

MODIFICATION OF PRESENT CONSTRUCTION  
METHODS IN TAIWAN:  
AN INDUSTRIALIZED SYSTEM FOR PUBLIC HOUSING

By  
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Submitted in Partial Fulfillment of  
the Requirements for the Degree of  
MASTER OF ARCHITECTURE IN ADVANCED STUDIES

At the  
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June, 1978

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The author would like to thank the following people who contributed much to make this thesis possible:

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Professor of Structures  
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Eduardo F. Catalano  
Professor of Architecture, Emeritus  
Massachusetts Institute of Technology

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Albert C. Huang  
Architect  
Glaser-deCastro-Vitols Partnership

Roderick C. Leung  
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## ACKNOWLEDGEMENTS

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Submitted to the Department of Architecture on May 12, 1978, in partial fulfillment of the requirements for the degree of Master of Architecture in Advanced Studies.

The objective of this thesis is to develop an industrialized housing system, aimed at present conditions in housing shortage and the overall housing industry in Taiwan. In the search for a more rational and feasible way to solve the shortage problem, the system concentrates on utilizing existing construction materials and labor skill available in Taiwan.

Almost every developing country faces the difficult problem of housing shortage. Often, advanced industrialized housing systems are imported whole-sale from developed nations and viewed as the only solution to mass-scale production of housing. What is often neglected are the timing and coordination of other relevant factors. This thesis reflects the attitude that, in the process of housing industrialization, the consideration of other conditional factors, as well as question of future long-run development, are vastly more important than

merely the final design and product.

The thesis consists of four main parts: The first is an analysis of present housing needs and the housing industry in Taiwan. From economic, social and technological points of view, the principal factors and constraints which affect the present design of housing system are summarized.

Part two concerns living space and function analysis. Different sequences of living spaces are derived from the measurements of furniture and housing equipment available on the market, and spaces necessary for living activities, coordinated with the basic modular system.

Part three consists of the proposed housing system. The housing system utilizes light-weight concrete panels as its basic structural element, attempting to demonstrate their combination and application.

The last part is a demonstration of the design proposal. Utilizing different plans, the proposal demonstrates five varieties of housing types, as well as illustrates their grouping schemes.

Thesis Advisor

Waclaw P. Zalewski, Professor of Structures

**ABSTRACT**

TITLE PAGE	1	SPACE AND FUNCTION ANALYSIS	16
ACKNOWLEDGEMENTS	2		
ABSTRACT	3	DESCRIPTION OF SYSTEM	33
TABLE OF CONTENTS	4	Structural Components	
INTRODUCTION	5	Component Production	
PRESENT CONDITIONS IN HOUSING	7	Reinforcing	
INDUSTRY		Applications of Structural	
Labor Skills and source of		Components	
Labor Force		On-site Connection	
Construction Technique		Construction Details	
Production in Major Building			
Materials		UNIT PLANNING AND GROUPING	50
Housing Supply and Demand		Unit Area Ranges	
Housing Investment and Housing		Unit Plan Catalogue	
Policy		Unit Planning	
		Unit Grouping	
BACKGROUND ANALYSIS OF HOUSING	12		
INDUSTRIALIZATION		REVIEW AND RECOMMENDATION	83
Social Conditions			
Economic Conditions		APPENDIX	
Technological Conditions		Calculation of Floor System	85
DESIGN OBJECTIVES OF HOUSING SYSTEM	15	REFERENCES	87

## TABLE OF CONTENTS

In the past two decades, due to the vast increase in population growth, as well as the concentration of population in the urbanization process, housing shortage has become a critical problem in Taiwan. The government had, as early as 1955, set up mechanisms responsible for the construction of public housing, which have since undergone various changes. However, these organizations have not been able to adequately cope with the demands of reality, and hence have not dealt effectively with the problem of ameliorating public housing in Taiwan.

Previous neglect, coupled with the pressures of increasing demand, have forced the Executive Yuan in recent years to include public housing within the country's major construction considerations.<sup>1</sup> The government has to look to industrialization and systematization of housing construction, if it is to seriously

consider an efficient method of increasing housing on a large scale.

Housing industrialization is a broad concept, referring not only to construction method, nor only to building materials. Often the term is viewed synonymously with prefabrication; indeed, its end result may be seen as the attainment of a prefabricated housing system. This train of thinking, employing as it does only the transfer of technology and import of ready-made products, disregards the conditions and limitations of objective reality, and can be quite dangerous. For housing industrialization to take root, technological potential is but one factor. Simultaneous development of other social criteria is also necessary for industrialization to flourish in Taiwan.

The purpose of this thesis is to analyze the present conditions of housing demand

## INTRODUCTION

and building industry. Base on this analysis, the concrete criteria as well as the feasible technological options for the development of housing industrialization in Taiwan will be made.

The latter portion of the thesis consists of an industrialized housing system design. This design represents an example of how, by reflecting present social conditions in Taiwan, the process of housing production can be industrialized.

- 
1. "Central Daily News", August 9, 1977 Editorial, October 3, 1977 p.3, February 17,1978 p.1

### Labor Skills and Source of Labor Force

Obsolescence of the apprenticeship system in the construction industry, as well as the limited availability of professional training, has led to shortage of skilled labor and decline in construction skill standards. According to vocational training statistics and other information (from June 30, 1974 to May 31, 1975), among those professional training organizations registered with the Ministry of the Interior, only 0.3% are in the construction industry, whereas in the same year construction labor made up 5.77% of the working labor force.

Not only has quality declined, but quantity is also insufficient in construction labor. According to a report of the Cheng-Kung University Building Industrialization Research Group<sup>2</sup>, utilizing present construction methods in

public housing and approximating 140 thousand housing units per year, the labor supply needed by 1980 will be 2.2 times that of 1970.

On the other hand, signs of instability are evident in the labor force for construction. Instability may be due to the short-term nature of labor employment, its limited benefits, the uncertainty of the construction market and the great degree of substitutability in manual labor. For instance, the shortage of labor supply in the month of July (harvest season in the countryside) demonstrates the close relationship between rural and urban labor supply.

### Construction Technique

Present construction methods remain in the traditional handicraft stage, thus not only unsuited to accommodate to new materials and skills, but also lacking a

## PRESENT CONDITIONS IN HOUSING INDUSTRY

rational, efficient approach to change and progress. Systematic analysis and adoption of new construction methods and skills have not been made.

In terms of machinery, contractors lack the necessary heavy construction equipment. For example, cranes were found to be missing in all the contractors surveyed.<sup>3</sup>

The above factors, added to the shortage of professional training, have all contributed to the present standstill in construction technique development.

#### Production in Major Building Materials

##### 1. Reinforcing Steel:

Before 1977, not only was there insufficient quantity of architectural steel, but there was often disequilibrium in supply and demand, leading to great instability in

market price. With the entrance into production of the China Steel Corporation at the end of 1977, the situation has been ameliorated.

##### 2. Sand and Aggregate:

River beds in Taiwan have historically been rich in sand and aggregate. However, due to large-scale extraction near urban centers in recent years, production had gradually declined. Transportation costs from distant sources have elevated expenses. Hence, prices of sand and aggregate have experienced the greatest variation in recent years.

##### 3. Cement:

Since 1963, a great proportion of cement produced has been exported. In 1969, due to a sudden increase in domestic demand and corresponding shortage in export capacity, much of

the international market was lost. Production in the following year reached only 70% of productive capacity. Presently, cement production is sufficient for domestic needs. However, adjustment of supply and demand, especially to fulfill the needs of large-scale housing production, requires detailed study and planning.

4. Brick:

Taiwan has excellent sources of clay deposits for fabrication of bricks. However, old-fashioned methods such as kiln-burning are subject to the vagaries of weather and are hence limited in scope.

5. Wood:

While not rich in lumber, Taiwan's plywood industry is nevertheless rapidly developing. The yearly increase in quantity is sufficient to

supply both domestic and international demands.

### Housing Supply and Demand

The gross density of Taiwan's population in 1976 was 441 persons per square kilometer. Compare to Holland's 387 persons/km<sup>2</sup>, Belgium's 318 persons/km<sup>2</sup>, Taiwan has the highest density of any area in the world.

Given that the minimum living space per person is 16m<sup>2</sup>, and each housing unit can accommodate 5.5 persons, the number of housing units short in 1975 came to 680,000. Furthermore, using the 1951-1975 population census as basis, the average of Taiwan's yearly increase in population is 350,000. Accordingly, new housing units needs merely to keep up with the population increase number 60,000 units. Added to factors such as the tearing down of old buildings, squat-

ter slums and housing damages due to natural disasters, necessary new construction comes to a total of at least 140,000 yearly.

From census and housing surveys in 1970 and 1975, it was revealed that the number of housing units increased by 440,000 in five years, bringing the yearly average up to not quite 90,000.<sup>4</sup> This kind of gap in demand and supply, widened over the years, can become a critical problem, especially in the urban areas.

#### Housing Investment and Housing Policy

In the past 15 years, housing investment in Taiwan has reached an annual average of 2.2% of G.N.P., and 10% of national fixed capital investment. Compared with other countries (Table I), Taiwan has very low capital investment in housing.

Under the present six-year economic plan (1975-1981), new dwelling units to be constructed, including those financed both publicly and privately, approximate 60,000. Of these, only one-third is public housing, utilizing government funding.

Upon completion of the ten construction projects presently underway, the Executive Yuan plans to continue with twelve major new undertakings. Plans are afoot for mass-scale public housing, which, if executed soon, can greatly alleviate the present pressures of housing shortage.

- 
2. B.I.R.G., Cheng-Kung University, "A Preliminary Study of Housing Industrialization", May, 1971, p.34.
  3. Lee, B.H. "Study of Labor and Work Period Conditions in Taiwan's Housing Construction".
  4. Economic Planning Council: "Overall Development Planning for the Taiwan Regional Area", March 1977, pp. 7-19.

TABLE I. International Comparisons of Housing Investment as Percentage of G.N.P. and Fixed Capital Investment

Country	Housing Investment as Percentage of GNP, % (Average for 1963-1973)	Housing Investment as Percentage of Fixed Capital Investment %, (Average for 1963-1973)
Australia	5.1	19.2
Brazil	6.7 (1963-1969)	41.8 (1963-1969)
Chile	3.6 (1968-1973)	17.1 (1968-1973)
Columbia	2.9	16.8
El Salvador	2.6 (1968-1972)	17.6 (1968-1972)
England	3.2	18.2
France	5.1 (1970-1971)	24.5 (1970-1971)
Ghana	7.3 (1968-1972)	63.4 (1968-1972)
India	2.7 (1963-1971)	8.7 (1963-1971)
Japan	6.5	19.1
Kenya	2.5 (1963-1974)	14.5 (1963-1974)
Malaysia	1.8	12.9
Portugal	3.9	20.8
South Korea	2.8	12.1
Taiwan	2.2 (1963-1977)	10.5 (1963-1977)
Thailand	3.2	13.9
United States	3.6 (1968-1973)	20.8 (1968-1973)
Venezuela	5.5 (1968-1972)	22.6

source: Economic Planning Council, "Overall Development Planning for the Taiwan Regional Area", March, 1977, pp. 7-15.

### Social Conditions

The principal housing problems facing Taiwan presently are lack of capital funds and the poor quality of housing, as well as the shortage of labor supply in meeting construction demands. To raise labor productivity and to rationalize the construction process, housing industrialization is a useful option to consider.

Two industries directly related to housing, manufacturing and construction, are backward in both organization and production method. For example, transportation, construction machinery, and processing of materials are still at an elementary level. Under these circumstances, rapid industrialization of housing production not only faces numerous obstacles, but may generate new ones. Given the present social conditions, industrialization at all levels should

proceed: improvements in construction methods, advances in partial industrialization, experimentation with advanced technological skills, etc.

### Economic Conditions

Looking to the experience of advanced industrialized countries, housing industrialization has two major advantages over traditional construction methods:

1. Significant drop in ratio of labor required.
2. Shorter construction periods.

However, in the initial period of implementing industrialization, due to certain fixed (for instance, prefabrication factories) and other variable costs, investment expenses are often high. Therefore, from an economic point of view, this is a critical stage, in being able to avoid large-scale investment, on the one hand, yet be able to

## BACKGROUND ANALYSIS OF HOUSING INDUSTRIALIZATION

shift from traditional construction methods to housing industrialization.

In the choice of construction material, consideration must be given to the supply available domestically. Reinforced concrete, widely used at present, is feasible as the major construction material. In many cases, concrete blocks may be substituted for shortage of bricks.

#### Technological Conditions

Increase in productive efficiency is a primary condition in meeting housing demand. Productive efficiency, broadly interpreted, includes the planning, design, construction and distribution of housing. Should any aspect lag behind, then overall efficiency will suffer as a result. In other words progress in construction skill can only raise productive efficiency to a certain extent;

only by advances on all fronts can overall results be achieved.

To solve the housing shortage problem, concrete, feasible proposals are needed to bridge the transition from the present stage to future industrialization. In the process of industrialization, labor skills should improve from professional training and construction experience, construction machinery should increase, and new construction techniques should continue to be imported.

Other considerations worthy of note:

1. Systematization and standardization of construction material processing.
2. Regulation and standardization of modules so as to move toward an open system in housing production.<sup>5</sup>
3. Consideration should be given to the

delivery of construction components,  
and regulations concerning safety.

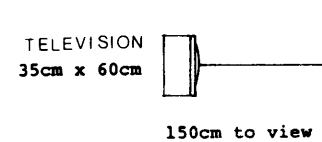
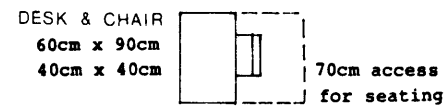
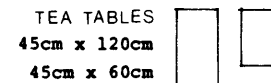
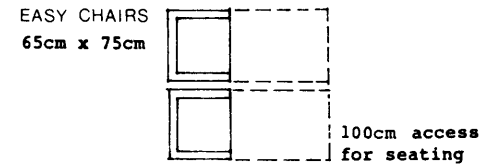
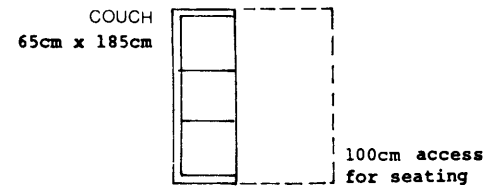
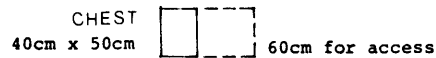
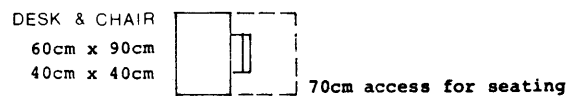
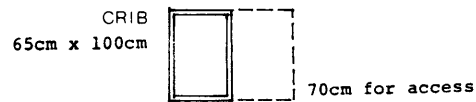
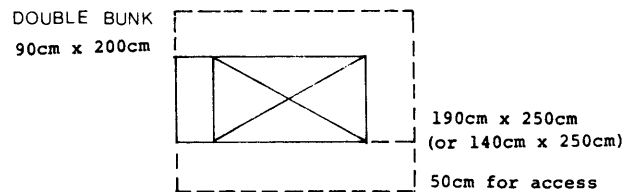
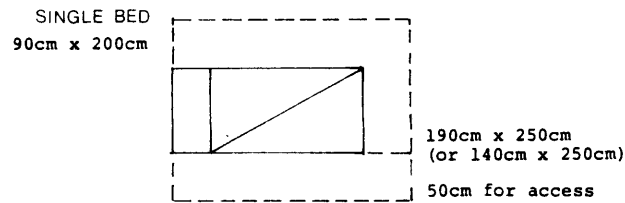
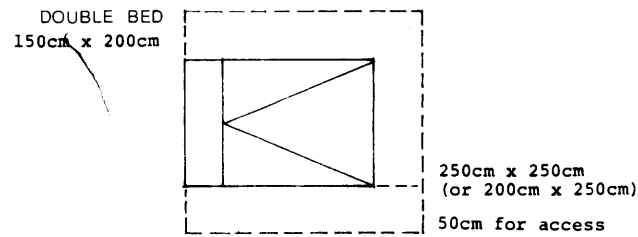
4. Systematization of management and organization, both in construction and in delivery.
5. Revision and updating of building codes.

- 
- 
5. 10 cm has been designated as the basic housing module by the National Bureau of Standards in 1968. A revision of regulations was made in 1976. Nevertheless, both cases are still at a preliminary drafting stage.

1. Reinforced concrete as principal construction material.
2. Utilize presently available construction equipment to avoid necessity of large-scale investment.
3. Consideration of capacity shortage in transportation and machinery; components should be light, and ideally could be fabricated at the construction site.
4. Components should be tailored to existing modular systems and also subject to building codes.
5. Avoid overly complicated construction methods.
6. Housing system should be geared towards the open system--utilizing locally available construction methods and materials.
7. Consideration should be taken of Taiwan's geographical limitations--housing systems should be adaptable to hillside terrain.
8. Housing type should be geared towards rowhouses with 2-3 floors, or walk-up apartments with 4-5 floors.

## DESIGN OBJECTIVES OF HOUSING SYSTEM

# SPACE AND FUNCTION ANALYSIS




# BEDROOM AND LIVING ROOM REQUIREMENTS

RANGE  
60cm x 60cm



60cm access to use  
all the equipments


SINK  
60cm x 80cm



COUNTER  
60cm x 60cm  
30cm x 60cm



WALL CABINET  
& COUNTER  
60cm x 80cm  
60cm x 60cm



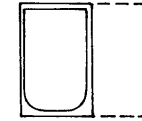
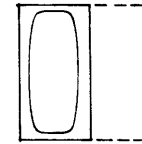
REFRIGERATER  
55cm x 60cm



WASHER & DRYER  
50cm x 80cm

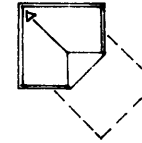
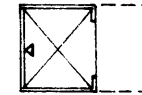


BATH TUB  
75cm x 140cm  
75cm x 120cm



65cm for drying

SHOWER  
80cm x 90cm  
90cm x 90cm



60cm to use

WATER CLOSET  
45cm x 70cm



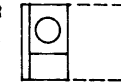
60cm to use

LAVATORY  
40cm x 50cm



60cm to use

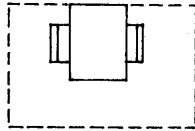
WASHER & DRYER  
50cm x 80cm



60cm to use

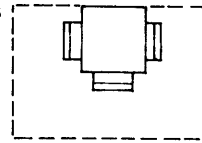
## KITCHEN AND BATHROOM REQUIREMENTS

2 PERSONS



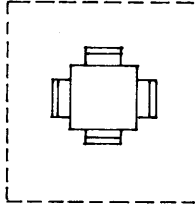
130cm x 200cm  
(table:  
60cm x 80cm)

3 PERSONS

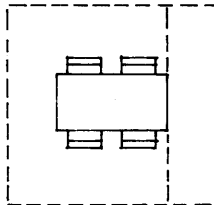


140cm x 210cm  
(table:  
70cm x 70cm)

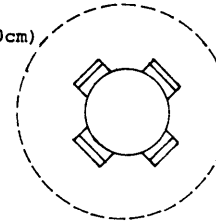
4 PERSONS



210cm x 210cm  
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70cm x 70cm)

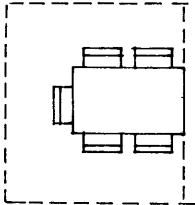


200cm x 200cm  
(or 200cm x 170cm)  
(table:  
60cm x 120cm)

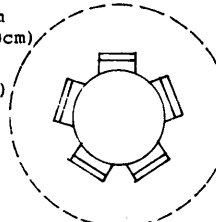


220cm diameter  
(table:  
80cm diameter)

5 PERSONS

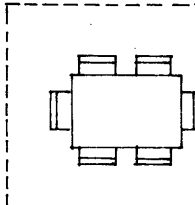


210cm x 230cm  
(or 210cm x 180cm)  
(table:  
70cm x 120cm)

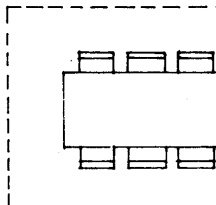


230cm diameter  
(table:  
90cm diameter)

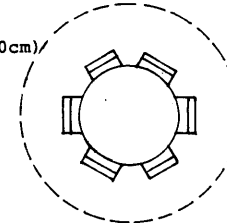
6 PERSONS



220cm x 260cm  
(table:  
80cm x 120cm)

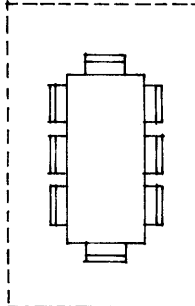


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(or 220cm x 230cm)  
(table:  
80cm x 180cm)

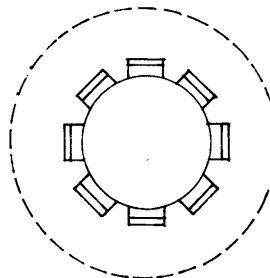


240cm diameter  
(table:  
100cm diameter)

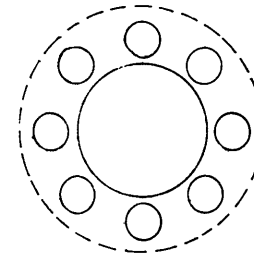
8 PERSONS



220cm x 320cm  
(table:  
80cm x 180cm)



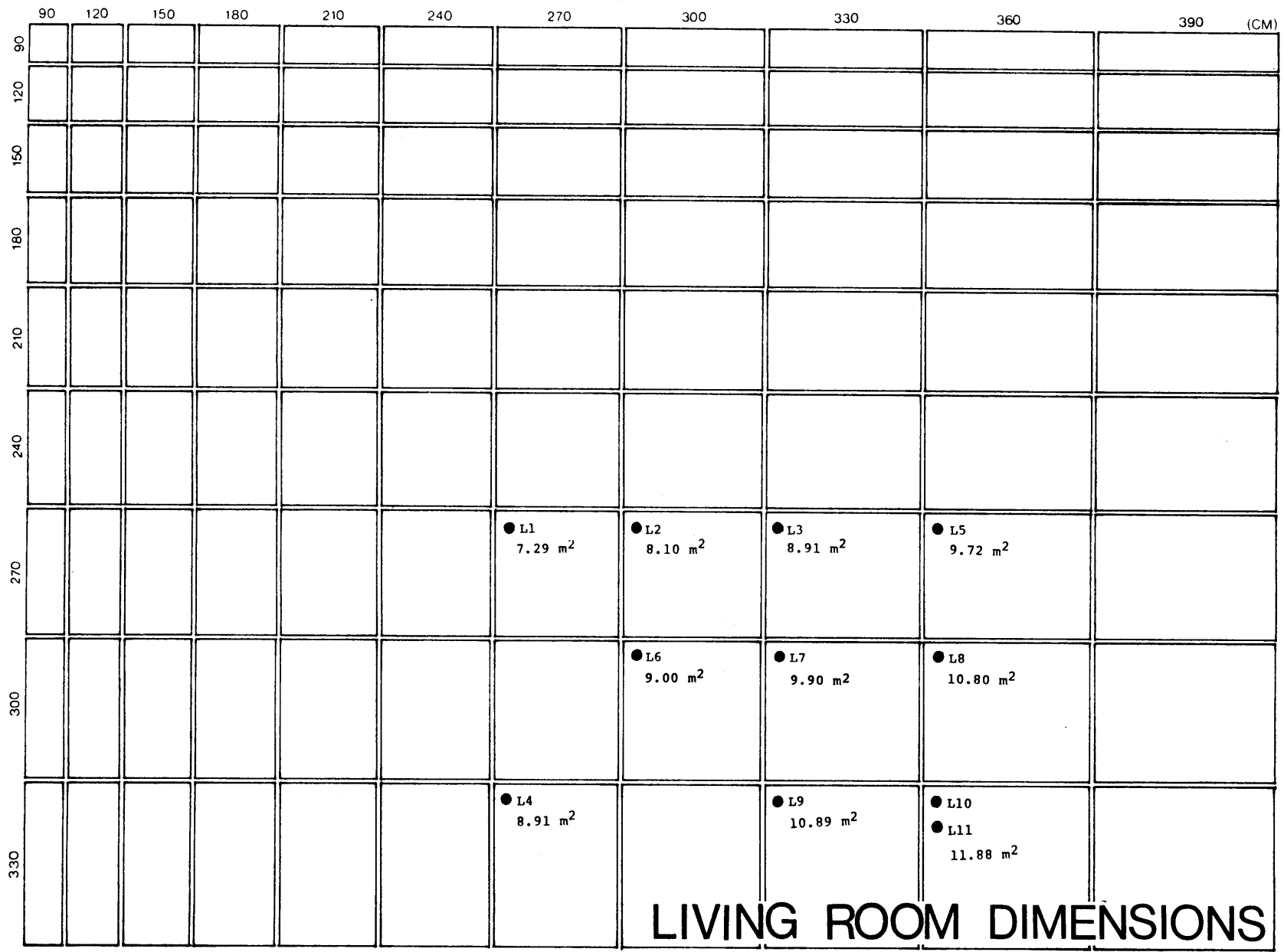
290cm diameter  
(table:  
150cm diameter)



270cm diameter  
(table:  
150cm diameter)

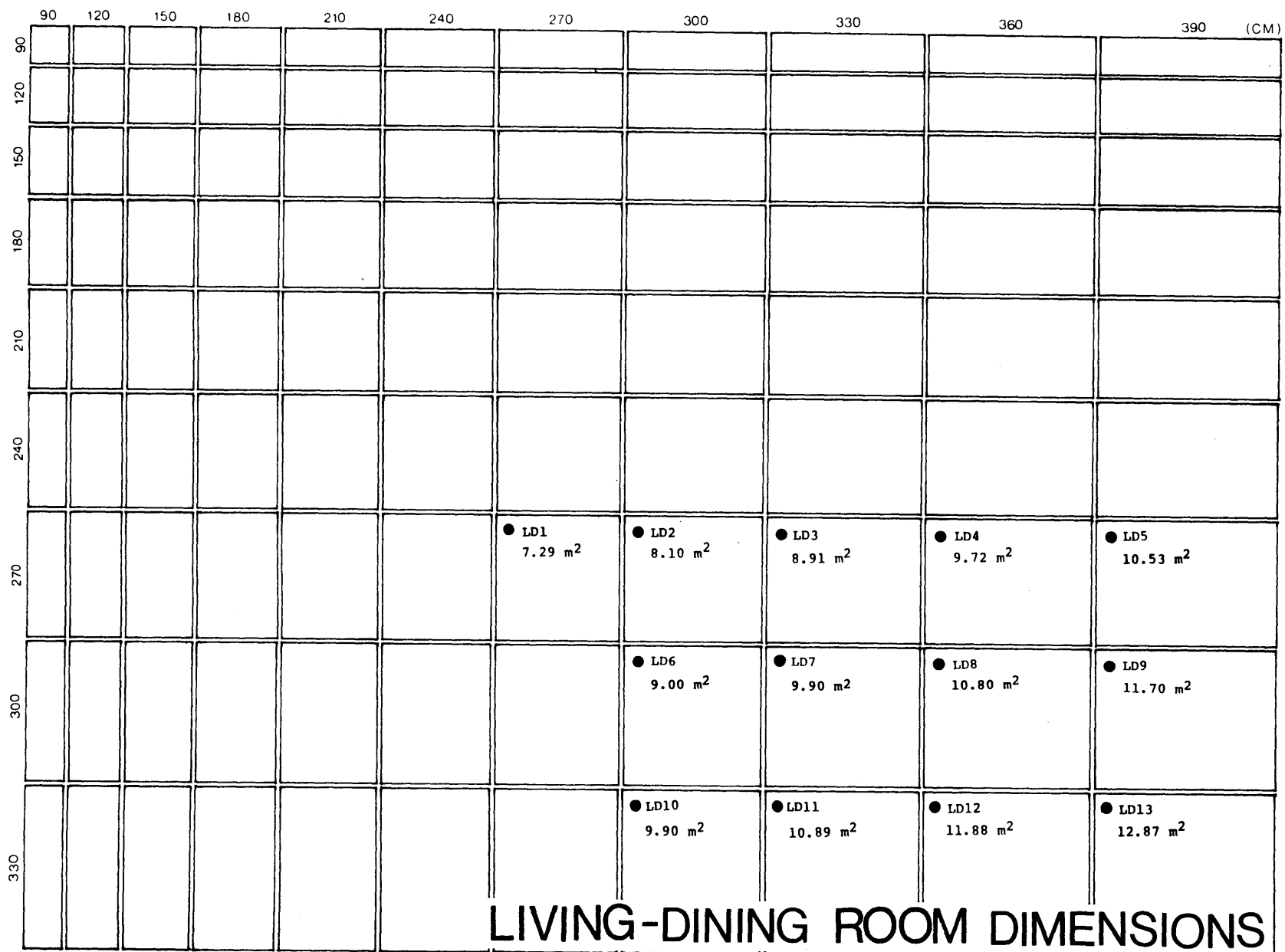
- chair: 40cm x 40cm  
70cm access for seating
- stool: 35cm diameter  
60cm access for seating
- 50cm for access

# DINING ROOM REQUIREMENTS

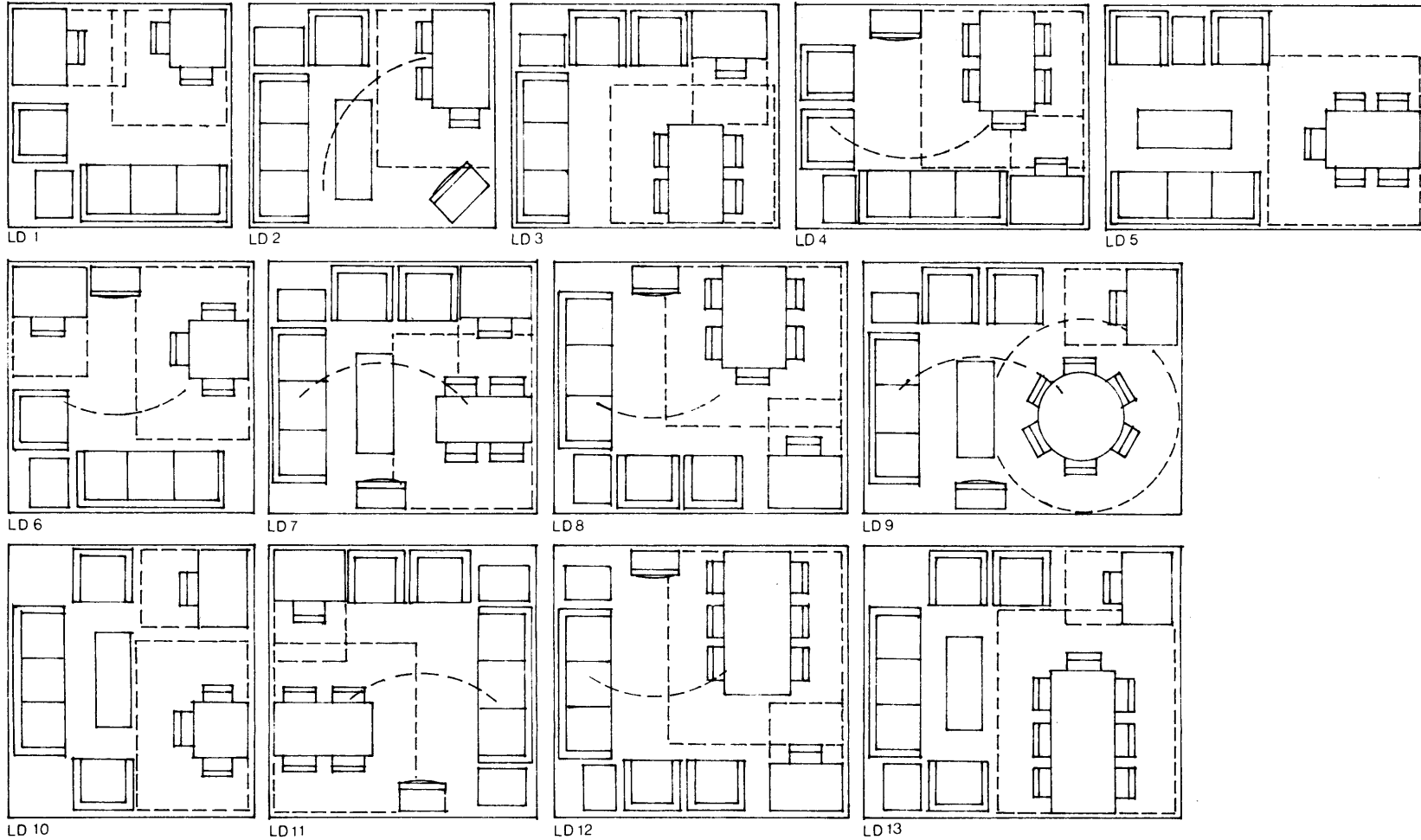




# LIVING ROOM ARRANGEMENT



# LIVING-DINING ROOM DIMENSIONS

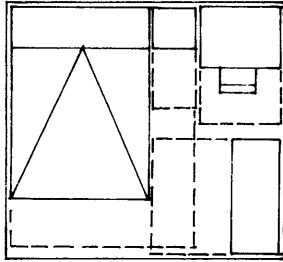


# LIVING-DINING ROOM ARRANGEMENT

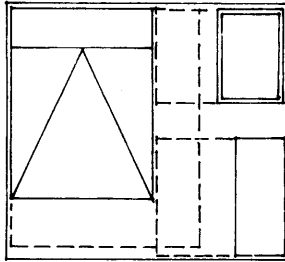
	90	120	150	180	210	240	270	300	330	360	390	(CM)
90												
120												
150												
180												
210					● b1 5.04 m <sup>2</sup>	● b2 5.67 m <sup>2</sup>	● b3 6.30 m <sup>2</sup>	● b4 6.93 m <sup>2</sup>			● b5 8.19 m <sup>2</sup>	
240					● b6 5.76 m <sup>2</sup>	● b7 6.48 m <sup>2</sup>	● b8 7.20 m <sup>2</sup>	● b9 7.92 m <sup>2</sup>	● b10 8.64 m <sup>2</sup>			
270					● b11 6.48 m <sup>2</sup>	● b12 7.29 m <sup>2</sup>	● b13 ● B1 8.10 m <sup>2</sup>	● b15 ● B3 8.91 m <sup>2</sup>	● b17 ● B5 ● B6 ● B7 9.72 m <sup>2</sup>	● B8 10.53 m <sup>2</sup>		
300						● b14 ● B2 8.10 m <sup>2</sup>	● B9 9.00 m <sup>2</sup>	● B10 9.90 m <sup>2</sup>	● B12 ● B13 10.80 m <sup>2</sup>	● B14 11.70 m <sup>2</sup>		
330						● b16 ● B4 8.91 m <sup>2</sup>	● B11 9.90 m <sup>2</sup>					

