ARCHITECTURE DEPARTMENT CHINESE UNIVERSITY OF HONG KONG

MASTER OF ARCHITECTURE PROGRAMME 2002-2003 DESIGN REPORT

TECTONICS IN BOXBUILDING

___HOUSING FOR TEMPORARY POPULATION IN SHENZHEN

ZHU Wen Jian May 2003

Tectonics in Box Building

__ Housing for Temporary Population in Shen Zhen

Zhu Wen Jian

To my parents, Zhu Shunrong and Li Xiulan.

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1. Acknowledgements

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2. **Preface**

In the Master's programme at the Department of Architecture, the Chinese University of Hong Kong, the last year is thesis programme.
My thesis "Tectonics in Box Building" is a design based on the research. How to find tectonics issues and how to solve them in my design?
This book documents the entire process from study , exploration to design.

3. Introduction

Possibly the history of industrilization of building can go well back to the first pan of the nineteenth century and considerable sucesses were registered in the second pan of the same century. It feel that the birth-date of industrialization of building can be taken as 1851with the construction of the Crystal Palace.

Possibly from the beginning of the nineteenth century up to the twenties all efforts were devoted to technological innovations. The possibilities of cast-iron and of reinforced concrete, and the introduction of the power-machine, were utilized with very satisfactory results. From the thirties to the fifties (and in some cases even today) the main efforts of thinkers, architects and some misguided industrialists were devoted to the modular-discipline.

These people thought that with a well-developed dimensional coordination most problems of industrialization would be solved, wastages avoided and productivity increased. Sometime towards the middle of this period the "joint craze" developed. The ambition of every student of industrialization was to discover "the joint", possibly "the universal joint". in the late sixties, which, offering a reliable joining technique, minimized the problem.

In parallel with the two above-mentioned "facts" we witnessed the strenuous fight between partisans of the "modular systems" - be they "light" or "heavy" - and the partisans of "model" industrialization.

The simplest example of a modular system is the toy called "meccano". Here a set of predesigned pans can be assembled following certain basic dimensional rules to obtain an infinite variety of products. In practice in the building trade the designers of the components will always have to start by establishing certain hypothesis of forms and dimensions, but not withstanding this, it has been demonstrated that with a suitable "catalogue" of components, considerable design flexibility can be achieved. Should a dimensional discipline be accepted in a given country or between several organizations and a predefined jointing technique be added, we would create a more sophisticated form of modular system which is defined as "componenting".

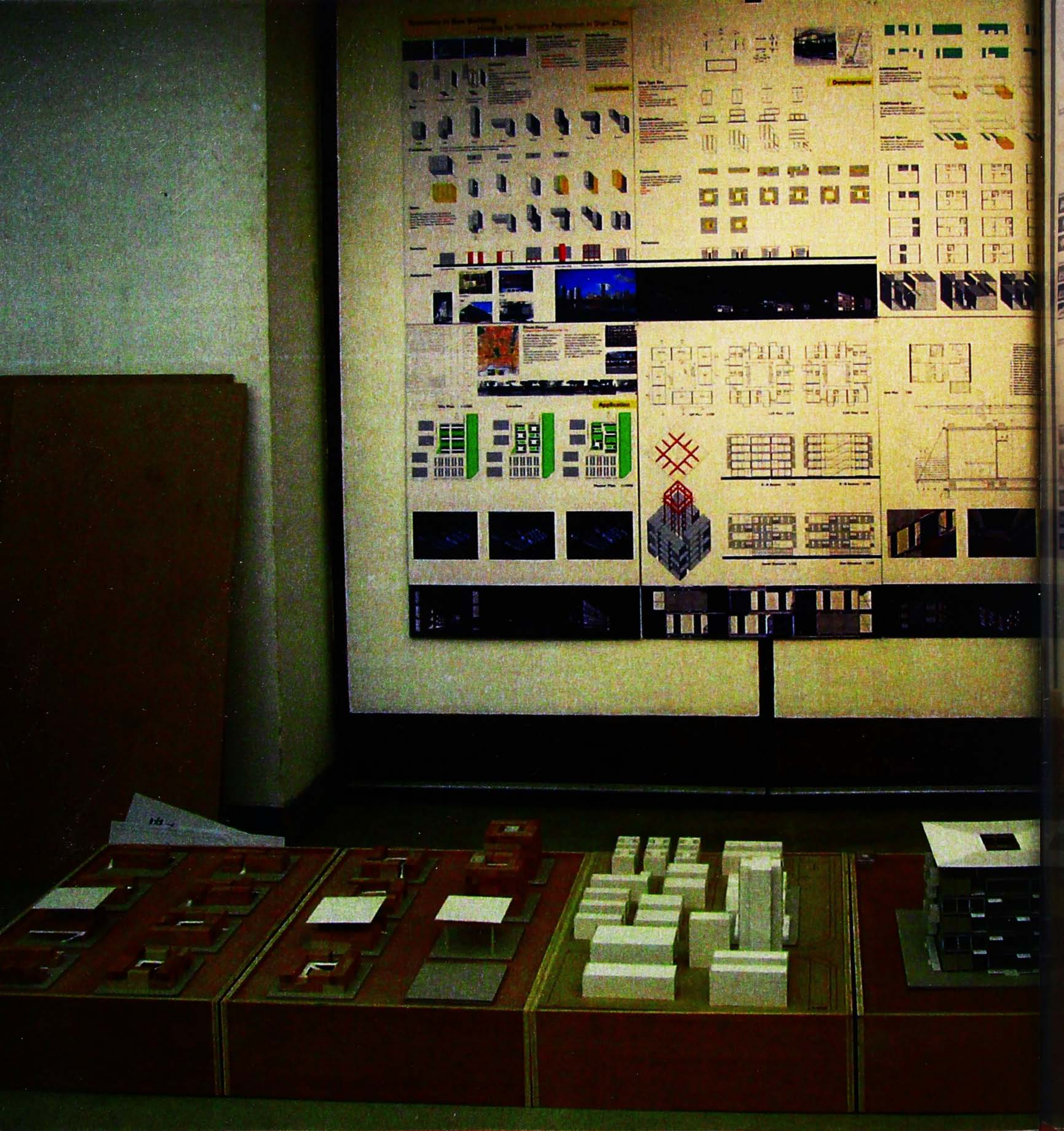
While a modular building system only allows for certain parts described in a catalogue to be utilized by the architect, in "componenting" we extend the freedom of the design, allowing him to choose from all kind of components produced.

What is the characteristic of modular building system? What is the principles of componets building? How can I use them to apply into my design? Based on these questions, I began my thesis programme on Sept 2002.

4. **Methodology**

In the thesis, study of box building will start from the basic box unit, seek of relationship between the boxes and space, structural system, principles of combination of boxes, and figure out the design principles and possibilities. Based on principles, we will explore other potential viriations.

These design principles, possibilities will possibly be applied and integrated into the thesis design and other industrialized building programmes.



5. Research

Sept 2002 - Feb 2003

In the early stage of thesis, large amount of precedents are collected and classified from different sources.

All researches are the abstractions and formalized models.

5.1 **Definition**

5.1.1 **Box**

All the box components are prefabricated in the factory.
The prefabricated box includes structure part and envelop part.

So the component should be
1. space unit
2. structure unit

5.1.2 **Box Building**

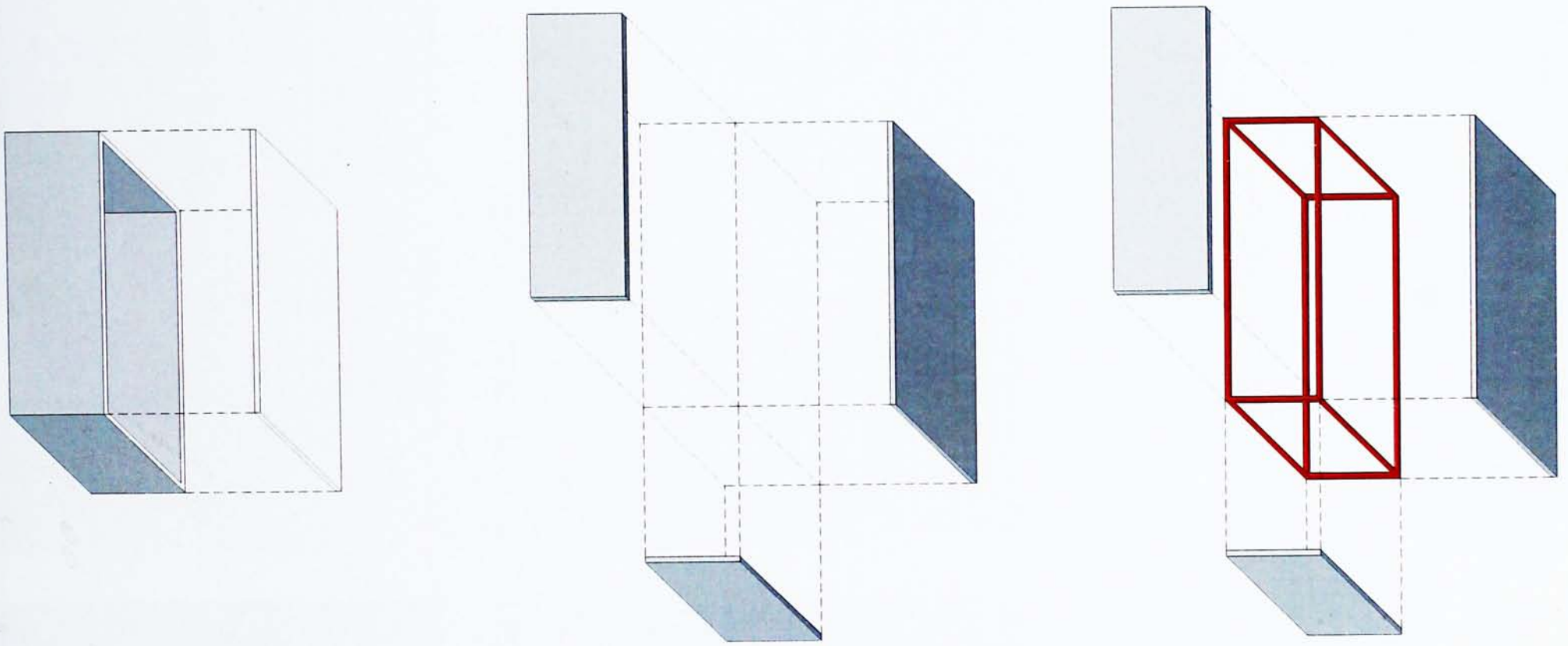
According to the different function of every box. The box has individual interior space and facilities. All the boxes are transported to the project site and assembled together.
The finish building is called box building.

5.2 **Box**

5.2.1 **Construction of Box**

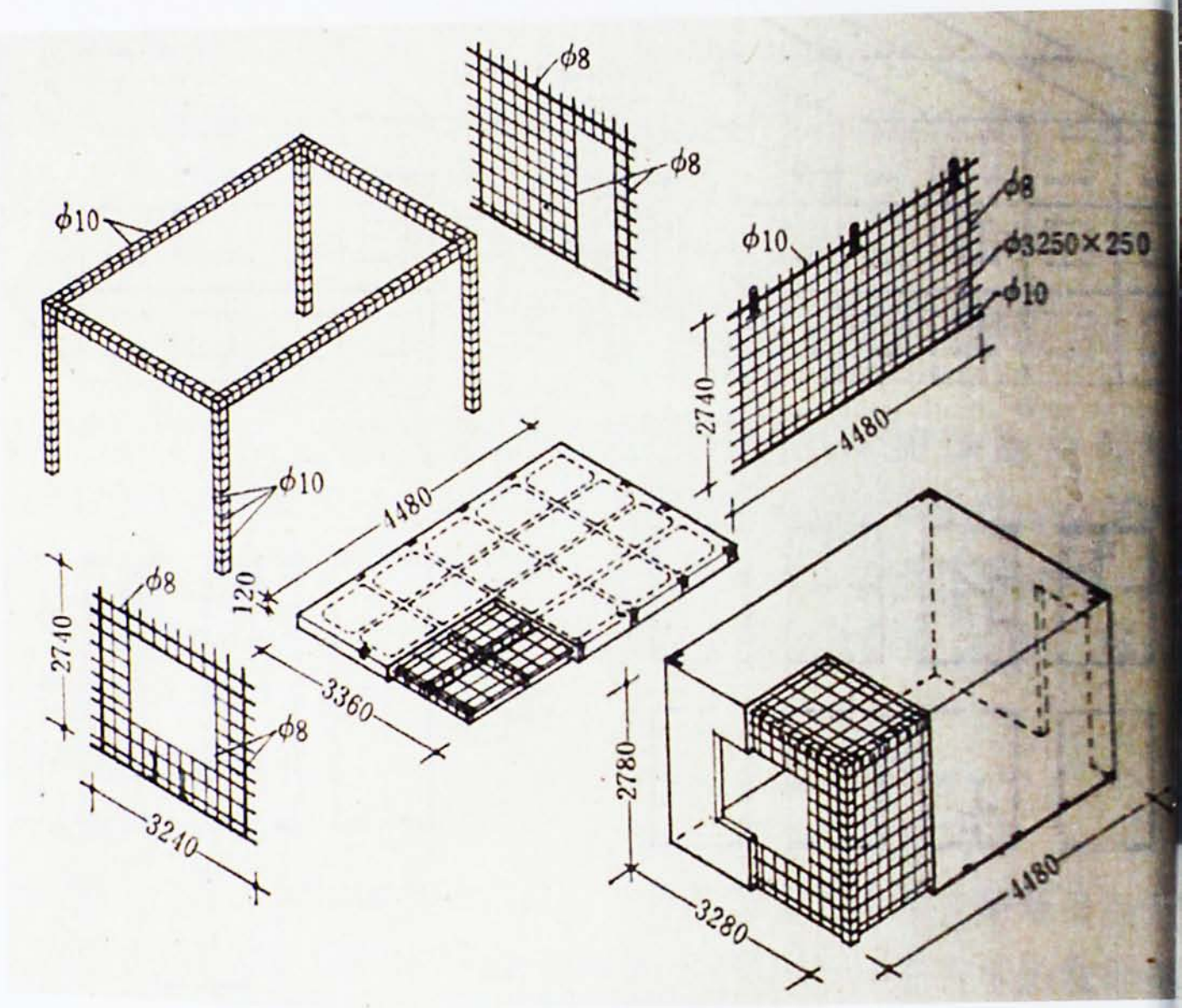
There are 3 types based on the different construction methods and materials.

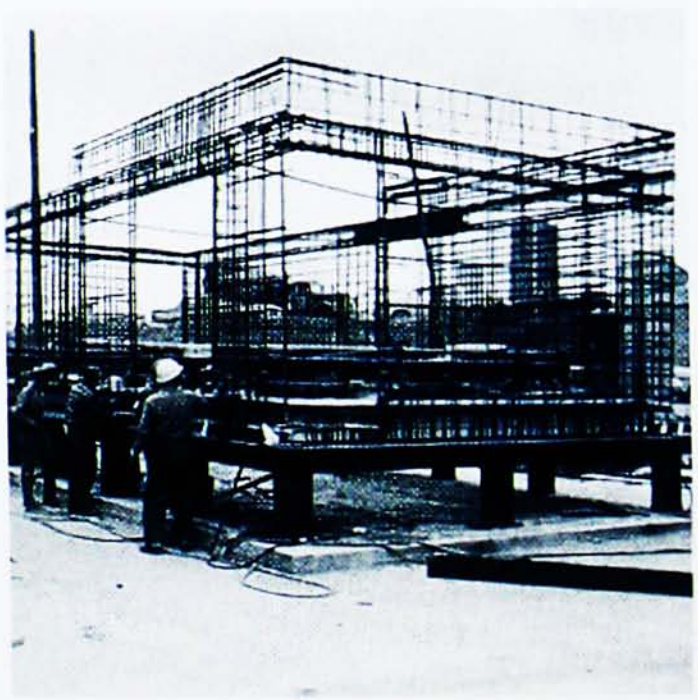
1. integer casting
2. panels combination
3. framework and panels combination

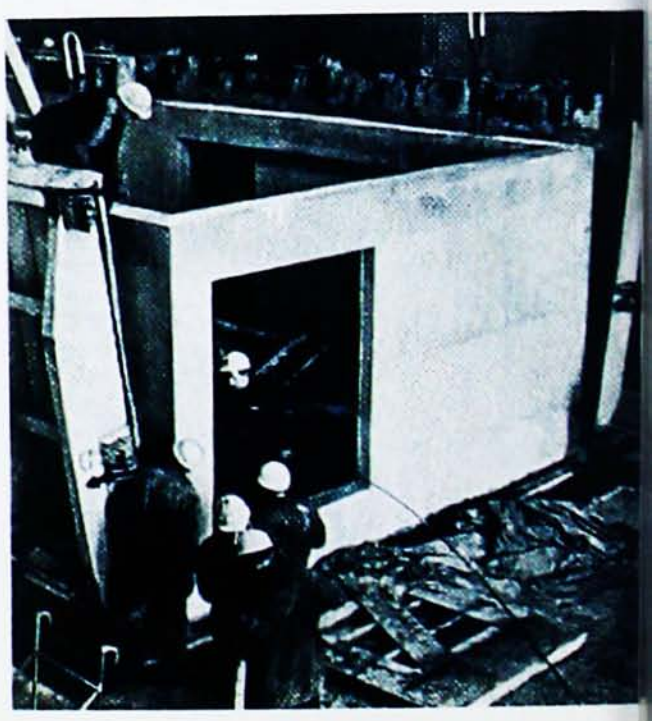


5.2.2 **Integer Casting**

Preparing the reinforcing cage and mold, and pour the concrete into the mold. After concreting, then remove the mold.



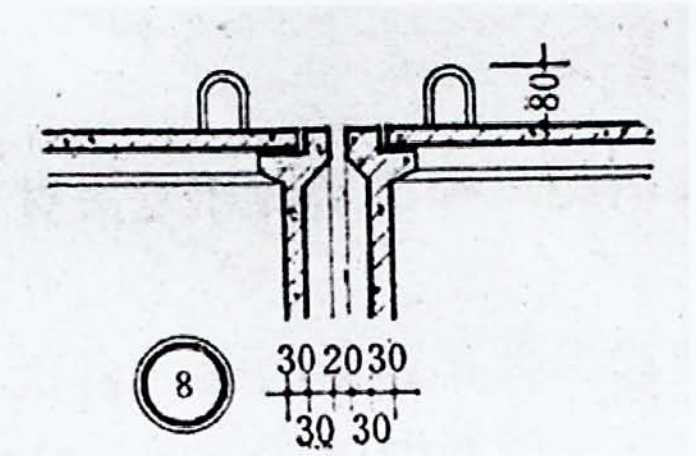


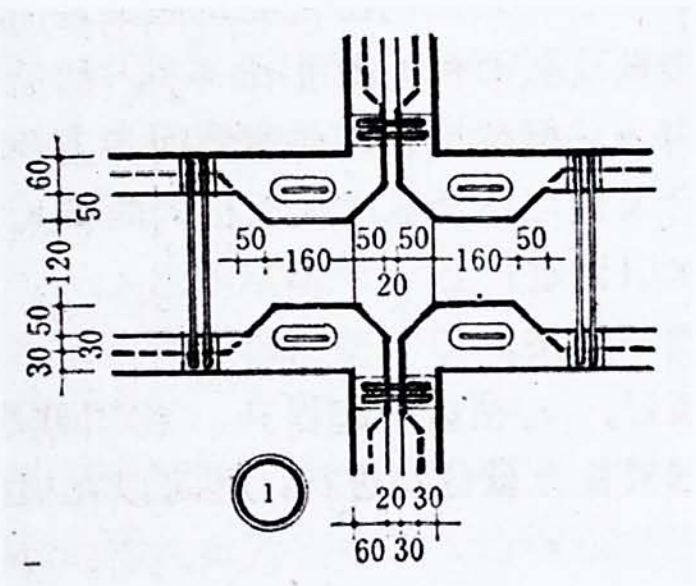


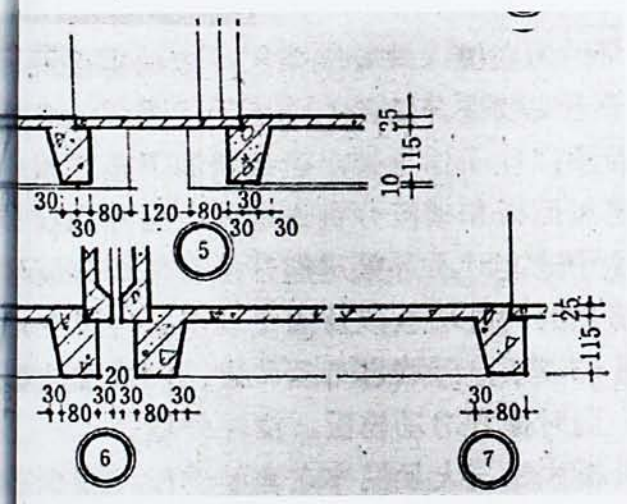
Moshe Safdie
Habitat' 67

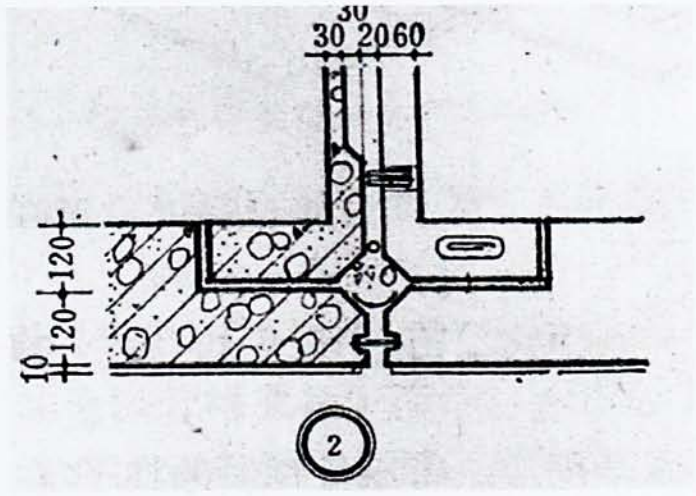
5.2.3 **Panels Combination**

Most of panels combination of box are prefabricted by the reinforced concrete. Different materials cause different connection methods. Here is a sample of joint of concrete panels.





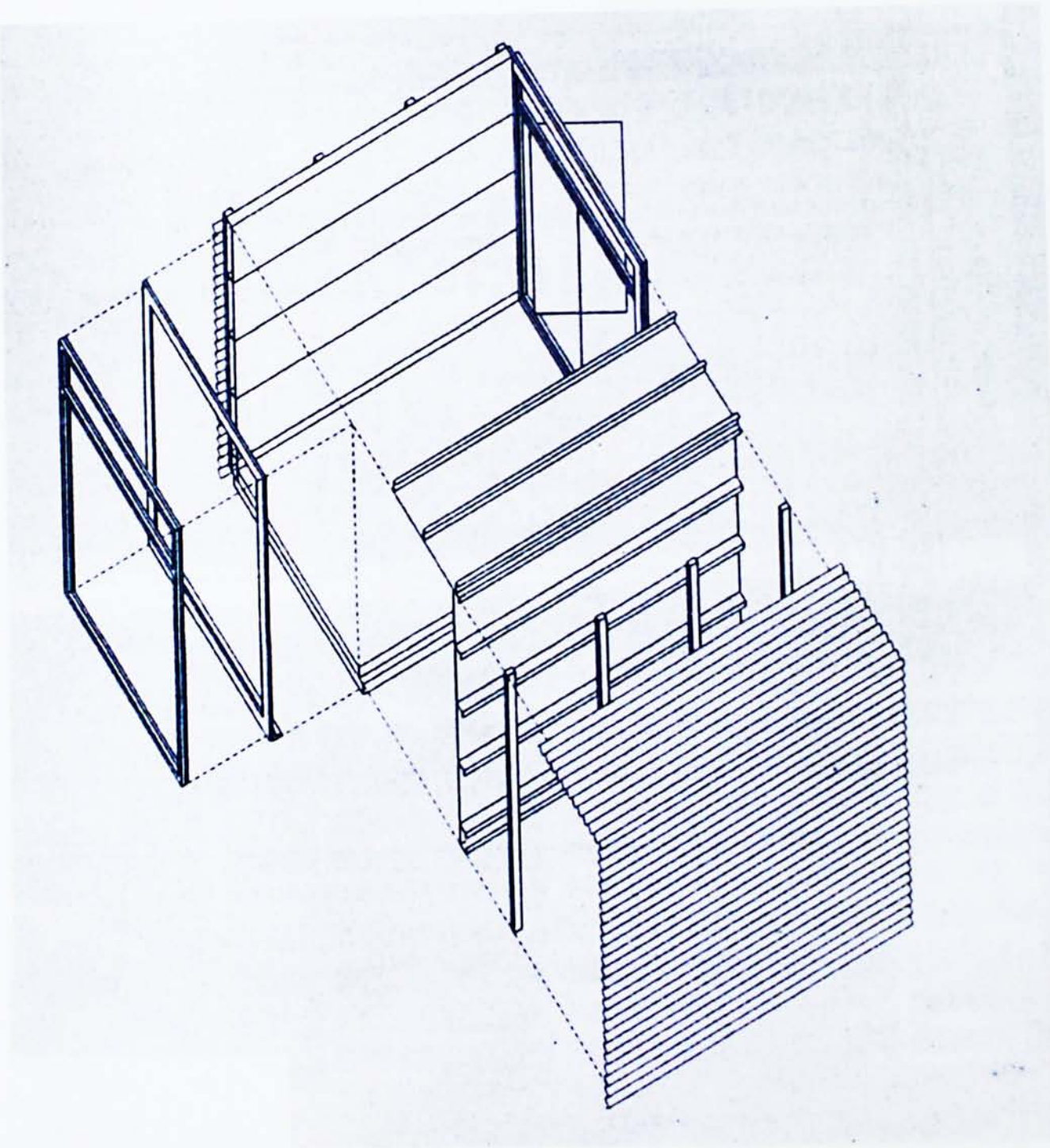




Gammon Limited HK
Dong Guan Project

5.2.4 **Frame and Panels Combination**

The most obvious precedents of frame and panels combination are container buildings.
Because the supporting structure of container is the frame, the frame usually is steel frame. And the envelop materials are different light-weight materials.



Dollmann + Partner, Stuttgart
Office Block in Fellbach

5.3 **Combination**

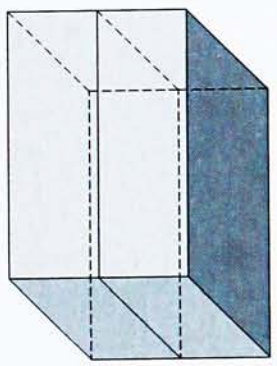
5.3.1 **Simple Combination**

To derive more possible combinations, we can just consider the most combinations of boxes can be assembled by the different simple combinations.

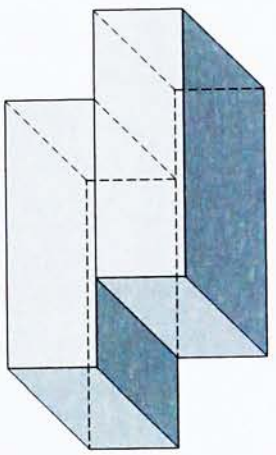
Simple combination is based on the combination of two box units. There are two strategies of simple combination.

5.3.2 **Strategy 1**

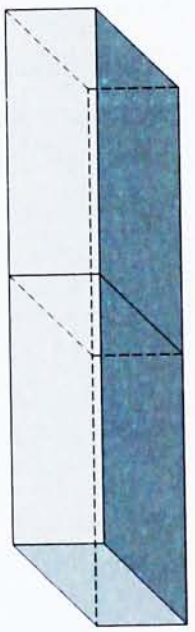
Two box units touch and form a bigger cuboid volume.



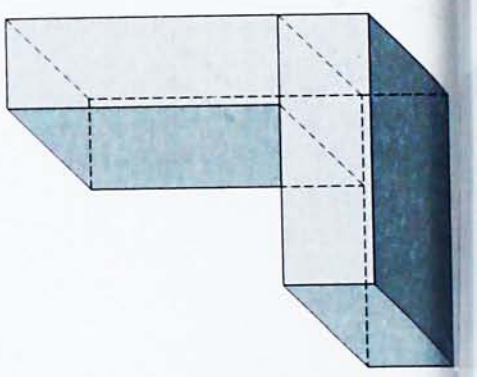
Parelle



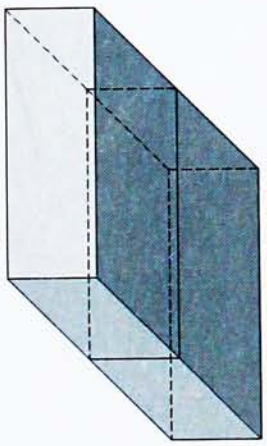
Shift



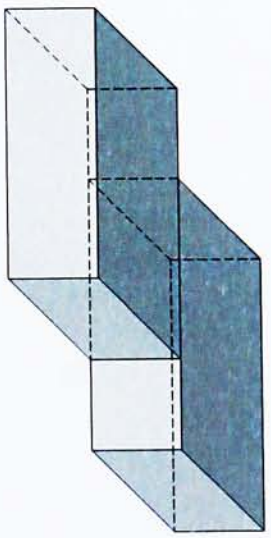
Serial



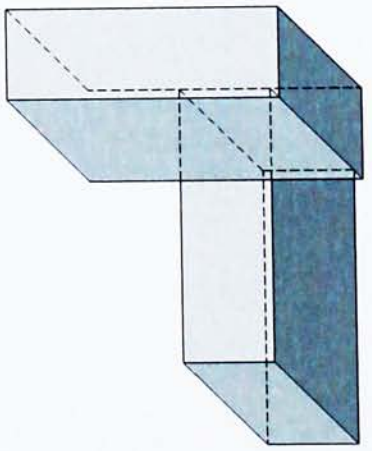
Rotate



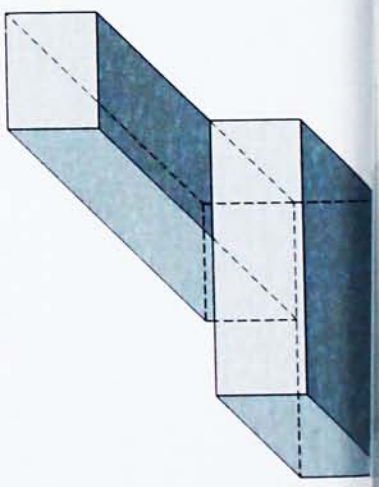
Stacked



Slide



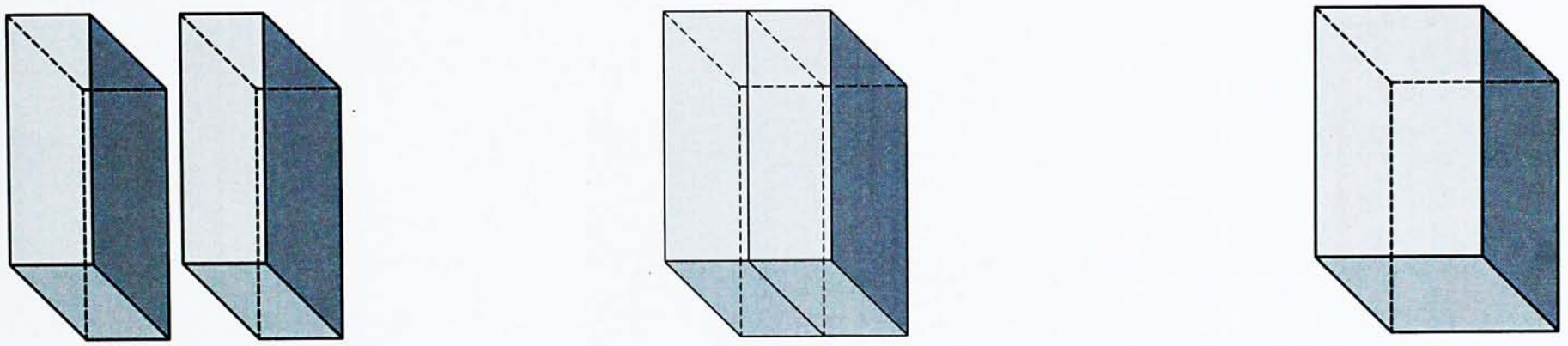
Overlap



Erection

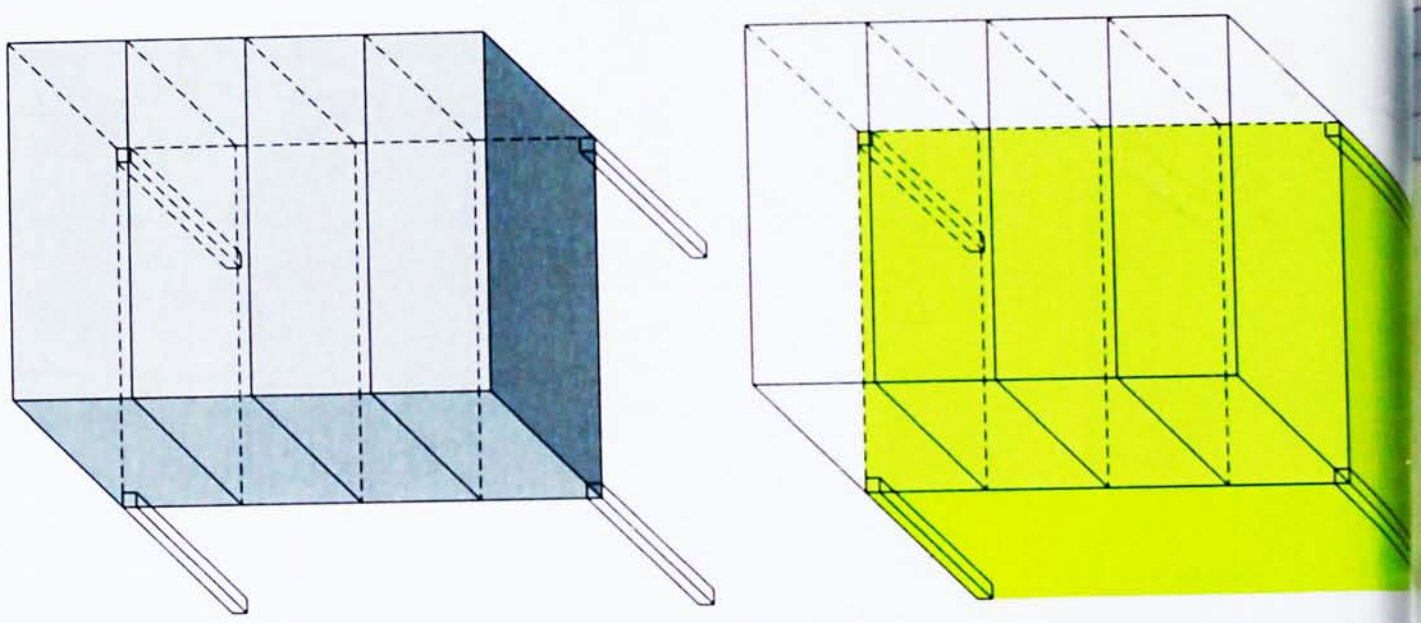
5.3.3 **Strategy 2**

All combinations formed according to Strategy1 can be created a bigger space within units volumes by removing faces.
We can call it merged.



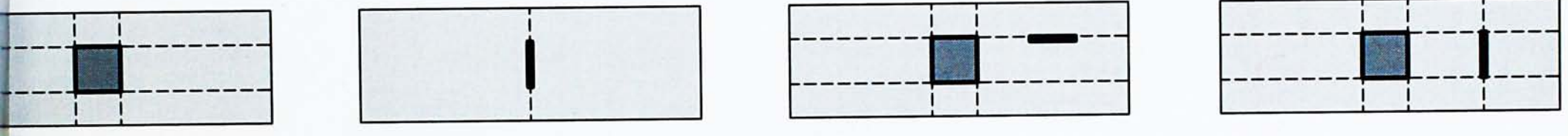
5.4 **Space**

Box buildings consist of boxes and additional elements. The spaces of box building includes two aspect meanings. One is the "in-box space" enclose by the box units. The other is the "additional space" which is defined by boxes and additional elements.



5.4.1 **In-Box Space**

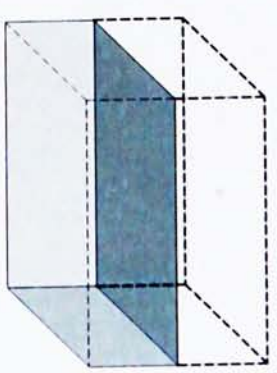
In box space is defined by the interior service core and division. And the relationship between these two elements is division can continue or strength the space defined by the service core. Another is division create the new subspace.

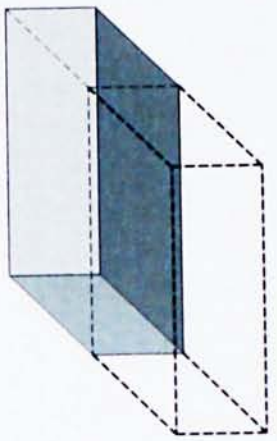


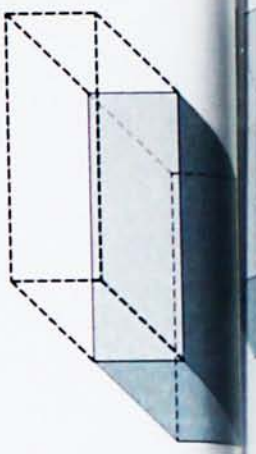
5.4.2 **Additional Space**

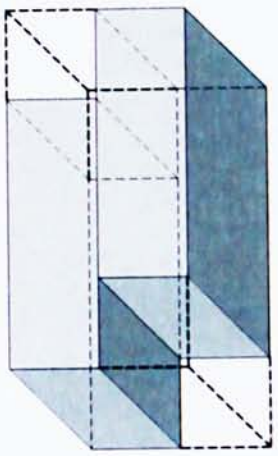
We can group the out-box space based on the relationship between the space and box.
As a tentative structure we distinguish between three groups of types.

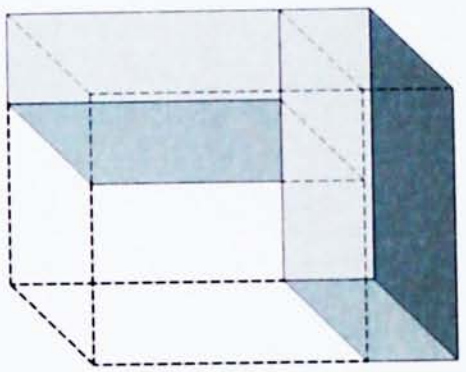
1. Simple types
2. Complex types
3. Special types

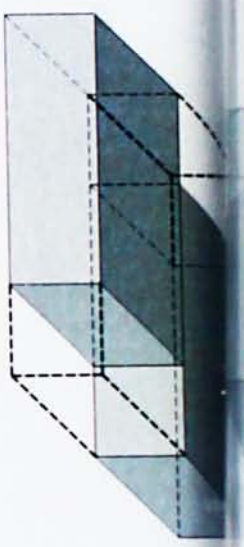


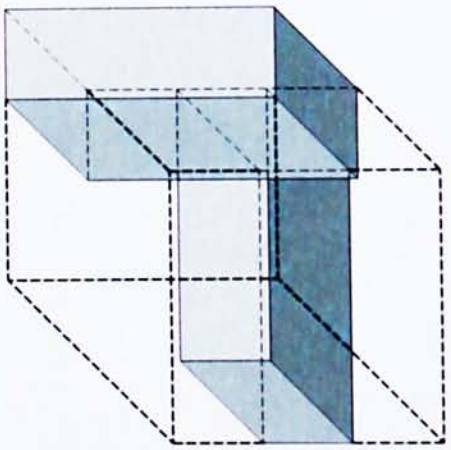


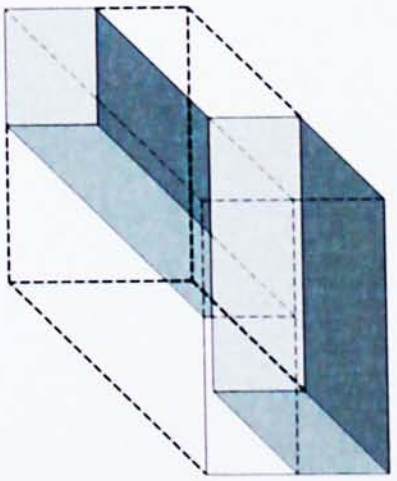


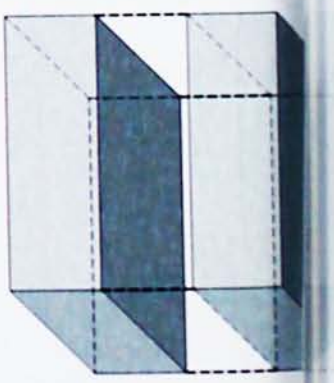


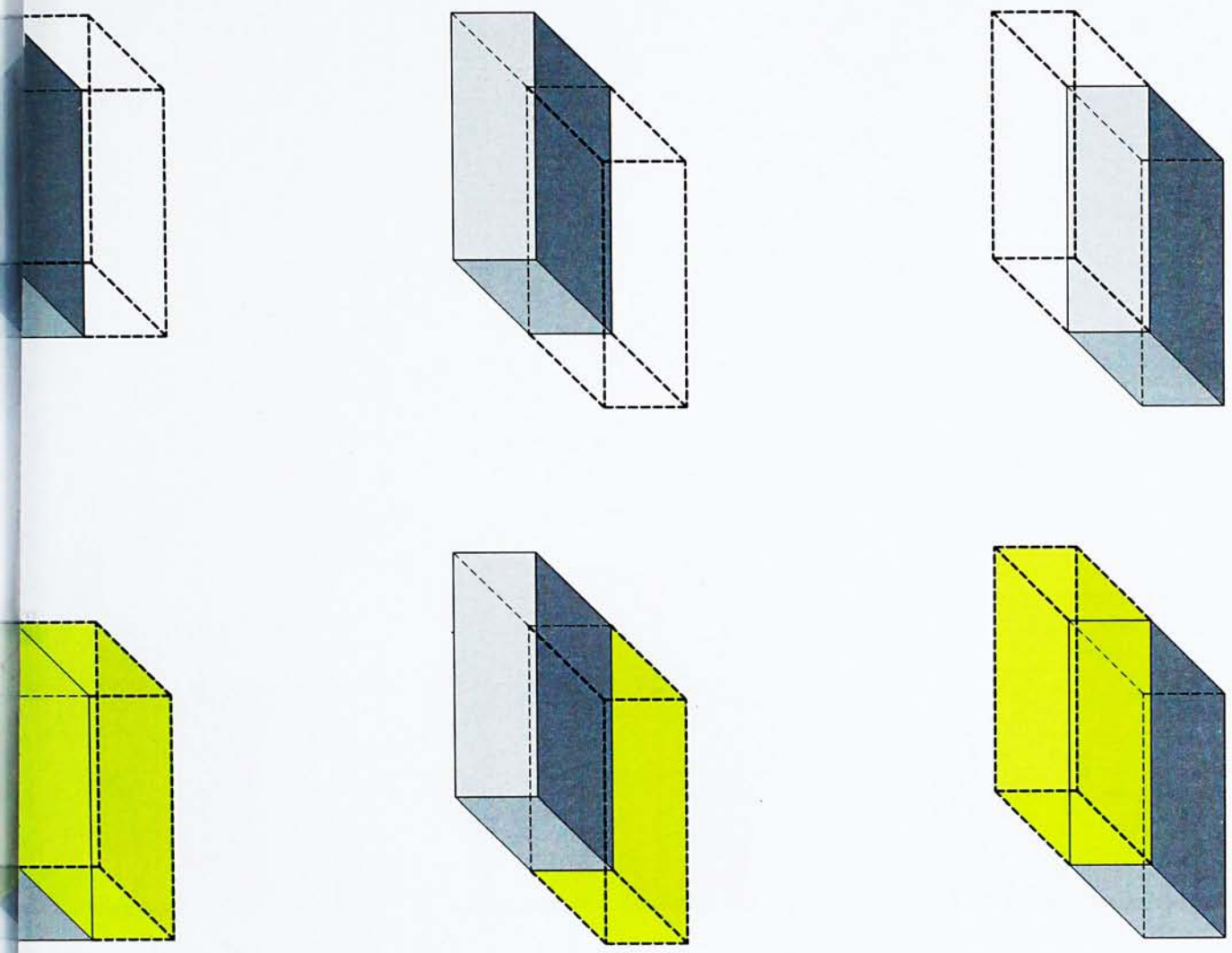










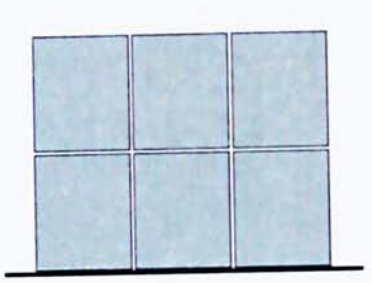


5.4.3 **Enclosing of Additional Space**

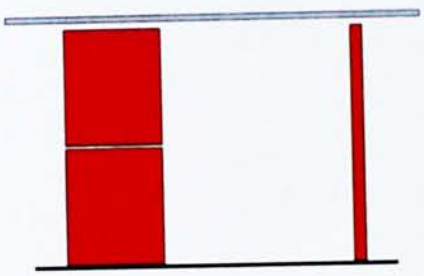
The outdoor box space has unlimited variation. But only have two encloseing relationship. One is semi open space, the other is full enclose space, we can call it interior out box space.

5.5 **Structure**

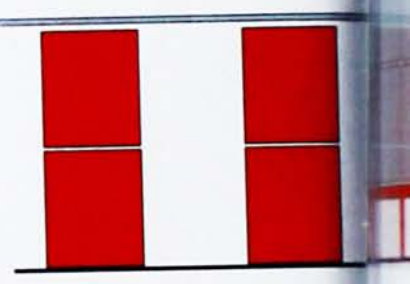
Based on the relationship between boxes and
structural system in the box building, we can
distinguish four types of structure of the box buildings.



