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Fire Safety and the Design of Apartments

FIRE SAFETY AND THE DESIGN OF APARTMENTS

a report to the
CANADA MORTGAGE AND
HOUSING CORPORATION

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1 EXECUTIVE SUMMARY

More and more of the population of Canada will choose to live in apartments to be closer to the urban activities or in the suburbs for economic reasons. The objective of this research paper is to assess planning and design criteria for apartment buildings of moderate height (up to 8 storeys) to assure the optimization of the plans and building layouts.

Apartment living is a long-standing European tradition for exactly those reasons that are now influencing housing patterns in North America. There are, however, fundamental differences between the European and Canadian layouts which, in many respects, work in favour of the European apartment plans but these would not be acceptable under the fire safety provisions of the National Building Code of Canada. The research was undertaken to investigate the reasons for, and the effectiveness of, the divergent approaches to fire safety and to recommend a course of action.

The European fire safety record is better than that of Canada and we recommend that serious consideration be given to changes to our regulations that will permit better apartment planning.

2 INTRODUCTION

2.1 DESCRIPTION OF WORK

Contacts were made with selected European architects, representative apartment buildings were chosen in climatic and socio-economic conditions similar to Canada. Germany and Finland were chosen for this investigation due to the researchers' prior contacts, work experience and an adequate command of the languages.

The rationale of site planning and building design were investigated through interviews with the designers and Code officials as well as a detailed review of the formative building and fire Codes. Published statistics and other relevant data concerning life and property loss in apartment buildings in the two selected countries were compared with similar information available in this country. An attempt was made to relate the data to the Codes and the design influenced by them. The report analyzes the differences, assesses the advantages and risks involved in the different approaches to fire safety and makes recommendations.

2.2 SCOPE OF RESEARCH

The most significant difference between European and Canadian apartment buildings of moderate height is in the disposition of stairs and the extent of corridors required to service floor areas.

The European layouts are characterized by apartments clustered about a short corridor, a staircase and an elevator (Fig. 1). They afford the following advantages:

- multiple aspects: a unit is not limited to only one exposure to sunshine, noise etc;
- through ventilation;
- more efficient room layouts;
- less space wasted on circulation, both within the unit and in external corridors.

The plan of a typical Canadian apartment building has the following characteristics:

- central double-loaded corridors, usually long and tedious;
- centrally located bank of elevators;
- exit stairs near the ends of the building;
- majority of units are limited to a single exposure and therefore inferior environmental conditions (e.g. north aspect, noise);
- through ventilation is not available to most units;
- lack of territorial control over common areas such as long corridors serving many units may be the cause of vandalism;
- comparatively large circulation areas (internal and external) causing higher building and maintenance costs.

The evolution of the Canadian apartment floor plans has been much influenced by fire exit requirements that make it mandatory to have specific geometric layouts and options for exits from units:

- each floor area to be serviced by two separate stair towers placed as remotely as possible from each other;
- distance from unit to exit is regulated;
- limitations are placed on length of dead-end corridors;
- option available to go in two directions.

These requirements make it impossible to design an apartment building in Canada on the European model. Thus the clear generic difference between the floor plans result from an obvious difference in attitude to fire safety. The research study has two principal objectives:

a/ to assess these different attitudes in two major areas:

- safety record: which is safer in terms of casualty and damage statistics;

- design requirements: what other conditions or methods of construction (if any) apply in Europe to make this planning possible;

b/ to make specific recommendations.

References to existing relevant research and literature on the subject are made throughout the study and noted in the bibliography.

2.3 SCHEDULE OF WORK

Stage 1
June 1 - 30, 1983: Search was conducted of existing literature; lists of required data were prepared; Canadian Code officials (federal and provincial) were interviewed; site visits and interview dates were confirmed with selected European architects and Code officials; travel plans finalized.

Stage 2
August 1 - 30, 1983: Travel to Germany and Finland; architects and Code officíals were met and interviewed; visits were made to typical buildings; sample building plans and Codes were collected.

Stage 3
September 30 - November 30, 1983: Data and interview material was analysed and the first draft of the report was prepared.

Stage 4
Completion - a report within six weeks of receiving CMHC comments and approval.

3 THE NATIONAL BUILDING CODE OF CANADA

3.1 INTRODUCTION

Life safety for the occupants of any floor area is dependent in the first instance on the use or occupancy of that floor area. The risks to the occupants occur in the early stages of a fire. These special life risks differ from one occupancy to another and, consequently, must be regulated differently. Section 3.3 of the NBCC (Ref. 8.1) regulates risks within floor areas, and these requirements apply regardless of the major occupancy of the building that contains them.

This section coveres two main areas: construction requirements within floor areas and access to exits. Access to exits is covered in Section 3.3 because these facilities - unlike exit facilites - are located within the floor area. Both the access to the exit and the exit itself are included in the term "means of egress".

3.2 EXITS

Generally, any floor area containing more than one suite requires only one doorway from each individual suite to provide an exit directly to outdoors or access to an interior corridor or exterior passageway.

The key issue of this study concerns the requirement in the NBCC that from the the doorway of each dwelling unit it must be possible to go in opposite direction to reach each of two separate exits:

> Subsection 3.3.1. Requirements Applying to All Floor Areas
>
> 3.3.1.3.(1) ... Each suite in a floor area that contains more than 1 suite shall have an exterior doorway at or near ground level or a doorway leading to an exterior passageway open to the outdoors, or to a public corridor; FROM THE POINT WHERE SUCH DOORWAY ENTERS THE EXTERIOR PASSAGEWAY OR PUBLIC CORRIDOR IT SHALL

BE POSSIBLE TO GO IN OPPOSITE DIRECTIONS TO EACH OF 2 SEPARATE EXITS.
(Authors' emphasis; Fig. 2).

There are exceptions in residential buildings. In buildings not exceeding three storeys, a doorway can open directly into an exit stairway or into an interior corridor or an exterior balcony or passageway served by a single exit stairway provided there is another separate means of egress from the dwelling.

Subsection 3.3.4 Residential Occupancy

3.3.4.3.(5) A doorway from a dwelling unit may open onto an interior corridor served by a single exit, or an exterior balcony served by a single exit stairway, or an exterior passageway served by a single exit stairway provided each dwelling unit has a second and separate means of egress.

This subsection is of limited design usefulness as it results in a second and independent stair for the unit. In all cases, dead-end corridors are severely restricted:

3.3.4.4.(1) Except for corridors served by a single exit as described in Sentence 3.3.4.4.(5), a dead-end public corridor is permitted only if it does not exceed 6 m in length, measured from the end of the corridor to the nearest exit.

(2) Dead-end corridors in Sentence (1) shall serve no more than 4 suites and shall contain no door openings other than for suites, arranged so that it is no necessary to pass more than 2 doors in travelling to the nearest exit.

A public corridor provides access to exit from a floor area containing more than one suite. It must be at least 1100 mm wide (a unit of exit width is 550 mm per 90 persons).

3.3 CONSTRUCTION REQUIREMENTS

Article 3.3.1.1 contains a general requirement for separation between suites by fire resistance rated construction. Article 3.3.1.3. requires that all public corridors be separated from the remainder of the building (regardless of occupancy) by fire separations that have a fire-resistance rating of at least 1 hour when the supporting floor assembly is rated 1 hour or more. When floor assemblies of less than 1 hour are permitted, the fire-resistance rating of the fire separation must be at least 3/4 hour, even if the supporting floor is not required to have a rating.

In residential occupancies, fire separations having a fire-resistance rating as above are required - 3.3.4.2.(1) - to minimize the number of persons initally exposed to a fire. Fire separations are not practical within individual dwelling units, but special requirements apply to multi-storey dwelling units - 3.3.4.2.(2). They must be separated from the rest of the building by 1-hour fire separations in all sprinklered buildings regardless of height, and in unsprinklered buildings up to 3 storeys. In higher unsprinklered buildings 2-hour fire separations are required because of the increased fuel load potential per square meter of building area i.e. fire loads on the multiple floors are considered "stacked" creating a greater fire potential.

4 THE BUILDING CODE OF BAVARIA (GERMANY)

4.1 INTRODUCTION

There are no national building regulations in West Germany. All references in this section are to the 1982 Building Code for the province of Bavaria (BCB) (Ref. 8.2) and to the Decree for the Implementation of the Building Code (DIBC) (Ref. 8.3) of the same province. This Decree contains detailed requirements based on some of the general provisions of the Code.

4.2 GENERAL REQUIREMENTS

Part 1 of the Code - similarly to the corresponding Part of the NBCC - deals with the scope of the Code and with the definitions. The important definition here is that of High Buildings:

> Art. 3 High Buildings are structures in which the floor of at least one living area lies more than 22 m above grade.

The concept of a "living area" is very wide: it encompasses not only any area intended for residential use but also areas that, because of their location or size, may be so used.

As in the Canadian Code, high buildings are subject to more stringent controls with regard to fire safety. The 22 m limit is determined by the reach of the "generally available equipment for firefighting and lifesaving"; above the limit these activities are considered more difficult if not impossible (Fig. 3). Differentiation according to the number of stories had been tried and abandoned because the height of the stories varies and therefore cannot be used to determine the critical height of 22 m.

4.3 SITE PLANNING

In general, the distance between buildings and between buildings and lot lines are regulated by

Articles 6 and 7 of Part 2 of the BCB.

Buildings can be constructed adjacent to each other but then they are considered as a single building (Part 2, Art. 6, Sentence 5, Clause 3). Fire safety in most practical situations is ensured by extensive use of "firewalls", defined in detail in Part 4, Art. 29 of the Code.

Art. 7 of Part 1 allows, under certain circumstances, exceptions to the requirements of the preceding Article, provided the design ensures "an adequate degree of fire safety and sufficient lighting and ventilation" (what is "adequate" and "sufficient" is not defined in the Code). In particular, local authorities have the right to extend the minimum distances over and above those prescribed in Art. 6, but not to reduce them.

The planning process takes fire safety into account by making densities dependent on the local firefighting capacities. The planning authority that allows higher densities must also ensure that adequate firefighting equipment is available.

Careful provision is made for access to buildings by fire-fighting vehicles in the Decree for Implementation (DIBC), Para. 3 which relates to Construction Requirements discussed below.

4.4 CONSTRUCTION REQUIREMENTS

General construction requirements related to fire safety are stated in Part 3, Section 1 of the BCB:

> Art. 17: Fire Safety
>
> (1) Buildings must be designed, constructed, altered and maintained such that the occurrence and spread of fire and smoke is prevented and, in case of a fire, that it is possible to effectively fight the fire and save people and animals.
>
> (2) Easily combustible building materials must not be used.
>
> (3) Special provisions for firefighting and

lifesaving must be provided in tall buildings.

(4) Fire resistant walls and floors must at least in their essential parts consist of non-combustible building materials.

(5) Buildings that because of their location, construction or use may be easily hit by lightning or in which lightning may lead to severe consequences, must be provided with permanently effective protection against lightning.

Compartmentation of buildings by means of fire separations and firewalls is dealt with in Part 2, Section 4, Articles 28 and 29.

4.5 EXITS

General requirements relating to exits are contained in Part 3, Section 4, Art. 33. The significant provisions are contained in the following Sentence:

(1) Every storey of a building that is not at grade level must be accessible by means of at least one stair (necessary stair). Additional stairs or a "safety stairshaft" (Sicherheitstreppenraum, Figs. 4a, 4b) may be required if lifesaving in a fire situation is not possible by other means.

Here the Bavarian Code departs significantly from the National Building Code of Canada. In principle, the Bavarian code requires that there must be provided at least two means of escape for the occupants or access for fire fighters. However, one of those means of escape may be an "emergency escape" (Notbehelf) - for example a ladder. Only in so-called high buildings (22 m and higher) where the higher floors cannot be reached by ladders, are two stairs required. In every case, regardless of the number of stories, a single stair will suffice provided it is constructed as a "safety stair" (Sicherheitstreppenraum). It is noteworthy that such stairs may be used even in high tower slabs and blocks as single exits (Figs. 6 - 11).

The construction requirements for stair shafts and exits are given in Article 34:

(1) Each required stair must be contained in a continuous stair shaft that, together with its access doors and exits, provides a safe means of escape...

(2) Any point within a living area or a basement must not be farther than 35 m from either a stair shaft or an exit to the outside. If more than one stair becomes necessary then they must be distributed in the building so that the escape distances are as short as possible.

(3) Each stair shaft as required in sentence (1) must have have a safe exit to the outside as close as possible. The exit must be at least as wide as the stair. Combustible materials are not allowed in stair shafts and their exits.

(4) The walls of stair shafts as required in sentence (1) and their exits into the open must be non-combustible and in buildings of more than two storeys must be constructed as firewalls...

(5) The roof of the stair shaft must comply with the firesafety requirements of the roof of the top storey. The stair shaft may be covered with a glass roof.

(6) Openings in stair shafts that lead to basements, attics, workshops, shops, storage areas and similar spaces must be equipped with self-closing and at least fire-retarding (feuerhemmend) doors...

(7) In buildings of more than five storeys where the stairs have no outside walls (innenliegend) at the top of the shaft must be provided a device for the elimination of smoke. Stair shaft must be ventilated and lighted. Stair shafts that have outside walls must have openable windows. Stairs with no outside walls must have a lighting system that is independent of the building.

(8) Safety stairs (Sicherheitstreppen, as mentioned in Sentence 1 of Art. 33) must have vestibules, galleries, shafts and ventilation equipment or other devices that make it safe from intrusion of fire and smoke from the storeys of the building even when the access doors from the storeys are open.

(9) Two basements situated one on top of the other must have at least two separate exits. Of the two exits at least one must lead directly into the open, either directly or through a stair on the outside wall. Separate stair shafts for each basements may be eliminated when there is no danger of fire.

(10) Sentences 1 to 9 do not apply to buildings containing only up to two dwellings and to farm buildings.

Note that sentence (2) allows for dead end corridors which by far exceed the NBCC limits. Additional requirements for stairs are stipulated in the DIBC, paragraph 9. These deal with handrails and balustrades, wall and floor finishes etc. Of interest are the required dimensions for stairs: the minimum width for an exit stair (notwendige Treppe) is 1 m. This can be reduced to 800 mm in buildings containing up to two dwellings; it can be further reduced for buildings which do not contain living areas. Greater width may be required in buildings where the stair serves more than 150 people.

4.6 VENTILATION

Ventilation shafts are generally regulated by Art. 38 of the BCB, but the requirements pertaining specially to fire safety are given in paragraph 12 of the DIBC: ventilation shafts be so constructed that they prevent the spread of fire and smoke into other storeys or compartments: in buildings of more than two storeys for at least 30 minutes; in buildings of more than five storeys at least 60 minutes; in buildings or areas of special fire risk and between fire compartments at least 90 minutes. This requirement does not apply to buildings containing up to two dwellings.

5 THE NATIONAL BUILDING CODE OF FINLAND

5.1 INTRODUCTION

Finland has a unified building code administered by the Ministry of the Interior. The regulations governing fire safety in the national Building Code of Finland (NBCF) were revised and updated as recently as 1981.

The Code is similar to NBCC in its concern for fire resistant construction and compartmentation to impede the spread of fire within the building and to the outside.
It restricts the use of structural timber to residential buildings not greater than two storeys in height. However, wood may be used fairly extensively in high residential buildings as a cladding material and internally within a fire compartment.

As with the Bavarian Code, the important distinction between NBCF and the NBCC lies in the area of residential buildings of not more than eight storeys and their exit requirements. The general requirement for exiting is for at least two independent exits. However, there is an exception for buildings up to 8 storeys in height where one exit is considered sufficient. In addition to the single formal exit the unit must also have an "emergency exit possibility". A balcony or window opening through which rescue is possible either by the rescue operations of the fire department or by a fixed ladder leading to the ground or another place of safety is acceptable. To comply as an emergency exit an opening must have certain minimum dimensions as quoted below.

5.2 CONSTRUCTION REQUIREMENTS

General construction requirements related to fire safety are stated in section E1, entitled Structural Fire Safety Regulations 1981 of the NBCF:

> 3.1.1 A building must satisfy all the fire

safety requirements for the preservation of life and to a sufficient extent property, and must therefore fulfill the following general requirements as they apply to the construction methods in use and the intended use of the building. These requirements are:

3.1.1.1 The ignition of the structural elements and pretective linings of a fire resistant compartment shall not constitute a danger, neither shall the creation of combustible or poisonous gases during a fire or the spread of a fire prevent an exit from this compartment.

3.1.1.2 A building shall in general be divided into fire resistant compartments so that a fire cannot spread unhindered within the building or to the outside. A fire should not spread outside of a fire resistant compartment so that either adjoining property or the exit from the building are endangered or so that property damage in general becomes unreasonably great.

3.1.1.3 A building should be so designed and constructed that a fire cannot easily spread to another building or elsewhere in the surrounding area.

3.1.1.4 A building and its elements of structure must not, as the result of a fire, be in danger of collapse after the start of the fire for a certain period of time, depending on the height of the building and the fire load.

Whenever it is considered necessary for reasons of personal safety or the environment, or in regard to the size of the possible damage, the building should withstand collapse throughout burning and of all permissible fire load and cooling phase.

