

ARCHITECTURAL PROPERTIES OF A STRUCTURAL THEME :
A THEMATIC EXPLORATION

by

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*Bachelor of Arts in Architectural Studies
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June, 1983*

*Submitted to the Department of Architecture
in Partial Fulfillment of the Requirements for the*

Degree of Master of Architecture

at the

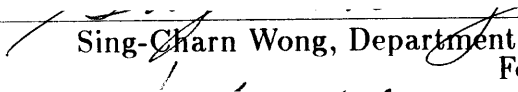
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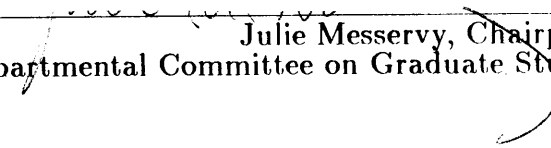
Signature of Author _____


Sing-Charn Wong, Department of Architecture
February 24, 1986

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Departmental Committee on Graduate Students

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MASSACHUSETTS INSTITUTE
OF TECHNOLOGY

JUN 06 1986

ABSTRACT

ARCHITECTURAL PROPERTIES OF A STRUCTURAL THEME: A THEMATIC EXPLORATION

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Abstract

The first objective of the thesis is to demonstrate a way of "designing" that comes as much from the forms at hand as from any outside criteria. It involves the establishment of a *structural theme* and the understanding of its architectural properties. The approach seeks the development of alternative interpretations within the *structural theme*. There is, however, neither context nor program to choose alternatives in. There is only the thematic development. The *structural theme* is pushed along, not with the objective to come to a completed "design" but with the objective to pass a variety of stages needed for a demonstration of the method involved. The second objective of the thesis is to explore the ways a *structural theme* can be communicated.

There are two parts to the study:

1. Part one of the study involves the formulation of the structural system. It also illustrates the design process of the structural elements. Rules are formulated for the elements by means of a grid position which will, therefore, allow the exploration of the horizontal and vertical relations among elements in the system.

2. Part two of the study demonstrates the deployment of the system. It includes the principles of horizontal and vertical deployments and fields.

Thesis Supervisor: N. John Habraken, Professor of Architecture

ACKNOWLEDGEMENT

I would like to express my sincerest gratitudes to my advisor, Professor John Habraken for his invaluable guidance, understanding, patience, and thought-provoking and insightful advice. I would also like to thank Reinhard Goethert for his constructive criticisms. I am most indebted to my family : Mama and Papa, Wing-Fat and Li-Ching, Chiu and Li-Kit, Shing-Wei and Men-Shang, Chung-Por and Li-Ming, Kwei-Kun and Li-Cheung, Woo-Kit and Li-Wan, and Shing-Yiu for their invaluable, sacrificial, continuous support. My gratitude towards them is beyond the means of expression. I am also very grateful to all my brothers and sisters in Christ, especially Tom and Lisa Lam, for their prayers and spiritual support. And finally, I want to especially thank my wife, Dilys, for her devotion, understanding, patience and love.

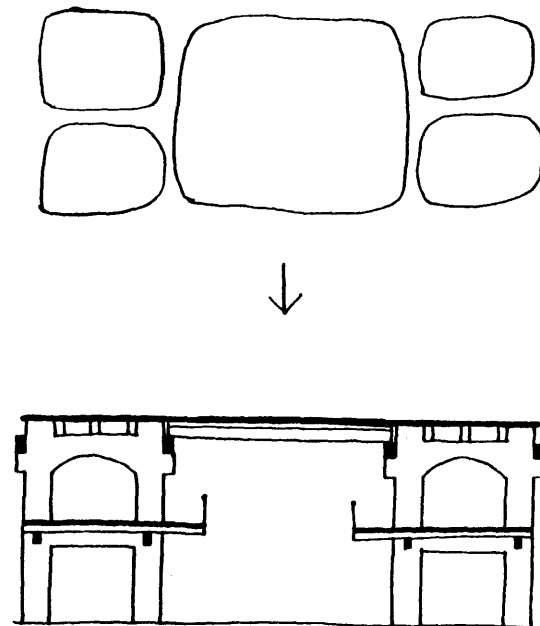
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I. INTRODUCTION

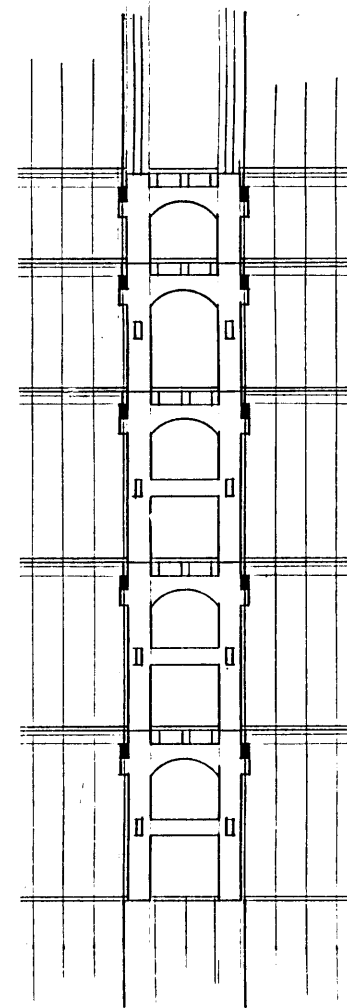
I first learned about the idea of thematic design in a course taught by Professor John Habraken in the fall semester of 1984. Since then the idea of designing with a theme intrigued me. In the spring semester of 1985, I was writing my thesis proposal and was also working on a project involving mixed-use building for my final studio in the spring program. The studio was again taught by John. We began the project by designing our own set of thematic structural elements which would finally become the theme of our building. I started out with the idea of a community type environment that included a large working space flanked by small offices. This idea later generated into a two-story high primary space with secondary floors built inside (figure I.1). One important idea about designing the spaces in this project was that they could be changed according to the duration and the nature of the activities. How to design spaces which were capable to 1) accommodate changes and 2) not be neutral but inviting interpretation activities became a challenge to me. The idea of a *structural theme* including a primary and a secondary system seemed promising in giving this challenge an answer. A little bit of that answer had already started to show in the design project I did for that semester.

I.1



I. INTRODUCTION

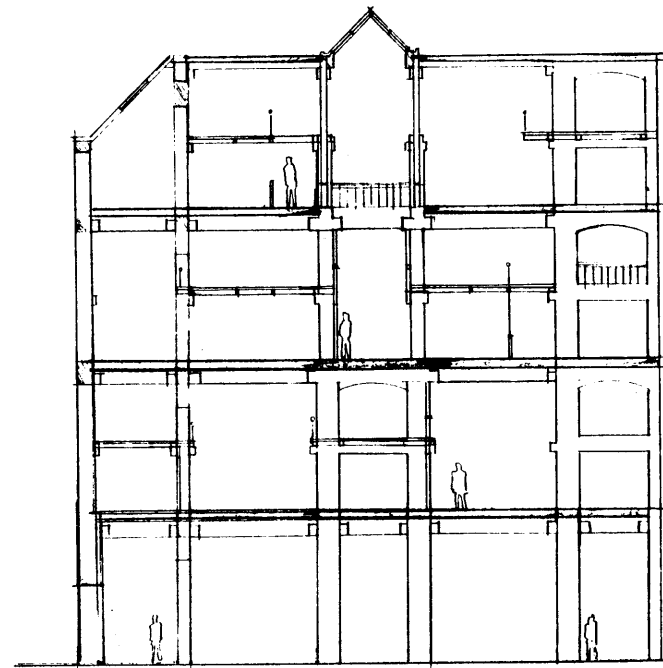
This thesis is a continuation of that project. The goal is not to further the design but to understand better the idea of *structural theme* and the process of formulating such a theme as well as to explore its properties. The portal system, first introduced in my studio project, is the subject of analysis. The first objective of the thesis is to demonstrate a way of "designing" that comes as much from the forms at hand as from any outside criteria. The approach seeks the development of alternative interpretations within the *structural theme*. There is, however, neither context nor program to choose alternatives in. There is only the thematic development. The *structural theme* is pushed along, not with the objective to come to a completed "design" but with the objective to pass a variety of stages needed for a demonstration of the method involved. The second objective of the thesis is to explore the ways a *structural theme* can be communicated.



I. INTRODUCTION

The drawings in the following pages are extracted from the studio project I did the past semester. This is a multi-use building at Massachusetts Avenue in Cambridge, all-purpose work space for the MIT museum and retail space on the ground floor.

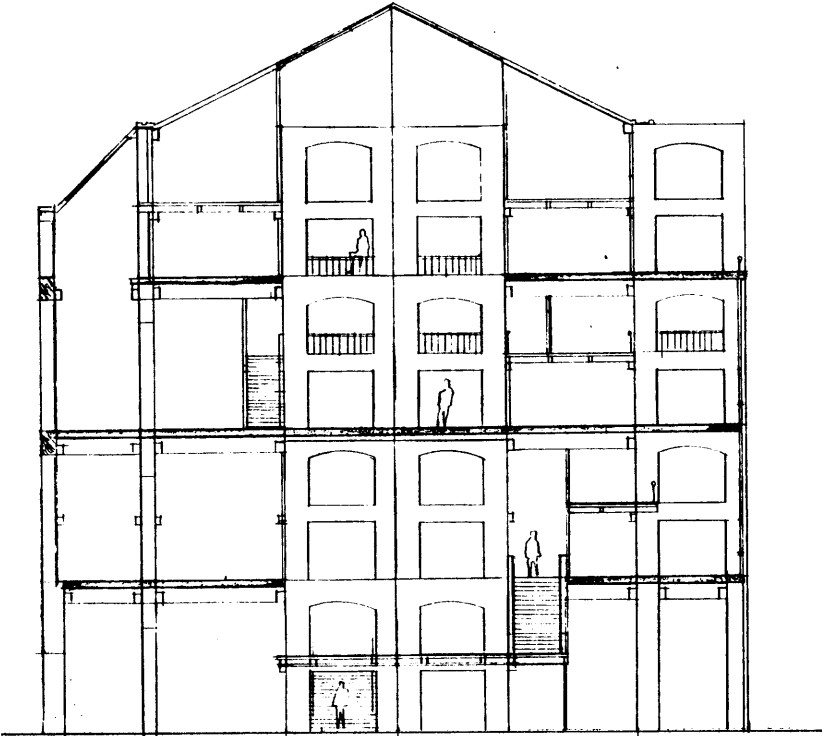
I. INTRODUCTION



0' 8' 16' 24'

SECTION

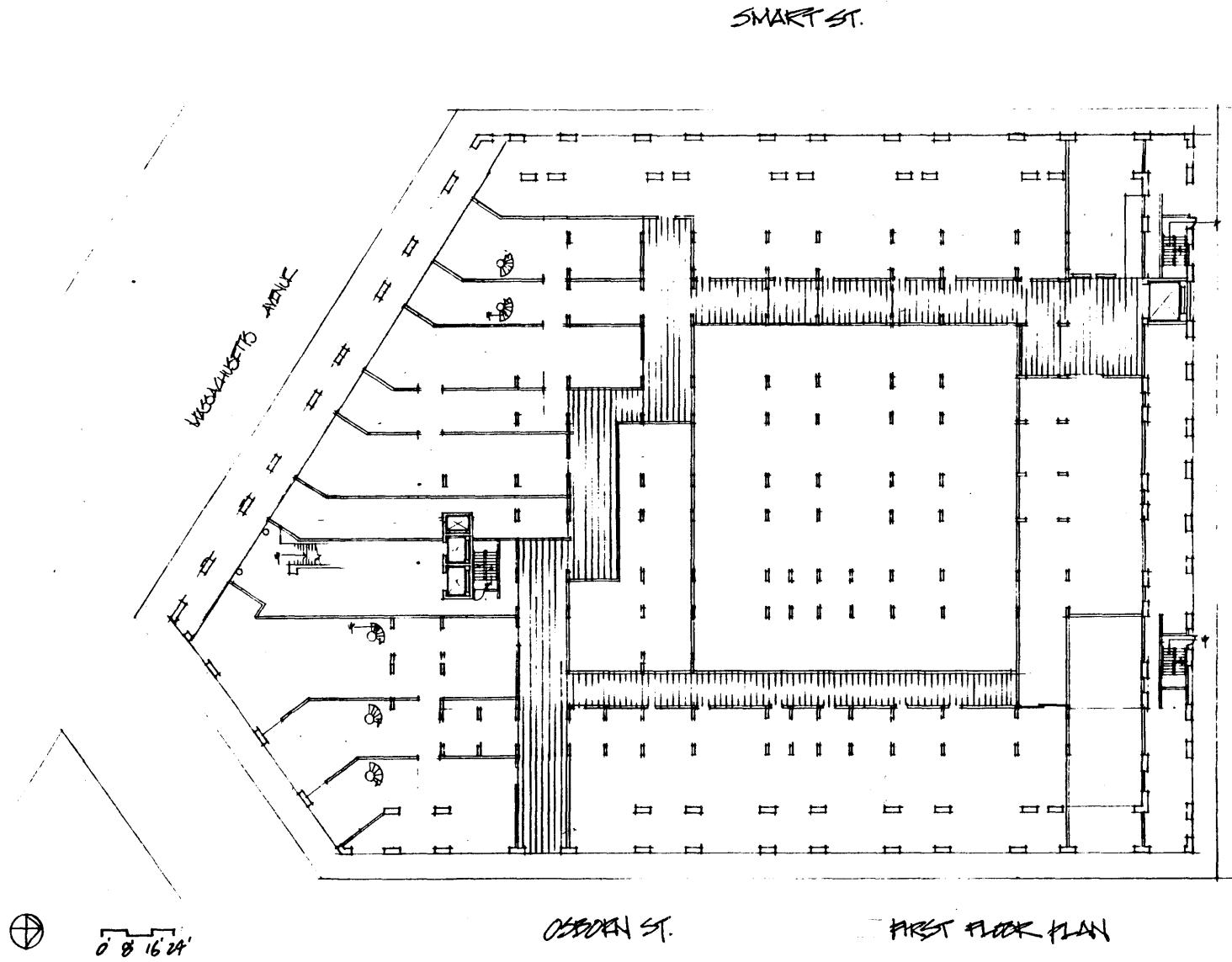
I. INTRODUCTION



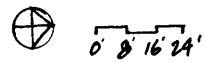
0' 8' 16' 24'

SECTION

I. INTRODUCTION

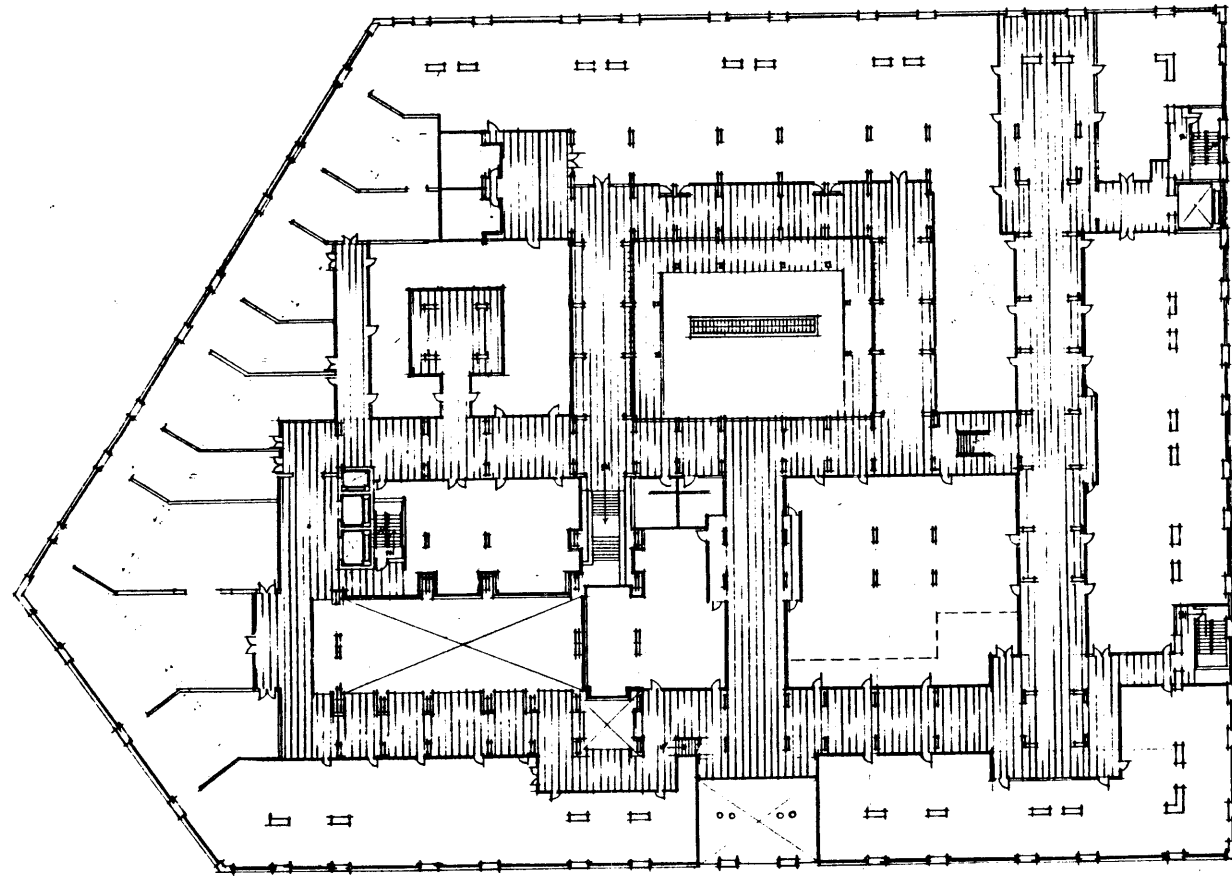


I. INTRODUCTION



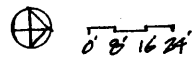
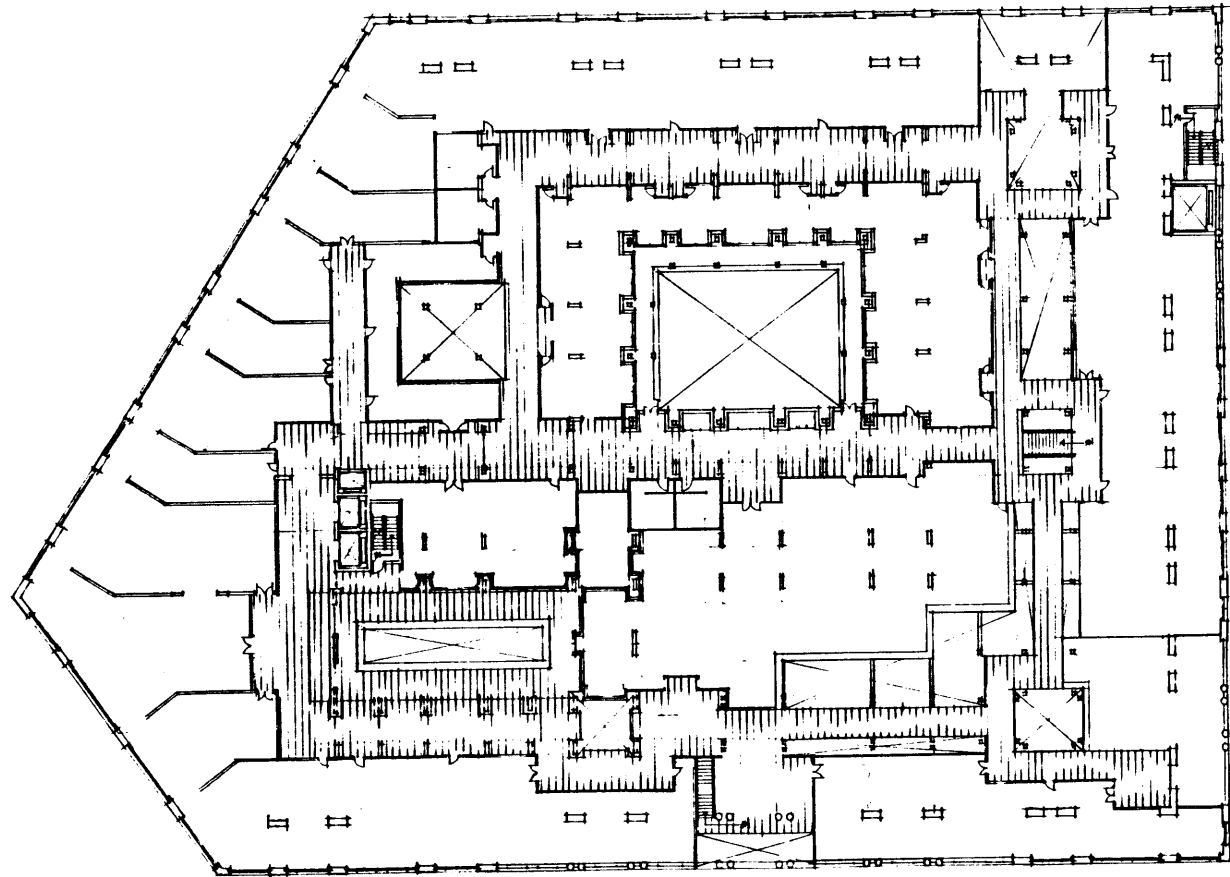
SECOND FLOOR PLAN

I. INTRODUCTION



THIRD FLOOR PLAN

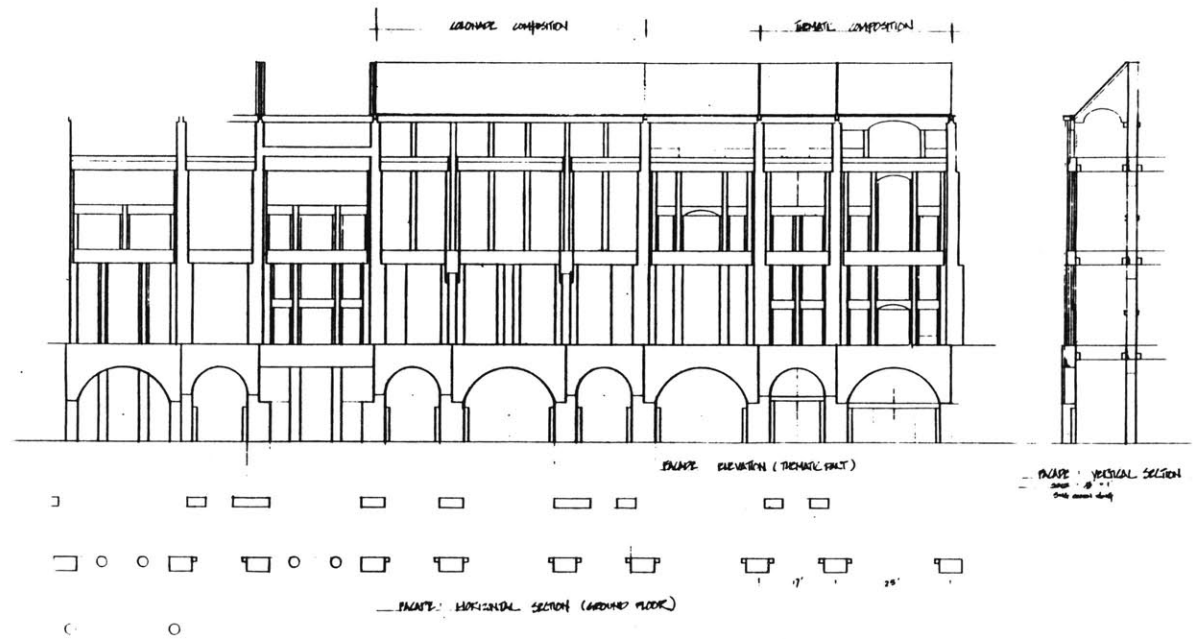
I. INTRODUCTION



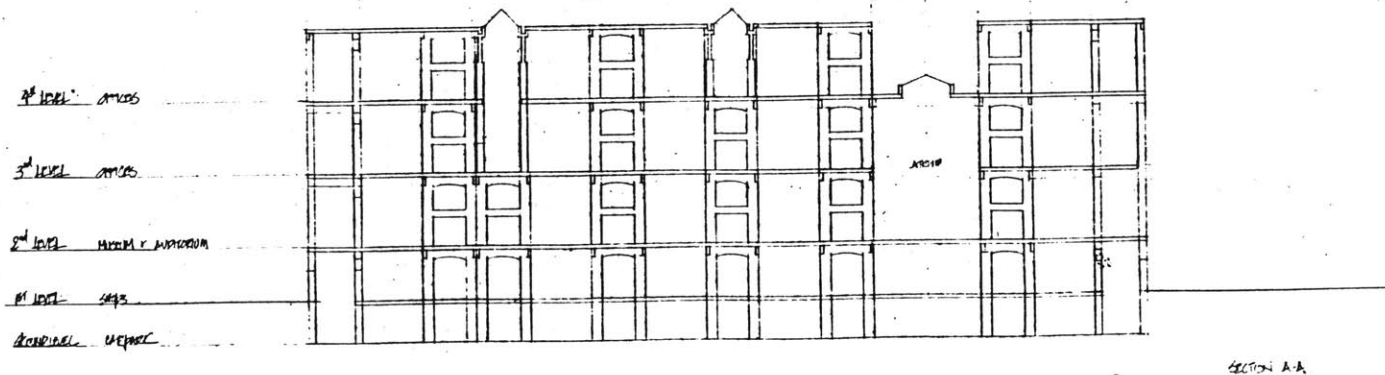
FOURTH FLOOR PLAN

I. INTRODUCTION

THEMATIC STUDY



I. INTRODUCTION



II. PRIMARY SYSTEM

II.1 Elements

The primary system basically consists of 1. vertical structural elements : portals (including structures on top of the portal to support the floor decks) and columns, and 2. horizontal structural elements : girders, beams, and floor decks.

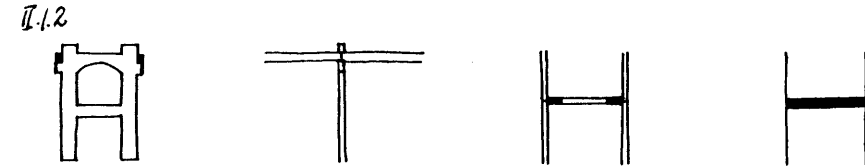
II.1.1 Portal

The main role of the portals is to support the girders as well as the floor decks. They also act as the element to resist external forces along the beam direction.



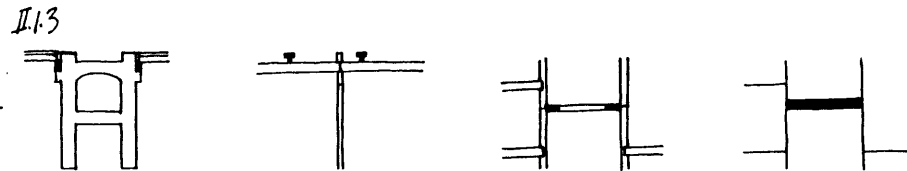
II.1.2 Girder/Portal

The girders are supported directly by the portals. The diagrams illustrate the structural configuration of the girders related to the portal viewed from the front (fig II.1.2.1), the side (fig II.1.2.2), and the top (fig II.1.2.3), as well as the symbolic structural diagram (fig II.1.2.4).



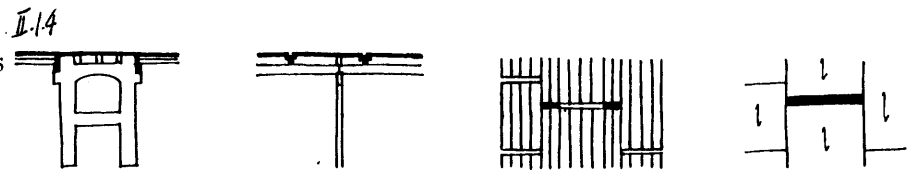
II.1.3 Beam/Girder/Portal

The beams are spanned directly between girders.



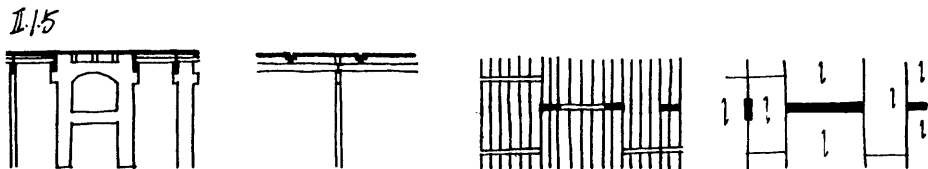
II.1.4 Floor/Beam/Girder/Portal

The floor decks are spanned directly between portals within the row of portals or between beams outside the row of portals.



II.1.5 Column/Floor/Beam/Girder/Portal

There are two types of columns. One type is designed to be placed on top of the portal and the other type is not.