# BEDROOM DIMENSIONS

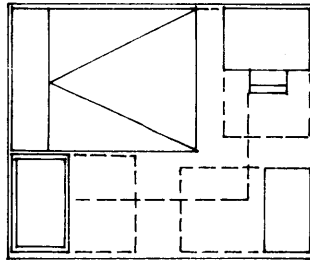
B: primary bedroom    b: secondary bedroom



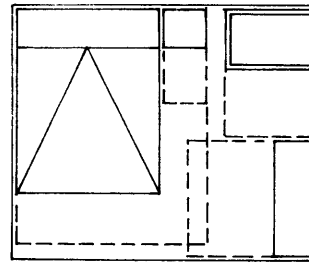
B1



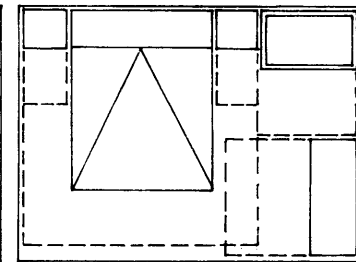
B2



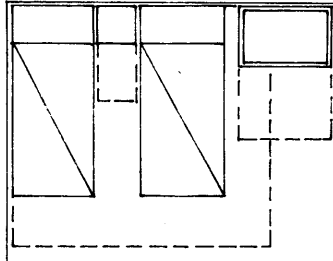
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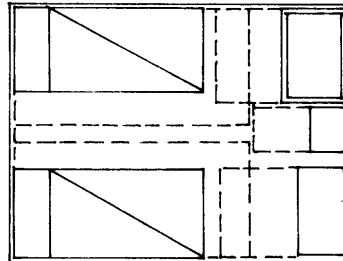
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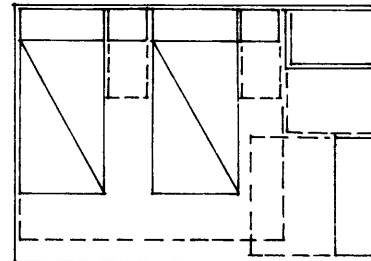
B5



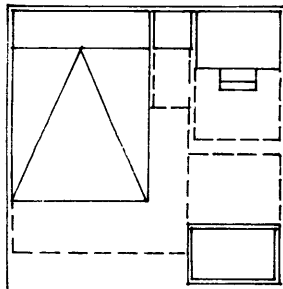
B6



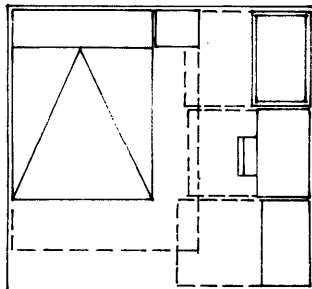
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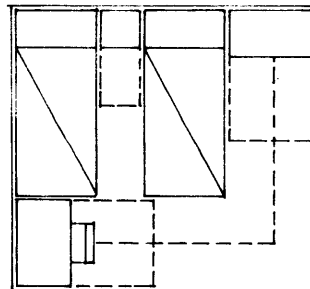
B8



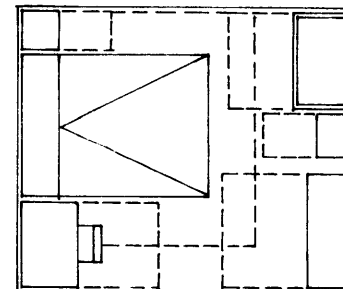
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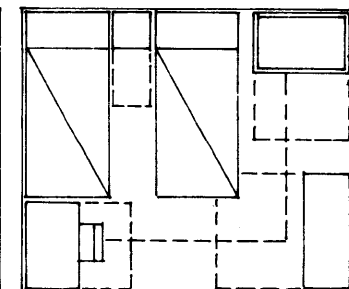
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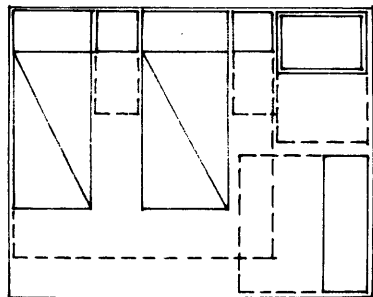
B11



B12

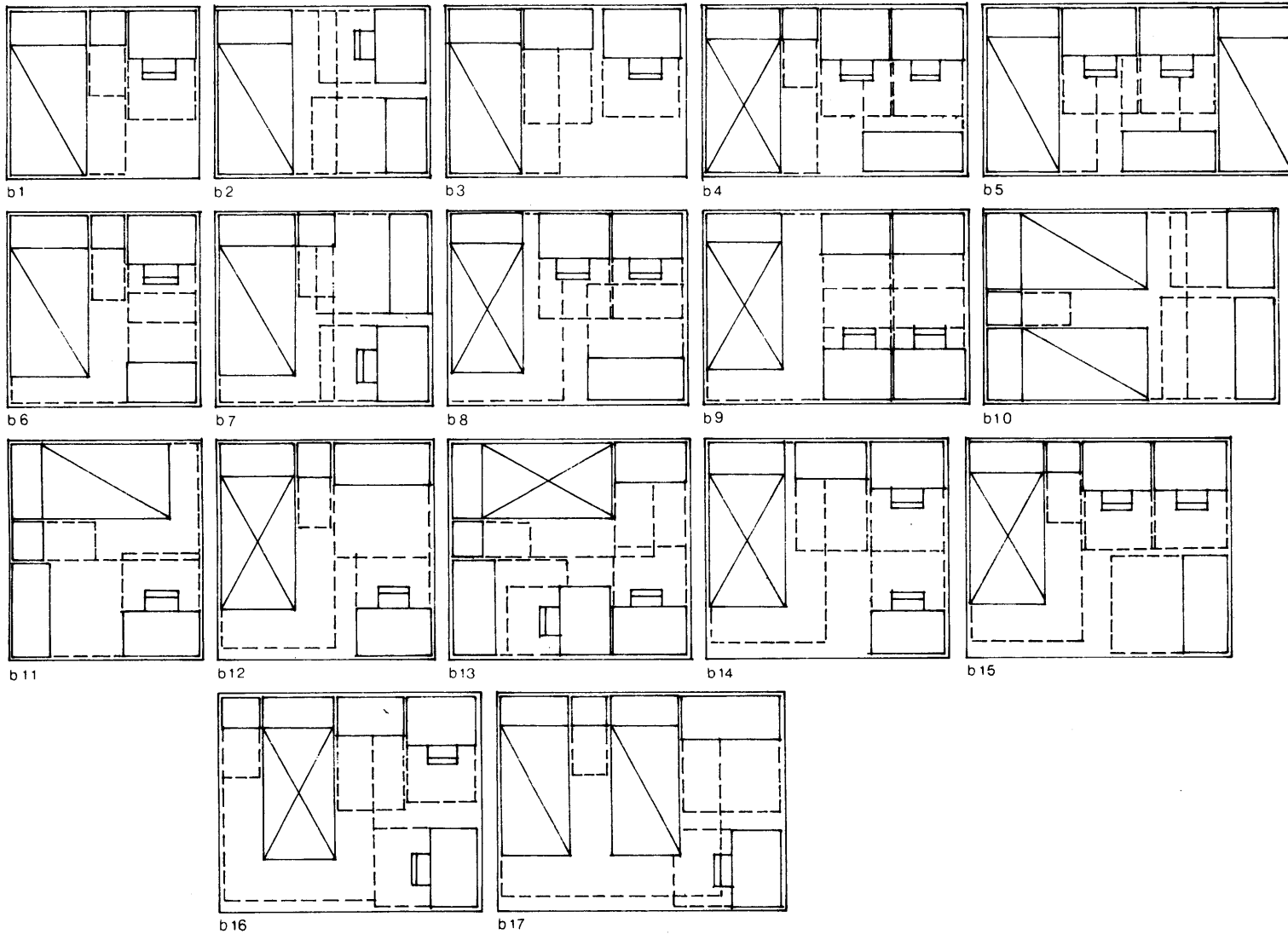


B13



B14

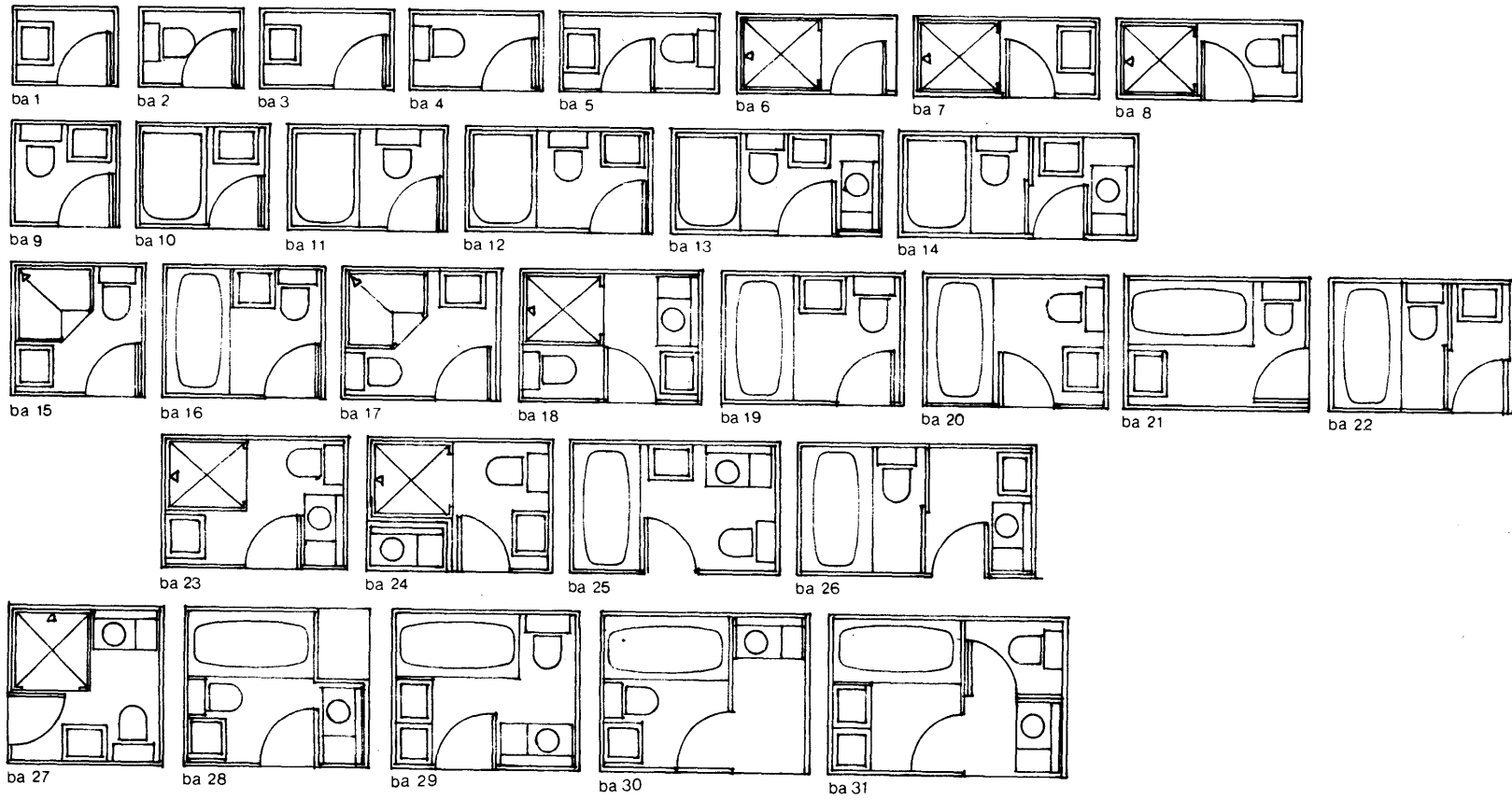
# PRIMARY BEDROOM ARRANGEMENT



## SECONDARY BEDROOM ARRANGEMENT

	90	120	150	180	210	240	270	300	330	360	390 (CM)
90		● ba1 1.08 m <sup>2</sup>	● ba3 1.35 m <sup>2</sup>	● ba5 1.62 m <sup>2</sup>	● ba7 1.89 m <sup>2</sup>						
120	● ba2 1.08 m <sup>2</sup>	● ba9 1.44 m <sup>2</sup>	● ba10 1.80 m <sup>2</sup>	● ba11 2.16 m <sup>2</sup>	● ba12 2.52 m <sup>2</sup>	● ba13 2.88 m <sup>2</sup>	● ba14 3.24 m <sup>2</sup>				
150	● ba4 1.35 m <sup>2</sup>		● ba15 2.25 m <sup>2</sup>	● ba16 2.70 m <sup>2</sup>	● ba18 ● ba19 ● ba20 3.15 m <sup>2</sup>	● ba25 3.60 m <sup>2</sup>	● ba26 4.05 m <sup>2</sup>				
180	● ba6 1.62 m <sup>2</sup>		● ba17 2.70 m <sup>2</sup>	● ba27 3.24 m <sup>2</sup>	● ba28 3.78 m <sup>2</sup>	● ba30 4.32 m <sup>2</sup>	● ba31 4.86 m <sup>2</sup>				
210	● ba8 1.89 m <sup>2</sup>		● ba21 ● ba22 ● ba23 ● ba24 3.15 m <sup>2</sup>	● ba29 3.78 m <sup>2</sup>							
240											
270											
300											
330											

# BATHROOM DIMENSIONS



# BATHROOM ARRANGEMENT

	90	120	150	180	210	240	270	300	330	360	390	(CM)
90												
120												
150			● K1 2.25 m <sup>2</sup>	● K2 2.70 m <sup>2</sup>	● K3 3.15 m <sup>2</sup>	● K5 3.60 m <sup>2</sup>	● K7 4.05 m <sup>2</sup>	● K9 4.50 m <sup>2</sup>				
180			● K10 3.24 m <sup>2</sup>	● K11 3.78 m <sup>2</sup>	● K13 4.32 m <sup>2</sup>	● K14 4.86 m <sup>2</sup>						
210			● K4 3.15 m <sup>2</sup>	● K12 3.78 m <sup>2</sup>	● K15 ● K16 4.41 m <sup>2</sup>	● K17 5.04 m <sup>2</sup>	● K19 5.67 m <sup>2</sup>					
240			● K6 3.60 m <sup>2</sup>		● K18 5.04 m <sup>2</sup>	● K21 ● K22 5.76 m <sup>2</sup>						
270			● K8 4.05 m <sup>2</sup>		● K20 5.76 m <sup>2</sup>							
300												
330												

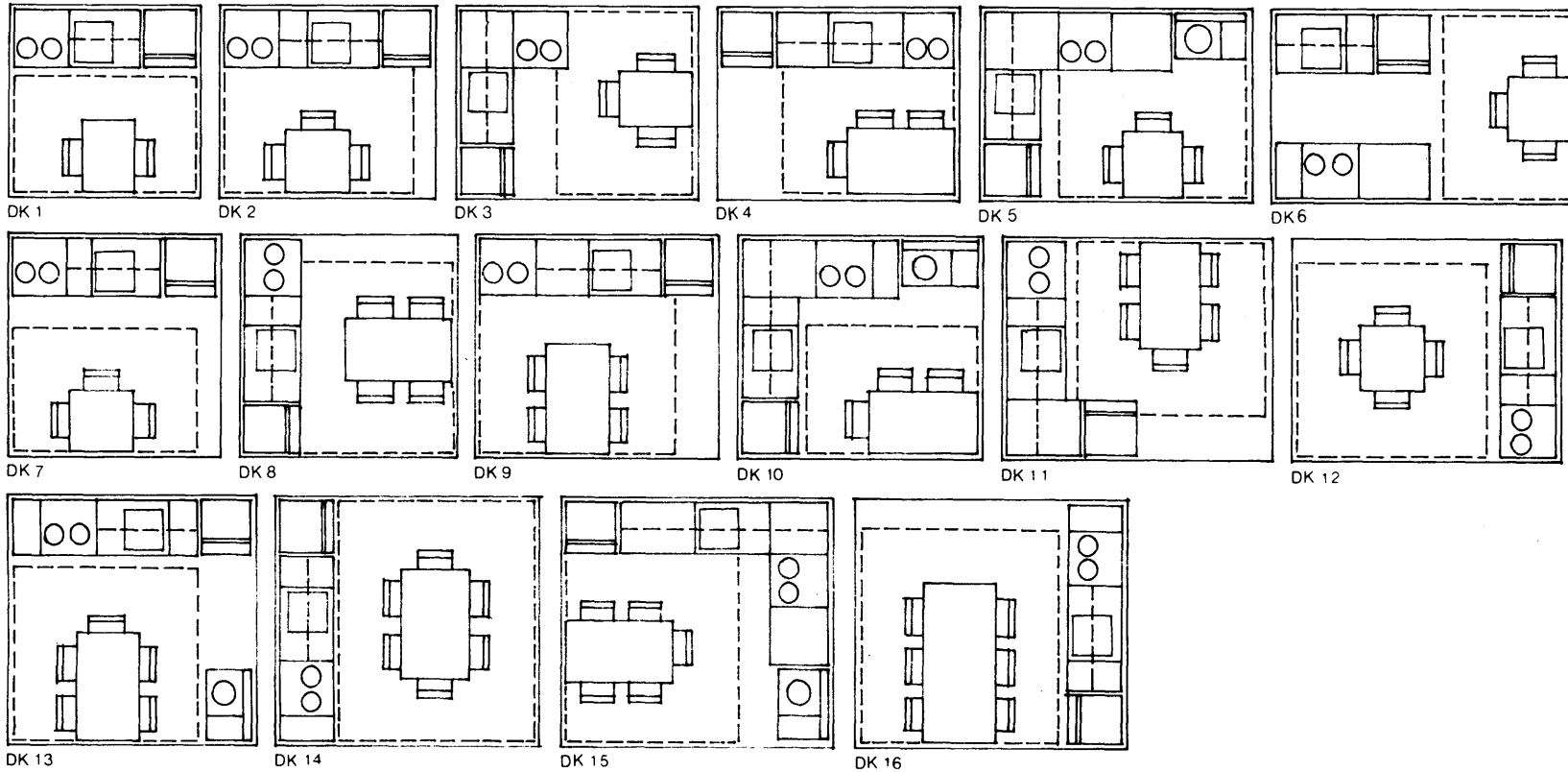
# KITCHEN DIMENSIONS



# KITCHEN ARRANGEMENT

	90	120	150	180	210	240	270	300	330	360	390	(CM)
90												
120												
150												
180												
210					○ DK1 4.41 m <sup>2</sup>	○ DK2 5.04 m <sup>2</sup>	○ DK3 5.67 m <sup>2</sup>	○ DK5 6.30 m <sup>2</sup>	○ DK6 6.93 m <sup>2</sup>			
240						○ DK7 ○ DK8 5.04 m <sup>2</sup>	○ DK9 5.76 m <sup>2</sup>	○ DK11 6.48 m <sup>2</sup>				
270					○ DK4 5.67 m <sup>2</sup>	○ DK10 6.48 m <sup>2</sup>	○ DK13 7.29 m <sup>2</sup>	○ DK14 ○ DK15 8.10 m <sup>2</sup>				
300						○ DK12 7.20 m <sup>2</sup>	○ DK16 8.10 m <sup>2</sup>					
330												

# DINING-KITCHEN ROOM DIMENSIONS



# DINING-KITCHEN ROOM ARRANGEMENT

## I. Structural system:

1. The structural system includes four kinds of light-weight concrete panels. By using these concrete panels, together with on-site connection which is primarily poured concrete, the beam, lintel, wall, floor and roof may be formed.
2. The above concrete panels may be formed by using only two different types of steel forms. By altering the parts on the steel forms, one may obtain different measurements.
3. The reinforcing arrangement of concrete panels may differ according to the load and varying structural functions.
4. The concrete panels can be made at the construction site, making fixed factory utilities or other

transport costs unnecessary. Delivery at the work site can be performed by manual labor, pick-up trucks, and crabs.

5. The design span of flooring is approximately 3m to 6m, with the maximum length of cantilever reaching one third of the design span.
6. At the construction site, only the minimum amount of formwork at the on site connection is necessary.

## II. Subsystem

### 1. Doors and windows

Existing wood and aluminum doors and windows may continue to be utilized, only their measurement should be standardized. The width of most apertures are 80cm, 140cm, 200cm, or 260cm. The width of doors can also be 70cm or 105cm.

# DESCRIPTION OF SYSTEM

2. Partitions:

Interior partitions should be placed according to 30cm modular grids, and can be made from any available materials. In the proposed design, the interior partitions and exterior walls are made of concrete block, measuring 10cm and 20cm in thickness respectively. Concrete block is used mainly because of lightness in weight (compared to brick), adaptability, and ease of installing piping.

3. Plumbing:

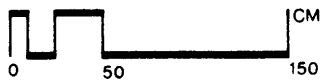
Water and waste pipes are distributed and collected vertically from stacks of paired units. The cold water is heated by a hot water generator in the kitchen and is lead to both kitchen and bathroom. It is suggested that to standardize fixture placement and orientation and to use a conventional plumbing

wall.

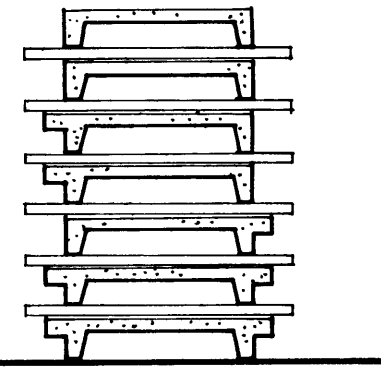
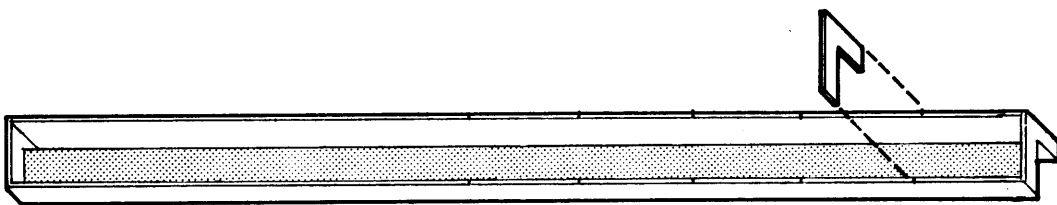
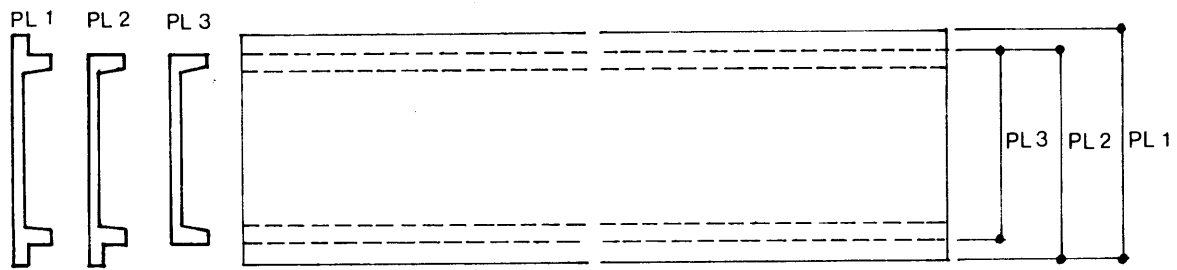
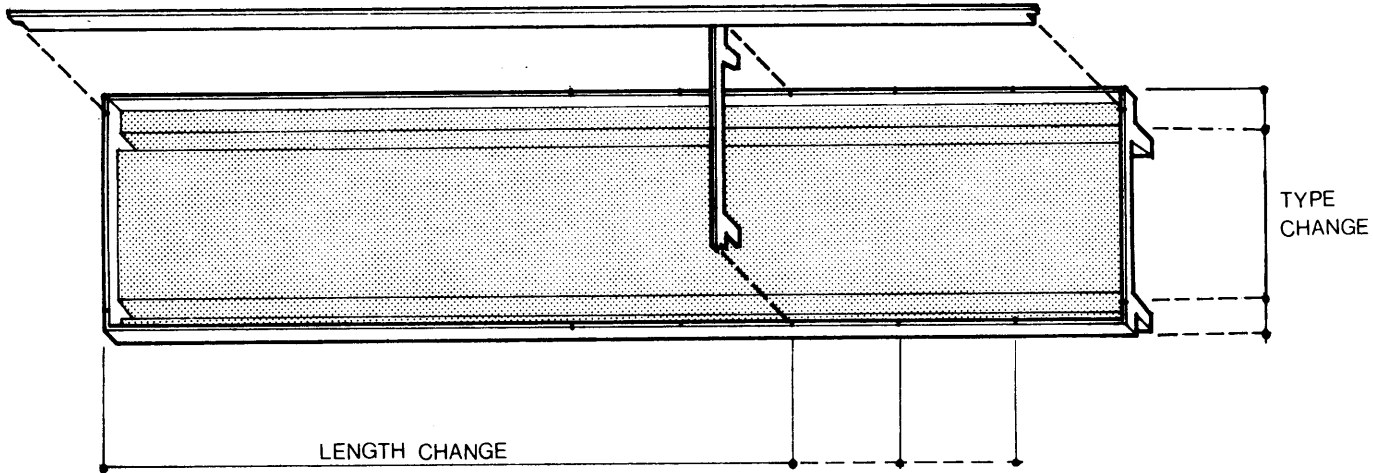
4. Electrical:

Power is distributed from the master switch board located in the staircase or corridor to each unit through electrical conduits within the chase for each stack of apartment. Horizontal wiring in each unit is located under floor through the hollow space. Plugs and switches are located in interior partitions, where power wiring travel vertically from the floor. Telephone wires and television cables may also be convey in the vertical chase.

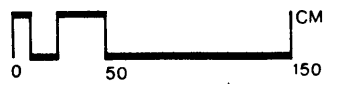
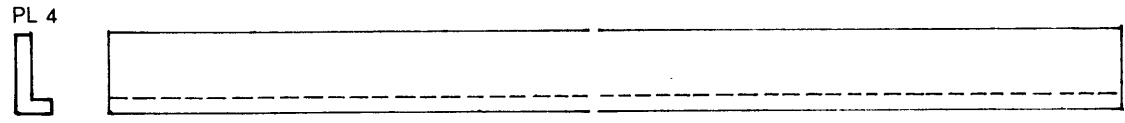
		USE	AREA OF CROSSSECTION	LENGTH (CM)	WEIGHT (KG)
PL 1		· WALL	253 CM <sup>2</sup>	260	158.07
		· FLOOR		300	182.39
				330	200.67
				360	218.87
				390	237.10
				420	255.34
				450	273.58
				480	291.82
				510	310.06
				540	328.30
PL 2		· WALL	233 CM <sup>2</sup>	260	145.57
		· FLOOR		300	167.97
				330	184.77
				360	201.56
				390	218.36
				420	235.16
				450	251.95
				480	268.75
				510	285.55
				540	302.35
PL 3		· WALL	213 CM <sup>2</sup>	260	133.08
		· FLOOR		300	153.55
				330	168.91
				360	184.26
				390	199.62
				420	214.97
				450	230.33
				480	245.68
				510	261.04
				540	276.39
PL 4		· LINTEL	104 CM <sup>2</sup>	70	17.49
		· BEAM		80	19.99
				105	26.24
				140	34.99
				200	49.98
				260	64.98