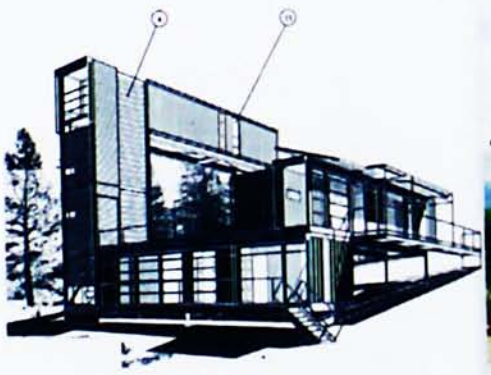
Self-supporting

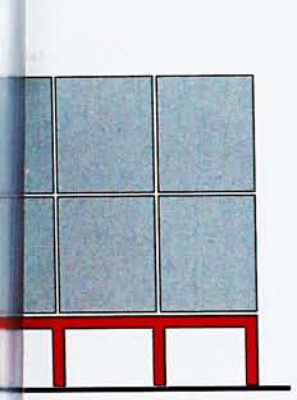


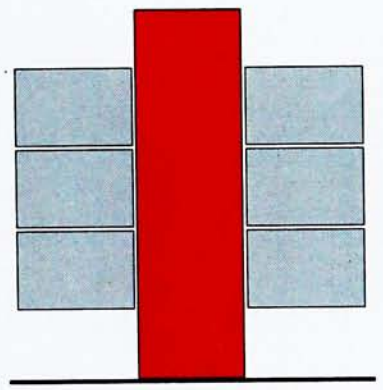
United supporting

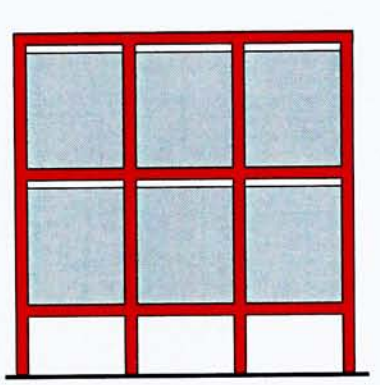


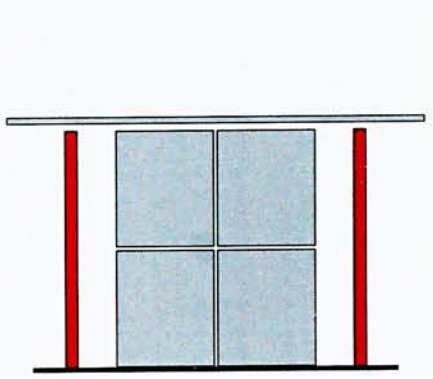
Solely supporting









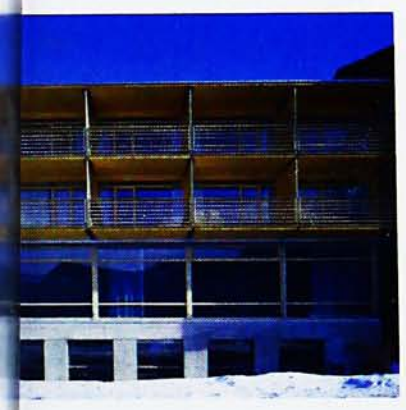


e supporting

Core supporting

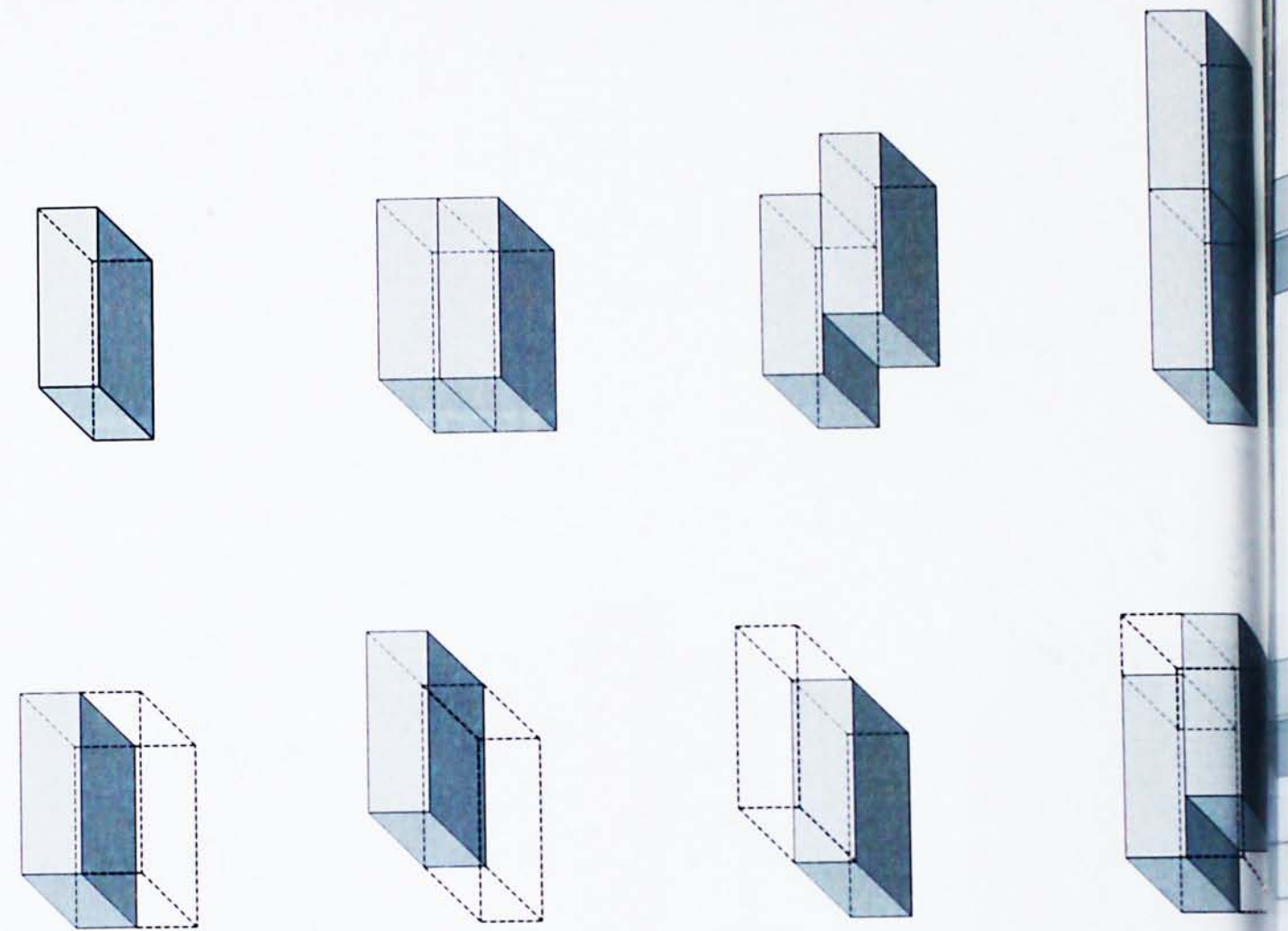
Frame supporting

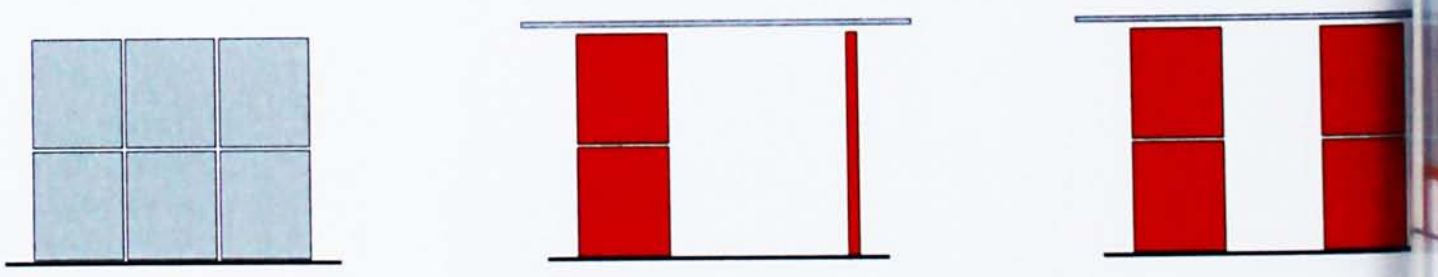
Independence

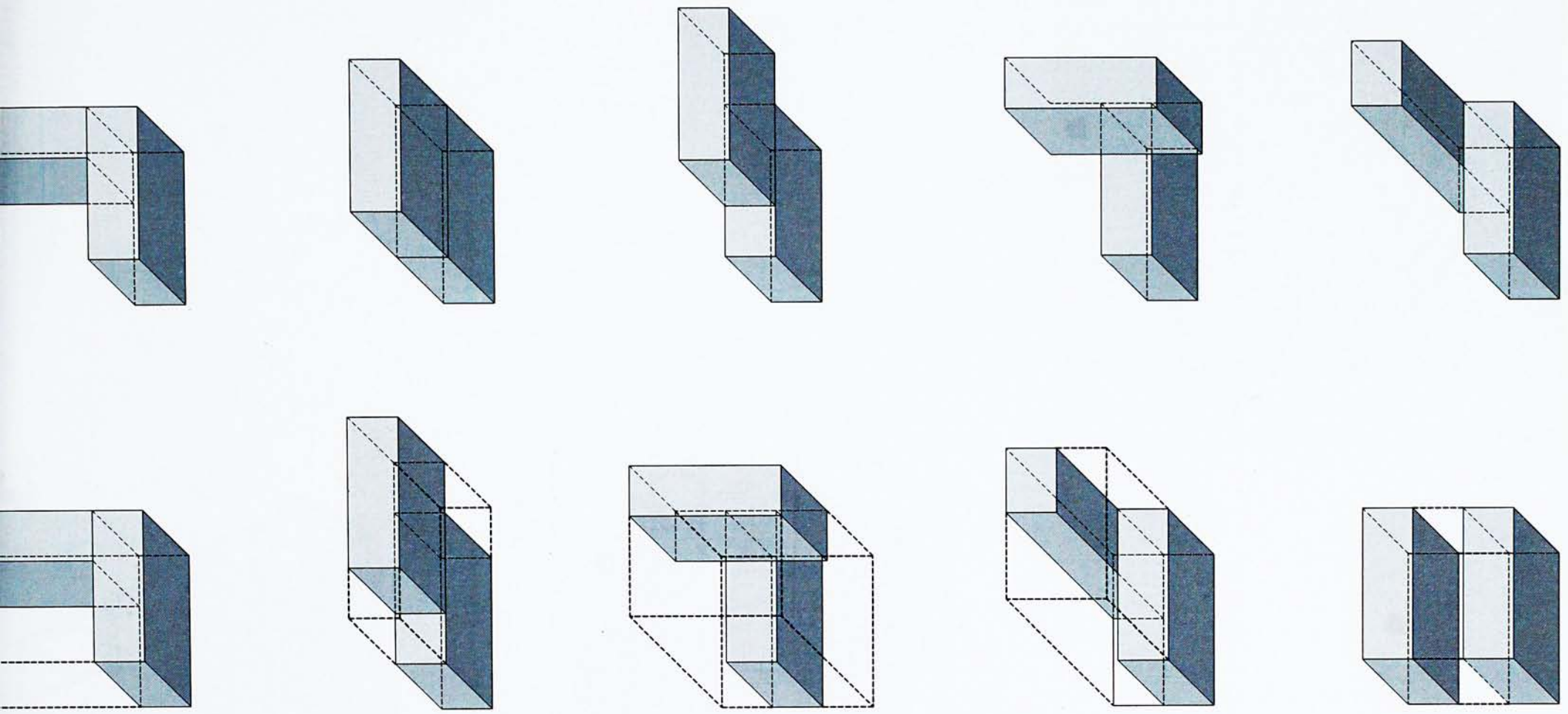


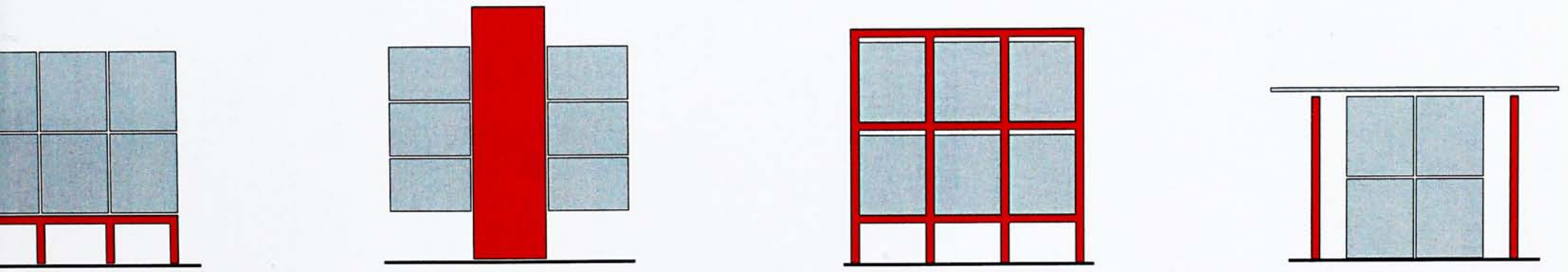
5.6 **Matrix of Box Building**

From above researches, we can summarize that all box buildings can be rebuilded by this matrix of box building.



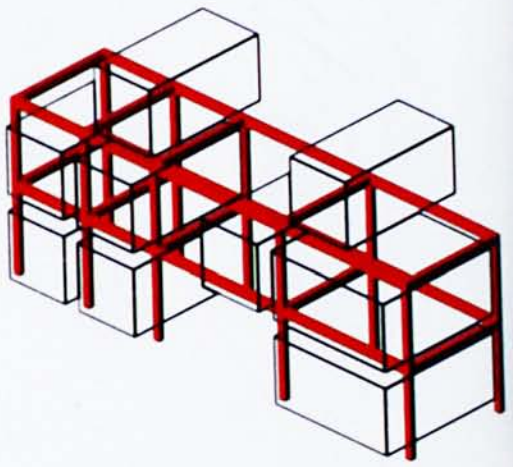


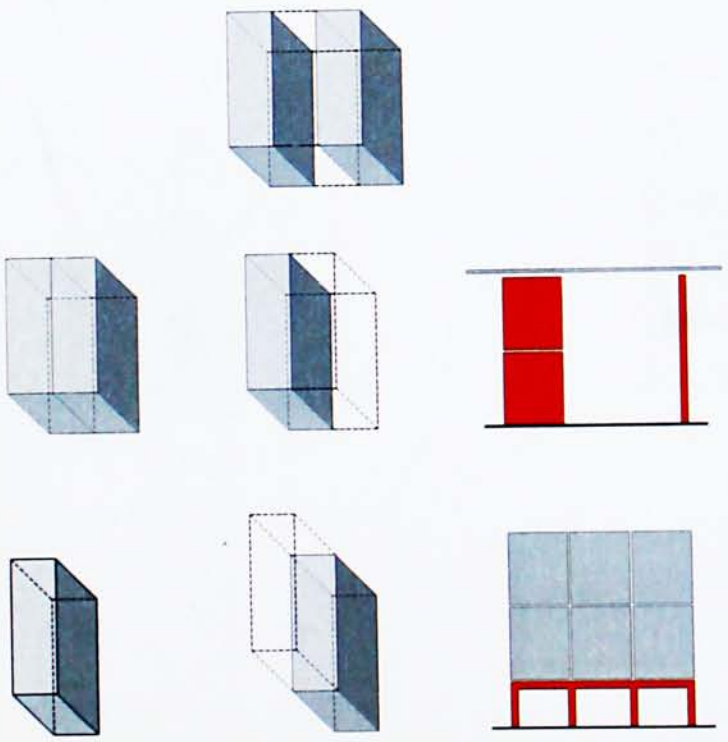


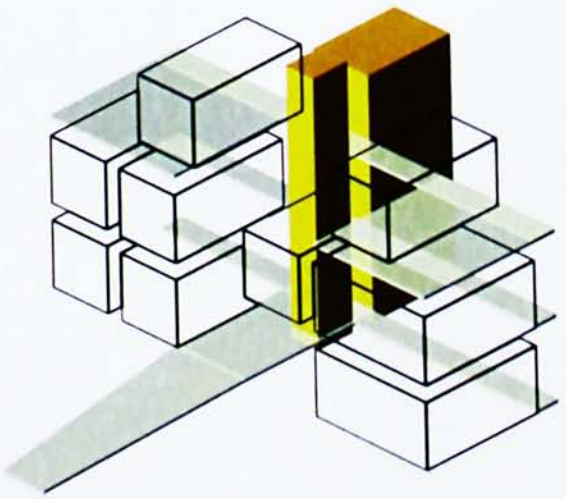


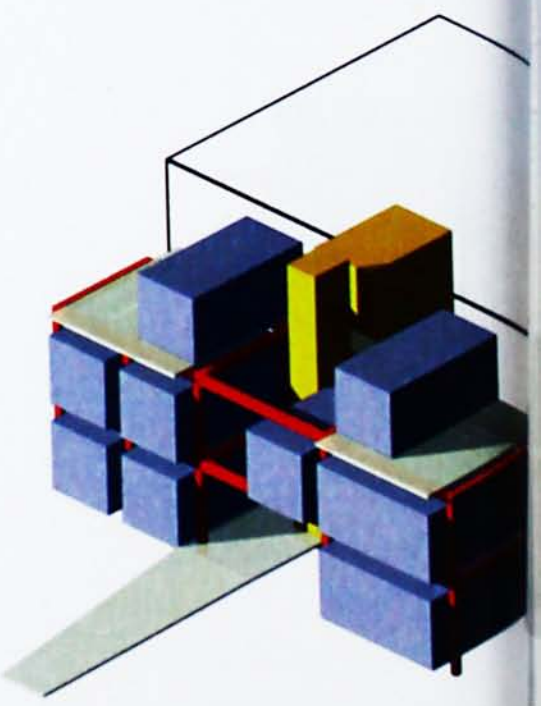
5.6.1 **Case 1**

Housing and commercial block in Rathenow



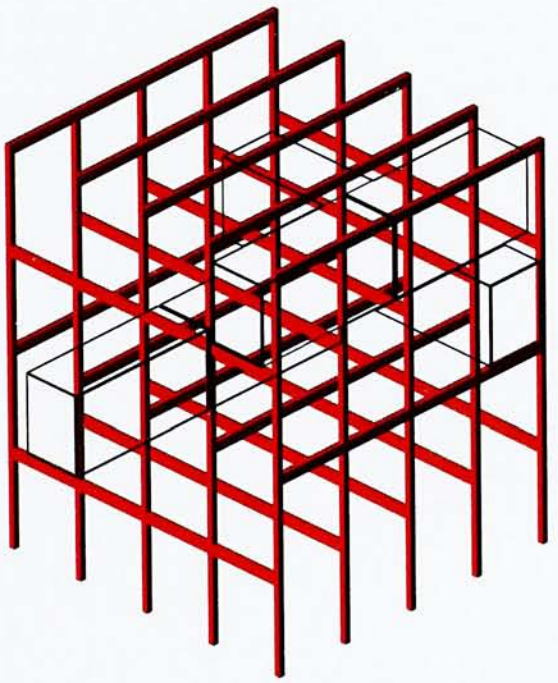


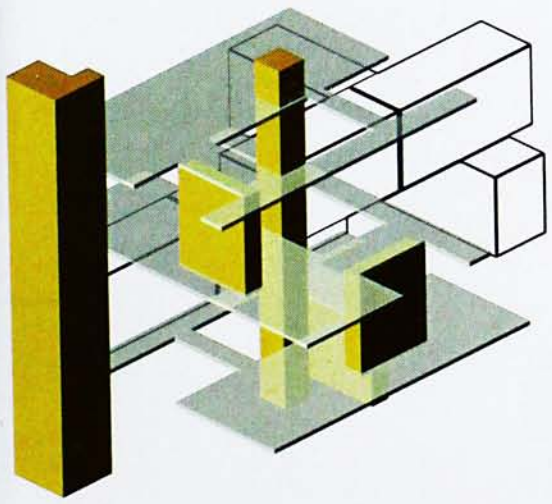


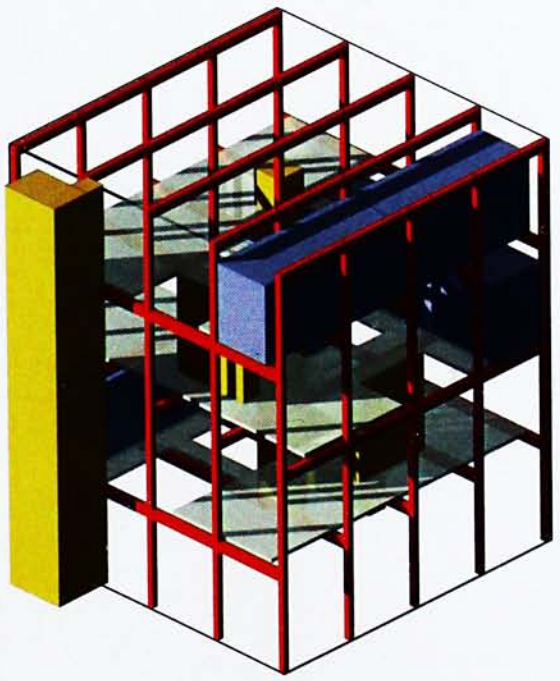


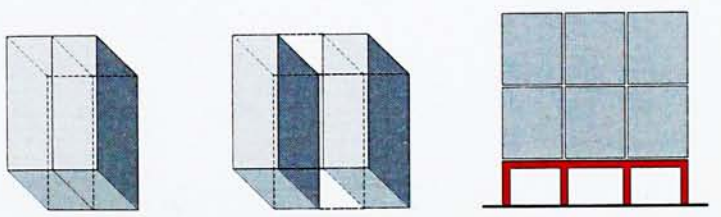
5.6.2 **Case 2**

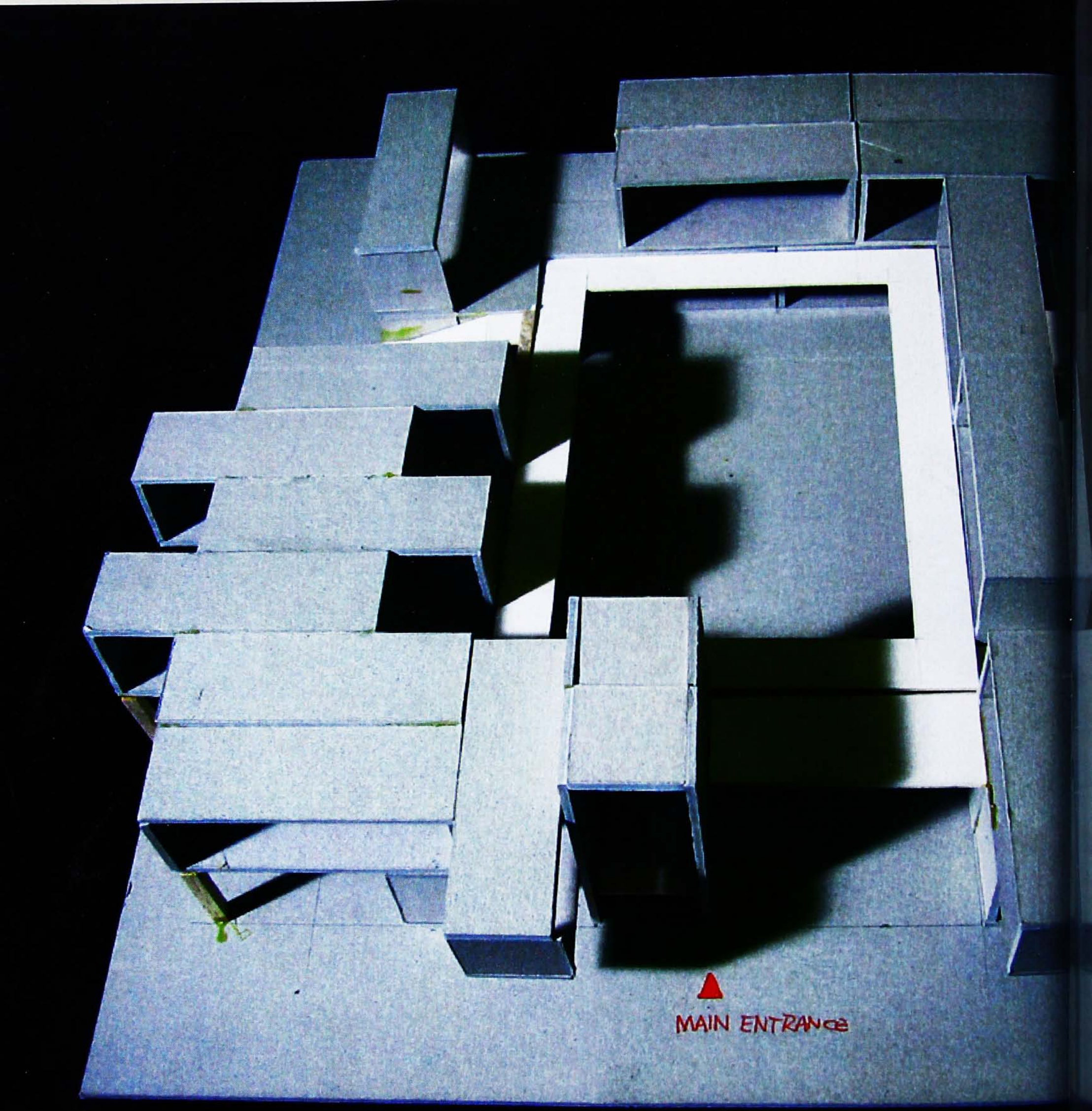
Office block in Fellbach
Dollmann+partner, Stuttgart










MAIN ENTRANCE

6. Exploration

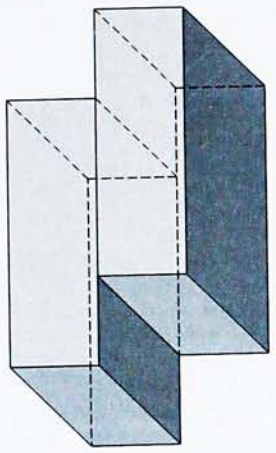
Nov 2002 - Feb 2003

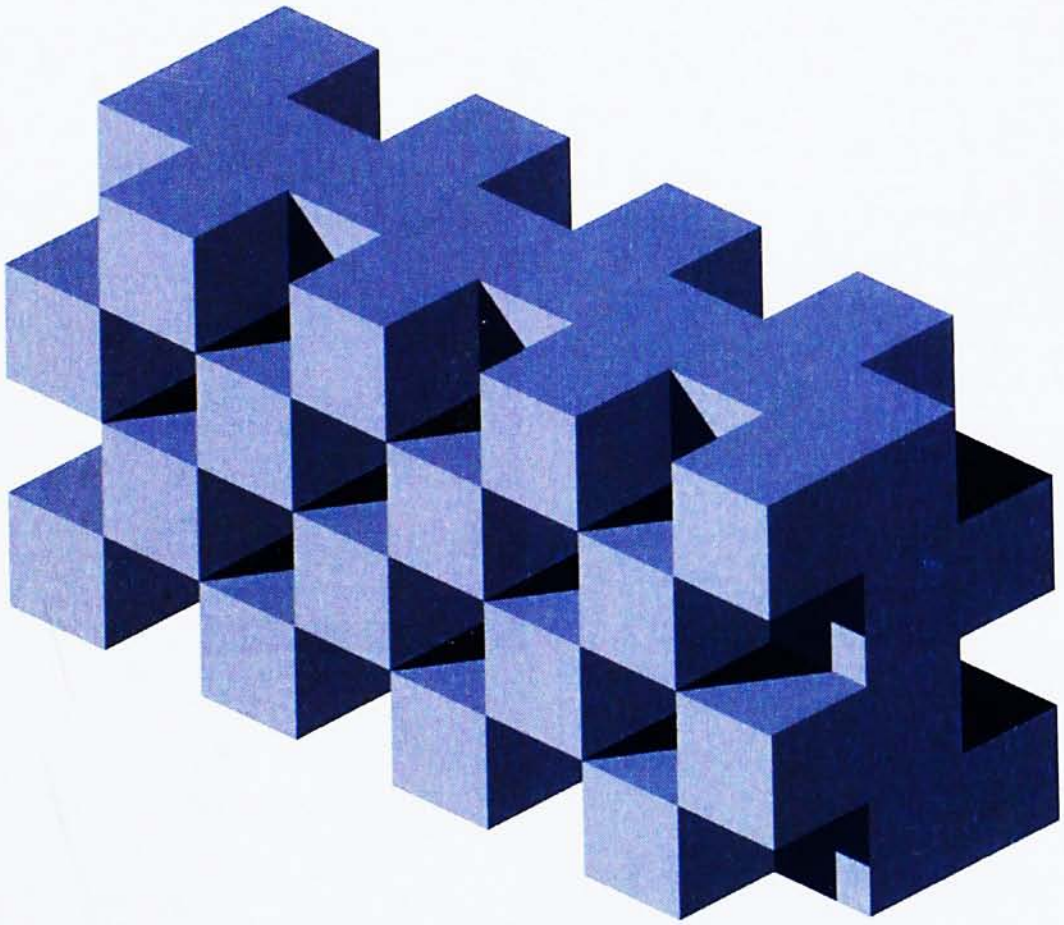
Based on all above principles and combinations, we considered one simple combination as a basic unit and began exploring. The focus is the possibilities of combination and formalization.

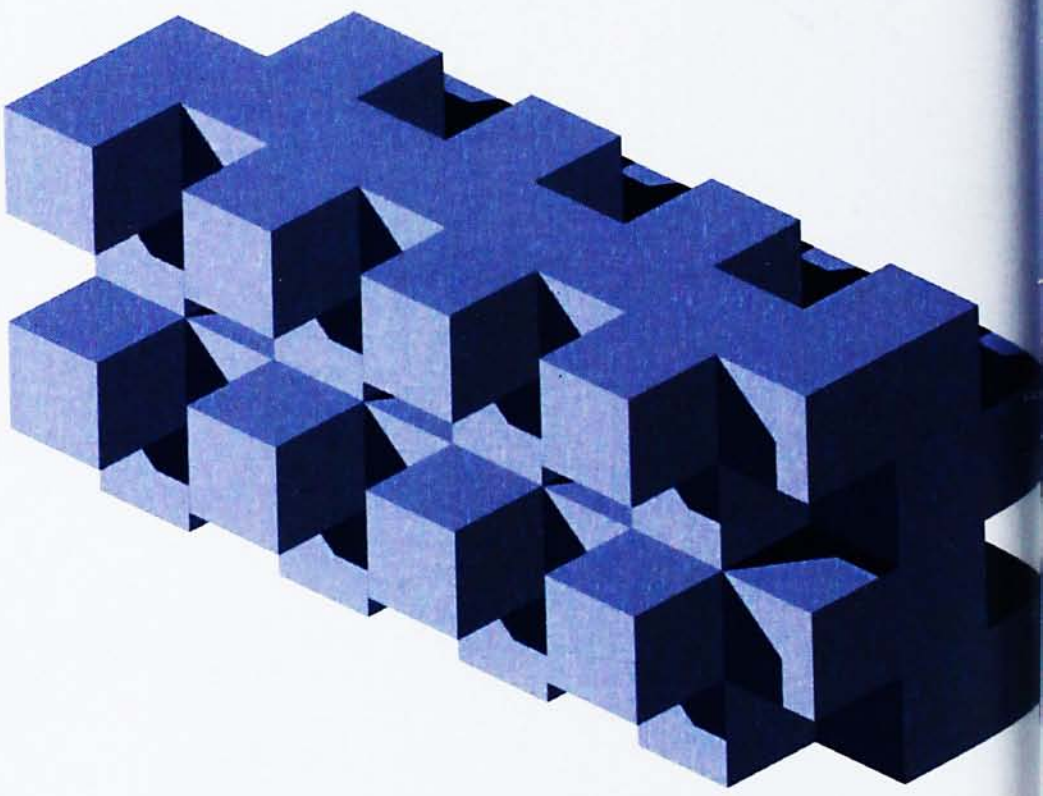
Experiment design is only a test of application of previous study.
We use the Gammon Limited Co., project Integer Pavilion as programme and just want to be a contrast to Gammon design.

