTS IN THAT REGION.
7. COSTS FOR INTEREST PAYMENTS DURING CONSTRUCTION TIME HAVE BEEN CALCULATED OVER 11 MONTHS FOR THE ORIGINAL PROJECT AND 8.23 MONTHS BY APPLICATION OF THE BOUWRIEEL INFILL SYSTEM.

FIGURE 11. OVERVIEW

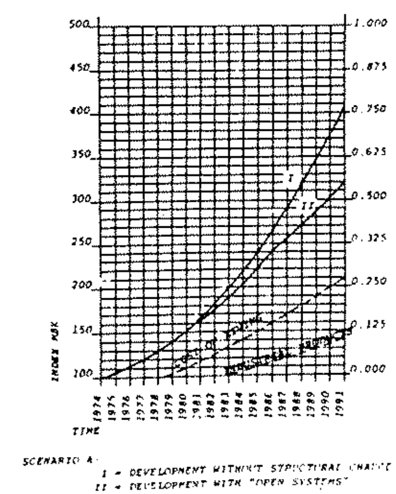


FIGURE 12. GRAPH: LONG TERM COST INCREASE

	1980		1991		1991	
			TRADITIONAL		SUPPORT/INFILL	
	COSTS	INDEX	COSTS	INDEX	COSTS	INDEX
2.1 LOAD BEARING STRUCTURE	16,250	154	42,208	400	34,505	327
2.2 BUILDING SHELL	33,100	154	91,027	421	23,900	363
2.3 MECHANICAL	11,000	145	27,669	140	20,831	254
2.4 INFILL	11,00	156	32,147	425	25,945	343
2.5 ON SITE ORGANIZATION	7,120	162	20,830	443	12,964	287
2.6 OVERHEAD	4,030	151	9,824	371	6,741	256
2.7 PROFIT PLUS RISKS 4%	3,390	153	8,944	404	7,156	120
TOTAL	88,000	153	232,653	404	186,050	120

FIGURE 13. OVERVIEW COST DEVELOPMENTS PER BUILDING PHASE

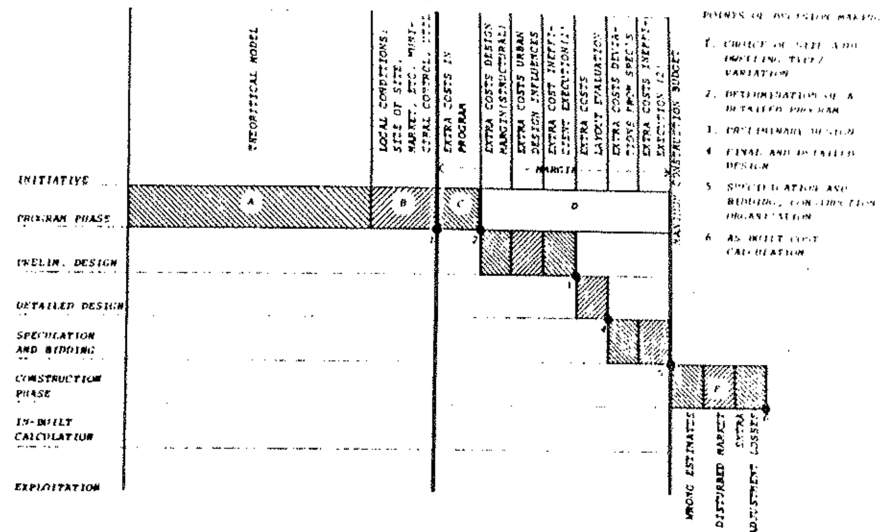


FIGURE 14. BUILDING COST COMPOSITION--PLANNING PROCESS

The subsequent way of working relating to cost estimation may be described as follows:

1. Based on the final design the partial budgets will be decided upon taking into account the final dwelling variation within the project.
2. The budget estimate will be made final. This is also done on the basis of the final design. Principal working details and specifications will be related to the assumptions mentioned in Step 3. This budget estimate gives a reasonable indication for the sum that would be needed to build the project. This budget estimate is still based on the partial budgets for building parts as incorporated in this method.
3. Comparison of the budget estimate with the maximum budget gives an indication of the difference between the real costs and the available resources.
4. The price of the project is finally determined on the basis of a calculation made by the builder.
   - With the selection of the contractor agreements have already been made about overhead, profit and risks percentages, on-site costs, and maximum construction time. An estimate of costs is calculated by the builder taking into account these agreements. The subsequent negotiations about this estimate can be divided in primary discussions about the amounts of material and labor needed and a secondary discussion about unit prices and norms.

Architect and cost-constultant should be knowledgeable about unit prices, norms and on-site organization to be able to negotiate on an equal basis with the builders.

The contract price that is the result of the negotiation is compared with the budget and the budget estimate (step 5.2). When agreement has been reached about the detailed costs the detailed builder's estimate becomes the basis for further negotiations if the costs exceed the initial budget or when the government authorities demand lower budgets or lower rents. Our experience is that it is often necessary during the negotiations to find (in details) more efficient and cheaper solutions. However, this period of negotiations need not last longer than six weeks after receipt of the builder's detailed estimate and we found it always possible to reach a final costs figure that came very close to our final budget estimate.

When we incorporate the separation of Support and Infill in this method a new firmly delineated future design process can be projected, using the same phases A through E as described above. This future design process is illustrated in fig. 15.

SUPPORT, INFILL AND COST CONTROL

What changes take place in the procedure and what possibilities come available in cost planning and cost-control when the separation of Support and Infill take place? There are no solutions available yet but the method described earlier is beautifully compatible with the separation of Support and Infill. Following the schematic description of the project planning process as described by W. Bakens in the architects yearbook, 1981, we will see what steps may be indicated and what evaluations may take place (fig. 15).

Step 1
Budgeting
Based on space use programs the "theoretical minimal dwelling" units are determined. These units, combined with a specific quality level description, give a cost figure. Additional costs relative to the local market and the local soil conditions are determined. A financial margin is added to arrive at the maximum budgets per dwelling program.

These maximum budgets relate to the complete dwelling units in the "traditional" way or to the sum of support and infill.

Separate budgets for Support and Infill

Particularly when separate bids are asked for support and infill, separate budgets will be needed. There are, basically, two possibilities:

1. In a "description of levels" a specification is given as to which parts of the building will belong to the support and which to the infill. For a few parts the decision may be left open because for choice to be made only in a later stage of the process. Taking the "theoretical minimum dwelling" as a point of departure, costs are estimated for the infill and the unallocated parts. The budget for the support will then be the sum for the total budget minus the infill costs, the costs of the unallocated parts and a part of the financial margin related to infill. Finally this support budget is reduced by the expected economies of construction costs due to a shorter construction time, etc. In this way, the total budget is divided in a support budget, a budget for the unallocated parts and a budget for the infill.

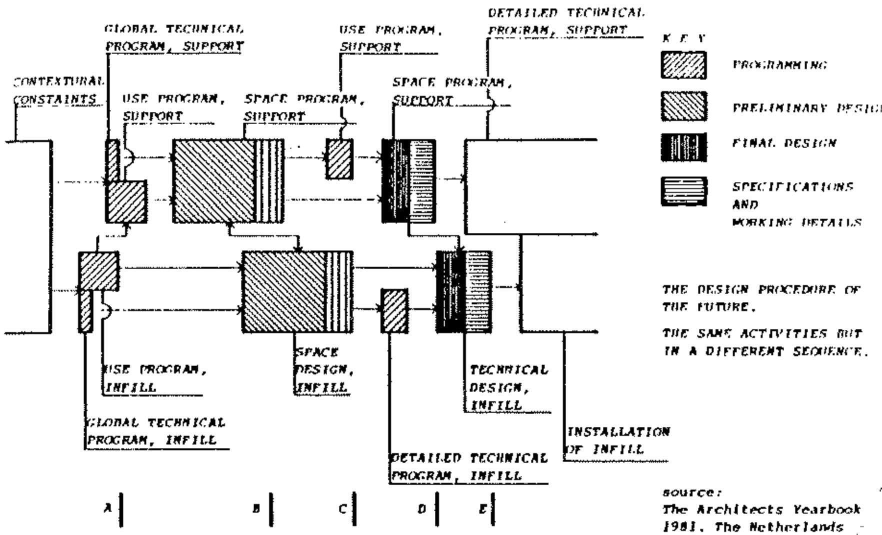


FIGURE 15.

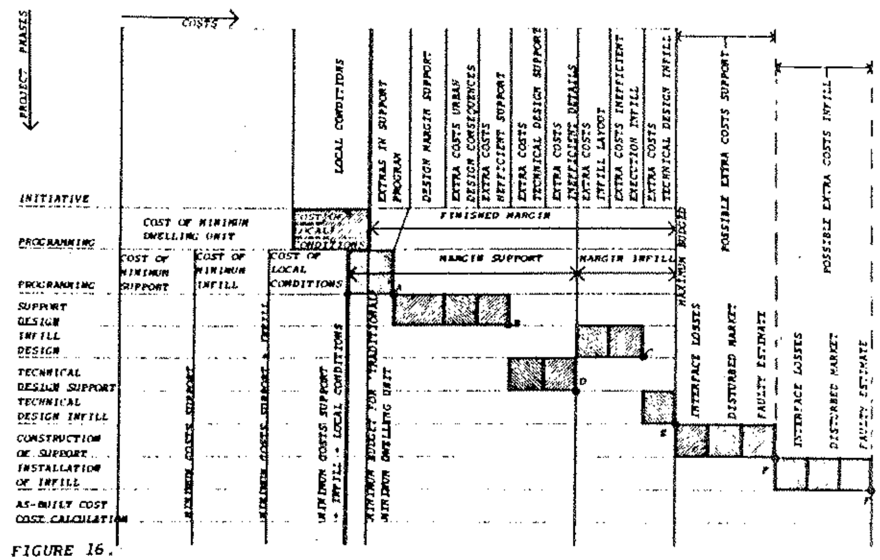


FIGURE 16.

2. After the separation of the building parts in support and infill categories, cost estimates are made for the support as well as the infill, based on the "theoretical minimum dwelling". For those parts that have not yet been allocated separate budgets are made. The margin available between the sum of these budgets and the total available budget is then distributed among the three separate budgets.

Step 2
Evaluation point A
The support program as well as the infill program are scrutinized for extra costs as compared to the points of departure. This happens in evaluation point A as indicated in the chart (fig. 16). These extra costs may already use part of the margin available in the partial budgets.

Step 3
Evaluation point B
There will be a "space design" of the support with layout examples to demonstrate that the space program does fit into the support. The support will be compared to the "theoretical reference units" of similar type and size relative to floor area, facade area, bay dimensions, etc., as discussed in the previous chapter on the ARO method.
The comparison between design and theoretical dwelling units will indicate to what extent the designer has succeeded to accomodate the support to the use program without "losses" (the design margin in the support). In addition the space design will be evaluated for its impact on the building process and the urban design. Compared with the available financial margin for the support this will give an indication of the feasibility of the design. (a correction must also be made for support walls that serve as partitioning within the dwellings.)

Step 4
Evaluation point C
The space design for the infill is final at this stage. Its costs can be assessed as compared to those of the theoretical dwelling unit. This is a simple process concerning total area for partitioning, number of doors, sizes of wet cells, etc. A correction must be made where support elements serve as partitioning. This evaluation will show how much of the financial margin for infill is used. There are today costing methods for infill packages that allow for a rapid estimation of infill variations.

Step 5
Evaluation point D
Specification and technical design of supports are final:
The evaluation is done as follows:
- Determination of final budgets for support based on dwelling layout. Budget estimates for the support and comparison with final budgets.
- Evaluation of support contractors estimate and price negotiations.

Step 6
Evaluation point E
Now the infill is final as well
- Calculation of final budget for completed ("traditional") dwelling
- Calculation of final budget infill
- Budget estimate for infill
- Evaluation of "contractors estimate" for infill and cost negotiations.
- Evaluation of costs for support and infill compared to final budgets for completed ("traditional") dwelling.
- Evaluation of separate costs for support and infill as compared to separate budgets.

Evaluation point F
The contractor for the support and the contractor for the infill will find after completion of the job whether a profit has been made or not. If profits were larger than expected the experience will not necessarily lead to lower prices in the next project. Losses, however, always lead to higher bids in the next project.
The chart of fig. 16 gives the relations between the cost elements and the project phases. The evaluation points have been indicated.

PARCELLING OF SUPPORTS

The capacity of the support to allow for alternative distributions of units of variable sizes may be available in the design phase only. This offers the opportunity to re-distribute dwelling units in the design until the project planning process is completed and bidding begins. However, the capacity for variable distributions may remain in the actual support building. When this is the case we speak of a support that can be parcelled. In that case it is possible to change dwelling sizes in the future. To build a support that can be parcelled demands extra costs. These costs are in fact an investment intended to avoid costs in the future; they consist of facilities in walls and floors such as:
- Openings in walls temporarily closed with removable materials
- Floors that can be partially opened to accomodate stairs
- Openings in floors that allow for future vertical ducts
- Extra joints in the supports basic drainage system to allow for later connections of additional drains.

The costs for these facilities usually imply an extra, but modest, budget of about Dfl. 1500.00 per dwelling unit; this figure is very little compared to the future savings it makes possible.

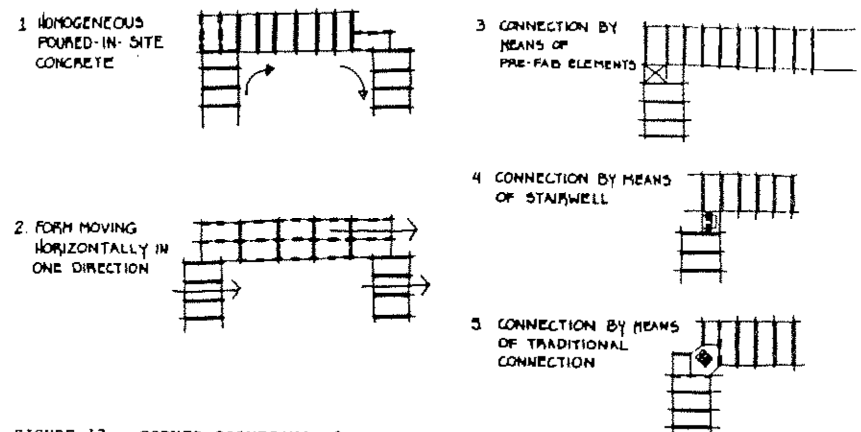


FIGURE 17. CORNEP SOLUTIONS: 5 TYPES

The choice of the support type is perhaps the most important design decision.

For this choice, two points are important:
- The support must accomodate the variety of dwelling programs without using a significant amount of extra floor area: there must be a tight fit.
  The support must allow for an efficient construction method.

The first point means that excess floor area for the sake of adaptability and variety must be avoided. With the little slack available in today's economoy this is understandable. It appears that the design of supports that can be parcelled tends to lead to more generous floor areas. This must be weighed against the considerable advantage of future adaptability.

In case of future change the cost to rearrange the infill for a given floor area of a support area is insignificant compared to the costs needed to rehabilitate that same area in a non-adaptable building.

As to the second point, the optimal use of the chosen building system is perhaps equally important in terms of cost as the matter of excess floor area.

ISSUES OF SUPPORT DESIGN

To design is to choose. The choices made can influence costs in an important way.

Consider what *building system* is adequate for the implementation of the design. Size of the project as well as type of support determine what is the best building system.

Influences on the load-bearing structure:
- Standardize major dimensions like bay widths and depths.
- Choose fixed and uniform openings for stairs and vertical ducts.
- Determine fixed and uniform positions for metering of utilities: water, gas, electricity.
- Make uniform floor heights.
- The way the system "changes direction" (see fig. 17) is important: this should interrupt the work as little as possible.
  If the support contains ducts, these must be distributed in a uniform and regular manner and be kept independent of the infill.
- The use of cranes should be kept in mind: all parts must be within easy reach.

Influences on the building skin.
- Roofs to be composed of a standardized set of roof elements.
- Reduce the number of ways in which roof and facade connect.
- Try to standardize the connection of roof and facade, floor and facade, and floor and roof (see Nen 2883, Dutch norms for coordination of building elements in housing).
- Elements heavier than 60 kg should be part of the structure, not of the envelope (exceptions are acceptable for the first 10 feet above ground level).
- Staggering of the facade should be in logic relation with all related parts (roof, floors).
- No masonry on top of pitched roofs.
- When prefabricated concrete elements are used the reduction of element types is extremely important. Cost may vary between Dfl. 800 to Dfl. 1500 per cubic meter due to the number of element types done.
- The position of the central heating unit has an impact on distribution of ducts and costs for ventilation ducts.

Influences on on-site organization.
- Shorter construction time and less use of cranes are important to reduce costs.

To find extra costs incurred relative to the "theoretical minimum" in the construction phase a checklist is available that is also used in the evaluation of Step 3 in "Support, Infill and Cost Control."

SUMMARY

Separation of Support and Infill can be successful and competitive on the short term on condition that the design of the support does not give too much extra floor area compared to the theoretical minimum floor area for dwelling unit types, and that the support can be built efficiently.

In the long run, large scale application of the support/infill approach can lead to significant improvement of productivity. This may become an important contribution to our attempts to keep housing financially feasible for those who need it most. It may also increase quality.

The project planning process can be accelerted significantly by means of separation of support and infill and cost control can be greatly improved.

"Lunetten"

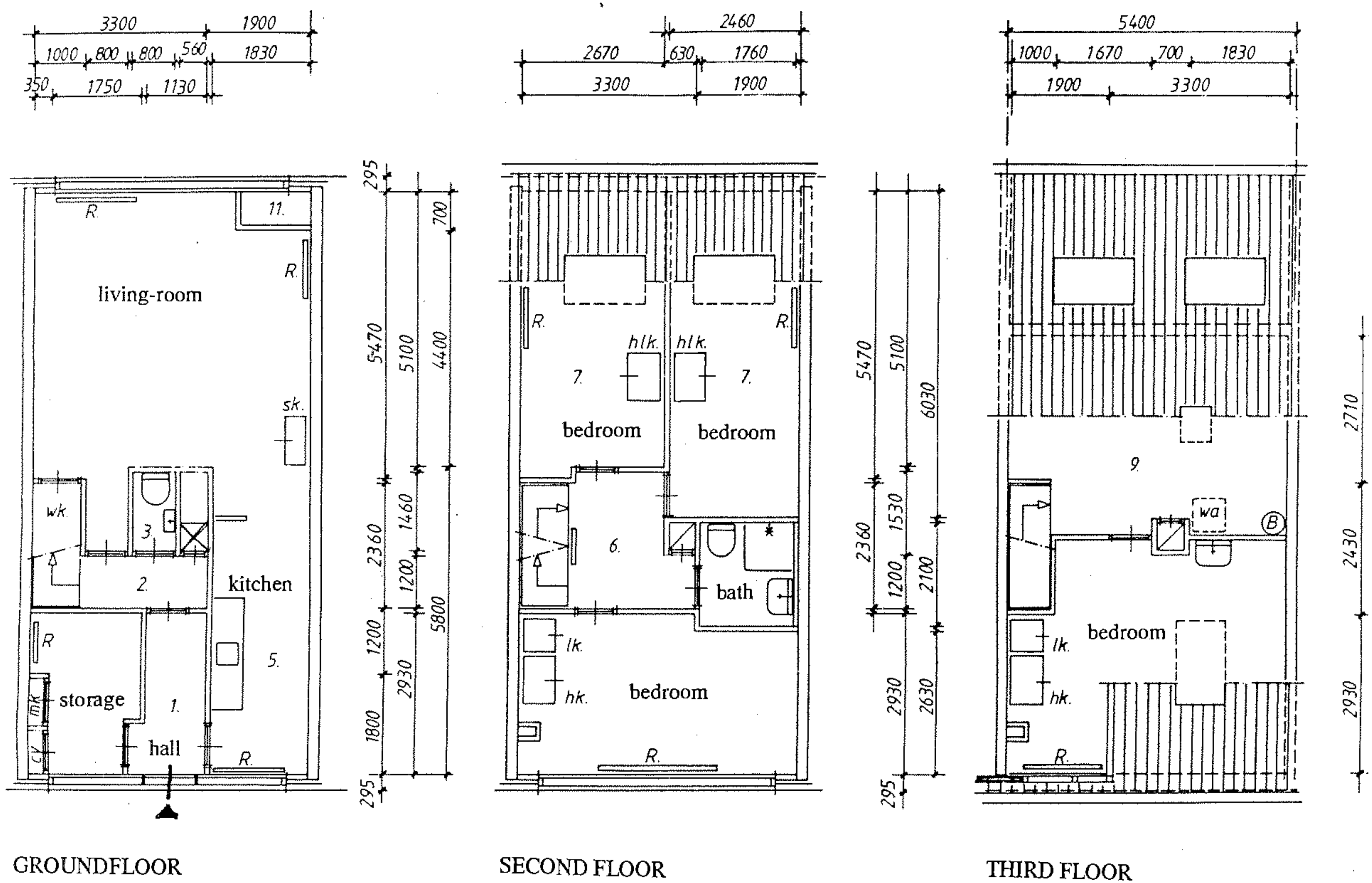
a low-cost Support-Infill project of 430 dwellings for rent
in Utrecht, the Netherlands.

Owner: the Housing Corporation "BOEX", Utrecht.
Architect: Ir. Frans van der Werf, Rotterdam.
Contractor: Wilma-Oost, Utrecht.

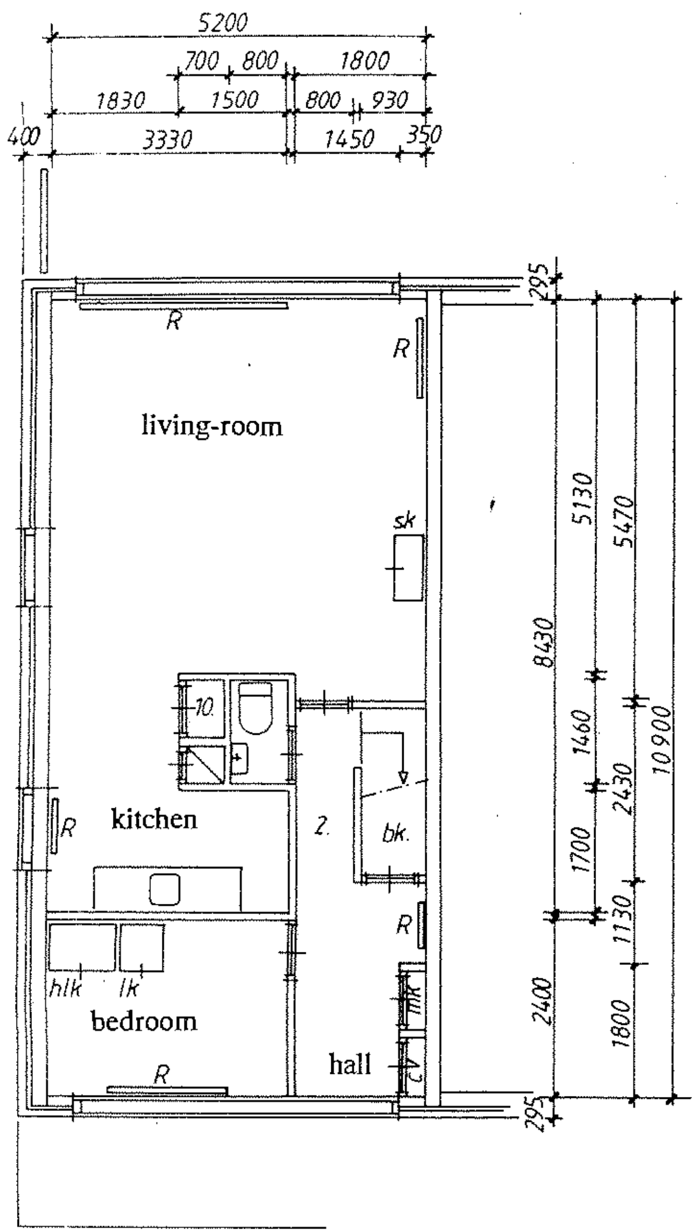
Some Dwelling Lay-outs

Voorschoterlaan 93 - 3062 KK Rotterdam - The Netherlands - Tel. 10 - 404 75 95 / 433 17 38 - Fax. 404 75 68

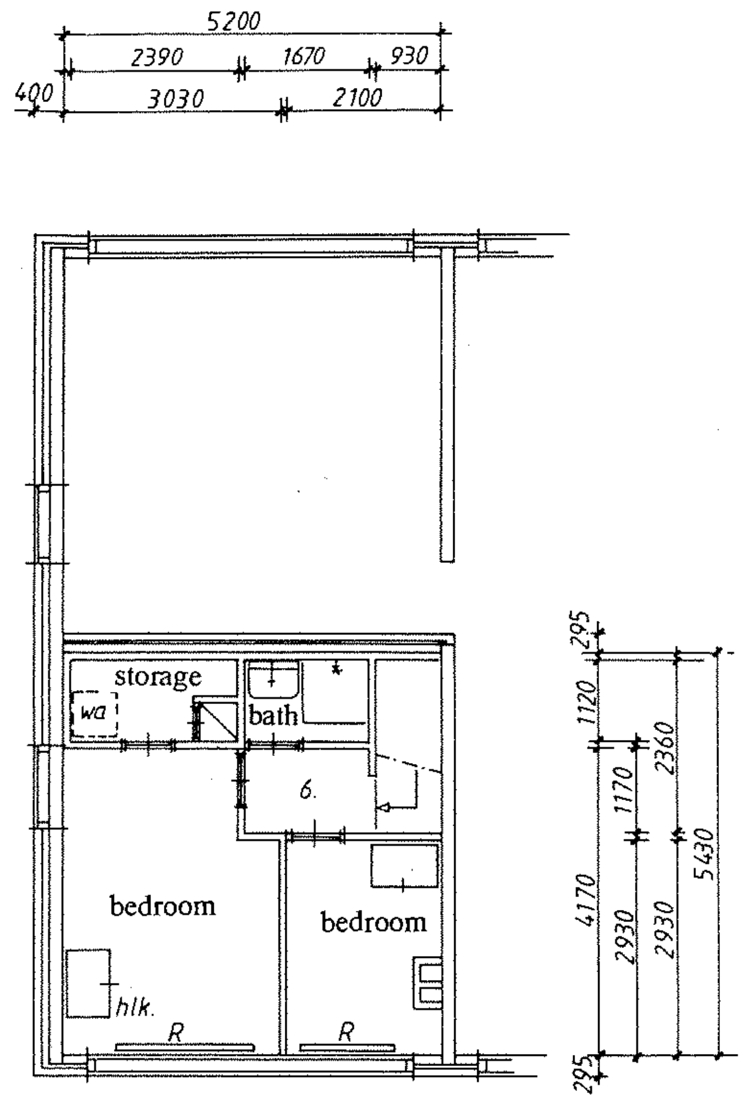

Flexibele woningen
op basis van drager-inbouw



FURKABAAN 35
type C2 - links k.

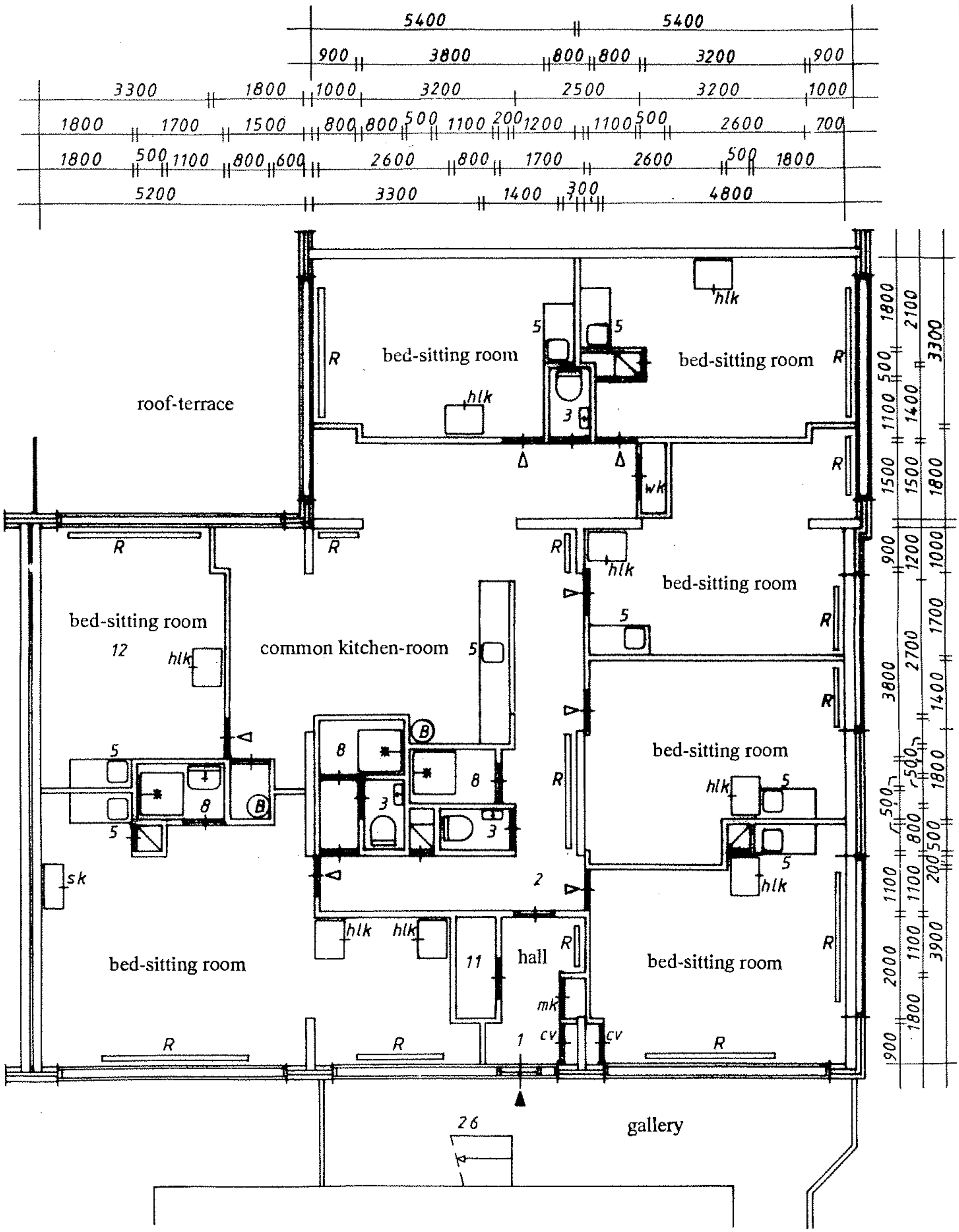


GROUNDFLOOR



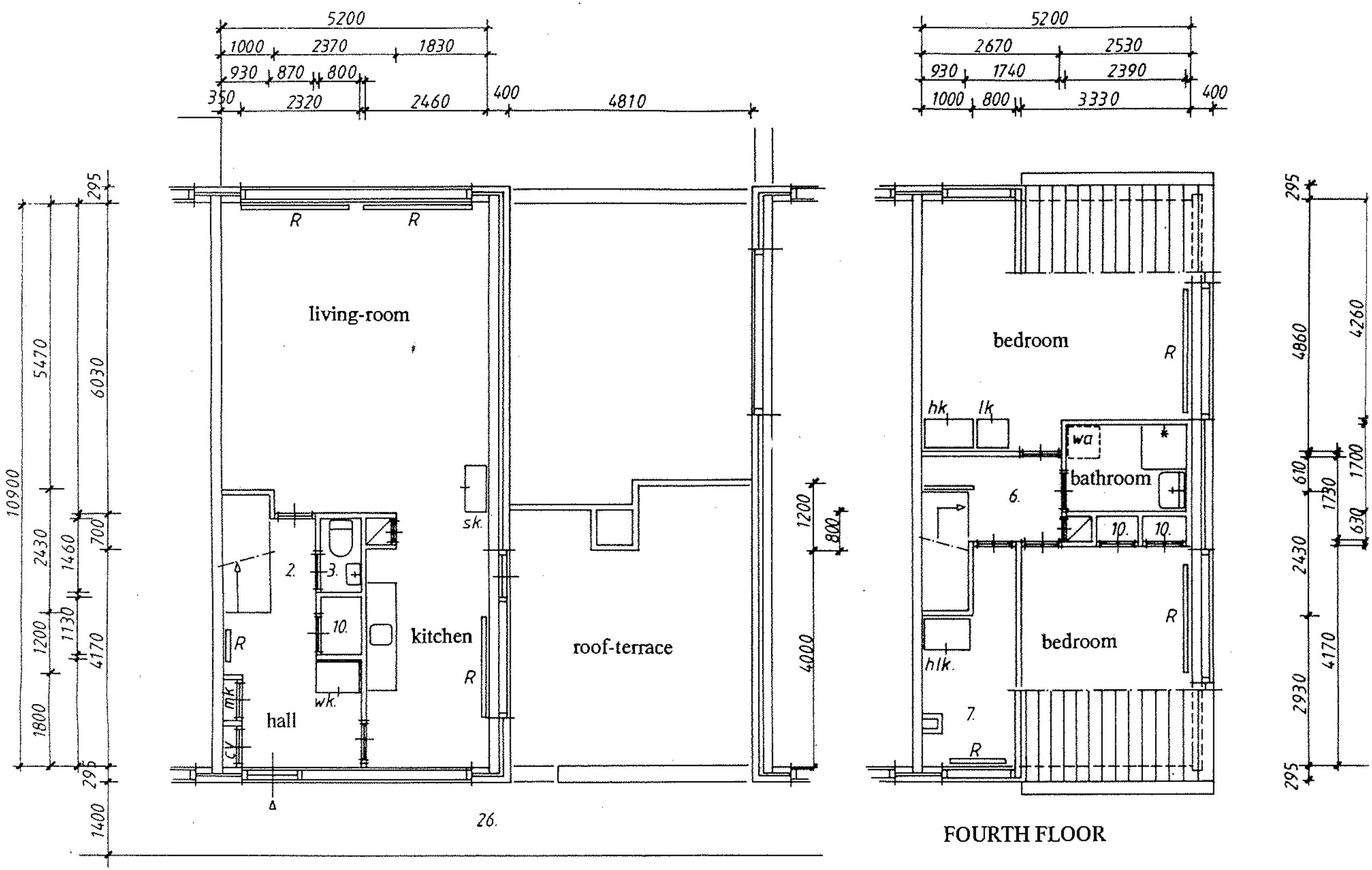
SECOND FLOOR

KLUSTER 7
HONDSRUG 661
type B6 rechts k. 142



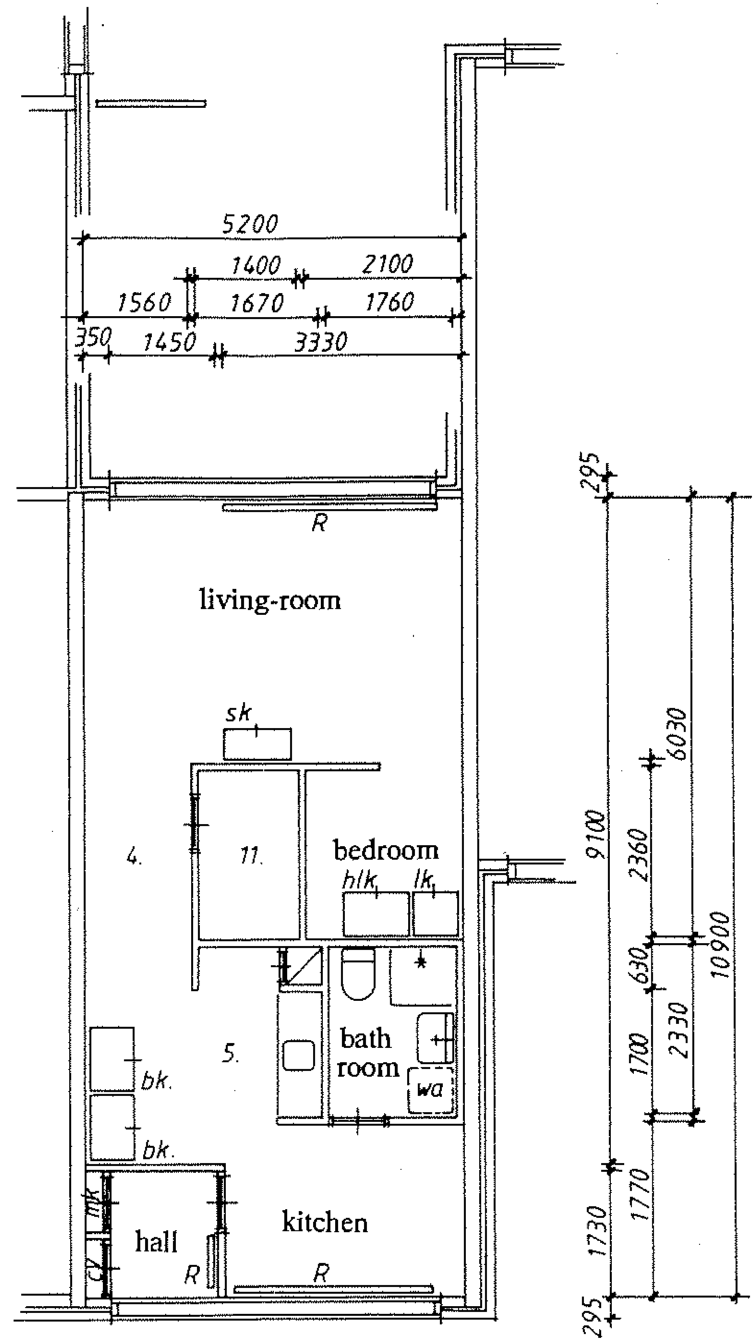
SECOND FLOOR

HONDSRUG 609 t/m 617, 621, 623



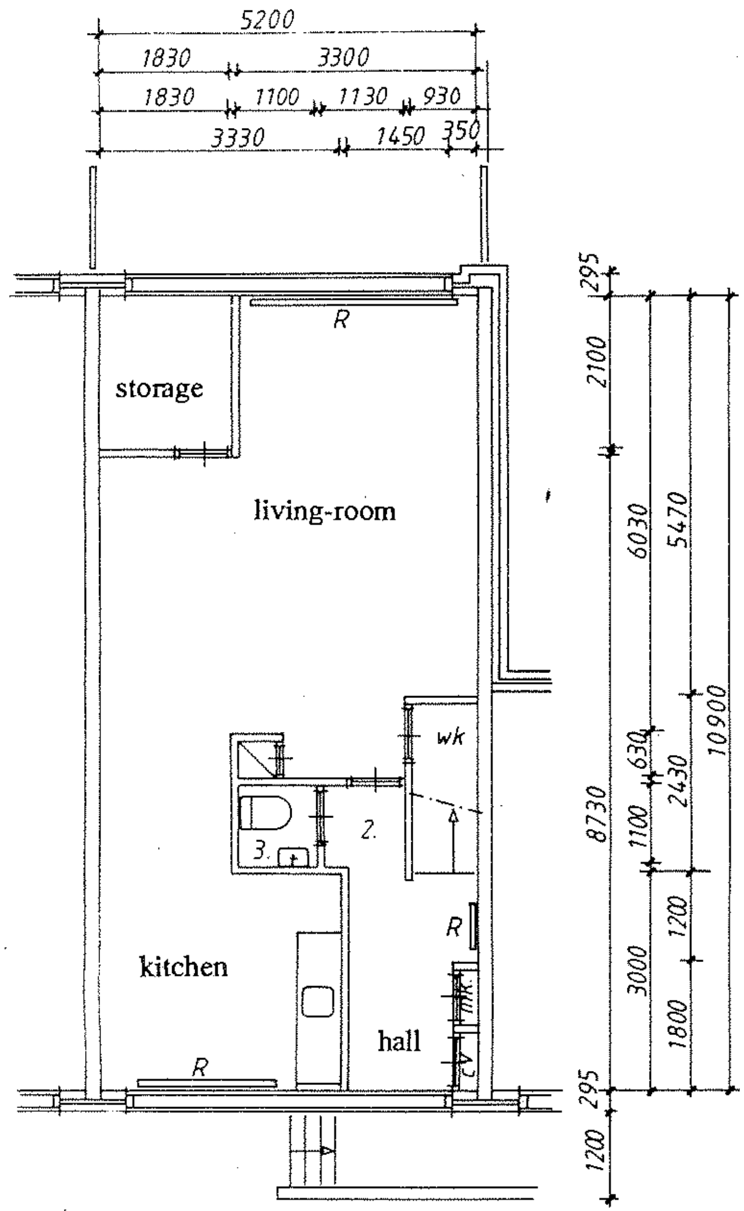
THIRD FLOOR

KLUSTER. 8.
HONDSRUG 887
type C4-links k. 142 b

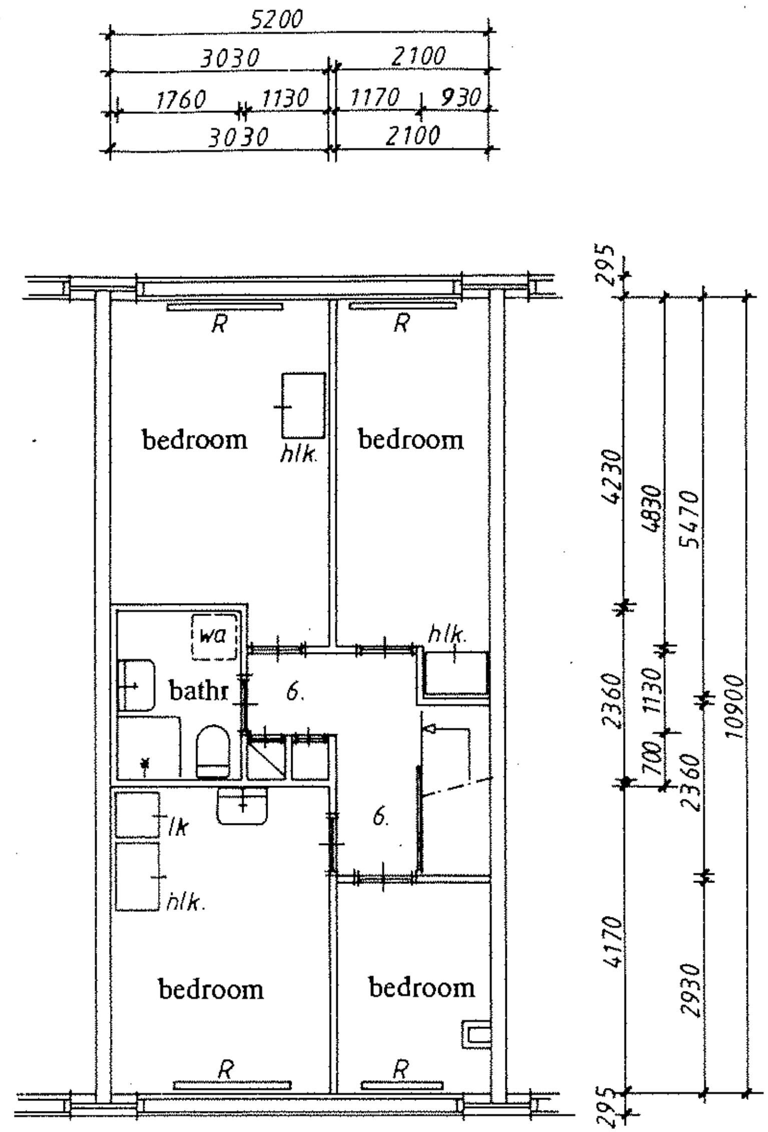


GROUNDFLOOR

KLUSTER 8
FURKABAAN 39
type A1-links k. 142

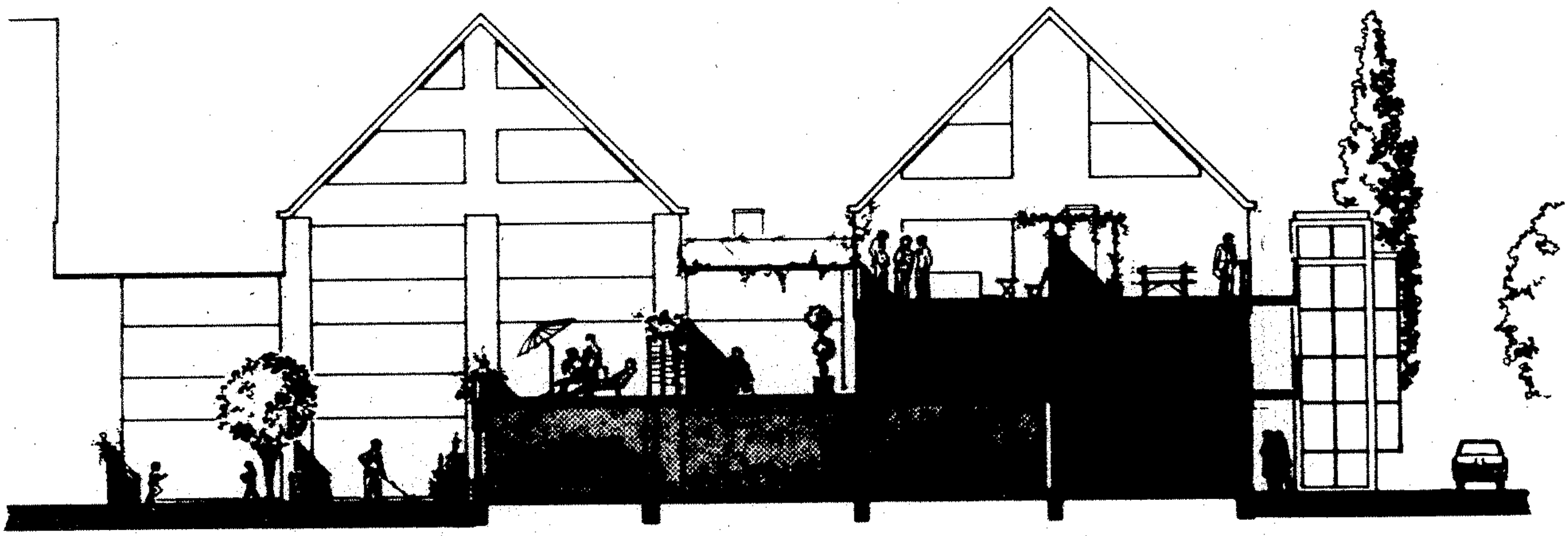


GROUNDFLOOR



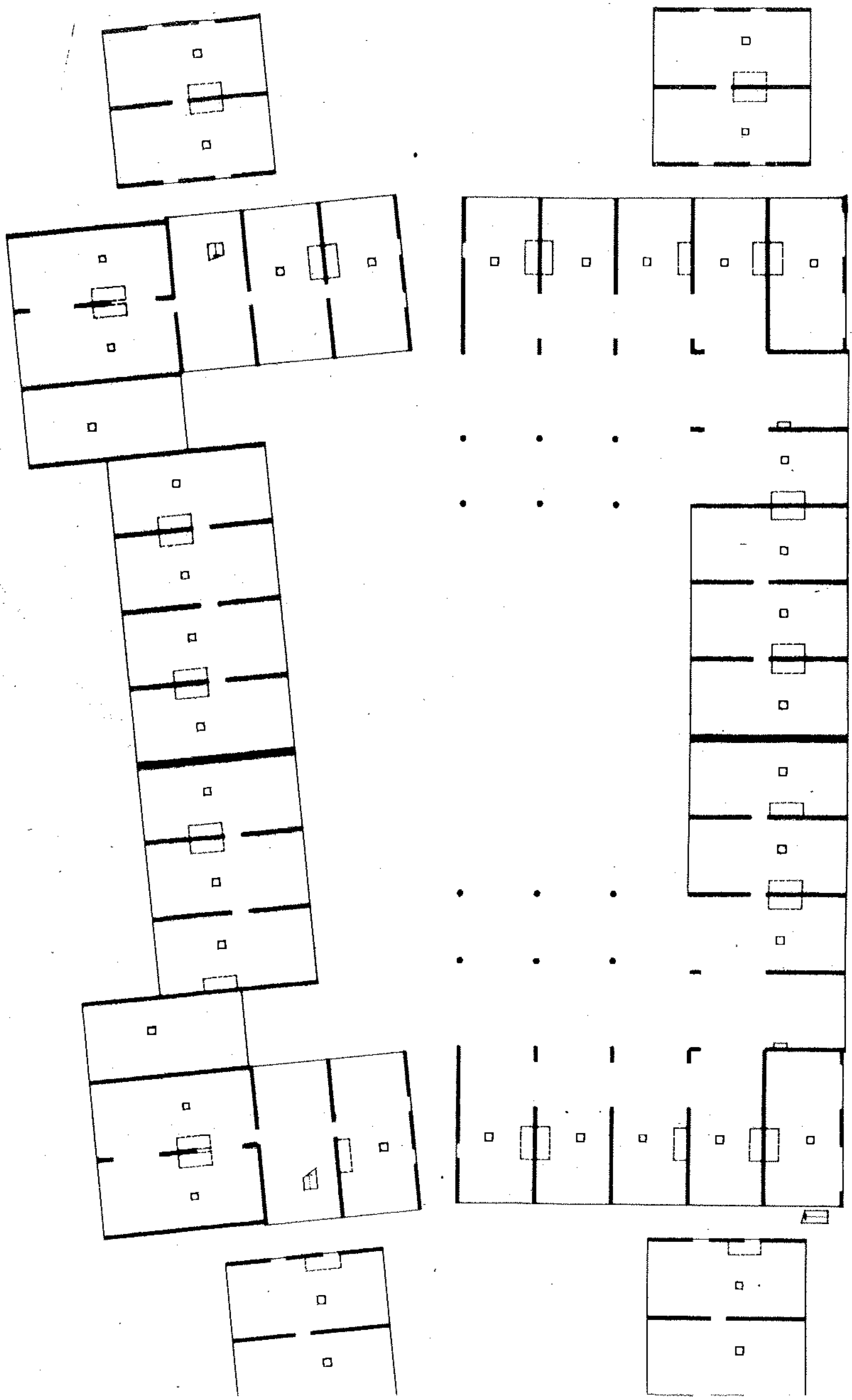
SECOND FLOOR

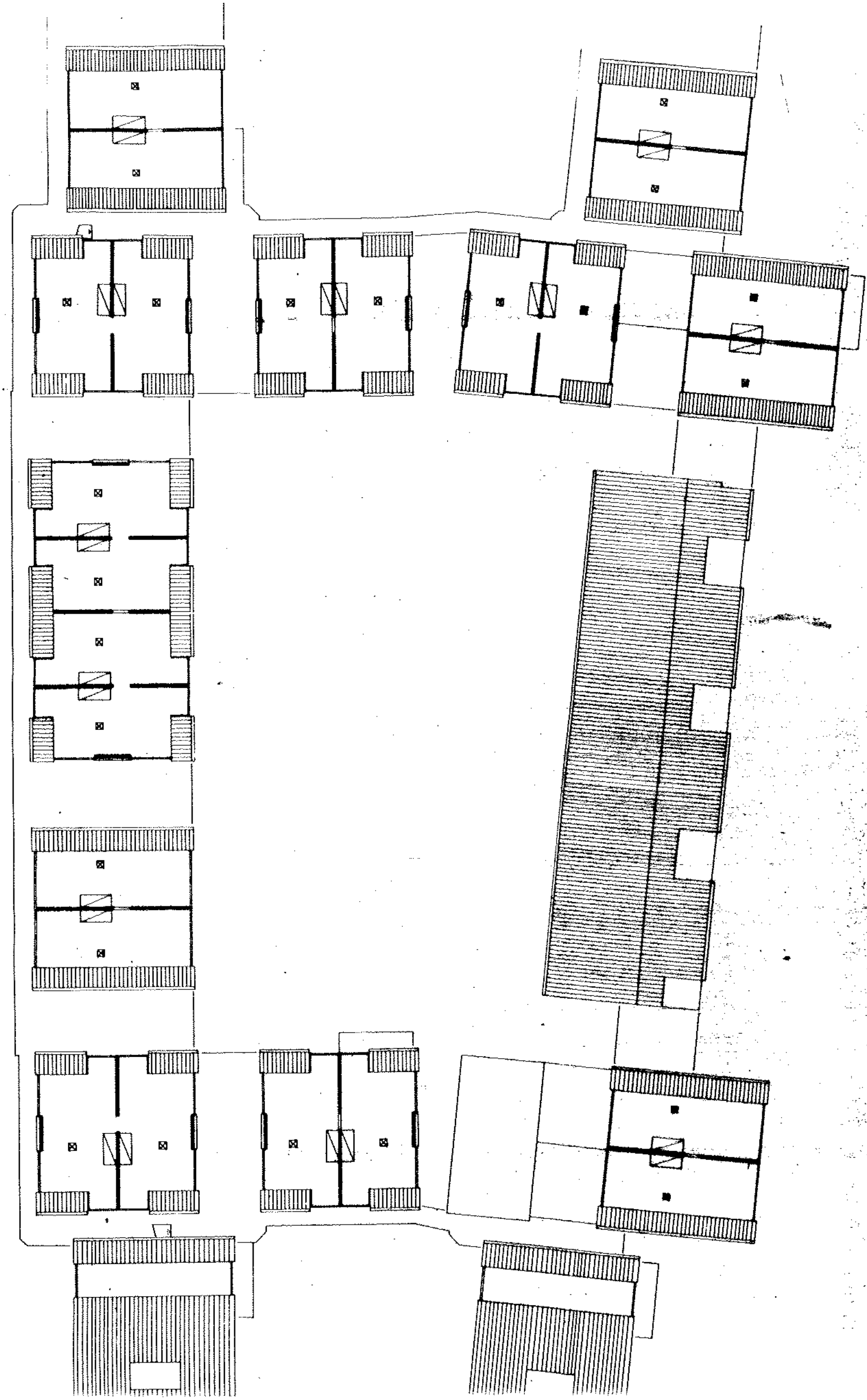
KLUSTER. 8
HONDSRUG 803
type C1-rechts k. 142



Lunetten

A
B
C





MAY WE ADD ANOTHER WALL, MRS. JONES?

M.R. Monroy
R.P. Geraedts

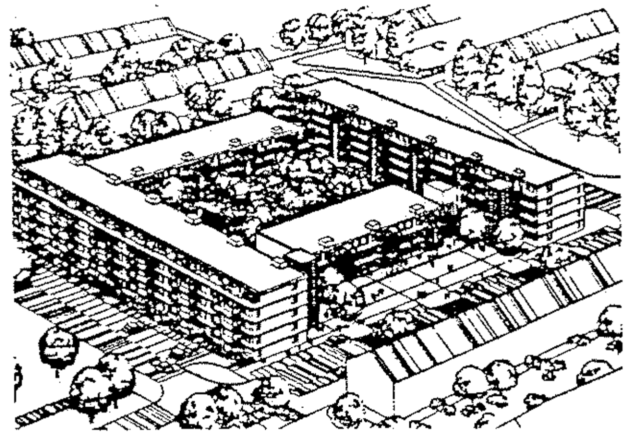
Better user participation possible due to the separation of support and infill with the aid of modular co-ordination and the microcomputer.

1. INTRODUCTION

On Tuesday 17 May 1983 Mr.C. Kok, the Deputy Secretary-General of the Ministry of Public Housing, Physical Planning and Environmental Hygiene, drove in the first pile for the Keyenburg project in Rotterdam. In his speech Secretary of State Brokx mentioned that this was the first pilot project in the field of modular co-ordination that was starting with the actual implementation.

Pilot projects in the field of modular co-ordination are part of the trial period in which experiments are being carried out on the basis of the modular co-ordination rules in accordance with the Dutch Building Standard NEN 2883.

Side by side with modular co-ordination, in this project the uncoupling of project and product - or of supply and demand - has been given shape by separating the support and infill. As a result of dividing the dwelling into two separate parts the occupants are able to have a say about the part that will be used for fifty or more years by the community (the support) and a right to co-determination as regards the part that they will use for a much shorter time (15 to 25 years) and which will then be replaced (the infill).

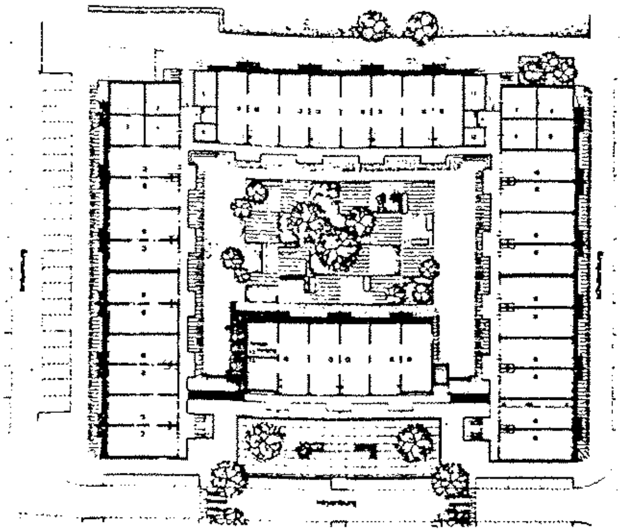


Keyenburg plan

The Keyenburg construction team consisted of the Stichting Tuinstad Zuidwijk Housing Association, the Kokon Architects' Working Group and the building contractor van Eesteren. Here Tuinstad Zuidwijk, in particular took the initiative in making the plan a support-infill project for the benefit of the occupants. The Kokon Working Group advocated the introduction of modular co-ordination under the motto *"We are not pursuing modular co-ordination for the sake of modular co-ordination, but because it permits a real separation between support and infill."*

2. PROJECT INFORMATION

The project consists of 152 dwellings at the Keyenburg in Rotterdam and comprises four residential buildings of three and five storeys built around a spacious inner court. The four buildings contain supports that can be divided up into dwellings of various sizes. At present they are divided into one and two-person units, but other dwellings are also possible. For example, on the ground floor some dwellings have been created for handicapped people. If required at a later date, larger dwellings can also be made on the various floors by combining bays, or parts of bays, located beside or above each other. The architectural measures required for this have already been taken and an assembly kit is made available to the occupants to enable them to determine the layout of their homes themselves. The choice of the quantity of infill enables them to influence their own housing expenditure.



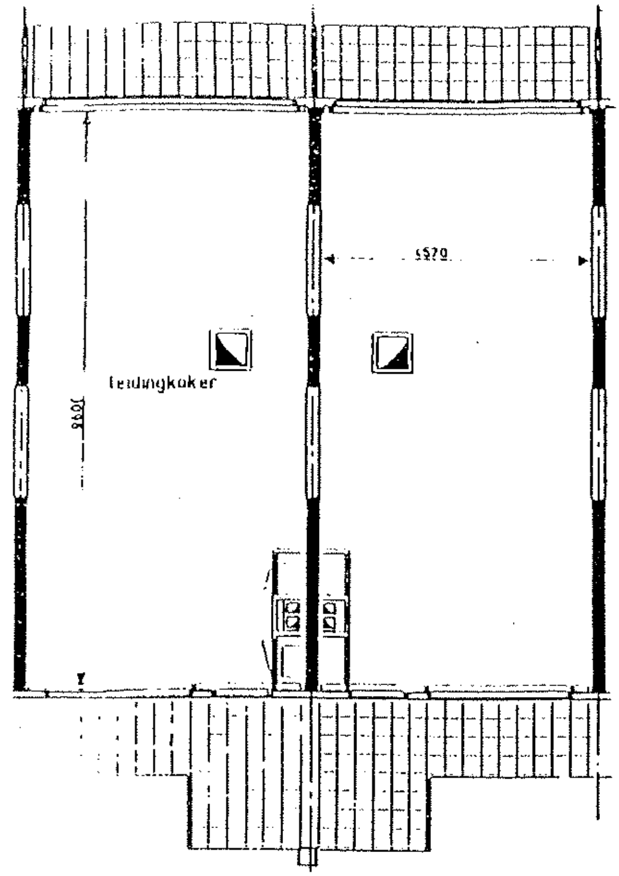
Layout plan

In addition to the separation of the support and infill, plus modular co-ordination, there is another special aspect to the project, namely the use of the computer as an aid in the user participation process.

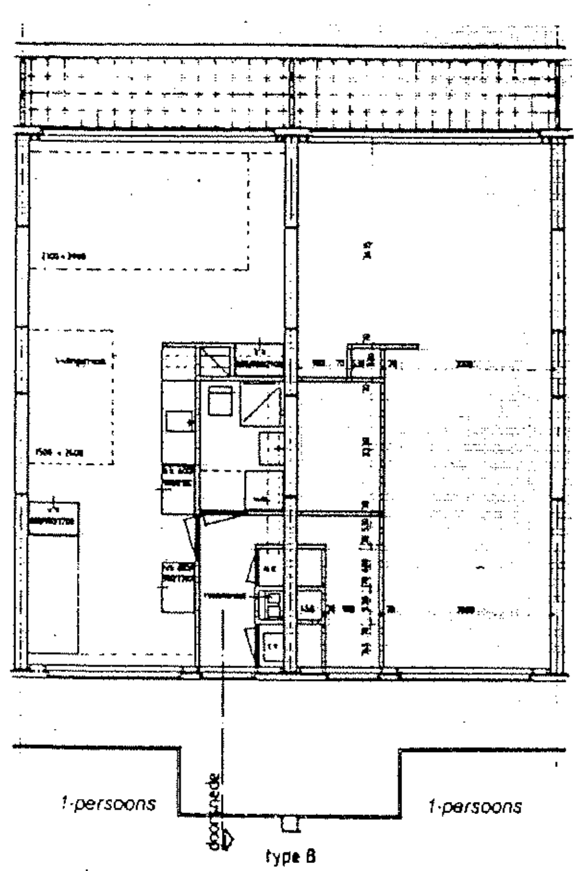
3. THE ARCHITECT AND THE COMPUTER

According to recent investigations, the introduction of the use of the computer in everyday building practice, as well as the need to do something about automation in the individual company, has recently been increasing apace. Information on this can be found in, among other things, the publication "Architekt en automatisering" (The architect and automation), a publication of the Ministry of Public Housing, Physical Planning and Environmental Hygiene based on a study carried out by the BNA (the Association of Dutch Architects). Views on the need to introduce the computer and the value that can be attached to this vary fairly widely.

"Some people assume that when automation is introduced there will be a drastic change in the office structure, while others regard it as an opportunity for tackling activities more systematically. Automation may prompt people to take a closer look at the



The support



Example of infill

systematics of office activities. For that reason, automation should be seen more as a means of achieving a different approach, rather than as an end of itself. One of the arguments for using computer (programs) may be that the basis for taking decisions is widened by increasing the supply of information. In this connection the result is an improvement in quality, rather than the assumed increase in quantities (faster and higher production)."

At present a distinction can be made between two trends in automation in the Dutch building industry. The first is characterised by the use of fairly large-scale and expensive equipment. This generally relates to large or medium-sized architectural firms which have been working on automation for some years and in which the computer has become an integrated and indispensable part of the office activities. Aspects which come to mind in this respect are drawings, design evaluations, calculations, plans, estimates, project administration and office administration.

The second trend is of more recent date and is developing, in particular, in the somewhat smaller offices with fewer financial resources. Admittedly, the possibilities of automation are recognised here, but there are still too many unanswered questions about what should be done with it, what its effect on the firm will be and what costs are involved. The computer generally makes its entrance on a small-scale and relatively "innocent" level, in the form of the microcomputer. The low investment required is no obstacle to many people and rapidly repays itself even if the new acquisition is used only as a word processor. As a result of the subsequent investigation of the further possible applications and their gradual extension, a more or less natural process of growth can be observed in these firms with regard to automation. The Kokon Working Group is an example of the latter trend.

4. USER PARTICIPATION AND THE COMPUTER

The Stichting Architekten Research was commissioned by Kokon to develop a computer program that can be used for and during the occupant consultations held in connection with the Keyenburg home construction project.

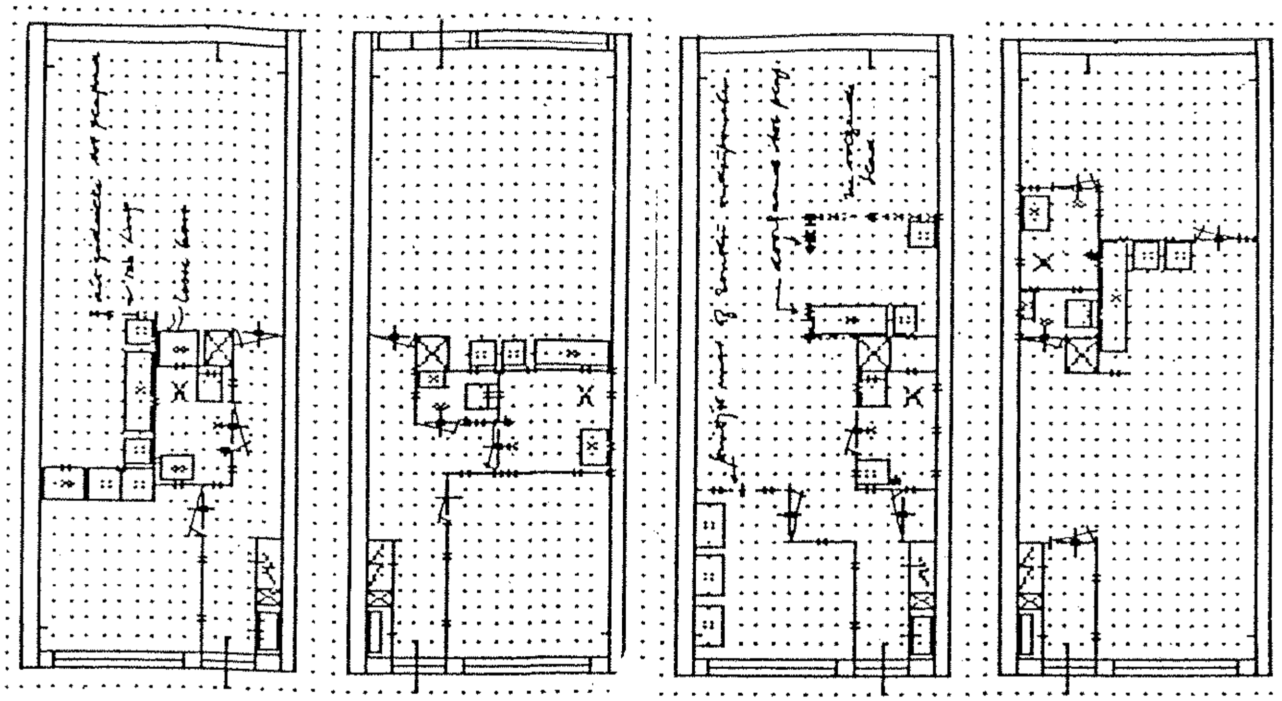
This program has been primarily developed for use in a microcomputer (international memory capacity 64 K). Depending on further developments in automation in the architects' firm, consideration will be given to extending this program and making it suitable for a computer with a higher capacity.

The first occupant consultations for the project were started on 1 June 1983. Thanks to the introduction into this plan of a separation between the support and the infill, as well as the use of modular co-ordination, which enables clear cut agreements to be made about the position and dimensions of the various building components, extensive possibilities for having a say and for user participation were created for the future occupants.

In order to give this concrete shape, two consultations were organised per occupant or per household at which the user's wishes with regard to the infill in the house could be expressed and a direct relationship could be established between the infill, on the one hand, and the costs/rents, on the other.

The above-mentioned computer program was developed in order to enable this direct relationship to be established during the consultations, to display both the ground-plan variations and internal possibilities rapidly in graphic form, and to enable statements to be made about the related costs and rents.

To promote efficiency, not all the information that is decisive for the ultimate costs and rents emerges during the consulting hours. In the mutual consultation between the SAR and KOKON a division was made between the elements which are most important to the occupants both space-wise and cost-wise, and the elements that can be added outside the occupant consultations in order to complete the total picture and the costs associated with it. In this connection, for example, the location of inside walls is more important than the number of running metres of gas pipeing.



Infill variations processed on the computer

For this purpose, it was necessary to make reasonably reliable assumptions about both the cost elements which emerged during the consultations and the cost elements added to these later on. In particular, all this was necessary because of the basic principle that the rents calculated during the consultations could only have an error margin of about one guilder.

The ground plans designed by the occupants are drawn with the aid of the computer and are calculated by estimating the cost of the elements. The results are automatically compared in the computer program with a reference dwelling with related costs and a reference rent determined in advance in consultation with the financier, i.e. the Ministry. Any differences between the infill variants developed and the reference dwelling are made visible, together with the most important cost-determining factors. In practice, these differences in cost are not adjusted with respect to the reference rent but are reflected in the service costs. In principle, therefore, the rents are the same for all the dwellings.

The computer program was developed by the SAR. The (rent) calculation method and the necessary key figures and other cost data were supplied by KOKON.

5. PROCEDURE AND PHASING

The following phasing was taken as the basis for organising the occupants' consultations and the way in which the computer should be integrated into these:

During the development of the computer program the occupants formulated their initial ideas on the basis of information sent to them, such as a drawing of the support, possible uses and explanatory notes.

At the first consultation the sketches brought along by the occupants are discussed with the user participation adviser. The results of this are hand-drawn floor-plans that are processed on the computer. An addition is also made to this by making assumptions about the elements that have not emerged during the first consulting hour. The result is a graphic representation of the floor-plan, accompanied by a cost estimate and rent calculation.

During the second consultation, in the space of half an hour, the desired floor-plan is simulated in a maquette of actual size for each occupant or household. Here use is made of the light and readily movable wall elements developed at Eindhoven University of Technology. As a result, the occupants suddenly acquire a much clearer view of the floor-plans designed by them and not infrequently modifications are made on the spot. These modifications are processed by the computer.

The results of the modifications are displayed and the effect of these modifications on the rent also becomes clear. The outcome is a final floor-plan layout, accompanied by an estimate of the costs and of the associated rent.

6. EXPERIENCES

In contrast to the original intention, whereby the computer was to be used directly during the second consultation to incorporate possible modifications in the floor-plans immediately and calculate their effects, this is now done outside the consultation. There are a number of reasons for this. Since a tight time schedule means that five sessions take place simultaneously for the first consultation and three sessions for the second consultation, the direct incorporation of any changed situations became a problem. There was not sufficient manpower and computer equipment for this. In addition, the discussions during the consultations were often very personal in nature and the advisers did not wish them to be interrupted by the obtrusive presence of such a technical aid.

Nevertheless, it may be said that there are definite advantages to the occupants as a result of the introduction of the computer, although they are not directly confronted with it. Thanks to the rapid and direct link that could be established between the desired infill, including a particular level of finish, and the related detailed costs, it was possible to respond effectively to such burning questions as: "What kind of infill do I get for what (minimum) rent?"

The data from the first user participation sessions have already been processed on the computer. Of the total of 152 dwellings available there are only two that have a completely identical floor-plan. The other 150 floor-plans all differ from each other to a greater or lesser extent. The greatest difference found with respect of the reference dwelling and the related reference rent is 16. This means that the rent of the one-bay houses would not be above 300 in any of the cases. The most important cost items causing this difference are to be found in the number of inside walls and cupboards, as well as in the wide diversity of kitchen types and finishes.

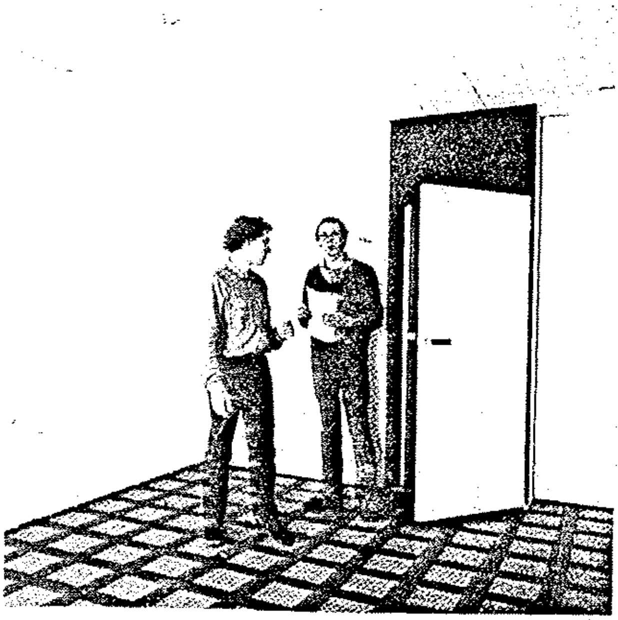
As regards the use of the computer program, it proved that the threshold of accessibility was low. In practice, about two hours' training was enough to enable architects to handle it. An average of half an hour was needed for the computer processing of data from the first consultation, resulting in a schematic representation of the ground plan, a detailed cost estimate and a comparison with the reference dwelling.

At the time when this article was written the results of the second user participation sessions were not yet known. When processing the data, however, use will certainly be made of the possibility of reproducing the various types of information at various "levels". In this respect, information about the support, the partition walls, the finishes and the various installations can be noted and reproduced separately as required.

7. CONCLUSIONS

In spite of a number of limitations of the program, such as the restricted graphic representation of the floor-plan on a schematic spatial level, it has been found that this represents hardly any disadvantage in practice. The original goal was achieved to establish a direct link between drawings and calculations in order to permit the user to have a say, so that rapid and well-founded decisions can be taken at an early planning stage. Better, more advanced, but also much more expensive graphic systems are commercially available when the main aim is the production and presentation of perfect drawings.

It has proved to be quite possible to become operational with a very short preparation time for the development of the program (1 month) and with the aid of relatively inexpensive equipment (approx. 17.000 guilders including software). The limitations of the equipment need not constitute any obstacle to effective use in this respect.



User participation using the maquette in actual size

The design and user participation process does not follow an essentially different course from a project in which no computer is used. It does, however, permit quicker and better decision-making and more variations can be generated faster.

This use of a computer as a supporting vehicle in the establishment of such a project would have been virtually impossible if another aid had not already been available and been used, namely the agreements about the positioning and dimensions of the various building components arrived at by means of modular co-ordination.

WERKGROEP KOKON ARCHITEKTEN B.V. WEENA 723 3013 AM ROTTERDAM TEL. 010 117180
RUIMTEPLANKALKULATIE. FILE: #5:EL.305.PRO

Projekt	KEYENBURG
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Bewoner	MELIS
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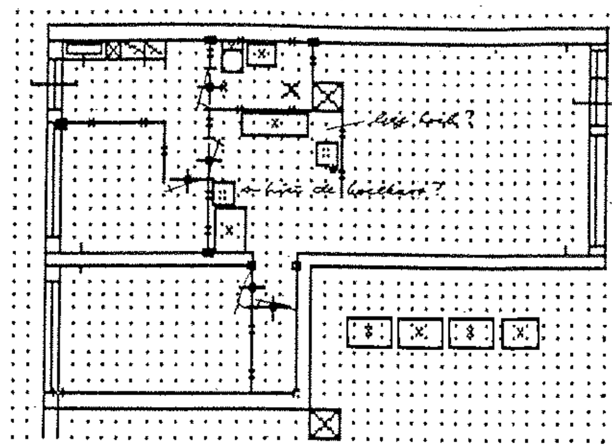

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TOTAAL VERSCHIL							1756.82	

Floor plan, costs and rent of an infill variation

Authors

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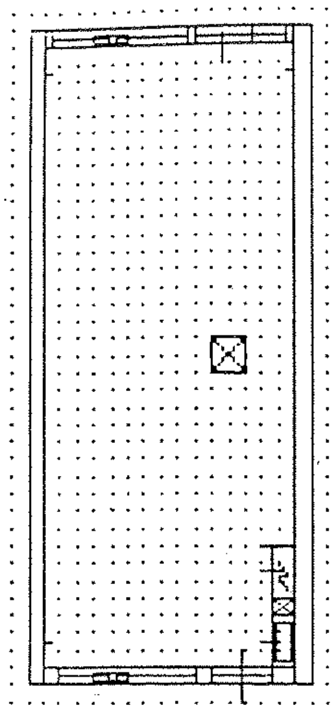
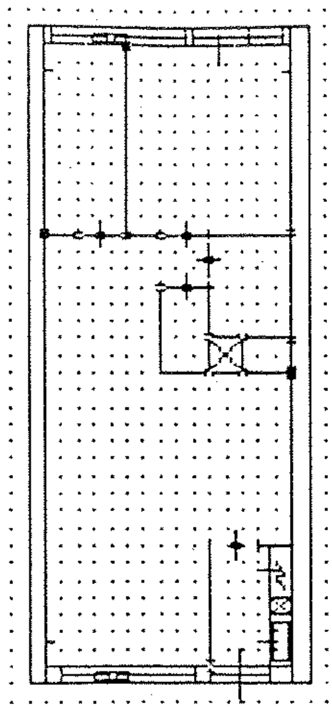
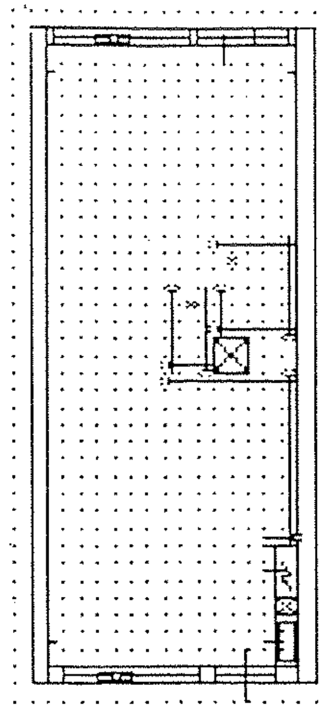
R. P. Geraedts
Staff members of Stichting Architecten Research, Eindhoven.