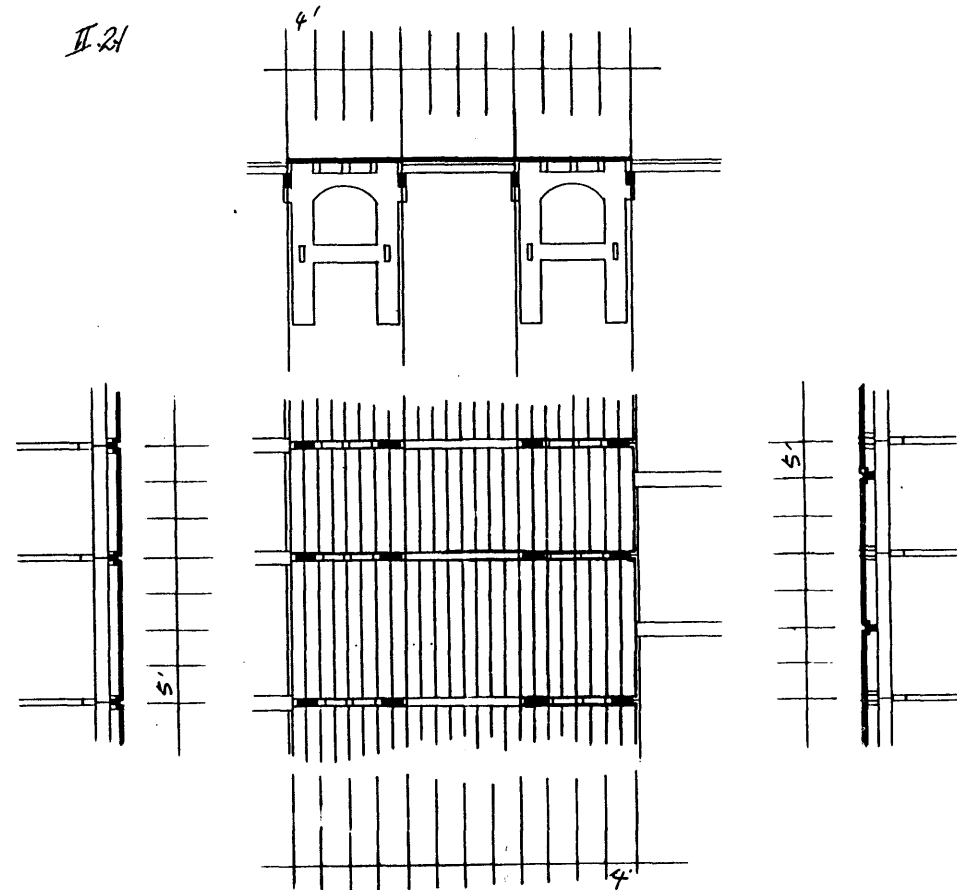
II.1.6 Shear Wall

Shear walls are occasionally placed along the girder direction to resist lateral forces.

II.2.1 Purpose of the position grid

At this point, a system is chosen and a catalogue of elements is formed. The next step is to create a field by these elements. However, before this can be accomplished, the details of the joints between elements and the range of sizes of the elements must be determined. We shall discuss how this can be decided in detail in the following chapter. Once the details of the joints and the range of sized of elements are determined, they should be kept constant aferward. This implies that the relative position of the elements should not be changed. A grid should be introduced at this stage to help relating the position of elements.

By means of a grid position, rules can be formulated for elements. It allows the structural elements to be deployed in continuous fields according to the predertermined rules without repetiton. Moreover, the deployment of structural elements can be interpreted in terms of dimensions modules. With the same elements and details, however, grid of different modules can be chosen which will influence the dimension of beams, girders and portals. For the demonstration in this thesis, we will stay with the grid explained in this chapter.

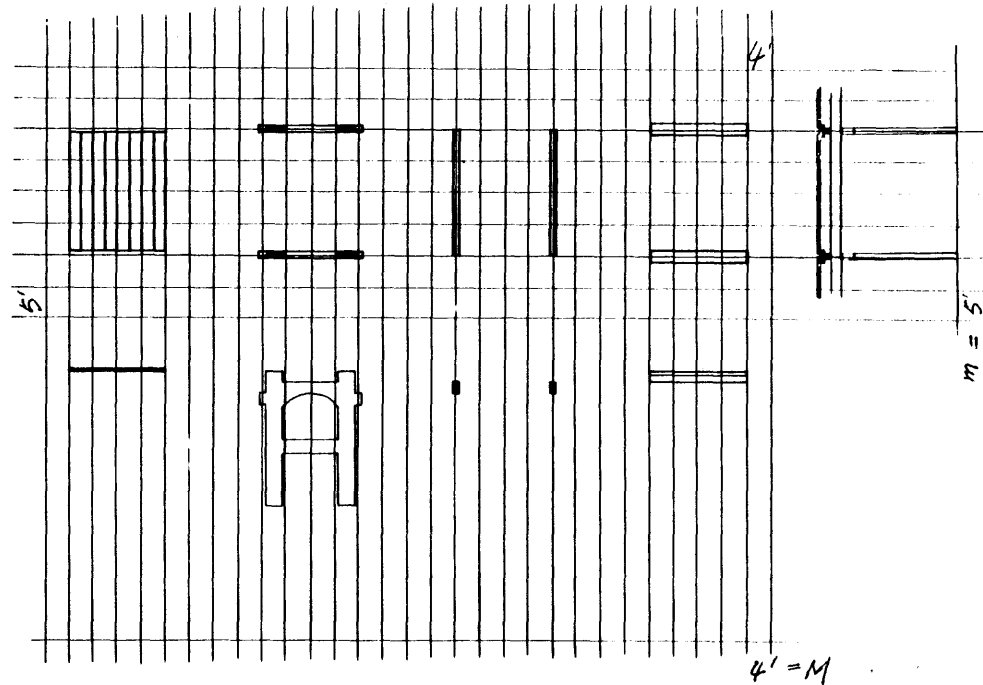


II.2.2 Relating structural elements to the grid

The way to relate the structural elements to the grid depends on how the elements are put together. The most important idea here is to relate all elements to a common grid so that the connection between elements are constant. For the same grid and the same element, different relative positions can be chosen. We are free to determine where the element should be placed in relation to the gridline, as long as the relation between the element and the gridline is constant.

The different intervals between the vertical elements and the different lengths of the horizontal elements in the same direction should be chosen from the multiples of a same number, so that both the intervals as well as the lengths can be interpreted in terms of modules.

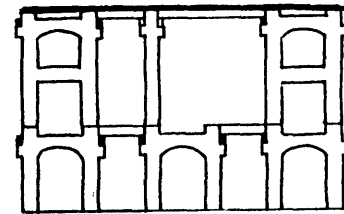
II.2.2



II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

II.3 Detail Description of the Elements



II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

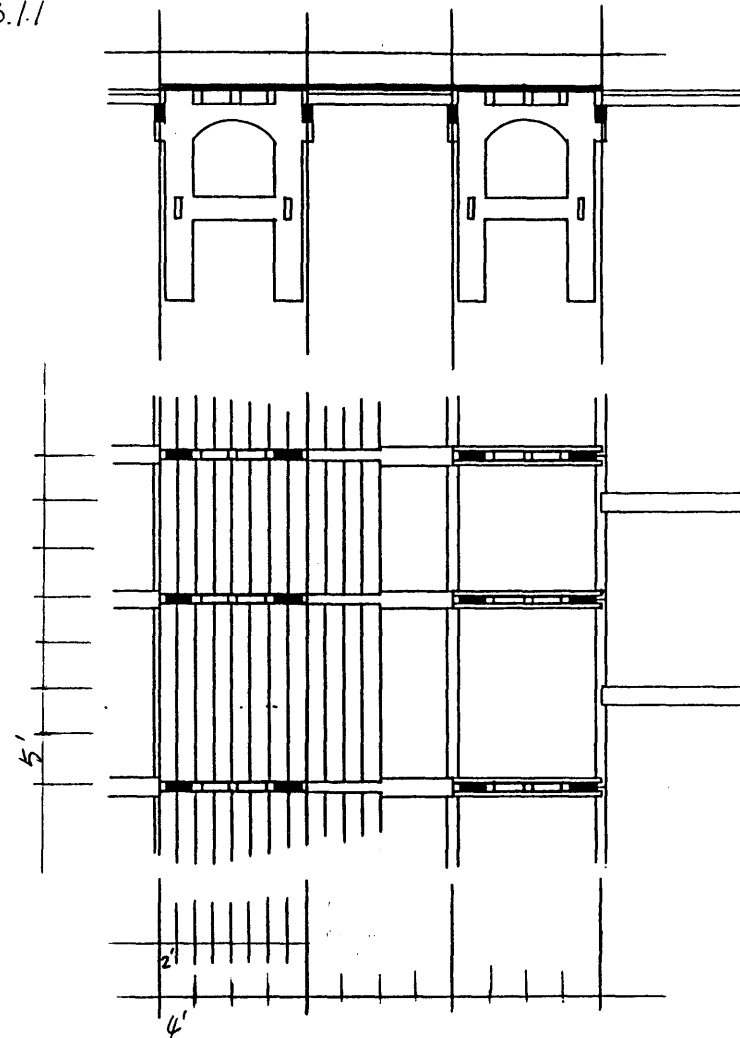
II.3.1 Floor

The material used for the floor is flexicore concrete decks. Flexicore decks offer high-speed floor and roof construction. Individual slabs are precast and are prestressed. The method is an efficient system.

II.3.1.1 Position of floor decks

The floor decks spanned only along the girder direction. There are two ways of supporting the flexicore decks. One way is to span between portals. The other alternative is to span between beams.

II.3.1.1



II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

II.3.1.1.1 Floor spanned between portals

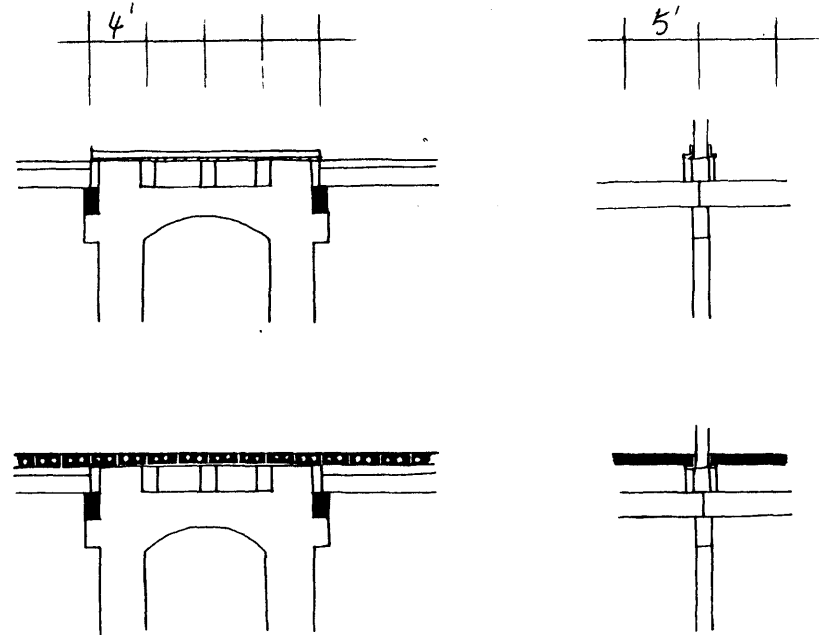
The deck thickness and the deck length are already determined by the different intervals between two portals. The lengths of intervals between two portals are 15', 20', and 25'. Because of the portal thickness between two decks, the real lengths of spanning by the floor deck are 14', 19' and 24' respectively. However, the spans will still be interpreted as 3 modules, 4 modules, or 5 modules in length at multiples of 5'.

The portals are designed to allow room on top so that mechanical systems can pass through. However, one of the function of the portals is to support the floor. Therefore, a special support system is needed (fig II.3.1.1.1). This special system is to be put into place after the portal is installed on site.

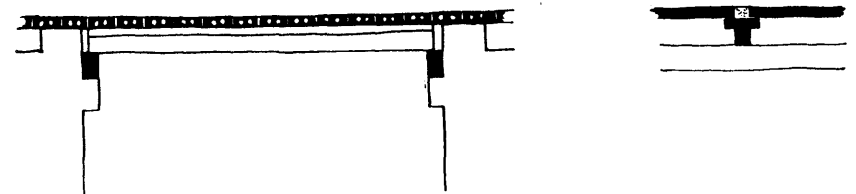
II.3.1.1.2 Floor spanned between beams

The floor decks are spanned between beams outside the row of portals. In order to keep the same interval between the end of two decks and to keep the increment of the beam length the same throughout the system, the width of the joint between the ends of the two decks must be equal to the exact width of the portal plus the thickness of the angles supporting the decks.

II.3.1.1.1



II.3.1.1.2

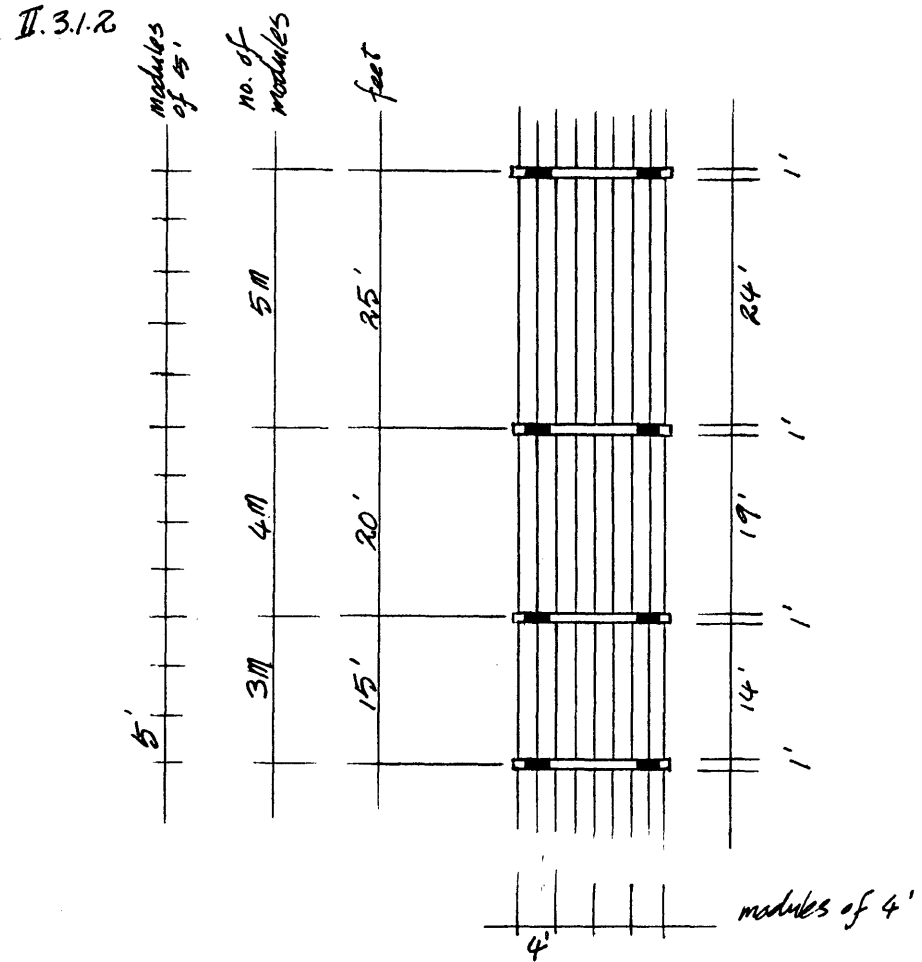


II. PRIMARY SYSTEM

II.3 Detail Description of Elements

II.3.1.2 Dimension of floor decks

Figure II.3.1.2 shows the dimension of the floor.



II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

II.3.2 Portal

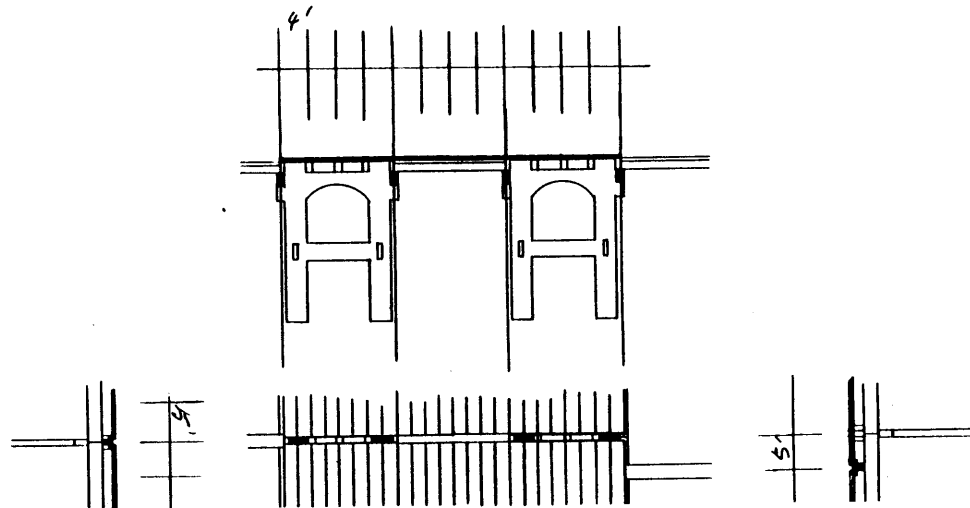
The portals are precast reinforced concrete elements. They are double storey structures. Due to their extreme height, each portal is built with an extra horizontal element at the middle for the purpose of bracing. The arch form of the portals is also designed to serve the same purpose.

The functions of the portals are 1) to support directly the floor decks within the row of portals lining up along the girder direction, and 2) to support the girders placed along both edges of the portal. The mechanical system is mainly carried along the row of portals. The design of the portal has provided room close to the ceiling for the mechanical circulation. Oversized mechanical equipments can be circulated under the arch of the portal. Each portal has specially designed elements around mid-height which the supporting element for the secondary floors can be rested on.

II.3.2.1 Position of portals

There are two directions of placing the portals. One direction is to place the portals along the girder direction, and the other is along the beam direction.

II.3.2



II.3.2.1.1 Placing portals along the girder direction

A range of intervals between the portals is desirable; however, it should be within the maximum spanning capacity of the floor deck chosen. Although longer distances can be achieved by putting a beam in between the portals to support the floor decks, there are reasons not to do that.

The first reason is because the beam is supported by the girders spanning between the portals, this means that the girder depth will have to increase because the longer the span is, the greater the load receives. Consistence in depth of the girders and provision of enough headroom for the secondary floor is preferable. The second reason is because of the beam being right under the ceiling. The original concept of having the mechanical systems circulate immediately under the ceiling will be complicated.

Although columns can be placed underneath the girders to shorten the span ,the beam is still in the way. Nevertheless the column can be placed at the ends of each row of portals and therefore, thematically, no beams should be span within the row of portals.

At this stage, the position-relation among all elements to the grid has already been established in section II.2.2 . The intervals between the vertical elements or the lengths of the horizontal elements can be interpreted in terms of modules. The different intervals between two portals should be chosen from the multiples of a same number.

The lengths of 15', 20', and 25' in a modular system of 5' seems to be a pretty good range for the distances between two portals at the floor spanning direction which also is the same as the girder direction. Moreover, it is within the maximum spanning range of the 8" flexicore concrete decks which is the most commonly used size of slab. Now, the intervals between portals can be interpreted as 3 modules, 4 modules, or 5 modules of 5' apart.

II.3.2.1.2 Placing portals along the beam direction

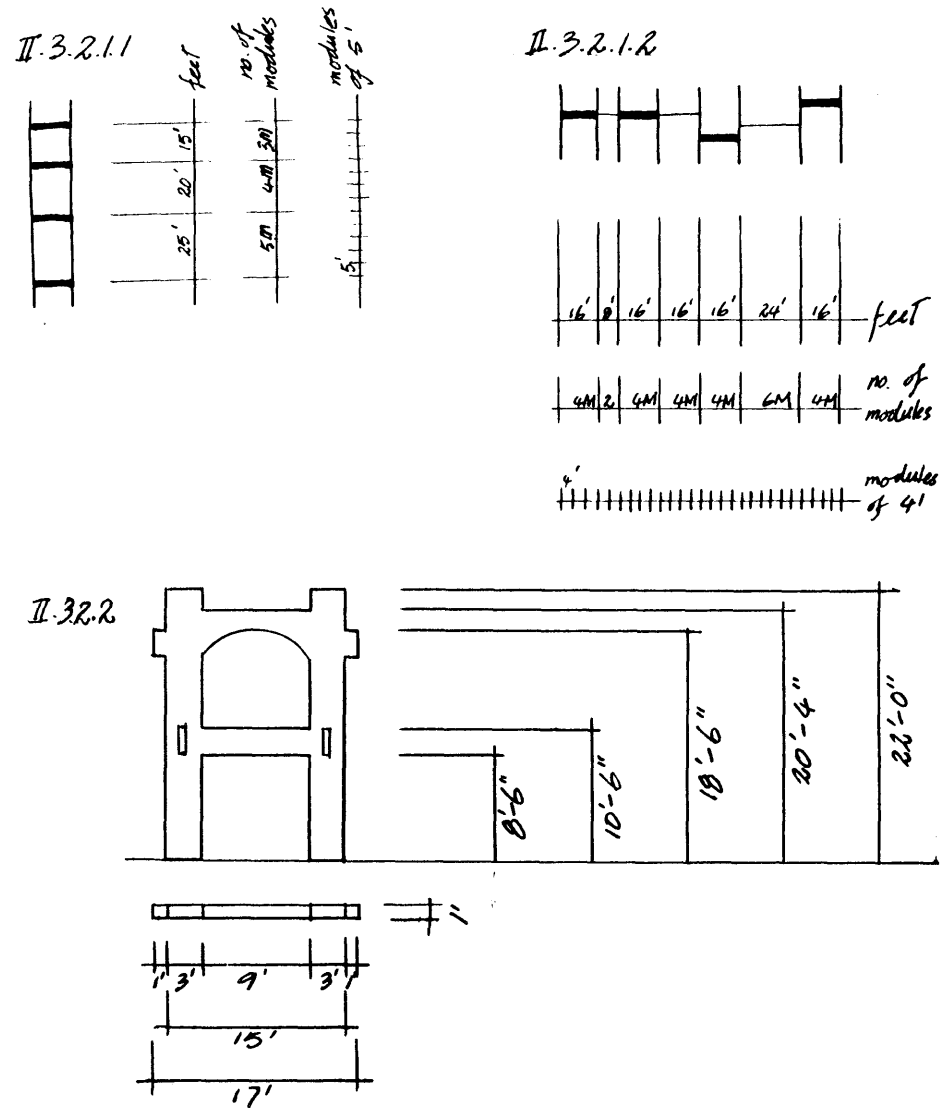
The different distances between two portals at the beam direction will be determined by the various beam lengths. This is the most desirable direction for the location of columns. Since all elements in this direction are positioned at multiples of 4', the intervals between portals in this direction will be interpreted as 1 module, 2 modules, or 3 modules to whatever modules of 4' apart within the limit allowed.

II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

II.3.2.2 Dimension of portal

Figure II.3.2.2 shows the dimension of the portal.



II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

II.3.3 Girder

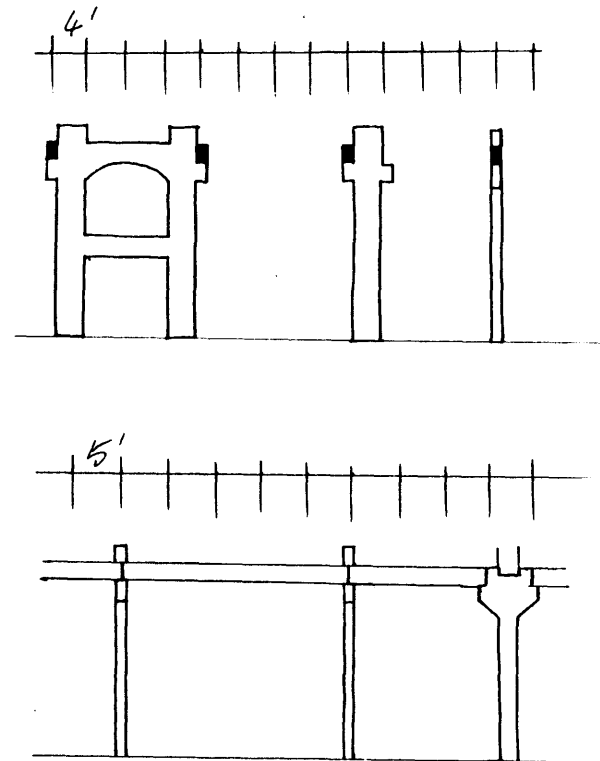
The girders are precast prestressed reinforced elements.

II.3.3.1 Position of girders

The girders are normally positioned between either two portals or two columns. They are seldomly placed between a portal and a column unless this does not require an extra beam to be placed in between; otherwise, the original purpose of providing room for the mechanical circulation system right underneath the ceiling will be defeated. It is preferable that the girders are lining up end to end for the purpose of transmitting the lateral force; otherwise, a special joint is needed.

The range of the girder lengths is exactly equal to the range of intervals between portals. It increases in modules of 5' starting from 15' up to 25'. Therefore, a girder 15' in length can be interpreted as 3 modules of 5' in length. The interval between two girders in the beam direction will be determined by the portal width or the beam lengths which is interpreted in 4' modules.

II.3.3.1



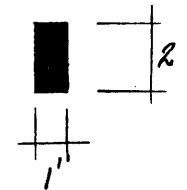
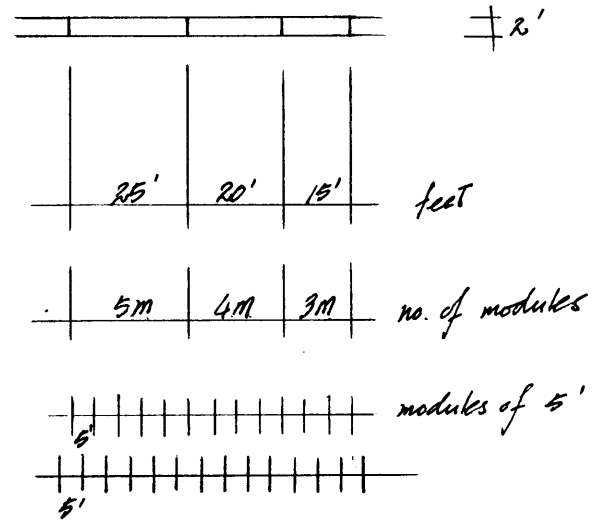
II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

II.3.3.2 Dimension of girders

Figure II.3.3.2 shows the dimensions of the girder.

II.3.3.2



II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

II.3.4 Beam

The beams are also precasted prestressed concrete elements.

II.3.4.1 Position of beams

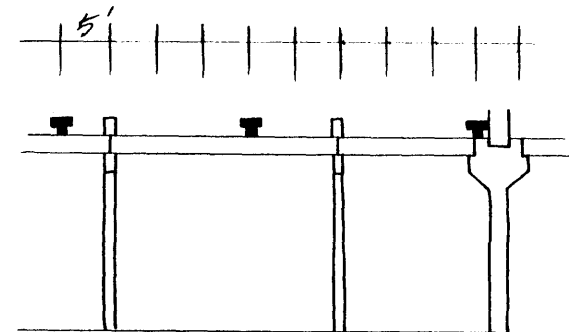
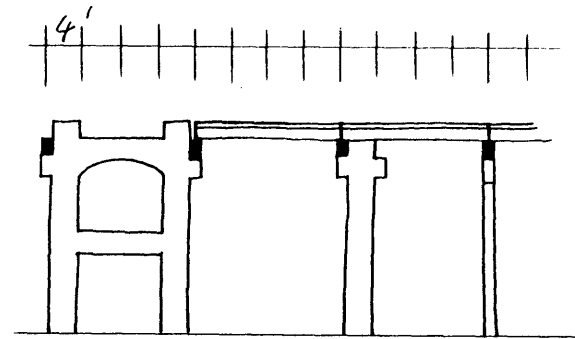
The only position the beams can be placed is directly on top of the girders. The existence of portals along the plane of the direction of beams allows the beams to move along the girder direction freely. The ends of the beams are always line up with the centerline of the transverse section of the girder.

The tee-shape of the beam is designed to support the floor decks with a distance equal to the width of the portal plus the angles so as not to disturb the consistency of dimension of the floor decks.

The length of the beams increases in modules of 4' up to a maximum of 7 modules (28') which is a typical span for the depth of a 2' deep beam. This implies that the interval between portals along this direction will also be increased at multiples of 4' depending on the length of the beam. It is important that the module of the length of the beams is a denominator of the module of the portals.

The intervals between two beams are equal to the length of the span plus the width of the joints, which are 15', 20', and 25' at multiples of 5'.

II.3.4.1



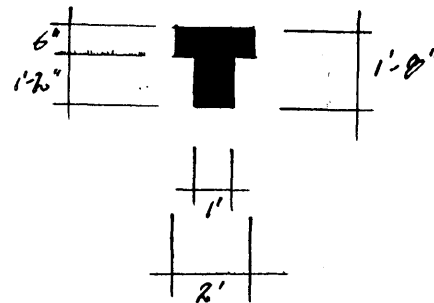
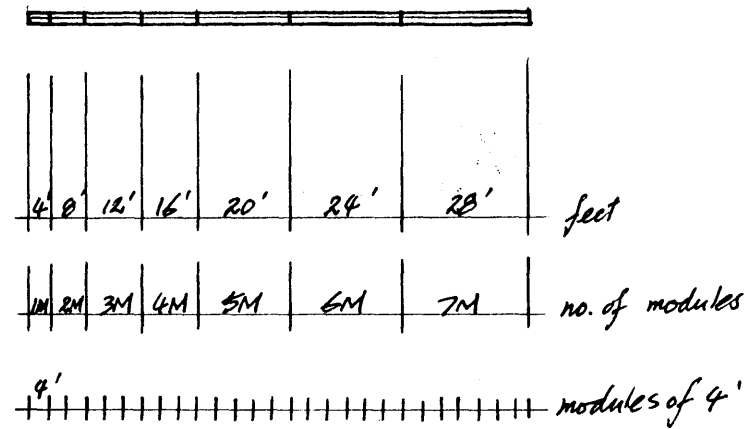
II. PRIMARY SYSTEM

II.3 Detail Description of the Elements

II.3.4.2 Dimension of beams

Figure II.3.4.2 shows the dimensions of the beam.