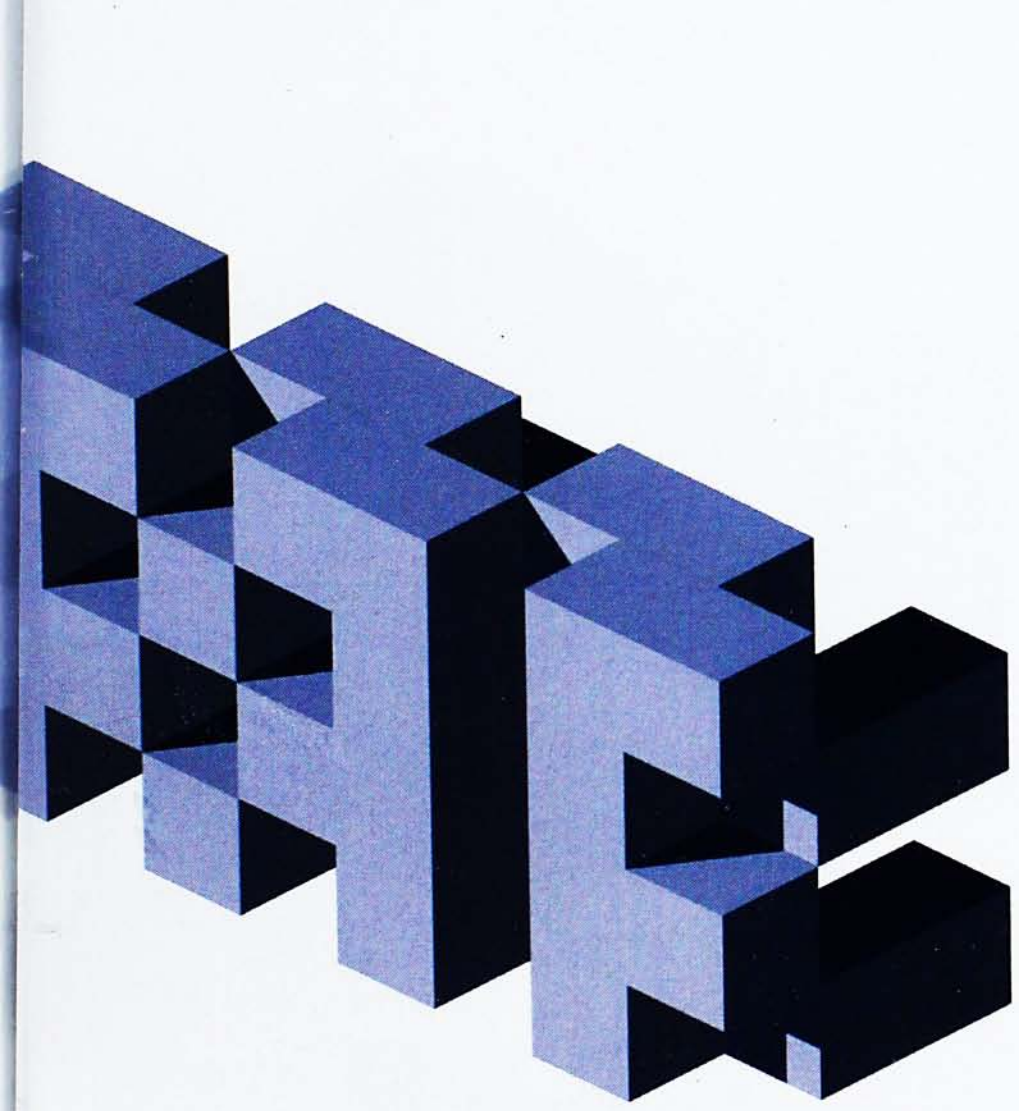
6.1 Exploration 1

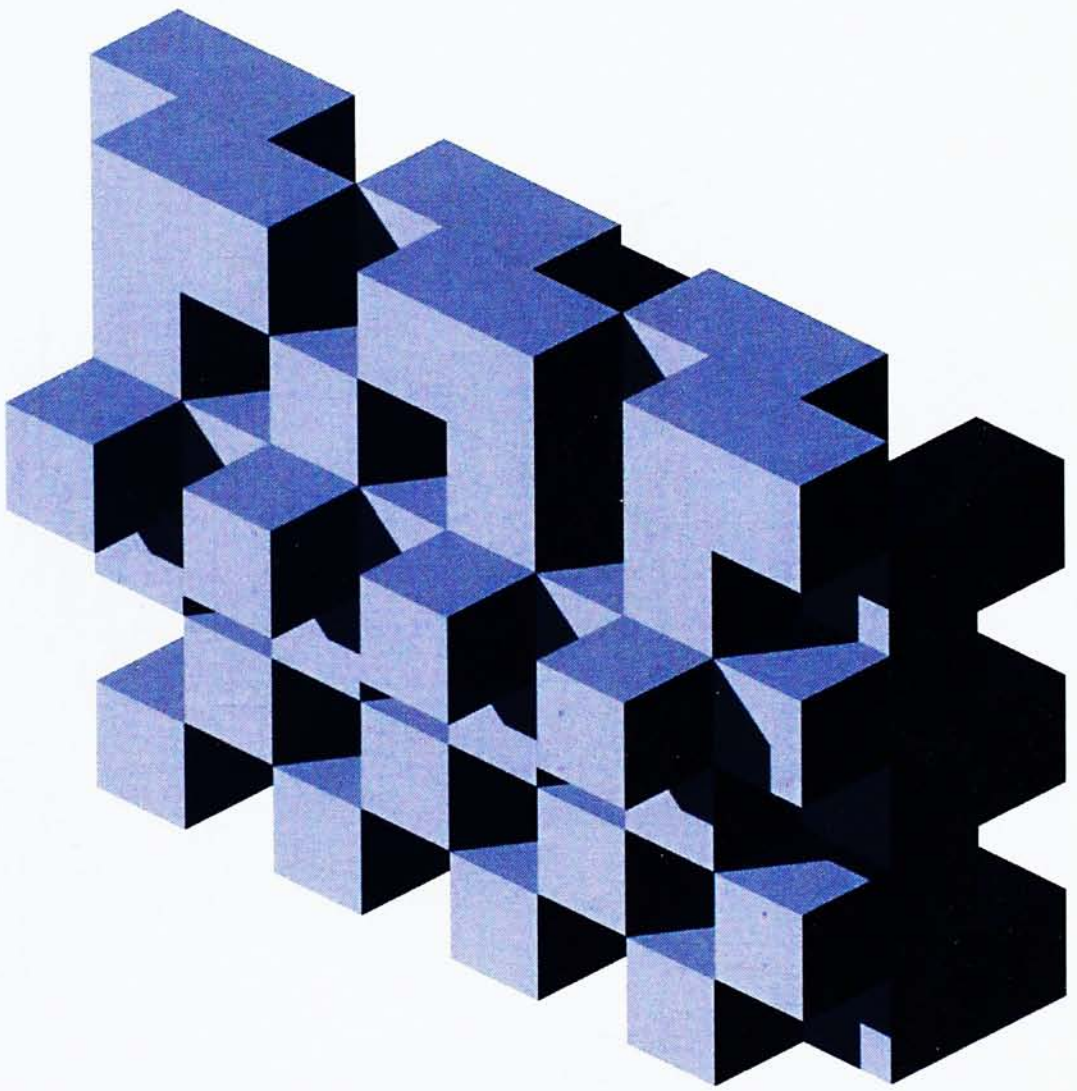
6.1.1 Linear Type



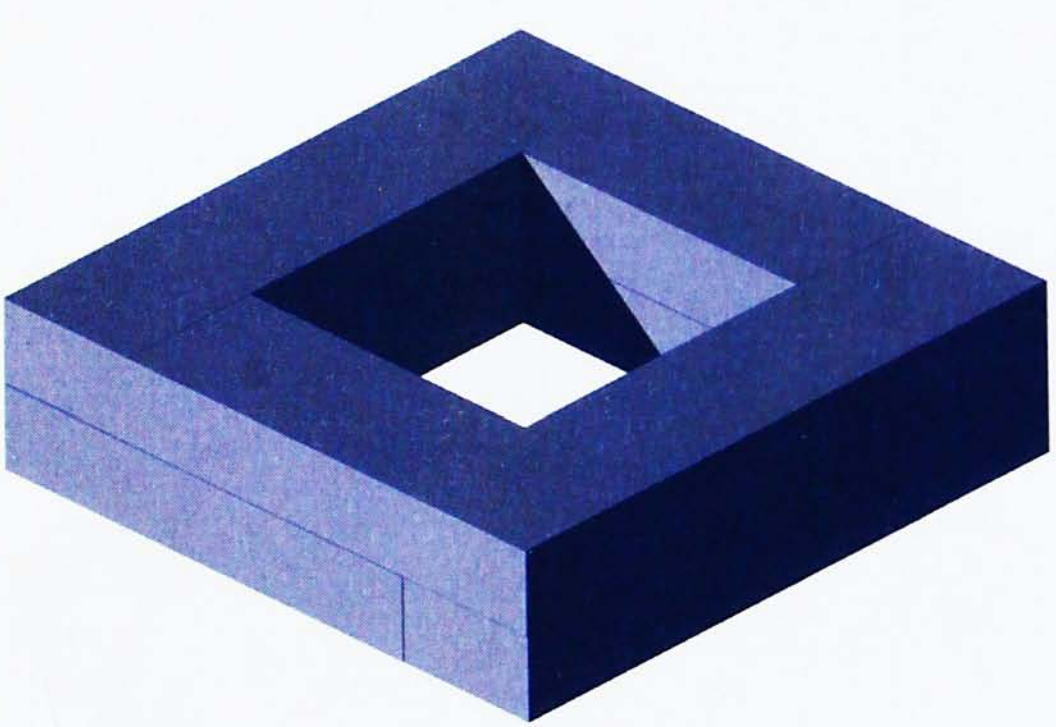


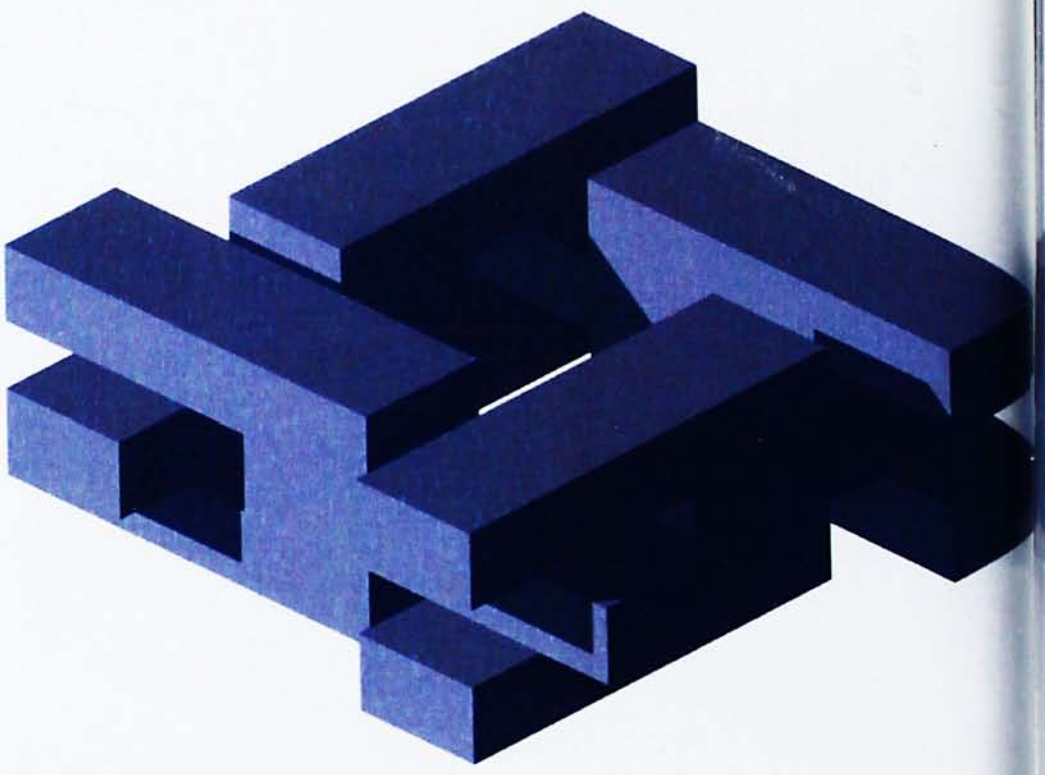


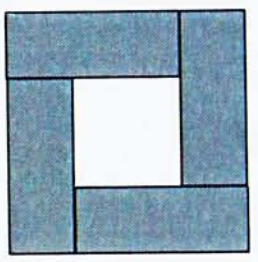


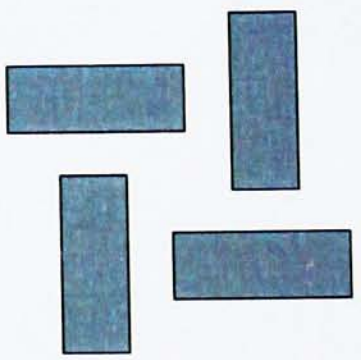


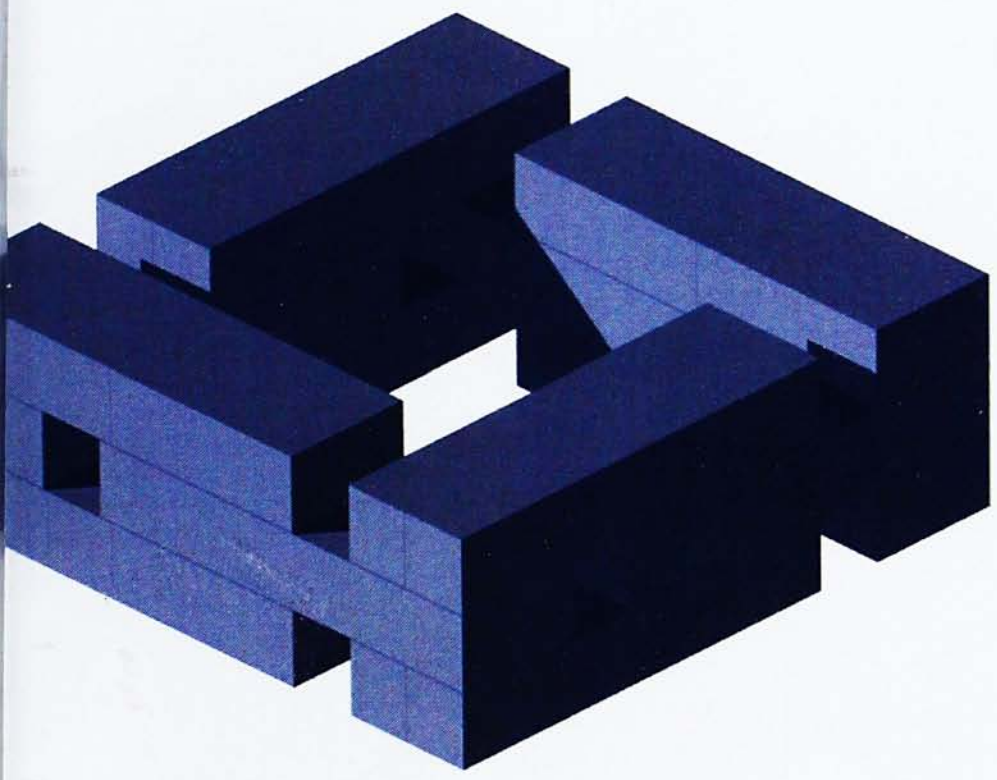
6.1.2 **Courtyard Type**

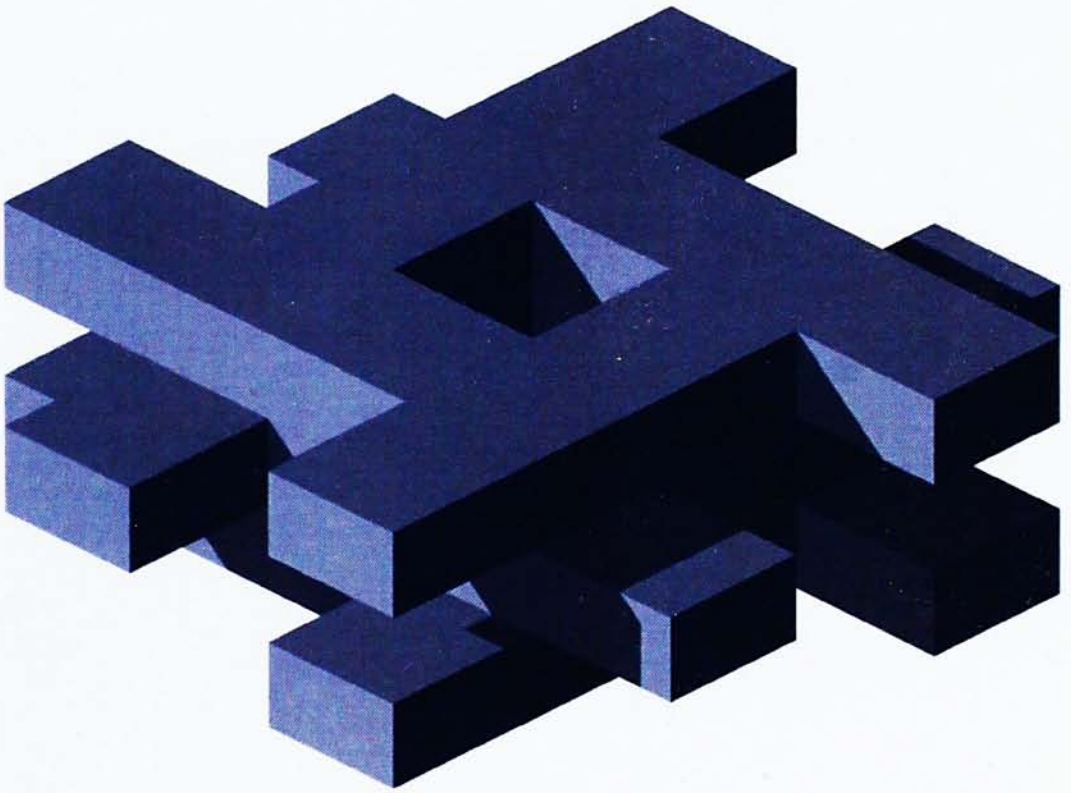


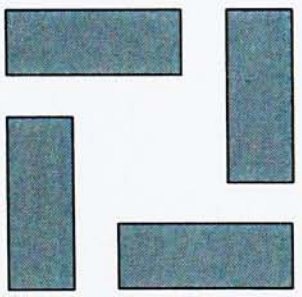


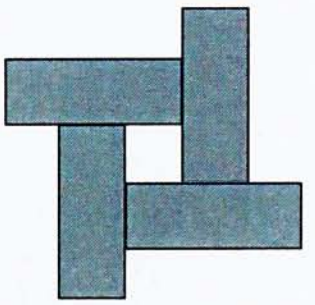






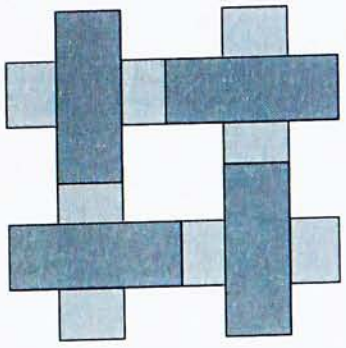


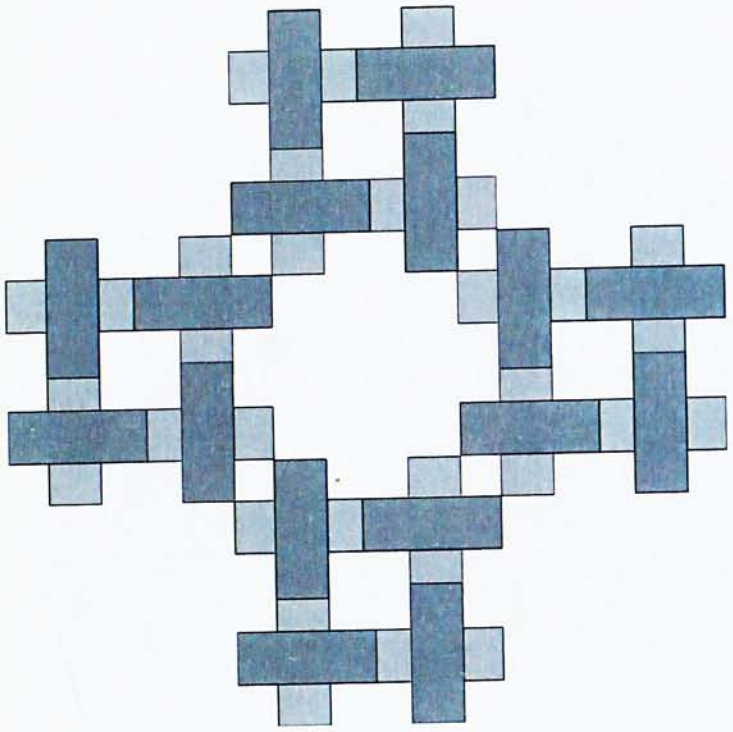


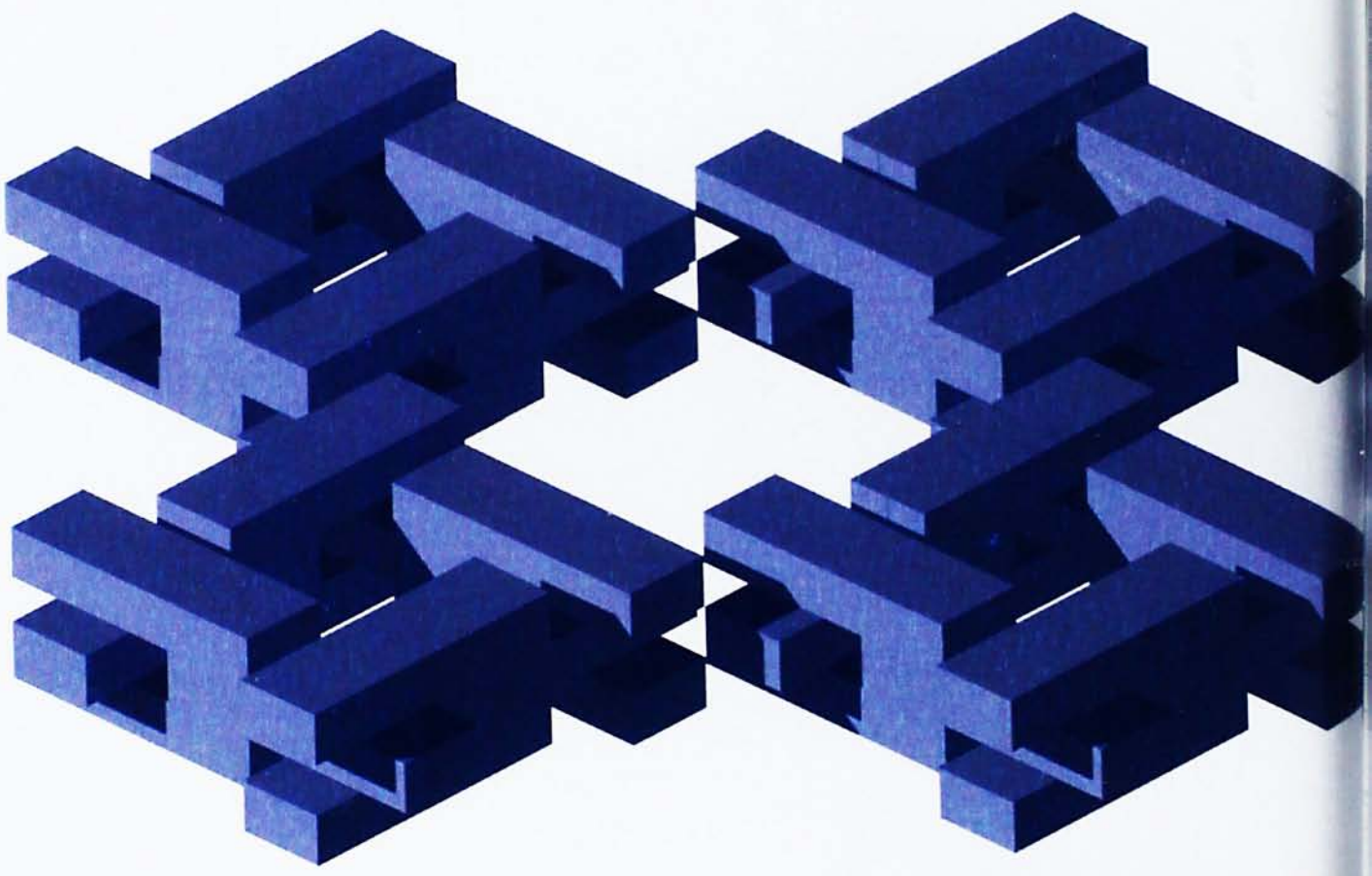


6.2 Exploration 2

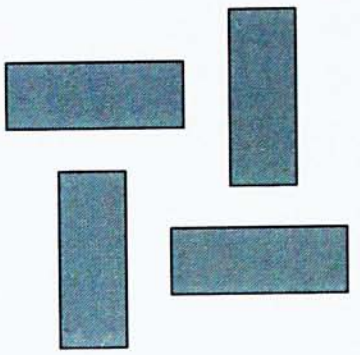
6.2.1 Combination1

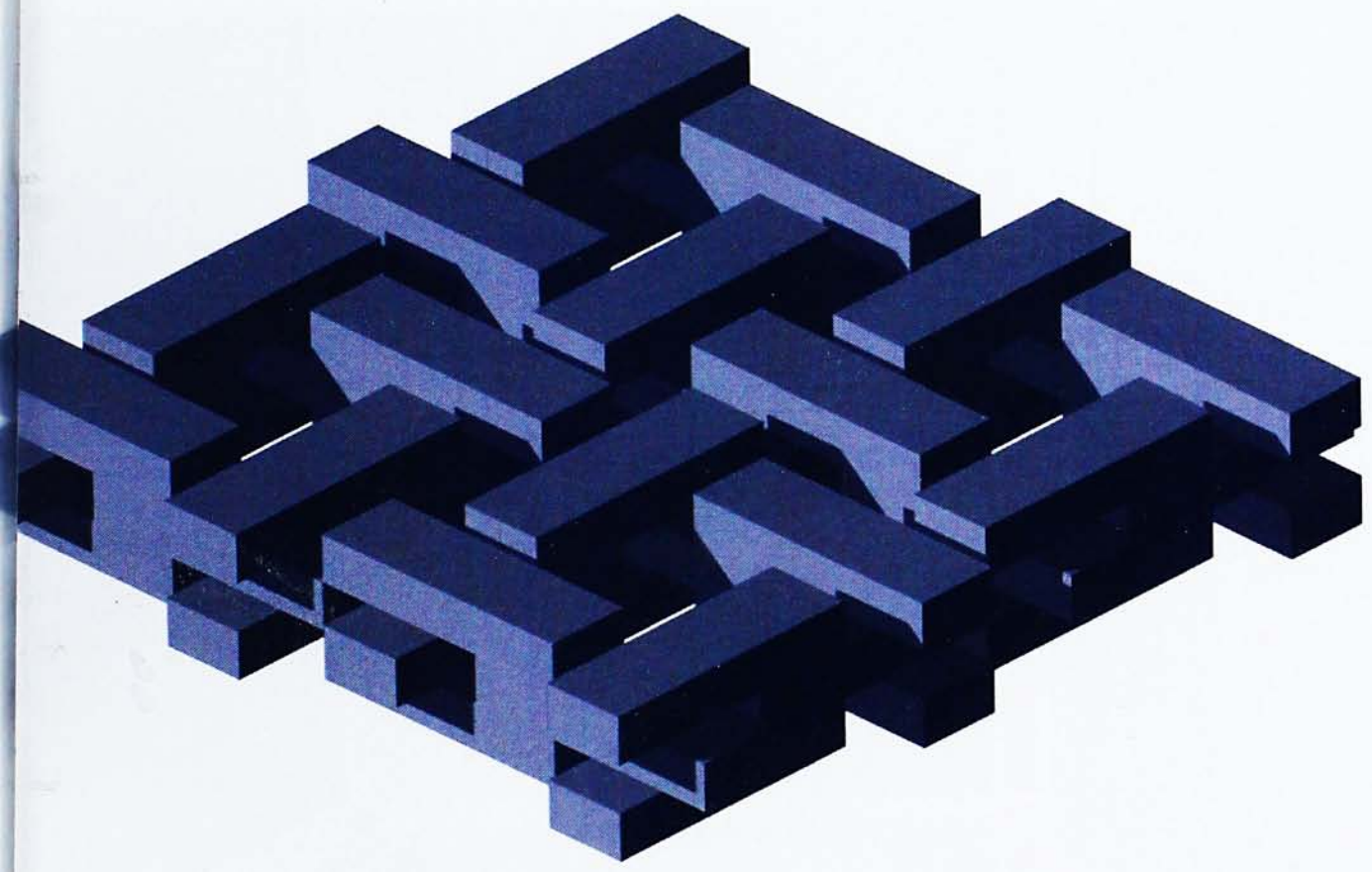


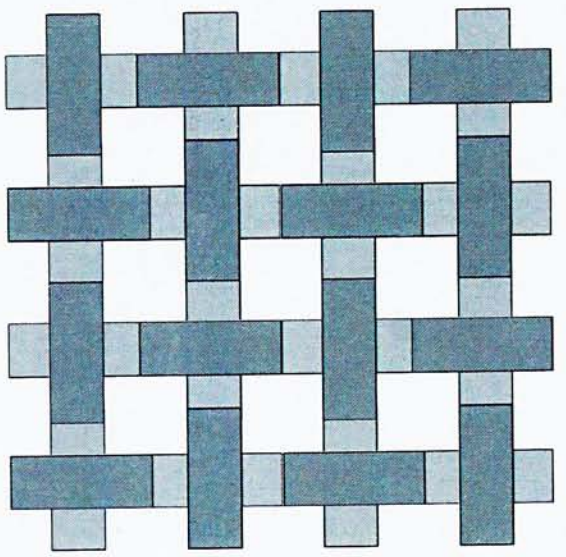




6.2.2 **Combination2**







6.3 Experiment

6.3.1 Integer Pavilion

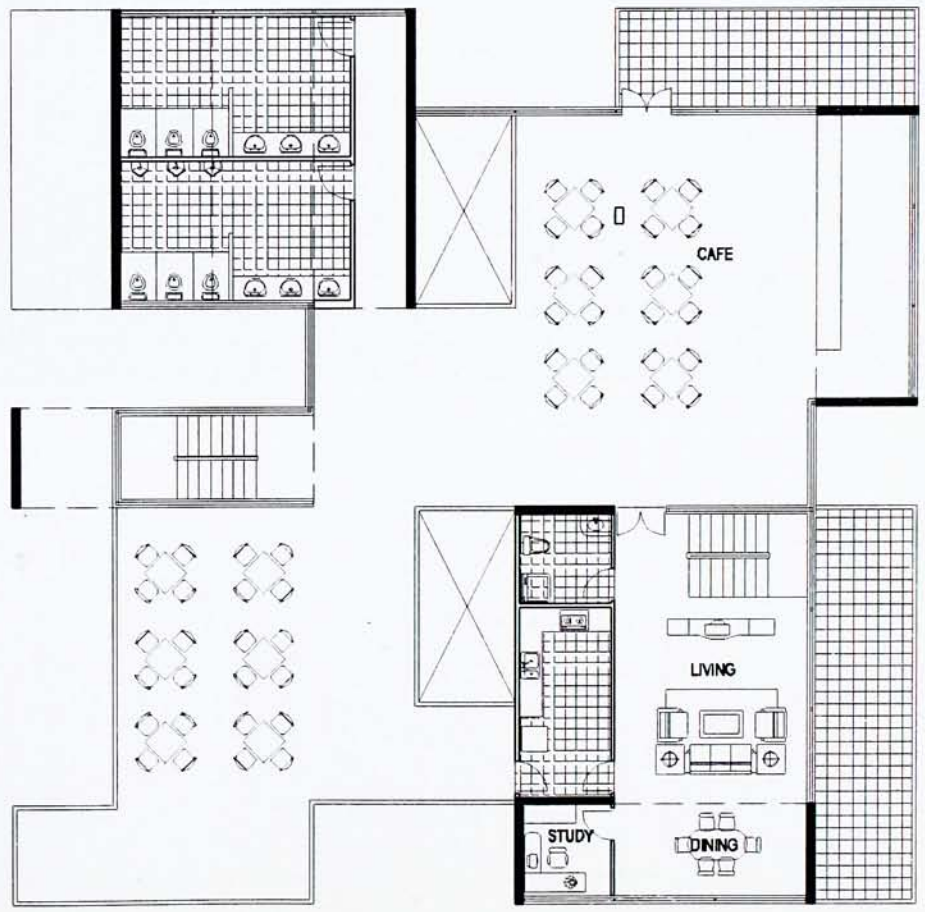
1. Show flat
2. Conference room
3. Exhibition
4. Guard
5. Store
6. Coffee
7. Ticket

Box unit
7.5M (L), 2.5M (W), 2.75M (H)

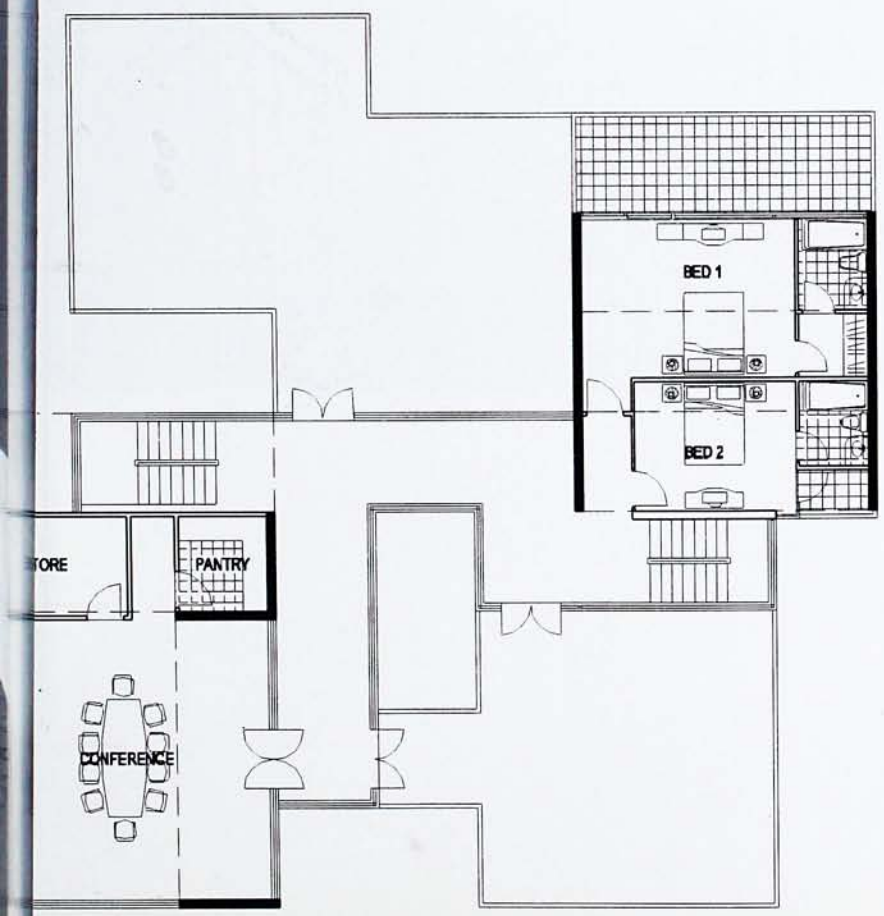
6.3.2 **Design 1**

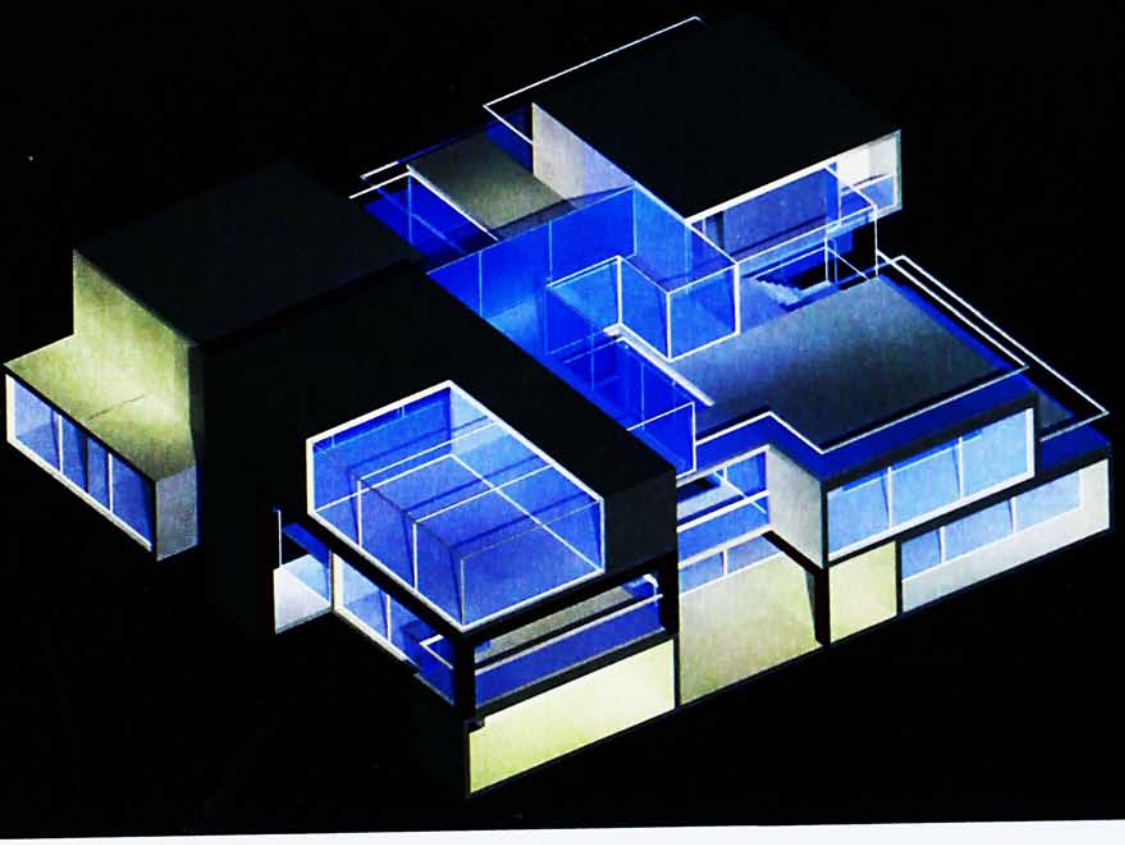
G/F Plan

1/F Plan

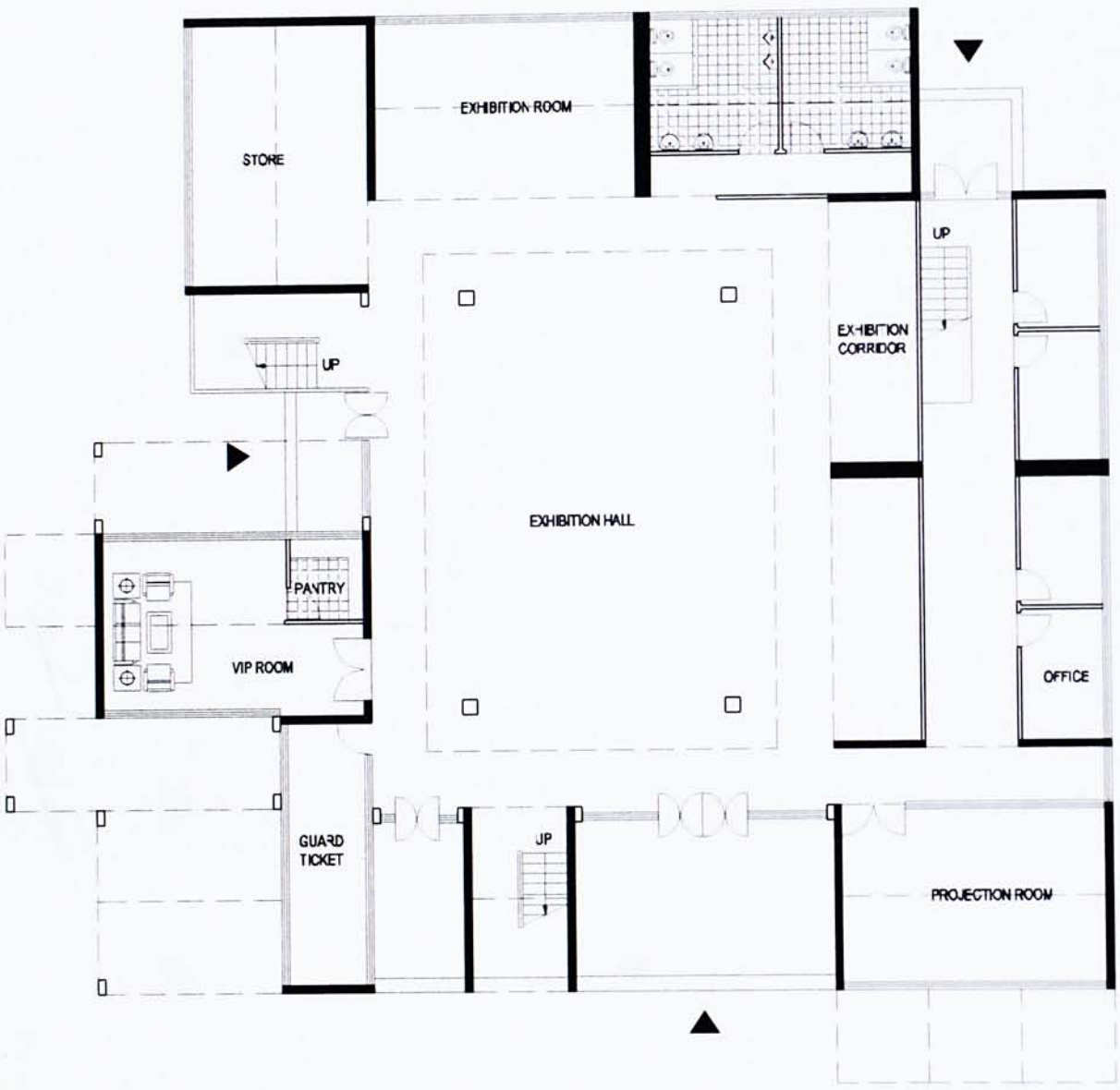


2/F Plan



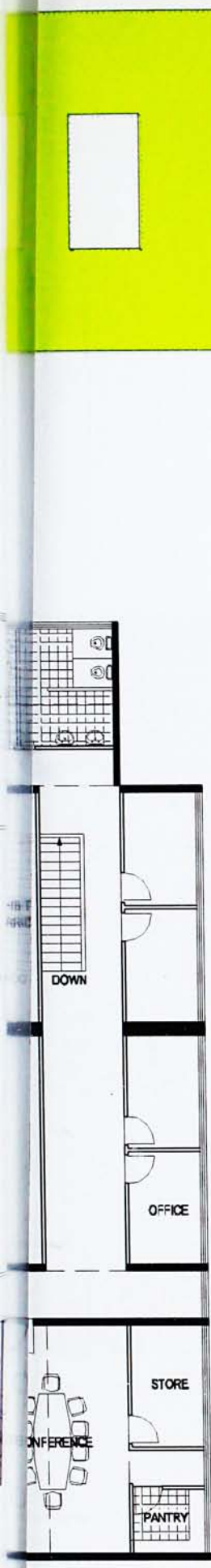


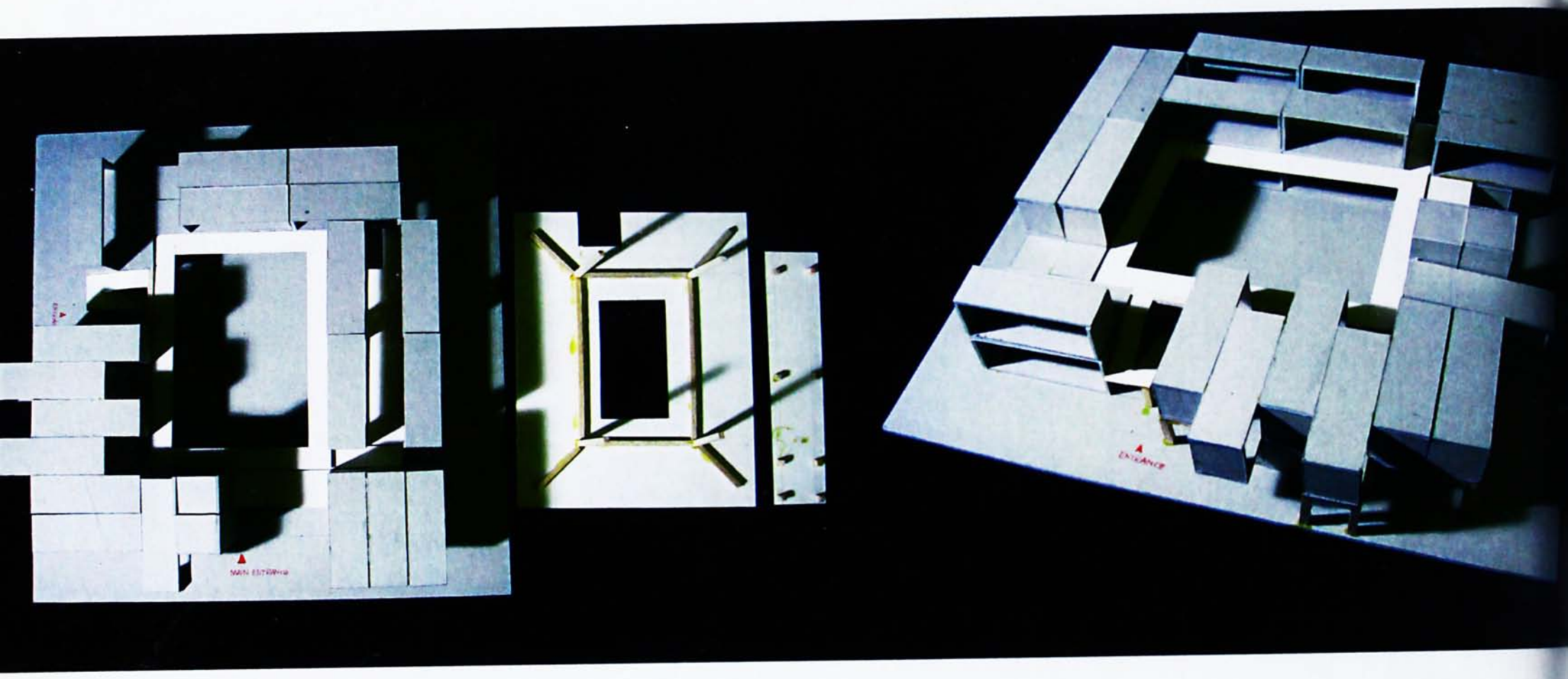
6.3.3 **Design 2**

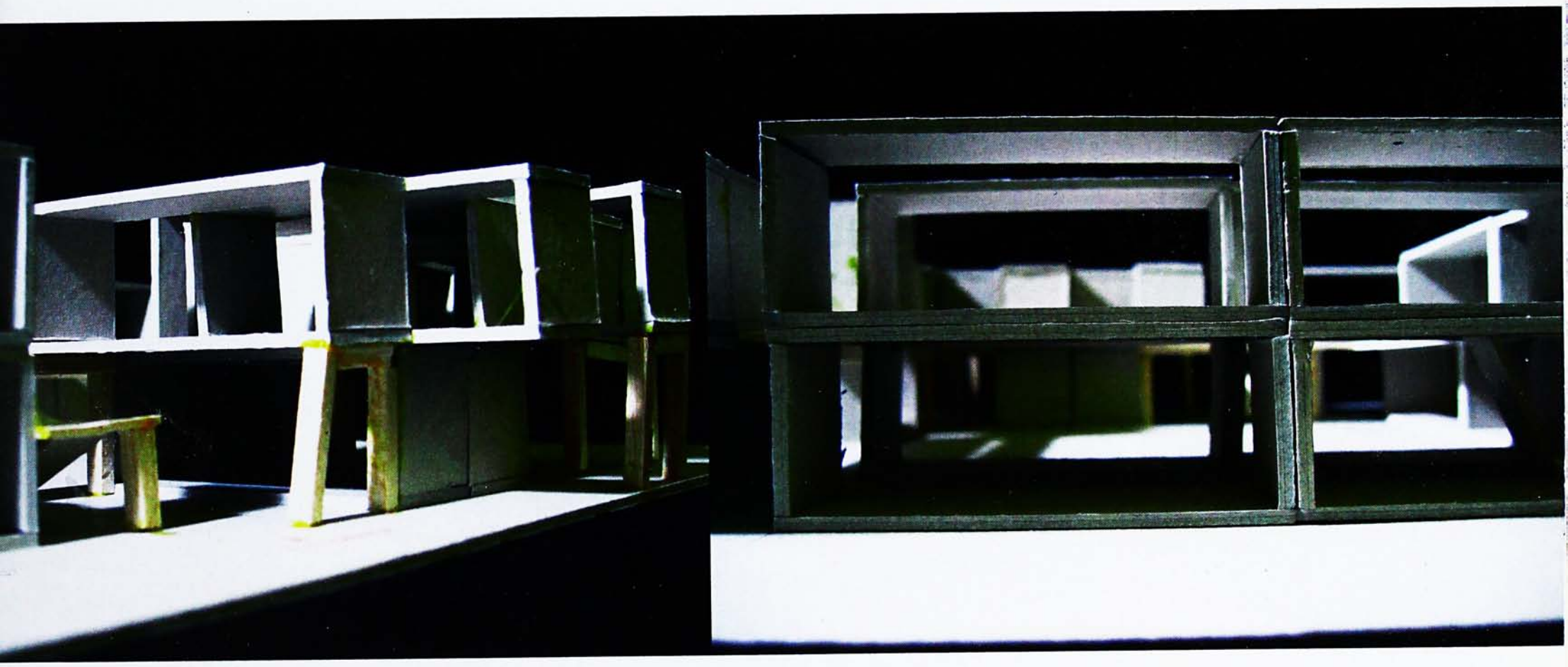


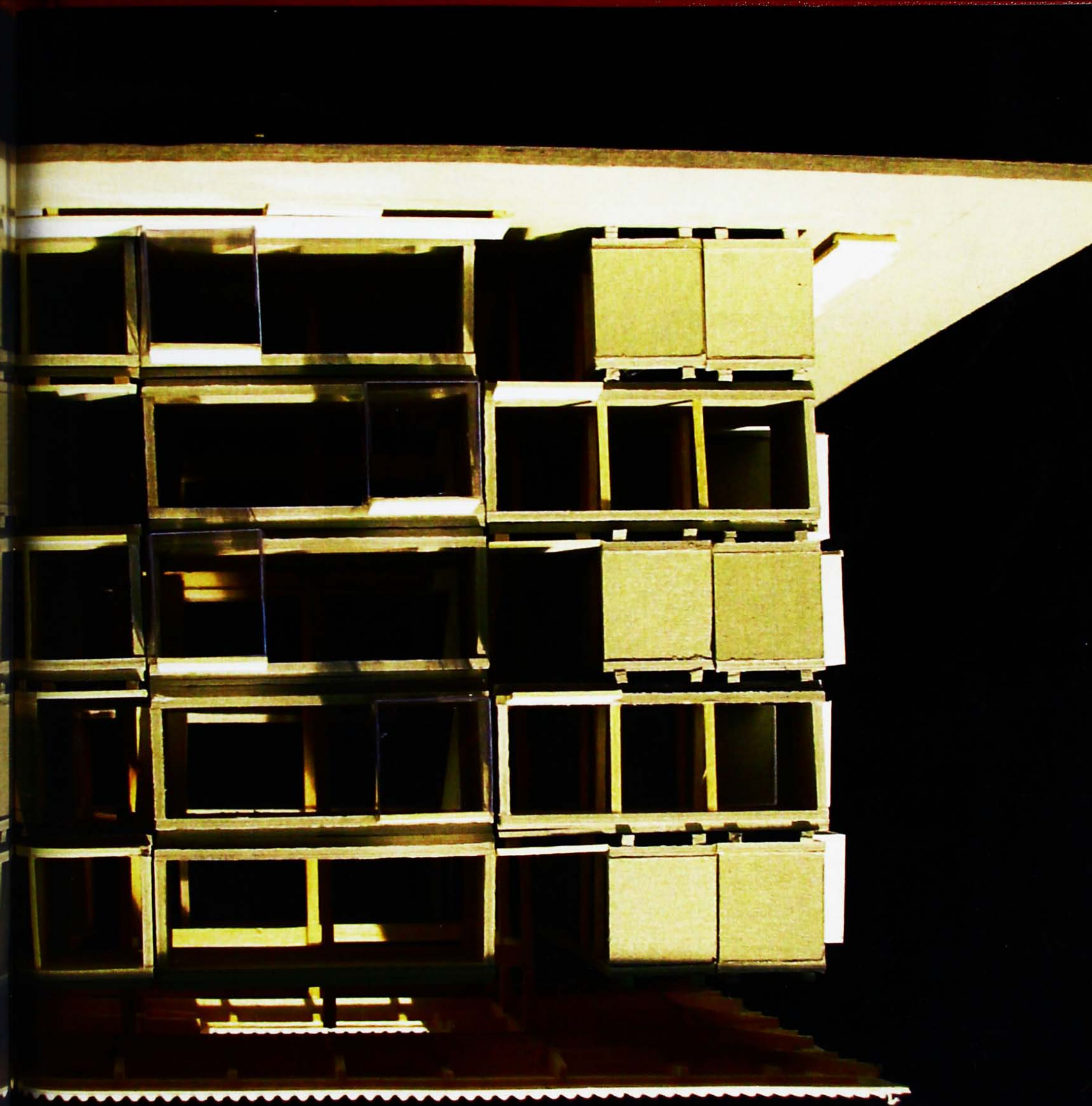
G/F Plan

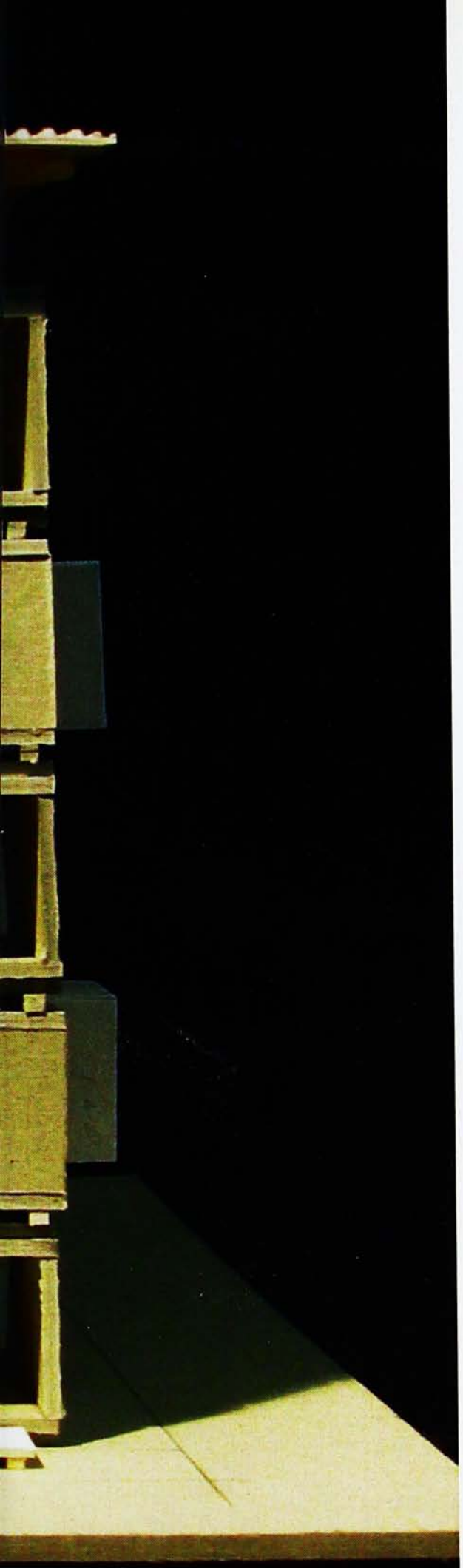
1/F Plan


DOWN
OFFICE
STORE
PANTRY


MAIN ENTRANCE
ENTRANCE







7. Design

Feb 2003 - Apr 2003

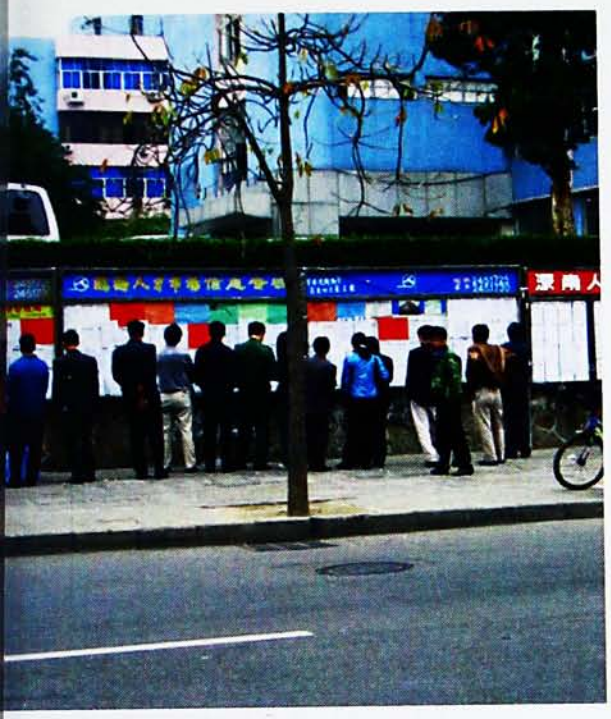
The final part of thesis is design application. Different site and programme cause different results obviously. At the same time, dissimilar materials also bring many variation. But even under the same site, programme and meterial, final result is not simplex neither.
In the final application, we only give one result to show the characteristic of box building.

7.1 Background

7.1.1 Housing for Temporary Population in Shen Zhen

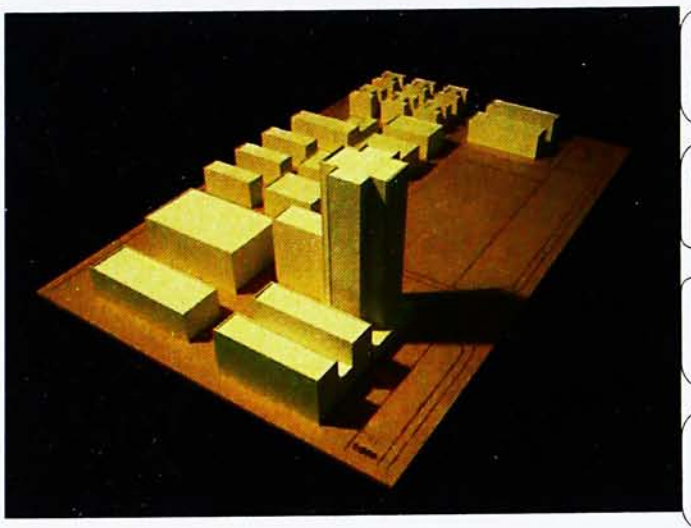
In 1980, Shenzhen, a small district town with approximate 310,000 residents was founded as the 1St Special Economic Zone in China. Nowadays, Shenzhen has a population of 4.7 million. Thereinto, permanent residents has 1.3 million, but temporary populario has 3.4 million. Most of them are young and working, the average age of which is only 28.

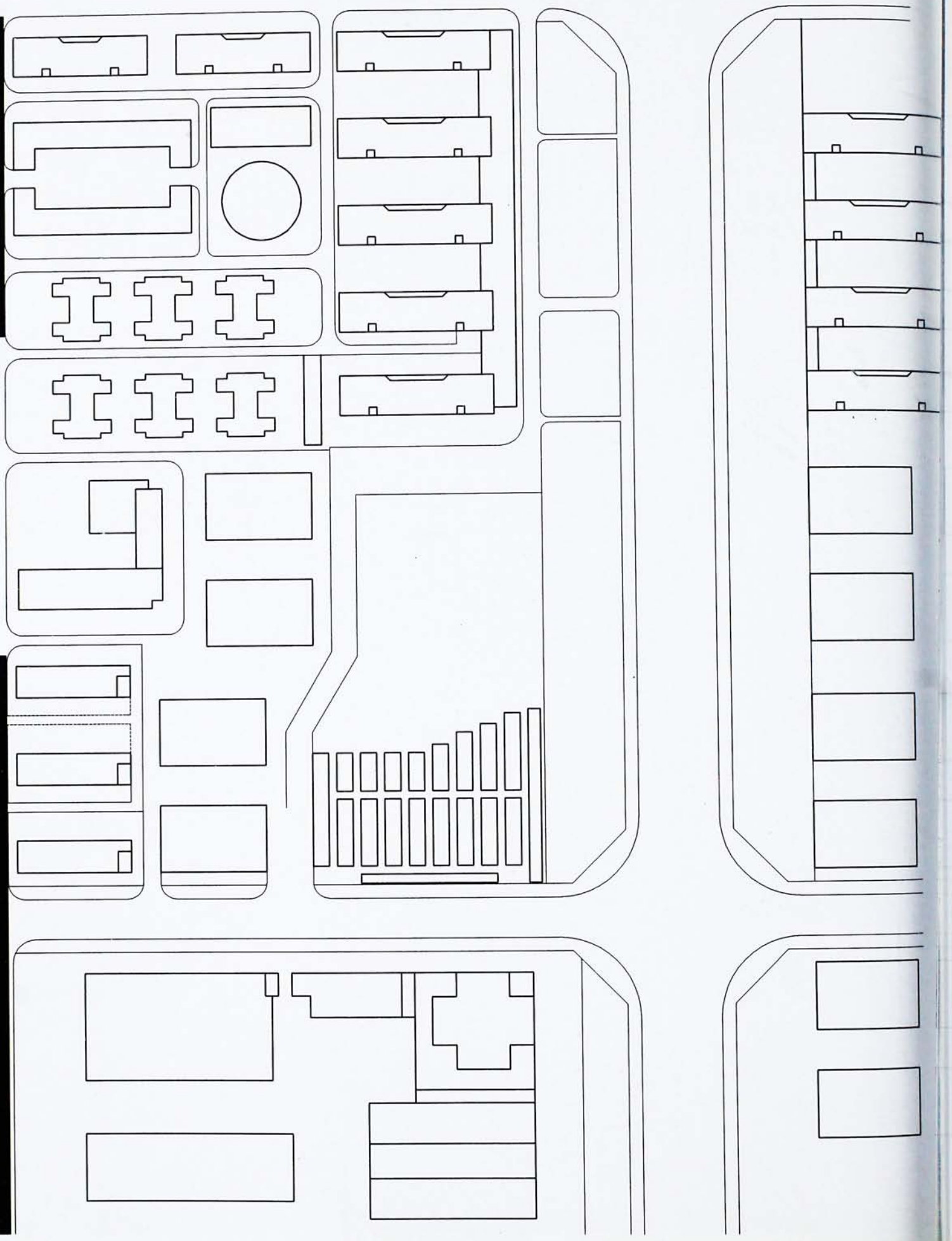
Because of the changeability of work, the temporary population usually change their living area. So the housing for temporary population should afford the most flexible room to the different person.
It is also necessary to build the housing quickly to be in response to the need of the different site.

