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BUILDINGS AS SYSTEMS

by

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Cambridge, Massachusetts
June, 1966

Dean Lawrence B. Anderson
School of Architecture and Planning
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Dean Anderson:

In partial fulfillment for the degree of Master in Architecture
I submit this thesis entitled, " Buildings as Systems ".

Yours respectfully,

Michio Ando

ACKOWLEDGEMENTS

I am grateful to all those members of the staff who offered their encouragement and criticism during the development of this thesis, and particularly to Mr. Waclaw Zalewski, Visiting Professor of Structures and Professor Eduardo F. Catalano, Thesis Supervisor.

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INTRODUCTION

A. PREFACE

There are various existences in this universe which are living having some relative connections with one another. Human being, who is one of these existences, is moving with time flowing on.

Architecture started as a shelter for man from changeable weather and invaders, and it has been advancing and progressing keeping pace with man's step. Man has to find and invent what he needs to go further. He is continuously changing not only his way of leading life, but also his social organization. After the Industrial Revolution, the industrial power which works for him instead of his own physical force, has been developed rapidly. Still now man is trying to find out more improved way to get the power speedily, economically, and mass-productively. In order to carry it out, it becomes necessary for him to know factors, properties, and characters of things around him. He has learned to analyze various kind of things which compose some systems of them.

B. PHENOMINA IN THE MODERN SOCIETY OF ARCHITECTURE

If we consider the latest society of architecture, we recognize that there are two main ways to create architectural space.

One of them is derived from natural conditions which we lived in once, in a shelter by mountain and on the seashore. Nature is still like what it was long time ago. We now see various scenery in nature which our ancestors might see, although the aspect of society is changing by modern technical industrialization. Nature, from which we feel nostalgia, has various creative patterns in herself. Consciously or unconsciously, people see nature to memorize in their brain. If we create design without any restriction, this must be one of ways to make architectural design. As I understand, there are several outstanding architects recently whom we call genius.

The other way to make design is that we utilize the modern industrialized things to make space. People are gradually getting accustomed to live among industrialized things which have modern texture themselves like train, car, airplane, and even city itself. It may come the time in the future when we feel some philosophy from them.

C. THE NECESSITY AND THE APPLICABILITY OF ANALYTICAL METHOD IN ARCHITECTURE

The way to create architectural space in which industrial mobilization is accomplished, has more potenciality in the future. Because this makes it possible for us to analyze building system to units, and reorganize them to another kind of systems which suitably meet the requirement of many situations under rules of construction process and design factors. Besides this way makes it easy to satisfy the demand of man, it is helpful to improve the quality of buildings.

On the other hand, upon recent conditions that the industrial mobilization is not sufficiently done, architects must use logic and clarity to put his emotion on a responsible level, namely, on the building made from units. It is ideal to find out some permanent system as a base by which it is possible to make buildings economically with modern technical mobilization, and to grow them to any direction and in any space.

The applicability of building depends on the quality of result from the research. This research is naturally restricted by the limit of capacity of modern science and industrial engineering. Therefore it is necessary to make the possibility

and potentiality keepint its step with progress of science and industrial engineering.

In order to increase the potentiality to create architectural space, we should make some suggestion under consideration of industrial power.

D. THE IMPORTANCE OF THE CONCEPT FOR ARCHITECTURE IN THE FUTURE

The recent modern science and industrial engineering are progressing steadily and rapidly, which makes more freedom of the selection to create the architectural space.

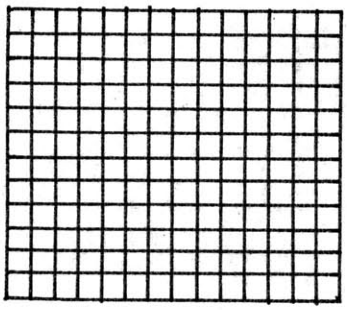
I believe that the building which has many possibilities will be made from this concept in the near future.