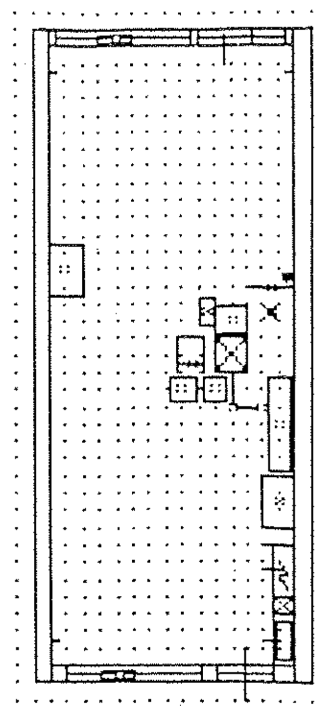
LEVEL 0: The support (incl. wiring and piping duct, central heating and meter cupboard)



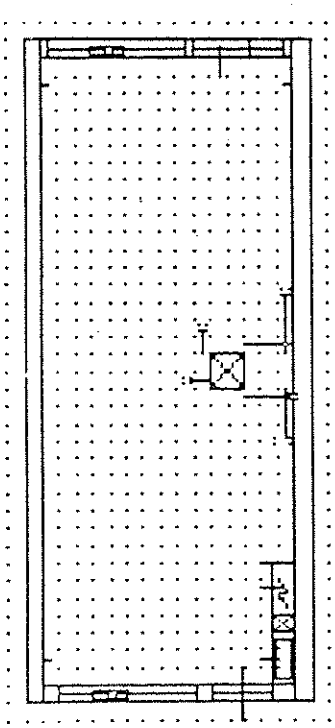
LEVEL 1: partition walls (incl. open and closed doors)



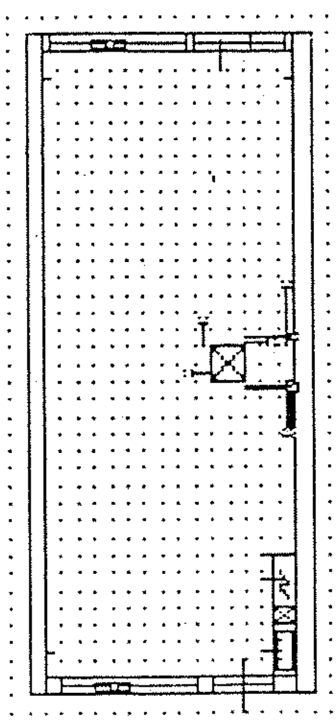
LEVEL 2: wall finish (tiles)



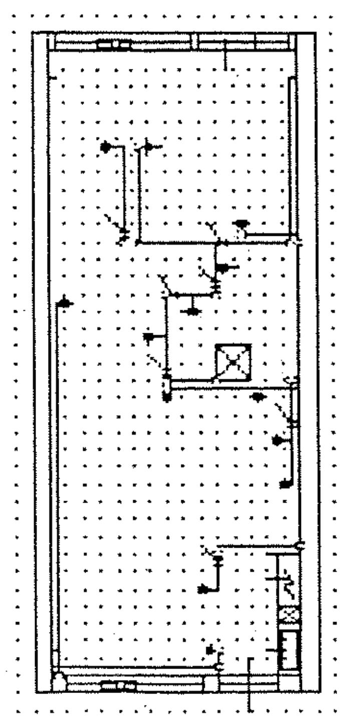
LEVEL 3: equipment (toilet, washbasin kitchen, cupboards)



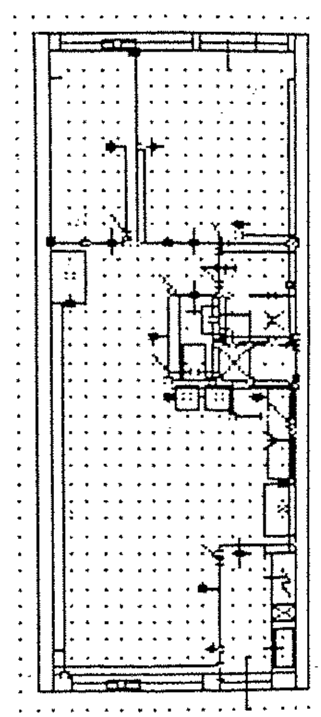
LEVEL 4: drainage system (Ø 50)



LEVEL 5: water pipes (hot and cold)



LEVEL 6: electrical system (wiring, light points, socket outlets)



ALL LEVELS

An example of information processing at various levels

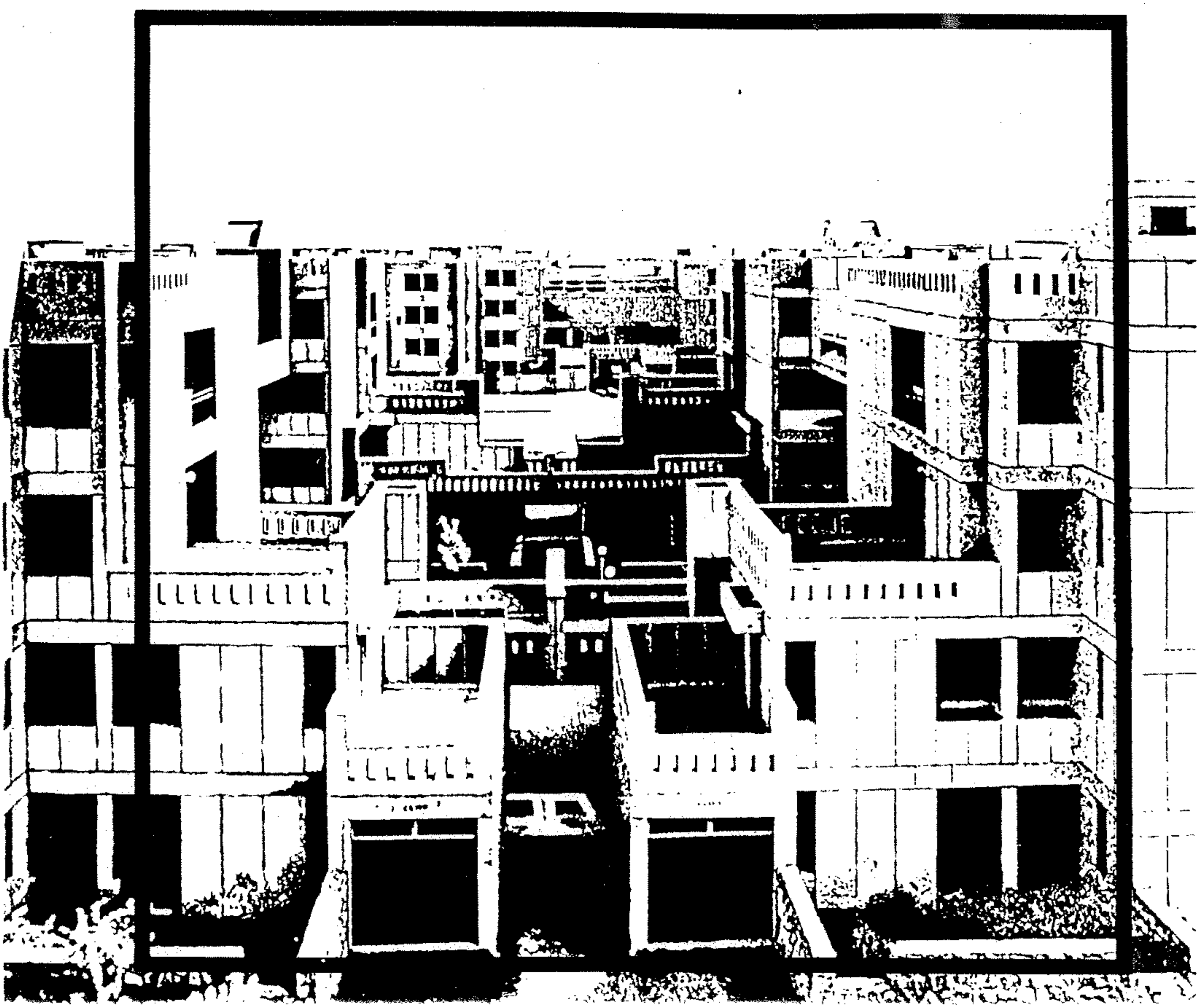
Designing in Islamic Cultures 5

Large Housing Projects

Design, Technology, and Logistics (1985)

The Aga Khan Program for Islamic Architecture

at Harvard University and the Massachusetts Institute of Technology



6. Reconciling Variety and Efficiency in Large-Scale Projects

John Habraken

One of the dilemmas that we all face—and have faced for many years, perhaps even generations—is how to reconcile our assumption that efficiency for large-scale production lies in repetition and uniformity and is therefore part of the modern condition, with our preference for variety and for local, small-scale environments. Architects and planners constantly wrestle with this problem. It has been a theme in our deliberations as well.

A related problem has to do with change and adaptability over time. It will be thirty, forty, fifty years before the money invested in a housing project is returned, if it is returned at all, so what is built has to last for a long time. The designer has to anticipate the future and must propose the house that people will still want to live in twenty years hence. But long-term decisions will often be in conflict with the short-term wishes of the occupants. Twenty years from now people will live differently, have different backgrounds and different expectations.

A large management organization in the Netherlands complained at a meeting recently that the property they had built fifteen years earlier and had carefully maintained was already considered by its inhabitants to be out of date. The tenants refused to pay a rent increase until their dwellings had been modernized. The management was in a quandary: if the buildings were to be modernized, they would have to invest large sums; if they were not, the tenants would not pay the rent increase. If that can happen in the Netherlands where, in those fifteen years, the economic development was not particularly dramatic, contemplate what can happen in other countries where economic growth is dramatic indeed and the difference in expectation fifteen years from now is beyond imagining. How do we deal with this conflict between change in expectation and project rigidity?

In this century, the Netherlands has been a laboratory for what can be done in housing—not because it set out to be, but because of circumstance. It is a small country with a homogeneous population, a solid economy, and a long tradition of reasonable housing for all its people. It was the first country to pass a housing law—back in 1902—that made government money available for sheltering the poor. The eighty years of bureaucratic and professional experimentation in public housing that followed has meant that the Dutch had to do all the good things and the bad things earlier than anyone else. It also allowed them to find out sooner than the rest what those good and bad things were. Among the latter, uniformity, monotony, and loss of identity and social coherence have been a concern in the Netherlands for years. In some respects the Dutch are therefore ahead of the rest of us.

In recent years, some developments have taken place in the Netherlands that may be useful elsewhere. The examples I will show you may be typically Dutch, but some of the principles that underlie them are neither site-specific nor culture-specific and should be generally applicable.

The largest home-building company in the Netherlands used to produce about 8,000 dwellings a year, and, since they operate as building contractors as well as developers, part of what they produced represents their own investment. Recently, this company decided to reorganize itself and adopt, neither a new technical system nor a new type of dwelling, but a new approach to organization and logistics. The solution they came up with was to take a normal mass-housing project—whether high rise or row houses or whatever—and eliminate from the construction stage all the kitchens, the bathrooms, the non-load-bearing partitioning, and even some parts of the façade. This would leave a building that would be an empty shell, but nevertheless finished in a certain way. It would have a façade and a roof, and look like a building from the outside. This shell they call the "support." They build it first, and because all the nitty-gritty, vulnerable parts are eliminated, it can be built quickly and to a large extent repetitively. They claim that the system saves time and thereby some overhead is recovered, and that in turn means that less money has to be borrowed.

After the shell is finished, a container arrives accompanied by a four-man team. It holds everything that goes into one unit—kitchen, bathroom, partitions, electrical wiring, piping—which the accompanying team then installs in a week or less. (The company hopes that eventually it will be able to reduce the time to four or even three days.) The team finishes the dwelling completely. When they are done, another container delivers the infill package for the next dwelling, and they start all over again. Any number of teams can be working simultaneously on the same project.

It is important to note that this approach is largely independent of the materials and technologies applied. A rigorous distinction between "support" and "infill" can be retained in this system no matter how the building is built—it can be traditional, partially prefabricated, fully prefabricated, in brick, or in concrete. The infill is technically independent of the "support" building it is placed in. It can be made in many different ways. It can be either high-tech or state-of-the-art. The particular company I referred to earlier has chosen the latter: their infill system is in fact a very clever combination of state-of-the-art elements that they can get mostly off the shelf.

There are a lot of advantages to this approach. The traditional way of finishing dwellings in large projects is modeled along the idea of the conveyor belt, except that it is the workers who move. One worker installs some piping; then another group puts in some partitioning; then another group works on the bathroom, and so on. The company I am referring to here claims that even in their best-managed traditional projects it took about twenty-five visits by sixteen different teams to finish it inside. If one of the teams arrives late or does something wrong, all the subsequent visits are affected, and conflicts arise because people mess up other people's work. We all know the logistical problems the builder gets into, especially when the sixteen different teams belong to eight different subcontractors. The company claims that the new approach with the container and the crew of four will reduce labor time on the site by 50 percent. Even if that is overly optimistic, it seems clear that money can be saved this way.

Other advantages accrue to the client. Because the infill is installed quickly and at the very end of the process, the client can postpone decisions about the floor plans. Because of red tape, projects are a long time in preparation in the Netherlands. It is not unusual for the floor plan that is built to be the floor plan the client found suitable three years earlier. Now the client can make up his mind a few months before occupancy. The support-infill approach does not require—and that perhaps is its greatest advantage—that dwelling floor plans be the same. In fact, the crew likes to do a different plan every week. This gives the client the opportunity to have future tenants choose the floor plans. All the builder requires is that the decision be made before the container has to be loaded.

The advantages of this new approach do not come without conditions. Design is crucial: a strict distinction between support and infill must be maintained. Efficiency depends very much on good support design. Good support design takes more study than design for the average housing project. Centralized management of the logistics becomes very important. Infill elements must be ordered from various manufacturers and stored. Floor plans must be translated into infill specifications; elements must be selected and packaged according to floor plan and sent off in time for each dwelling to be assembled in the support.

For a builder there are advantages of scale. The size of projects built in the Netherlands is often less than 200 units—there is simply not enough space left to build projects any larger than that. In the traditional way of working, the local project manager shopped around to subcontractors and manufacturers to find the doors, windows, kitchen elements, the piping and plumbing that were the most suitable for a particular project and then negotiated for the best price. Under the new system, where infill is no longer project specific, a firm can order these elements for a full year's production and negotiate directly with the manufacturers. If, for instance, a manufacturer is guaranteed an order for door frames for so many thousand dwellings a year, the builder can give his own specifications and still get a low price. Both builder and manufacturer can develop a better infill system over time because the system is no longer project dependent. The support-infill approach has triggered a debate about its impact on the building industry. There is indeed already at least one company in the Netherlands that has a complete infill package on the market and is ready to install it into any support that meets interface specifications.

Today the load-bearing system—that is, the real structure—represents only about 30 percent of the building cost; the skin—that is, the roof and the façade—another 40 percent; the load-bearing system plus the skin comprise the support building. The infill represents about 25 percent of the building cost. That in itself is relatively little, but the infill is precisely what changes over time and what has to be kept up to date. Kitchens, for instance, have to be renewed every ten or fifteen years; heating systems every fifteen years; partitioning begins to be pushed around within twenty years. If the infill is computed over the life of the support structure, the total investment may rise to 65 percent of initial building costs. The builder developing an infill system wants to be there when the dwelling is changed and filled in again.

The particular company I mentioned in the beginning is working on its first thousand dwellings, after some experimental projects. But it is not alone. A trend is developing in the Netherlands. Several builders, manufacturers, architects, developers, and large investing companies have come together in a non-profit association with the intention of implementing and improving this particular strategy. They have decided that there are advantages in it for all of them. Even as competitors, they benefit if legal, technical, and management problems can be studied jointly, and they can also pressure the government. They announced their intention to form this association at the National Building Fair in the Spring of 1984, and by September already had more than a hundred contributing members.

Economic conditions in the Netherlands have not been good in the last four or five years, particularly in the building industry. It was not the department of housing and building, but the department of economic affairs, that set aside money to investigate better ways of tackling the industry's problems. For many years a foundation for building research has been operating, which is financed partly by a half-percent of the gross budget of all building projects. Every contractor has to pay his half-percent into that pot, and the money is used to investigate matters of interest to the building industry.

About a year and a half ago this organization launched a study to determine the housing industry's future. The group began by studying three different economic future projections for the country that the Shell Oil Company (which is based in the Netherlands) had made. Shell had done some very extensive studies on a Europe-wide basis, and they made their future scenarios available to the government. The scenarios represent attempts at forecasting what will happen under various assumed situations. The housing study group then matched these projections with four different building strategies: the conventional way of building today, which is a sort of mixed, partly prefab, very pragmatic way of doing things; the expensive fashion of recent years, which is to reduce project scale and vary façades and floor plans in each project, but still use the conventional way of building; the massive large-panel prefabrication systems common in the fifties and sixties; and, finally, the approach just described, which they called the "open-building" approach. The conclusion of the study was that the last was the only one that promised to lower cost in all three economic futures.

Not everybody will accept these results. As these things go, the study's assumptions are debatable, and it will be some time before its conclusions are clear. But this approach is at least challenging the other better-known ways. It is generating considerable discussion, not to mention passion, in building circles in the Netherlands today because, of course, it will affect everybody.

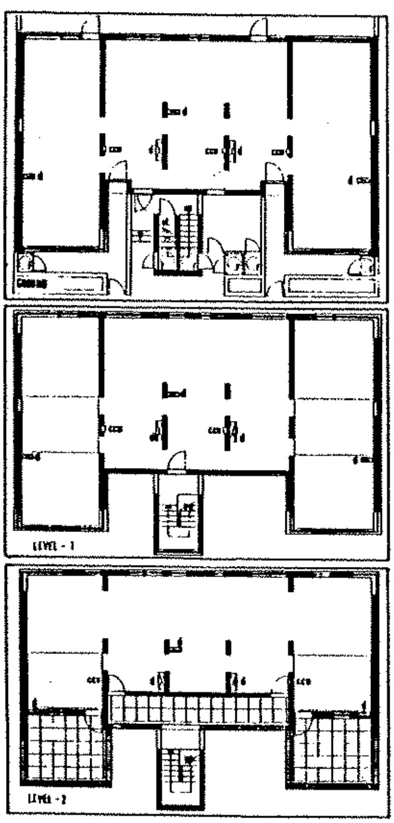
All this is not, however, something that developed overnight. The support-infill history goes back at least twenty years. In 1965, about ten architectural firms got together to finance a research institute to look into alternative ways of thinking about housing. This institute, called the Foundation for Architect's Research (SAR), developed and promoted the support-and-infill system. From the beginning, they advocated it for several reasons—it provides variety, allows user participation, is more efficient, and is a better way to industrialize. They studied methods for support design, coordination of support and infill, ways to distinguish the different systems that are needed, and so on. As time went on, more and more people became interested; by now SAR has more than fifty sponsors from various parts of the building industry who pay modest dues to finance research. It has become in its twenty years of existence a group whose members try to implement their findings in their own work. Several experimental projects were built as a result of their studies, and though there is nothing outwardly spectacular about them, they did demonstrate the viability of the new approach. In the course of time principles of modular coordination were worked out as well and, after years of discussion and study, recommended by the government.

In one of these projects designed by Nabeel Hamdi and completed in London about five years ago, the floors were finished and the walls stuccoed to finish the support. The Greater London Council then invited the future tenants to suggest their own floor plans. These were translated into working drawings and eventually filled in.

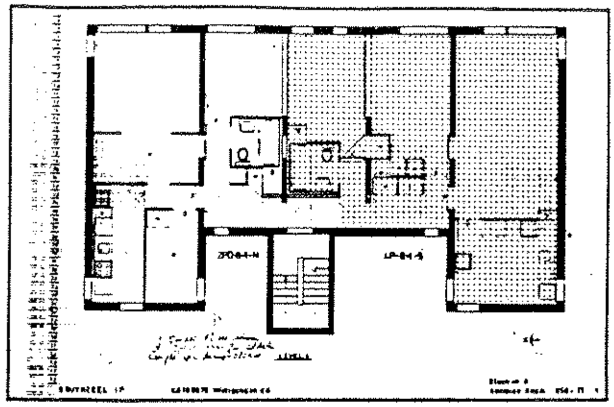
Another project was based on a configuration of courtyards that allowed for both public spaces and private yards. The façade was varied with the use of different colors and different panels, some closed, some open, according to the user's preferences, thus distinguishing one dwelling from another. In other words, parts of the façade became infill. In this system the frame of the opening was fixed, but the tenant could choose whether it was open or closed, transparent or opaque, a door or a window. Although the unit is still very much controlled by the architecture, it allows for a variety of personal touches.

The load-bearing elements, the vertical stacks for ducts, and the openings for stairs in these projects are all part of the support structure designed and built before any floor plan is

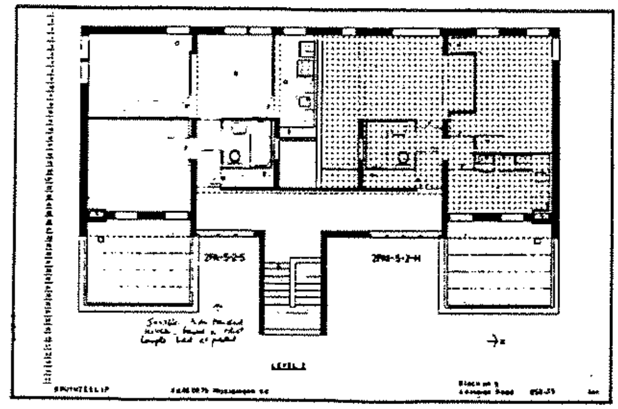
Fig. 1 Project for 45 dwellings, Adelaide Road, London. Nabeel Hamdi (P.S.S.H.A.K.), architect, for the Greater London Council. Completed 1978.



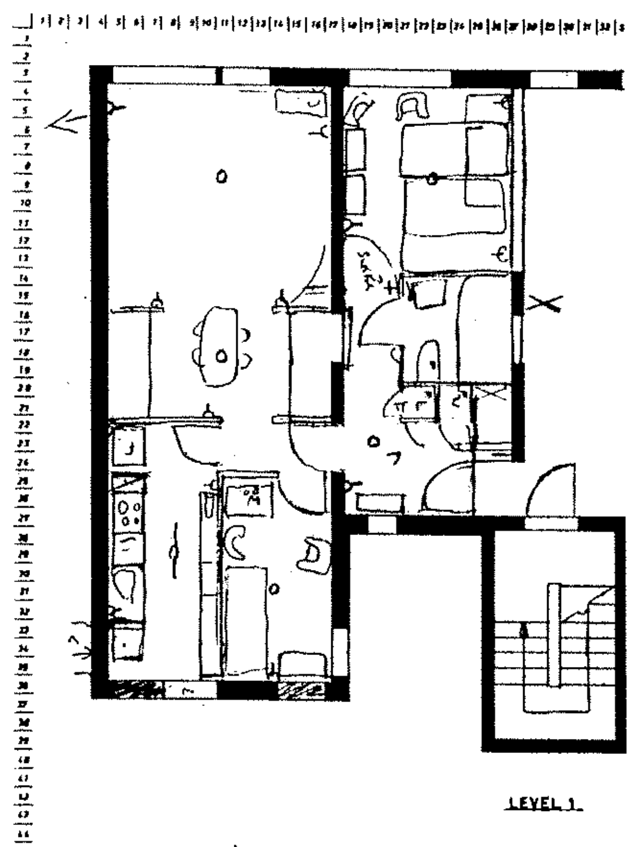
1.1 The three floors of the walkup-type support structure with fixed loadbearing walls, facades, and vertical ducts.



1.2 Example of two infill plans on a second floor

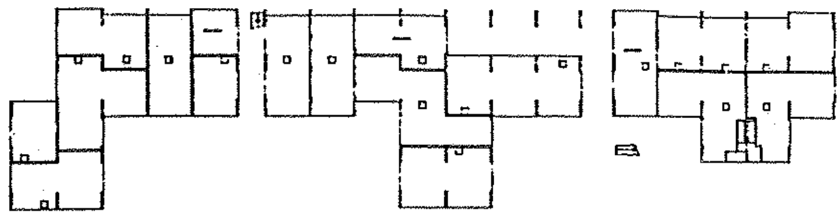


1.3 Example of two infill plans on a third floor

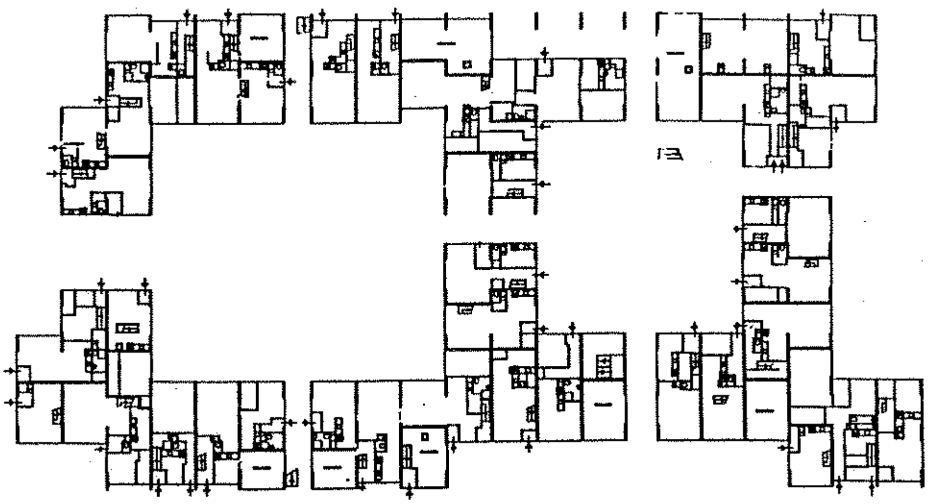


1.4 Sketch for layout as determined by user to instruct infill specification

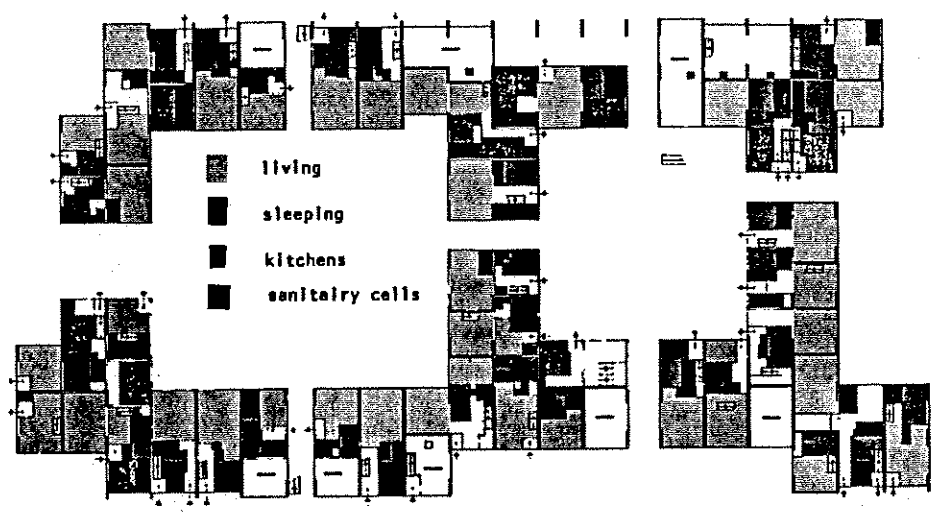
Fig. 2 Project for about 125 dwellings. "Molenvliet" neighborhood, Papendrecht (near Rotterdam), the Netherlands. Architect: Frans van der Werf. Completed 1978.



2.1 Ground-Floor plan of eastern half of the project, showing the regular system of loadbearing concrete piers, the brick infill party walls, and the infill partitioning, kitchens, and bathrooms.



2.2 Shows part of the structure of fig. 2.1 without infill, but with the party walls already decided. Note the openings for the vertical ducts in the middle of the bays.



2.3 The same floor as fig. 2.1 with indication of the functions. The irregular pattern resulting from the individual adaptation of each dwelling to user needs.

2.4 Two facades illustrating the variety achieved with a standard window frame which is identical throughout the project, and choice of infill by doors, windows, glass, or opaque panels.

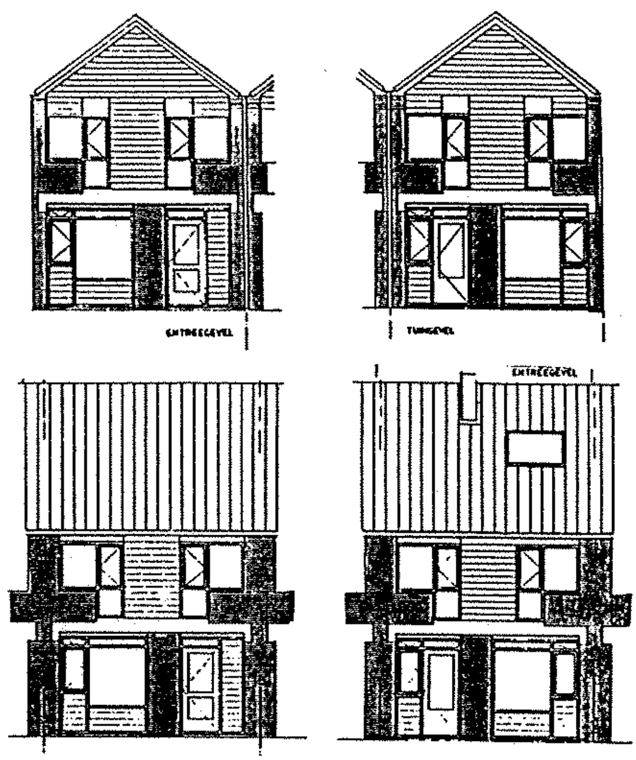
known. The size of each dwelling need not be decided in advance. The architect can offer not only a choice of floor plan but also a choice and variety of dwelling size. The result is an irregularity unusual in large projects. The tenants can, of course, explain very clearly why they draw up the floor plans as they do; their plans are quite sensible from their point of view. But these are often floor plans an architect would never dream of, if only because they cannot be repeated twenty or a hundred times. In these experimental projects, the architects set out primarily to provide adaptibility for user participation within a "normal" budget. The builder I mentioned earlier, on the other hand, believes primarily in the efficiency of the approach and regards the variety simply as good for sales.

In yet another project—two-story row houses this time—the architect did not solicit plans from the tenants, but instead produced a booklet showing ten or twelve ground-floor variants and ten or twelve variants that could be combined. The people who were to rent these houses could pick the plan they wanted, and the builder would then install it within three or four weeks. In a project consisting of small apartments, the architect intended to keep openings in the load-bearing party walls that could be filled in so that larger dwellings could be made later by combining two bays. This particular project was built because the government had recently given incentives to build small apartments for single people, but the concern of the builder was that in the future the dwellings would be considered too small. The strategy he chose turned out to be too expensive, however, so it was decided instead to pour the whole wall in concrete, but to leave out reinforcement in particular areas so openings could be made later. One would think that it would be impossible to come up with more than one or two different solutions for a one-bay studio apartment but in fact no two of them are alike, and each of the tenants is convinced that his or hers is the only good floor plan in the whole building.

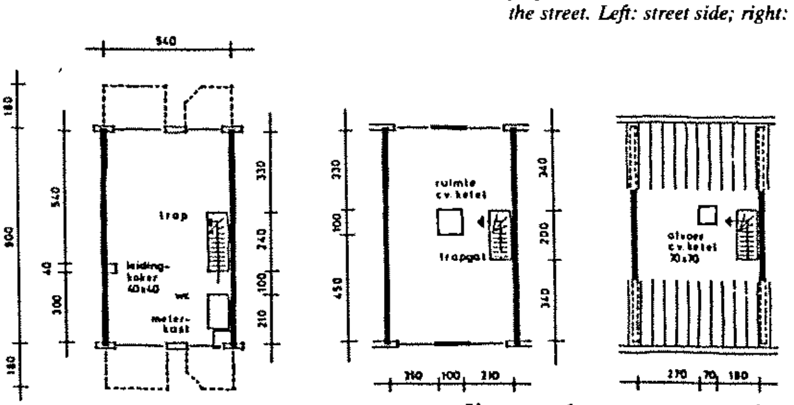
In addition to new construction, the container infill system has been proposed for the renovation of nineteenth-century housing projects in the larger cities. The idea is to leave party walls, floors, and façades, but to remove all else, repair the empty shell, and install the infill system.

For many people the idea that variety can be more efficient than uniformity is difficult to accept. It seems contrary to common sense. But uniformity in building does not mean—as it does in manufacturing—mass production of components, and it is the latter that is efficient and provided for by infill systems as they are generally applied. For on-site assembly, efficiency lies in the reduction of steps that have to be executed. Repetition of a large number of steps in a complicated, but uniform sequence, as is done in mass-housing projects, is not more efficient than the execution of a smaller number of simpler steps in varying sequence.

In any project that is complex, whether buildings or computers, machines, airplanes, or whatever, production always involves a succession of interventions on different levels. The regional planner makes a regional plan, an urban designer makes the urban design within a regional plan, then an architect makes a building in the urban design. We have organized ourselves so that each level that comes into play involves a different party, requires different expertise, and exercises different controls. It is possible that the same person might do both an urban design and a building design, but it is not common.



3.1 Facades of the rowhouse dwellings, one type with roof perpendicular to the streets and the other with roof parallel to the street. Left: street side; right: back side.

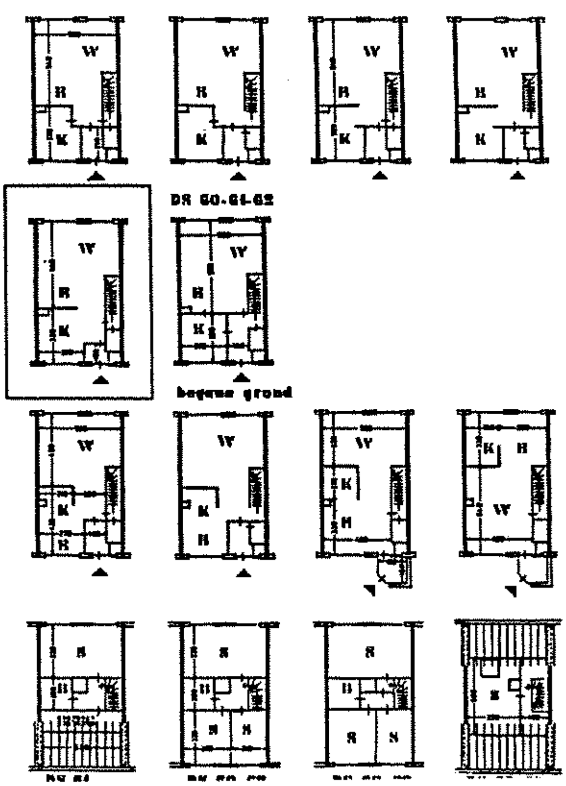


3.2 The floors as completed before infill.

The building process is exactly the same. We recognize that the dwelling today has become more complicated, and we assume that work at a large scale cannot be done on all levels by the same group. Remove the infill, and the building can be built efficiently. Another party is left to deal with the infill in its own, most efficient way. The relation between the support and the infill is exactly the same as the relation between the urban design and the building. The higher level makes the first move on a large scale, then the lower level makes its own move on a small scale. Variety can result, but it is not necessarily the goal. If twenty different architects were each invited to design a building, it would be unlikely that they would come up with the same building twenty times. Variety would be inevitable, because each architect would seek the appropriate solution for his own client. That kind of variety can be very efficient.

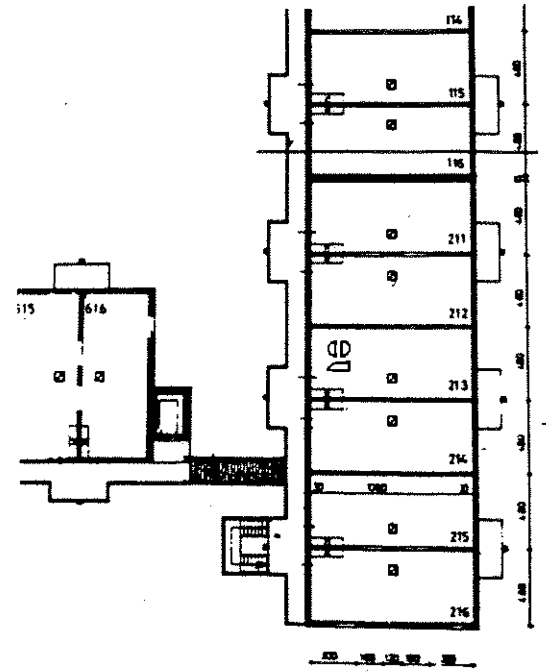
The same is true on the building level: it is efficient to allow the lower level to make its own decisions and ensure variety that way. On yet another level, that of people furnishing their rooms, variety is natural as well. What we are talking about is not a technical system or a specific product, but the organization of the building and design process. The reason the Dutch experiments were successful was that they introduced a distinction between levels of control and recognized that it could be advantageous to have different parties operating on each of these levels.

Sites-and-services projects, as applied in other parts of the world, utilize exactly the same approach. One party lays out

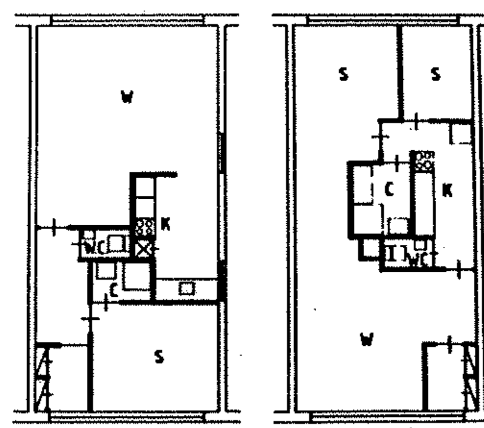


3.3 Overview of the various layouts which could be chosen by the occupants. The alternative enclosed in a box is the standard version on the basis of which dwelling prices were determined. Prices for all other alternatives based the subsidy, the annual rent rebate, and the total cost for the project on this standard dwelling.

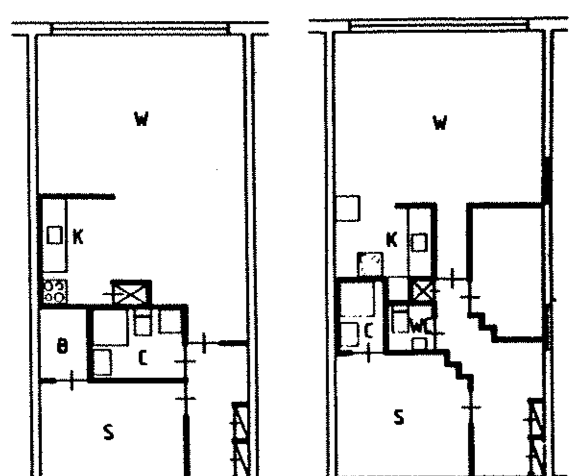
Fig. 4 Project for about 120 units. "Keyenburg," Rotterdam. Architect: Frans van der Werf. Completed 1984.



4.1 Part of a typical floor before infill.



4.2 Example of infill variation.



4.3 Example of infill variation.

the sites and puts in the services, another party builds the house. The fact that one of the parties can be either a user or someone who asked an architect to design a building for investment is secondary. The levels themselves are what is important. Some people argue that the support building, once it is made independent of the more vulnerable infill system, can be regarded as an investment of not just forty years (the length of a mortgage in the Netherlands), but sixty or seventy years. The longer the mortgage on a building, the cheaper it will be for people to buy into a support structure. On the other hand, the infill should be regarded as a durable consumer good like a car; it can be paid off in ten or fifteen years. Financing the dwelling might be more advantageous to the user this way. Recently, economists like Ranko Bon at MIT and Tempelmans Plat in Eindhoven have begun to study the merits of costing subsystems in buildings on the basis of their expected use life.

Discussion

TAY KHENG SOON: Can you elaborate on the controls regarding the interior layout? If the tenants dictate the plans, how can the builder deal with building regulations, ventilation requirements, and so on? Second, is there any indication that residents will soon also want to control or to change the exterior appearance of the building?

HABRAKEN: For the experimental projects in the Netherlands (and, I think, in London as well) the authorities were willing to relax their rules and to see what happened. As long as safety was not endangered, people could do what they wanted. If plans posed fire hazards, or would lead to inadequate ventilation, or something like that, they were of course modified. Originally the Netherlands had very strict rules governing floor plans; the government spelled out, not only the dimensions, but also how the rooms had to relate to one another and so on. Partly because of support-infill experiments, but primarily because of general dissatisfaction with the regulations, space standards are now much relaxed. The trend is to look more at the overall area for a floor plan and the capacity for so-and-so many bedrooms. Building regulations were important in former times, when the government had to protect the user against developers who would force floor plans on them that were bad or unhealthy, but now, after eighty years of public housing, the population knows what it wants, and nobody will be able to force anything on them. Natural ventilation is also less crucial today. So the tendency is now toward loosening control. Control will probably be exercised over the quality of the infill elements to eliminate hazards and ensure proper functioning.

As to your second question, about the exterior, my impression is that the tenants find interior adaptability more important. Two of the experiments I showed offered a very clever balance between control on the outside by the architect and freedom for the user. I have not heard of any pressure by users to do more than that. Owner-occupied town houses, however, are a different matter. There the tendency is to give as much variety as possible to the façades. Architects have been providing options such as porches and a variety of entrances.

TAY: Another problem with built-in flexible planning is that the landlord can take advantage of it to subdivide the dwelling into very small rental cubicles to increase his income from the building. Some kind of control would have to be exercised to prevent that from happening. As for the exterior, whenever the poor grow prosperous they immediately want to tack up some visible evidence of their new wealth. Salesmen and small-time subcontractors prey on them, selling them all sorts of decorative items that allegedly lend prestige. A lot of this stuff ends up on the outside of their houses. In Singapore one sees apartment blocks that are covered with very elaborate metal grilles on the doors and windows. If the HDB allowed it, each tenant would paint his own piece of façade differently.

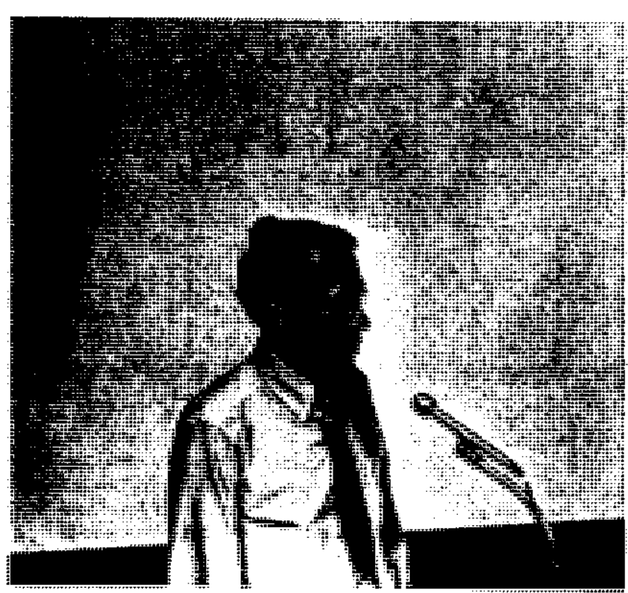
HABRAKEN: Whether the façades have to be controlled or not is, of course, debatable. If we distinguish two levels—a level for the architect and a level for the user to fill in—then of course we have to decide where one control stops and the other begins. That is a question that is not easy to answer; it probably has to be discussed for each place and time.

YASMEEN LARI: The best thing about this system is precisely that it is flexible. The level of control can be changed according to the situation and to the country.

QUESTION: It is all very well to ensure maximum flexibility, but it can increase costs if it involves extra pipe work, wiring, etc. You showed an example where the wiring went all around the room. If only one wall had been assigned to sanitary purposes, the wiring required would have been reduced by a quarter or so. Have any studies been done on potential cost-cutting of this sort?

HABRAKEN: Yes; it has been studied almost to death, because yours was one of the major arguments used against the approach. Another was that varying floor plans and using a modular system would inevitably result in a bigger overall dwelling than a single, optimized floor plan would give. It is a similar argument—that flexibility and variety take more space and more material than standard units do.

Both are possible, but not unavoidable; that is where good design comes in. It is not easy, for instance, to design a good support that will give the maximum number of possibilities for interpretation and still have a very simple support with dimensions that are normal. It takes more time to design, but if the time is taken and the problem studied, I can assure you that there is no waste in either respect. Perhaps careful calculation would reveal a few feet of extra plumbing in some of the



units, a little less plumbing in others—it depends on what people want to do. But even if the total comes to a bit more, it is far outweighed by the efficiency of the installation and the time saved in labor. I have not yet heard a convincing argument on those grounds against the system. The average in square meters, plumbing, etc., is overall about the same as it would be with one uniform floor plan. It is, of course, possible to make the support with input in the wrong places, to make openings in the walls in the wrong places and end up with extremely inefficient floor plans. But that is a fault of a particular design, not the approach itself.

QUESTION: In Singapore, although there is no doubt that people like to put their individual stamp on things, they are not really disturbed by living in a uniform environment. Why is it such an important consideration in the West? Has a comparative study ever been made of people living in an apartment of their own design as against those living in a predetermined environment? If so, was there really a difference in level of satisfaction? Is there any theoretical reason why it is so important to have variety in one's living environment? Finally, on a more practical level, how long does it normally take for the developer or contractor to settle on a plan with the tenant?

HABRAKEN: One does not have to defend the system on the grounds that variety is important. Variety is achieved by it, but one can argue for the system solely on the grounds of efficiency. It is good for building. In the Netherlands, it was also often argued (and probably still is) that people are not upset by uniformity of plan. In a market where it is difficult to find a house, people are happy with what they get. Certainly in Holland the plans were good, and at the time there was no reason to complain. But twenty years later, investors found that users were complaining about their accommodations, so in the long run variety became an issue. How important it is for a user to make his own floor plan from the beginning is debatable. There are people who say, let us just build the same uniform floor plan; if they want to change it they can.

So far these have all been experimental projects—the participants were volunteers. I have not been told about people who said they did not want to be involved in the planning, but I suspect they existed. Eventually, perhaps, this way of working will result in such a variety of apartments that users will be able to pick out an apartment they would not want to change. These are two different situations actually: one involves participation in the original design; one involves changes when a tenant moves into a house perhaps many years later. It is no different from the situation that exists in the free market in houses. Some people prefer to buy a ready-made house which they may change here and there; others prefer their own architect and their own design.

How important participation is, I do not know, but undeniably the people in these projects did take a great deal of pride in their designs. I will be very curious to find out what the turnover rate in them will be compared to ordinary housing. It is too early to tell, but people do like to live there. In the Dutch projects, turnover will probably be minimal because the Dutch tend to stay in the same neighborhood. They only move away under duress, when the house is no longer suitable and they cannot find a better one nearby.

One owner of an experimental infill project gave his own reasons for favoring tenant participation. He claims that when something goes wrong in his older projects, leaks in the bathroom or whatever, the tenants call him immediately. In the new one, the tenants fix it themselves. Although in both cases the people are renting, he claims that he has less trouble with his tenants in the self-help house because they take pride in their own work.

The question of how much help user design takes: in the English project the client and the architect arranged a series of meetings to instruct the users how to draw up their plans. Nabeel Hamdi, the architect on the project, thinks they overdid it. They were too anxious to keep the tenants happy. In another project I showed, the architect gave only two sessions to each user. In the first one he asked them to select the space where they wanted to live and gave them its plan with a grid; they were told that they could do anything as long as the walls were on the grid, and the bathrooms connected to the vertical plumbing stacks. The second session was for questions. The architect told me somewhat wistfully that in that second session nobody ever asked him what to do. They came, but it was because they knew what they wanted and wanted help carrying it out. In the third project, as I mentioned earlier, the architect did not talk to the users at all. He simply provided a catalogue of twenty different floor plans, and the tenants ordered from the catalogue. In the Netherlands there is a kind of typology of houses that people are familiar with and within which all these projects fall. Architecturally they are not radically new, so it is not difficult for prospective tenants to make their choice.

QUESTION: What user participation occurs after the building is finished? In the London and Netherlands projects did users have any say about the quality of the spaces in and around the project?

HABRAKEN: In the various projects, common spaces were handled in various ways. In the project with the courtyards, the architect convinced the municipality that the collective users should control them. Then he sat down with the people and they discussed together the designs he would make.

THE SUPPORT APPROACH

ILLUSTRATIONS
FOR THE
TWO DAY LECTURE SESSION

MURCEP

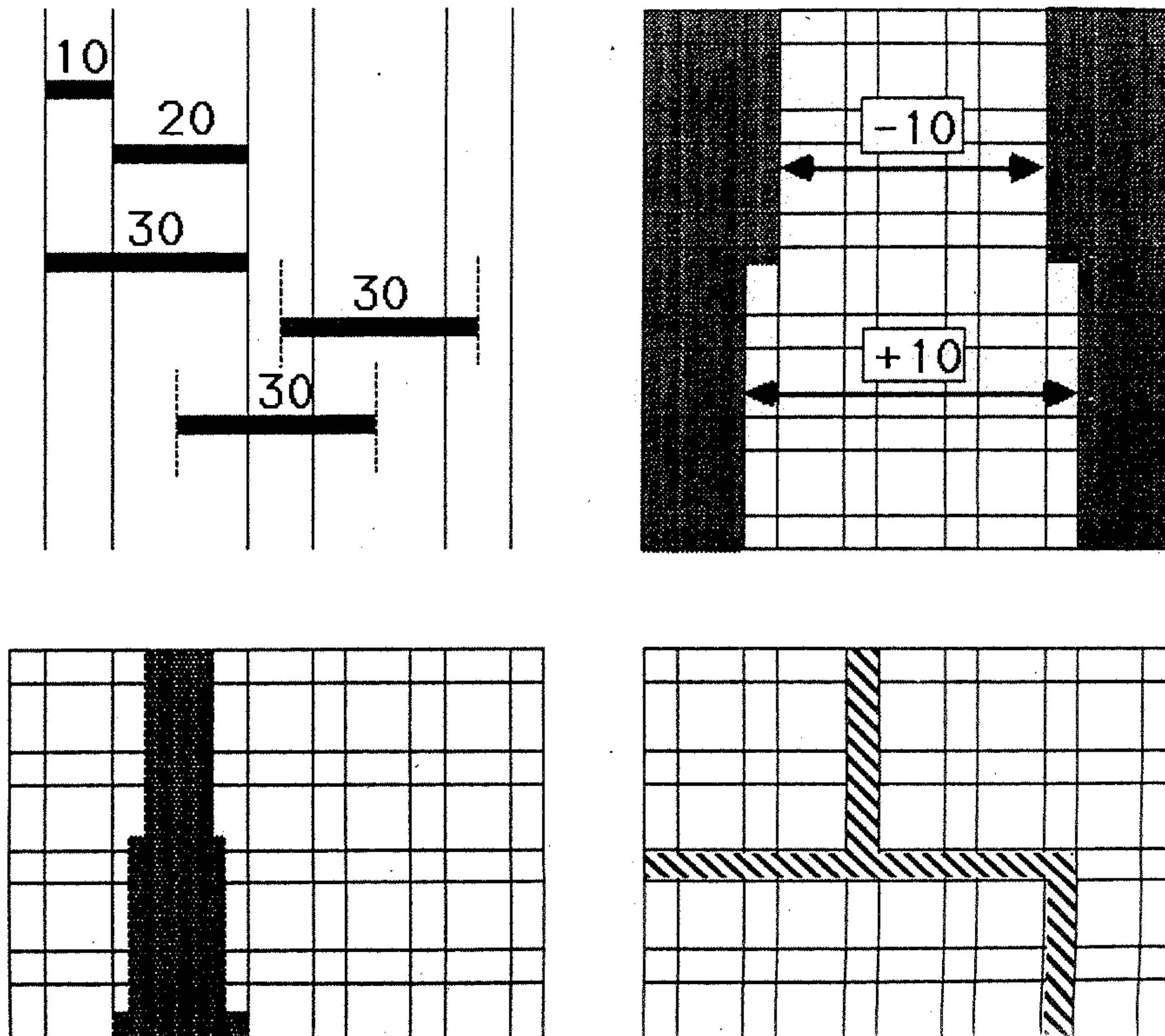
MAY/JUNE 1986

N. JOHN HABRAKEN

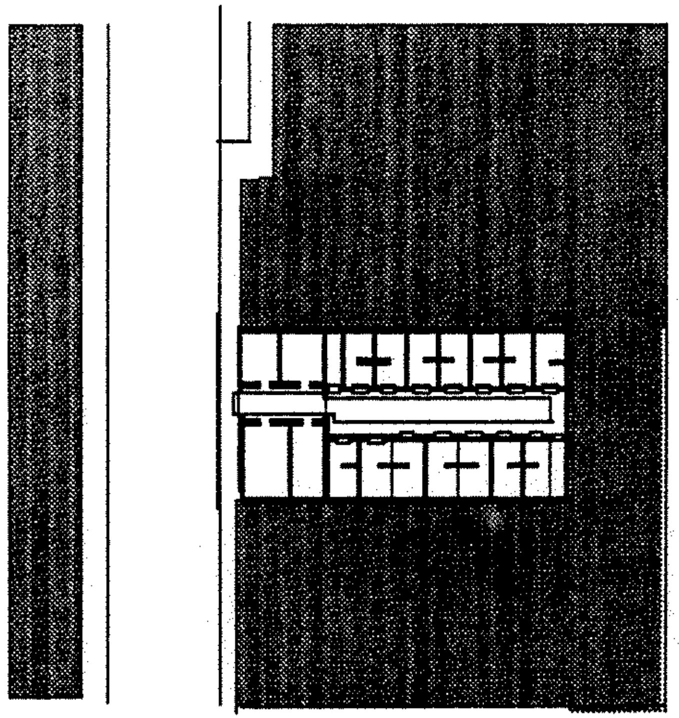
SHEET A
ZONE DISTRIBUTION

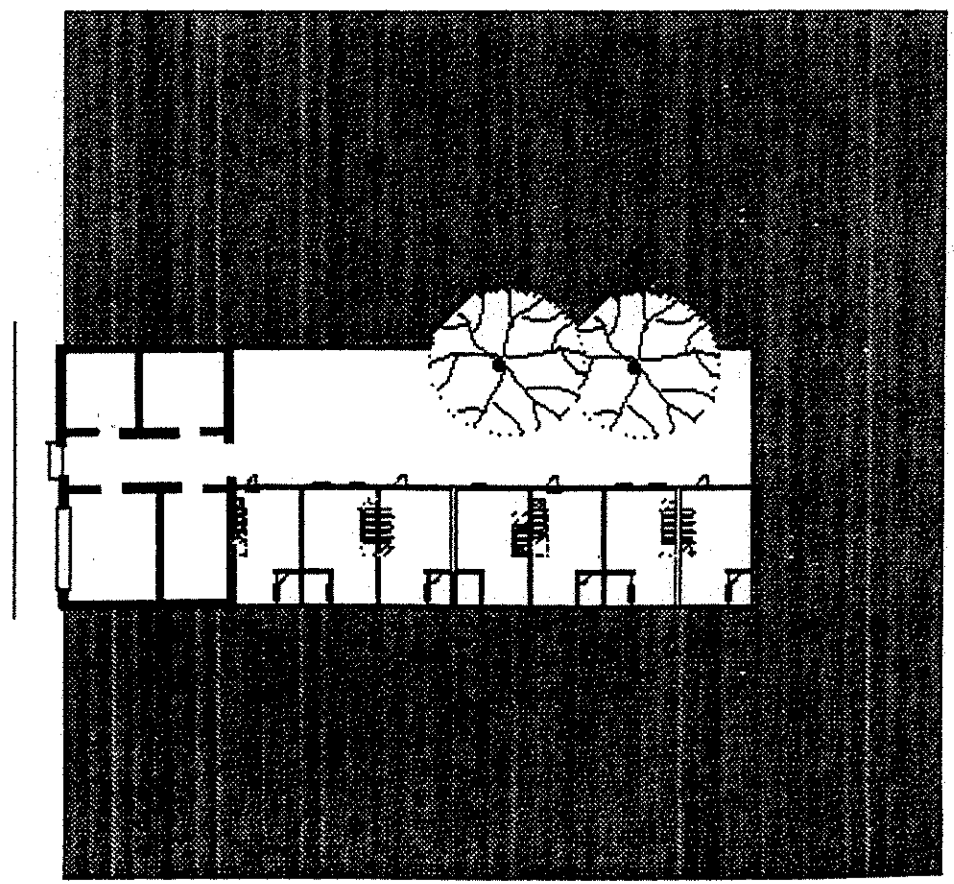
A B
C D

A. BAND GRID
B. SPACE DIMENSIONS
C. POSITION OF SUPPORT WALLS
D. POSITION OF INFILL WALLS



MURCEP SESSIONS
SHEET 2
MODULAR COORDINATION





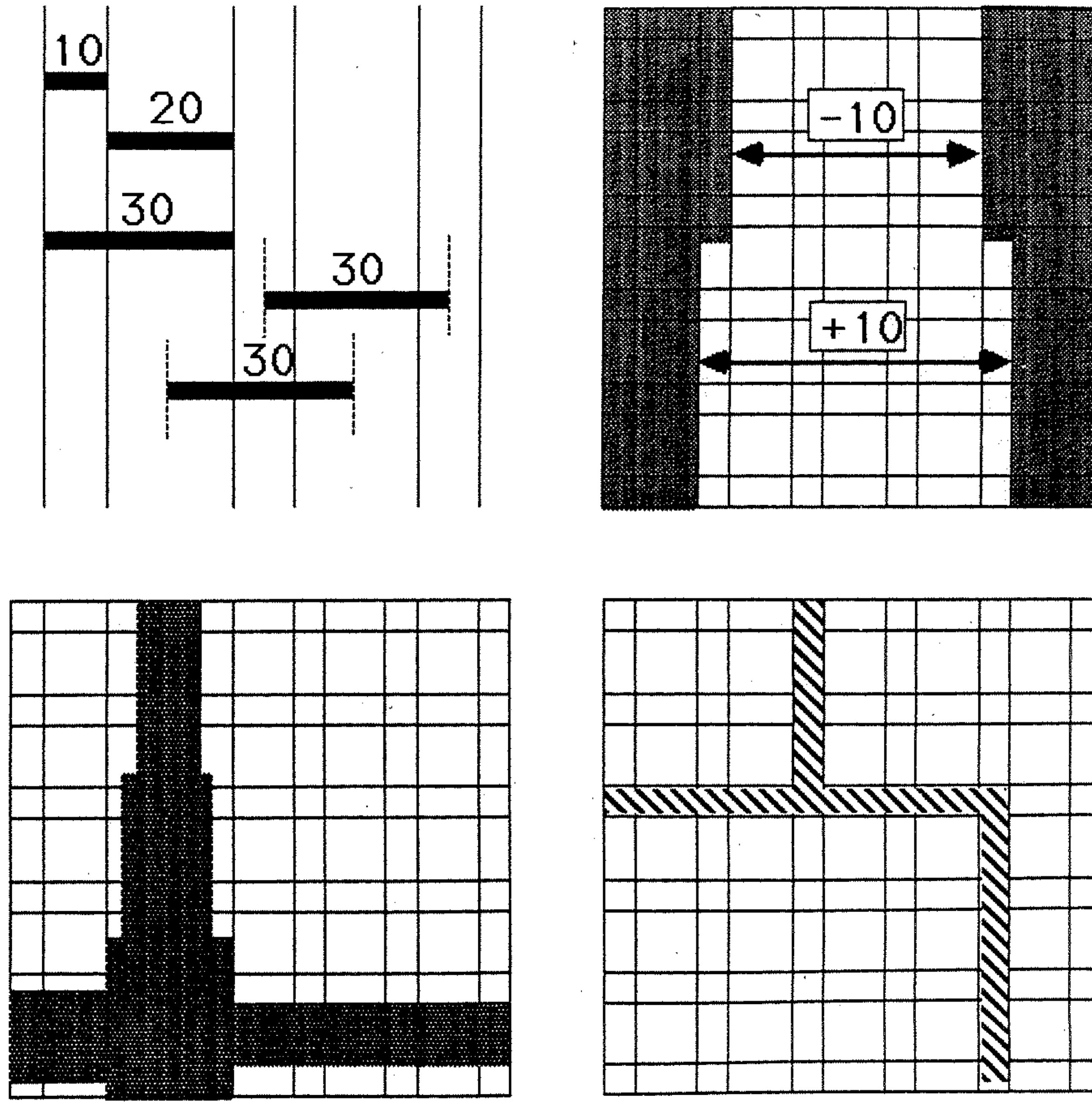
1

MURCEP SESSIONS
SHEET 1
SITUATION O FTHE EXAMPLE
DEVELOPED IN THE NEXT SHEETS

A B

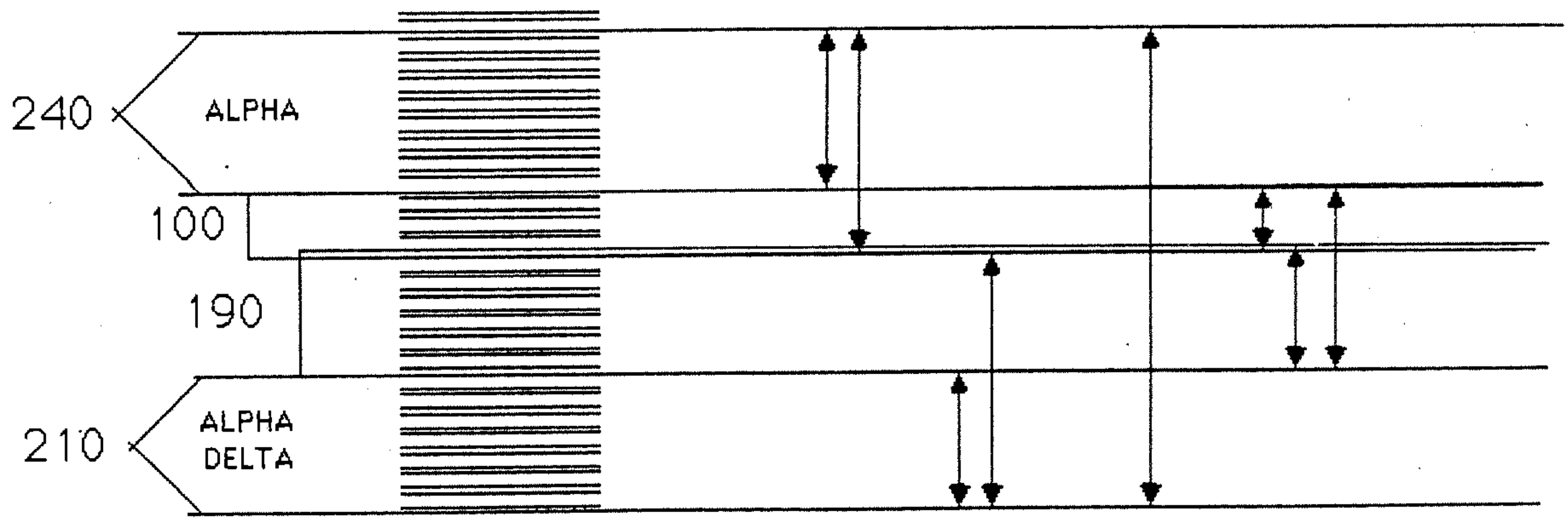
C D

A. BAND GRID
B. SPACE DIMENSIONS
C. POSITION OF SUPPORT WALLS
D. POSITION OF INFILL WALLS

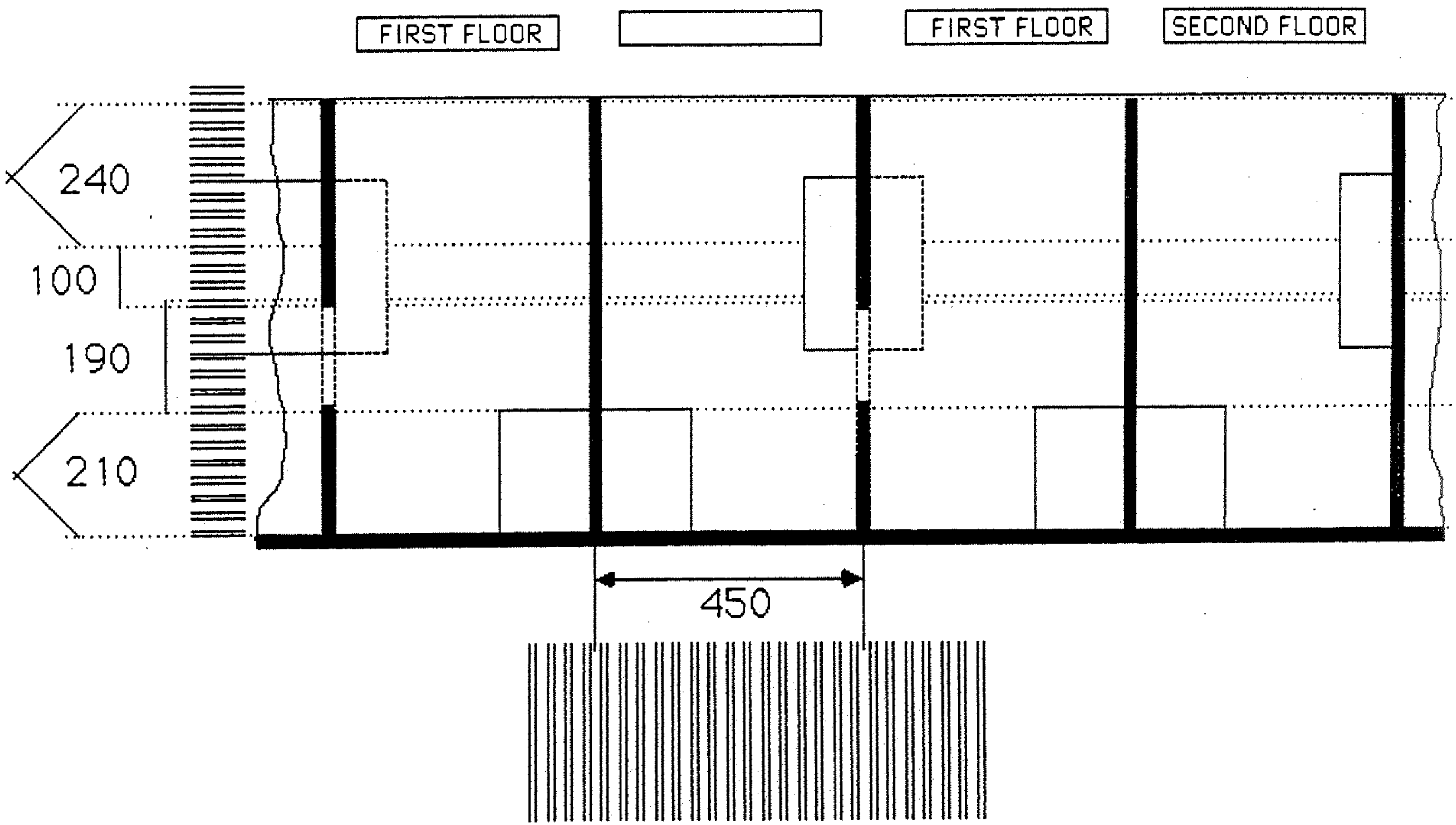


MURCEP SESSIONS
SHEET 2
MODULAR COORDINATION

2

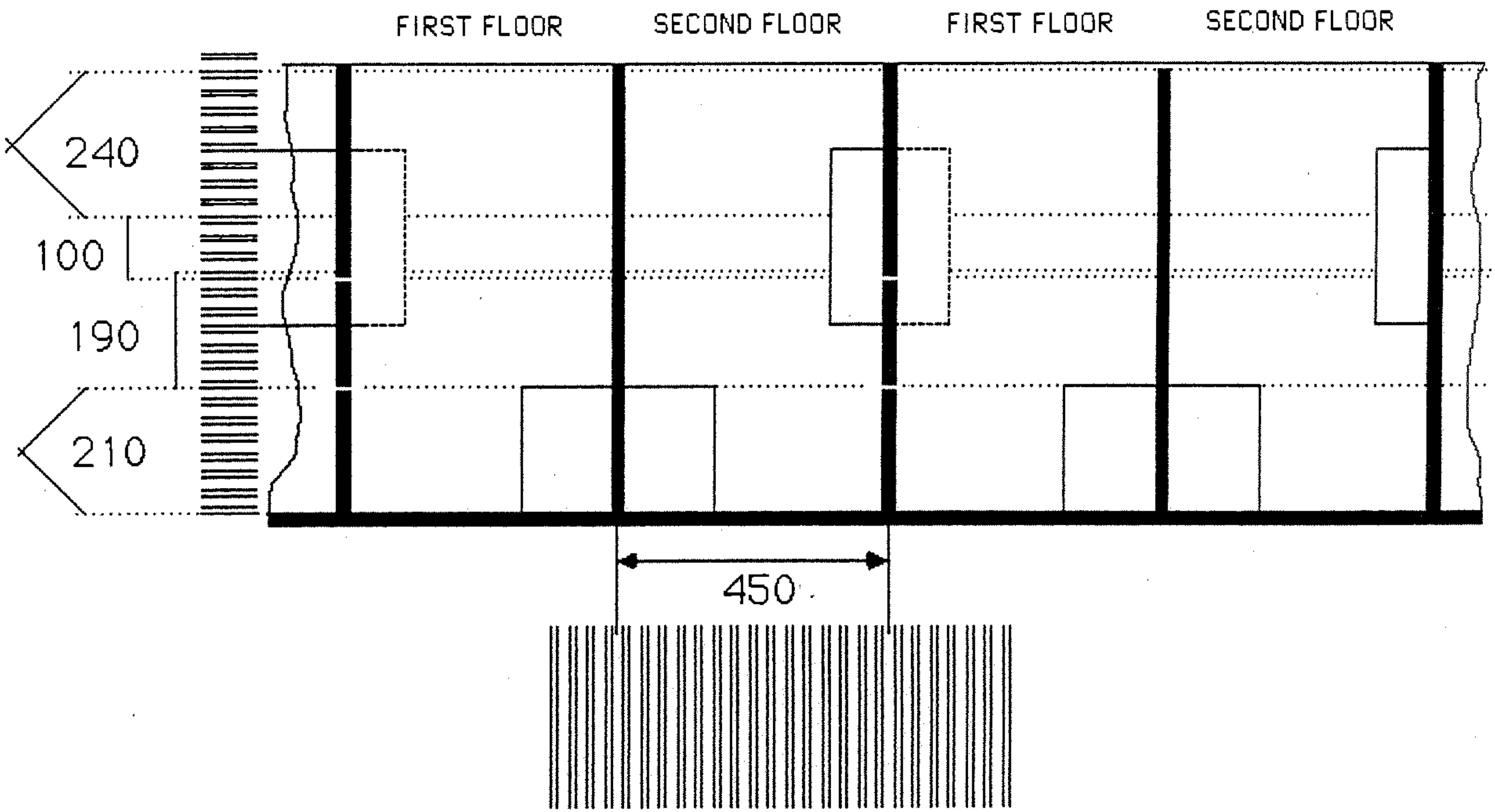


MURCEP SESSIONS
SHEET A
ZONE DISTRIBUTION



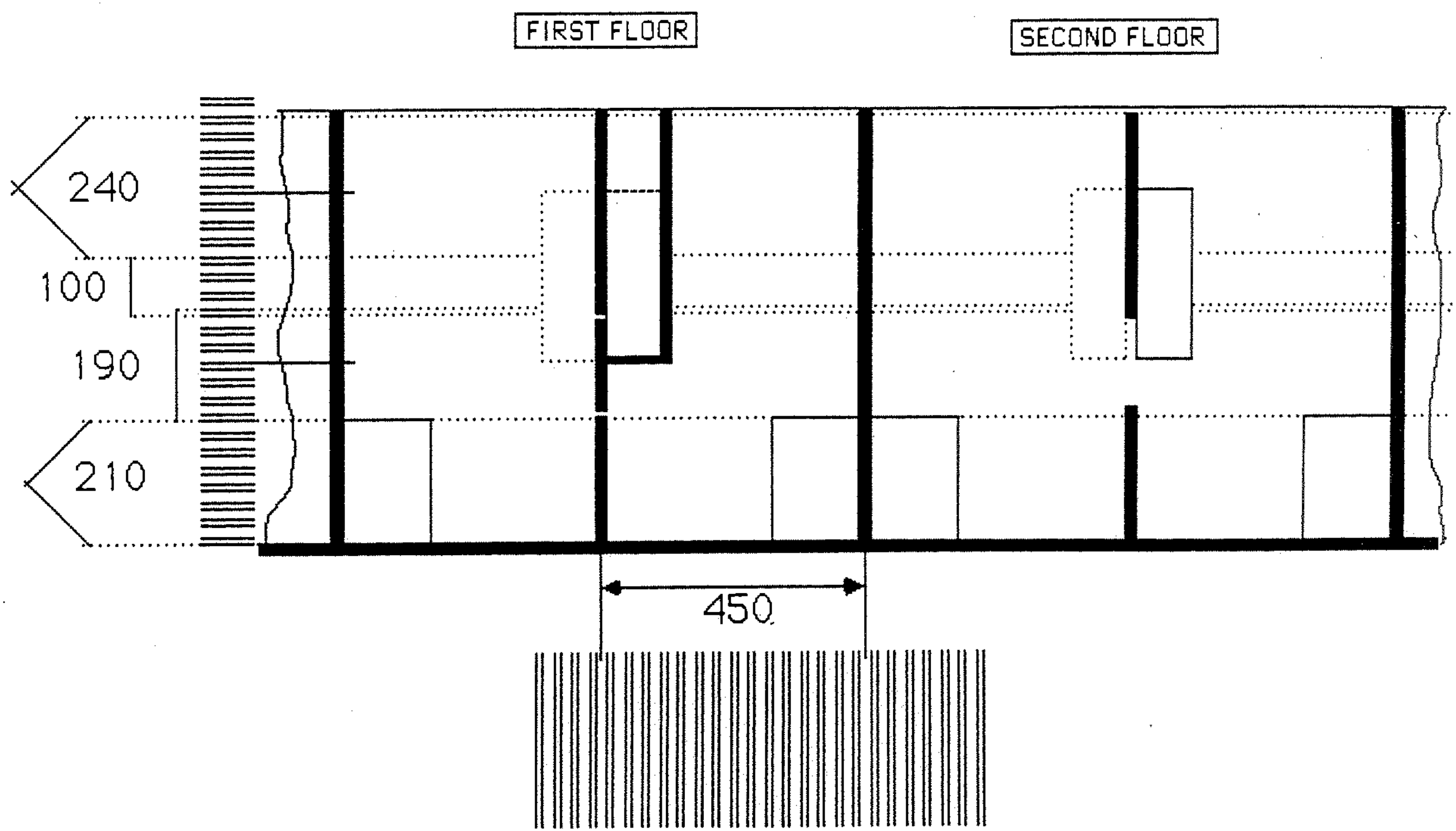
B

MURCEP SESSIONS
SHEET B
MINIMUM SUPPORT



C1

MURCEP SESSIONS
SHEET C1
TERRITORIAL DIVISION



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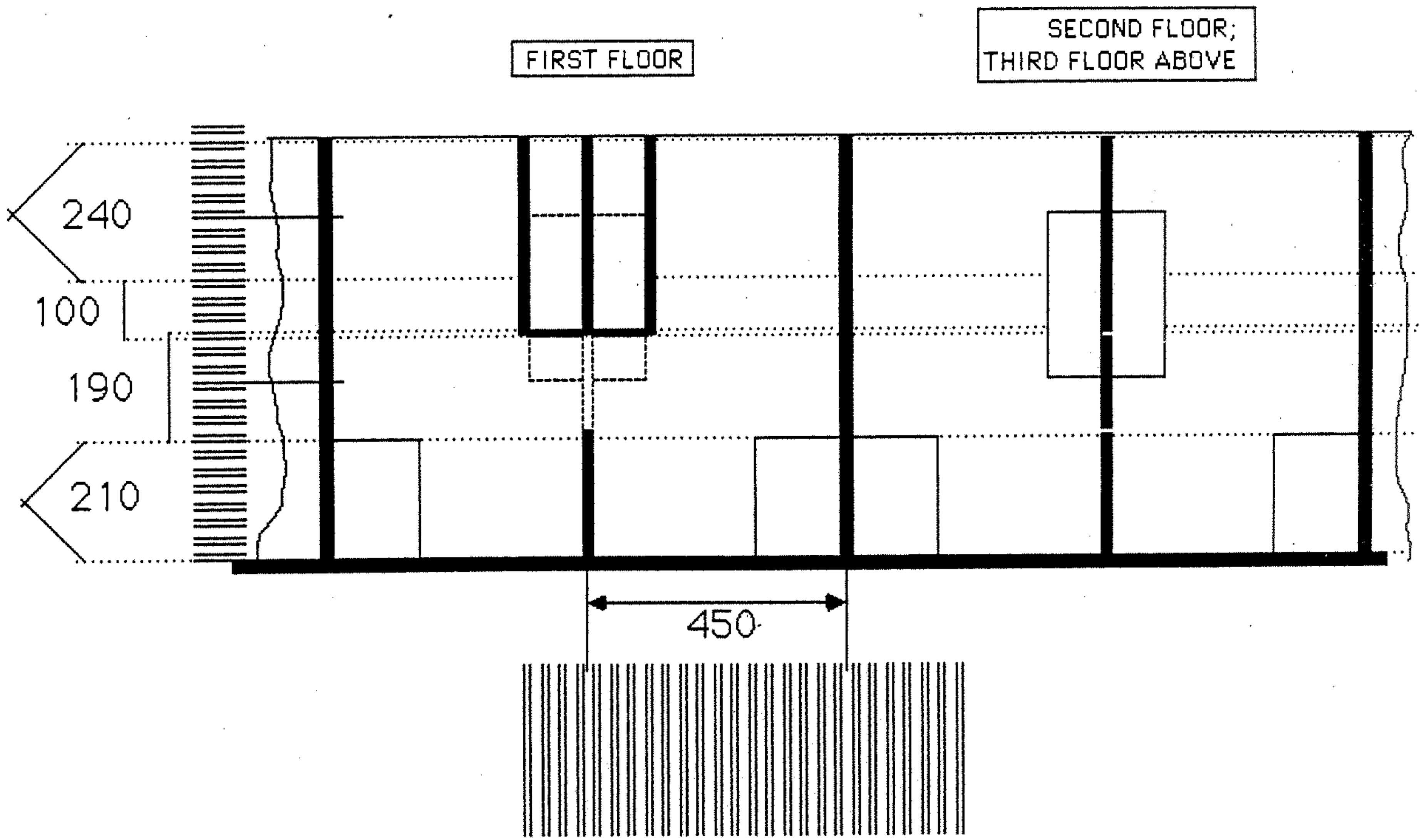
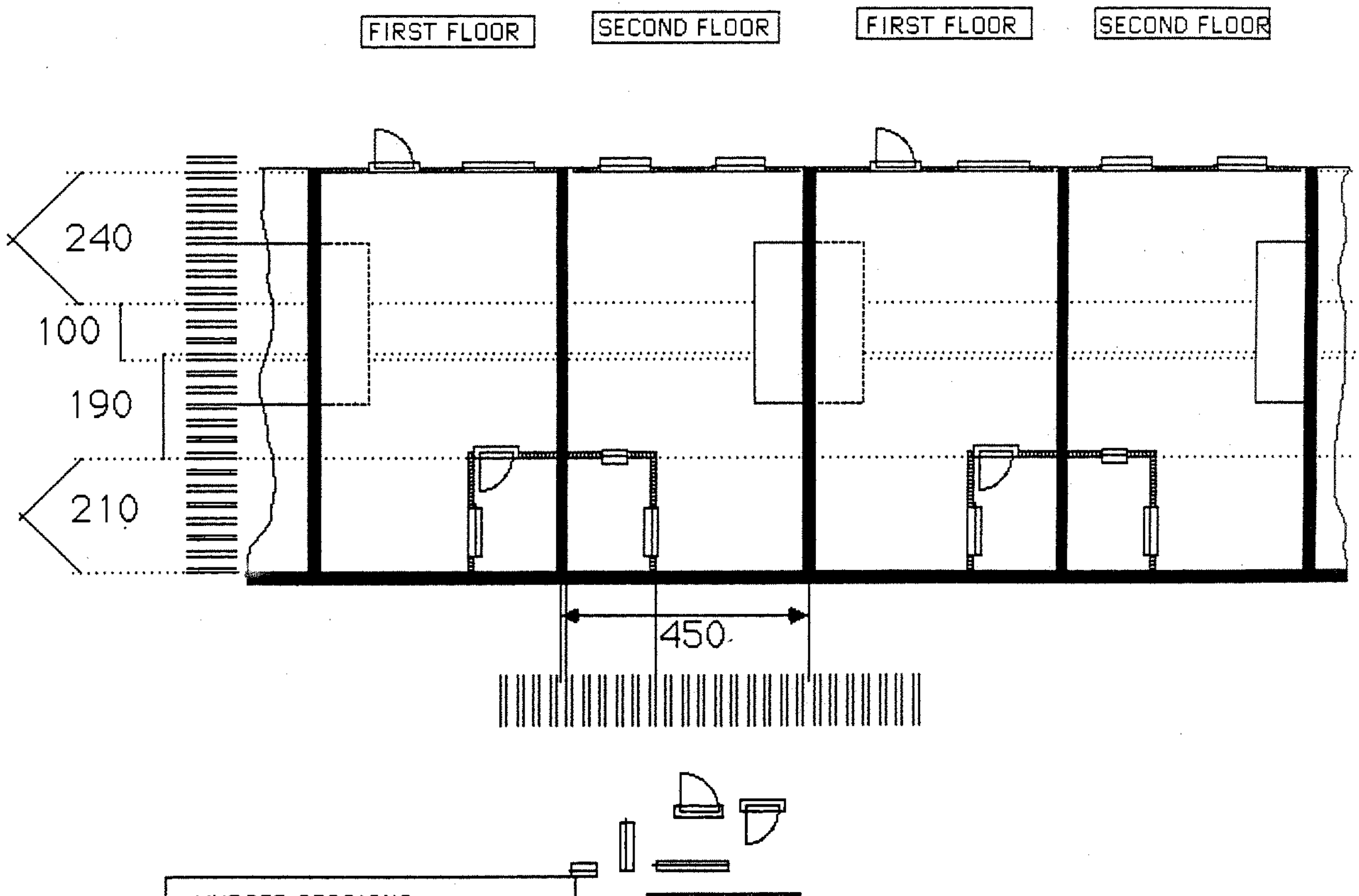
MURCEP SESSIONS
SHEET C2
TERRITORIAL DIVISION