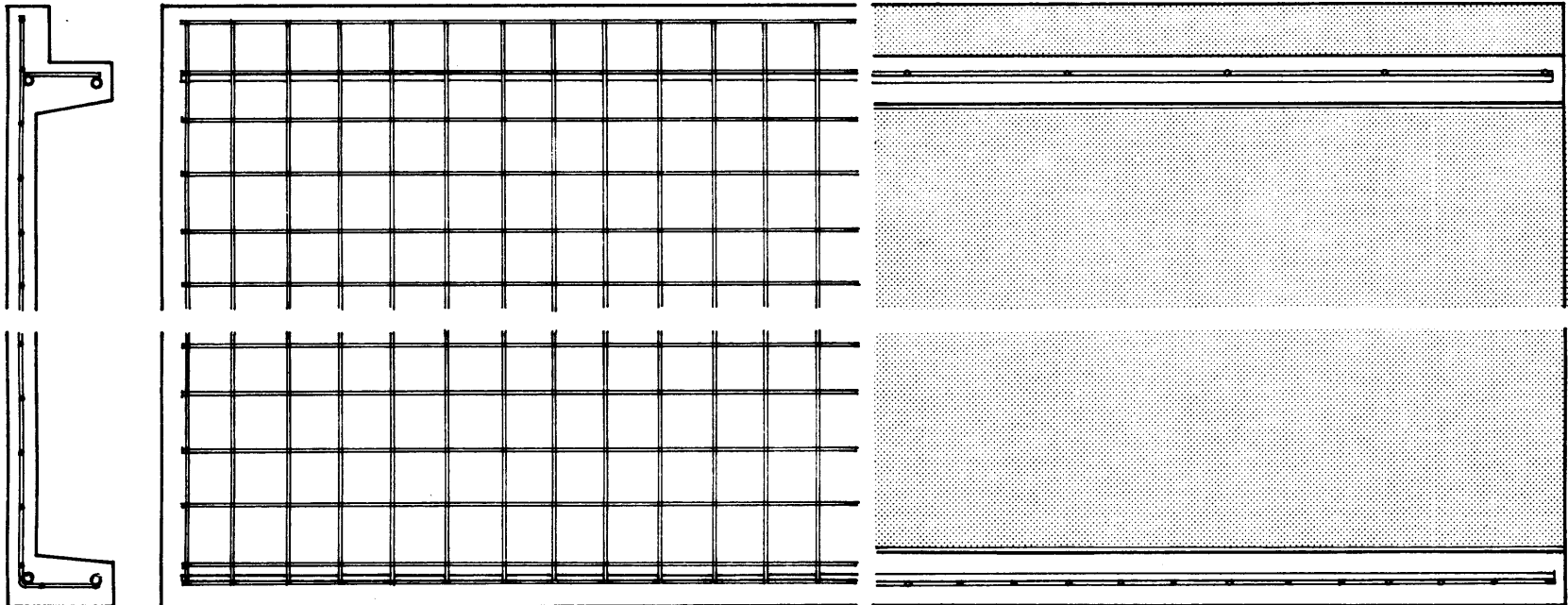
## STRUCTURAL COMPONENTS



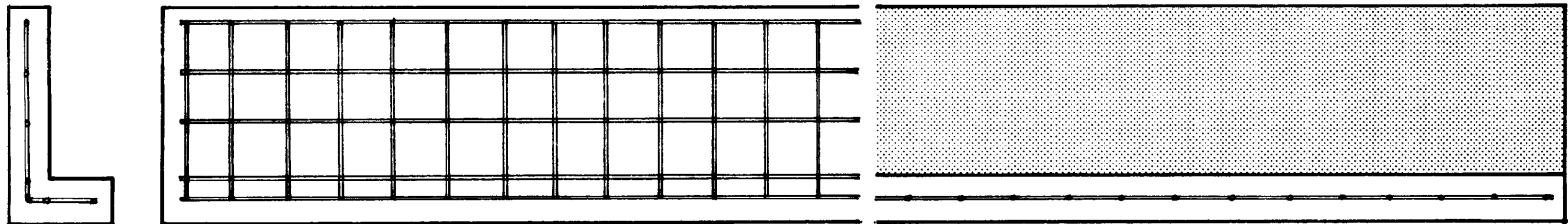
STACKING AND CURING



# COMPONENT PRODUCTION



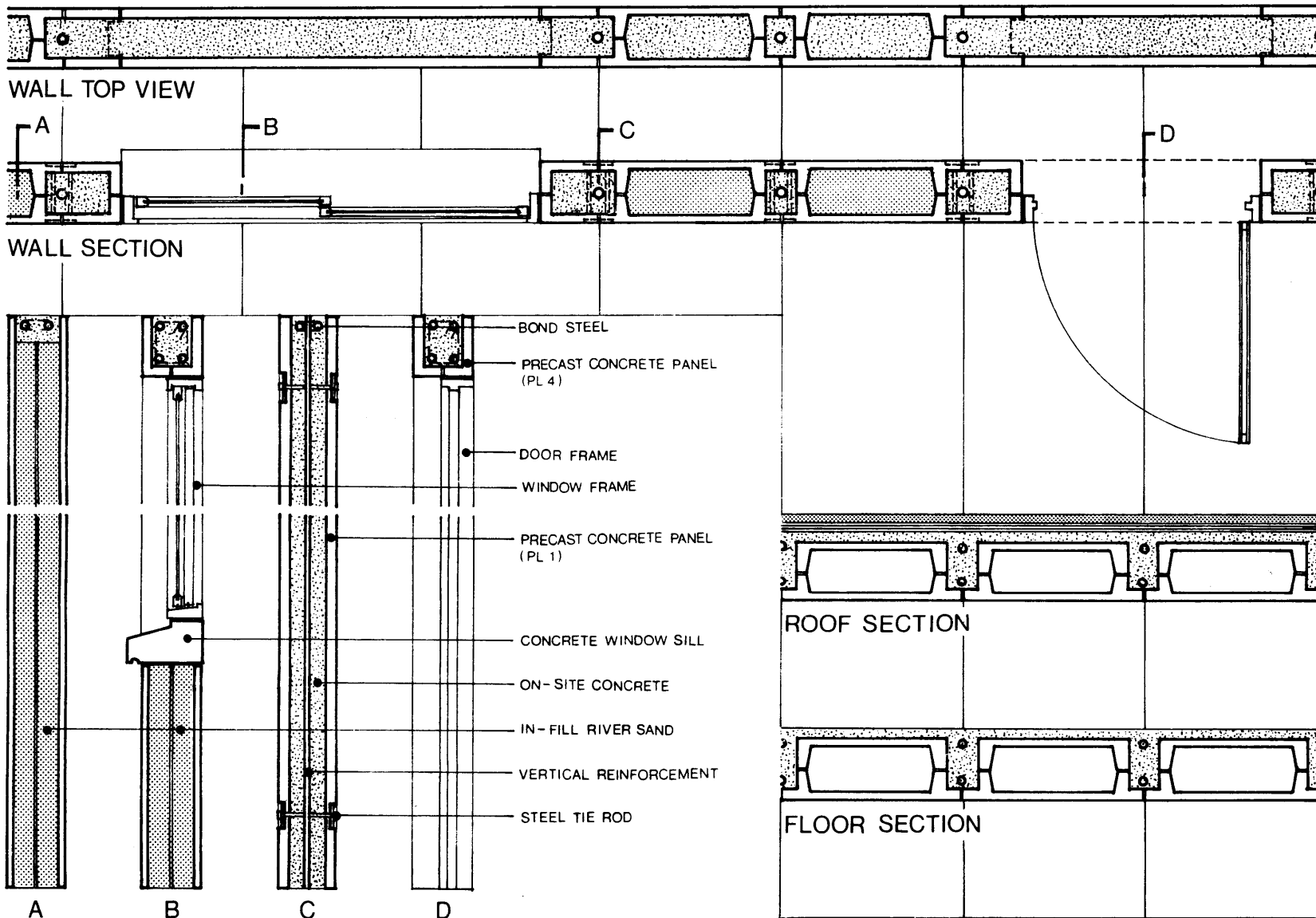
PL1 • PL2 • PL3



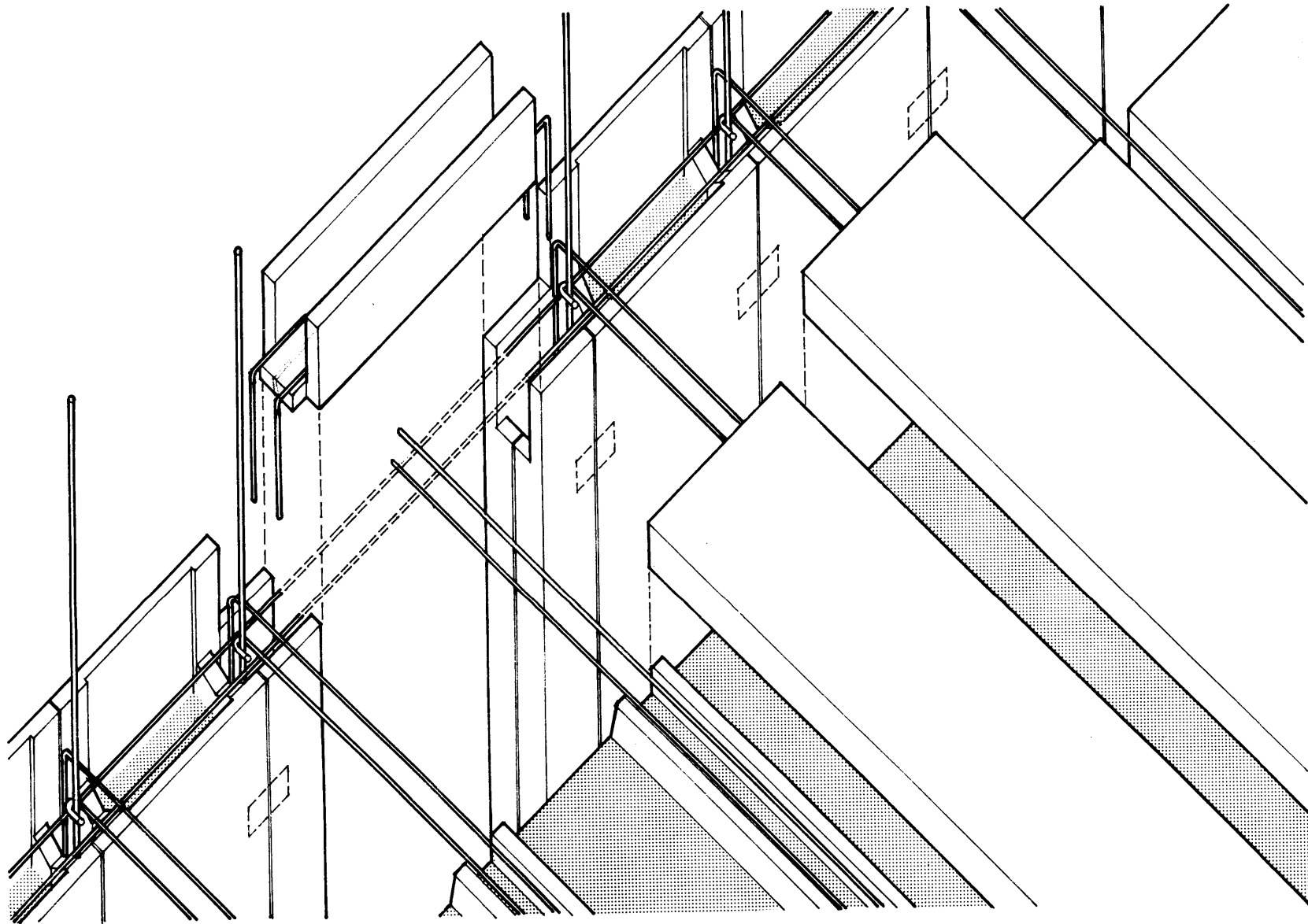
PL4



# REINFORCING

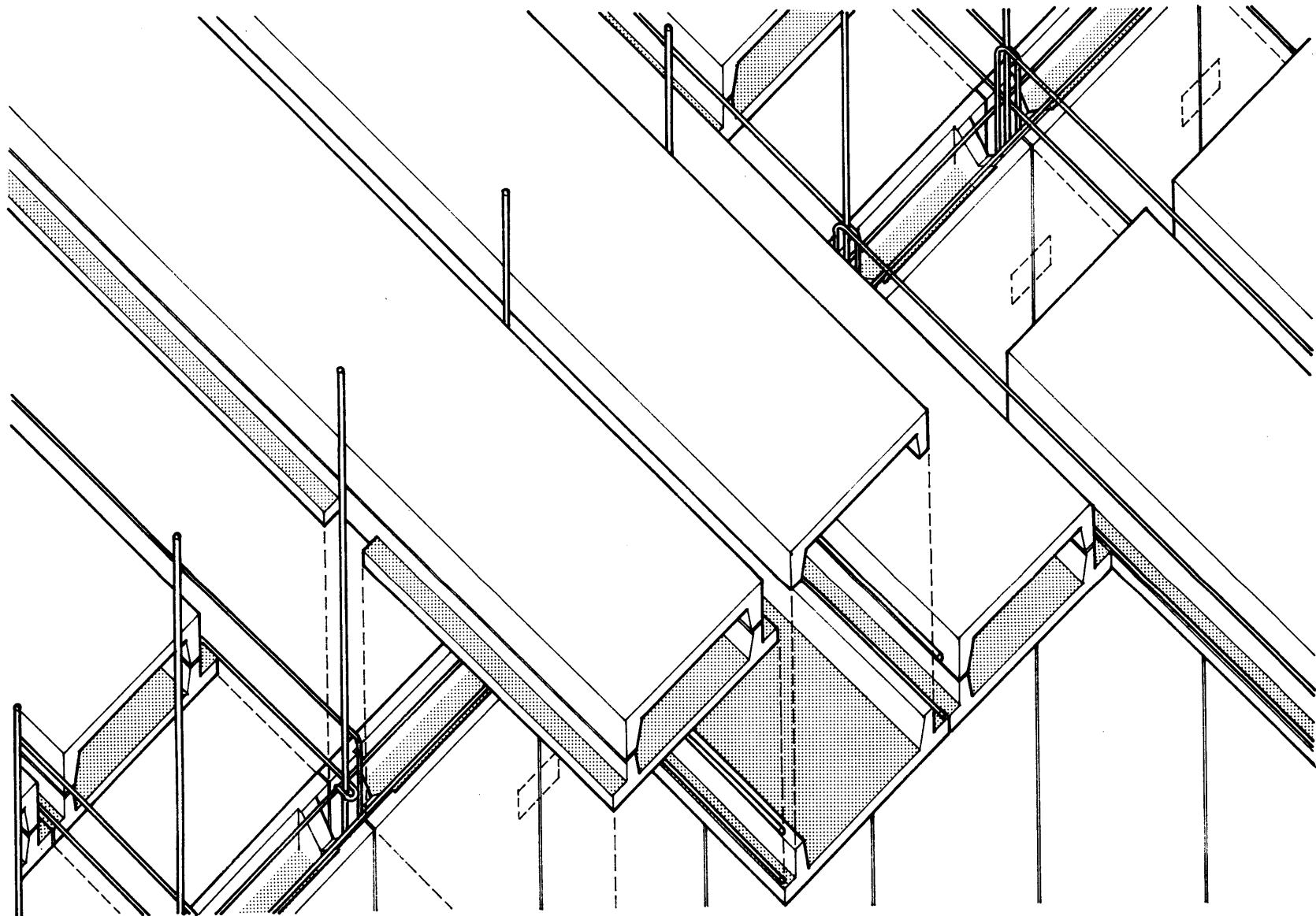


# APPLICATIONS OF STRUCTURAL COMPONENTS

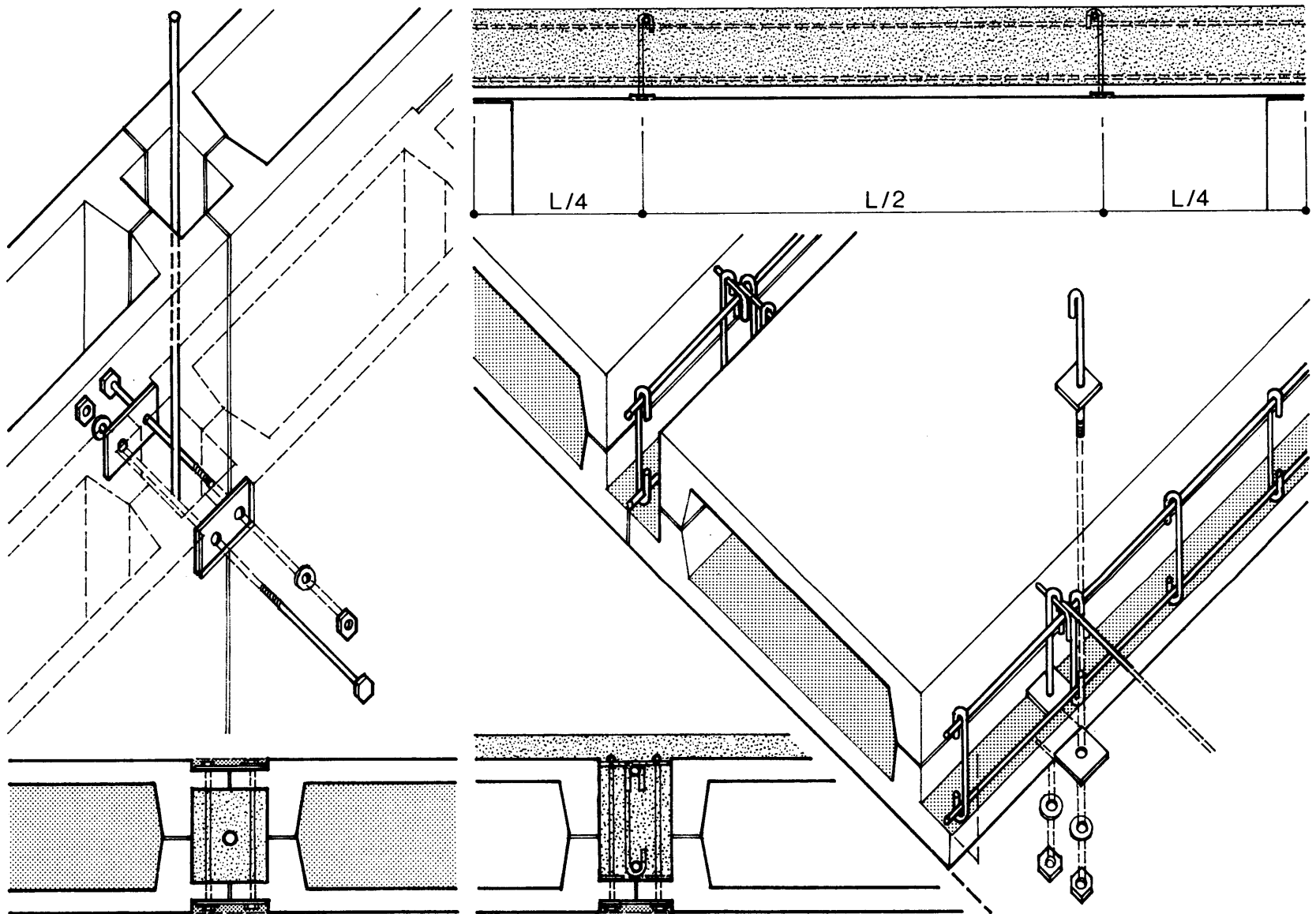


FLOOR AT EXTERIOR BEARING WALL

# ON-SITE CONNECTION



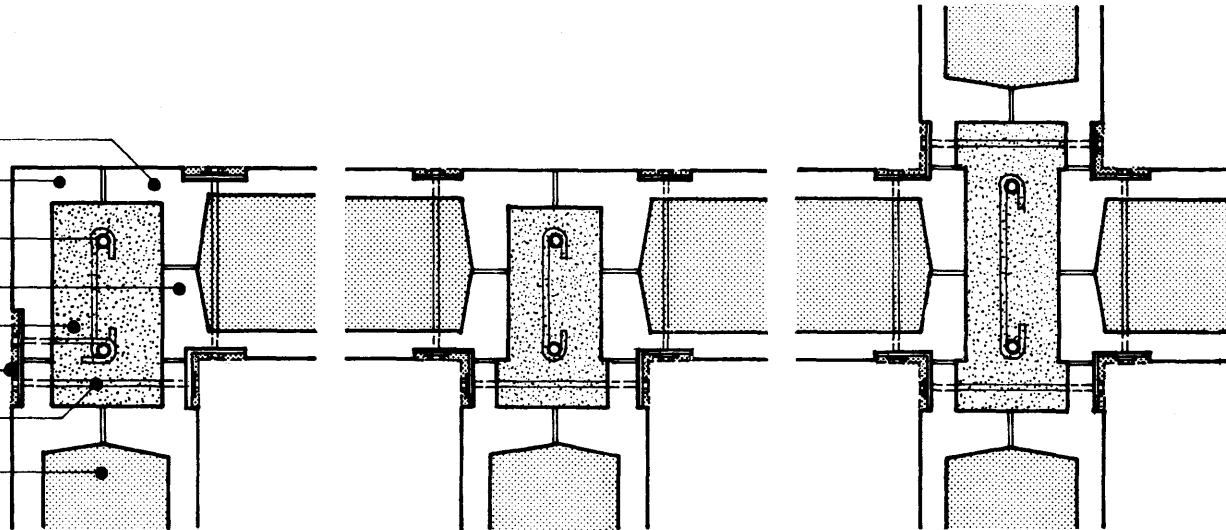
FLOOR AT INTERIOR BEARING WALL AND CANTILEVER



TIE ROD CONNECTIONS AT BEARING WALL AND FLOOR

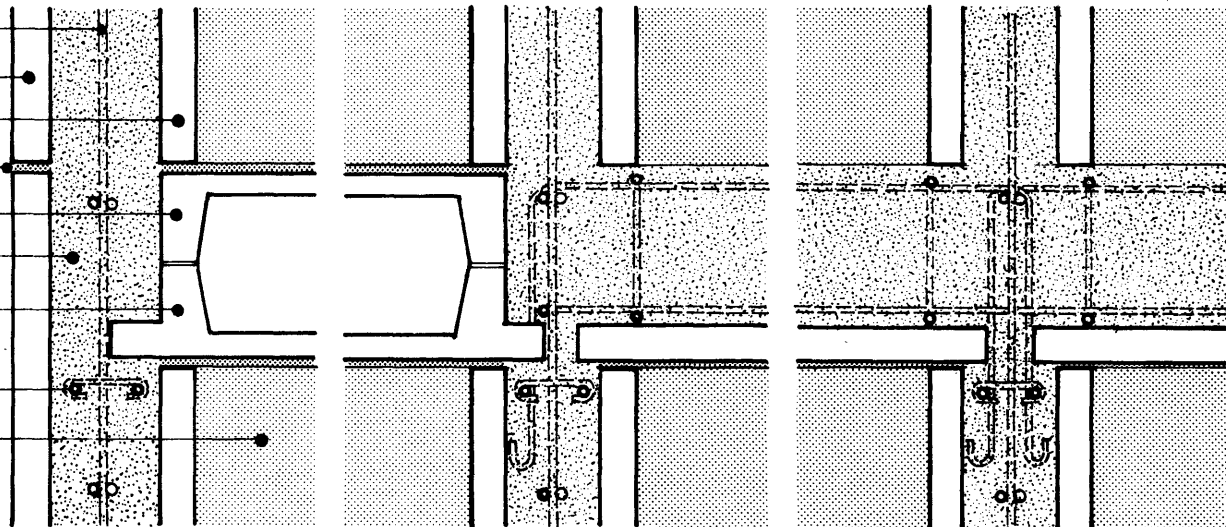
- PRECAST CONCRETE PANEL (PL 1)
- PRECAST CONCRETE PANEL (PL 4)
- VERTICAL REINFORCEMENT
- PRECAST CONCRETE PANEL (PL 2)
- ON-SITE CONCRETE
- GROUT
- STEEL TIE ROD
- IN-FILL RIVER SAND

**PLAN**



- VERTICAL REINFORCEMENT
- PRECAST CONCRETE PANEL (PL 4)
- PRECAST CONCRETE PANEL (PL 1)
- GROUT
- PRECAST CONCRETE PANEL (PL 3)
- ON-SITE CONCRETE
- PRECAST CONCRETE PANEL (PL 3)
- BOND STEEL
- IN-FILL RIVER SAND

**SECTION**



L JOINT

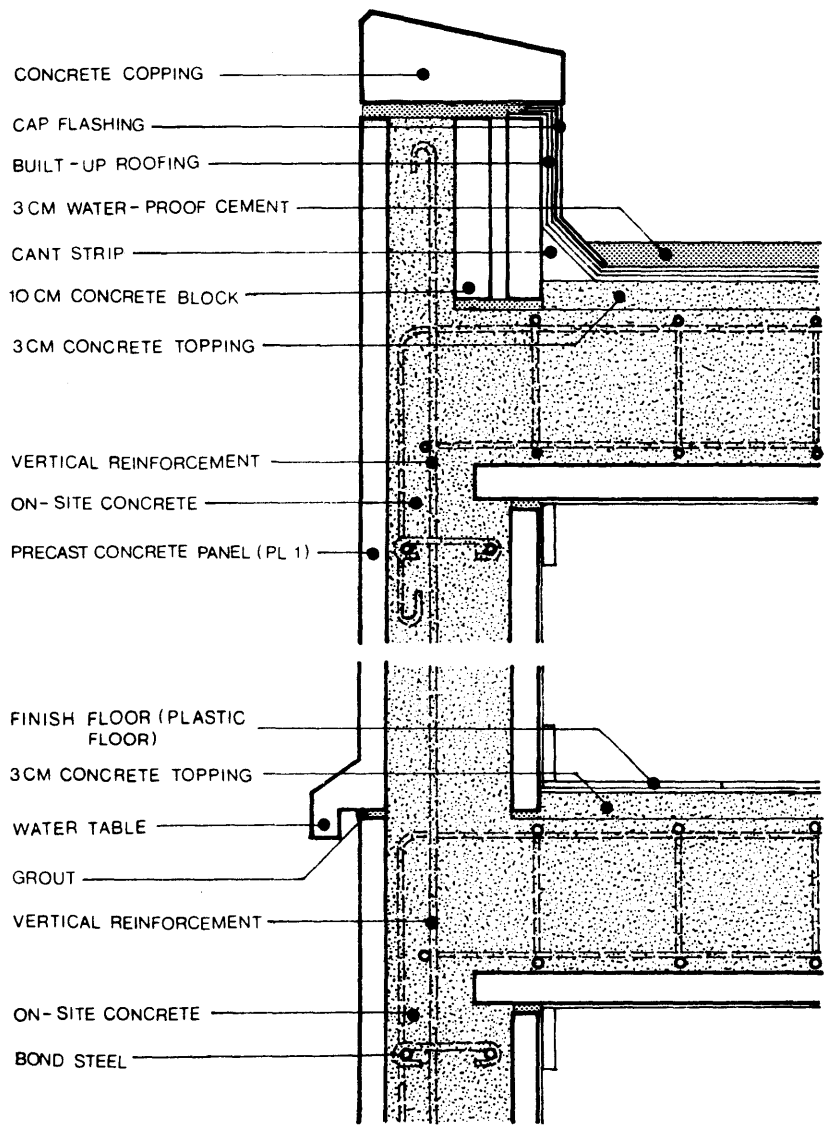
T JOINT

+ JOINT

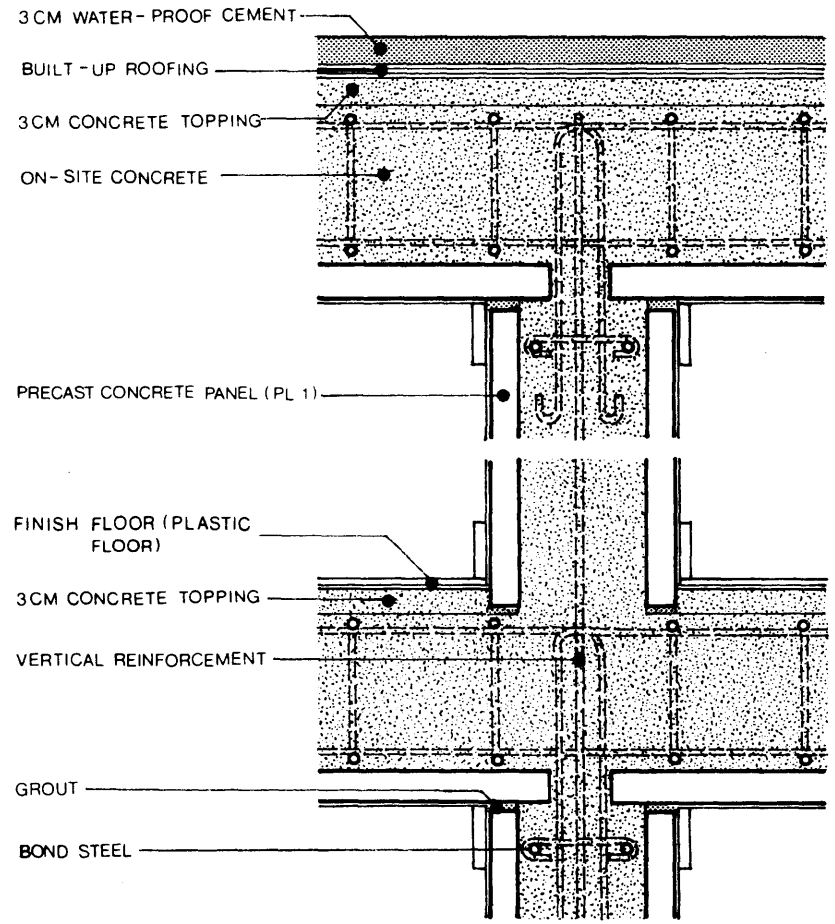
**BEARING WALL INTERSECTIONS**



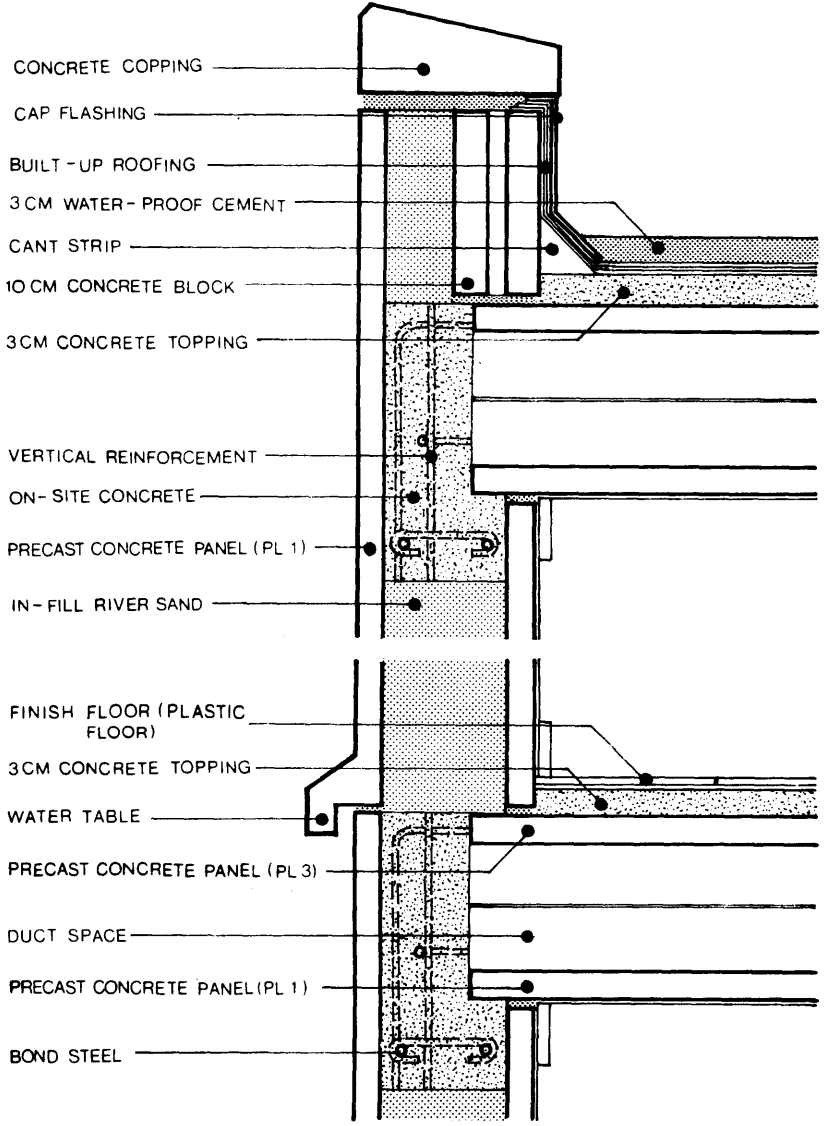
**CONSTRUCTION DETAILS**



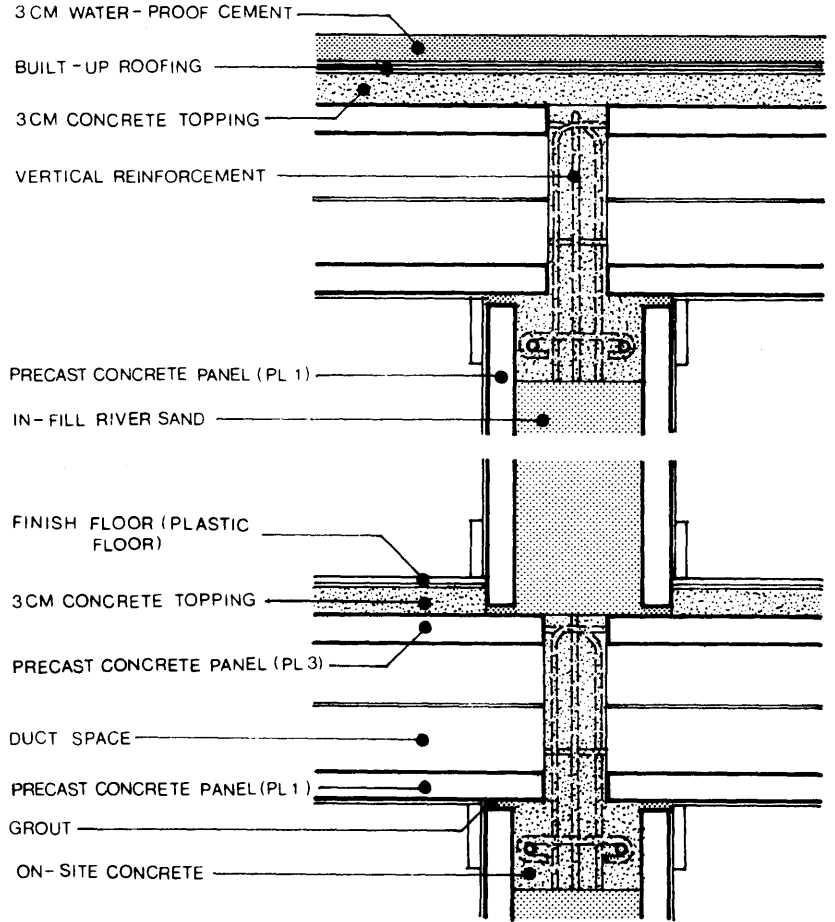
RIB - COLUMN AT EXTERIOR BEARING WALL



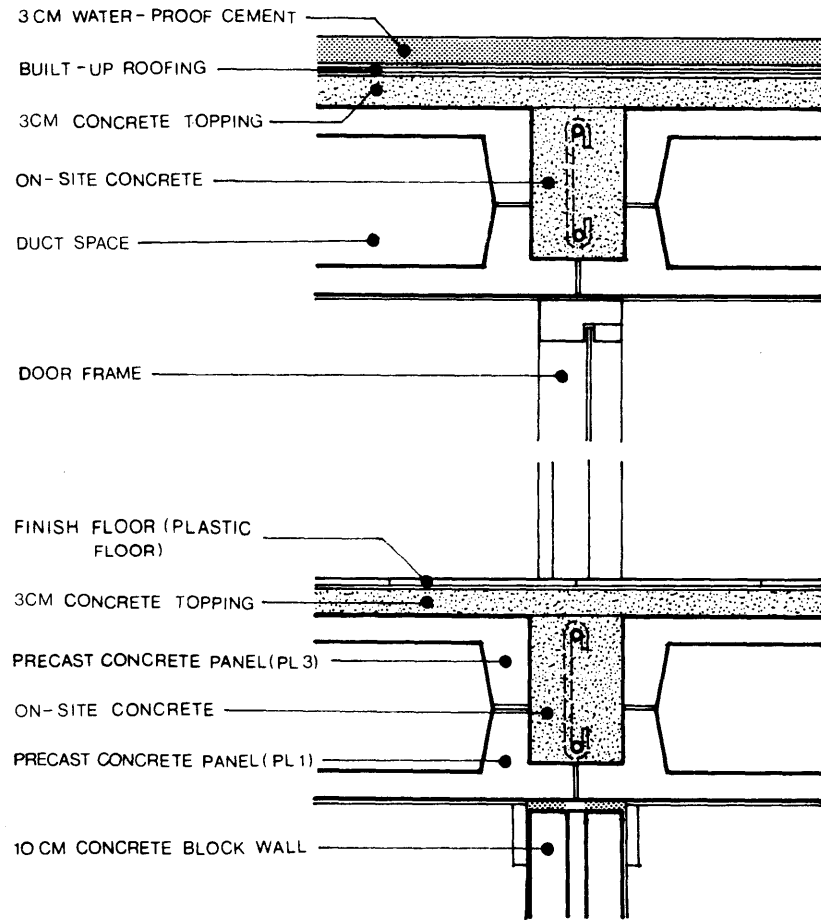
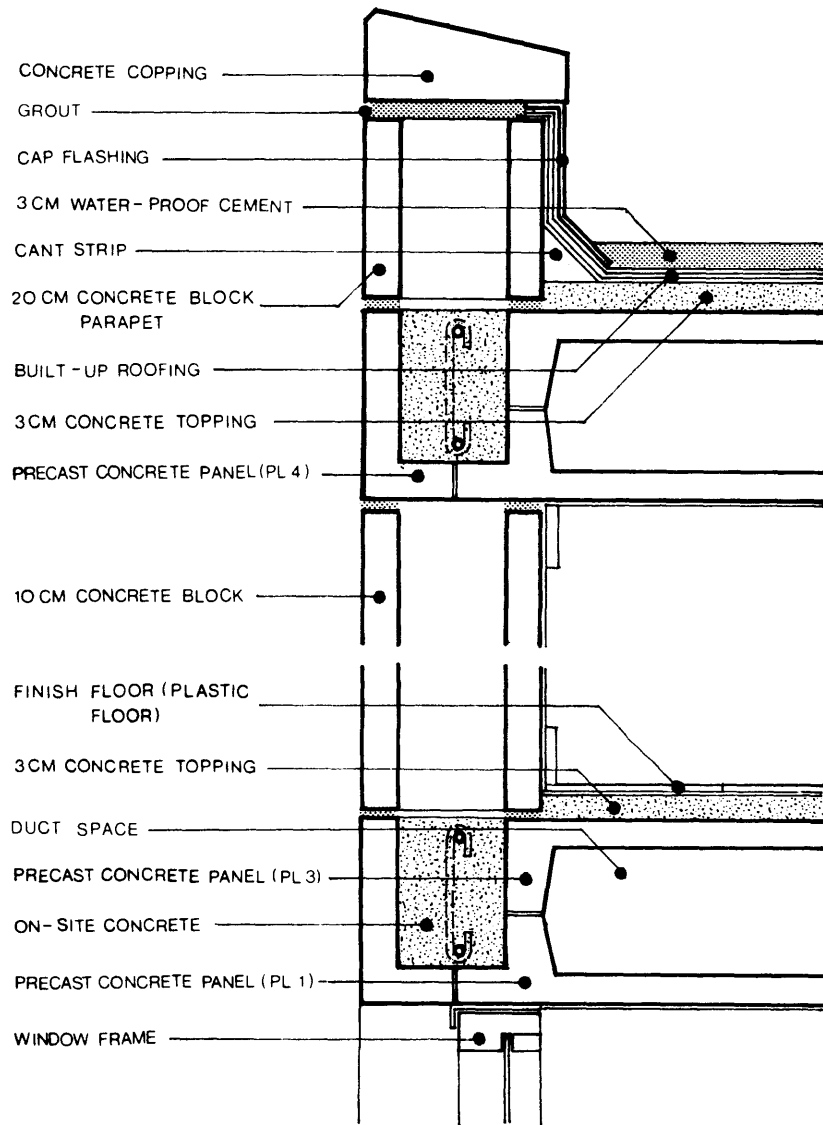
RIB - COLUMN AT INTERIOR BEARING WALL