II.3.4.2.



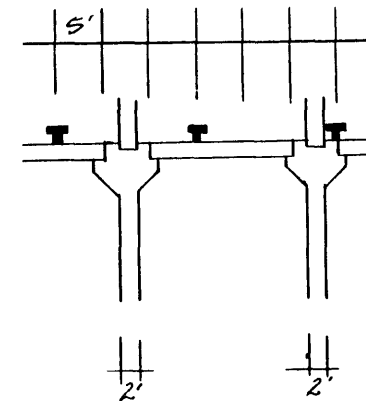
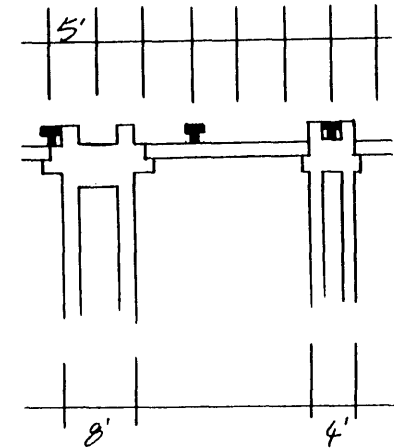
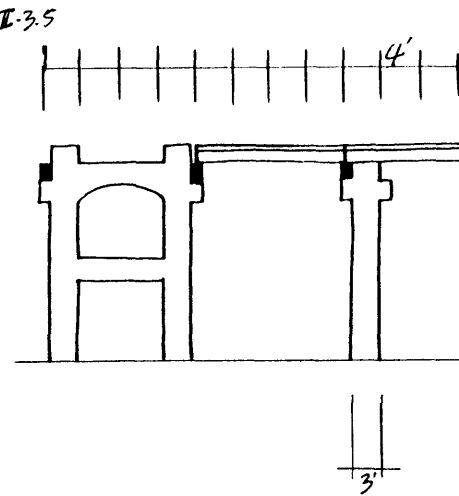
II. PRIMARY SYSTEM

II.3 Detail description of elements

II.3.5 Column

The column is the last to be design among all other structural elements in the primary system. The process of designing columns is highly influenced by the way the overall system works since the position relationship of all other structural elements are already determined. It is important for the design of the columns to follow the development of the system instead of working against it. It is vital to keep the design of the joints and the lengths of the elements consistent throughout the system. However, the vertical continuity of the column should not be neglected or sacrificed.

The columns basically can be divided into two categories. In the first category, the column is designed to have an option of placing on top of the portal. In the second category, the column is not designed to be placed on top of the portal.



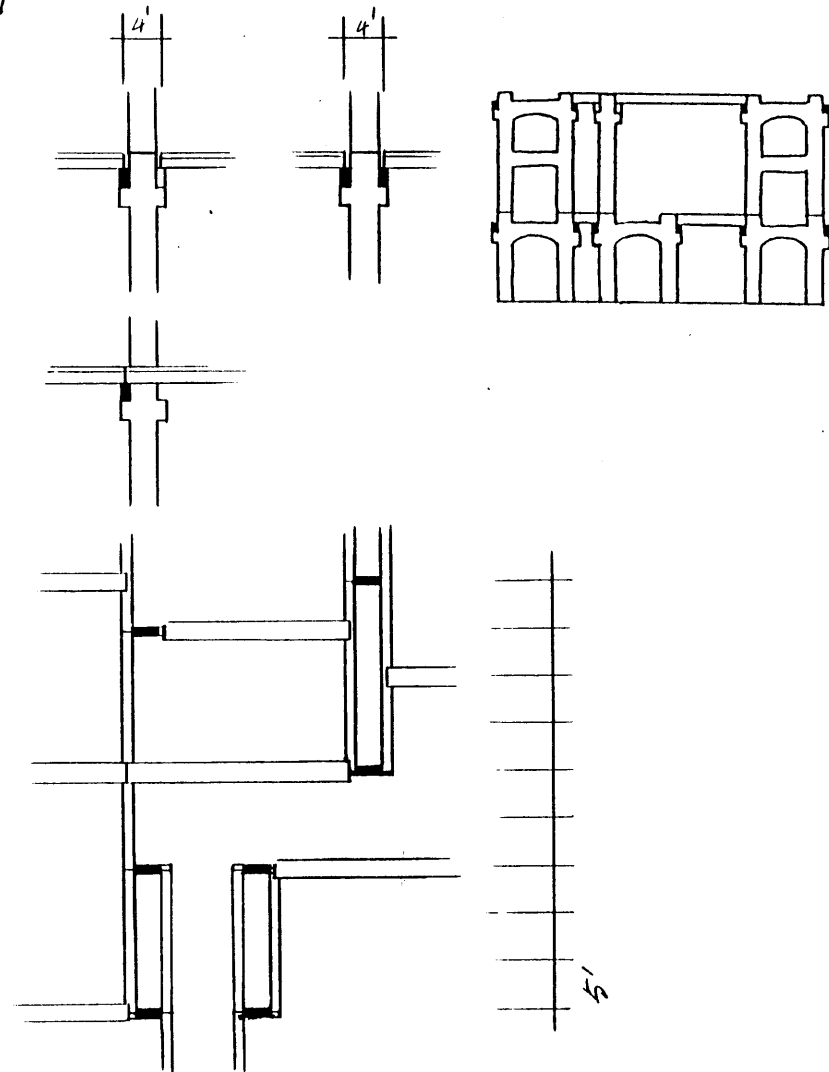
II. PRIMARY SYSTEM

II.3 Detail Description of Elements

II.3.5.1 Column *a* – Column designed to be position on top of the portal

The size of the foot of the of the column should not exceed the size of the top of the portal. In this case, the longer side of the section of the column is parallel to to the beam direction. The design satisfies the criterion that the column must be placed on top of the portal and at the same time provide support for the girders and the beams without sacrificing the vertical continuity of the column itself.

II.3.5.1



II.3.5.2 Column *b* – Column designed not to be positioned on top of the portal.

There is more freedom in designing the column in this case because it normally starts from the ground. However, consideration should be given not to disturb the dimensional consistency in length of the girders and the beams. There are two different developments in column *b* – column *b1* and column *b2*. The design of column *b1* has its central axis lined up with the plane where the beams may be positioned. The design of column *b2* avoids lining up with the plane where the beams may be positioned.

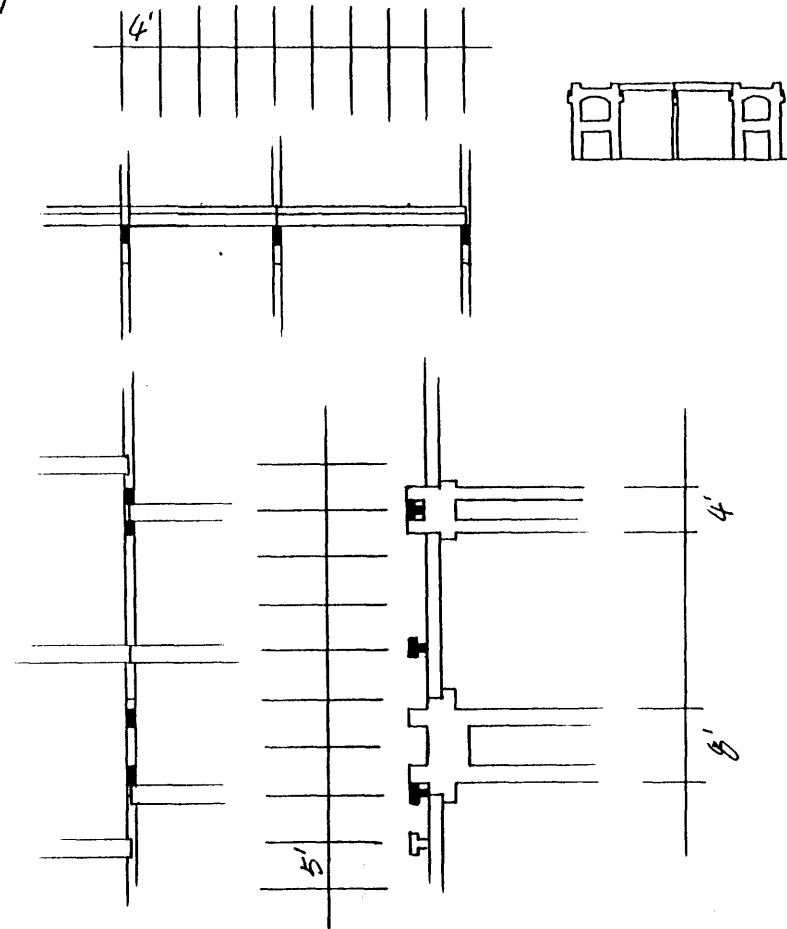
II. II. PRIMARY SYSTEM

Detail Description of Elements

II.3.5.2.1 Column *b1*

This is an example of a column that is designed not to be placed on top of the portal and, at the same time, not to have its central axis lined up with the plane where the beams may be positioned.

II.3.5.2.1



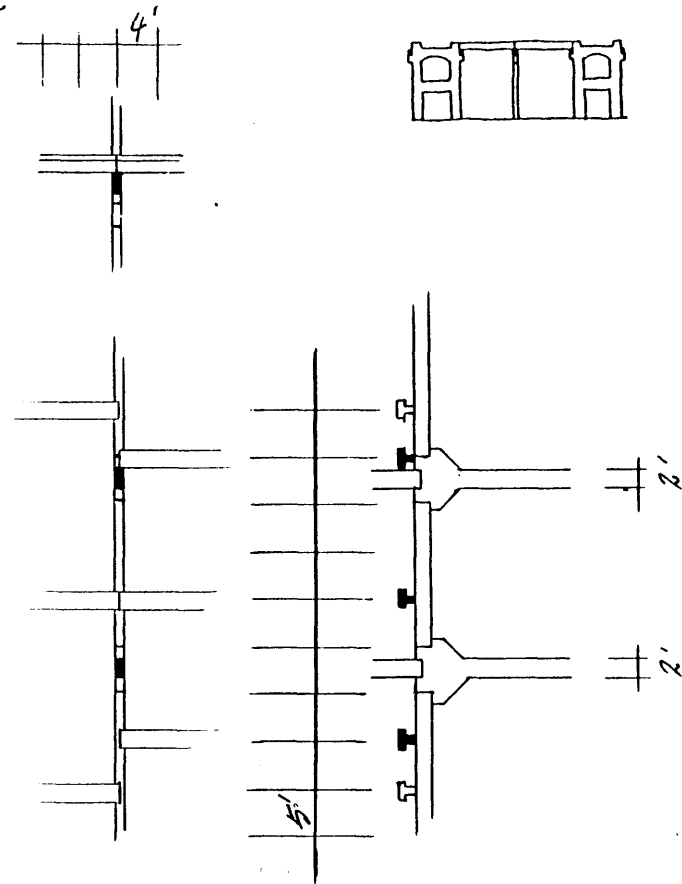
II. PRIMARY SYSTEM

II.3 Detail Description of Elements

II.3.5.2.2 Column *b2*

This is an example of a column that is designed not to be placed on top of the portal and, at the same time, not to be lined up with the plane where the beams may be positioned.

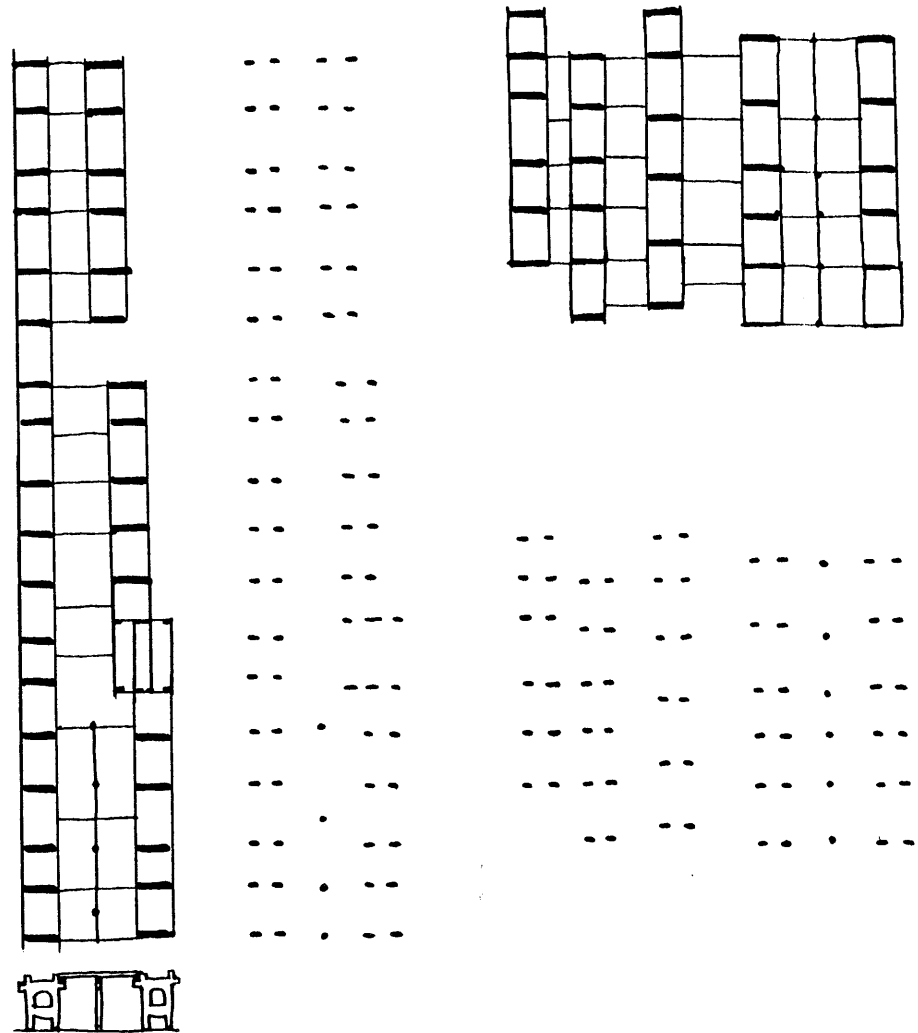
II.3.5.2.2



II.4 Relation in the System

II.4.1 Horizontal relation in the system

There are two axis to the horizontal relation in the system. One axis follows the direction of the girder, and the other follows the direction of the beam. The two are perpendicular to each other.



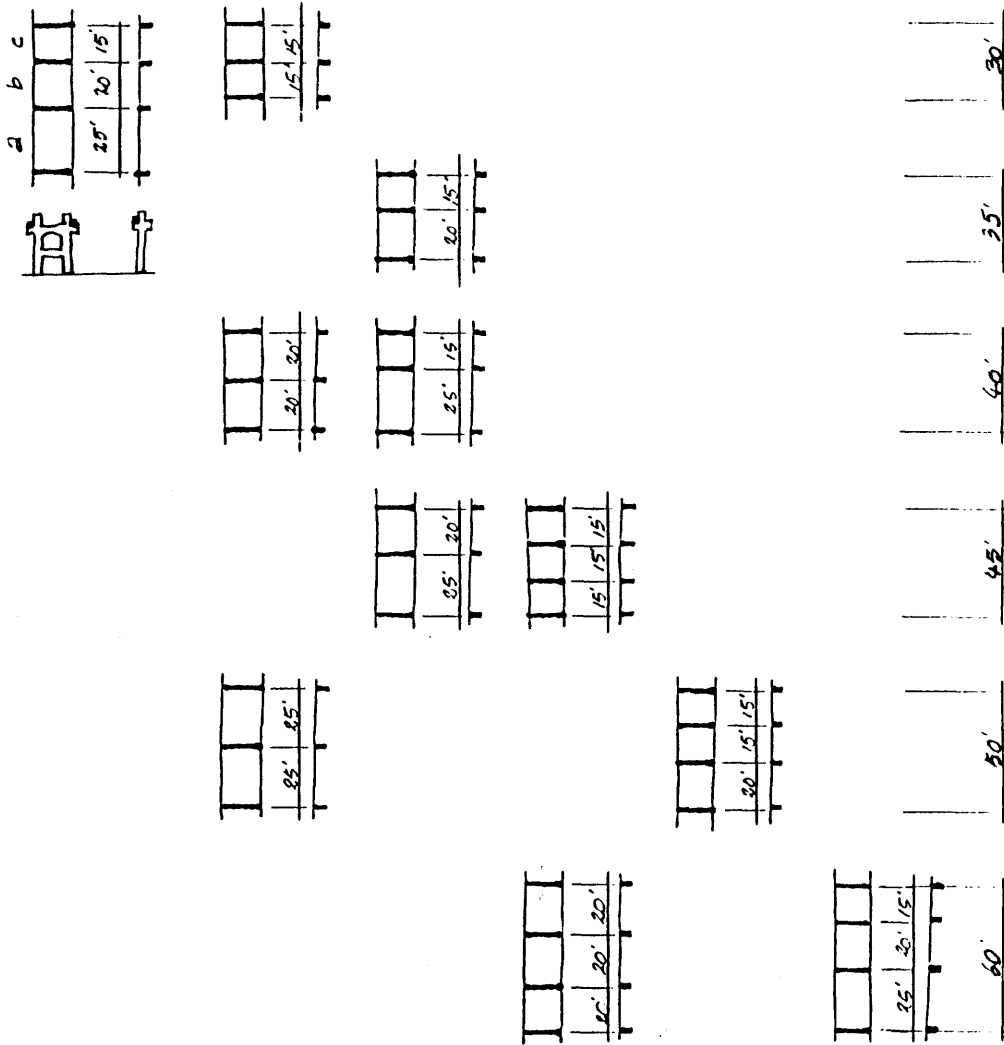
II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.1.1 Horizontal relation of elements along The girder direction

In the girder direction, the intervals chosen are 15', 20', and 25' based on a common module of 5'. The sum of the smallest and the largest intervals is twice the length of the interval in between. Figure II.4.1.1 gives only the vertical elements as an example to illustrate the dimensional relations of the different intervals.

II.4.1.1



II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.1.1.1 Position of portals along the girder direction

Portals usually line up in a row so that the girders are placed end to end to transmit the lateral forces in this direction.

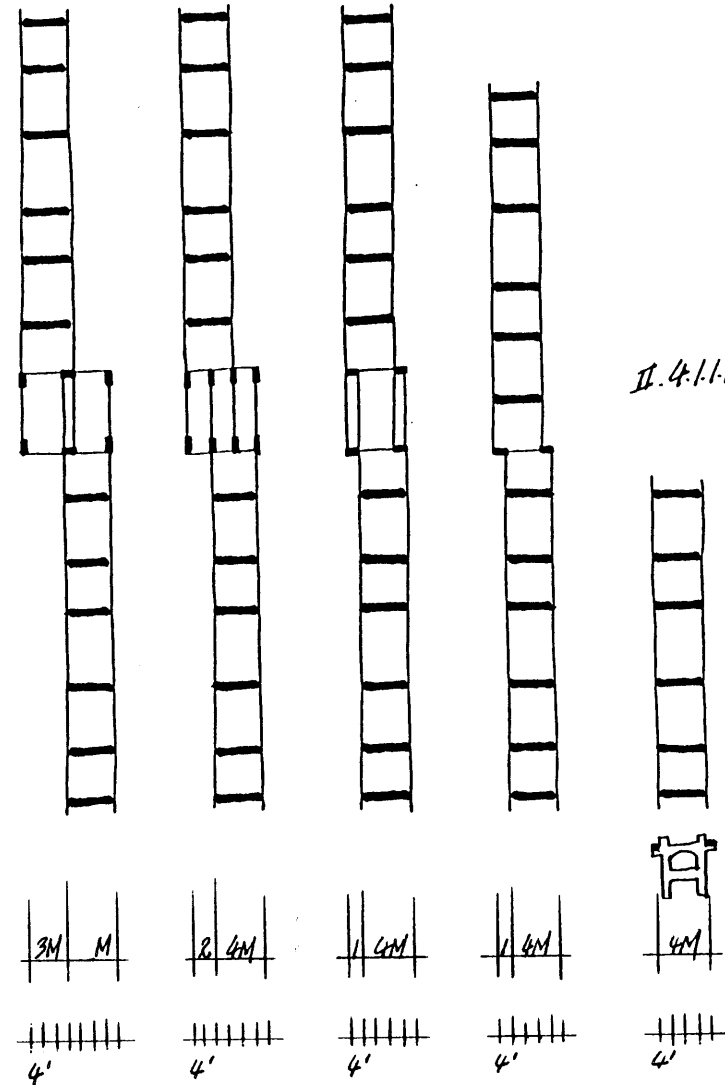
II.4.1.1.1.1 A single row of portals

A single module of portals lining up straight along the girder direction. Lateral forces along the girder direction is transmitted through the girders.

II.4.1.1.1.2 Connecting two overlapping rows of portals

Figure II.4.1.1.1.2 shows rows of portals shifting 1 module, 2 modules, and 3 modules of 4'. Columns are used to make the transition. Doubling the number of columns in each row with extra connection will help to form a better connection. This is also an appropriate place to put shear walls.

II.4.1.1.2



II.4.1.1.1

II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.1.1.2 Position of girders along the girder direction

Girders are normally lining up straight end to end except at the intersection of shifting rows of portals (See section II.4.1.1.1.2). The lengths of girders in the girder direction is in a modular of 5' of no more than the maximum span of the floor deck which is 25'.

II.4.1.1.3 Position of beams along the girder direction

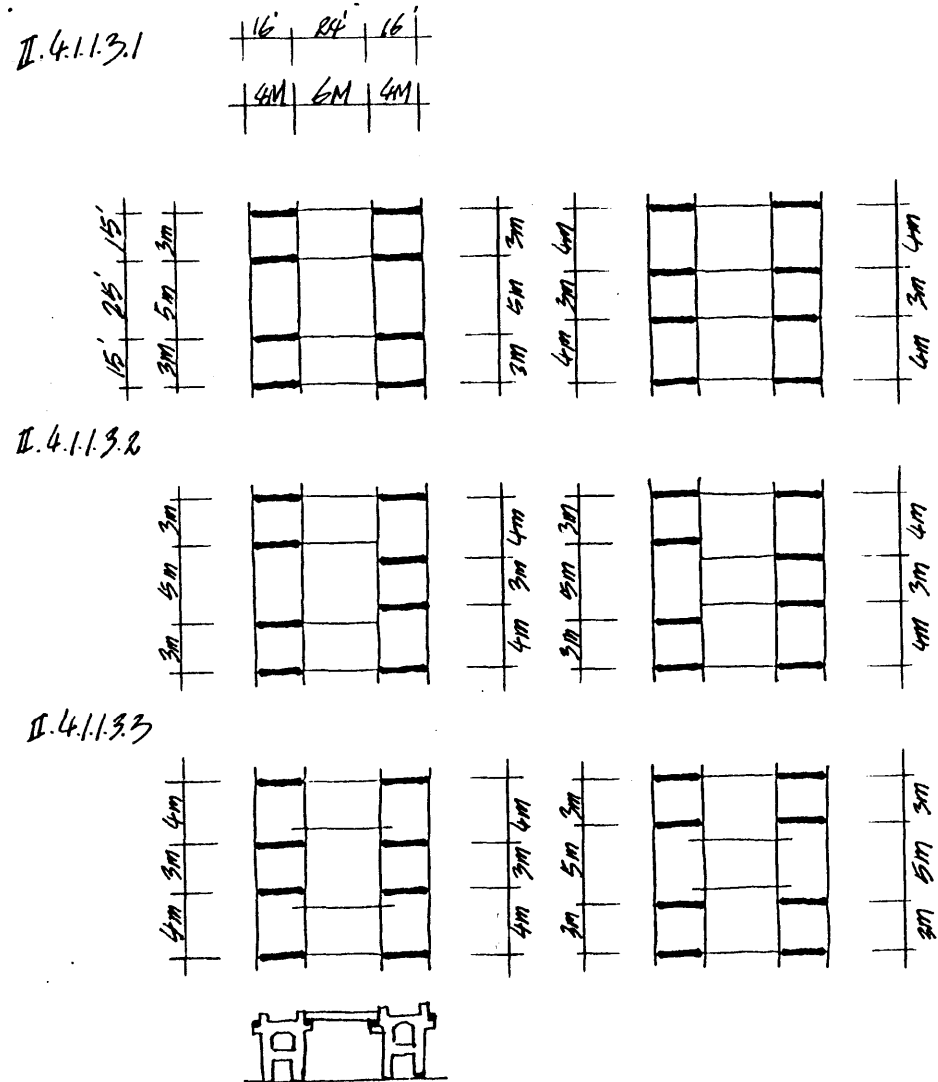
The intervals between beams in the girder direction is also in modules of 5' of no more than the maximum span of the floor deck which is 25'. The position of beam can choose either to line up or not to line up with the portals.

II.4.1.1.3.1 Beams lining up with portals on both sides

Figure II.4.1.1.3.1 shows the position of all beams line up with portals on both sides.

II.4.1.1.3.2 Beams lining up with portal on one side

Figure II.4.1.1.3.2 shows the position of some beams line up with portal only on one side.



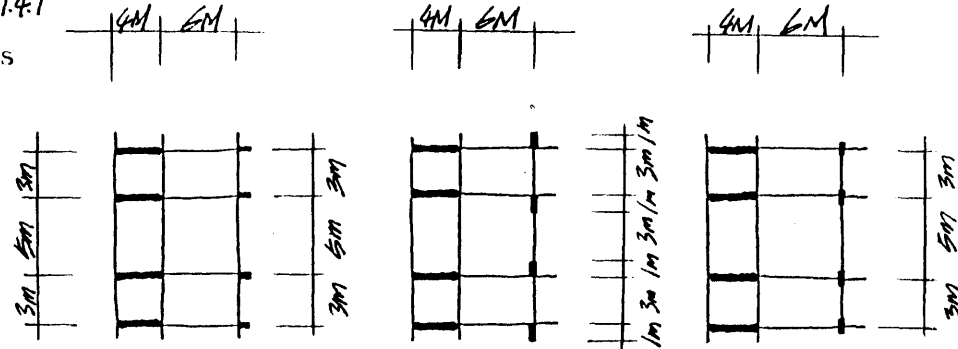
II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.1.1.4 Position of columns along the girder direction

In the girder direction, thematically columns are not positioned within a row of portals except at the end of the row or at the interlocking connection of a shifting row of portals. However, rows of columns can be placed on their own alongside a row of portals. This is a method employed to extend the distance between two portals.

The columns can be positioned either in line with or not in line with the portals. II.4.1.1.4.1

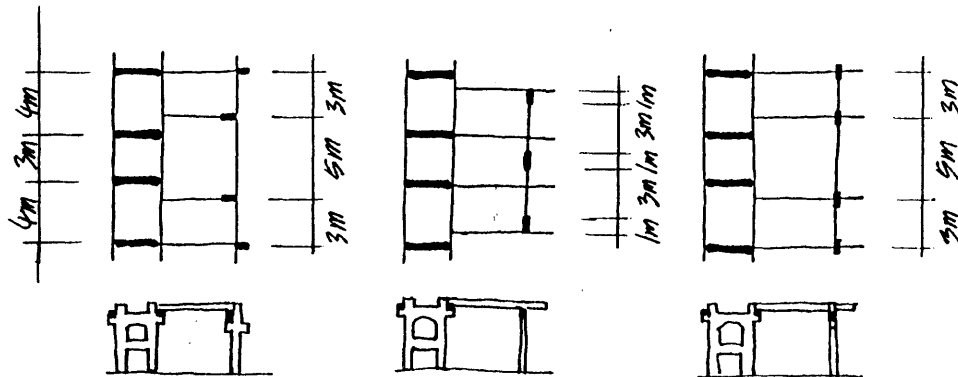
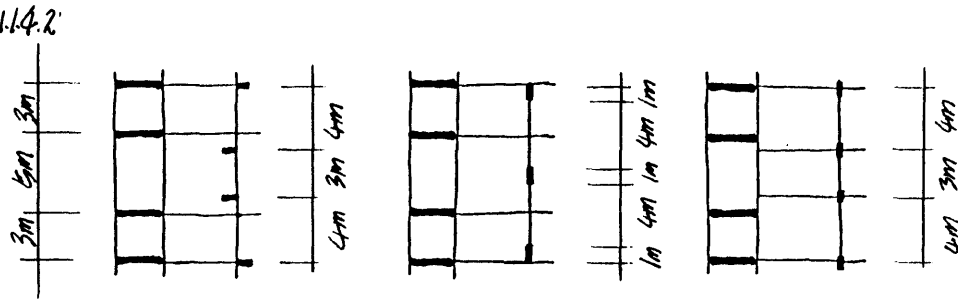


II.4.1.1.4.1 Row of columns positioned in line with portals

All three types of column, column type *a*, type *b1* and *b2*, are in line with the portals.