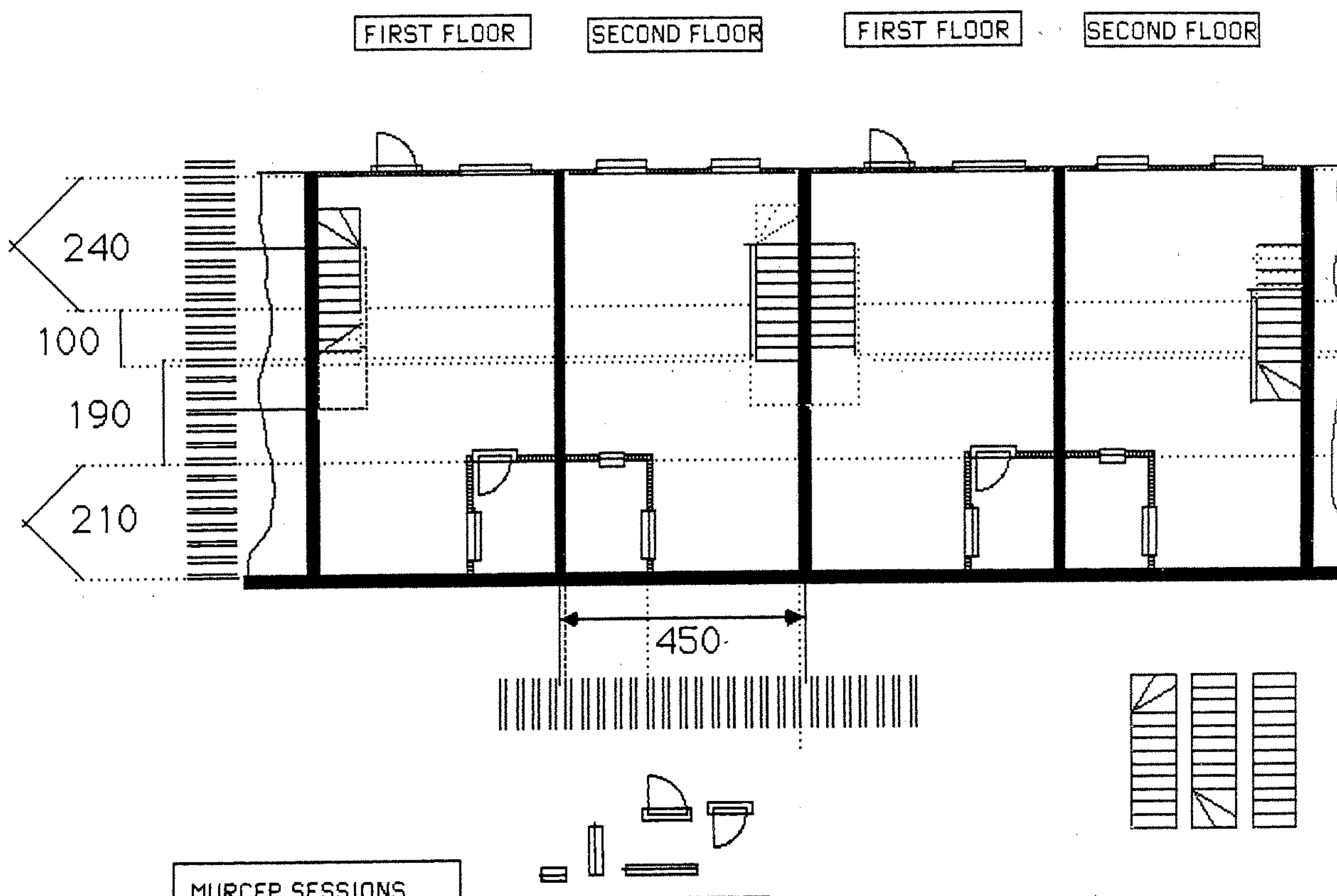
C3

MURCEP SESSIONS
SHEET C3
TERRITORIAL DIVISION



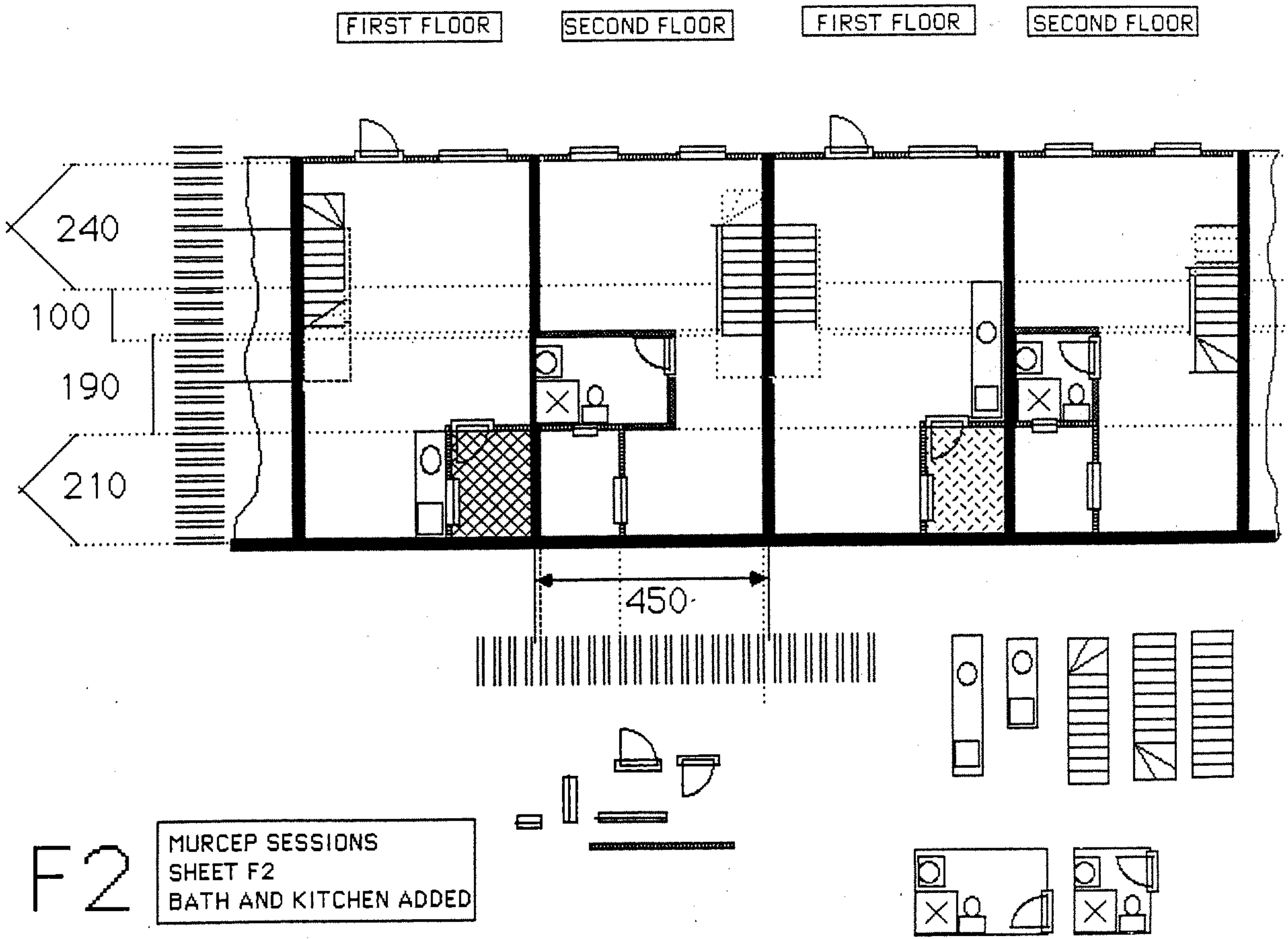
D1

MURCEP SESSIONS
SHEET D1
SUPPORT WITH FACADE WALLS



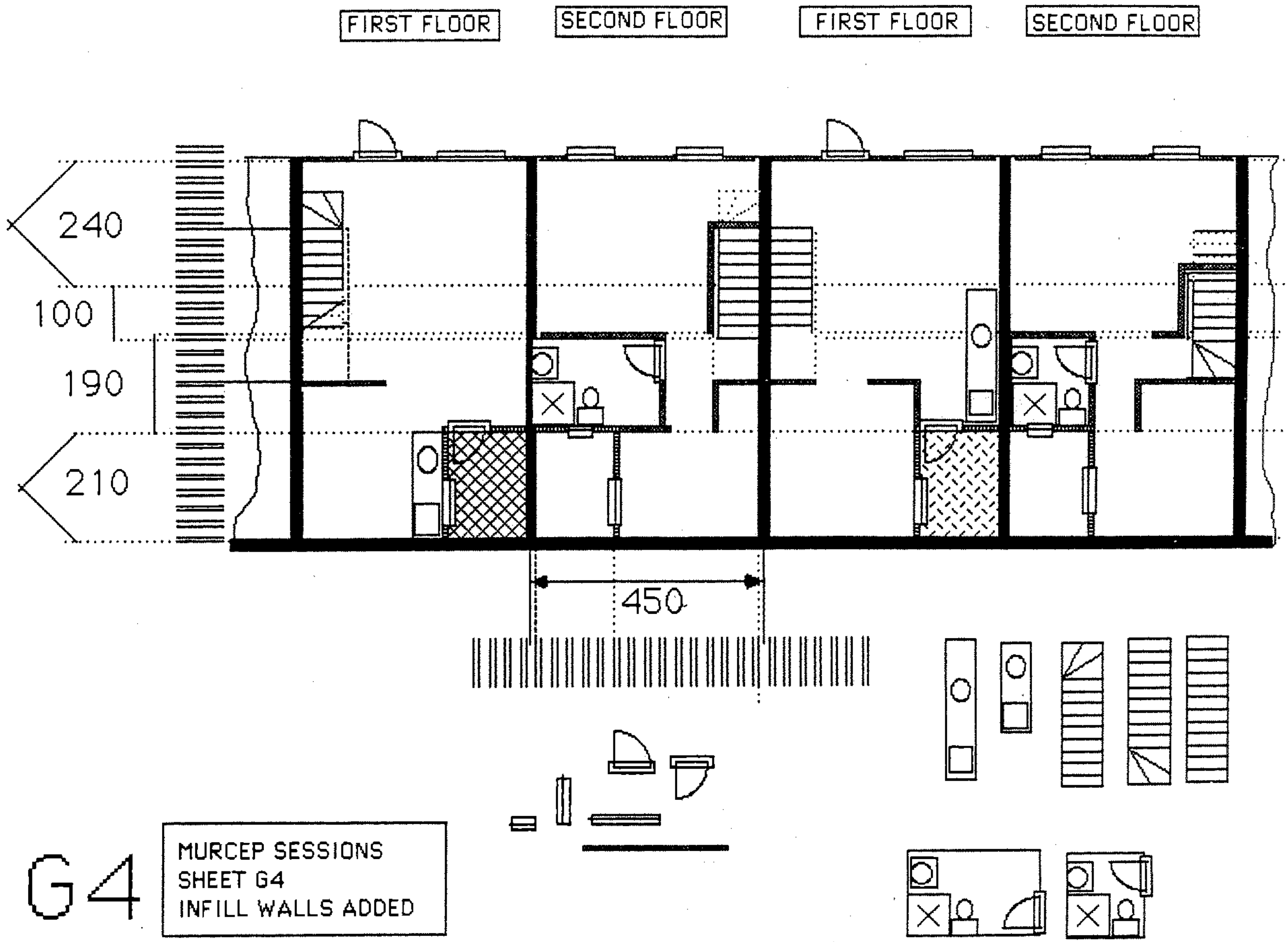
E1

MURCEP SESSIONS
SHEET E1
STAIRS IN SUPPORT



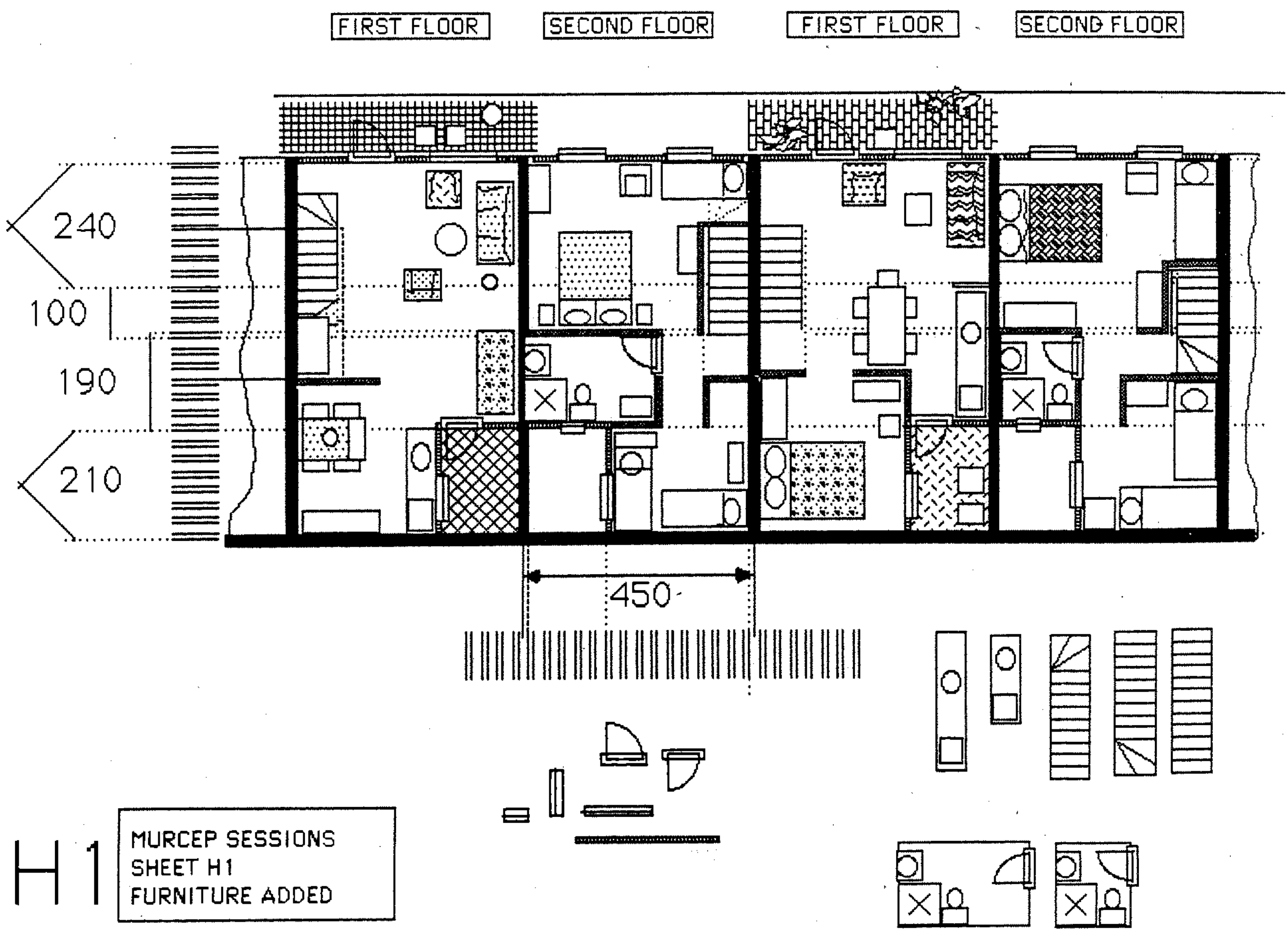
F2

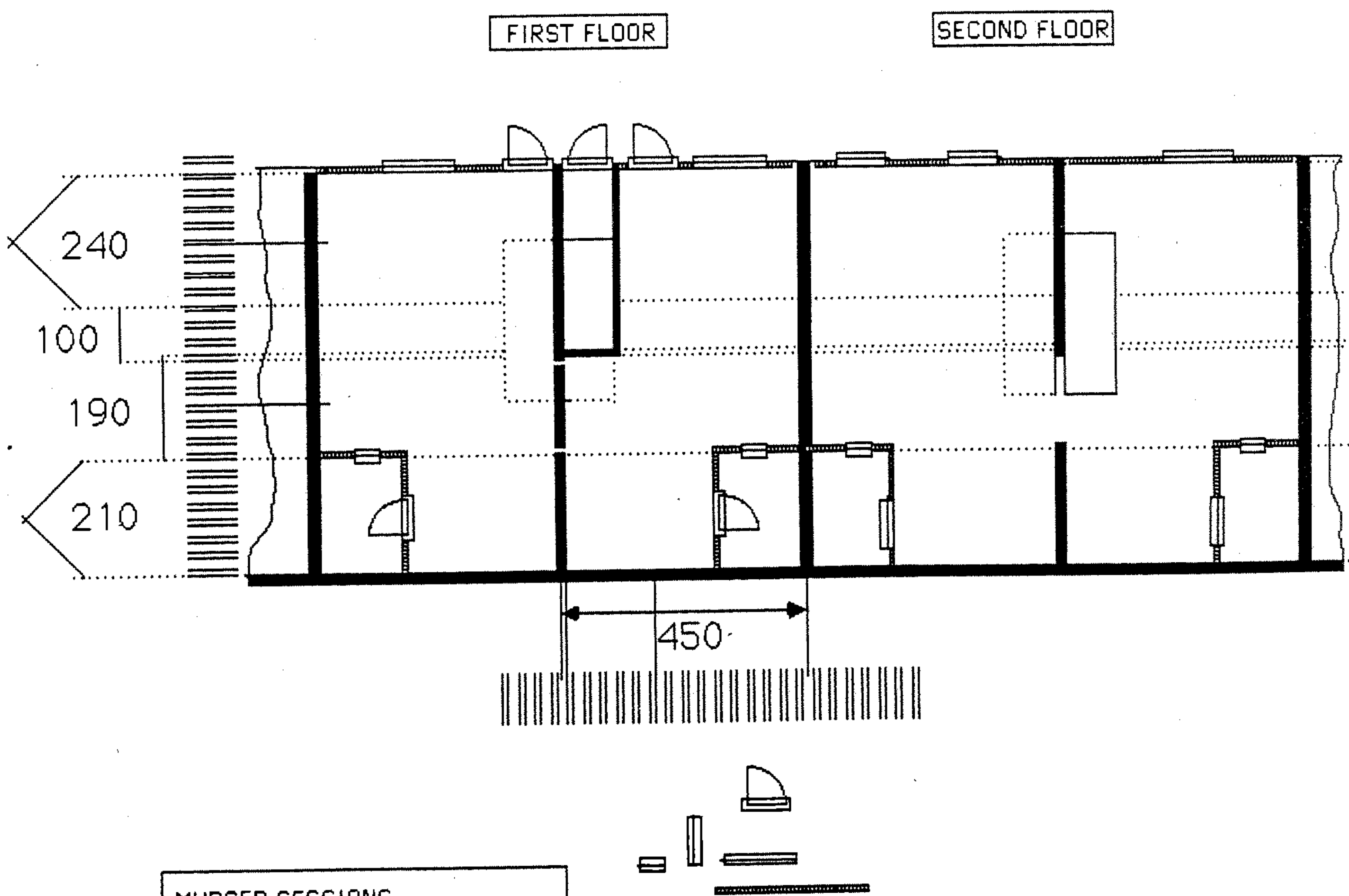
MURCEP SESSIONS
SHEET F2
BATH AND KITCHEN ADDED



G4

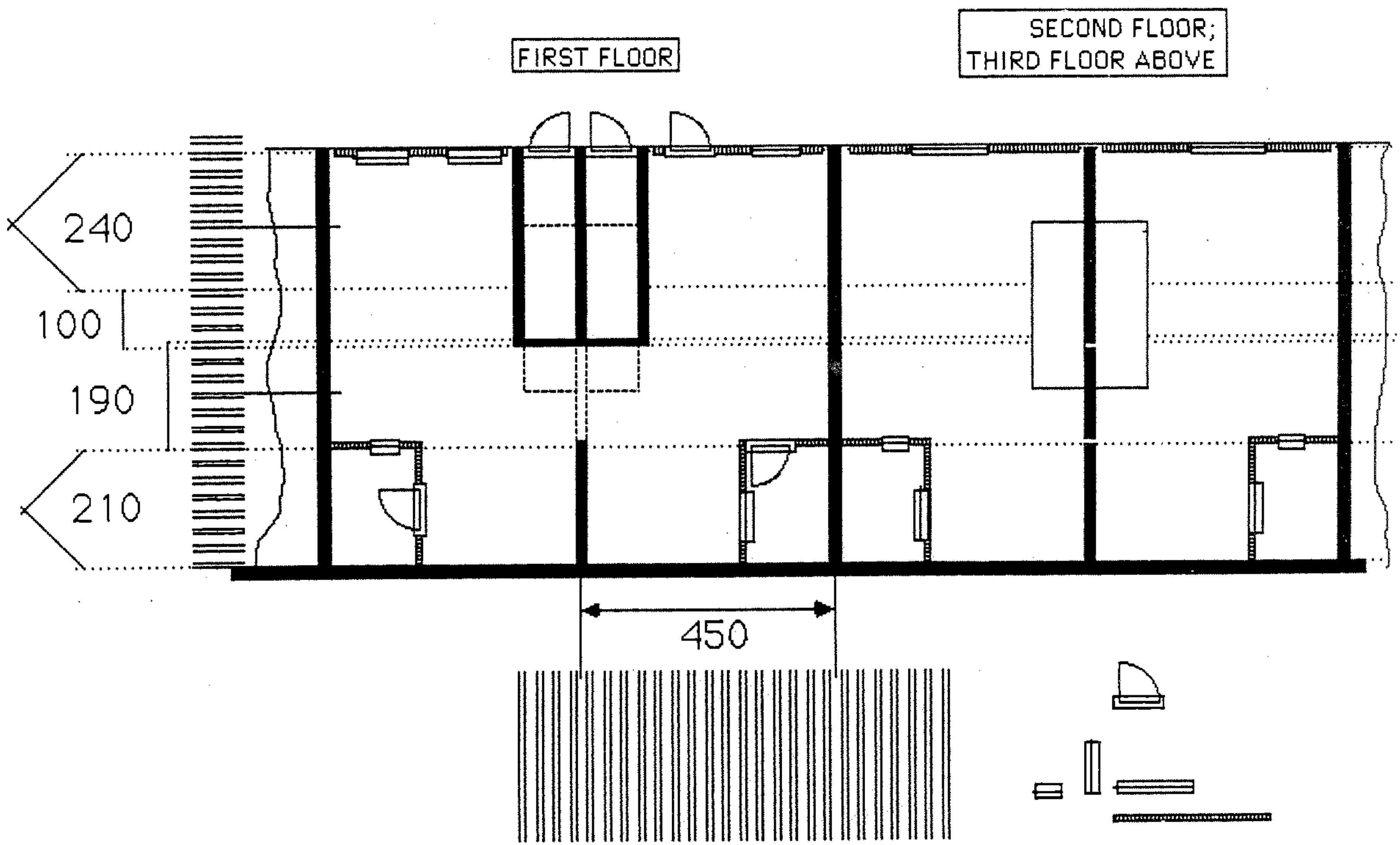
MURCEP SESSIONS
SHEET G4
INFILL WALLS ADDED


FIRST FLOOR
SECOND FLOOR
FIRST FLOOR
SECOND FLOOR
240
100
190
210
450
H1
MURCEP SESSIONS
SHEET H1
FURNITURE ADDED



D2

MURCEP SESSIONS
SHEET D2
SUPPORT WITH FACADE WALLS



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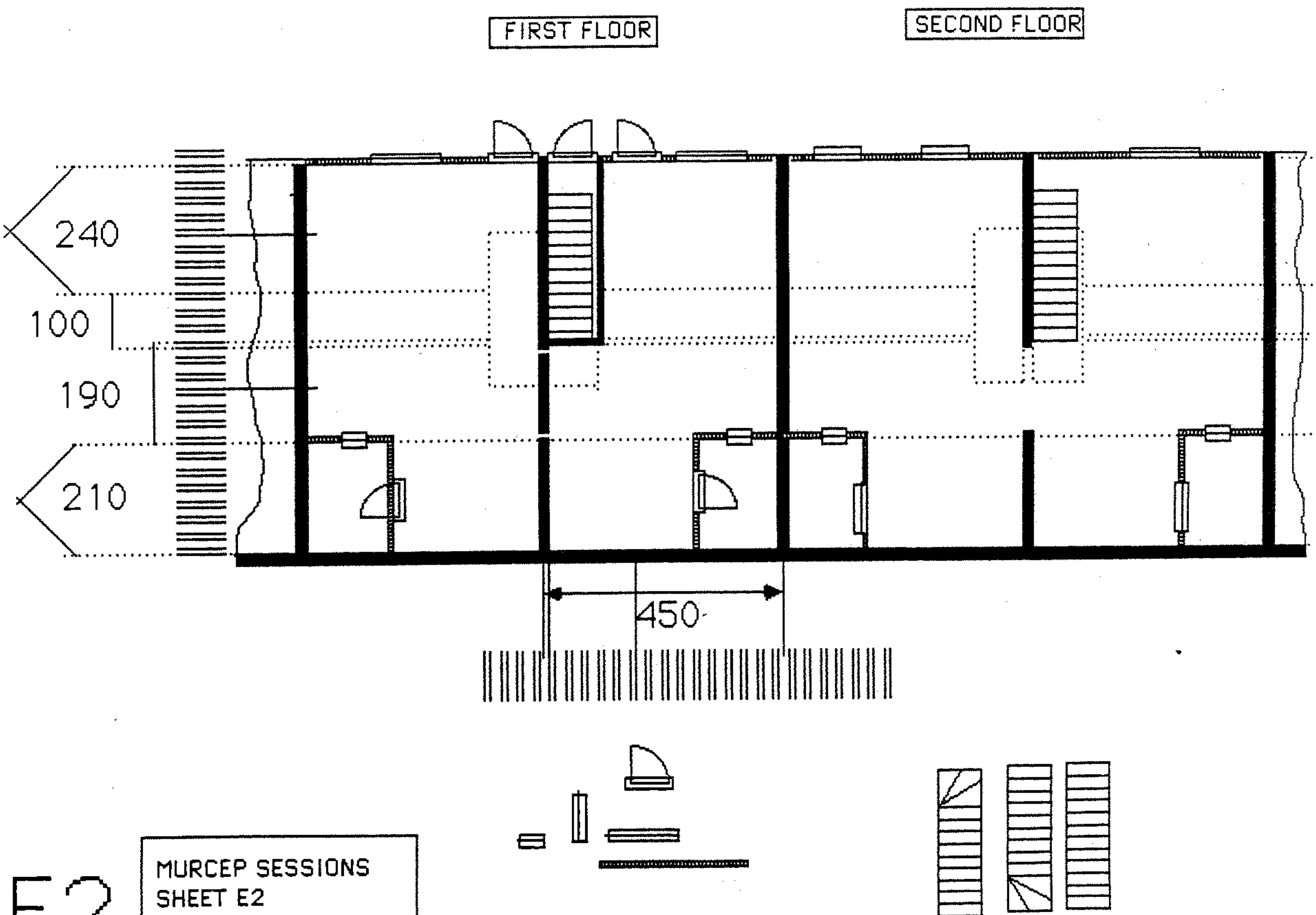
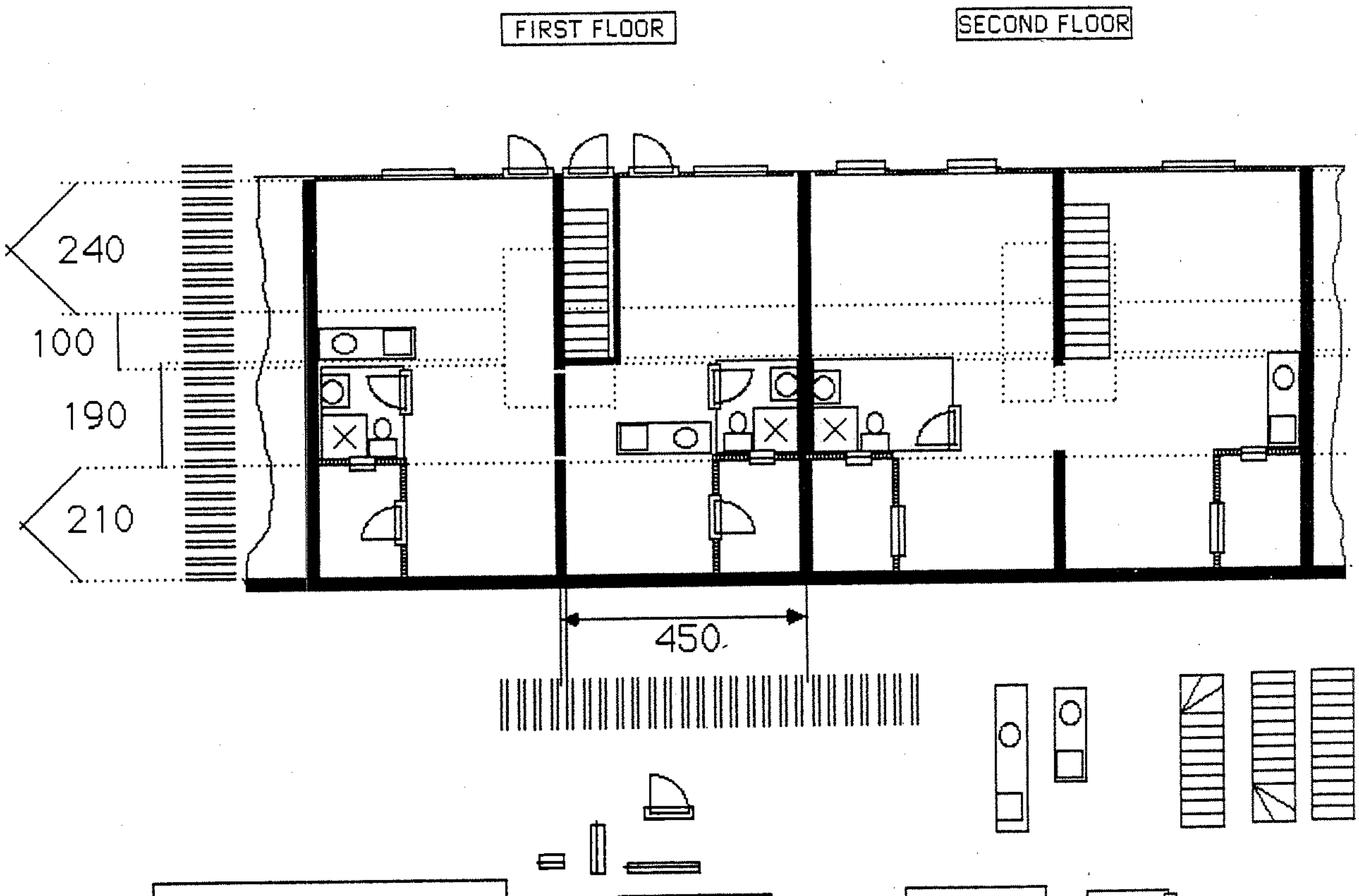
MURCEP SESSIONS
SHEET 3
FACADE WALLS



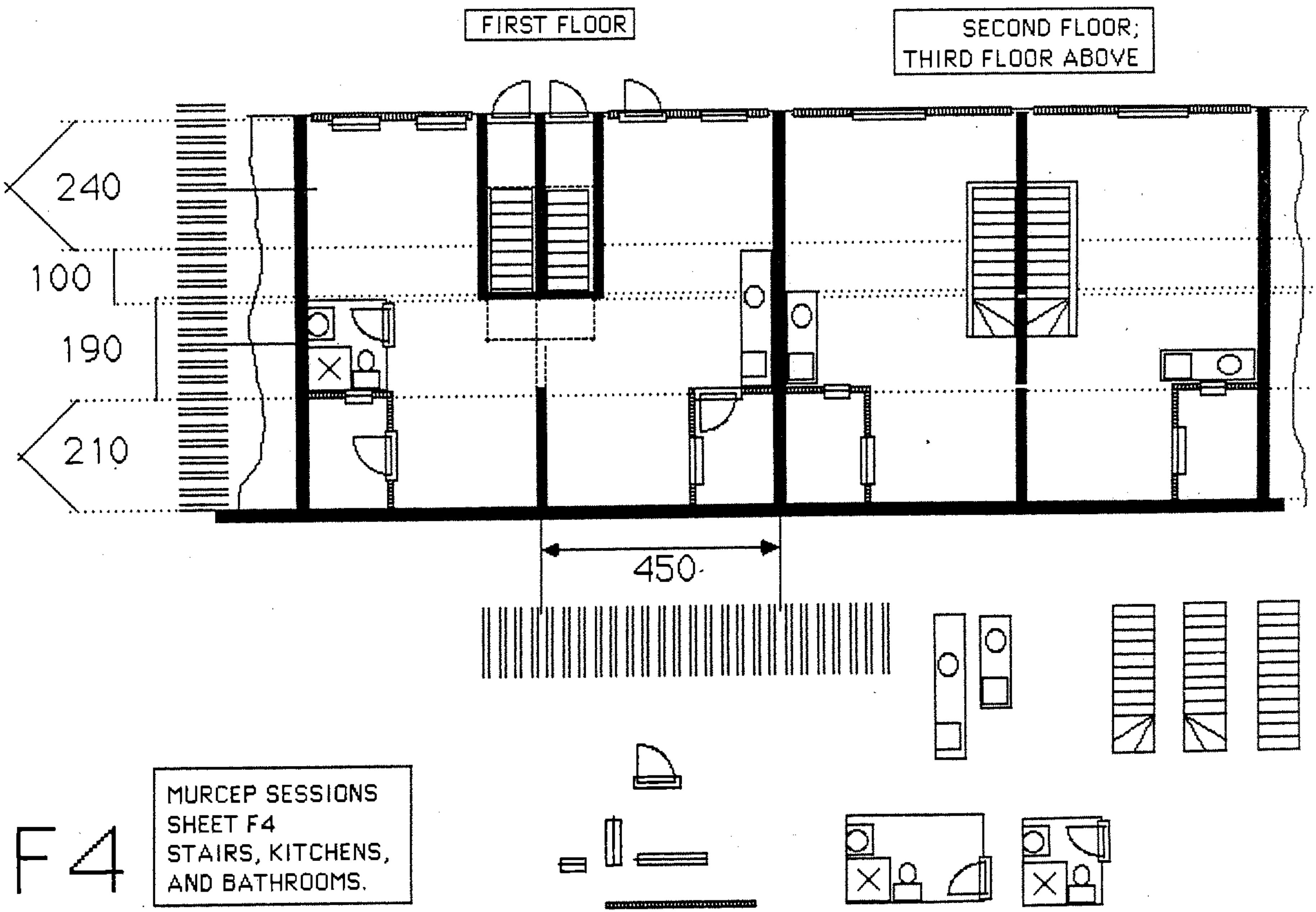
E2

MURCEP SESSIONS
SHEET E2
STAIRS IN SUPPORT



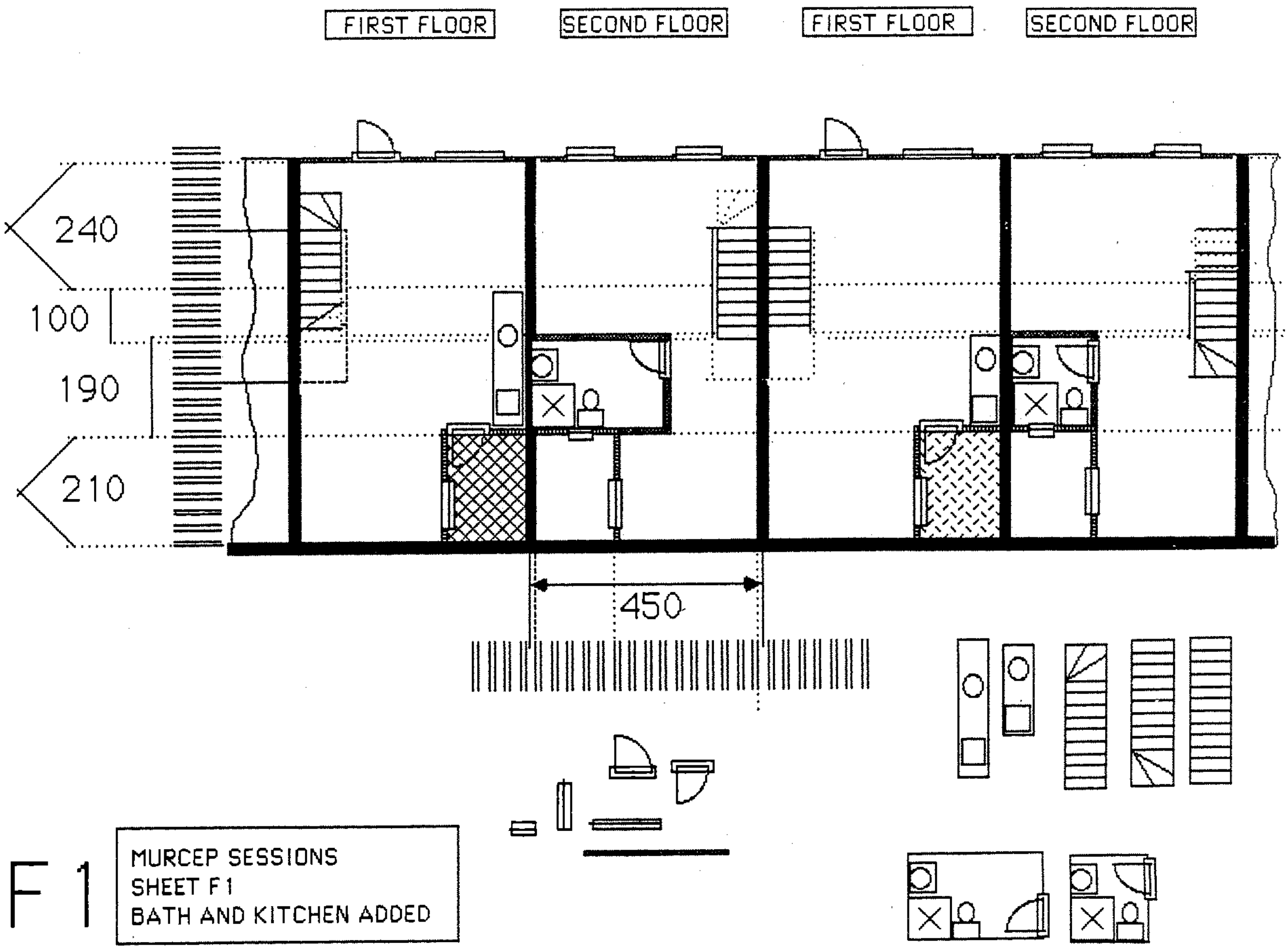
F3

MURCEP SESSIONS
SHEET F3
KITCHENS AND BATHROOMS



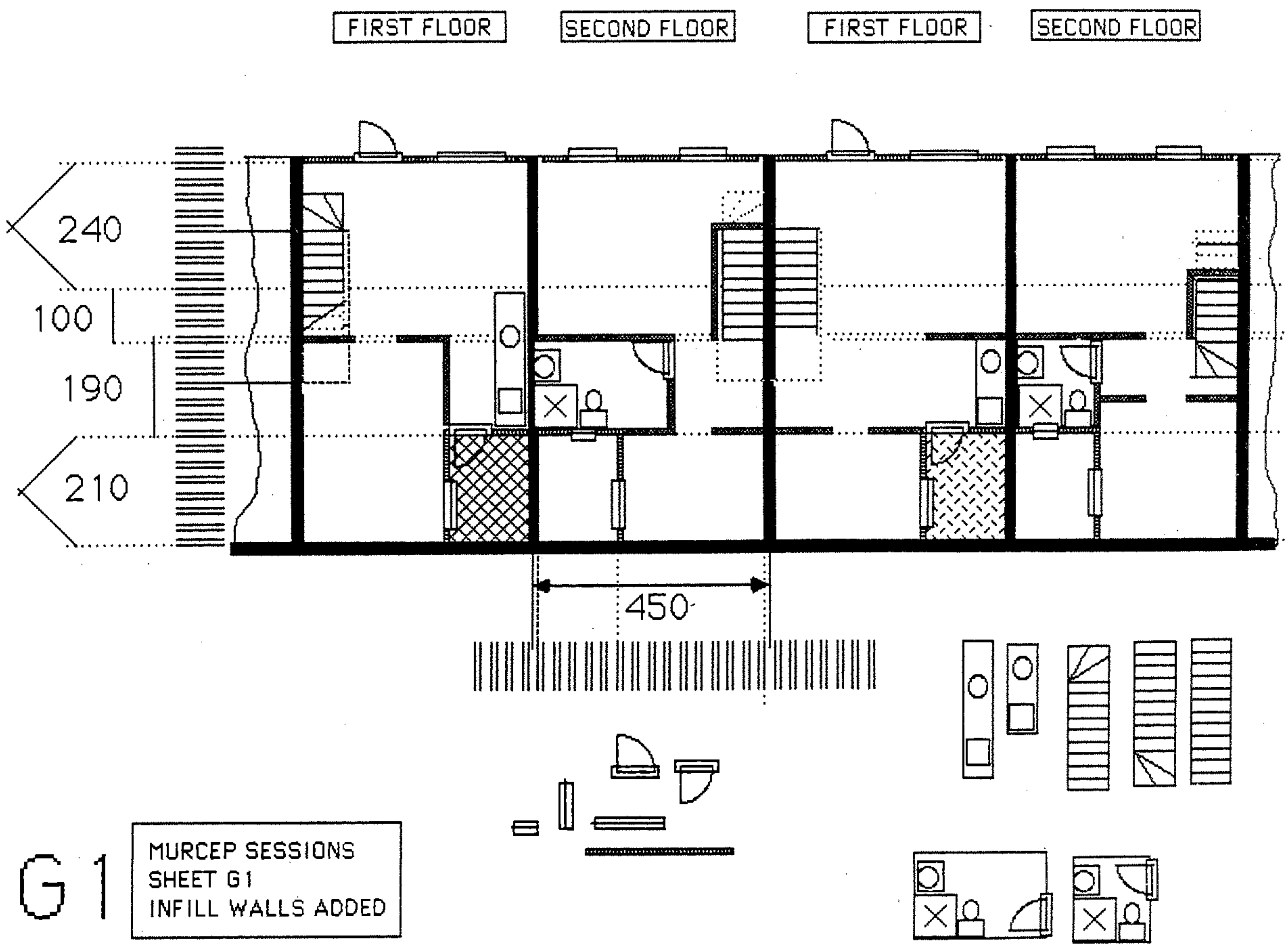
F4

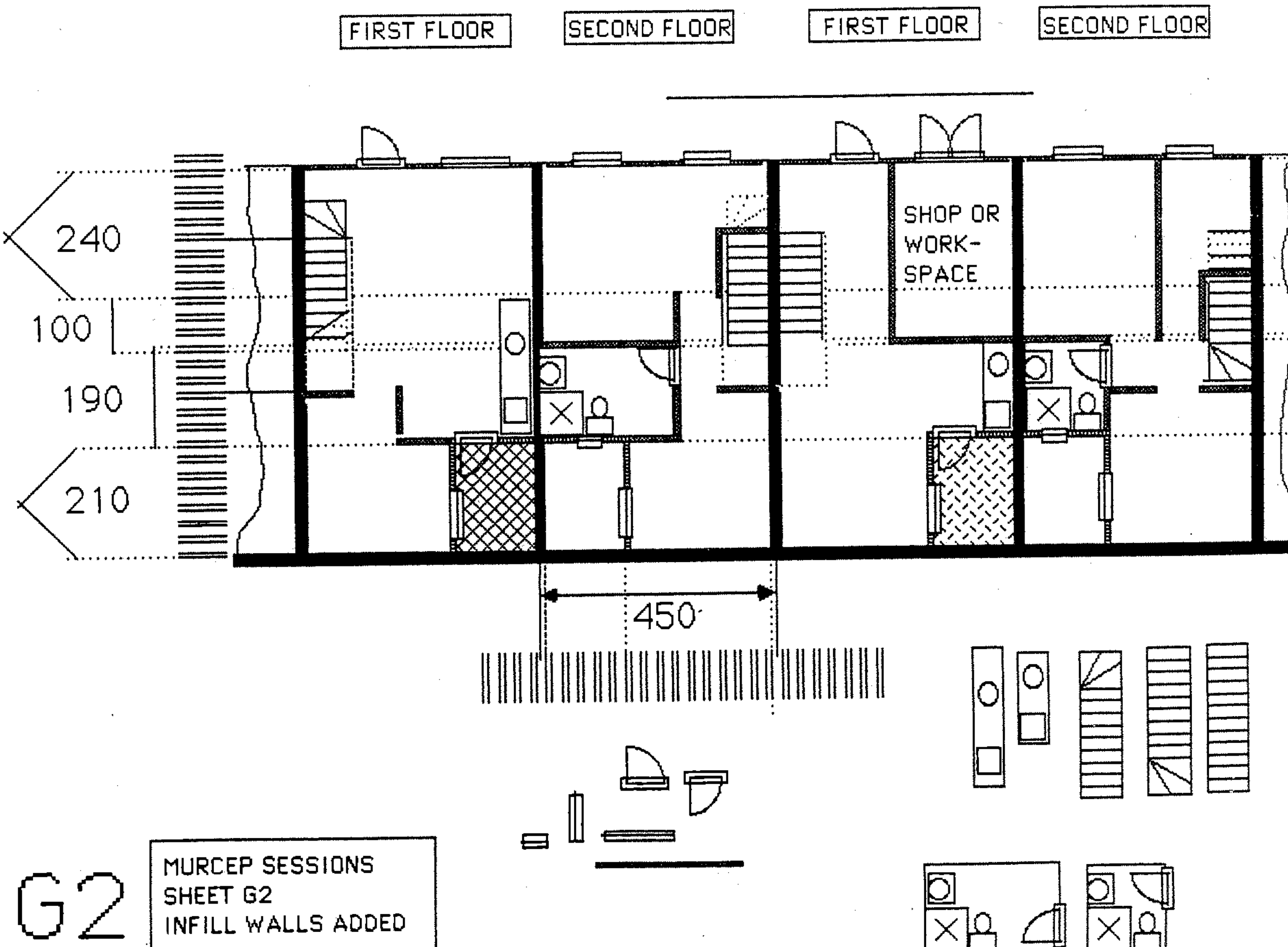
MURCEP SESSIONS
SHEET F4
STAIRS, KITCHENS,
AND BATHROOMS.



F1

MURCEP SESSIONS
SHEET F1
BATH AND KITCHEN ADDED


FIRST FLOOR
SECOND FLOOR
FIRST FLOOR
SECOND FLOOR
240
100
190
210
450
G1
MURCEP SESSIONS
SHEET G1
INFILL WALLS ADDED



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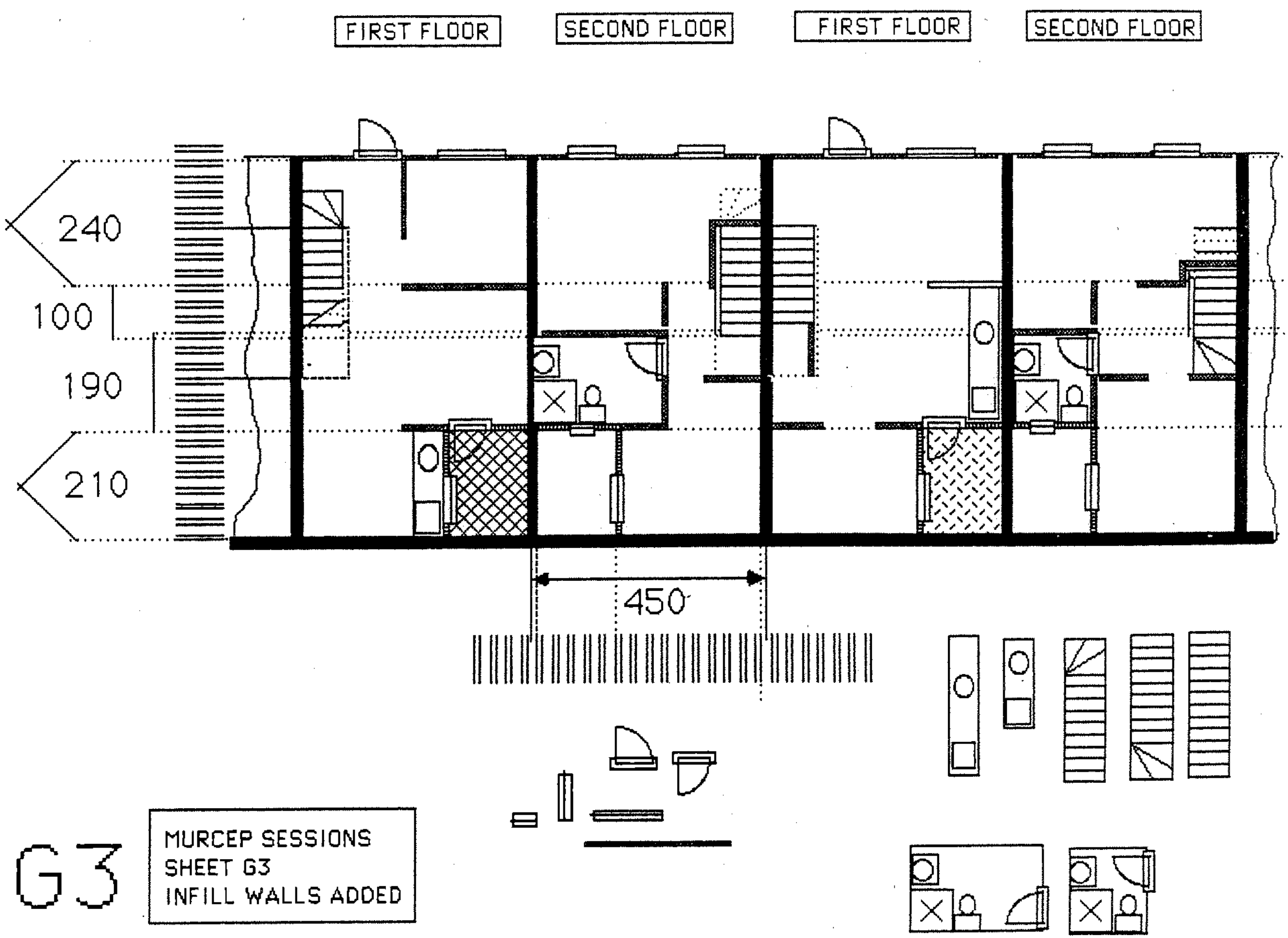
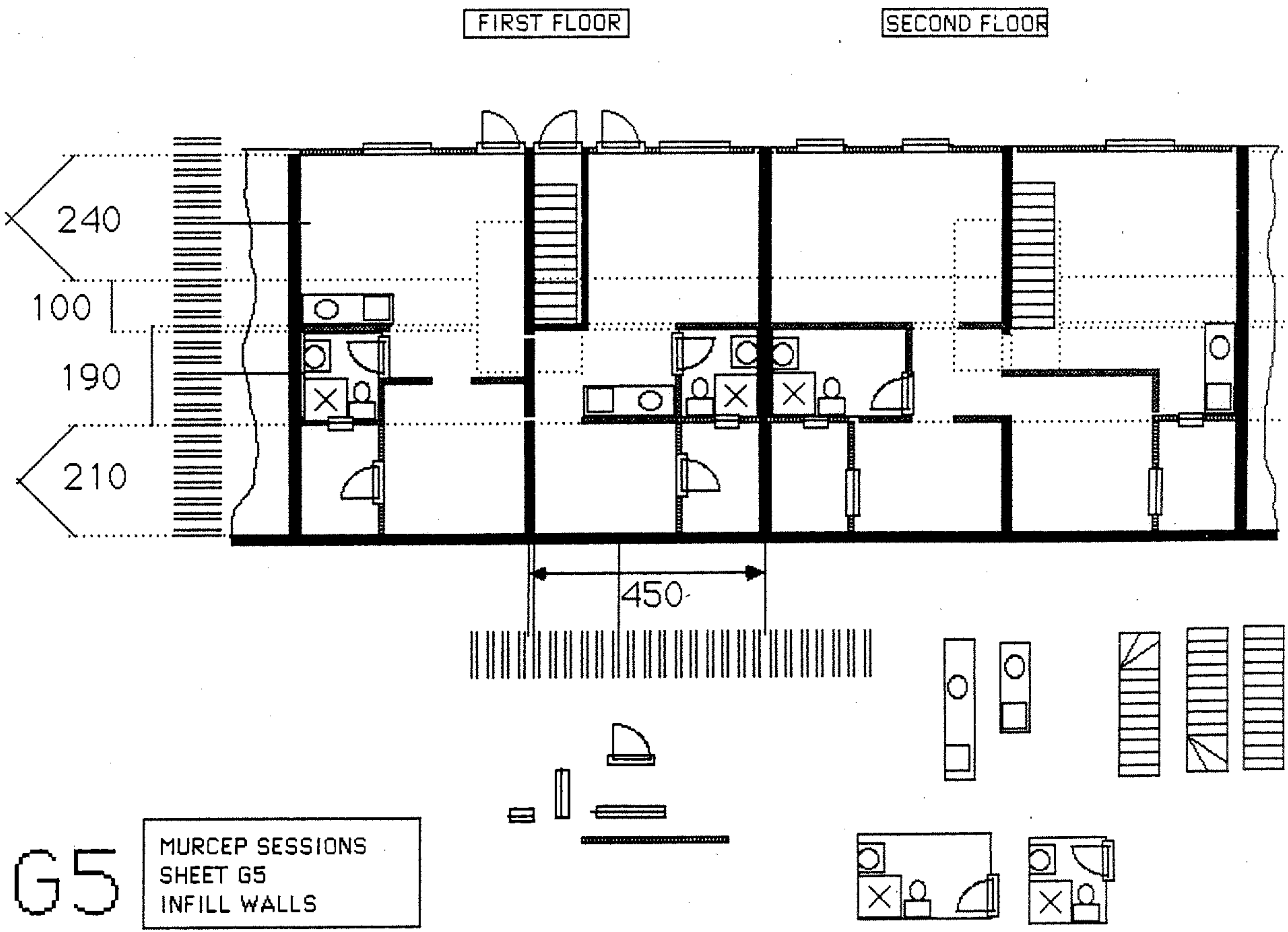
MURCEP SESSIONS
SHEET G2
INFILL WALLS ADDED



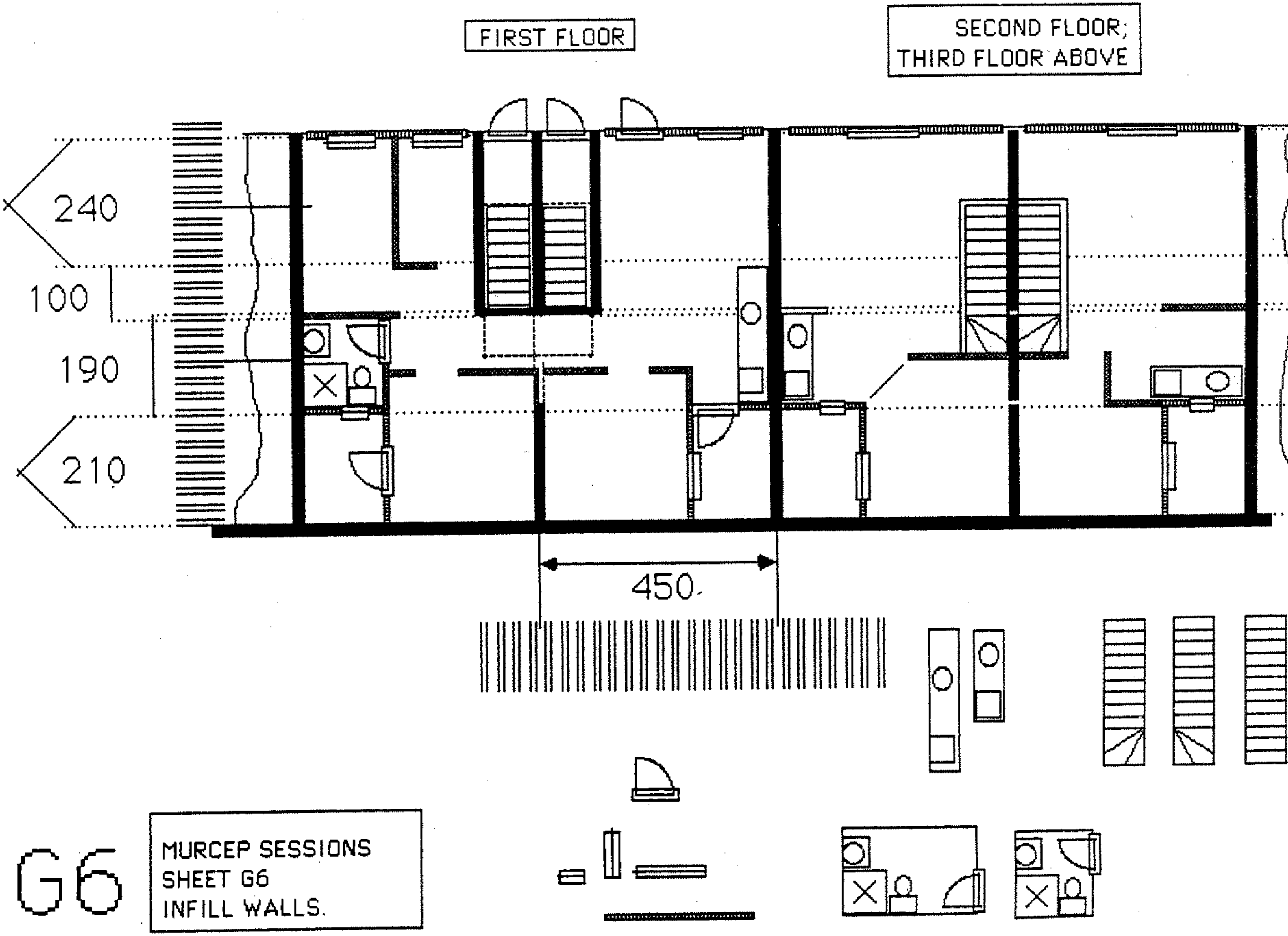
G3

MURCEP SESSIONS
SHEET G3
INFILL WALLS ADDED



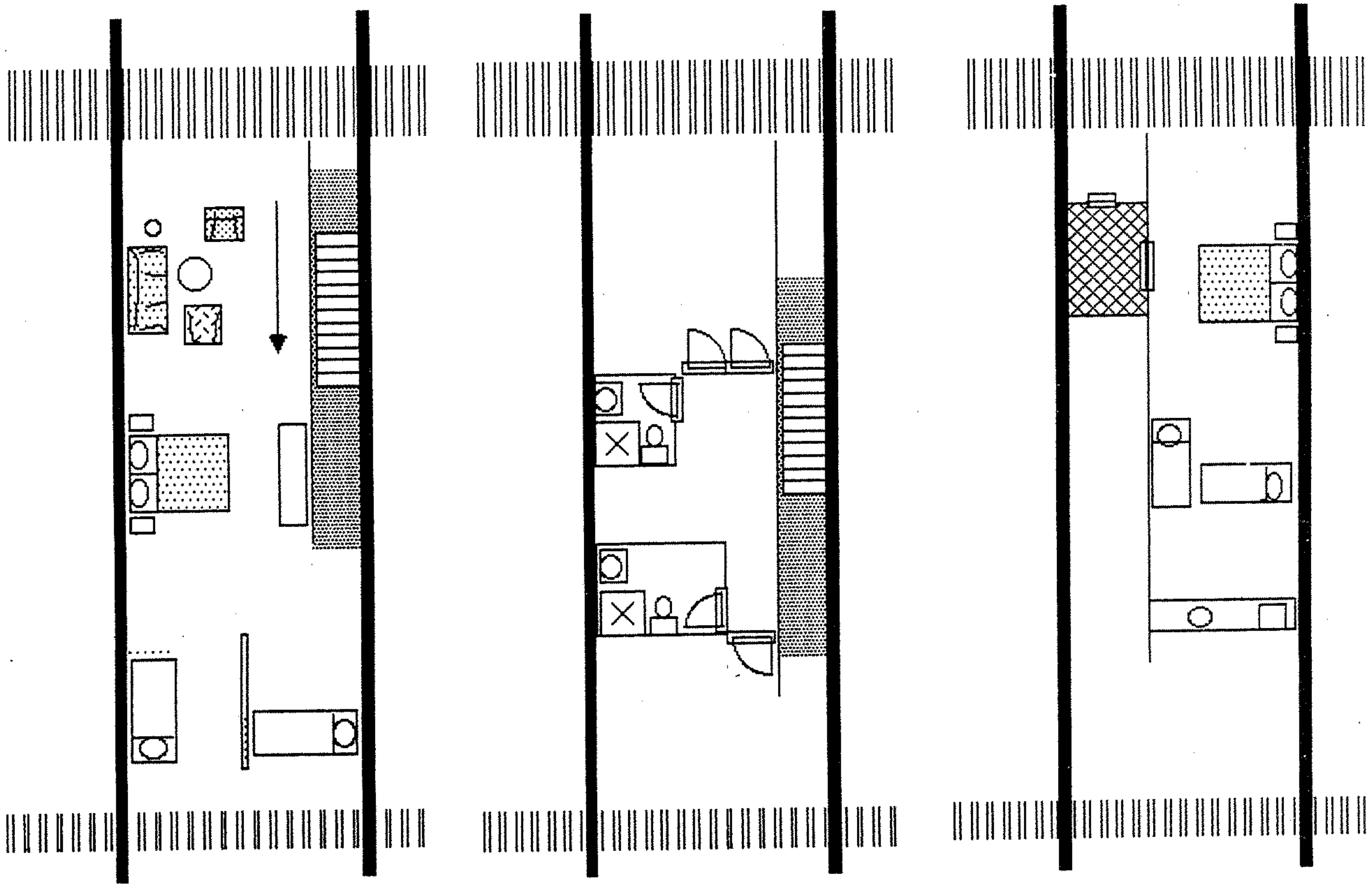
G5

MURCEP SESSIONS
SHEET G5
INFILL WALLS



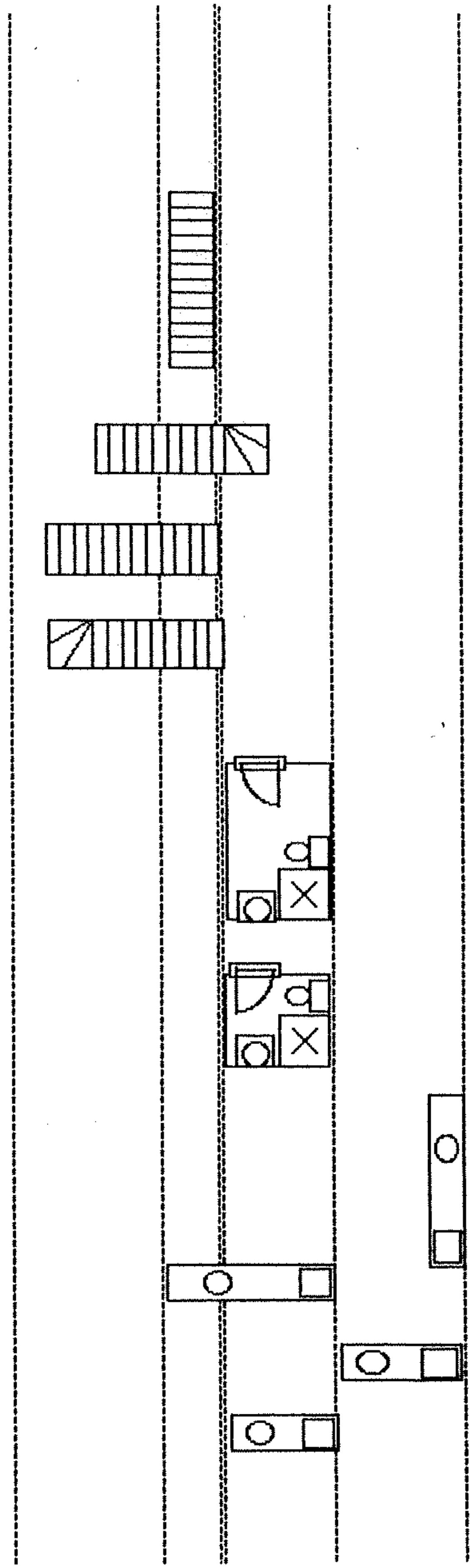
G6

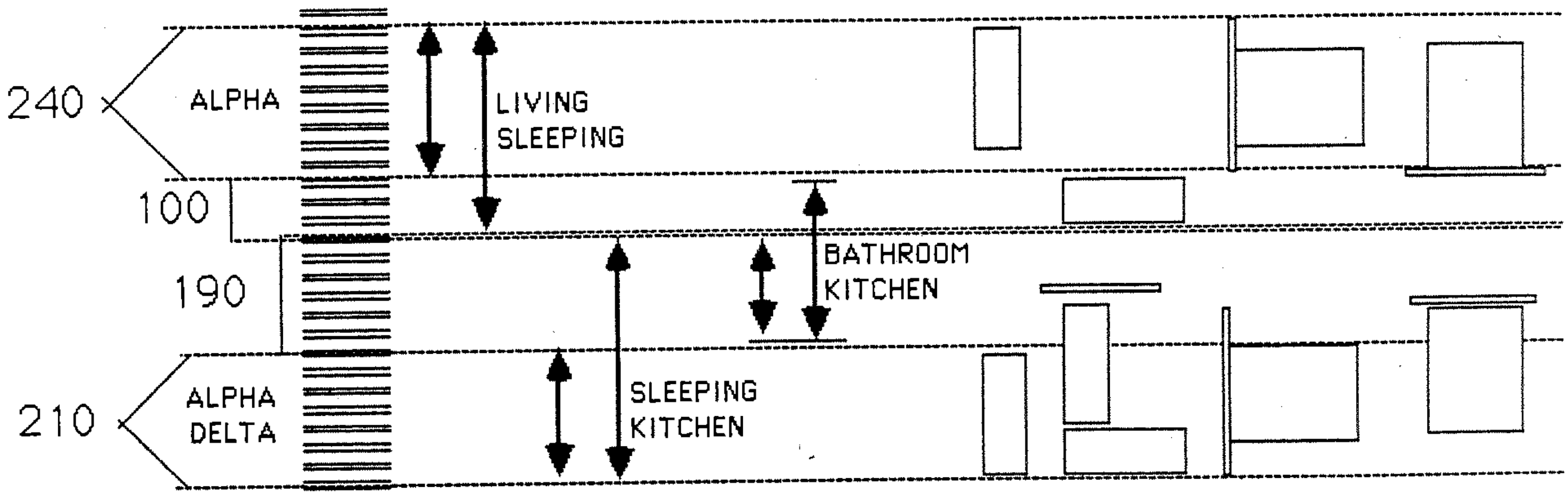
MURCEP SESSIONS
SHEET G6
INFILL WALLS.



3

MURCEP SESSIONS
SHEET 3
SECTOR ANALYSIS.





4

MURCEP SESSIONS
SHEET 4
ZONE ANALYSIS

	AUTHORITIES	LOCAL COMMUNITY	HOUSEHOLD
A – ZONE DISTRIBUTION			
B – MINIMUM SUPPORT			
C – TERRITORIAL DISTRIBUTION			
D – FACADES			
E – STAIRS			
F – KITCHENS AND BATHROOMS			
G – INFILL WALLS			
H – FURNITURE			

4

MURCEP SESSIONS
SHEET 4
CONTROL DIAGRAM

	A	C	H
ZONE DISTRIBUTION	■		
MINIMUM SUPPORT	■		
TERRITORIAL DISTRIBUTION	■		
FACADES	■		
STAIRS	■		
KITCHENS AND BATHROOMS	■		
INFILL WALLS	■		
FURNITURE			■

	A	C	H
ZONE DISTRIBUTION	■		
MINIMUM SUPPORT	■		
TERRITORIAL DISTRIBUTION	■		
FACADES	■		
STAIRS			■
KITCHENS AND BATHROOMS			■
INFILL WALLS			■
FURNITURE			■

	A	C	H
ZONE DISTRIBUTION	■		
MINIMUM SUPPORT	■		
TERRITORIAL DISTRIBUTION		■	
FACADES			■
STAIRS			■
KITCHENS AND BATHROOMS			■
INFILL WALLS			■
FURNITURE			■

	A	C	H
ZONE DISTRIBUTION	■		
MINIMUM SUPPORT	■		
TERRITORIAL DISTRIBUTION		■	
FACADES		■	
STAIRS		■	
KITCHENS AND BATHROOMS			■
INFILL WALLS			■
FURNITURE			■

A – ZONE DISTRIBUTION

B – MINIMUM SUPPORT

C – TERRITORIAL DISTRIBUTION

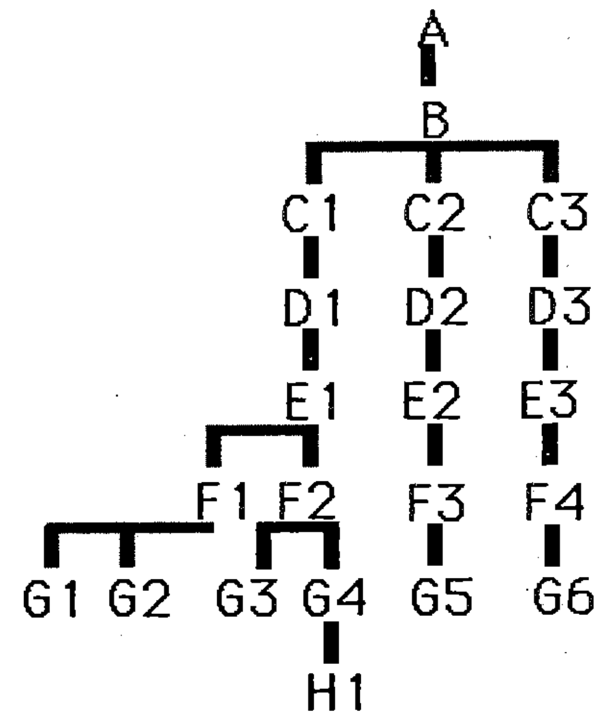
D – FACADES

E – STAIRS

F – KITCHENS AND BATHROOMS

G – INFILL WALLS

H – FURNITURE



MURCEP SESSIONS
RELATIONS OF THE
PLAN VARIANTS

THE SUPPORT APPROACH

SUMMARY OF THE PRESENTATIONS
OF THE
TWO DAY LECTURE SESSION
FOR THE
MINISTRY FOR URBAN AND RURAL CONSTRUCTION
AND ENVIRONMENTAL PROTECTION
PEOPLES REPUBLIC OF CHINA

N.JOHN HABRAKEN

June 1986

Table of Contents.

The session will be divided in four parts , coresponding with the mornings and afternoons of the two days. If time is available the evening of the first day could be used for more discussions and for the showing of more projects; and the evening of the second day could be used for more questions and discussion. In all cases discussion will be possible at the end of each presentation.

***

First Presentation: PROJECTS.

<u>1.1 Introduction:</u>

1.1.1. The support approach rests on the division of the dwelling in two parts. The "support" and the "infill" or "detachable units"

The support is the more permanent part. Usually a support includes many dwellings and it contains all that is shared by the users of these dwellings. It is the communal part of their building.

The infill are all those parts in the individual dwelling that can be changed and determined by the users themselves.

1.1.2 . There are many reasons for this approach, the most important advantages are:

<u>Adaptability to user needs.</u> Within the same project different floorplans can respond to needs of different users.

<u>-Adaptability to changing lifestyles over time</u>. When economic conditions improve people can individually improve the equipment and finishing of their dwellings.

<u>-Easier variety in dwelling size.</u> Within many supports different sizes of dwellings can be determined after the support is built but before people move in and infill is installed.

<u>-Greater effectiveness of work by professionals</u> (designers, managers,builders). Because support types can be used many times without danger of uniformity they can facilitate the speed of construction. Communication and coordination are facilitated because the design of supports can be done methodically .

<u>-Economic advantages.</u> Studies and experimental projects have shown that on-site labor and overall construction time can be reduced when the support approach is used. But this takes carefull reorganisation of the building process

-Better opportunities for production. Supports can be highly standardized and lend themselves for prefab systems because they do not include the difficult and vulnerable parts of the dwelling. Infill elements lend themselves for standardisation and mass production.

1.1.3. Difficulties in the support approach. To fully gain the advantages it offers the support approach needs a different organisation of the housing process. This affects all professionals involved and often demands a re-orientation of methods and habits. This needs carefull planning.

However, a single project can be succesfull and economically competitive if all professionals cooperate with the new approach and all aspects are studied with care.

1.1.4. In order to better discuss the principles and methods we will first discuss some projects that have been build.

1.2. First Project.
"Molenvliet". Architect Frans van der Werf. Papendrecht, The Netherlands.

1.3. Second Project.
"Keyenburg" Architect Frans van der Werf. Rotterdam, The Netherlands

1.4. Third Project.
"Adelaide Road" Architect Nabeel Hamdi. London, England

1.5. Fourth Project.
"Tepito". Architect Jorge Andrade. Mexico City, Mexico.

***

Second presentation: THEORY

Many theoretical issues can be raised relative to the support approach. We will discuss only two that seem to be of particular importance.

2.1 The question of Levels.

2.1.1. Support and infill can be seen as systems on different levels. The infill can be changed without disturbing the support, but the support can not be changed without disturbing the infill. Therefore we say that the support is of a higher level than the infill.

2.1.2. The above explanation of the concept of levels shows that they can be recognised through change. Change is the result of people doing something. he support approach introduces the concept of change in architectural methodology.

2.1.2.1. Levels have to do with control. On each level another party can have control. The support can be the responsibility of the collective of users or of the authorities. The infill can be the responsibility of the individual user.

2.1.3. We find the distinction of levels throughout the built environment. The street network, for instance, is of a higher level than the buildings that line up along the street. The latter can change without disturbing the first. The furniture is of a lower level than the walls that make the room because the furniture can be changed without disturbing the walls. And so on...

2.1.4. When we design something in the built environment we always operate on a certain level

There is always a level where we work ourselves.

There is always a higher level in which we work.
There is always a lower level for which we make space.

When we design we must conform to what is given on the higher level and we must take care that our work offers good opportunities to those who will work on the lower level.

2.1.5. We can see systems that represent a level. For instance a 'support system' or an 'infill system'. The things we normally speak of in the built environment - like 'bedroom', dwelling', or 'neighborhood' - are not systems but 'wholes'. They are the combination of two systems on different levels. We can make a diagram to illustrate the relation of 'systems' and 'wholes'.

2.1.6. In modernist mass housing the concept of levels is ignored. The mass housing project is therefore inflexible. The support approach re-introduces the concept of levels.

2.2 The question of industrialisation.

2.2.1. In the production of buildings the distinction between three concepts must be understood. These concepts are industrial production, prefabrication and mechanisation.

2.2.2. Industrialisation and prefabrication are both forms of production that do not take place on the building site but elsewhere. Their difference is important and can be explained as follows:

2.2.2.1. Industrial production is the making of something before one knows where and by whom it will be used. In industrial production *the producer must take the initiative* to produce before a specific user or buyer is known. The industrial product must be usable in many places by many different people because it must be produced continuously in large quantities for a large market. Therefore, industrial products are usually small and relatively neutral. elements like doors, windows, pipes, bricks, tiles, sanitary equipment, electrical equipment, etc. lend themselves for industrial production.

2.2.2.2. Prefabrication is the making of parts for a specific building in another place. Here *the producer does not take the initiative* but must wait untill the building has been designed before production can begin. His production depends on specific projects. Therefore he can not make true mass production. But he can make large elements that need not be neutral or generally usable. Large concrete panel systems are prefabrication systems.

2.2.3. Mechanisation takes place when we use machines to help us to do the work. We can mechanise both prefabrication processes and Industrial processes. We can also mechanise the work on the building site. Mechanisation is not the same as industrialisation. We can have industrial production where everything is done by the human hand.

2.2.4. Detachable units are generally applicable in many projects and in many different supports. Therefore the support approach makes industrial production of detachable units possible. But the support approach does not need industrial production. It is also possible with traditional technology.

2.2.5. A same support principle can be used many times and in large projects without making uniform dwellings. Therefore supports lend themselves for standardisation and prefabrication and also facilitate mechanisation of the building process on the site. But supports can easily be built in simple traditional technologies too. They do not require mechanisation or prefabrication.

***

Third Presentation: DESIGN

In the design of a support we can distinguish several aspects we must pay attention to:

3.1. Aspect one; Type

A support is not a neutral construction in which everything is possible. A support represents a specific dwelling type. To begin a design the type of dwelling must be determined. The type must at least show the general distribution of spaces in the dwelling and the principle of circulation in the building. It is often good to start with the design of a single typical floorplan.

3.2 Aspect two; Variations

We can make variations of the typical floorplan.

This is done to find out what parts in the dwelling must belong to the infill and what parts belong to the support.

3.2.1. The exploration of variants can be done more systematically by holding constant certain parts and changing others. For instance, we can hold the overall size and shape of the dwelling constant and change what is inside.

When we do so we can also keep bathrooms and kitchen constant and change only walls and room sizes. Or we can seek different positons of kitchens and bathrooms and for each position see what room arrangements can be made next.

3.2.2. These explorations of the internal arrangements reveal the walls and columns that can be part of the support. We now can turn to alternative designs of the support while always coming back to a study of the floorplans.

3.2.3. When studying the support we also want to know how different dwelling sizes can be made in it; for instance by leaving openings in support walls to combine bays.

<u>3.3. Aspect three: Capacity.</u>

When we make a decision about a part of the support, for instance the distance between two support walls, we want to understand what infill variations are possible after that decision. To find out we make sketches of the different ways in which the space between the walls can be used. When we do so we are *exploring the capacity* of the space between the two walls.

3.3.1.The operations mentioned mentioned under 3.2. are examples of capacity explorations. Each time we hold a part of the dwelling constant and seek what variations are then possible.