5.3 · EXITS AND ESCAPE ROUTES

General requirements relating to exits are contained in Section E1 subsection 4. The significant provisions are contained in the following clauses.

4.2.1 Each exit compartment in a building, in which compartment people reside or work other than temporarily, must in general have at least two exits independent of each other and located in an appropriate manner.

Instead of the second exit from the compartment, it is acceptable to have access to another compartment through a fire resistant door, if there is immediate access from there to an exit leading straight to the outside. In this case the exit compartment with maximum occupant load is the basis for the exit measurements.

In certain cases outlined below an emergency exit or the possiblity of an emergency exit, may replace the second exit from the compartment.

4.2.2 If the height of the building and the purpose of the exit compartments are such that one exit is considered sufficient, then the compartment must also have the possibility of an emergency exit. Requirements would apply only to residential buildings less than eight storeys in height ...

4.2.2.1 As a emergency exit possibility may be considered an appropriately situated balcony or window opening through which rescue is possible by the rescue operations of the fire department (Fig. 12).

The travel distance from the remotest point within the unit to the primary exit stair (distance A-B in Fig. 12) must be less than 30 m. There is no evident concern for the dead end situation because of the existence of the secondary exit.

A window which serves as an emergency exit possibility must always be easy to open and have a free, unobstructed opening at least 600 mm high and 500 mm wide, so dimensioned that the sum of the height and width is at least 1500 mm.

The NBCF departs significantly from the NBCC. Although in principle both codes share the requirement for two exits they differ greatly conceptually and practically. The NBCF expresses a concern for having two exits from each dwelling compartment whereas the NBCC emphasizes the need for two exits from each floor area of the building. In buildings of eight storeys and less where the height of the floor of the top storey above grade is not more than 22 metres the second exit from the dwelling compartment can be "an emergency exit possibility". Balconies and windows if appropriately sized and located may serve as an emergency exit.

5.4 SITE PLANNING

Planning for fire prevention, fire fighting and emergency rescue starts at the conceptual planning stage for a new community. Planners take into consideration the capability of local fire brigades to handle the proposed project. If current rescue apparatus cannot reach 8 storeys then projects can be delayed until such equipment is locally available.

In theory, the fire brigade is to have access to at least one window or balcony for each apartment unit (Figs. 13, 14). In practice, this requirement is not often met. Fire prevention officers review and comment at the planning stage but their requests for changes can be overruled by the town planners if they conflict with certain planning objectives. Usually alternate methods of access or exit possibilities are agreed to in order to provide equivalent protection. It seems that considerable latitude and discretion is available to plan examiners and fire prevention officers in their assessment of a proposed new building or community.

Site planning is dealt with in section 5 of the NBCF.

5.1 Emergency Road

5.1.1 The fire department crew and emergency vehicles must have a means of access sufficiently close to the buildings, and points from which to obtain water, in order to effectively perform their fire fighting and rescue operations.

5.1.2 Whenever construction on a site has been permitted only on condition that the fire department has access to the resulting building(s) from one or all sides for the performance of fire fighting or rescue operations an emergency road suitable for the vehicles of the fire department must lead to all the points mentioned above.

6 CONCLUSIONS

6.1 INTRODUCTION

The differences in apartment plans and building layouts between Canadian and European models can clearly be attributed to each community's exit philosophy. The concerns for compartmentation, fire resistance ratings, structural integrity, smoke control, alarm systems although not identical to the letter are so in their intent and effectiveness. It is in the area of exit from apartments and buildings where the code differences clearly reflect the divergent concepts.

The European model is based on the requirement for two exit possibilities from each apartment. The principal central access stair serves as the primary exit for each apartment. The apartment unit's windows and balcony are considered as the second or secondary exit from the unit. The expectation in the use of the secondary window/balcony exit possibility is that the local fire department rescue team and equipment will complete the link to the ground and safety. This expectation is commonly shared by apartment dwellers, fire fighters, architects and planners. This unanimity of understanding is reflected in planning regulations and building codes.

6.2 SAFETY RECORD

When challenged as to the safety of the single stair exits various European officials were surprised that one would consider any other approach to building evacuation for buildins of moderate height. Great and justifiable pride is taken in their low life loss record (see Table 1). Fire chief P. Vimpari of the town of Kajaani, Finland, noted that in his ten year career in his municipality he was aware of only two window or balcony rescues. This low incidence of emergency rescue, he explained, was fairly typical for the country of its modern housing stock. The earlier timber apartment dwellings that relied on individual wood-fired heater had a very bad record.

However, the timber buildings were usually only two storeys and external rescue was relatively easy if required.

Herr J. Bierlein, the fire chief of Nuremberg/Hafen, looking back over a career spanning 30 years, could not find one instance where building evacuation either by the main stair or secondary (window/balcony) exits had caused problems.

6.3 SAFETY PROVISIONS

The European two exit possibilities for each unit are quite different in type, location and dimensional standards. The primary stair exit tends to be an internalized stair connecting all floors of the building to grade. The continuity of the stair and shaft can create a chimney effect and hence a smoke control problem, making the stair exit untenable. Similar exit stair contamination has been observed in recent Canadian fire tragedies but the buildings were in every case of the high-rise type. It is far less likely in buildings of moderate height, as discussed in this report.

Individual apartment balcony and window exit possibilities are by nature a direct access to the exterior and fresh air. The concept of two entirely different forms of exit possibility, one internal and one external, gives each apartment dweller a real choice.

European fire prevention bureaus issue safety pamphlets that reflect the two options available. The literature cautions dwellers to check the stair for smoke before venturing into it (See Appendix 1). If smoke is present they are advised to close and seal the door and openings and to a window or balcony and signal to people on the ground their location and difficulty. A significant safety feature here is the fact that the dweller is warned of smoke contamination in the exit stair BEFORE he leaves the relative safety of his apartment (assuming that the fire origin is somewhere else).

The concept of exit options is also inherent in the Canadian philosophy of exit. The approach to achieving the two exit possibilities is quite different in type, location and effect in fire situations. The option given to the apartment dweller is the choice between two stair systems connected by a common corridor. Smoke contamination of both stairs is a possibility that can confront those trying to exit from a floor area after they have left their apartments.

Fire drills and fire prevention literature have reinforced the concept of responding to fire alarms by the rapid exit from the building via exit stairs (Appendix 2). Codes are absolute in the requirement for two separate, remotely located stairs to afford each floor area two exit possibilities. The option that is really given is which stair to choose. In most cases the stairs are identical in every respect and they can fail or succeed in the same way and at the same time.

The choice of exit stair in some circumstances may not be an informed choice. It is easy to imagine a scenario where a person fleeing his/her apartment runs to the closest exit stair. When the stairs are approximately the same distance away he/she just has to guess. In either case, if the stair is unusable for some reason, probably by smoke contamination, the other stair is at the opposite end of a long corridor which may by that time be full of smoke so that even the way back to the relative safety of the apartment may not be open any more.

We seem to have locked our thinking into one approach and keep re-engineering it to overcome any perceived possibility of failure without examining alternatives. We are placing all our faith in the same exits. Window and balcony emergency rescue is successfully carried out in Canada as well as in Europe but is not considered an acceptable emergency option in any officially codified way. The two-exit approach may be valid in tall buildings; in buildings accessible to rescue by window or balcony it is clearly not the best way.

6.4 FIRE BRIGADE RESCUE

The response time of the fire brigade varies between approximately 4-5 minutes in major cities in Canada; it may be much longer in remote locations (up to 40 minutes). However, given the excellent compartmentation of modern apartment buildings, the most logical safeguard against the possibility of fire or smoke danger to the inhabitants of a building due to delay would appear to be a better sealing compartment entrance door.

It is interesting to note that the British Standard Code of Practice CP3 (Ref. 8.5), which generally takes a pessimistic view of fire brigade rescues, supports the same notion:

> It has become apparent, and generally agreed, that external rescue by the Fire Service may not always be possible from blocks of flats and maisonnettes ... Modern traffic conditions and congestion, as well as parking around blocks, may delay the attendance of the fire brigade; furthermore, reliance on such appliances as manipulative types of escapes or mobile ladders is considered to be unsatisfactory. Also, the assumption should no longer be made that entire buildings, whole floors, or even adjoining dwellings need to be evacuated if a fire occurs. Owing to the high degree of compartmentation provided in dwellings in modern blocks, the spread of fire and smoke from one dwelling to another and the need to evacuate the occupants of adjoining dwellings are unusual. The occupants should be safe if they remain where they are.

Once the principle of rescue by the fire brigade is discounted, the same regulations may be applied to moderately high buildings (up to 24 m - 80 ft in the British Code) and those above that limit. Even with this (apparently quite unreasonably) extreme position regarding rescue by fire brigade, the British Code still allows apartment buildings with a single exit stair. It is also recommended that the entrance door of a dwelling should be self closing and fire resisting (2.2.1.6).

Another important safety feature that tends to work in favour of the European model is the size of the building. Clusters of apartment units surrounding a single stair are separated from other clusters by fire walls and thus constitute separate buildings. Smaller buildings mean smaller fire loads, an important safety factor which is recognized by the NBCC.

6.5 PSYCHOLOGICAL FACTORS

The typical European stair hall directly accessible from the surrounding apartments is a highly visible and familiar feature that the apartment dwellers know well. They know where it is and where it goes, both at the top and the bottom. It is not a mysterious construction at the nether ends of long corridors, hidden behind heavy steel doors and populated by muggers. This may be an important safety feature:

> Psychological and physiological factors must be considered in addition to physical factors in planning exits... Fatal panics have occurred where there was no fire in a building but people thought there was a fire. On the other hand, where people have had confidence in a building and its exits there have been orderly evacuations without panic even tough actual danger was present... It is also important that all exits from a building are used as a matter of daily routine so that occupants will be familiar with them. - (Ref. 8.6).

Additional territorial benefits accrue as a consequence of the European stair arrangement, as discussed in Ref. 8.7.

6.6 ECONOMIC CONSIDERATIONS

Cost benefits accrue mainly in the savings in built floor area. As exit stairs in the European models are not required to be connected, corridors can be kept to a minimum. In the example of a three-storey walk-up apartment building from Finland (Fig. 15) a 1.6 m wide corridor connecting two of the stairs would be at its shortest 13 m long, giving a total of 20.8 m2 of extra space. To conform to the NBCC this additional corridor space would have to be provided along with doors and walls to separate the stairs from the corridors.

Using the 1983 Yardsticks for Costing (Ref. 8.8), the cost range for apartment construction would be $300.00/m2 to $500.00/m2. That would represent an extra for the corridor alone of between $6,000.00 to $10,000.00 per floor. As crude and simple as this example is, it does illustrate that there are economies to be had that come directly from code regulations that balance exit requirements between stairs and secondary balcony or window exits.

In buildings over three storeys and up to eight storeys where elevators are mandatory the cost savings from the reduction in corridors are offset by the high cost of providing a separate elevator for each stair hall module. The usual provision of only one elevator per stair hall module could cause concern for the reliability of equipment.

The German examples (Figs. 6 - 11) would be more in keeping with our apartment designs in that banks of elevators service generally more units per floor that the earlier Finnish example. These examples use more corridor to gain accesss to the single escape stair. This approach overcomes the concern for elevator breakdown, with any savings deriving from the use of a single exit stair.
In any case, according to Finnish and German architects, the proximity of apartments to the stairs and the "neighbourly" atmosphere seem to encourage dwellers to use the stairs rather than the elevator much more often than in the Canadian apartment buildings with corresponding energy savings.

6.7 DESIGN: APARTMENT PLANS AND BUILDING LAYOUTS

It is in the area of greater flexibility in apartment planning and building layout that the European model excells. The flexibility chiefly comes from the possibility to have groups of units on each floor serviced by a single exit stair. Once the necessity to connect the stairs in each group of units with a corridor is removed, the apartment and building layouts are liberated considerably. Without the bisecting access corridor dual or multiple aspect can be the norm for a greater number of apartments. The advantages of having more than one principal window exposure are numerous. The principal ones are light, view options, cross ventilation and the ability to zone rooms towards the sun or away from noise. The typical Canadian double-loaded corridor building can offer such features on the end units only.

Although a number of the European apartment buildings tend to be in the form of long structures they are typically made up of small individual building blocks consisting of a small number of apartments grouped around a stair/elevator combination. These individual blocks or buildigs, separated from one another by fire walls, are joined to create larger building elements.

As there is no need to connect the stairs of one block to those of another with an access corridor it is clearly easier to manipulate the individual blocks to respond to topography and site geometry. Sites of irregular shape and pronounced elevation change can be more readily dealt with using the European model.

The reliance on window/balcony rescue is dependent on good access. The carefully planned site layout required in Europe for fire safety reasons with its good access for fire fighting and rescue vehicles is advantageous regardless of internal safety arrangements (Figs. 16 - 28).

7 RECOMMENDATIONS

7.1 INTRODUCTION

The findings of the report clearly indicate that:

- the European model is at least as safe, if not safer, than the Canadian practice;

- it compares favourably with the Canadian practice from the economic point of view, especially in the three-storey walk-up examples where no elevators are required;

- indisputably, the design flexibility of the European model is far superior to the restricted number of alternaties available to Canadian architects under the provisions of the NBCC.

7.2 DESIGN AND CODE RECOMMENDATIONS

It is recommended that the European model be adopted for buildings of moderate height (up to 22 m, or a similar limit adapted to North American rescue equipment standards).

Within the present building legislation there exist vehicles that will permit the design and construction of apartment buildings not conforming to certain provisions of the NBCC.

The possibility should be explored to construct apartments buildings on the European principle with a long-term view of changing the legislation to permit a more balanced approach to fire safety.

7.3 APARTMENT ENTRANCE DOORS

In spite of the fact that neither the German nor the Finnish Code require it, the authors feel that self-closing fire-rated doors would greatly enhance the safety of the apartment dwellers, as suggested in the British Code CP3. This would improve fire safety even under the present NBCC.

7.4 SAFETY INSTRUCTIONS

On the adoption of the European model serious consideration should be given to changing the fire safety instructions of Appendix 2 to bring them into conformance with Appendix 1. This action may be considered under the present NBCC as a possible alternative, especially if recommendation 7.3 above should be adopted.

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11 APPENDIX 2: FINNISH FIRE PREVENTION TECHNOLOGY

1973 Helsinki Fire Dept undertook the preparation of guidelines for the prevention of fire dealing with fire fighting and life saving access to buildings. The guidelines were first published in 1974 and revised in 1983 to reflect the needs of the latest legislation.

The following is an edited translation from Finnish.

11.1 INTRODUCTION

Fire fighting and rescue operations is divided into two main areas of concern:

a/ fire prevention
b/ operative action.

In general, the planning and architectural requirements for fire prevention especially in residential buildings have been adequately taken care of. The reason for this among other things is that in Finland there are regulations regarding structural fire prevention. It is recognized that structural solutions do not completely exclude the possibility of the spread of fire, neither do they prevent other mishaps. For that reason society has to be prepared for the outbreak of fire and accidents. Operative readiness is the responsibility of the City of Helsinki Fire Department and includes fire fighting, rescue and emergency ambulance service.

In contrast to the structural fire prevention regulations, the requirements for operational action have not in general been adequatly taken care of in planning. The reason for this is that in Finland there are no regulations for operative action. The lack of such regulations has often resulted in the total disregard in planning for the needs of operative action. Afterwards it has been generally impossible to provide adequate technically efficient operations e.g. on site manoeuvrability. The requirements for various sectors of operative action have to be taken care of already in the building planning and design stage.

As a result of these concerns the City of Helsinki Fire Chief initiated in 1973 a work group to draft guidelines that would take into account the needs for both structural and operational requirements in planning, building design and construction. These guidelines were first published in 1973.

11.2 ACCESSIBILITY AND TRAFFIC CONNECTIONS

11.2.1 GENERAL

The accessibility of a planning area depends on the traffic connections of the surrounding city districts. In general, the fire department does not have control over these arteries. The above mentioned factors have an impact on the operative preparedness of any given district, therefore the fire department sees it as necessary to receive a report from the city indicating to what extent the needs of the Fire Department have been taken into account in the final plan.

11.2.2 ACCESSIBILITY

The geographic distance of the nearest fire station is the primary factor in the accessibility of the planning area. In considering the operative readiness of a given station this is not the only factor; it also depends on the traffic connections. This has been clearly demonstrated in the time studies of emergency vehicle performance.

According to studies the response time within the entire city was on average five minutes. It is necessary to reserve a site for fire stations so that the time for the first emergency vehicle to arrive at the scene does not exceed five minutes. Accessibility during rush hours should be improved by the possibility for a priority at intersections. This system is still not fully in practice. An effective measure would be the reservation of priority lanes for public vehicles (buses and emergency vehicles) and the use of streetcar lanes. The expressways and roads should have emergency access, exit and U-turn possibilities where indicated by the Fire Department.

11.2.3 TRAFFIC CONNECTIONS IN THE PLANNING AREA

Roads of all types should be planned in such a way that the width, height and the turning radii of emergency vehicles (as given by the Fire Department) are taken into account. Special care has to be taken with pedestrian streets to assure that trees and planting boxes do not obstruct.