ABSTRACT

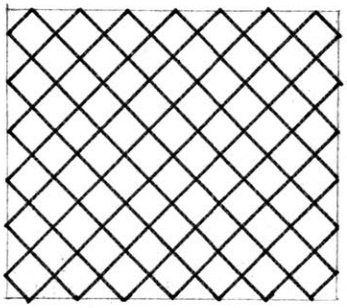
This thesis serves to illustrate how a structural system is derived from clear techniques of construction to form a self-sufficient building unit with its own integrated mechanical services.

The system is designed to grow in two directions as well as diagonal directions while the integrity of the building to which it is applied is preserved at any stage of growth.

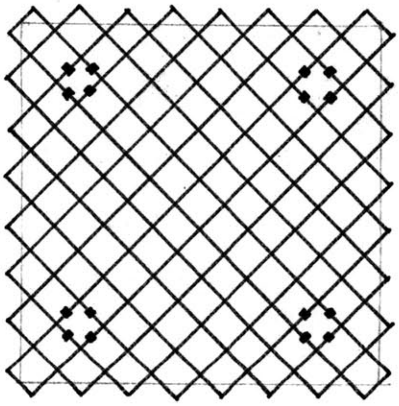
Here it is applied to any type of building which does not need long span. However, recent building always changes its need extremely quickly and the system of construction must provide flexibility and potentiality for growth to prevent the obsolescence that arises when expansion or alteration is virtually impossible even though the structural shell of the building is still intact.

1. 

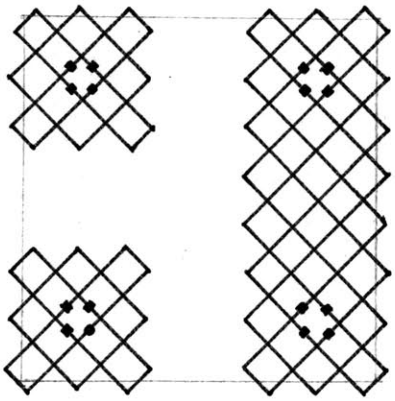
Members which carry the load are composed of bottom beams and upper beams. Bottom beams, 5'x 5', will be applied for making partition.

2. 

Upper beams which run through diagonally are main beams in this structure. The span of the beams is 7 ' x7 '.