3.3.2. Finally, when the support design is finished we must also explain what is possible within it. That means that we must demonstrate the capacity of the support. We do so by showing the variations that are possible in it by means of placing infill elements.

3.3.3. the previous point also shows that a capacity study demonstrates the relationship between two levels. The higher level makes a form within which variations are possible on the lower level.

In the fourth presentation we will discuss in more detail the formal methods for exploration of capacity.

3.4. Fourth aspect; division of support and infill.

One of the most important decisions the designer must make is what elements will be part of the infill and what elements go into the support.

3.4.1. The support is always more than a load bearing structure. It must comprise all those parts that the user cannot change individually , not only because they are technically inflexible, but also because they are the responsability of the community.

3.4.2. Within the support we will find plumbing, sewage, electric conduits, facade elements and many other parts that are not load bearing.

Within the infill we may find many of the same elements: there are also plumbing, electric wires, doors and perhaps windows.

3.4.3. We may find non-load bearing walls as part of the support (for instance to separate two dwellings) and also as part of the infill.

3.4.4. Thus the distinction between support and infill depends on what the user is allowed to decide about and about what must change in the future to accomodate user needs. This is not a technical question.

3.4.5. As a general rule one must try to minimise the infill and maximise the support while trying to achieve the best possible adaptability. But in each case and in each country and for each income level the separation may be different.

3.4.6. Bathroom and kitchen equipment must usually be part of the infill because these elements will need replacement and improvement over time.

3.4.7. Sometimes the whole facade can be part of the support. Sometimes parts of the facade can be changed by the user, sometimes the whole faced is infill.

3.5. Fifth Aspect; Materials and Parts.

The support approach does not require any special materials or building elements to be used.

3.5.1. Supports can be built like any other building. In residential construction walls between dwellings must have sufficient sound insulation to assure privacy. Therefore loadbearing walls are often appropriate elements for support design. Unless a highrise support is planned, a concrete or steel column and beam structure is often more expensive, because many walls must be built in to separate the dwellings anyway and often these walls can bear the floors as well. The flexibility offered by a column and beam structure is usually not needed for a good support.

3.5.1.1. Because good supports can be designed in load bearing wall systems large concrete panel systems are also possible in support design.

3.5.1.2 In many cases the designer does not know exactly what materials will be used for the construction of the support. For instance a load bearing wall can be built in bricks, in hollow concrete blocks, large concrete panels or combinations of such materials. the dimensions of these materials will vary To avoid problems in the dimensioning of the building when the specification of the materials will change in the course of the design a method has been developed to work with *nominal dimensions* in the initial design stage. The exact material dimensions can be determined later. This dimensional system is explained in the fourth presentation.

3.5.2. Infill elements can be ordinary materials as used in all residential construction. Infill walls can be of brick, gypsum panels, wood, or any other material already used for non-loadbearing partitioning. To make the infill more easily changeable the designer may avoid plumbing and electrical wiring in those walls that are most likely to change.

3.5.2.1. Eventually special infill systems of modular elements may be developed when this proves to be more economical.

3.5.3. Systems for gas, water and electricity belong partly to the support and partly to the infill. A good support design provides a few places in each dwellings where bathroom and kitchen equipment can be connected to the support. From this connection more pipes and wires may run to the equipment. In this way a variety of bathroom and kitchen layouts is possible around the same point of connection in the support. To determine the correct position for such points of connection is one of the most important decisions to be made in support design.

3.5.3.1. It is very important to make sure that the connection of bathroom and kitchen equipment to the support is made above the floor of the support to make sure that changes do not interfere with the spaces below.

3.5.4. Internal stairs for dwellings with two or more floors can be part of the support or part of the infill.

3.5.4.1. If the stairs are part of the support their position must allow for different floorplans without change of the stairs. In many cases it is sufficient to have fixed stairs that are part of the support.

3.5.4.2. To make the stair part of the infill so that it can be changed requires that the floor is changeable as well.

3.5.4.3. An intermediate solution is to make a fixed opening in the floor that allows for different kinds of stairs to be placed in it.

***

Fourth Presentation: Methods

4.1 Designing a good support is more difficult and time consuming than the design of a normal housing project. This is because many variants must be compared. Once a support has been designed however, the same principle can be used many times.

4.1.3 . Demonstration of capacity (see 3.3.) is essential in the design of supports because without it we do not know what the support can do and then it is also impossible to compare the support design with alternative support designs to decide which is the best.

4.1.2. To facilitate support design and capacity analysis formal methods have been developed. The so called SAR method of support design is explained in detail in various publications. The major elements are 'methodical tools' and 'methodical operations'.

<u>4.2 Methodical Tools.</u>
The following methodical tools are available.

4.2.1. A modular band grid with *position rules for elements.*
The band grid allows us to make rules how walls and columns and facades of the support are placed in it and also how infill elements are placed in it. When we use the position rules with the band grid we can determine nominal dimensions of spaces before we know the exact thickness of walls and columns.

4.2.1.1. By means of the grid and the position rules the designer creates a *system of elements* of the support and the infill.

4.2.2. Zones and Margins. Different zones are defined in the method. Each space in the support belongs to one or more zones. The zones represent certain qualities of location. They represent combinations of the following distinctions: inside or outside, public or private, and, if inside, near the outside or not.

4.2.2.1. The designer determines the zone distribution in the support. With the zone distribution he can make *position rules for functions* in the support.

4.2.2.2. The dimensions of the zones and margins determine the minimum and maximum dimensions for the functions allowed in them. By choosing the dimensions of the zones the designer makes rules about minimum and maximum dimensions of rooms in the support.

4.2.2.3. Thus the zones allow the designer to make a *system of spaces* within which the floor plan variations are made.

<u>4.3. Methodical Operations</u>

With the grid and the zones as tools the designer now can make systematic capacity studies. There are a number of methodical operations he can perform to analyse and demonstrate the capacity of the support.

4.3.1 One: Room capacity alalysis

This chart gives the relation between room dimensions and functions. It determines for each room dimension which functions can go in it. Thus the capacity of each dimension is notated to the left or to the top of the chart and we can deduct from them the capacity of a room.

4.3.2. Two: Zone Capacity Analysis

This operation produces a drawing which illustrates what room sizes and function fit in the zones and their adjacent margins. It can also give the position of infill elements like kitchen and bathroom elements in the zones. It also can give the position of certain support elements like ducts, facades and stairs in the zone distribution.

4.3.3. Three: Sector Capacity Analysis.

A sector is part of a zone of a certain length. The support, combined with the zones, gives sectors. One can see a support as a combination of sectors.

Of each sector the capacity can be studied. A Sector study gives the room and function combinations possible in the sector.

4.3.4. Four: Territiorial Distribution Analysis

In many supports different sizes of dwellings are possible. The space occupied by a dwelling oin a support we call a 'territory' Each territory is a combination of sectors. The territorial analysis shows the possible combinations of territories in the support.

4.3.5. Five: Basic Variant Analysis

Within one territory we have a sector group that makes a dwelling. In each sector group different floorplans are possible. A basic variant gives the distribution of functions in a sector group. Usually one sector group allows for a number of basic variants.

The basic variants give us a good understanding of the capacity of a sector group.

4.3.6. Six: Floorplans.

Given a basic variant in a sectorgroup we can make different floor plans that all have the same basic variant but differ in the sizes of the rooms and the position of doors, storage spaces, kitchen and bathroom elements. The floorplans are subvariants of basic variants.

4.4. Sequence of Operations

The sequence of operations given above is not necessarily the sequence in which the designer works best.

4.4.1. In the design process we must be free to begin at any point. For instance: when we study the type of dwelling in the beginning of the design process and seek the first variations of rooms (following aspect two) we may sketch in a few basic varriants and see what floorplans they make. The designer may begin with a sketch of the support and later bring in the zone distribution, or he may first determine zones from the dwelling type and then sketch a support in the zone distribution. Often we already have fixed standards for room sizes and functions in the beginning, but sometimes we may determine the room capacity chart in a later stage after basic variants have been studied.

The operations described above are like the tools of a carpenter. When making a table or a cabinet the carpenter will determine what tool he takes from his toolbox as he goes along. Some carpenters use many different tools some use only a few. Sar Method offers a toolbox but does not prescribe the sequence in which the tools must be used.

4.4.2. It is important to see how the operations of 4.3. serve two purposes:

First, they are used for us to design the support making quick capacity studies as we go along.

Second, they are used to give a demonstration of the capacity of the finished support for the benefit of those who must work with the design.

Only in the second case we will find a well ordered sequence of documents informing us about the capacity of the support.

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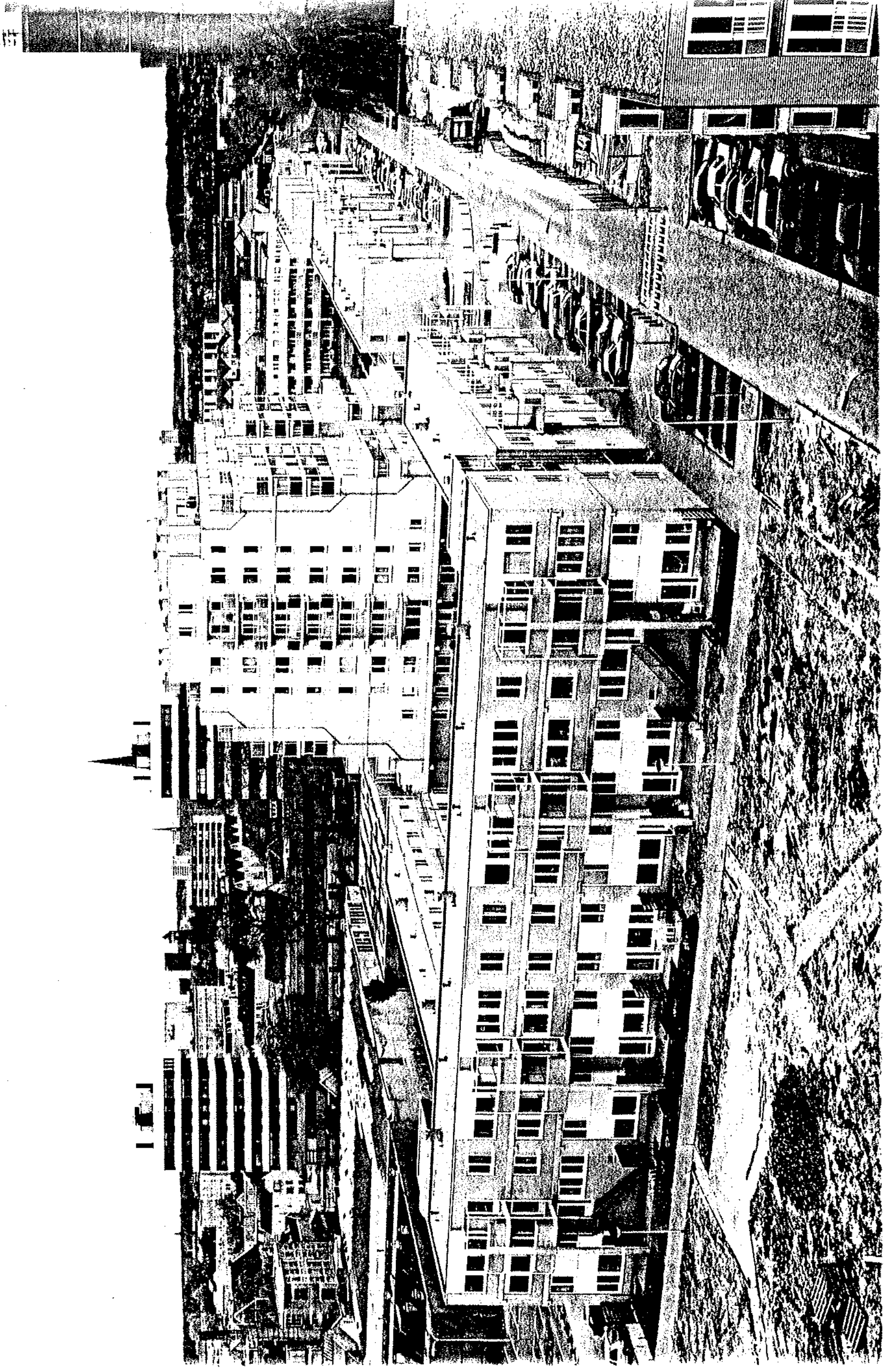
"Berkenkamp"

a low-cost Support-Infill project of 253 dwellings for rent
in Enschede, the Netherlands. (1987 - 88)

Owner: the Housing Corporartion "Licht en Lucht", Enschede
Architect: Ir. Frans van der Werf, Rotterdam.
Contractor: Trebbe, Enschede.

Some dwelling lay-outs



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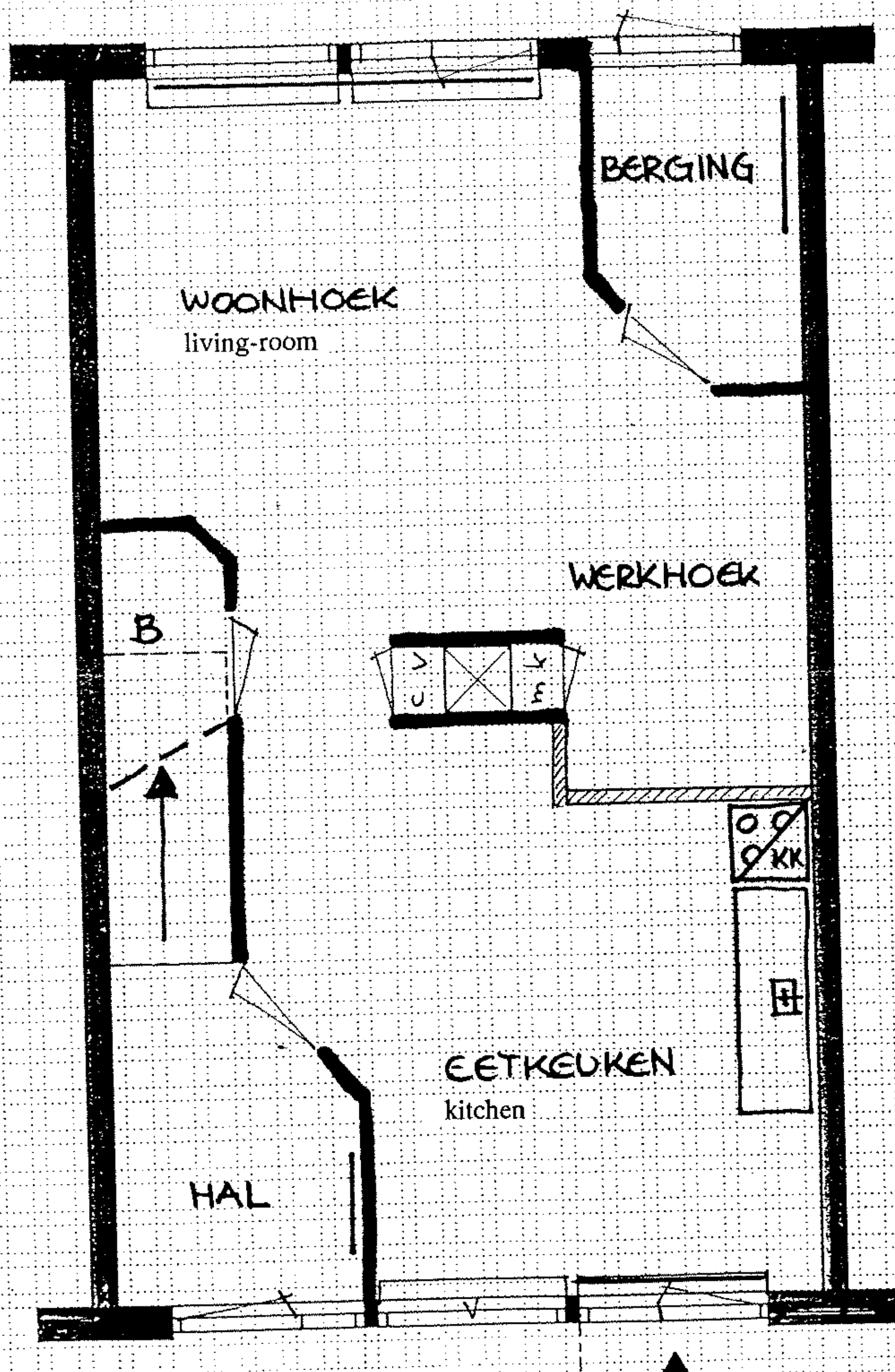

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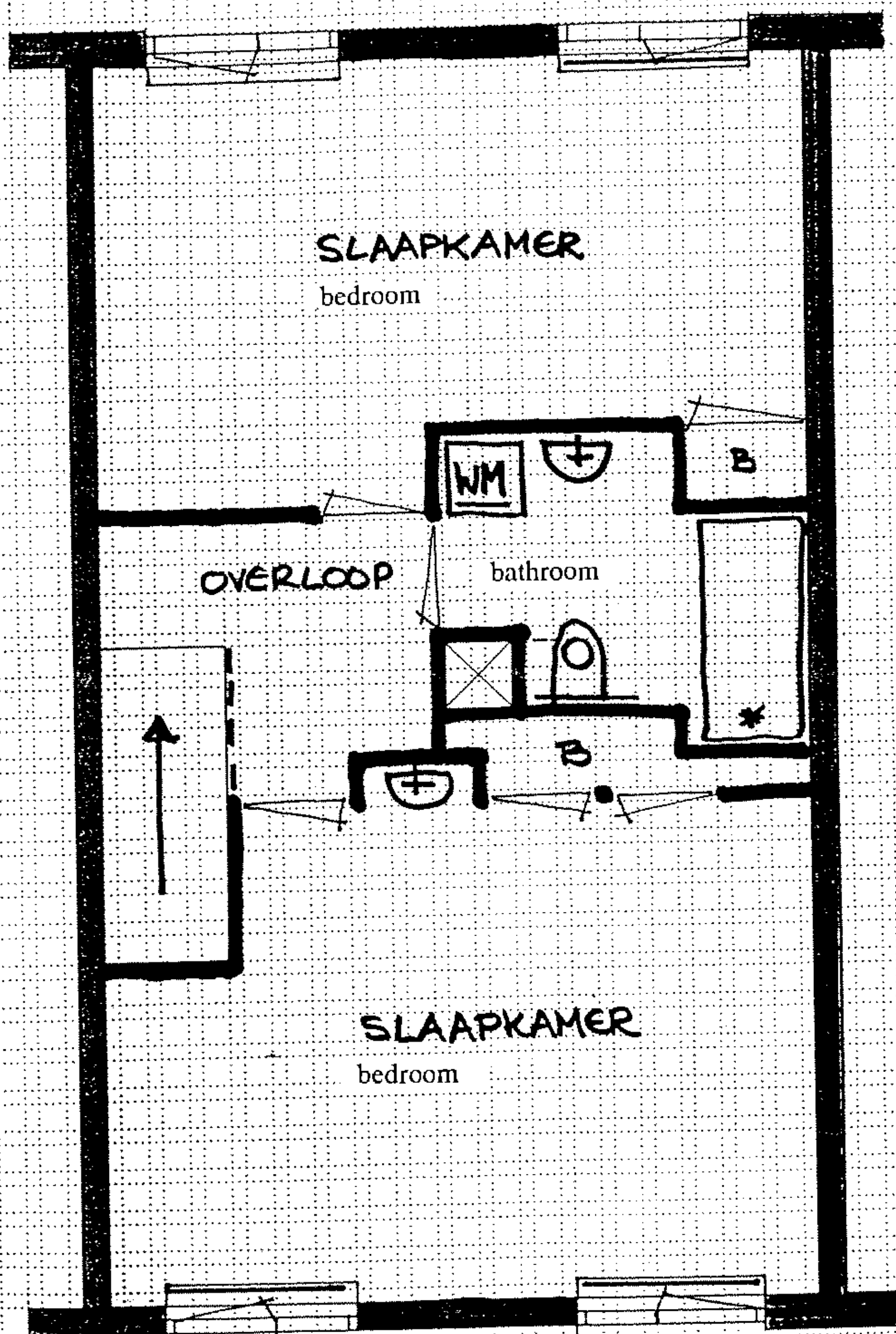

eerste verdieping

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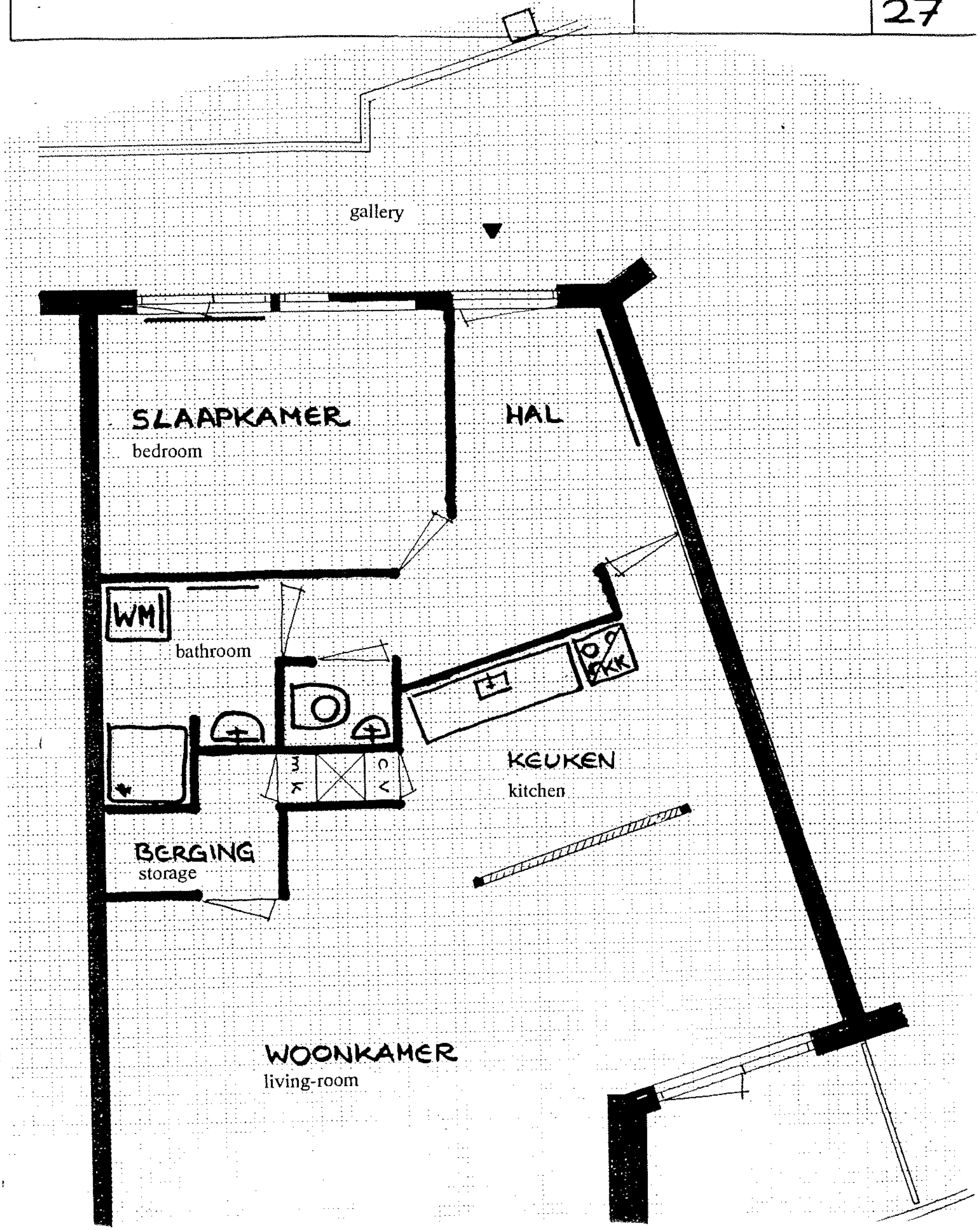

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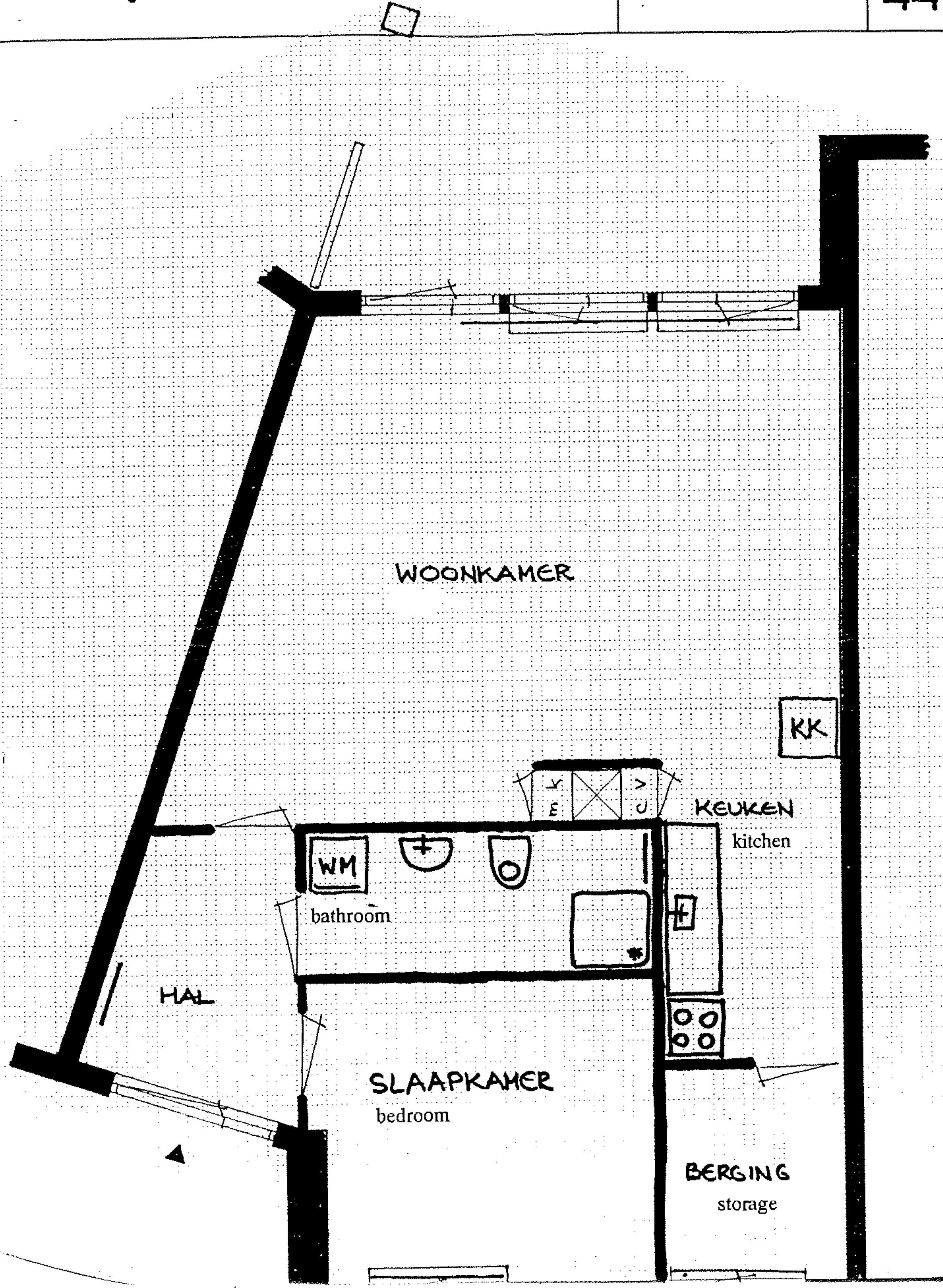


Management Lessons in Housing Variety

by Stephen Kendall

Although in the United States the two segments of housing construction—interior and exterior—are handled by one general contractor, the responsibilities for interior and exterior construction of housing units are increasingly being divided between two distinct providers in both the Netherlands and Japan.

This division of responsibility for building systems is seen as necessary to accommodate both initial demands for variety in dwelling unit variation and changes in occupant (market) demands over the life of the building. At the same time, the increased variation that is possible using the support and infill combination is understood to be efficient, in large measure, because the design and construction processes have localized the interfaces between two "bundles" of construction, the "base building" or support, and the "tenant work" or infill.

What is infill/support?

The goal of the support/infill system of construction is to produce housing units in significant quantities efficiently, but with the flexibility to allow for a variety of floor plans and finishes. This strategy would permit decisions on the design and layout of interiors, including the location of kitchens and bathrooms, to be independent of the decisions about basic construction.

In this way the outer shell of the building, the support, would be a permanent structure designed to change very little. The interior walls and fixtures, the infill, would be variable, allowing for flexibility in meeting individual resident preferences and in responding to changing market demands without requiring significant alterations to the building's exterior.

The support is the part of the building containing common territory (hallways, building stairways, elevators, and other shared spaces) and main building elements (structure, main piping and wiring systems, and most, if not all, of the building envelope).

First a support is designed. This involves a design process somewhat different from conventional housing design, but rather similar to the design of speculative office buildings. The support is evaluated according to its capacity to hold a number of variants, that is, a number of different floor plan sizes, layouts, equipment systems, and so on. This design process is accomplished by an architect in close collaboration with a contractor and developer. It requires the use of systematic design methods, which enable rapid development and evaluation of schemes. In this kind of design process, computers are clearly useful.

Next, the support is built. In both the projects illustrated, the support is a conventionally built concrete structure. It is tied to the locality—its codes, climate, streetscape—and thus local conventions make sense. Decisions about what physical elements belong to the support are made in each project, according to the economics and priorities of the parties involved in the project.

The design of the support is planned to be very repetitive. Because of this, building operations are very efficient and can be completed without involvement of the conventional "finishing" decisions. Sequencing of materials and trades is consolidated and streamlined.

The infill consists of the individual dwelling units and building systems controlled by households (dwelling-specific piping, wiring, partitions, fixtures, kitchens, and so on). While the support is being built, household selection and individual dwelling design can be done simultaneously, with visits to the site to confirm the designs that the future occupants are planning.

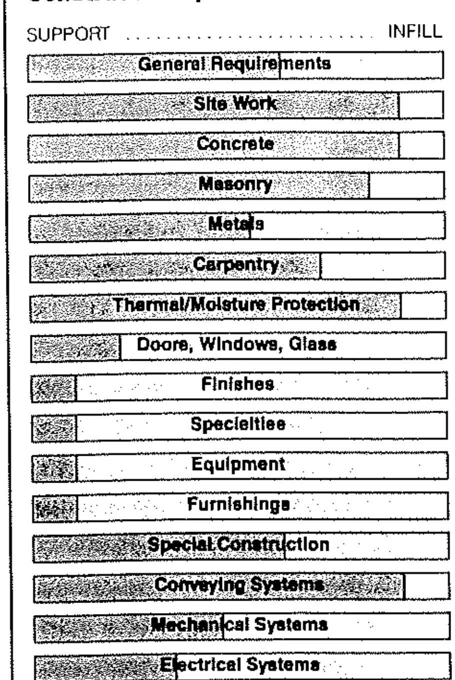
Infill decisions—about the dwelling layouts, equipment, and finishes—can be deferred to much later in the critical path than in conventional projects, enabling the project owner to make last-minute adjustments that more accurately reflect market conditions.

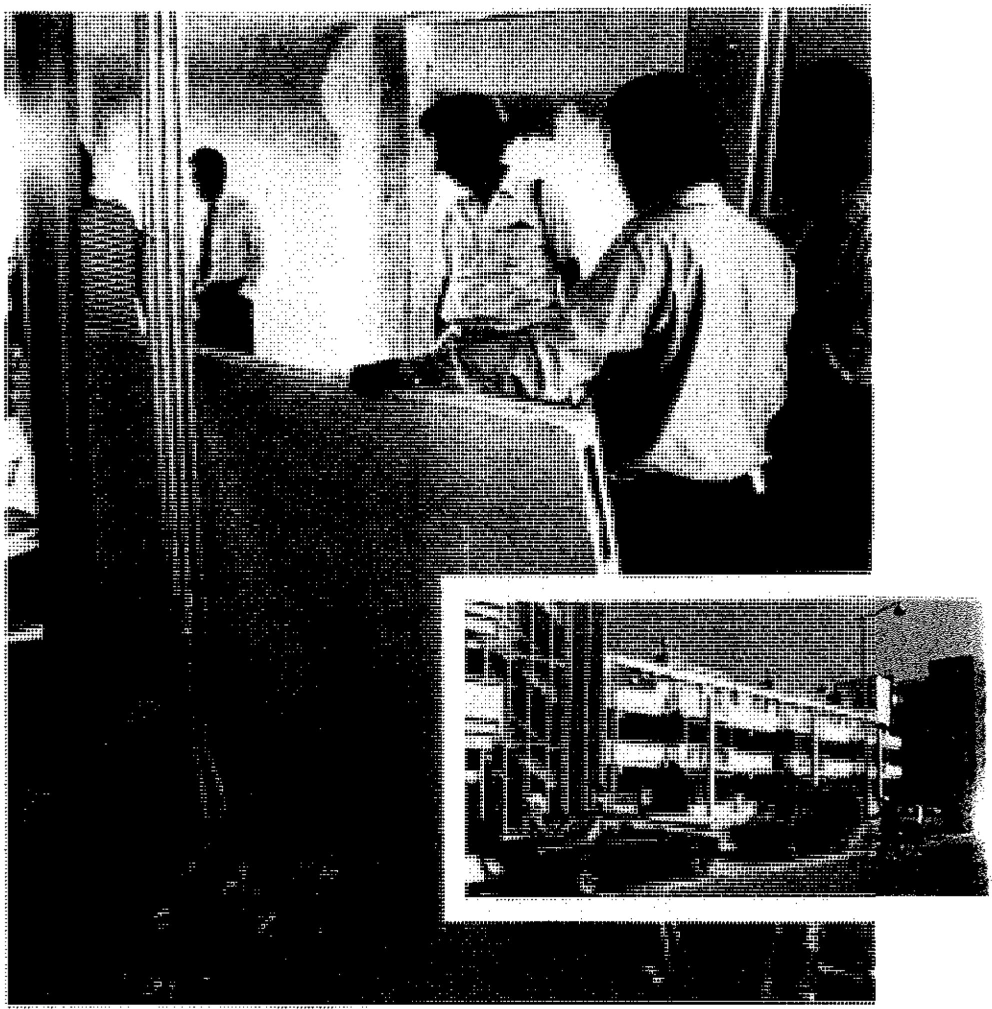
Next, the infill is installed. Infill can be assembled from general elements, which may be regulated by national codes or production requirements.

The infill package for each unit arrives in a container from the infill producer or supplier, who may have an inventory of elements from which to fill orders or who may not produce elements before receiving an order. Infills must be carefully coordinated at critical interfaces with the support portions of the various building systems.

The distinction between these "bundles" of building elements is not made along the lines of building systems or trade jurisdictions, but crosses typical

FIGURE 1
Construction Specification Data





At Keyenburg, workers install a variety of prefabricated infill configurations in response to tenant demand for personalized living space.

systems boundaries to follow the two levels of control.

Figure 1 shows this division schematically on a standard chart of construction "divisions" of the Construction Specifications Institute. In the schematic it shows that a percentage of each "division" goes to support, the rest of that division to infill; the precise delineation of the division is specific to each project design. What is designated as infill or support may also be altered by changes in regulations, by technical questions, or by resident/manager preference.

The infill subcontractor can work in all units at once. Because all elements are included in the infill package, there is no assembly-line problem; no problems of scheduling crews one behind the other, creating the usual bottlenecks and delays. Instead, as in the Keyenburg project, a building team of four workers (trained not along conventional trades jurisdiction lines, but with cross-trade skills) finishes an infill installation in a unit, then moves to another dwelling. With several four-person crews in a project, the work is completed rapidly.

Because infill elements are used widely in supports and in other buildings, they can be produced in large quantities, even before it is known where the element will be used. Further, builders can negotiate with infill manufacturers and contractors for good prices because they will often be ordering large numbers of infill packages.

Finally, there is less time required on the site, installing the infill systems of the dwellings—usually the most time consuming operation. This feature cuts indirect costs in supervision, equipment, labor, and interest on construction loans. This strategy also may mean that new financing strategies can be explored to carry the support, distinct from financing for the infill.[1]

The difficulty has always been that to fully customize a unit—to get the full measure of market variation—too many decisions had to be made too soon in the design and construction process. If these decisions are not made up front, then customizing often means ripping out the work someone else has built to make the special improvements. Designing carefully and organizing construction in these distinct bundles of support and infill make variation easier to handle and future renovation less trouble.

Usages of support/infill concept

Recent projects in the Netherlands and Japan give some insights to the question of reconciling variety and efficiency in housing design, construction, and management.

Starting in the Netherlands in the late 1960s, detailed research was conducted to discover how households can take initiative in individualizing their dwellings without sacrificing mass construction efficiencies.

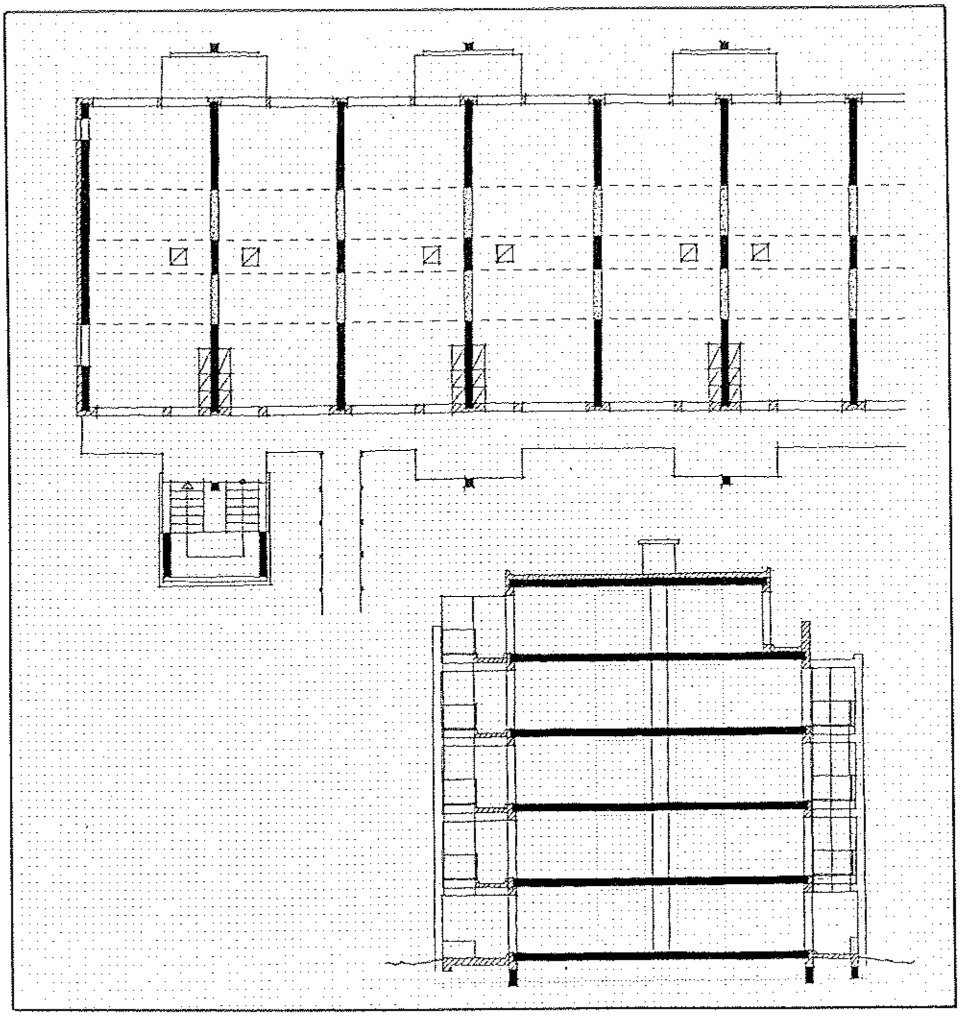
In a traditional multifamily housing construction, individuals were virtually locked out of the control of important decisions in the layout, equipment, and finishes of their dwellings. The idea, however, of some participants in the research, was that an environment would not be healthy and alive if households could not take initiative in relation to their dwelling places: to change, personalize, and otherwise identify them as their own.[2]

The design and construction methods of support and infill that were developed to address this problem have begun to find a wide audience, and a number of support/infill projects are being built in the rental sector, giving new information of particular interest to design and building professionals, developers, and property managers.[3]

Beginning in the early 1970s, a number of professionals in the Japanese housing field found ways to integrate the innovations from the Netherlands with their housing processes. They organized a family of built projects in the Japanese public housing sector, generally called "open housing projects."[4] Private corporations (such as Shimizu Construction Company and others) are now proposing projects which address these same design, construction, and management issues for an increasingly affluent and mobile urban population.[5]

Among the proposals recently submitted to New York City's Battery Park City Authority for the development of lower cost housing at Battery Park City was a plan submitted by Bond, Ryder & Associates that was based on the use of an infill system.[6]

A project in the Netherlands and one in Japan can illustrate this new strategy.



construction of the support had actually started. A computer model was used to aid in project development and cost estimation for both owner and tenants and for the infill system layout (Figure 4). A full-scale model was used as an aid in showing future tenants the arrangement of walls and equipment they chose.

In the last year, a new R&D joint venture has been organized and funded to develop what is called a "second generation infill system" in the Netherlands. Technical support and infill systems developed and used in a number of previous projects had not been completely satisfactory, although they had taught good lessons.

The new development venture now underway with financial support from private industry plans to devise better hardware and software for building supports and for designing and producing the infill systems needed for them. The project team of architects, a contractor, and a product manufacturer expects to have a full scale mock-up with accurate production cost estimates by mid-1988, and a small project by fall of 1988.

The contractor who is now working with the development team in the Netherlands on the second generation infill system has said that simply by organizing his construction process in the support/infill distinction, with no new building systems, he can reduce the time to complete a dwelling unit from 240 hours to 180.

He believes that with a well-designed and well-organized infill system, he can further reduce the time for finishing a unit to around 120 hours. This is time on site. Of course, there is also off-site preparation time. Nevertheless, this reduction in on-site time has been an attractive argument for him to promote this new way of working.

Keyenburg

In the Keyenburg suburb of Rotterdam is a support housing project, initiated by a foundation for social housing (Tuinstad Zuidwijk, one of the biggest in Rotterdam).[7] It is a rental project.

This foundation currently builds and renovates large numbers of housing units subsidized by government programs and produced and managed under various layers of regulation. But it is also investigating possibilities for building without subsidy and thus free of the associated restrictions. Building without subsidies will give the foundation more flexibility in balancing supply and demand at the local level where it operates.

This project is the type of building which the foundation believes can give those advantages. The building is designed so that it can be subdivided into a variety of dwelling unit sizes and configurations, even though the structure is based on only one bay size. The key is that the structural walls are not continuous, but have carefully positioned openings which allow the dwelling unit sizes to be independent of structural bays (Figure 2). Currently the building has 152 dwellings, each one of which has a unique floor plan (Figure 3).

In the Netherlands, renting is not seen so much as a transitory status; people may stay happily in the same apartment for decades.

The dwellings as built are one- and two-person units, with some handicapped units on the ground level. There are some small shops along the street on the lower level. There are four buildings in the project, three of them five stories, one three stories, organized around a courtyard. They are masonry buildings, built of cast-in-place concrete, clad in brick. The buildings were erected with the use of a standard tunnel form operated from a crane, which itself can move along a track down the center of the court. It has elements of contemporary Dutch post-modern design in the expression of details in lintels, railings, and other nonstructural elements, yet it is very much in the Dutch vernacular in building form and in the way it is set in the urban fabric.

The design process used by the architect[8] allowed final decisions about the dwelling mix to be made in consultation with future occupants, after the

Free plan housing in Japan

In Tokyo, the Japan Housing and Urban Development Corporation (Kodan), which builds thousands of housing units each year for sale and rental, has been initiating experimental projects over the past 15 years, which seek new

FIGURE 3

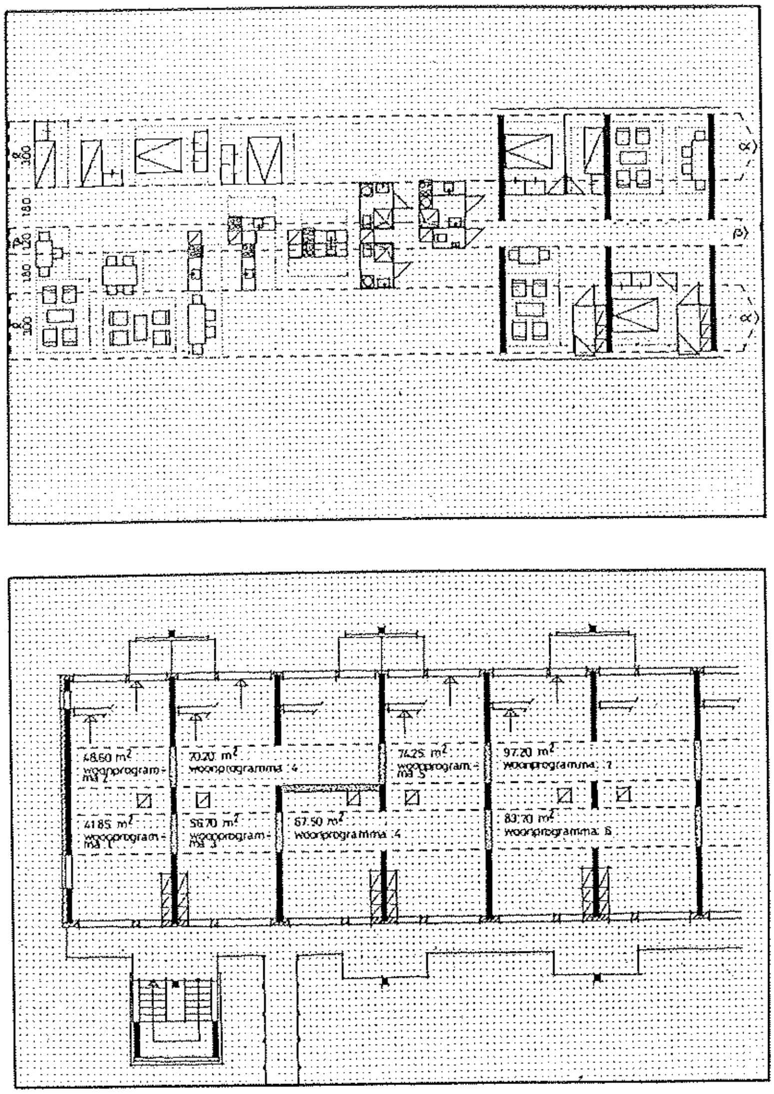
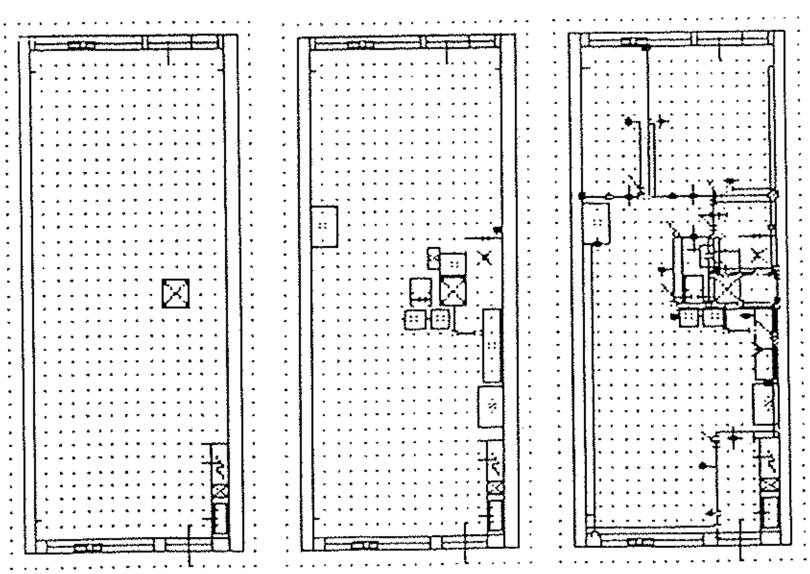


FIGURE 4

Layers of Infill



ways of opening up the design, construction, and management processes to shifting market demands.

Kodan has recently been criticized for building too many for-sale units during a time of increasing demand for affordable rental units. The criticism occurred at a time when rents were increasing as land costs soared in main urban centers, while the number of rental units was declining. Many people who could not afford to buy were being squeezed out from even the rental market.

A project called Free Plan Rental Housing was built in a Tokyo suburb and entered the rental market as another experiment in a succession of such initiatives. The project is a five-story walk-up apartment building, typical in outer appearance to most freestanding blocks in new Japanese developments. The building contains 30 rental dwelling units. The plan is organized on a basic three-bay design with a common stair (Figure 5). As in the Dutch projects, the separation of support and infill is made (Figure 6).

In the project, Kodan owns and manages the support and rents territories in it to households. Households purchase infill packages to make dwellings in the support. Infill is understood to have a shorter life expectancy than the support.

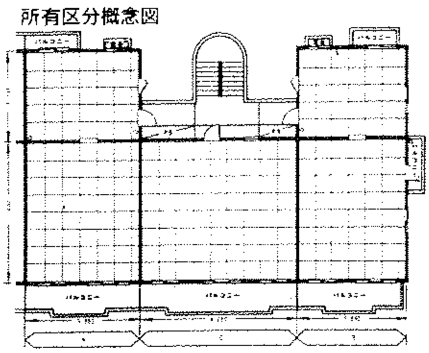
Kodan advertises for new tenants when a vacancy is expected and also selects the new tenants. The infill can be sold by the vacating tenant to the new tenant, if the new tenant wants it, under specific conditions agreed to between tenant and Kodan at the time of signing the rental contract. Kodan may underwrite the sale of infill to subsequent tenants, under specified conditions written into the rental contract, or may itself purchase the infill.

There are three types of infill packages offered at this Japanese project.

• *Free-space type:* Occupants can design, subcontract, or build by self-help. There is no dependency on Kodan. If this option is chosen, Kodan will not purchase the infill unless it is specifically approved in the design check stage of rental contract negotiation. It can be sold to another new tenant.

FIGURE 5

Basic Design of Support



• *Menu-select type:* Kodan provides a range of choices in plan, equipment, walls, and finishes and installs the infill on the basis of tenant selection. Kodan may purchase the infill based on a depreciation schedule, if the new tenant does not buy it.

• *Semi-free type:* Kodan provides some choices in infill; the tenant provides the rest. This is a combination of the free-space and menu-select types, with similar constraints on sale of infill.

What now appears to be the necessary next step to support this new management approach to rental housing is the development of more efficient ways to build the infill. The current Japanese projects use mostly conventional building systems and have not yet achieved the speed of infill installation that is needed to justify the added costs.

Many off-site issues of materials handling and logistics, approvals, trade jurisdictions, and basic system design have still to be addressed in more detail. Such research is currently underway in this area.

It is interesting to note that in Japan, developments in design, management, and organization and in building technology, advanced component manufacturing, materials, and construction processes have developed in separate streams until recently. This rental free plan project, along with several others in the past five years, have made a direct effort to link these two segments for improving housing design.[9]

Lessons for the U.S. scene

There are really two sources of variation in a housing stock. One comes when the household (whether the tenant or the owner) wants to take the initiative and change something. The second comes when the building owner takes the initiative. Both happen all the time, but what is always needed are ways to make the boundaries between the responsible parties in these initiatives manageable, in very direct, technical terms.

No matter who takes the initiative—building owner or household—the chances are that in practice "lower" (infill), or household, level variations will occur at a faster rate than change at the "higher," or base building level (support). By delineating the interfaces between these two levels, renovation and ongoing maintenance become easier. Making that explicit means that it is not only possible, but in management terms good policy, to untangle and localize these interfaces.

These two projects demonstrate a new way of designing, building, and managing housing in their respective countries. Architects, building contractors, developers, and managers appear to have discovered a more efficient way to get their jobs done. Households have also benefited individually. So, apparently, has the overall residential environment.[10]

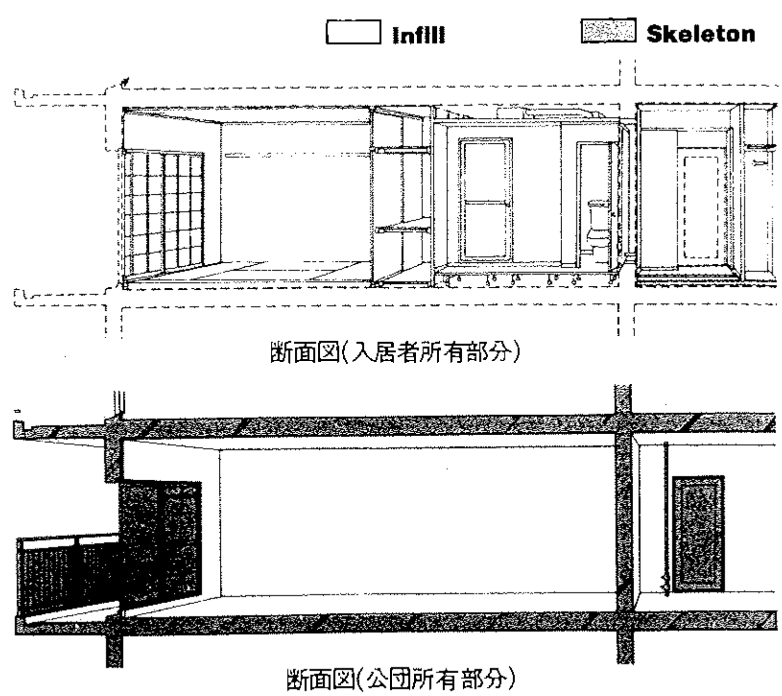
These projects, which are just a few in a growing number of support/infill projects around the world, demonstrate the results of feedback from development, management, and even the product manufacturing sector in design and construction.

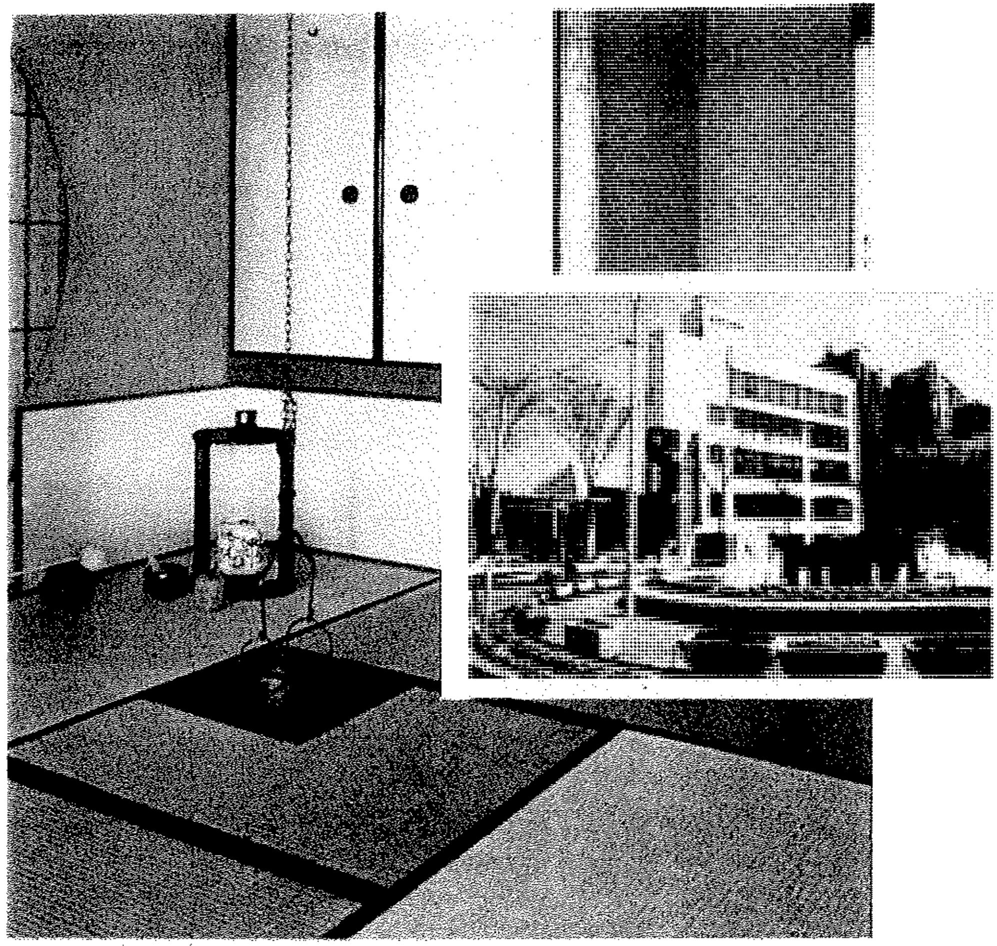
The implications of this approach should be of interest in the United States. If the market really "pushes" technology, we should soon expect to see new technical advances in the hardware for building that will enable the support/infill concept to find a place in the U.S. market.

This means that new service organizations will come into being, specializing in supplying and servicing "infill packages." These companies will cut across conventionally understood building systems (plumbing, electrical, appliances, HVAC, finishes, and so on). Their advent will mean adjustments in work jurisdictions in the trades, contracting, designing, and, possibly, financing. It also means new

FIGURE 6

Skeleton and Infill





In Japan, infill options permit either traditional or western living within the same modern concrete high-rise.

business ventures, new subcontracting concepts, new opportunities for commodity producers to contribute to the housing products market.

Demographic patterns show a slowing of demand for new housing. And while there is currently a resurgence of demand for single detached housing, multifamily housing is now and will remain a vitally important piece of the whole housing supply in the U.S. Increasing numbers of households are being priced out of the single-family market. And as commuting times stretch to unbearable hours around big cities, more and more families will inevitably seek the attributes of detached home ownership in the form of attached housing, akin to the traditional row-house form so prevalent in the Netherlands.

My reading of real estate advertisements in newspapers around the U.S. tells me that many parties in residential development are experimenting with new ways to organize the bits and pieces of various construction segments, particularly in urban and suburban low-rise, middle-density projects. This is leading to new financing packages, new management strategies, new ways to distribute responsibility, and, I think, to new technical strategies in housing.

There is growing impatience with the high cost of residential construction and the relatively poor quality of design and construction accompanying it. Meanwhile, the market seeks variety and identity, and relatively mobile and affluent "up-scale" segments seek custom dwellings.

But there seems to be a conceptual lag in the industry. Housing still is considered as a "unibody" artifact. Everything depends on everything else. Trades fall over themselves trying to get their work done quickly and watch other trades tear out the work they have just put in. The need for change and variety, while tacitly understood by everyone in housing, has not been fully grasped and translated into the necessary sophisticated technical and management processes.

In the U.S., we have a penchant for demanding tremendous variety in housing choices at all levels. The problem now is to organize this variety more efficiently, finding new agreements, new ways of working, and new building techniques that raise the efficiency of all parties, while enabling each to move quickly and effectively to meet the demands of the market.

The new concept of support/infill offers a distinct construction and management package, giving freedom to change dwelling layouts and equipment independent of the building's exterior, but in a coordinated way. The lessons of variety and efficiency learned from the housing industries in the Netherlands and Japan should not fall on deaf ears.

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An Efficient Response to User's Individual Preferences

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An Efficient Response to User's Individual Preferences.

A paper for the Housing Design 2000 Conference.
Singapore, September 1992.

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AN EFFICIENT RESPONSE TO USER'S INDIVIDUAL PREFERENCES.

Introduction.

In this paper I present a new way of outfitting residential units by means of a so called 'Infill System'. An Infill System allows the rapid installation of partitioning walls, central heating, kitchen and bathroom equipment with all piping and wiring related to such equipment. Installation is done per unit according to the floor plan chosen for that particular unit.

The infill system approach is not only of interest because it offers an individualized approach to large residential construction projects involving apartment buildings and townhouses. Its major attraction is that it is also economically competitive compared to existing modes of outfitting dwelling units. It therefore constitutes a breakthrough combining increased adaptablity with more efficient production.

I will first discuss how infill systems offer an efficient and user friendly approach to the renovation of existing housing stock. Next I will discuss briefly about the commercial advantages of infill systems in new residential construction. (page 4) I will then say more about the specific infill system from which I derive the information given in this paper and with the development of which I am personally involved. (page 5) Finally I will also briefly sketch the development of this new approach as it evolved in the past twenty years in the Netherlands. (page 8)

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Renovation, social dimensions of the Infill Approach.

The following scenarios are what actually happened recently with two units installed by way of a pilot project in the Netherlands. They illustrate how the use of infill systems can change the traditional ways of dealing with the problem of renovation of existing residential property in large projects.

<u>First scenario</u>

A unit in a public housing estate is vacated by users who move to another town. The housing authority in charge of the estate contacts new users from a waiting list. They are informed that the authority wishes to renovate the unit before they move in.

The prospective users, a young couple who both work, are given a number of alternative floor plans for their unit as worked out by an architect commissioned by the authority. They meet with the architect. As a result they decide that a variation on one of the initial alternatives answers their needs.

The new floorplan is very different from that of the unit which is now vacant. The original apartment (Fig.1) was designed in the early sixties for a family with two to four children. It had three bedrooms, a very small bathroom with only a sink and no shower or bath, and a narrow kitchen. There was no central heating. All rooms were around a small hallway. The new apartment (Fig.4) has a single large bedroom with an adjacent bathroom with shower and laundry machine. The kitchen is in a new location in open relation to the living room. There is also a small guest room.

The new floorplan is approved by the housing authority and a new monthly rent is agreed upon. The authority sends the floorplan to a company that specializes in installing infill systems for residential construction and requests a price. Agreement is quickly reached because this job is part of an ongoing contract between housing authority and infill systems company for the renovation of the entire housing estate over a period of time. As part of the same overall contract a small local contractor is called in to clear the existing apartment and prepare it for new infill. A job that takes about a week.

Beginning the second week a container is delivered in front of the apartment building. A small conveyor of the type as is also used by furniture movers is installed to hoist parts from the container towards the unit's balcony on the fourth floor.

A crew of three people now installs the infill system. Within ten workdays they deliver the finished apartment to the users. The next few days the users have curtains and floor covering of their choice installed by a local interior decorator and their furniture is brought in.

Second scenario

A couple in their late fifties, users of an apartment in the same rental public housing estate as mentioned in the first scenario, decides that their apartment no longer fits their needs. However, they are reluctant to relocate to another, newer housing estate because they have lived in the present apartment for a long time. They like the neighborhood where they have friends and relatives and are familiar with shops and other public facilities. They decide they prefer to have their old apartment renovated and ask for the cooperation of the housing authority. (Fig.4)

This is the start of a procedure similar to the one described above, but in this case the couple moves out of their apartment to stay with their daughter and son in law for three weeks. Their furniture is put in storage. In the first week the apartment is prepared for infill. In the next two weeks the infill package is installed.

Within a month they live in a completely new apartment fitted out exactly according to their wishes.

Voluntary expenses.

As part of the normal procedure for renovation the users are asked to select the bathroom equipment and kitchen equipment to be installed in the new floorplan. The elder couple can afford to spend more compared to the young couple who are just starting. They select a very well equipped kitchen. Also the bathroom equipment they want is of high quality. The representative of the housing authority informs them that with their selection the costs of the infill package far exceeds the estimated costs on which the rent for the new unit was calculated. The couple responds that they are well aware of this and are prepared to cover the difference*1). Accordingly they pay the authority a lump sum and the equipment they selected is installed in their rental unit *1).

Advantages for the user

Seen from the perspective of the users the procedure described in the scenarios is of course attractive. It gives them an opportunity to select their own floor plan and they are free to decide on the quality level of the equipment to be installed. Moreover the process is quick. Within several weeks after the rental contract is agreed upon the units are ready.

Advantages for the owner.

It can be expected that the owner of rental property will appreciate the procedure as sketched above for social reasons. Tenants who have selected their own interior accommodations can be expected to complain less and will treat their environment with respect. Moreover, serving their tenants on a one on one basis makes it possible to take into consideration the differences of income among them. Those who can spend more, and are indeed willing to do so, can have more. It is no longer necessary for the owner to expect all users, regardless of their differences in life style and income, to accept the same single floor plan equipped on a level that is just affordable to those with the lowest income.

Economically attractive.

Less obvious is that the owner of rental property also will find this way of working economically attractive compared to the alternatives available to him.

First of all, custom floor plans by means of infill systems as sketched in the two scenarios are not more expensive in direct costs. The price of the single infill unit to be installed independently, including cleaning out of the building shell and preparing it for the infill system, is competitive with the price paid to contractors for a comparable job in traditional renovation processes.

If here things are equal, economic advantages for the owner follow because the whole process becomes much easier to control and can be done in a more gradual fashion. To illustrate this we may first consider the alternatives against which the new infill system approach should be compared.

Traditional alternatives.

Without the infill systems option the owner of an apartment building has basically two alternatives where renovation was concerned:

- In a first alternative the building will be vacated and gutted completely to be refitted, after which new tenants are admitted or former tenants may return. This procedure is inevitably socially destructive. It also takes extensive planning and a good deal of social engineering before the building is empty. Even if the owner tries to help tenants to find new places to live there will be those who find it difficult to leave but equally difficult to stay in a gradually emptying building.

- In a second alternative the building is renovated while the tenants stay in place, in which case they are submitted to a long period of discomfort and noise when workers go in and out to redo bathrooms and kitchens and electric circuitry, taking apart most of the house before they put it back together again. This procedure asks much patience and endurance of all parties involved and also a good deal of cooperation between owner and contractor. It is not uncommon that a full time social worker is occupied with helping tenants to cope. Inevitably there are older people and those who are ill or already under stress for other reasons who now have to live through all this for months on end.

Compared to these traditional ways for renovation we now may consider from the owner's point of view the advantages of the new alternative offered by infill systems.

User friendly adaptation as a result.

In both traditional cases the contractor insists on some economy of scale where the same parts can be installed in the same way in all units. Uniform floor plans are required. For the owner it is difficult and very time consuming to come to a single proposal acceptable to all tenants. Usually the emphasis is on equipment. The original plan is maintained as much as possible while better bathrooms and kitchens somehow are installed. Differences in life style, occupancy, and income can not be taken into consideration. In the end no one is satisfied. The lowest income tenants feel they cannot afford the new rents. Those with a higher income feel they do not get what they want.

In case of infill renewal, on the other hand, variety of floor plans is the natural outcome of the process and not more expensive than uniform floor plans. This is because the infill process treats each unit separately. All subsystems are installed by the same crew in a single procedure. Making two or more identical plans does not offer any advantages in terms of installation time or costs. Neither does it matter if several units must be renovated at the same time or in the same building. At all times the infill system for each unit is delivered in its own container and installed by a separate crew.

No gradual deterioration.

Whereas the infill system does not care if floor plans are uniform or different, the benefits of personal adaptation are considerable for both tenants and owner. Tenants get what they want within the limits of what they can afford. Having been involved in choosing the environment they live in, they will be more responsible users. Demand for repair and maintenance will decrease.

For the owner of the property this means that overall quality remains good with less effort.

Most important, however, is that in the one-on-one infill renovation process overall deterioration of the property is avoided. Renewal is now a continuous process of gradual adaptation to tenants' needs. Each time when a tenant leaves renewal and adaptation is possible. Because infill time is short vacated units can be renovated and rented again within a month. As we have seen in the second scenario, renovation of a unit can happen while a tenant takes a three weeks vacation. In this way renovation and adaptation become a form of continuous maintenance and violent swings in the condition of the rental property, from massive renewal after years of overall stagnation can be avoided.

Separation of 'Support' and 'Infill'.

To renovate a housing estate not only the interior of the units must be renewed. The customized infill of single units must be complemented by improvement of the facilities shared by users like stairs, elevators, entry ways, parking facilities and landscaping.

Essential to the infill approach is that a clear distinction is made between the infill proper which is done in response to individual user's needs on the one hand, and the so called 'support' building that holds the individual units on the other hand. For the latter the owner must take initiative. In the case of the two scenarios sketched earlier for instance, the housing authority has planned complete replacement of the existing stairwells and the addition of elevators for the four story apartment block. (Fig.3). It also plans for the replacement of some garage and storage space on the ground floor with new dwelling units. These works will be done in consultation with the group of tenants involved, but the work itself remains outside the units and is done at its own pace. In the same way the facades are cleaned and treated against moisture penetration and window frames are repaired at the outside.

These more general activities concerning the building as a whole for the benefit of all tenants no longer relate to the renovation of the units themselves. Bids can be put out independently and contractors know much better what is expected and find it easier to determine prices.

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New Construction: commercial dimensions of the Infill Approach.

What has been said so far shows that the infill approach is not only a technical innovation but has important social implications. However, these go hand in hand with commercial aspects. This becomes particularly clear when we consider the use of this approach as applied in new construction in the up-scale market.

Differences of supply and demand.

Developers know that prospective buyers always demand changes in the floor plan of the units offered to them. Even when they like the floorplan they may want a door to be displaced to accommodate a beloved piece of furniture which otherwise will not fit in. Or they may want a wall replaced or taken out. Usually they like to choose their own bathroom and kitchen equipment as well as the colors of tiles and other surface finishing.

The response of developers to such demands for change and adaptation varies with the market situation. If competition is strong they may have to give in more readily than when there is a great deal of demand.

But, if they had their way, developers would prefer not to offer any choice to buyers at all for the simple reason that it will cost them money. It is not at all certain that the costs of customization can be passed on to the buyer. The contractor's price is based on fixed, predetermined floorplans and specifications. Any change will disrupt his planning, will cost more money and take more time. Contractors are well aware that the developer demands a change because otherwise the unit will not sell. This puts them in an advantageous position to negotiate the price of the adaptation. But it is also true that it is difficult for the contractor to manage such changes and to determine their exact costs. Prices will be established accordingly.

This situation, which is familiar enough to all of us, basically puts developers, buyers and builders, on a collision course.

Reconciliation of Conflict.

The infill approach reconciles this conflict. The developer now asks for bids on the support building only and will be supplied with a finished building complete with facade, and all such facilities as are offered to all users: entrance lobbies, elevators, public stairs and corridors, parking facilities and landscaping. In short, the building as finished will clearly establish the kind of lifestyle and quality of services that the buyer needs to know before he can decide if the location is of interest to him. But the inside of the apartments will remain empty and ready to be filled in. Floors are smooth and ceilings finished and painted. At a fixed place in each unit there is access to electricity, water, gas, and sewage for the infill system to connect to for further distribution in the unit.

Building this 'support building' should not offer any surprises to the builder. He will be in control of logistics for a well defined job. The builder is in fact freed from the part of the construction process that usually constitutes the greater risk to him and takes most of the overhead for on-site management and for coordination of subcontractors. It is well known that money is easily lost on finishing the interiors of dwelling units where it is gained in setting up the larger structure holding them. The builder, in short, now can do more with less overhead costs.

The developer from his part, now knows precisely what he can expect from the builder in terms of product and timing. For the infill he contracts the infill systems company. He is now in a position to offer the buyers exactly what they want and can structure his prices accordingly.

We can conclude that the infill approach sets free all parties involved: the buyer, the developer, and the builder. It may also show how the system is not only a technical innovation but has very interesting commercial implications, putting developer and builder in a mode of operation that offers superior service to the buyer in a way that can be logistically and financially well controlled. This, of course, gives them a decidedly competitive advantage over those who operate in the traditional mode.

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Open Systems, technological dimensions of the Infill Approach.

In this context it is important to mention that the infill system providing this commercial breakthrough is a so called Open System. Open systems in building technology utilize as much as possible materials and components that are already on the market. For the infill system this means that partition walls and wall finishes, door frames and doors, kitchen and bathroom equipment, all are taken from the open market. This is radically different from what many people have in mind when they think of a industrialized system. The infill system we are talking about here is not so much hardware oriented as software oriented. It is based on a few important principles:

Separation of Support and Infill.

The first and foremost principle on which the approach is based is that the infill system is clearly distinguished from the rest of the building in which it is installed. What is not infill is by definition 'Support'. This comprises not only the shell of the building, including facade and roof, but also all load bearing parts as well as the major conduits that feed the individual dwelling units: those for gas, electricity, water and sewage. These conduits run to a specific point in each unit from where further deployment is done by means of the infill system.

Once the infill system is separated from the support it can be studied on its own. As far as the particular system is concerned on which I report here, we established the following principles for its development:

Re-ordering of the deployment of conduits.

We found that the bulk of the costs of an infill package is in the technical equipment needed for the unit, including all the piping and wiring that go with it. This comprises at least the following technical subsystems: heating, ventilation, sewage, hot and cold water supply, electricity, telephone, television, and various safety and control systems.

We found that a significant part of the costs of these systems is not their hardware but their installation. Installation demands multiple visits by different crews for different subsystems. It is a very difficult task for the job manager to orchestrate these visits successfully. We also know that very often one crew's work interferes with that of another and that the earlier crew must return to repair what got damaged later on.

The key to a successful infill system is therefore to find a new way to distribute all the conduits of the technical systems assuring that interfaces are eliminated as much as possible. In other words: we want to make sure that conduits can run through the unit without getting in the way of each other. Moreover we want to make sure that conduits can be installed without workers having to cut open walls or having to leave walls partly finished, waiting for conduits to be installed.

Our search for disentanglement of subsystems resulted in the invention of two new hardware components: the 'Matrix Tile' and the 'Base Profile'. The two together serve as context for almost all other subsystems. In other words they are the embodiment of the chosen ordering principle. (Fig.5).

Dimensions and Positions.

Having re-ordered the distribution of the conduits and, by doing so having minimized the interference of subsystems among each other, we now had to codify this ordering principle in exact positional and dimensional terms. Once a certain subsystem is deployed we want to know precisely where all its parts are and what dimensions they have. This is achieved by the use of a so called 'band grid' as has been applied already for many years by those interested in open building systematization. A band grid allows for positioning rules for each subsystem thus formalizing the ordering principle that is chosen.

Contrary to modernist ideas of systematization our approach does not demand a dimensional standardization of parts but is based on positioning rules relating each subsystem, and each part in it, to the grid. Some parts, like door frames, have a range of fixed dimensions as determined by the manufacturer. Other parts, like a pipe or a stretch of wall, have variable dimensions. Variable dimensions result from a part's position in a larger configuration. They may also depend on the position of parts from other systems that it must connect to. The latter also being deployed according to their own rules in the overall ordering concept.

Variable dimensions are not random, however. When the positions of all parts in the grid are known, dimensions can be calculated from the position information available and, consequently, each particular part with its own particular dimensions can be individually known and therefore produced.

This way of working makes it also possible to apply the infill system in buildings that follow their own dimensioning system or have no clear dimensioning system at all. In other words: the application of the infill system does not require that the building in which it is applied be designed in any systematic way. All that is needed is that eventually the positions of the building's parts are determined in the infill grid. These positions may not be subject to any rules but nevertheless can be determined. Once this is done the dimension of infill parts connecting to them can be calculated.

Although knowledge about the use of positioning rules in a band grid is already in the public domain for many years, the specific method of calculating actual dimensions of parts from given deployment rules is not. It has been developed for the benefit of the particular infill system I am reporting on here, Production and Installation.

Given an exact dimensional drawing of the desired floor plan our method allows for its translation in a technical design based on the positioning rules as discussed above. This translation is done with the help of a specially developed computer program. It is a kind of dedicated cads program which understands deployment rules and can calculate dimensions in the way explained earlier. The result is not only a set of technical drawings but a specification list of all parts needed for the particular infill package at hand. This information is fed into the production phase of the infill package itself. Parts are subsequently selected from stock, cut to size if needed and/or otherwise worked upon, sometimes combined with other parts, and finally packaged to be stored in a container.

This process, beginning with the technical translation of a submitted floorplan and ending with the container ready for shipping, is what is called the production phase. It is a phase that requires a highly sophisticated production process where each single product is a unique combination of a large number (about twenty) of well defined subsystems.

But the product is not assembled. Its parts are transported to be put together in the building for which the floor plan was designed in the first place.

This second phase is the installation phase. It is basically a building job in which a fully prefabricated kit of parts is put together.

The separation between a production phase and an installation phase is important because each phase represents a very different way of working and organizing.

The net result, however, is that the installation phase becomes relatively easy and can be done within a very short time, reducing labor costs dramatically.

Saving on-site labor costs.

It should be noted that the savings in labor costs on the site are not the result of repetition of tasks as is the case in the traditional building technology but of principles already discussed that may be summarized as follows:

1) The minimization of the interface between subsystems. This facilitates installation. Each subsystem can be laid out in one act and need not be dealt with again.

2) The prefabrication of all parts so that on-site cutting and adjusting of dimensions is almost eliminated.

3) The elimination of on site measuring. Because of the use of the matrix tile no measuring is needed for the installation of any parts after the first few matrix tiles have been put in place.

4) The elimination of on-site mistakes. Because deployment of subsystems is done following clear positioning rules in the base grid, workers can easily read drawings and understand how things go together, thus reducing the risk for mistakes.

5) The elimination of the need for ad-hoc problem solving. Workers need not solve detail problems on the spot. The way things come together is fully predetermined.

Balance of costs.

The gain from saved labor costs in the installation phase pays for the production phase, resulting in a total for direct costs which is not more than what is needed with the traditional way of outfitting a dwelling unit. But at the same time the important social and logistical advantages explained earlier are gained, giving those who adopt the infill approach a competitive advantage in the market.

This shift from on-site labor costs to costs of industrial production also allows the utilization of subsystems that are deemed too expensive in the traditional mode of residential construction. For example, throughout our infill system we use electric cables and connectors that were originally designed for application in office furniture. The higher costs of these superior parts are easily compensated for by the fact that laying out these cables - in the appropriate channels without interference with other systems - can be done so fast that much more is saved in labour time than is paid in additional costs in hardware.

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Past developments.

A breakthrough as is represented by the infill systems approach does not come overnight. It should be expected that it is the result of a long period of gestation and development. The original idea of the distinction between support and infill was suggested in the early sixties *2), The basic methods used in our system for the distribution of all parts by means of positioning rules related to a modular grid have been pioneered by the SAR research group *3). In the late sixties and early seventies with financial support of architects offices and building manufacturers. In the early eighties modular positioning as advocated by SAR became formally recognized in the Dutch standards for modular coordination. The most important aspect of this development was, in my personal opinion, that it resulted from a concerted effort of an small number of dedicated individuals who succeeded in making positional coordination the topic of a broad based debate involving representatives of all parts of the building industry *4). This was the begin of an industry wide debate on first principles of residential construction.

Meanwhile other architects had implemented the support/infill distinction in a number of housing projects in the Netherlands. Their work demonstrated that the application of the distinction, with its advantages for user and owner, even without a sophisticated infill technology could be done within the constraints of costs and regulations of public housing *5).

One important result of the pilot support/infill projects was that they triggered the interest of some builders who began to see the potential for cost efficiency in this approach. The topic became particularly relevant when in the late seventies a severe recession in the Netherlands triggered by the international oil crisis forced the government to reduce substantially its financial support of housing construction. This, for the first time after the second world war, forced competition among builders in the lucrative field of public housing. As usually happens in times of re-examination, different directions were taken by different parties. Where some sought to achieve a better competitive position by drastic cost cutting in management and materials combined with more economic design, others recognized that Dutch housing was already among the cheapest in Europe and decided that only a new approach could open a promising future. They organized themselves in a not-for-profit foundation called Open Bouwen (= Open Building) to push for an alternative way *6). Open Bouwen advocates the distinction of different levels of intervention in the built environment, the general concept on which the support/infill separation is based. It also promotes the clear distinction of independent subsystems and their coordination by means of positioning rules in a common grid. The Open Bouwen movement has members from all branches of the building industry, from architects to developers, builders, and manufacturers, to managers of public housing estates. It operates on the assumption that the basic principles are sufficiently clear but that now practical implementation needs to be encouraged.