EXTERIOR BEARING WALL



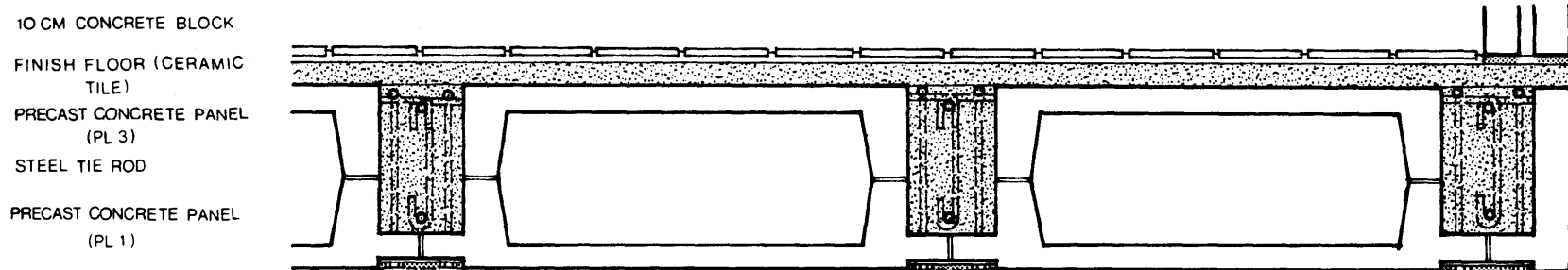
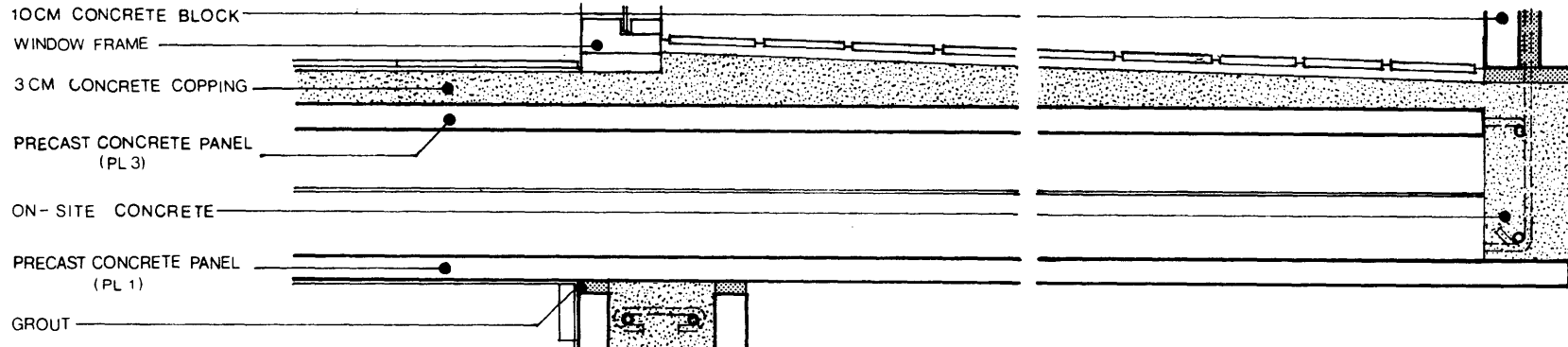
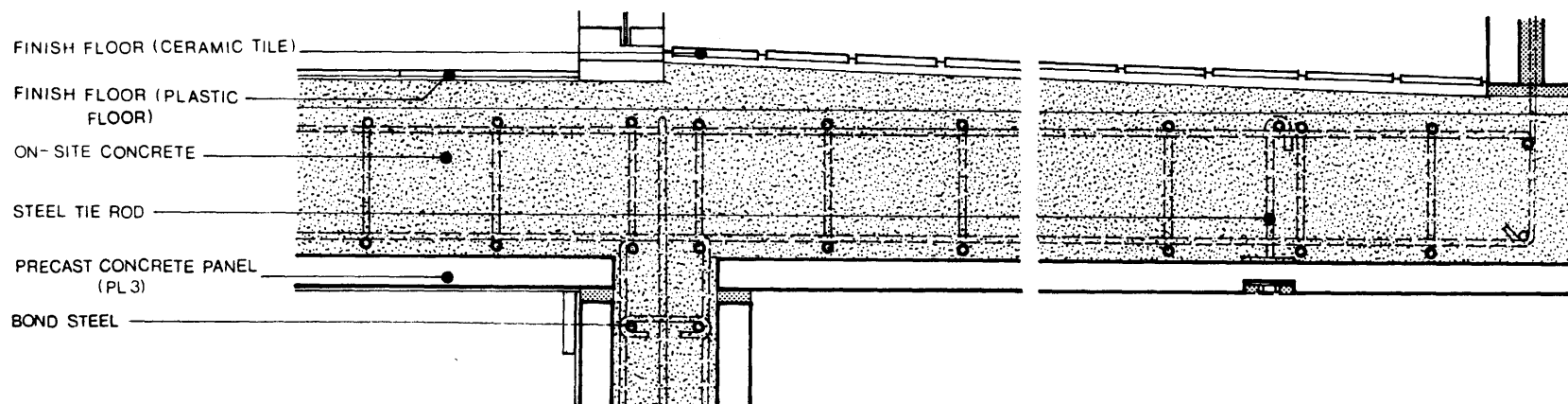
INTERIOR BEARING WALL



EXTERIOR NON-BEARING WALL

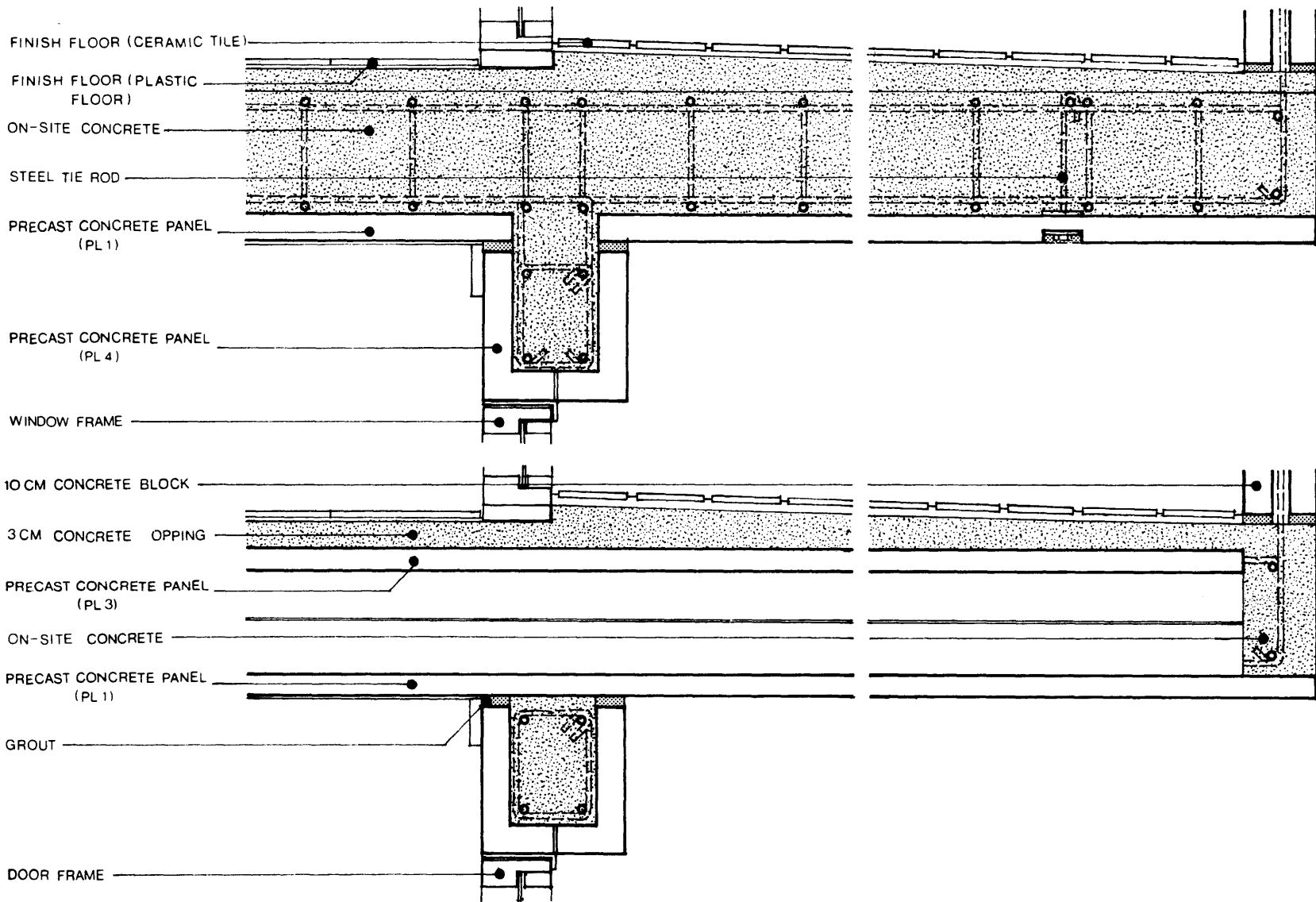
INTERIOR PARTITION WALL





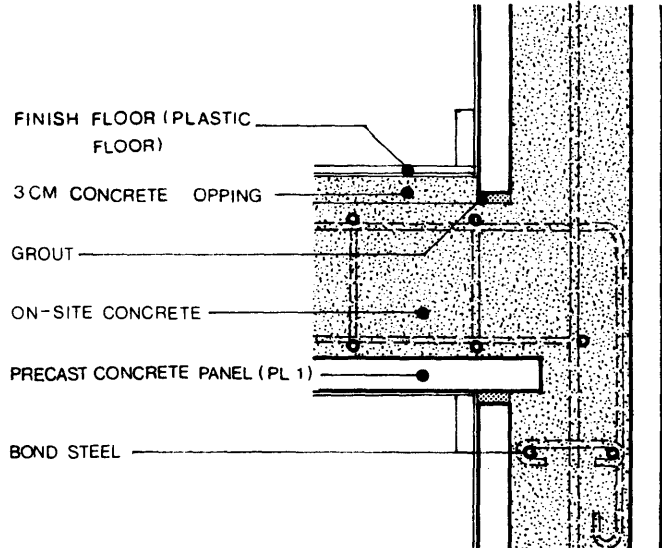
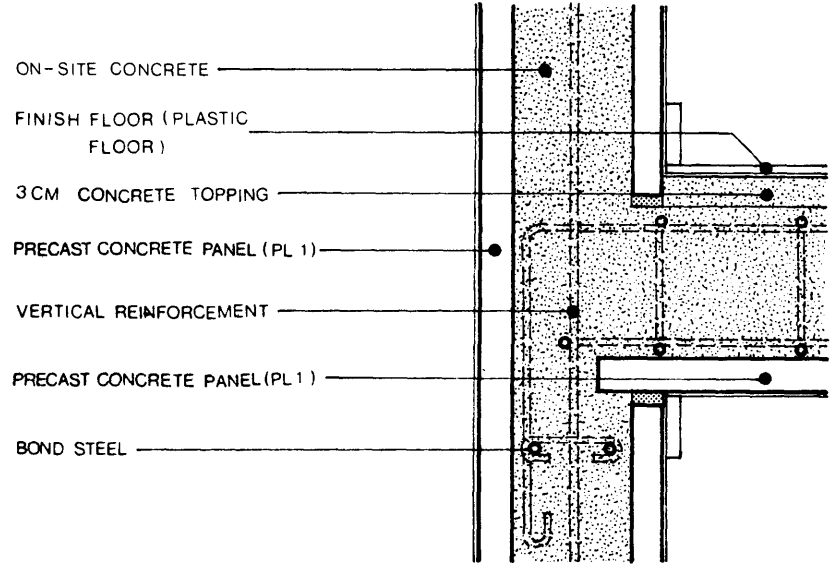
CANTILEVER AT EXTERIOR BEARING WALL



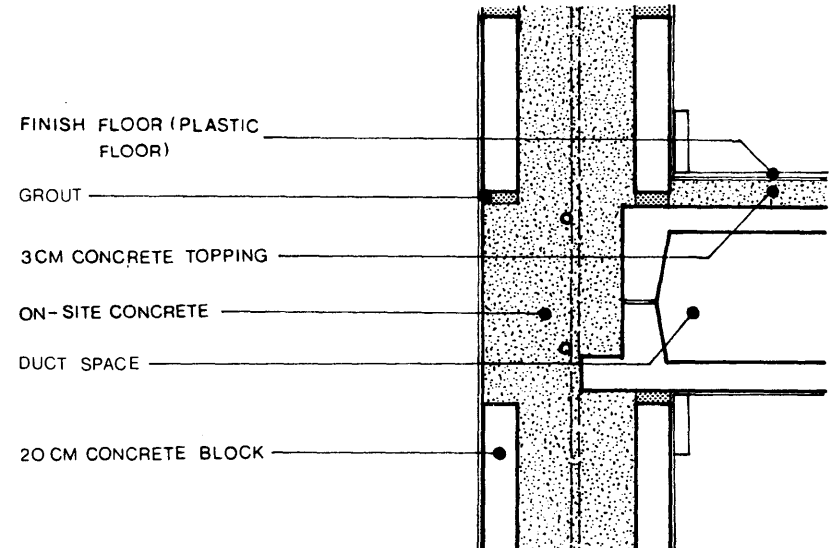
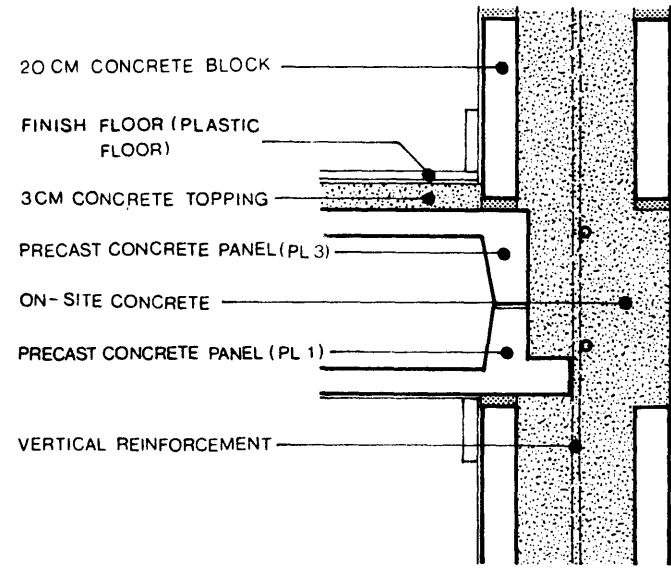


CANTILEVER AT EXTERIOR LINTEL

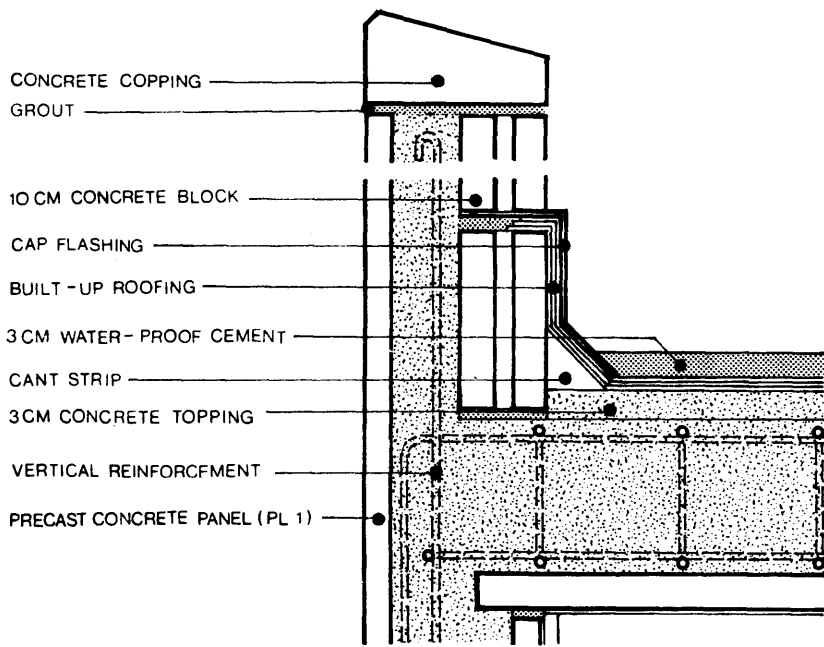




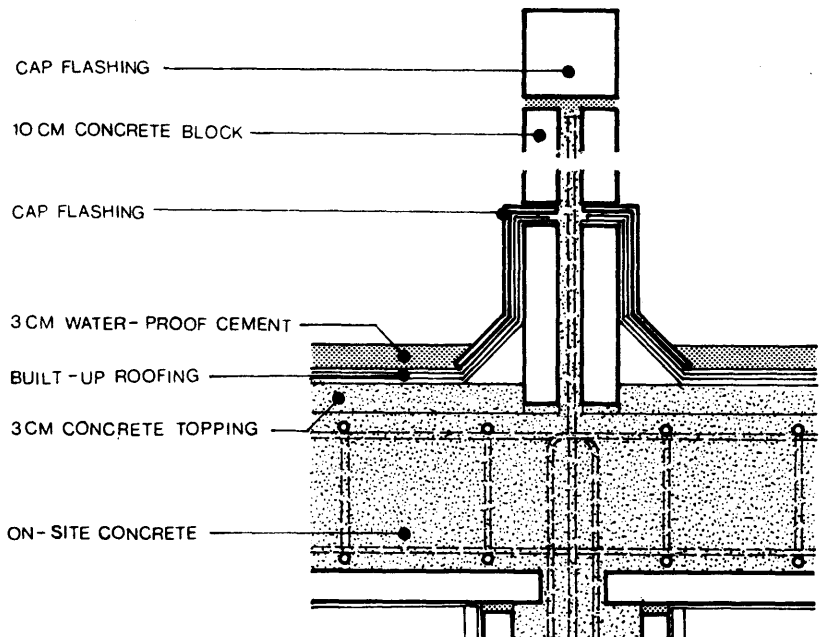
LEVEL CHANGE AT BEARING WALL



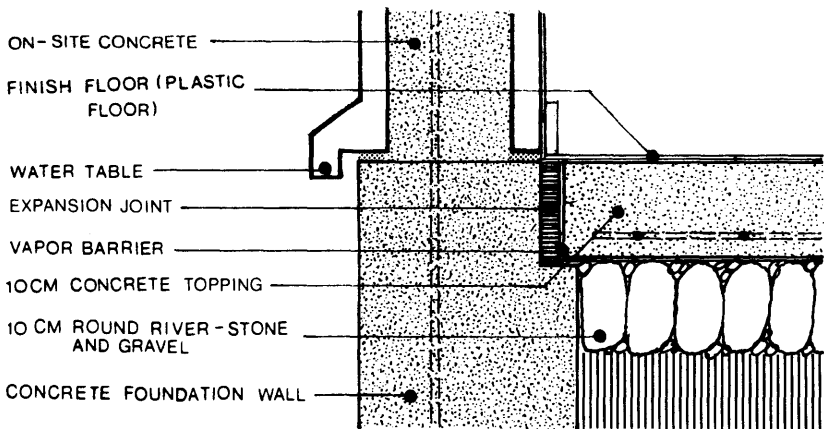
LEVEL CHANGE AT NON-BEARING WALL



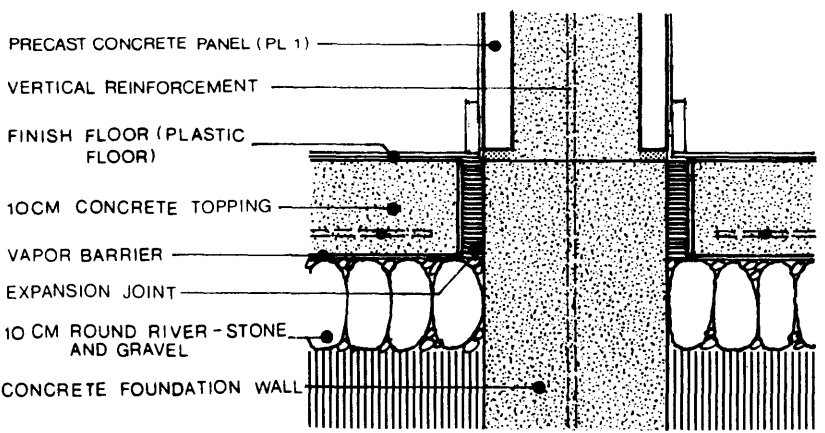
PARAPET AT EXTERIOR BEARING WALL



PARAPET AT PARTY WALL



EXTERIOR BEARING WALL AT GRADE

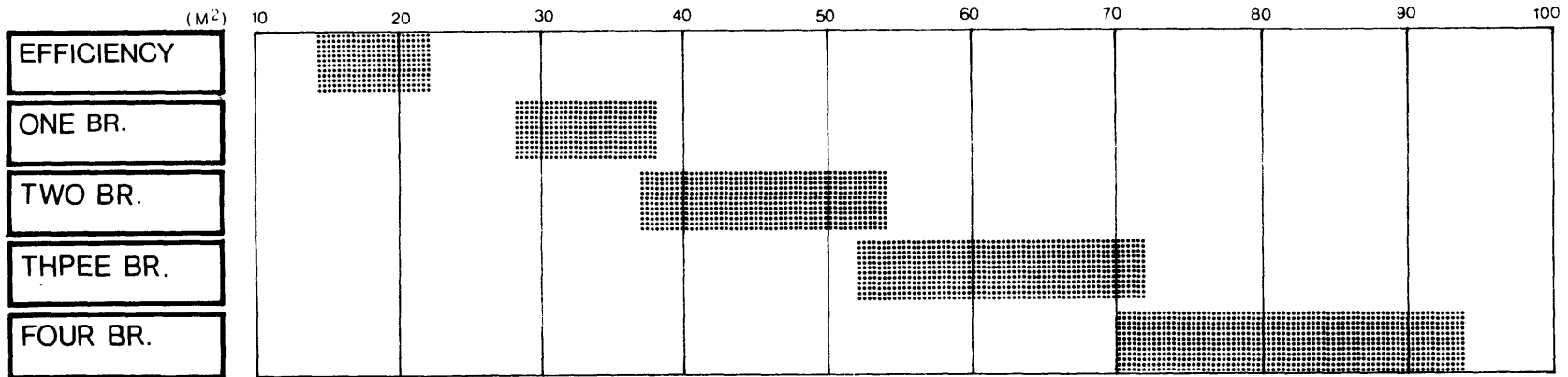


INTERIOR BEARING WALL AT GRADE

# UNIT PLANING AND GROUPING

	EFFICIENCY				ONE BR.				TWO BR.				THREE BR.				FOUR BR.			
	I	M	A	G	I	M	A	G	I	M	A	G	I	M	A	G	I	M	A	G
LIVING SPACE	2.10	6.00	8.10	10.20	1.80	7.50	9.30	10.80	2.10	7.80	9.90	12.00	2.40	9.60	12.00	14.40	2.56	12.45	14.40	16.96
DINING SPACE					0.90	3.00	3.90	4.80	1.20	3.60	4.80	6.00	1.50	4.50	6.00	7.50	1.68	5.52	7.20	8.88
KITCHEN	0.45	3.45	3.90	4.35	0.45	3.15	3.60	4.05	0.75	3.45	4.20	4.95	0.90	4.14	5.04	5.94	1.05	4.83	5.88	6.93
BEDROOM, PRI.					0.90	7.80	8.70	9.60	0.90	7.80	8.70	9.60	0.90	7.80	8.70	9.60	0.90	9.00	9.90	10.80
BEDROOM, SEC.									0.90	7.50	8.40	9.30	0.90	7.50	8.40	9.30	0.90	7.80	8.70	9.60
BEDROOM, SEC.													0.90	7.50	8.40	9.30	0.90	7.50	8.40	9.30
BEDROOM, SEC.													0.90	7.50	8.40	9.30	0.90	7.50	8.40	9.30
BATHROOM	0.36	2.64	3.00	3.36	0.36	2.62	3.00	3.36	0.45	2.79	3.24	3.69	0.60	3.45	4.05	4.65	0.75	3.75	4.50	5.25
CLOSET SPACE	0.30	1.80	2.10	2.40	0.45	2.01	2.46	2.91	0.60	2.46	3.06	3.66	0.90	3.42	4.32	5.22	1.14	4.56	5.70	6.84
CIRCULATION, PER.	5%	0.69	0.85	1.02	6%	1.56	1.86	2.13	7%	2.48	2.96	3.46	8%	3.83	4.55	5.29	10%	6.29	7.31	8.39
TOTAL UNIT AREA	14.58	17.95	21.33		27.64	32.82	37.65		37.88	45.26	52.86		51.74	61.36	71.40		69.20	80.39	92.25	
SUGGESTED AREA	14	18	22		28	33	38		37	46	54		52	62	72		70	82	94	

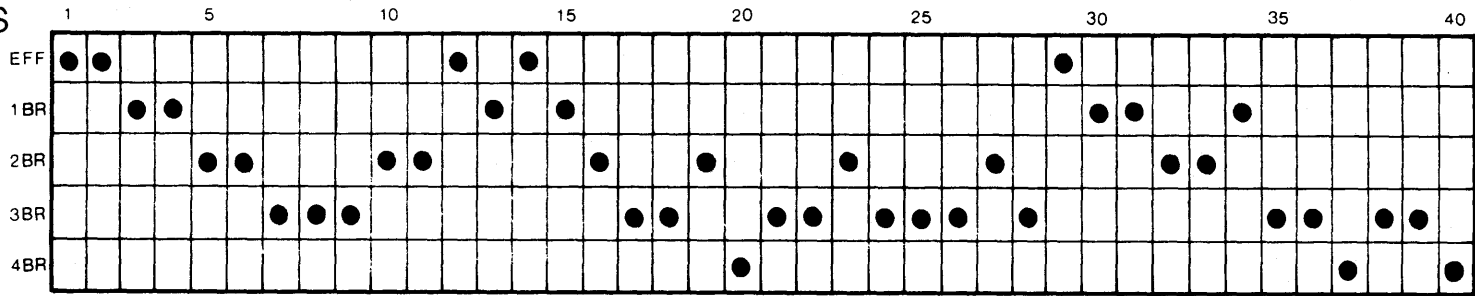
I : INCREMENT      A : AVERAGE AREA  
M : MINIMUM AREA      G : GENEROUS AREA



reference: "A Preliminary Study of Housing Industrialization"  
B.I.R.G. Cheng-Kung University, May 1971, Part 3  
"Space Study of Mass Housing", Council for International Economic Cooperation and Development, Dec. 1967  
"Housing Unit and Criteria of Site Planning", China Urban Design Center, Apr. 1971, Chapter I

## UNIT AREA RANGES

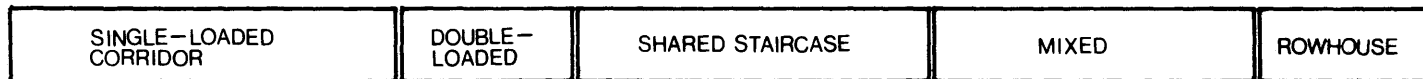
UNIT TYPES



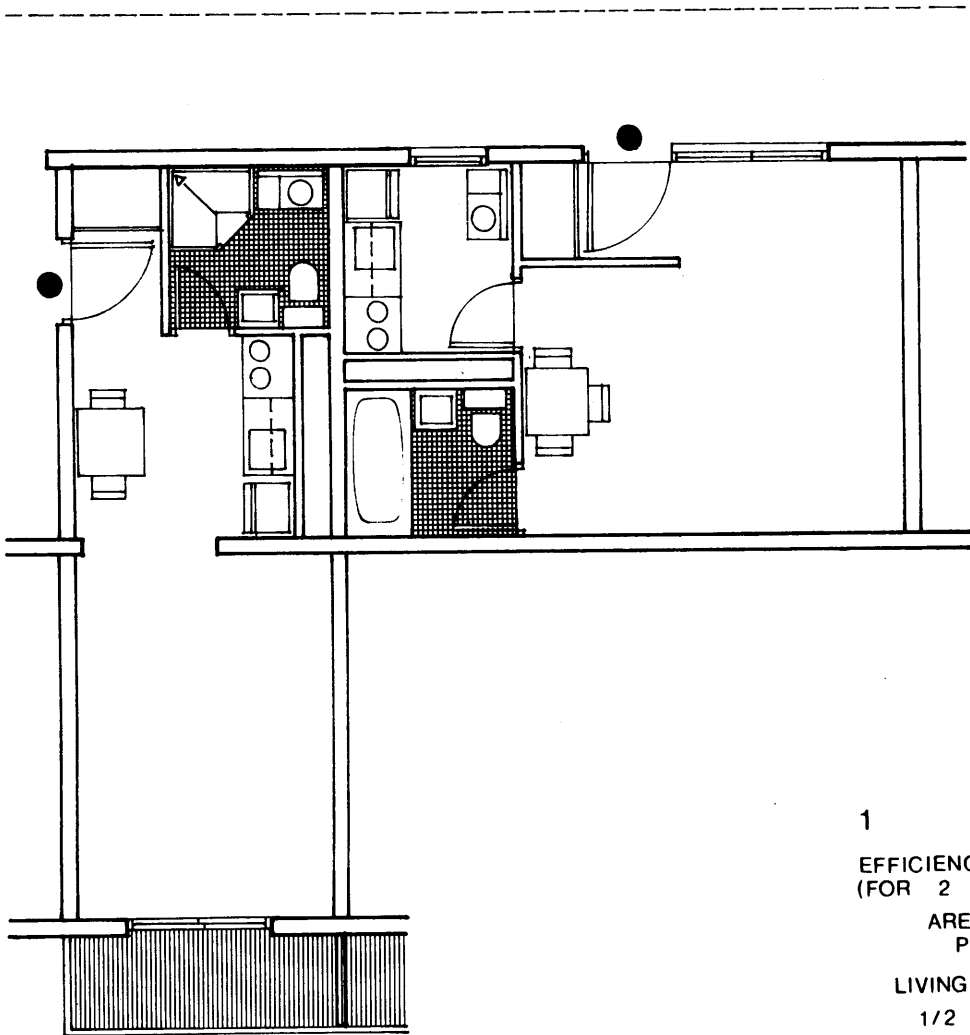
UNIT AREAS



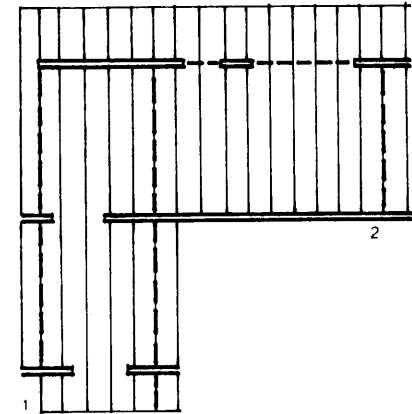
BUILDING TYPES



UNIT PLAN CATALOGUE

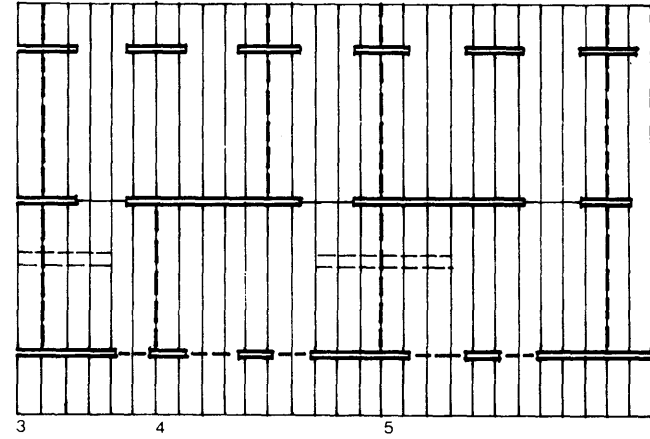
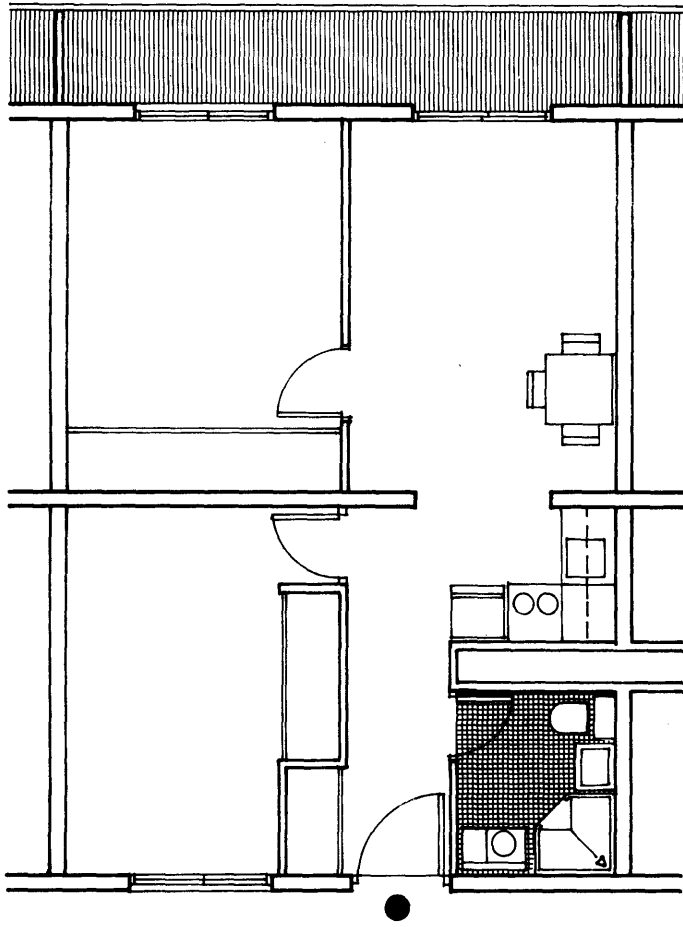


1  
 EFFICIENCY UNIT  
 (FOR 2 PERSONS)  
 AREA PER. 12.00  
 PERSON M<sup>2</sup>/PERSON  
 LIVING AREA: 24.00 M<sup>2</sup>  
 1/2 PORCH: M<sup>2</sup>  
 TOTAL: 24.00 M<sup>2</sup>  
 SHARING AREA: 6.00 M<sup>2</sup>  
 (CORRIDOR)