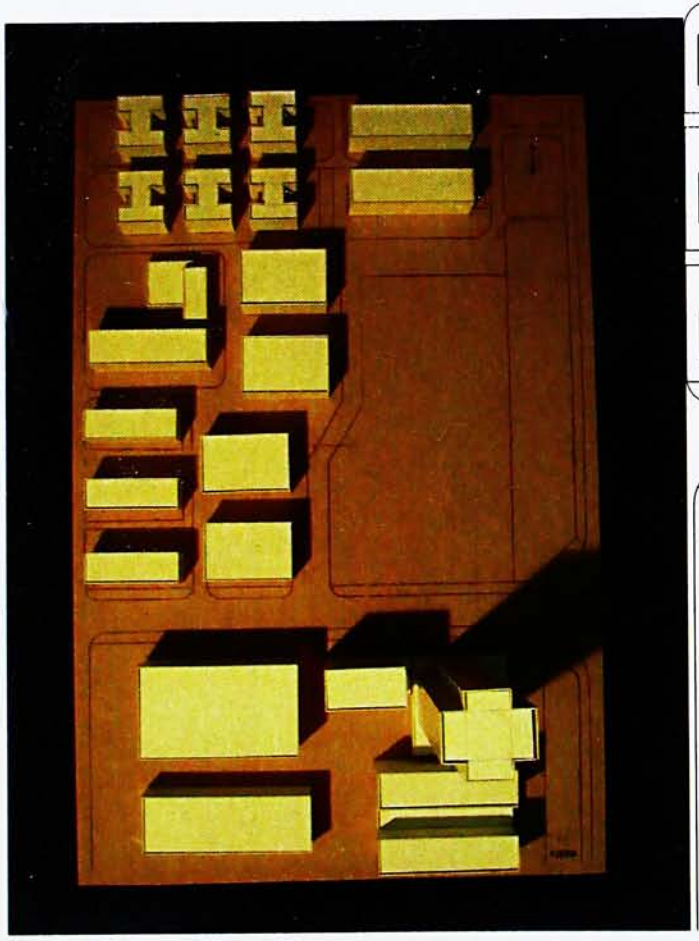



效果图施工图
招牌刻字
新新文具

7.1.2 **Site**







7.2 Research Issues

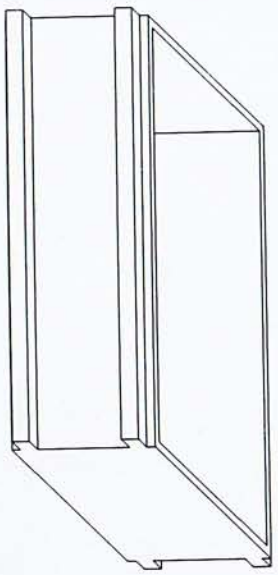
Based on the different situation, box buildings are adapted to fulfil different role. We specifically look at four issues of adaptation and response:

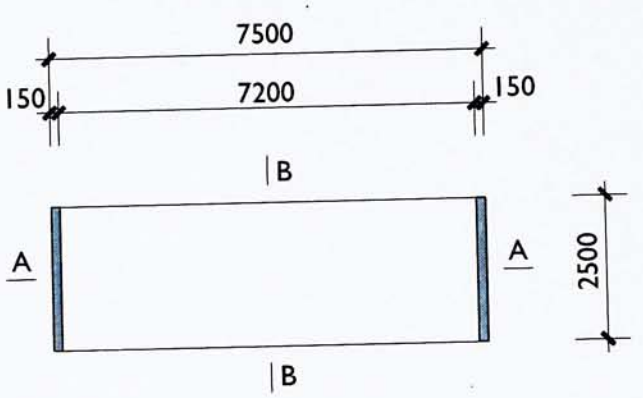
1. Functional **Adaptablity**
2. **Variety** of Sapce and Structure
3. **Flexbility** of high speed construction
4. **Multiformity** of tectonics expression

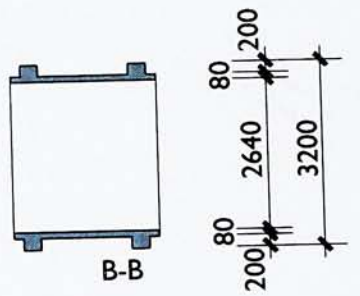
7.3 **Box Design**

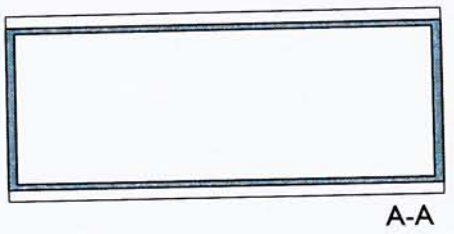
7.3.1 **One Type Box**

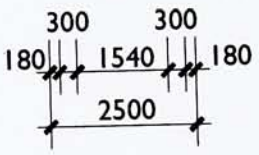
In the thesis design, all the explorations and designs are based on the only one type box.
Material:
Reinforced concrete

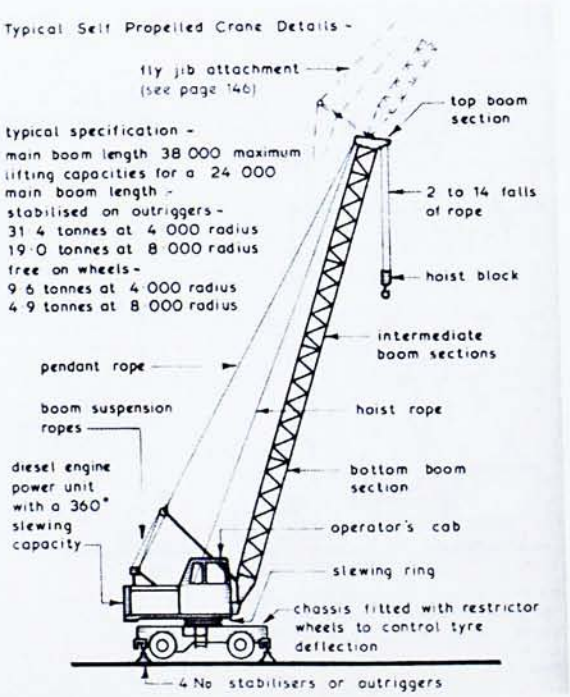


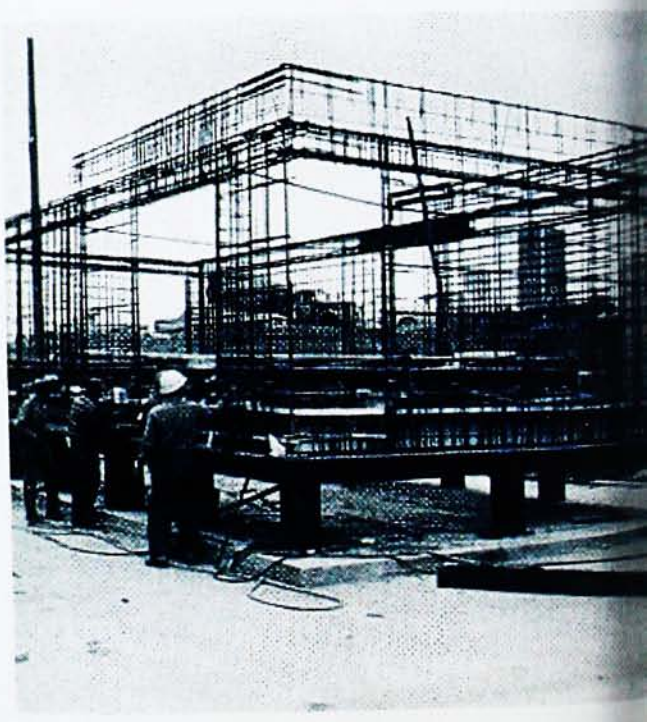






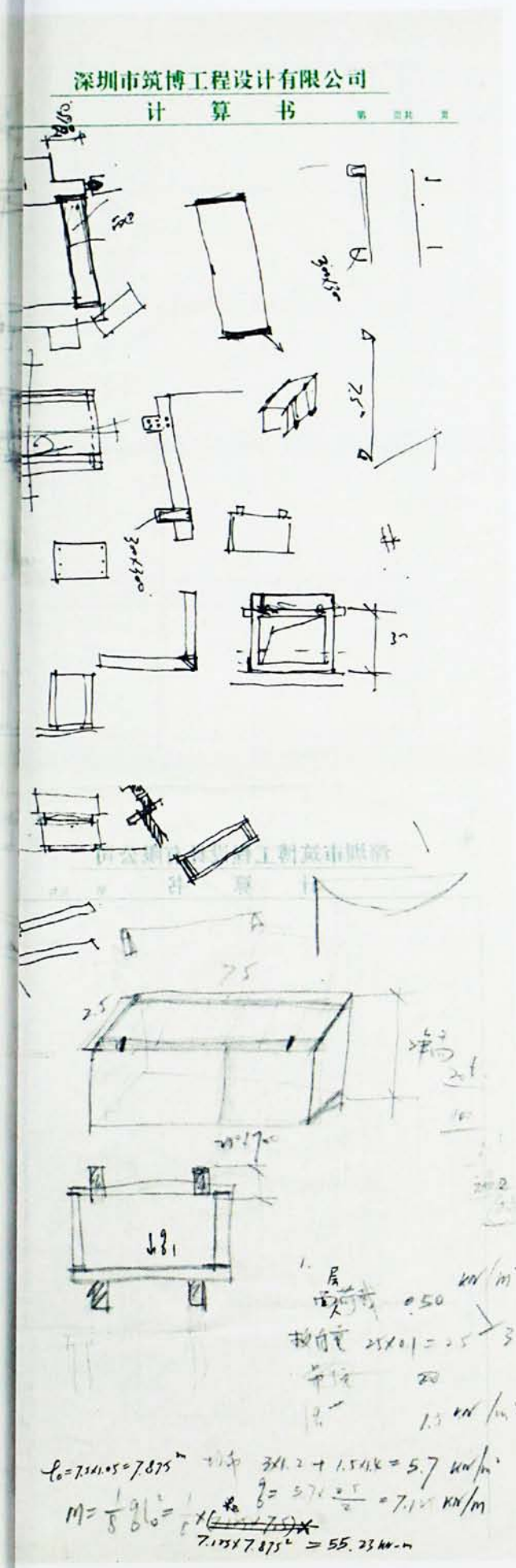


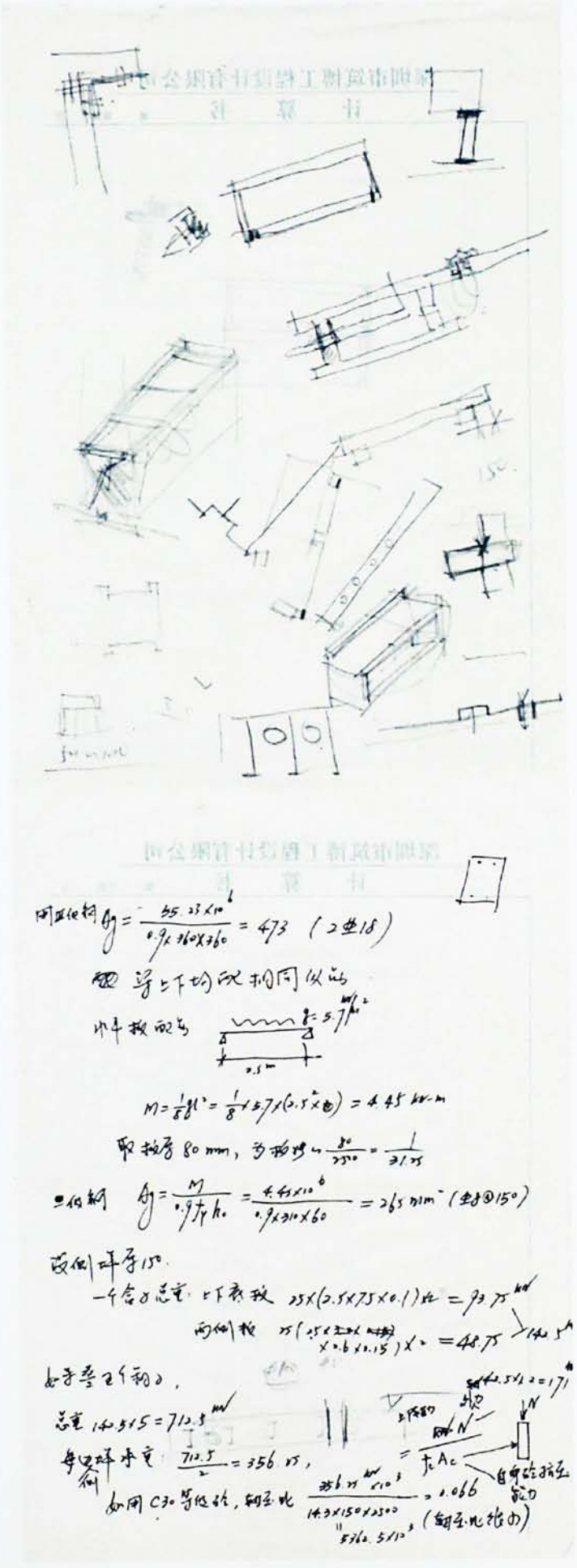




7.3.2 **Structural Calculation**

Calculated by Ms. Wei Xiaoying (Structural Engineer, Shen Zhen Zhu Bo Design & Engineering Co.,Ltd)

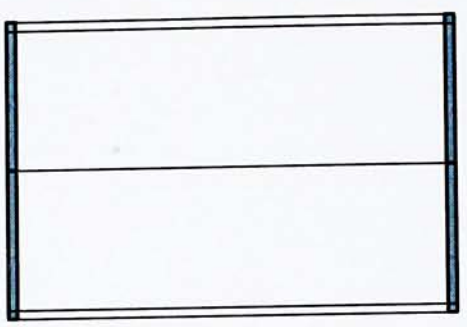


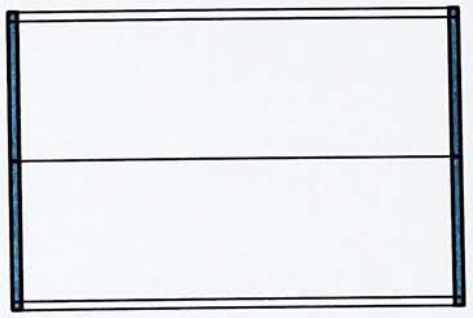


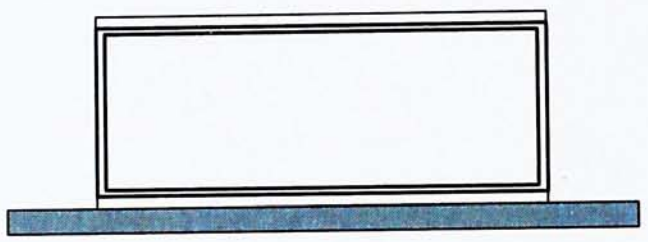
7.4 **Combination**

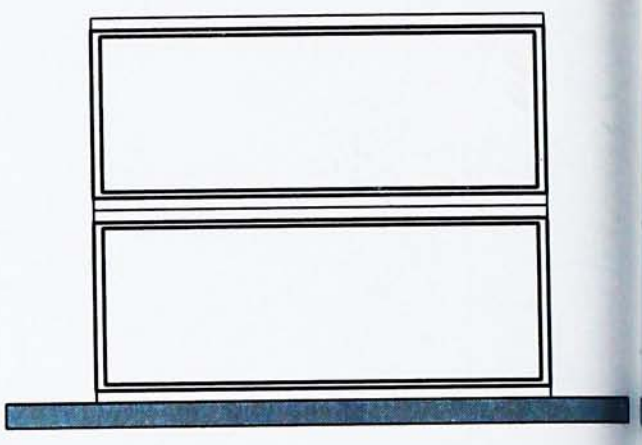
Because of the construction and dimention of that reinforced box, the combinations of boxes are based on the two parallel box units.
There are three domain vertical combination types:
Stacked, Slide and Overlap.

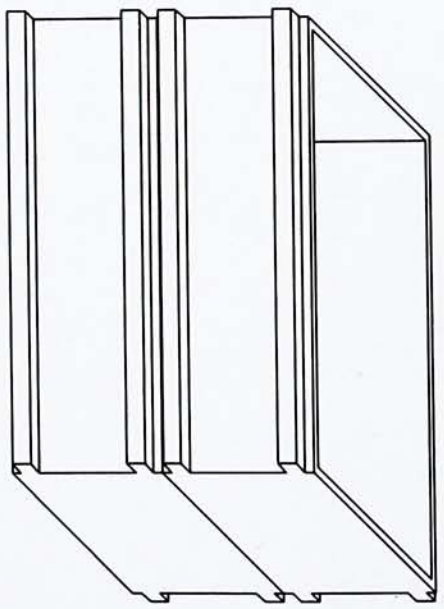
Especially in last two combination, the additional structural elements should be used to support the upper box units.

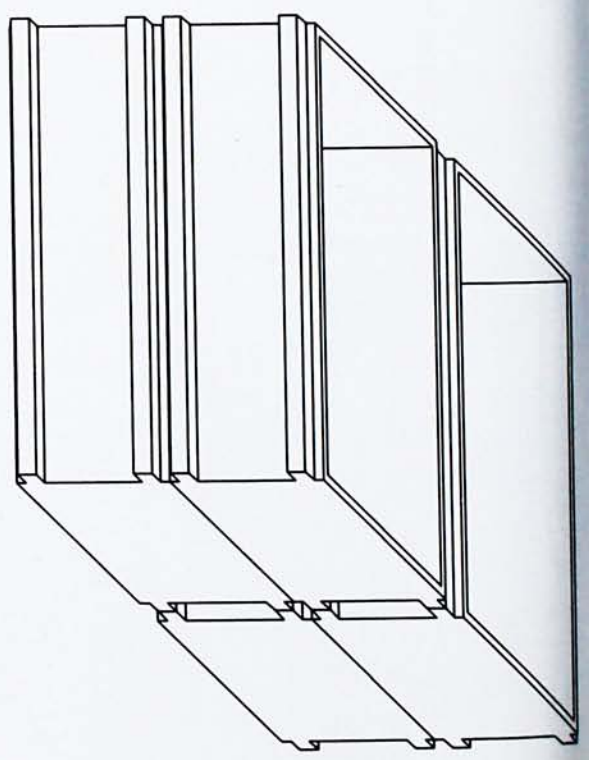


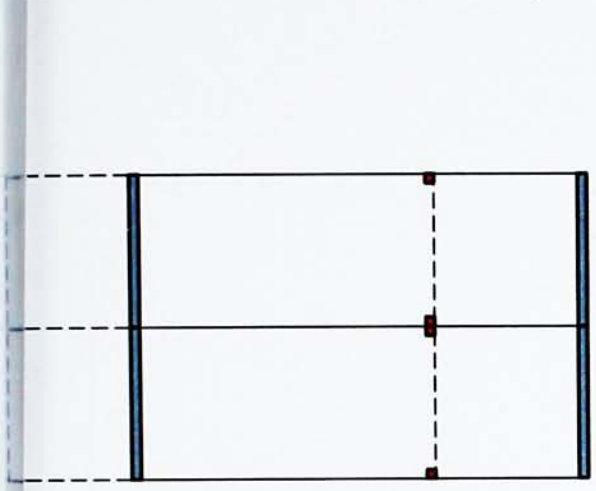


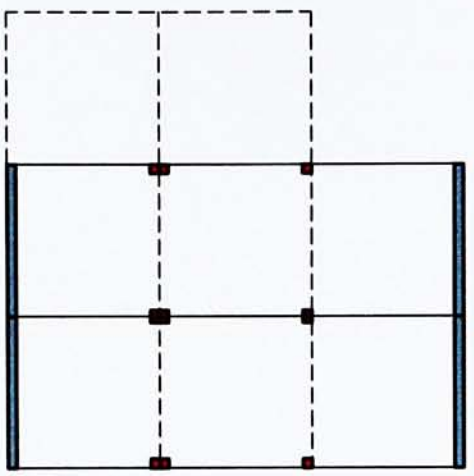


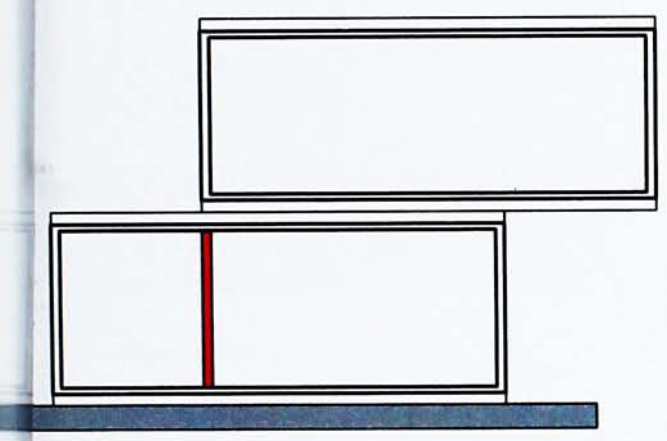


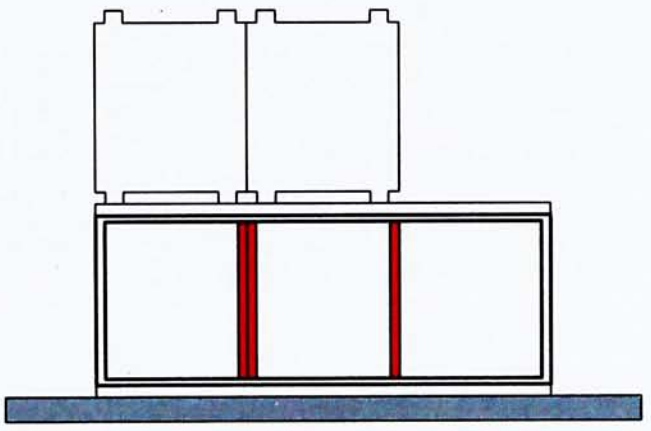


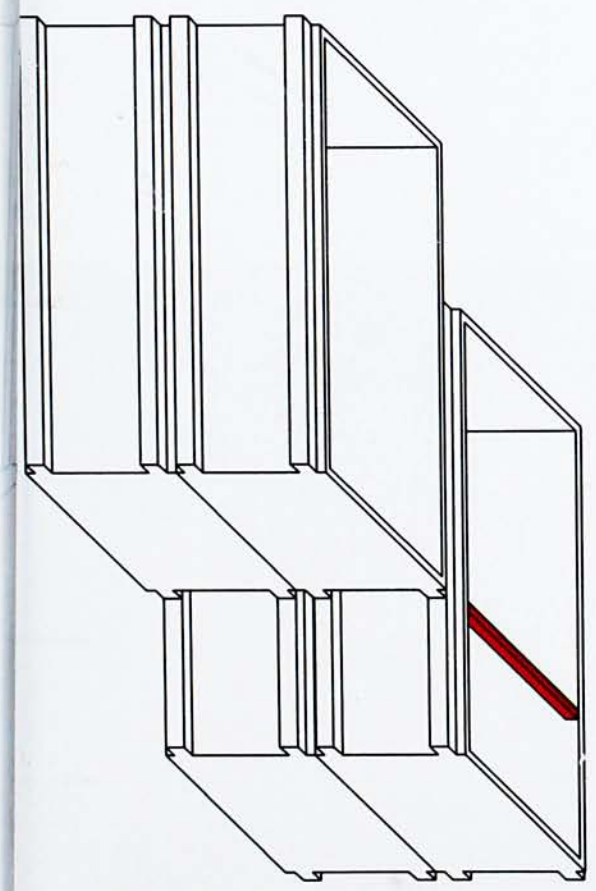


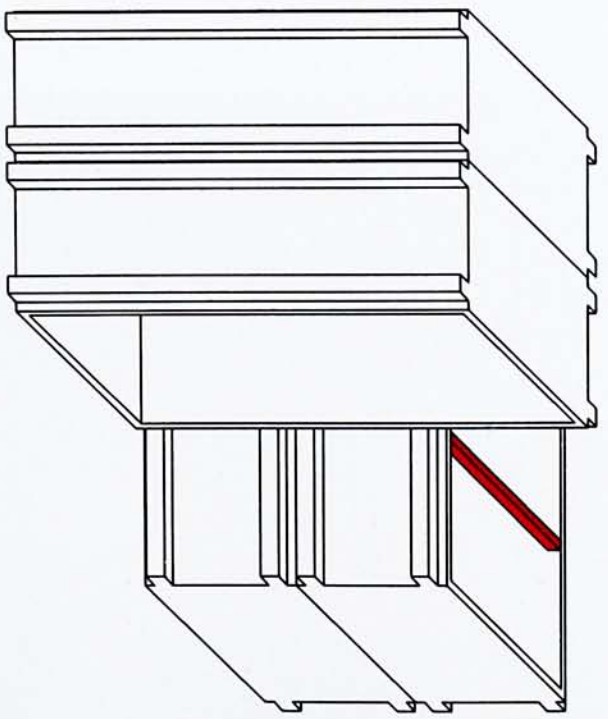








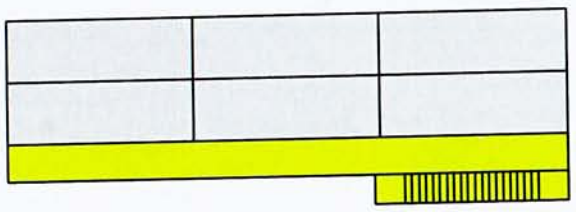


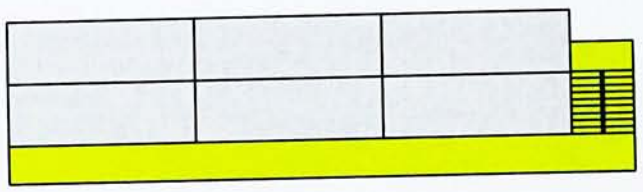


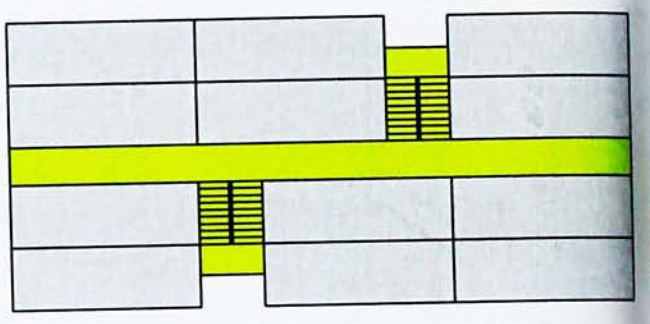
7.5 **Formation**

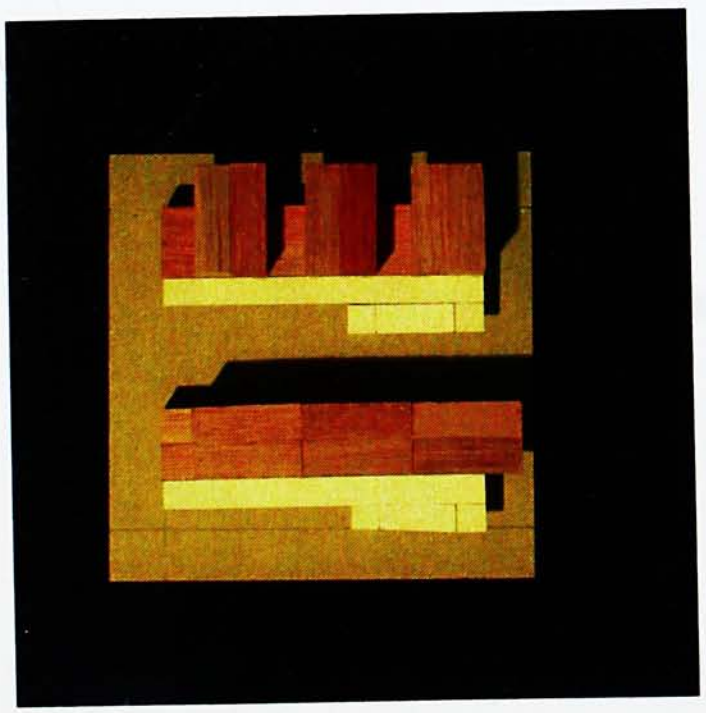
7.5.1 **Linear**

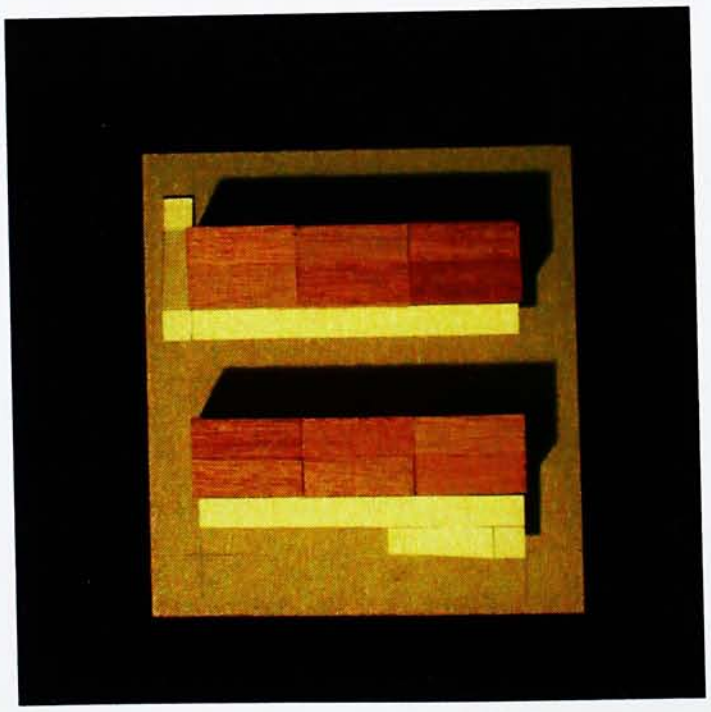
According to the relationship of boxes and circulation, box buildings are organized and designed in response to the different site.
There are three types:
Linear
Courtyard
Tower