II.4.1.1.4.2 Row of columns positioned not in line with portals

Some of the columns are not in line with the portals in all three types of columns.



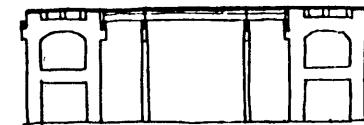
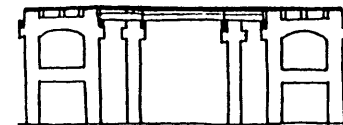
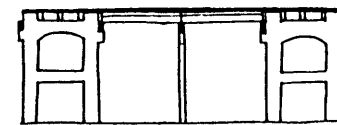
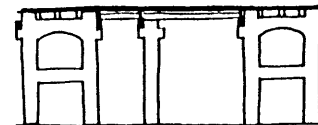
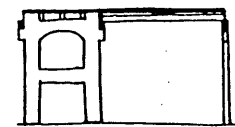
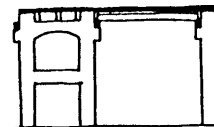
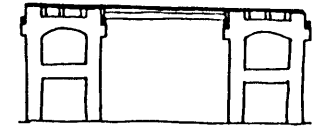
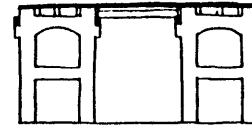
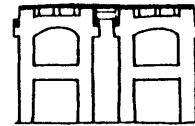
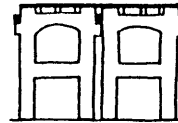
II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.1.2 Horizontal relation of elements along the beam direction

In the beam direction, the interval between two portals is determined by the span length of the beam. Sometimes, column may be placed in between portals to increase the distance between two portals in this direction. The module used for the beam is 4'; therefore, the interval between two portals as well as the length of the beams will be a multiple of the 4' module. They can be interpreted as, for example, one module apart, two modules apart, or seven modules apart.

II.4.1.2



II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.1.2.1 Position of portals along the beam direction

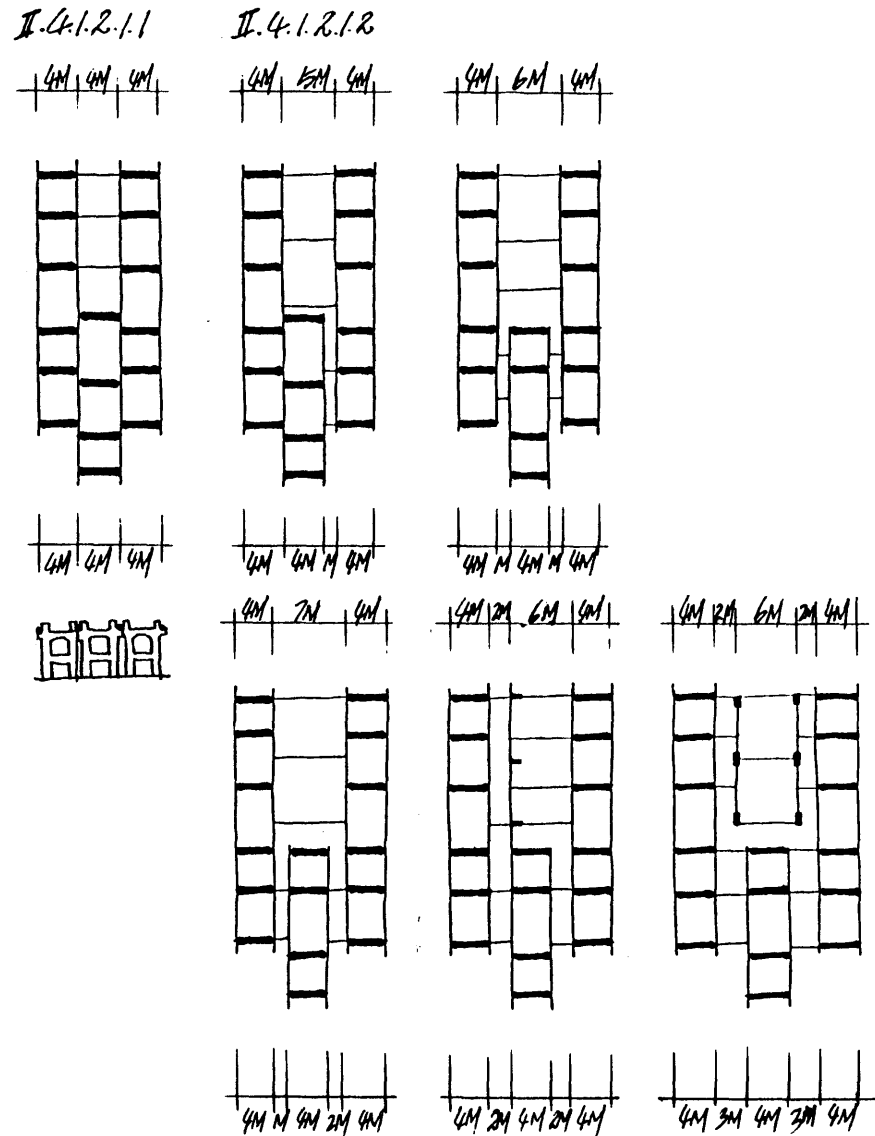
Interval between portals in the beam direction is normally determined by how many beams of what length are in between, including columns. Positioning of portals in this direction has much more freedom than in the girder direction because the portals are not required to line up in a same plane with each other.

II.4.1.2.1.1. Rows of portals lining up adjacent to each other

It is important to notice that in this situation, two rows of portals share the same row of girders; therefore, no portals can be lined up right next to each other.

II.4.1.2.1.2 Rows of portals a module or more apart

A beam must be introduced between two portals if they are a module or more apart along the beam direction. If the interval is 4 modules apart, an additional row of portals can be put in between; however, the position of these portals in the middle should not line up with any of the portals in the adjacent rows (See figure II.4.1.2.1.1 above).



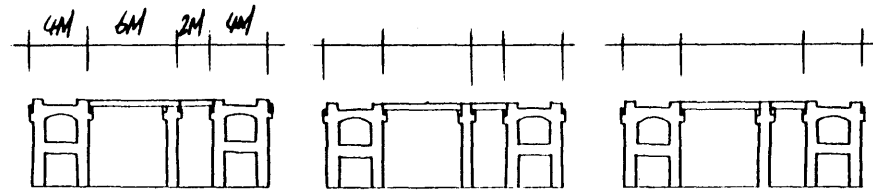
II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.1.2.2 Position of girders along the beam direction

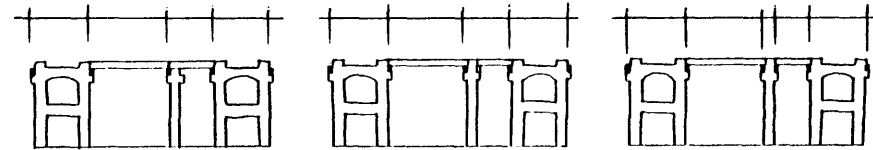
II.4.1.2.2

Girders can be placed on top of either side of the portal, or on top of either side of the column in column type *a*, or directly on top of the center of column type *b*.



II.4.1.2.3 Position of beams along the beam direction

Beams can be positioned on top of girders between portals or between a portal and a column. Sometimes, they may even be placed directly on top of column in some types of column. The beam length varies from 1 module up to 7 modules of 4' (See also figure II.4.1.2.2) .



II.4.1.2.4 Position of columns along the beam direction

There are two types of columns as mentioned before in section II.3.5 , column type *a* and column type *b*. The positions allowed in each type is different due to the difference in orientation of the wider side of the column in each type.

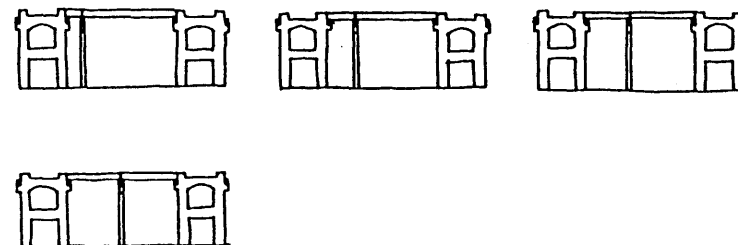
II.4.1.2.4.1



II.4.1.2.4.1 Columns placed on top of portal

Column type *a*, because its width basically occupies almost the whole length of the module in the beam direction, has less choice of positions than column type *b* within the same interval between two portals. The column supports the girder at its side.

II.4.1.2.4.2



II.4.1.2.4.2 Columns placed not on top of portal

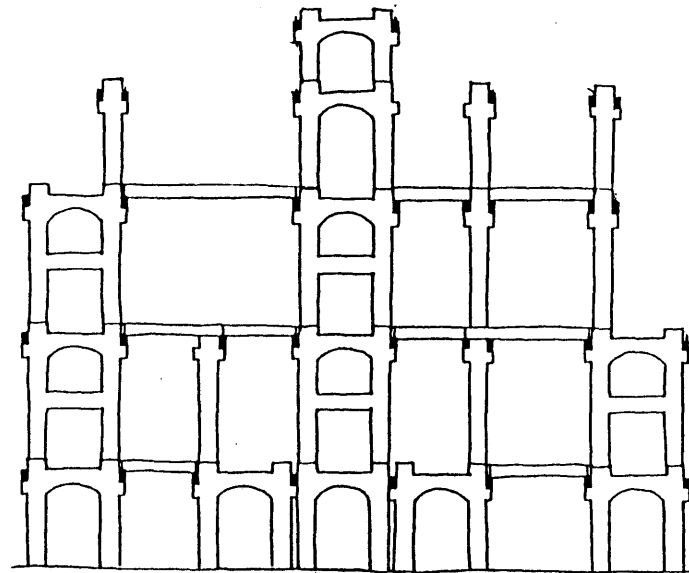
Column type *b* has one more choice of positions than column type *a* within the same interval between two portals in the beam direction which is the central position. The column support the girder directly at the center from underneath.

II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2 Vertical Relation in the System

The vertical relation in the system includes elements like portals and columns.



II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2.1 Vertical relation of portals

There are different types of portals according to height, and they have different relations with each other.

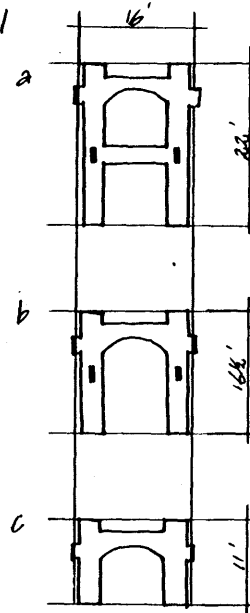
II.4.2.1.1

II.4.2.1.1 Types of Portal

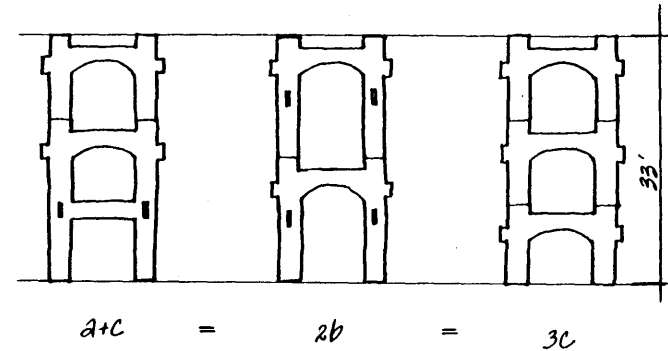
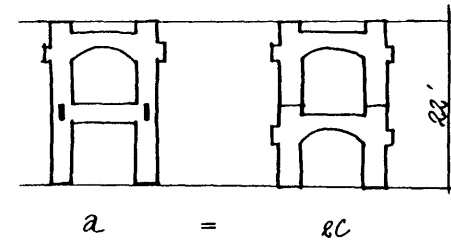
The three types of portal a , b , and c are 11', 16-1/2', and 22' in height respectively. Their widths are the same. They are equal to 4 modules of 4' and can be deployed in a grid of 4' modules in the beam direction.

II.4.2.1.2 Relation in Portals in height

The relations of the vertical dimensions of the portal types are $a = 2c$ and $a + c = 2b$. This provides a lot of different combinations among vertical stacks if portals can be achieved, resulting in a lot of different combinations of floors.



II.4.2.1.2



II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2.1.3 Stacking of portals

The portals can be placed right on top of each other; however, they should not be supported by columns.

II.4.2.1.3.1 Portals stacked according to height.

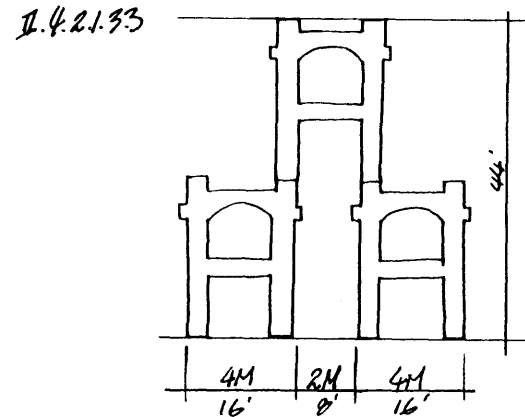
The height of floors may be created from high to low starting from the ground.

II.4.2.1.3.2 Portals stacked irrespective of height

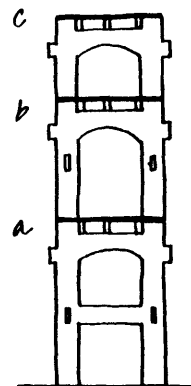
Different floor heights can be created at the same level.

II.4.2.1.3.3 Stacking a portal across the top of two portals

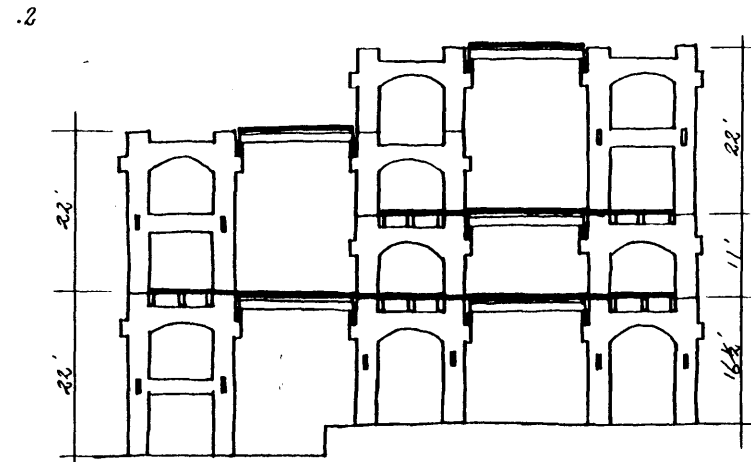
This is an interesting move and can be done occasionally under the condition that the two portals supporting the third portal are 2 modules apart, and at the same time the three portals are lined up in the same plane along the beam direction.



II.4.2.1.3.3.1



II.4.2.1.3.2.



II.4.2.2 Vertical relation of columns and portals

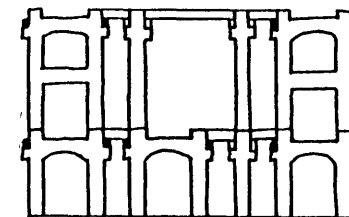
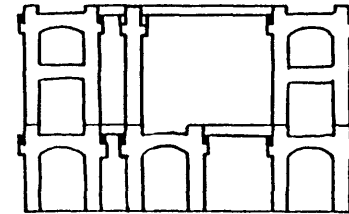
As it is mentioned in section II.3.5 earlier, there are two types of columns: the type that can be placed on top of the portal - column type *a*, and the type that cannot be placed on top of the portal -column type *b* which again is subdivided into type *b1*, and type *b2*. The vertical development of the two are very different.

II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2.2.1 Vertical relation of columns that placed on top of portal - Column type *a*

The design of this type of columns is heavily restricted by the fact that it is located on the top of the portal. Every design consideration should respect the size of and the location of the support from the portal below.



II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2.2.1.1 Vertical position of column type *a*

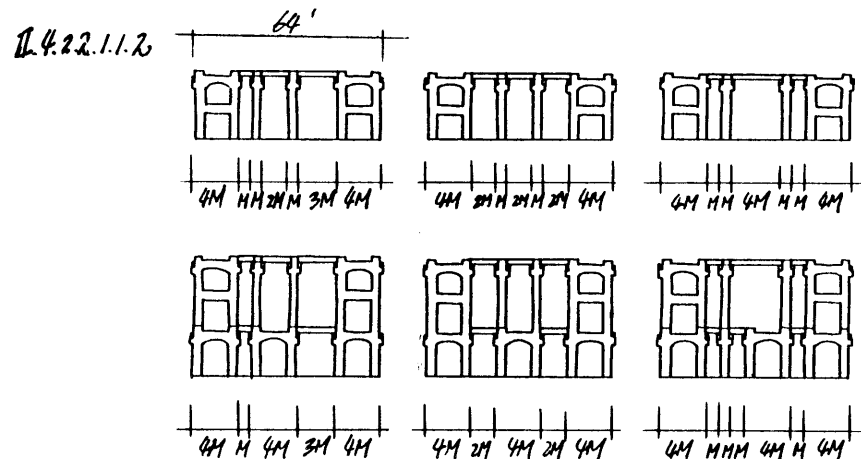
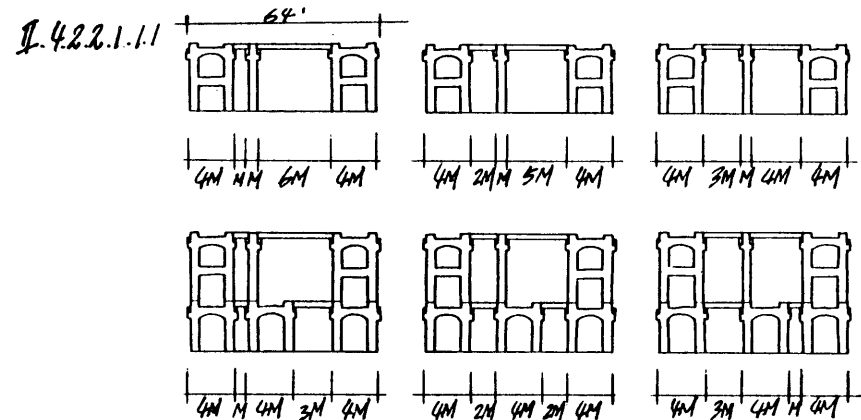
Under this type, the placement of a column is greatly influenced by the position of the portal it is resting on, and vice versa.

II.4.2.2.1.1.1 Location of a single column above a portal

A specific location of a column is required by a location of a portal underneath to support it, unless the column is started from the ground.

II.4.2.2.1.1.2 Location of two columns above a portal

Each portal has two specific locations for the placement of a column.



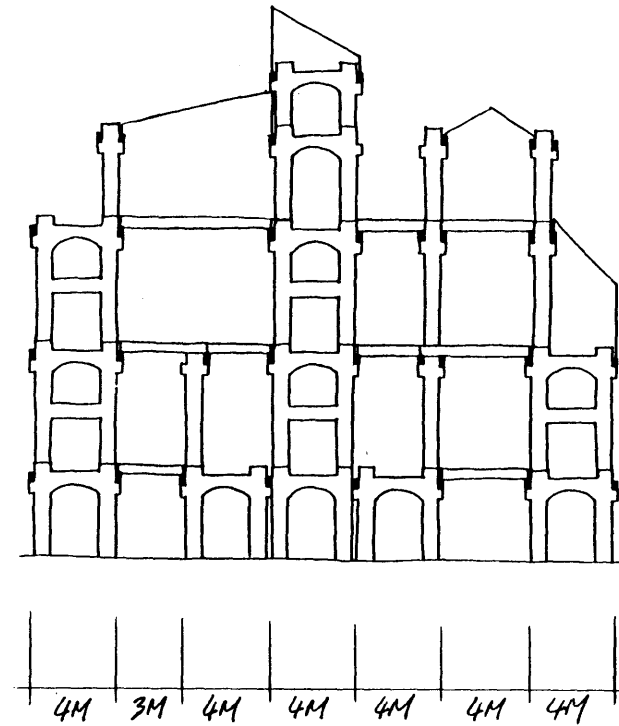
II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2.2.1.1.3 Location of columns above three adjacent rows of portals

Under this situation, the columns will be 3 modules away from the central row of portals if only the middle row of portals goes up. Moreover, if another row of portals at the edge is equal to or less than 3 modules away from the outside row of the three central rows of portals, the floor above requires no column in between the portals.

II.4.2.2.1.1.3

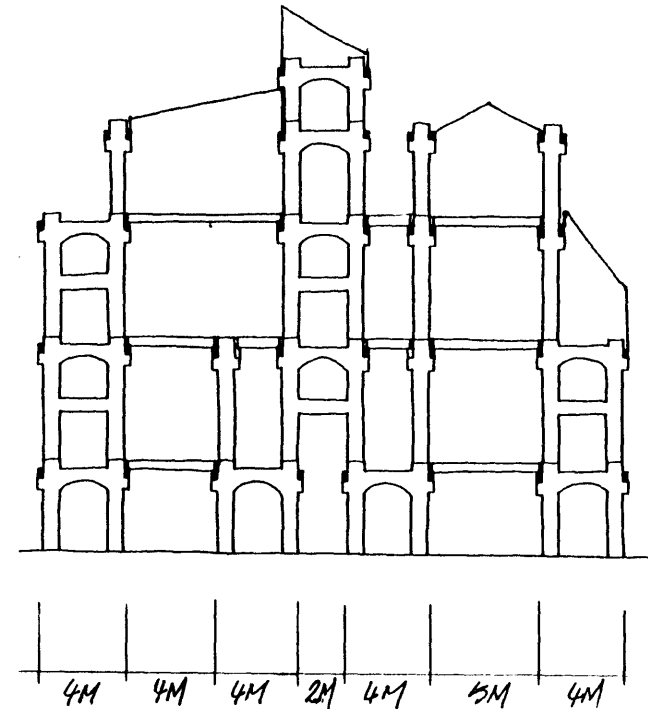


II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2.2.1.1.4 Location of columns in situation of two portals supporting a third portal across. *II.4.2.2.1.1.4.*

Under this situation, the columns will be 2 modules away from the central row of portals. If the maximum interval between the row of portals at the edge and the outside row of portals in the middle at the bottom is equal to or less than 4 modules, the floor above requires no column in between the portals.



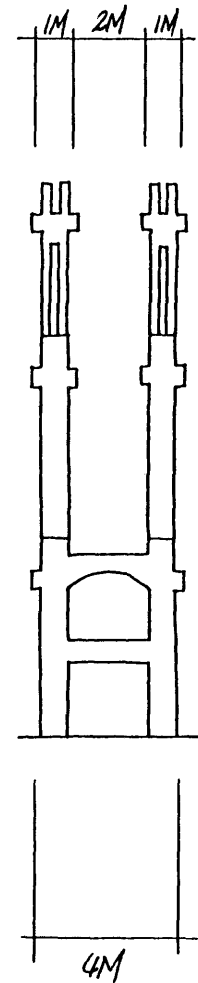
II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2.2.1.2 Decreasing section of the column type *a*

The relation of the column may be reduced appropriately in the vertical development according to the load it must carry. A higher floors the section of the column may decrease and/or a different material may be used.

II.4.2.2.1.2



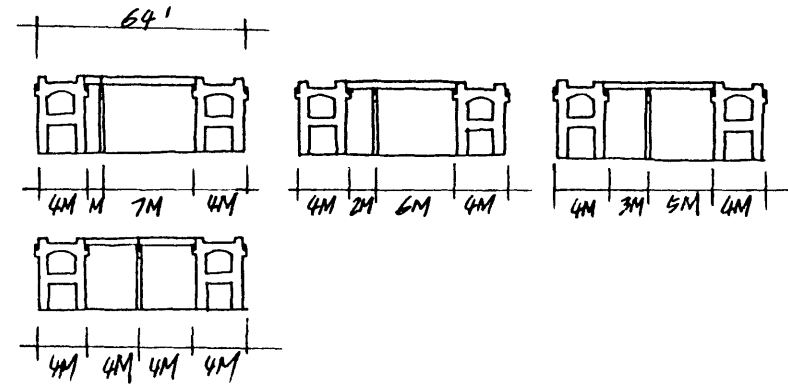
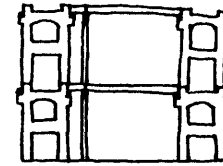
II. PRIMARY SYSTEM

II.4 Relation in the System

II.4.2.2.2 Vertical relation of a column not on top of the portal - column type *b*

As is mentioned in section II 3.5.2 , there are two different types of development in column type *b* : column type *b1* and type *b2*. There is relatively more freedom in the design of these types of column than in the design of column type *a*, because there will be no dimensional restriction imposed from the portal.

II.4.2.2.2



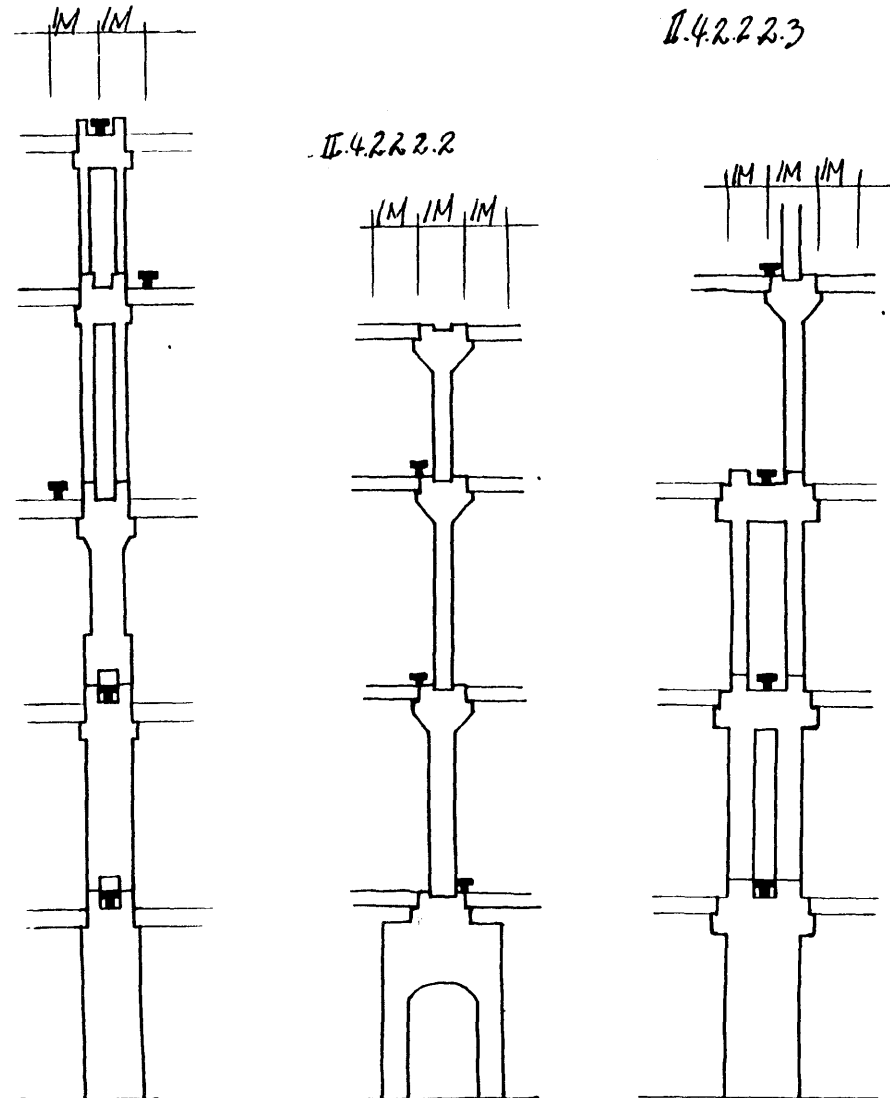
II.4.2.2.2.1 Vertical position of column type *b*

Column type *b* has no positional restriction relative to the location of the portals. Nevertheless, the position of the column still has to respect the location of the girder.

One interesting possibility is, if the width of a type *b1* column is long enough, the column may be able to support a type *b2* column on top of it (see figure II.4.2.2.2.3).

II.4.2.2.2.2 Decreasing in section of the column type *b*

The section of column may be reduced when the loads decrease. This may eventually lead to significant change of the form of the column. It is again very important not to change the position, relative to the grid, of the girder or the beam it receives. Figure II.4.2.2.2.2.1 shows the decrease in section of column type *b1*, and figure II.4.2.2.2.2 shows the decrease in section of column type *b2*.