2  
 EFFICIENCY UNIT  
 (FOR 2 PERSONS)  
 AREA PER. 12.75  
 PERSON M<sup>2</sup>/PERSON  
 LIVING AREA: 24.00 M<sup>2</sup>  
 1/2 PORCH: 1.50 M<sup>2</sup>  
 TOTAL: 25.50 M<sup>2</sup>  
 SHARING AREA: 4.50 M<sup>2</sup>  
 (CORRIDOR)

## UNIT PLANING



3 • 4

1 BEDROOM UNIT  
(FOR 2-3 PERSONS)

AREA PER. 13.25-19.68  
PERSON: M<sup>2</sup>/PERSON

LIVING AREA: 36.00 M<sup>2</sup>

1/2 PORCH: 3.75 M<sup>2</sup>

TOTAL: 39.75 M<sup>2</sup>

SHARING AREA: 11.25 M<sup>2</sup>  
(CORRIDOR)

5

2 BEDROOM UNIT  
(FOR 3-4 PERSONS)

AREA PER. 13.25-17.67  
PERSON: M<sup>2</sup>/PERSON

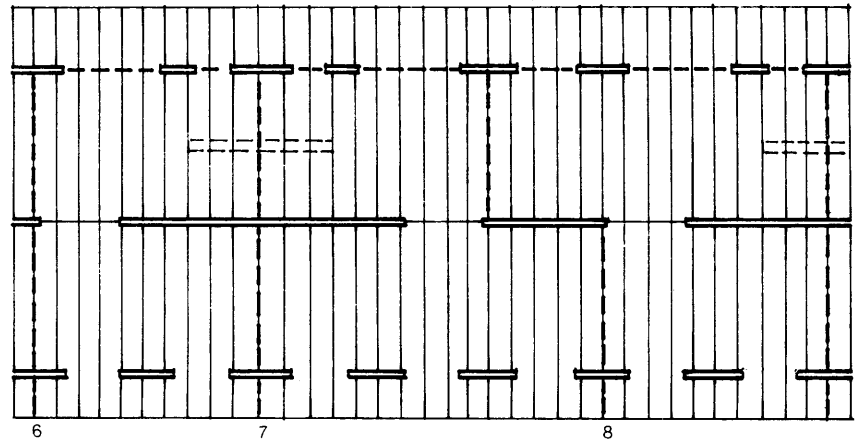
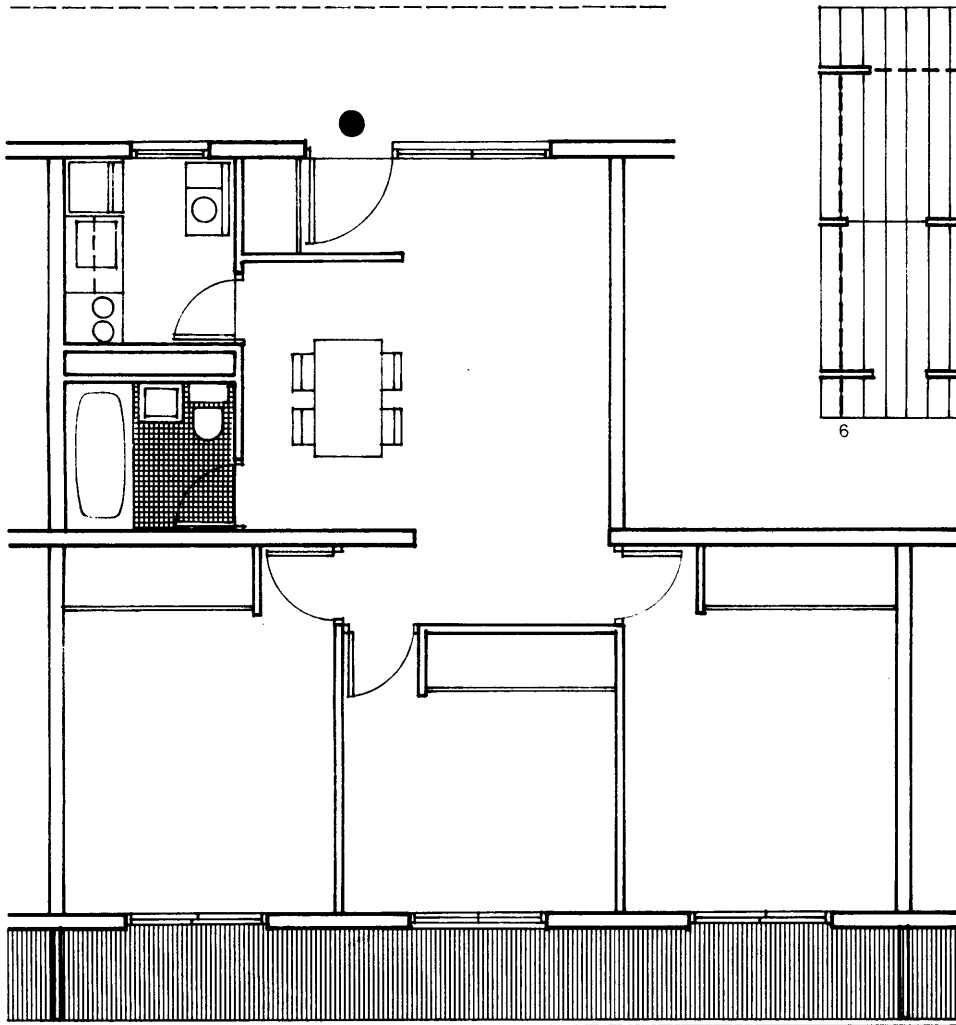
LIVING AREA: 48.00 M<sup>2</sup>

1/2 PORCH: 5.00 M<sup>2</sup>

TOTAL: 53.00 M<sup>2</sup>

SHARING AREA: 15.00 M<sup>2</sup>  
(CORRIDOR)





**6 2 BEDROOM UNIT  
(FOR 3-4 PERSONS)**

AREA PER. 12.75-1-.00  
PERSON: M<sup>2</sup>/PERSON

LIVING AREA: 48.00 M<sup>2</sup>

1/2 PORCH: 3.00 M<sup>2</sup>

TOTAL: 51.00 M<sup>2</sup>

SHARING AREA: 15.00 M<sup>2</sup>  
(CORRIDOR)

**7 · 8 3 BEDROOM UNIT  
(FOR 4-6 PERSONS)**

AREA PER. 10.83-16.25  
PERSON: M<sup>2</sup>/PERSON

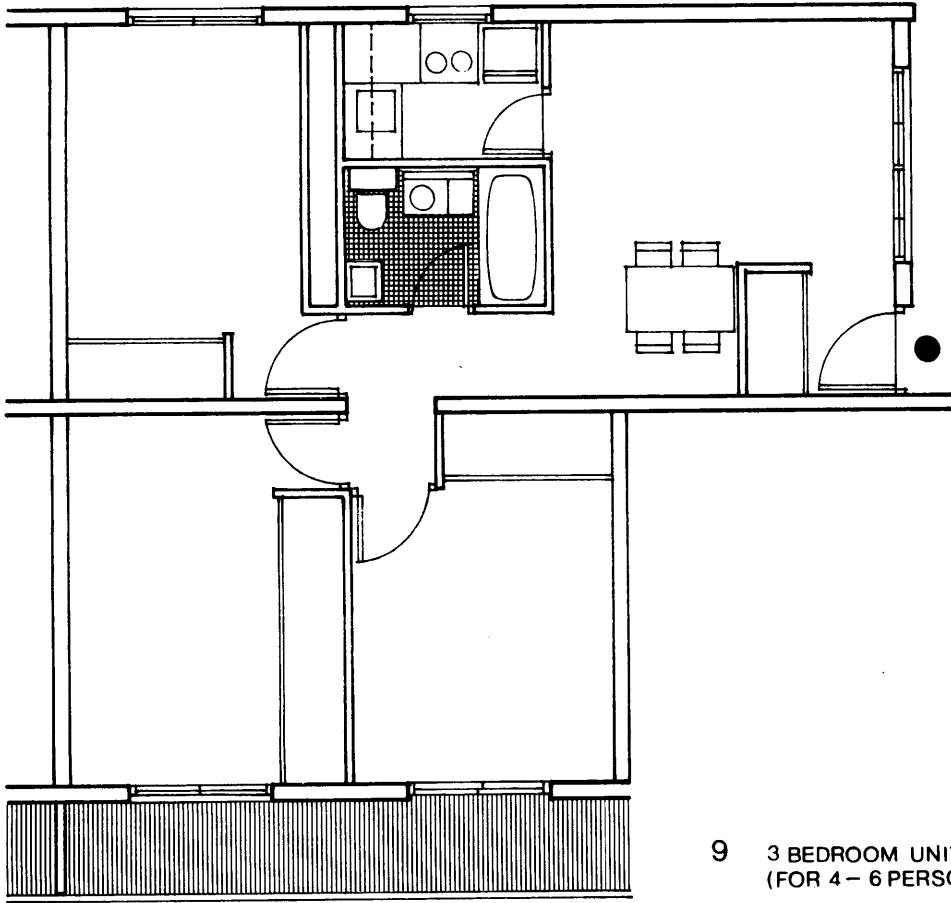
LIVING AREA: 60.00 M<sup>2</sup>

1/2 PORCH: 5.00 M<sup>2</sup>

TOTAL: 65.00 M<sup>2</sup>

SHARING AREA: 18.75 M<sup>2</sup>  
(CORRIDOR)





9 3 BEDROOM UNIT  
(FOR 4 - 6 PERSONS)

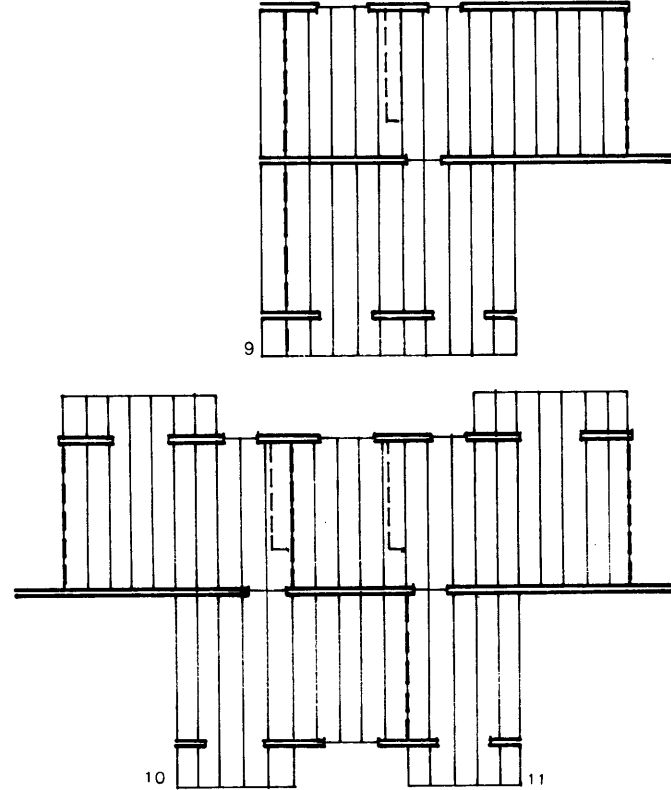
AREA PER. 10.50-15.75  
PERSON' M<sup>2</sup>/PERSON

LIVING AREA: 60.00 M<sup>2</sup>

1/2 PORCH: 3.00 M<sup>2</sup>

TOTAL: 63.00 M<sup>2</sup>

SHARING AREA: 2.25 M<sup>2</sup>  
(CORRIDOR)



10-11 2 BEDROOM UNIT  
(FOR 3 - 4 PERSONS)

AREA PER. 12.90-17.20  
PERSON' M<sup>2</sup>/PERSON

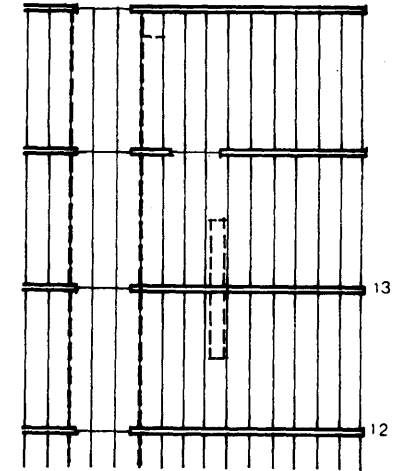
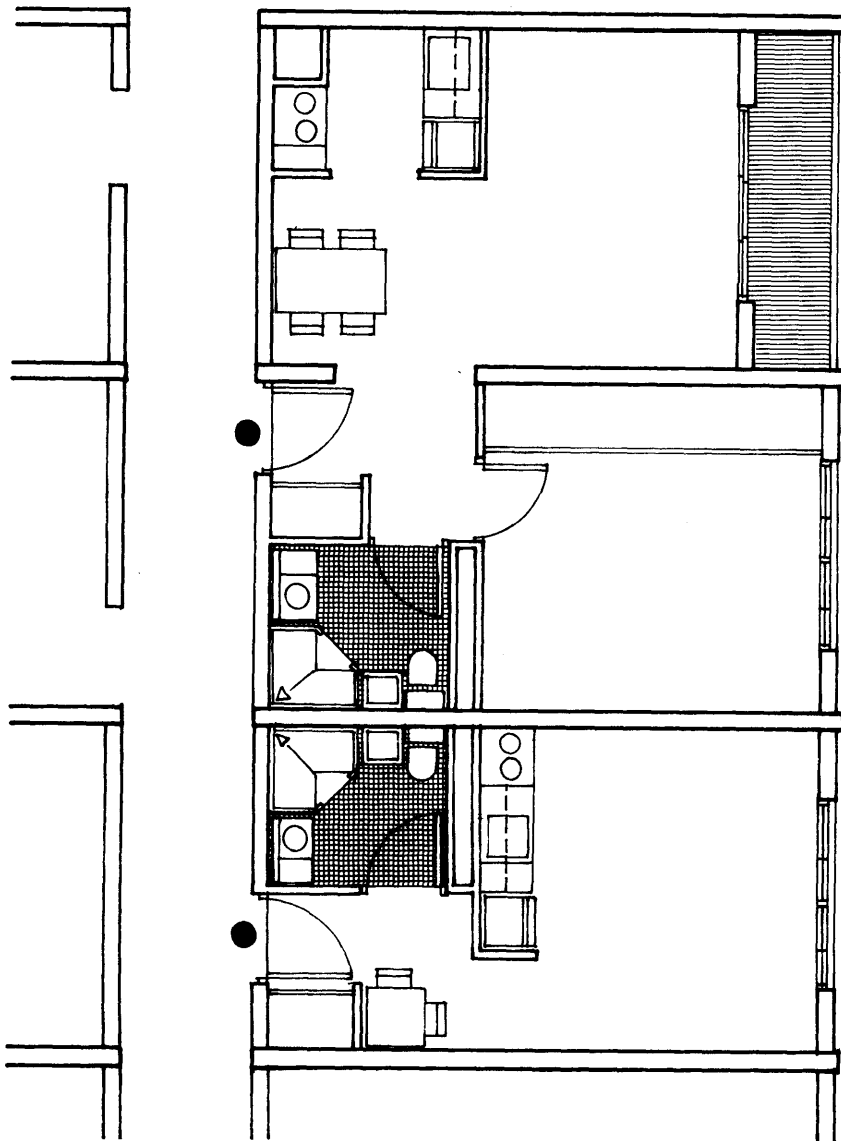
LIVING AREA: 48.00 M<sup>2</sup>

1/2 PORCH: 3.60 M<sup>2</sup>

TOTAL: 51.60 M<sup>2</sup>

SHARING AREA: 2.25 M<sup>2</sup>  
(CORRIDOR)





12

EFFICIENCY UNIT  
(FOR 2 PERSONS)

AREA PER. 10.80  
PERSON: M<sup>2</sup>/PERSON

LIVING AREA: 21.60 M<sup>2</sup>

1/2 PORCH: M<sup>2</sup>

TOTAL: 21.60 M<sup>2</sup>

SHARING AREA: 2.52 M<sup>2</sup>  
(CORRIDOR)

13

1 BEDROOM UNIT  
(FOR 2-3 PERSONS)

AREA PER. 13.80-20.70  
PERSON: M<sup>2</sup>/PERSON

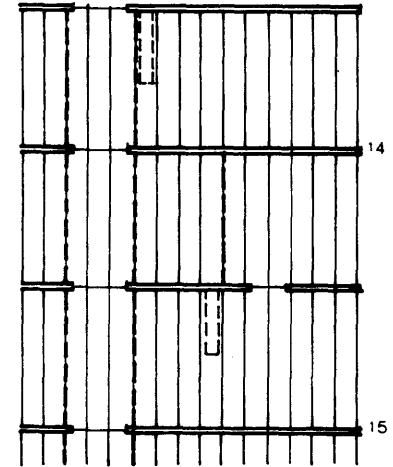
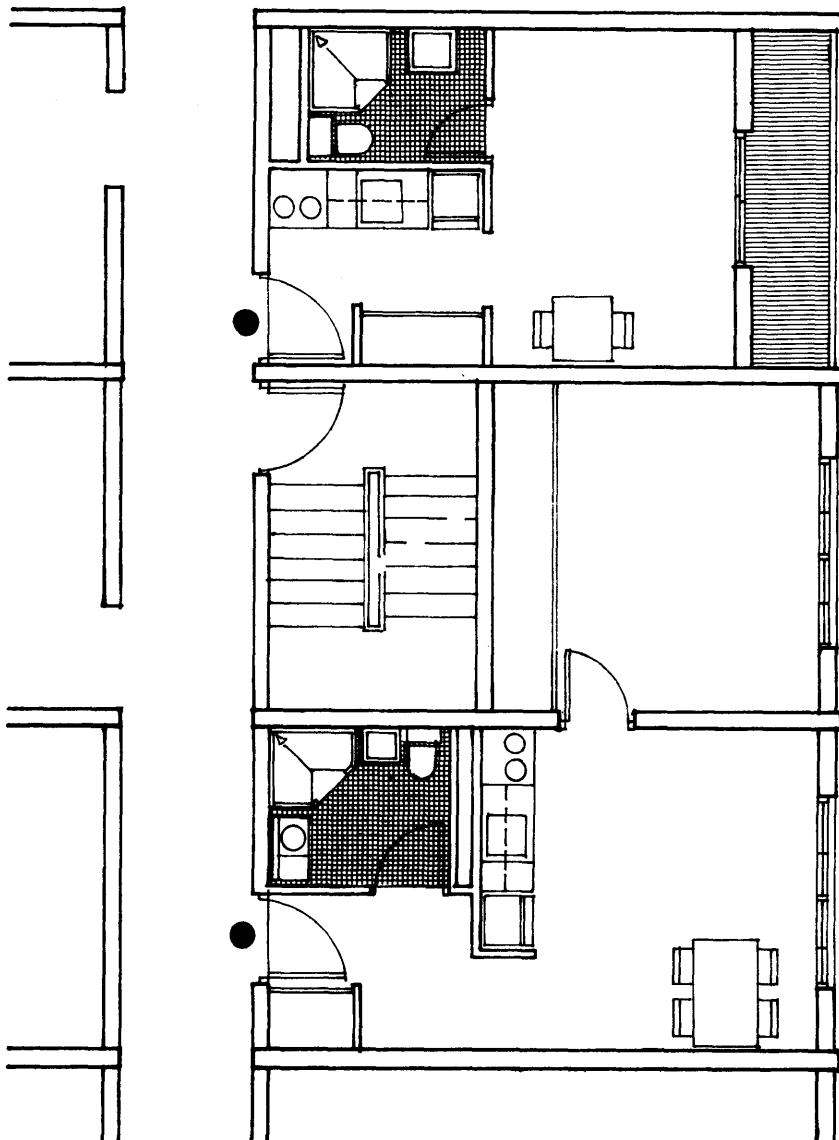
LIVING AREA: 39.60 M<sup>2</sup>

1/2 PORCH: 1.80 M<sup>2</sup>

TOTAL: 41.40 M<sup>2</sup>

SHARING AREA: 5.04 M<sup>2</sup>  
(CORRIDOR)





14

EFFICIENCY UNIT  
(FOR 2 PERSONS)

AREA PER, 10.05  
PERSON: M<sup>2</sup>/PERSON

LIVING AREA: 18.00 M<sup>2</sup>

1/2 PORCH: 1.80 M<sup>2</sup>

TOTAL: 19.80 M<sup>2</sup>

SHARING AREA: 2.52 M<sup>2</sup>  
(CORRIDOR)

15

1 BEDROOM UNIT  
(FOR 2-3 PERSONS)

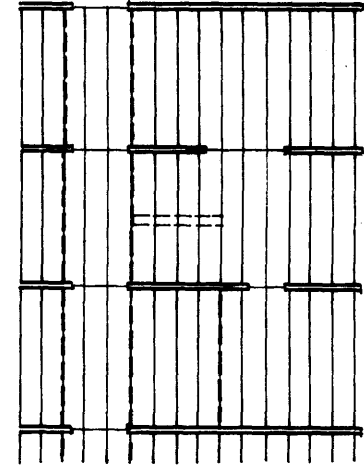
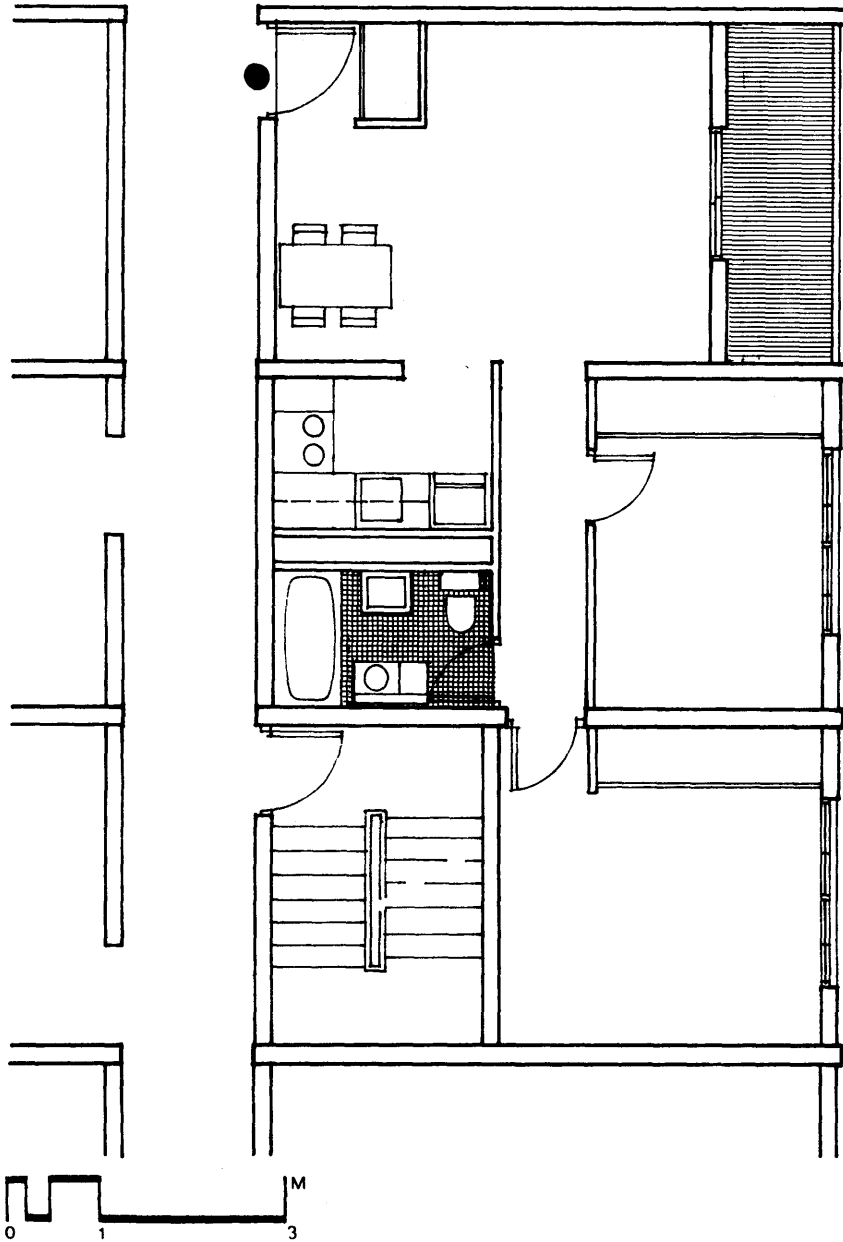
AREA PER, 11.52-17.28  
PERSON: M<sup>2</sup>/PERSON

LIVING AREA: 34.56 M<sup>2</sup>

1/2 PORCH: M<sup>2</sup>

TOTAL: 34.56 M<sup>2</sup>

SHARING AREA: 5.04 M<sup>2</sup>  
(CORRIDOR)



16

2 BEDROOM UNIT  
(FOR 3-4 PERSONS)

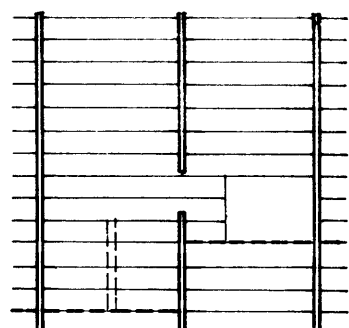
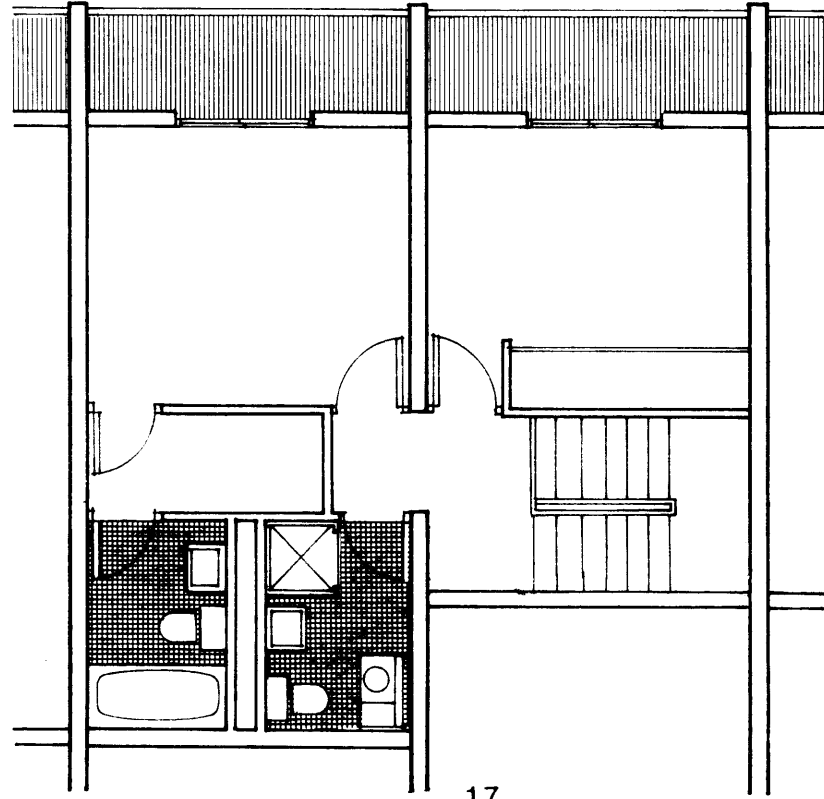
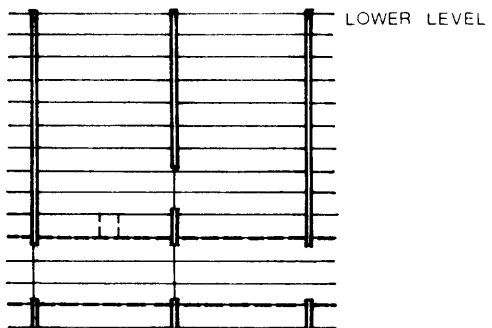
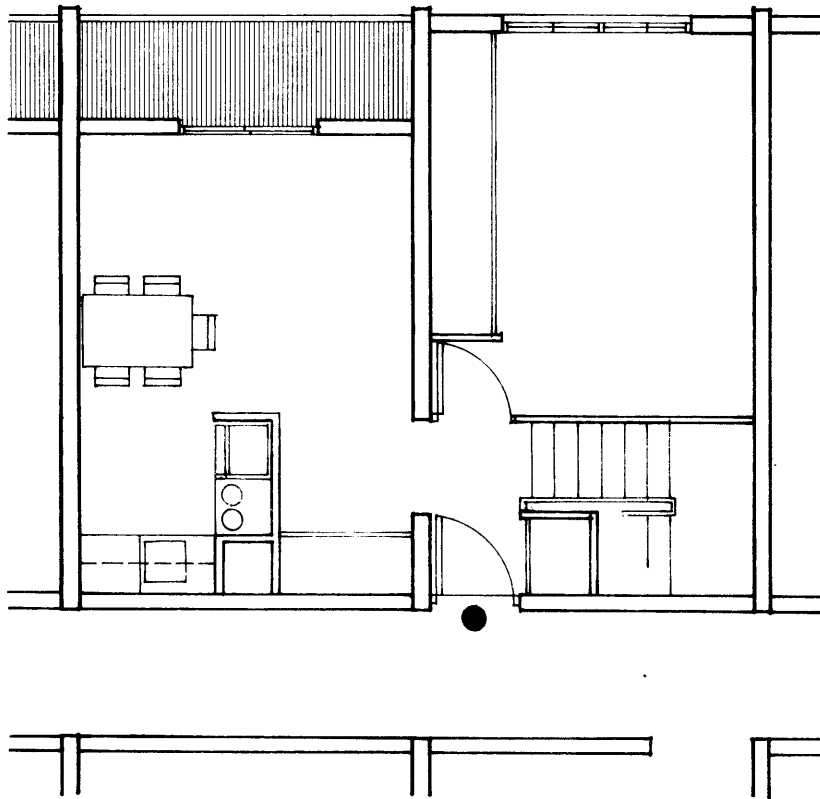
AREA PER. 13.50-18.00  
PERSON M<sup>2</sup>/PERSON

LIVING AREA: 51.84 M<sup>2</sup>

1/2 PORCH: 2.16 M<sup>2</sup>

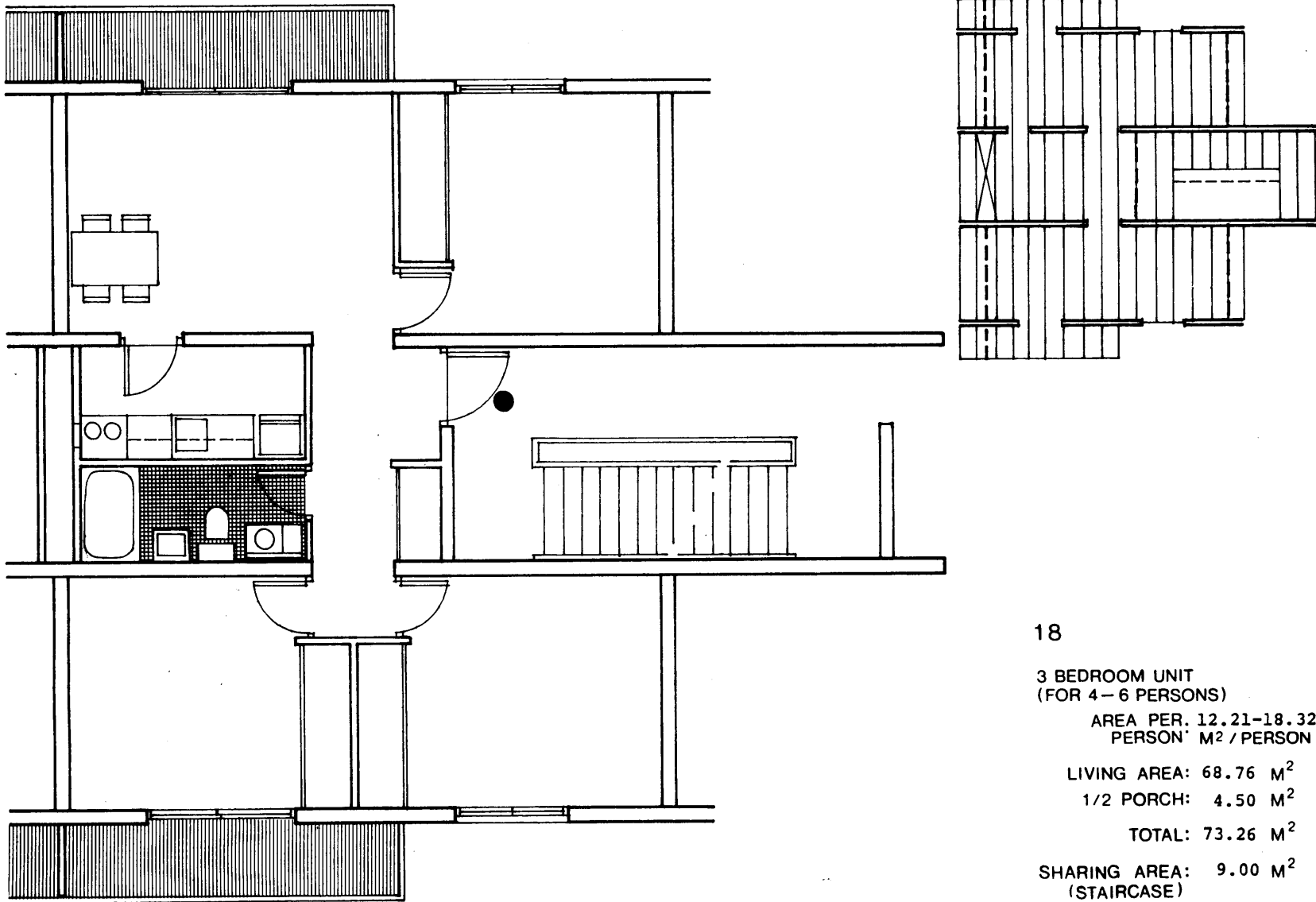
TOTAL: 54.00 M<sup>2</sup>

SHARING AREA: 5.04 M<sup>2</sup>  
(CORRIDOR)