Emergency access roads over structural decks must be designed to support the weight of the fire vehicles, as given by the Fire Department.

Where inadequate structural strength prohibits fire vehicle access then clear signage or barriers should be used.

11.3 TACTICAL MANOEUVRING SPACE

11.3.1 INTERNAL MANOEUVRING SPACES

For successful fire fighting and emergency operations adequate site area has to be available. These activities have to be taken into account at the planning stage. Blocks and lots have to be planned in such a way that emergency vehicles can reach the buildings under all predictable conditions. The development of the lot has to permit adequate manoeuvrability adjacent to the buildings.

The rescue of people from burning buildings requires more manoeuvring space than what is required for fire fighting alone. In high occupancy buildings more space has to be reserved on the lot for rescue operations. Special use buildings (such as hospitals) require additional consideration. The height of the building has an obvious impact.

In addition to the rescue operations from the ground, especially in the context of high buildings, the possibility of rescue from the air has to be taken into account.

Designing the internal spaces of the building must make it possible for fire fighter to have safe access to the built-in fire fighting equipment.

11.3.2 EXTERNAL MANOEUVRING SPACES

The main principle in desinging the external manoeuvring space is that on the side of the building with entrances there has to be adequate and barrier-free space for manoeuvring. For ambulances this space requirement is absolute. In places where special fire precautions are necessary such as industrial installations special strategies must be worked out with the fire department.

Fire prevention planning has to be presented to the fire department along with the structural requirements for fire safety as outlined in the National Building Code of Finland.

The above-mentioned main principles may be modified in special circumstances.

In the planning of outside tactical manoeuvring spaces the dimensions of vehicles mentioned in section 4.2.3 have to be taken into consideration. In addition, the following characteristics of vehicles must be taken into consideration:

LADDER AND PLATFORM TRUCKS
- minimum distance from wall: 6 m
- working slopes not greater than: 5%

LADDER TRUCK
- vertical reach 30 m
- fire rescue capacity approximately 3 persons per minute excluding the handicapped.

PLATFORM TRUCK
- vertical reach 30 m
- fire rescue capacity 1 person per minute, excluding the handicapped.

In buildings equipped with automatic sprinker or fire alarm systems there must be an unhindered access to the fire alarm centre (annunciator panel).

11.3.3 MANOEUVRING FROM THE AIR

In high buildings (over 28 m) the roof structure must be designed so that there is adequate space for rescue operations by helicopter, with safe access for people. Since the helicopter will not be landing, the roof loads need not be designed to take into account the total weight of the helicopter.

Rooftop, ducts antennae, chimneys etc must be located and designed so that they do not obstruct the helicopter approach and the access for the rescued. The minimum free manoeuvring space must be 85 m x 60 m.

Wissen Sie . . .

... daß Sie beim Ausbruch eines Brandes durch besonnenes Verhalten und durch richtigen Einsatz der Lösch- und Sicherheitseinrichtungen wesentlich zur erfolgreichen Brandbekämpfung beitragen können?

... wo sich in Ihrem Hause die Lösch- und Sicherheitseinrichtungen befinden?

... wie ein Feuerlöscher oder ein anderes Löschgerät in Betrieb genommen wird?

... wo Versorgungsleitungen — Strom, Gas, Wasser — zentral abgeschaltet werden können?

... daß Sie durch gute Kenntnisse der möglichen Brandgefahren im Haushalt und am Arbeitsplatz wirkungsvoll mithelfen können, den Ausbruch eines Feuers zu verhindern?

Sollte es trotz aller Vorsichtsmaßnahmen doch einmal zu einem Brand kommen, dann befolgen Sie bitte die nebenstehenden Ratschläge Ihrer Feuerwehr.

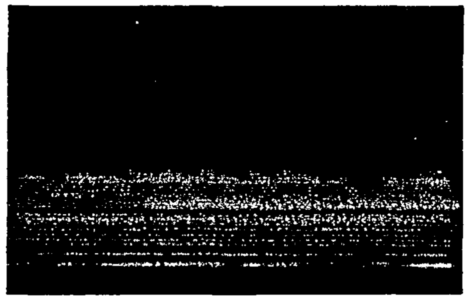
Fire Department Instructions

- Nuremberg, Germany
  translations following page

Die Feuerwehr rät:

1. Wenn Sie Ihre brennende Wohnung (Arbeitsraum o. ä.) verlassen, schließen Sie die Tür hinter sich! Sie grenzen den Brand damit ein und sichern sich und anderen den Fluchtweg.

2. Können Sie das Telefon erreichen oder haben Sie sich selbst gerettet: Feuerwehr über Notruf 112 alarmieren.



3. Benutzen Sie nur sichere Fluchtwege. Der sicherste ist die Treppe. Benutzen Sie zum Verlassen des Gebäudes nicht den Aufzug. Er könnte (aus welchen Gründen auch immer) stehen bleiben.

   Warnen Sie auf Ihrem Weg ins Freie Ihre Mitbewohner (Mitarbeiter).

   Öffnen Sie wenn möglich alle auf Ihrem Fluchtweg liegenden Treppenraumfenster.

   Haben Sie schon einmal über Ihre Fluchtmöglichkeiten nachgedacht?

4. Ist Ihnen der Fluchtweg versperrt (z.B. durch Verqualmung des Flures oder Treppenraumes), bleiben Sie in Ihrer Wohnung (Arbeitsraum o.ä.). Halten Sie die Tür geschlossen. Gehen Sie an ein Fenster (möglichst zur Straßenseite) und rufen Sie um Hilfe oder machen Sie sich durch Winken bemerkbar.

5. Warten Sie das Eintreffen der Feuerwehr ab. Befolgen Sie ihre Weisungen. Werden Sie nicht ungeduldig, Ihre Mitbewohner (Mitarbeiter) sind vielleicht in größerer Not als Sie.

6. Der Brandschutz in hohen Häusern (über 5 Vollgeschosse) und in Hochhäusern (der oberste Fußboden liegt mehr als 22 m über der Erdoberfläche) unterliegt bei uns sehr strengen baulichen Auflagen (z. B. Sicherheitstreppenräume). Springen Sie bei Gefahr nicht aus dem Fenster und erwarten Sie niemals einen Sprungtucheinsatz. Die Gebäudehöhe eines Hochhauses läßt derartige Einsatzmittel nicht mehr zu. Ein Versuch ist tödlich.

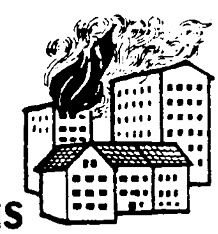
7. Stellen Sie sich der Feuerwehr zur Verfügung. Wir brauchen Ihre Personen- und Ortskenntnis!

8. Bemerken Sie als Unbeteiligter einen Brand, alarmieren Sie die Feuerwehr: Notruf 112.
   Verlassen Sie sich nicht auf andere! Vielleicht retten Sie durch Ihren Anruf ein Menschenleben!
   Merke: Einsätze zur Brandbekämpfung und Menschenrettung sind grundsätzlich kostenlos!

9. Für weitere Fragen steht Ihnen Ihre Feuerwehr gerne zur Verfügung.

Fire Department Instructions - Sweden

OM DET BÖRJAR BRINNA



i villa - radhus

GÖR SÅ HÄR

i höghus - hyreshus

(apartment building)

Först av allt. Rädda alla ut! Följ den uppgjorda räddningsplanen. Om det är rök – känn på den stängda dörren till ditt rum så den inte är varm. Korta andetag – håll för munnen – låg ställning. Kommer du ut – stanna där!

RÄDDA

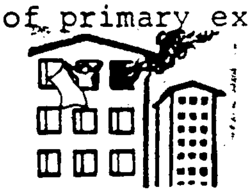
Vid rök i trapphuset – stanna i lägenheten. Gå ut på balkongen. Hoppa inte! Klättra inte i panik! Stäng så många dörrar som möjligt mot branden. Bor du i ett hus med mer än åtta våningar finns en särskild brandtrappa. Kontrollera att trappans alla branddörrar är stängda och hur du – även i mörker – når dem. Alla i huset måste känna till trappans användning i ett nödläge.

(check of safety of primary exit)

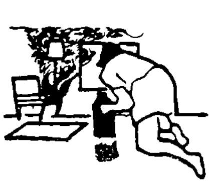
Larma med hjälp av visselpipa eller för oväsen så alla i huset vaknar. Ring brandkåren – 90 000 (Det kan dröja en halv minut innan SOS-centralen hinner svara). Ta det lugnt – så hinner du mera!

LARMA

Upptäcker du en brand – varna dem som bor ovanför eller i samma plan som branden. Ring brandkåren via SOS-numret 90 000. Tala om din adress, kommun och vad som hänt. Kommer du inte ut – gör andra uppmärksamma på din situation i en genom att vifta med ett lakan i fönstret samtidigt som du ropar på hjälp. Undvik panik – tänk igenom situationen först.



(signal location to rescuers)



Om branden är liten – försök släcka den. Använd villans brandredskap, vattenslang eller brandsläckare. Håll dig nära dörren så du kan retirera. Nära golvet är inte rök och värme så besvärande. Om branden ökar – gå ut och stäng dörrarna!

SLÄCK

En liten brand kan du släcka själv. Använd vatten i första hand. En våt handduk kan vara mycket effektiv. Det går också bra att kväva branden med en filt eller matta. Stäng dörren mot brandrummet om du misslyckas. Vädra inte förrän branden är släckt. Förbered dig för olika brandsituationer i huset.

(act quickly to prevent spread)

Appendix 1.

FIRE DEPARTMENT INSTRUCTIONS - NUREMBERG, GERMANY

1 When you leave a burning apartment (or room) close the door behind you! This way you restrict the fire and ensure a safe escape route for yourself and others.

2 If you can reach a telephone or if you are already in a safe place let the fire department know by dialling 112.

3 Use only safe escape routes. The safest is the stair. Do not use the elevator to leave the building! it can get stuck for various reasons. On the way, alarm the other residents of the building. If possible, open all the windows in the stair shaft.

Have you ever given some thought to the escape possibilities in case of fire?

4 If the escape route is blocked (e.g. by smoke in the corridor or in the stair shaft) stay in your apartment. Keep the door closed. Go to a window (on the street side, if possible) and call for help or make signals.

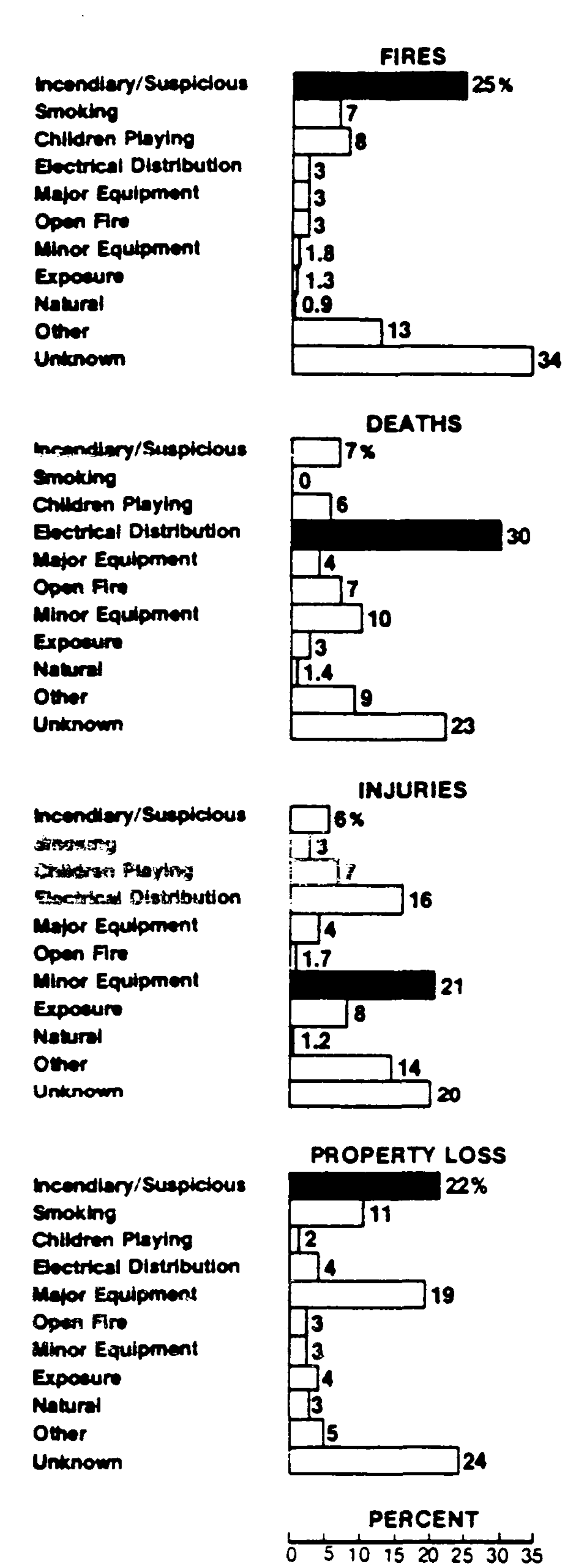
5 Wait for the arrival of the fire department. Follow their instructions. Do not be impatient - your neighbours may be in greater need of help than you.

6 The fire safety in tall buildings is subject to very strict building regulations (e.g. it must be provided with safety stairs). Never jump from the window. Because of the height of the building such attempts result in death.

7 Be ready to help the fire department. We need your knowledge of the building and the people who live in it!

8 If you notice a fire, always alarm the fire department. Do not rely on other people to do it! Your call may save human lives!

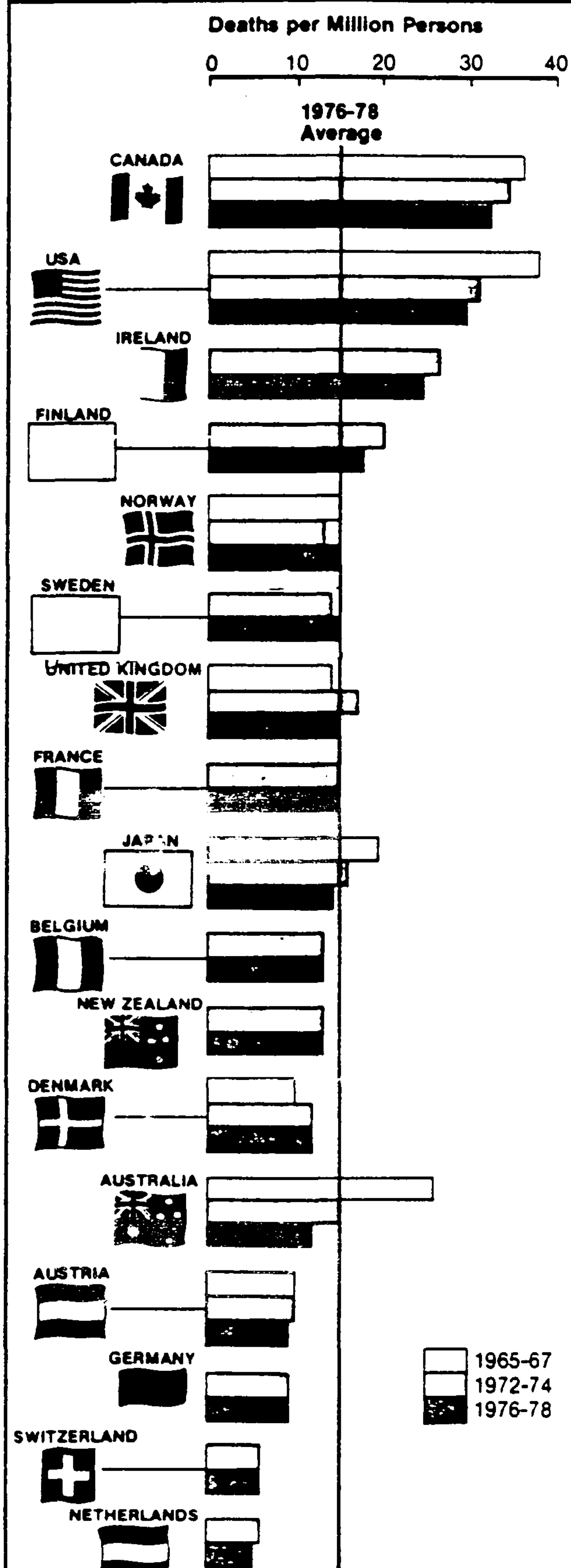
FIGURE 2.10: Causes of Outside/Other Fire Losses[1]—1978



[1] Fires from outside spills and explosions are excluded.