III. SECONDARY SYSTEM

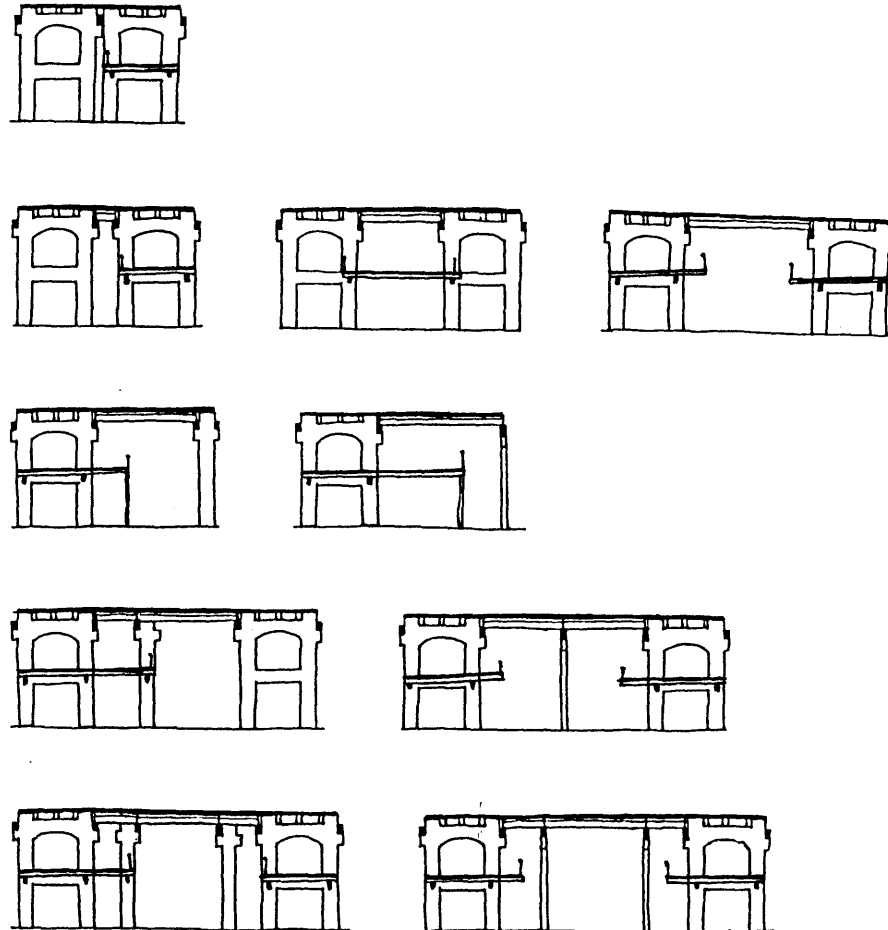
There are two types of secondary system in this thesis, the secondary floor system and the partition system. Neither the installation nor the removal of any part of such systems should involve any changes in the primary system.

III.1 Secondary floor system

The secondary floor system includes horizontal elements and vertical elements. Since the idea of a secondary system is that it can be erected or demounted without affecting the primary system, it should be build of light weight material, and the method of jointing the elements should not be permanent.

The choice of materials for a secondary system can vary a good deal according to the preference of designers or users. Nevertheless, there is a principle for choosing the material for the girders and the beams (See section III.1.1.1).

III.1



III. SECONDARY SYSTEM

III.1 Secondary Floor System

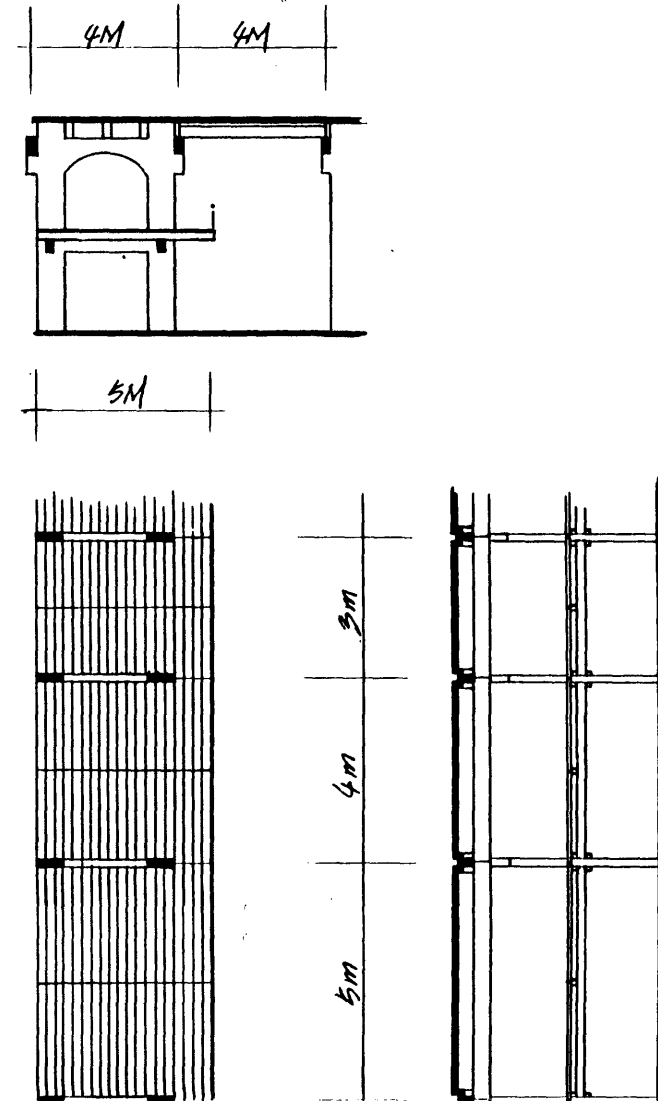
III.1.1 Types of element in the secondary floor system

There are two types of elements, the vertical elements and the horizontal elements.

III.1.1.1 Horizontal elements of the secondary floor system

The horizontal elements include girders, beams, and floor decks. The spans of secondary floors between portals are relatively long; this is because the girders spanning between portals should be capable of spanning that distance without the support of columns; otherwise, there will be too many secondary columns within the interval between portals. Moreover, the beam must cantilever from the row of portals to provide an extra 4' space intended for circulation on the secondary level, so the material used for the beams should be allowed for relatively long spans. The material chosen for the girders and the beams in this thesis is Gluelam. The material for the floor should not be permanent. It should be relatively easy to assemble. Wood seems to be an appropriate material for the secondary floors.

III.1.1.1

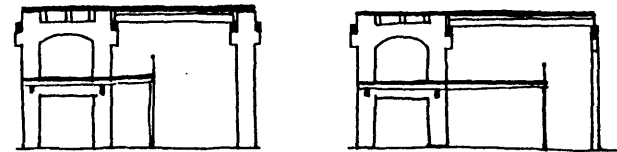


III.1.1.2 Vertical elements of the secondary floor system

The vertical elements include supports for the girders from the portal and columns. The device connecting the girder to the portal should be designed according to the way the girder is supported by the portal. In this case, the girder is rested on top of a short horizontal element placed in a built in slot at an appropriate height of the portal.

The columns can be of any material as long as they are demountable.

II.1.1.2

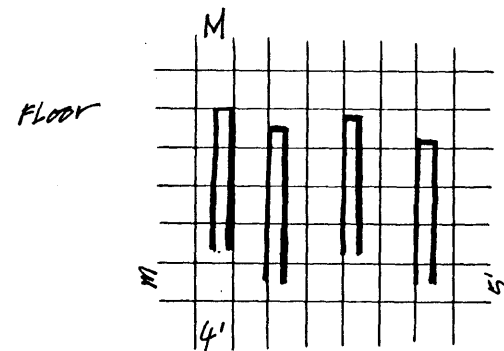
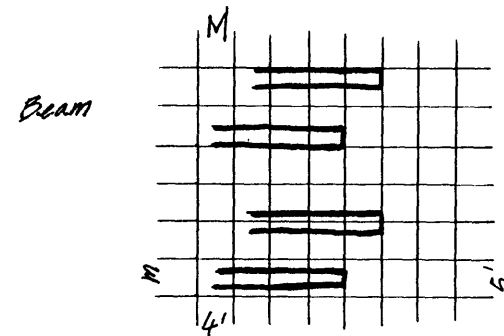
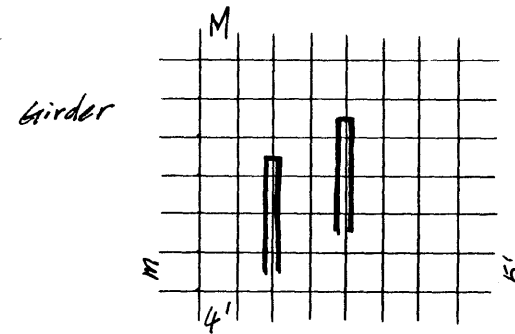


III. SECONDARY SYSTEM

III.1 Secondary Floor System

III.1.2 Relation of the elements of the secondary system to the grid

III.1.2



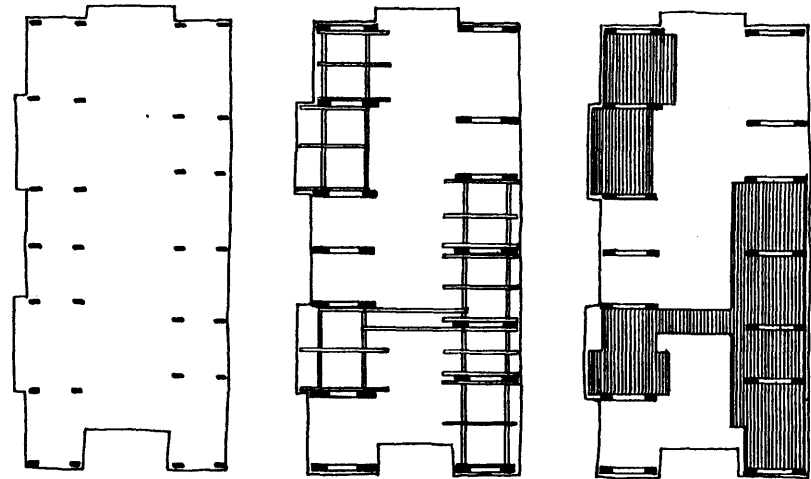
III.1.3 Direction of the secondary floor system

There are two directions of the secondary floor. One of them is in the girder direction, and the other is in the beam direction.

III.1.3.1

III.1.3.1 Development of the secondary floor along the girder direction

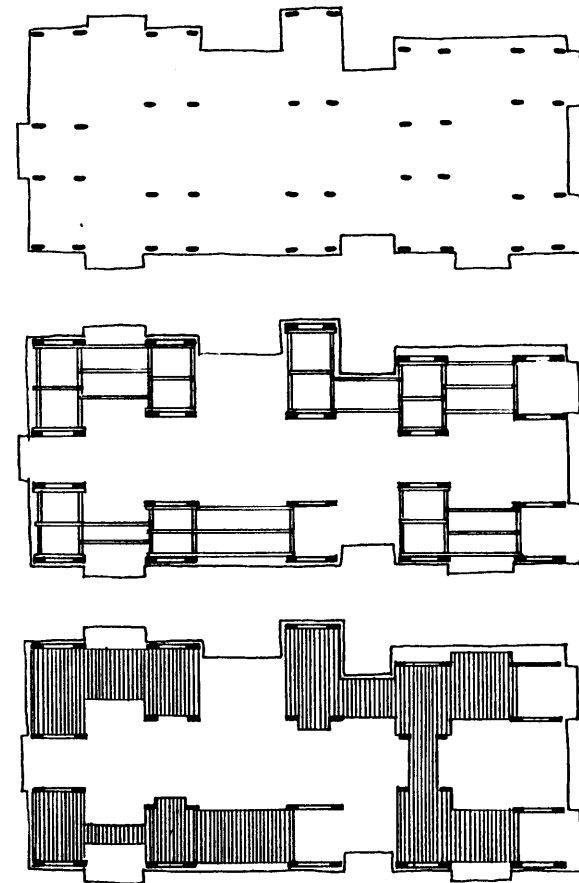
In the direction of the girder, the beam in the secondary system can cantilever its floor 4' out of the row of portals. This 4' space can be used as a continuous circulation for the secondary floor; therefore, people can have two options of circulation on the secondary floors. They can either circulate outside the row of portals or circulate through the row of portals.



III.1.3.2 Development of the secondary floor along the beam direction

In the beam direction, there can be no continuous circulation outside the portals for the secondary floor. It has to be done within the space between two portals. The floor itself can only occasionally cantilever 4' out of the end of the portal.

III.1.3.2



III.2 Secondary partition system

III.2.1 Types of secondary partition system

There are two types of partition system. The first type, partition type *a*, is to be put on top of the primary floor as well as the secondary floors, and the second type, partition type *b*, is to be put only on the primary floors.

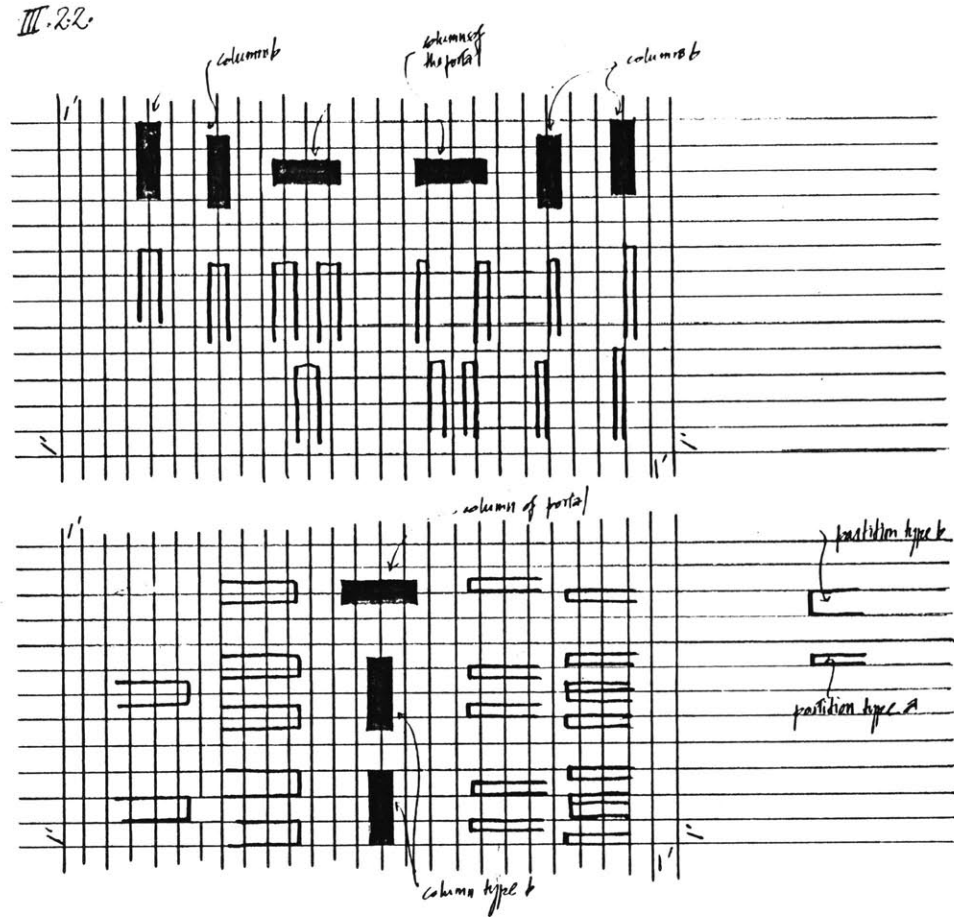
III.2.1.1 Secondary partition type *a*

This type of partitions normally installed after the secondary system is in place. The partitions should be made out of light weight material, for example, a two-by-four stud wall system. They can be used for a relatively short period of time. They can be manipulated more frequently to create different configurations for different purposes in the course of the lifetime of the building.

III.2.1.2 Secondary partition type *b*

This type of partitions can be made out of relatively heavy material, concrete blocks for example. They are used for relatively permanent separation. Nevertheless, the demolition of such partitions should not affect the primary structure.

III.2.2 Relation of the partitions to the grid



III.2.3 Direction of the secondary partition system

There are also two directions for each type of partition, namely the girder direction and the beam direction. Both directions of partition can exist simultaneously in any direction of development of both the primary and the secondary floors.

III. SECONDARY SYSTEM

III.2 Secondary Partition System

III.2.3.1 Secondary partition on the floor development in the girder direction

III.2.3.1

III.2.3.1.1 Secondary partition type *a* on the secondary floor in the girder direction

III.2.3.1.1.1 Before further subdivision

III.2.3.1.1.2 After further subdivision



III.2.3.1.2



III. SECONDARY SYSTEM

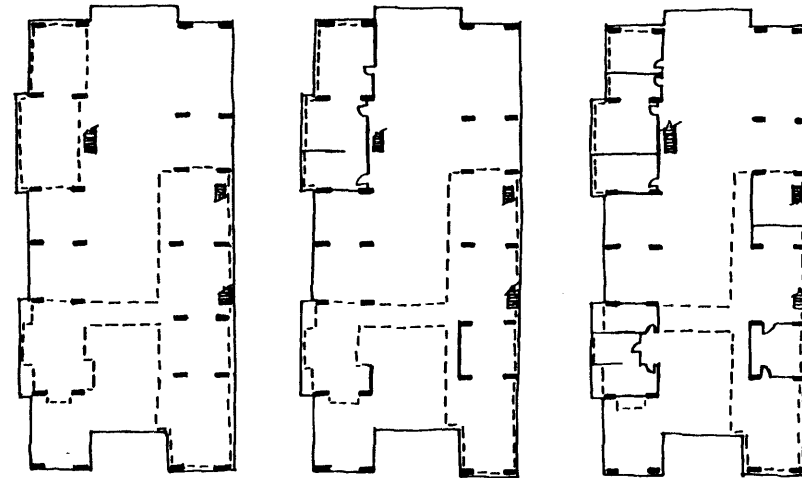
III.2 Secondary Partition System

III.2.3.1.2 Secondary partition type *a*
on the primary floor, in the girder di-
rection

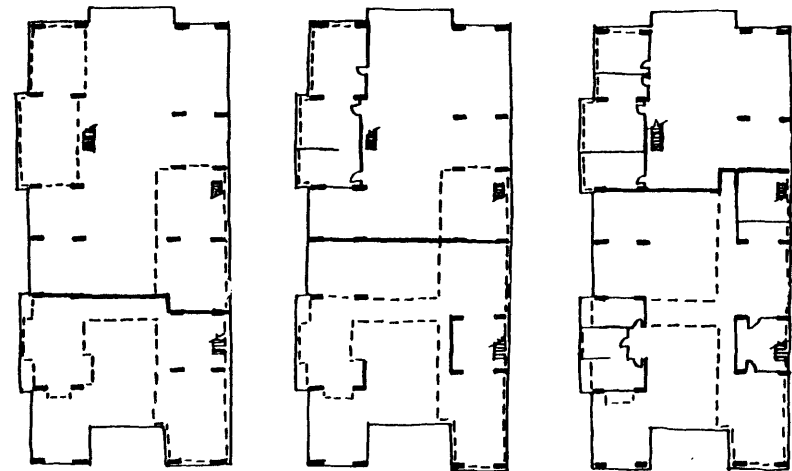
III.2.3.1.2.1

III.2.3.1.2.1 Before further subdivision

III.2.3.1.2.2 After further subdivision

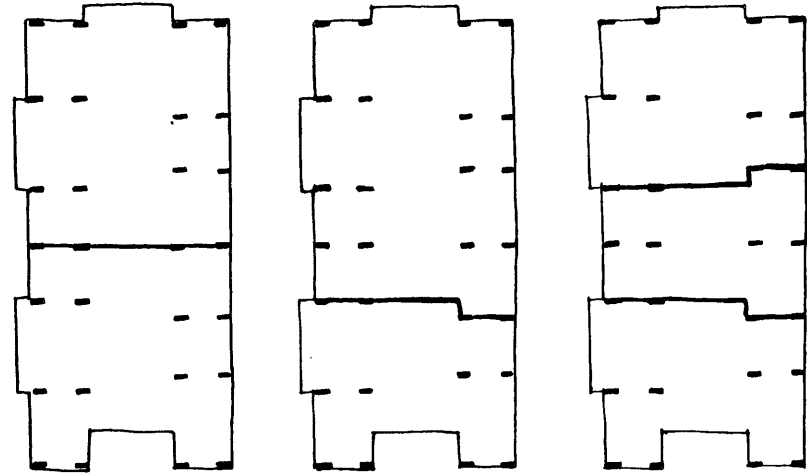


III.2.3.1.2.2



III.2.3.1.3 Secondary partition type *b*
on the floor development in the girder
direction

III.2.3.1.3



III. SECONDARY SYSTEM

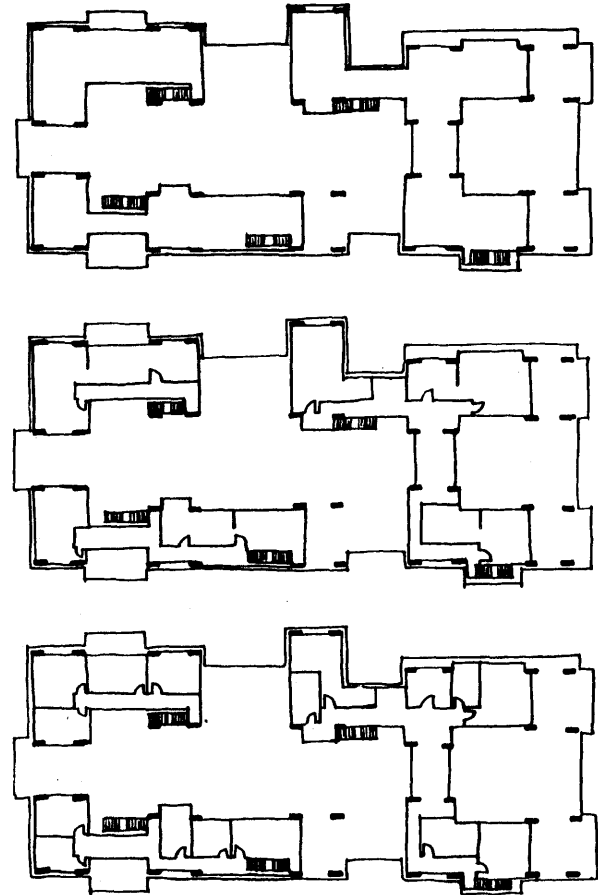
III.2 Secondary Partition System

III.2.3.2 Secondary partition of the floor development in the beam direction

III.2.3.2.1 Secondary partition type *a* on the secondary floor in the beam direction

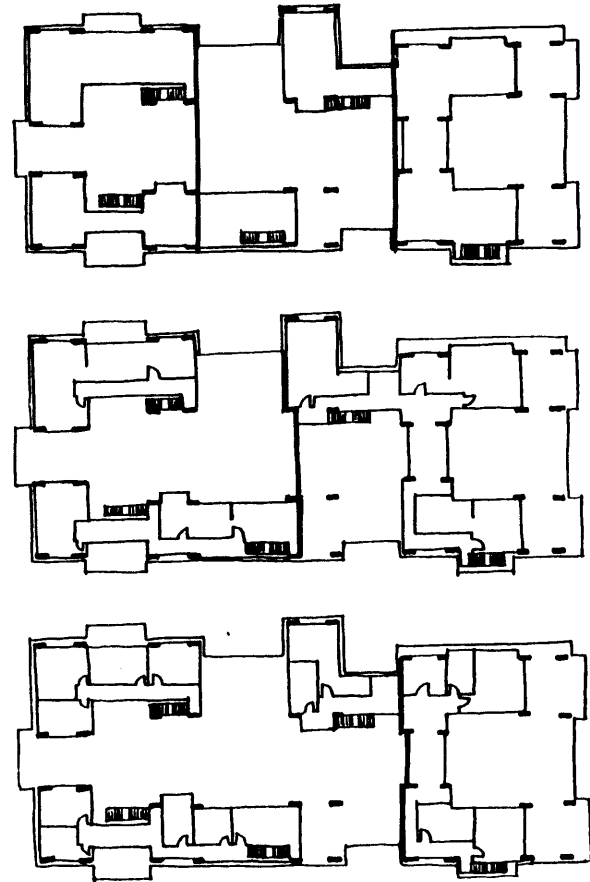
III.2.3.2.1.1 Before further subdivision

III-232.1.1



III.2.3.2.1.2 After further subdivision

III.2.3.2.1.2



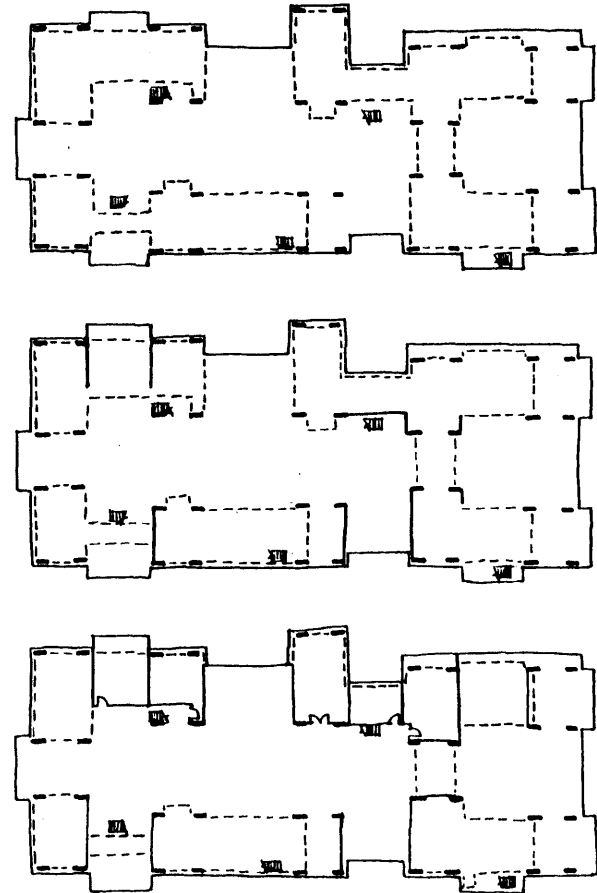
III. SECONDARY SYSTEM

III.2 Secondary Partition System

III.2.3.2.2 Secondary partition type *a*
on the primary floor in the beam di-
rection

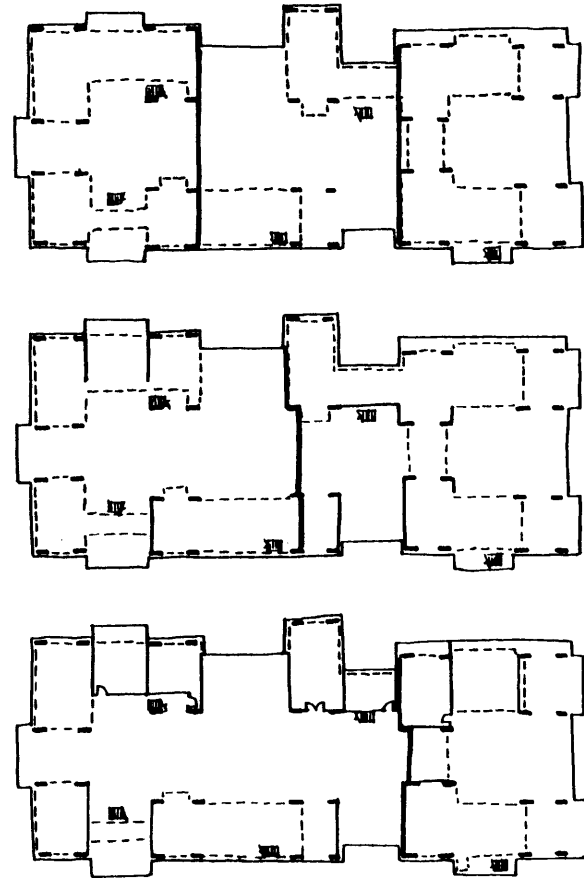
III.2.3.2.2.1 Before further subdivision

III.2.3.2.2.1



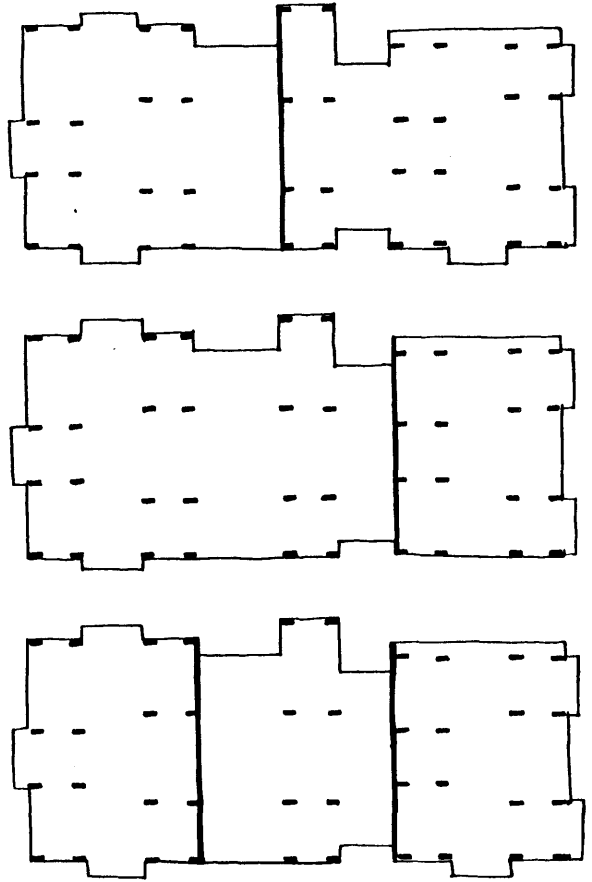
III.2.3.2.2.2 After further subdivision

III.2.3.2.2.2



III.2.3.2.3 Secondary partition type *b*
on the floor development in the beam
direction

III.2.3.2.3



IV. FACADE

In this thesis, we concentrate on the design of the primary system. The design of the facade is left to the preference of individual designer. However, it is important for the thesis to include explanation of how facade is related to the system.