17

3 BEDROOM UNIT  
 (FOR 5 - 7 PERSONS)  
 AREA PER. 12.13-16.99  
 PERSON: M<sup>2</sup>/PERSON  
 LIVING AREA: 78.48 M<sup>2</sup>  
 1/2 PORCH: 6.48 M<sup>2</sup>  
 TOTAL: 84.96 M<sup>2</sup>  
 SHARING AREA: 5.04 M<sup>2</sup>  
 (CORRIDOR)



18

3 BEDROOM UNIT  
(FOR 4-6 PERSONS)

AREA PER. 12.21-18.32  
PERSON M<sup>2</sup>/PERSON

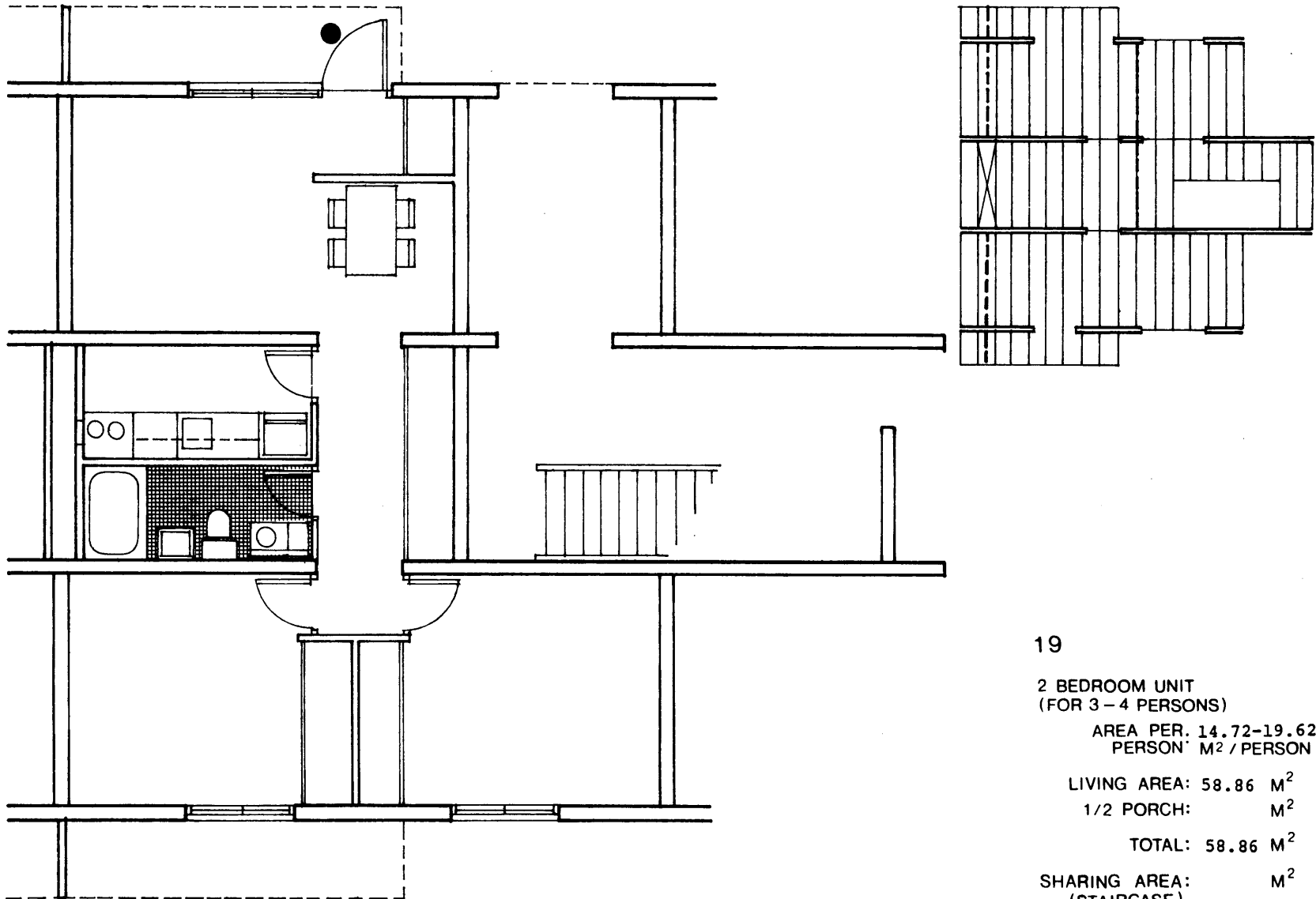
LIVING AREA: 68.76 M<sup>2</sup>

1/2 PORCH: 4.50 M<sup>2</sup>

TOTAL: 73.26 M<sup>2</sup>

SHARING AREA: 9.00 M<sup>2</sup>  
(STAIRCASE)





19

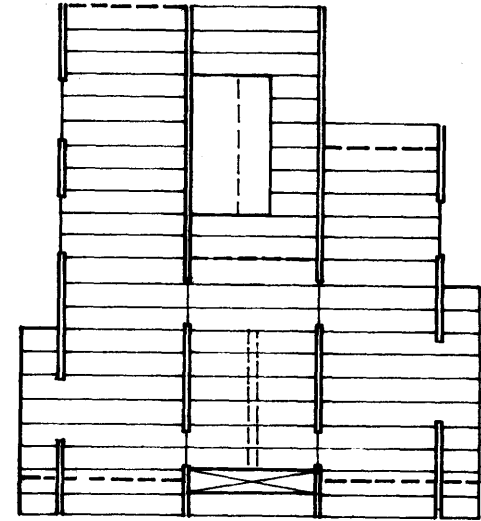
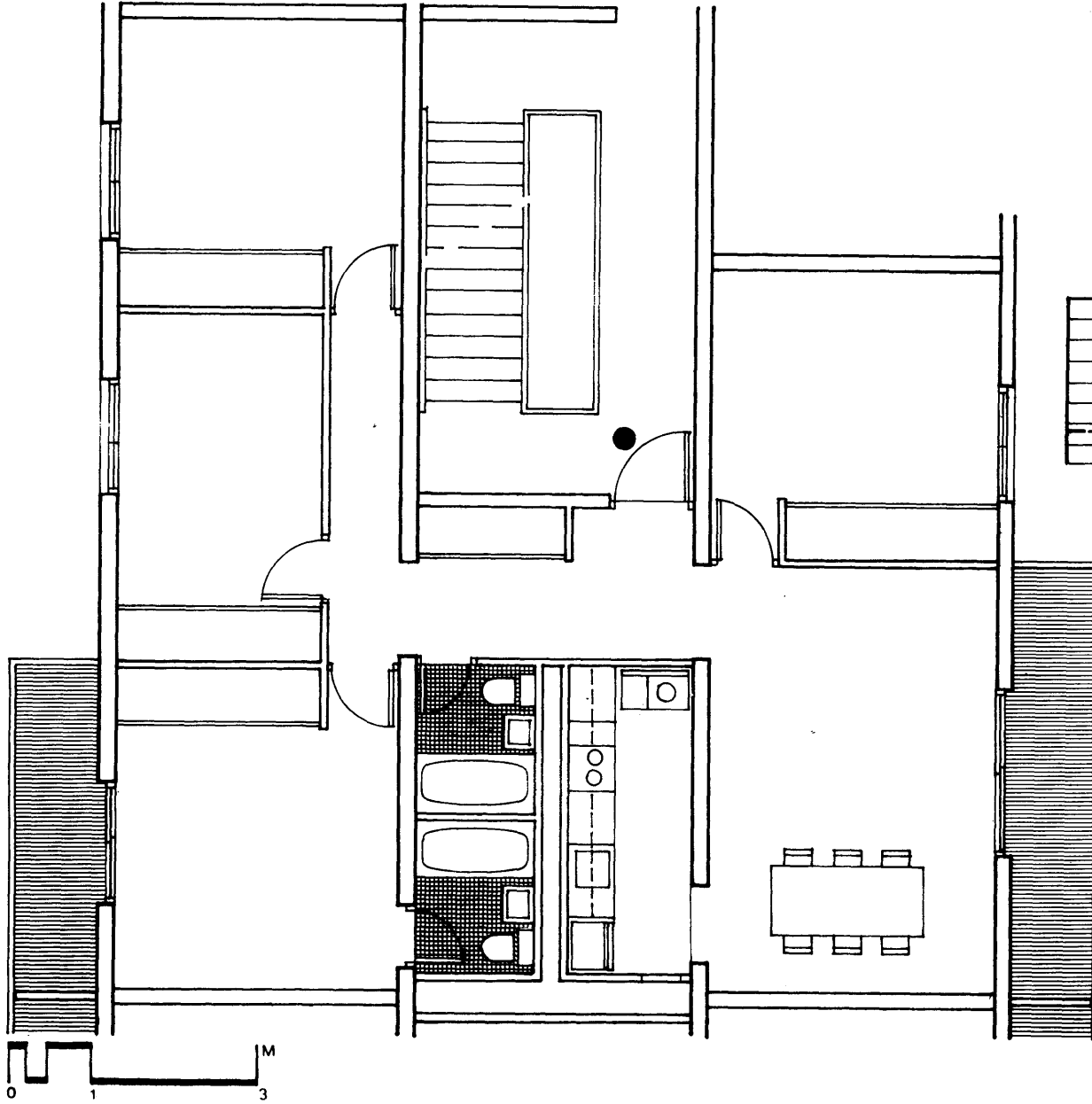
2 BEDROOM UNIT  
(FOR 3 - 4 PERSONS)

AREA PER. 14.72-19.62  
PERSON M<sup>2</sup> / PERSON

LIVING AREA: 58.86 M<sup>2</sup>  
1/2 PORCH: M<sup>2</sup>  
TOTAL: 58.86 M<sup>2</sup>

SHARING AREA: M<sup>2</sup>  
(STAIRCASE)





20

4 BEDROOM UNIT  
(FOR 6-8 PERSONS)

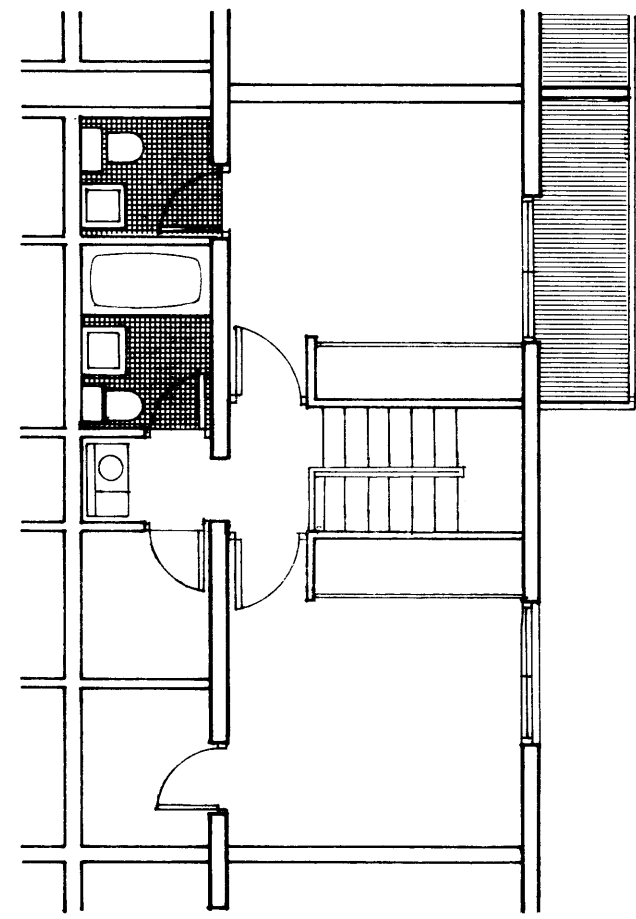
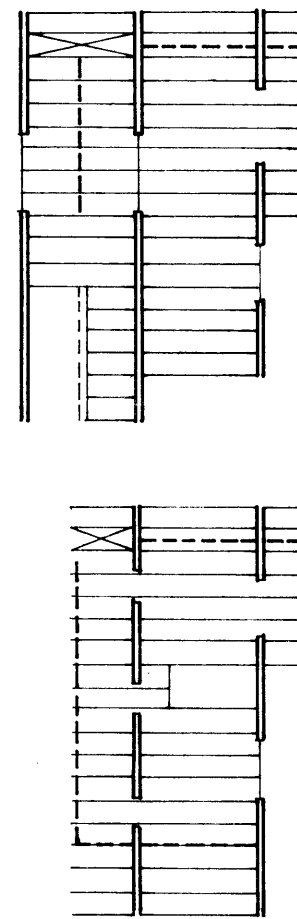
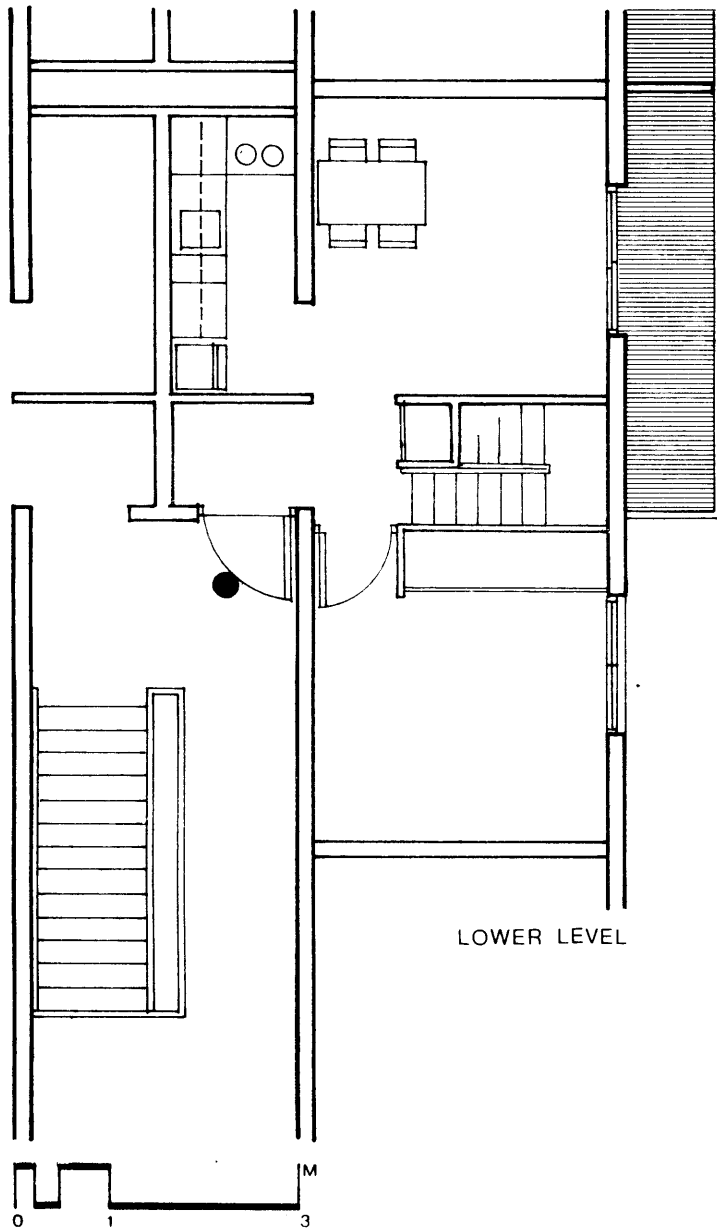
AREA PER. 12.31-16.41  
PERSON' M<sup>2</sup> / PERSON

LIVING AREA: 93.96 M<sup>2</sup>

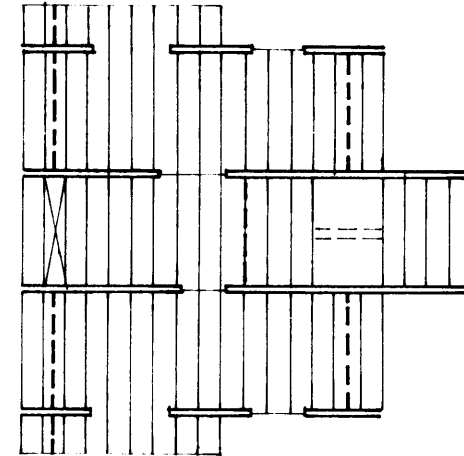
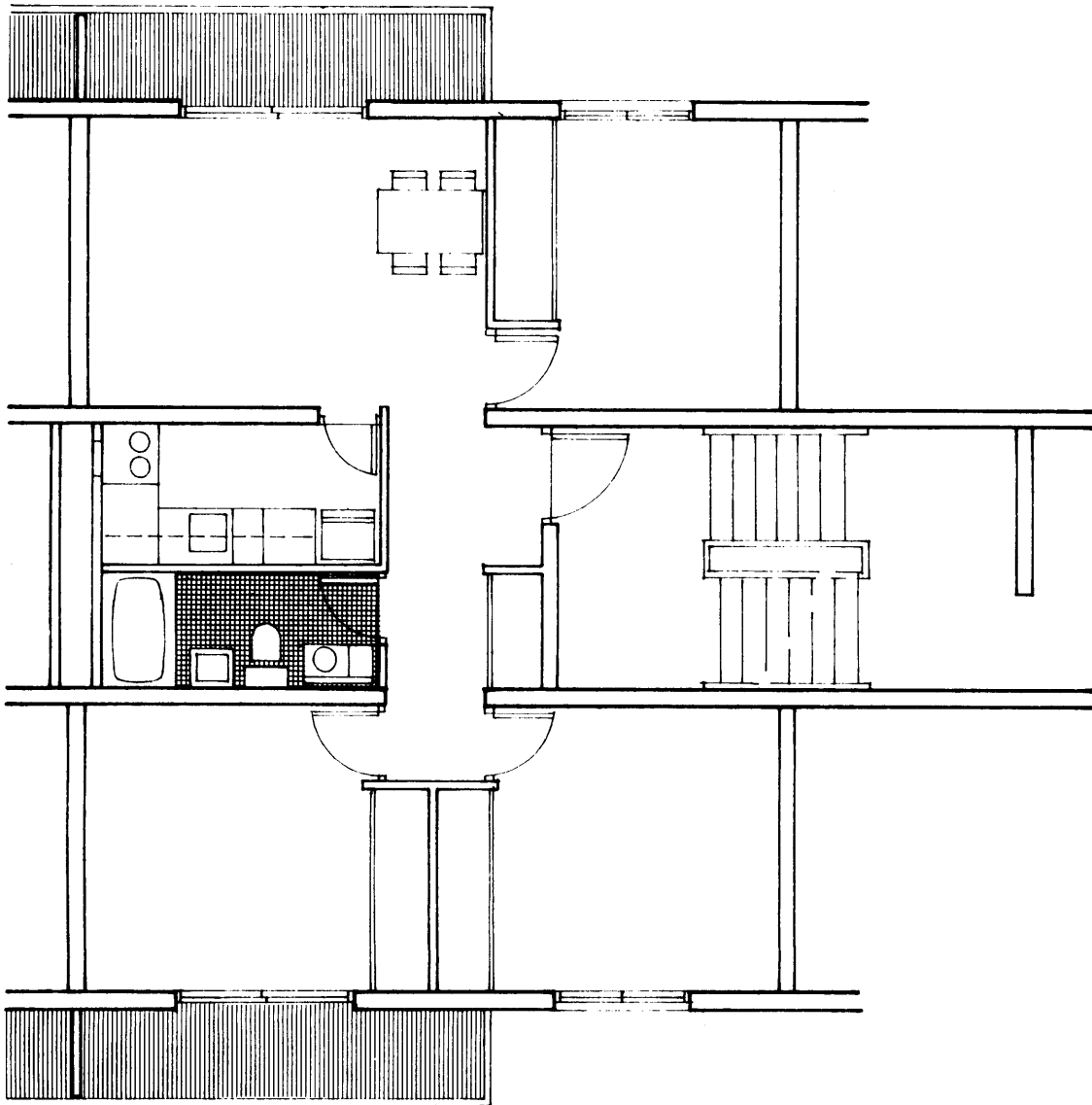
1/2 PORCH: 4.50 M<sup>2</sup>

TOTAL: 98.46 M<sup>2</sup>

SHARING AREA: 10.80 M<sup>2</sup>  
(STAIRCASE)



21 3 BEDROOM UNIT  
 (FOR 5 - 6 PERSONS)  
 AREA PER. 13.21-15.85  
 PERSON M<sup>2</sup> / PERSON  
 LIVING AREA: 73.26 M<sup>2</sup>  
 1/2 PORCH: 6.00 M<sup>2</sup>  
 TOTAL: 79.26 M<sup>2</sup>  
 SHARING AREA: 4.50 M<sup>2</sup>  
 (STAIRCASE)



22

3 BEDROOM UNIT  
(FOR 4-5 PERSONS)

AREA PER. 14.26-17.82  
PERSON' M<sup>2</sup> / PERSON

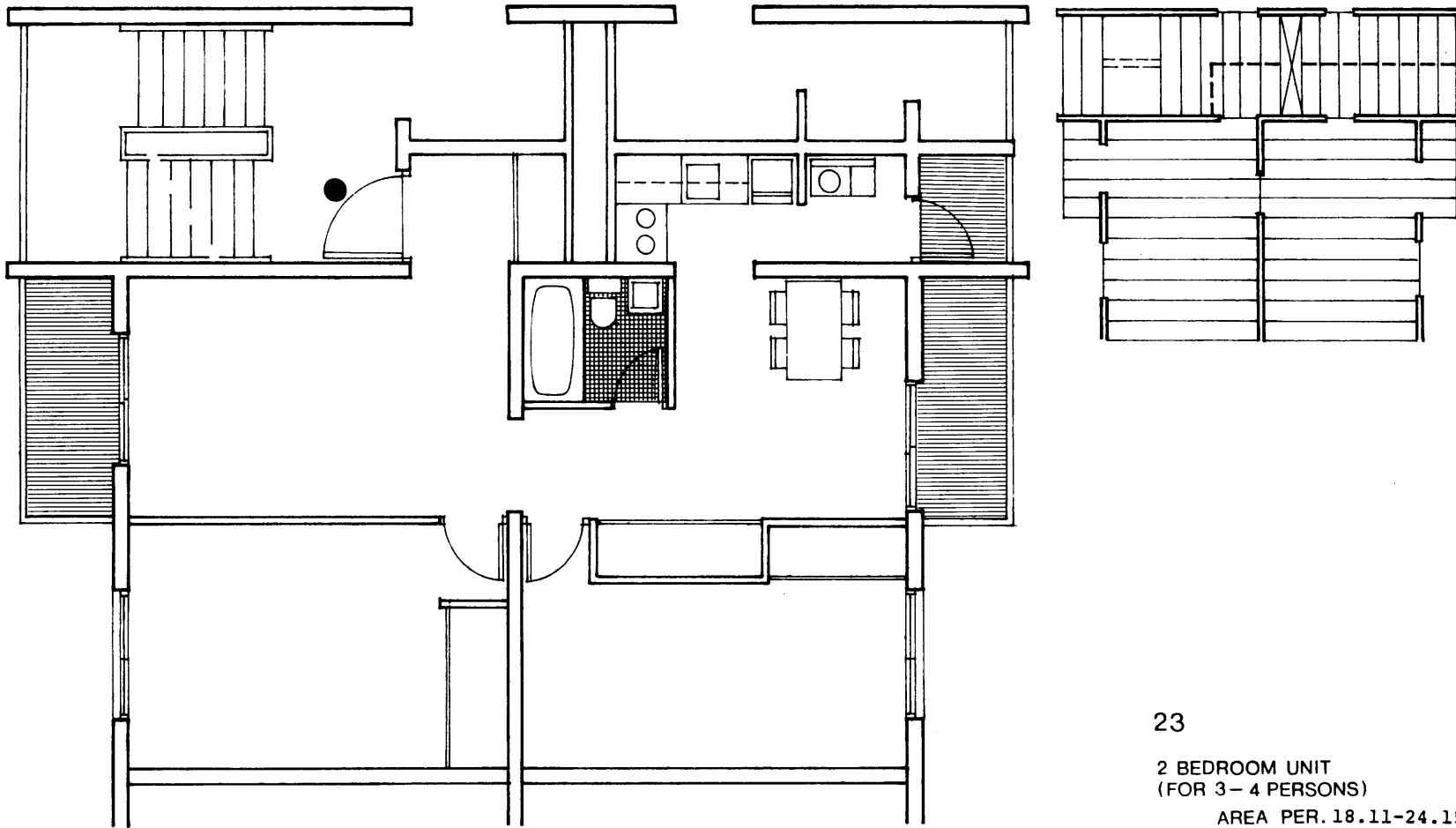
LIVING AREA: 66.78 M<sup>2</sup>

1/2 PORCH: 4.50 M<sup>2</sup>

TOTAL: 71.28 M<sup>2</sup>

SHARING AREA: 8.10 M<sup>2</sup>  
(STAIRCASE)





23

2 BEDROOM UNIT  
(FOR 3-4 PERSONS)

AREA PER. 18.11-24.15  
PERSON' M<sup>2</sup> / PERSON

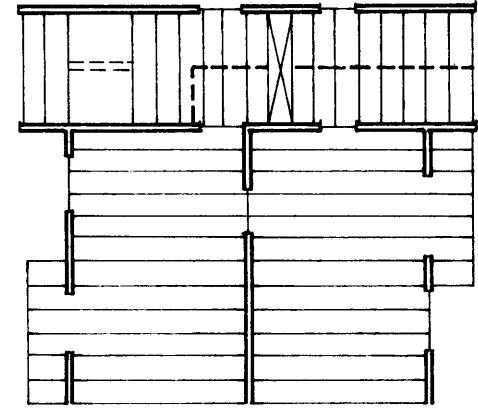
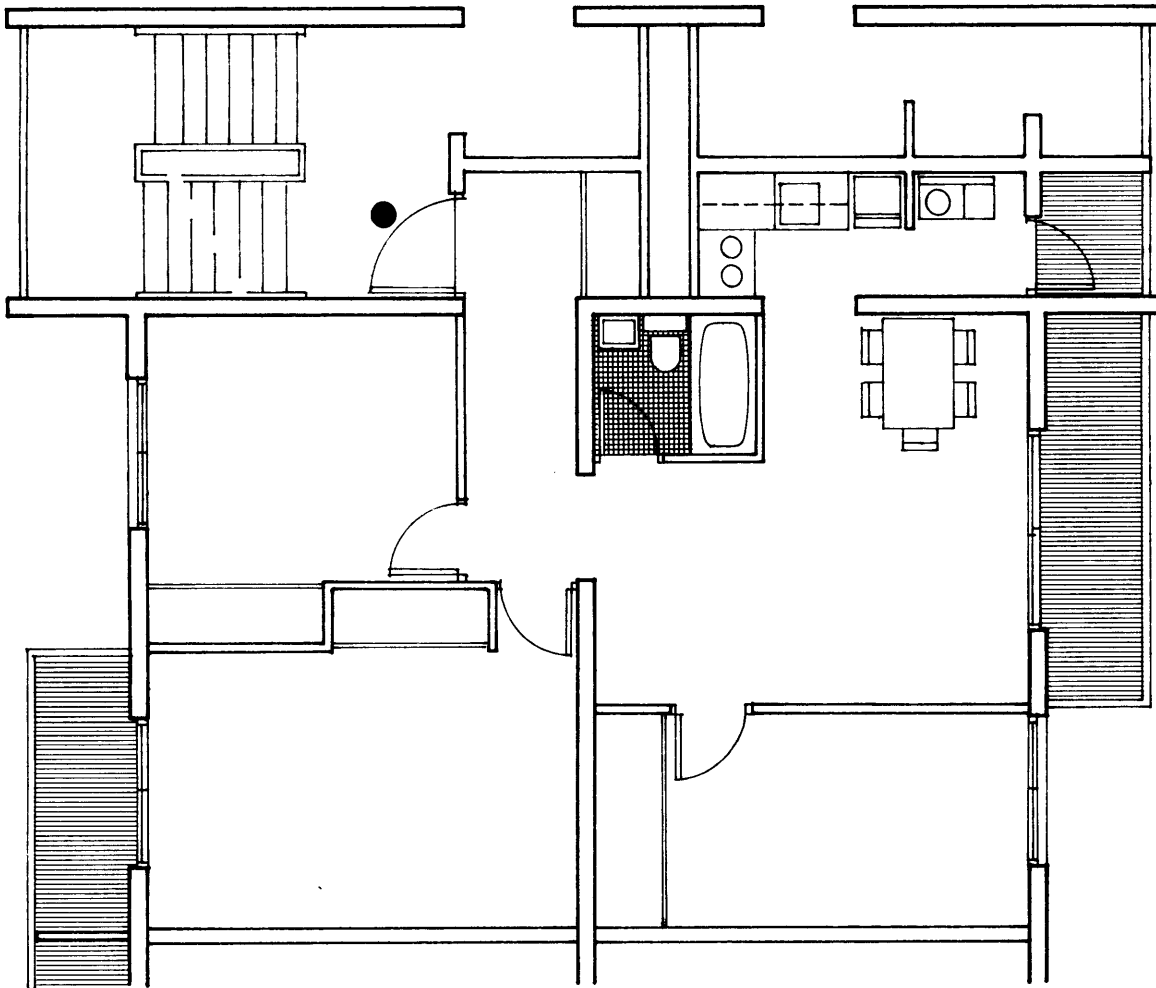
LIVING AREA: 68.85 M<sup>2</sup>

1/2 PORCH: 3.60 M<sup>2</sup>

TOTAL: 72.45 M<sup>2</sup>

SHARING AREA: 6.75 M<sup>2</sup>  
(STAIRCASE)





24

3 BEDROOM UNIT  
(FOR 4-6 PERSONS)

AREA PER. 13.16-19.73  
PERSON' M<sup>2</sup> / PERSON

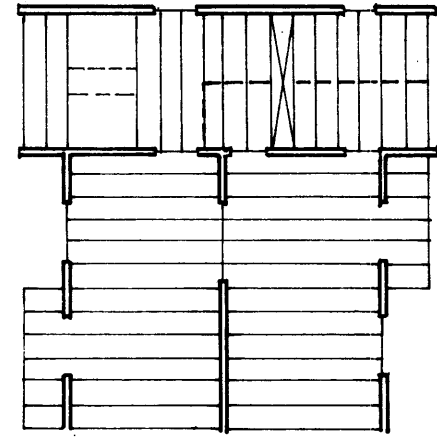
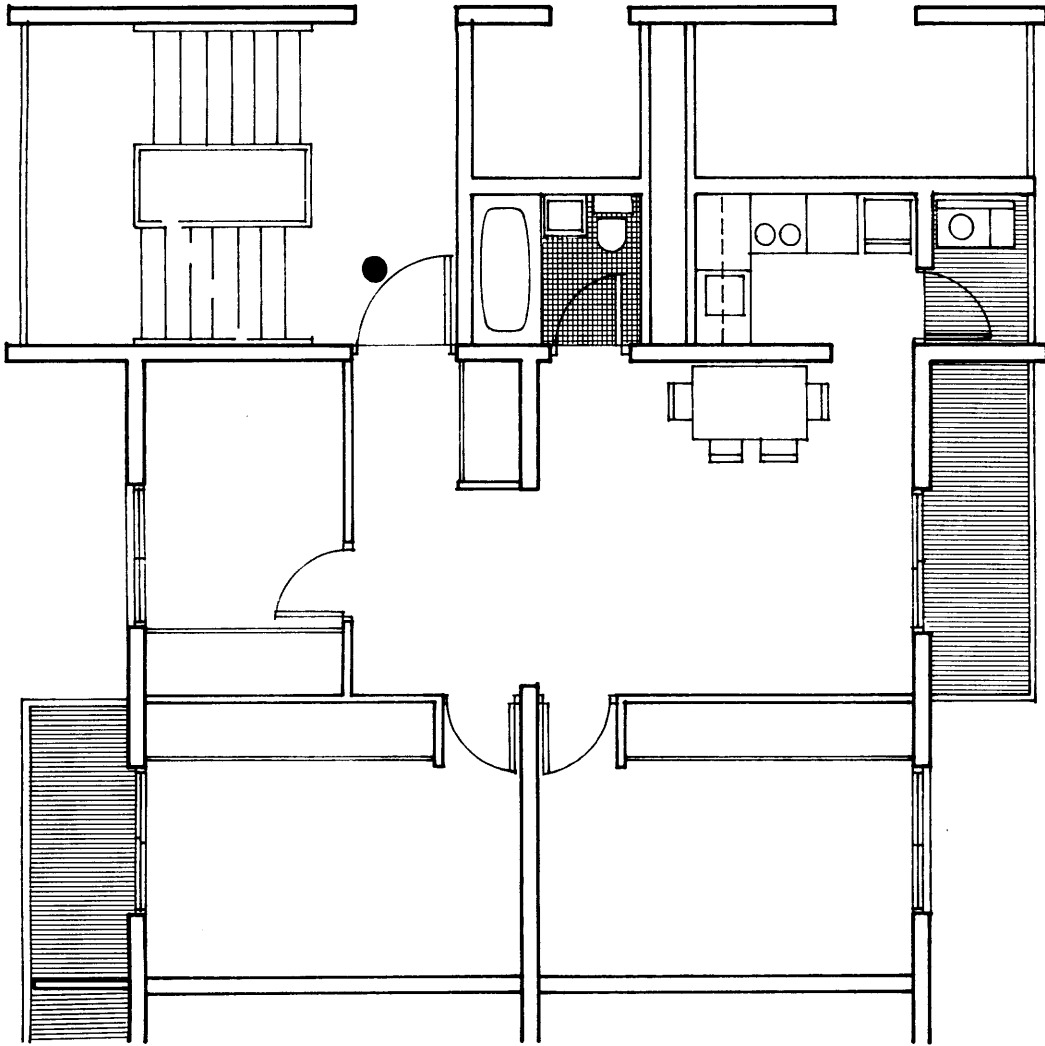
LIVING AREA: 74.61 M<sup>2</sup>

1/2 PORCH: 4.32 M<sup>2</sup>

TOTAL: 78.93 M<sup>2</sup>

SHARING AREA: 6.75 M<sup>2</sup>  
(STAIRCASE)