SOURCE. 1978 NFIRS data (203 988 fires with 70 fire deaths, 949 fire injuries, and $54.8 million property loss)

FIGURE 2.11: International Fire Death Rate—Indices (Excluding Transportation)

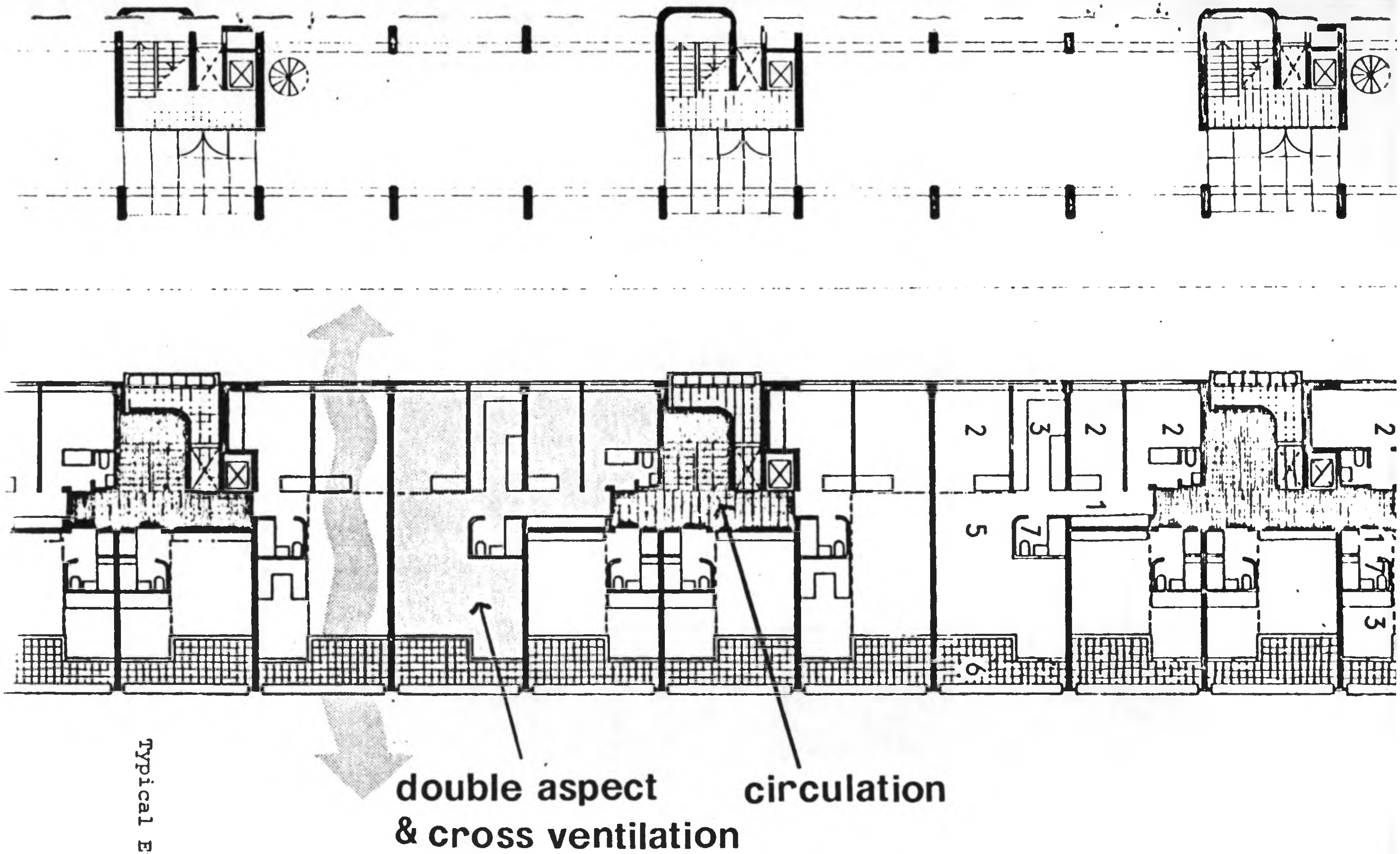


SOURCE: Georgia Institute of Technology. 1980

Table 1

Fire Safety and the Design of Apartments

ILLUSTRATIONS



Typical European Model

Figure 1.

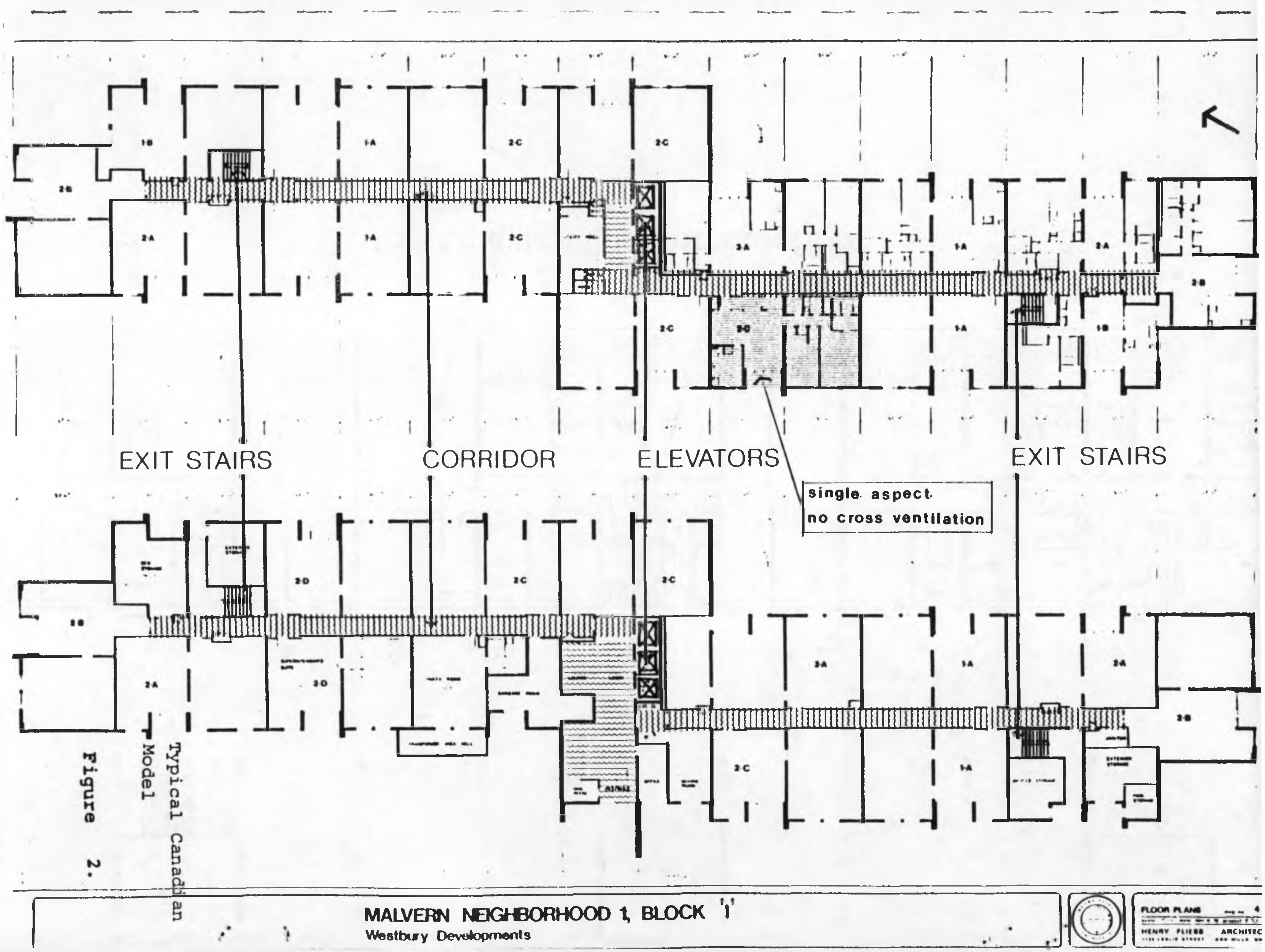
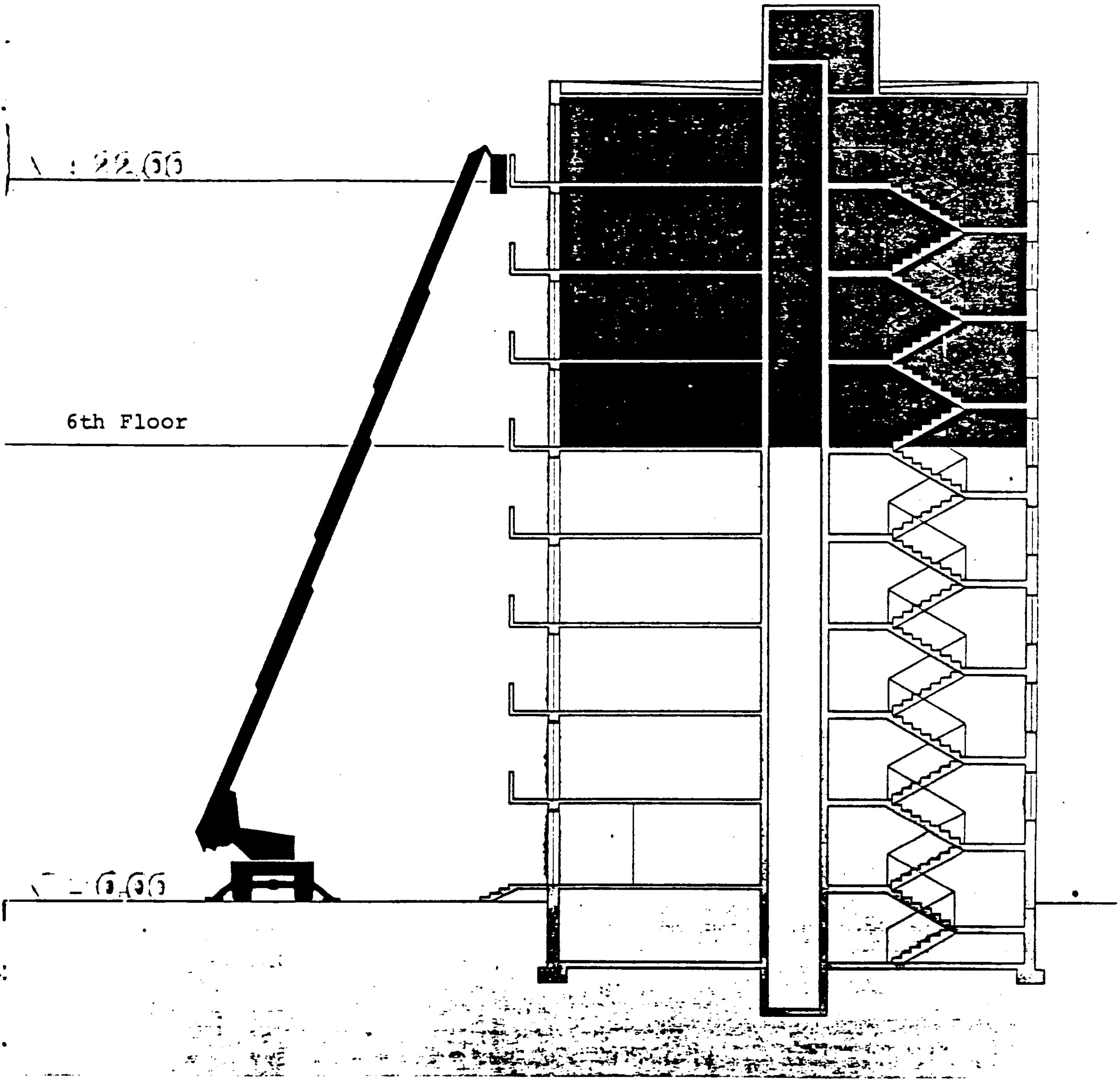


Figure 2. Typical Canadian Model

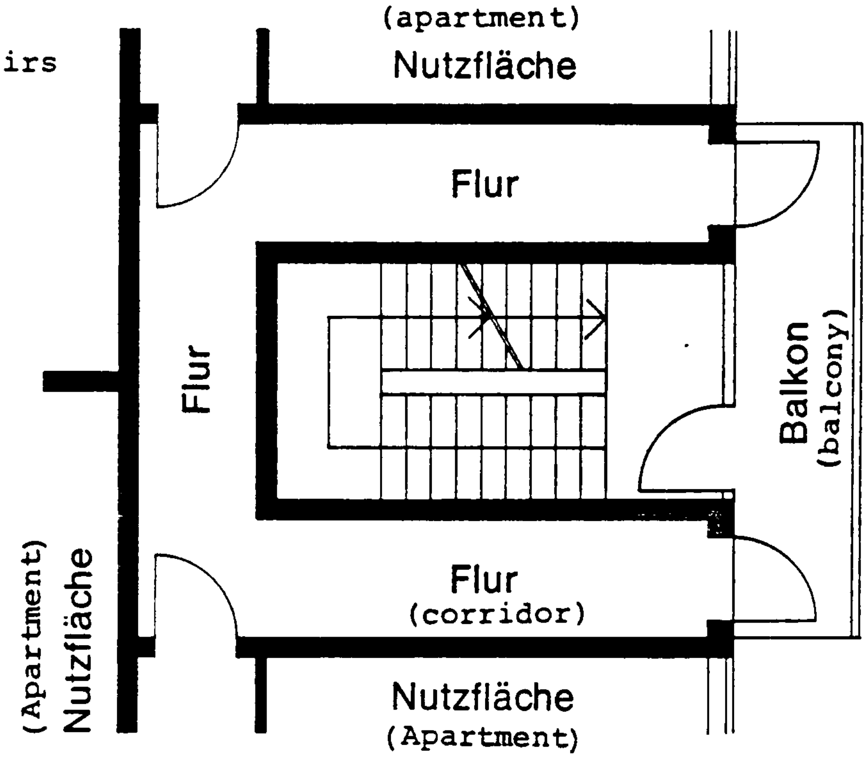
Fire Department Access to 22 Metre Limit