IV. FACADE

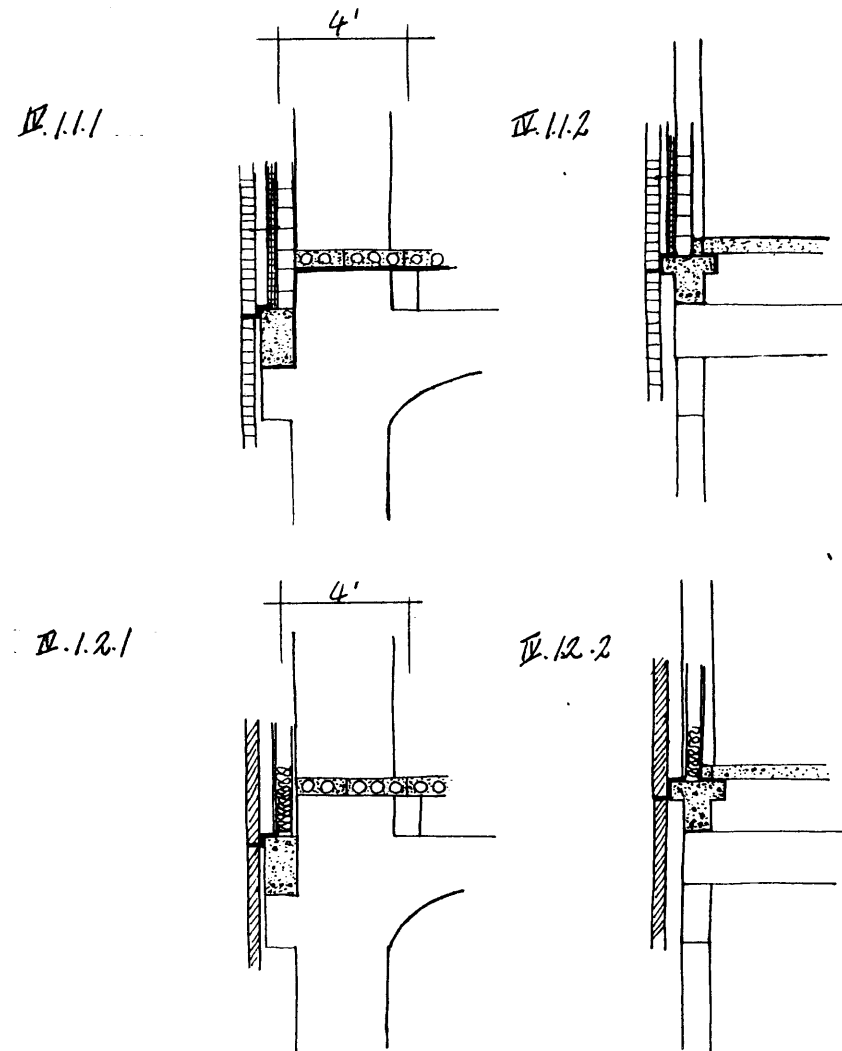
IV.1 Relation of Facade to the System

IV.1 Relation of Facade to the System

The facade will be supported by the girder in the girder direction and by the beam in the beam direction. Followings are some examples demonstrating how the facade is related to the system in different situations.

IV.1.1 Brick Veneer Wall Figure IV.1.1.1 shows that the wall is supported by the girder in the girder direction. Figure IV.1.1.2 shows that the wall is supported by the beam in the beam direction.

IV.1.2 Metal Curtain Wall Figure IV.1.2.1 shows that the wall is supported by the girder in the girder direction. Figure IV.1.2.2 shows that the wall is supported by the beam in the beam direction.



IV. FACADE

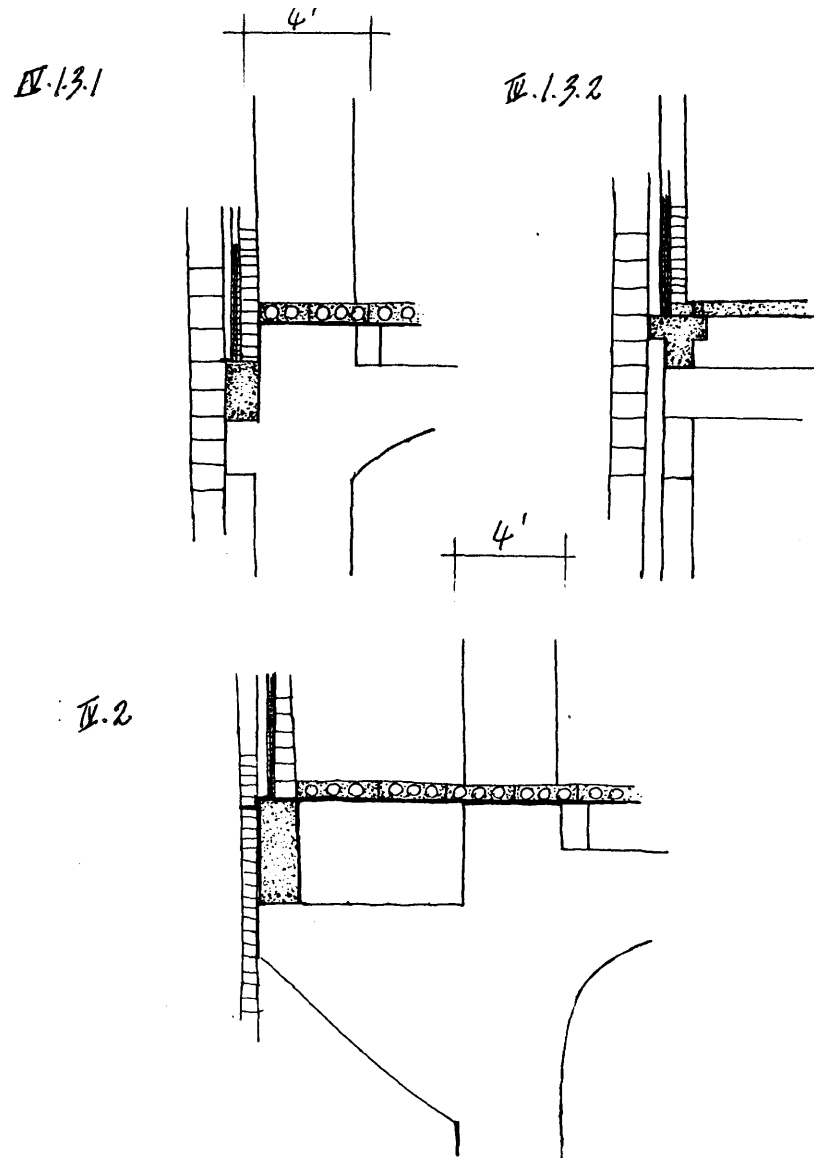
IV.1 Relation of Facade to the System

IV.1.3 Masonry Wall

Figure IV.1.3.1 shows the relation of the wall to the system in the girder direction. Figure IV.1.3.2 shows the relation of the wall to the system in the beam direction.

IV.2 Portal along the edge

Girders supporting the facade can be supported by specially designed portals positioned along the edge. These portals allow an additional 6' projection from the typical portals.

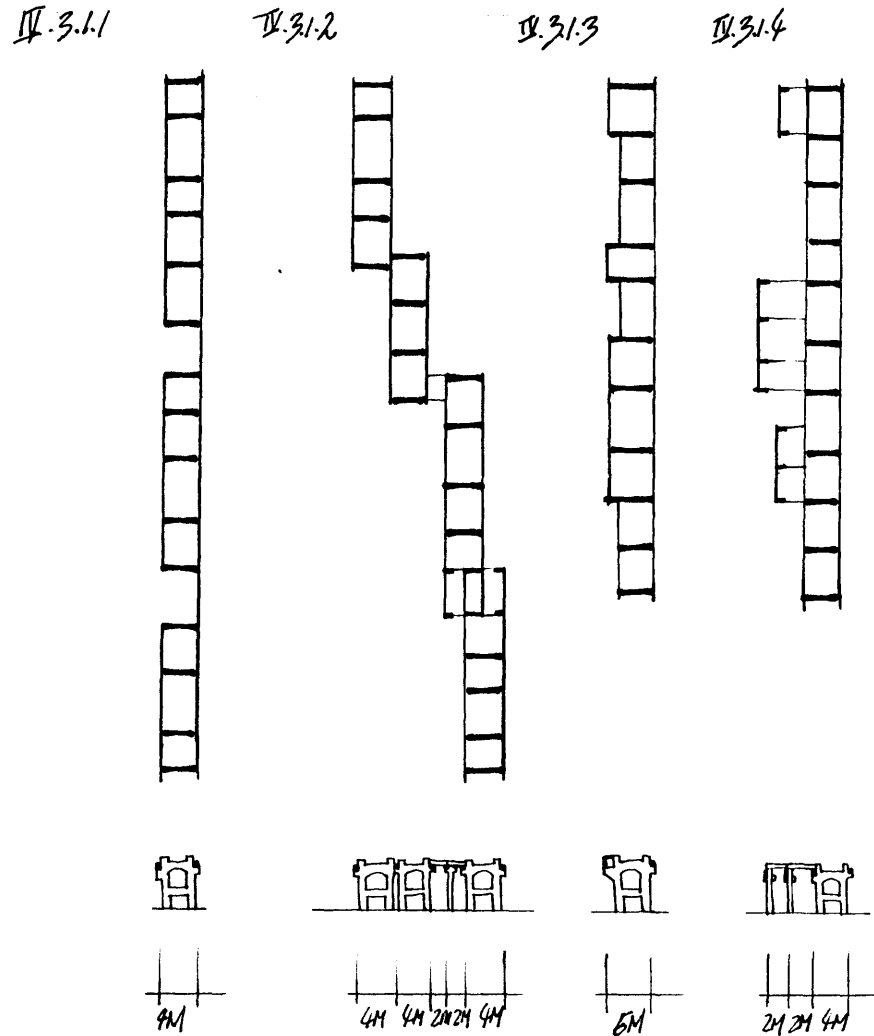


IV.3 Profile of the Edge

There are four ways to modify the profile of the edge : indentation, shifting of portals, introducing columns, and modifying the designed of the portals.

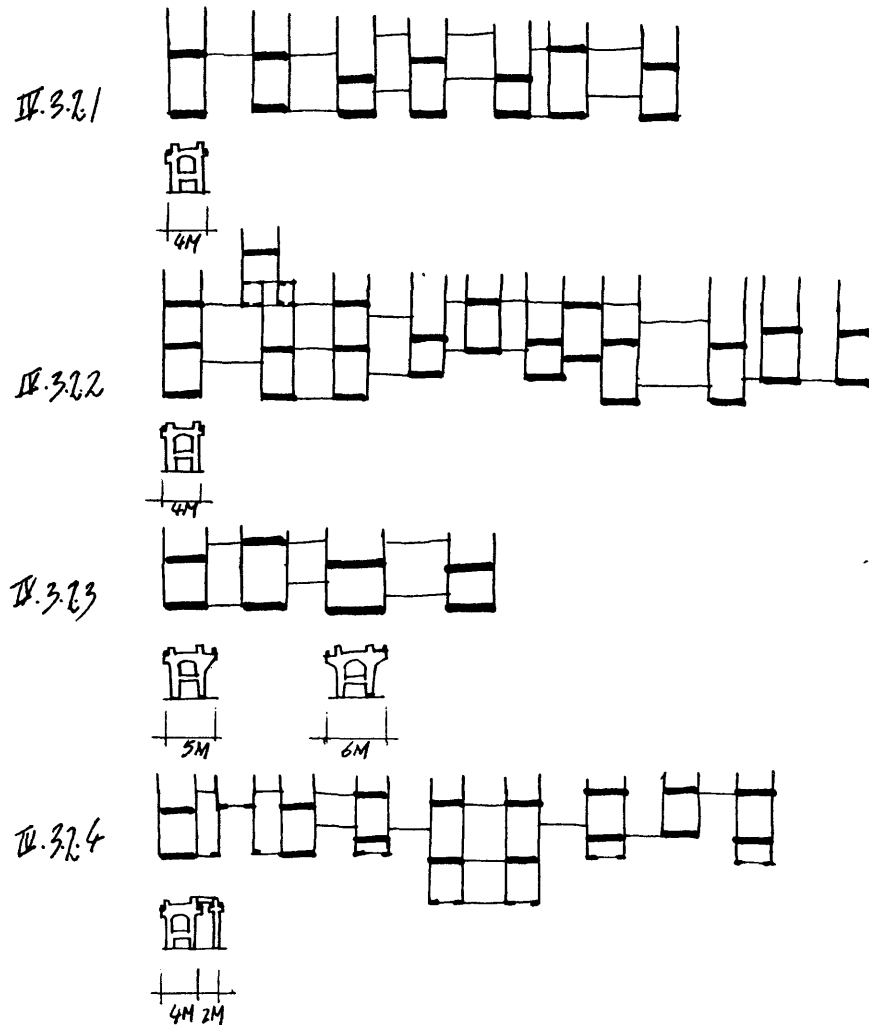
IV.3.1 Profile of the edge along the girder direction

The profile of the edge in the girder direction is relatively flat because the portals are usually lining up straight in this direction. However, the profile of the edge can be modified by indentation (figure IV.3.1.1), shifting of portals (figure IV.3.1.2), introducing columns (figure IV.3.1.3) and modifying the designed of the portals (figure IV.3.1.4).

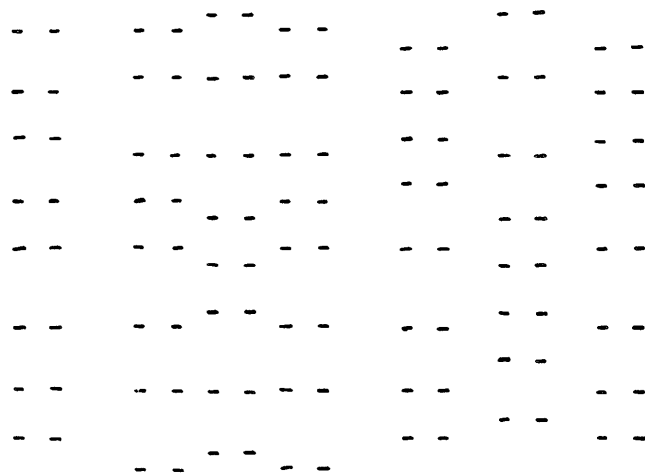
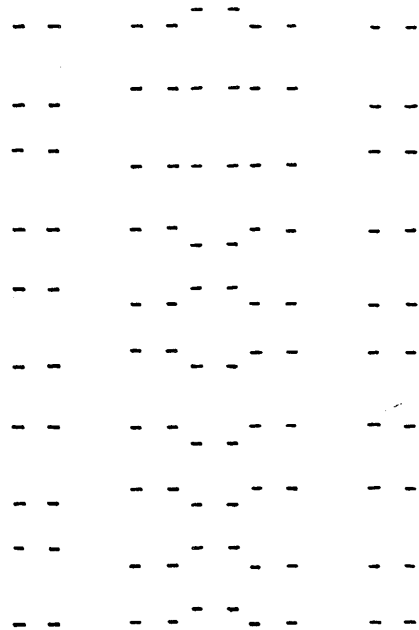


IV.3.2 Profile of the edge along the beam direction

The profile of the edge in the beam direction can be more undulating than in the girder direction because the portal has more freedom to shift in this direction. The profile of the edge along this direction can also be modified by indentation (figure IV.3.2.1), shifting of portals (figure IV.3.2.2), introducing columns (figure IV.3.2.3) and modifying the designed of the portals (figure IV.3.2.4).



V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE



V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

V.1 Relation of Number of Rows of Portals to Their Intervals

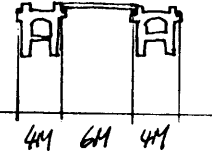
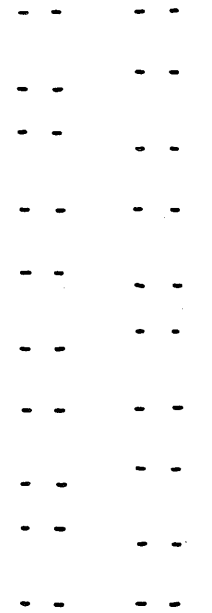
Different number of rows of portals suggest different length of interval between them. It also suggests the location of the circulation. The longer intervals seem to be more appropriate to be located close to the edge, and the shorter intervals close to the middle. The circulation will mostly fall into the central rows of portals so that the work spaces have proximity to the natural sunlight.

V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

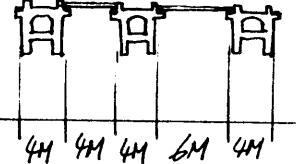
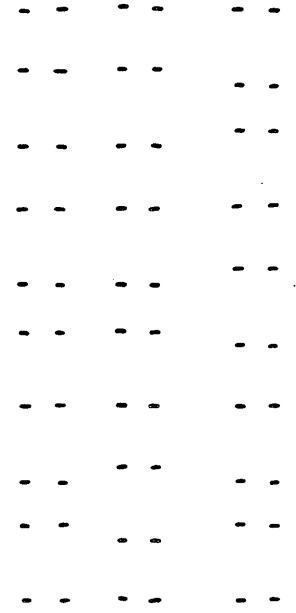
V.1.1 Two rows of portals

With only two rows of portals, the interval between the the rows should be maximized as possible because of the proximity to the natural sunlight on both sides. Interval of 6 or 7 modules is appropriate. Sometimes a row of columns can be introduced to increase the distance.

V.1.1



V.1.2



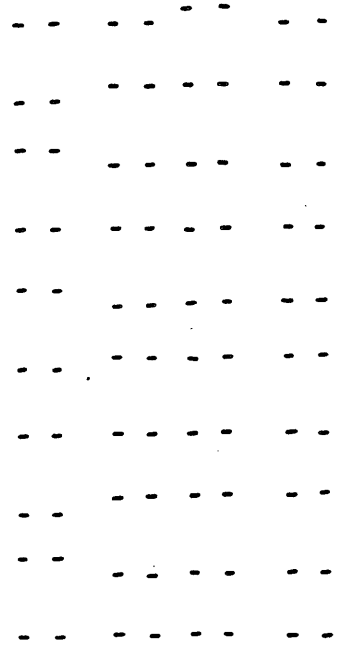
V.1.2 Three rows of portals

In the case of three rows of portals, the interval range may be from 4 to 6 modules. The circulation is most likely to be placed inside the central row of portals.

V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

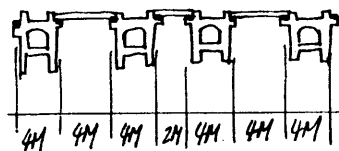
V.1.3 Four rows of portals

In the situation of four rows of portals, the interval between the inner two rows should be the shortest, for example, 2 or 4 modules in length. The appropriate length of other intervals should be 4 to 5 modules. The circulation can be located in either row of portals which is close to the middle.

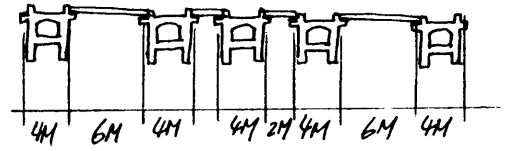
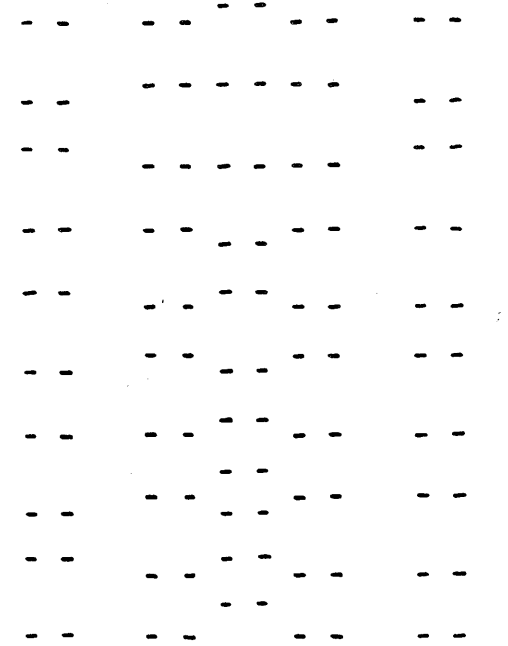


V.1.4 Five rows of portals

Five rows of portals is the maximum number of rows that can go without the introduction of courtyard either in the middle or at the side. The intervals which are close to the middle should be short compared to the intervals close to the edges. The circulation is most appropriate to be put inside the middle row of portals.



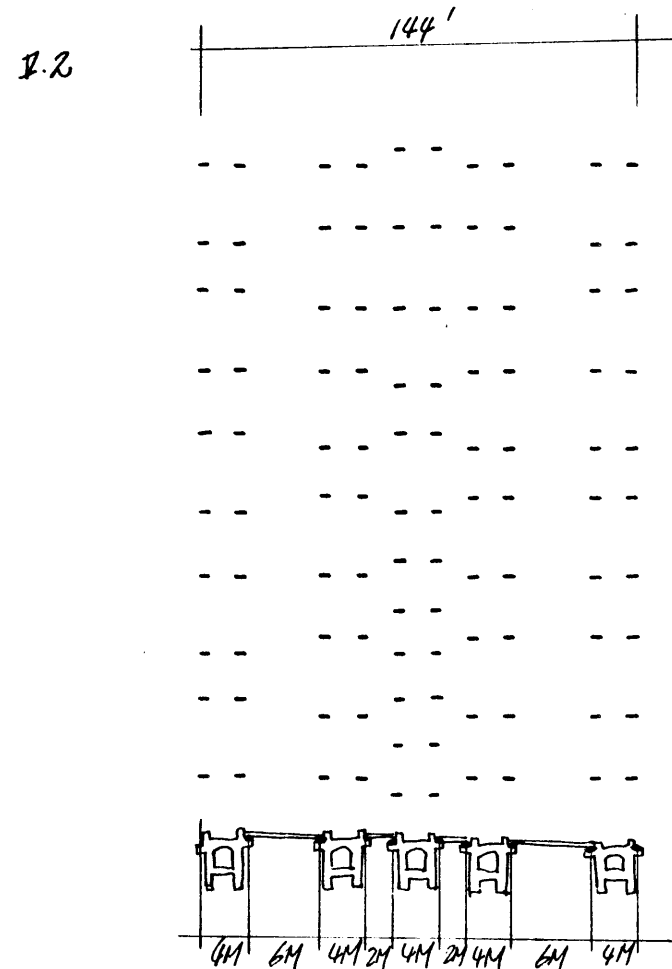
V.1.4



V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

V.2 Relation of distance between portals to circulation

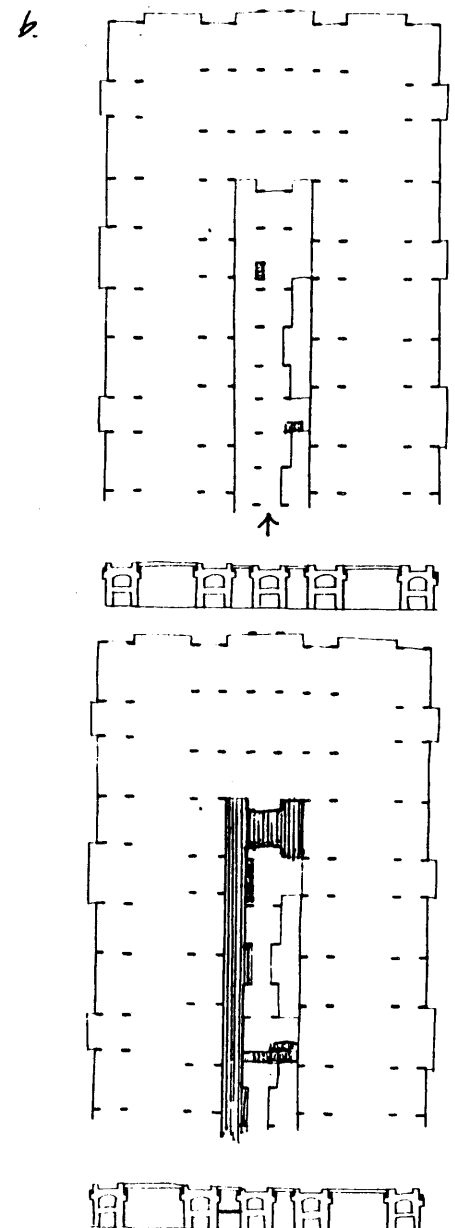
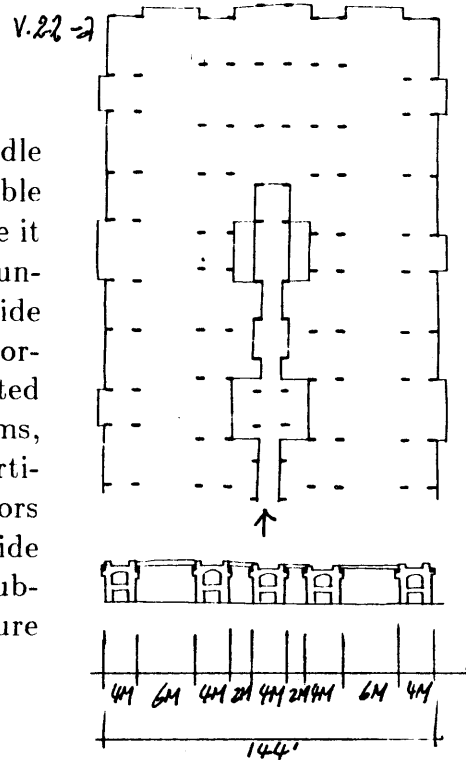
This series of exploration are to investigate how the variation of distance between rows of portals influences the configuration of the circulation. The variation of distance between rows of portals will be done with a fixed number of rows and within a fixed overall width. We will use five rows of portals from the last section as an example. The exploration will start form the case with smaller distance up to the case with bigger distance between the middle rows of portals.



V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

V.2.1 Five rows of portals – Case 1

With five rows of portals, the middle row of portals seems to be the most suitable location for the public circulation because it is the place where it is too deep for the sunlight to get to. The zone of 2 module-wide space which is next to the middle row of portals is good for spaces used as service-related activities like storage rooms or rest rooms, for example, it can be the location of vertical circulation like stair-ways and elevators (figure *a*). The zone of space is also wide enough for the location of a secondary public circulation to the main circulation (figure *b*).

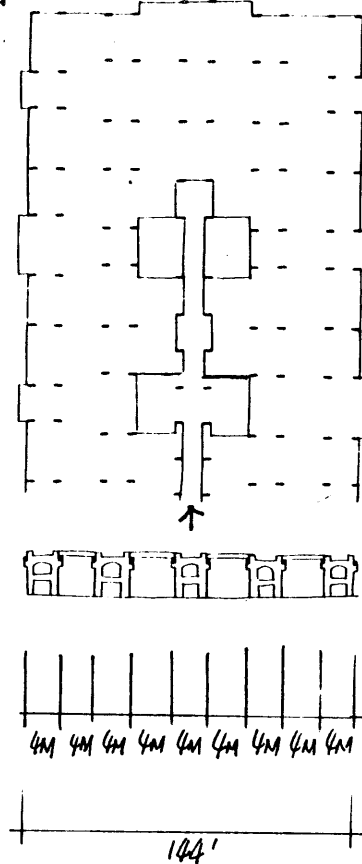


V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

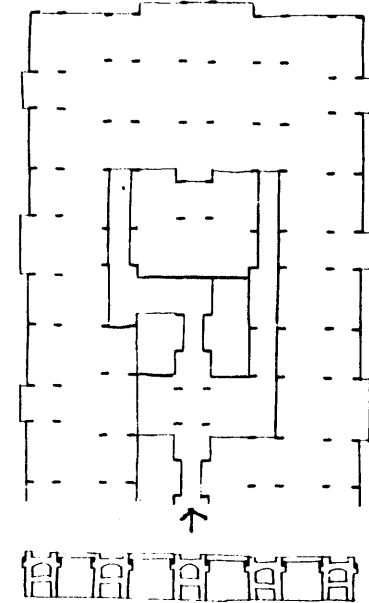
V.2.2 Five rows of portals - Case 2

In this case, both intervals next to the central row of portals are equal to 4 modules. The central row of portals again can be used for the public circulation, and the zone of space in between two rows of portals on both side of the circulation can be used as the service spaces (figure *a*). With interval of 4 modules on both side of the central row there will be too much space for just to accommodate the service activities, and plus the size of the space the zone of space is also good for the location of a small community meeting space, for example, a small lecture room or a conference room (figure *b*). The circulation in that area will have to be located inside the row of portals next to the central row on both side.

v.2.2 - a



b.