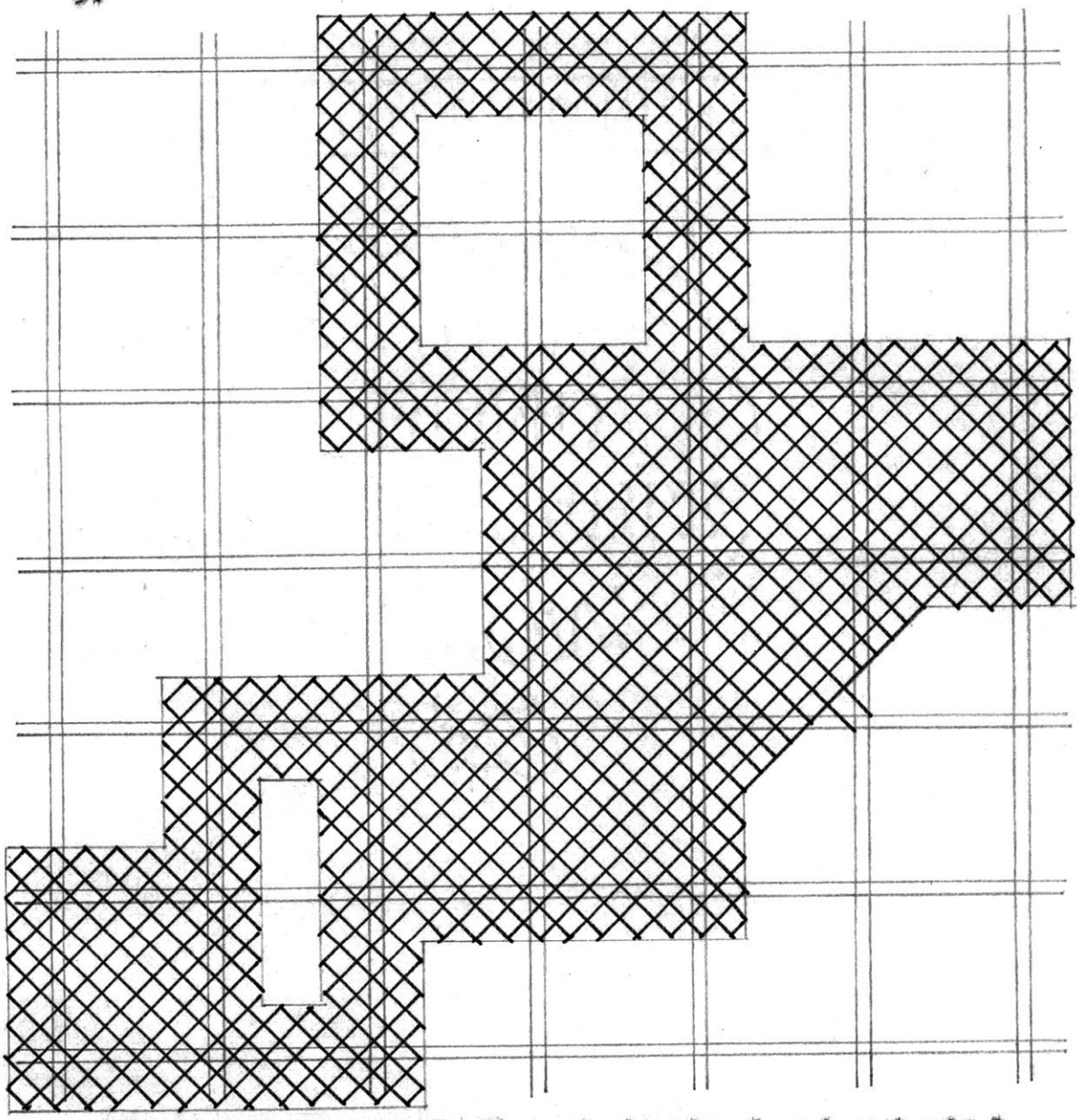
3. 

The loads on the bottom and upper beams are transferred to the column clusters, 5' x 5', which are composed of four columns. Span of the column clusters is 50 feet.

4. 

The system of the beam is cut in the place, 15' away from the center of column clusters and provides flexible sections for making space.

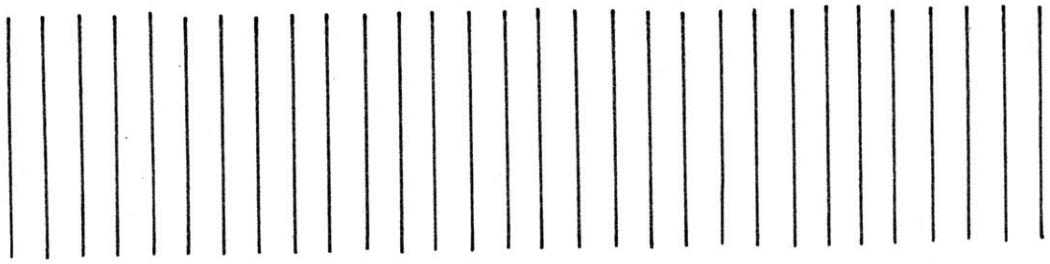
5.



The symplicity of the organization of structural and mechanical units provides the potenciality for growth in diagonal directions as well as two directions, and for making void area in the building.

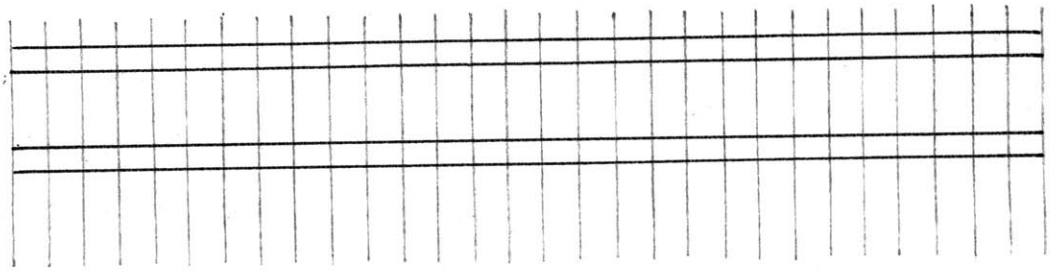
THE SPATIAL FLEXIBILITY

1.