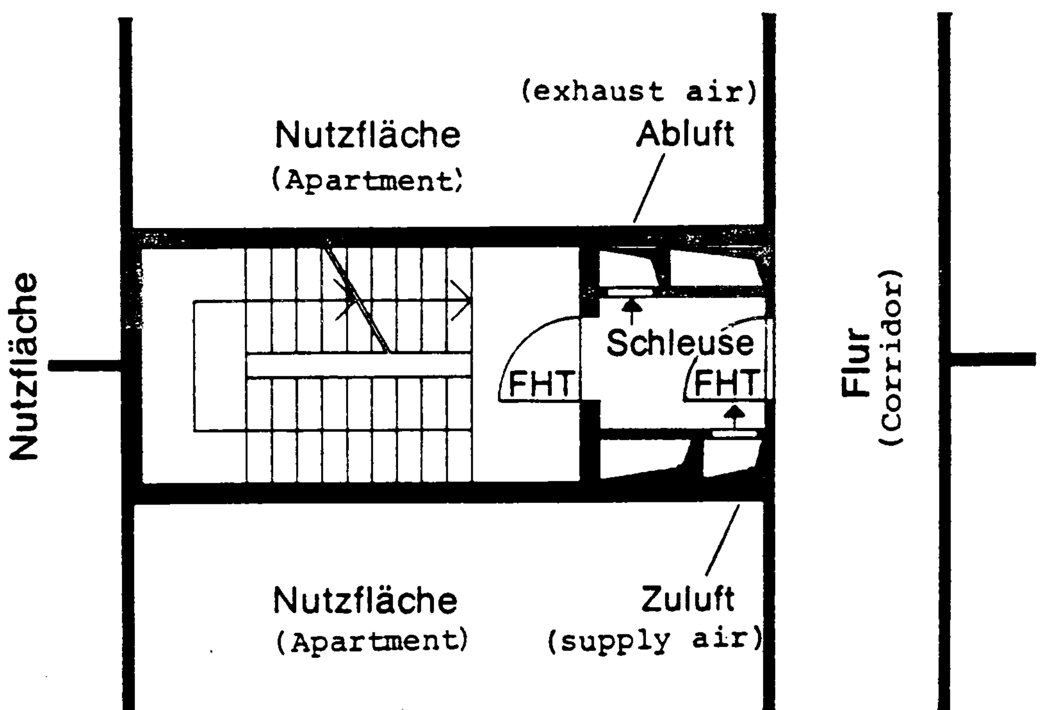
From: Bavarian Insurance Office

Figure 3

· Safety Stairs



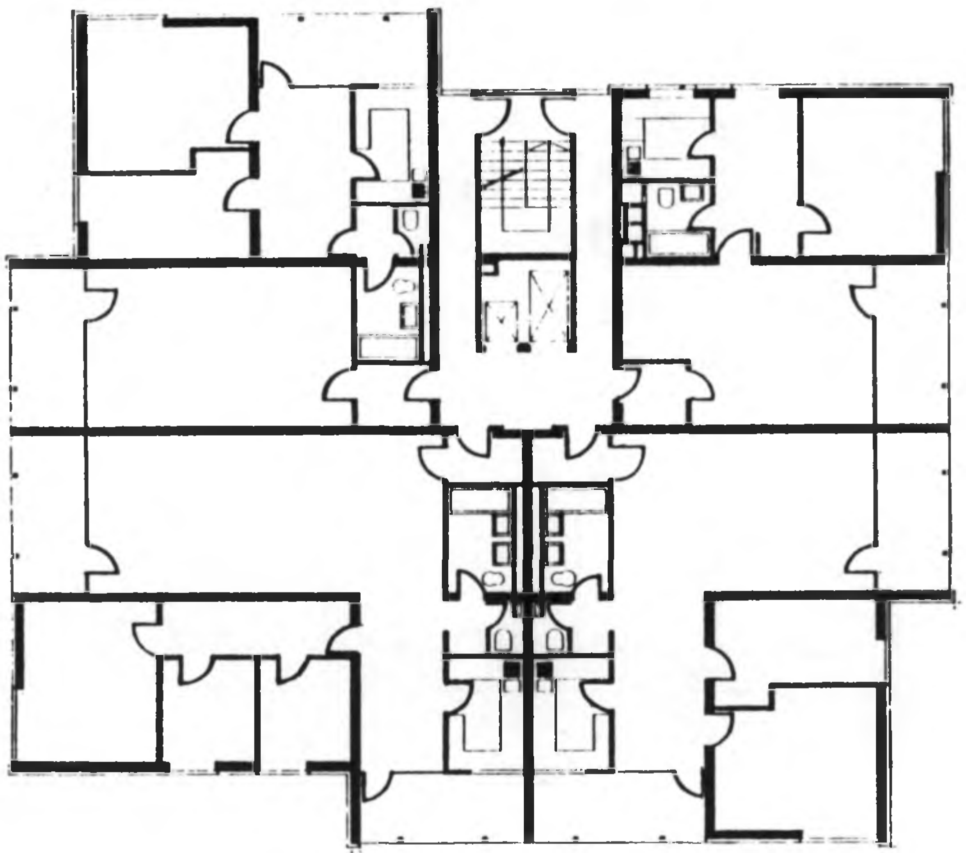
a.) natural ventilation



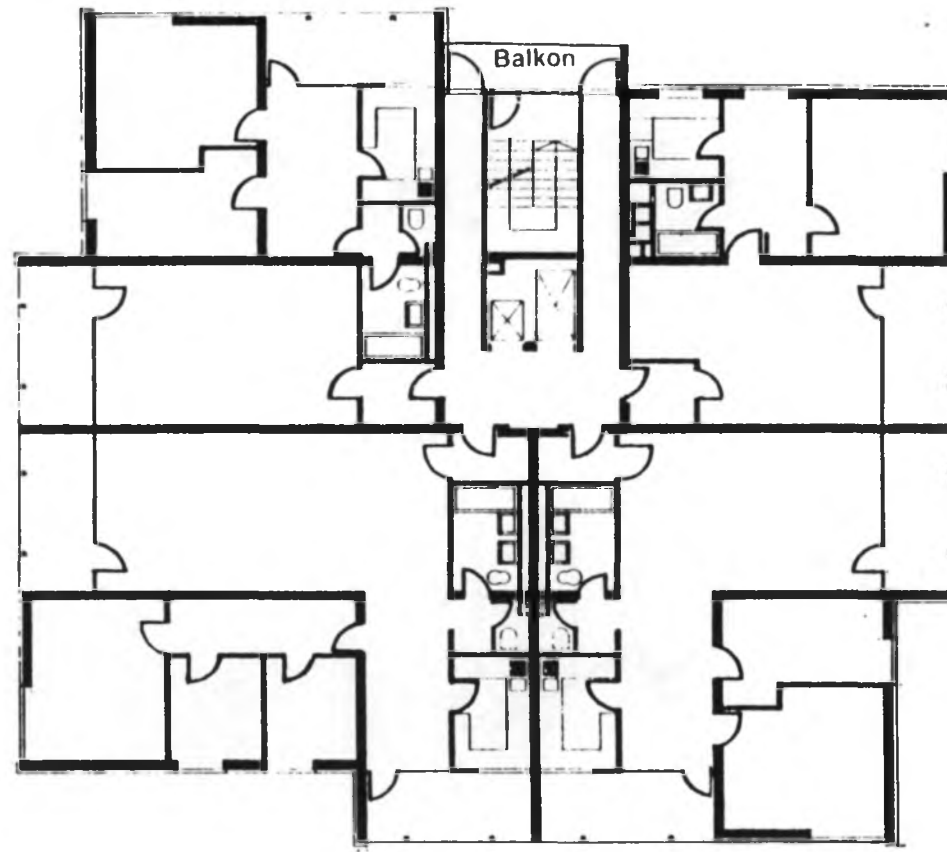
b.) artificial ventilation

Figure 4.

From: Bavarian Insurance Office

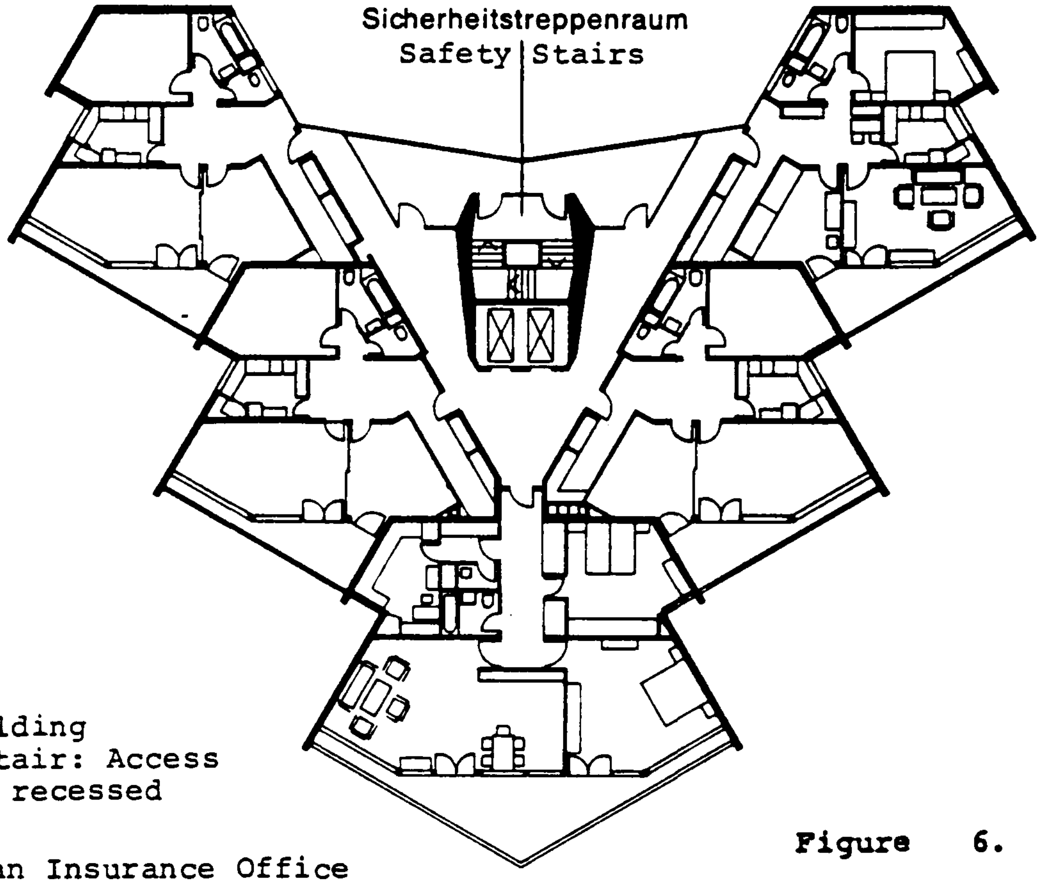


Stair configuration for up to 22 m



Stair configuration for over 22 m (note "Safety stair")

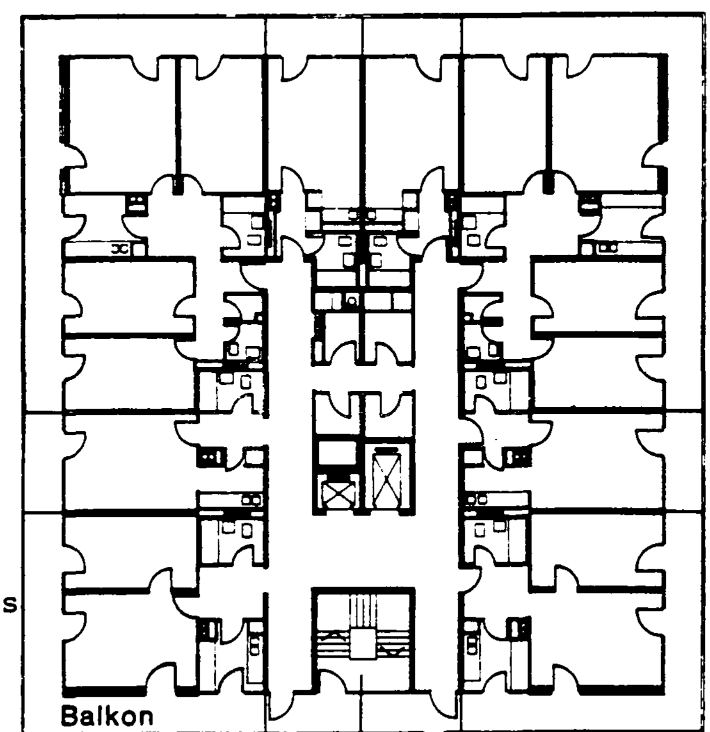
Figure 5.



Apartment Building
with Safety Stair: Access
from exterior recessed
balcony.

From: Bavarian Insurance Office

Figure 6.



Apartment Building
with Safety Stair: Access
from exterior balcony.

From: Bavarian Insurance Office

Figure 7.

Figure 8.

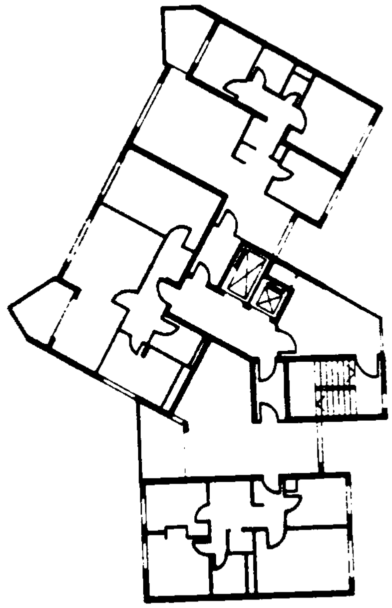


Figure 9.

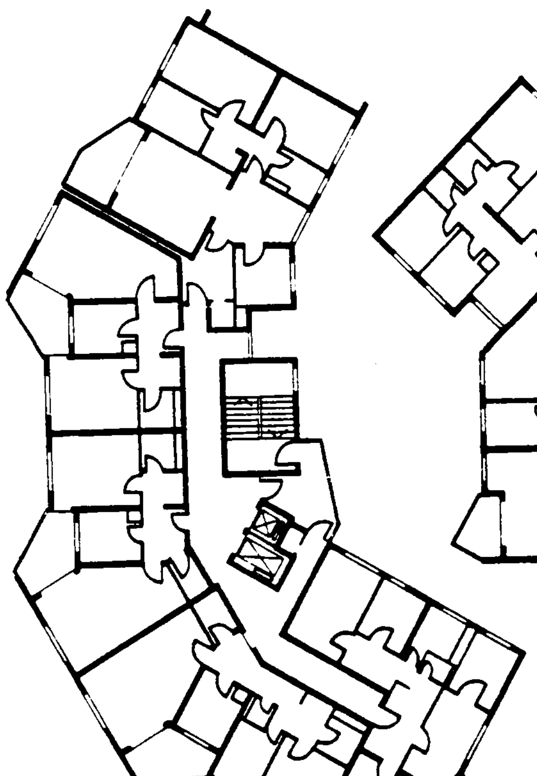


Figure 10.

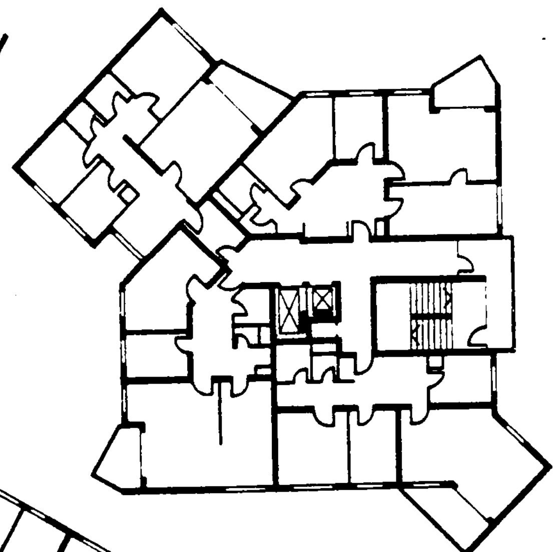


Figure 11.

Example of Bavarian
Apartment Houses

From: Bavarian Insurance Office

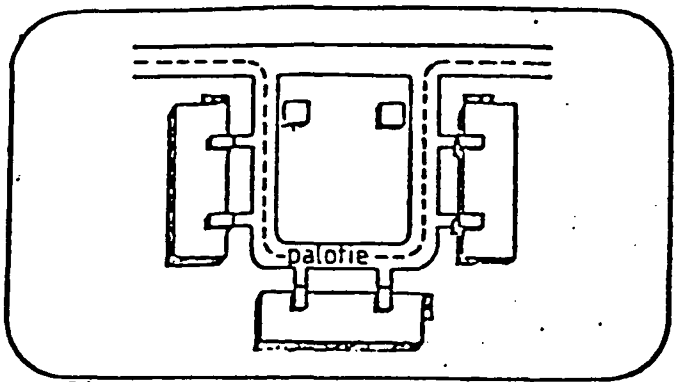


fig.13 fire access road

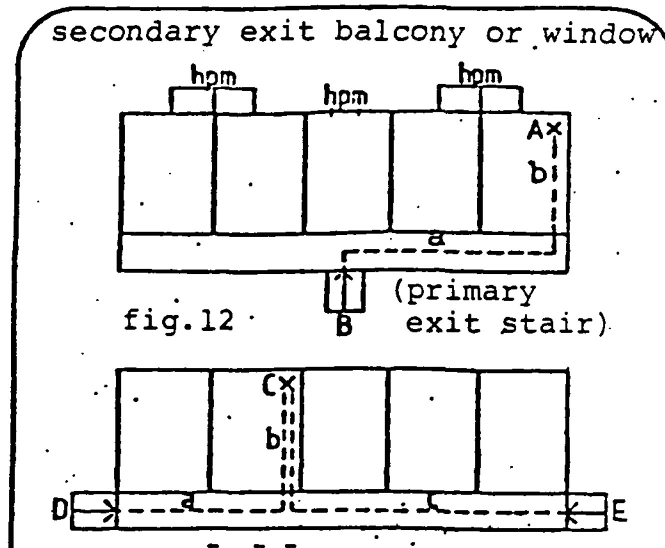


fig.12

LUHTIKÄYTÄVÄTALON KULKUTIEN PITUUS, PALOAHIDASTAVA / PALOAPIDÄTTÄVÄ RAKENNUS

Kerrostaloalueella palotie johdetaan pääsääntöisesti rakennuksen toiselle pitkälle sivulle.

Kulkutien pituus A-B lasketaan huoneiston kustakin kohdasta maanpinnalle B, jolloin A-B ≤ 30 m. Mikäli poistuminen voi tapahtua kahden portaan kautta, lasketaan matka b 2-kertaisena, jolloin a + 4b + c ≤ 90 m.

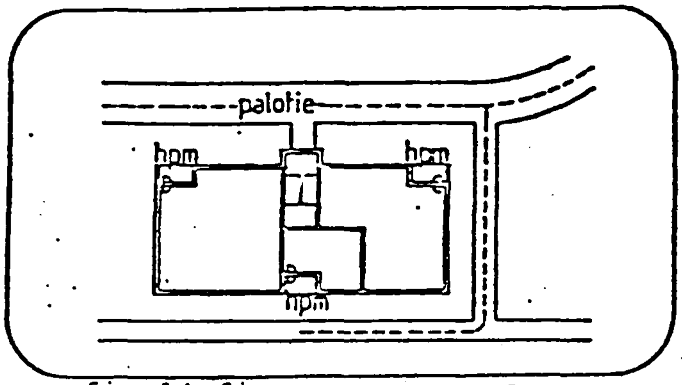
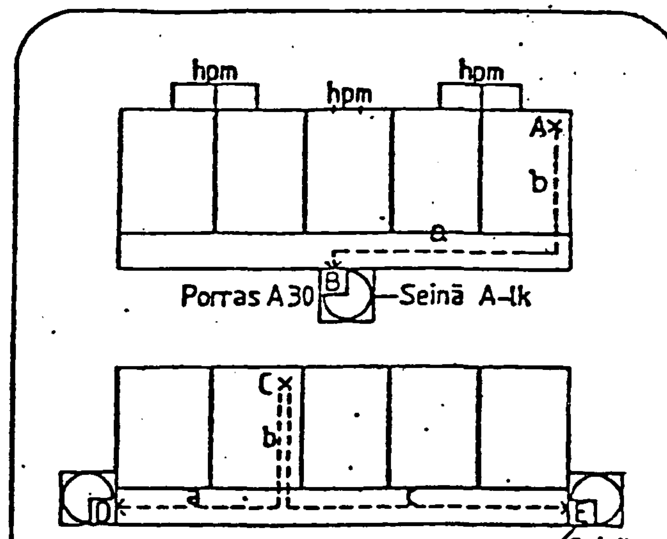
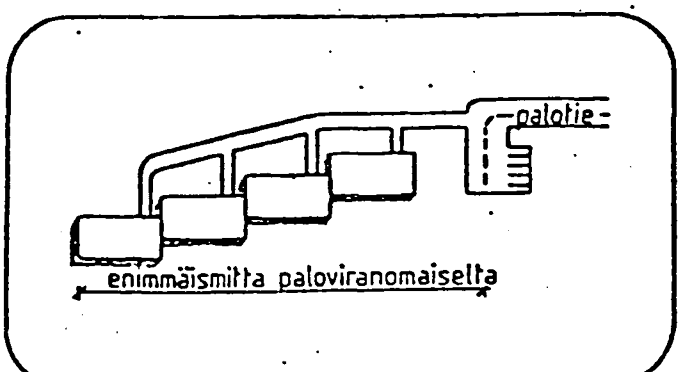


fig.14 fire access road

Palotie tulee johtaa rakennuksen kaikkien hätäpoistumismahdollisuuksien läheisyyteen.