Among the more notable results of the Open Bouwen initiative was the organization of a center for technical and design studies, by the name of OBOM, in the Technical University of Delft, financed by this university and the government *7). In a separate development a number of studies about the economics and management of open building projects were done under the supervision of committees formed by representatives from the building industry and their consultants and financed by the ministry of economic affairs.*8).

It eventually became clear that a more sophisticated infill system was needed to replace the ad-hoc systems that had been applied in the support / infill projects done so far. In the course of time technical developments in the Netherlands had already produced a number of more advanced subsystems for residential construction. Among those can be mentioned a number of partitioning wall systems, industrially produced door frames that can be installed in a few minutes, and hot water heating systems that serve a single unit and fit in a closet. In brief, the time was there for a more comprehensive approach utilizing recent technological innovations as well as the methodological knowledge developed so far.

The Matura infill system about which I have reported here was a response to this need for a 'second generation' infill system. Its development took about five years and it is presently licensed for commercial production in the Netherlands.*9).

However, this is not the only infill system presently under scrutiny in that country. In another initiative, a combined effort by a number of manufacturers is under way under the name 'Esprit' *6). Esprit advocates a 'plug in' solution maximizing flexibility for the user, It aims for more advanced subsystems and new designs for integrated equipment in bathrooms and kitchen. Pilot projects have been implemented. Commercial production on a continuous basis is expected within a few years.

Another, much more pragmatic system has been applied in a few small office buildings and will be demonstrated for residential use in a project that presently is under way. Under the name of 'Interlevel' this system offers a very affordable raised floor of minimum height (about 10cm) under which conduits can run freely and on top of which partitioning systems and kitchen and sanitary equipment from the open market can be installed *6).

This brief sketch may suffice to show that the approach I have spoken of comes from a broad-based development that was under way in the Netherlands for several decades. It is against the background of this steady development that I hope my paper may now inform a larger audience of what is afoot.

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Notes.

1) In this particular case the lump sum paid by the tenants exceeded 20% of the costs of the infill package as delivered. Some observers believe that rental users as an average would be prepared to contribute 15% of the infill package price out of pocket. This extra money is not needed to make the infill package competitive with the traditional way of outfitting renovation units, but it is an indication of the willingness of users to invest in their dwelling environment if they get what they really want.

2) First suggested in the Dutch publication: De Dragers en de Mensen. Scheltema & Holkema, Amsterdam, 1962. First English edition under the title Supports, an Alternative for Mass Housing, the Architectural Press, London, and Praeger, New York, 1972.

3) SAR, Stichiting Architecten Research. (Architects Research Foundation), Eindhoven 1965-1991, of which the author was director until 1975.

4) Major players were, among others, Ir. John Carp, at the time director of SAR, Prof. Age van Randen at the Technical University Delft, and architect Frans van der Werf, Rotterdam.

5) Most advanced among the many attempts to implement the support/infill idea were the projects by architect Frans van der Werf. Particularly the Molenvliet project in Papendrecht, the Lunetten project in Utrecht and the Keyenburg project in Rotterdam influenced the Open Building approach.

6) For more detailed information about any of the organizations and systems mentioned in this article readers are advised to write to the Open Bouwen foundation: Stichting Open Bouwen.Post address: Stevinweg 1, 2628CN Delft, The Netherlands.

7) OBOM ('Open Bouwen Ontwikkelings Model' or 'Open Building Development Model'). Founded 1985. Prof. A.van Randen director until 1992. Presently led by Prof. R. Brouwer.

8) Among many others a major role was played by Karel Dekker, finance and management consultant, who authored a number of pathbreaking studies on new ways for financing and budgeting housing projects based on the support infill distinction.

9) The Matura system is licensed by Matura International bv, Delft, The Netherlands. It was developed by Infill Systems bv. a partnership of N.J. Habraken, Prof. A van Randen, Mr. Ir.F.J.M. de Vries, J. van Vonderen.

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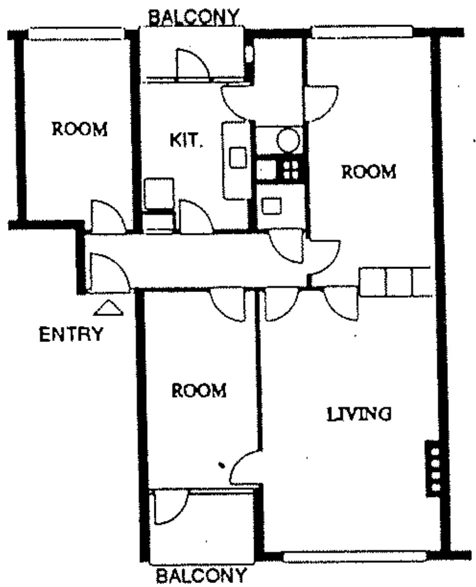


FIG.1.1

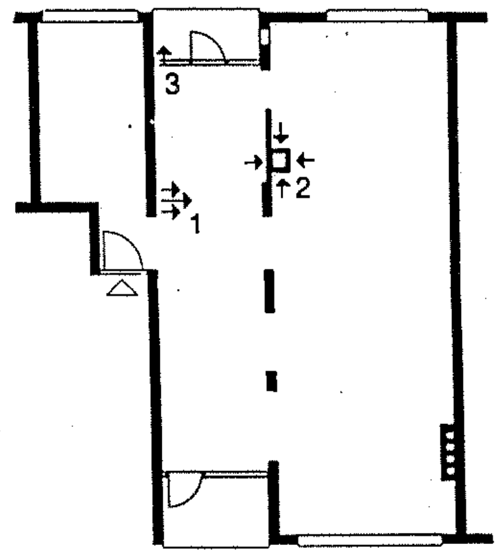
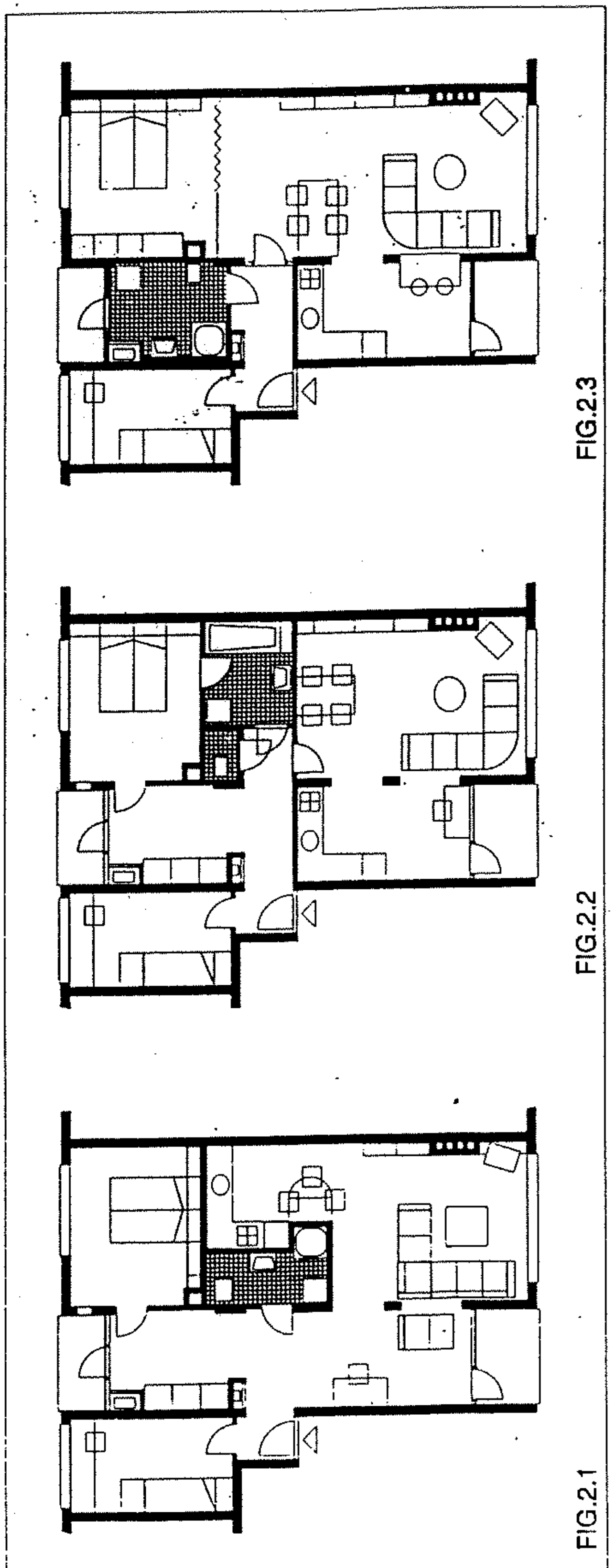


FIG.1.2

Fig.1.1: The original plan

Fig.1.2: The support building prepared for infill.
1. Connecting points for gas, electricity, and water
2. Sewage main and ventilation shaft.
3. exhaust for gas heater.



Figs.2: Three floorplan alternatives presented to the users.

FIG.3.1

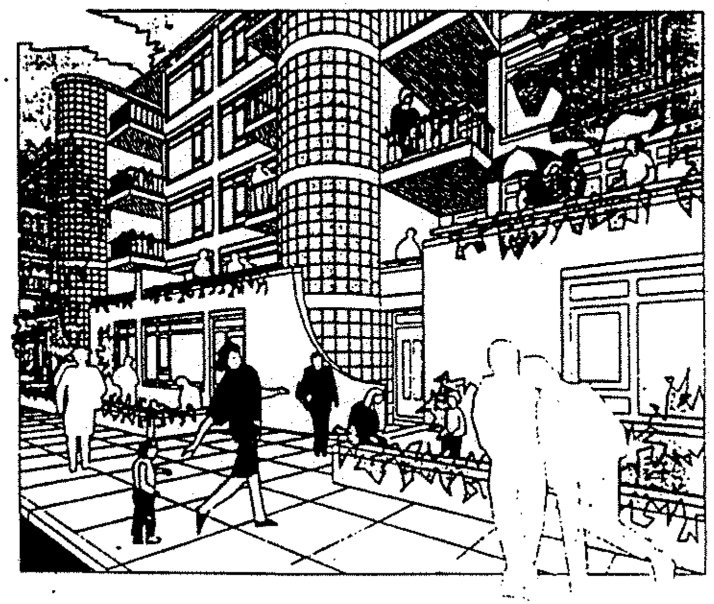
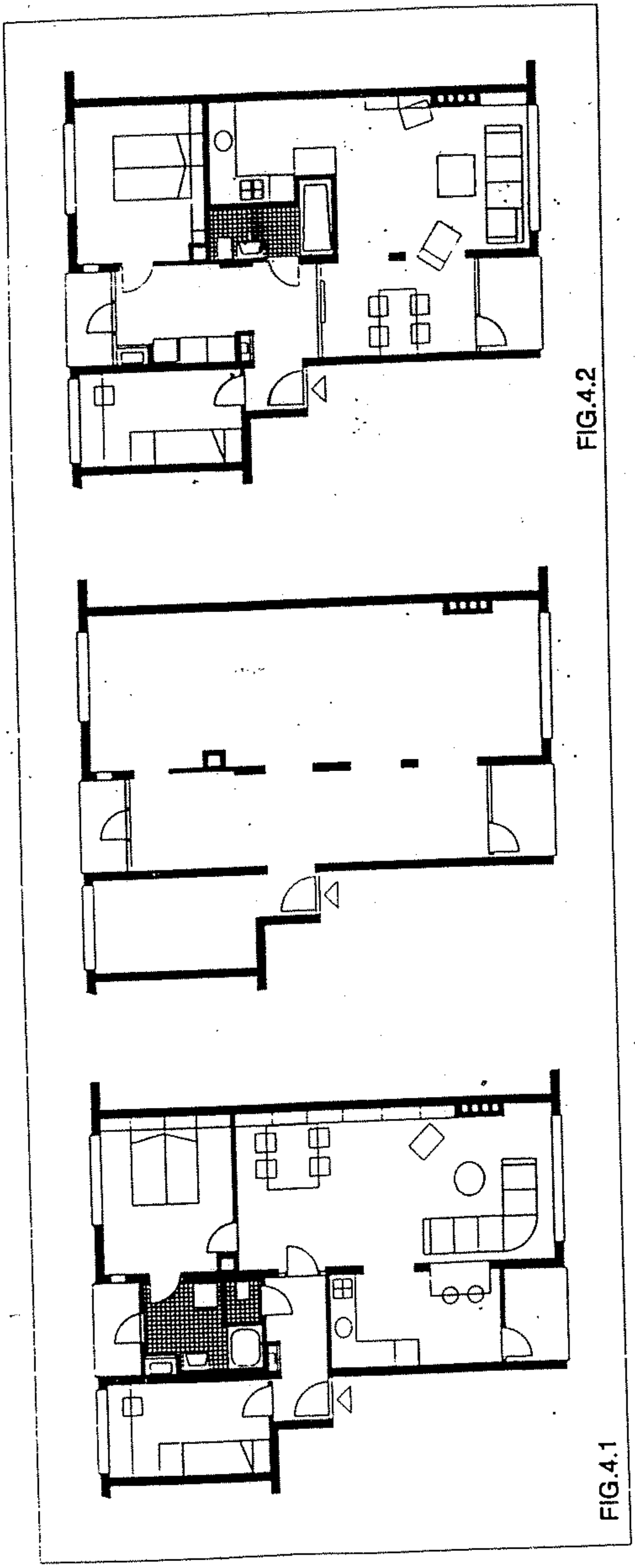


FIG.3.2

Figs. 3. The renovation of the public domain.

Fig. 3.1 The building in its present state
Fig. 3.2 The proposed renovation. In addition to a general face lift and improved landscaping, public stairs have been pushed out and glazed in while elevators are added inside. Balconies are enlarged and on ground level apartments for the elderly are added. All this is done independently from the individual renovations of the dwelling units.



Figs. 4 : Plans as executed.

Fig. 4.1 : The plan of scenario one, compare with fig. 2.3
Fig. 4.2 : The plan of scenario two, compare with fig. 2.1

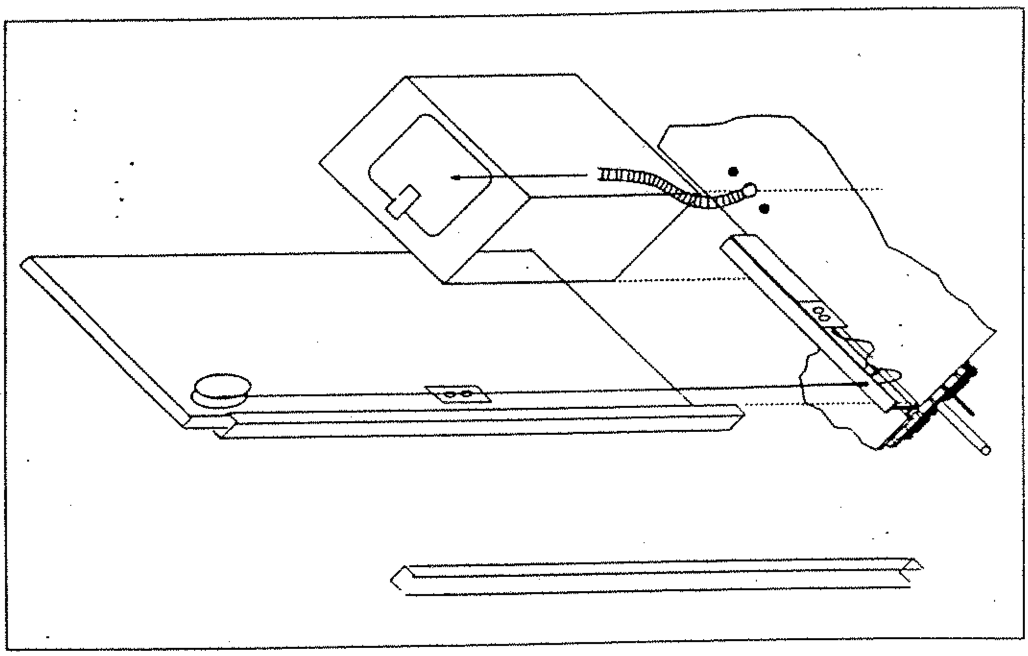


Fig. 5 : Organization of the Matura ® Infill System.

The so called lower system is structured by two new components: 1. A Matrix tile holds conduits for water, central heating, and sewage, and is layd on the load bearing floor, and covered with a floor board. 2) A base profile holds all electricty and electronics. Elements of the upper system are from the open market and connected to the conduits of the lower system.

last page.

OPEN BUILDING STRATEGIES IN POST WAR HOUSING ESTATES

YPE CUPERUS & JOOP KAPTEIJNS

ABSTRACT

Many post war housing estates are in a derelict state and are unattractive to live in. At the same time these projects have the potential for better housing conditions. What they lack is the potential to change according to today's needs. This paper characterises post war housing estates in terms of problems, quality and quantity. In addition an Open Building strategy (a level oriented approach) is explained and three studies undertaken by the OBOM Research Group will be discussed. In each of these studies one level (Tissue, Support and Infill) is high lighted. A level oriented approach sets the conditions for a gradually changing environment, which can follow and fit the changing needs of a society and its people and thus reducing problems of vandalism and unsafety in the residential environment.

Keywords: Open Building, Change, Decision making, Levels, Post war housing;

INTRODUCTION

A considerable part of the housing demand in the industrialised world has to be found in the existing stock. This paper focuses on the problems, possibilities and solutions of the post war housing stock, because this is where serious problems arise, where there usually still is a high quality available (the housing estates are still young in terms of life time expectation) as well as large quantities: many large scale projects have been built during the fifties until the seventies.

This paper describes a series of research projects undertaken by the OBOM Research Group of the University of Technology Delft. A level oriented approach in housing estates and their environments is advocated and illustrated with examples in various projects in The Hague in The Netherlands. By distinguishing different levels, solutions can be isolated and generated per level without disturbing side effects: Interior, building envelope and landscaping are improved in separate plans. Simultaneously problems that are not limited to one level (think of safety aspects in the housing environment) can be addressed by co-ordinating the separate plans.

Although the ideas and examples were derived from the Dutch context, its underlying principles can be recognised in other countries, cultures and climates. Therefore the results of the research projects described may have a much wider application than described in this paper.

SERIOUS PROBLEMS, QUALITY AND QUANTITY

Two major problems in the post war housing stock can be distinguished. First there is the technical deterioration of the buildings, secondly the lay-outs tend to become substandard. These problems coincide with a considerable uniformity of dwellings, mainly existing of two and three bedroom dwellings. These problems will be discussed in brief in the light of demographical and social developments.

Technical deterioration

The technical deterioration of Post war housing estates mainly concerns the building envelope, the main duct systems, the public entrances. Especially the concrete surfaces that are exposed to the weather and the roof finishings need repair. The existing facades usually include many thermal bridges and show an overall bad thermal performance, consequently leading to internal condensation and fungus growth inside and on the inner surfaces of walls. Thermal insulation needs to be added in order to lift the technical quality up to today's standards of comfort and hygiene and health. The window frames are usually in poor condition. The moving parts need to be replaced and double glazing needs to be mounted. In many cases the main sewage system show defects, the material used is asbestos cement and therefore need to be replaced. The existing ventilation systems usually consist of shunted channels that work on natural draft. These systems have insufficient capacity in terms of today's standards. Public entrances are worn

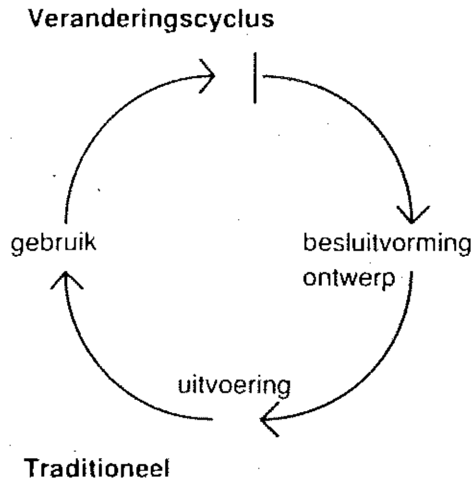


Figure 1. Cycle of Change

Measures regarding the environment have the highest priority, if not, only the poor without a choice will stay.

LEVEL ORIENTED APPROACH

The traditional way plans are developed and the building process is organised results in large scale and intermittent adaptions. There seems to be a certain logic to this, since all composing elements of the built environment are connected to each other in some sort of way. Replacement of one element can not be done without disturbing or damaging the other. If elements can not be exchanged independently, why not simultaneously?

The large scale and intermittent character of the traditional planning process obstructs a flexible adaptation. The notion of being overtaken by the events over and over again is a frightening idea for many a politician or town planner.

The concept of Open Building offers new perspectives. To start with all elements of which a neighbourhood, building and dwelling are composed are allocated to different levels of decision making. These levels are called: "tissue lever, "support" and "infill". By separating the tissue support and infill level a different process of change is made possible. It allows change to happen in small steps. ("change per unit").

Change in the built environment is characterised by a three stage cycle: planning, construction and reuse. **(Fig.1)** In the first stage change is anticipated, designs are made and decisions are taken. After construction the built spaces and facilities will be used, until the moment they not longer satisfy the user's needs. This is the start of a new cycle of planning, construction and reuse.

Depending of the elements involved in the process of change in the built environment the difference between the traditional process of change and an "Open" process of change becomes apparent. In the traditional process building complexes are changed as a whole, whereas in an "open" process the elements change per level.

The traditional planning process only distinguishes sections of a neighbourhood (building complexes) that are considered to be indivisible. These sections are planned and constructed as a unity and will be changed as a unity. They make a characteristic residential environment with identical buildings and identical dwellings.

Such a section (tens to hundreds of dwellings) is the smallest element considered to be "changeable". Due to its large scale changes have a low frequency and therefor a long period of anticipation and preparation. There is no relationship with the individual need for change of the scale of one dwelling. **(Fig.2)**

The concept of Open Building introduces the distinction tissue, support and infill within the unities of a section. The elements that compose the neighbourhood, building and dwelling are allocated to different levels of decision making. Since these levels are independent from each other, on each level elements can change according to the three stage cycle of their related level. In the traditional process of change (part of the) tissue, support and infill are affected simultaneously. This can be referred to as a vertical planning cycle. In an open process the cycle of change is not determined by the indivisible section, but by its level. This is called a horizontal planning cycle. **(Fig.3)**

The horizontal approach shows two distinctive advantages. The one refers to the residential

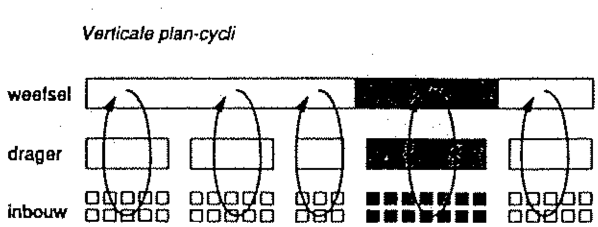


Figure 2. The Vertical Process

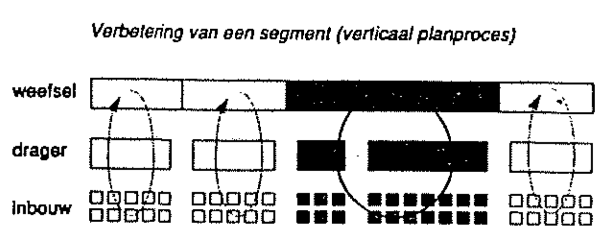


Figure 3. Improvement of One Section

Figure 7. Residential Environment

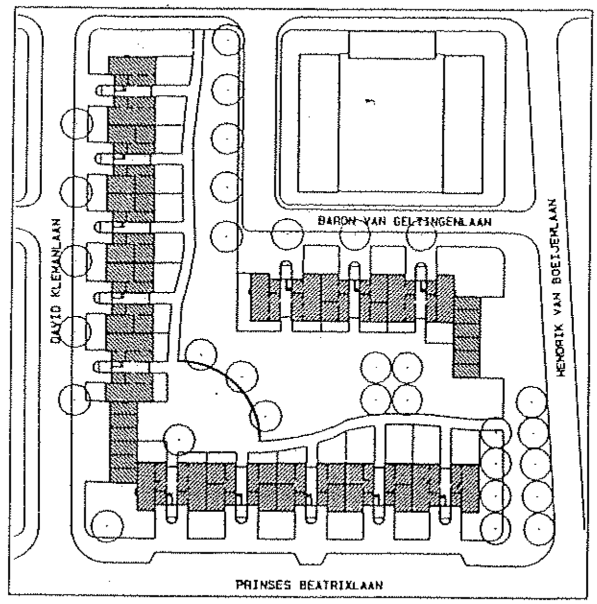


Figure 8. Situation

IMPROVEMENT PER DWELLING

In the fall of 1989, commissioned by the housing corporation "Patrimoniums Woningen" the OBOM Research Group did a feasibility study to adopt a horizontal planning process on a thirty year old housing complex in Voorburg, The Netherlands. The project consists of three five storey blocks containing 130 walk up flats. These apartments are enclosed by thirteen staircase halls. **(Fig. 7,8)**

In this study improvement measures were investigated on three levels: the residential environment, the support, including the options to add elevators and enlarged balconies and new lay outs for the apartments. In addition a the needs of tenants and ways to finance the renovation of the estate were investigated. Based on the outcomes of this study it was decided to start a horizontal planning process to upgrade the complex and its surroundings. Two steps had to be taken. First of all the renovation of one apartment was initiated as a pilot project. Secondly an architect was commissioned to develop independent proposals for the envelope of the building blocks and its environment. In this chapter the pilot project will be discussed in brief.

The pilot project was prepared by an investigation of the capacity of the support. A major constraint was that the apartments had to be renewed while the complex stayed inhabited. This means when removing the old inner partitions, the ducts that service the upper apartment (electricity, water, gas supply and sewage) have to remain intact, as well as the ducts that service the apartments below: ventilation and chimney channels. This resulted is the "stripped plan. **(Fig.9, 10)** In order to determine the capacity of the Support an extensive lay out study was undertaken on the basis of the stripped plan. Then the architect had a meeting with the new tenants who expressed their wishes. A new lay out was developed, fitting the needs of the tenants. **(Fig.11, 12,13)** The next step was to

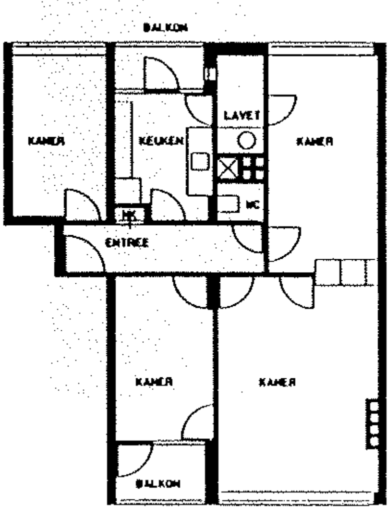


Figure 9. The Old Layout

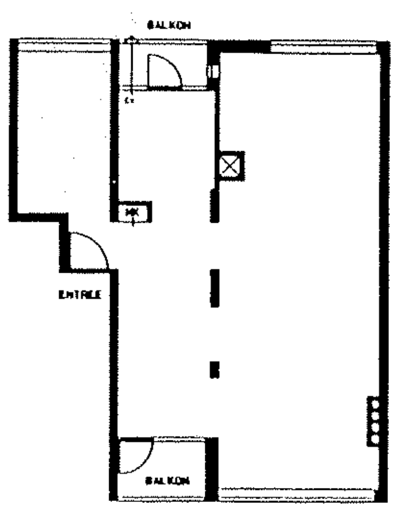


Figure 10. The Stripped Plan

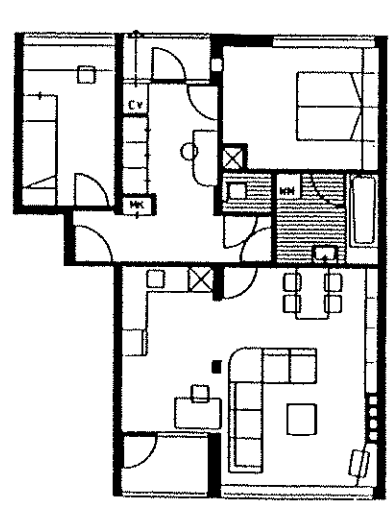


Figure 11. One Infill Option

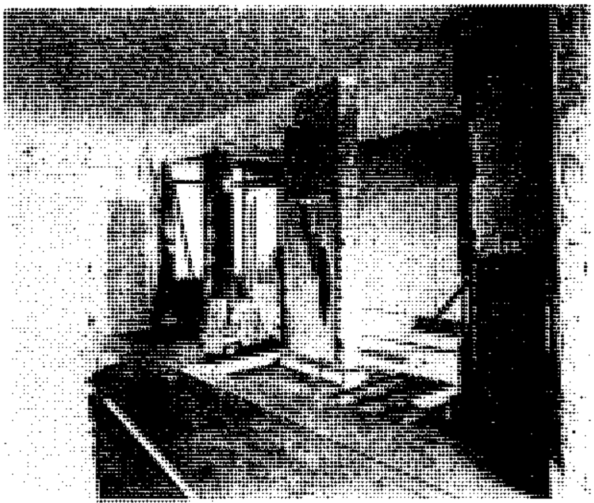


Figure 16. The Infill Process

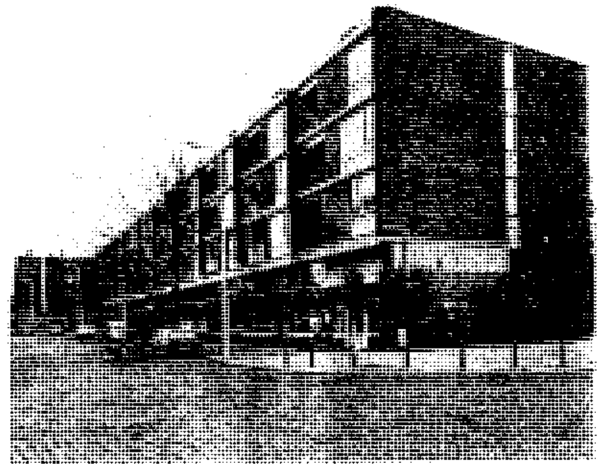


Figure 17. Residential Environment

finally the base board channels are closed by clicking in the skirting. (**Fig.16**) (Kapteijns, 1990).

The horizontal and the vertical process compared

The described process takes two weeks. This means that in a horizontal planning process the house owner can upgrade an apartment, while only missing out on one or two months rent per apartment, while the social structure of the neighbourhood stays unchanged. With a tenant turn over of 10 percent per year it will take ten years to have the stock concerned renewed. In the traditional vertically planned building process building activities can only start after the whole block has been abandoned. Considerable costs have to be made to supply alternative or temporary housing facilities. Tenants who want to return have to move twice, many of them might prefer not to return. The social structure has been destroyed and will take a long time to recover. In addition, the adoption of a subsystem like the Matura system makes the improved dwellings better prepared for future maintenance and change.

IMPROVEMENT PER BUILDING BLOCK

In 1990 the study "Level oriented management in post war housing areas" was undertaken for the Ministry of Housing, Physical planning and the Environment. Subject to the study was the residential project "De Rade" in The Hague. The project is typical for post war housing estates and their problems in the Netherlands. It was built in 1960 and consists of 5 building blocks containing totally 133 gallery apartments. The buildings consist of four storeys and are accessed by a public stairway each, without elevators. The

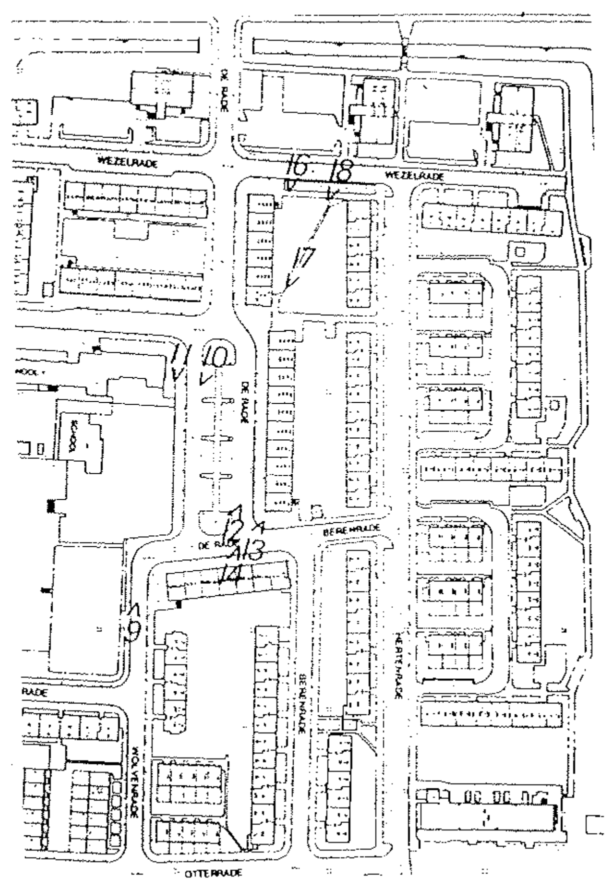


Figure 18. Situation

project shows signs of continuous vandalism and some of its shops are boarded up. (**Fig.17, 18**)

The study proposes the development of separate plans on three levels, being the tissue level, support and infill. In this chapter the support plan is discussed and concentrates on the management aspects of the major maintenance.

and a balcony when open. This option adds to the potential of the dwellings and simultaneously decreases the improvement costs of the balcony floor, because balcony floor and balcony door and window frame have been inner an inner climate allowing a lower technical standard. Closing off the balcony will affect the overall appearance of the facade. Option B leaves the balcony open and therefore requires a higher technical quality of the balcony floor and door and window frame. **(Fig.20, 21, 22)**

The horizontal and the vertical process compared

The building costs for a traditional complex oriented approach and a level oriented approach have been compared. In order to make the two approaches comparative the costs of the complex oriented approach had to be broken down in environmental, block and dwelling measures, corresponding with tissue, support and infill level. The results differ: the traditional complex oriented approach brings the complex back to its original quality level, whereas the level oriented approach results in a complex including "new" dwellings having the potential to be adapted to the user's needs. The level oriented approach, being the horizontal process introduces the tools to better balance and direct the intended quality levels. In addition measures can be financed per level and alternative resources can be addressed. The level oriented approach allows renovation per unit. This consumer oriented approach will increase the market value of the estates in a rental market with an decreasing demand (which already is the case in the less urbanised areas in The Netherlands). The infill options are determined by the constraints of the support. The level oriented approach allows to redefine the capacity of the support and therefore improve the possibilities on the infill level.

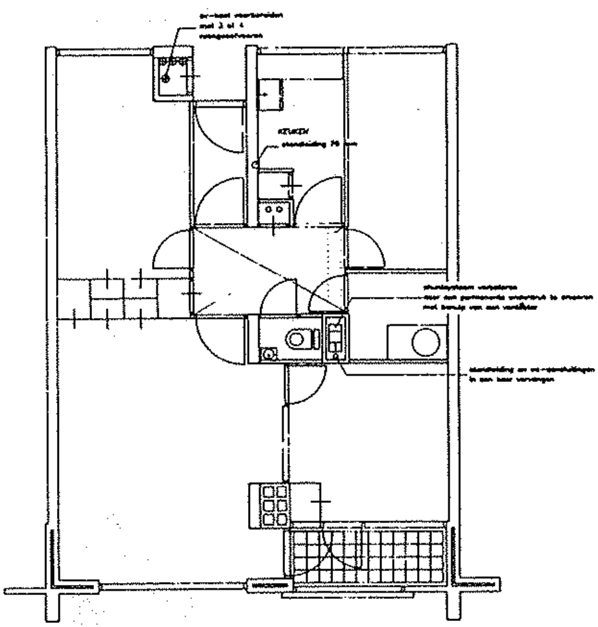


Figure 20. Support Plan with Balcony

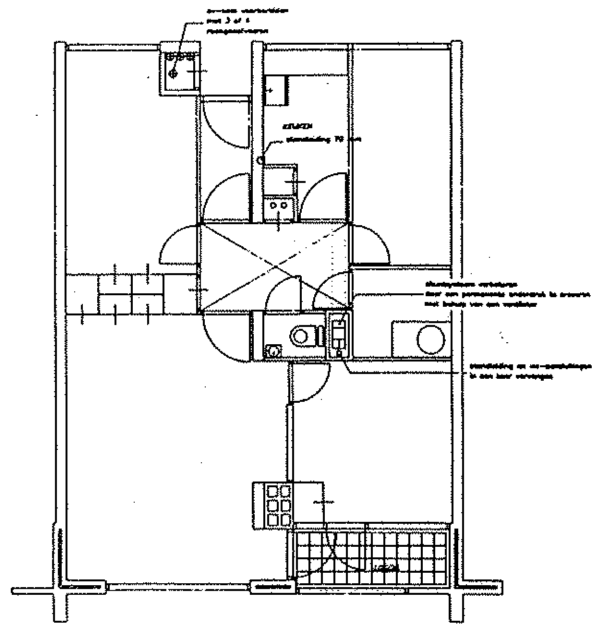


Figure 21. Support Plan with Sun Lounge

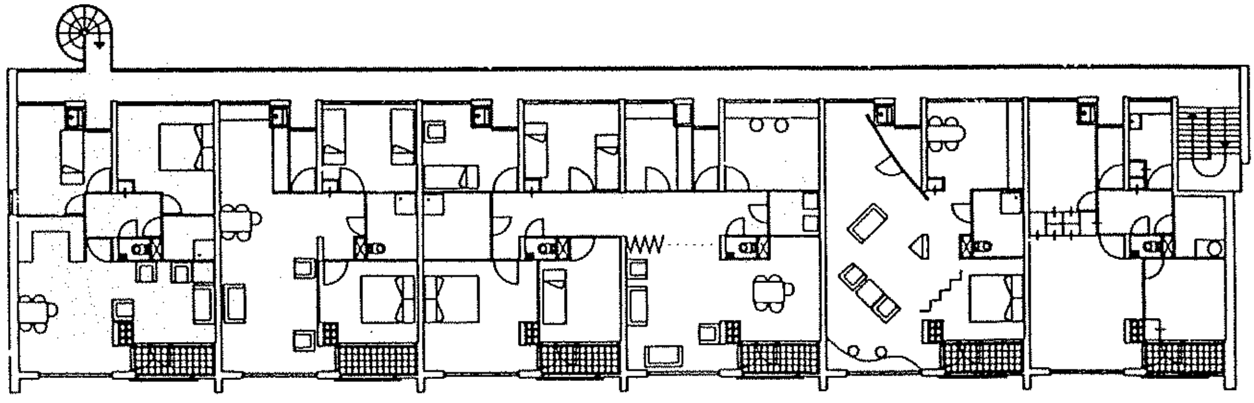


Figure 22. Infill Options

polluting behaviour. These zones should be detailed either with continuous brick flower boxes or with facade walls directly connected to the pavement. The dirt collecting zone has been removed and has been replaced by a brick base that can be cleaned easily. The option to grow flowers and plants in the thus created boxes adds extra decoration and signs of care to the environment. (**Fig.25**)

IV The street side: a deep front garden

If there is a green zone between the long front facades of apartment blocks this zone can collect dirt and increases the distance between dwellers and thc street. Therefore these zones show be transformed in front gardens, similar to those in pre war housing areas. The front gardens should be bordered with low stonc or brick walls. The brick based walls keep the din out and make the pavement easy to sweep. In addition public grcen is given back to the personal territory of the tenant or owner user. Privately maintained gardens usually are better looked after and are more decorative than public green areas. (**Fig.26**)

V Garbage Collections

Garbage bags on the streets waiting to be collected are a source of dirt and pollution. Garbage bags should be kept from the streets N possible. It can be acceptable when it can be put along the road, visible from the dwellings, thus subjected to social control. It would be preferable N the garbage can be stored in a closed area on the premises to the building block, only accessible for the dwellers and garbage collectors. This solution would keep the streets clean. The garbagc area would be manageable through self regulating social control. (Kapteijns, 1990).

The horizontal and the vertical process compared

Open areas in-between building blocks include the borders of properties of two landlords. The horizontal approach looks at urban spaces, its use and control. This opens the way to structuring solutions on a much largess scale than determined by ownership. It concerns the urban fabric of the city, it is dealt with on the tissue level. Consultation and deliberation with other parties involved is necessary, which at first glance is a complicating factor. However, collaboration also includes sharing costs and in addition it results in a more continuos environment. The vertical approach on the contrary emphasises the quilt like structure, that was introduced when the areas were developed separately. However, by restoring the situation of thirty years ago, the problems that have risen since will not be attacked, let alone turned back. (Rijksplanologische Dienst, 1992).

CONCLUSION

In this paper four OBOM studies on problems in post war housing projects were briefly described. A level oriented approach was advocated and explained, and in addition three examples on three levels were explained in more detail. Some final remarks need to be made.

Uncoupled yet related

The distinction of levels offers a tool to distinguish long term decisions on elements with a long life cycle from short term decisions on elements with a short life cycle. It shows a subdivision of the broad range of decisions to be taken. However an ordinary subdivision of problems might lead to a series of disintegrated solutions. A level oriented subdivision on the contrary includes the conditions for a much more coherent result. Levels of decision making are not only separated, they are inter related at the same time.

The concept of levels implies a hierarchical relationship between parts. Elements of a lower level can be changed without effecting elements of a higher level. Furniture can be moved around without effecting the walls of the room. Inner partitions can be replaced without effecting the load bearing construction of the building, however it will have its effects on the finishings of the room. (Habraken, 1983).

Conditions for change

In order to adapt to changing needs, the potential to change is a very important characteristic of the built environment. The level oriented approach creates these conditions. However, the potential to

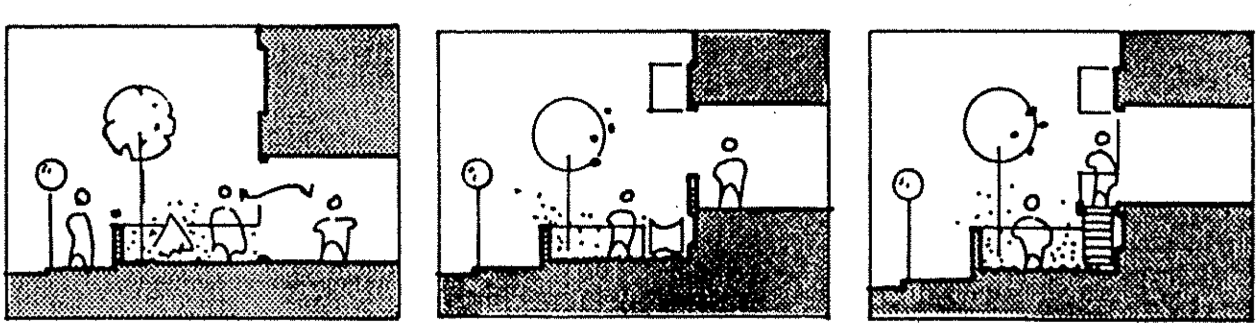


Figure 26. A Deep front Garden

from: UNITS, National Apartment Assn.

BUILD-OUT WHEN YOU LEASE

Marketing and Cost Deferral Benefits of Just-In-Time Units

By Stephen H. Kendall and David J. MacFadyen

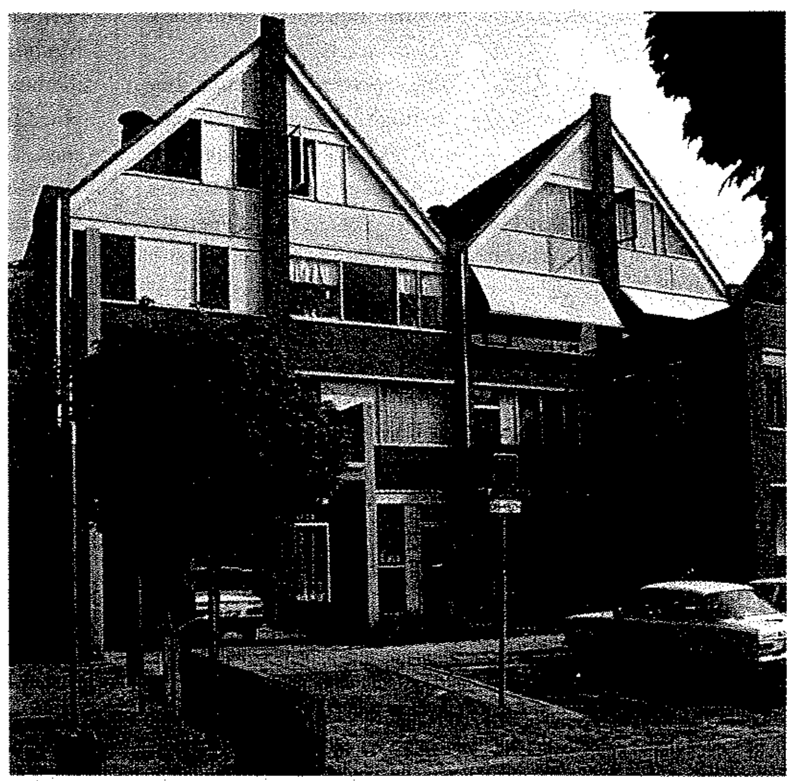
A concept has been coming into practice in Europe that benefits housing developers, owners, and builders, as well as residents. By building residential base buildings and only then specifying and fitting out housing unit interiors, all parties are gaining advantage. As in advanced manufacturing industries, it is becoming clear that it is no longer more costly to produce product variety in housing than product uniformity.

Leading development organizations in Europe have learned how to defer marketing decisions about unit mix, floor plans, equipment, and finishes until just before occupancy. They can save money by making these decisions weeks instead of years before occupancy, eliminating much guesswork and the added costs of changing orders to correct mismatches between assumptions and actual market conditions.

Perceptive contractors calculate that they can benefit by having simpler construction operations, because the technical systems specific to individual units do not need to be coordinated and paid for in the base building phase. New, specialized residential fit-out contractors are forming to provide complete fit-out packages, organized off-site, which are rapidly installed by trained installation crews.

Residents ready to sign leases are benefiting by having expanded choices, including being able to decide on unit plans, as well as detailed decisions, instead of having to occupy dwellings designed on uncertain marketing studies.

Owners of older properties are benefiting in their renovation and repositioning schemes, when they set-up and fit-out their projects with this concept. Once renovated and fitted out, upgrading their buildings one unit at a time is possible, presenting fewer technical difficulties and reduced disruptions than buildings conventionally constructed.



The open building concept allows developers to exercise variety of design, on exteriors as well as interiors, as shown in this project in the Netherlands.

DEVELOPMENTS IN THE NETHERLANDS: RELEVANCE TO THE U.S. MARKET

These benefits are being recognized in a major way, especially in the Netherlands, but also in France and several Scandanavian countries. In the Netherlands, with a population of 15 million, housing quality has become a major issue in the last five years. People there say that the Netherlands is already built; that there is basically enough housing to meet needs. The time has come, they say, to renovate existing units and to build new housing to meet new demands for variety and quality. Households of all ages and life stages, with increasingly varied requirements, no longer are willing to live in standardized dwellings or dwellings decided by so-called housing experts. The consumer society expects not only quality products and workmanship, but customization of dwellings.

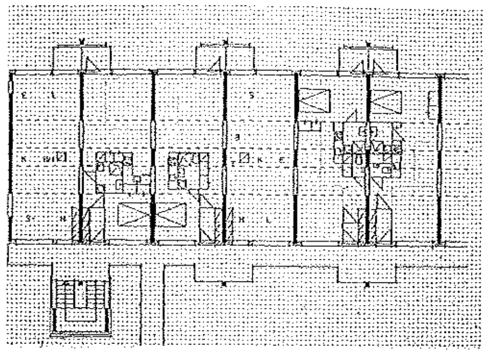


Figure 1. Keyenburg project in Rotterdam, showing plan options; Frans van der Werf, architect.

Figure 2. High-rise project in Enschede; Frans van der Werf, architect.

There, as in the U.S., housing experts recognize that they know less about what units to build because of a dramatic increase in the demand for housing variety over only a decade ago. We see demand for home offices of various layouts and internal relationships (one futurist predicts that 20 percent of us will be working in home offices by the year 2000[1]): mingled units, elderly housing, accessible units of various kinds, more smaller households, increased interest in the co-housing concept, and many other trends.[2] It is now becoming clear that demographic and lifestyle changes are making it necessary to create not new dwelling types or solutions, but better ways to organize variety.

Building owners, product manufactures, architects, and construction organizations are listening carefully to these trends, and are interested in new strategies to profit from them.

Anticipating these developments by more than two decades, a few foreward-thinking Dutch architects, product manufacturers, and technical experts have been conducting baseline research, supported in some cases by government funds. Their work has been the basis for the formation of an organization called the Open Building Foundation, which promotes the "base building/fit-out" concept.[3]

Presently, four different companies are coming to market in the European Community with their own fit-out systems for both the renovation and new construction markets. These systems are all based on what are called the "open building" principles, whose purpose is to meet the new demands for consumer-oriented housing.[4]

How the Base Building/Fit Out Concept Works

All open building projects built to date in the Netherlands and those currently in the pipeline in both the subsidized and open markets--and there are many hundreds of units in them--follow the same basic steps:

A base building is designed using the Capacity Analysis Method, as shown in Figure 1. This architectural design method allows the development team to evaluate the proposed building to be sure it can be fitted out in a variety of ways. The base building can be of any conventional type--multi-story elevator, as in Figure 2; garden apartment walk-up, as shown in Figure 3; or row house configuration, as shown in Figure 4--and of any conventional or unconventional construction method. Most in the Netherlands built to date are concrete buildings using tunnel form construction technology often used in southern U.S. markets, as shown in Figure 5.

After the base building is complete or nearly complete, as shown in Figure 6, and unit mix decisions are made, individual floor plans are specified. This can be done in a number of ways. Individual households may hire their own interior designers or architects, or the developer can provide design services. This process, using just a few consultation sessions, leads to customized units, as shown in Figure 7. If that is not desired, the developer can work directly with design service providers to specify the units based on their marketing research, with little or no consultation with future occupants. This latter process is as normal in the Netherlands as it is in the U.S., but is now being called into question.

Once the units are specified, bids are solicited from competing "infill system" providers, as they are called in the Netherlands. The company awarded the contract organizes a "fit-out package" for each dwelling at an off-site facility, as shown in Figure 8. This organization can exercise pricing leverage because it is supplying many projects and can do quantity purchasing. All the parts necessary to completely fit

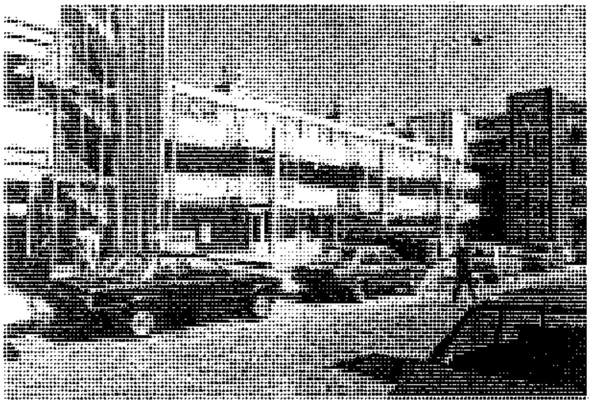


Figure 3. Keyenburg Project.

Figure 5. Base building phase; Lunetten project.

Figure 4. Project in Lunetten, near Utrecht; Frans van der Werf, architect.

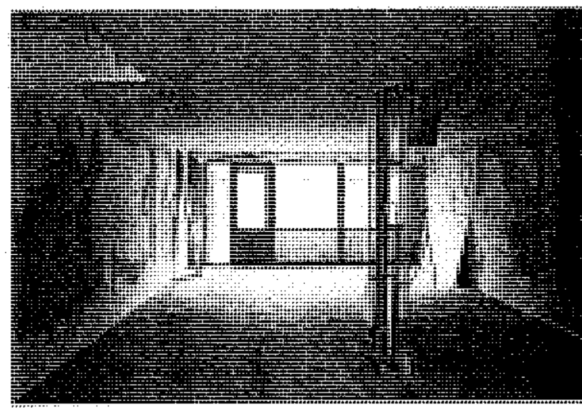


Figure 6. Interior of a residential unit ready for fit-out package.

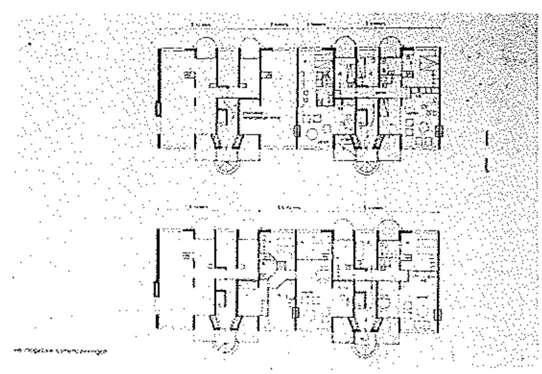


Figure 7. Fit-out options in a renovation project, Voorburg.

out each unit are assembled into one or two containers and delivered to the site, as shown in Figure 9. This package includes all the necessary materials and parts: HVAC equipment, piping, wiring, cabinets, fixtures, parts to make walls, doors, trim, and other interior construction elements.

No two units or their fit-out packages need be alike because of the support offered by sophisticated computer software programs.

Accompanying each interior fit-out package is an installation crew. One crew may be responsible for a number of different units in the same project. Because they are all somewhat different, each presents a new challenge. Because they are well organized, packages and crews are trained, and responsibilities are clear, installation is quick and to a high quality standard. The crew unloads parts from the container through the front door of the dwelling they are working in, in the order the parts are used, and completes their work in a week for an average size unit, as shown in Figure 10. When they are finished, the unit is ready to decorate and receive furniture and personal possessions, as shown in Figure 11.

Economic Benefits

Enough actual building has been done using this concept that start-up companies coming to market with new interior fit-out systems are confident that it will cost no more to operate this way than to work conventionally. Even before these companies began investing millions of dollars on product and organizational research and development in the past five years, they were convinced by studying realized projects built with ordinary technology that the concept provided the anticipated benefits at costs equal to the traditional approach.[5]

Stepping through the construction of a leased residential building using this new concept illuminates the potential advantages to U.S. firms adopting this concept. A residential base building is constructed just as many commercial and office buildings are constructed today in the U.S.--without any interior fit-out. Structural and mechanical systems

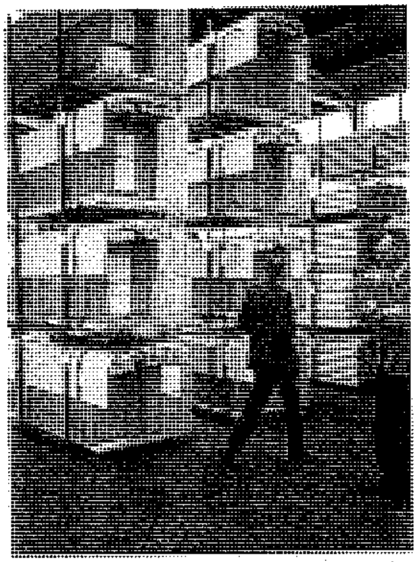


Figure 8. Custom bundled fit-out elements in a factory, ready for delivery to site.

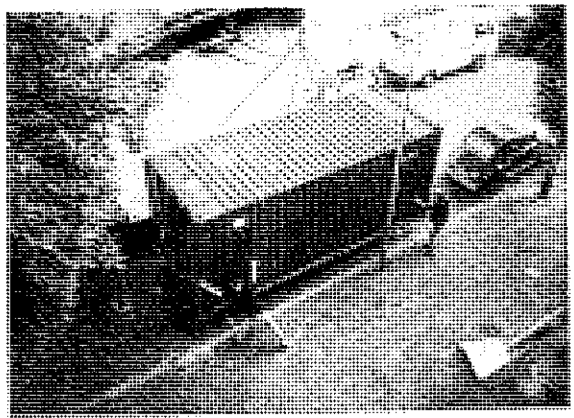


Figure 9. Container being delivered to the Voorburg project for the fit-out of one unit.

Figure 10. Installation crew at work.

layouts determine the potential for interior space division. A multi-story base building might, for instance, have 500 square-foot bays with a plumbing stack in each. This makes possible dwelling units of 500, 1,000, 1,500, 2,000, and 2,500 square feet. A large building might accommodate up to 1,000 small units, 200 large units, or any desired mix in between. The construction cost of the base building would be approximately 60 percent of the total building cost.

When individual units are leased, their layouts and details are specified. A week later, a complete interior fit-out package for each unit is delivered to the building site and the parts unloaded and installed in the correct order. An average size unit's fit-out is completed in one week by a four-person crew. Interior construction investments only occur at the start of income from leasing. Money is not spent to finish unleased units.

Anecdotal evidence suggests that there are many instances when a large residential building comes to market with the wrong mix of unit sizes, resulting in financial compromises. Further evidence suggests that often one or more unit designs do not rent quickly. Deferring unit design decisions avoids both of these problems.

The owner is assured of a marketable mix of unit sizes and designs at the time the project comes to market. A few models can be finished for marketing. Decisions can be made to match, not forecast, market demand. The original occupants can have more options, within the owner's guidelines, of interior layout, equipment, and finishes.

Separating the base building from the interior makes on-site construction easier and more efficient. The base building is free of most piping, wiring, and ducts. This reduces complexity and trade coordination. The total base building construction time can be up to 20 percent less then when using traditional methods, producing cost reductions in financing, construction equipment, on-site supervision, insurance, materials damage and pilferage, and all costs associated with site office operations.

The installation of the interior is a self-contained activity for each unit. Simple, effective quality control of each unit is assured by preparation of the interior system parts at a distribution center, controlled parts delivery to the site, and installation by a trained assembly team. Waste and construction debris from interior fit-out are limited to the packing materials. On-site cutting and drilling are virtually eliminated.

Total building costs in Europe, for projects using this new approach, have been comparable to those of traditional building processes. With any innovation, costs can be expected to come down as experience is gained and volume increases. Detailed cost studies, based upon the first decade of Dutch experience, suggest cost reductions of 2 to 4 percent per year. They expect the new approach to ultimately be 20 percent less costly than current practice.[6]

Realignments Needed to Reap the Economic Benefits

Open building advocates agree that it makes economic as well as organizational sense to distinguish a base building phase from an infill phase. Unlike in the U.S., where the office building market already operates with this concept in principle, there was no parallel in the Dutch building industry.

Open building projects were slow in coming. For a period of 10 years, work focused on understanding how architects could design buildings this way. This baseline research was supported by private companies, architects, and development organizations, and carried out by university and private research organizations.[7]

But starting in the late '70s and early '80s, several projects, numbering more than 400 units, were built, paid for in part from funds in experimental government housing programs.[8] These projects demonstrated that contracts could be made, construction processes organized using conventional building materials, and building permitting could be divided along the lines of base building and fit-out. The buildings were architecturally uncontroversial, the construction quality was good, and the anticipated decision deferrment advantages became apparent to the developers and constractors, as well as the government ministries which administered the grants.

These projects also made clear that realignments in construction organization, financing, permit and approval processes, and design services were taking place, and more would be needed.

If this approach is to be adopted in the U.S. market, similar adjustments will be needed. Permitting, inspection and approvals, financing, and construction management practices that have evolved for current practice will have to be reconsidered to facilitate the divided building process described here. Precedents in non-residential construction can lead the way for the necessary changes of practice in the residential market. Precedents in factory-built single family housing--particularly the experiences with "closed-panel" systems--can also provide guidance for residential interior fit-out systems packaging, installation, and approvals.

Current trends in construction and industrial management are very supportive of this new building approach. Governments, code bodies, and other interested parties are constantly seeking approaches to enhance housing affordahility and quality. The institutional changes necessary for a valid test of this approach to residential consrruction appear tractable.

For the approach to gain wide acceptance in this country, one or more companies supplying interior fit-out packages and installation crews will have to emerge. Many organizations, from sophisticated lumber yards and home centers, to producers of factory-built houses, may have the capacity and interest to serve this marker segment.

Key to the concept is software support. The increased complexity in design and materials specification processes, shop floor organization, and installation logistics cannot be controlled without sophisticated computer aided drawing programs. Existing software developed in Europe to support this concept could be licensed and modified, or software now in use in the United States could be extended to do the job.

There is the potential for the development of new products well suited for base building/interior fit-out construction. But, it is possible to implement the approach using standard products and materials now available. The concept's full potential will be realized when software and hardware designed for the approach are developed in the United States.

Initial projects inevitably cost more than the inherent cost of the new way of building. The most important question is how research and development activities and early demonstration projects can be funded.

Kendall is a registered architect, design educator, and building researcher with a Ph.D. in architecture from the Massachusetts Institute of Technology. He is an associate professor of interior design at Marymount University in Virginia. MacFadyen is a building researcher with engineering degrees from MIT and an MBA from Northwestern University.

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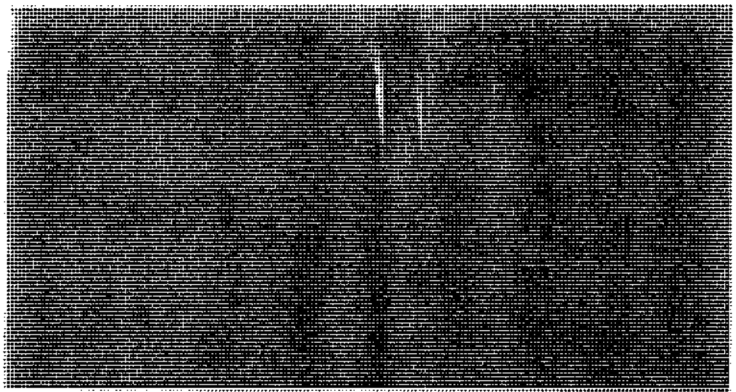
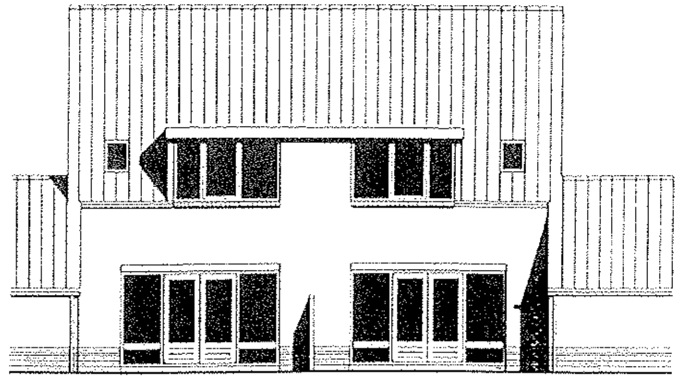
Figure 11. Complete kitchen in the Voorburg project; Hank Reijenga, fit-out architect.

OPEN Stock

A European multi-family housing concept that pairs base building construction and "off-the-shelf" fit-out packages has potential for the U.S. market.

by Stephen Kendall





Courtesy Joop Kapteijns

Below, a 450-unit project in Lunetten near Utrecht; architect Frans van der Werf; estimating by ARO Consulting; base building by Wilma Oost; fit-out by Bruynzeel. Right, elevation of Rotterdam townhomes designed by Joop Kapteijns.

All photos courtesy the author

A radical concept with major implications for housing has gradually been coming to market in Europe in the past two decades. The idea is to build residential base buildings, then decide unit mix and layouts, deferring costs and decisions until the units are actually marketed. This "open building" concept has potential for the United States, where it could solve a number of knotty housing problems.

Open Building

In a typical new open building project, a residential base building is designed and constructed. The base is the part of the building that is common to all the dwelling units. It includes the structure, roof, facade, and thermal barrier, internal public areas, stairs, elevators (if they are required), and building level mechanical, plumbing, and electrical system risers and main feeds.

A building organized this way can be very efficient to design and construct, since no elements specific to individual dwellings are entangled in the base construction. This reduces costs associated with trade coordination, on-site supervision, insurance, material damage and pilferage, and financing, and it generally speeds completion of the work.

Because the base building is designed to allow optimal choice of unit mix—not determine it—the actual mix can match rather than anticipate market demand. In a fashion similar to "just-in-time" design and production in many sophisti-

A [illegible]-unit project in the [illegible] district of Rotterdam; architect Frans van der Werf; base building by van Eesteren; fit-out by van Eesteren, Nijhuis, and others.

cated manufacturing industries, individual dwelling plans are specified only weeks before occupancy. No two units need be the same for reasons of cost, partly because of sophisticated software support that produces detailed specifications and dimensions of all fit-out parts.

At an off-site location, an "infill system" provider assembles into one or more containers all the interior construction elements needed for each dwelling. This fit-out package includes the piping, electrical and HVAC systems, fixtures, cabinets, parts to make walls, and other elements going into specific units. A small installation team accompanies the containers to the site and, in a week, completes the fit-out of an average 93 m^2 (1,000 ft^2) dwelling so that all it requires are carpeting, wall coverings, curtains, and the new occupant's personal possessions.

The concept is independent of construction technology. Despite appearances, it is not primarily a technical concept but a way of distributing and organizing decisions. Once the method is understood, certain technical solutions appear more applicable than others. For instance, the idea is being applied currently in buildings of concrete construction. Some studies have been made, however, in applying the concepts to wood-frame technology.

Advantages

The developer benefits from open building by being able to defer design and financing costs on individual units until sale or leasing. The long, multi-year lead time between decision-to-build and occupancy makes this decision deferment strategy particularly attractive since market research is widely believed to be unreliable at best and often wrong. Because decisions can be made closer to lease-up time, unit sizes and layouts can match the market. Thus, demand for units tailored to particular needs, such as the office-at-home, mingles, or retirement units can be easily accommodated. Customizing is also possible.

The contractor for the base building benefits by repetitive and simplified site operations and approvals, and construction is faster because "fit-out" will be handled later in the infill phase. The problems associated with unit variation, and the changes in unit mix and layouts inevitably made during building design and construction, are not the contractor's problem.

"Fit-out package" providers, a new sort of organization, have competitive advantage because they can offer variety at no more cost than uniform plans. Operating from central distribution centers with regional scope, they can purchase in bulk while delivering custom fit-out packages.

Purchasers of dwellings benefit in turn because they can specify their own dwellings' layouts, fixtures, equipment, and finishes, or they can modify plans according to options offered by the developer.

Building owners and managers benefit in the long term, because when buildings are set up this way, future adaptation and technical upgrading is less difficult than it is in traditional projects.

Older buildings requiring substantial alterations can be selectively gutted in such a way that the result is a base building with capacity for unit variation. Further, it is possible using this strategy to rehabilitate a building one unit at a time, because all mechanical systems, drain lines, and so on belonging to a given unit are contained within the unit being altered. Normally, the ceiling of one unit contains the drain lines of the unit above it. When there is no unambiguous separation of systems according to units, financial, legal, and technical difficulties arise. The open building concept goes a long way to sorting out these problems.

After intensive R&D in the past six years, four different residential fit-out companies have appeared in the Netherlands. Each company, described below, has its own approach to the open building concept.

Interlevel

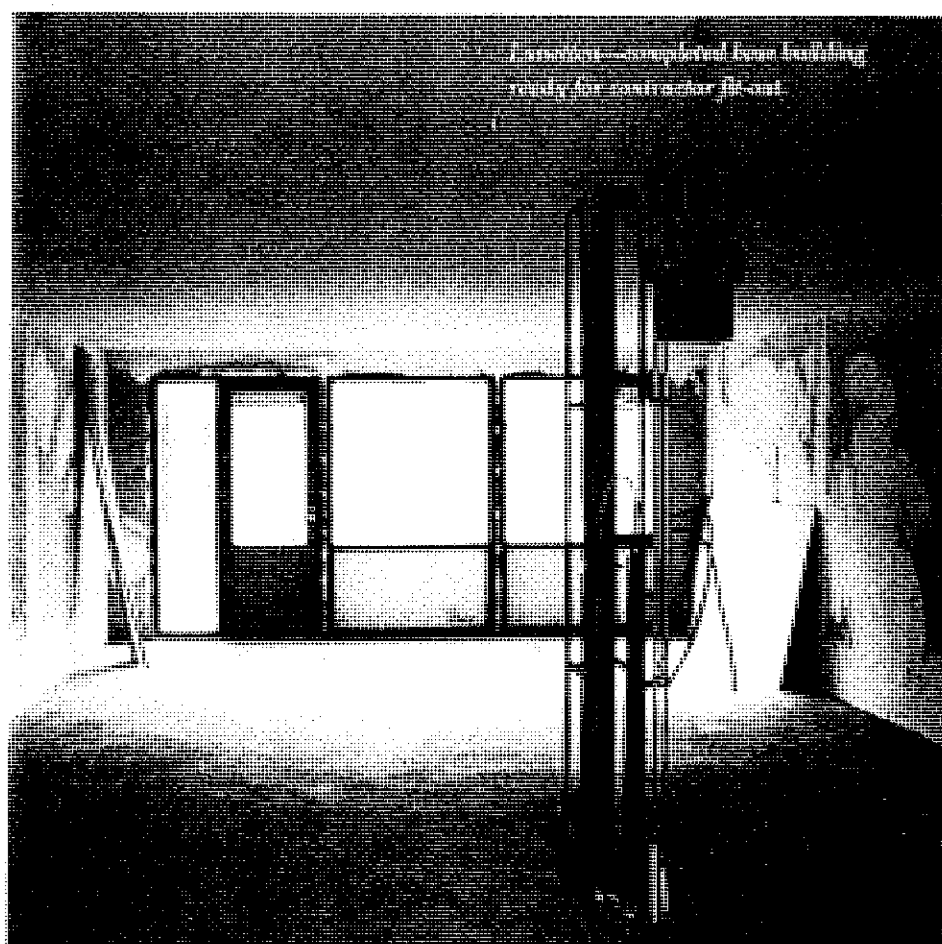
Interlevel, for example, started in the office building market. It uses a very inexpensive raised floor made of particleboard planks supported on plastic legs fitted with threaded steel adjusters. Ducts, pipes, and wiring can be placed under it, free of walls. This technique has been used successfully in office buildings on entire floors and now has been specified and installed in some residential projects.

An Interlevel project of 23 townhomes designed by Joop Kapteijns was recently occupied in a suburb of Rotterdam. In this project, a 75 mm (3 in.) "horizontal underfloor plenum" was used to run a portion of the wiring, domestic water supply, and hydronic heating lines. The underfloor space is located in a zone across the middle of the upper floor, giving the plan variations needed. The rest of the floor was built in the conventional way, with a rough 150 mm (6 in.) concrete slab poured first, followed by conduit and piping not subject to plan variation poured into a 50 mm (2 in.) concrete finish topping.

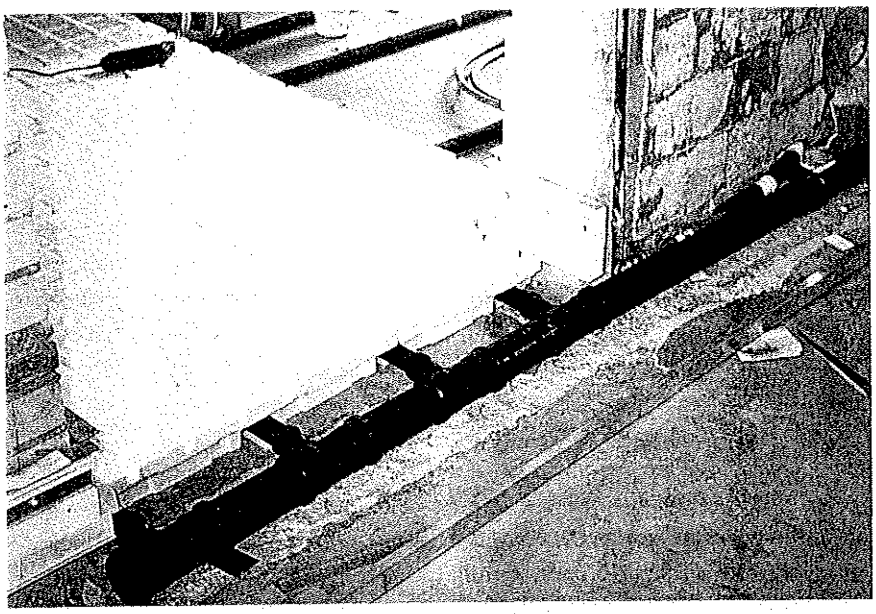
Using this approach, the client, a housing association, was able to offer somewhat customized interior layouts at no extra cost. In addition, the developer offered features such as roof dormers and oversized sliding patio doors that tenants paid for directly.

Actibo

Actibo, a recent initiative, markets custom homes to middle- and upper-income clients who want detached houses or two-story attached units. The firm intends to use high-quality products already on the market that require no building code changes or invention of new building elements.



Interlevel—completed base building ready for contractor fit-out.



Top, Matura Matrix Tile with piping. Above, Matura subfloor installation. Matura also makes a Baseboard Profile for wiring.

Pipes from ground-level spaces—kitchen, laundry, and bath locations are decided after the shell is completed—run through holes drilled by the installation team into the under-slab crawl space. Pipes from the second floor are clustered in a vertical stack with ducts and wiring and inserted through the second-floor slab, with the core drilled at the time the floor plans are worked out.

Wiring runs in the walls and in surface-mounted baseboard enclosures already on the market. Hydronic heating lines (air conditioning is virtually nonexistent in Dutch dwellings), water supply lines, and some conduit for wiring go in the 50 mm (2 in.) loose-fill topping—instead of the normal concrete topping—which is covered by a subfloor called Fermacell, made of gypsum and recycled paper products. Finished flooring of various kinds are applied to this subfloor. The topping and subfloor are part of the "fit-out" contract, as are the pipes and conduit laid in it.

Walls consist of metal studs with Fermacell panels screwed in place and joints taped and spackled. Bathroom floors are made watertight by use of a single membrane layer under the tile floor. The stair location is assumed to be part of the base building, but the stair itself is part of the fit-out package. Dutch stairs are typically prefabricated off-site for each house and are freestanding, making them independent of walls.

Actibo believes that the added cost of materials in this approach will be offset by higher quality, durability, customizing potential, and rapid delivery. Installation crews are to be made up entirely of new entrants to the building industry, to avoid having to change habits and attitudes.

Esprit

Esprit is a consortium of companies started in 1984. The Esprit concept emphasizes "plug-in" solutions maximizing flexibility for users, with advanced subsystems and equipment.

In the first phase of Esprit's development, four companies joined together to create a marketing plan, with support from a university consumer research center. This phase was financed by a fl 0.5 million ($312,000) investment, in part a government loan. The consortium members included a construction company, a building materials manufacturer, and engineering consultants.

Phase two aimed to develop products and a prototype development of houses in Zoetermeer. It was funded with fl 1.15 million ($718,000) from private sources and fl 870,000 ($540,000) from the Dutch Ministry of Economic Affairs. The original consortium was augmented by companies manufacturing partitions; electrical, security, and communications systems; and kitchens and doors. This phase focused on developing new interior wall systems; integrated electrical, communications, and security systems; a special bathroom raised floor; and a so-called "plug-ready" kitchen.

Phase three will be complete in 1995, with private funds of fl 14 million ($8.75 million) and government funding of fl 1 million ($625,000). The plan is to develop ten demonstration projects in new units and in renovation. Three units were completed in Eindhoven in January 1993 in a renovation project. Esprit plans to be commercialized in the European market during this phase.

Matura

Matura's concept was developed by a small research organization, Infill Systems, Inc., headed by two architecture professors. They were joined by an office fit-out contractor and an executive from one of the largest Dutch housing development and construction companies.

Matura offers a fully prefabricated and adaptable fit-out approach using over 20 subsystems already on the market: walls, doors and frames, finishes, and equipment for kitchens and bathrooms. These parts are integrated into an adaptable whole using two newly developed elements, the "Matrix Tile" and the "Baseboard Profile," which provide design flexibility, fast installation, and changeability.

The technical innovation is based on a radical principle of spatial distribution of piping and wiring subsystems made possible by the two new elements. This new distribution concept means that interference between subsystems—and therefore between those installing them—is minimized.

The hardware is organized with a "lower system" and an "upper system." The lower system contains the Matrix Tile (made of expanded polystyrene), approximately 100 mm (4 in.) thick with grooves in both directions, on top at 100 mm (4 in.) intervals and on bottom at 300 mm (12 in.) intervals. Minimum-slope, PVC slip joint water drainage lines—code approved with the Matrix Tile—run in the lower grooves. Polybutylene home-run water supply lines are placed in the top grooves. Flexible gas lines, if they are specified, go in

Platform Research for Open Building

The open building concept was introduced by Professor N. John Habraken, in a book published in 1962 (the English version, *Supports: An Alternative to Mass Housing*, was published in 1972). Interested by the concept, a group of prominent Dutch architects started a research foundation, Stichting Architecten Research (SAR), in 1964 to investigate how architects could design buildings in the new way.

The SAR group, led by Habraken and then John Carp, and with an annual budget of $125,000 from architects, builders, manufacturers, and government research contracts, developed the basic architectural methods needed to design base buildings with "capacity" to hold varions nnit mixes and plans. In the mid-1970s architect Frans van der Werf won a large government-sponsored competition with an innovative design using open building principles. The project, in the town of Papendrecht, was built in 1978. Another, larger project near Utrecht was later designed by van der Werf without government subsidy.

These projects broke new gronnd. New cost estimating procedures, supply chain arrangements, and architectural methods were developed and refined. A few years later, van der Werf designed another project in Rotterdam's Keyenburg district using computer-aided design.

In these and subsequent open building projects designed by van der Werf, deJong and van Olphen, A.J. Kuipers, Alain Courtris in Paris, and others in Japan and elsewhere, the advantages of the new organizational concepts became apparent. In 1985 the Open Building Foundation was formed to promote these concepts. By 1990, several government ministries were supporting technical research (amounting to about $1.8 million) in codes, permitting, and modular coordination principles to stimulate indnstrial production of compatible elements (now adopted as a basic part of the Dutch Standards for Modular Coordination).

These early projects and research results set the stage for the developments now nnderway in the private sector. Those taking part are convinced that even in a small country of 15 million inhabitants, the market will reward the development efforts. Some look ahead to the larger markets of the European Community. ◆ **S.K.**

the bottom grooves. A fireproof subfloor is laid over the matrix tile after the pipes are in place, after which floor finishes are installed in the normal way.

The baseboard profile, part of the "lower system," is a composite wood and plastic element shaped like an I beam with a tongue on its bottom that fits into one of the grooves in the top of the matrix tile. Half of this "profile" is used against outside or demising walls. Power, data, security, and other wiring runs are located in the trays in the sides of this element. Currently, a pluggable power wiring system (manufactured by the German company Wieland) normally found in office furniture is used because of the speed with which it can be installed. Wood or plastic baseboard covers have convenience outlets, as well as speaker and phone jacks.

The baseboard profile is also the base for a variety of "upper system" wall options. The least expensive so far is made of metal studs and gypsum board, but other options exist. Also in the upper system are doors and frames, which can be installed in minutes, as well as cabinets and plumbing fixtures that can be selected from any supplier. Finishes such as wallpaper, carpet, vinyl flooring, light fixtures, window treatments, and furniture are not included in the system at this time.