25

3 BEDROOM UNIT  
(FOR 4-5 PERSONS)

AREA PER. 13.86-17.33  
PERSON' M<sup>2</sup>/PERSON

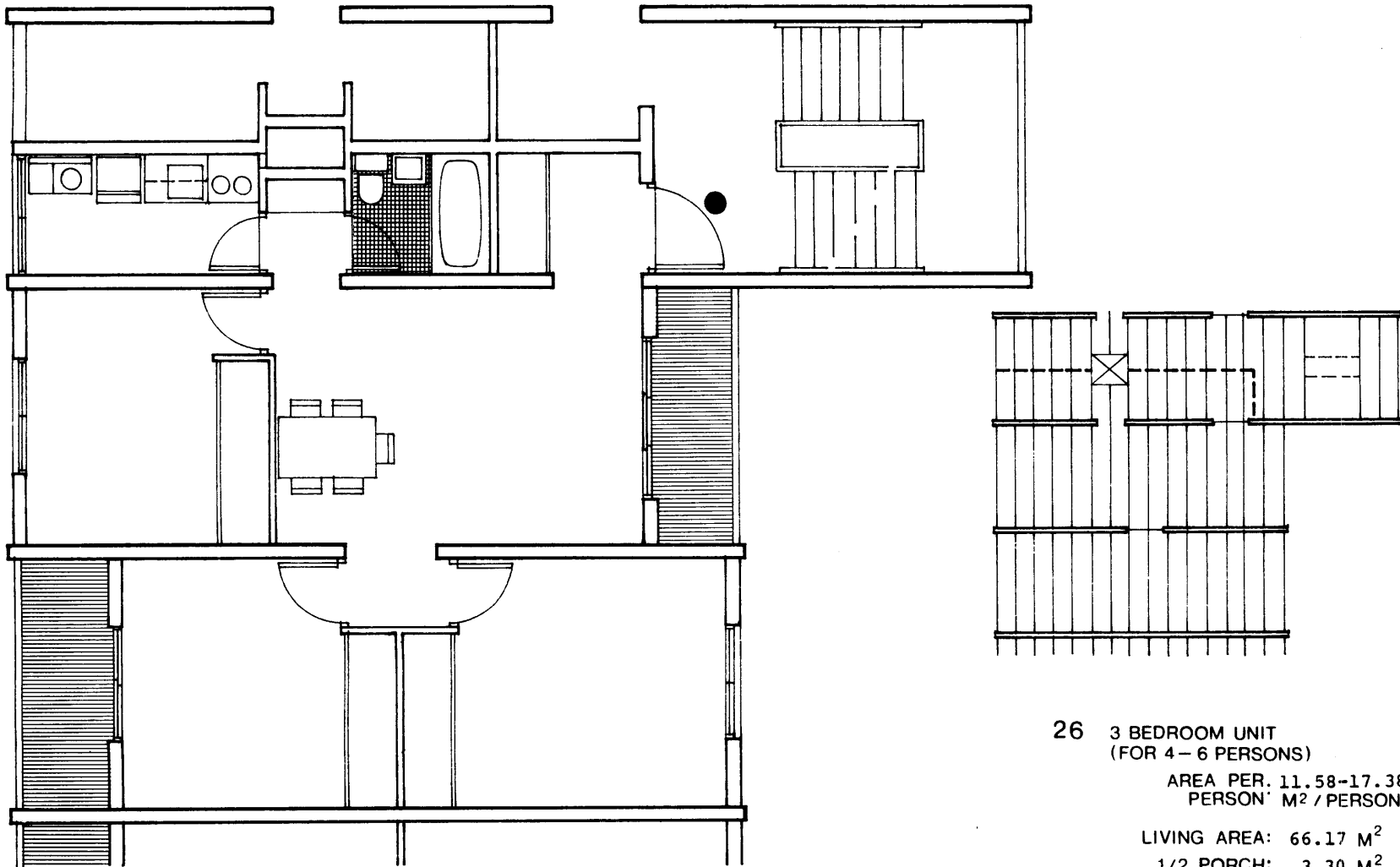
LIVING AREA: 65.34 M<sup>2</sup>

1/2 PORCH: 3.96 M<sup>2</sup>

TOTAL: 69.30 M<sup>2</sup>

SHARING AREA: 7.92 M<sup>2</sup>  
(STAIRCASE)





26 3 BEDROOM UNIT  
(FOR 4-6 PERSONS)

AREA PER. 11.58-17.38  
PERSON' M<sup>2</sup> / PERSON

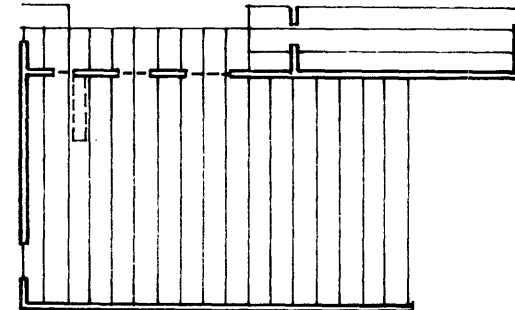
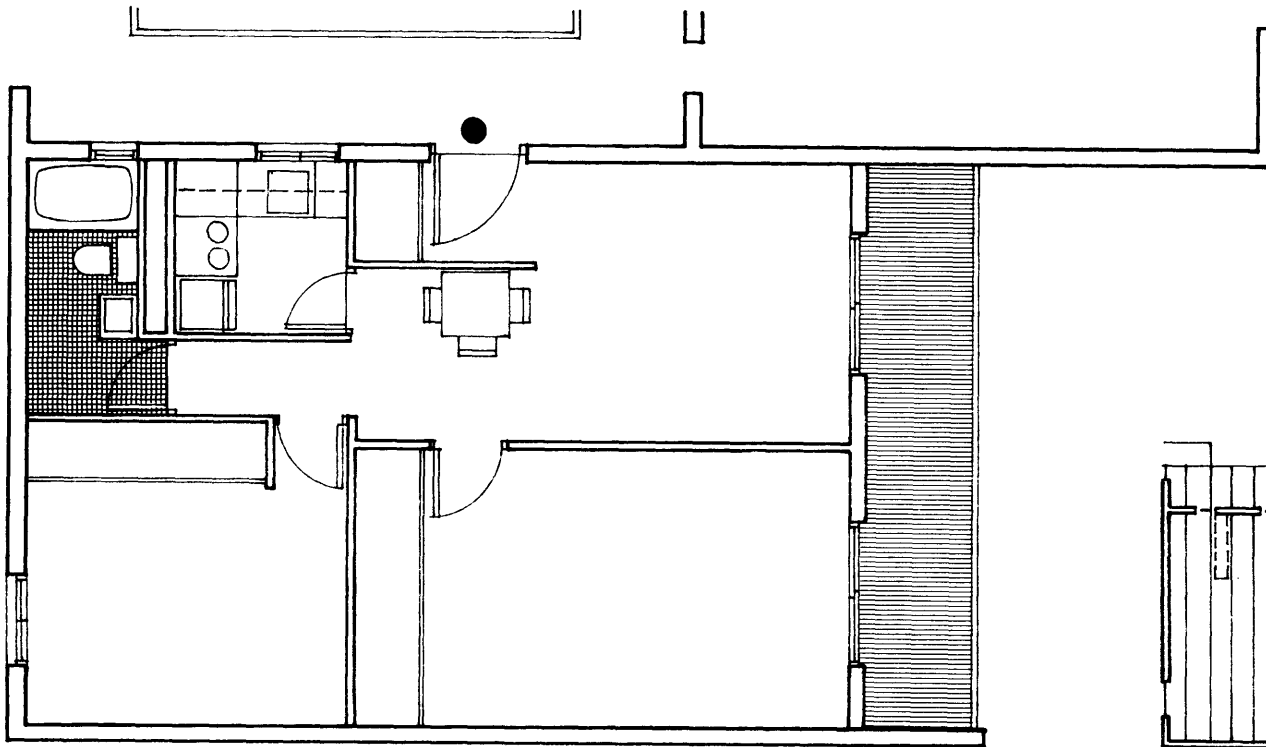
LIVING AREA: 66.17 M<sup>2</sup>

1/2 PORCH: 3.30 M<sup>2</sup>

TOTAL: 69.47 M<sup>2</sup>

SHARING AREA: 7.43 M<sup>2</sup>  
(STAIRCASE)





**27 2 BEDROOM UNIT  
(FOR 4-5 PERSONS)**

AREA PER. 12.96-16.20  
PERSON: M<sup>2</sup>/PERSON

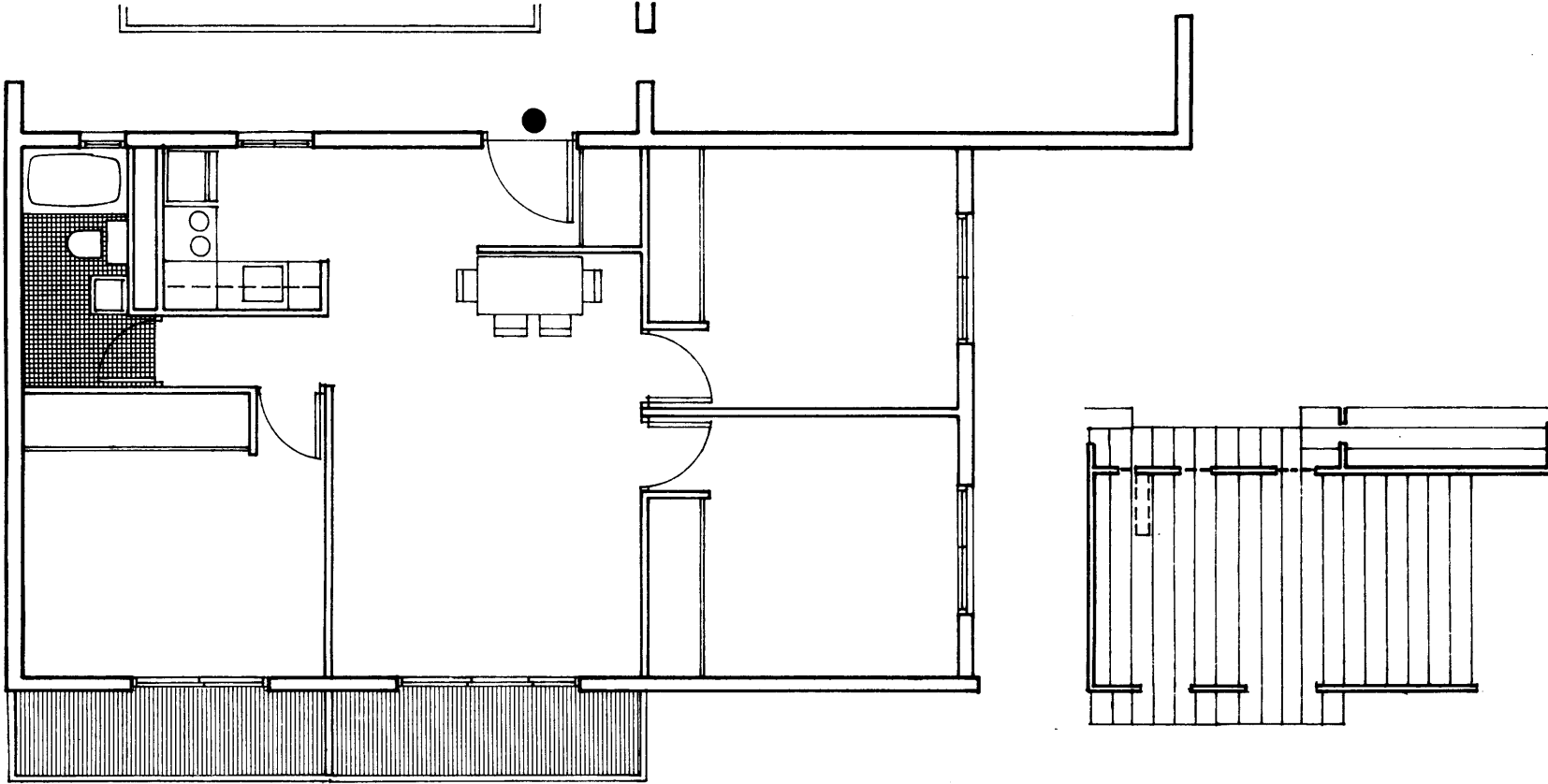
LIVING AREA: 61.20 M<sup>2</sup>

1/2 PORCH: 3.60 M<sup>2</sup>

TOTAL: 64.80 M<sup>2</sup>

SHARING AREA: 7.20 M<sup>2</sup>  
(CORRIDOR)





28 3 BEDROOM UNIT  
(FOR 4-6 PERSONS)

AREA PER. 12.00-18.00  
PERSON M<sup>2</sup>/PERSON

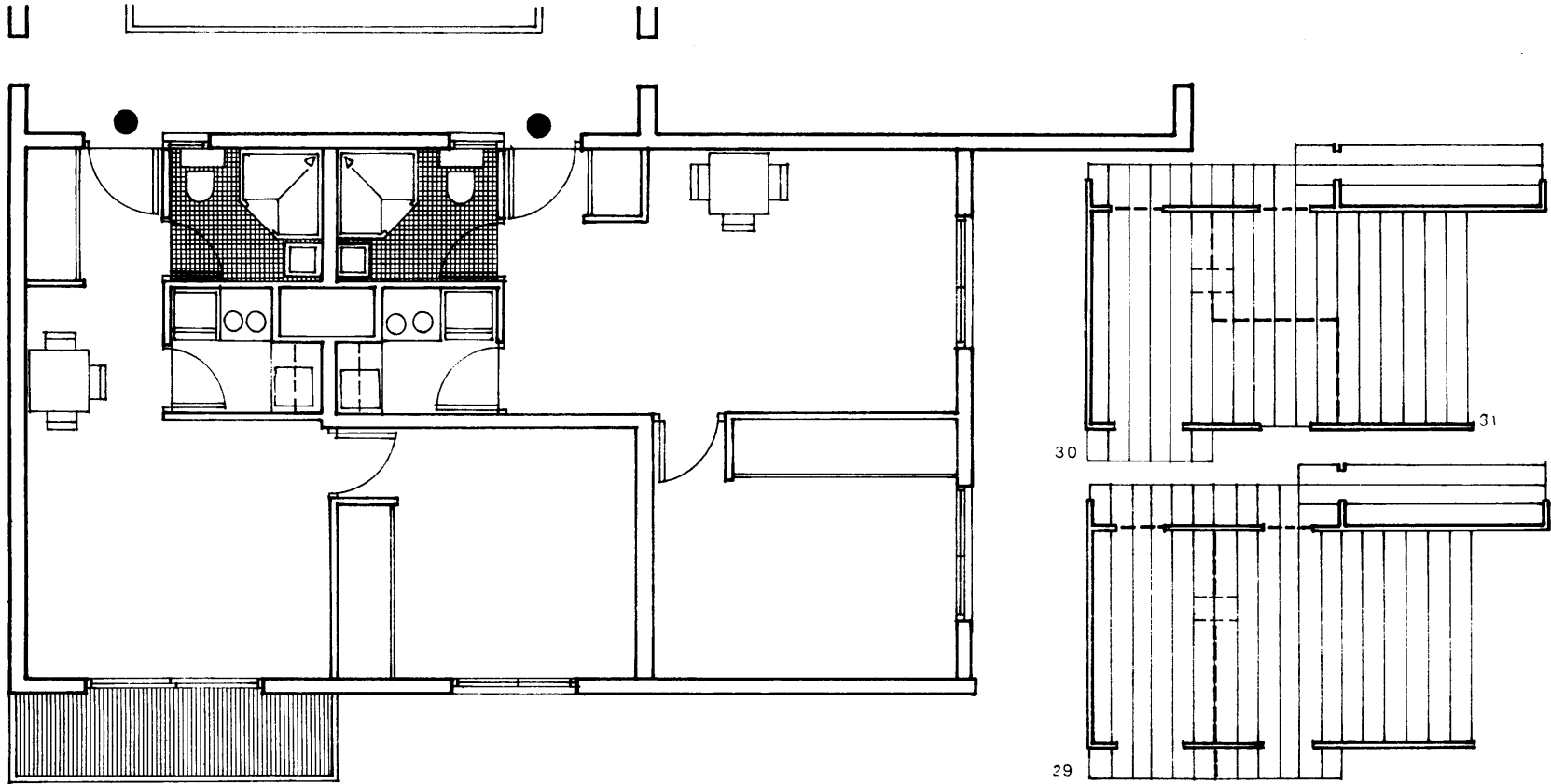
LIVING AREA: 64.80 M<sup>2</sup>

1/2 PORCH: 7.20 M<sup>2</sup>

TOTAL: 72.00 M<sup>2</sup>

SHARING AREA: 7.20 M<sup>2</sup>  
(CORRIDOR)



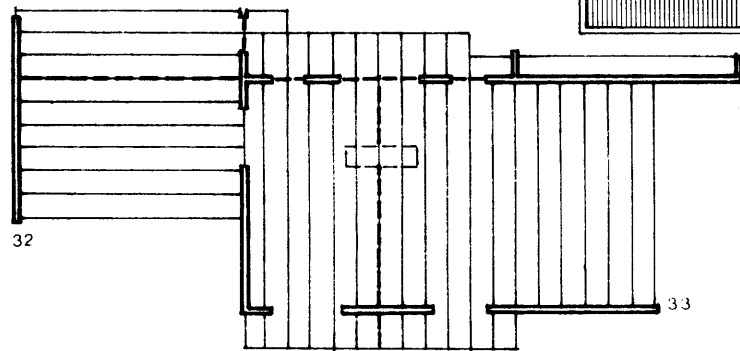
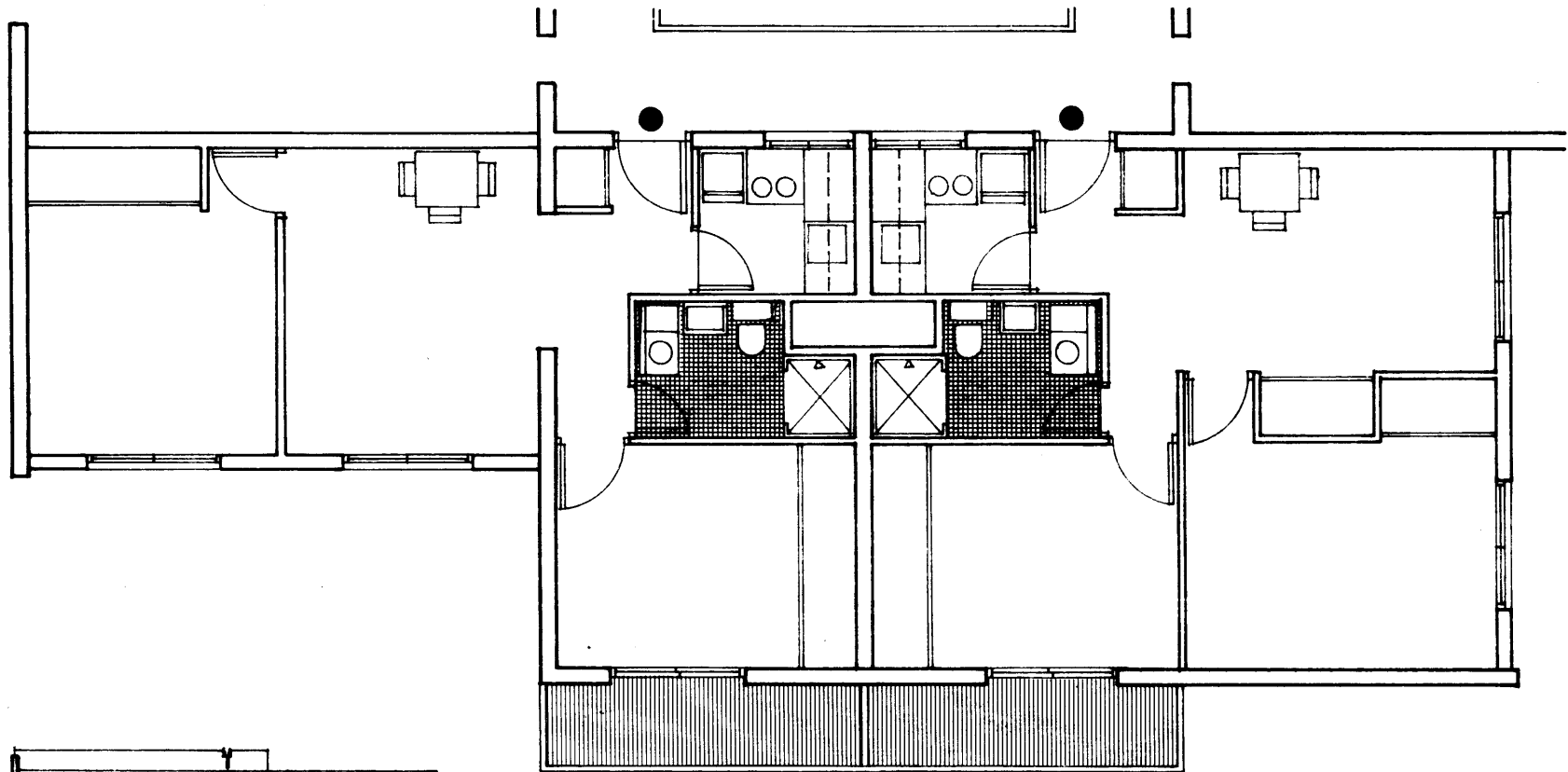


**29** EFFICIENCY UNIT  
 (FOR 2 PERSONS)  
 AREA PER. 11.70  
 PERSON M<sup>2</sup>/PERSON  
 LIVING AREA: 21.60 M<sup>2</sup>  
 1/2 PORCH: 1.80 M<sup>2</sup>  
 TOTAL: 23.40 M<sup>2</sup>  
 SHARING AREA: 3.60 M<sup>2</sup>  
 (CORRIDOR)

**30** 1 BEDROOM UNIT  
 (FOR 2-3 PERSONS)  
 AREA PER. 11.40-17.10  
 PERSON M<sup>2</sup>/PERSON  
 LIVING AREA: 32.40 M<sup>2</sup>  
 1/2 PORCH: 1.80 M<sup>2</sup>  
 TOTAL: 34.20 M<sup>2</sup>  
 SHARING AREA: 3.60 M<sup>2</sup>  
 (CORRIDOR)

**31** 1 BEDROOM UNIT  
 (FOR 2-3 PERSONS)  
 AREA PER. 10.80-16.20  
 PERSON M<sup>2</sup>/PERSON  
 LIVING AREA: 32.40 M<sup>2</sup>  
 1/2 PORCH: M<sup>2</sup>  
 TOTAL: 32.40 M<sup>2</sup>  
 SHARING AREA: 3.60 M<sup>2</sup>  
 (CORRIDOR)





32 • 33 2 BEDROOM UNIT  
(FOR 3-4 PERSONS)

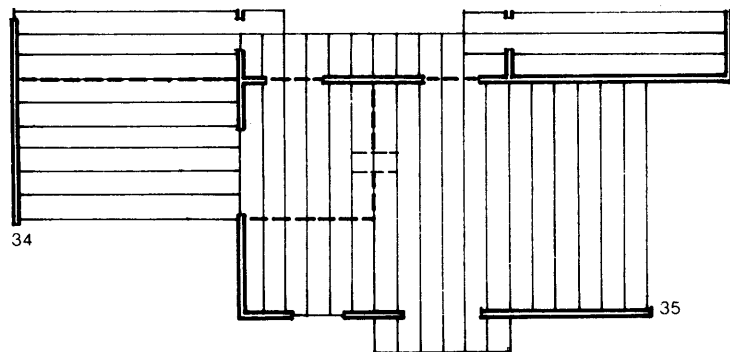
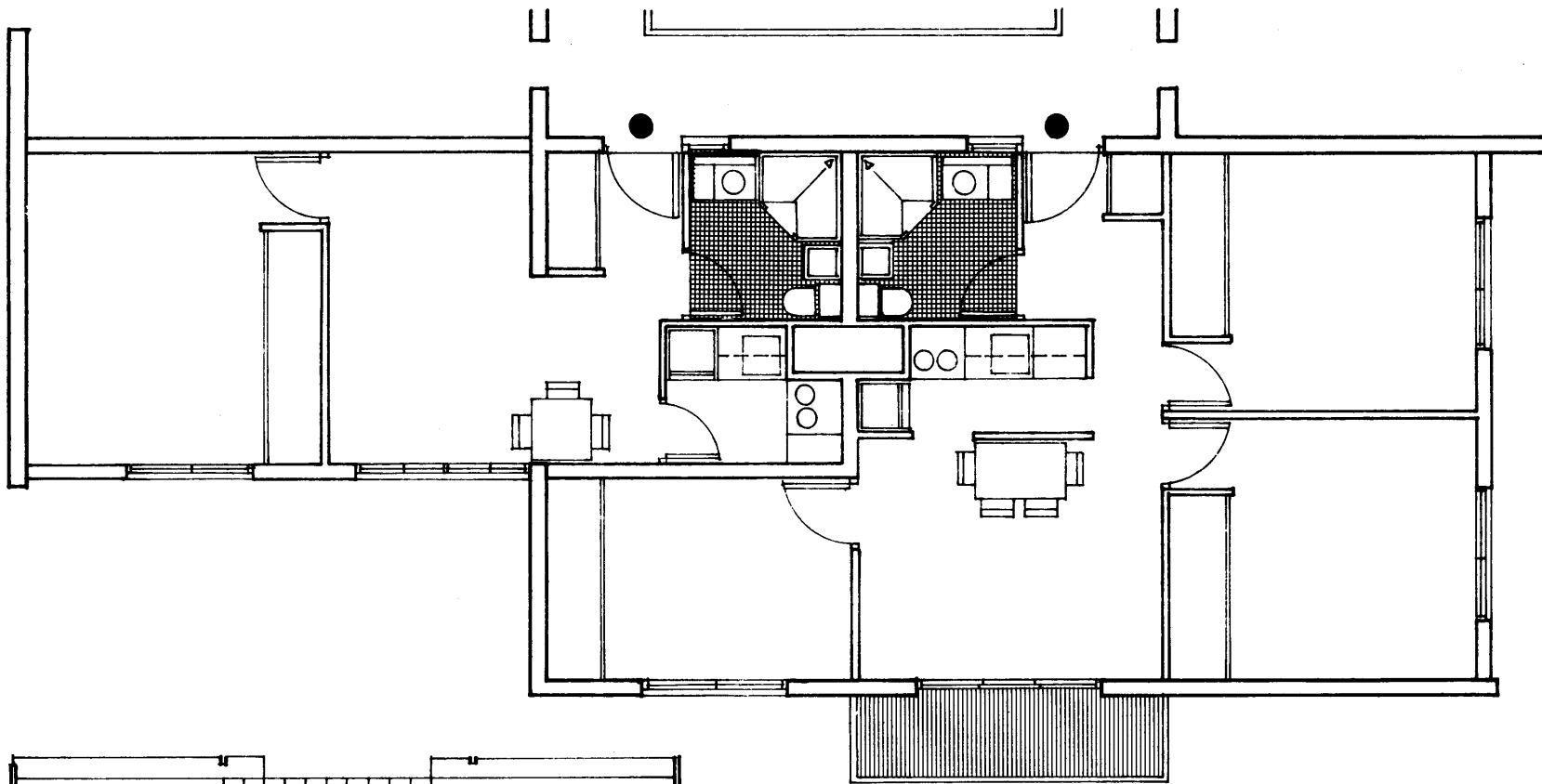
AREA PER. 11.25-15.00  
PERSON: M<sup>2</sup>/PERSON

LIVING AREA: 43.20 M<sup>2</sup>

1/2 PORCH: 1.80 M<sup>2</sup>

TOTAL: 45.00 M<sup>2</sup>

SHARING AREA: 3.60 M<sup>2</sup>  
(CORRIDOR)



**34** 1 BEDROOM UNIT  
(FOR 2-3 PERSONS)

AREA PER. 11.25-17.28  
PERSON: M<sup>2</sup>/PERSON

LIVING AREA: 34.56 M<sup>2</sup>  
1/2 PORCH: M<sup>2</sup>  
TOTAL: 34.56 M<sup>2</sup>

SHARING AREA: 3.60 M<sup>2</sup>  
(CORRIDOR)

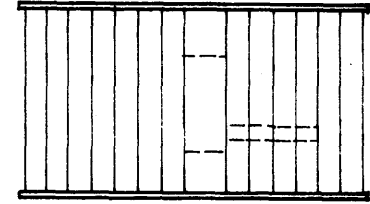
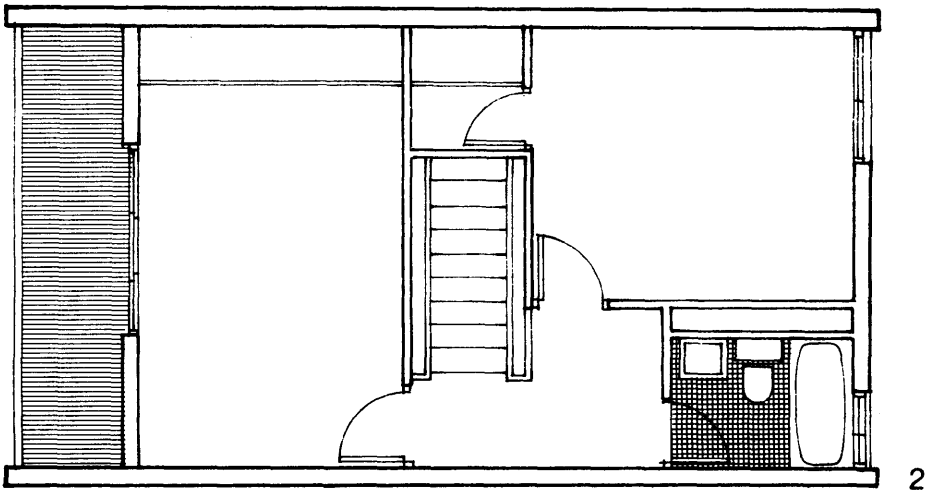
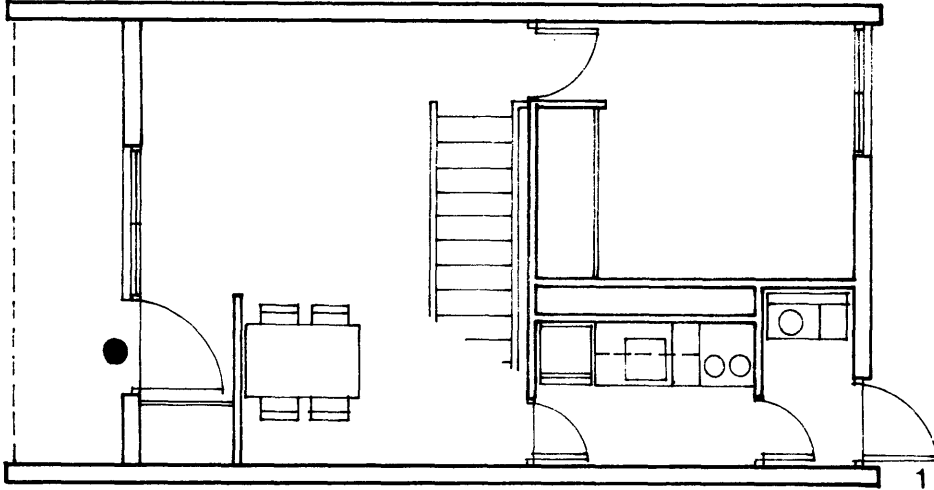
**35** 3 BEDROOM UNIT  
(FOR 4-5 PERSONS)

AREA PER. 10.37-12.96  
PERSON: M<sup>2</sup>/PERSON

LIVING AREA: 51.84 M<sup>2</sup>  
1/2 PORCH: 1.80 M<sup>2</sup>  
TOTAL: 53.64 M<sup>2</sup>

SHARING AREA: 3.60 M<sup>2</sup>  
(CORRIDOR)





36

3 BEDROOM UNIT  
(FOR 4-6 PERSONS)

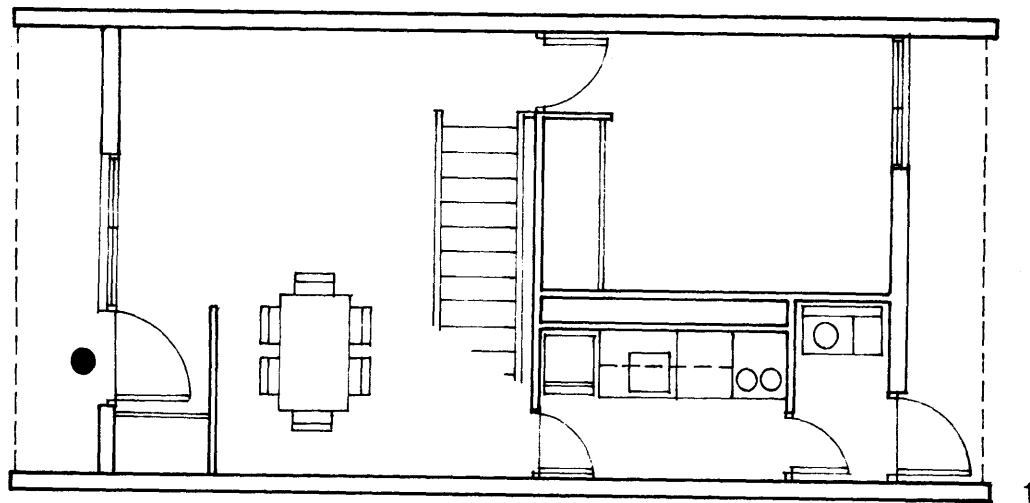
AREA PER. 12.96-19.44  
PERSON' M<sup>2</sup> / PERSON