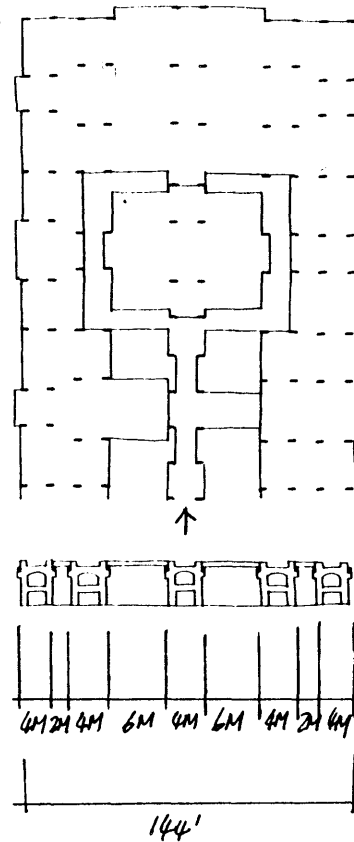


V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

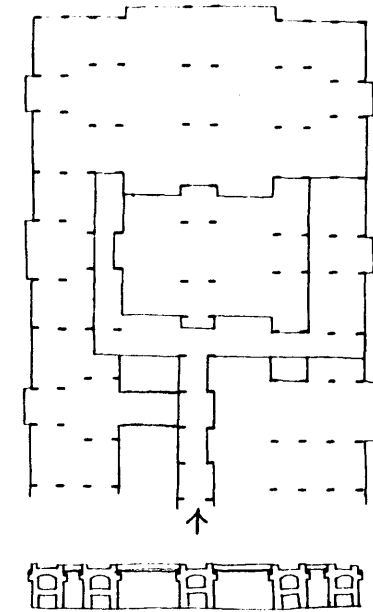
V.2.3 Five rows of portals - Case 3

In this case, the intervals next to the central row of portals are 6 modules in length. The zone of space next to the central row of portals is best for the location of a large community meeting space, for example, a large lecture room or an auditorium. The three figures, figure *a*, *b*, and *c*, show three different sizes of a community space in the same arrangement of rows of portals, and their relations to different configurations of circulation created from the arrangements.

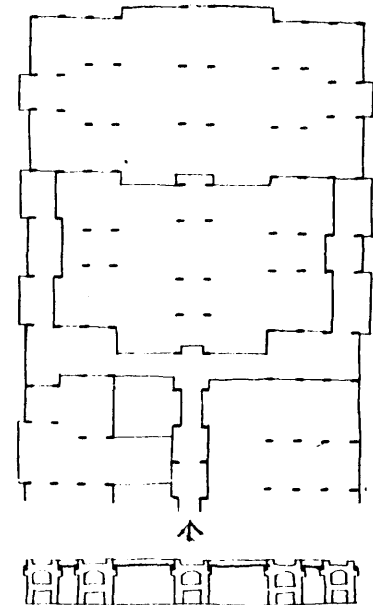
V.2.3-a.



b.



c.

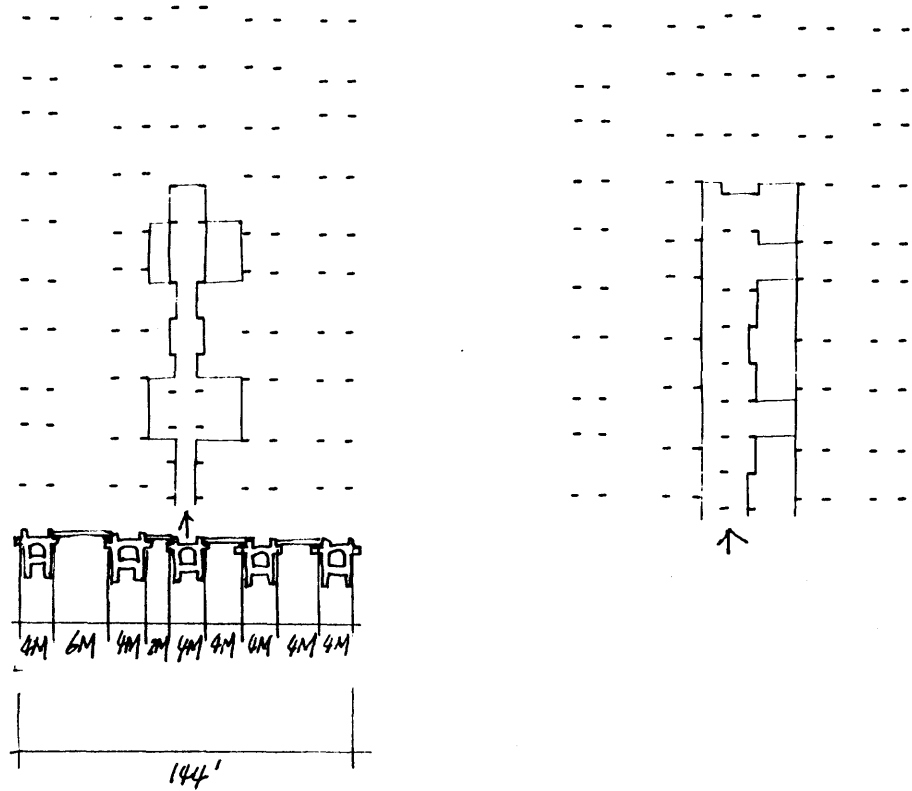


V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

V.2.4.

V.2.4 Five rows of portals - Other cases

There are also other cases in between those described earlier. They can be interpreted the same way as the cases we have studied earlier.



V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

V.2.5 Five rows of portals – Substitution by row of columns

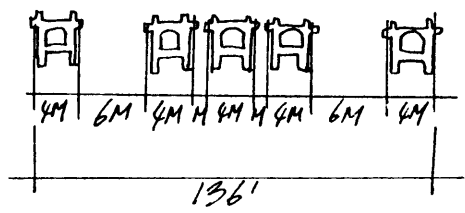
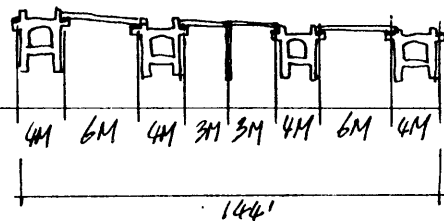
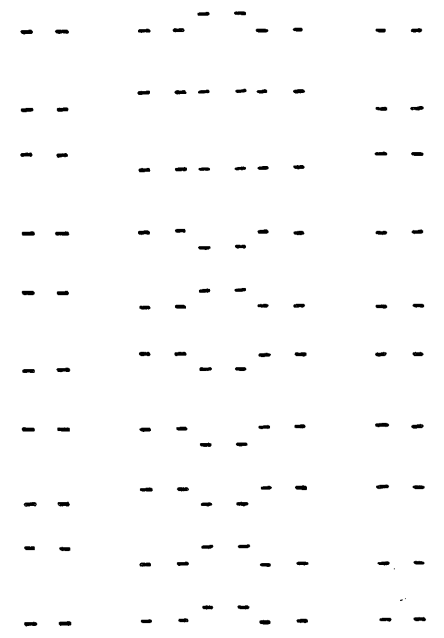
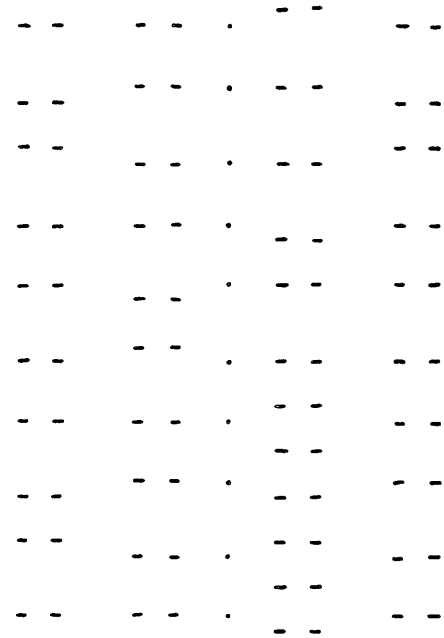
Sometimes, a row of portals can be substituted by a row of columns.

V.2.5

V.2.6

V.2.6 Five rows of portals – Change of overall dimension

Besides the length of the intervals can be changed, the overall dimension can also be changed.

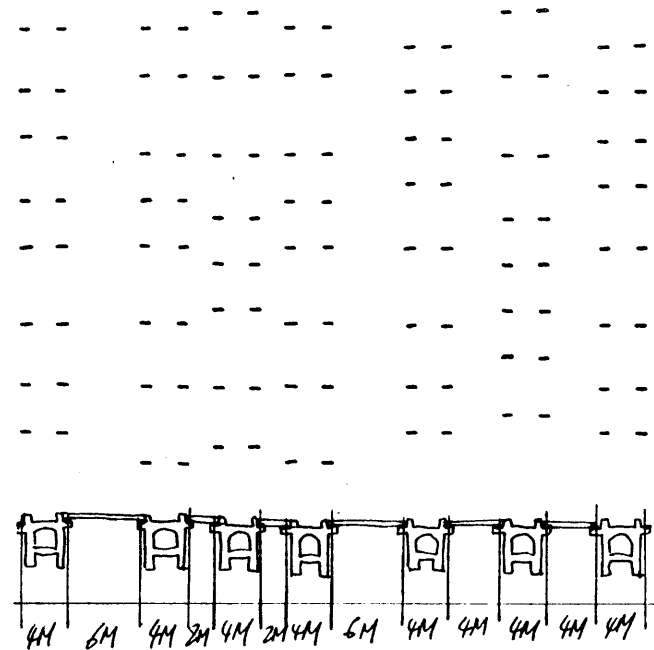


V. PRINCIPLES OF HORIZONTAL DEPLOYMENT - BUILDING SCALE

V.2.7 Five rows of portals – In the beam direction

The same method of interpretation can be applied on the rows of portals running along the beam direction.

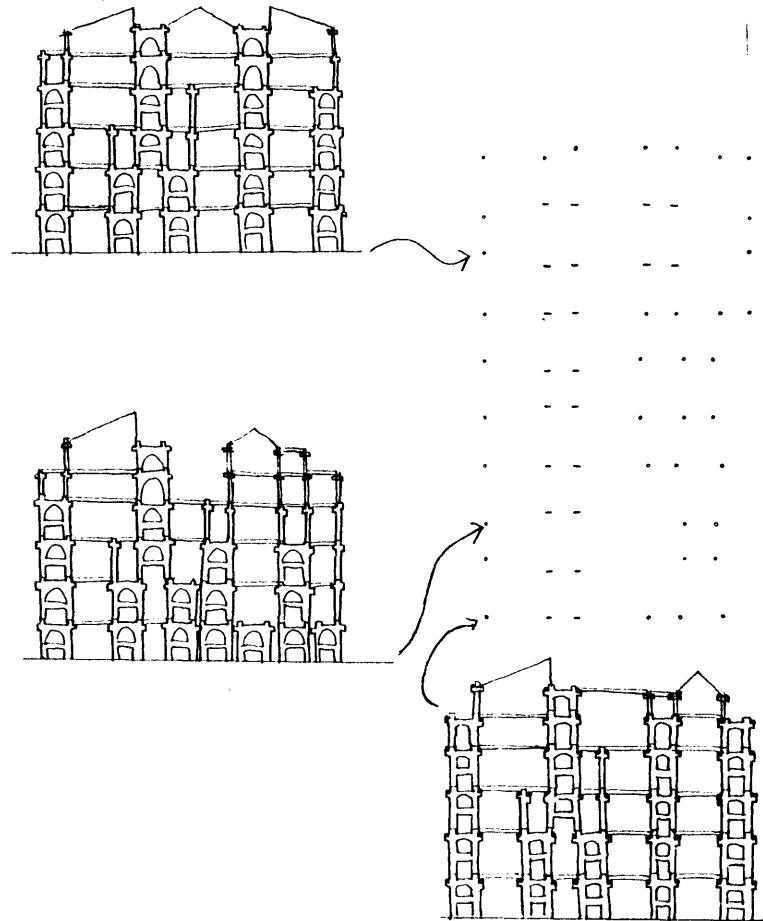
V.2.7



VI. PRINCIPLES OF VERTICAL DEPLOYMENT - BUILDING SCALE

VI. Principles of Vertical Deployment -- Building Scale

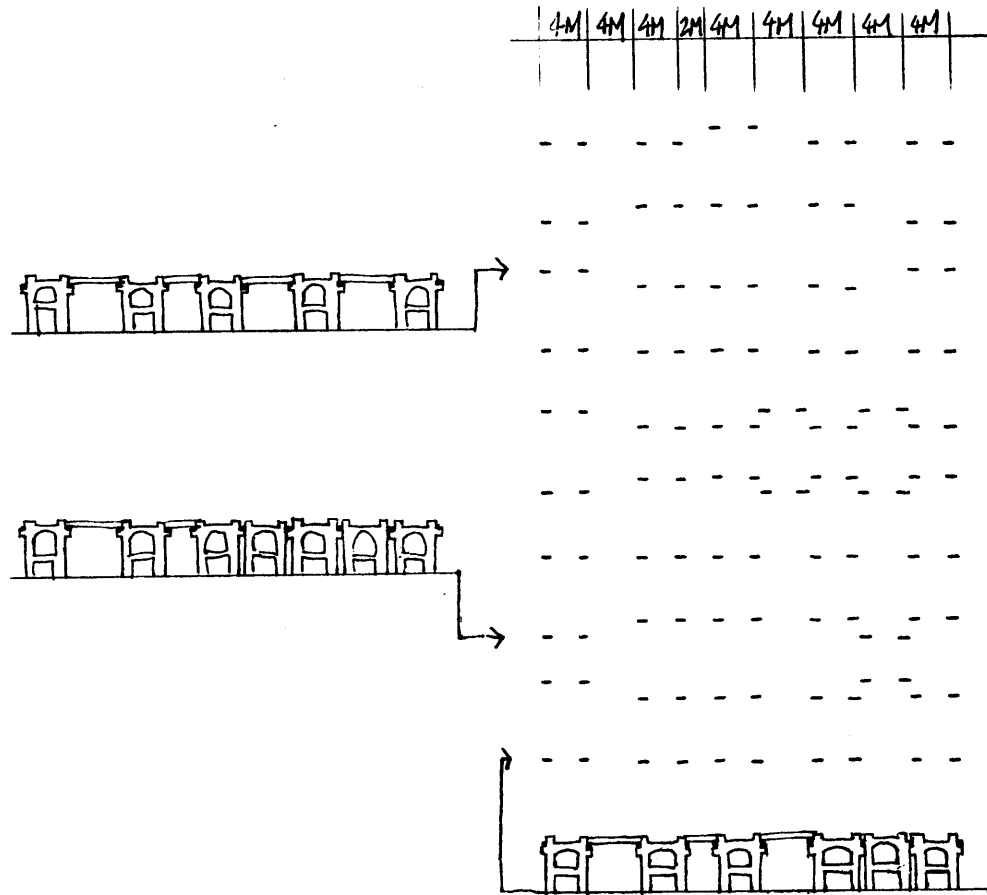
The intention of this series of diagrams of the deployment of the primary system is , firstly, to show the hierarchy of the order of structural elements in the vertical direction. Secondly, it is to illustrate the principle of the "thinning" of structure which the number of elements decreases upward. There will be lesser quantity of elements at the top than at the bottom. Thirdly, it is to give examples of decreasing in material of the elements. This six storey building is only an example.



VI. PRINCIPLES OF VERTICAL DEPLOYMENT - BUILDING SCALE

1st Floor

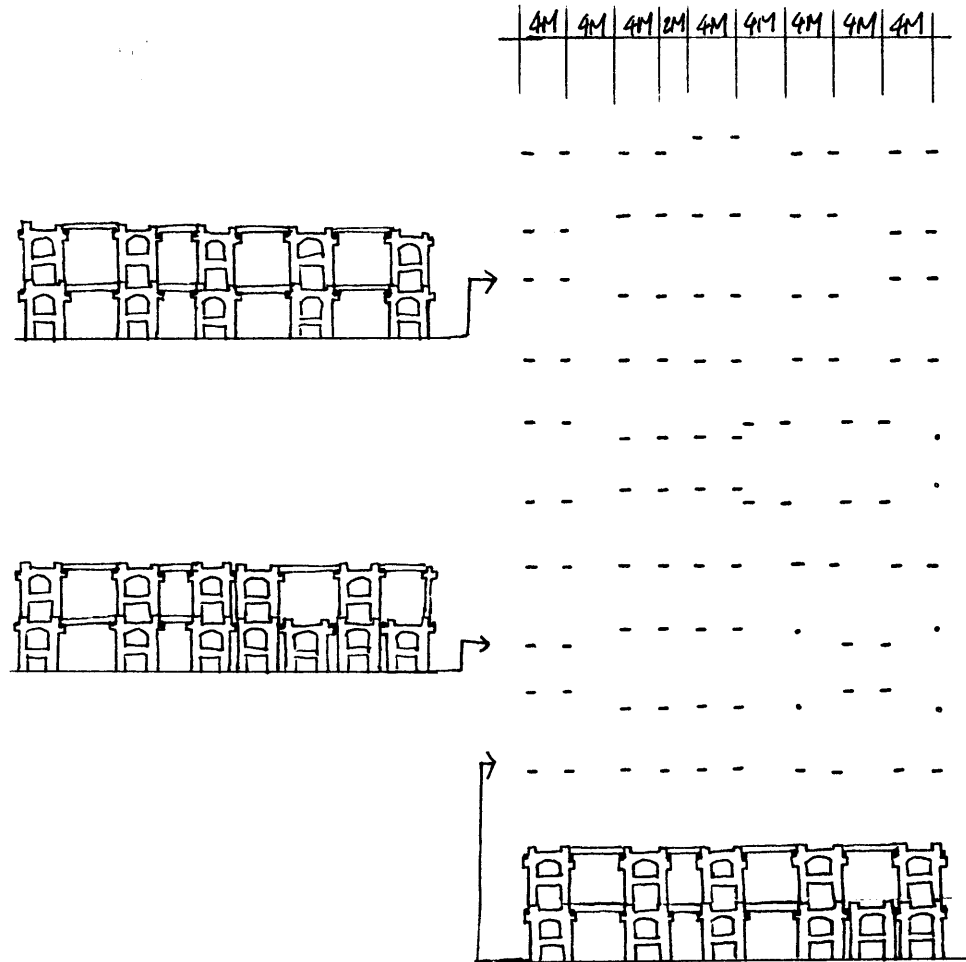
The bottom floor has the greatest quantity of structural elements since every piece of element above has to be supported from below, and the quantity of element will only decrease upward.



VI. PRINCIPLES OF VERTICAL DEPLOYMENT - BUILDING SCALE

2nd Floor

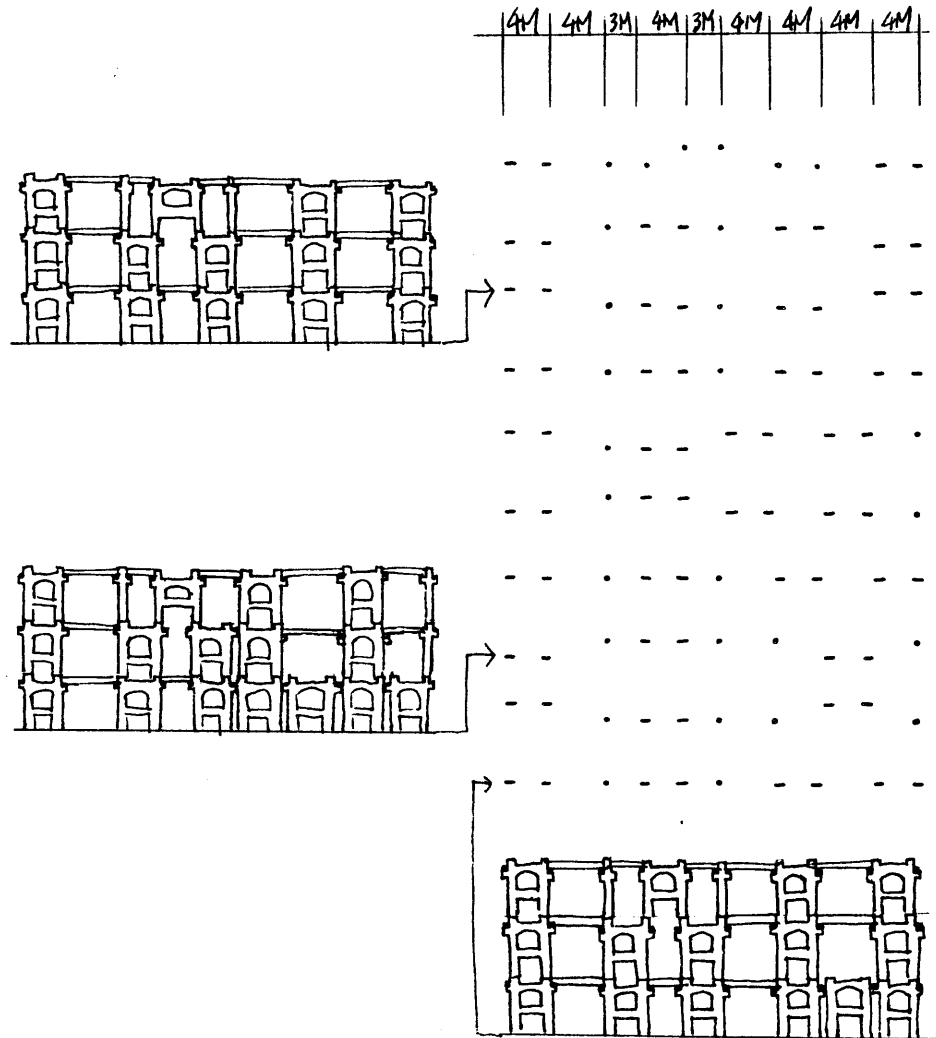
The quantity of structural elements starts decreasing. Some portals have been replaced by columns.



VI. PRINCIPLES OF VERTICAL DEPLOYMENT - BUILDING SCALE

3rd floor

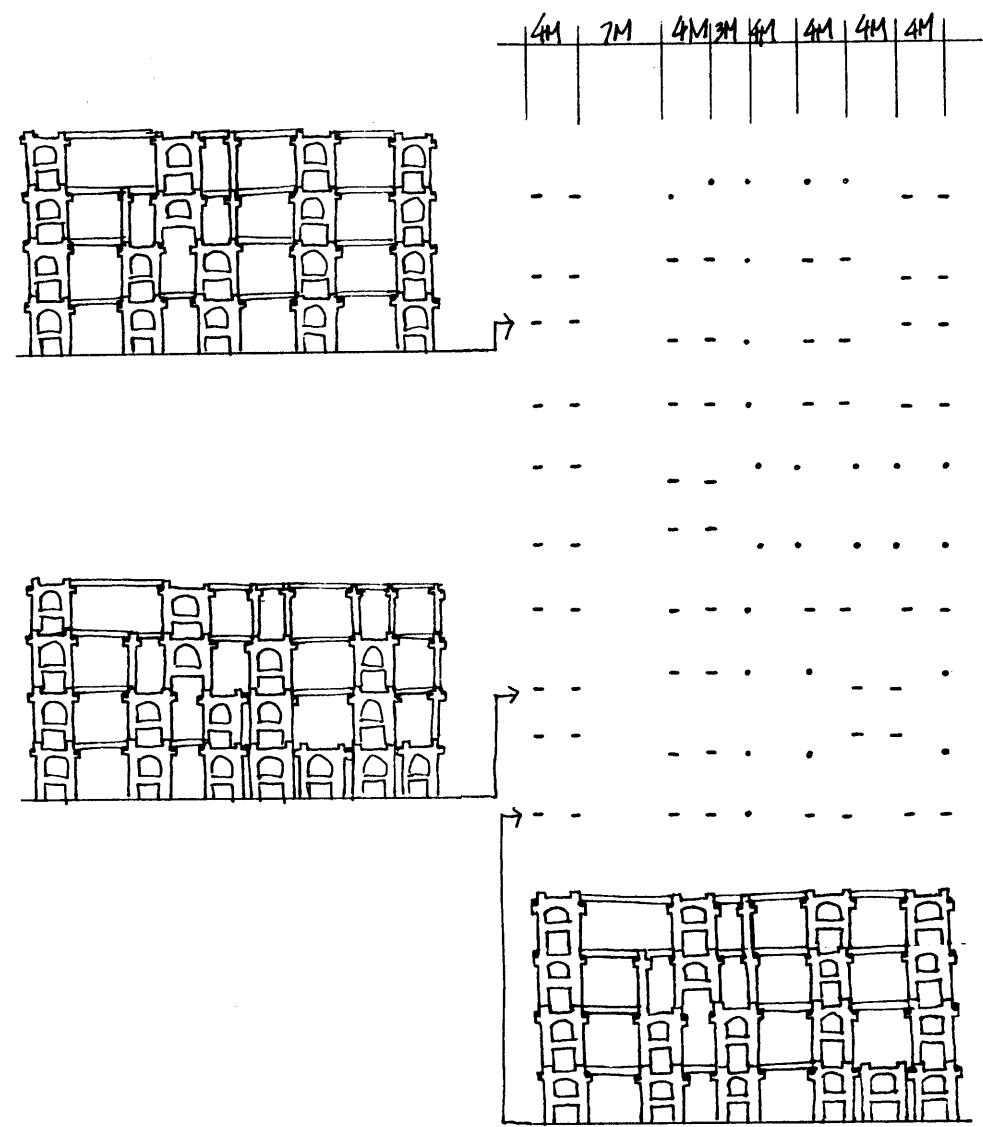
There are more portals replaced by columns. There is also a shifting of one row of portals from directly above another row to span across two rows of portals. There is only four rows of portals on this floor compared to the five rows of portals on the floor below. The configuration of both structure and space are very different from the floors below.



VI. PRINCIPLES OF VERTICAL DEPLOYMENT - BUILDING SCALE

4th floor

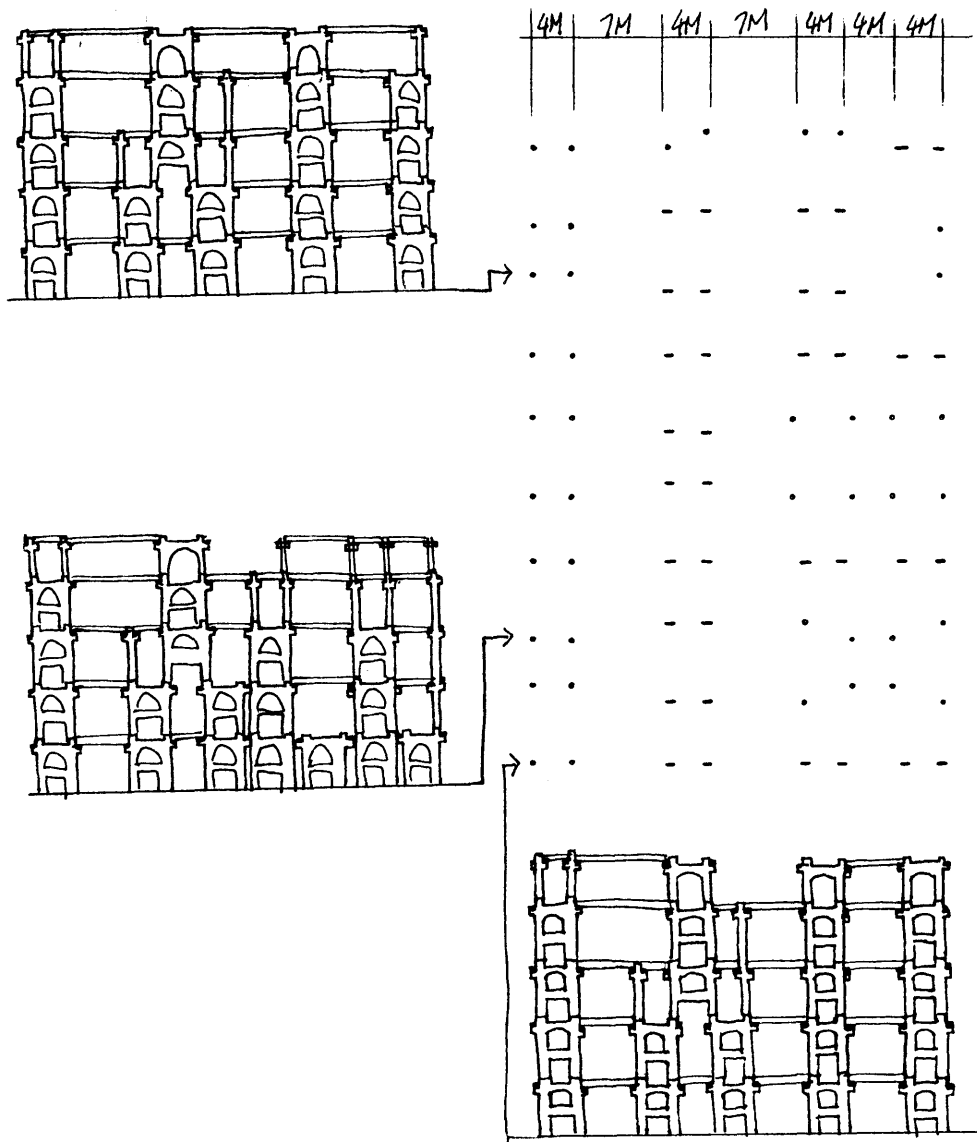
A whole row of columns disappears. One of the span between two rows of portals becomes bigger. The density of structural elements is lower than the floors below.