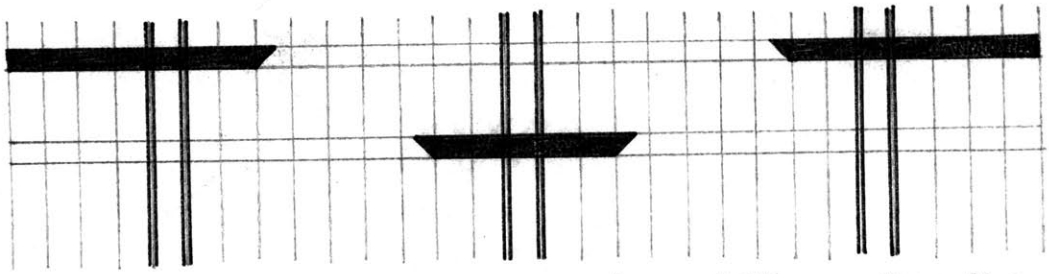
As the span of bottom beam is 5' x 5', the potential partition for deviding the vertical space may be put every five feet.

2.



Although 10' ceiling height is a economical solution in general, the ceiling height may be changed as desired.

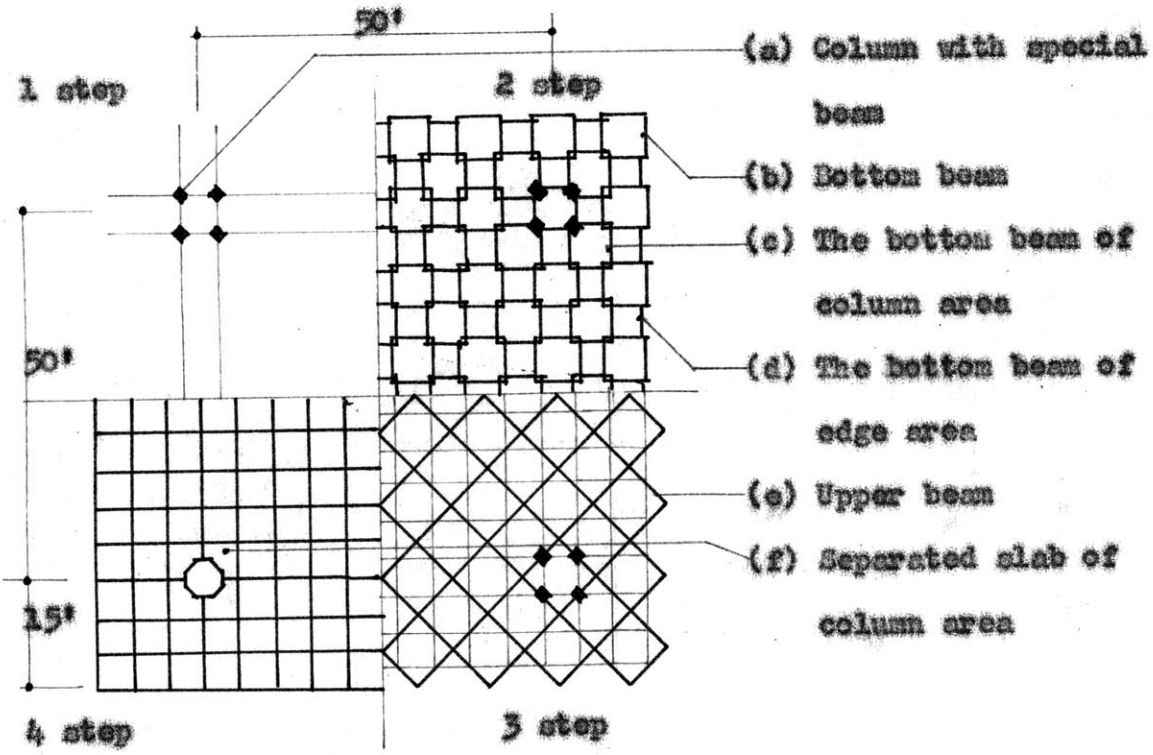
3.