To test the system, Matura installed its product in several different kinds of buildings in several cities. Two were in Eindhoven, in new subsidized and private-market townhouse projects. Two units were also fitted out in a rehab project in Voorburg, in which two tenants moved out for a few weeks and returned to customized units. The complete installation cost per unit, carried by the building owner who wished to rehab the obsolete units anyway, was fl 28,500 ($17,800) for each 75 m^2 (800 ft^2) unit. The rents increased $130 per month. In addition, an elderly couple living in one unit decided to upgrade the fit-out package by investing another $12,500.

The new technical developments are supported by a proprietary computer program called MaturaCad. Together, the

The opportunities for the open building approach in the United States are worth taking seriously.

MaturaCad software, Matrix Tile, and Baseboard Profile constitute a system with patents in many countries, including the United States. In the Netherlands, it is currently licensed to a new division of Janssen and DeJong, Inc., one of the largest Dutch construction and engineering conglomerates. This division specializes in producing and delivering Matura installations and has committed more than $3 million over the past three years in gearing up. The company currently is developing staff and a distribution yard and is negotiating for installation contracts. They expect to break even in four years, delivering 1,200 units per year.

Opportunities and Realignments in the United States

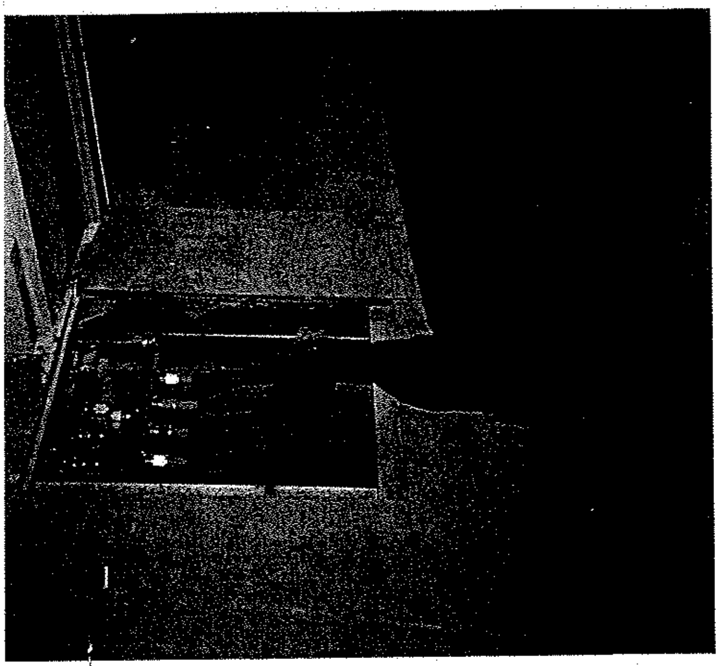
The opportunities for the open building approach in the United States are worth taking seriously. The office market here already operates in a similar way. In addition, new hardware and software systems now exist as a consequence of the idea of base building and fit-out. Specialized "tenant fit-out" contractors have been formed to offer special expertise in this market. Architects now design base buildings, and interior designers do tenant fit-out designs. Financing and permitting have developed to match the process, and the tax code recognizes the distinction between fixed assets and equipment (which constitute an increasing portion of fit-out).

Panelized housing builders, operating regionally in the wood-frame residential market, also operate in much the same way when they deliver complete house packages. More limited "residential fit-out packages" could conceivably be delivered and installed by these or similar organizations.

Several "hardware" and "software" issues will have to be addressed if this concept is to be adopted in the United States, however.

On the hardware side, while the approach can work today without development of new building products, certain elements (such as those that Dutch companies are developing) would make the process easier to implement.

For one thing, the idea of disentangling subsystems to minimize technical and trade interference needs to be un-



The Interlevel floor system in a project in Ijsselmonde, Rotterdam.

derstood. As part of that, the minimal slope piping concept would have to be tackled—a problem that some experts believe will not present a barrier, since European fluid dynamics tests should be replicable in the United States. Residential wire management, now approaching the complexity of some office buildings, also needs to be addressed, and doors and frames that can be installed rapidly need to be developed. Also needed are new HVAC systems with downsized distribution technology.

On the software side, the concept of multi-skilled installation teams needs to be understood and implemented. This would mirror developments in some sophisticated manufacturing organizations, where the normal assembly line is being replaced by production teams. Approval and inspection processes, now entangled with conventional building-level and unit-level design and construction, will need to be divided. Eventually, it might be possible to have "fit-out" systems approved as complete products by organizations such as Underwriters Laboratories, the various model building code groups, or the National Conference of States on Building Codes and Standards (NCSBCS), thereby streamlining on-site inspections and further innovation.

Residential financing instruments will need to be developed along the lines of base building and fit-out. These "levels" may have different institutions backing them and offering different financing product terms and rates.

Architects and interior designers already know how to design this way even if they have not done it for residential projects. Resistance may be due to a fear of losing control. Open building, however, can enable them to *gain* control of a process too often dominated by forces other than the needs of actual—not statistical—inhabitants.

Building contractors already have the estimating tools to give good base building prices for residential construction. Now needed are new kinds of companies that can provide fit-out packages efficiently. It may be that large "home centers" already have this capacity.

There are many ways to implement residential fit-out. Once the concept is understood, there is every reason to believe the idea will take hold in the United States. ♦

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Author's Note

Initial projects inevitably cost more than the inherent cost of a new way of building. The most important question is how research and development activities and early demonstration projects can be funded. I and others familiar with the U.S. housing industry are actively pursuing avenues that hold promise; however, suggestions and expressions of interest will be appreciated. Contact Stephen Kendall, Architecture and Interior Systems, 604 Winona Court, Silver Spring, Maryland 20902; (301) 649-6803 (voice and FAX).

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Technics Focus

Open Building for Housing

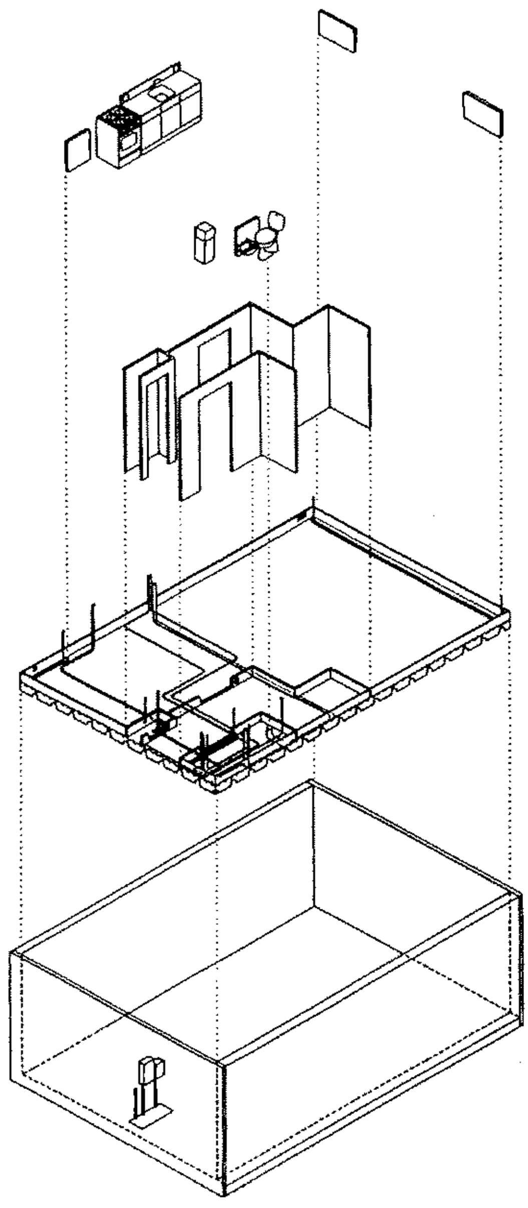
Architect **Stephen Kendall** discusses an approach to multifamily housing design and construction that allows more home-owner choice.

Abstract

In "Open Building" housing projects, a residential "base building" is constructed and then fitted out to meet, rather than anticipate, the needs of varied households. This is accomplished by the off-site preparation and on-site installation of a prefabricated "fit-out" package for each dwelling. The author argues that this method, used successfully in the Netherlands, should be adopted in the U.S.

At a meeting of the AIA's Housing Committee last May, William Devereaux, principal with the Burkus Group, voiced several concerns. Prospective home owners are asking for one thing, he said, and are being sold something else. Furthermore, he said, because of the way housing is delivered in the U.S., most architects don't work for the actual households. Marketing consultants and architects at the meeting explained that when designing "product," as some call houses, they face increasing difficulties, including new and changing household types, new technology and regulations, as well as financing, legal, and development processes that are beyond their control. For architects balancing community and individual housing goals, entangled regulations and processes are impediments to personalized design.

These are the main issues "Open Building" aims to resolve. Open Building is an approach to housing processes and technology that has been taking root in Europe, particularly in the Netherlands. Despite differences in architectural practice and the building industry there and in the U.S., Open Building offers practical alternatives to help solve some of our housing problems, and can help improve the marginal participation of architects in the housing process.



1 DIAGRAM OF A SERVICED SPACE WITH "FIT-OUT" OF UTILITIES, PARTITIONS, FINISHES, AND EQUIPMENT.

Open Building In Practice

Regardless of architect, developer, or technology, whether rental or owner-occupied, developed by a public authority or in the private market, Open Building projects follow certain common processes. A residential base building is designed and built, or made by renovating an existing building (1). A base building will have a set footprint and relation to the urban fabric, and common interior spaces and mechanical systems. What is not determined are the unit mix and unit layouts.

When a household is ready to buy or lease a dwelling, agreements are reached about costs, allowances, finances, and design guidelines. Each new occupant may hire a designer, or the developer may provide design services. Plans and specifications are finalized, and about two weeks later, following well-organized off-site preparation and the rapid on-site installation of a "fit-out" or "infill package," the household moves in and takes up living in and improving the dwelling as households do everywhere.

Future alterations made to the dwelling will not disturb neighbors since no parts of the fit-out package are dependent on other units. Within the dwelling itself subsystems are disentangled and organized. For example, drain pipes and duct work serving one unit are not placed in the ceiling of the unit below, and wiring is not spread in a spaghetti tangle through all the walls and floors.

The main aspect of this approach – distinguishing a base building and tenant improvements – is a familiar process in other building types. Most office buildings undergo this process all the time; it's called "churn." Some banks and chain stores are moving toward nearly complete prefabricated fit-up packages for each project, organized off site to suit the particular requirements of each space, and installed rapidly by an installation crew. Combining interior construction and FF&E (furniture, finishes, and equipment) represents a major evolution of single-source control and responsibility and of efficient customization.

The first large-scale Open Building project (2) built in Papendrecht, the Netherlands, in 1977, designed by Frans van der Werf of Kokon Architects, contains 122 units, each different. A conventional apartment complex (3) built in the 1960s in Voorburg, the Netherlands, was retro-fitted by Reijenga, Postma and Haag into a base building. Shaded area in plan (4) shows extent of one base unit. Units were fitted out with floor layouts determined by tenants.

This "fit-up" or "fit-out" process is more difficult to organize in housing than in other use types because there are more parties; a space with many households would hold fewer office tenants. Further, the resource distribution systems serving these households (electrical, plumbing, heating, air conditioning and ventilation, sprinkler lines, central vacuum, and so on) are more complex and have become completely entangled as more are introduced to support new regulations and lifestyles.

Making Variety Efficient

In most countries large multifamily housing design has assumed that technical and management efficiency and affordability require uniform plans and integrated management. This meant that user input in housing design had to be eliminated.

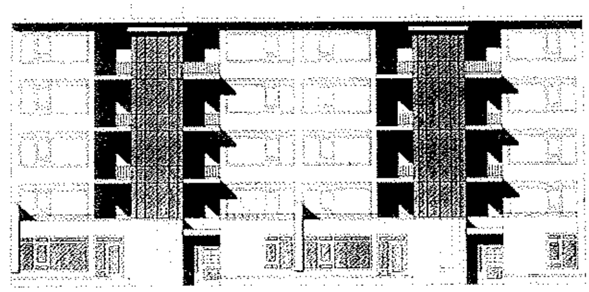
When centralized housing efforts stalled in the early 1980s, a new paradigm was needed. Open Building, first conceived in 1960, provides proof of a new approach.[1] The idea coming to be recognized is that if certain processes are realigned, it can cost the same or even less to have users decide their dwelling plans. In multifamily housing this is a particularly radical concept. In the U.S., the pressing issue is to organize efficiently and coherently the housing variety we have grown to expect. Open Building allows us to do this without diminishing peoples' control over their household.

By dividing a residential project into base building and fit-out, a developer can defer unit decisions until time of purchase or lease, rather than try to forecast demand many months or years in advance – a notoriously risky business. Too many projects end up with units difficult to lease or sell, or with the wrong mix of unit sizes because, between the time of the commitment-to-build and occupancy, market conditions change. Changing plans and specifications midstream in housing production – as often happens – is the cause of cost overruns and lawsuits. Open Building helps resolve these problems.

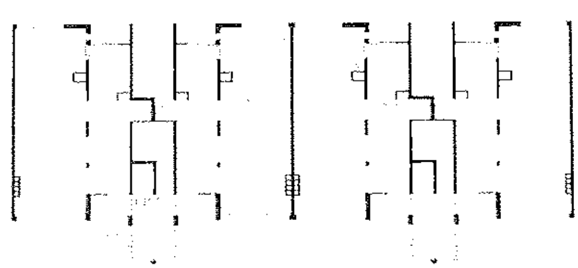
Open Building also defers substantial costs. Given the increased costs of dwelling unit interiors, with as much as 50 percent of total costs in the "fit-out" category – the ability to control and defer this large cost package makes sense (5). It is also a way to manage uncertainty by building with great efficiency what is permanent and repetitive – a base building, devoid of all the particularities of unit layouts – and organizing fit-out as "just-in-time" products.

Stephen Kendall

2



3 VOORBURG BUILDING ELEVATION



4 VOORBURG RETROFITBASE BUILDING PLANS

The Keyenburg Open Building project (6, 7), designed by van der Werf, was built in 1987 in Rotterdam with 152 units, each with a different plan, including those for the disabled and the elderly. Retail uses are found at street level. Its cost was 10 percent less than a comparable building with identical units constructed in the traditional fashion, and resident satisfaction is high.

Fit-Out Packages

Organizing a fit-out package for each individual dwelling is very different from conventional practice. In a conventional high-rise, we stock each floor with all the materials needed for that floor. Materials are hauled from one place to another. Waste is a problem until it is carted off. Some parts are damaged as hauling takes place, and must be repaired. Each trade sometimes has to undo what the previous one did, with little incentive for quality because the next trade in line will have to deal with it. The construction manager has too much to supervise. There are usually too many of some building elements and not enough of others because plans change during construction, as marketing consultants, having the developer's ear, suggest changes in the mix and amenities to maximize return on investment.

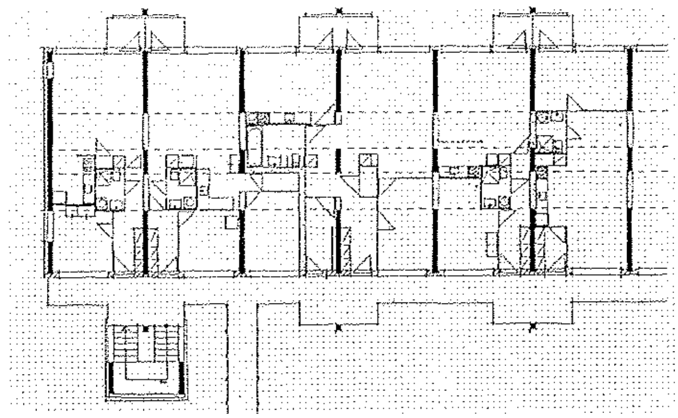
Fit-out packages solve many of these problems. Parts for each unit, small enough to go through a door, come to the job in containers and are loaded directly into the unit to be fitted out. Containers are stocked offsite at a distribution center, which orders in quantity and serves as a terminus for the suppliers of all the subsystems (over 25) found in any unit.

CONSTRUCTION COST SHARE FOR WOOD-FRAME DETACHED HOUSE

	BASE(%)	FIT-OUT (%)
PRELIMINARIES	.5	.5
FOUNDATION	10.2	
ROUGH STRUCTURE	16.6	
FULL ENCLOSURE	15.1	
FINISHING TRADES	3.0	9.8
FLOORING		7.0
INTERIOR TRIM CARPENTRY		3.0
INTERIOR DOORS		1.6
CERAMIC TILE		.7
CABINETS AND VANITIES		4.2
APPLIANCES		1.7
ROUGH AND FINISH PLUMBING	1.2	5.0
ROUGH AND FINISH ELECTRICAL	1.3	2.3
LIGHTING FIXTURES		1.0
COMPLETION	4.8	
SPECIALTIES	3.6	3.2
OTHER	1.1	1.0
TOTALS	**57.4**	**42.6**

Source: NAHB, 1991 - The Future of Homebuilding, 1991-1993 and Beyond

5 COST BREAKDOWN ACCORDING TO BASE BUILDING AND FIT-OUT ELEMENTS



6 KEYENBURG PARTIAL FIT-OUT PLAN

The plumbing supply house, for example, palletizes all the fixtures for a given unit, and this pallet is placed in the container with the pallet of HVAC equipment, ducts and so on (7). Once the containers are on site, the parts go into the unit in the sequence required, and are installed. There is minimal cutting, minimal waste, and no need for "borrowing" from one unit's package for another. Several teams can work in different units at once, each responsible for its own fit-out packages.

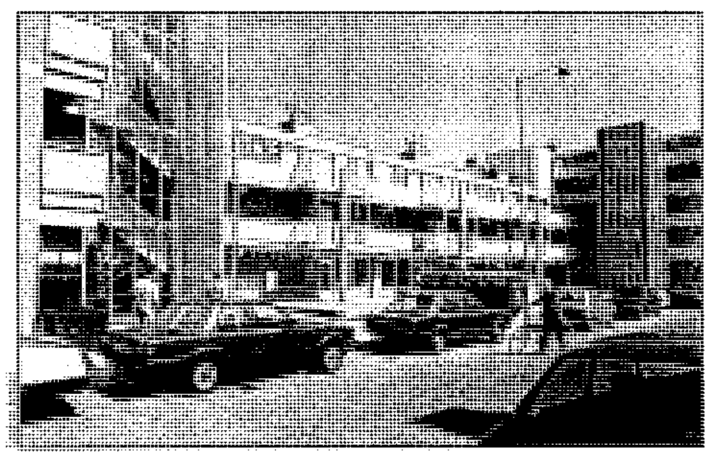
Trade sequencing, one of the most obsolete characteristics of the building industry, is also changed. If the automobile indus- try can use teams, each responsible for a given car's assembly from start to finish, why can't the building industry install fit-out using teams? Doing things this way may change on-site skills requirements as well as the preparation done off site.

The Open Building concept clusters approvals on two levels in a divided building permit process. Essentially, community requirements are built into the base building. These have to do with local zoning, design review, public utilities, and transportation. If there are targets for numbers of units, particularly related to parking, public utilities, and impacts on other public services, the developer must demonstrate the capacity of the proposed base building to meet those targets, knowing that requests for regulatory approval of unit mix and plan layout adjustments are normal during project implementation and are usually approved if they are reasonable.

Requirements for the fit-out are essentially the same as UL-approved products, or products approved by the National Conference of States on Building Codes and Standards. That is, fit-out can follow national, not local, standards for product and systems performance, making true mass production of such parts feasible. The unambiguous technical and legal disentanglement of parts belonging to each household from the community "part" makes this possible. What is private is really private, of no concern to others. It can be insured, financed, altered, and maintained without burden or dependence on the neighbors, just as in a single-family house. What is shared – the base building – is subject to home owner or condominium association rules and community regulations.

Open Building Technology

The basic concept of Open Building is disentanglement of physical systems according to two levels of decisions: the community level and the individual level, which translate to the base building and the fit-up. The principle is to put physical systems together in an unambiguous way with the



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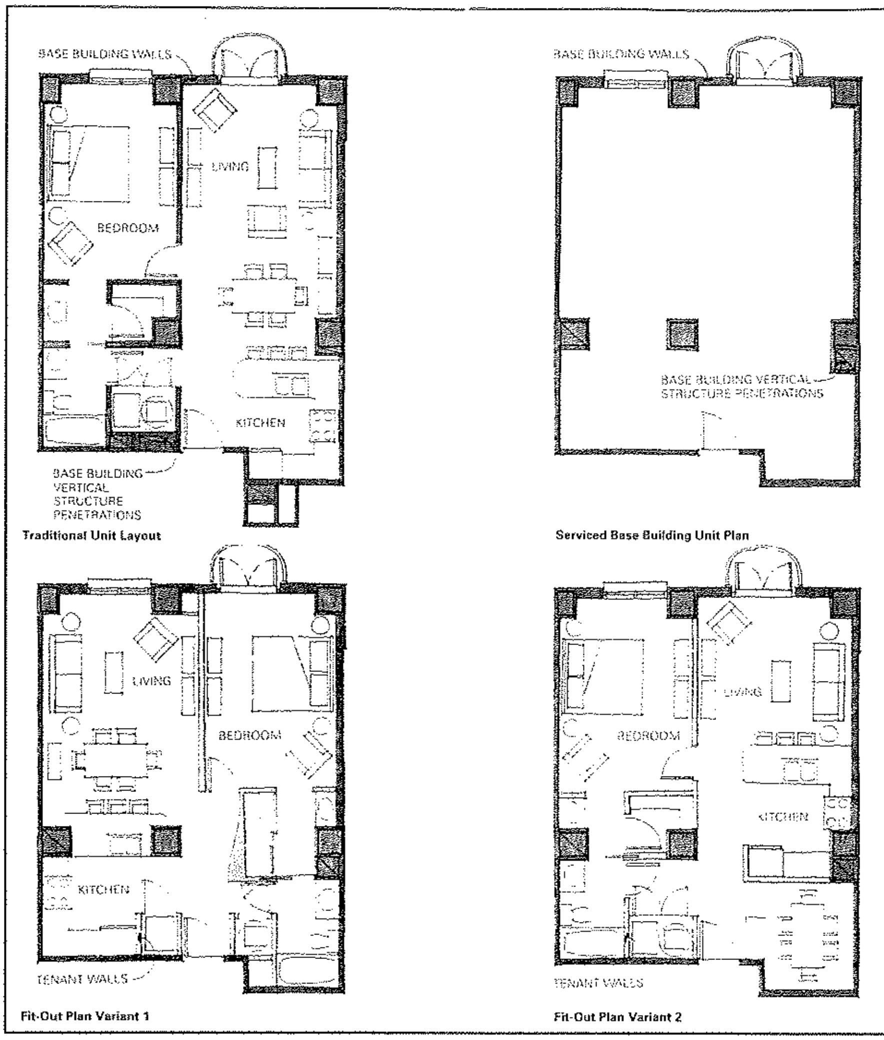
party controlling them and not to mix base building parts with fit-out parts. Once this concept is understood, technical choices at each level can be made according to design and market criteria suitable for the time, place, and people making the decisions.

Building product manufacturers, using their strengths in research and industrial mass production, can begin to make products that match the market of fit-out buyers. Architects and interior designers already working this way in nonresidential projects can adapt their attitudes and the software needed to support their work in the residential market. Contractors can build base buildings with greater efficiency and quality without the entanglements of specific unit elements. New residential fit-out companies, one of the most important innovations of Open Building, can organize to compete for fit-out contracts for base buildings of any plan type or construction. Applications to date in France, Japan, and the Netherlands are concrete slab construction. But system entanglement in wood-frame construction makes Open Building attractive for this type as well.

In the Netherlands early Open Building projects of the late 1970s and early 1980s used ordinary building technology but reorganized systems and decisions in accord with the new concept. In time, conditions in the market evolved, and now there are four different fit-out companies. One provides fit-out made entirely of stock products available to anyone. This company hopes to profit by good organization of suppliers and on-site

For phase three of a residential project in Boca Raton, Florida (8), the author worked with Richard Heapes of Cooper Cary and Associates on preliminary studies using Open Building. The studies demonstrated that, even in the smallest, variation was possible in units above and below each other. The fit-out design can be determined by the occupants or recommended by the developer.



8 DESIGN STUDIES, PHASE THREE, MIZNER PARK, BOCA RATON, FLORIDA

installation crews. Another company uses an inexpensive raised floor, first developed and applied in the office market, under which certain ducts and pipes are routed above the normal concrete floor slab. Everything else used for fit-out is conventional. Another provider, a consortium of companies, is developing many new plumbing, ventilation, electrical, partitioning, and kitchen cabinet systems for its fit-out packages. A fourth company has introduced two new elements that organize piping and wiring and expedite technical design and installation: a 10-cm-thick floor element within which drain and supply pipes are routed, and a partition base in which wiring is run. All other parts this company uses are stock products already common in Dutch housing. All four companies are currently fitting out units in both retrofit and new projects, with more projects in the pipeline.

In the U.S., after this new approach is understood and applied, new building parts may be needed to make the Open Building concept practical and easier to accomplish. Recent studies done with two Washington, D.C., architectural firms, CHK Architects and Cooper Carry and Associates (8), have shown that it is not necessary to introduce new systems to make the process work at the design stage. In the first, a residential tower by CHK was examined to understand the merits had the building structure and HVAC risers been consolidated and positioned to allow variation in unit plans above and below each other, something that the traditional approach does not allow. Cooper Carry's study led to preliminary design using Open Building for housing in a new town center in Florida.

Architects, contractors, and developers pay close attention to the realignments needed on the organizational side. However, most recognize that improvements in certain technical systems will make it easier to customize individual fit-out and accomplish rapid, high-quality installation.

Conclusion

Housing is not simply a technical "product" but a balancing of individual households and community – a matter of the distribution of control over physical technology and territory. Open Building demonstration projects should be undertaken to examine financing, regulatory approvals, off-site preparation of fit-out packages, new building elements, fit-out installation teams, and software to manage the Open Building process.

Stephen Kendall, AIA ■

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Notes

1. Habraken, N. John, *Supports: An Alternative to Mass Housing*, The Architectural Press, London, 1972.

Support and Infill:

Design and Implementation.

N. John Habraken.

SUPPORT AND INFILL: DESIGN AND IMPLEMENTATION.

Introduction.

In this paper I will discuss a number of concepts and methodical principles useful for those of us who are interested in variation, adaptability, and change in the built environment.

By way of introduction I will report on the application of an infill system with which I am involved myself. This is to illustrate the distinction between 'support' and 'infill' and to give information on the present state of the art in infill systems development.

Next I will discuss the general concept of levels in the built environment - of which support and infill are two examples - as relatively independent domains of design intervention.

From there we will have opportunity to look at use of zones in design as a means to assess and organize the capacity of a higher level form to contain lower level variations.

When operating on a certain level our design is about the judicious deployment of several systems in relation to one another. The 'systems' concept is closely related to the concept of variation and change. We will discuss means to deploy systems in space.

Finally we will look briefly at the changing context for architects and urban designers, and the need for new methods and tools.

**

1. Implementation: example of an infill system.

I have been involved with the design and development of a so called 'infill system' which presently is introduced on the Dutch housing market. To give you an example how it works I show the renovation of an apartment that was first built in the early sixties in the Netherlands.

On fig, 3.1 you see the original plan of the apartment. This kind of unit is no longer adequate for todays inhabitants. There is a very small bathroom with only a single sink that must be used by the whole family. The kitchen has not enough equipment. There are three bedrooms because these apartments were built for large families, while now the average size of a household is less than three people. Finally there is no central heating.

In. fig. 3.2 you see the apartment cleared of all non load bearing parts. This empty shell is the 'support' building. It is the same for all inhabitants. Note also that the support is not just walls, columns, and facade, but also the points where supply can reach the infill: the connections for water, gas, and electricity, and the connection for drainage and ventilation.

The architect for this renovation project - by the name of Henk Reyenga - designed a number of different possible floor plans for this unit.(fig.4) Because an infill system was to be used, he knew that every unit to be renovated could be adapted to the needs of the inhabitants. The infill systems are installed one at the time by a team of three workers who do everything. They come with a large container in which all parts for a single unit are stacked in an orderly manner. This allows them to quickly install the whole unit, including all the conduits for heating, ventilation, gas, water, and drainage, and including all equipment as well as the partitioning walls. This infill job is done within two weeks because everything is highly systematized, and all parts

Once we know the distinction of levels, particularly between the support and infill level, we have new opportunities as a designer. The architect does not need to be concerned anymore with all the details of the dwelling unit, just as the urban designer need not worry about all the individual buildings that his plan provides a context for. For a large project, he does not need to design a dwelling unit to be repeated a hundred times. He now can think of the most important aspects of the building level: the quality of the communal spaces and the communal services.

A good example of the new possibilities of support design is given by the project designed by architect Frans van der Werf[2] in the town of Papendrecht, near Rotterdam.(in the Molenvliet neighborhood) He did not design a building, or a group of buildings, but a three dimensional infrastructure that operated on the urban design level as well as the support level. This resulted in what we call an 'urban tissue'.(figs. 1 and 2)

As is shown in fig.2 the plan of the support is based on regular bays. Their arrangement is to make a whole built field within which we still can choose the size of the dwelling. At the same time the urban spaces are clearly defined.

The users could choose more or less bays to live in, then they could design their own floor plans in it. The result gives a wide variety of interior designs. For each of the inhabitants the individual house design makes perfect sense because it responds to their needs. but this kind of variety would have been impossible if one architect had to design everything.

The architect could give all attention to the buildings themselves, as you can see from fig.1, there is a good deal of variety in the larger design, but there is also a good deal of regularity. The architectural plan is very systematic, as we will see later on, and therefore it allows for a lot of variety within the chosen system.

3. The capacity of the higher level design.

The important question to consider, when we think of designing on the support level, is how we know that our support offers the best possible space for the infill plans?

The first decision to be made is to choose a certain type of dwelling unit.[3] The interesting aspect of types of houses is that they give regularity to many different houses, but within the type there is always endless variety. So it makes a lot of difference, for instance, whether you design apartments with horizontal galleries, or apartments with vertical stairs and elevators, or when you choose the so called 'walk-up' apartment where units share a common stair to the street.

Once the type is chosen it is important to determine the width and the depth of the bays, because these are the spatial units within which the infill must come, and it is by the combination of bays that a dwelling unit is defined. Different combinations give different sizes of units and different spaces for units of the same size.

Often architects use two or more different bay width to be combined. this gives more choice for combinations. With two widths a, and b, we can combine aa, bb, and ab, or aba, bab, etc. (fig.7)

But more than the width of bays must be decided. There is not only the depth of the bays, but also the position of openings to connect bays with one another, and the places where the infill can connect to the supply lines of the support: the water, gas, and electricity, and the drainage and ventilation.(fig.3.2) These are the umbilical cords of the infill with the larger infrastructures of supply on the urban level. Their position must be chosen in a strategic way to allow the most variety in plans.

To be able to make all these decisions we can make use of the concept of 'zones'. Zones are continuous areas parallel to the facade by which we can assess the depth of the building. We can attach certain position rules to zones. For instance we can decide that the zones directly behind the

the same direction. But the building encloses courtyards, and the dwelling units are related to the courtyards, so their orientation is in two direction. This means that we have houses where the space runs parallel with the walls, but other houses have spaces that run perpendicular to these walls. This gives a variety of dwelling types while the structure is very regular and one-directional. The structure itself is varied in different ways: by the height of the buildings, their connection to one another, and their arrangement around the courtyards. Here too we find a systematic approach that creates variety.

Basically, a system is no more than a choice of certain elements or parts, and some rule about the way these elements can be combined. Once we have set up such a system, we have limited ourselves to a certain universe of parts and certain ways to relate them. But we quickly find that, within these limitations, the variations we can make are endless. It is like making music, You choose a certain scale and a certain melody, but within that limitation you can make endless variations. Good composers can make great music that way; not so good composers will still make something structured that we can understand. In architecture this is the same. The systems we work with I call 'thematic systems' because they give us the 'theme' with which we play. Of course, good architects can do great things with a architectural theme, but in all cases the thematic system will allow variety in an orderly way, making it possible to be built efficiently and to avoid monotony.

This principle of variety through systematization can be applied on all levels. For instance we can use it when we make facades. In fig.10 we have a study by Thomas Hille for a number of elements within a facade.[7] In fig.11 you see how they have been applied to make a facade. Each dwelling unit has its own facade and no two entrances are the same. We can imagine how a whole street could be built without ever repeating exactly the same facade. Yet everything is clear and organized. You may want to study this example to figure out what the rules of combination are. The easiest way to find that out is to design a faced with these parts yourself. You then can compare your combinations with those of Hille.

5. Designing systems.

In the examples discussed so far we have seen that there is almost no boundary between the use of a system and the design of it. While we work on the design we work out the system at the same time and then we use it. While using it we may find out that we want to change the system, until it allows us to do what we want. This is the right way to use thematic systems in design.

But there are also cases in which the person who designs the system is not the same who uses it to design with. For instance, the facade system used by Hille could easily be applied by other architects working in the same project. In real life, the making of such a system would entail the design of the parts and their manufacturing. The facade system entails industrial product development. This takes time and effort and investment. It therefore makes most sense if it can be used in more than a single project: it should be used by more than one designer.

The support system as designed by Chow, in fig.7, on the other hand, may not need standardized units. It is only a means for designing. But if Chow was working in a large project, other team members might decide to use her system so that there would be coherence in the overall plan, yet each would make his own variations within the system. Therefore the use of a system by a number of designers need not be done for reasons of manufacturing only. It can make good sense architecturally, because it facilitates cooperation among designers without taking away their own individuality in their own work.

But technical systems are a different matter, their design takes a good deal of effort and development. An architect will not easily decide, for instance, to design a new sewage system or a new electrical system. We know that this takes specialization, much testing and a codification.

The grid is chosen in such a way that we are sure cars can be parked under the buildings. In this small sketch the rules of positioning of a whole neighborhood are codified. Dimensions of streets and buildings follow from there. These rules were used in a team study for a overall design. Individual parts I have already shown in the work of Hille and Chow.

This larger architectural grid can be connected to the smaller band grid on which, as we have seen, the infill system operates. And the larger urban grid, that tells us how streets relate and how buildings can be deployed, can also be connected to architectural grid. Such connections are the free choice of the designers.

Given a basic gird of about one foot,(30) cm., each designer, on each level can figure out what suits him best, and make a connection to lower land higher levels of design.

Another use of band grids on different levels can be seen in the design of the recently completed experimental building for Osaka Gas Co, in Osaka, Japan, designed by a team under the chairmanship of prof. yositika Utida.[10](fig.16) Here the basic ten twenty centimeter band grid as used on the infill level, is translated to a general 60cm grid. This, in turn, is used on the support level for a band grid of bands of 60 and 120 cm., delineated by to cm. bands. Fig.17 shows how the columns of the building all fit into the narrow bands of 60cm.and therefore have distances of a multiple of 180cm. This building is experimental in many ways, both technical and architectural. It is also a support infill project. The dwelling units have been designed by 11 different architects. In this project the team also designed a flexible facade system with its own rules of combination and positioning.(see fig 16).

Earlier, when we discussed Chows support design, we saw the use of zones. Zones also are means for positioning things. The difference with a band grid is not one of principle. Because band grids are also used to make position rules. But the difference is nevertheless important. A band grid is regular, it repeats itself and gives us a neutral field in which to make deployment rules for technical parts.

A zoning is not repetitive, it is local and is not used for the positioning of technical parts so much as for the positioning of specific functions or subsystems. It gives us an ordering of a given location that will be different elsewhere, while the grid may still be the same.

This difference of grids and zones also is found on all levels. In the infill system section as given in fig13 we see that the conduits are placed in particular zones that relate vertically. Each zone is a horizontal field in which the conduit assigned to that zone can freely travel without interference with conduits in other levels. The dimensions of the zones are related to the conduits they must contain.

6. Summary.

I have given a quick survey to show how the same principles apply on all level, albeit in somewhat different ways. On each level we need band grids to organize the deployment of technical systems and parts, and understand their connections and relations. But on each level we also can use zones, to structure our architectural and organizational decisions, and make rules about the deployment of functions and spaces, and certain architectural parts like, for instance the stairs, and entrances in Chow's design.

On all levels we must combine different technical systems, and also will design our own - more architectural - systems to achieve freedom for variation and yet be efficient and clear to those who must work with our designs.

One lesson of this experience can be that architectural designers must understand systems and be interested in them. This is not only because architectural design uses systematization, but

Molenvliet project, overview

FIG.1

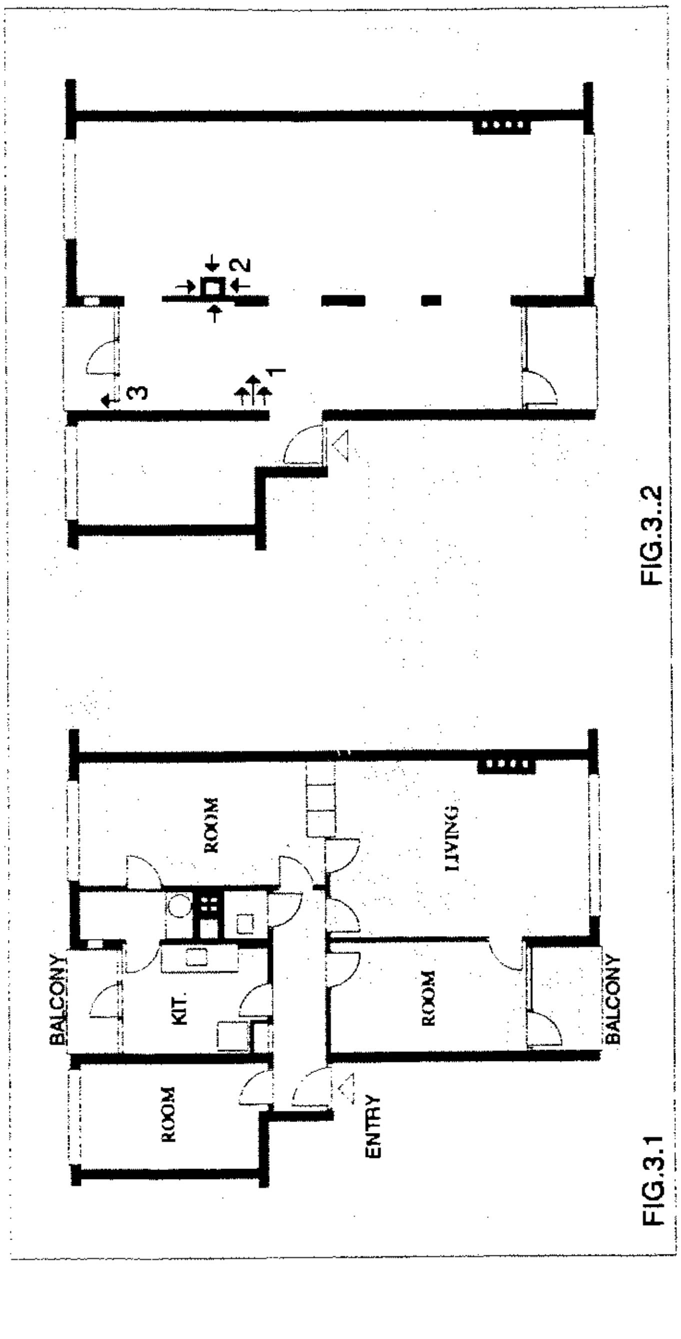


Fig.3.1: The original plan

Fig.3.2: The support building prepared for infill.
1. Connecting points for gas, electricity, and water
2. Sewage main and ventilation shaft.
3. exhaust for gas heater.

FIG. 3

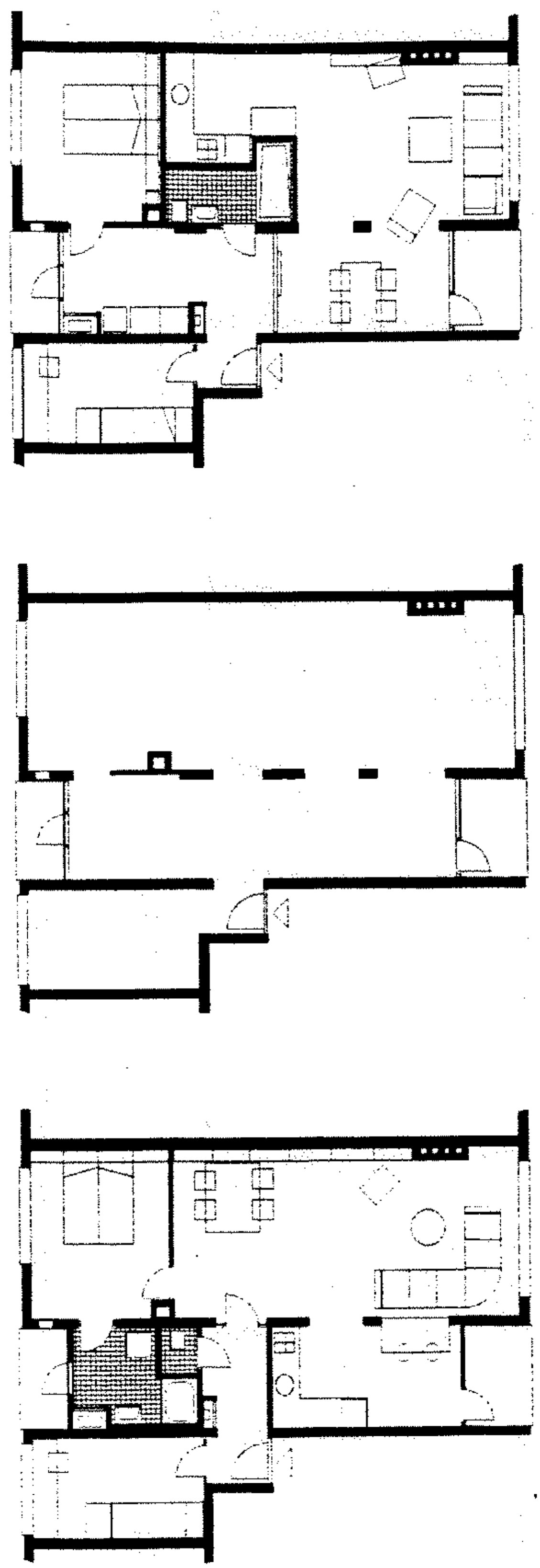


FIG.5.2

FIG.5.1

Figs. 5 : Plans as executed.

Fig. 5.1 : The plan of scenario one, compare with fig. 2.3
Fig. 5.2 : The plan of scenario two, compare with fig. 2.1

FIG. 5

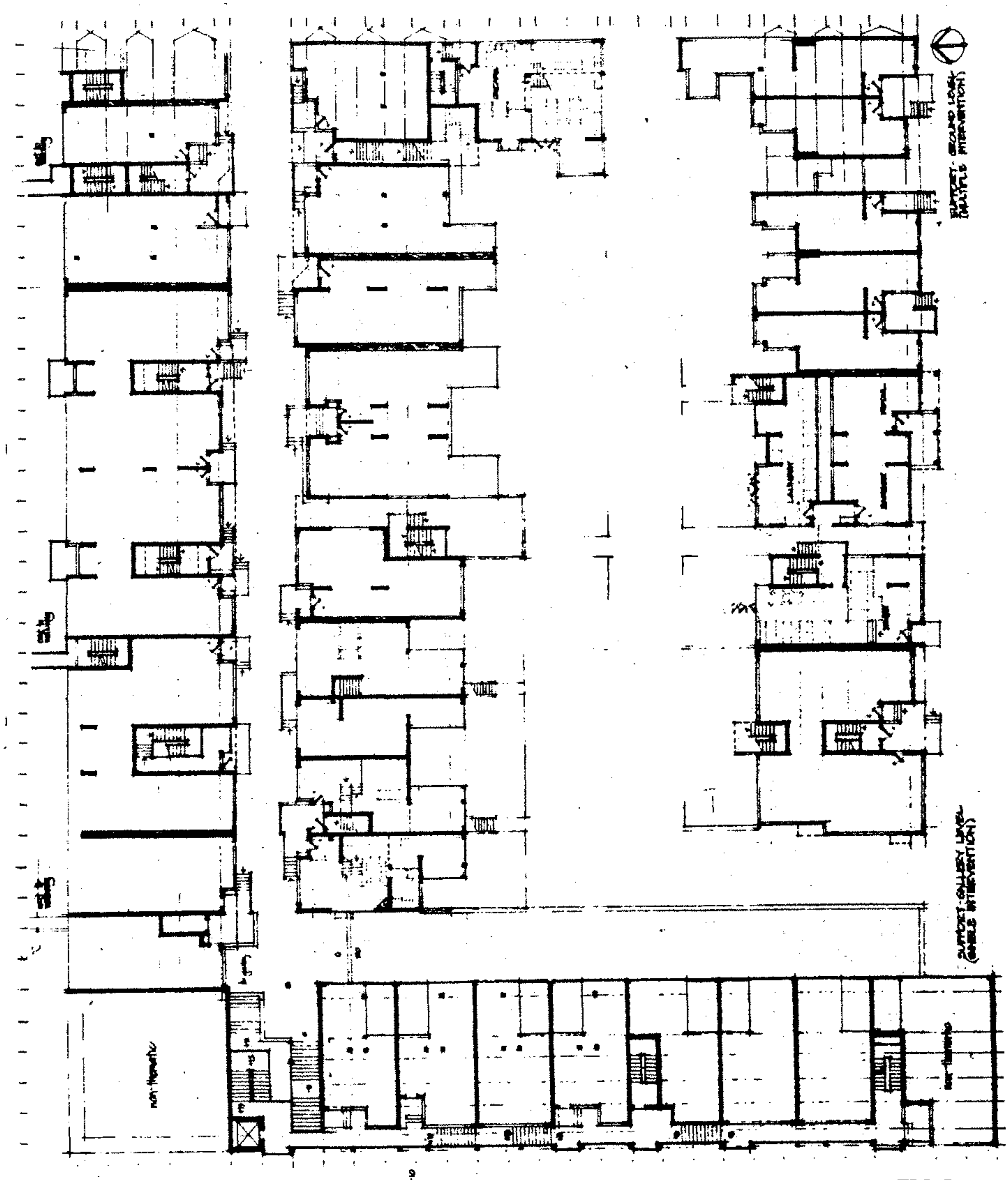

SUPPORT - GROUND LEVEL
(MULTIPLE INTERVENTION)
SUPPORT - GALLERY LEVEL
(SINGLE INTERVENTION)

FIG. 7

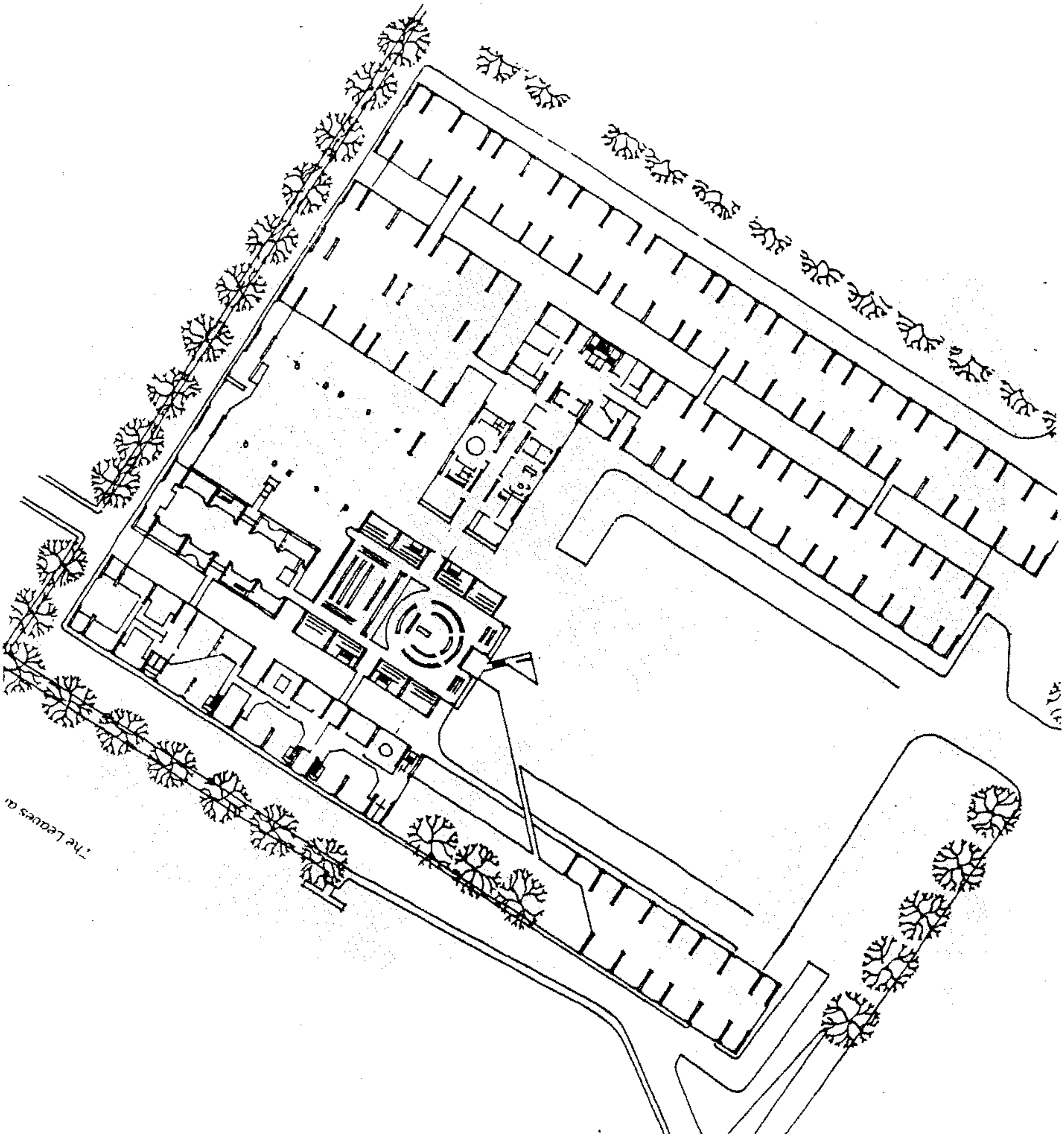


FIG. 9

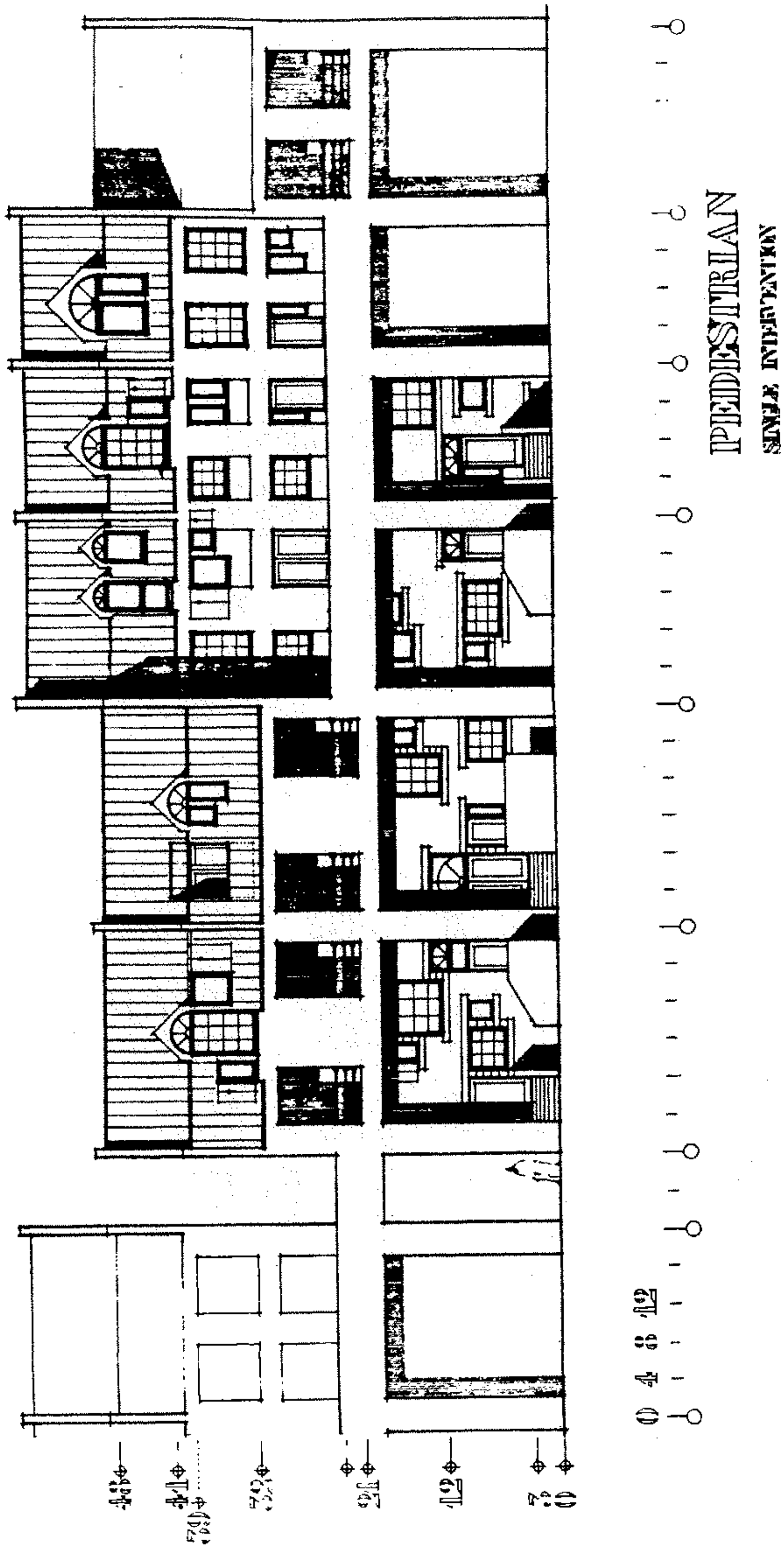


FIG. 11

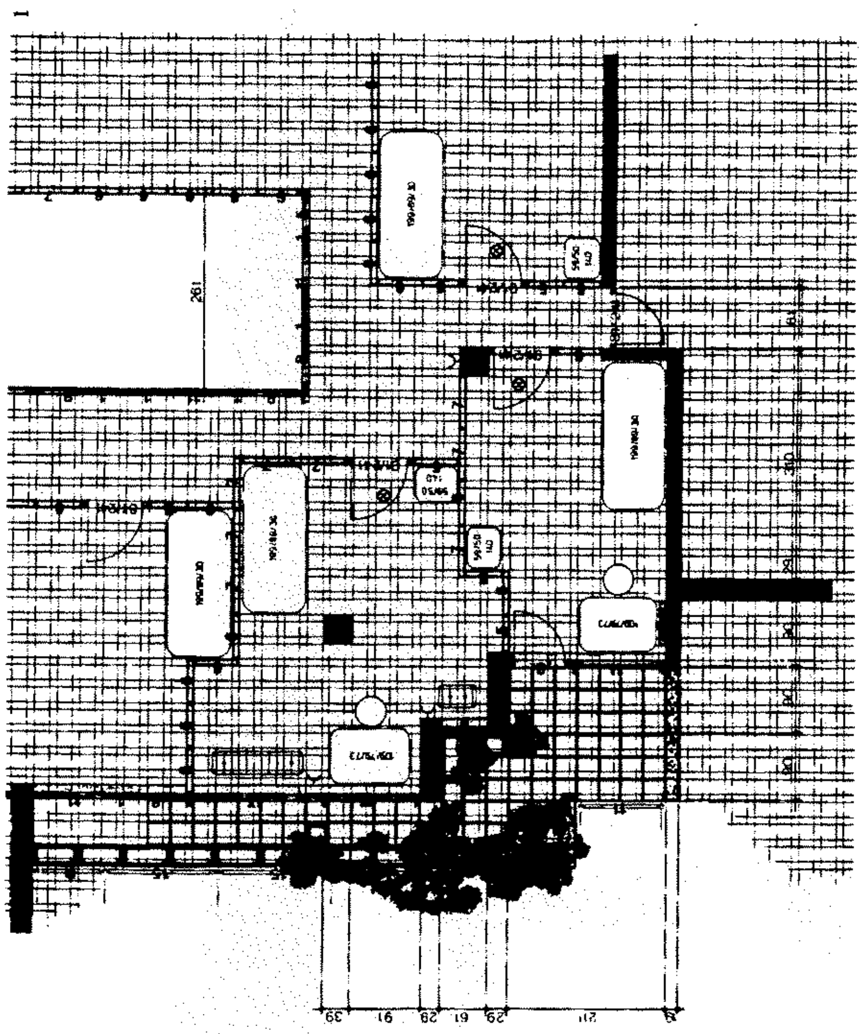
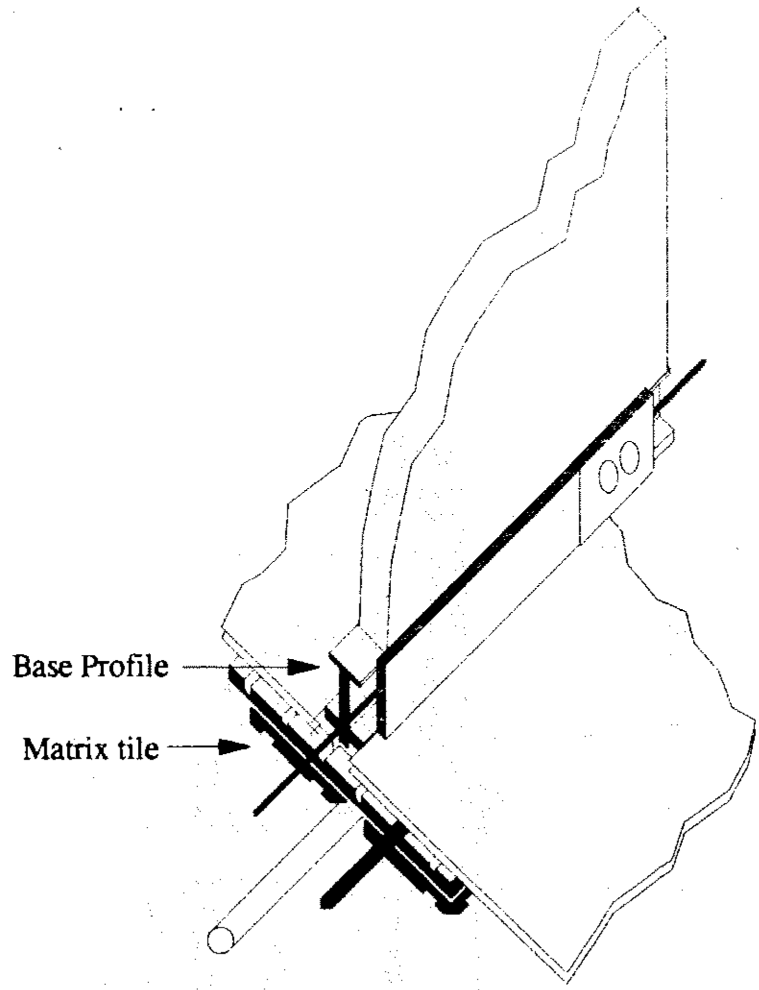
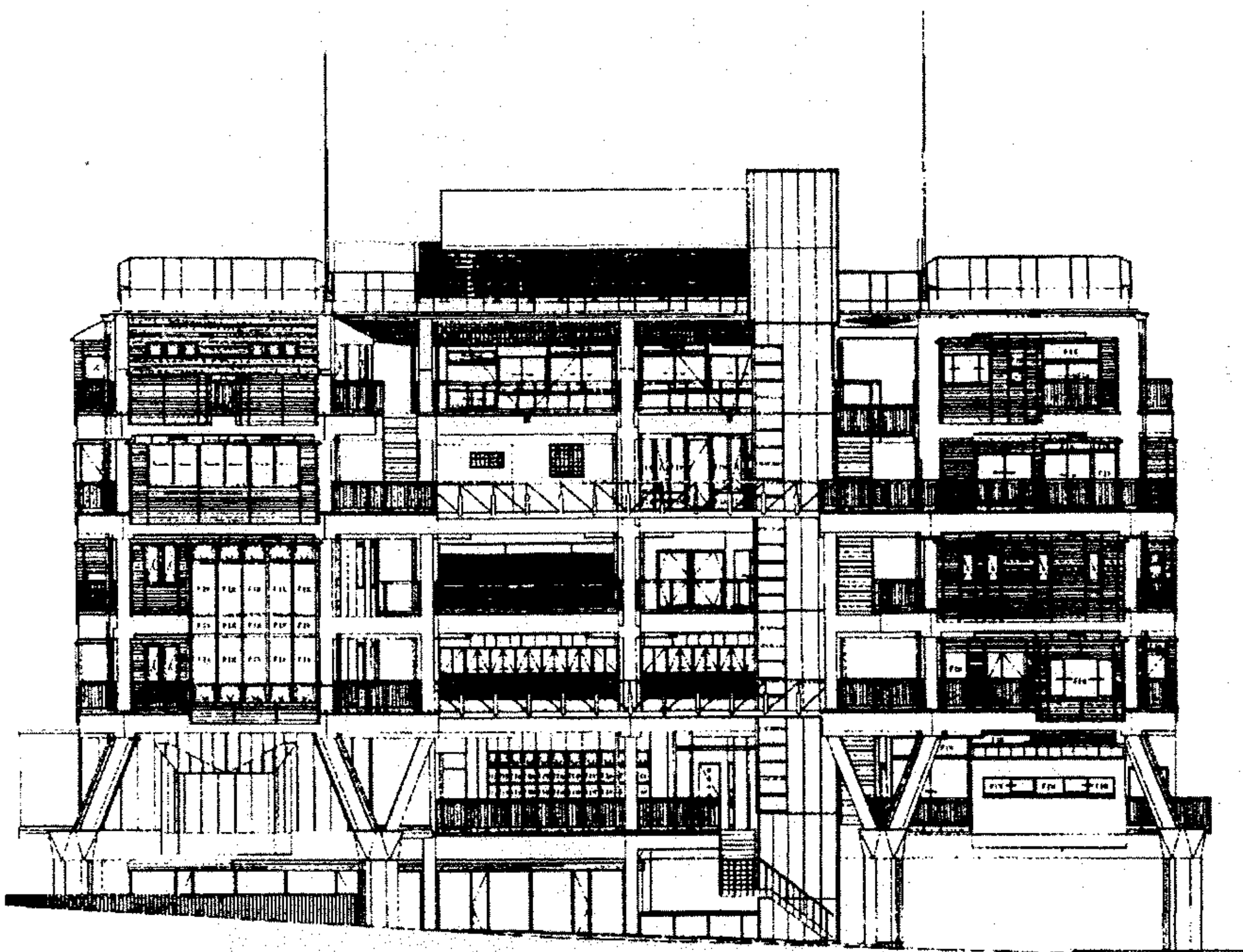


FIG. ~~13~~ ~~14~~ 12



Matura Infill System

FIG. 14



South Side View

FIG. 16

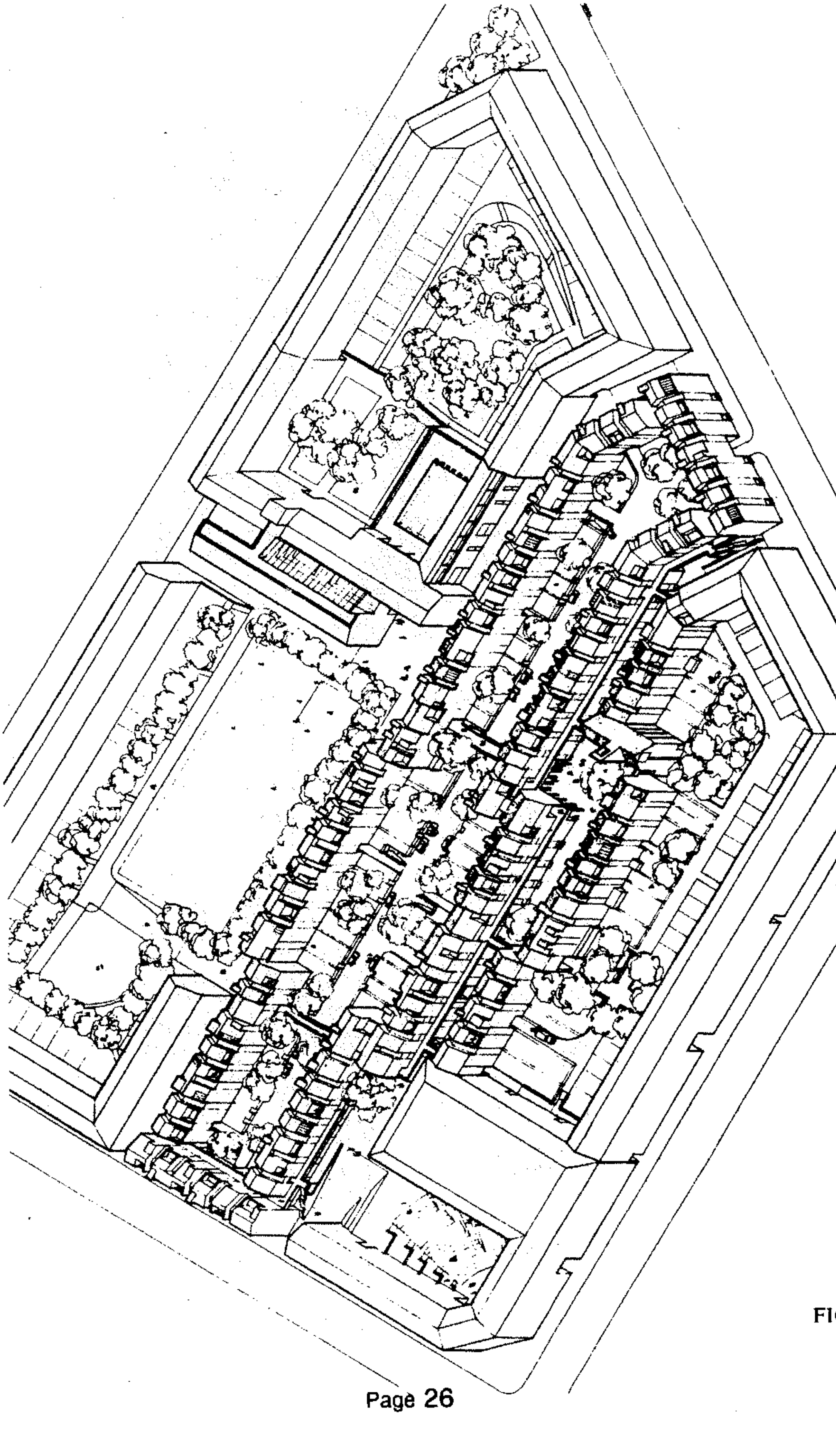


FIG. 18

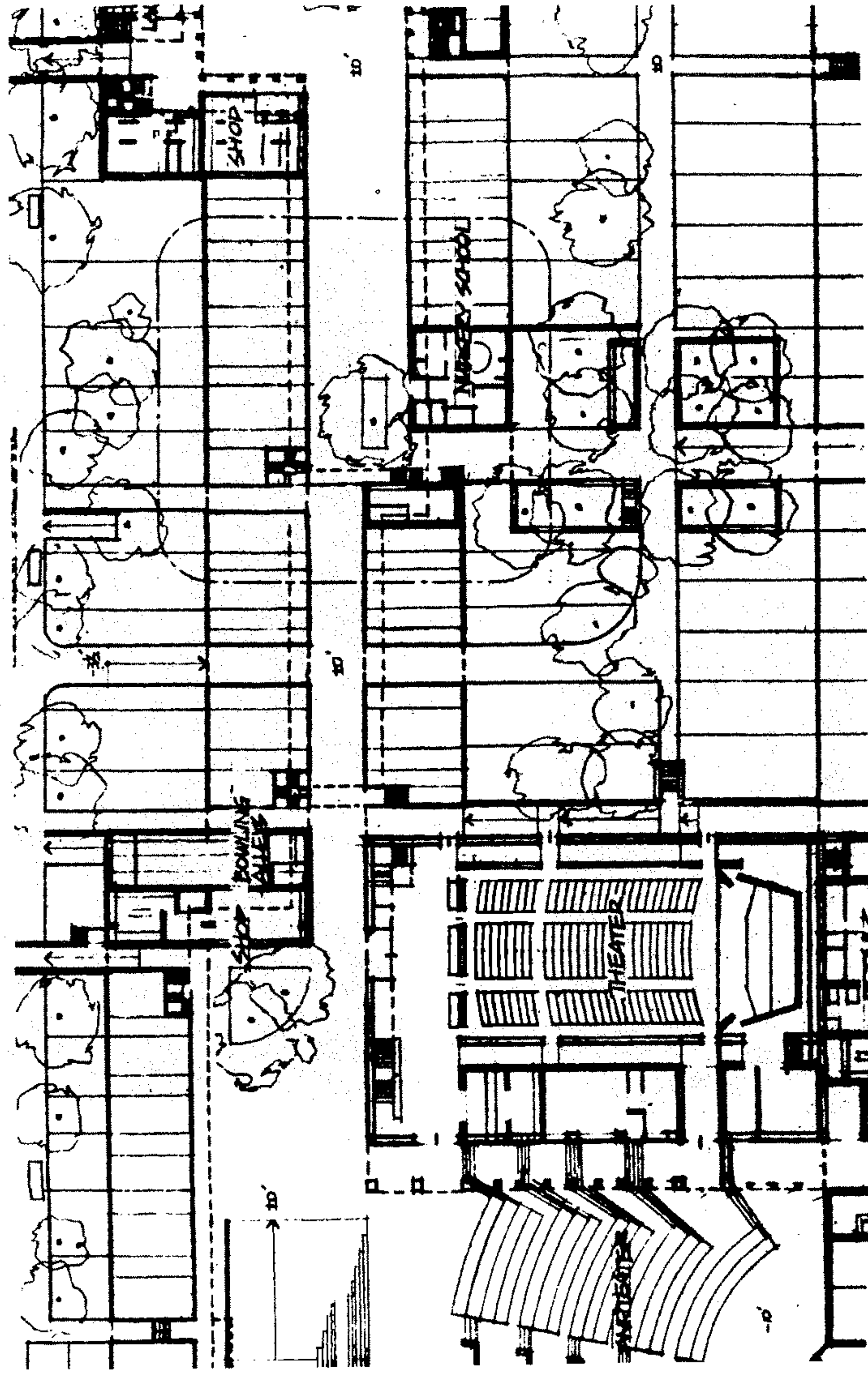


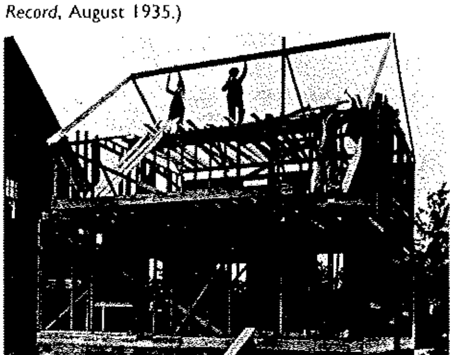
FIG. 20

The Entangled American House

Stephen Kendall

The entangled service systems in the floor cavity of a normal residential project, 1993.

A balloon frame house in 1935. (*The Architectural Record*, August 1935.)



A visit to an ordinary dwelling or apartment building under construction in any neighborhood in the United States, just before the sheetrock is hung, is a good way to assess the state of entanglement in American house-building.

Imagine what we will see. Amidst the normal jumble of building-in-progress, the smell of sawdust, remnants of wiring insulation, dried mud and debris on the subfloor, and empty styrofoam hamburger containers, a keen observer will see the exposed wall and ceiling cavities crammed full of parts. Immediately evident is an almost unbelievably confused array of installed pipes of varying types and sizes for supplying and carrying away fluids, air ducts of several shapes for moving air, thousands of feet of wires for electric power and communications, and, in some jurisdictions and some building types, sprinkler lines for fire suppression.

It was only five generations ago, around the time my grandfather was in his teens, that plumbing and central beating, and later wiring, became commercially available at reasonable costs and were promoted by architects and developers for use in apartment buildings and houses. [1] These entrails now dominate housing processes in ways unimagined at tbat time or even thirty years ago.

A State of Entanglement

In virtually all construction types, multi-family and detached, wood frame and concrete, the technical and organizational entanglement of American residential building has reached a critical state. The overall lack of order of the relation of resource distribution parts to the rest of the buildings they serve is an indication of the problem.

What we can see of the interweaving of parts lacks the clarity and elegance still attributed to wood framing or other structural systems. Today, walls and floors of sticks of wood or substitute materials—the main elements of the beloved and ordinary 2x4 system which first came into use in the 1830s in Chicago [2]—are filled to overflowing. Many of the wooden or steel structural elements are fastened in place and then pipes, wires, and ducts knitted haphazardly into them. This is especially destructive now in traditional wood-frame construction, where holes are bored on-site as needed and, often at random by each trade, frequently with no coordination.

Each part of these service and structural systems no doubt represents, in itself, the best product for the least cost, available from the world-wide building products industry, each installed by a different trade and each serving a perceived need.

This interweaving process seems to have worked up to now for four main reasons: the remarkable structural redundancy and forgiveness of wood or steel framing, the expectation that the next stage of work in this conventional chain of events will cover any depredations of the previous player, the relatively low cost of materials, and the availability of skilled workers. None of these can be taken for granted today.

Because the cavities between wall studs in all construction types and floor joists in framed buildings have been available by nature of frame construction, they have been filled in no particular anticipatory order in a historical progression by the first to get there. Trade jurisdiction work rules, starting in the craft guilds but having migrated into the work force in general, followed the emergence of new parts and processes, dividing the work accordingly. Now, separations of work patterns, incrementally added over decades, are as antiquated and convoluted as the paradigm of bouse building they accompany.

This entanglement is the fault of no one in particular, making it difficult to establish cause or to measure responsibility. It is therefore difficult to remedy. In an important way, the diffused responsibility for this "system" is both its liability and its strength: it is a living system controlled by no one trade or company but is shared and gradually improved by all who use it.[3]

The Interplay of Technical and Organizational Patterns

The situation of entanglement would not be so much a problem if it were only technical in nature. However, as with many situations made visible by observing technical hardware, the issues are not divorced from their organizational and social ambiance. Now, the entire constellation of actors—manufacturers, designers, constructors, regulators, and users—is likewise enmeshed, producing conditions ripe for poor quality, bigher costs, disputes, and loss of decision flexibility.

Among the many social and organizational forces at work, five stand out.

Demographic Shifts

Most of us have read about or directly experienced the rapidly shifting demographics in our neighborhoods and regions and the changes of household types and sizes accompanying the larger statistical perturbations. In part because of these social dynamics, housing developers today build for specific market niches and unit mixes in their projects. The way buildings are organized today, building income may suffer, and operating costs increase if piecemeal or even substantial upgrading or "repositioning" of a building is needed to maintain its attractiveness in the market.

If these statistically targeted buildings are not entirely obsolete, facing abandonment or mistreatment, they at least may not make a good fit with the next statistical cohort of households. While in a very large aggregate sense all of these mismatches may even out, in any one building or locale the discontinuity can have telling but difficult to measure negative effects on household well-being, contributing to a sense of powerlessness over the place of dwelling at a very personal level where dwellings mean the most to us as inhabitants, an effect often felt in the community at large.[4]

Decision Deferment

We also know that, in housing developments that take several years from planning to occupancy, developers seek to defer the costliest decisions and most-likely-to-change decisions as long as possible. They want to keep their options open in order to quickly change unit mixes and layouts when new household formations appear in their market research. These are the costliest decisions. But the impulse to delay sends ripples through the entire chain of actors, pushing all action to the last possible moment, compressing an already difficult and entangled process. Unless well organized, this decision-deferment process, which is desirable for some, can cause major cost and construction management conflicts for others.

Control

Many households want a direct say in major interior layout, fixtures, and equipment decisions, no longer content with moving into dwellings someone else has decided have "good layouts and feel." This may be a case of households wanting to reclaim "territorial control" of housing decisions from experts remote from the realities of living in the house being built, experts who, often lacking other means, base decisions on statistics rather than actual individuals. Organizing for variety without driving up costs is a constant challenge for builders and development teams. Many are pushing variety as far as they can within the present paradigm of housing production efficiency.[5]

Change

Industry statistics show clearly that expenditures on house renovations, adaptations, and upgrading are mounting beyond $100 billion each year in the U.S. market.[6] These commitments to dwelling adaptation are more difficult and expensive for both professionals and do-it-yourselfers to realize because of the entanglements of parts and the parties involved, as discussions with contractors or building owners and inhabitants reveal.

Organizational and Supply Chain Reconfigurations

Finally, many industries are reorganizing their supply chains in response to new concepts of value creation. Ikea is an example of a large organization, with sophisticated supply chains . in tow, that offers a new division of labor, including customers taking on certain key tasks of assembling well designed but lower-cost products. The Hechinger Company and Home Depot represent other organizations restructuring to new demands. They offer surprisingly comprehensive design and construction services and the logistics to make it happen. The concept of "mass customization" is now discussed among industry forecasters, including the Global Business Network in California. Robert Reich, Secretary of the Department of Labor, discusses the concept of "multi-disciplinary work cells" in a recent book.[7] The United Brotherhood of Carpenters and Joiners now takes interest in new cross-trade affiliations to alleviate jurisdictional disputes, and is exploring various proactive training and apprenticeship programs that they believe may be needed in the future, as unions seek market recovery in residential construction. [8]

The latter reconfigurations, taking place nationally and internationally, are good examples of responses to new social, economic, and technical conditions having a direct bearing on housing processes.

An important threshold seems to have been crossed in a fascinating incremental process accomplished without anyone trying or perhaps even noticing. No one has sufficient autonomy to act, change the direction of their decision path, or adapt what is already built, without engaging—often in conflict—dozens of other actors, each controlling some physical parts, each with their own problems and priorities.

This is truly a situation of loss of freedom across the board, not at all what we have expected from our way of building houses and the mythic democratic, market-driven housebuilding culture that has grown up with it. This loss is significant because it is happening in a political economy in the United States that we have traditionally associated in very strong terms with household level control of housing activity and housing improvements. Paradoxically, in a society stressing individual rights and responsibilities, we find that control of design decisions by occupants, apart from expensive custom-designed single family houses, is considered a nuisance or disturbance by many housing experts who take an inside-out view of the market.

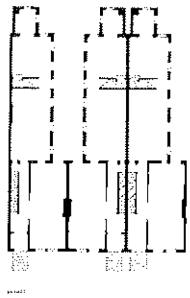
This view, which still holds a constricted view of efficiency and is based on obsolete concepts of standardization and unified expert control, is very much at odds with the very nature of healthy housing activities.

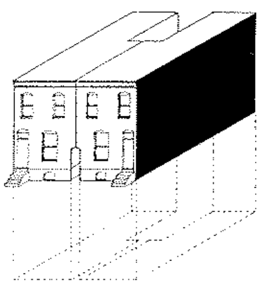
A Short History of Entanglement

Early American Houses

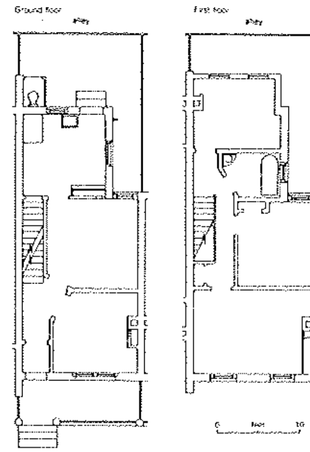
American houses built in the eighteenth and nineteenth centuries are a good background against which to trace the evolution of our present entanglement, because then, neither electricity, plumbing, nor central heating were present.