VI. PRINCIPLES OF VERTICAL DEPLOYMENT - BUILDING SCALE

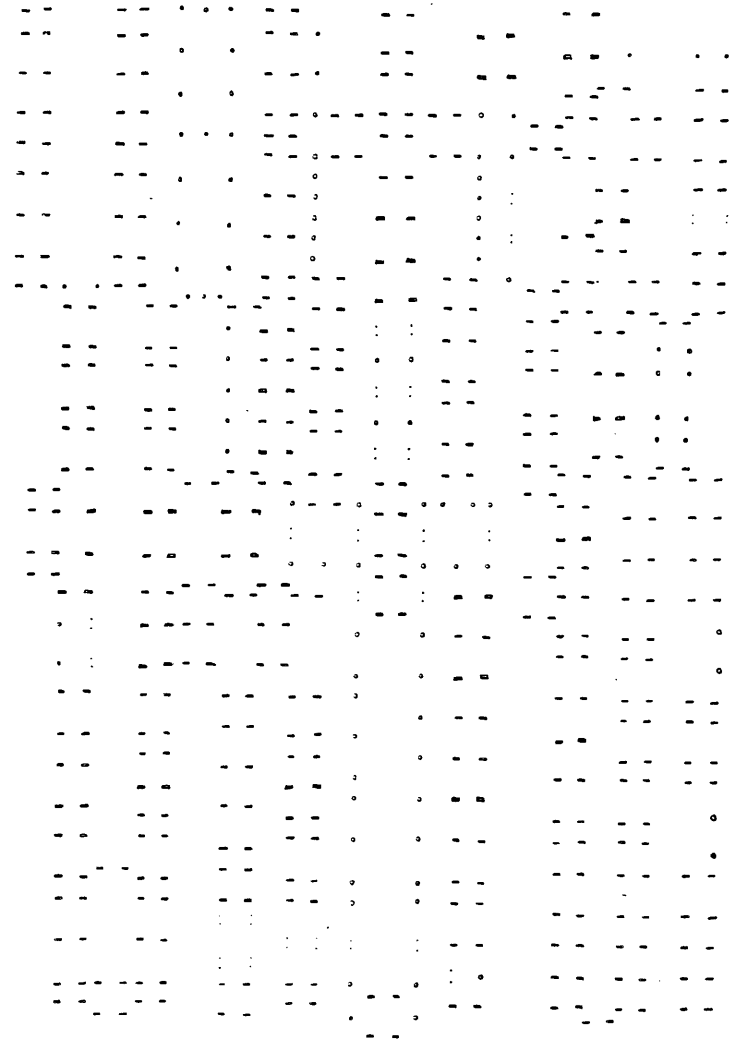
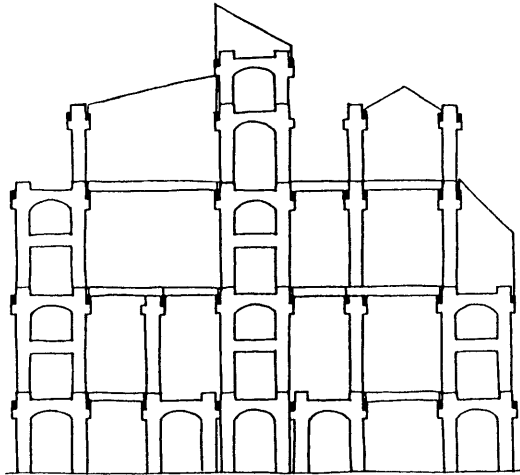
5th Floor

A whole row of portals is replaced by two rows of columns. Outdoor court begins to appear.



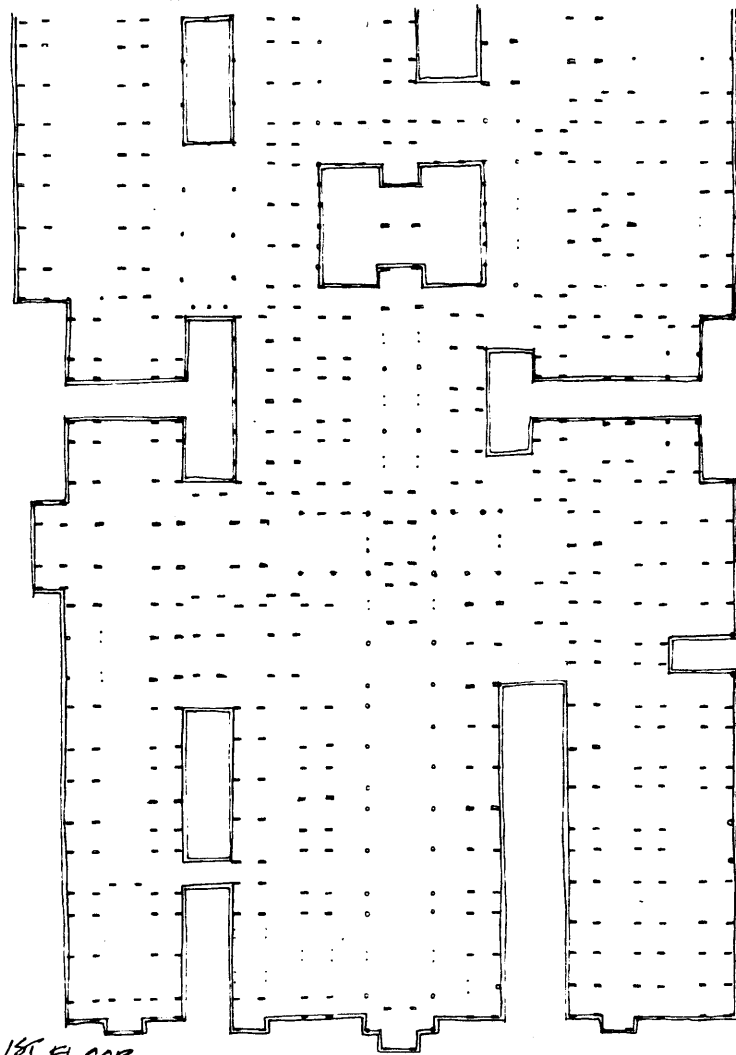
VII. FIELDS -TISSUE SCALE

With what we know, now a large plan can be made. On the basis of the grid, a general organization or a field according to all the rules and properties of the *structural theme* can be determined. Within this structure, different territorial and functional interpretations are still possible. We are not going into it in this thesis. The following drawings in this chapter are only to demonstrate within the field what alternative solutions of building form can be achieved.

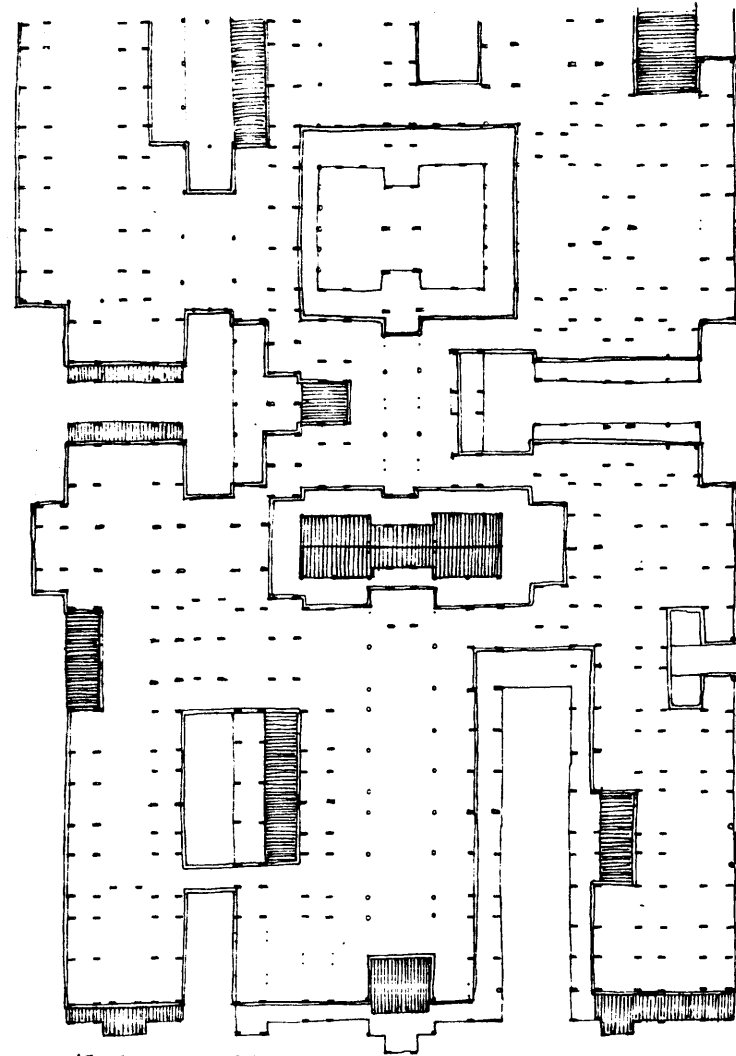


VII. FIELDS - TISSUE SCALE

ALTERNATIVE ONE
- COURTS



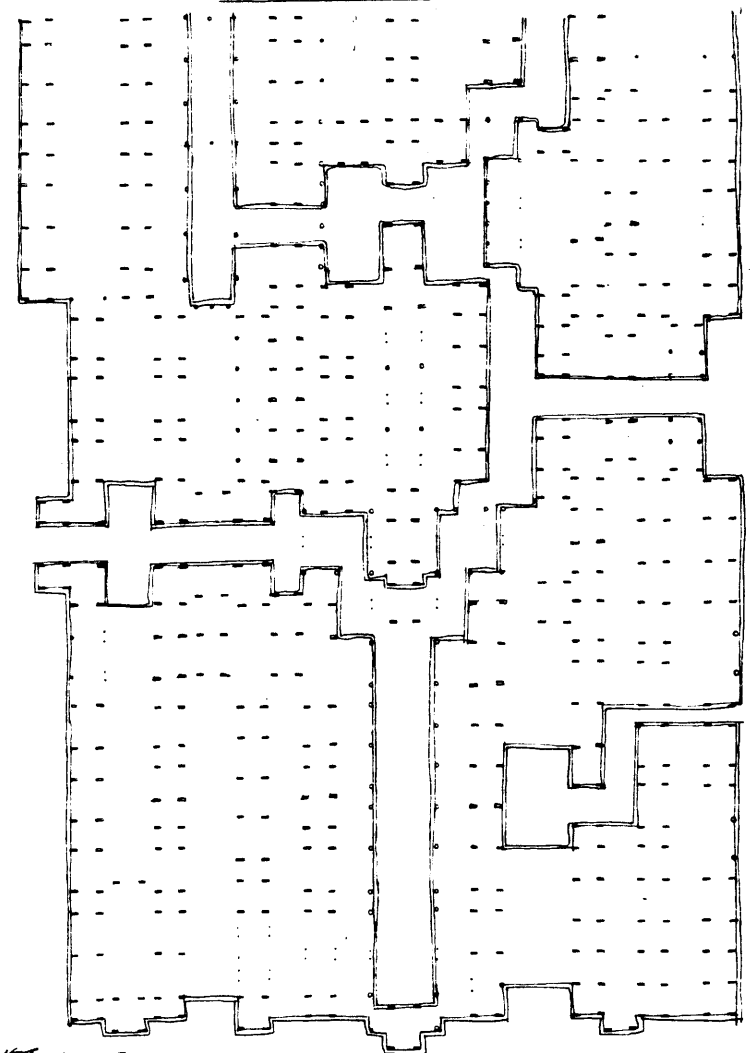
1st FLOOR



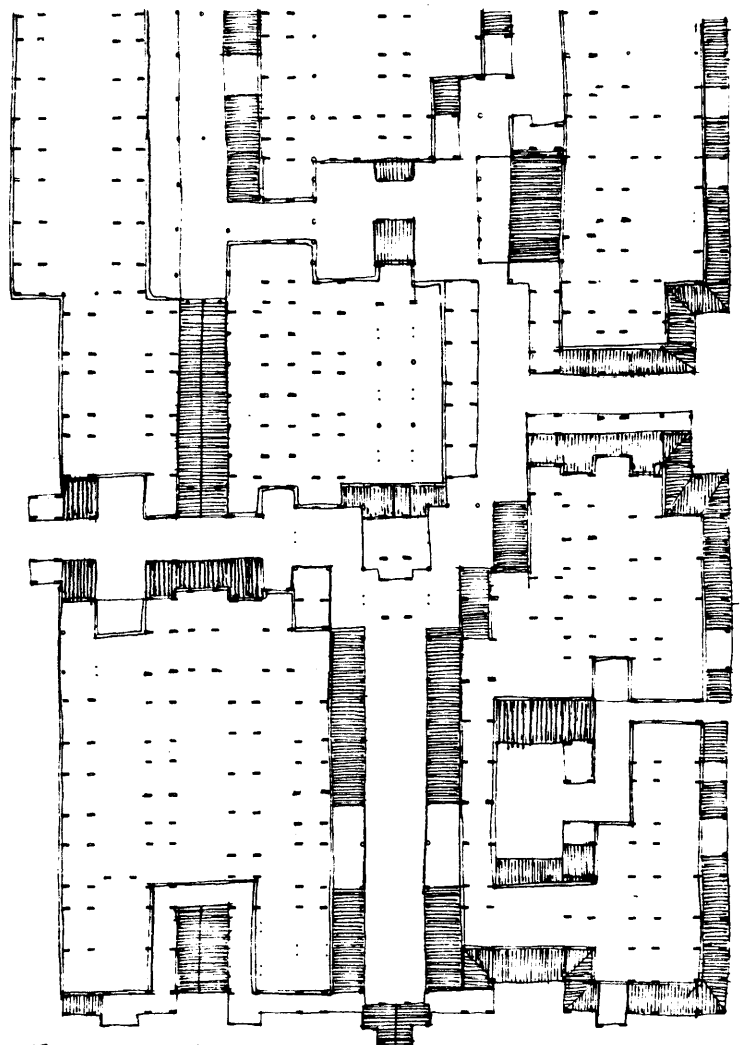
UPPER FLOORS.....

VII. FIELDS - TISSUE SCALE

ALTERNATIVE TWO
- STREETS



1ST FLOORS



UPPER FLOORS.....

VIII. CHANGE OF ELEMENTS IN THE SYSTEM

The thesis started with the spatial organization large laboratory spaces or work spaces flanked by small office spaces. These spaces were materialized into a structural system which facilitated such an organization of activities and eventually became the basis for a structural theme. This structural theme was then used with the help of a position grid to cultivate a field which eventually would support and facilitate a coherent environment of unlimited internal variety.

The initial concept of the organization lead to the design of a system consisting of a primary system and two secondary systems. The primary system included structural elements among which the portal was the key for the *structural theme*. Rules were formulated based on the relations among all elements in the primary system after which the specific form of the elements as well as their details could be designed. Capacities as well as constraints in the relations among various elements in the system were subsequently explored and demonstrated.

Once the properties of the structural theme are clear, we can return to the elements themselves. Now, we know the rules of the system. We want to modify the form of the elements within the constraint of the rules and while maintaining the same type of spatial relations. There are basically three types of modifications for the elements of the system. There are 1) the change of dimensions of the elements, 2) the change in form of the elements, and 3) the change in material of the elements. Let us take the key thematic element - the portal as an example.

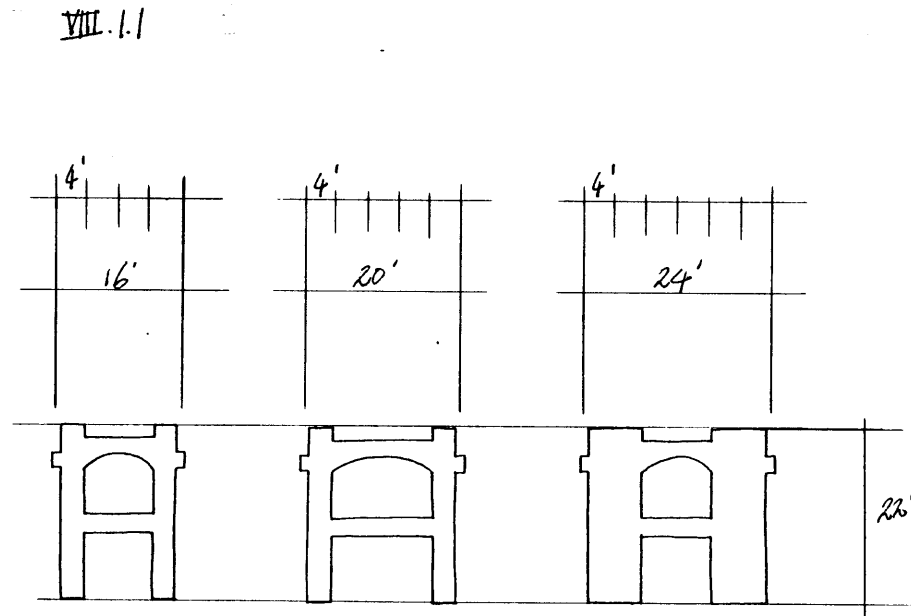
VIII. CHANGE OF ELEMENTS IN THE SYSTEM

VIII.1 Change of dimensions

By change of dimensions within the system, the position relations will remain the same. These relations are the most fundamental to the system. It is clear that when we change the module of the system and/or the position rules, all dimensions of elements will change. Keeping module and position rules constant, however, we still can change elements.

VIII.1.1 Change of width of portals

In the earlier part of the thesis, we designed a 4 module-wide portal. There is no reason why we cannot have a 5 module-wide portal of the same height. Naturally, the new portal will create new relations to the system as a whole; for instance, it will be unlikely to be placed on top of the 4 module-wide portal. Rather the 4 module-wide portal may be placed on top of it. Moreover, a change in proportion is inevitable. We can also design a 6 module-wide portal of the same height.

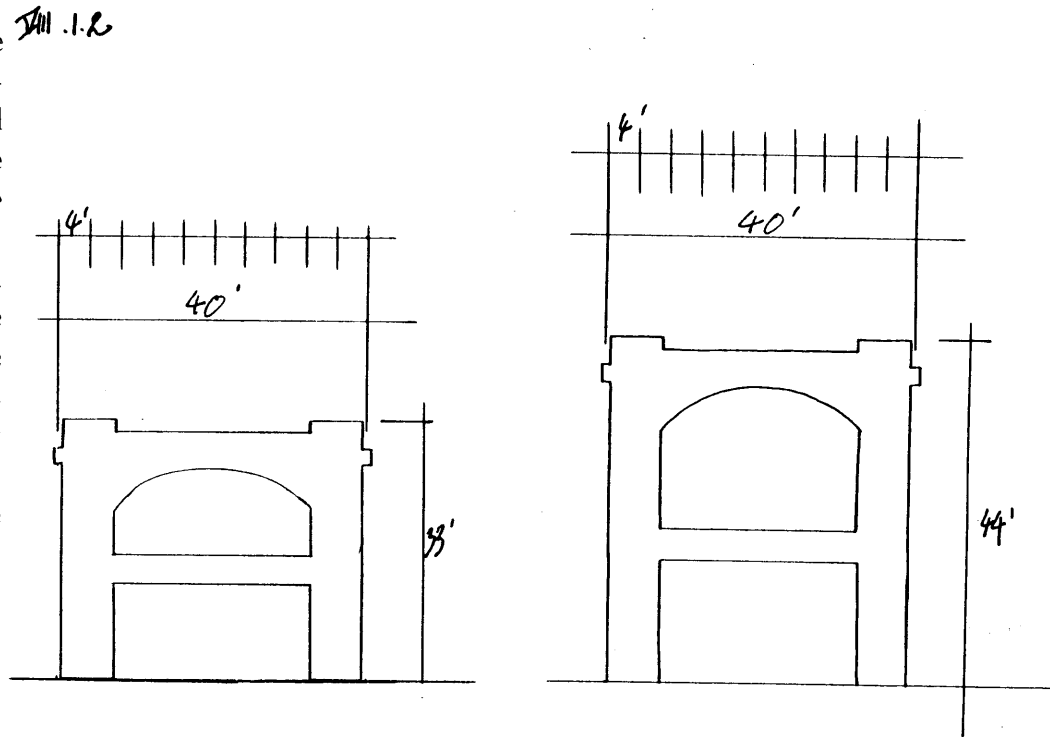


VIII. CHANGE OF ELEMENTS IN THE SYSTEM

VIII.1.2 Change of dimensions in both width and height

We may also design a 10 module-wide portal of 33' in height. In this case, besides that the proportion of the portal will be changed, the function associated with the form will also be different because of the higher spaces that are the result.

We may design a 10 module-wide portal of 44' in height. But this is pushing it to the limit in that the structure may not easily be a precast element due to its enormous size. It may be possible to construct such a portal by the cast-in-place method. It is, in that case, appropriate to place it at the bottom of the building so that all the precast elements will be on top. With this height we reach the point where non-thematic elements appear in a design : elements outside for a specific program or side.

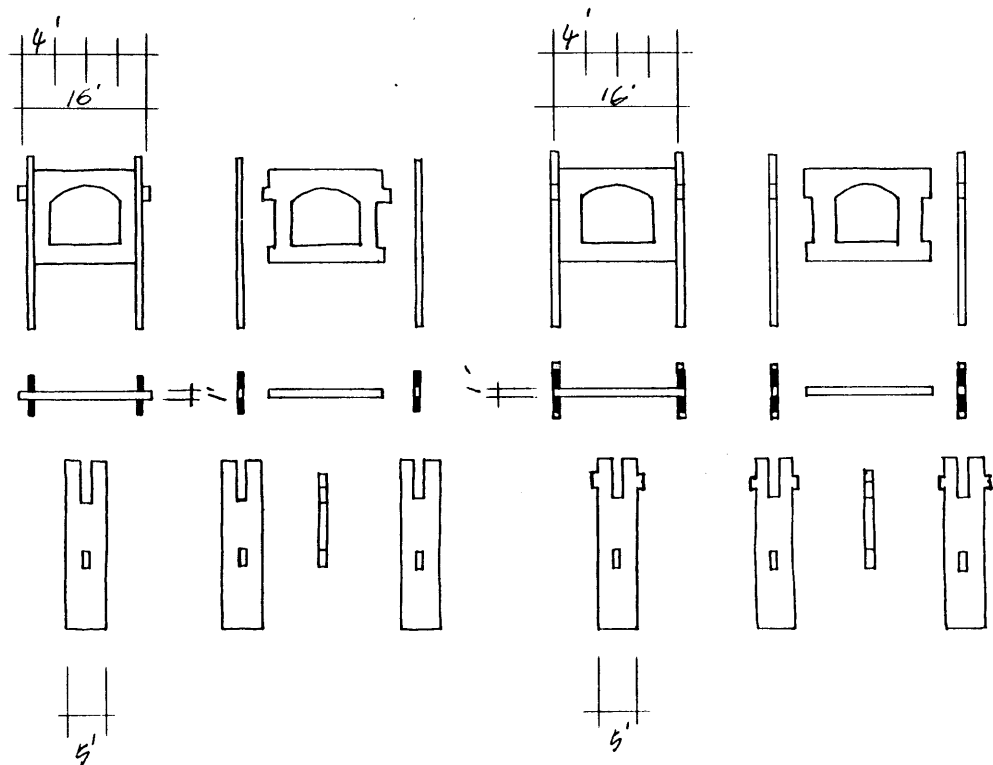


VIII. CHANGE OF ELEMENTS IN THE SYSTEM

VIII.2 Change of form

This is a kind of modification of a higher order than change of dimension. In the example given here, portal is again designed in reinforced concrete. This time, it is composed of three pieces. The main piece at the center fits into a column with its width perpendicular to the direction of the portal on both sides. The change in design of the portal does not change its relations to other elements except the columns. The direction of the column is turned 90 degrees. In fact, this design contributes greater stability to the portal itself. This particular alternative can choose to either receiving the girder on its sides, or receiving the girder along the longitudinal axis of the column part of the portal. In the latter case, the portal itself has to provide support for the beams placed along the same plane the portal is positioned.

VIII.2

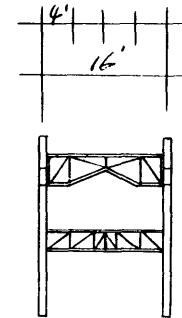


VIII. CHANGE OF ELEMENTS IN THE SYSTEM

VIII.3 Change of material

We may use steel instead of reinforced concrete for the building material of the portal. This kind of modification again is even more fundamental than the change in form. A whole new series of deformation and change in form of the portal can be started all over again. The change will not only affect the shape and dimensions of the portal but may also influence the dimension as well as the building material for the rest of the elements in the system.

VIII.3

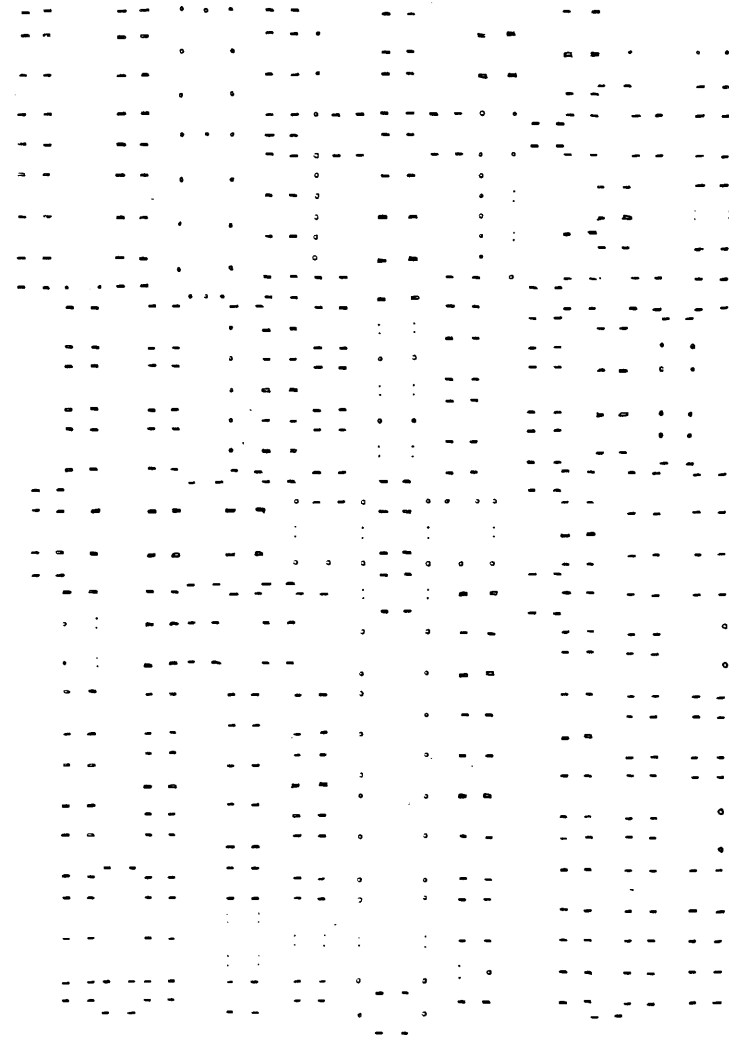
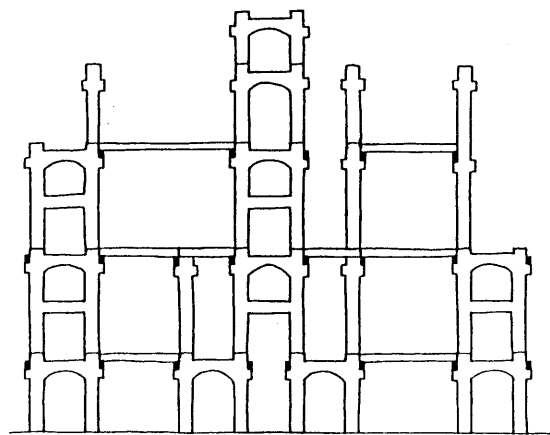


IX. CONCLUSION

In this thesis, we started out with a spatial concept that generated a structural system. With the system worked out, we could do a lot more than just by the space itself. The form helped to create even more types of space than we could imagine. After we had gone through all steps of exploration, we could demonstrate that the structural system was governed by a set of rules which we might call the *structure* of the system. These rules remained in the three types of modification on the structural elements. It was with this structure that we could create different configurations and arrangements of elements and spaces as they have been illustrated throughout the thesis. With these rules or structure of the system, we could dematerialized the original set of structural elements and replace it by a different set. We could also notice that form was an entity in itself and worth to be explored on its own, independent of function or site.

With this basic understanding of the process of form making, the already established structural theme and its illustrated properties, having available a family of forms within the domain of the structure of the system, we could begin to think about designing coherent environments with great variety in building scale, in tissue scale or eventually in urban scale. This concluded one of the two objectives that I had started out to investigate in the beginning of the thesis.

When the scale of the project becomes bigger, the number of people involved including the users and professionals is bigger. The result will lead to a broader variety of expertise involved. Therefore, the bigger the scale of the project, the greater the need for effective communication. It is here that the structure of the kind of system I have explored is most needed as the basis for communication including activities like designing, organizing, evaluating, and exchanging information. It was particularly this second objective which is to use a *structural theme* as the basis for communication, in addition to understanding the properties of the *structural theme*, that led me into my experiment. I wanted to illustrate how a *structural theme* of a thematic system might be an effective way to design allowing participation of a variety of groups or individuals. It was this second objective that I present my work in the format of a reference book. In this way the thesis may serve as the example of a document used to facilitate communication among all parties involved in the design process.



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