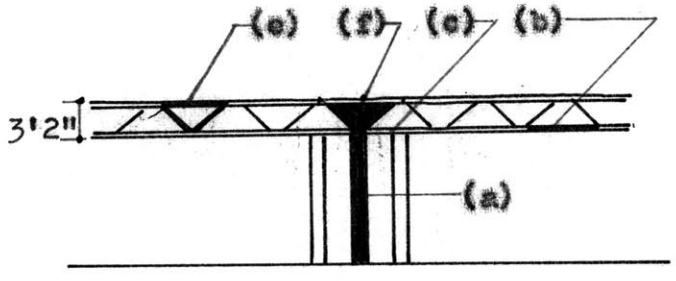
The system of beams is cut at the place, 15' away from the center of column clusters and it provides a potential for making changeable space in the building.

THE DESCRIPTION OF STRUCTURAL SYSTEM

The one bay of the structure measures 50' x 50' and is composed of six basic precast concrete elements.



THE PLAN OF ONE BAY



SECTION

Each unit is composed of:

(a) The hexagonal shaped column precasted by reinforced concrete is in a body with one unit of beam. Four columns are cast by concrete mortar with seperated slabs in a horizontal position. While the steels in the columns go through the holes in slab and are cast by welding and concrete mortar with next column in a horizontal position.

(b) A precasted bottom beam, 5'x5' and 4" thick and 2" thick partially, is provided with channels and perforations through which run the post-tensioning cables. The joint part of two botton beams and one upper beam is cast by concrete mortar.

(c) The bottom beam in column area is provided with same members as mentioned in (b). While one corner of the beam is removed in order to connect with column by concrete mortar. The removed part is reinforced with steels for transportation.

(d) The bottom beam in edge area, 1'x5', is provided with same members as mentioned in (b).

(e) Upper beam is 3' deep. It is in a body with slab, 5'x5'x5", and provided diagonally with channels and perforations. Especially, large channels are run inside the slab of upper

beams to connect with next unit in which the reinforcement is stopped that is pierced from next unit.

(f) Separated slab which has holes to pierce reinforcement in column area is provided for the connection with next column.

ERECTION

Step 1 Placement of footing foundation

Step 2 Setting up formed columns

Step 3 Erection of scaffoldings

Step 4 Placement of lower beam units

Step 5 Placement of upper beam units

Step 6 Pouring grout to joint parts

Step 7 Post tensioning

Step 8 Slab reinforcement and pouring concrete for making floor

Step 9 Revert back to step 2

CORES

There are two cores ; one of them, 45'x45', is a major core which is used for service in such ways as bank of elevator, scissor staircase, washroom, flight elevator, vestibules and storage. The other, 20'x10' has a fire staircase for emergency. They are located in a place which does not disturb two way structure. The location of major cores is among column cluster, permitting an orderly four directional circulation within the building.