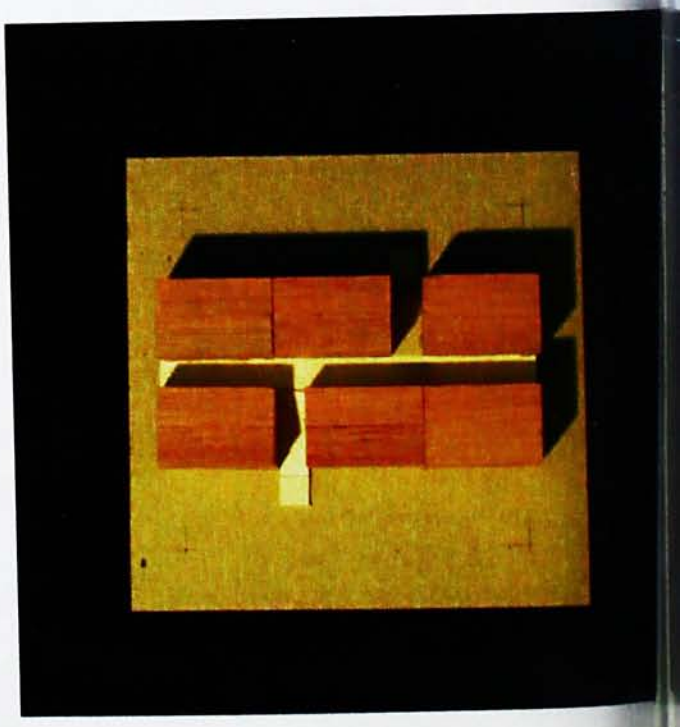


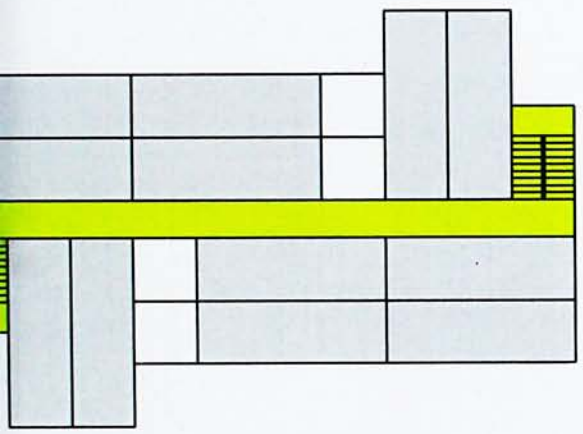


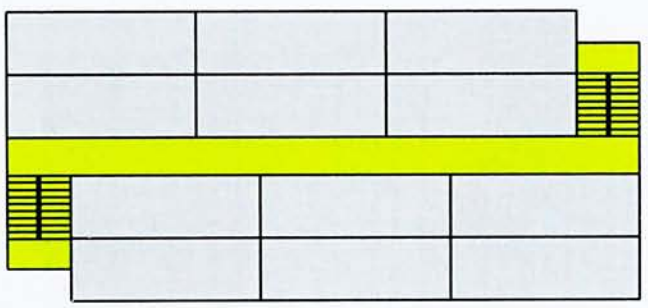


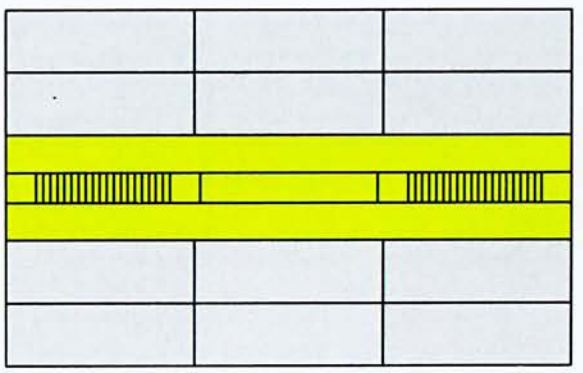


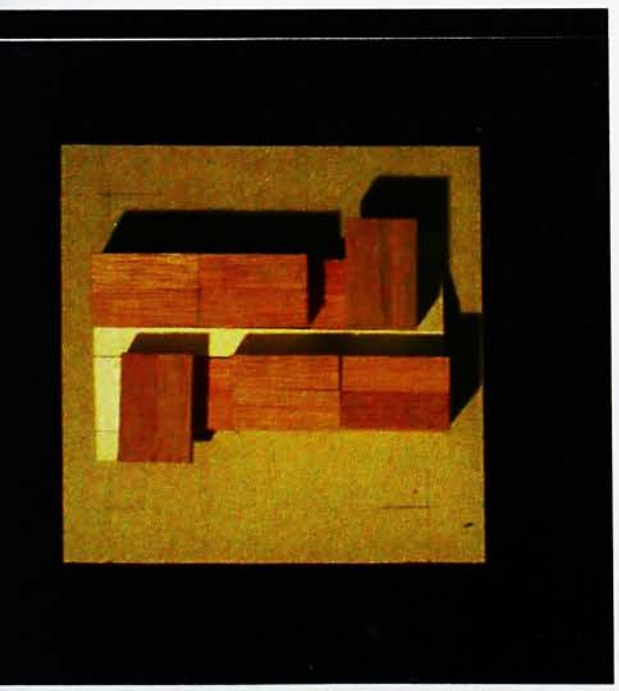


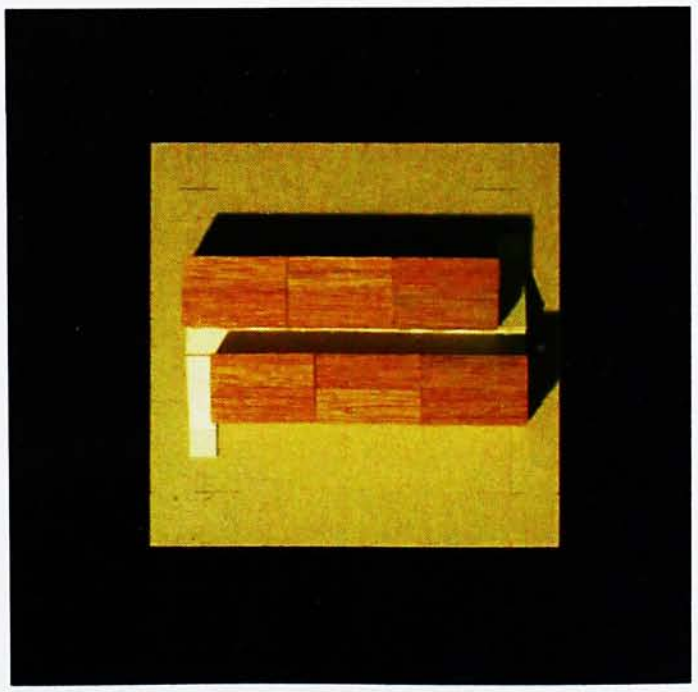


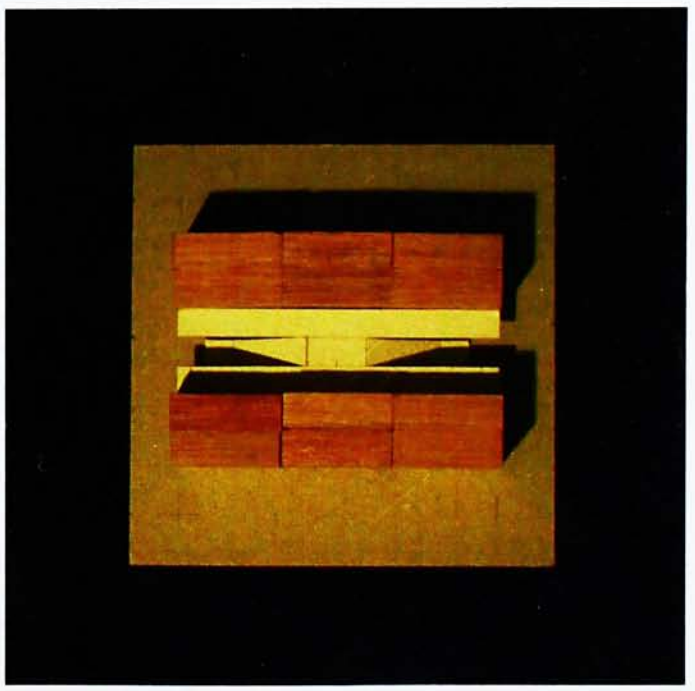




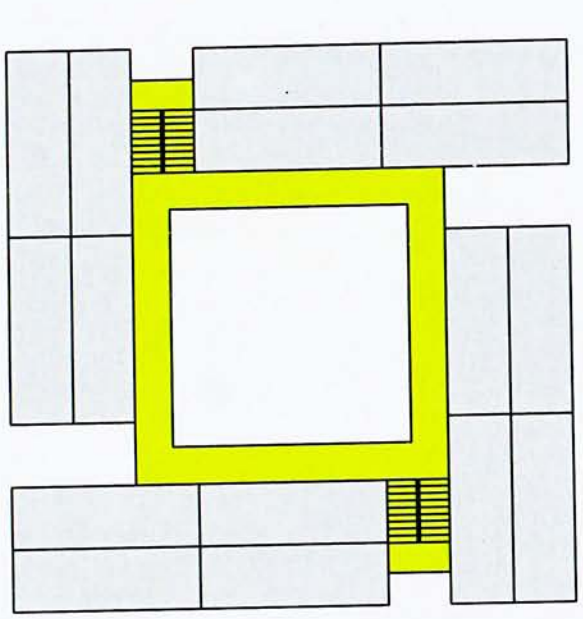


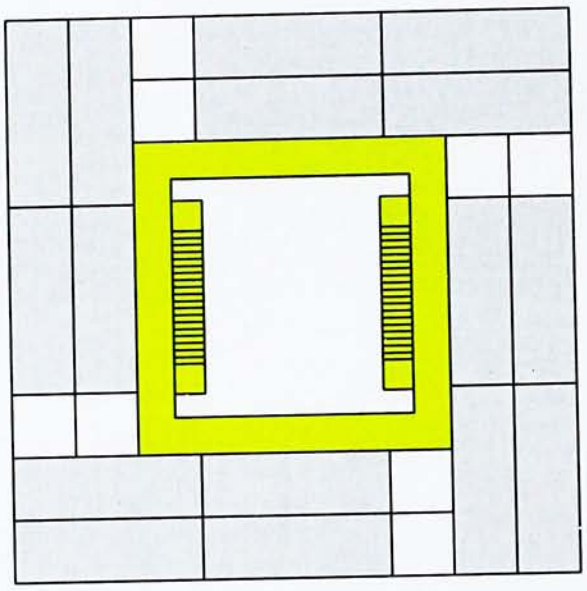


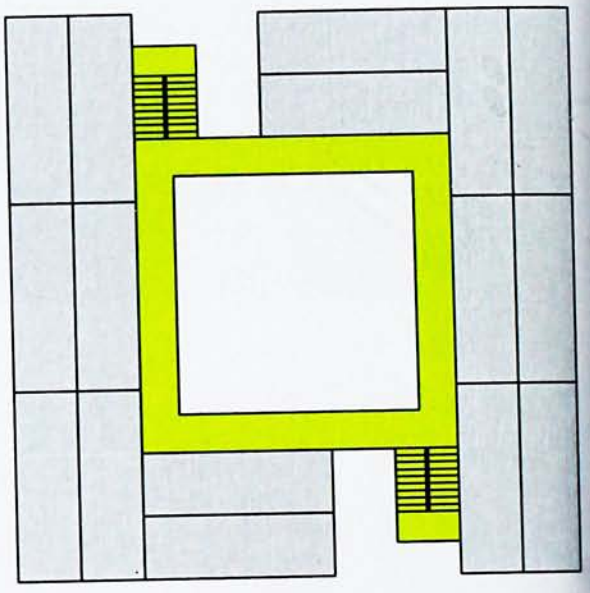


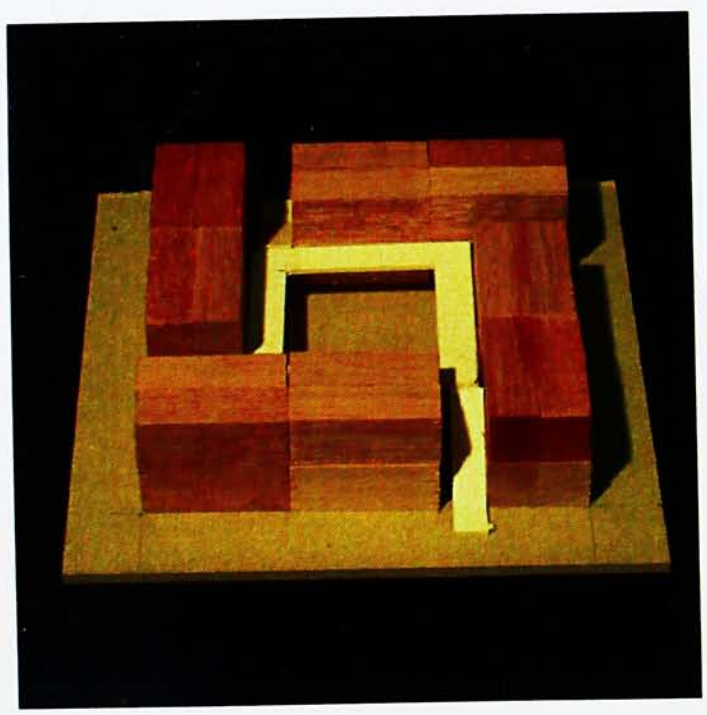


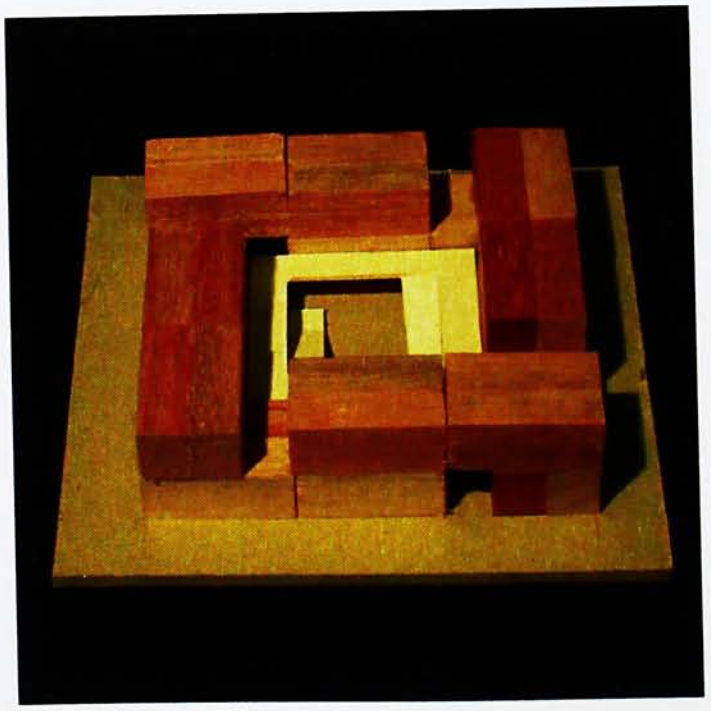
7.5.2 **Courtyard**

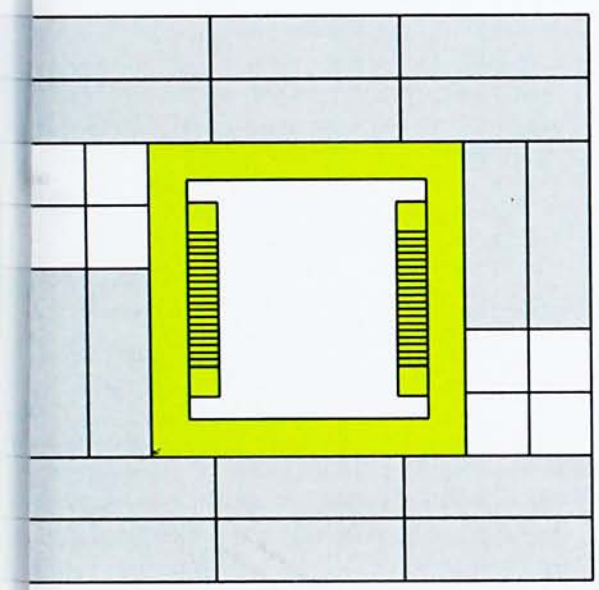


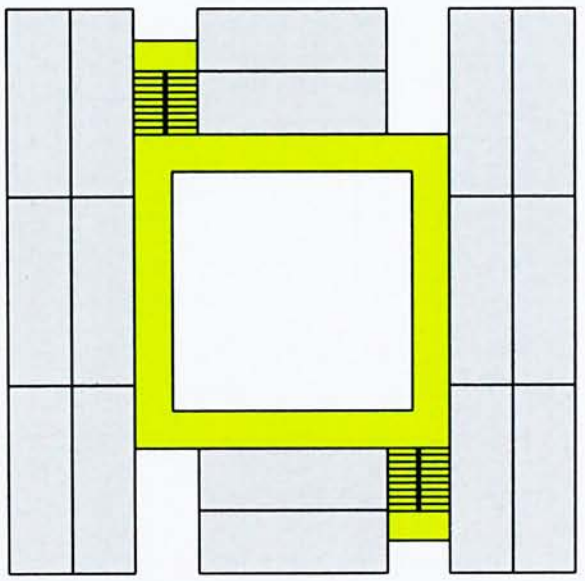


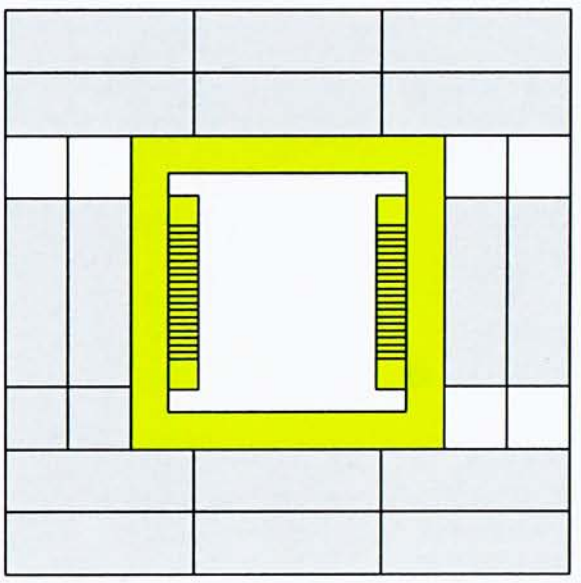


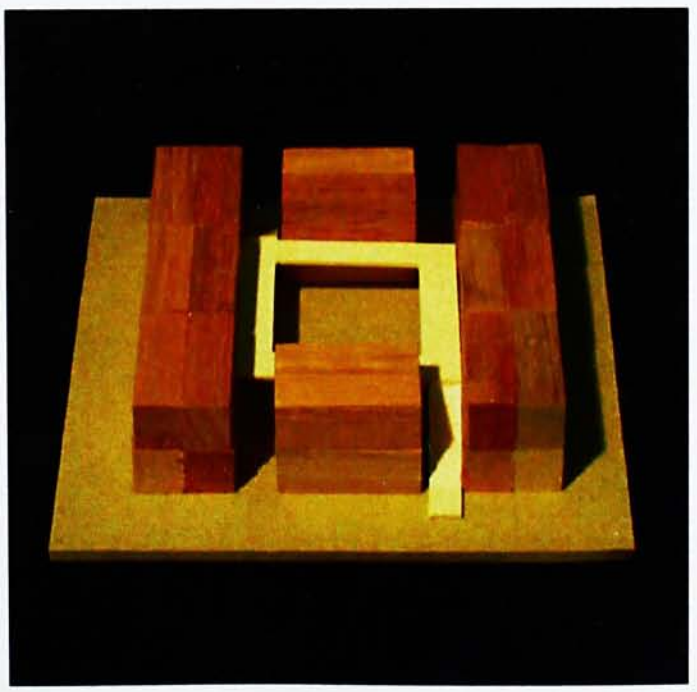


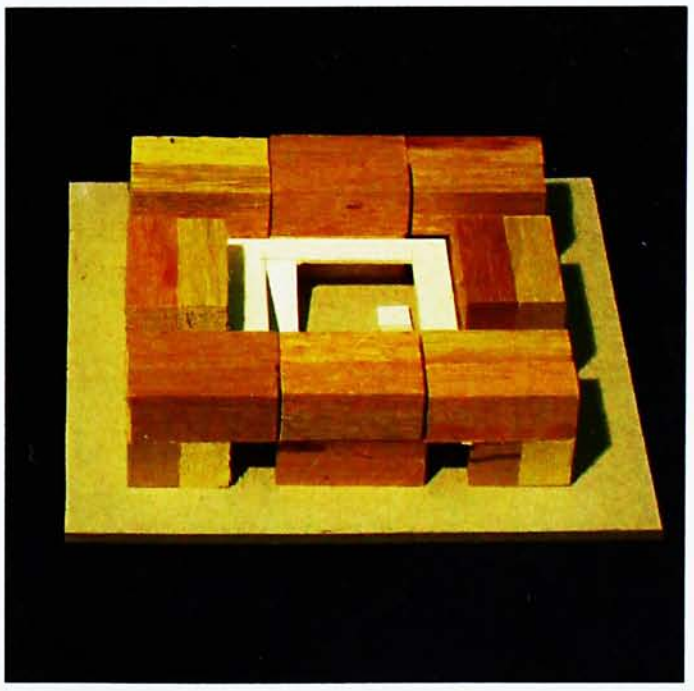




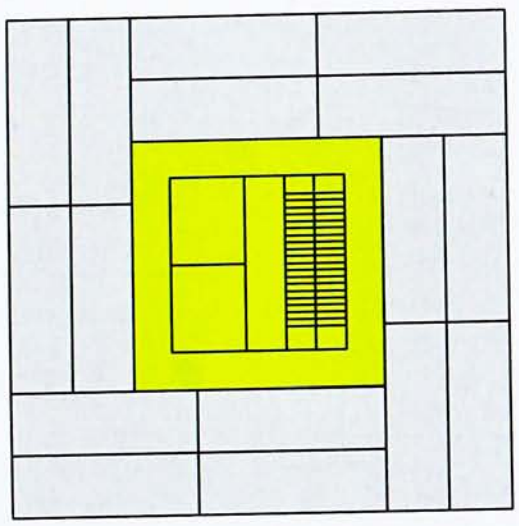


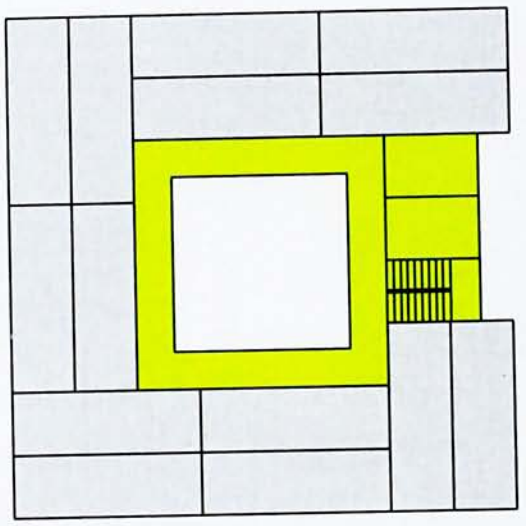


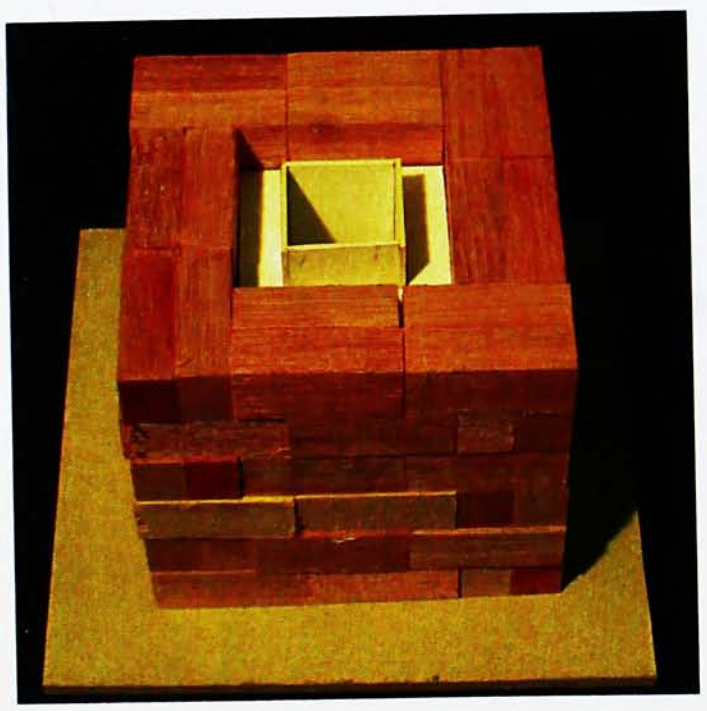


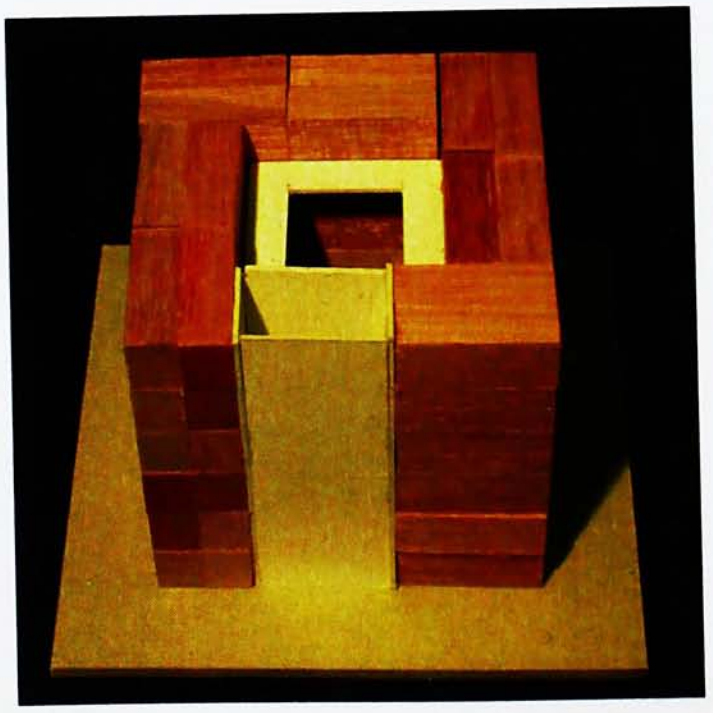


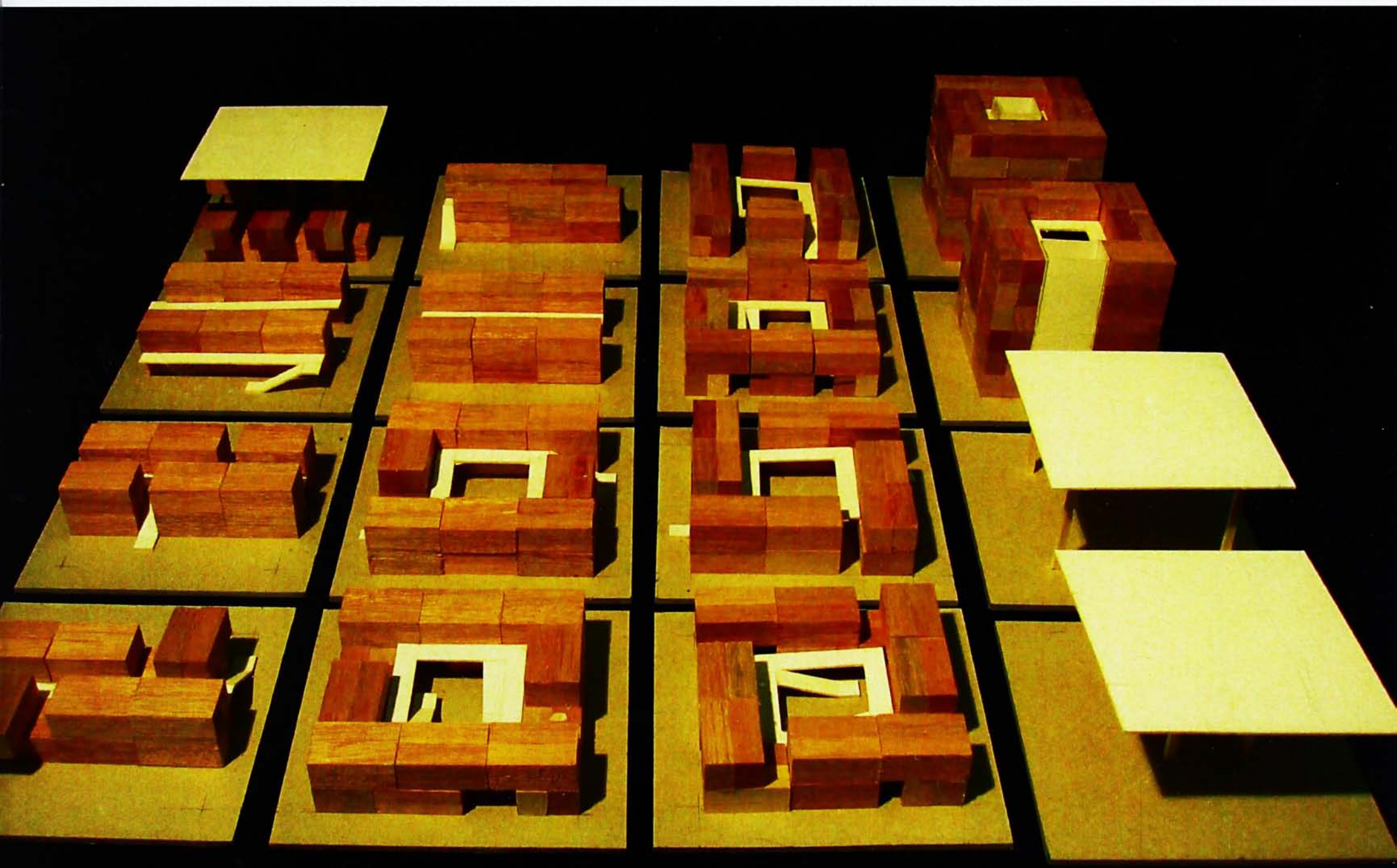
7.5.3 **Tower**





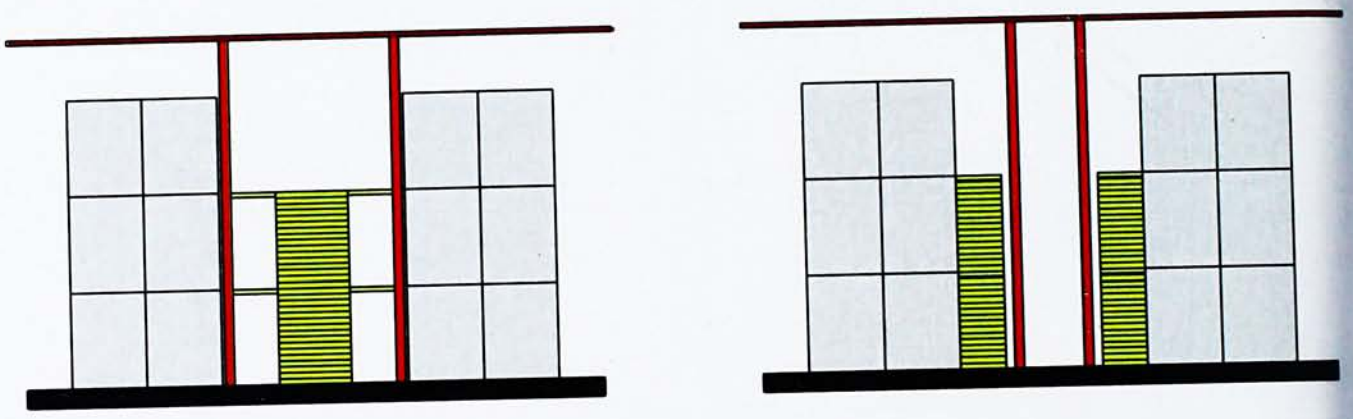


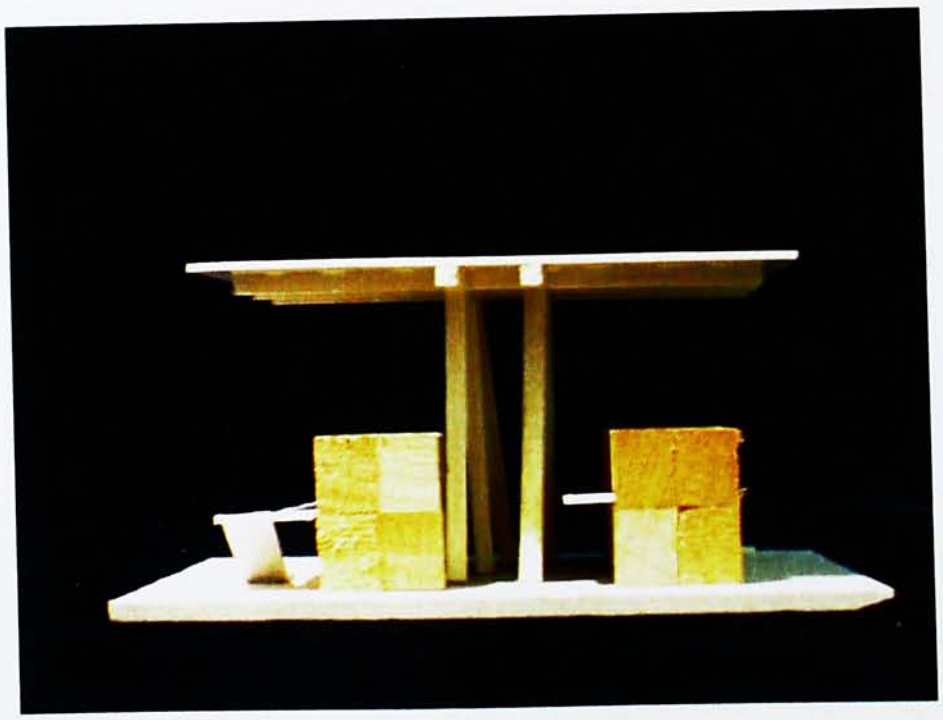


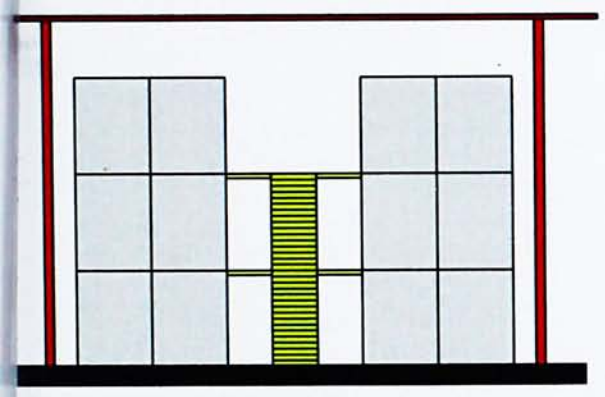


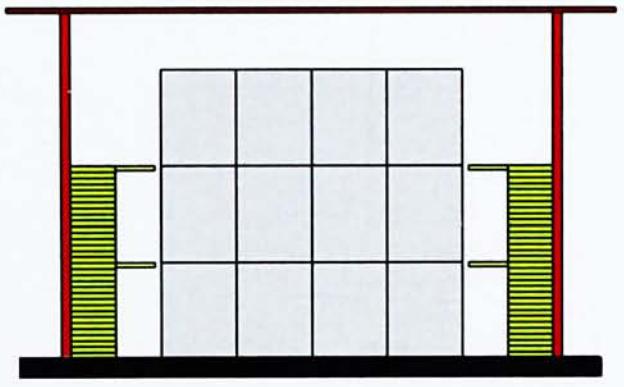
7.6 **Structure**

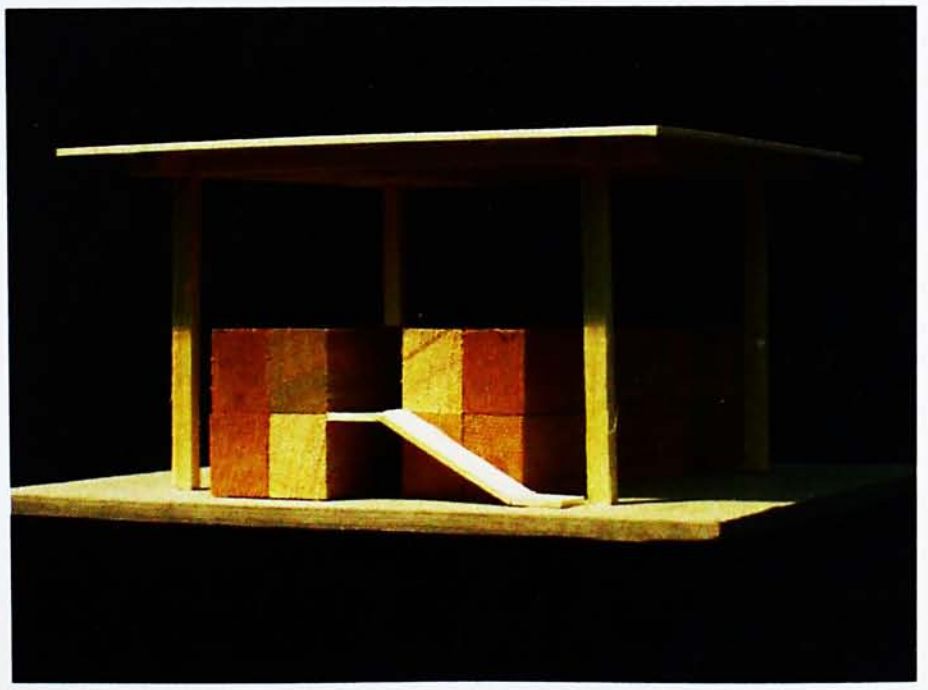
Because the material of box is reinforced concrete, the choice of structure system is independence system.





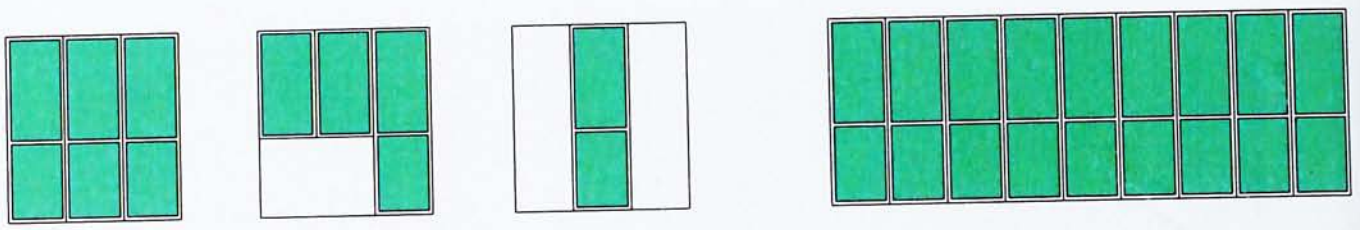


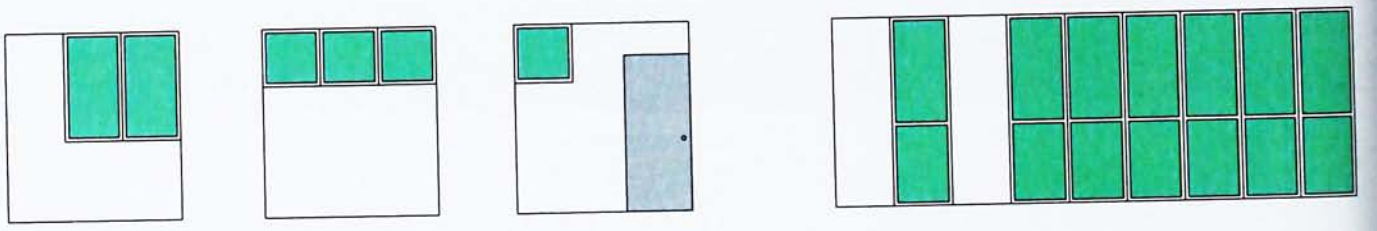


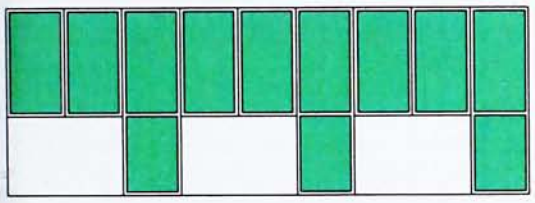


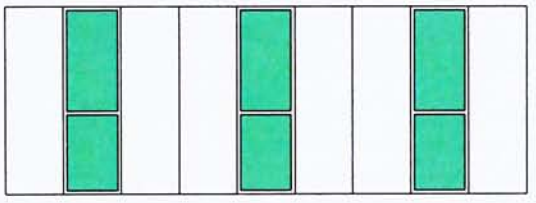
7.7 **Additional Wall**

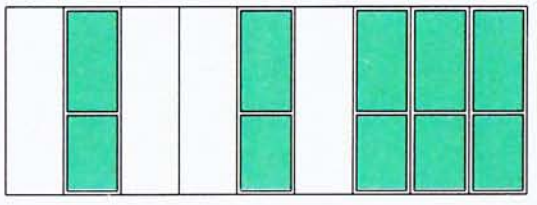
The additional wall elements of box can be also prefabricated in the factory. Based on the different room, we can create different combinations of additional wall elements.

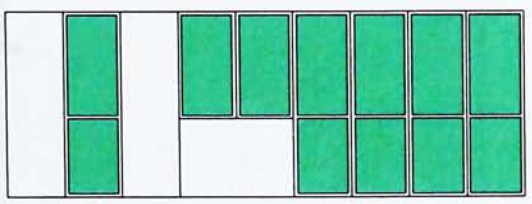


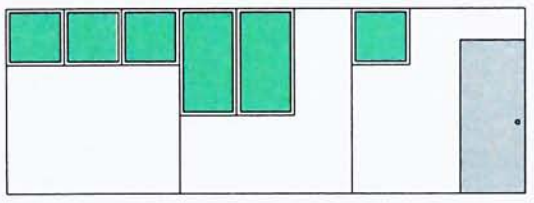


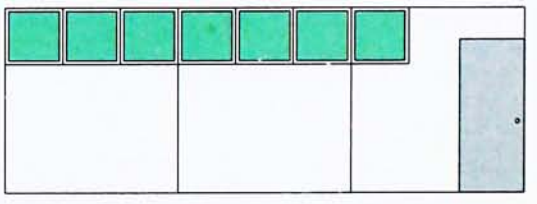






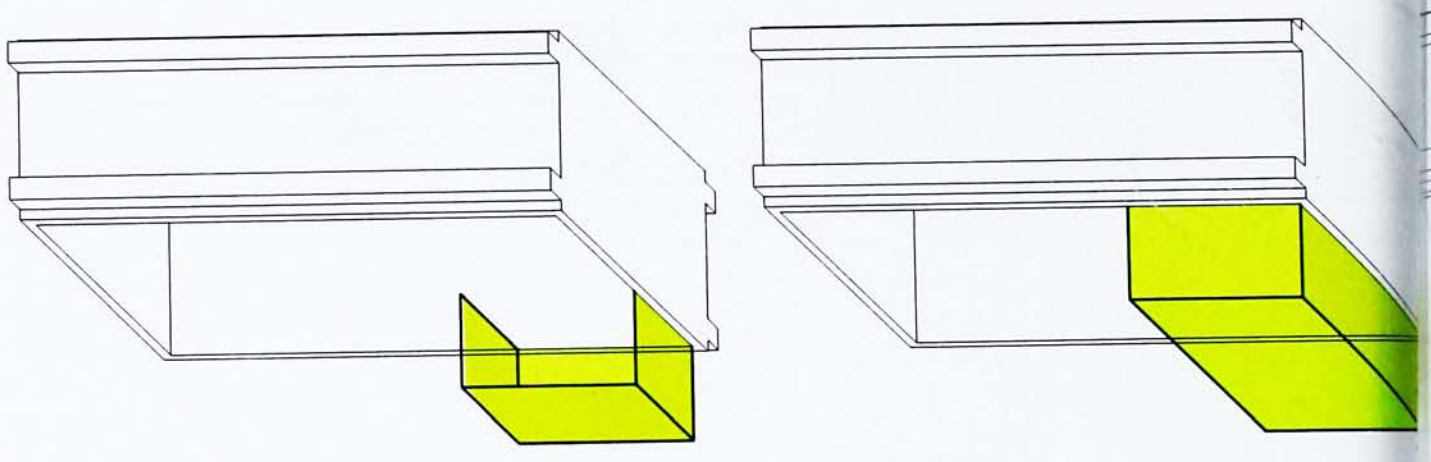


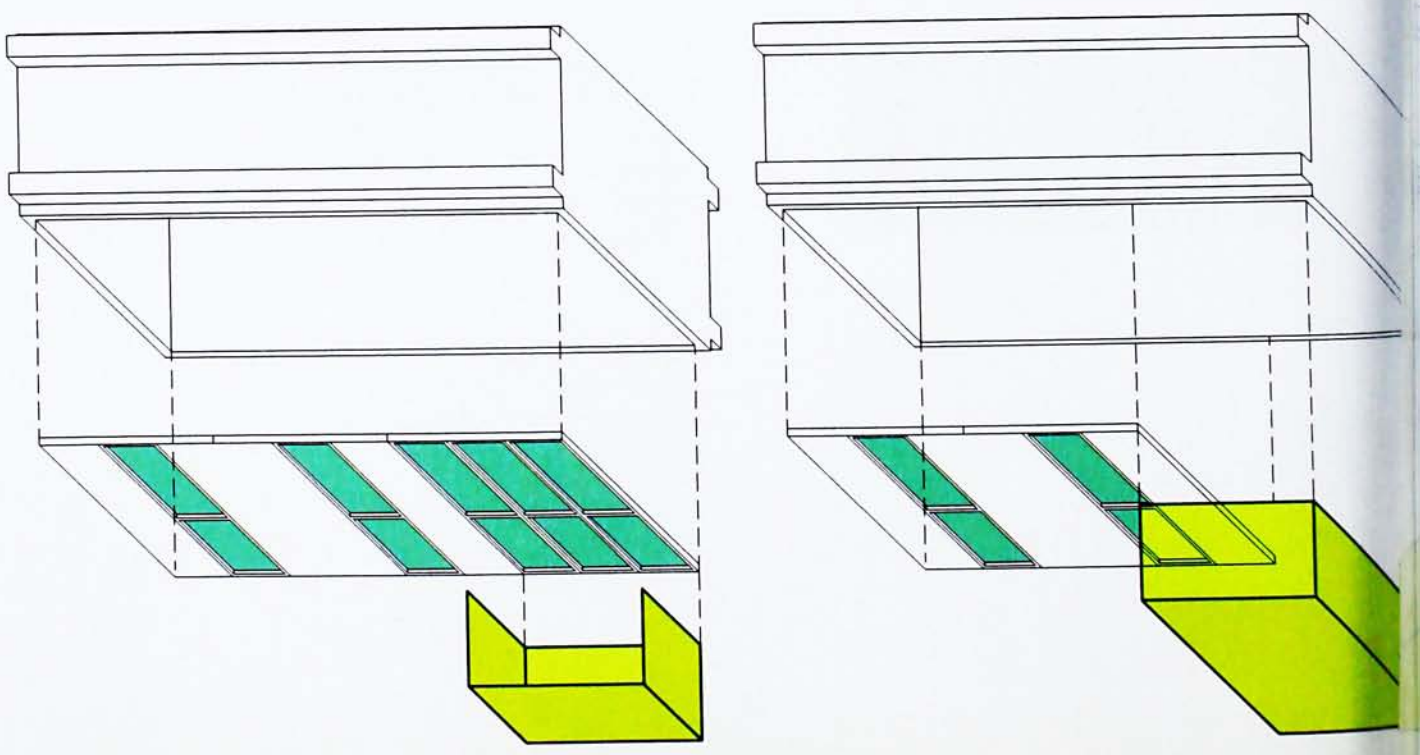


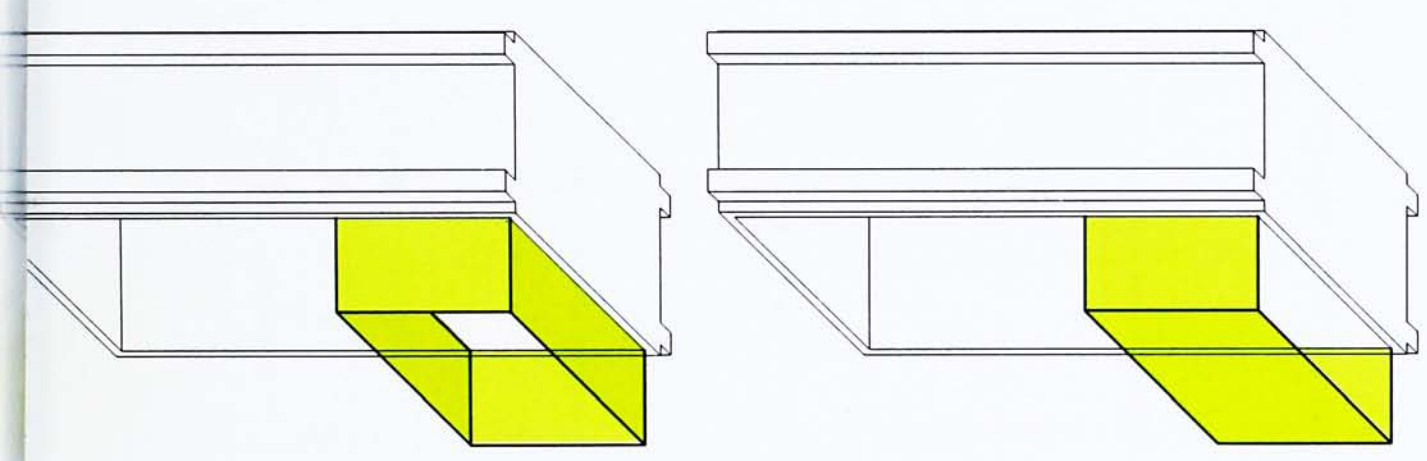


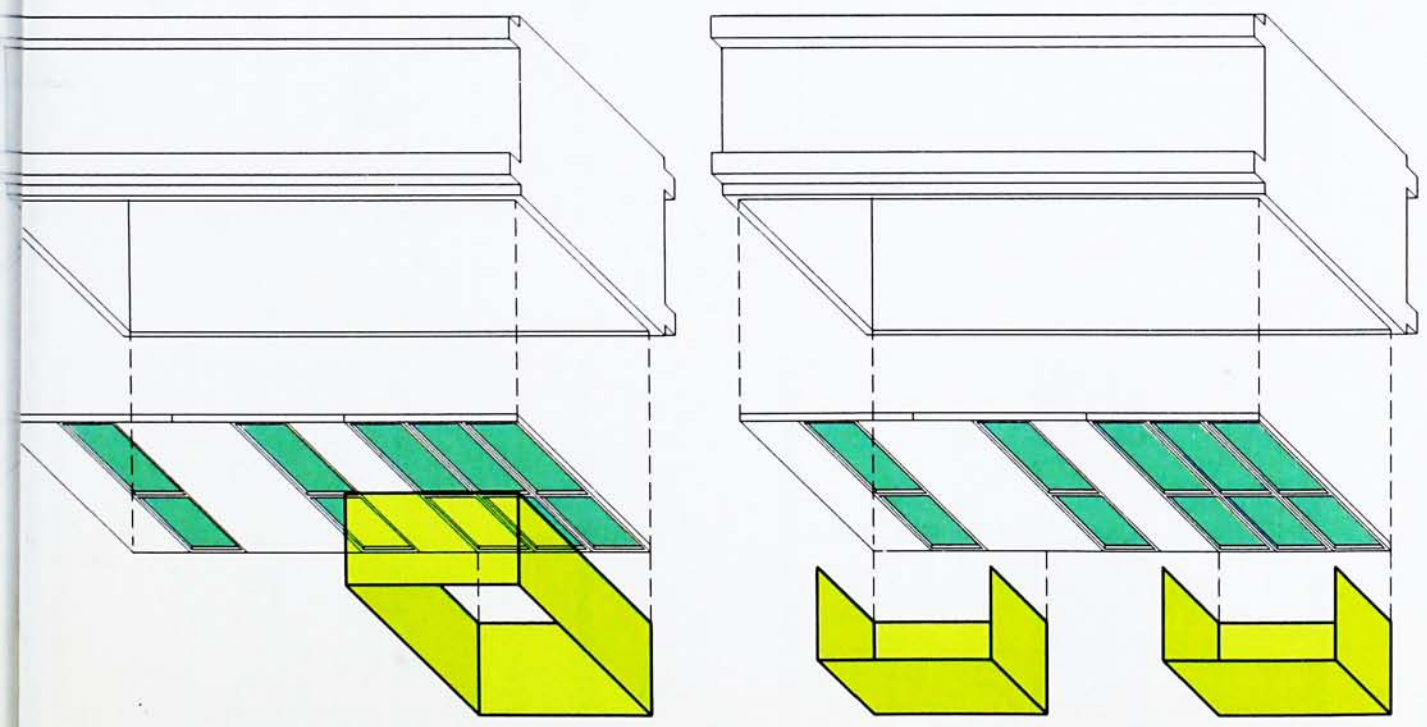
7.8 **Additional Space**

We can defined the additional outdoor space by the balcony and shading elements.
Enclose glass box can create additional indoor space.



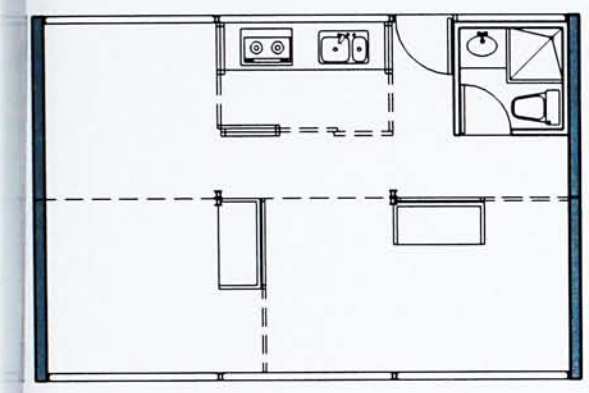
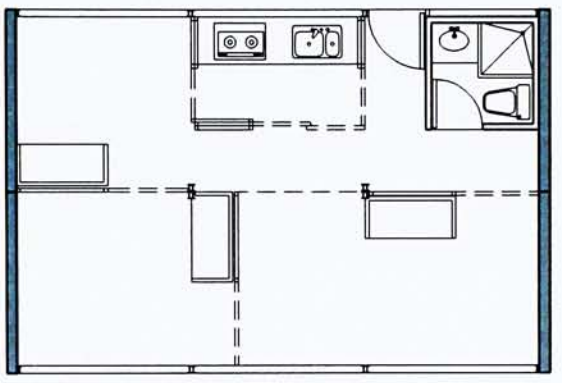
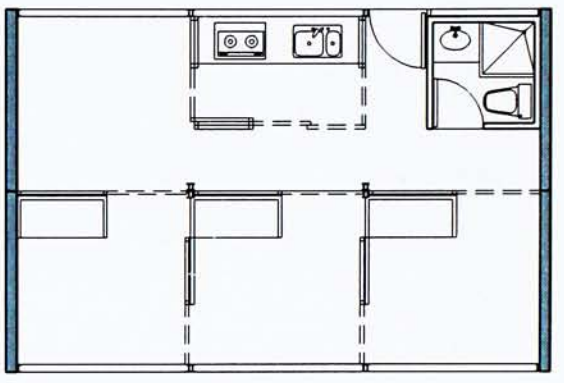
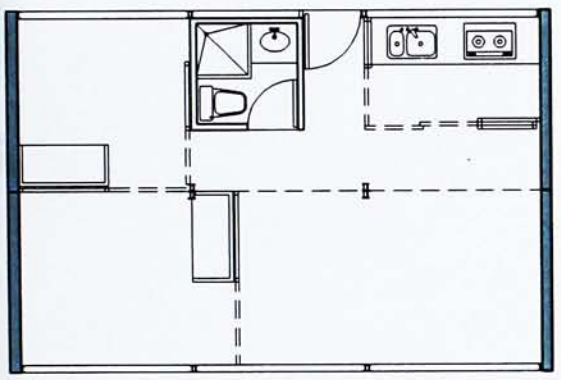
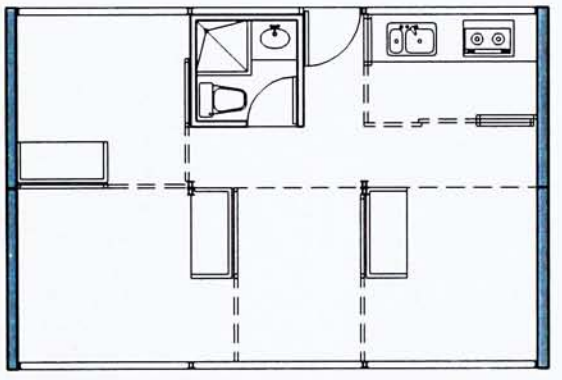
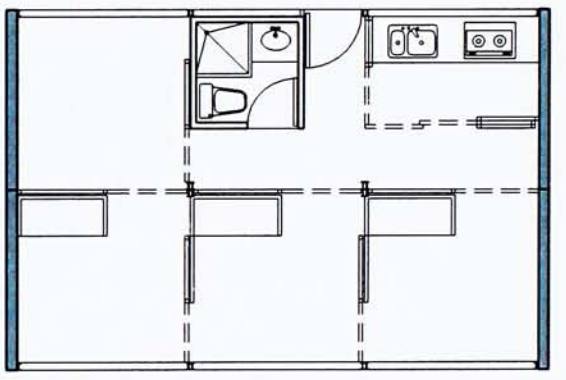
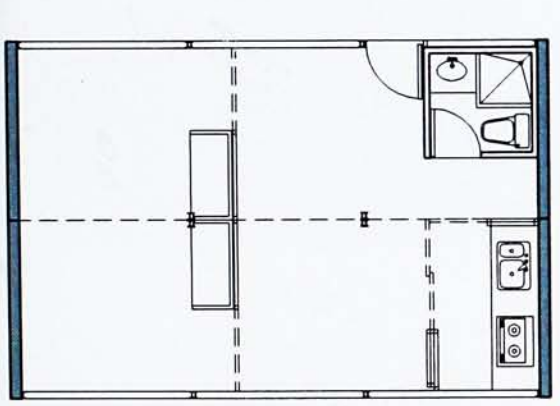
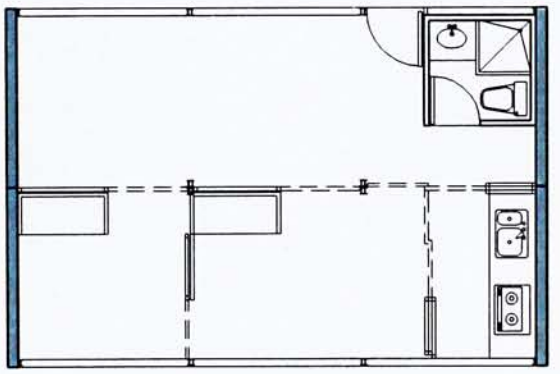
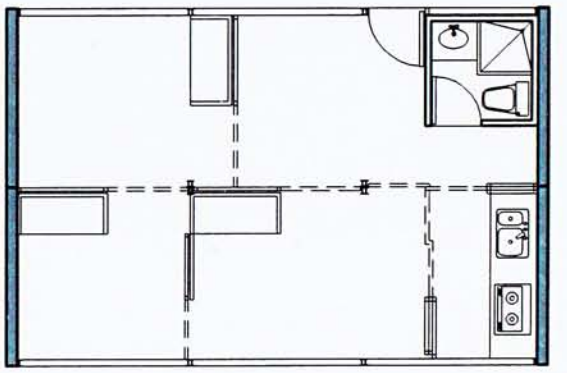
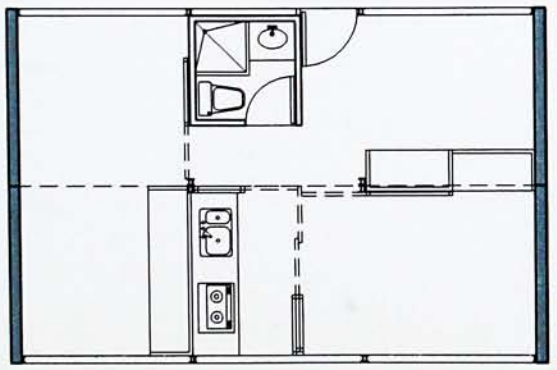
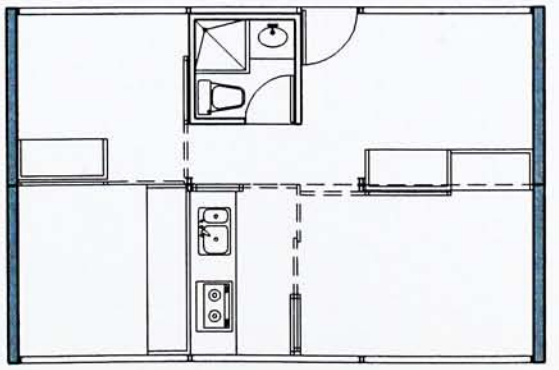
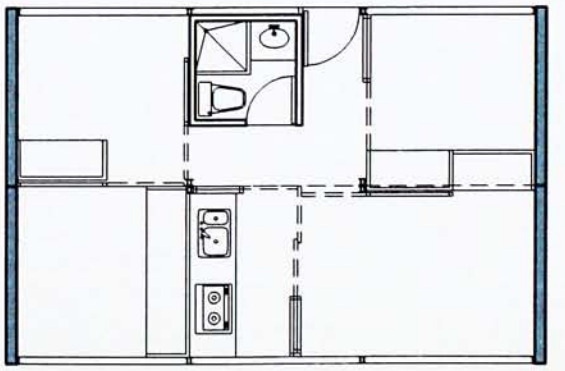


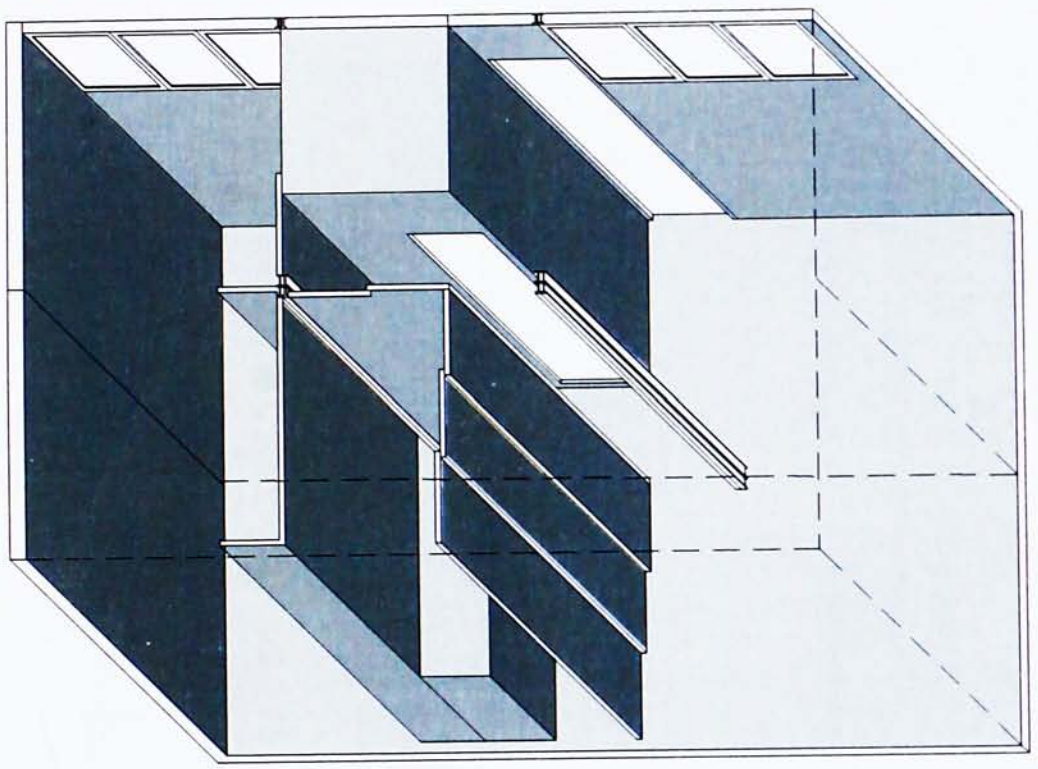


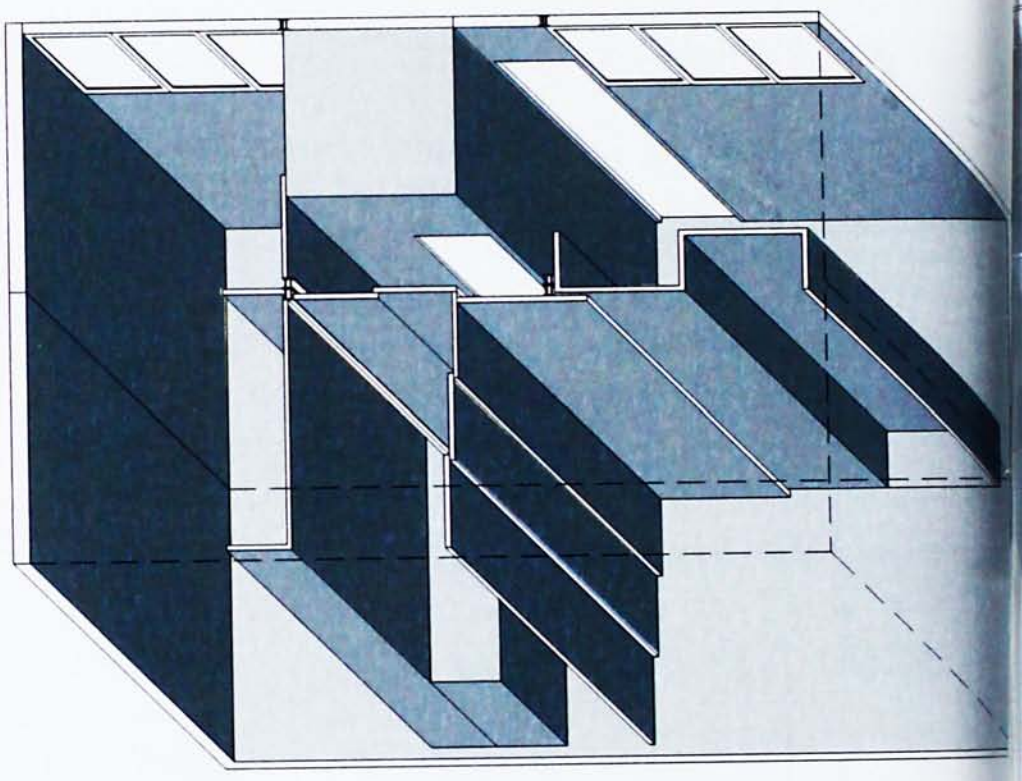


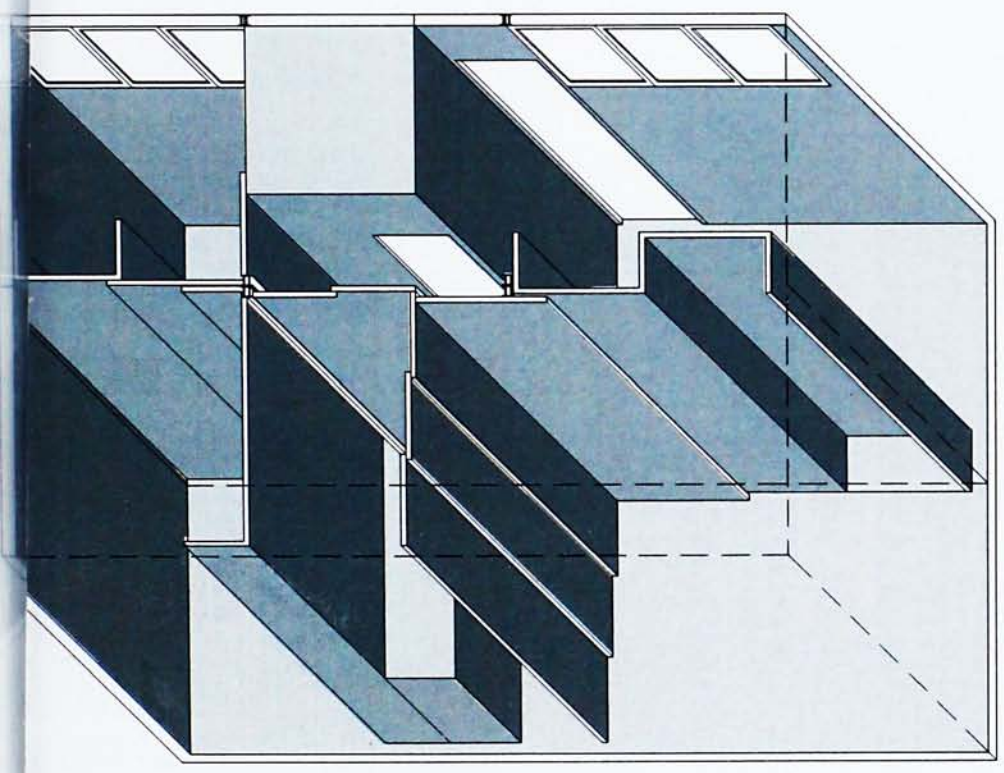
7.9 **Interior Space**

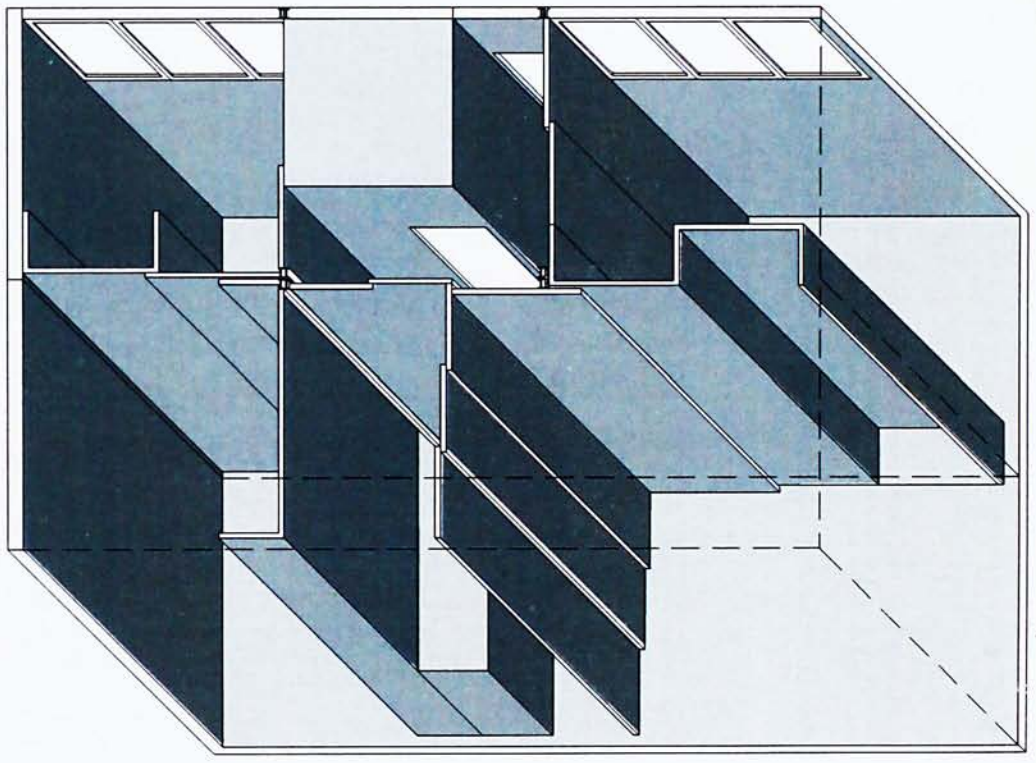
In response to the uses of different amount of dweller, we can use the flexible wall to partition room with considering the kitchen and toilet as service core.