LUHTIKÄYTÄVÄTALON KULKUTIEN PITUUS, PALONKESTÄVÄ RAKENNUS



Palotie pientaloalueella.

Kulkutien pituus A-B lasketaan huoneiston kustakin kohdasta porrashuoneen ovelle B, jolloin A-B < 30 m. Mikäli uloskäytäviä on kaksi lasketaan matka b 2-kertaisena, jolloin a + 4b + c ≤ 90 m. Porrashuoneen (uloskäytävän) ulkoseinät voivat olla A-luokkaisia ilman palonkestoaikavaatimusta. Huoneiston vastainen seinä pitää kuiten-

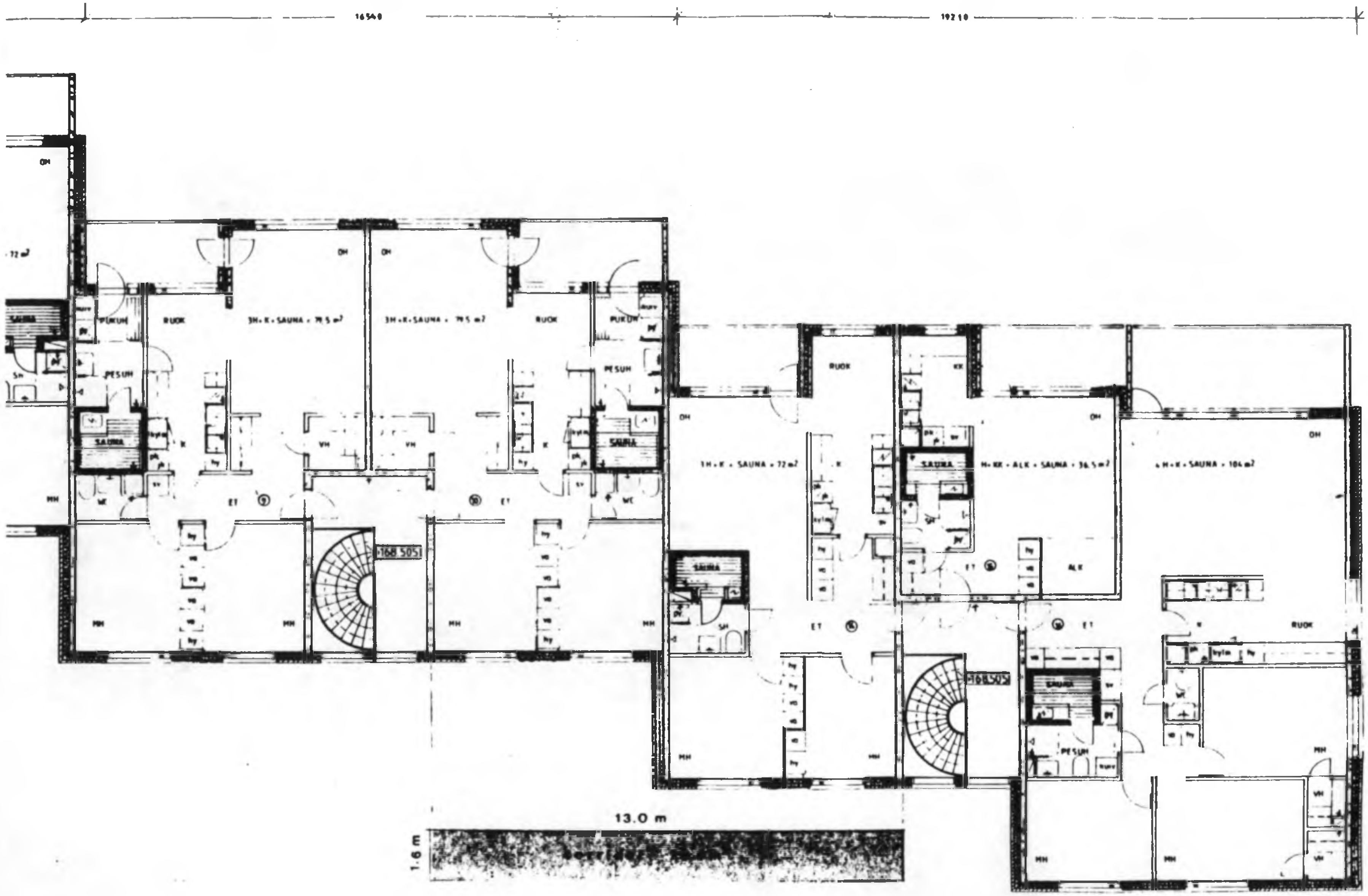
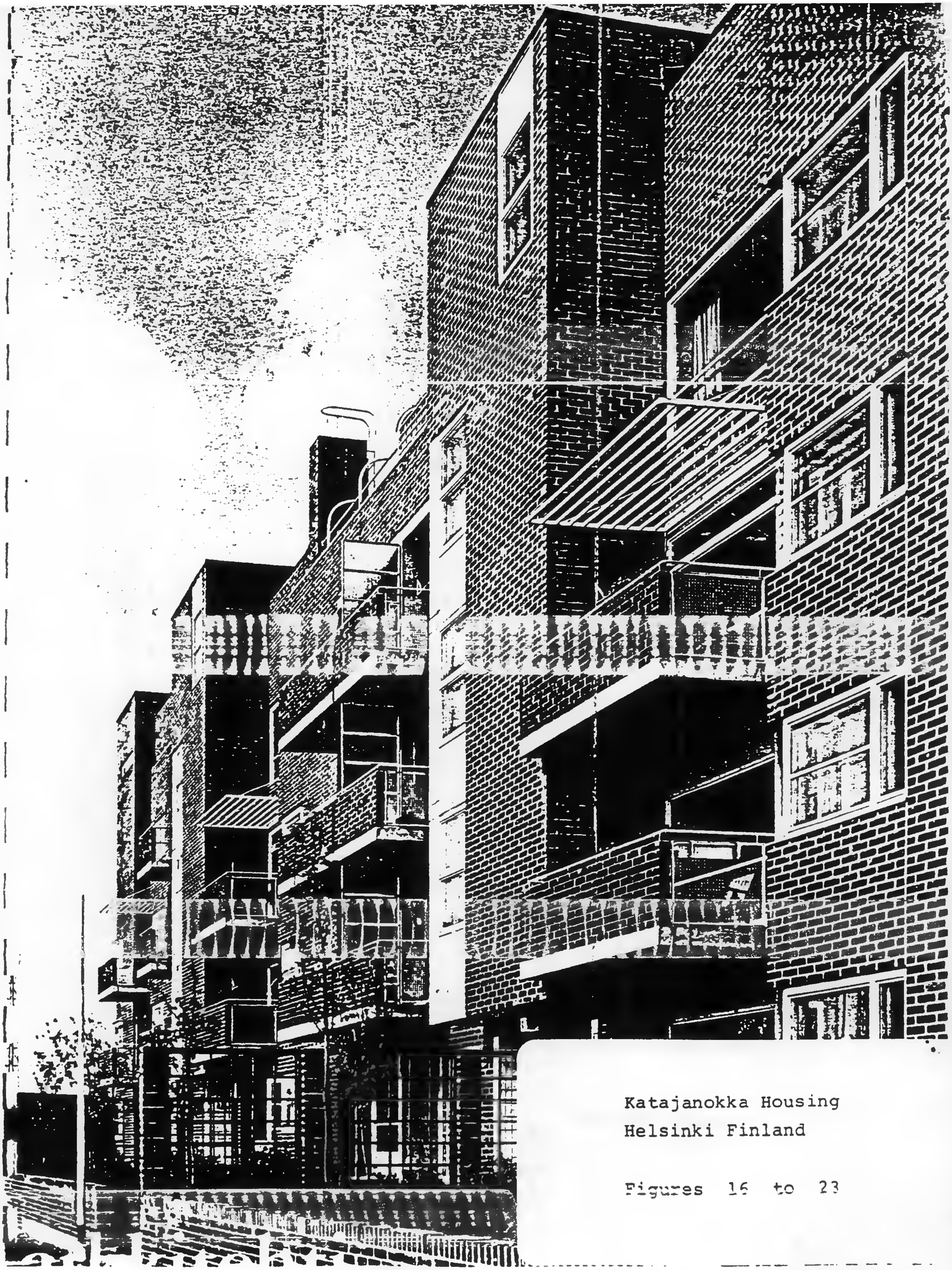