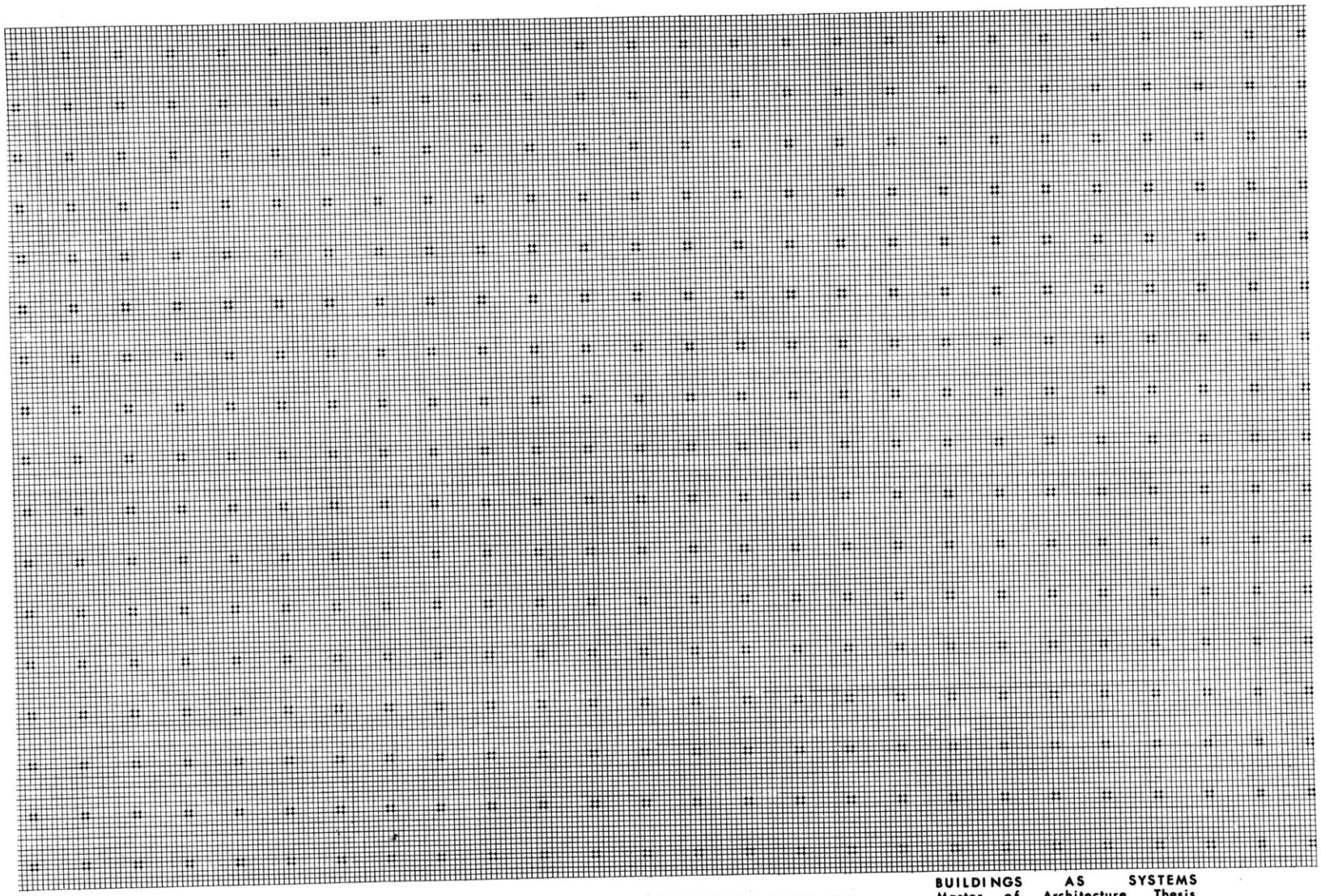
Washrooms have a movable partition dividing the space to accommodate the men to women ratio.

The speed of flight elevator is 200 ft per minute.
The speed of passenger elevator is 500 ft per minute.

THE DESCRIPTION OF MECHANICAL SYSTEM

The mechanical service comprised of supply and return air ducts and pipes for hot and cold water, and vent,and waste, are run to the appropriate floors in the column clusters. Beam depth of 3'2" is needed for openings to be made in the structure for the passage of mechanical services. It allows drain pipes to have sufficient slope in their distance to be housed within the structural depth. As a result, the building is free to grow as needed and take with it the necessary mechanical services in its structure. The building unit is therefore self-sufficient.

The air handling system is high velocity 4000 F.P.M. two duct system calculated as .66 sq.ft. of supply duct for every 1000 sq.ft. of floor area served and in low velocity 1200 F.P.M. calculated as 1.25 sq.ft. of return duct for every 1000 sq.ft. of floor area. So that the column clusters do not become overly large with services, the building confined to the height of five to six floors. Supply and return air utilize the different diffuser. The supply and return ducts are always run diagonally. Supply ducts and return ducts are not put upon one another. Ducts are invisible on the ceiling line. Pipes, which are invisible on the ceiling line, are run in two directions. The special panels are used for acoustics in the beams on the boundary line of rooms. One unit of illumination is composed of 4-40W lamps with diffuser of supply or return duct.