In these early houses, which people could afford to build, often following principles of compositional clarity and formal simplicity brought from European traditions [9], the few spaces were organized in such a way that they could be and were used for many household activities. Often, sleeping, living, bathing, and cooking occurred in one space in a time-sharing approach. It was normal to have change of use in harmony with the seasons and, of course, change of activity patterns when a new family moved into a house. This was accomplished by the repositioning of furniture and

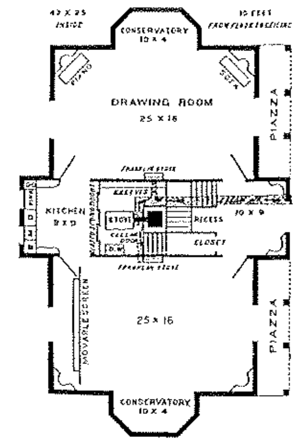




Plans of nineteenth-century rowhouses in Reading, Pa., showing general spaces with kitchen or bathroom at the rear. (Steven Holl, *Rural & Urban House Types in North America*, Pamphlet Architecture 9, New York, 1982.)



A plan of a Philadelphia mechanic's house in the early twentieth century, showing a kitchen in the rearmost space, a toilet attached to the back of the house, and a bathroom without toilet on the second floor. (Parish, H.L.. *One Million People in Small Houses*, Philadelphia, 1911.)



Drawing of the central utility core proposed by Catharine Beecher in 1869. (from *The American Woman's Home*. Catharine E. Beecher and Harriet Beecher Stowe, 1869. in Russell, Barry. *Building Systems, Industrialization and Architecture*, Wiley, New York, 1981.)

storage elements such as wardrobes, armoires, and the like. Rooms were labeled "hall," "north parlor," "south parlor," "chamber," etc. Few could afford to build use-specific rooms. Indoor toilets and bathrooms were non-existent, and kitchens were found in any room where a fireplace provided a place to cook or located in a shed attached to the back of the house.

Houses of the Industrial Revolution

During the last half of the nineteenth century, indoor plumbing for water distribution and drainage was gradually and then rapidly introduced into houses and apartments, accompanying rapid urbanization, gradual increase in household affluence, and justified fears of threats to public health, safety, and welfare. This was supported by the development of inexpensive, mass-produced, cast-iron and lead piping, and public water systems. The first vented trap to remove sewer gases from toilet rooms was introduced in 1875, the introduction of the first really sanitary water closets took place about 1890, and publicly funded sewers and waste treatment plants were built in the same era. These public and private initiatives enabled bathrooms to migrate, in stages, from the privies in backyards to attached toilet rooms tacked onto the back of houses, and finally to take their place inside, even in multifamily apartment buildings.[8] Building regulations in most large cities required indoor plumbing by the end of the nineteenth century. [11] Even so, 45 percent of households did not have complete indoor plumbing as late as 1940. [12]

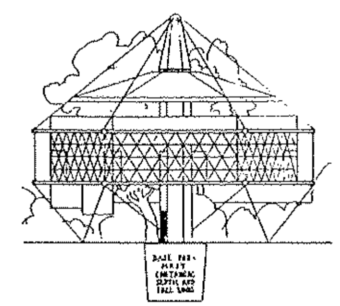
Other pipes brought natural gas to give illumination, still other pipes brought steam for heat. In the period between 1900 and 1920, wires began twining through walls and floors and behind baseboards, replacing gas as a means of illumination and serving a burgeoning supply of electrical appliances plugged into convenience outlets.[13]

The mechanical removal of odors and humidity, and the addition of cooling to the technical services load, with the need for more equipment and distribution lines and ductwork, waited until decades later to make an appearance inside houses as standard features. Then, these developments happened quickly, in the span of several generations, following World War II.

Functionalism

The migration indoors of bathrooms and kitchens attached to their resource tethers, taking place from the 1880s onward, coincided with the Victorian concept of dividing indoor space into distinct "functional" territories.[14] Particularly with the detached house, this concept of spatial order related directly to specific uses was a distinct departure from long traditions. These traditions were rooted, in many cases, in the principle of types, in which "functions" or "uses," and even "territorial distributions," would be decided independently by those who inhabited buildings.[15]

Thus, during the Industrial Revolution, house design experienced an important evolution.



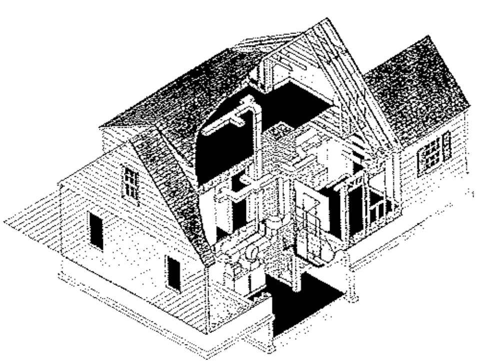
R. Buckminster Fuller's Dymaxion house, showing a central service core. (*Building Systems, Industrialization and Architecture*, Wiley, New York, 1981.)

From spatial and geometric orders offering a certain *capacity* for a variety of habitation patterns, house design took on *functional determinism.* This way of thinking locked in specific uses by two means: the arrangement of walls tightly wrapped around the spatial requirements of an activity, and the attachment of resource tethers serving these specialized spaces. In short, spatial arrangements and uses, distributed for reasons established by convention even prior to the introduction of mechanical systems, were now captives both of "arrangement and dimension based on function" and the resources needed to serve them. Thus, for example, cooking equipment went into spaces previously called "kitchen" prior to the use of gas and electric appliances, and bedrooms became special purpose spaces by the introduction of built-in closets, replacing wardrobes and movable cabinets, which had previously allowed any space to be a sleeping room.

There were efforts, however, to radically rethink the distribution of services in houses in ways independent of the particular distribution of functions or uses in a house. In 1869, for instance, Catharine Beecher's proposal for an American Woman's House clustered all services in a central core serving all rooms in the house, each claiming adjacency to the central core. [16]

Much later, but in the same spirit of efficiency and rational planning, Richard Buckminster Fuller's first Dymaxion House of 1927 had a central mechanical and structural core from which services were to be distributed to surrounding living spaces. He made this proposal while criticizing what he called the International Bauhaus Movement's superficial approach to mechanical systems, an approach that, he said, "never went back of the wall-surface to look at the plumbing...." This was an important but seldom voiced criticism of a movement that had been precipitated in the first place by the invasion, before 1914, of houses and streets by mechanical services. [17] The criticism was accurate, but the proposal seems to have missed the mark, given what is known today.

These early efforts at promoting a "standard, functional" mechanical core for all houses can still be seen in standardized floor plans in so-called "low cost housing schemes" in which bathrooms and kitchens are repetitively back-to-back, an arrangement argued to be more efficient and less costly than any alternative. While this efficiency argument may have held at one time in circumstances of bureaucratic management, it has certainly not been particularly relevant as a "standard" in the American experience, except when organizations based on bureaucratic control have built for an economic class denied control of the act of dwelling. Even here, doubts are beginning to surface about the correctness of those assumptions, given the realities of housing dynamics.



An integrated house from the Modern Housing of Washington, D.C., development. — "In its construction, modular design, standardized plans, a studied production "flow pattern," and novel construction practices combine to effect substantial cost-and time-savings..." (*The Architectural Forum*, November 1937.)

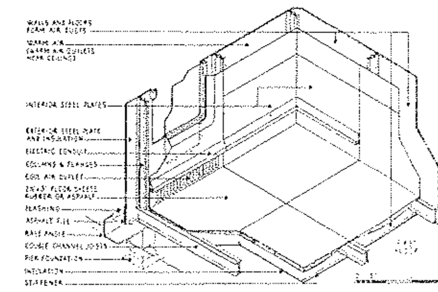
Early Years of Experimentation

The building technology and architectural journals of the 1930s, following directly on the new and widespread availability of resource distribution systems in houses, are full of evidence of tremendous experimentation with improvements in house building. This surge of work, almost all of which sprang from private initiative, lasted until the Second World War and took place during the Great Depression when relatively few new buildings were built. Aside from the experimental work, much of the practical efforts of the time were spent correcting and modernizing existing buildings with current mechanical systems, efforts that accelerated after the Housing Act of 1937 and the formation of the Housing and Home Financing Agency in the same period.

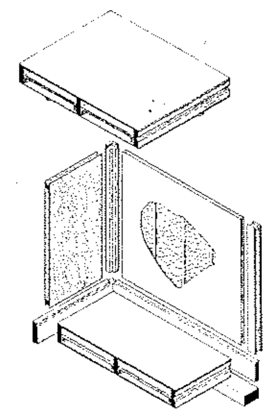
Despite or perhaps because of the newly introduced resource systems, these published experimental efforts from the 1930s reveal a curious lack of attention to these systems. With only a few exceptions, published accounts in the architectural press of the time focused hard on new ideas for the space-defining elements of houses, their construction, and appearance: walls, floors, roofs, foundations, and all the elements of which they are made. At the same time, most ignored or only grudgingly accommodated the pipes, ducts, and wires needed to make the houses liveable.

In these schemes, if cavity walls of new materials and shapes were proposed—and many were—the new resource systems must have been assumed to go between, inside, and through the cavities. Some explicitly stated that this was the intention. When solid-core prefabricated walls and floors were proposed—and there were and still are many—there is seldom any mention of where wiring, piping, and duct work are to be placed. Presumably, they are placed in dropped ceiling plenums in basements, hidden in closets, or otherwise "put in afterwards."

The reason these newly present systems largely escaped the attention of the architectural and building inventions of the 1930s is worthy of speculation in more depth than can be accomplished here. But whatever paradigm was at work then is still at work today: these non-architectural elements will be put in later, after the important work—usually, in architectural thought, the structure and spatial enclosure—is completed, or, they will be "integrated."



A diagram of a Van Ness Steel House. (*The Architectural Record*, 1935.)



A prefabricated all-wood house assembly. (*The Architectural Record*, August 1935.)

The Post-War Period

Many fine histories of housing design, technology, and production chronicle the period World War II and the early 1970s when the now infamous Operation Breakthrough project of the federal government closed its hooks. After that, the literature becomes markedly thin, as though all the enthusiasm of the previous fifty years had dissipated.

A careful reading of efforts that were recorded reveals only passing references to the creeping entanglement involving pipes, ducts, and wires. This absence is understandable, since, until the widespread introduction of forced air for heating in the late 1940s and air conditioning in the late 1960s, the technical repertoire had not changed markedly for over forty years. For example, by the 1940 census, fewer than 58 percent of households had central heating.[18]

When resource systems are mentioned at all in the housing innovation literature during the period after 1972, the discussions are frequently framed in terms of systems integration. This is a concept that has directly or indirectly dominated much of the research thinking about housing and other building technology since the 1960s.[19]

The basic principle of integration is to put as many subsystems as possible into one unified, preferably mass-produced assembly. This was, and in some quarters still is, thought to be the key to better results. In fact, this approach can be described as an effort to rationalize and standardize the physical positioning of parts currently found in practice: pipes, wires, and ducts within floors and walls. In a significant departure from daily practice, however, many proposals for systems integration suggested that the interweaving of parts could be standardized to enable mass production of elements so configured, independent of any particular project. In what now seems a curious linkage, this strategy was thought to be a way to achieve "flexible" and "adaptable" housing schemes.[20]

Whereas placement of service lines within walls and floors could, on a project-by-project basis, meet the highly variable demands of construction and market requirements until recently, efforts to standardize this intricate interweaving—and thus reduce the variety of configurations—could not possibly succeed. No one wanted to build standard floor plans in large enough numbers to make an investment in such mass-produced, high value-added, integrated component production worthwhile.

This was especially so as increasingly complex systems were introduced in the last twenty years: humidification and dehumidification depending on the season, more sophisticated and complex heating and cooling systems, central vacuum systems and other appliances and fixtures each requiring several service hookups, more power and communications cabling, a diversification of power or energy sources, ventilation systems, fire suppression sprinkler systems, and the like.

By the late 1980s, faith in systems integration had largely waned, with the exception of such rare industry development efforts as General Electric's Living Environments Project and the follow-up IBACUS consortium. Systems complexity had increased, demand for variety had continued unabated, but no new paradigm emerged on the screen of the American housing industry to help sort out and simplify the tasks.

Shedding the Limitations of Functionalism and Entanglement

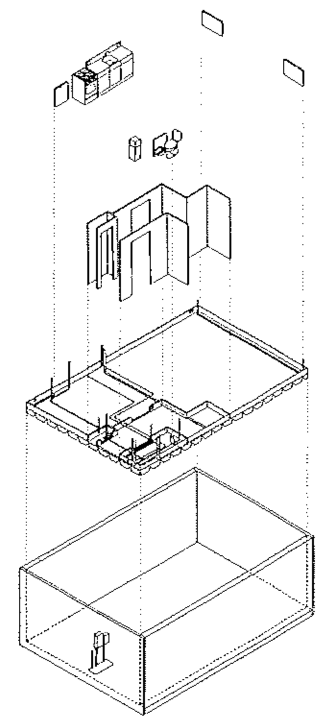
The principle direction of thinking dominating housing technology up to now, can be called the *unibody / integration* view. This view corresponds closely to attitudes held in currency by many industry leaders, writers, and academics up to the 1990s, but is now obsolete. It is fundamentally a static, technical view in the narrow sense, trapped in a model of centralized control and standardization. Because of this, it is unsympathetic to the full reality of healthy housing processes in the United States.

The *unibody / integration* perspective ignores one old reality and one new idea in housing, which the state of entanglement we have now reached compels us to see in a new light. Recognized together, these two concepts may hold promise for shedding the limitations of functionalism and entanglement.

The first old reality is the fact that as dwellings change, they undergo gradual, fine-grained adaptation to remain current and healthy, a process often initiated by households or for their benefit, making for a widely distributed pattern of control. This is pervasive, constituting a vital economic and social activity, only partially accounted for, and is certainly not a heroic activity concerned with style or winning awards. Further, this characteristic of housing has long eluded those professions blinded by an obsession with self-expression and the belief in the superiority of professional values.

The second somewhat new idea is the principle of levels, which concerns the way the built environment organizes itself hierarchically according to the distribution of control over it.[21]

This later concept is evident in nonresidential projects such as office buildings and retail facilities, where it has been conventional practice for some time in the U.S. to organize on the basis of levels. In these projects, a "base building" is constructed, consisting of loadbearing elements, shared spaces, and common mechanical systems. This part of the whole is designed to last



A diagram of a dwelling organized on the principle of base building and fit-out. All installations specific to the dwelling are in the fit-out, except for the main supply and return pipes and ducts. This approach is applicable to both new construction and renovation. Matura Netherlands™. (from *Entangled Building?* (ed) E. Vreedenburgh. OBOM, Technical University Delft, The Netherlands, 1992.)

longer than any activity at the "fit-out level," about which each occupant may decide and for which each is individually responsible.

The facts of change and distributed control converge in the levels concept. The base building is meant to be "fixed" relative to the more variable fit-out. One party (the aggregate of individual occupants or a separate entity) controls the base building, and a number of independent parties each controls its own "fit-out," retaining a degree of technical and legal autonomy and responsibility set out in the agreements of occupancy

This approach is applied as a matter of course in the office and retail section, taking many forms. It may have merit in U.S. housing as well, to liberate a process now so entangled. A model of this practice has been patiently moving forward in the Netherlands, dealing with a difficult mix of government and market forces. Hundreds of housing units have been built using it. According to people doing the work there, a new stage of application has now been reached. New multifamily residential projects, as well as renovations in both the subsidized and private markets, are being built. In them, base buildings are being "fitted out" with units meeting household preferences, at a cost equal to the unibody/integrated approach, which is conventional there too and equally outmoded. These projects offer developers the new benefit of matching rather than anticipating user requirements and getting the work done more quickly than before. They demonstrate how variety, previously considered to be the source of higher cost and more difficulty, can actually be more efficient.[22]

This base building/fit-out approach also has an interesting dimension that should satisfy architectural formalists and functionalists alike. Well-designed base buildings can be constructed following sound and enduring principles of built form, offering capacity and giving opportunity for a wide variety of territorial distributions and functional layouts. Thus, architects and builders can literally "give" form and space to others who then have the freedom to put the given forms to use in their own and changing ways. It is an important kind of organized hand-off in a complex process, one which may now be able to respect the fundamental need for historical continuity at the level of the building as part of the public environment, while respecting the need for continuous though slow cultivation of the interior spaces in respect to evolving household needs.

A Turning Point in Housing

A real turning point in meeting the problem of entanglement in American housing will come when several events occur. First, wiring, piping, and duct management following the unibody/integrated paradigm in currency today—"just put the pipes and ducts in the cavities or anywhere they will fit"—will have to become an economic burden to most actors in the housing game, especially builders and users. It may already have reached this point, both in initial construction and in down-stream alterations.

Second, there will have to be widespread recognition of the ubiquity and magnitude of investments in altering existing dwellings as a percentage of total investments in housing. This data is relatively well known, but our building traditions are only slowly waking up and adjusting to this reality.

Third, the unibody/integration model will have to be displaced by the levels model as a normal basis for organizing complexity. Despite the many differences between commercial projects and housing—many fundamental differences in their respective places in our social, economic, and cultural fabric—the base building/fit-out strategy is a useful model that should be carefully studied and tested in housing practice.

The reality of technical entanglement is being recognized in many industries and countries. It is given many different names,"sorting out," "design for assembly," "disentangling," "base building/fit-out," "working on levels." There are, however, advantages beyond those gained in solving technical problems, critical as they are to improving the state of the art in housing. The concepts of levels and the principle of disentanglement also enable us to rethink again the organizational question of the balance between the community and the individual, mediated as always through the control of the built environment.

A visit to a multifamily residential project under construction and organized this new way offers a tangible image. Opening the front door, our future occupant sees an enclosed but bare space, with columns or bearing walls at certain locations, and exposed vertical plumbing and ventilation lines in a cluster. With the assistance of a designer, or by referring to several prepared model-unit designs, an interior design is prepared matching our household's preferences perfectly. Because a sophisticated computer software program is used, the design is transmitted directly to an off-site facility where all specified parts—including walls, equipment, cabinets, fixtures, piping and wiring, and heating and cooling equipment—are prepared or organized. Accompanied by a trained, four-person installation crew, this package of parts is transported to the building, or delivered just-in-time from other suppliers, one week after the order has been placed. In a carefully choreographed sequence, parts are brought into the dwelling space and installed. After one week , carpet installers arrive, followed by drapery hangers, and the furniture is brought in. The elapsed time between the initial visit to the bare space and completed fit-out and occupancy is less than three weeks for an average size dwelling, at a cost equal to that had the conventional approach been used, and offering the additional advantage that future changes will be easier to accomplish."

This scenario represents a new paradigm. The question is how to shift paradigms, in an industry and a process characterized by individual parties acting individually. We need to learn how to intentionally embark on a new concept pathway, on which each will find opportunities unavailable if the path isn't established in the first place. This would be a rare event in the building industry.

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OPEN BUILDING FOR HOUSING REHABILITATION

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ABSTRACT

An innovative strategy for rehabilitating public housing is being adopted in the Netherlands. The strategy, known as Open Building, distinguishes three levels of physical systems and control: the neighborhood, the base building and the individual dwelling. By organizing responsibilities this way, physical adjustments can take place on each level with reduced conflict compared to traditional approaches. Upgrading one-unit-at-a-time, for instance, is less difficult, and allows investment decisions to be targeted and timed with more precision and in smaller increments than in traditional renovation. Each dwelling can now match occupant requirements and ability-to-pay, at costs no greater than making all units the same. Lastly, an Open Building project's common elements can be upgraded without vacating the building, yielding social, economic and technical benefits for all parties.

INTRODUCTION

Open Building is an approach to the gradual improvement of urban residential environments, both public and private. The principle is that each dwelling should be able, over time, to match the needs of the household occupying it. Each dwelling should be understood as an individual unit of control, capable of being manipulated independently, in the context of a community level. The community level consists of that part of the physical environment - the common infrastructure of spaces and physical systems - shared by all individual units.

The concept of treating each dwelling in a multi-family building as a separate decision presents difficulties in the traditional approach used by large management organizations such as large public housing authorities. Building managers have become accustomed to treating a large residential project as a unity, believing it to be efficient, in part because buildings are not constructed to enable efficient one-unit-at-time adaptation. Without Open Building, public authorities have basically two options for building renovation, neither of which is desirable.

TRADITIONAL APPROACHES

The first option is to vacate an entire building and proceed with either selective or gut-rehabilitation. Tenants may move back in or new tenants must be found, approved and settled. This is hard on the social fabric, takes extensive planning to relocate households and their possessions, and large expenses are incurred in the social engineering processes involved. A sizable loss of income is also assured during the period of renovation.

The second option for a housing authority is to do the renovation work while tenants stay in place. In this case, occupants are treated to long periods of disruption and noise while workers move in and out redoing units, replacing equipment and mechanical systems, painting, and putting in new cabinets and finishes. Because of the difficulties of working in an occupied building, a high level of cooperation is required between all parties, especially the owner and the contractor, but also the occupants, a level of cooperation which is often hard to achieve.

In both of these approaches, original layouts are usually retained while new bathrooms and kitchens are installed. It is not always the case, however, that the old floor plans are suitable. Work in one unit is often tied to neighboring units because the physical systems belonging to the entire building are not clearly separated from those serving individual units, nor those of one unit from others. Differences in life style, life stages and income cannot be respected, because it is considered efficient to standardize all the units as much as possible. This leaves no one satisfied. Some households feel that the new rents are too high, and some feel that they do not get what they want and can afford.

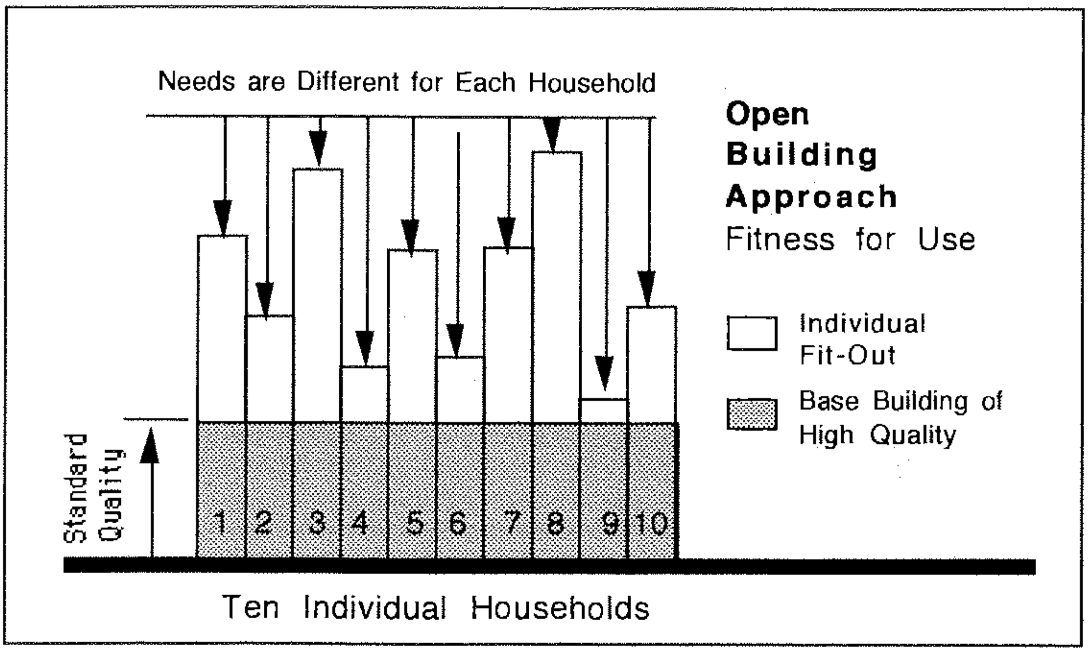


Figure 2: An Open Building Project; Units Attuned to Each Household

UPGRADING THE BASE BUILDING AND THE SITE

While it is important to upgrade each dwelling in response to individual preferences and ability-to-pay on a unit-by-unit basis, the building's common facilities, such as stairs, elevators, central mechanical systems, facades, entries, parking facilities and landscaping, also need to be improved in most cases. For these common elements, the building owner has to take initiative, while consulting with the building's occupants. This work is done at its own pace, and can be handled with bids independent from the work on the individual units. As such it is easier for contractors to know what is expected and to determine prices.

REPORT ON A CURRENT OPEN BUILDING RENOVATION PROJECT

Recently, the first phase of an Open Building renovation project was completed for the housing corporation Patrimoniums Woningen in Voorburg, The Netherlands. It involved a block of three buildings constructed in 1962. The complex has 110 flats accessed by 13 stairwells, two units to a landing. The first phase included the following tasks in one of the blocks containing 50 units.

••• a face lift of the site, (Site or Tissue Level) including: (see page 9)

> adding 10 new small dwellings with gardens at ground level, replacing storage units, to improve street "life";
> adding 4 new, 2-story for-sale dwelling on the edges of the existing multi-story buildings.
> upgrading the landscaping, parking area, and other site features, and adding freestanding, brick storage units.

••• renovation of the block (Base Building Level): (see pages 9 and 10)

> adding elevators and new stairs
> enlarging balconies
> improving the thermal insulation of roof and facades
> replacement of original glass with insulated units and repairing window frames

••• inside the dwelling units (Fit-out or Infill Level): (see pages 9 and 10)

> renovation of individual units if individual tenants wish to invest money to do so(a number already have done so).
> when vacancies occur, new tenants can choose a completely new interior, matching their needs and expectations.

ISSUES EFFECTING THE DECISION TO RENOVATE

Investments needed to renovate a project of this size involve complex decisions, and involve a number of criteria:

> how is the housing project situated in relation to shopping, schools, public service and recreation facilities;
> how is the image of the project, related to:
  - the age of the area
  - the maintenance of the public space
  - the kinds of households living in the area, according to age, public assistance, education, etc.

At every level, two kinds of measures are possible:

> changing the distribution of control, which usually means reducing the scope of control by the central authority and delegating responsibility to occupants and/or to an on-site manager.

> changing the physical systems, adding features, removing certain elements, or adjusting systems already in place.

Examples of changing the control distribution include the following:

> at the neighborhood level, there is the possibility to decentralize the responsibility for the landscape areas, parking places, play areas, etc.

> at the base building level, responsibility for managing the building can be decentralized and given to an on-site manager with a separate budget.

> at the dwelling level, responsibility for the fit-out by individual tenants is possible as well as complete ownership of the fit-out by occupants.

These measures are summarized in the following diagram:

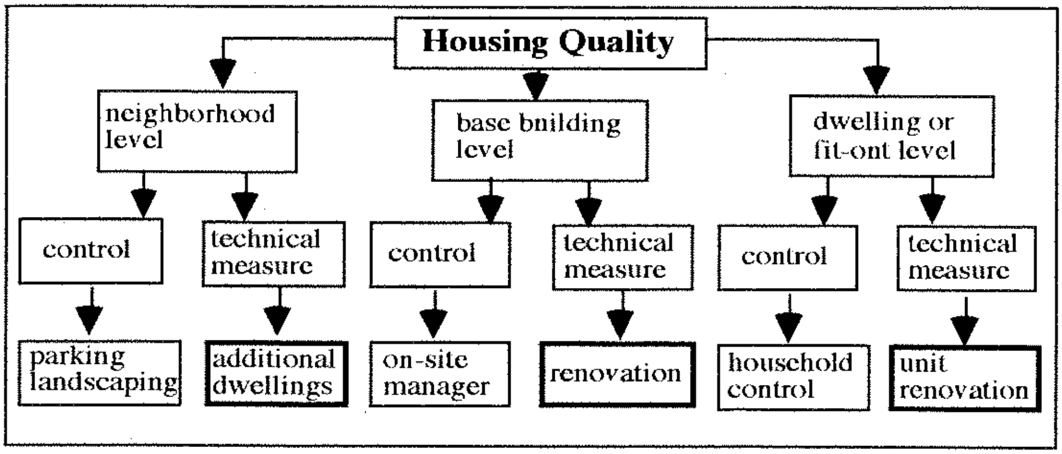


Figure 5: Strategies to improve the housing quality

MEASURES AT THE NEIGHBORHOOD LEVEL

The overall residential environment is normally considered to be the responsibility of the local government. In the case of Dutch public housing, the Local Housing Authority normally has responsibility, although it may be shared with the municipality.

In the Voorburg project, the housing authority decided to improve the quality of the neighborhood environment as part of the architect's commission for the renovation of the project. First, new dwellings were installed at the street level on the front of the buildings. New dwelling units were also built on the ends of the existing blocks, replacing old garages and thereby enclosing the private side or backyards. These improvements have been made by the housing corporation, with the support and participation of the city of Voorburg.

RENOVATION OF THE BASE BUILDING OR SUPPORT

At the level of the base building, a number of changes have been made (see pages 9 and 10)

> an hydraulic elevator has been added at each stairwell in the same slab opening that had contained the old stairway. A new stair was then built outside the volume of the building, with a glassblock enclosure allowing each to be naturally lit. New ground level entry halls were built at each elevator/stair.

> the exterior facade of the block was upgraded with improved thermal insulation and insulated glass in renewed wood window frames.

> the existing balconies on the street facades of have been enlarged and their concrete work improved. Facing the interior common space, smaller balcony extensions have been added in certain locations.

> additional dwelling units were added at ground level, suited particularly (but not exclusively) for elderly people and individuals with physical diasbilities. They are small units facing the public street, reestablishing the buildings in the traditional Dutch manner of directly and closely fronting the sidewalk with large picture windows. These units replace the storage units which had occupied the ground level in the front.

> the building level mechanical systems, vertical utility stacks for gas, water and drainage, electricity and ventilation equipment have been improved. A new vertical stack has been added adjacent to the new elevators providing exhaust ducts and space for new supply lines for water, gas and electricity.

INVESTMENTS IN THE RENOVATION

The investments in the renovation are depicted in the graph below. Values are given in dollars per dwelling.

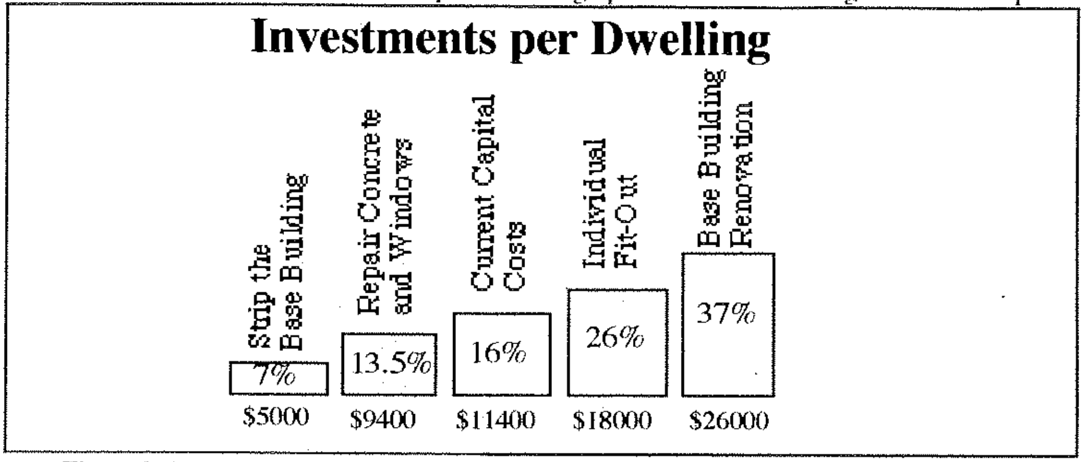


Figure 8: Investments per dwelling for the existing project

INVESTMENTS IN THE NEW DWELLINGS

The investments in the new dwellings are depicted in the overall cost table below (Figure 9). The overhead costs of the main contractor were 22%: 11% for site organization and site services, and 11% for general overhead and profit. Changing the process and splitting the responsibilities into two separate contracts, one for the base building and the other for the fit-out could save at least 50% of the overhead of the main contractor for the fit-out part.
This means that after delivery of the base building, the site organization and site services and equipment are fully the responsibility of the supplier of the fit-out. According to the calculations of the main contractor, the Matura Infill System will be $600-$1000 more expensive per dwelling compared to a traditional fit out process. However, the overhead costs of the main contractor alone, related to the interior finishing work, are +/- $3000 per dwelling.

This means that at least 50% of this could be saved if the Matura Infill System were used. Another advantage in its use is the decrease of interest costs during construction, because of the shorter building time, made possible by the more efficient fit-out installation using the Matura System. The savings is about 10 weeks on a project of this size.

PROJECT	Base Building	Fit-Out	Total	Overh'd	Tax	Total	Other	Invest-ment
10 dwellings	$28000	$11000	$39000	$8600	$8300	$55900	$6100	$62000
4 new du's.	$46000	$16000	$62000	$13600	$13200	$88800	$16200	$105000
4 garages	$8000		$8000	$1800	$1700	$11500	$1500	$13000

Figure 9: Cost Distribution of the Project

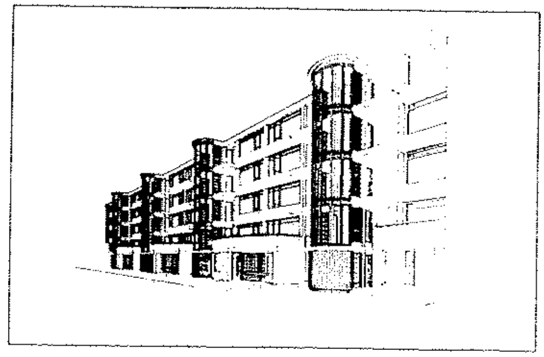
CONCLUSIONS ABOUT BUILDING COSTS

The general conclusion is that in the case of a renovation project, an "infill" or fit-out system like the Matura Infill System is the lower cost solution. Further, because of the advancements incorporated in this system's off-site and on-site logistics and installation procedures, it can not be compared with a traditional one-unit-at-a-time renovation. The price associated with this new approach is now a question of market supply and demand, between the tenant and the supplier of the fit-out system.

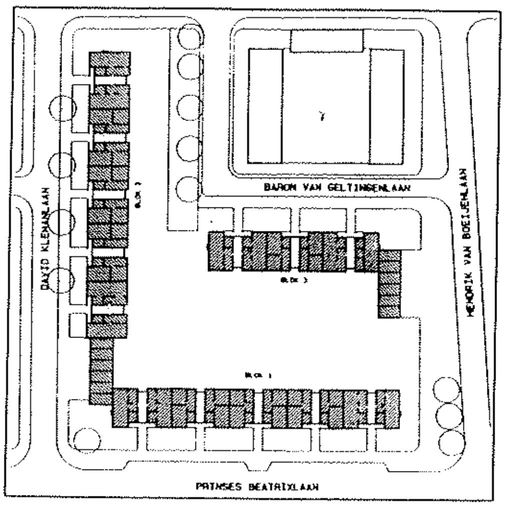
LONG TERM OPERATION AND MAINTENANCE COSTS AFTER RENOVATION

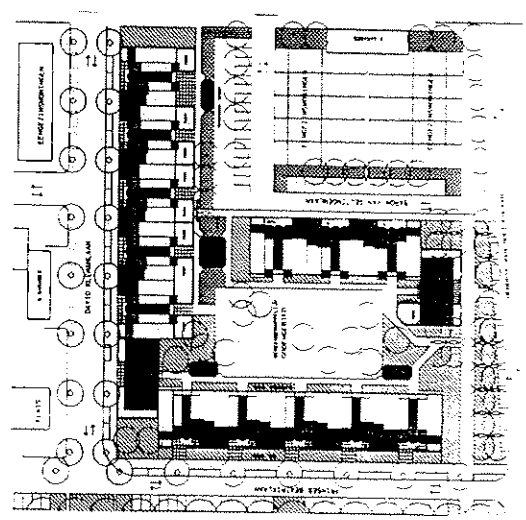
The long term costs and income from the rents has to be in balance over time. In the chart below, the results of calculations in regard to this necessary balance are shown. The first 3 years show a profit. The next 13 years show a deficit. After 16 years, the results are again positive. The net present value over 30 years includes a positive salvage value for the base building, a very important factor for the housing corporation.

THE SITE AND BASE BUILDING BEFORE AND AFTER RENOVATION

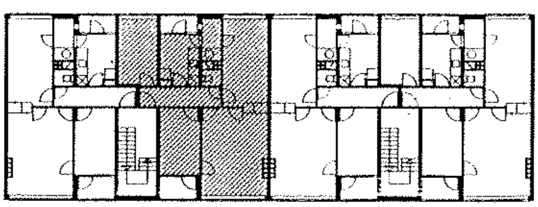


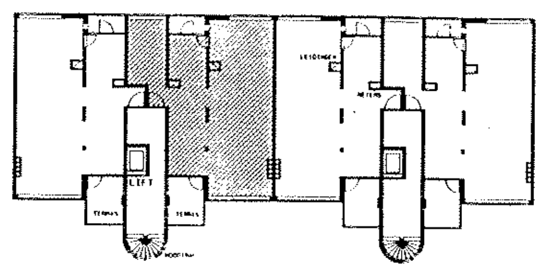
• A view of the existing block (left) and a view of the renewed block showing new stairs, balconies and ground floor units (right).

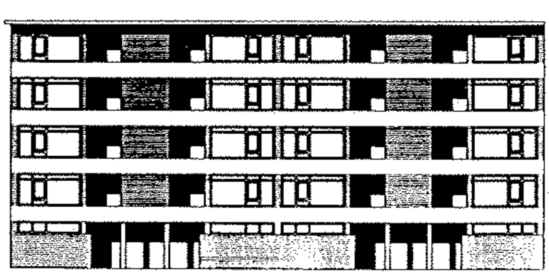


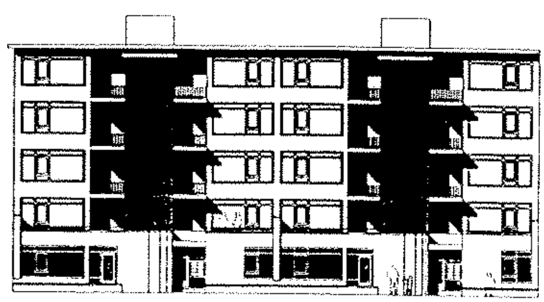


• The site plan before upgrading (left) and the present site plan showing new pedestrian walkways, entrances to the building from both sides, new for-sale units replacing the rows of garages, and new freestanding storage units.









• The original base building plan and facade (built in 1962) as it appeared prior to renovation, showing a typical 5 room dwelling (left). On the right, the renewed base building facade, showing how the internal load-bearing structure was modified to increase each dwelling unit's capacity to hold a variety of layouts in the same space(right)

VIEW OF THE RENEWED BUILDING'S STREET FRONT

A CAD generated drawing of the renovated base building or support in the Voorburg project.

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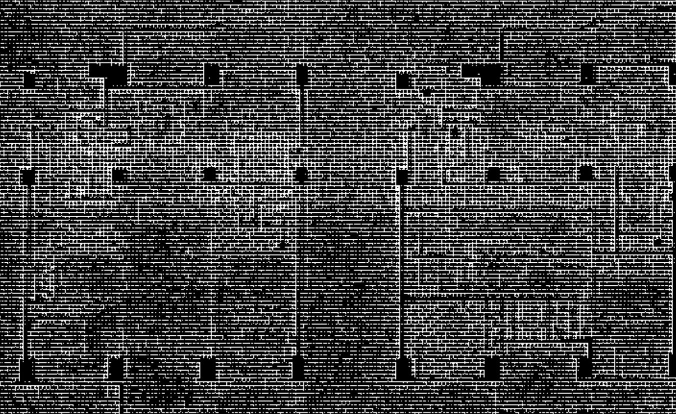
About the Authors

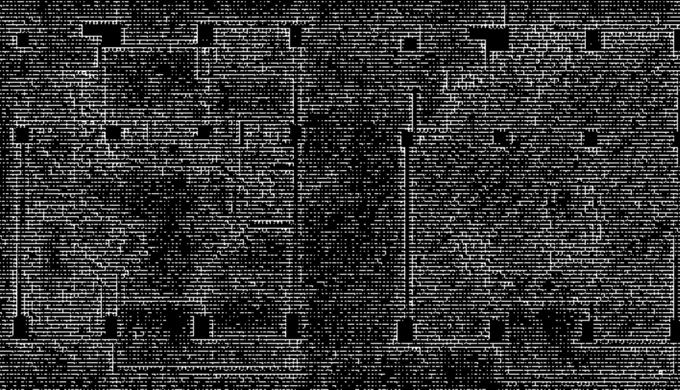
Karel Dekker is a building economist and principle of the consulting firm KD Consultants in Voorburg, the Netherlands. His work involves economic and strategy planning for private companies and governments in the EC, including infrastructure planning and building construction. He has done some of the seminal economic analysis showing that Open Building can cost less.

Dr. Stephen Kendall has a PhD in Architecture from MIT a professional degree from the University of Cincinnati, and a Masters of Architecture and Urban Design from Washington University in St. Louis. He is an architect, educator and building researcher. His advocacy of Open Building has led to two workshops of major US organizations to explore the opportunities in adopting Open Building. He has studied Open Building practices and projects in Japan and Europe, and has pnblished the major assessments of this approach in the US market.

Open Building

A New Approach to Multifamily Architecture, Interior Design and Construction





Assessment of Developments in the Netherlands and Japan
Implications for Housing and Design Professionals in the U.S.

Dr. Stephen Kendall, AIA

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OPEN BUILDING

A New Approach to Multi-family Residential Construction Which Reconciles Consumer Preferences and Efficient Production

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OPEN BUILDING IN JAPAN AND THE NETHERLANDS

Introduction

The International Society of Interior Designers supported two study trips, to Japan and the Netherlands, to investigate the Open Building approach to the development and renovation of resideutial projects. The results of the studies suggest that the adoption of Open Building in North America can dramatically improve the housing delivery process as well as offer important new opportunities for many parties with economic stake in housing production and renovation.

Open Building is a broad concept which concerns the means by which buildings of all kinds, including multi-family projects, can be designed, constructed, and adapted in response to the preferences of individual users and households. In this approach, the changeable building interior is distinguished from the more permanent base building. With this formulation, the traditional American advocacy of consumer choice finds its place in residential projects. The approach is conceived in such a way that the needs and preferences of individuals, which change more quickly, and the needs of the community which are more enduring, are always considered in relation to each other rather than separately.

Open Building practice shows that the well established belief that it is not possible for each household to determine its own dwelling in a multi-family building is obsolete. It is often argued that, aside from the question of whether households want to exercise this choice, technical and organizational problems make such a vision of individual choice impossible to accomplish. It is also argued in some circles that if residents decide on their own dwelling layouts, finishes and equipment, professional control will be eroded and the quality of the resulting environment will be lower.

On these study trips, it has been exciting to discover work now being done which shows how tailoring a dwelling's interior to a specific user's preferences is not more costly, and does not reduce the importance of professional participation or result in lower quality environments. Rather than decreasing the need for the artistry of professional guidance, Open Building in practice requires design professionals to rethink and lead, rather than withdraw from their roles in residential development activities. It also opens a broad new market of individual clients who can now imagine the possibility of deciding what has here-to-fore been excluded from consumer choice - the design of dwelling spaces in multi-family building types, tailored to their unique preferences.

The application of Open Building in the field of residential project development is the focus of this report. The approach concerns all facets of the design and building of residential projects. Many of the principles apply with equal utility to other building types such as health care, office and retail facilities. There is merit in undertaking further investigations of the Open Building approach, to explore its application to the design and installation of interior environments of all kinds.

Pictures pertaining to this visit are included in the Appendix.

The design and building technology innovation activity in Japan far exceeds that in the US in scope, depth and continuity for many reasons that cannot be taken up here. Docnmentatiou in the Japanese language is exteusive, far exceeding anything in the US on design and building innovation.

The work is being doue by consortia of design professiouals, university professors, developers, contractors, snppliers and product mannfacturers, and is being spearheaded by initiatives coming both from government ministries, from quasi-public agencies, and from the private sector. To date, much of the effort is aimed to supply the fast changing Japanese domestic market, but increasingly, products and know-how resulting from current work are exportable. A great deal of effort is being applied to lowering building costs, while increasing quality and meeting the increasingly diverse market of consumers and organizations, who demand more choice in building design and interior environments.

The trip to Japan focused on progress in realizing residential Open Building projects since my last visit in 1991. The idea of distinguishing the long lasting and common part of a residential multifamily project (the base building or support) from the more individual and shorter lived parts (the infill or fit-out) has been under development in Japan for over 20 years. During that time, many demonstration projects have been built. Structural design, planning flexibility, regulatory and approval processes, construction management, cost control, CAD, new building elements, and financing mechanisms have been carefully studied and tried out in practice. Many hundreds of housing units have been built and are occupied following this basic approach. A special edition of the journal *Open House International*, published in 1987 and edited by this author, reported on some of these developments.

Two major projects were visited and are summarized here.

Osaka Gas Experimental Housing NEXT 21

Osaka Gas, a utility whose charter requires sponsorship of activities for the public good, spent 5 years on this effort. The project was fully occupied in March, 1994. On this trip, a visit to the project took place with the principle design team architects and a representative of Osaka Gas.

The goal of the project was the development of an alternative housing solution for the 21st century. The NEXT 21's base building provides a vertical urban domain with sidewalks, gardens, and open public spaces. The idea was to create a standard but organic frame within which custom dwelling units could be inserted. The project succeeds admirably both at the level of urban design and architecture, and at the level of the provisions for individual household living.

A key concept for the dwellings was to provide a vocabulary of design materials and components to be used by outside designers. This "open system" facilitates the smooth integration of new houses within the matrix, in contrast to the "closed system" of project-specific elements used by architects in Japan today. There are a total of 18 units designed by 13 different design firms, each unit having its own interior concept and expression on the facade. Four units were designed with respect to specific families. The six story reinforced concrete frame provides 45,750 sq ft, on a site of 15,450 sq ft, with a building footprint of about 9000 sq ft. Off street parking is provided for 18 cars within the footprint. Part of the building is occupied by Osaka Gas meeting rooms, the offices of a nature conservation organization, and innovative total energy (co-generation), waste water and garbage treatment systems in the building's lowest level.

NEXT 21 is the first multi-family housing project in which each dwelling unit is fully independent. The result is a building viewed from the street as an organized collection of houses each identifiable but each clearly part of a larger 3 dimensional order. It is built at a very high quality, with excellent materials choices and design concepts, and at a high cost associated with the fact that it is a demonstration show-case project. The total energy and recycling systems are state of the art and in some cases completely new for residential applications, and are very impressive. English language reports are available.

The interior design work in the individual units is striking and compelling. Many different life-styles are accommodated, including a three generation family, a group of young people sharing a dwelling, households with children and those without, elderly couples, and so on. The interiors integrate traditional

Background to Open Building

The basic concept of Open Building was introduced in a book by N. John Habraken, Supports: An Alternative to Mass Housing. In this book, first published in Dutch in 1960, and in English some years later, Habraken introduced the idea of the "natural relationship". This idea suggests that dwelling environments are healthy to the extent that both the community and the individual have a direct and identifiable scope of control and responsibility in its shaping and its continuing cultivation. In practice, this means that the community should decide about certain aspects and that individual households should decide about other aspects, and that in each circumstance, these interests need to find a balance. He suggested that this balance can be found in healthy dwelling environments in all cultures, even if expressed in different ways. Habraken proposed that this basic balancing of interests should be made real in the construction of "supports" (or base buildings), which are the responsibility of the community level, and that these "supports" should then be "fitted-out" by the decision of each occupant determining his or her own dwelling. He also suggested that professionals were essential in supporting both spheres of activity, and sketched these roles in some detail.

In 1964, a number of prominent individuals in the Netherlands (architects, builders, developers, product manufacturers and others) invited Habraken to head a new research foundation, SAR (Stichting Architecten Research) set up specifically to investigate measures in the design and construction of residential buildings that would make this concept real. A document called SAR 65 was produced the next year. It detailed the methods designers would need if they were to design "supports" with the capacity for a variety of "fit-out" suited to the requirements of each household. Later work of the SAR developed these methods in further detail, and extended them to the design of urban neighborhoods on the one hand and, on the other, the requirements for the design of industrially produced interior systems for the consumer market.

The concept gained sufficient interest so that a number of projects were realized in the period between 1968 and today in England, Germany, France, and the Netherlands. Thousands of units were built. The early projects were experimental and received government support, but the latter developments were realized under normal market conditions. Projects based on this concept were also realized in several developing countries, including Mexico and Egypt. Open Building projects, in both uew construction and renovation, continue to be realized in Japan, France, the Netherlands, Finland and China.

In Japan, the work of advancing the Open Building approach has been stimulated since the late 1960's hy a committed group of individuals in industry, universities, and government. Numerous study tours of Europe have been taken to assess work-in-progress there. These visits resulted in a number of experimental projects which were built between the mid-70's and the late 1980's. The Ministry of Construction and the Ministry of International Trade and Industry have both been involved in stimulating innovation in residential construction related to Open Building. The most recent completed project was financed by the Osaka Gas Company, and is discussed below. Others are also being built and are in various stages of planning, in the normal housing market.

The rest of this report summarizes the visits to Japan and the Netherlands, and gives further information on related activities and organizations. It conclndes with an assessment of the relevance of the Open Building approach in the US, and summarizes efforts currently under way to disseminate information about this approach.

Open Building in Japan

Background

The study trip to Japan (July 14-26, 1994) presented opportunities to observe a very high level of exciting, innovative work. Several site visits were made, technical reports were obtained, and interviews were conducted with contractors, architects, interior designers, and developers involved in the housing industry and design and construction innovation generally.

Japanese themes and materials and spatial relationships with contemporary standards and styles. Special attention was paid to the vertical interior dimension, so that many units have highly expressive ceiling design solutions. Typical of contemporary Japanese homes, the bathrooms are exqnisitely finished and sport the latest advances in plumbing fixtures. Each unit has its own security system and closed circuit video to the building entrance. Becanse the building is made to accommodate future change, each dwelling layout can be modified independently of the others, including the location of kitchens and bathrooms.

Mansion Industry System. Daikyo Development Corporation, Ltd.

"Mansion" in Japan refers to a multi-family residential building; either an apartment or condominium building. This 14 story, 200+ unit condominium project is under construction in Fukuoka, on the island of Kyushu, six hours west of Tokyo by the bullet train. Parking is provided in the building at the rate of one car/dwelling. There are 6 unit sizes in the building.

The normal construction schedule for a project of this size is two years. By adopting an innovative base building construction technology and by using a new interior "fit-out" system (a 700 sq ft unit's fit-out can be completed in one week by a crew of two), the construction time to completion of this project is reduced to under one year. Despite the aggressive search for a reduction in time to complete the project, it was also the goal of the project to enable each dwelling unit to be tailored to the specific requirements of the buyer.

The technical brochure obtained in the construction office describes four systems:

> a MFIS or <u>Mansion Frame Industry System.</u> Base building construction uses a steel frame/site-cast reinforced concrete column and beam system which does not require removable formwork, speeding erection and reducing labor. Concrete floors are precast.

> an MEIS or <u>Mansion Exterior Industry System</u>. This refers to a cladding of thin fiber reinforced panels which cover the rough columns and other vertical surfaces.

> an MIIS or <u>Mansion Interior Industry System</u>. This refers to a new interior "fit-out" system. An access floor is used, approximately 3 inches high, made of plastic panels which rest on pedestal blocks, with a factory attached wooden floor surface (not unlike the US made "Powerfloor"). Partitions are made of 1" stud channels of heavy gauge steel assembled in sections about 2'-0" wide. Inner partition frames made this way are installed, then ceilings and floors. Ceilings are dropped to different heights depending on desired spatial feel, and to conceal HVAC equipment, recessed lighting and cabling. Wall frames are covered by a plywood backed panel with a thin foam padding, covered by a washable vinyl decorative material, and attached to the metal stud partitions by snap-on devices similar to those used to attach interior panels in cars. Door and window trim are also snapped into place. "Unit bathrooms" are used. Kitchens are normal kitchens available in the Japanese market.

> an M(M&E) IS or <u>Mansion Machine and Equipment Industry System</u>. This refers to the cabling, drain-waste-vent and heating and cooling systems. National (Panasonic) has developed a preterminated residential cable system for all power lines, used in this project for the first time; it enables rapid completion of the electrical installation by untrained workers following a simple wiring plan and quick reconfiguration of wiring and outlet locations. Water supply lines use quick connect couplings, homerun flexible plastic piping with manifolds, and some drain lines to the main stack are flexible lines with a quick connect system. These power, supply and drain lines run under the access floor and under the floor of the "unit" bathroom. Power lines then are routed up in the partitions and into the dropped ceilings for ceiling fixtures.

Further items of interest in Japan:

The <u>Ministry of Construction</u>, (MOC), in another of a series of regular innovation activities it has sponsored or stimulated over the years, organized a competition in 1991 for the development of new approaches to multi-family urban housing for the 21st century. Twenty one teams were selected, and each presented detailed building and neighborhood design proposals (at their cost) to a committee of respected building industry professionals from many fields. The submissions came from:

Ohki Construction Company
Mitsui Construction Company
High Rise Research Consortium
New Japan Steel Company
Takenaka + New Japan Steel + Matsushita
Arai Construction Company
Daikyo Development Company + MMS
Sekisui House
National House
Misawa Home
Matsuo Construction Company
Taisei Prefabricated House Company
NKK
Taisei Construction Company
Shimizu Construction Company + Toyota
Konoike Construction Company
Haseko Development Company
Asahi Chemical Company
Daiwa House
Sekisui Chemical
Inoue Industries

Most of the proposals, published in a hard-cover book with color illustrations, include detailed studies of the use of CAD in design, product manufacturing and construction, as well as marketing and interior design concepts. Most show detailed studies of new structural systems, as well as new interior "fit-out" systems approaches, many using access floors and advanced partition and resource distribution systems designs and finishes. One of those selected by MOC was the MIS project noted above, currently nearing completion. Others are undoubtedly under construction.

The Ministry of International Trade and Industry, (MITI), being competitive with MOC, has been active in stimulating innovation in housing products. It has launched a series of R&D projects, starting in 1976, to establish industrial technologies to provide houses of high quality at reasonable prices. The first was "House 55 Project" (1976-79). In 1989, it initiated the fourth project, a 7 year effort called WISH 21. It is a project which aims to stimulate the development of "open components" for both building construction and the "fitting-out" of dwelling interiors suited to the market. The name WISH 21 stands for Housing Development Project for the 21st Century. The organization stimulating this effort is the Research Association of Technology Development for New Industrialized Houses.

Its main themes of research and development include:

> development of a simulation system for living space design with the participation of the households;
> development of highly functional construction materials and housing equipment, and their industrial production technology;
> development of highly functional and comfortable interior materials and housing equipment;
> development of the overall residential energy utilization systems;
> construction of experimental houses for energy evaluation.

The members of the Association include:

Asahi Chemical Industry Corp., Ltd.
Osaka Gas Co., Ltd.
Omuda Cement Company, Ltd.
Kyocera Corporation
Sanyo Electric Co., Ltd.
Shokusan Jutaku Sogo Co., Ltd.
Nippon Steel Corporation
Sekisui House Ltd.
Daikin Industries, Ltd.
Daiwa House Industry Co., Ltd.
Dantani Corporation
Tokyo Electric Power Company
Toto Ltd.
Nippon Sheet Glass Co., Ltd.
Japan Quality Assurance Organization (JQA)
Hitachi Chemical Co., Ltd.
Matsushita Electric Industrial Co., Ltd.
Minolta Camera Co., Ltd.
Yamaha Motor Company, Ltd.
Asahi Glass Co., Ltd.
Ohbayashi Corporation
Kajima Corporation
Komatsu Ltd.
Shimizu Corporation
Shin Nikkei Co., Ltd.
Sekisui Chemical Co., Ltd.
Daiken Trade and Industry Co., Ltd.
Taisei Corporation
Takenaka Corporation
Tokyo Gas Co., Ltd.
Toshiba Corporation
National Housing Industrial Co., Ltd.
NKK Corporation
Hakeko Corporation
Fujitsu Ltd.
Matsushita Electric Works, Ltd.
Mitsui Home Company, Ltd.

Shimizu Construction Company has developed a new flat slab base building type. A project using it has been built in a Tokyo suburb. This is important because up to now, only column and beam structural systems have been used in high rise buildings, a structural design which limits plan variety and obstructs the visual and spatial flow of spaces in a dwelling or tenant space. This conventional structural design also makes the design and production of good fit-out systems difficult and expensive because of the frequent beams crossing rooms. The new flat slab type will make the development of competitive fit-out systems easier, and give added freedom to interior designers in developing innovative interior designs and systems, in collaboration with others in the industry.

An architect and professor at Kyoto University and Fukuoka University is working with local housing authorities in Hiroshima and Osaka. He has designed several Open Building projects which have been built, and several more are in planning. They are called "two-step housing". He was on the design team of the NEXT 21 project. He is also organizing a consortium of companies in the Hiroshima area to develop an "infill" or "fit-out" system for the market. Local cabinet makers in the Fukuoka region, which has a strong tradition for high quality cabinets and wooden storage units, are expanding into the production of partition systems. Manufacturing interests including companies facing declining markets for existing prodncts (including automobiles) are also interested.

Numerous Japanese delegations have been and continue to go to Holland, England, France and other European countries to observe first hand the Open Building and other housing innovation efforts there.

Raised or access floors have been used for over a decade in high-rise residential projects. A national trade journal regularly reports on and evaluates the over 20 access floor types on the market. While costing more than not using them, they give added freedom to space layout, give easy access to cabling and piping and enable very rapid installation of the building's interior.

The initiatives moving Open Bnilding into practice in Japan are not coordinated by any single party. Some do not know of the other's activities. This indicates something important, namely that similar problems are being recognized in many places and that the Open Building approach has been determined independently to have merit.

The field of Interior Design in Japan is currently following two lines of development. One is organized around what are called "Interior Coordinators". These professionals are not certified but are able to study at Interior Coordinator Academies located in many large cities. The other is similar to our profession of Interior Design, with more formal education and, it appears, certification. There is increasing interest in both these fields in the developments in Open Building, since both recognize that the "fit-out" level of work exactly corresponds to their claim of expertise.

The opportunities for extensive exchanges between US and Japanese colleagues in the Interior Design, interior product manufacturers, contractors and regulatory agencies are broad. There is merit in expanding the level and scope of contacts to the benefit of the growth of the profession and the improvement of the common knowledge base.

Open Building in the Netherlands

Background

Between August 12 -25, 1994, a study trip to the Netherlands was undertaken. On this trip, the focus was in understanding how various product and project-based organizations are responding to significant reconfigurations in the bnilding industry effecting, in particular, the design professions' roles and responsibilities. An effort was also made to learn about efforts to design, develop and apply industrially produced building products and building components. Of particular interest were developments effecting interior design and interior construction. Significant efforts along these lines were apparent, aimed at improving on-site work and meeting consumer preferences and, in general, advancing the quality of the built environment.

Pictures of some of these developments are included in the Appendix.

It was also apparent that Open Building activities in the Netherlands were continuing on a number of fronts. The trip therefore included a visit to a housing renovation project, and the showroom of a company manufacturing and installing a residential interior "fit-out" system in it. The visit also included observation of the companies' fabrication and distribution center, and interviews with two of its directors and one of its staff. An informal discussion took place with a staff member of the Open Building Foundation, an association of companies and individuals interested in promoting the widespread adoption of the concept in practice. An interview was conducted with a consultant specializing in building industry economic forecasting and planning, and a meeting was organized with two architects currently working on Open Building residential projects, from whom published information on their new projects and similar activities were obtained.

Voorburg Renovation Project

A large housing corporation in Voorburg, near Den Haag, decided several years ago to upgrade its stock of 5 story, rental housing built in the 1960's. They decided to adopt the Open Building approach as a pilot project for the renovation of a block of three buildings containing 100 +/- units. Cost calculations and economic projections were prepared by KD Consultants, which has developed the basic methodology for economic analysis and cost accounting of Open Building projects, and consults now with the government of Finland and several development companies and contractors there and in the Netherlands.

In the Voorburg project, an "infill" system is being used, developed by Matura International and produced by its subsidiary Matura Nederland. (Matura International developed the system and holds the patent rights to the Matura Infill System in many countries, including the US).

The base building (the part of the building which is common to all the individual units, and includes the structure, facade, circulation system, and common mechanical equipment pipes and ducts) has been completely renovated. The "base building renovation work" includes the addition of a new elevator at each existing stairwell, the replacement and repositioning of the stair, the enlargement of balconies, and the installation of new vertical risers for building level mechanical services. The base building has been expanded, with the addition of spaces for new dwellings (about 500 sq. ft. in area) on the ground level of each block of flats, facing the street, intended especially for elderly or single people. The storage space lost to these new units has been replaced in typical freestanding brick storage units behind the building. Also, to provide greater privacy and sense of control of the common space between the buildings, and to increase the economic return to the housing association, several two story attached units have been built at the ends of the 5 story blocks, and are now being sold and "fitted-out" according to the buyer's preferences. A few of the individual rental units in the original 5-story blocks had previously been renovated using the Matura Infill System. Each floor plan and equipment specification was determined by its new occupant.

The Contents of a Matura Infill System package

A Matura "Infill or Fit-out System" as used in these units has 23 basic subsystems (comprising over 2000 individual parts), organized in two main groups, called a "lower system" and an "upper system". This is a new kind of product in the market, and comprises innovations incorporating systems disentanglement principles, CAD, industrial production for building, logistics, and reorganization of on-site work.

The Matura "lower system" comprises a specially designed floor element called a "matrix tile" which is placed directly on the structural slab. Horizontal drain lines (plastic slip joint hubs and pipes without solvent bonding) and "home-run" water and gas supply pipes are placed in it. Horizontal gray water drain lines have a 0 slope, a condition which has been tested and approved specifically for use with this "matrix tile" which holds the drain lines securely in position. Cabling and some ventilation duct work can also be located in this element. A subfloor is laid on this matrix tile. Finish flooring is conventionally placed on this subfloor. A specially designed wiring raceway element is placed under all partitions and around the perimeter of rooms . It has a removable baseboard cover (presently available in several styles) allowing secure placement of all power and communication cabling. Almost all power and data cables are in this raceway, making installation very efficient (wiring a house takes 2 hours). A preterminated power cable and connector block system is used, manufactured by the Wieland company of Germany (which is seeking to introduce this product in the US). This design enables the occupant to reposition convenience outlets and telephone and cable TV jacks as needed to suit furniture rearrangements, or to upgrade cabling as needs change.

This "lower system" comprises the patented part of Matura's product, and introduces two elements, and their connectivity principle, not previously in the market: the "matrix tile" (named after the matrix of grooves in its top and bottom sides as guides for the piping), and the wiring conduit / wall base with its cover, called the "baseboard profile". These two elements are made of inexpensive materials. They are the principle design innovation, helping to "disentangle" and also "locate" the piping and wiring subsystems away from the inner partition walls and the building structure or common building elements. This lower system is presently sold only as part of the complete Matura Infill System which includes the "upper system".

The "upper system" comprises all the other elements needed to complete a dwelling unit. These include the door frames and doors, walls (now made of metal studs and gypsum board), kitchen and bath cabinets and fixtures, the space heating and domestic hot water systems, and tilework in the bathroom as well as plumbing fixtures. The Dutch market requires use of tiled bathroom floors and walls, considerably slowing the fit-out work compared, for example, to Japan, where ready-to-install "unit bathrooms" - available in many styles and sizes - are conventional. All "upper" system elements in the Matura system are conventional building and finishing products or their substitutes, available from numerous suppliers.

The completed units are conventional in appearance. The innovation is hidden, and does not effect style or space layout, but makes it easier to achieve variety of layout, finishes and equipment in multi-family buildings. Installation progresses one-unit-at-a-time, and is very efficient. Each unit is a separate decision and constitutes a separate logistics process. Also, by organizing new construction this way, the base building is dramatically simplified. From the time the occupant decides their floor plan and specifications, three weeks elapses before they can move-in to the completed unit. The process is now competitive with the conventional approach to finishing units, and costs of future projects should continue to decline.

The occupants of one of the recently completed rental units left their keys with the building owner so their unit could be shown. They are so enthusiastic about their new apartment, for which they paid out-of-pocket an additional 12,000 guilders ($7,000) to have the kitchen of their choice, that they leave out a photo album of their house before, during and after renovation. The for-sale units now being completed are also conventional in appearance, but their layout, finishes, and equipment are determined by their buyers.

Installation of Units

In the Voorburg project, new ground floor units have been added to revitalize the street level in conformance with the traditional Dutch street. Their interiors were installed one-unit-at-a-time, by a trained 3 person multi-skilled installation crew. The first unit took 12 days and the last 8 days. The space and the plan layout was the same for each unit. In contrast, the two rental units in the upper floors of the existing block that have recently been renovated have different floor plans, also realized by the Matura Infill System.

The work on the second of the 2-story for-sale units, took the installation crew 11 days to complete, from the time the containers arrive until the interior decorator comes and installs the finish floors and draperies. The crew learned from earlier installations that since setting and grouting the bathroom tile is the most time consuming single task, they could speed completion by erecting the bathroom walls ahead of the other walls, to allow the tile setter to begin. The crew members said they enjoyed the challenge of installing different fit-out packages, and clearly took pride in their accomplishments, supporting each other in all the tasks. The interior of the dwelling during installation was clean and free of clutter or debris.

Matura Nederland Showroom and Distribution Center

The Matura Showroom in Breda contains a mock-up of a dwelling unit, showing the various technical elements, equipment, and the range of consumer choices. It is equipped for presentations to prospective clients and visitors. There are catalogues of available fixtures, finishes and cabinets, which are used by the

Matura marketing staff member (trained as an Interior Designer) when she works directly with clients in determining floor plan, equipment and finishes.

The "distribution center", located in a nearby industrial warehouse building, contains the fabrication shop where "infill packages" are prepared and the containers for each unit stocked for delivery to the installation site. Many parts are prefabricated, and some simply pre-cut, to speed on-site installation and reduce ou-site waste and disorganization. Some parts are ordered from a supplier to Matura's specifications, such as the haseboard cover, part of the baseboard profile and the matrix tile. All parts for a unit (up to 1000 sq ft.) are loaded into one container (about 14 feet long) in reverse order of their installation sequence on-site. A second container is also delivered to the site, containing all the tools needed for the job as well as a construction-site toilet and sink for the installation team. These containers are trucked to the installation site. Two men currently are working at this facility and can produce one complete "infill" unit per week.

Matura is currently gearing up its software and facilities in preparation for expanded production.

Joop Kapteijns, Architect

Kapteijns, an architect in Eindhoven, has, among his other projects, designed several Open Building projects; an office building and several residential developments. The project now under construction is interesting, in that two separate bid documents were prepared for the project, and two separate sets of bids solicited. One set specified the base building for the project of 71 attached houses for sale. The other gave the general requirements for the fit-out level of work, and illustrated sample floor plans for the bidders to use for cost estimating. For each set, different bidders were asked to submit prices.

The base building contract was awarded and a final price negotiated when the infill or fit-out contractor was selected. Three fit-out providers were invited to submit prices. Their bids were within $500 of each other on a basic bid of $17,000/infill unit (for a 1000 sq ft house, typical for the market niche of this developer). The project went to Interlevel, which provided the fit-out for a previous project, while the highest price was submitted by Actibo, and the median price was submitted by the Matura Company.

Frans van der Werf, Architect

This architect, who has designed a number of Open Building projects each signaling an important advance in building methods (Papendrecht, 1978; Lunetten, 1982; Keyenburg, 1984; Enschede, 1986 - see Appendix), is now designing a 165 unit elderly housing Open Building project. It has a number of apartments for independent living, and a number of units for those needing continuing care. The project also includes a medical clinic, meeting rooms, a restaurant, crafts rooms, and other facilities. It also applies organic building form and ecological building principles. The architect and client plan to invite fit-out companies to submit bids for the fit-out of the independent living units. The client is committed to the concept because of the project's capacity for future alterations when continuing care requirements change. Construction is scheduled to begin in January, 1995.

Further Items of Interest in the Netherlands

> New "product" divisions are being considered in the market. These include foundations, structure, facades, roofs, and interiors such as the Matura system. This means, for instance, that single companies are moving in the direction of supplying entire facades, producing and installing them, including all components, and even providing design services. This is similar to the development that the US producer Rollscreen has made in moving from a manufacturer of standard windows to a provider of custom facades and customized sun-rooms, and the access floor company Powerfloor's product which incorporates AMP, Inc's cabling in one "product" with sole responsibility. It is also similar to the discussions at Steelcase North America to market a "slab-to-slab fit-out" system. This kind of activity constitutes the development of new "intermediate products" provided by one company. It incorporates the principles of responsiveness to customer variety, the efficiency of sole responsibility and reduced supply chain costs.

> The British company Redland, a manufacturer of concrete roof tiles, with 85% of the Dutch market and interest in the Japanese market, wants to organize a consortium of roof product manufacturers to make an integrated roof "product" installed and guaranteed as a whole.

> The Swedish producer of wooden windows, Mÿrosgo, has moved into the production of prefabricated wooden houses.

> The larger building contractors now talk about "co-makership" with subcontractors working as teams on many projects, not selected for each job on the basis of lowest cost.

> The largest Dutch construction company HBG (Hollandsche Beton Group) has acquired a software product using an object oriented programming language, for integrated design/cost estimating/production organization.

> The Dutch utilities (such as the gas utility) have just implemented a new policy allowing a "QUALITY CERTIFIED INSTALLER" (QCI) to submit a certificate of completion for a job, instead of submitting to separate plan reviews before construction starts and periodic inspections during construction. The utilities make occasional, spot inspections on random sites to verify quality. To be certified as a "QCI", a company must demonstrate qualifications to install a certain "product", covering an approved scope of work. This certification is granted by the "association" of all the separate utilities. This development resulted from many pressures to reduce the often ponderous and arbitrary control of local building officials, which clogged up the approval process and cost a lot of money in delays, staff time, and so on.

The question is, what is a certified product? One example is the Matura Infill System. With this new policy, no local building code official has to approve a Matura installation. There is understandable resistance to eliminating local, preemptive control of on-site building activity. In this context, infill systems make sense, because the local officials can still review plans of the "base building" which is local in nature, but they can have confidence in allowing QCI's to work on the infill level in the way mentioned, if it can be demonstrated that the prodnct meets national health and safety standards.

Summary and Conclusions:

Important realignments are taking place in the European building industry. One significant trend is the design, development, and application of higher value added products to serve the increasing demand for variety and cost control by the market of renters and home buyers. The manufacturing, supply chain, construction and design sectors are readjusting accordingly.

Various government ministries promote projects and studies to understand these developments. For instance, a recent 32 page publication from the Ministry of Housing and the Environment called "Flexible Housing" discusses five projects and lists product manufacturers, designers and builders associated with them. In addition, The Netherlands Industrialized Building Foundation was formed in 1988. It is a joint venture between industry, designers and architects. It has published a book called Booosting in Business: 35 profiles of designers, developers and entrepreneurs in building construction. (the three o's stand for design, development and research in Dutch) There are a number of other private sector organizations and ministries stimulating and conducting research and development activities in building innovation.

General contractors have found that they are losing share of project construction revenues to snbcontractors, and subcontractors are loosing share to product manufacturers. Profits are shifting "upstream" along the value chain, presenting interesting challenges to product designers, as well as interior designers and architects. As building product manufacturers move to "time-based manufacturing" (as Wiremold is in the US, with short cycle time which is demand based) direct links are now possible between customers and manufacturers, eliminating many conventional steps, services and companies. This allows projects to be organized much more closely to individual end-user preferences. It also changes the relationships between all the parties in construction and development processes, including the roles of the various design and management professions.

Everyone is competing for consumer's increased discretionary spending. The central governments are almost uniformly withdrawing from taking initiative in research and project stimulation in western Europe. The idea in the building related industries is increasingly to stimulate households to spend for their houses at a level equal to their spending on vacations and SONY AV equipment.

Further, the renovation market in the Netherlands and Europe is now growing very fast. The question now is how to prepare the existing residential stock for the next 50 years of economic use, when change in user needs will not be less than in the recent past. The issue is how to increase the efficiency of renovation in the face of increased demands for variety and consumer choice, a scarcity of labor (skilled or otherwise), and the need for more adaptability in later years of building project's life cycles.

It is clear that Open Building is just one development among many in the general movement toward closer alignment of product manufacturing and construction projects. With the support of computers, flexible manufacturing, design for assembly, the concept of systems disentanglement, and other similar innovations, it is now possible to produce high value added products in off-site facilities, tailored exactly for rapid installation to meet end nser preferences, rather than mass-produced parts for anonymous markets.

Work serving building projects is increasingly shifting to off-site locations. The Open Building approach is one way to organize this shift. Its advantage is that it recognizes that buildings are inherently located on a site, and that a certain portion of the building must be controlled in light of the community interests at the site. On the other hand, the more personal "infill" parts of buildings, less tied to the local situation and more changeable, can be industrially produced to advantage, and can be tied less to the local community interests and more to the responsibility of the individual user as items of personal property or equipment.

The final note of interest is that the European market in design, manufacturing and construction is fast consolidating, but remains subject to diverse local and national customs and traditions. Sorting out what is generally applicable and what is inherently local is at the root of the shifts in the building industry in the European context. It is a microcosm of similar movements internationally and is thus an interesting part of the world to observe and study carefully for lessons the US industry can draw upon to its advantage.

Implications for the Design Professions

Open Building will have positive consequences for the design professions. It explicitly formulates and provides a methodological basis for a scope of work that includes the direct interior environment - interior construction and FF&E - as well as the basic architecture of large buildings. It also suggests methods for designing building components that support consumer choice and long term asset value, by recognizing that part or set of parts in buildings which changes most frequently. Knowledge about the changeable interiors of buildings is at the core of an increasingly significant part of the future as the incremental adaptation of buildings continues to dominate work in the field or at least equals the value of new construction.

For architectural interests which seem to focus on the longer lasting part of the built environment, especially as it relates to the urban fabric, Open Building provides an important methodological foundation. This neatly sets a context for the increasingly important work of interior designers, who, for their part, can now consciously focus their concerns on the adaptable and changeable interior part of the built environment. In that sense, Open Building defines and provides direction for an expanded role for the interior design profession and also is an important formulation for an open architecture.

In this case, a number of tasks, skills, methods and roles become clearer for all professionals. Interior designers can be useful participants in design teams by evaluating the capacity of proposed base buildings. Product designers can be instrumental in supporting the design of new interior systems suited to end users - and to future adaptation in residential, hospitals, office buildings or retail facilities. And architects can continue their traditional role in artfully guiding clients in the determination of base buildings that respect both new technical opportunities and necessities, and their environmental and historical contexts.

The "fit-out" level of residential projects, as it is being developed in Japan and the Netherlands, constitutes a very substantial percentage of total building costs, both initially and in the long term. The ability to defer the investment in this percentage until unit contracts are determined increases the leverage of the developer in meeting changes in the market, and changes in occupant preferences. This is a valuable marketing tool, but is also an important way to reduce risk in project development. If the "fit-out" for a unit is not determined until the owner or occupant is known, the problem of units that will not sell or rent is virtually eliminated. The ability of professional knowledge-in-practice to support these economic priorities will be an advantage as roles continue to be reconfigured.

Open Building as a Basis for Research in Product and Project Design and Construction

The principles of Open Building offer a structure for research linked closely to advanced practices in the manufacturing industry. Because no one party can control everything in complex projects, despite the desire on the part of some to do so, improved methods are needed for distributing design work, and then coordinating it. This need is present at all levels of design, from products to projects. Implicit in the Open Building approach is the theory of levels, articulated by Habraken and already used in practice although in largely implicit ways. The principle in brief is that the built environment is organized in such a way that a change at one level forces adjustment at the next lower level, but that a change at the lower level can be made without effecting change at the higher level. Retail and office building projects follow this principle. It is also the relationship between interior construction (a higher level) and FF&E (a lower level), and between the urban tissue and buildings. The further articulation of this paradigm for design research and practice is now called for. This work will certainly be forthcoming in coming years, given the directions already emerging among the various professions involved in shaping the built environment.

Open Building as a Basis for Development of Advanced Practice in the Building Industry:

As Open Building is adopted, changes in building industry activity can be expected in the following areas:

> opportunities for advances in TQM at all levels of building product manufacturing and construction;
> reduced risk to lenders because of deferred decisions and investments;
> new opportunities for technology and process transfer between residential and commerical sectors;
> development of a new industry and supply constellations dedicated to interior-fit-out production, installation, and servicing;
> increased consumer choice; orientation of discretionary spending to building related activities;
> new opportnities for professional training in job skills related to fit-out installation;
> streamlined approval processes without jeopardizing legitimate health and safety concerns;

Dissemination of Information on Open Building in North America

Open Building represents a beneficial way of thinking and practice in the fields of product and project design and production. Based on this, a number of information dissemination activities have been organized in the past year, and others are currently underway.

A two day national workshop was held in January, 1994, hosted by Armstrong World Industries at their Innovation Center in Lancaster, Pennsylvania. It was attended by 50 individuals representing architectural, interior design, product manufacturing organizations, development, banking and regulatory interests, and representatives of the US Department of Housing and Urban Development, as well as the United Brothers of Carpenters and Joiners union. Presentations were made by Japanese and Dutch professionals active in their respective countries, working to commercialize Infill Systems and design Open Building projects.

Based on the level of interest generated at this workshop, a second was organized in May, 1994 in Washington, DC. This workshop was hosted by the Office of Housing Research at Fannie Mae. More than 40 people came, representing a similar spectrum of interests.

Additional workshops and study trips to Europe and Japan are planned. A non-profit educational and research institute is being formed to foster studies and educational activities for a broader public understanding of Open Building and other approaches to improving the quality of the built environment.

Acknowledgments

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NEXT21 in the Open Building Perspective

N. John Habraken

A Three Dimensional Neighborhood

The NEXT21 project does not look like a building. It is more like a small, three dimensional neighborhood. Coming from the street one can walk a public path through the entire structure, from floor to floor crossing a bridge halfway over the common garden below, until one ends up at the roof garden. In this walk one experiences all elements of a true neighborhood: the public path, the houses, their private gardens and the small public park. As in any good neighborhood one can walk through it in different ways, to come down, eventually, on the other side of the building, entering again the city streets.

This continuity of the urban space inside the building is the logical result of the design process that was followed: two groups of architects each operated on a different level. First there is the team that makes the support structure, creating a three dimensional urban framework. Next there are individual architects designing individual houses inside the framework. This hierarchical organization of the design task produces a unique architecture: a natural variety without the monotonous repetition of windows and balconies so typical for apartment buildings. The result is not unlike the variety of forms we find in a small village where all houses are individual but, at the same time, part of a larger whole and made in the same materials, following similar rules.

However, NEXT21 is not a romantic return to the past. On the contrary, it shows how the correct use of today's technology can enrich and humanize the new urban environment.