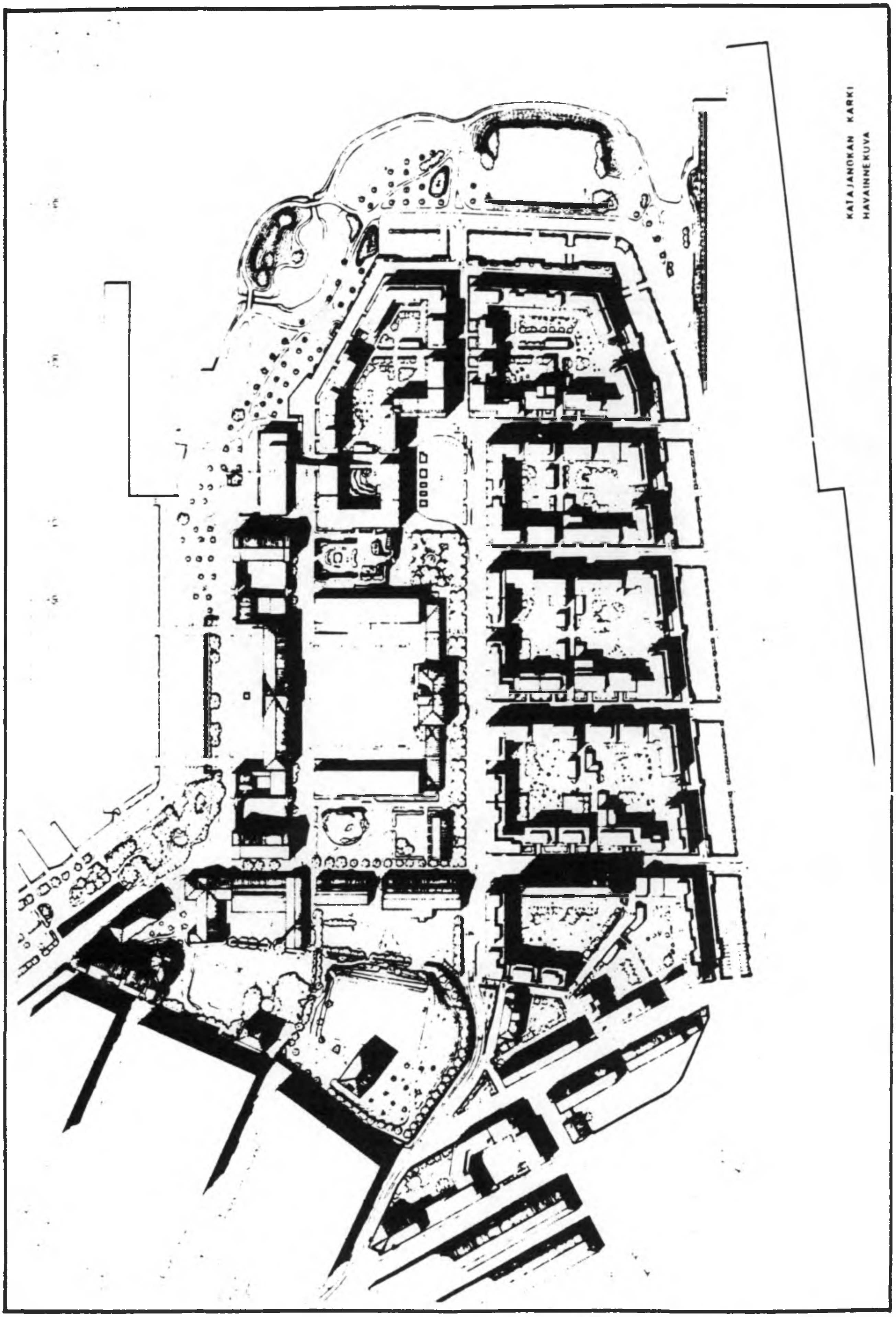
Figure 15

3 Storey Apartment Building - Finland



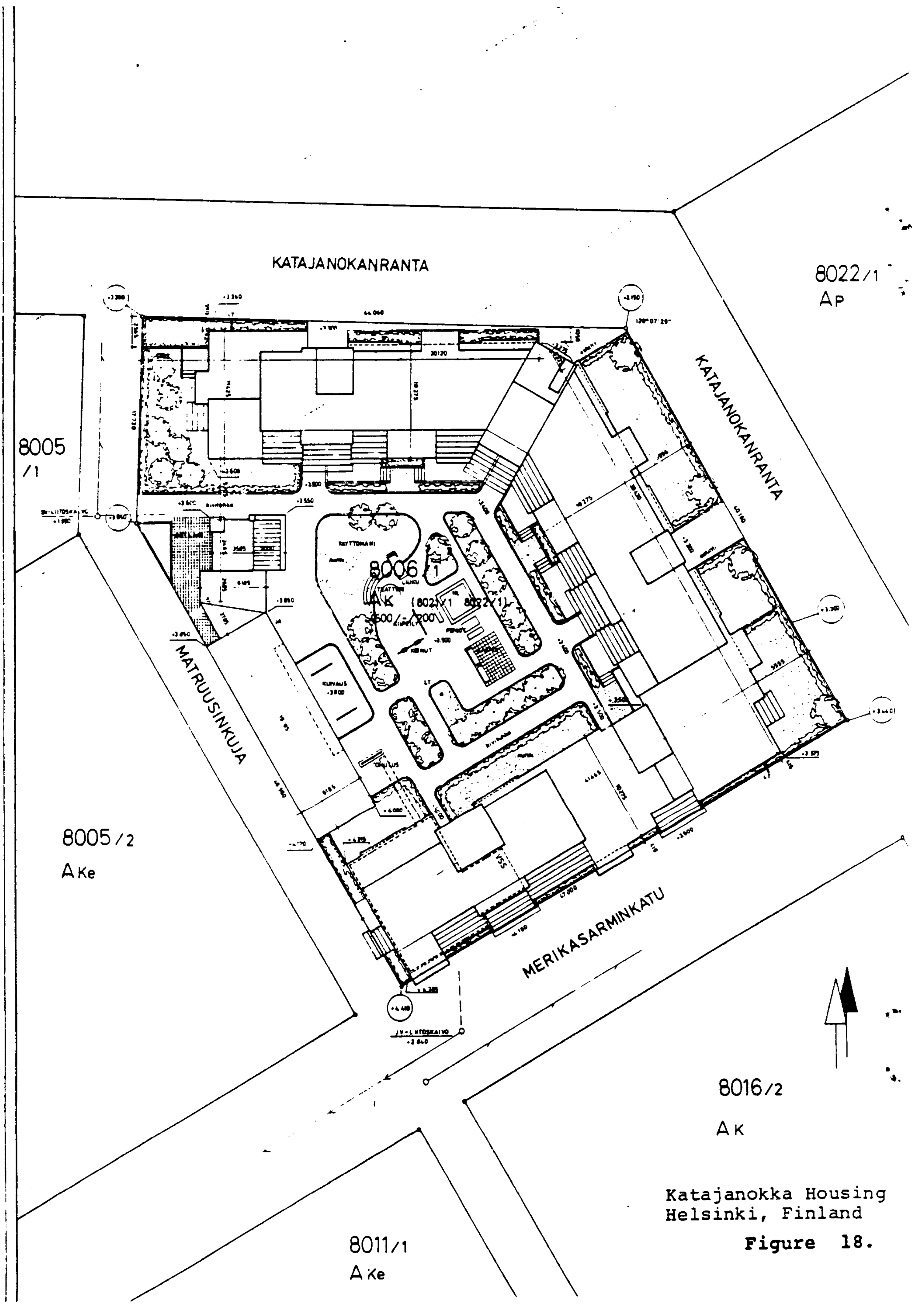
Katajanokka Housing
Helsinki Finland

Figures 16 to 23



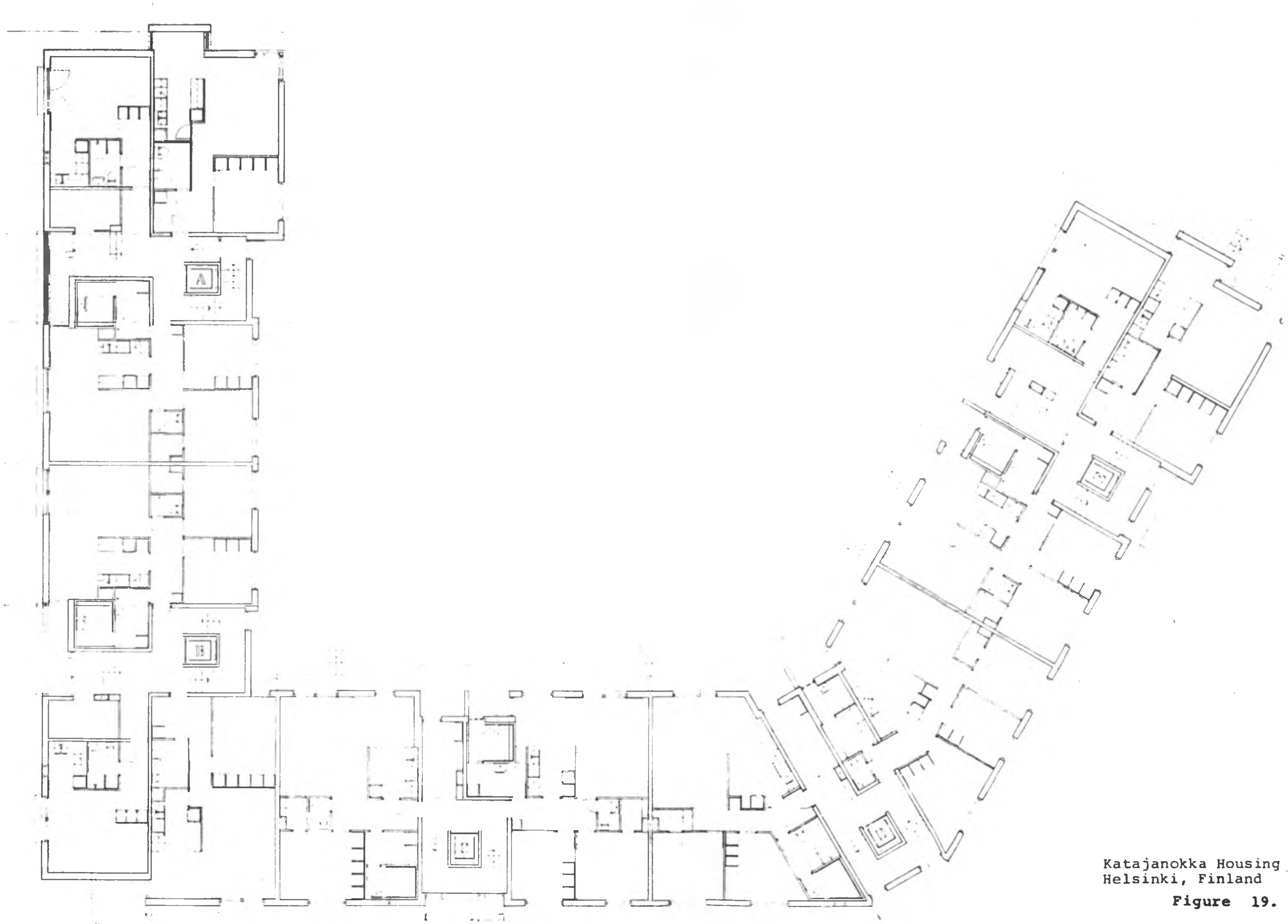
Katajanokka Housing
Helsinki, Finland

Figure 17.



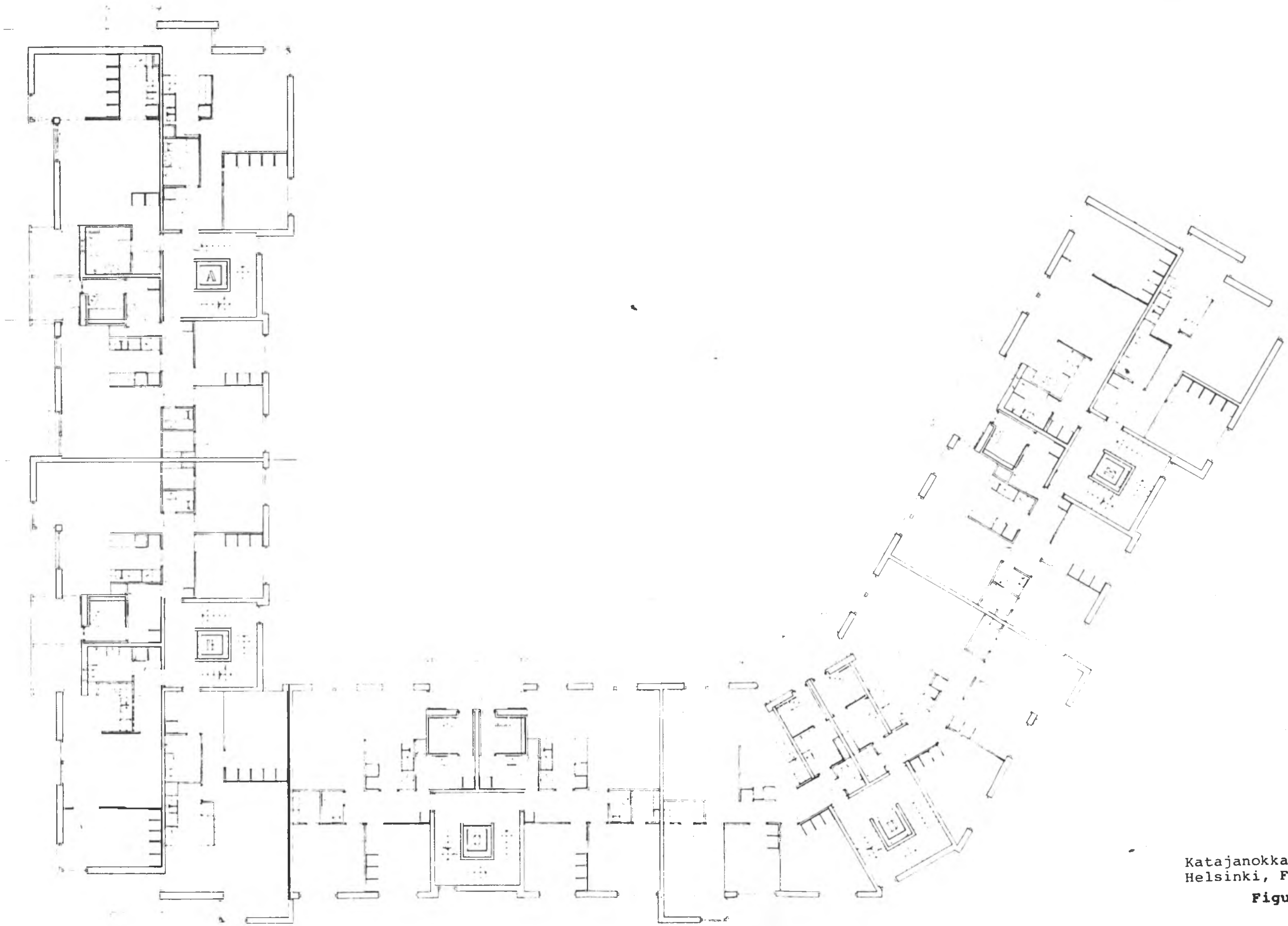
Katajanokka Housing
Helsinki, Finland

Figure 18.



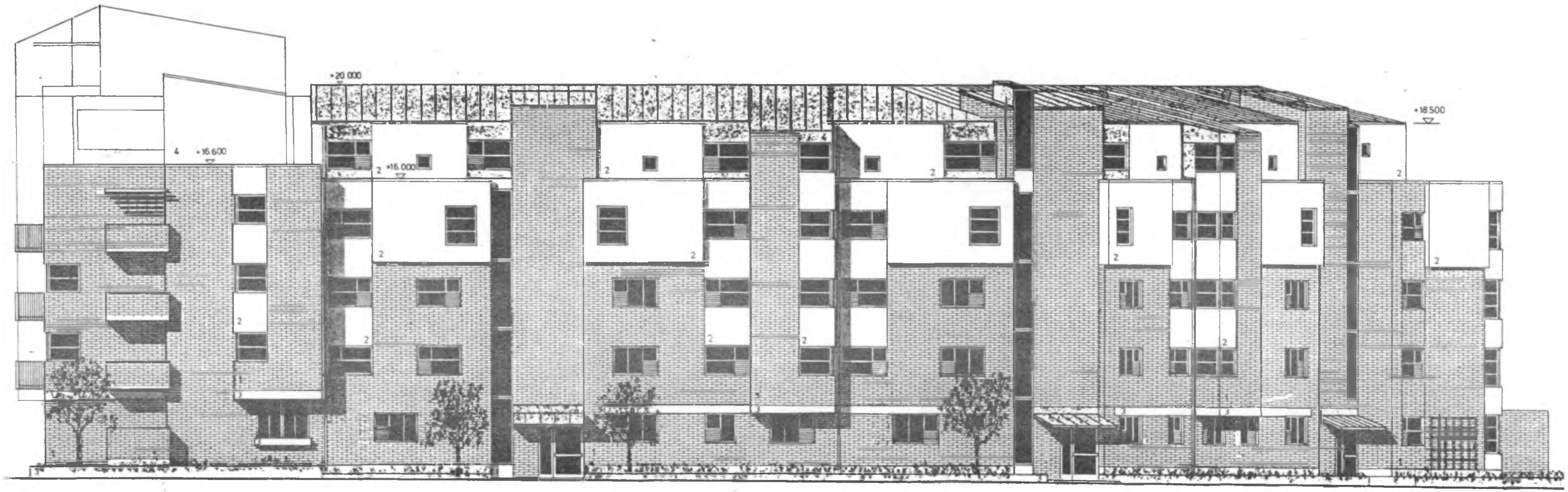
Katajanokka Housing
Helsinki, Finland

Figure 19.



Katajanokka Housing
Helsinki, Finland

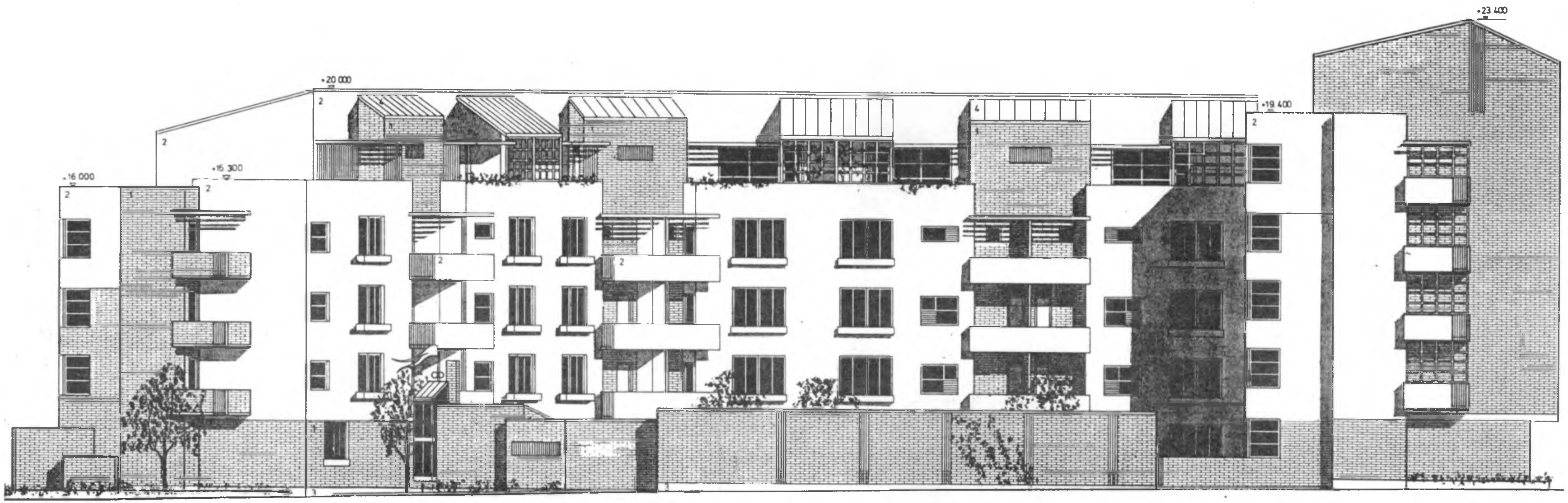
Figure 20.



1 TIILILAATTA, PUNAINEN
2 OHUTRAPPAUS, VALKOINEN
3 BETONI
4 PELTI, TUMMANRUSKEA

Katajanokka Housing
Helsinki, Finland

Figure 21.



1 TIILILAATTA, PUNAINEN
2 OHUTRAPPAUS, VALKOINEN
3 BETONI
4 PELTI, TUMMANRUSKEA

Katajanokka Housing
Helsinki, Finland
Figure 22.

Katajanokka Housing
Helsinki, Finland

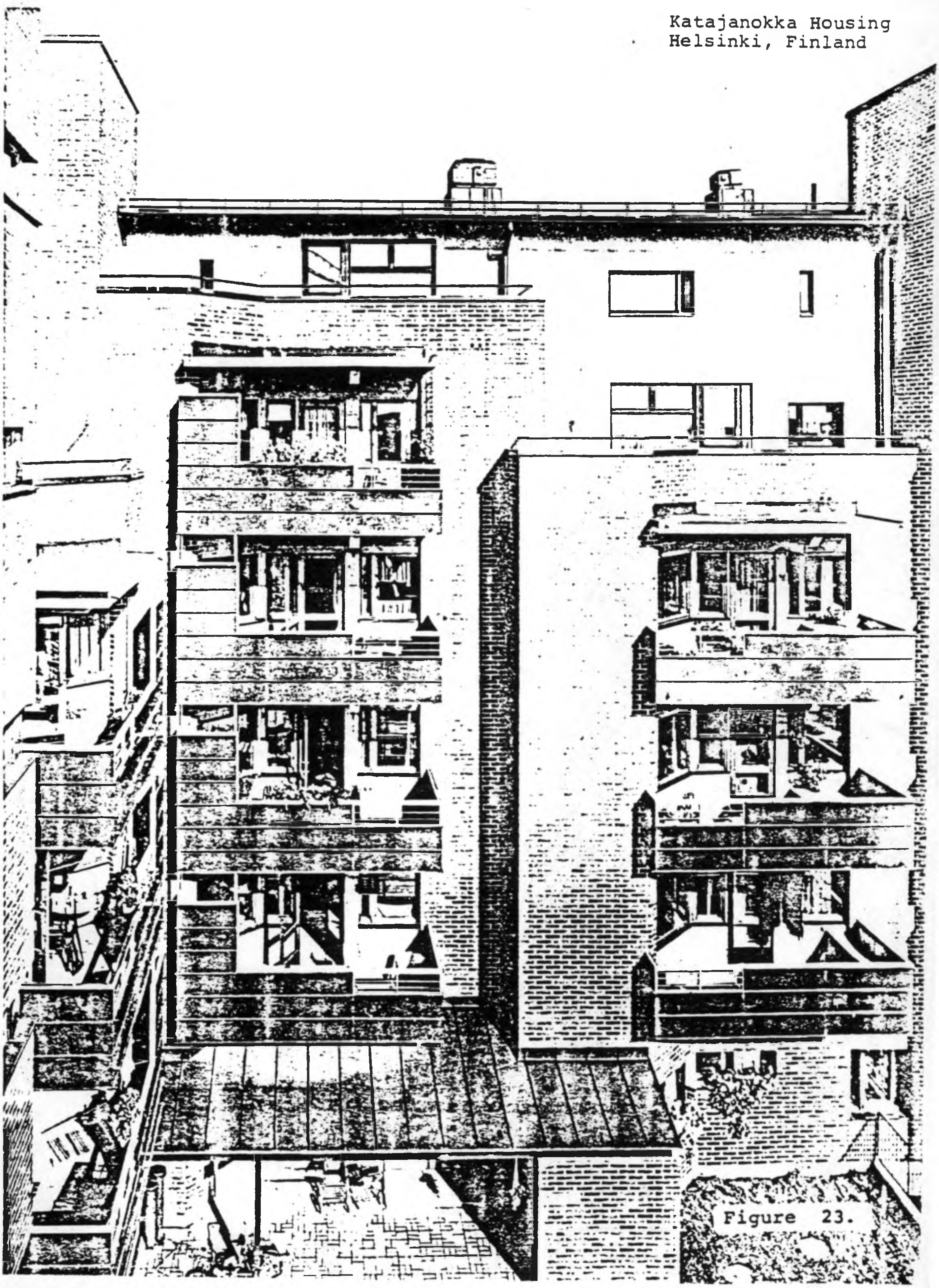
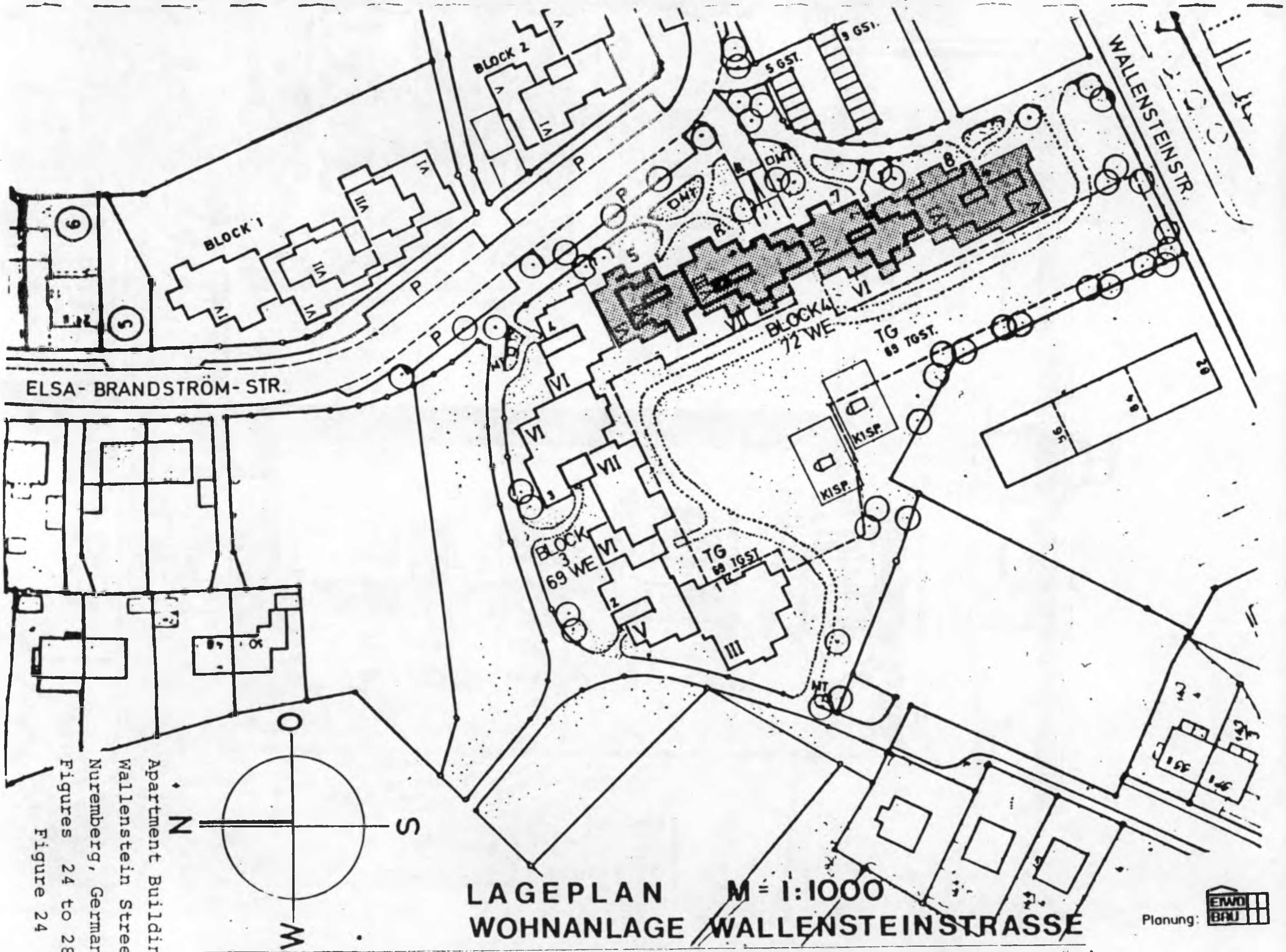