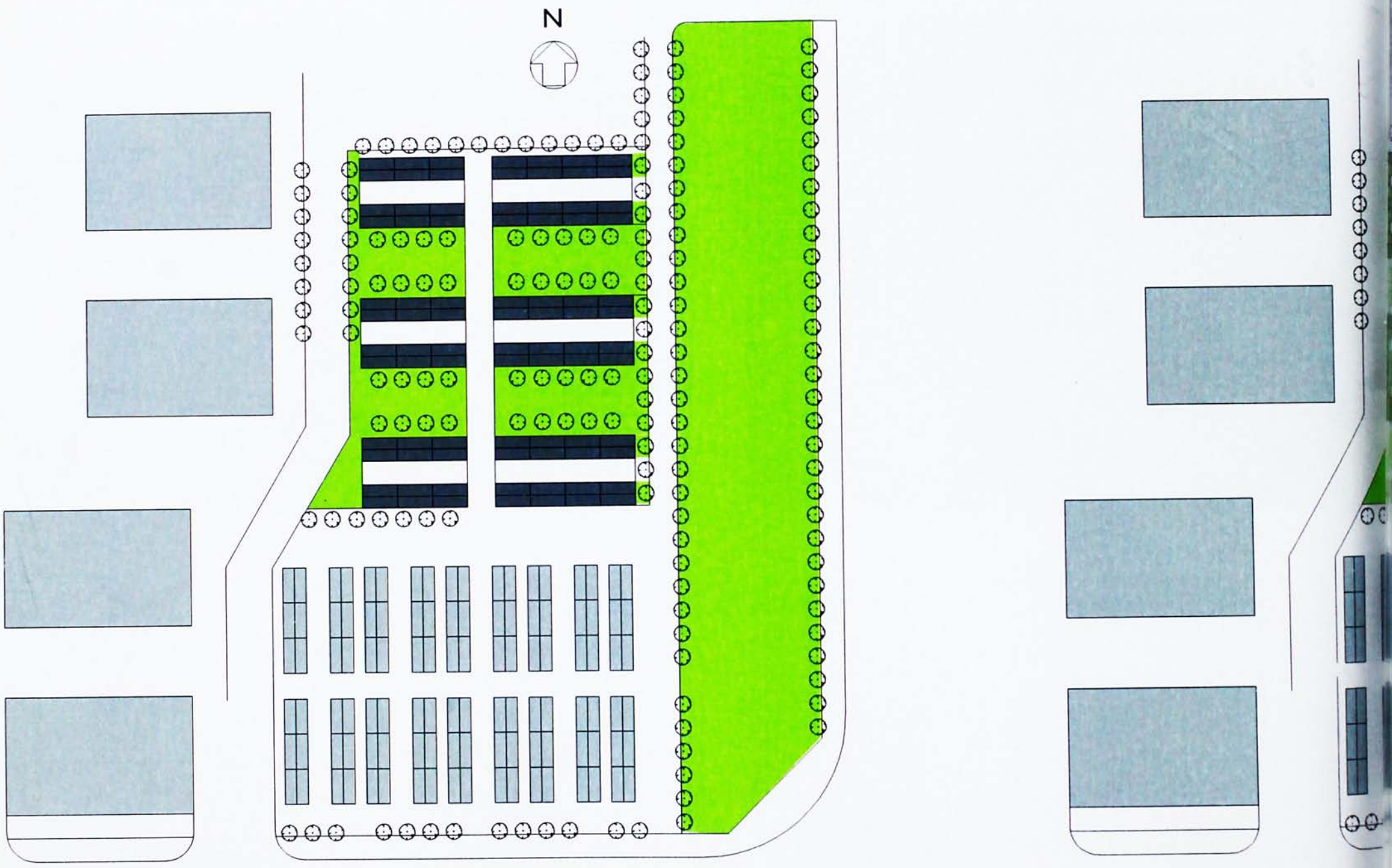


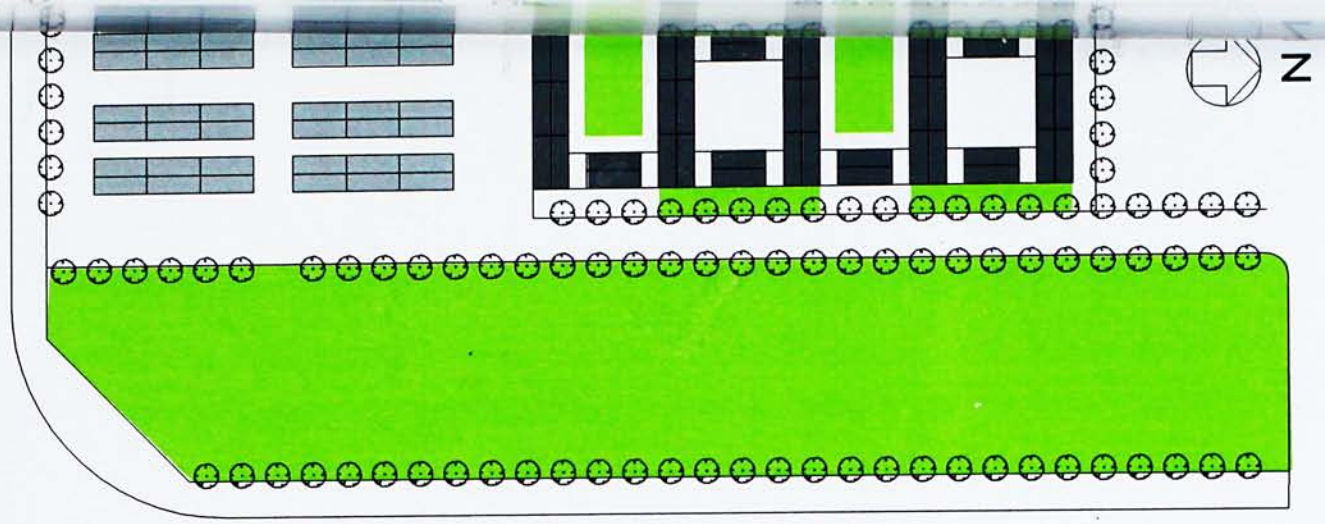


7.10 **Final Applicarion**

7.10.1 **Master Plan**

Because this site is no typical context, the master plan have also had different proposal design.

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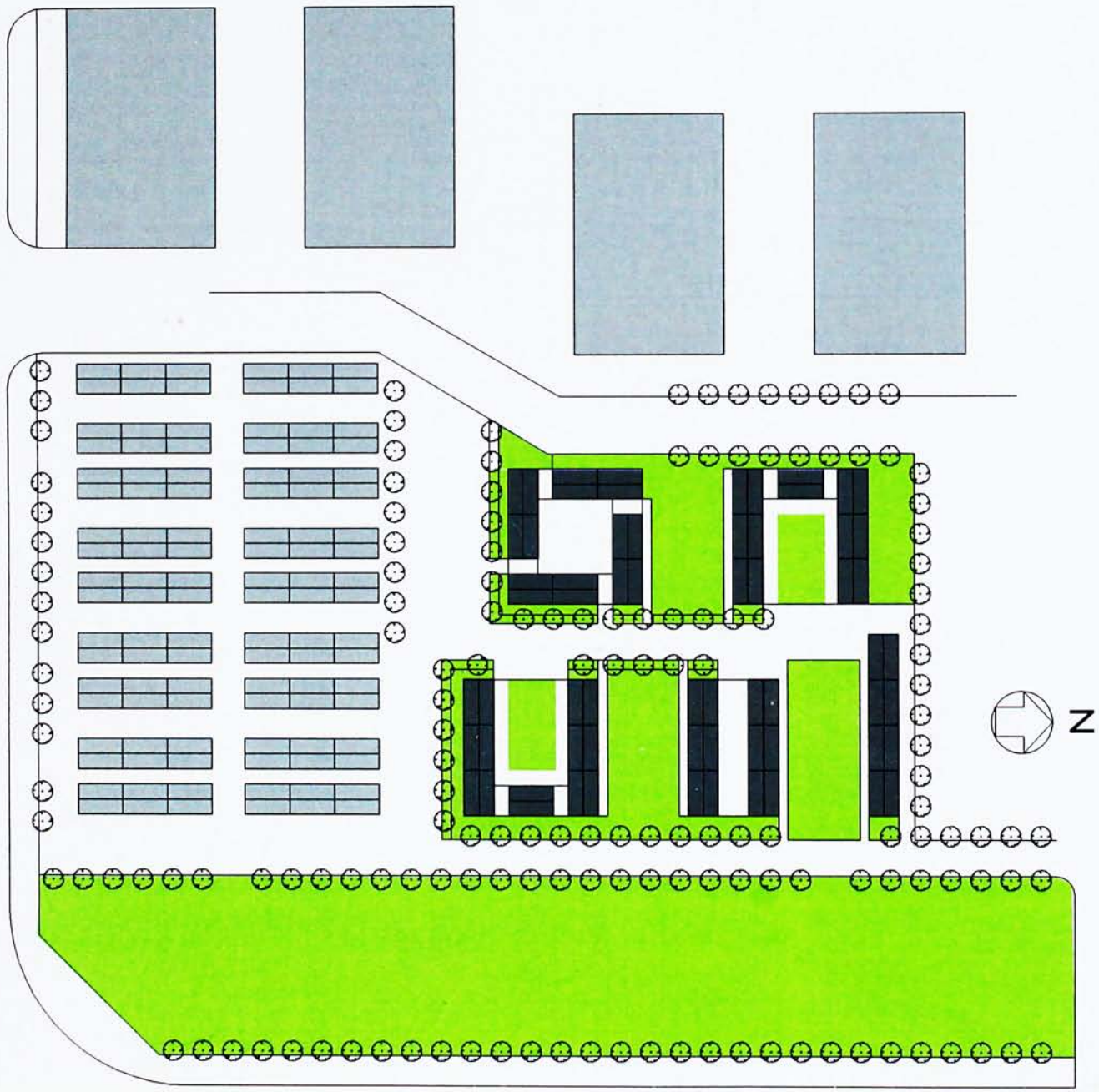
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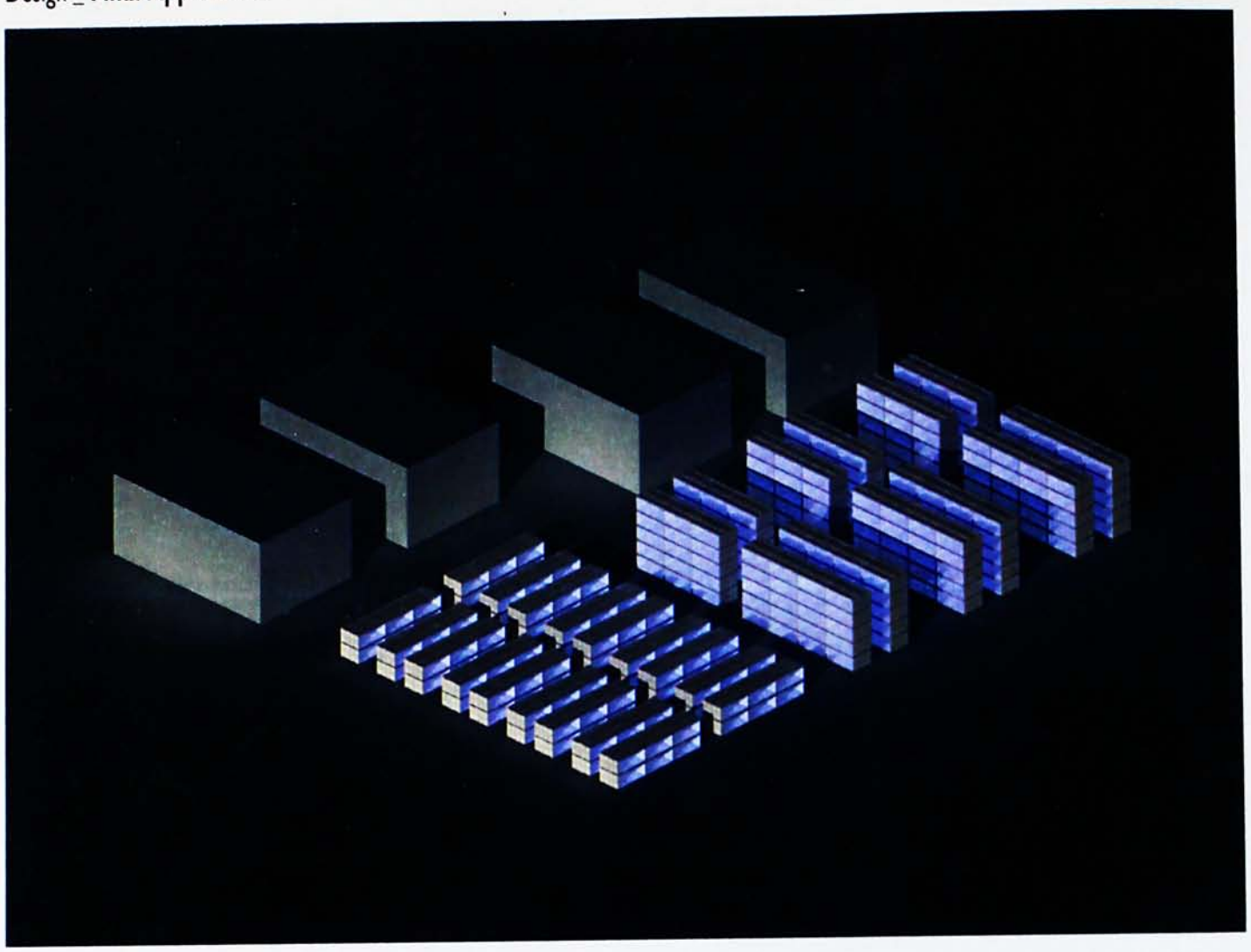

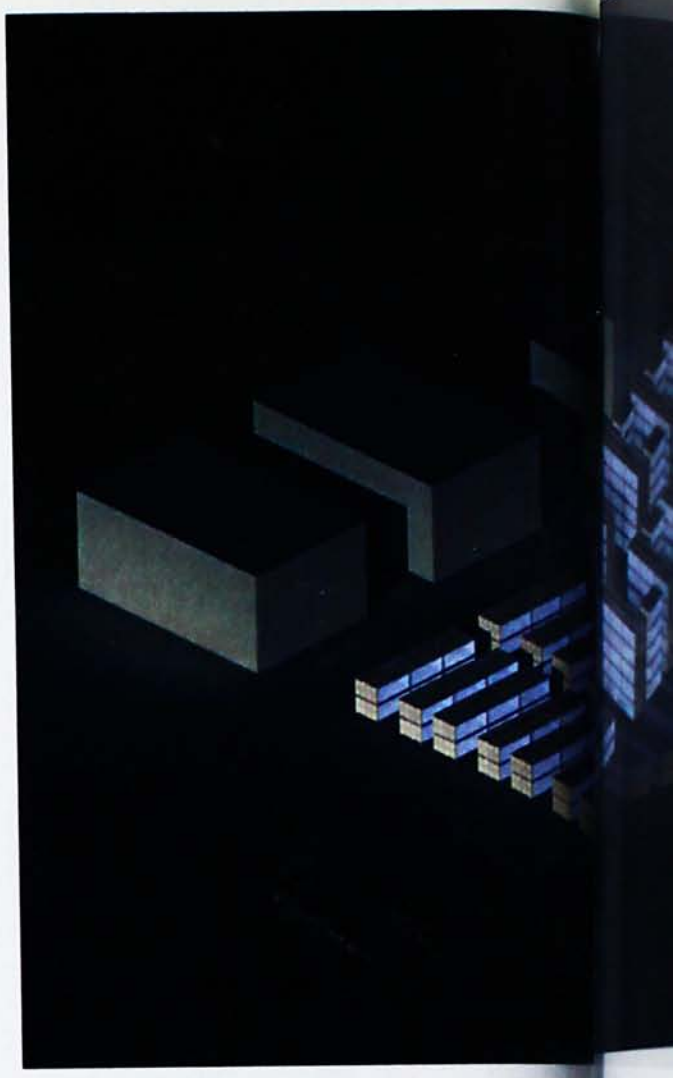

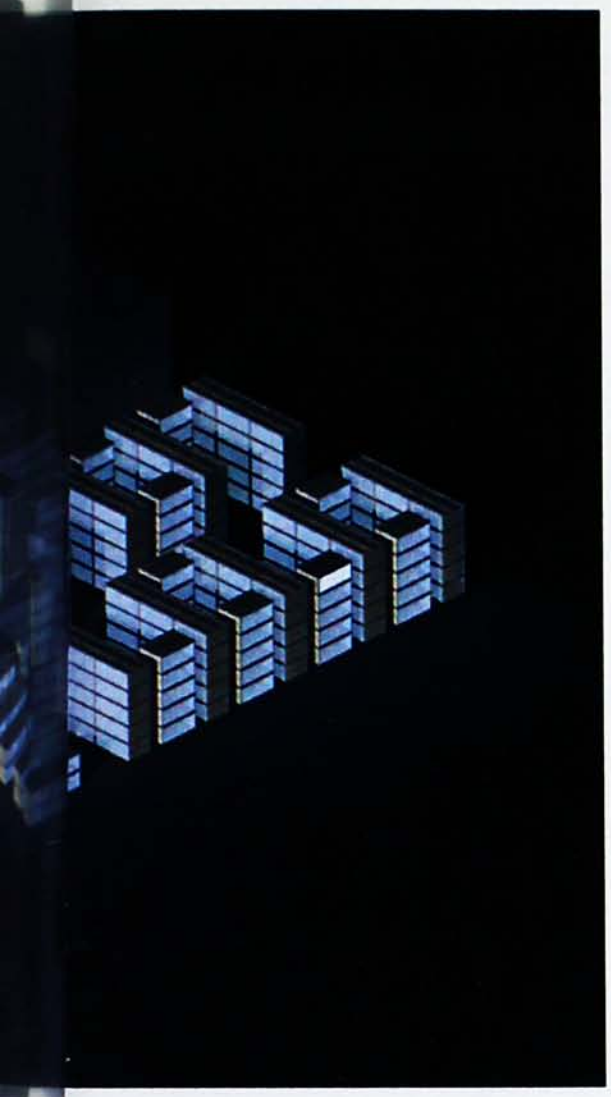

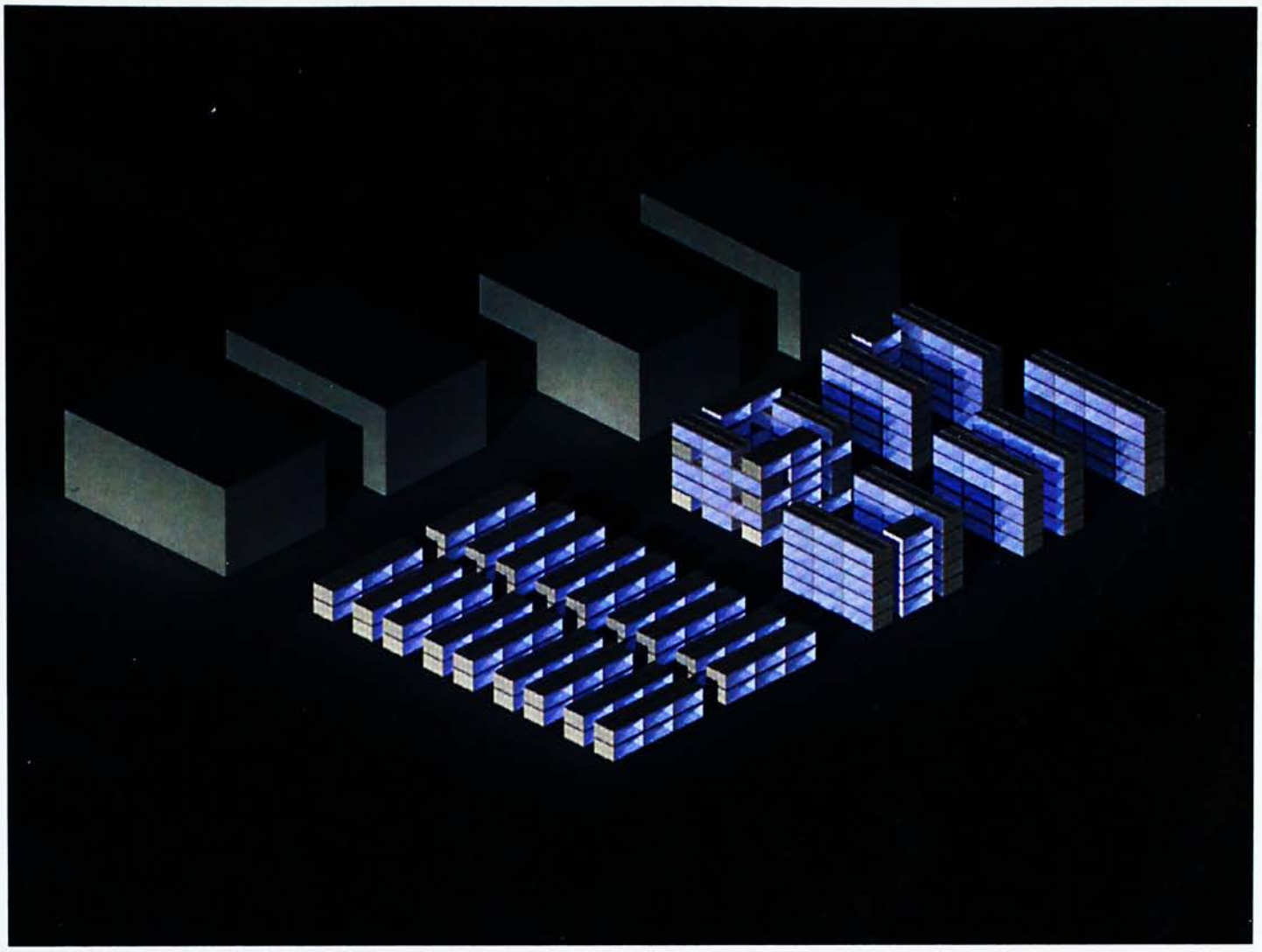

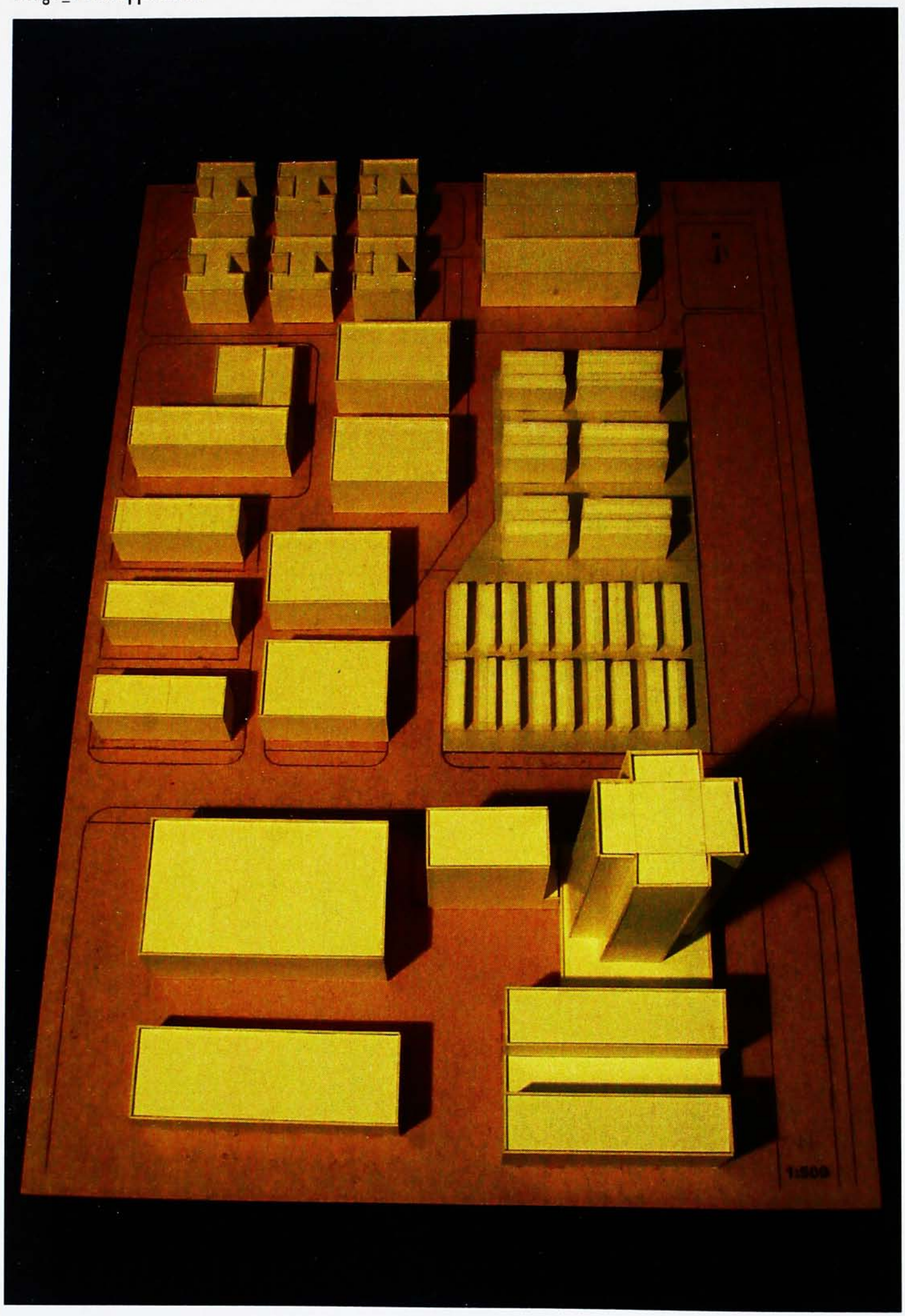
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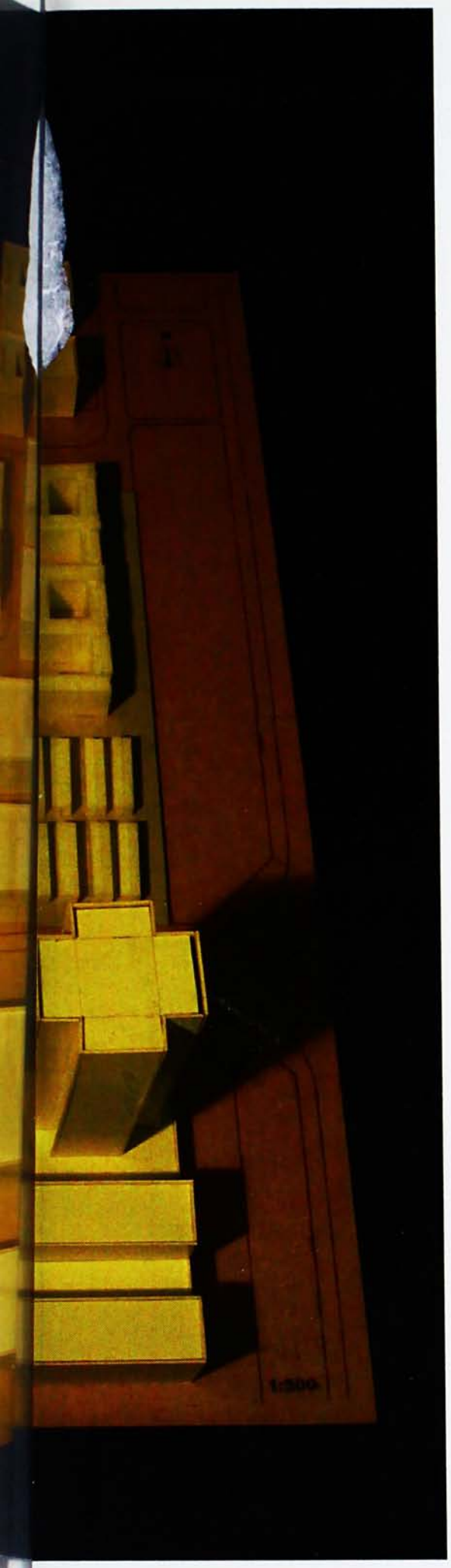
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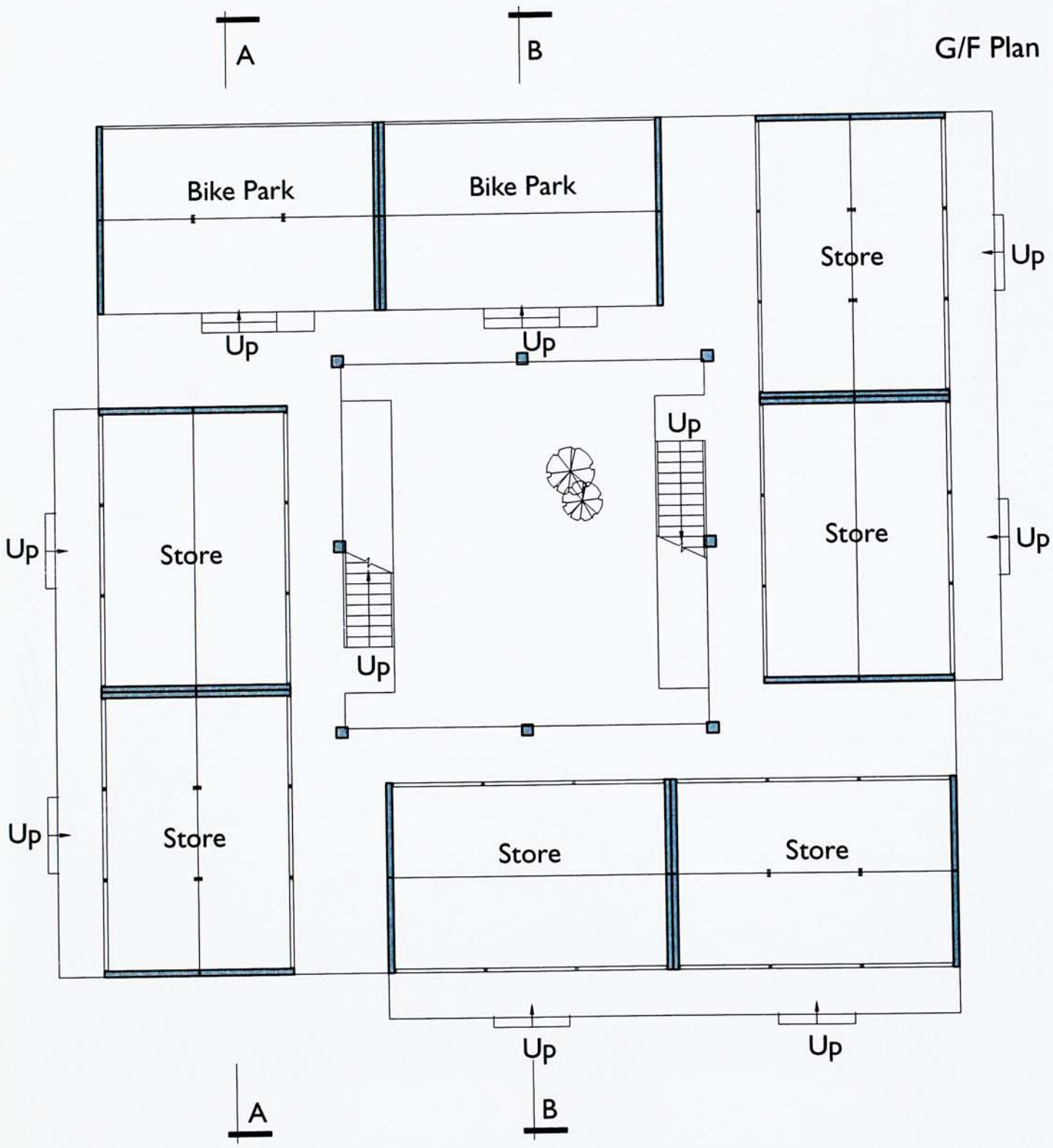
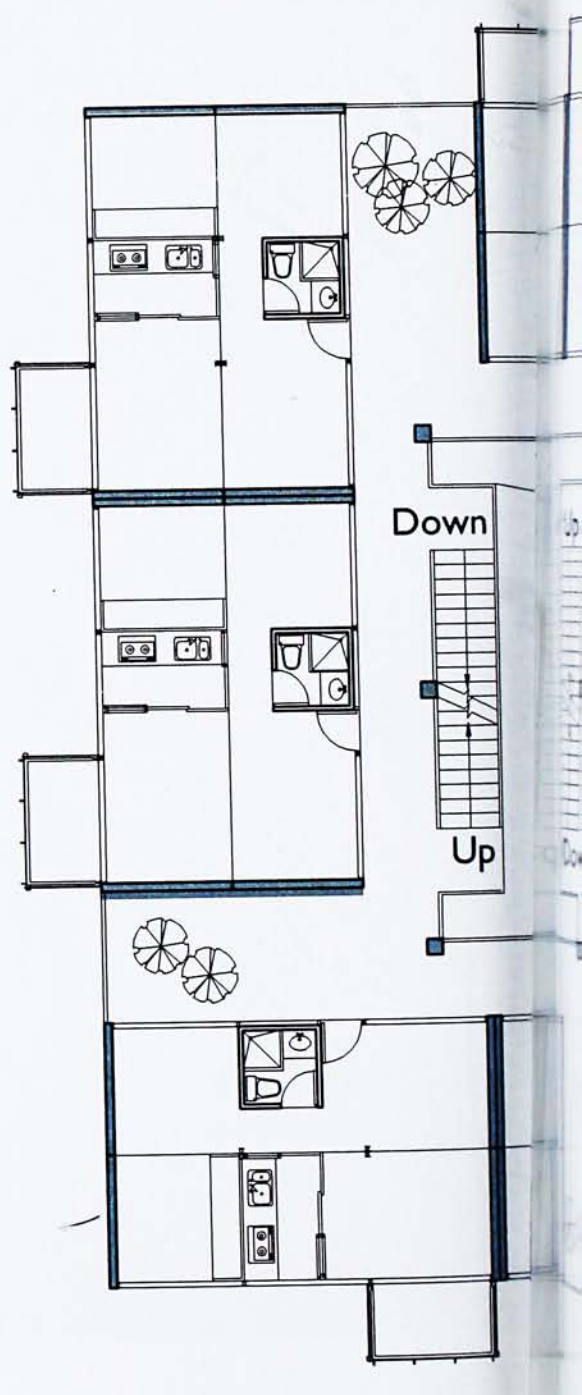
1:500

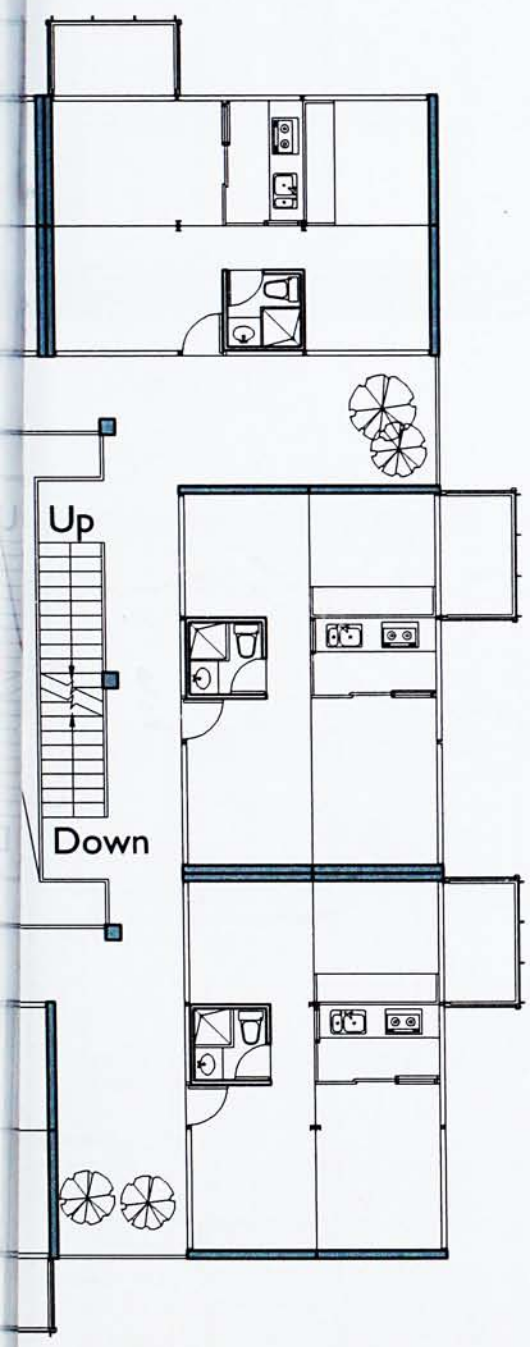
7.10.2 **Plan**

I select one of the proposed buildings to design further. Using these three combination to enclose courtyard.