LIVING AREA: 74.88 M<sup>2</sup>

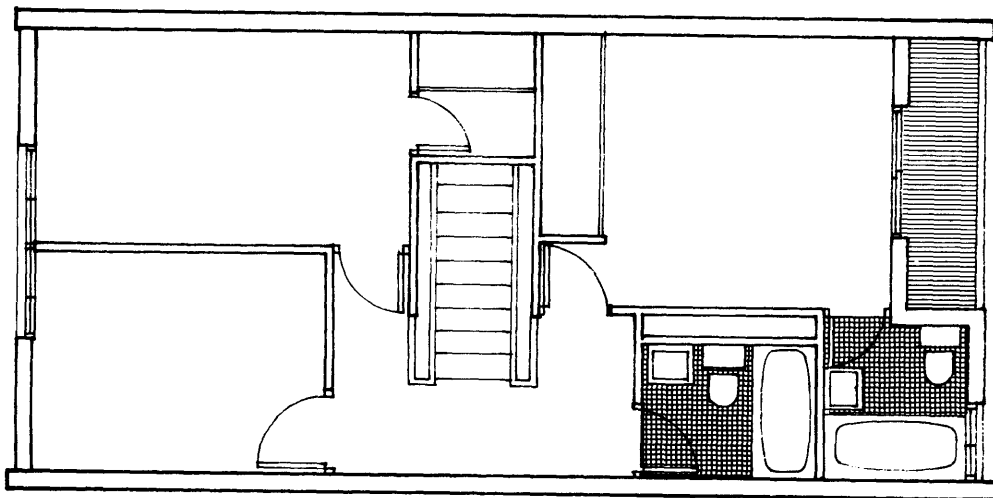
1/2 PORCH: 2.88 M<sup>2</sup>

TOTAL: 77.76 M<sup>2</sup>

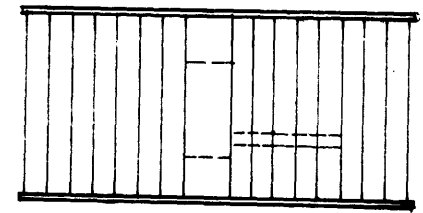




1



2



37

4 BEDROOM UNIT  
(FOR 5-7 PERSONS)

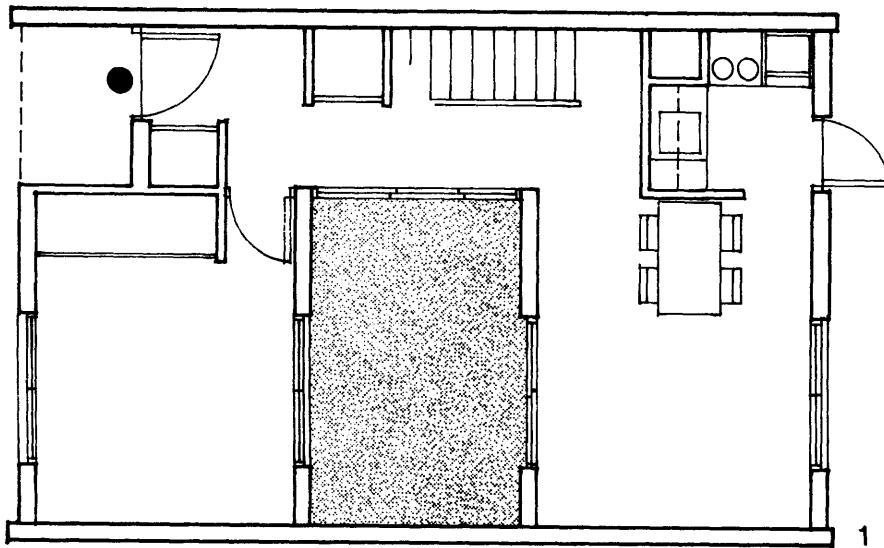
AREA PER. 12.54-17.56  
PERSON M<sup>2</sup> / PERSON

LIVING AREA: 86.28 M<sup>2</sup>

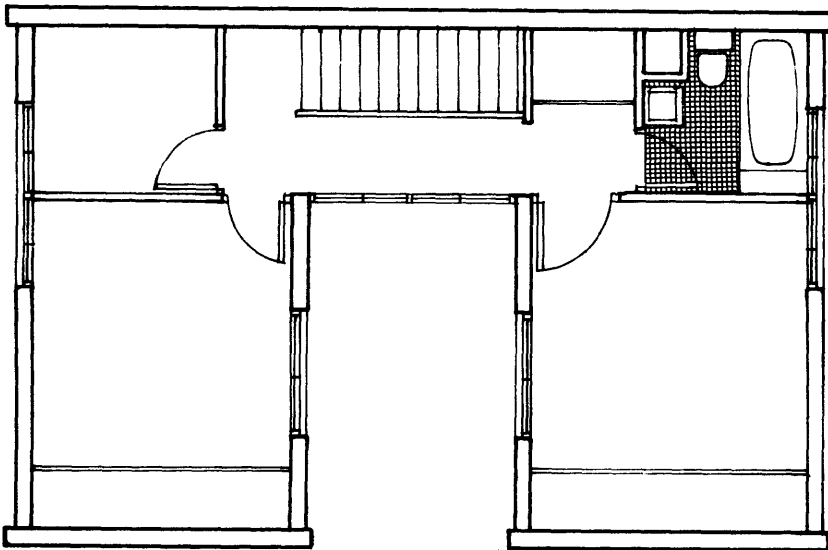
1/2 PORCH: 1.50 M<sup>2</sup>

TOTAL: 87.78 M<sup>2</sup>

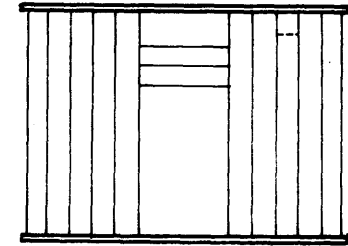




1



2



38

3 BEDROOM UNIT  
(FOR 5 - 6 PERSONS)

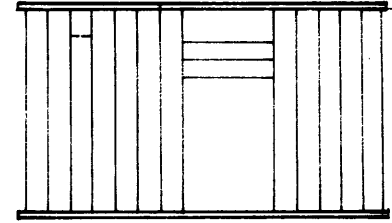
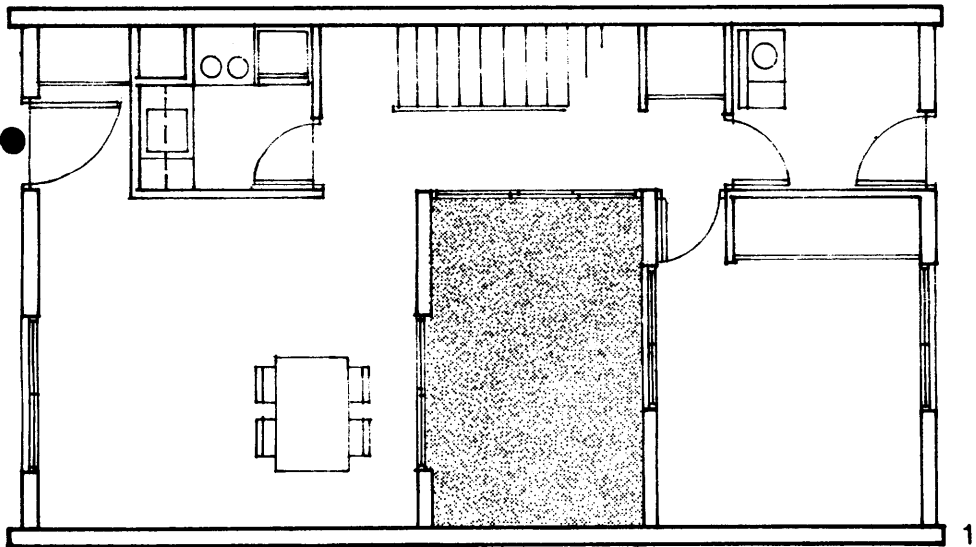
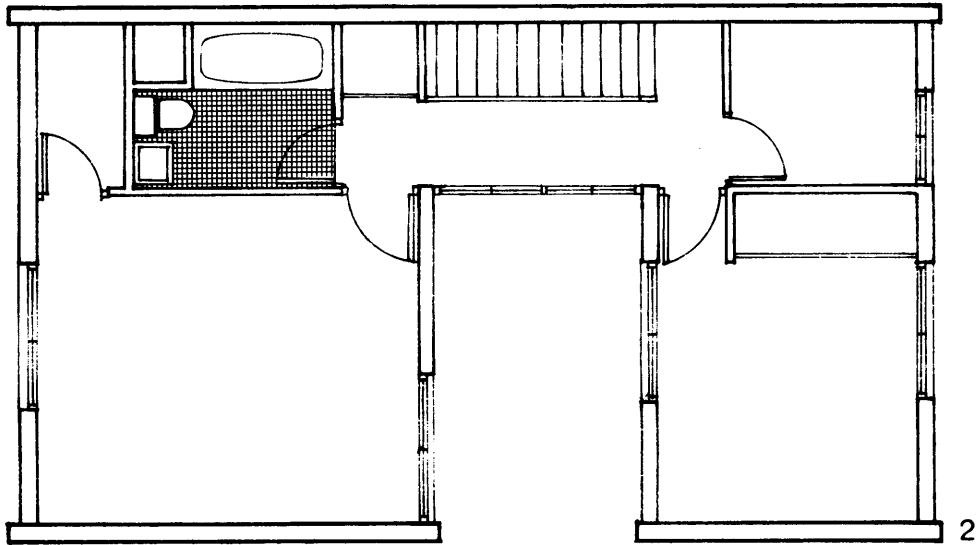
AREA PER. 14.28-17.14  
PERSON M<sup>2</sup> / PERSON

LIVING AREA: 81.36 M<sup>2</sup>

1/2 PATIO : 4.32 M<sup>2</sup>

TOTAL: 85.68 M<sup>2</sup>





39

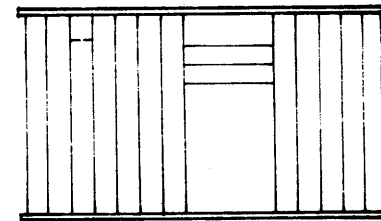
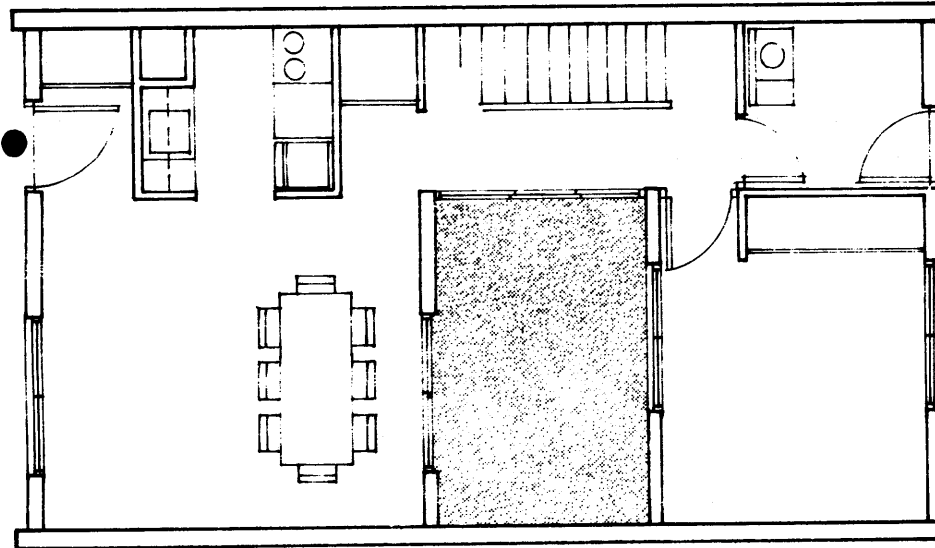
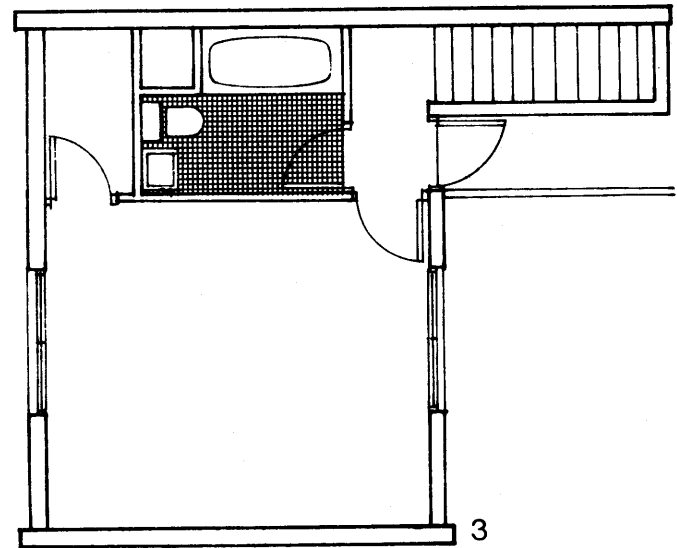
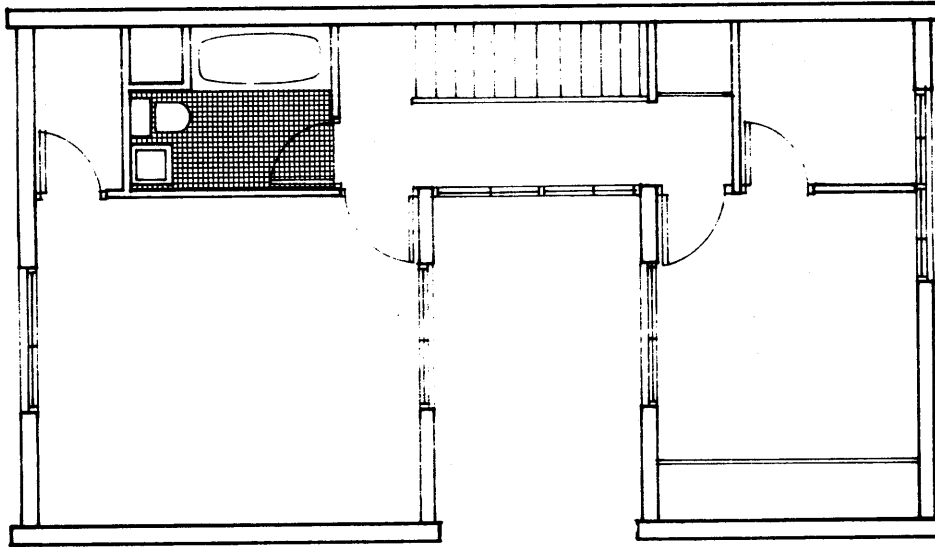
3 BEDROOM UNIT  
(FOR 5 - 7 PERSONS)

AREA PER. 12.96-18.14  
PERSON' M<sup>2</sup> / PERSON

LIVING AREA: 86.40 M<sup>2</sup>

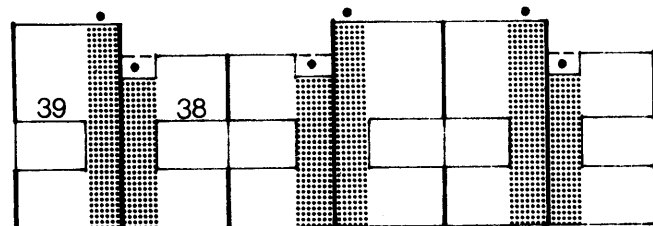
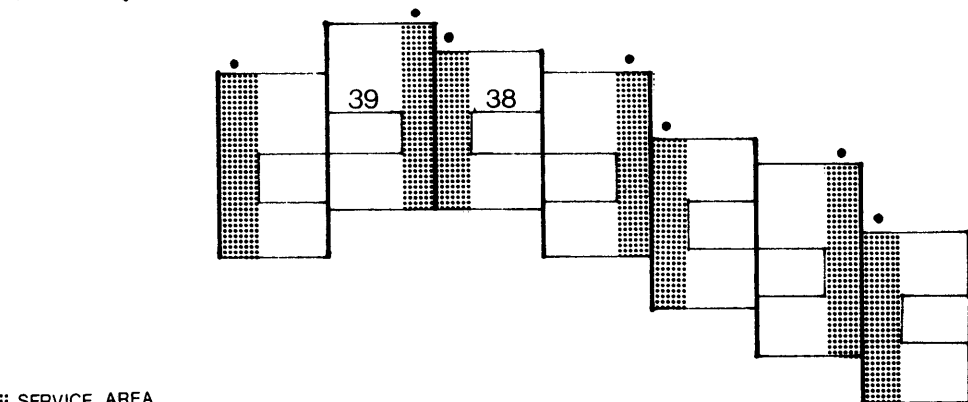
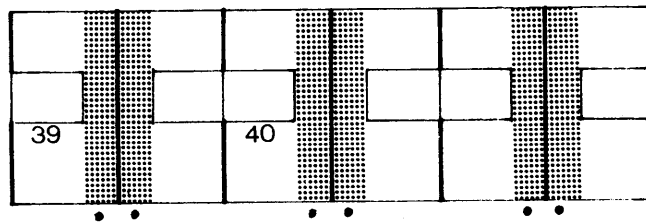
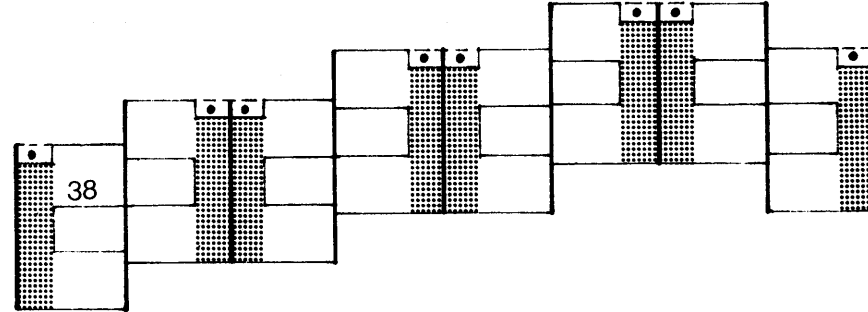
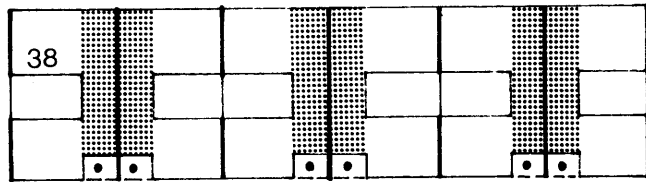
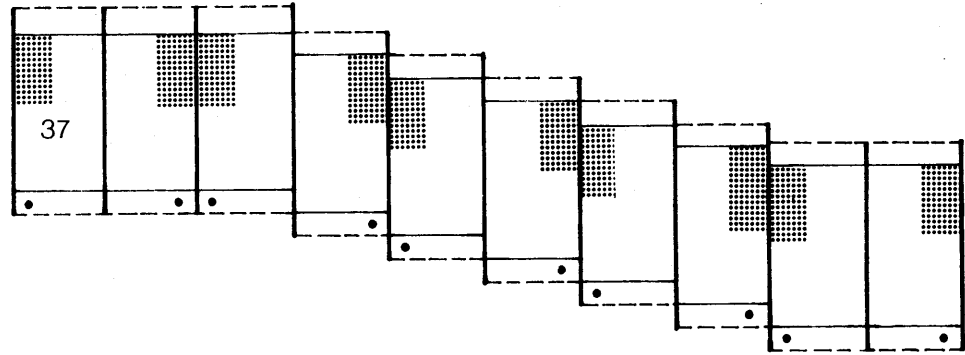
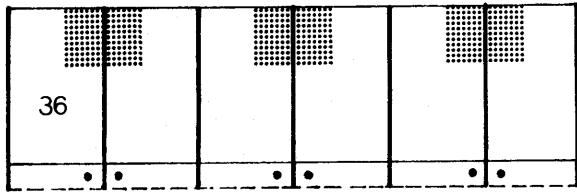
1/2 PATIO : 4.32 M<sup>2</sup>

TOTAL: 90.72 M<sup>2</sup>



40  
 4 BEDROOM UNIT  
 (FOR 8-10 PERSONS)  
 AREA PER. 12.07-15.09  
 PERSON' M<sup>2</sup> / PERSON  
 LIVING AREA: 116.40 M<sup>2</sup>  
 1/2 PATIO : 4.32 M<sup>2</sup>  
 TOTAL: 120.72 M<sup>2</sup>

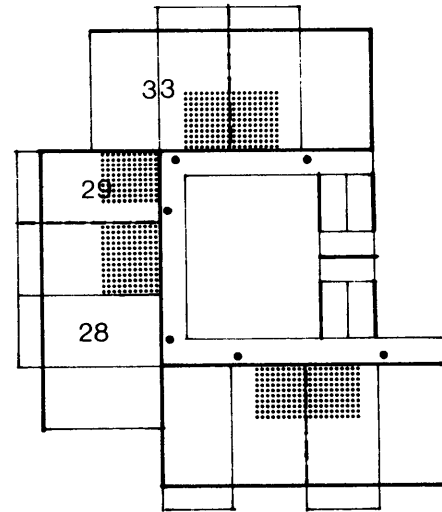
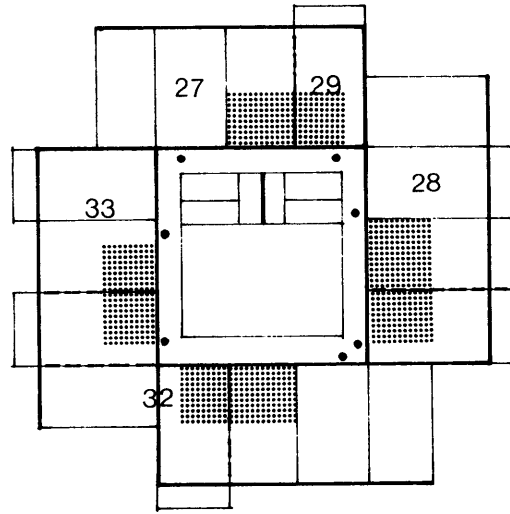
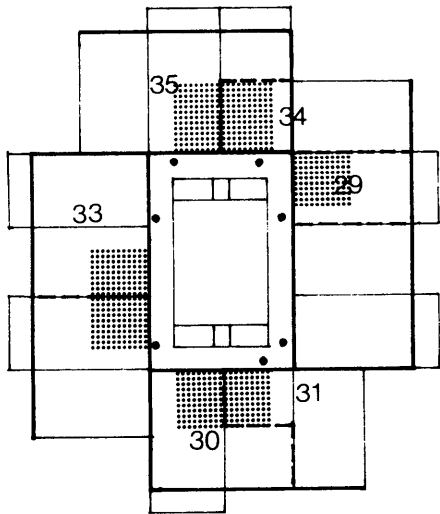
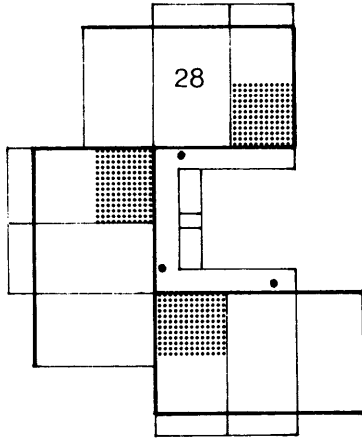
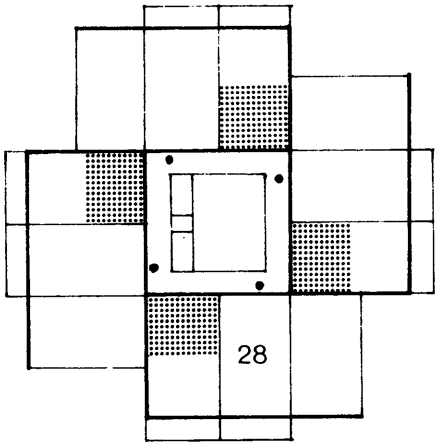




■■■■ SERVICE AREA

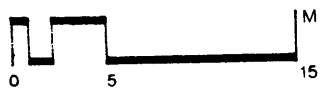
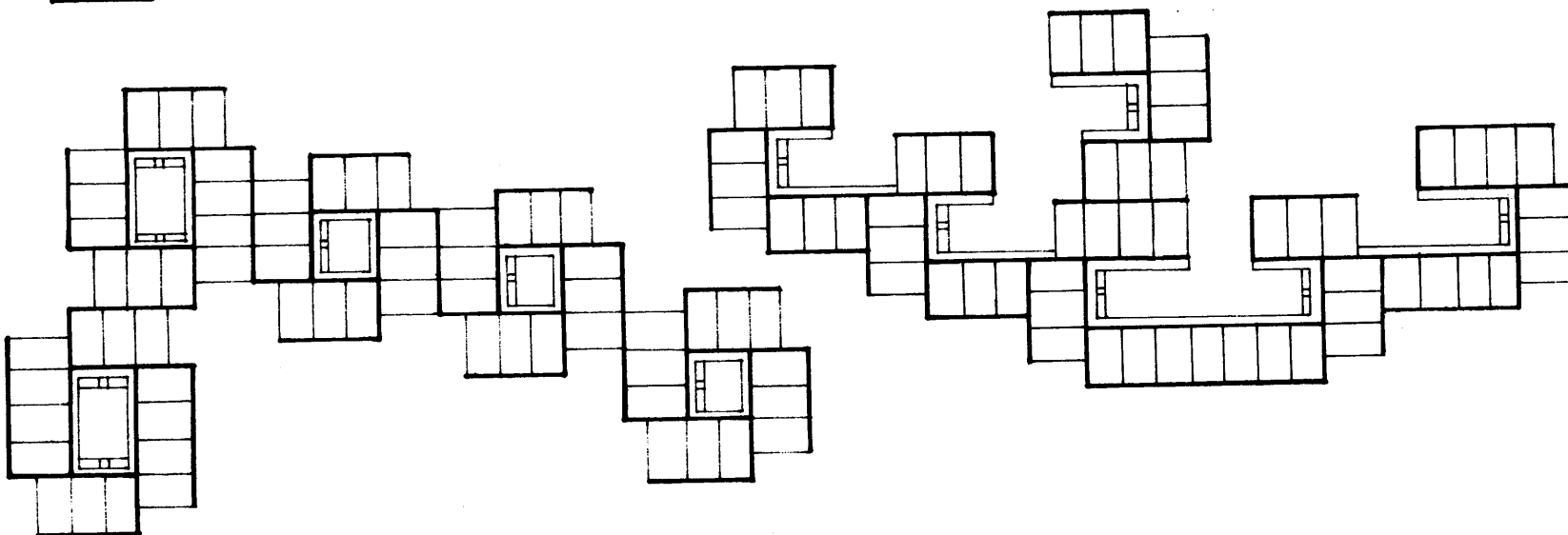
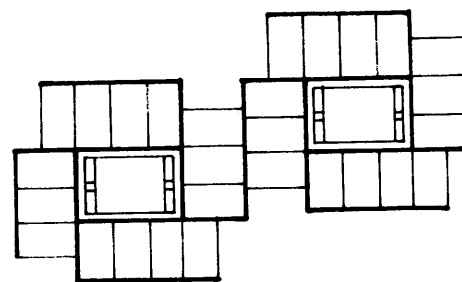
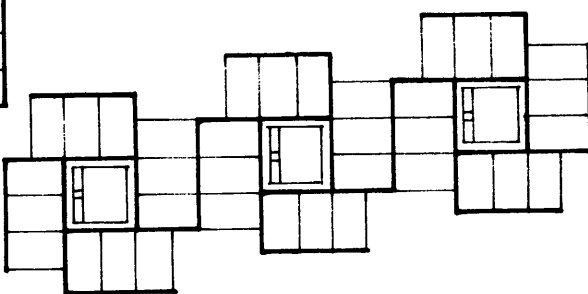
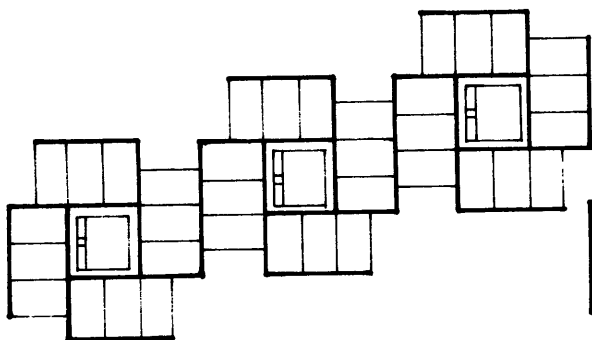
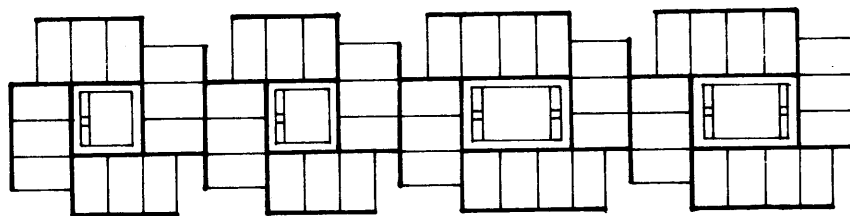
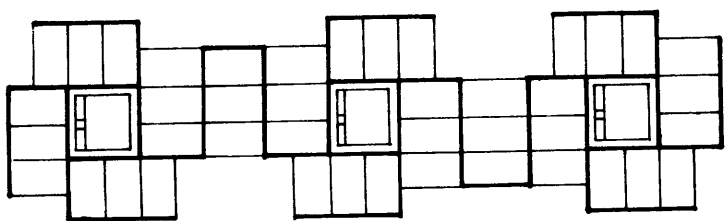


# UNIT GROUPING



▣▣▣▣ SERVICE AREA





The main advantages of the housing system proposed above are:

1. It utilizes existing construction equipment, materials and technology.
2. The construction of the bearing wall takes less time than the present method. Hence, quite some time can be saved in the construction of the bearing wall in flooring construction.
2. The construction of the bearing wall takes less time than the present method. Hence, quite some time can be saved in terms of formwork erection in flooring construction.
3. It can satisfy the present demand in public housing for various building types, and it is also suited to sloped sites. The height is limited to five floors and below (or six floors, with the top floor being a duplex unit), which is the highest the building code allows with the absence of elevators.
4. In terms of the coordination of structural modules and design modules, it is conducive to the development of the open system.
5. Under changing conditions in the future, the proposed housing system has the potential to develop into a factory-fabricated, predominantly pre-casting housing system.

With regards to the concept of production, this thesis maintains that housing industrialization is a variable; it should vary according to the amount of investment, labor supply, background conditions of housing industry and demand for housing.

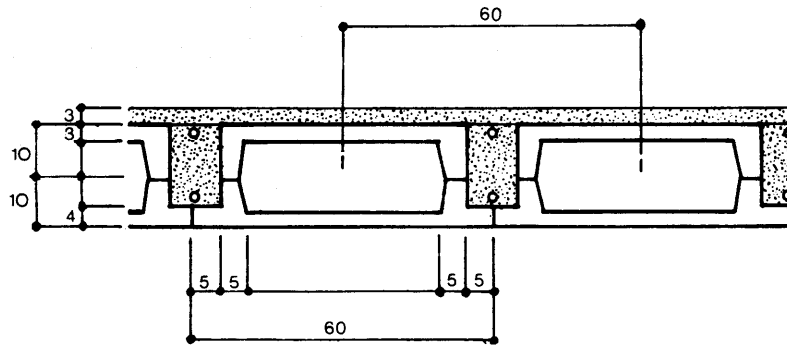
The following aspects need further study and development:

1. Design of construction and connection methods of other light-weight components. In terms of future development, this type of components should

## REVIEW AND RECOMMENDATION

evolve into large-scale components suitable for assembly at the factory.

2. Connection design for earthquake resistance.
3. Building codes should be revised and updated according to housing industrialization production.
4. Analysis of building costs and demand in building materials.
5. Further analysis should be made of housing demand, as well as long-term planning and development.



#### REINFORCEMENT IN RIB:

##### I. Load:

weight of prefabricated panels,

$$(213+253) \times 0.24 = 111.8 \text{ kg/cm}$$

weight of added concrete of topping and rib,

$$(60 \times 3 + 16 \times 10) \times 0.24 = 81.6 \text{ kg/cm}$$

total weight of concrete floor  $111.8 + 81.6 = 193.4 \text{ kg/cm}$

finish  $72 \times 0.6 = 43.2 \text{ kg/cm}$

partition  $72 \times 0.6 = 43.2 \text{ kg/cm}$

---

total dead load  $279.8 \text{ kg/cm}$

live load  $200 \times 0.6 = 120.0 \text{ kg/cm}$

---

total load  $\div 400.0 \text{ kg/cm}$

#### CALCULATION OF FLOOR SYSTEM

##### II. Maximum Moment:

if span = 3m

partial restraints at supports is,

$$M_{\max} = \frac{wl^2}{10} = \frac{400(3.0)^2}{10} = 360.0 \text{ kg-m}$$

##### III. Reinforcement:

design depth,  $d = 15 \text{ cm}$

$$A_s = \frac{M}{0.866d \cdot f_s} = \frac{360 \times 100}{0.866 \times 15 \times 1400}$$

$$= 1.98 \text{ cm}^2$$

##### IV. Shear stress:

$$V_{\max} = 400 \times 3 \times 0.5 = 600 \text{ kg}$$

$$\text{shear stress} = \frac{V}{b \cdot d} = \frac{600}{10 \times 15} = 4.0 \text{ kg/cm}^2$$

use 1 - #5 as tensile steel,  
1 - #3 as bond steel.

#### REINFORCEMENT IN PANEL:

Stage I.- 3cm bulb slab of panel under own weight and weight of 3cm fresh concrete.

## APPENDIX

I. Load:

3cm precast panel	3x24 = 72 kg/cm
3cm poured concrete	3x24 = 72 kg/cm
construction load	50 kg/cm
total load	<hr/> 194 kg/cm

II. Maximum Moment:

$$M_{\max}^1 = \frac{wl^2}{10} = 3.6 \text{ kg-m} = 360 \text{ kg-cm}$$

III. Reinforcement:

design depth,  $d = 1.5 \text{ cm}$

$$A_s^1 = \frac{M}{0.866d \cdot f_s} = \frac{360}{0.866 \times 1.5 \times 1400} = 0.2 \text{ cm}^2$$

Stage II. - Additional load to 194 kg/cm of stage I.

I. Load:

2 times of normal live load	400 kg/cm
partition	42 kg/cm
finish	42 kg/cm
total load	<hr/> 484 kg/cm

II. Maximum Moment

$$M_{\max}^2 = \frac{434 \times 43^2}{10} = 800 \text{ kg-cm}$$

III. Reinforcement

design depth,  $d = 4.5 \text{ cm}$

$$A_s^2 = \frac{800}{0.866 \times 4.5 \times 1400} = 0.15 \text{ cm}^2$$

from the above,

$$A_s^1 + A_s^2 = 0.2 + 0.15 = 0.35 \text{ cm}^2$$

since minimum reinforcement of concrete should not less than 3% of the area of concrete, ie,

$$A_c = 100 \times 3 = 300 \text{ cm}^2$$

$$A_s^{\min} = 300 \times 0.03 = 0.9 \text{ cm}^2$$

chose  $A_s = 0.9 \text{ cm}^2$

use welded-wire fabric #66-00

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