Figure 23.



Apartment Building
Wallenstein Street
Nuremberg, Germany
Figures 24 to 28
Figure 24

Site Plan Apartment Building Wallenstein St. Nuremberg

Apartment Building Wallenstein St. Nuremberg
Elevation

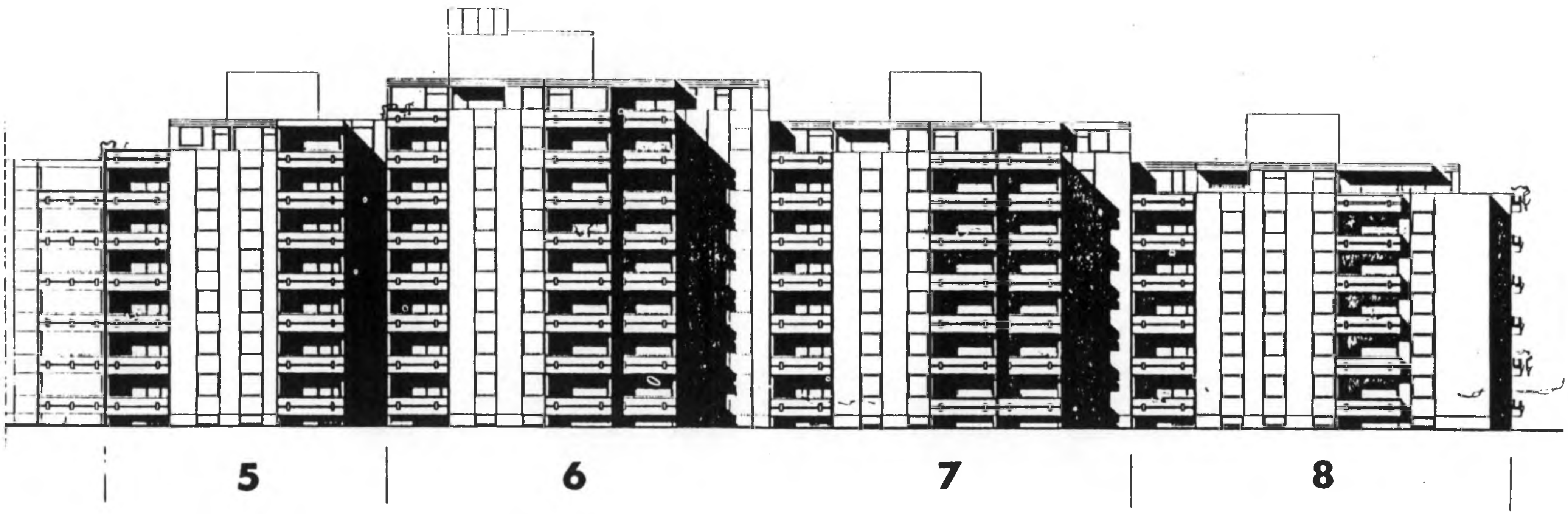
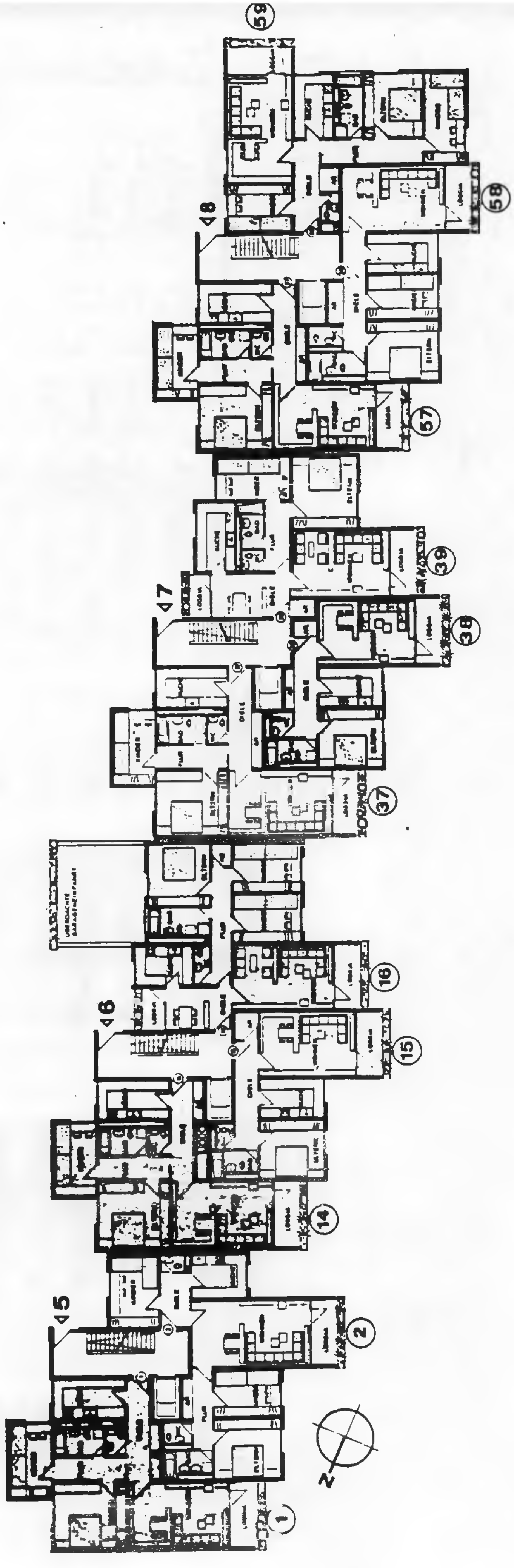
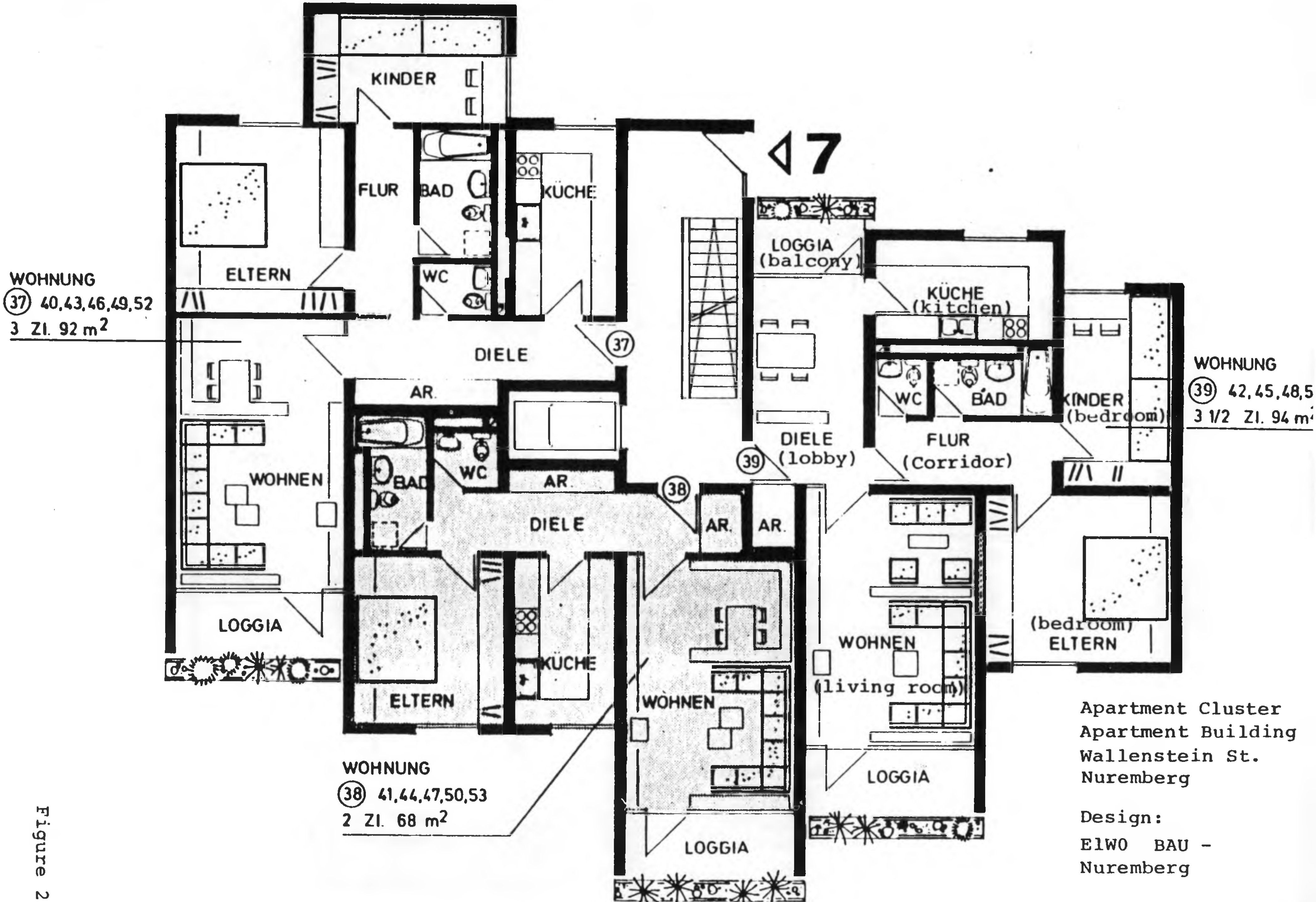


Figure 25



Design:
ElWO BAU - Nuremberg

Figure 26

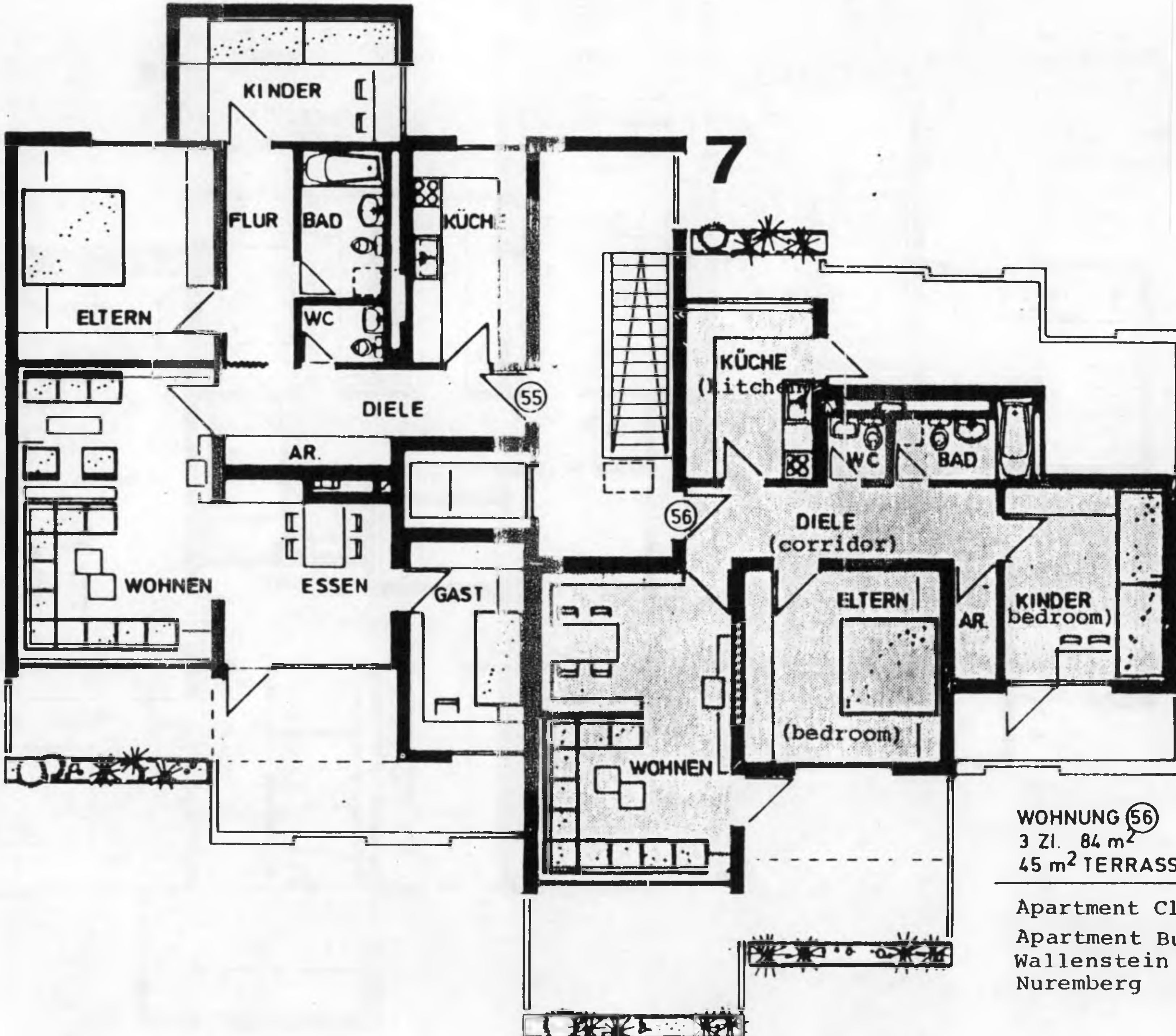


Apartment Cluster
Apartment Building
Wallenstein St.
Nuremberg

Design:
ElWO BAU -
Nuremberg

Figure 27

WOHNUNG 55
4 1/2 ZI. 114 m^2
17 m^2 TERRASSE



WOHNUNG 56
3 ZI. 84 m^2
45 m^2 TERRASSE

Apartment Cluster
Apartment Building
Wallenstein St.
Nuremberg

Figure 28