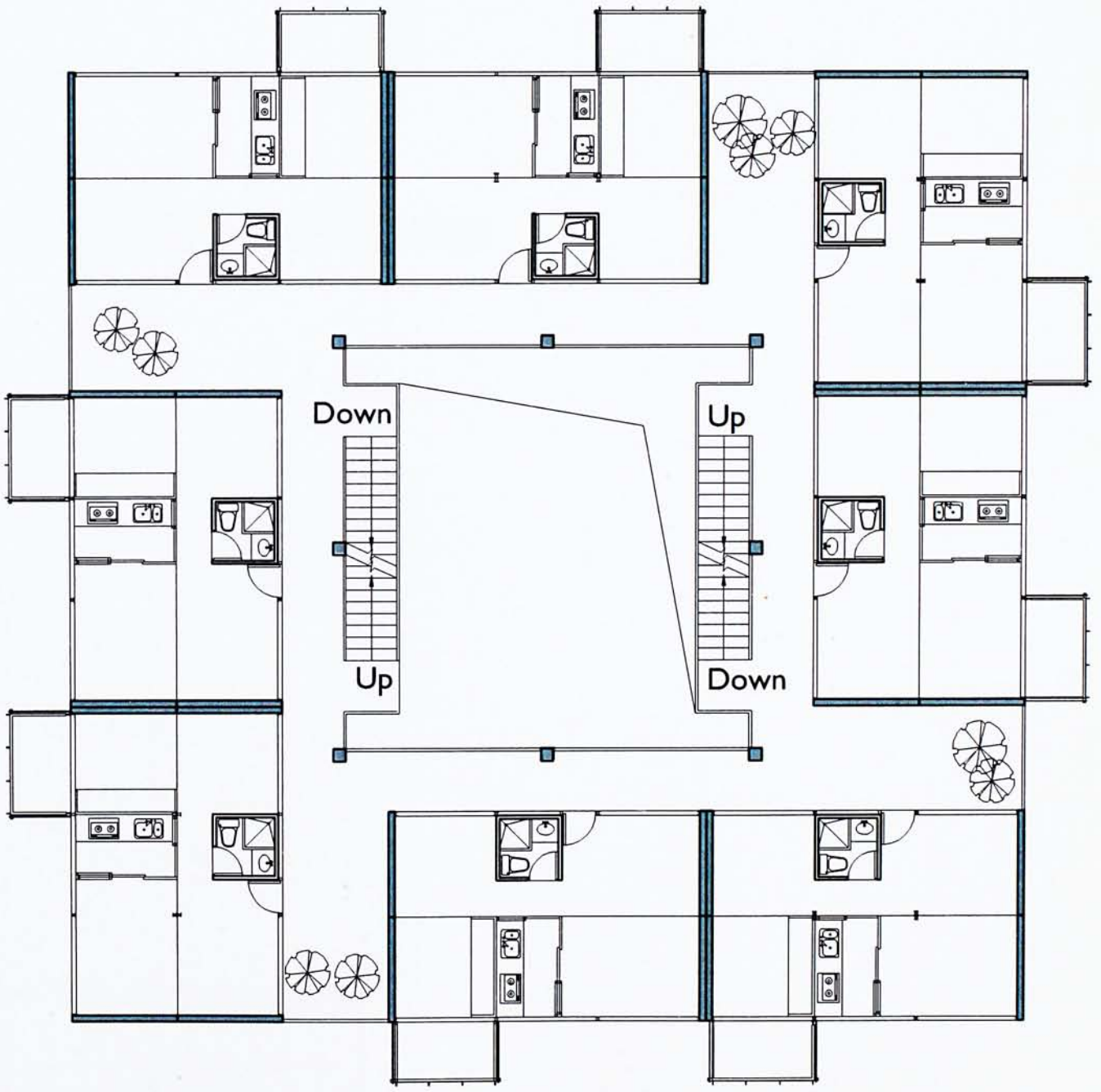




1,3/F Plan



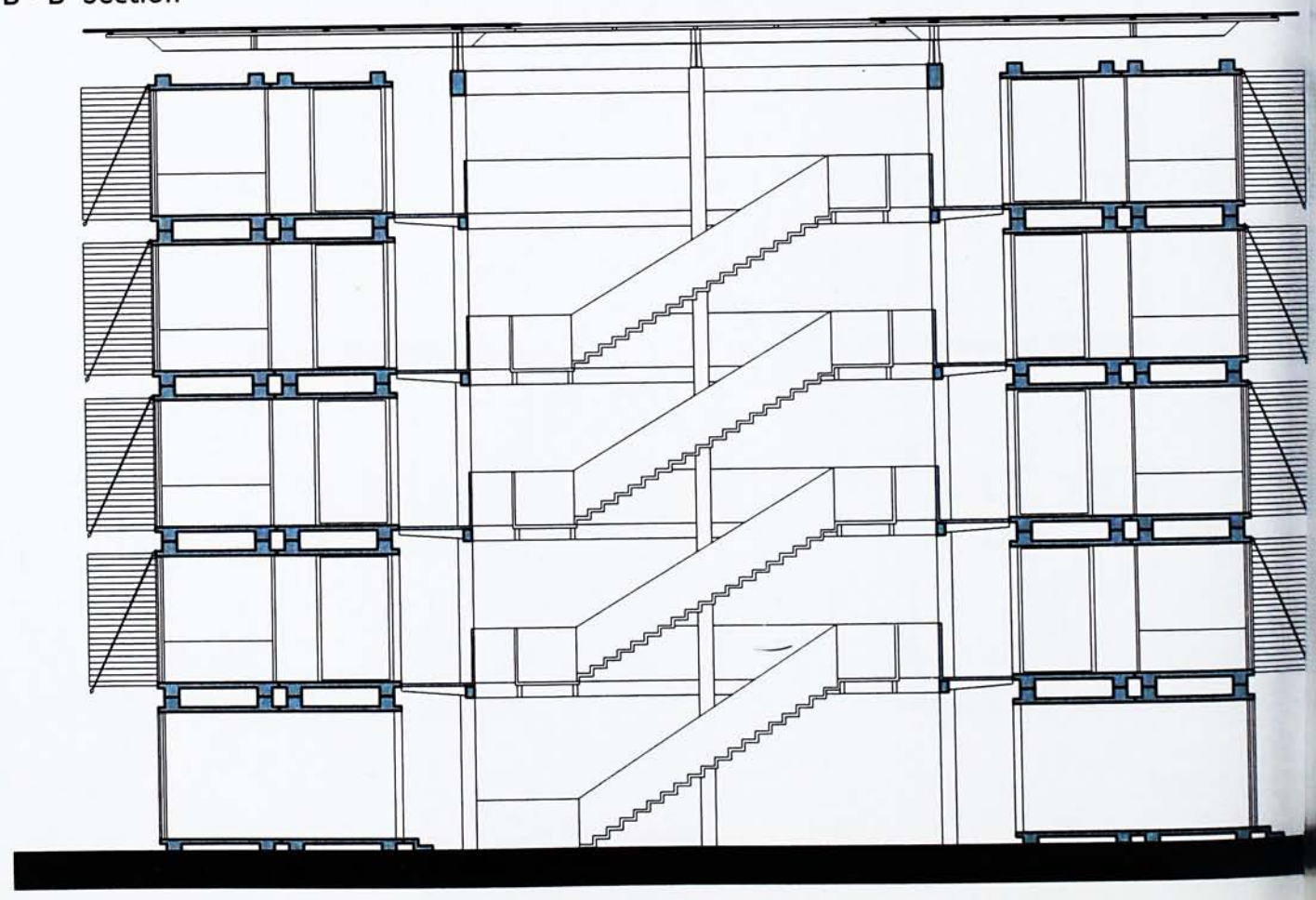
2,4/F Plan



7.10.3 **Section**

A - A Section

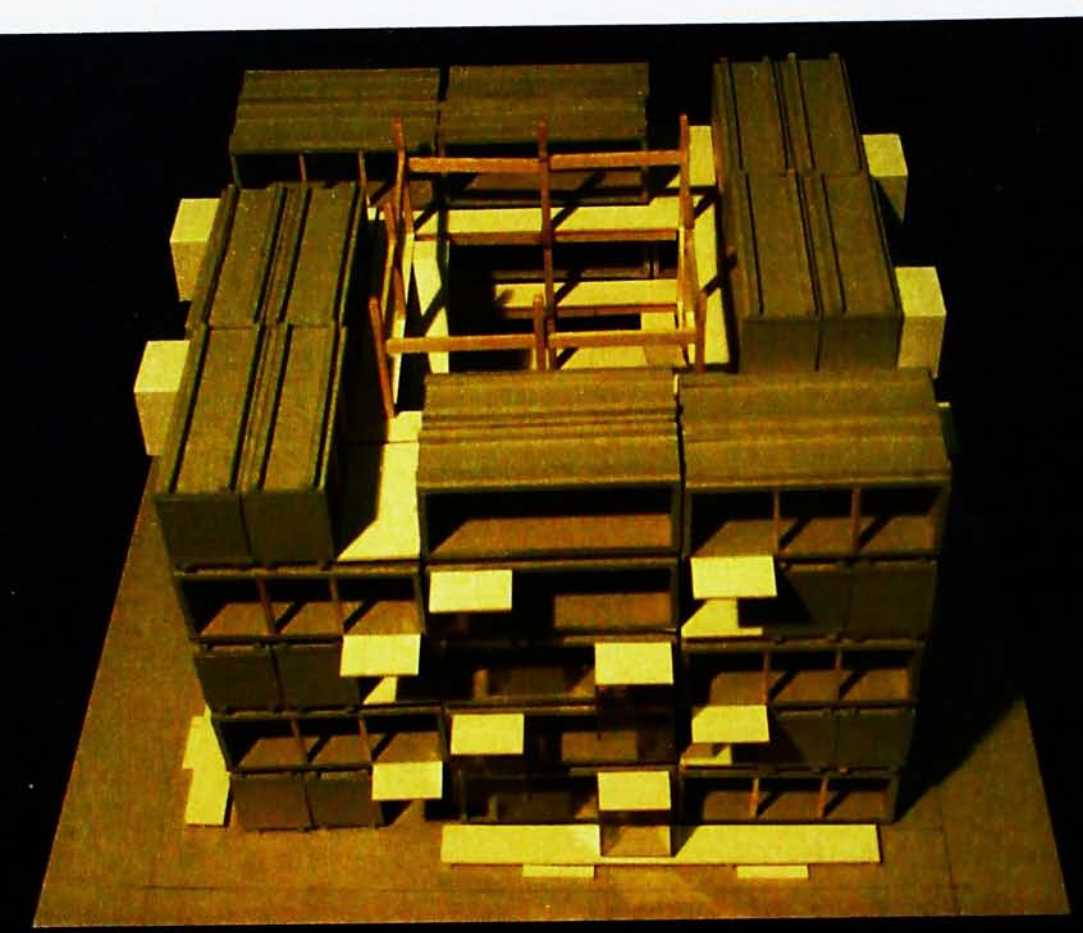
B - B Section

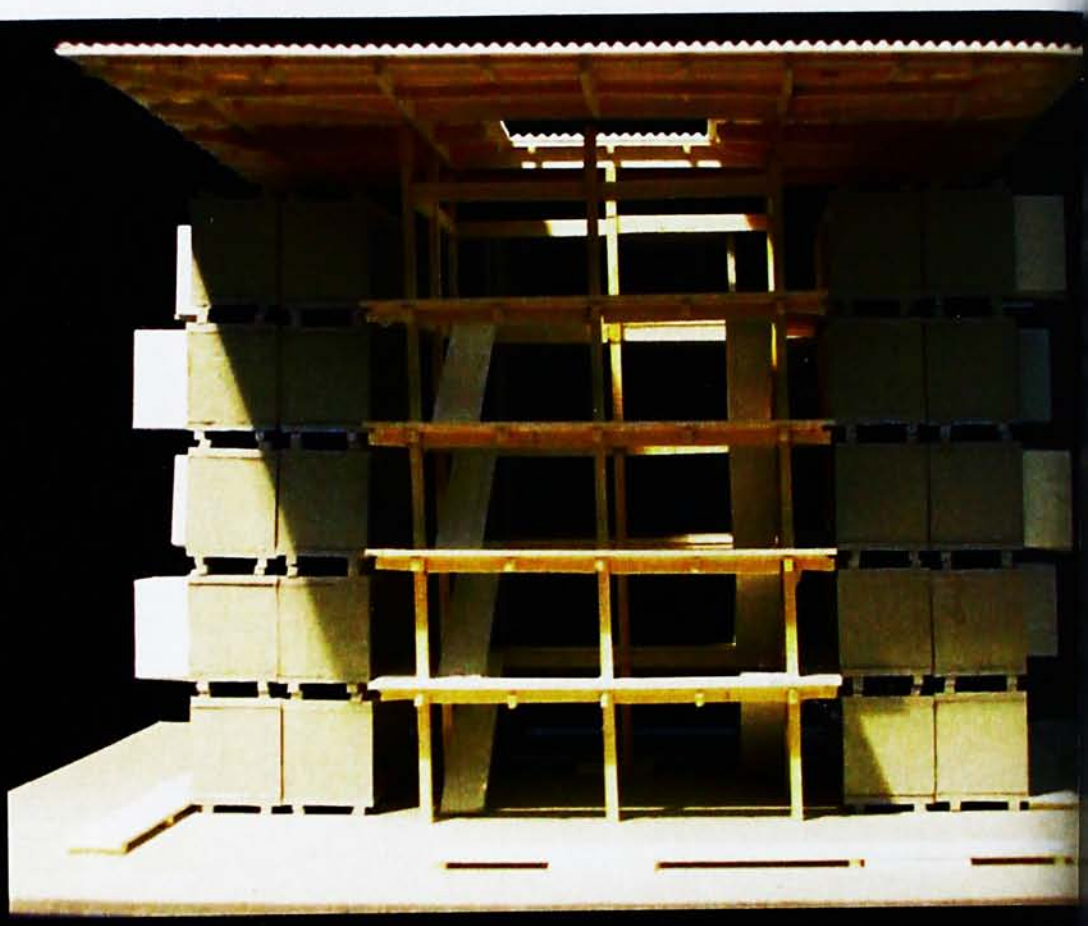


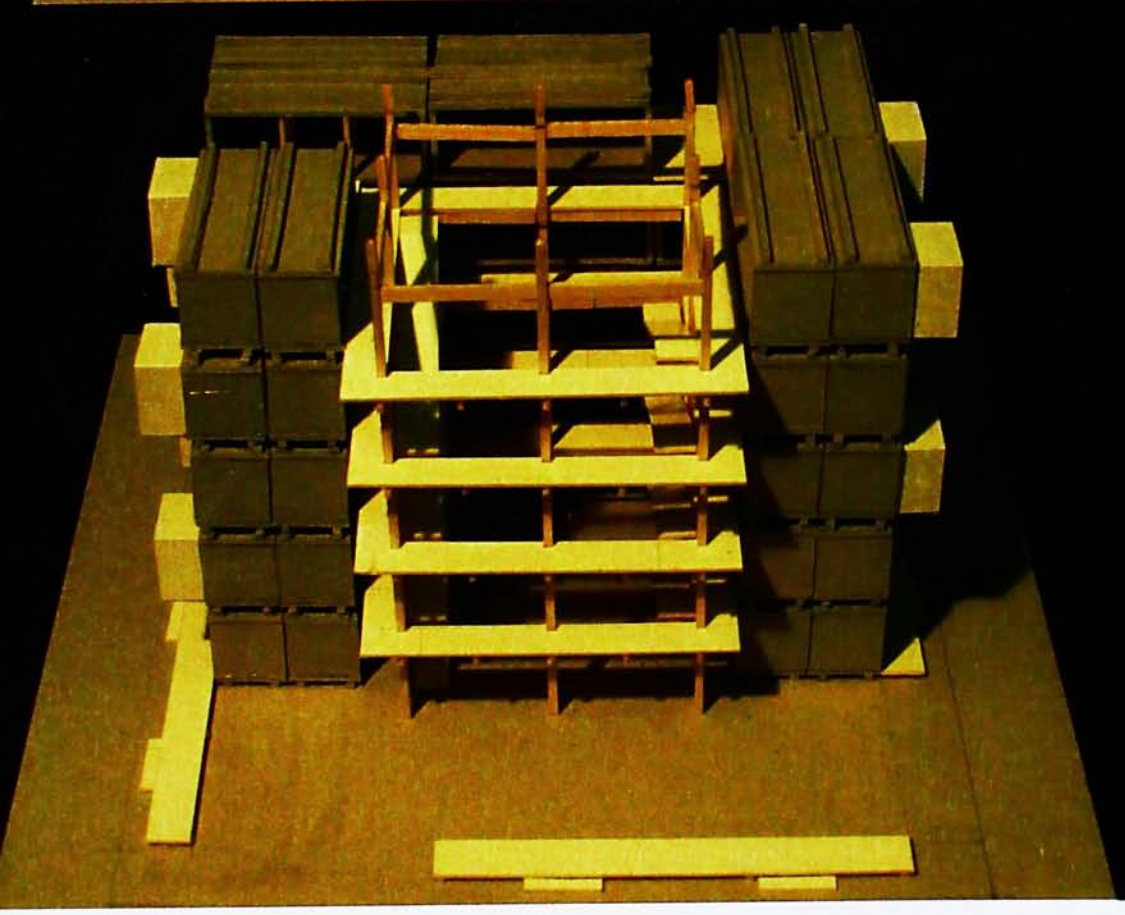
7.10.4 **Elevation**

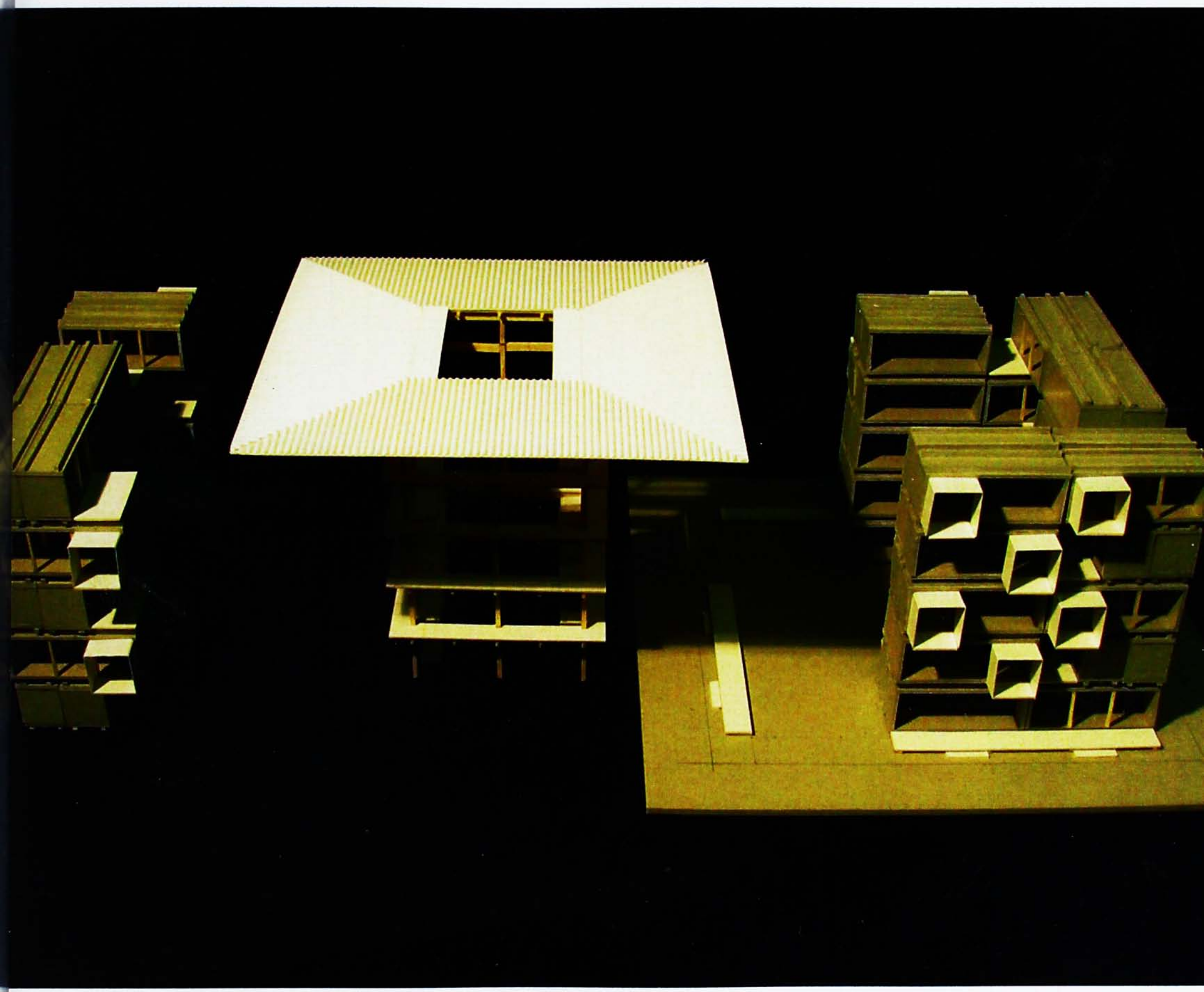
South Elevation

East Elevation

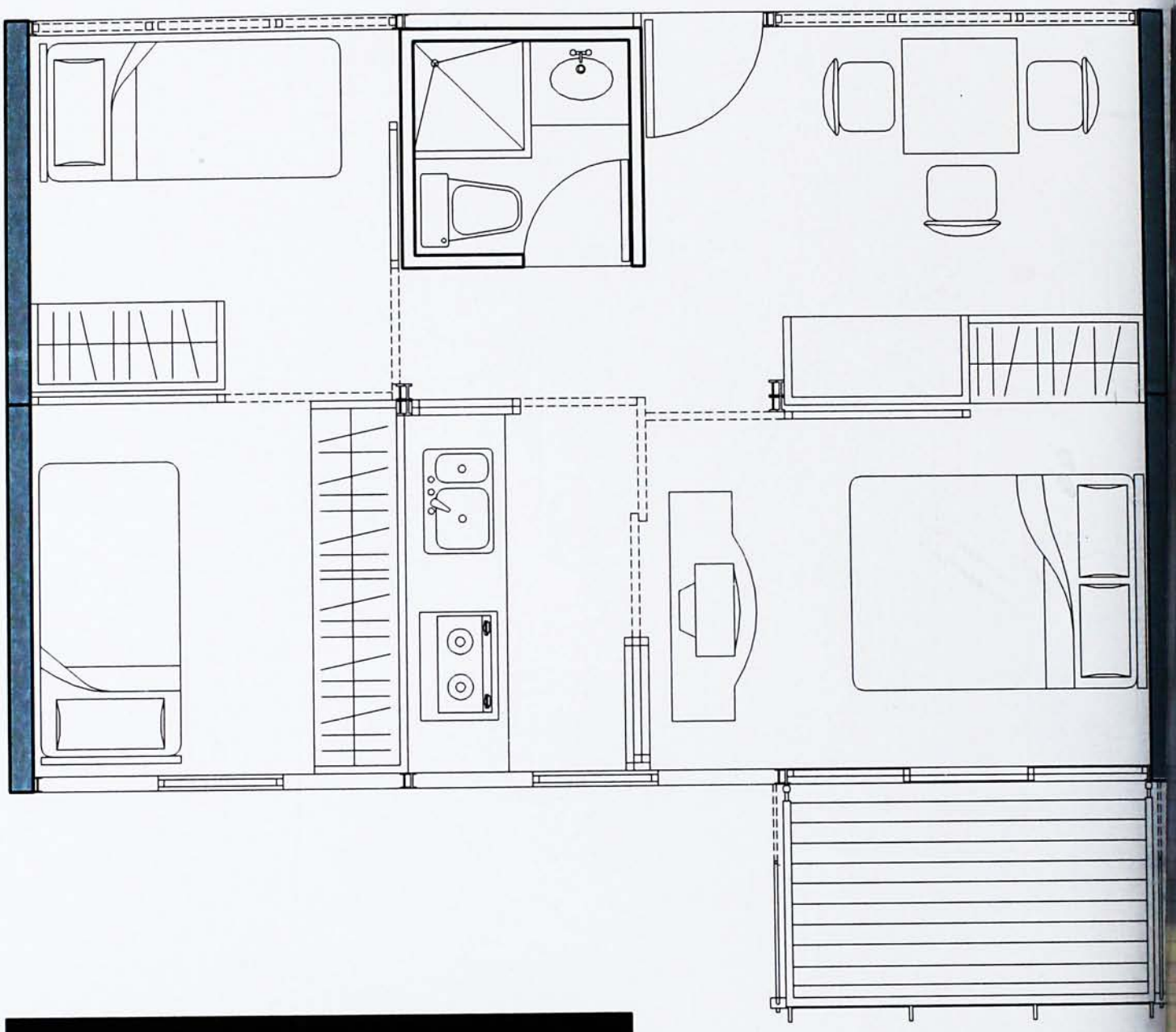


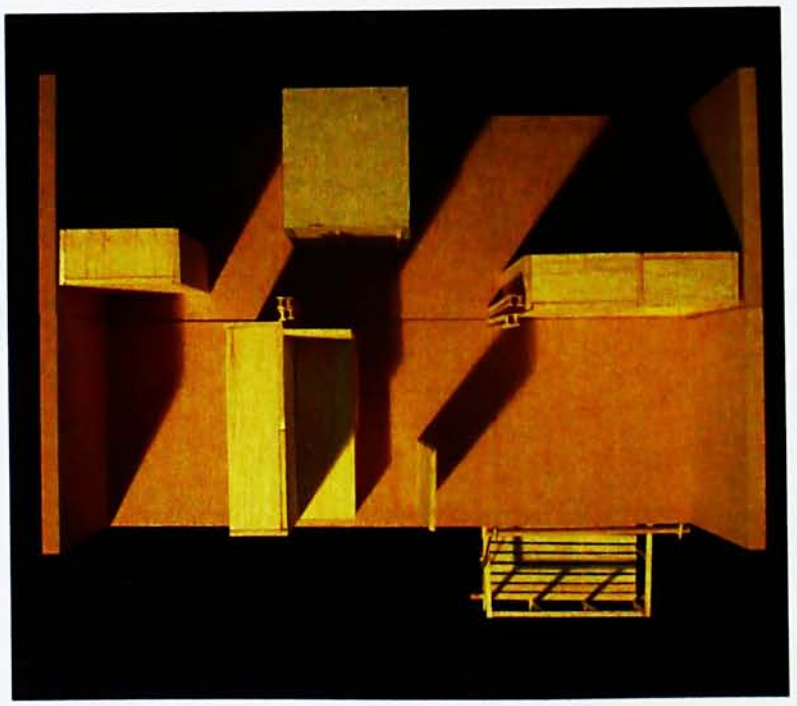


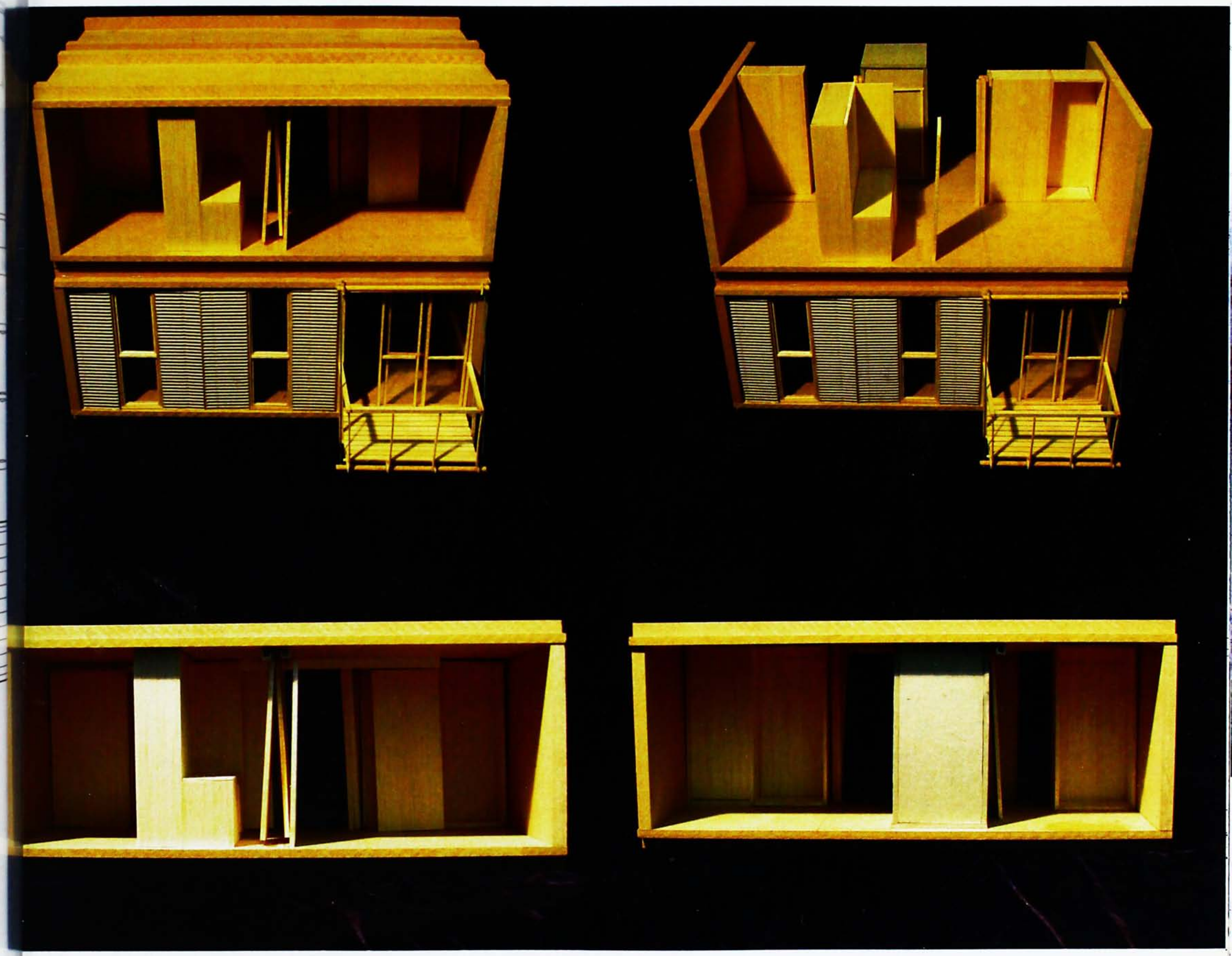




7.10.5 **Unit**

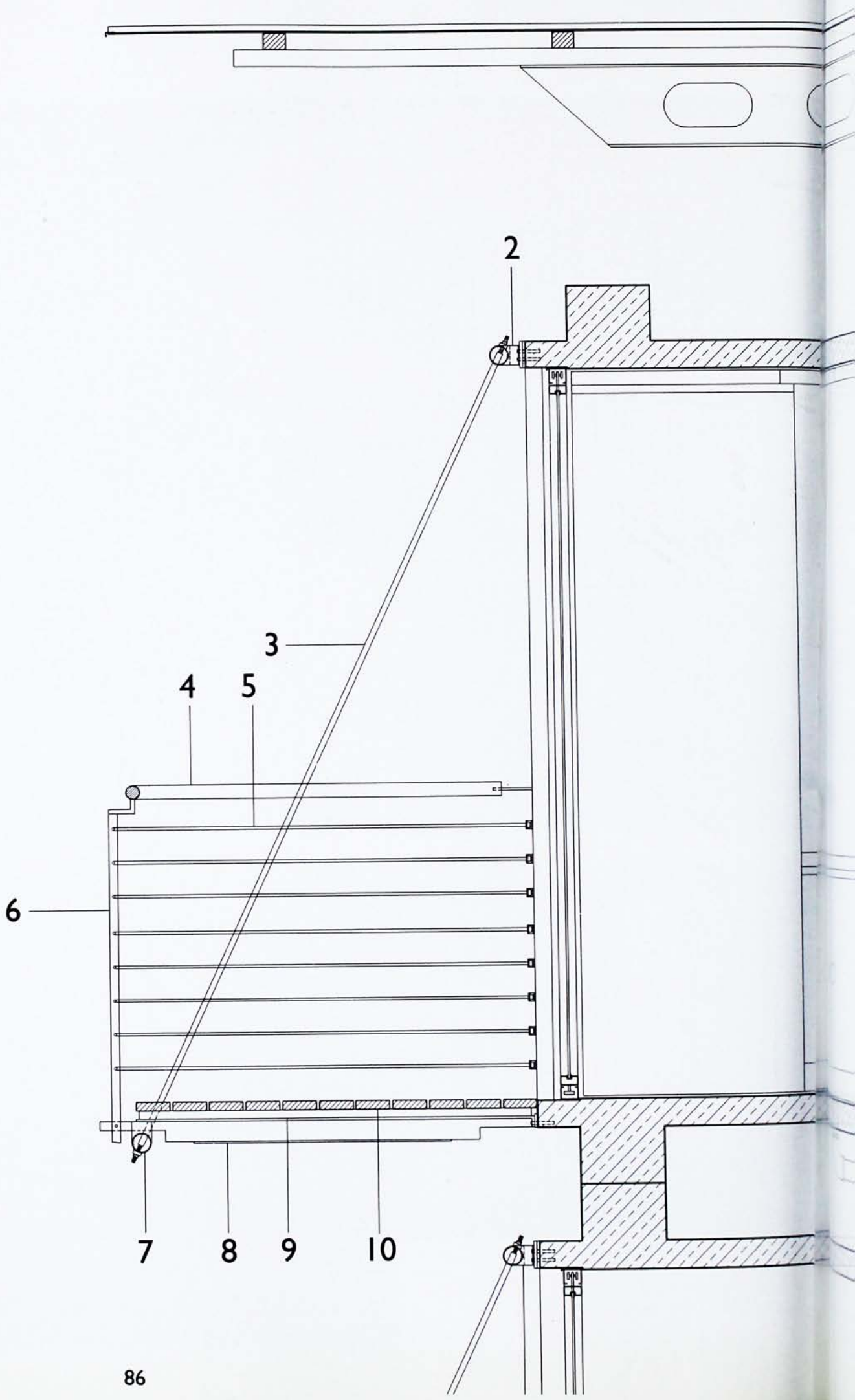


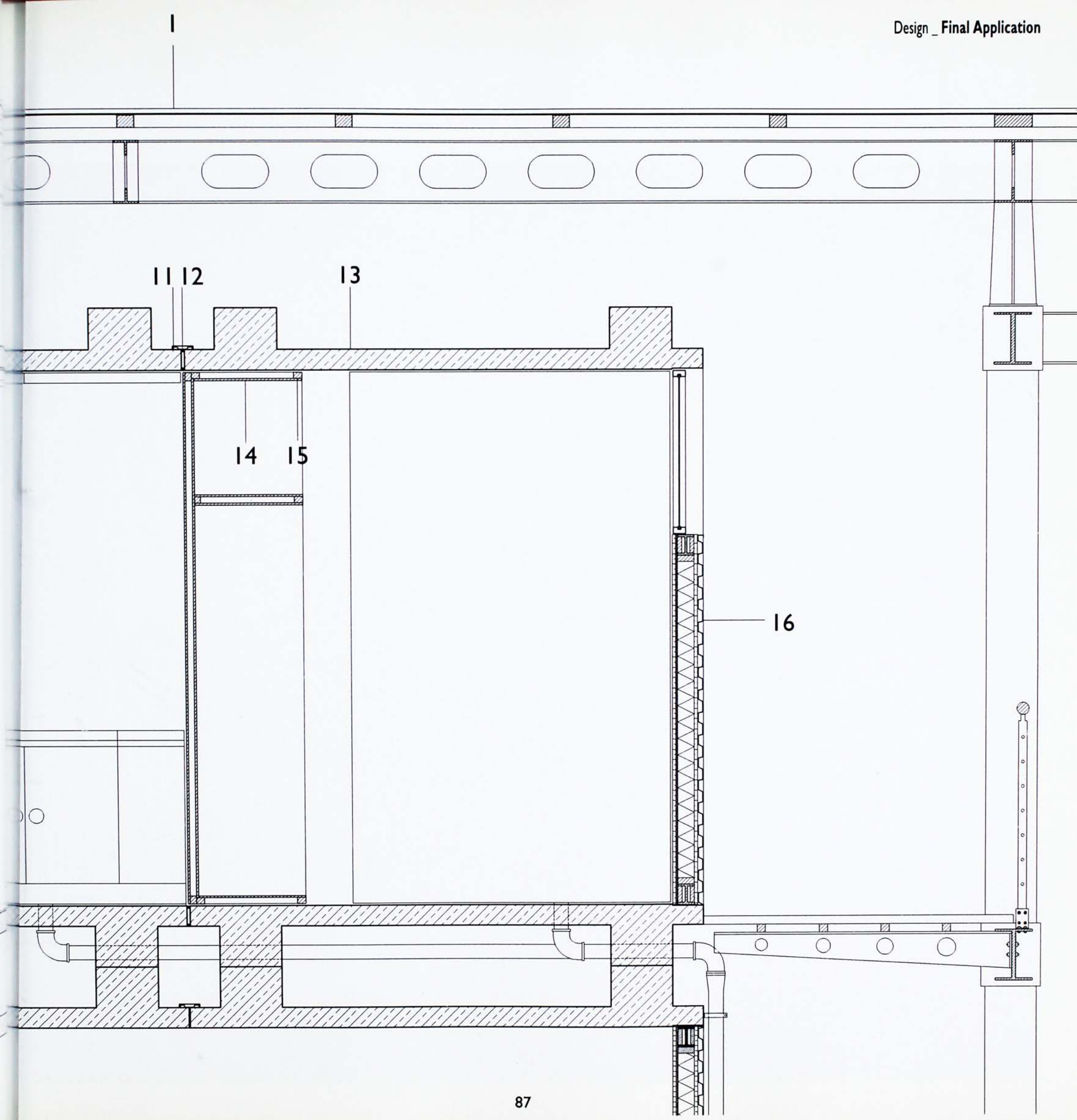




7.10.6 **Detail**

1 roof construction:
aluminium profile sheet roofing
60/80 mm galvanized steel purlin
80/100mm galvanized steel purlin
main I-beam 300mm deep with
50/350 mm openings in web
2 10mm flat steel straps welded to tube
3 20mm dia. stainless-steel balustrate cable
4 60mm dia. wood handrail
5 6mm dia. stainless-steel balustrade cable
6 40mm dia. tubular aluminium balustrade post
7 80mm dia. steel tube 4mm thick
8 steel I-beam 140mm deep with M8 threaded bolts 30mm long in top flange
9 50/30mm hardwood bearers
10 40mm wood floor boarding
11 titanium-zinc capping bent to shape
12 silicone jointing strip
13 100mm prefabricated reinforced concrete
14 30/30mm solid timber chord
15 15mm wood boarding
16 wall construction:
18/76mm corrugated sheet aluminium
15mm gysum fibreboard
80mm mineral-fibre thermal insulation
vapour barrier
15mm palsterboard

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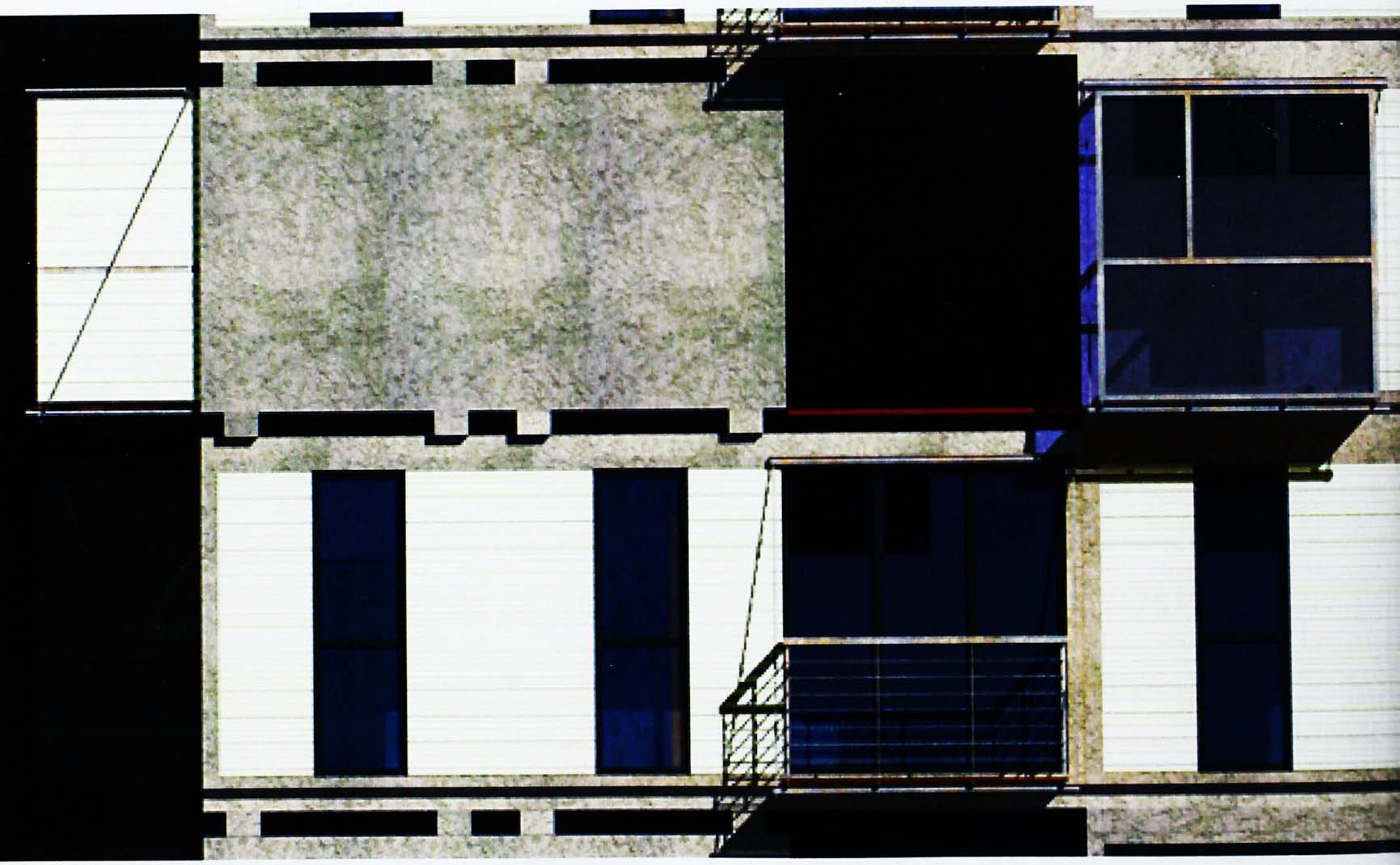

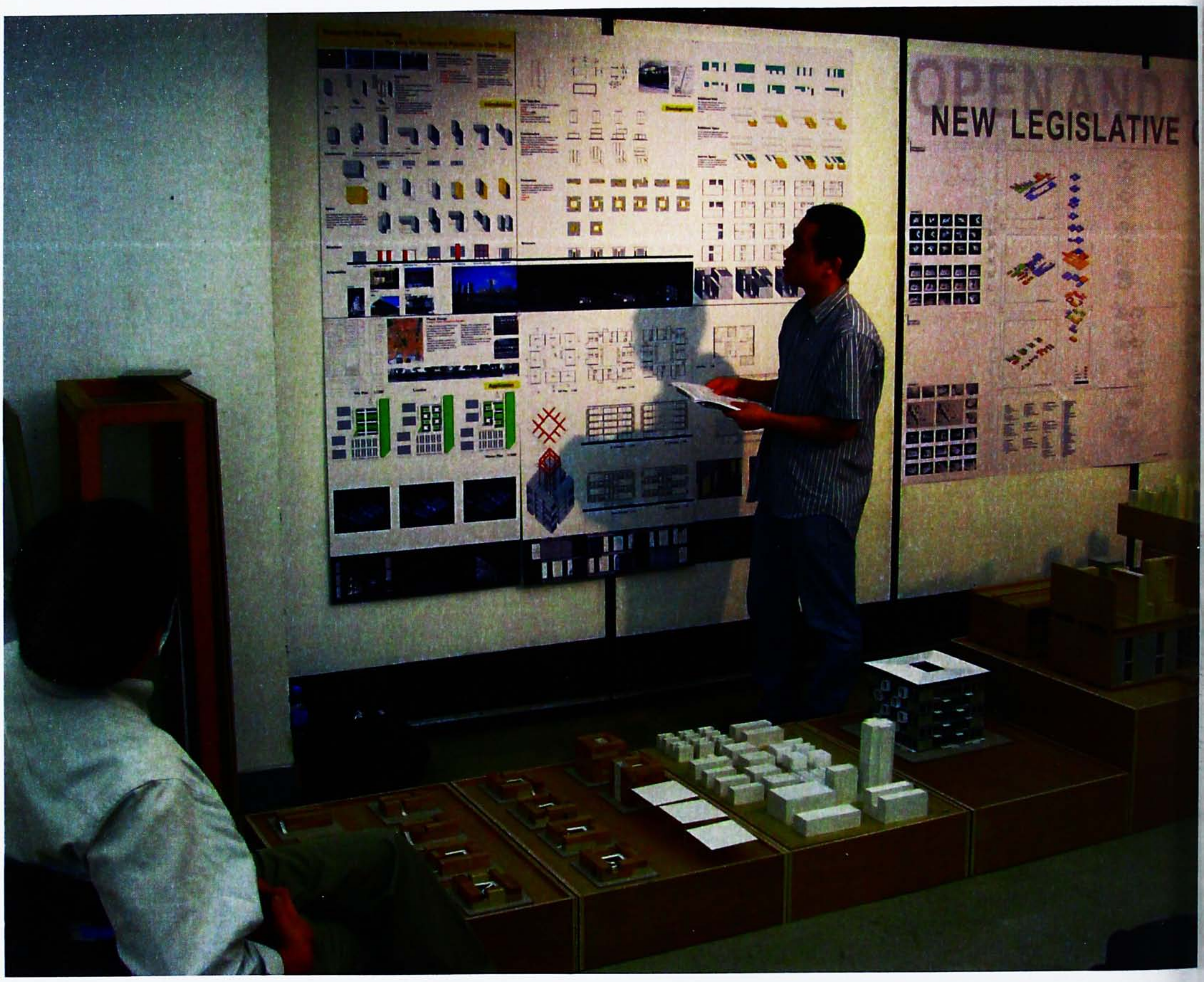
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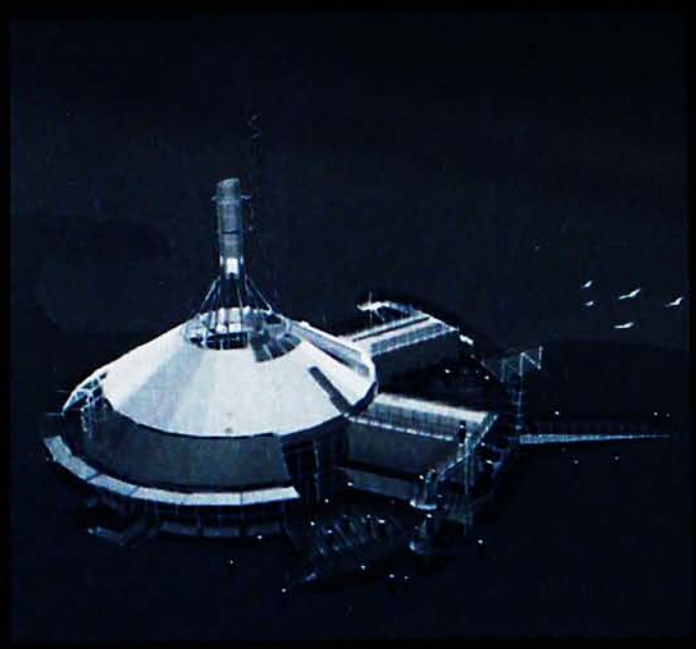
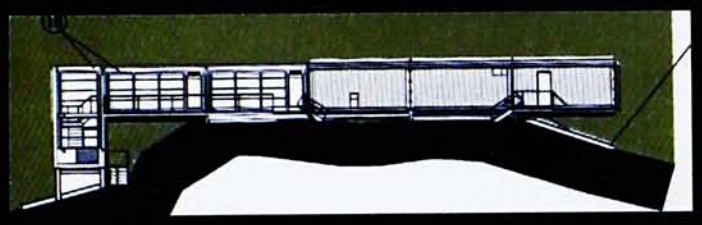
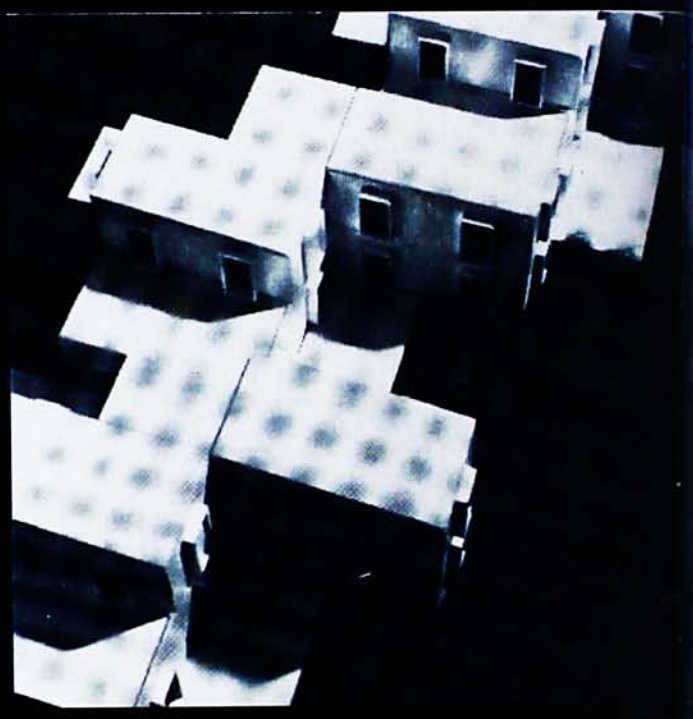
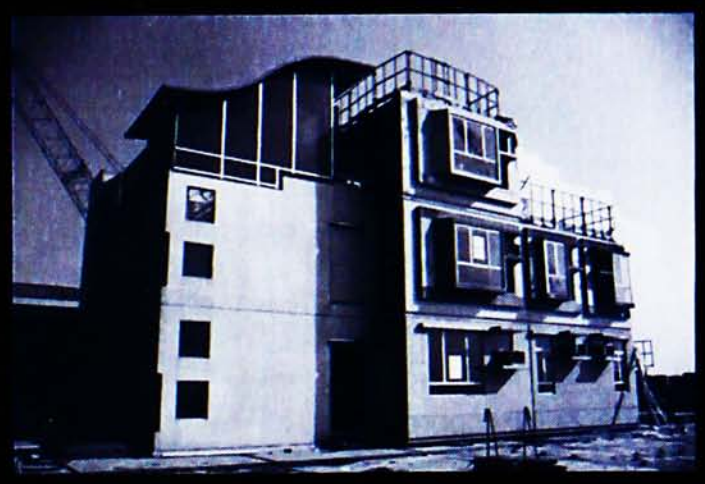
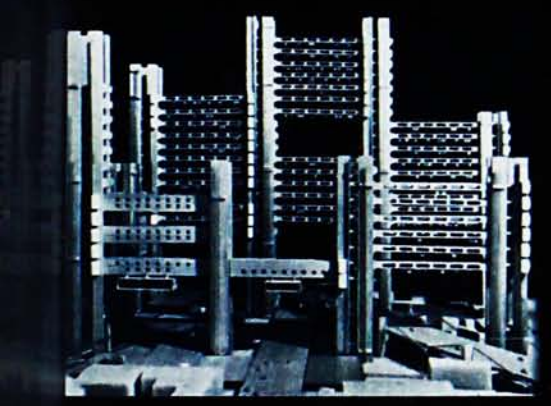