A Unique Team

The NEXT21 project represents a fundamentally new way of thinking that is best known as the Open Building approach. Open Building advocates the independence of subsystems in buildings and the distinction of the Support level from the Infill level. Fundamental principles like that take a long time to grow, involving many people and many experiments. The Open Building movement has been under way for decades and is steadily gaining momentum. It is truly international in that it takes place in different countries at the same time, following the initiative of different parties, involving designers, builders, developers, and manufacturers.

For many years already both leaders of the NEXT21 project, professor Yositika Utida and professor Kazuo Tatsumi, each in their own way, have been major contributors to the Open Building experimentation. Therefore the true significance of the NEXT21 project can best be understood in the Open Building context. This allows us to see exactly why it is such an important project.

The team that made this project was uniquely qualified for the ambitious task. Not only do we find a remarkable number of experts working together, but there was also a client—the Osaka Gas Company—willing to make a long term investment and eager to solicit the cooperation of the best qualified people in the country. The knowledge and experience of professor Utida is well known. For many years he has played a leading role in all nationwide programs of systems development. His experience, combined with his remarkable ability to lead other, equally gifted designers, methodologists and technologists, made him by far the best person to guide and coordinate such a difficult project. The basic idea of the separation of the general structure from the individual houses has already been advanced by professor Tatsumi for many years under the name of 'Two Step Housing'. In the course of time, professor Tastumi, in close cooperation with professor Mitsuo Takada, has conducted a number of experimental buildings. They have now combined their experience with the Open Building leadership of Utida in the full scale demonstration of NEXT21.

The Architect's Role

NEXT21 is the first Open Building Project where different architects operate on different levels. For more than two decades now Support/Infill projects have been done. Their major goal was to offer user participation.Usually the designer of the support would help the occupants to find the best response to their needs. Now, in NEXT21, design responsibility for the infill houses has been delegated to a number of individual architects who were not involved with the support design. Thus, for the first time we have a demonstration of professional architecture on separate levels: the level of the Support and the level of the Infill. This is a very important step in the Open Building movement because it shows the full potential for a new architecture and a new urban design. Now we can see how developers can draw on the services of architects in separate stages of a project. It also opens a new way of architectural thinking, rejecting the idea of the big monolithic building,introducing true three dimensional urban design.

Individual Identity

In terms of technical systems the NEXT21 project is the first Open Building project I know that offers an independent facade system. As many projects in various countries already have demonstrated, it is quite possible to make good internal variation without expressing it in the exterior. In history the expression of the individual dwelling unit to the outside always was a cultural question more than a technical one. Some cultures like to show individual facades, others do not. But in the Open Building experiments full external variation has always been avoided for technical reasons. Now, the NEXT21 project has a brilliantly conceived facade system that allows the change of the panels to be done from the inside, without the need for scaffolding. It makes the facade a truly independent system on the infill level. The resulting external variation is convincing. We find overall coherence combined with small scale variety. The idea of a three dimensional neighborhood is very clearly expressed in this way. From now on the variable facade is no longer a technical issue, but an architectural one.

Methodological Principles

The internal flexibility of the NEXT21 project is achieved by normal finishing technology. It was a wise decision to use conventional ways of making the houses inside. This assured the high quality of the detailing by the individual architects, and also allowed for the free choice of materials and components available on the open market.

The most difficult problem with internal flexibility always lies with the organization of the many cables and conduits that come with modern houses. In Europe specialized infill systems, offering new ways for the deployment of all these conduits, are now entering the market. Development of new infill technology takes many years and cannot be done on the basis of a single experimental building. The NEXT21 project therefore uses available conduit technology, but this does not make the design task easier. On the contrary, to organize all these pipes and cables without conflict, in combination with the deployment of internal partitioning and the equipment for bathrooms and kitchens, posed a very difficult methodological problem. The NEXT21 design team has confronted this problem in a sophisticated way. By doing so they have expanded our knowledge about the use of coordinating grids and zoning. Based on the careful studies of professor Seiichi Fukao, in close cooperation with Shinichi Chikazumi of Shu-Koh-Sha Design Studio, coordinating grids on several levels, closely interrelated, organize the design of all the subsystems. I believe this methodological aspect of the NEXT21 project should be studied carefully by all who want to follow this way of working.

The Way to Go

Many other important aspects of the NEXT21 project can not be mentioned in the available space. But these few remarks may be sufficient to show why NEXT21 is presently the most important demonstration of both the general principle of Open Building, and the more specific principle of Support/Infill separation. Immediate commercial application was not the objective. We already know from developments elsewhere that the Support/Infill distinction can have economic advantages and can be implemented in a commercial way. NEXT21 has a different goal. It demonstrates, more clearly than any other project so far, a new way of making urban architecture. It also demonstrates the methodological principles that make this new way possible. Therefore NEXT21 shows a better way to design high density environments: combining the dignity and freedom of the individual dweller with the coherence and permanence of the urban neighborhood. This is the most important goal of the Open Building approach.

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American Institute of Architects
College of Fellows Grants Program
for

Documentation of Open Building in Japan and China

Next 21, Osaka

Dr. Stephen Kendall

January, 1995

Selected Open Building Projects in the Netherlands

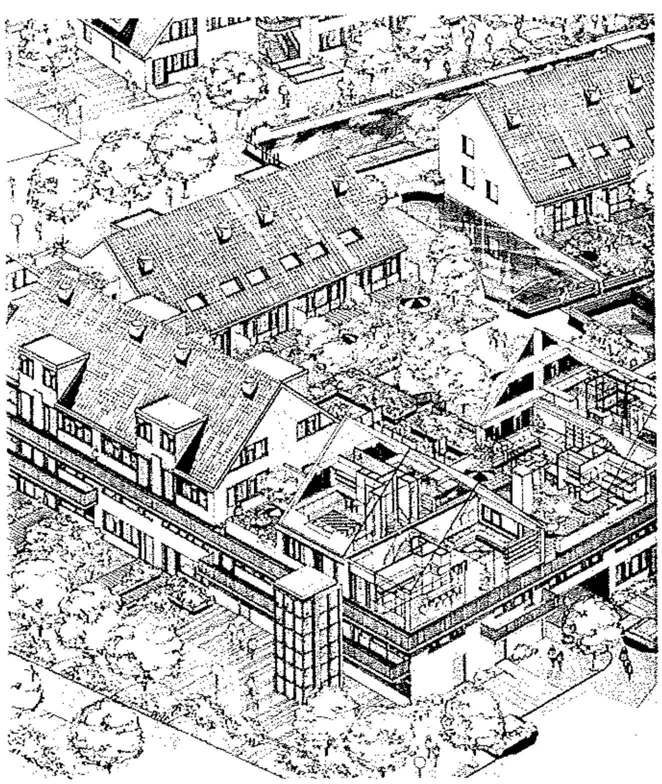
New Construction

More than 1000 units of housing following Open Building principles have been built in the Netherlands, designed by a number of architectural firms. The principle innovation has been the reorganization of the decision making process. Conventional building types have been used, including row houses and housing organized around courtyards. Ordinary technology was used in most cases, including concrete base building construction, prefabricated facade panels faced with brick veneer, and ordinary interior construction and mechanical systems, organized to match the base building / fit-out distinction which is the basis for Open Building projects. New projects in the planning phase will use advanced interior fit-out systems now in the market.

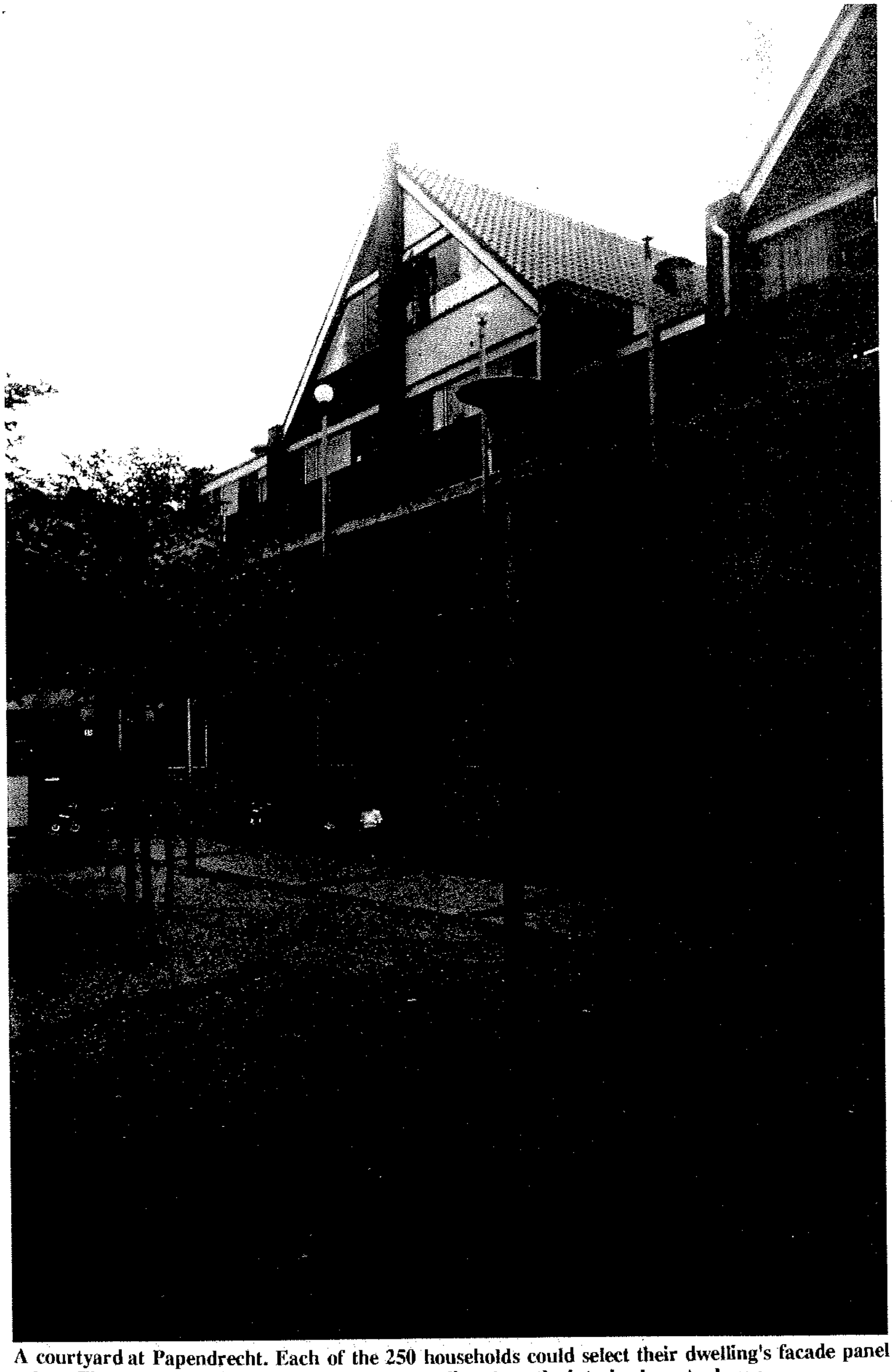
Papendrecht / Lunetten /Keyenburg

(1977) (1982) (1984)

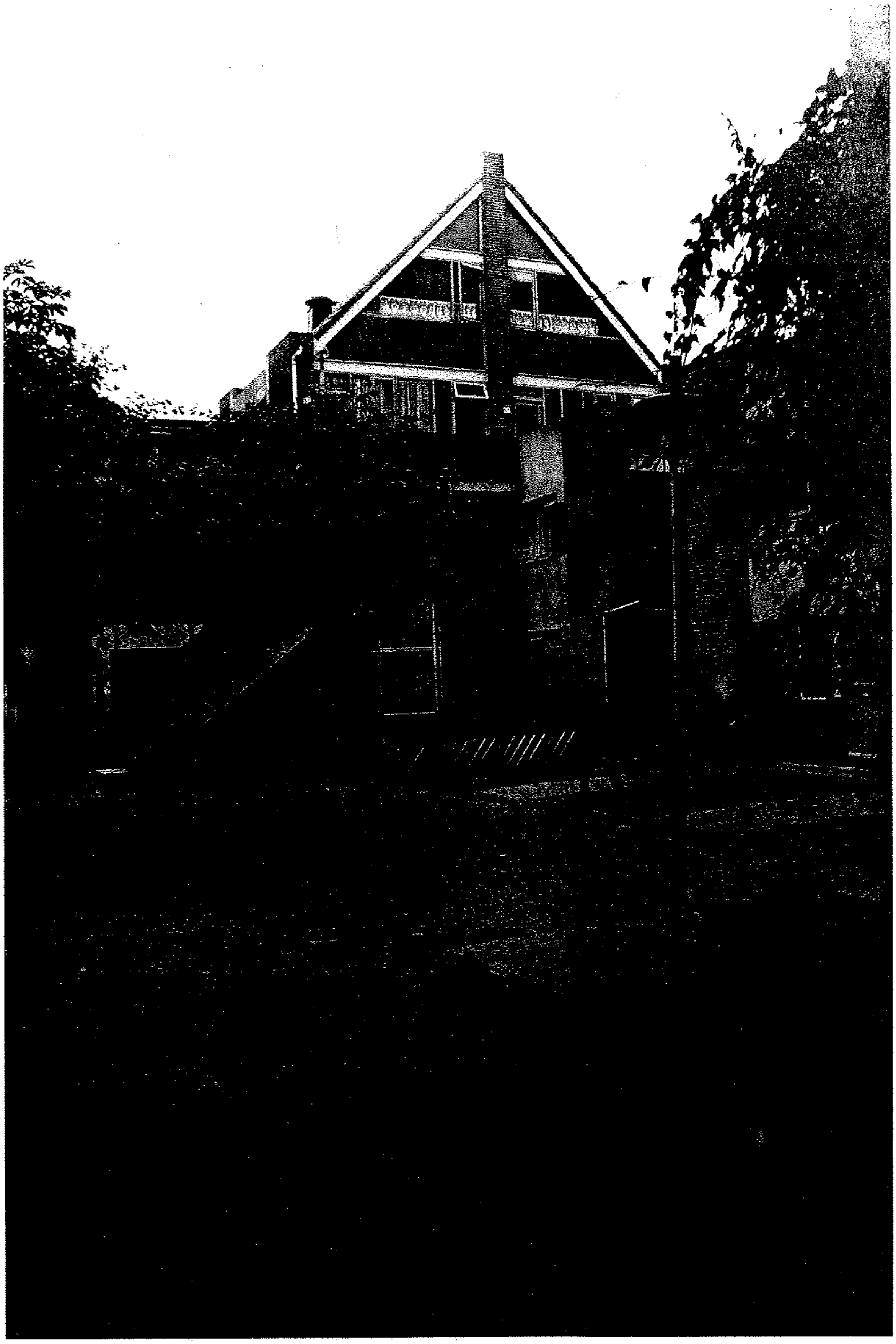
Frans van der Werf, Architect



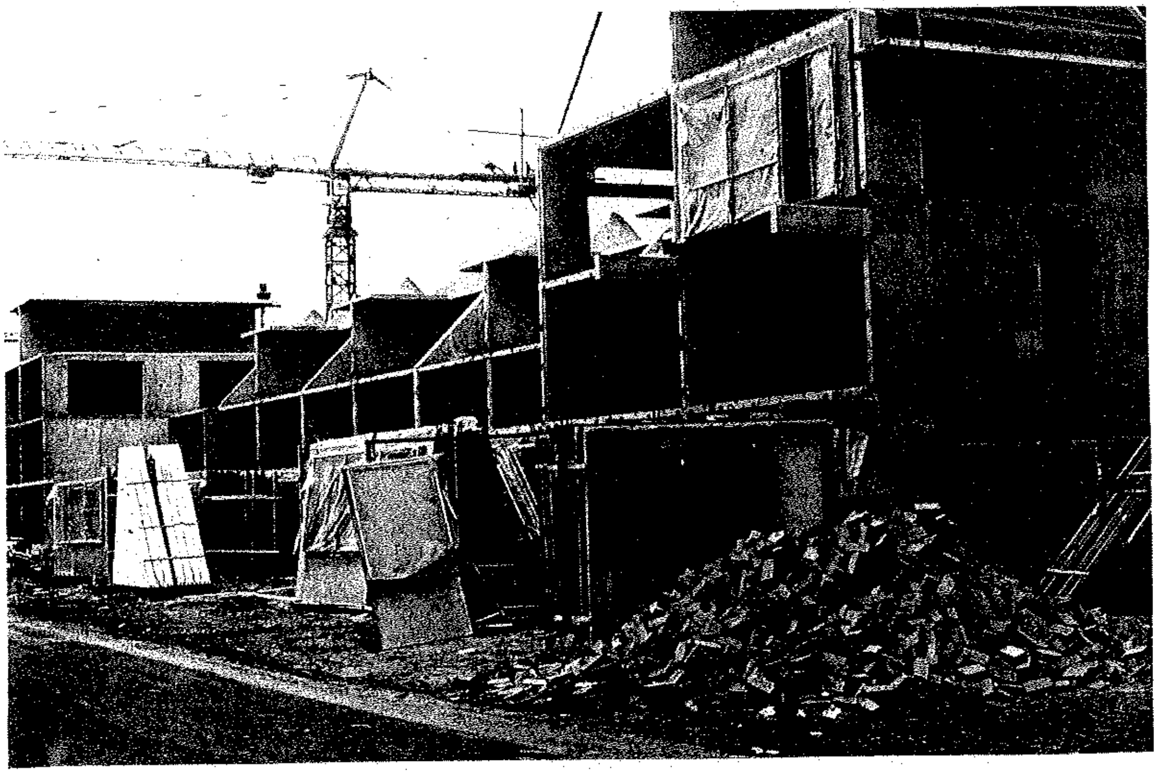
Molenvliet, Papendrecht, the Netherlands, 1977.



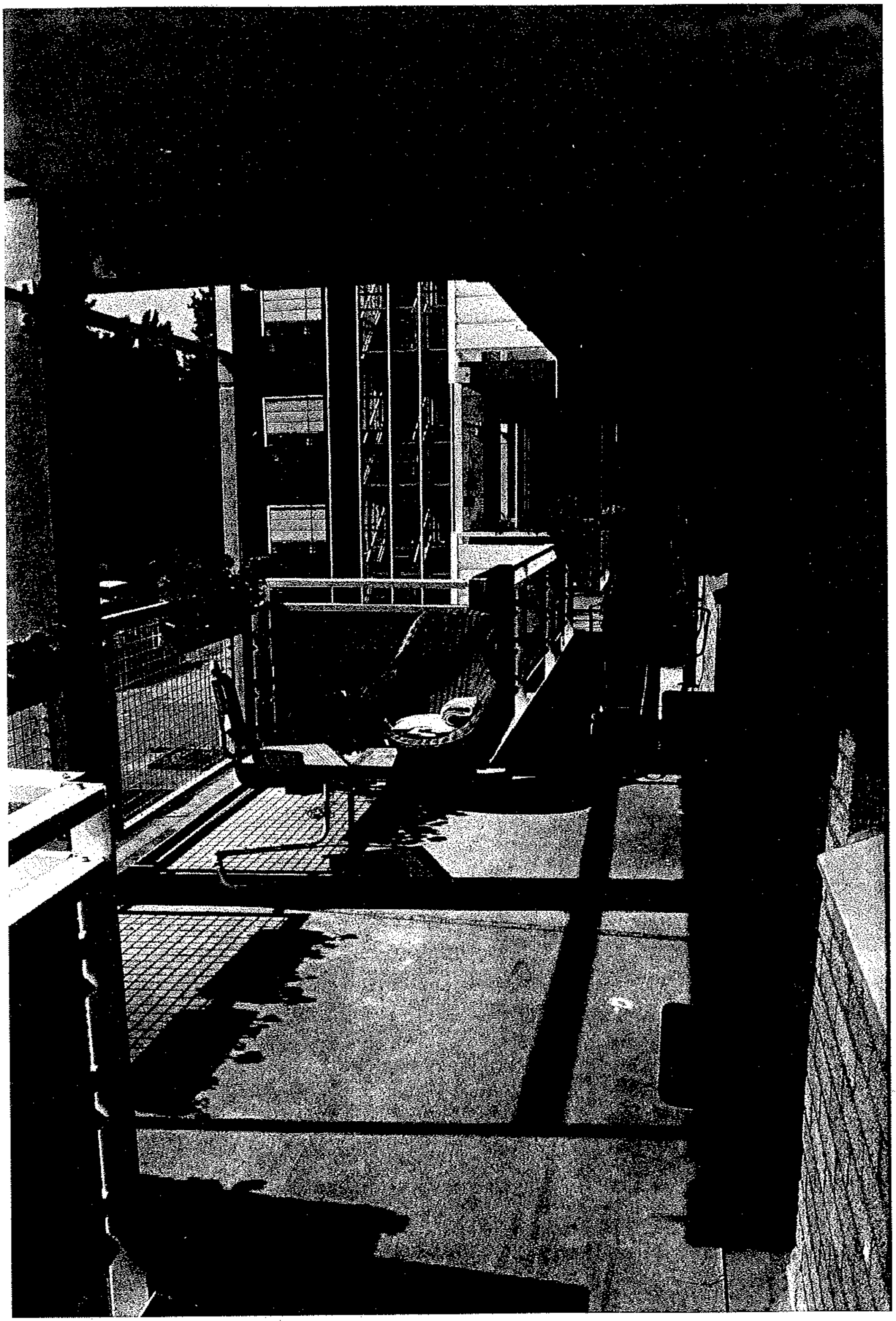
A courtyard at Papendrecht. Each of the 250 households could select their dwelling's facade panel colors. The pattern of windows and doors relates directly to the interior layouts chosen.



Papendrecht. Uses are mixed; located in this courtyard are dwellings of various sizes and layouts, a doctor's office and a small shop for motorcycle parts.

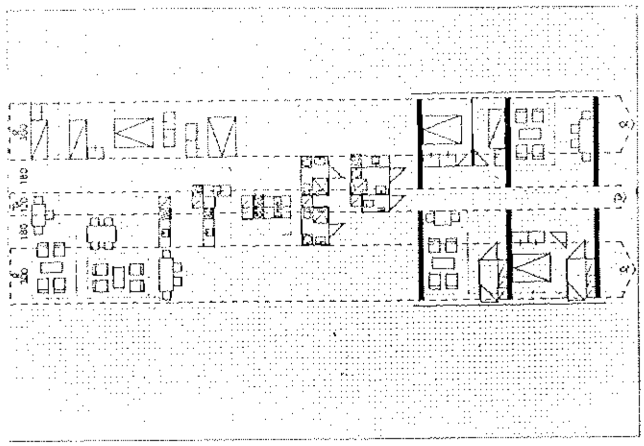


The base building of the project in Lunetten, near Utrecht. Tunnel forms, placed and repositioned by crane, make the construction efficient and accnrate. Because virtnally no piping or conduit is in the concrete pour, the work goes fast. Prefabricated exterior wall panels are craned into place. After the bnilding is enclosed, interior fit-out is installed, one unit-at-a-time. Some dwellings occupy two, some three floors, others occupy two adjacent bays. Some larger units are occupied by groups of 6 or more students attending a nearby University. Architect: Woerkgroep KOKON

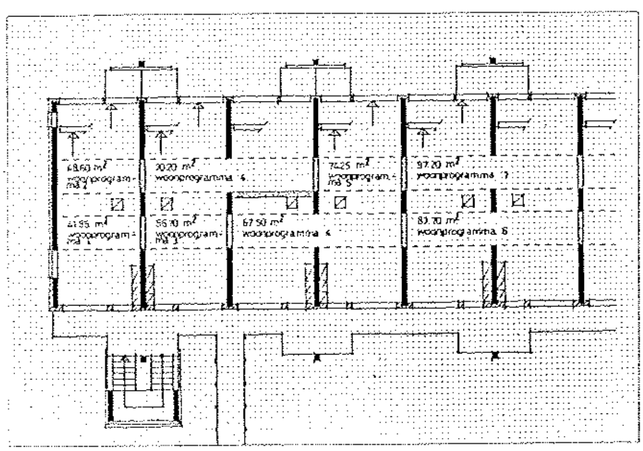


The access balcony and porch of an Open Building project in Keyenburg, an inner suburb of Rotterdam. Architect: Frans van der Werf

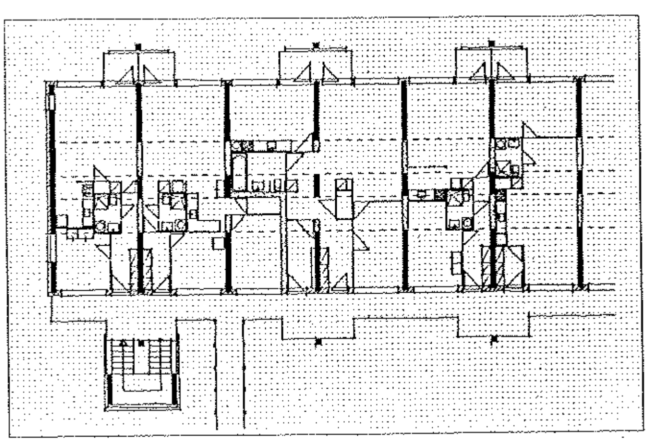
The design process for the Keyenburg project.



The method of evaluating the "CAPACITY" of the proposed base building before it is constructed.



A diagram of part of the base building indicating the range of unit sizes possible. The small square in each bay is the vertical plumbing stack.



The dwelling layouts which were actually fitted-out in one part of the building. None of the 152 units is alike. Elderly and handicapped access units occupy the ground level, along with shops and community spaces.

Selected Open Building Projects in the Netherlands

Renovation

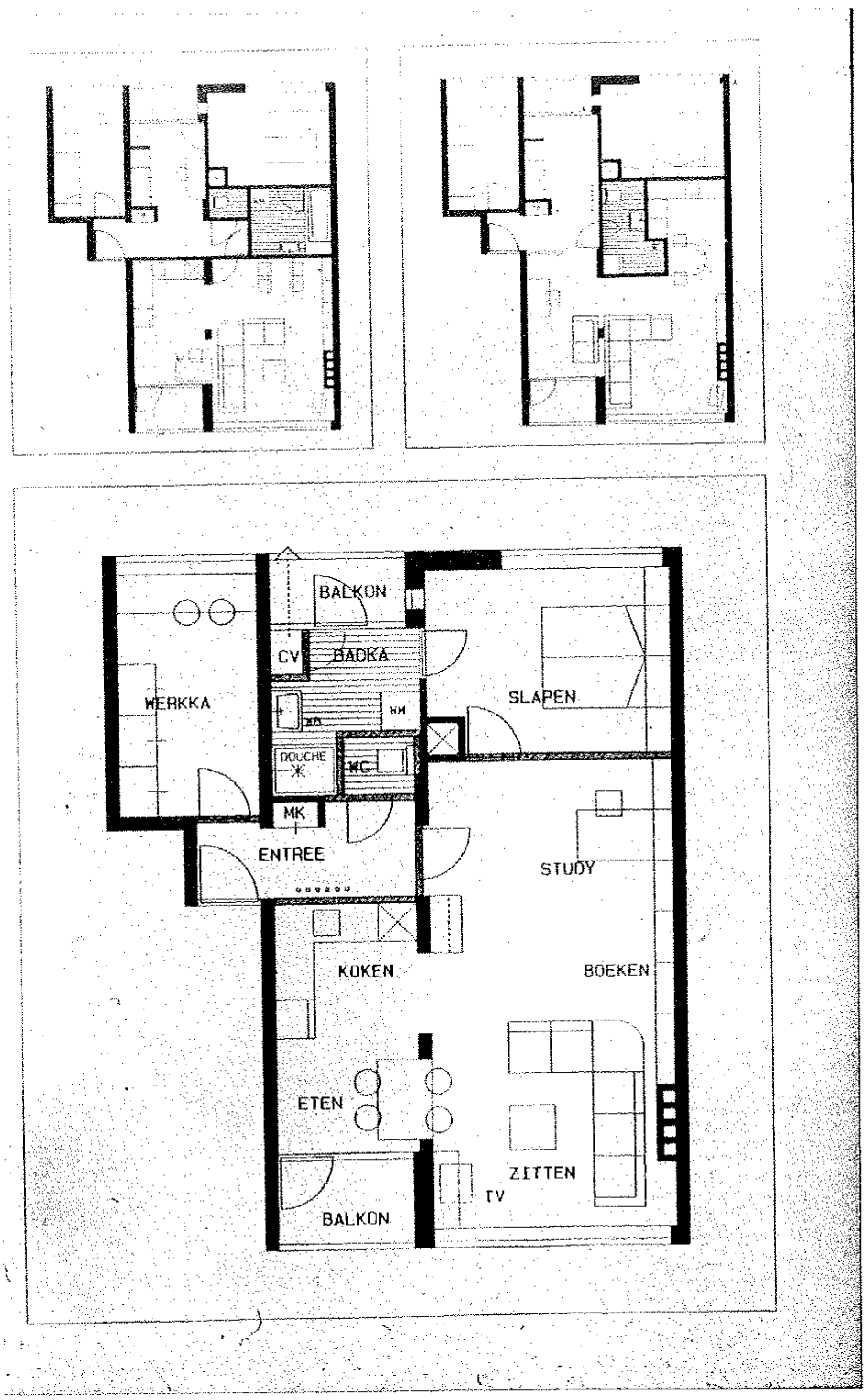
Open Building projects are also being realized currently in the renovation of obsolete multifamily buildings. These projects are taking advantage of the introduction of commercially available residential infill or fit-out systems, making it possible to renovate large buildings on a unit-by-unit basis as needed. Two systems are in the market: the "Interlevel" system, and the "Matura" system. The concept of incremental dwelling unit improvement is being matched in some cases by renovation of the base building level, including public circulation and accommodations, mechanical systems, and facades. These fit-out systems are being used because they offer a more economical and predictable way of organizing the renovation process.

Voorburg

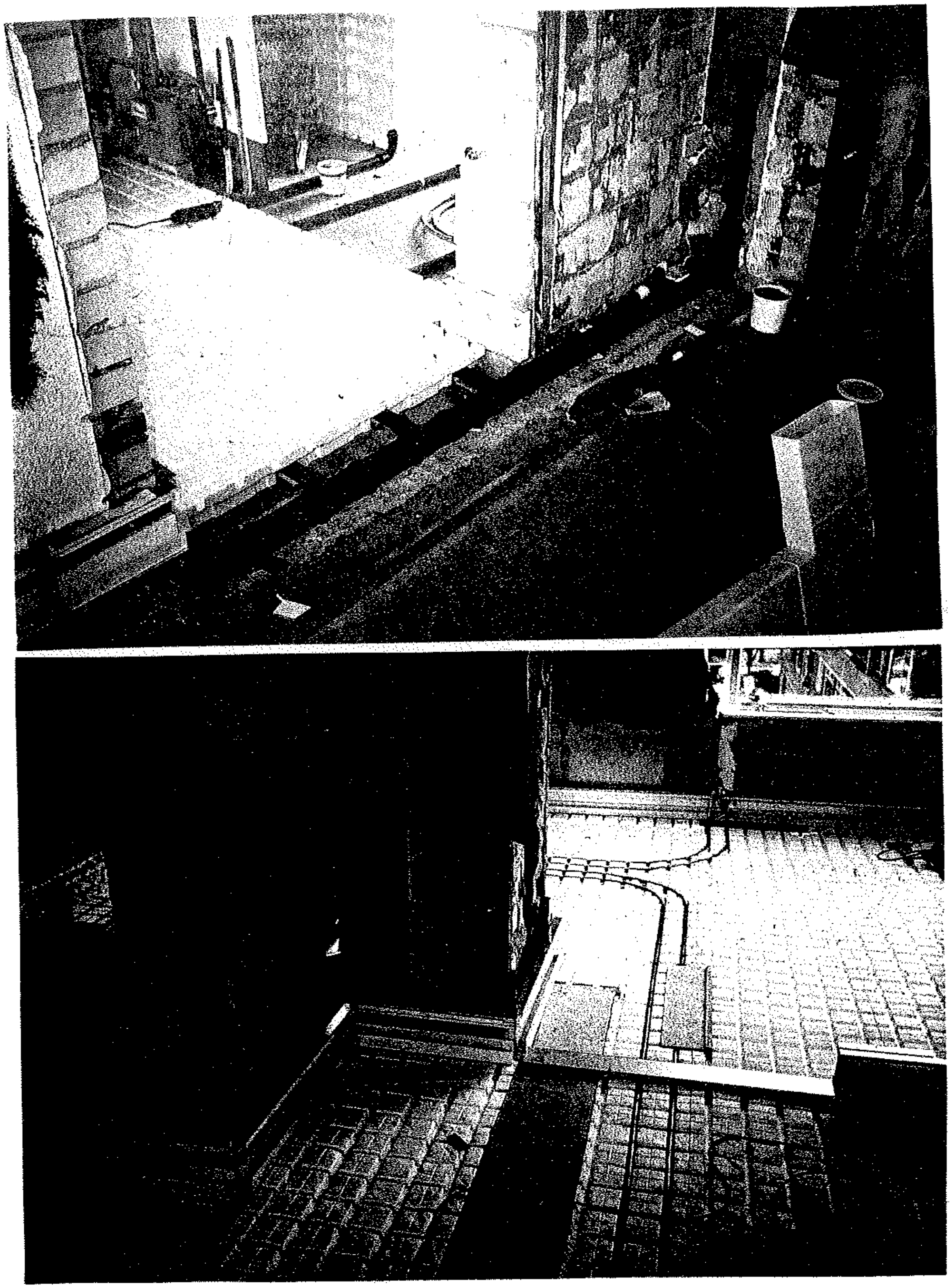
Henk Reijenja, Architect

One block in housing association's project in Voorburg, the Netherlands. Built in the 1960's, all units are uniform and lack amenities demanded in the market. The association is loosing tenants, and decided to upgrade using the Open Building approach. Several units were fitted-out in 1990, prior to the base building renovation.

The Voorburg project showing the renovated base bnilding, with new, enlarged balconies and stair, a new elevator at each stair hall, and new efficiency units facing the street on the ground. Architect: Henk Reijenga



Three dwelling unit layout options to replace the uniform plan. In one case, the plan shown in the larger drawing was installed for a young couple. An elderly couple in the unit downstairs selected the plan illustrated in the upper right, and spent a large sum of their own funds on an upgraded kitchen. The elapsed time between gutting the old unit and move-in to the new unit was one month. This time has been reduced in the recent installations, which continue one-at-a-time.



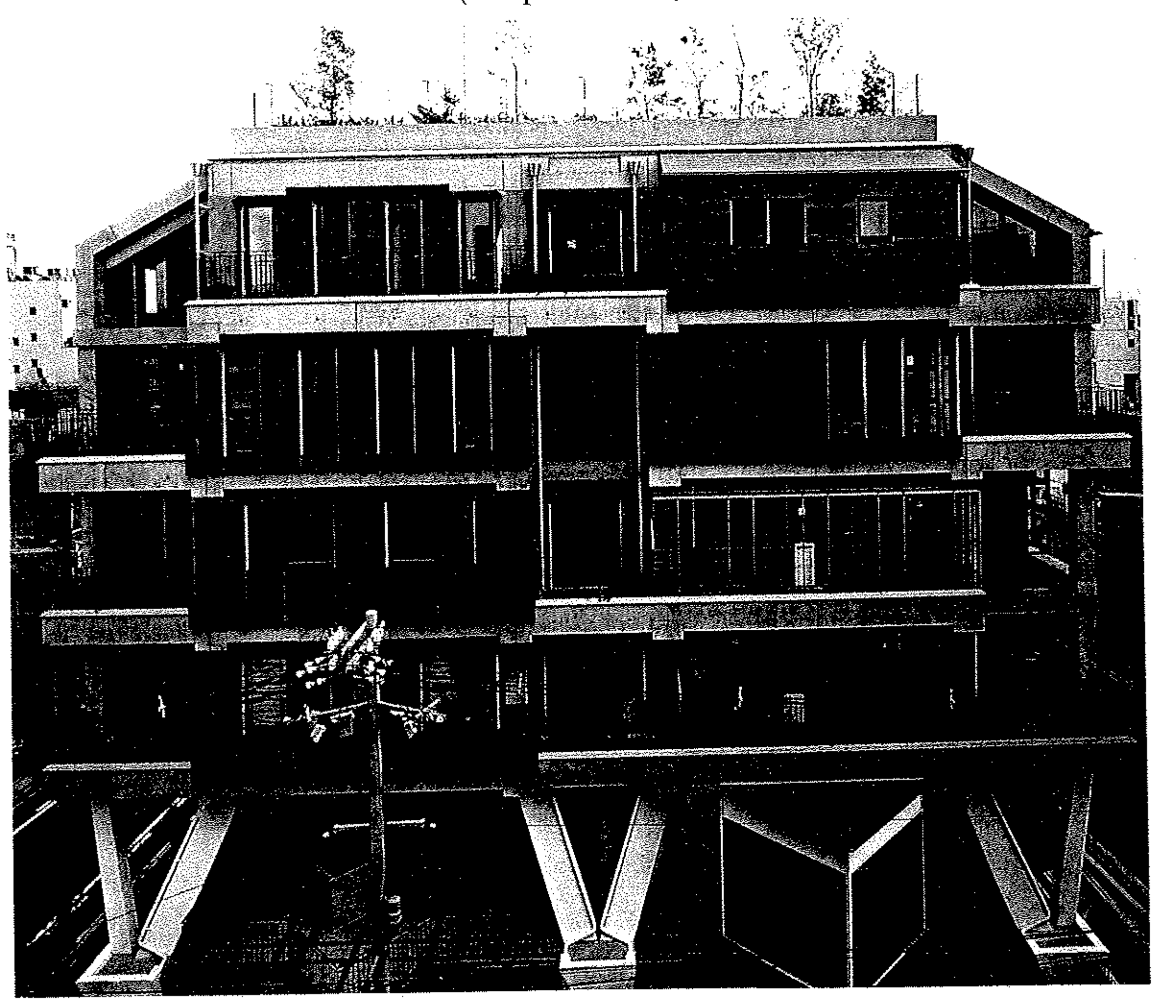
The installation of the fit-out system in the Voorburg renovation scheme, provided by Matura, Inc. Shown here are the floor element in which horizontal piping and some ducts are positioned and the partition base in which cabling is located behind a removable baseboard cover. This work is followed by the installation of the upper portion, including walls, cabinets, fixtures and finishes. The finished unit, which took 10 days to complete following demolition clean-up, is normal in appearance, but is tailored to the household's preferences in layout, color, finishes, and style.

Open Building in Japan

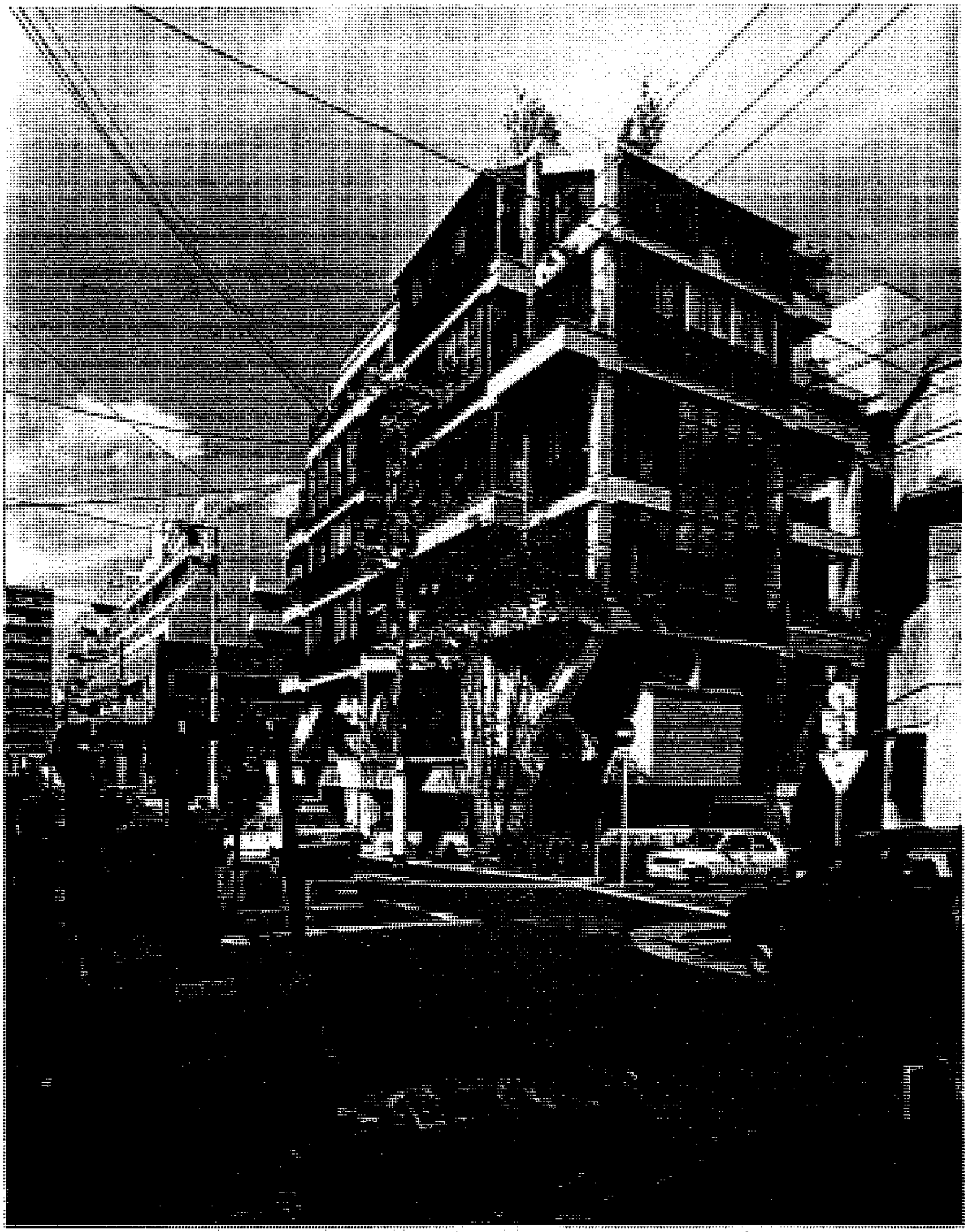
Hundreds of units of housing following Open Building principles have been built in Japan over the past decade, both with experimental funding from various governmental agencies, and in the market. Various parties have been instrumental in moving the concept into reality, including architects, university research groups, private developers and construction companies, product manufacturers, and government and quasi-government agencies and organizations. Major national competitions have stimulated the development of Open Building innovations.

NEXT 21

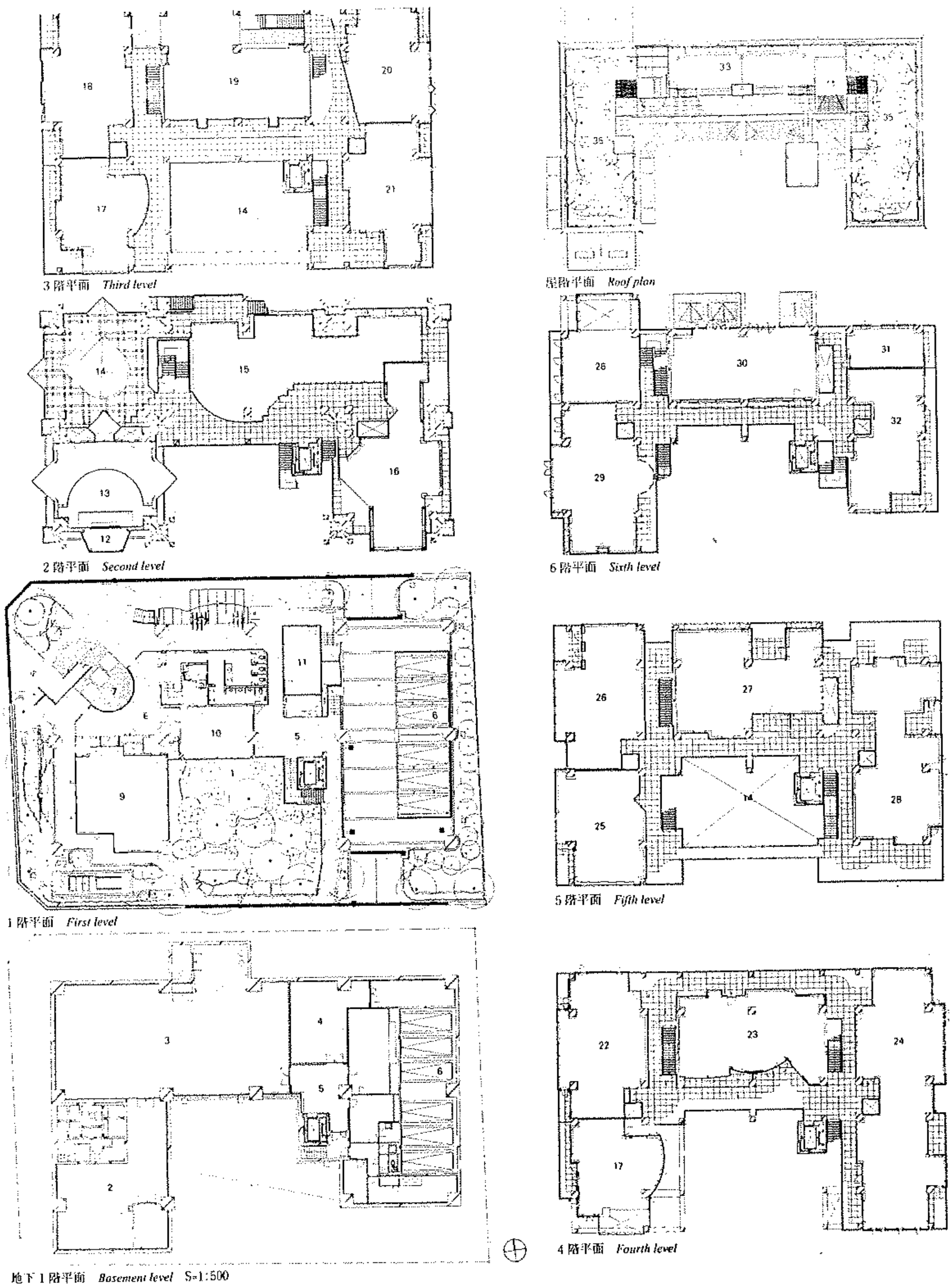
Yositika Utida and SHU-KOH-SHA Architectural and Urban Design Studio, Coordinating Architects; Sponored by Osaka Gas
(completed 1994)



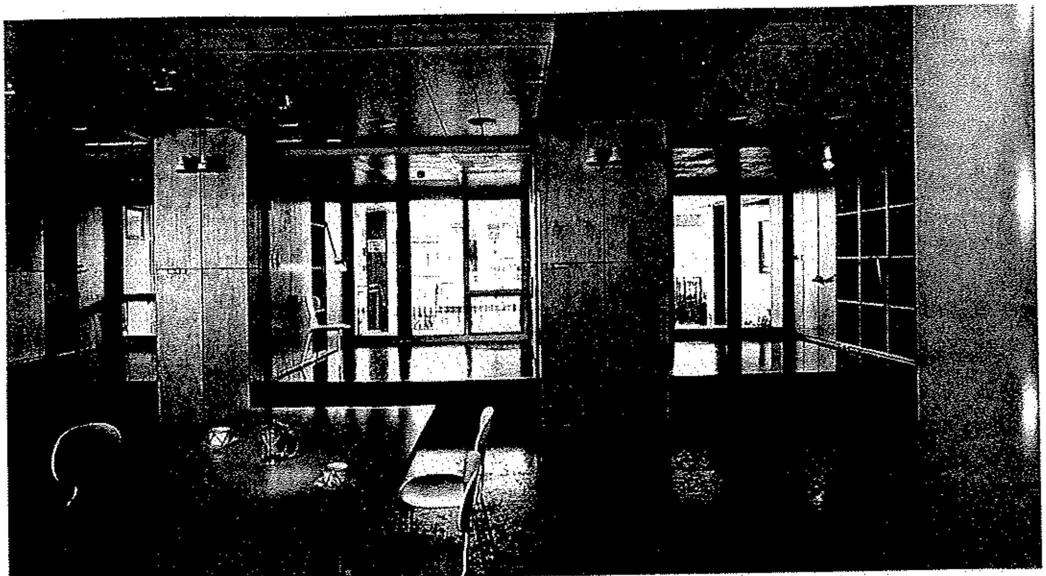
This shows one facade of NEXT 21, each dwelling using the same kit-of-parts differently.



NEXT 21, sbowing the fonr levels of dwellings above the base contaiuing shops, a nature center, and the display and meetiug rooms of the Osaka Gas Company, sponsor of the project.



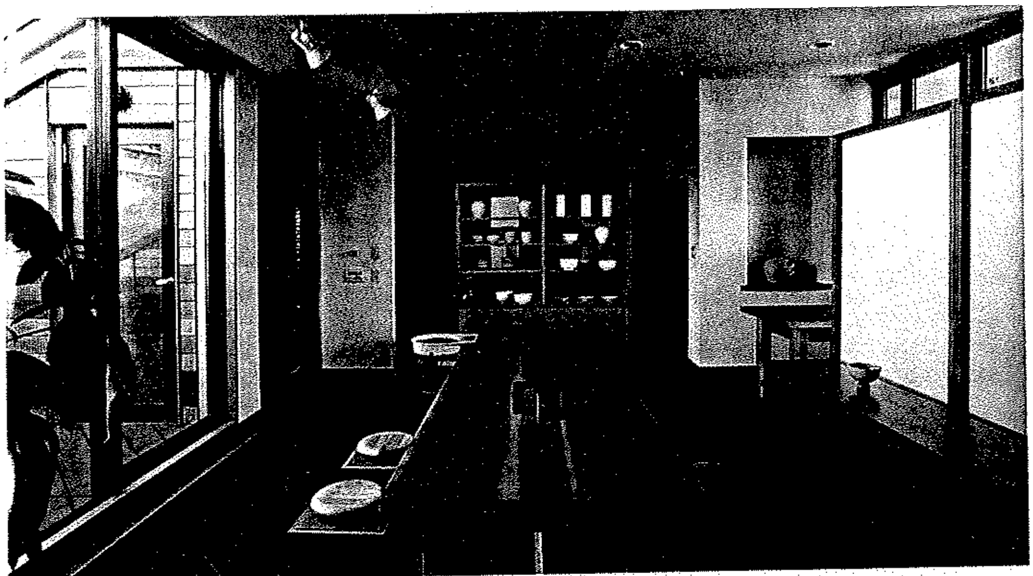
The eight levels of NEXT 21. The basement holds the energy systems. The roof is a garden.



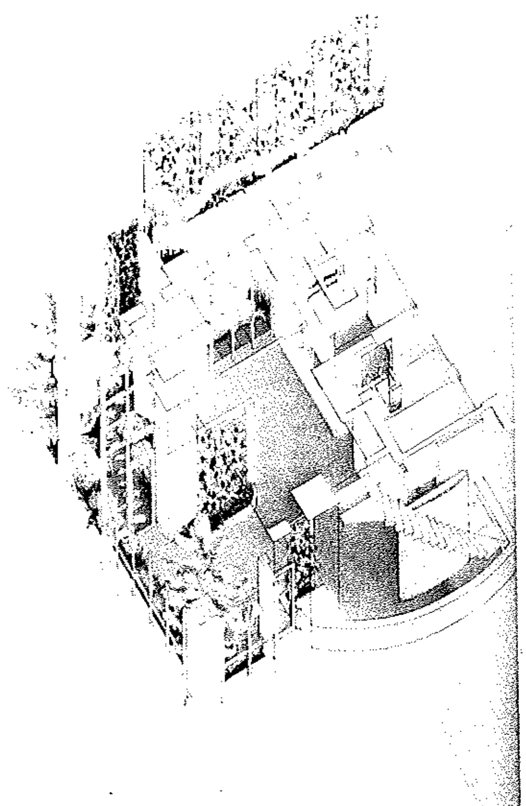
303の室内(スペースA)よりスペースBを通して屋外を見る

504の北側の庭

Views of an interior and several gardens on the third and fourth levels in NEXT 21.



4 503の室内



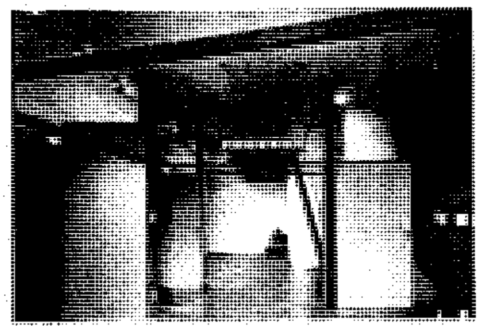
作画：小倉康正

5 301の植栽のある南側吹抜

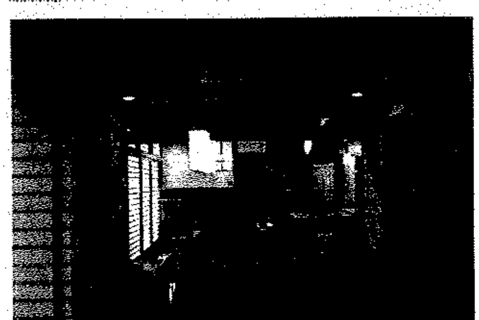
301

Views of interiors of dwellings in NEXT 21

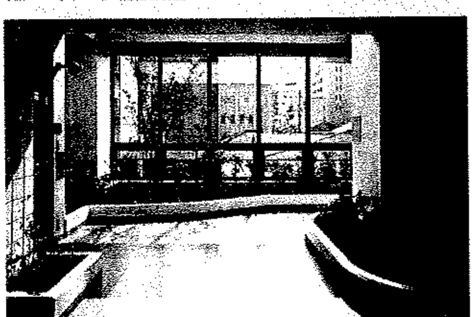
[102] *House with work space*



[103] *Harmony house*

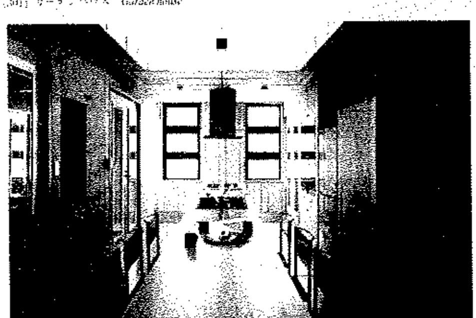


[104] *House for a family of three generations*

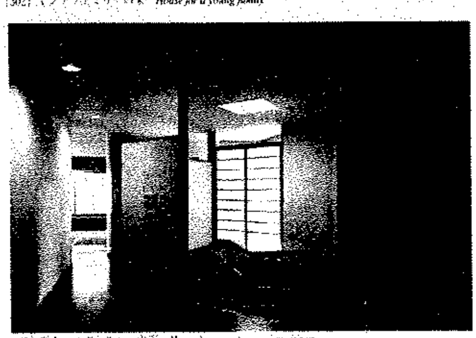


[301] *Garden house*

[302] *House for a young family*



[303] *House for unconventional family*



[305] *House for an active senior citizen*

Thirteen architects designed the 18 individual dwellings in NEXT 21.

Open Building in China

Serious efforts in China began with an experimental project designed by Professor Jia-sheng Bao in Wu Xi in 1985. More projects followed. Other activity to develop fit-out systems is being carried out by Mr. Zhang Qinnan, an architect in Beijing, Vice President of the Architectural Society of China (counterpart of the AIA) and Council Member of the Science and Technology Council of the Ministry of Construction. His research group has developed model units in three different cities and the published a Handbook on Open Building Design in paper and multimedia disk formats.

The Open Building project in Wu Xi. Architect: Jia-sheng Bao

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THE POTENTIAL FOR RESIDENTIAL OPEN BUILDING IN THE UNITED STATES

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ABSTRACT: Adoption of Open Building in the United States housing industry can occur in the coming decade, based on experience in office and retail construction which already operate with an "INFILL" or "FIT-OUT" level. Conventional housing construction and renovation face technical and management problems caused by severe systems entanglement, leading to increased conflict, lower quality, and reduced capacity for long-term adaptability. The paper reports on developments in the US that set the stage for adoption of Open Building in the housing industry.

1. SUMMARY OF OPEN BUILDING PRINCIPLES

- First, systems are separated on two levels: the "base building" or "support, and the "fit-out" or the "infill". Each is independent in its design and construction. This is aside from whether one company makes all the parts or the parts come from many suppliers.
- The "support" or "base building" level allows standardization of basic construction: this does not lead to uniformity because the infill will be different for each unit. Here is the advantage of large scale building projects.
- The "infill" or "fit-out" level lends itself to advanced prefabrication and rapid on-site installation by means of computer controlled processes.
- On both levels, continued development of improved subsystems is possible. Each subsystem is made out of industrially manufactured parts that allow for mass production because they can be used everywhere in any project.
- On the "fit-out" level, subsystems are, for instance, wall panels, door frames and doors, kitchens, bathroom , heating, cooling and electrical equipment and all kinds of conduits, pipes and cables. Parts of the facade may also be included, such as windows.
- To use all of these subsystems on both levels in the most efficient manner, Open Building advocates all possible steps that encourage the development and coordination of subsystems such as performance specifications for subsystems; rules for modular coordination in design; methods of systematic design of buildings including CAD programs that support systematization; emphasis on logistics, organization and prefabrication.

2. CHANGES IN THE US CONSTRUCTION INDUSTRY LEADING TO OPEN BUILDING

The US construction industry is very large. Investment in new building constitutes 10% of a $7 trillion US Gross Domestic Product. Investment in new residential construction last year was $210 billion, while investment in housing renovation and repairs was $115 billion.

The construction industry is highly disaggregated, is dominated by market decisions and is changing, due in part to advances in information technology. Several trends are worth noting.

One of the biggest changes is in the distribution system. It is loosing layers, and those remaining are restructuring. Manufacturers sell direct to retailers. Intermediaries are being eliminated, effecting manufacturers, suppliers, and the design and management professionals.

Second, the construction and building product market is more consumer oriented. Consumers can bypass traditional intermediate organizations such as independent design consultants and suppliers, effecting the construction and housing industries in ways that are not fully understood. Ikea, for example, found that consumers want to participate in "creating value". Their emphasis on good design, instant delivery, and "assemble -it-yourself" products is a result. Another example are the "Home Projects Centers", such as Hechingers and Home Depot. These are very large building products suppliers for the "do-it-yourself" market. Hechinger's employees 20,000 in over 130 stores in 19 states, and had revenue of $2.4 billion last year.

Third, the roles of contractors and subcontractors are changing. An increased volume of the on-site work is done by subcontractors. General contractors are loosing share of the work. But subcontractors also find their positions changing, with the introduction of higher value added manufactured products. They are burdened by obsolete boundaries between trades, causing friction. A new emphasis is placed on teamwork skills rather than competitiveness.

Fourth, there is an increasing variety of specialized materials and component suppliers. Some product manufacturers sell their products installed by their own forces. Currently, this activity is limited to simple products like roofing, roof trusses and windows. The trend is projected to expand. Some materials dealers now organize complete interior fit-out packages for a tenant job and supply them to the remodeler to install.

Fifth, changes in the market for buildings point to changes in the labor force. The US construction industry is facing a labor shortage. There is also a shortage of skilled workers, and industry analysts predict that the problem will get worse. Even with an increase in training programs, the incentives are lacking to attract the present generation of young people, as it was in the past. Now, immigrants are seen as the only large, available labor pool.

Some observers suggest the need for multi-skilled "installers" who can do many kinds of work in teams. Most smaller contractors are "installers". They know how to do every job. Building and apartment maintenance programs are increasing multiskill training through the US Department of Housing and Urban Development and cities around the country. The US Department of Housing and Urban Development recently asked the AFL-CIO Painters Union and Carpenters Union to enter into non-jurisdictional contracts to speed rehabilitation of public housing.

All building trades in the United States, unionized or open shop, are burdened by jurisdictional boundaries that are not well aligned with emerging strategies in the building industry.

Sixth, more knowledge is now embedded in products. Gradually, more complex design and technical decisions are being made farther up the value chain - by the manufacturers. The use of higher value-added products, despite their higher first cost, may result in lower total project costs, because on-site work can be done faster or eliminated. This effects architects and engineers, making their work easier and faster while requiring new roles and knowledge of systems coordination.

In the US, we now are at a threshold. Adjustments in construction management techniques alone no longer produce needed efficiencies. Increased pressures for both variety and efficiency in building require new generations of products and processes to reduce technical interfaces and speed installation and alteration work, using already available products on the market. There is reason to believe that the principles of Open Building offer important answers in how to do this.

3. AN UNRECOGNIZED DEVELOPMENT IN US DESIGN AND CONSTRUCTION

There is a major unrecognized development in US construction practice concerning the introduction of a new level in the built environment. It can be called the FIT-OUT LEVEL. "Base building" and "fit-out" are now common terms in the US industry.

Today, many kinds of non-residential buildings in the US are organized in exactly this way. A "base building" is constructed without determining the configuration or layout of individual territories. These spaces are then "fitted-out" according to the requirements of each. This makes sense because the interiors of such buildings are subject to more rapid change than the buildings they occupy. This reality matches organizational and economic forces at work in society.

Within each of these general levels there are other levels. For example, we have what is called FF&E. This stands for furniture, furnishings and equipment. Components previously classified as interior construction are now found in the FF&E category. Some access floors are an example.

Different contractors may be involved: one general contractor constructs the base building, while completely independent organizations are hired by each tenant to finish its space. Still other contractors are hired later to replace one tenant with another.

Exactly the same thing happens regularly in office buildings, corporate headquarters, and government buildings. Medical centers also follow this model. This has been the convention for years, and is becoming more sophisticated. It constitutes a huge market for design and construction services and for manufactured building systems of all kinds, and is gradually producing two industries, each with its specialized service providers, materials, systems, and construction organizations. This distinction will become more important in the future as more attention is focused on the huge renovation needs of our existing building stock.

This strategy is not first of all a technical development, although technology is involved. It is first of all concerned with new distributions of responsibility in the society and the building industry. This practice has evolved slowly and is now so widespread that its impact is not discussed. This is a problem, because the improvement of this practice depends on its being clearly understood. When this understanding exists, buildings and the building process can be improved, allowing businesses and users to profit in many ways.

4. SIGNS OF BASE BUILDING / FIT-OUT PRACTICE IN THE UNITED STATES

The Design Professions

The clearest result of the introduction of this new level among the design professions is the emergence of the interior design profession in the last decade. An agreement was recently reached between the AIA (the American Institute of Architects) and the largest organizations representing interior designers. Architects may claim responsibility for all aspects of a building design, with their consultants. Licensed interior designers may claim responsibility for the design of the entire building fit-out. This can include non-load-bearing walls, heating and air-conditioning systems, lighting, finishes and furniture. This scope of design decisions constitutes more than half of the cost of many buildings today. Schools of Interior Design now exist to educate people for these new roles.

Construction Organizations

Many construction firms have separate divisions specializing in base building construction and fit-out work. Some specialize only in base building construction. Others organize everything needed to finish a tenant space, bringing together access floors, systems furniture and furnishings, walls, cabling, heating and cooling ducts and equipment from many suppliers. They establish good relations with preferred suppliers who deliver quickly.

Systems Furniture Companies

Large furniture manufacturing companies have begun to study broader roles in providing complete interior fit-out "packages" for large clients. Steelcase North America, for instance, now is well along in the product development of a "slab-to-slab" interior fit-out system. It adds a very low-profile wire management access floor to its existing systems furniture products. In coordination with ceiling providers, Steelcase may soon offer a complete fit-out package.

New building products are being introduced because this distinction between base building and fit-out is the industry convention. This requires better coordination, not integration. US businesses and developers are not interested in complex, closed systems, because they think that their decision flexibility is limited in negotiations about price and quality.

5. THE NEXT STEP: RESIDENTIAL OPEN BUILDING

Retail and office developers in the US have learned the benefits of distinguishing base building from fit-out. The products, services and distribution channels serving these building types are organized to match. After almost 25 years of evolution, many believe that this arena is poised for a second generation of infill systems product development.

Residential developers have yet to see the profit in adopting the Open Building strategy. The reasons for this are complex, and deserve more study. This will change out of necessity. More mechanical sub-systems now appear in residential buildings, and are increasingly entangled. The complexity and the pressures for efficiency and variety are increasing.

The use of advanced fit-out systems will start in residential buildings whose construction is similar to office buildings. But it will eventually become profitable to distinguish two levels of activity even in buildings constructed in the 2x4 tradition. As manufacturers learn how to make higher value added systems that solve on-site problems, they will have to adopt the principles of Open Building in order to manage the complexity. Several forces point in this direction.

First, demographic and social conditions. The population of elderly people with money will increase. Elderly households often have special needs and preferences. The next occupant may have very different preferences, and the financial means to accomplish them. Buildings will have to be adaptable, and builders and designers will have to learn new roles and methods to serve the demand. People are marrying later in life, and have fewer children. More unrelated individuals live together. More young people continue to live at home for a longer time. Units built to suit yesterday's household types will not be suited to today or tomorrow.

Second, patterns of urban growth. Multifamily high-rise housing will remain concentrated in central cities, and will remain a small percentage of total housing production. The fringe cities ringing large US metropolitan regions have ample space for row-house units within reasonable commuting time of jobs. With an increase in telecommuting, distances to work do not matter so much, decreasing the demand for high rise housing. But the demand is for individual choice while also cutting costs and getting more amenities. More efficient building techniques are needed to resolve these apparent conflicts, and to renovate older buildings.

Third, costs. In a calculation of costs of a single family house, the items reasonably placed in the "fit-out" column account for nearly 45% of total house costs, including electrical, plumbing and heating/cooling systems. [3] Land costs are increasing as a % of total costs while construction costs remain temporarily stable, suggesting higher density and more complex development patterns.

Increasing costs of new construction will make rehabilitation more attractive, especially in multi family buildings. The huge bubble of housing built in the 1970's - 25 million units - now face modernization, ranging from "gut-rehab" of the entire interiors, to selective rehabilitation of mechanical systems and finishes, roofs and windows. New strategies are needed to cut costs of modernizing the millions of obsolete multifamily buildings.

The technical problems facing current residential construction. The confused interweaving of systems inside the walls and floor cavities of the traditional 2x4 house building system is a matter of fact. Complex environmental control systems have been added into the technical repertoire for houses only over the past 3 generations. Architectural inventors in the first half of the 20th century tried to solve the problems by "integrating" these systems with the space defining elements of houses. As the number and complexity of these resource systems increased, the problems of integration became overwhelming, both technically and organizationally. The ideal of "integration" could not be matched in practice. [4] This was particularly the case given the highly disaggregated structure of the US economy and building industry, and the highly varied market of consumers.

6. RECENT STEPS TOWARD THE ADOPTION OF RESIDENTIAL OPEN BUILDING

In 1994, an effort was begun to inform the U.S. housing community about Open Building. Articles were published in national professional journals. Armstrong World Industries, a world leader in the manufacture of ceiling and floor materials and products, hosted a national workshop in January, 1994. Thirty US and foreign organizations, companies and government agencies were represented. In May, 1994, the Office of Housing Research at FANNIE MAE in Washington DC hosted a second workshop. [5] Fannie Mae is a $2 billion public / private enterprise owned by shareholders and chartered by the Federal Government to support financial lending for affordable housing. It is an intermediary between primary mortgage lenders and the global capital market.

Several residential projects in the US have recently been built which begin to move in this direction, but without the benefit of residential fit-out systems. One is the Banner Building

Condominiums, Seattle, Washington, a new building offering "shell" space for 14 two story "live-work" dwelling units, each with access to all utility systems [6]. Another is the renovation of the Richard Allen Homes, a large, distressed public housing project in Philadelphia, Pennsylvania [7] which is being completely gutted, with new unit sizes and layouts, new mechanical systems and some new additions.

7. CONCLUDING REMARKS

In retail buildings, the basic unit of territory to be manipulated and controlled is the individual shop. This is conventional. Construction processes await a next generation of fit-out systems from product manufacturers, to reduce costs, improve on-site installation efficiency and improve quality.

In office buildings, the basic territorial unit is the work station, the department or the tenant. Again, the distinction between base building and fit-out is conventional in this type of use, and the tax code, building regulations, financing, and the roles of brokers, designers and owners reflect it.

In the residential market, the time is right to introduce the Open Building strategy for both new construction and renovation of the existing stock. The household as the basic social and territorial unit in residential environments should be supported by introduction of residential fit-out systems.

Those advocating Open Building in the US residential market see the need for two kinds of activity. First, an independent "think tank" should be formed to examine the implications of the Open Building strategy in residential building. There are many independent, non-profit organizations in the US devoted to housing and urban policy, but none dedicated to the examination of a concept which links policy and physical issues as Open Building does. Detailed public domain studies are needed on regulations, finance, mechanical systems and other interior installations, construction and design methods, and marketing strategies. Funding is being sought.

The second process that must be stimulated in the US is the commercialization of fit-out systems. This will require investments in market and technical feasibility studies of existing technology, and the development of new systems. I also believe that this should include the transfer and licensing of foreign "fit-out" products in the North American market, from Japan and Europe. "Fit-out" technology is uniquely suited to international trade. Investors are being sought.

The US housing industry is very large, parochial, and slow to change. However, the housing process has reached a certain threshold which must be crossed. The present condition of combined organizational and technical entanglement must be confronted directly. Realignments already underway in construction logistics, demographics, and roles point strongly toward the adoption of Open Building practices in the residential field in the United States. For that reason, Open Building is not either a utopian vision or an academic theory, but a practical strategy. It can provide answers to difficult technical problems. In the process of solving these technical difficulties, the natural relationship between people and their direct living environment can be strengthened. The concern for the well being of the built environment and its inhabitants is after all our central motivation.

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Europe's "Matura Infill System" Quickly Routes Utilities for Custom Remodeling

Housing System Like U.S. Office/Retail Approach Where Base Building is Fitted Out

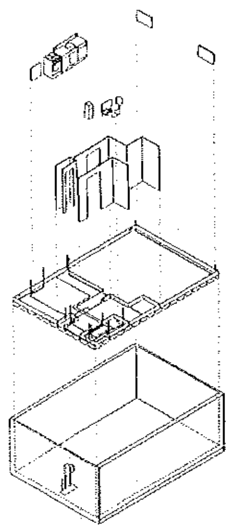
By Stephen Kendall, PhD

Breaking even financially can be difficult for builders of any size, especially in multi-family and townhouse projects. As one builder said, "Everyone wants our house the way *they* want it." The result is that builders either limit variation to a few simple choices or move to high-end projects where margins are large enough to give buyers anything they prefer. Anything in between causes higher prices and many headaches.

This is unfortunate, because the middle of the market for multi-family housing—households earning $60,000 to $100,000 per year—is an obvious place for major improvements in technology and a very important place to make money if the know-how is there—because the market is so large. This includes new construction and also the already large and growing multi-family and townhouse renovation market. Not only elderly or retired empty-nesters, but younger and middle-aged couples who like urban amenities are demanding customization at a reasonable price.

The place where customization matters most is interiors. In multi-family or townhouse projects, this is the only place where significant variation is even possible. Of course, buyers can get special windows or exterior treatment. But interiors are the place where money is spent; where the most extended discussions occur over finishes, equipment and floor plans.

Can we do better supplying this market?

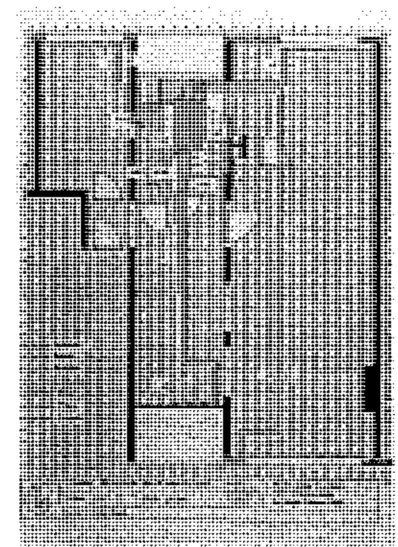


Conceptual drawing of "Matura Infill System" and space to be fitted out. Lower system is comprised of "Matrix Tile," piping, "Baseboard Profile" and cabling. Upper system elements include partitions, equipment, cabinets and finishes. Pipes, cables and upper system elements are off-the-shelf building products.

European product ready for licensing in United States

In Europe, the fully prefabricated "Matura Infill System" provides residential customization at a competitive price. The idea is akin to our office/retail construction, where a "base building" is constructed without determining the "fit out." Once the interior layout and equipment is decided for an occupant, it is quickly installed. It works in office/retail projects, so why not in residential? One reason this has not worked so far in residential is that residential is more complicated and more entangled with pipes, wires and ducts per square foot than commercial fit-out. So it is important that a system is now on the market that solves the problem.

The Matura Infill System, is an "open system" utilizing sub-systems and parts that are available on the market. All of these subsystems are integrated into an adaptable whole by means



Technical drawing generated by "Matura-CAD" shows water and hydronic lines, partitions and doors. All are laid out in the "tartan grid" positioning modules measuring 4" X 8".

of two newly developed elements: the "Matrix Tile" and the "Baseboard Profile." These elements provide flexibility in design, fast installation on site, and changeability in the future.

Matura is based on a radically new distribution of resource distribution lines—sewage, water, heating, electricity, etc.—made possible by the Matrix Tile and Baseboard Profile. Interfaces among these lines and between them and the partitions is minimized. Their routing is organized so that each is installed freely without interference with other systems. And because these lines are not buried in structural walls or floors, their installation is extremely rapid. No pipes or wires from one unit penetrate the space of any other unit.

One of the advantages of this system is that it fits in any physical context. Installation does not pose special demands on the structure or facade. Thanks to the free distribution of resource distribution lines, the location of vertical service shafts does not determine floor plans any longer. This makes

Matura factory worker building system components before they go to the site. MaturaCAD software provides design information enabling all parts to be accurately pre-cut.

the system attractive for renovation projects.

Matura dealers use trained teams of three workers to install each unit one at a time, complete in about two weeks per unit. This means that large projects with uniform floor plans are no longer a prerequisite for efficient residential construction. By employing several teams at ouce, each doing a different floor plan in different units, more units can be filled in simultaneously.

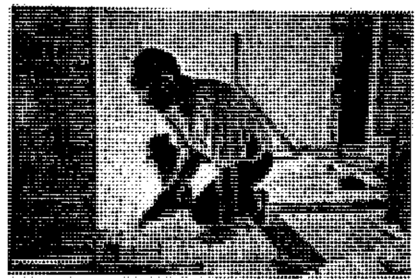
All of this is made easier by the use of proprietary software which allows the quick translation of a floor plan into a technical design of all subsystems. The technical design, in turn, automatically feeds a database which steers the selection, dimensioning and cutting of all parts needed for one dwelling unit and determines their packaging order in a container. The container is delivered to the site and parts are brought into the space for installation. Included in the software is proprietary know-how concerning the dimensional coordination of all parts allowing these parts to be cut to size before they reach the site.

Benefits

The Matura Infill System offers advantages for all parties involved.

For the builder, on-site installation of interior work goes faster, with less overhead and fewer logistical problems.

For the developer, there is freer choice of floor plans which can be de-



Worker at the site lays Matrix Tiles on the structural floor. When the tiles are set, utilities will be routed through the tiles' grooves.

cided only weeks before installation. There is also a choice of wall types, doors and door frames, wall finishes, HVAC, kitchen and sanitary equipment and cabinets in a Matura package.

For the household, there is the possibility—if they want—of determining their own floor plan. Any decoration and finishing scheme can be accommodated. Outlets for electricity, telephone and television can be moved or upgraded to correspond to chosen arrangements of furniture. Adaptation of the floor plan and technical systems can be done in the future.

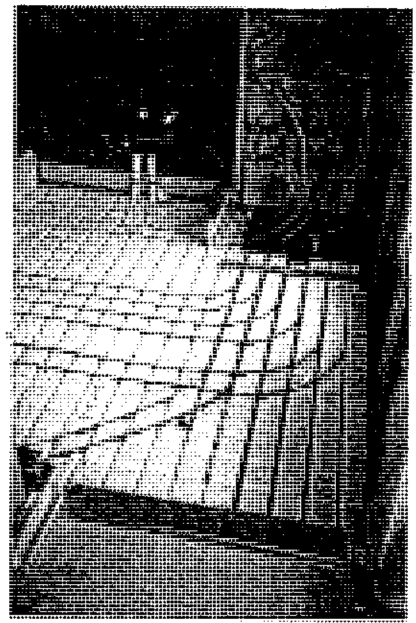
For manufacturers, any technical system in the Matura Infill System (including HVAC, kitchen and bathroom equipment) can be replaced by a newer or preferred version without interference with other subsystems. This means that alternative or improved snbsystems can be offered swiftly and economically as part of the total infill system.

Application in Netherlands

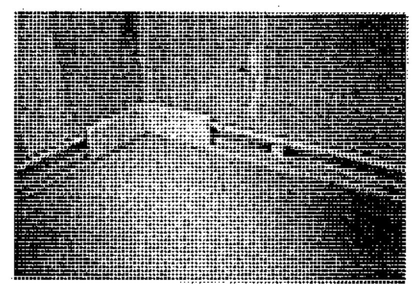
A residential unit became vacant in a concrete, flat-slab, five-story multifamily building constructed to normal Dutch standards in the early 1960s.

The building owner decided to gut and modernize the unit, while at the same time starting a long-term project to upgrade the base building. The Matura company was contracted to do the fit-out for the unit and asked an architect to work alongside. Two weeks were required to gut the unit. During that time, the new tenant met with the architect and a floor plan was decided from several options. The architect's drawing went to the Matura company. One month after being vacated, the unit was ready for occupancy with an entirely new interior matching the new tenant's preferences.

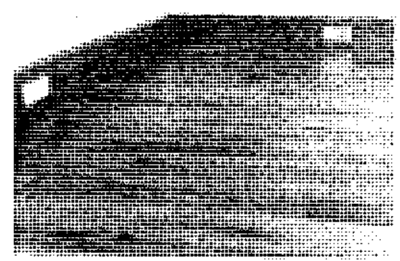
Later, an elderly couple downstairs decided to modernize their apartment.



Water and hydronic heating pipes fit in the top grooves and converge on the utility closet where the gas-fired water heater is located.



Pre-terminated cable is in place along Baseboard Profile. Finishing work is about to begin. If wanted, outlets be easily relocated later.



Flooring and baseboard cover feature stained-wood finish. The remodeling job is complete.

They discussed their requirements and preferences with the architect, stored their furniture, left on vacation and returned a month later to a completely modernized apartment with a special kitchen which they wanted and paid for above the standard that the building owner was willing to purchase.

Between the apartment blocks on the site, a number of new, two-story townhouse units were built and fitted out using the same system.

Currently, a 50-unit, new construction project is underway in the Netherlands. Other clients are lining up. Costs are competitive with traditional construction, but Matura offers many advantages not available in traditional construction.

A German developer is planning to use the Matura Infill System in a large project in Berlin to help him control costs. A company in the United Kingdom is assessing the system for adoption in the large rehabilitation and privatization market there. Developers in Finland and Sweden are also taking a serious look.

The Matura Infill System, or a similar product based on the same principles of separating base building and fit-out should be introduced in the U.S. housing market. It will solve problems and satisfy a growing market for customized interiors in new construction, in renovation of older multi-family buildings and in converting obsolete office buildings to residential use. The concept may also be applied to detached wood-frame houses in time.

Apartment building in the Netherlands after units were upgraded with the Matura Infill System. The first-floor units are designed to provide housing for senior citizens.