9. Appendix

Precedents

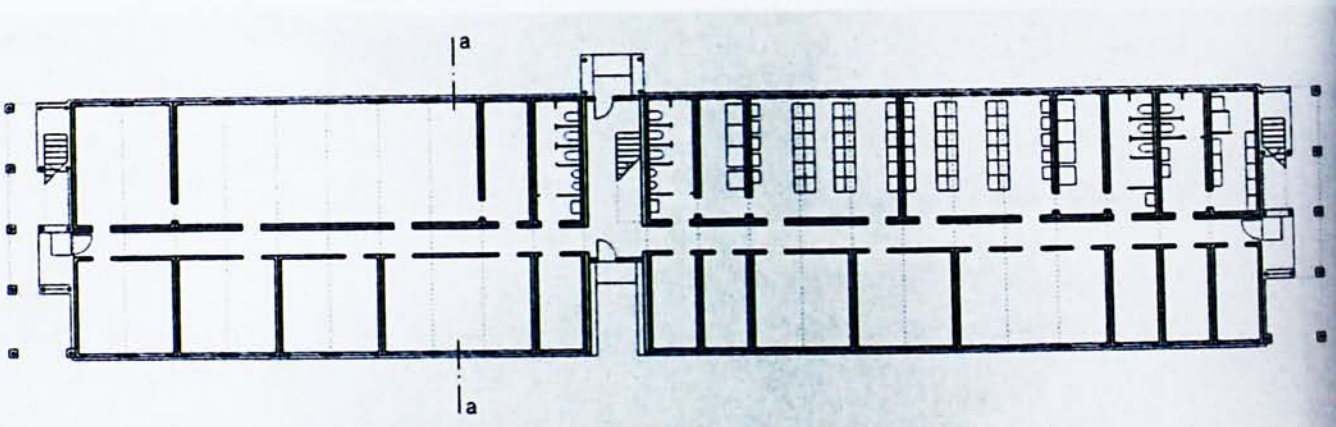
Office Building in Munich

Guggenbichler + Netzer

Combination:
Paralle and stack

Structure system:
United supporting

Material of box:
Prefabricated container



Hotel Extension in Beazu

Kaufmann 96, Dornbirn

Combination:
Paralle and stack

Structure system:
Base supporting

Material of box:
Wood panel

Modules specifications:
size: 7.50m*4.00m

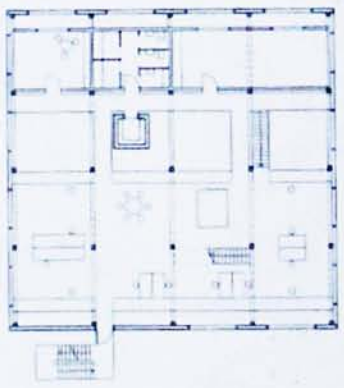
Office Block in Fellbach

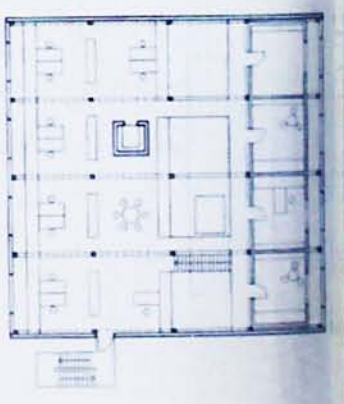
Dollmann+partner, Stuttgart

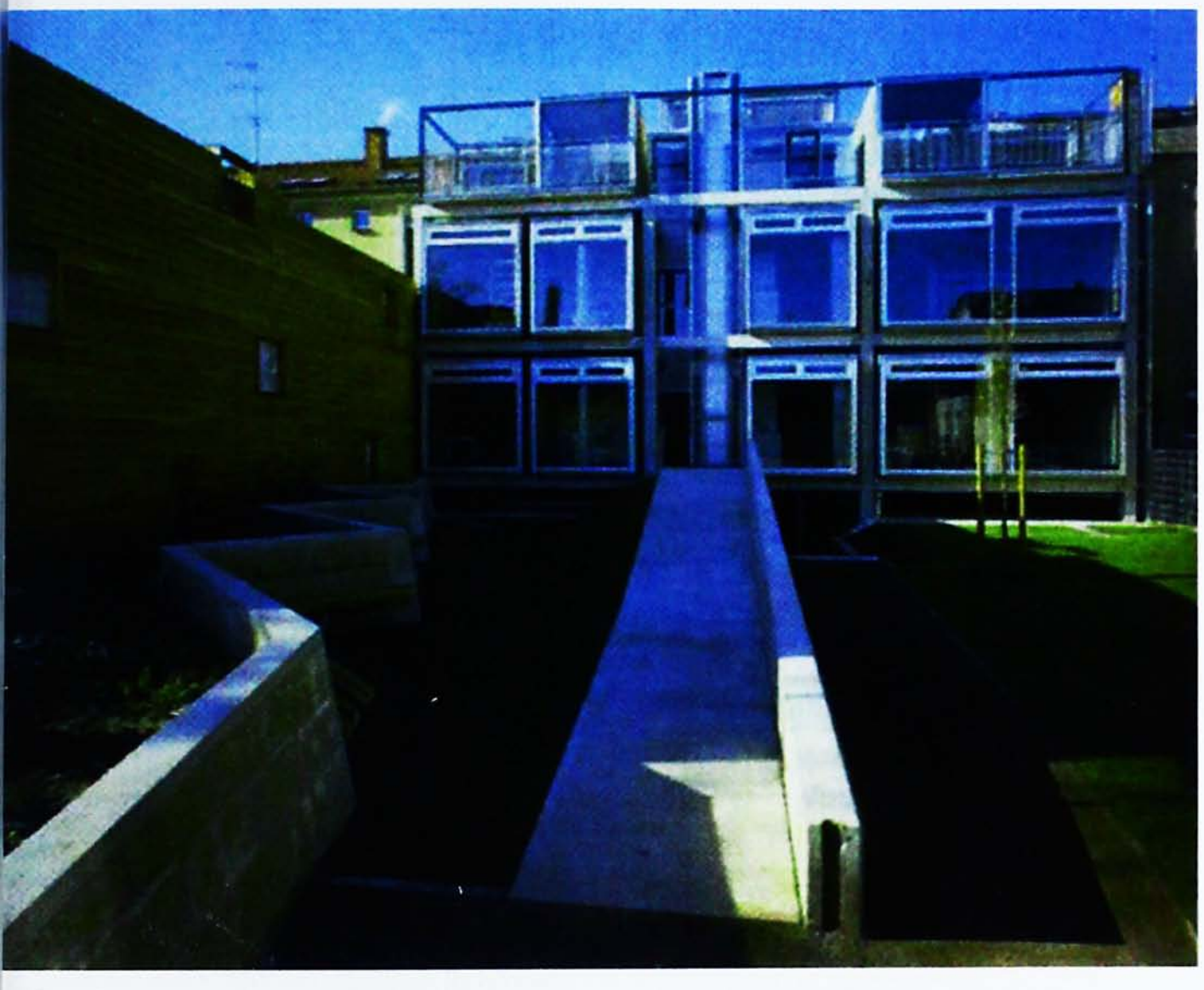
Combination:
Paralle and stacked

Structure system:
Framework supporting

Material of box:
Prefabricated container







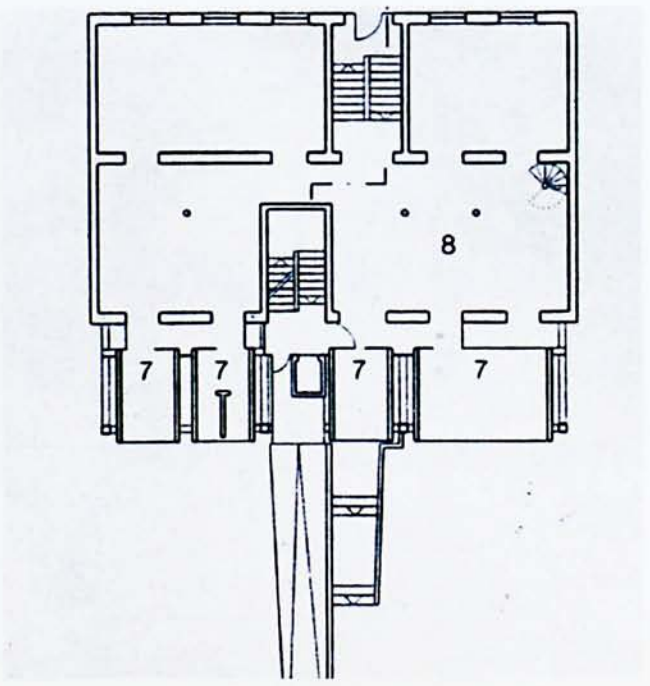
Housing and Commercial Block in Rathenow

Jochen Keim+Klaus Sill

Combination:
Paralle and stacked

Structure system:
Framework supporting

Material of box:
Prefabricated container



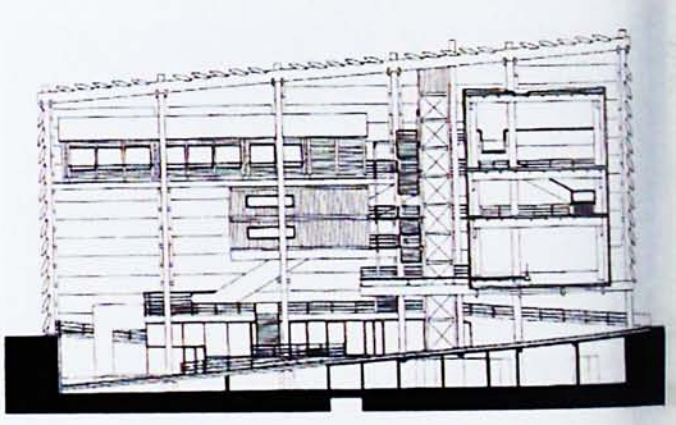
Pavilion of Belgium Expo'92

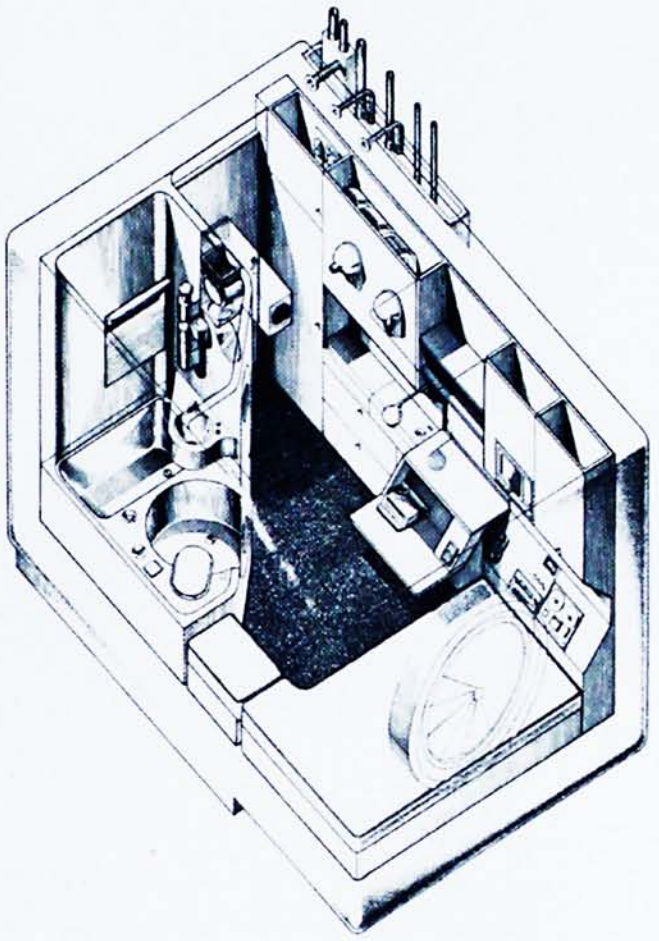
Driesen, Meersman, Thomaes, 1992

Combination:
Paralle and stacked

Structure system:
Framework supporting

Material of box:
Prefabricated container





Nakagin Capsule Building

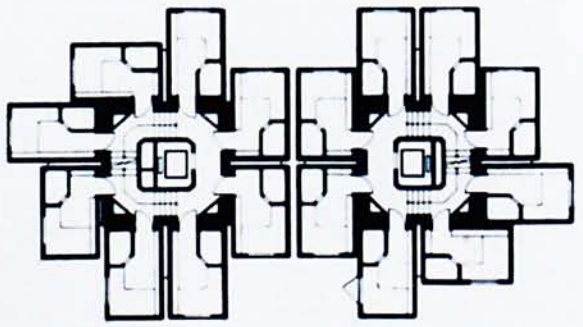
Kisho Kurokawa, 1972

Combination:
Paralle, rotate, overlap and stacked

Structure system:
Core supporing

Material of box:
Reinforced concrete

Modules specifications:
size: 8ft W, 12 ft W



A High Rise Modular System of Construction

Gammon Skanska Limited

Combination:

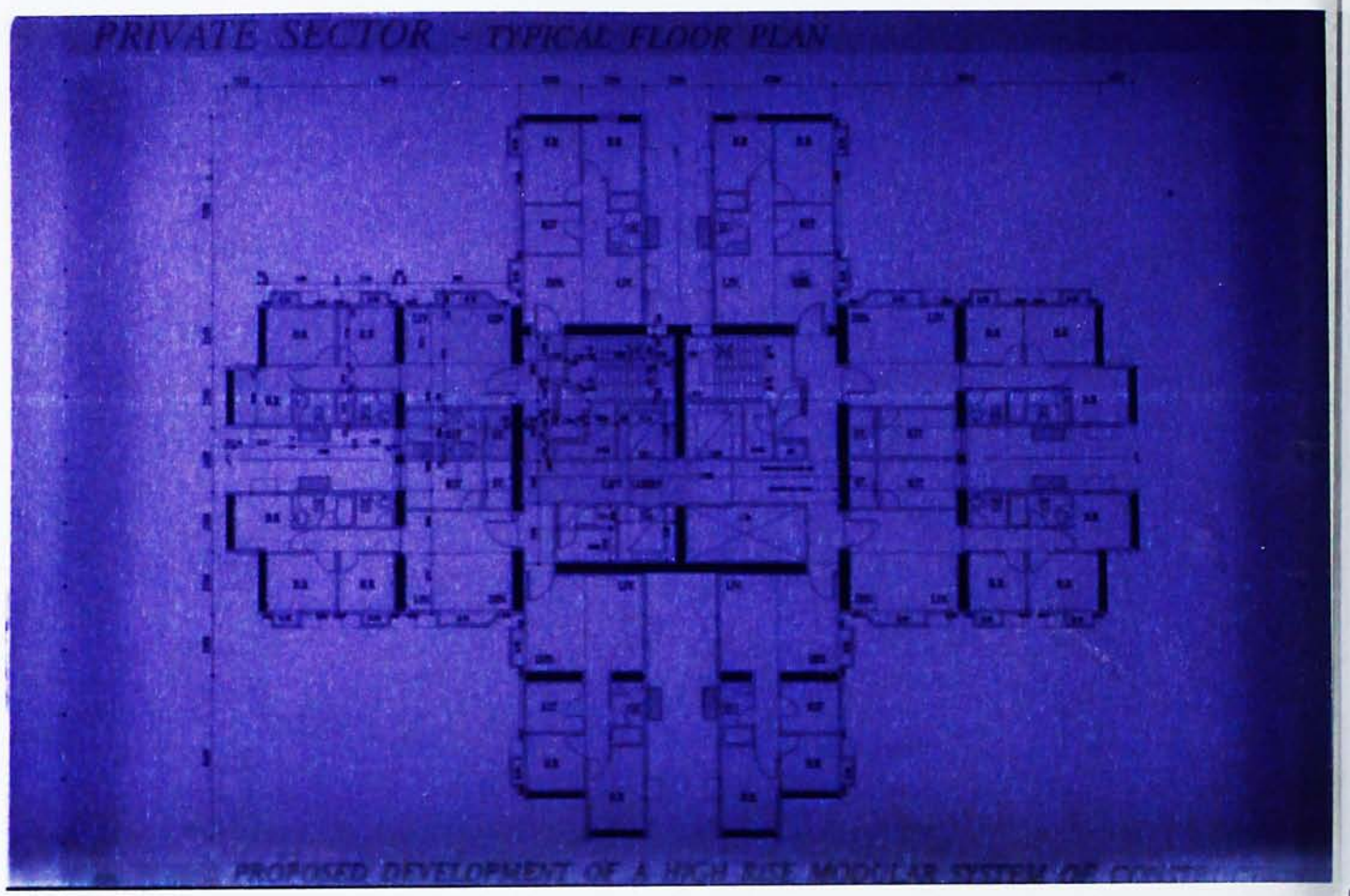
Paralle, shift and stacked

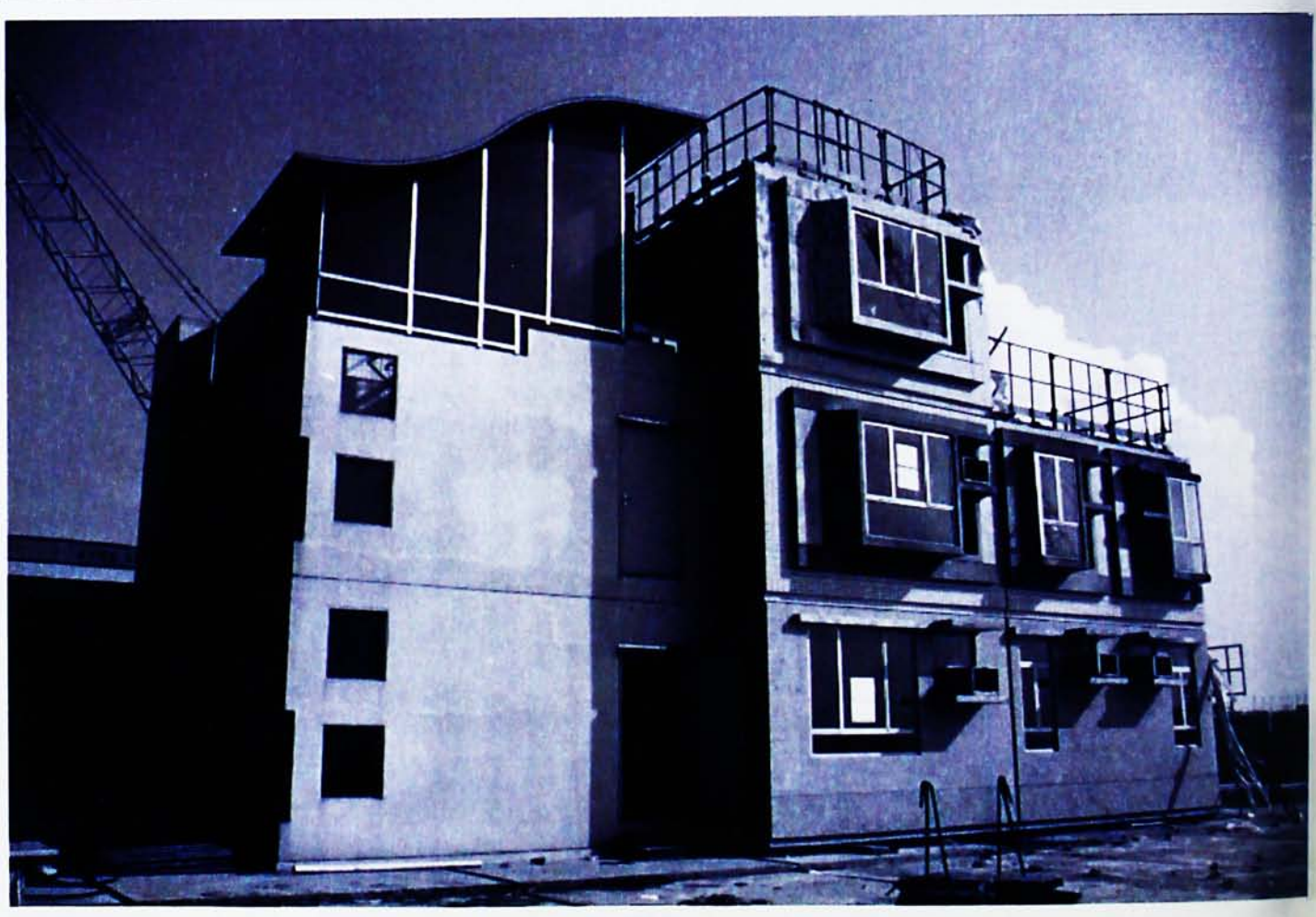
Structure system:

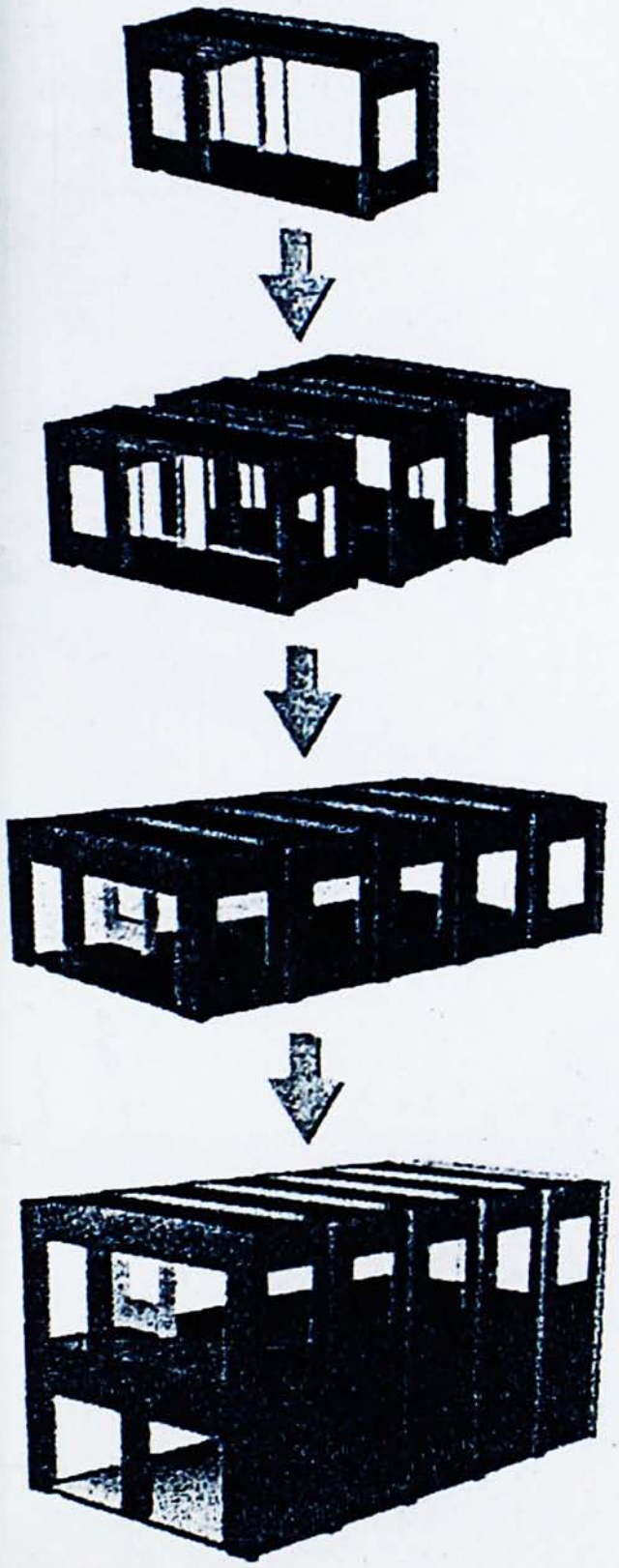
Core supporting

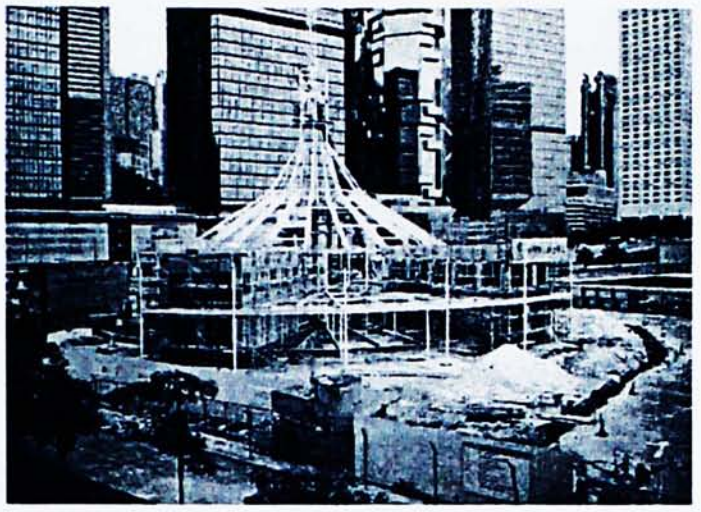
Material of box:

Reinforced concrete









Integer programme HK

Gammon Skanska Limited

Combination:
Parallel and stacked

Structure system:
Independence

Material of Box:
Reinforced concrete

Modules specifications:
size: 8.5L , 2.5W, 2.75H
weight: 25t max
36 modules per floor
15 module types
grade 40 concrete
floor & facade 125mm
roof &wall 75mm

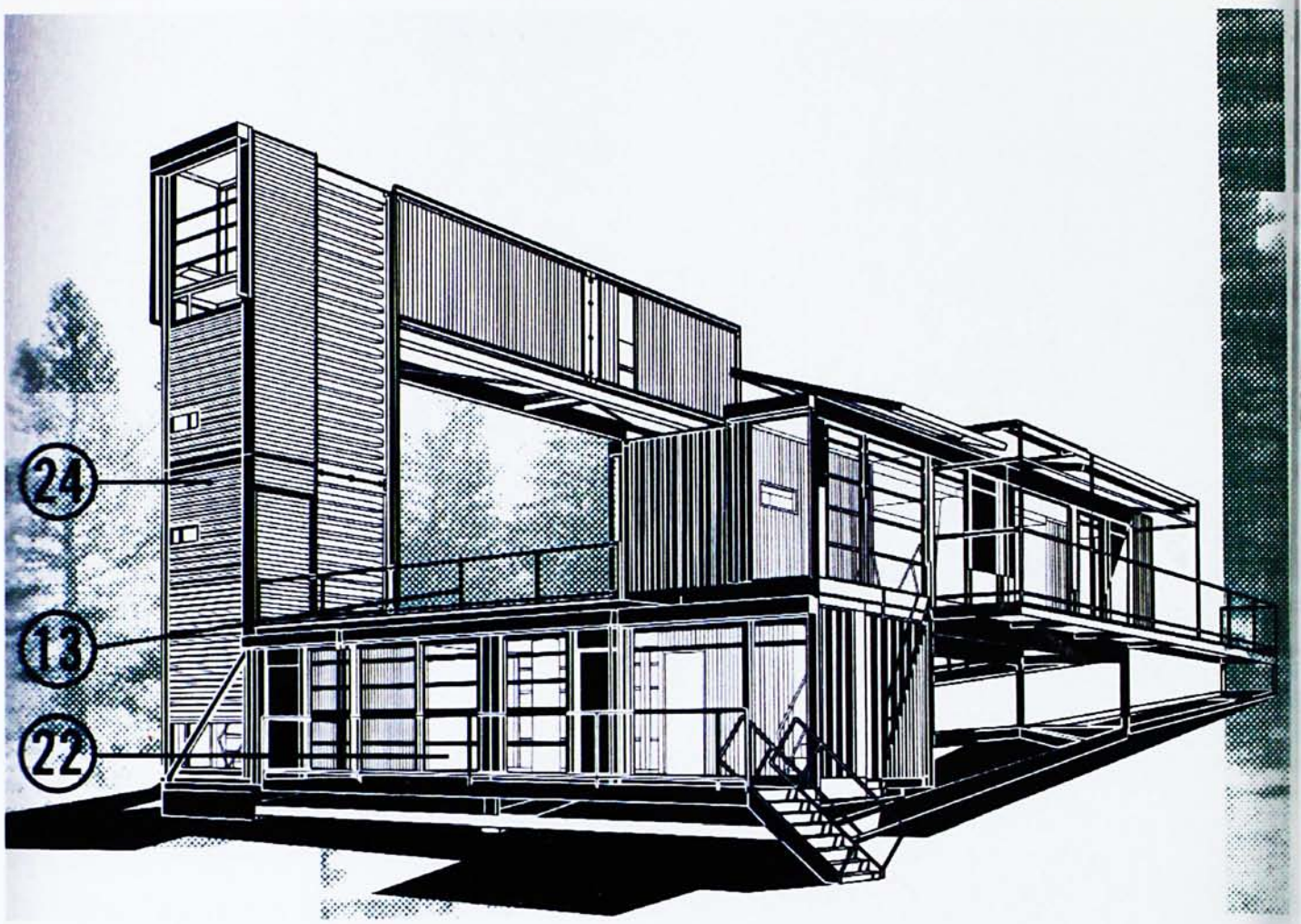
High Sierras Cabins
Meadow's Edge Cabin

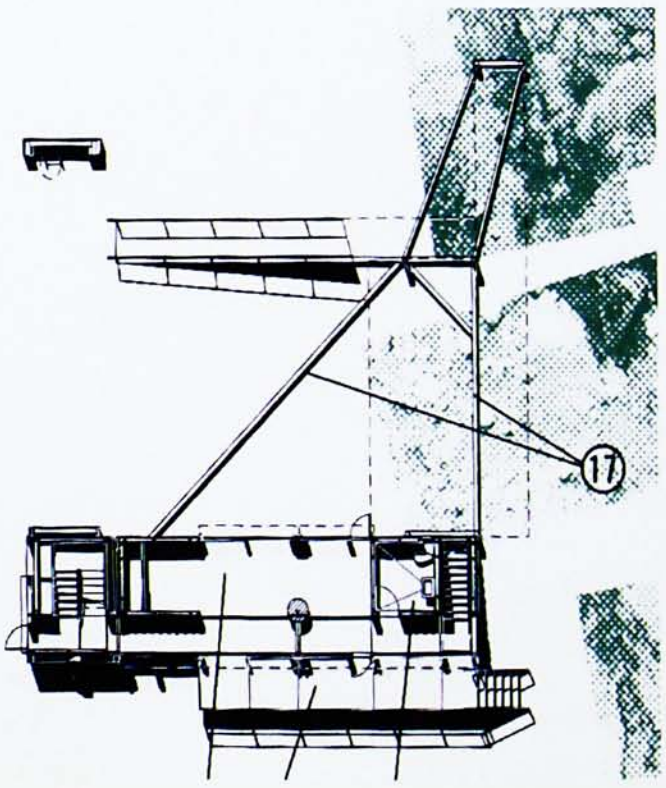
Wes Jones, 1995

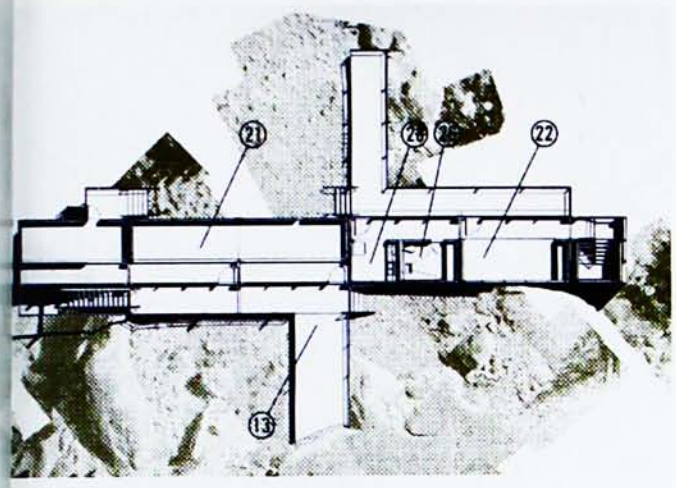
Combination:
Serial, overlap and stacked

Structure system:
Self-supporting solely supporting

Material of box:
Prefabricated container







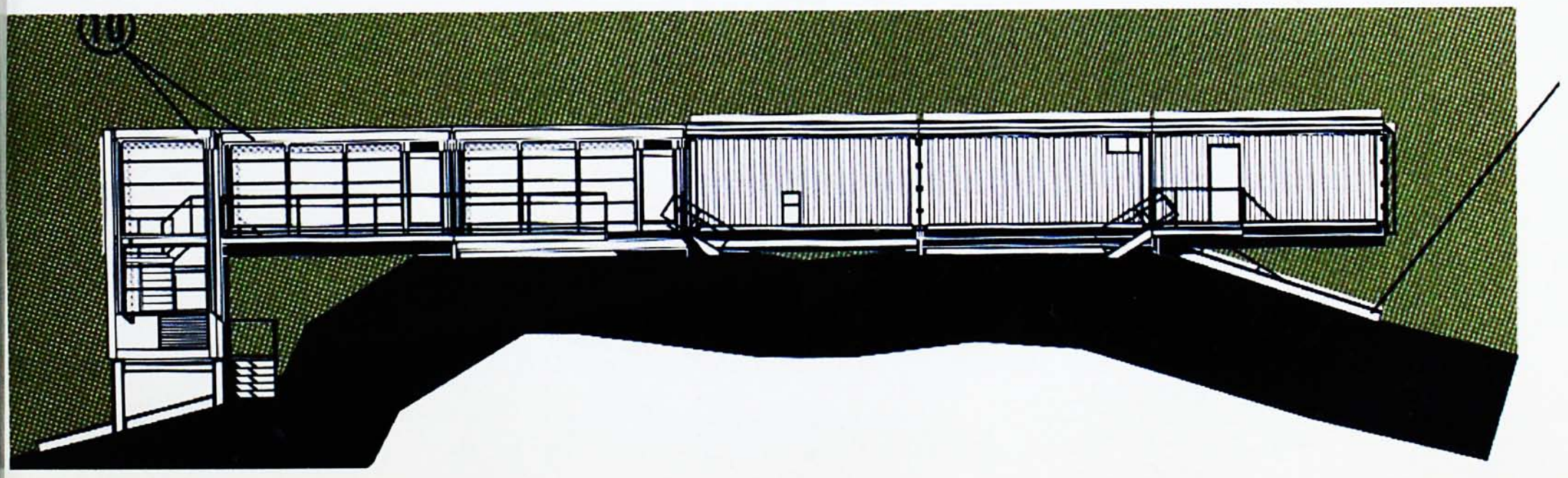
High Sierras Cabins Coyote Rock Cabin

Wes Jones, 1995

Combination:
Serial and overlap

Structure system:
Self-supporting and solelysupporting

Material of box:
Prefabricated container



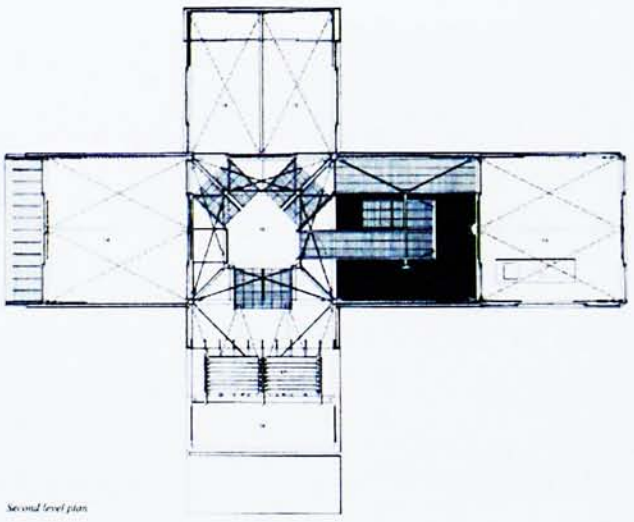
Nested cube in Process I

Ideyuki Amashita, 1993

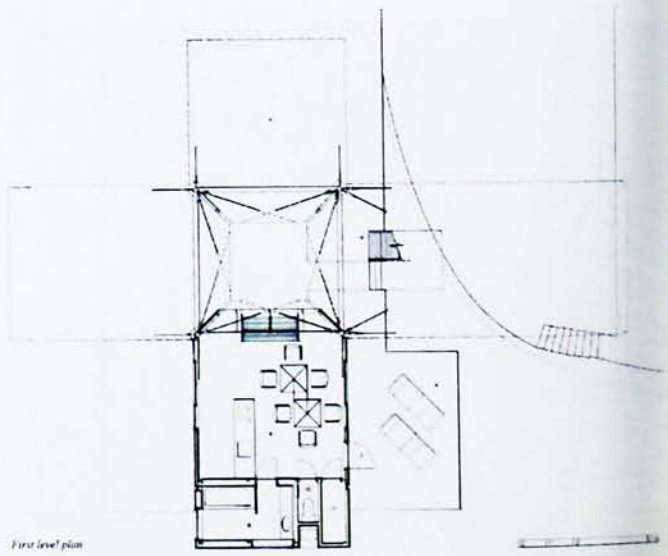
Combination:
Paralle

Structure system:
Base supporting

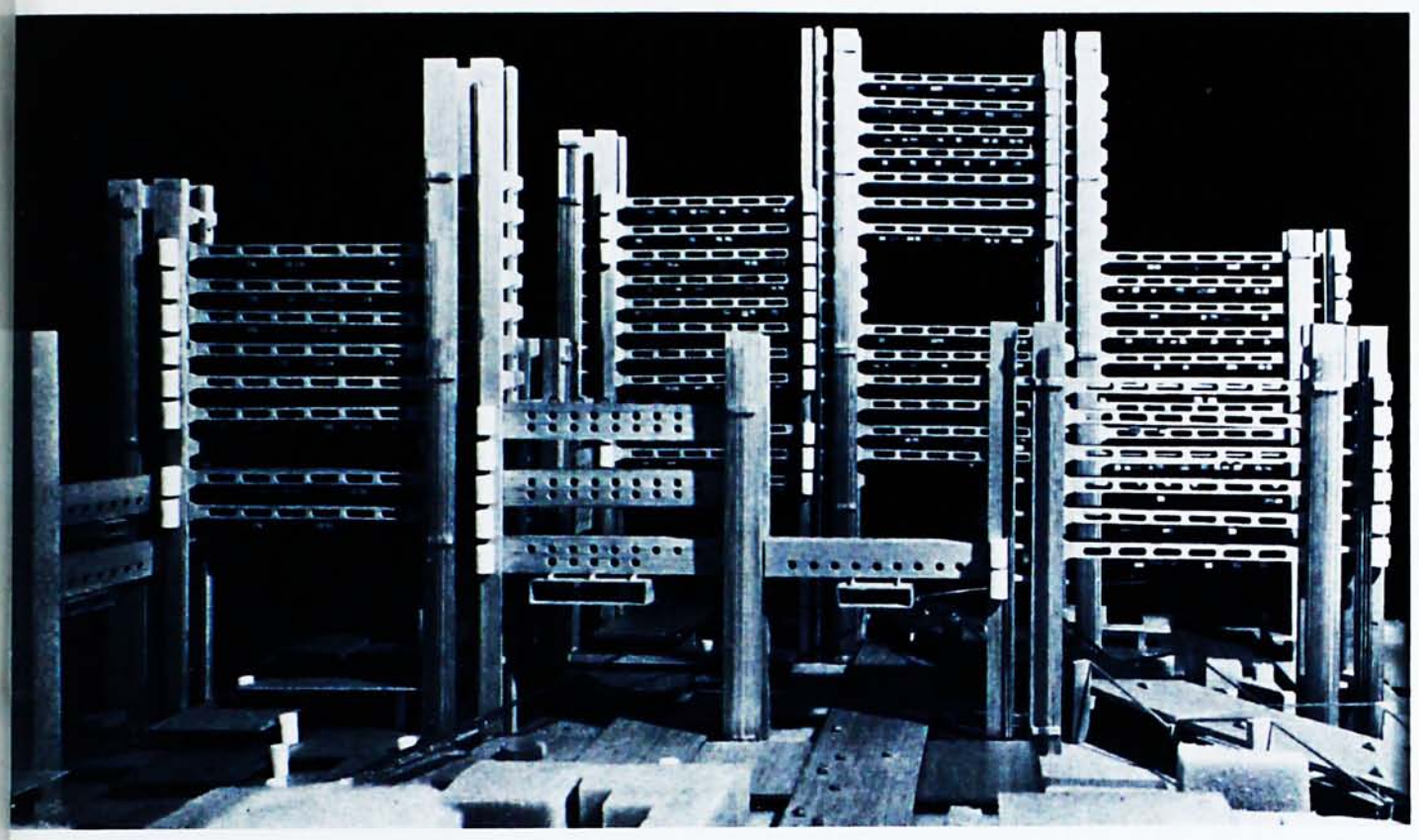
Material of box:
Reinforced concrete



Second level plan



First level plan



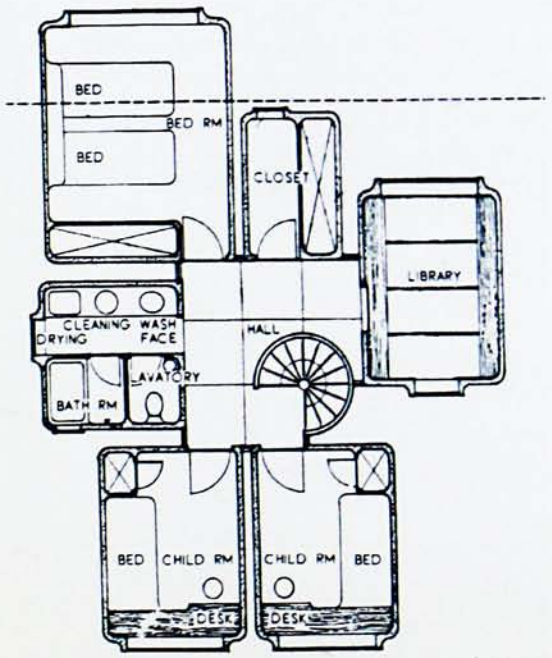
Urban Megastructure

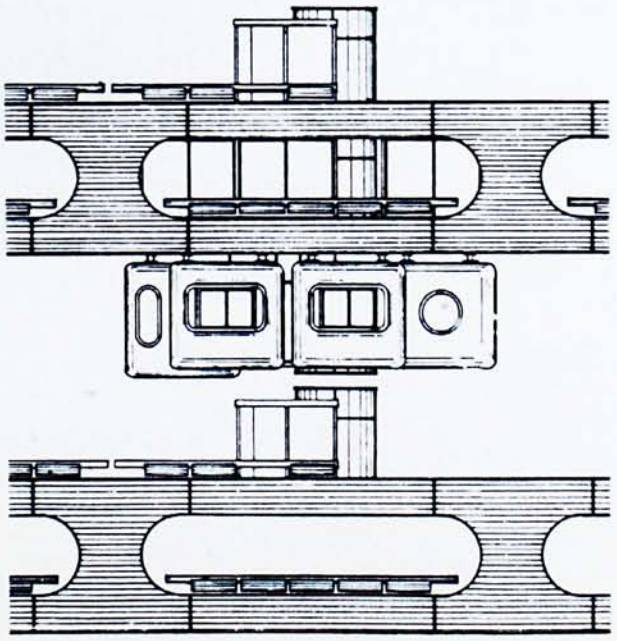
Akira Shibuya, 1966

Combination:
Paralle

Structure system:
Core supporing

Material of box:
Reinforced concrete





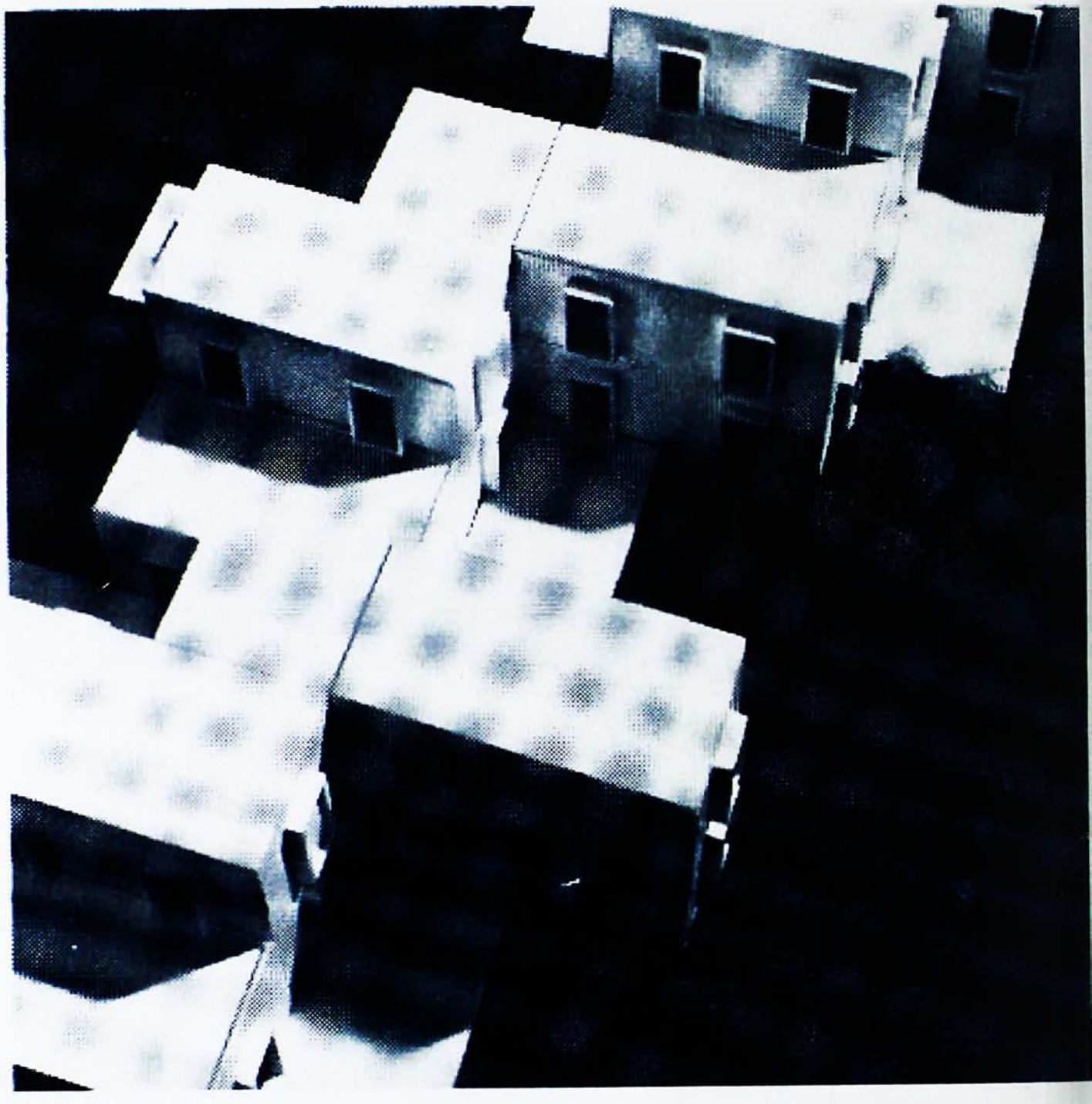
Taisei Overseas System

Kisho Kuaokawa , 1971

Combination:
Paralle, stacked and overlap

Structure system:
Self-supporing

Material of box:
Reinforced concrete



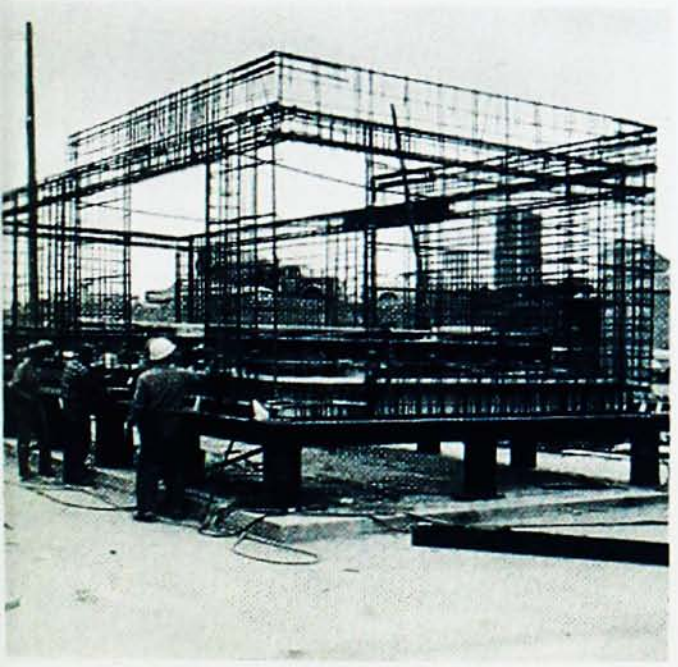
Habitat'67

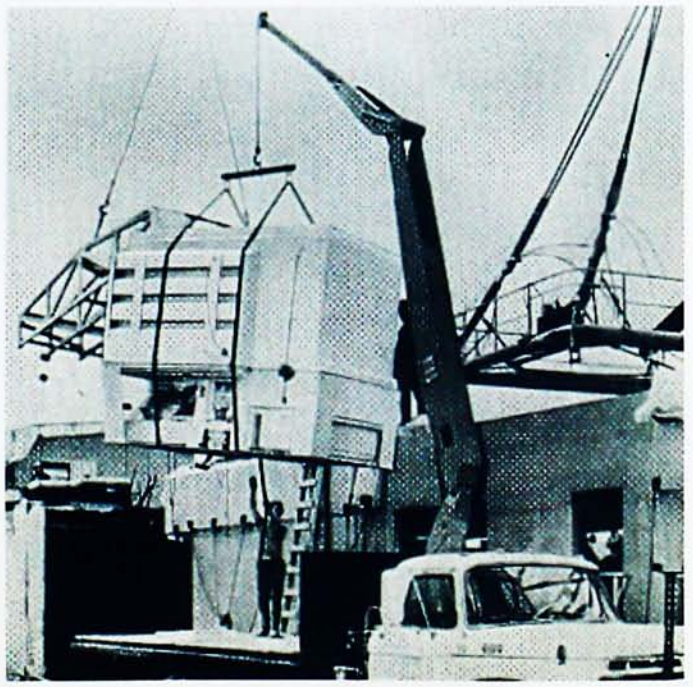
Moshe Safdie

Combination:
Shift and overlap

Structure system:
self-supporing

Material of box:
Reinforced concrete





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May 2003

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