5 50 100 200

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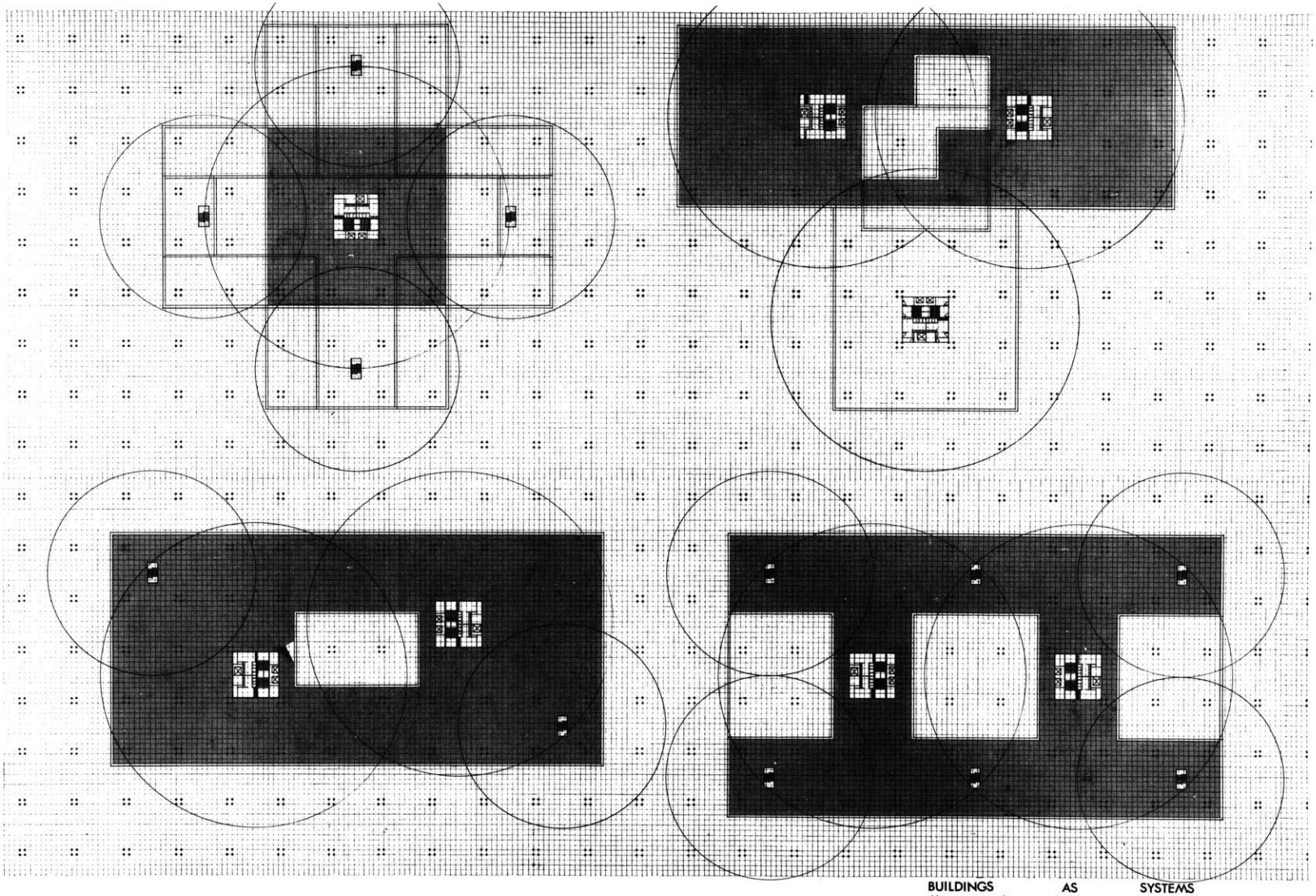

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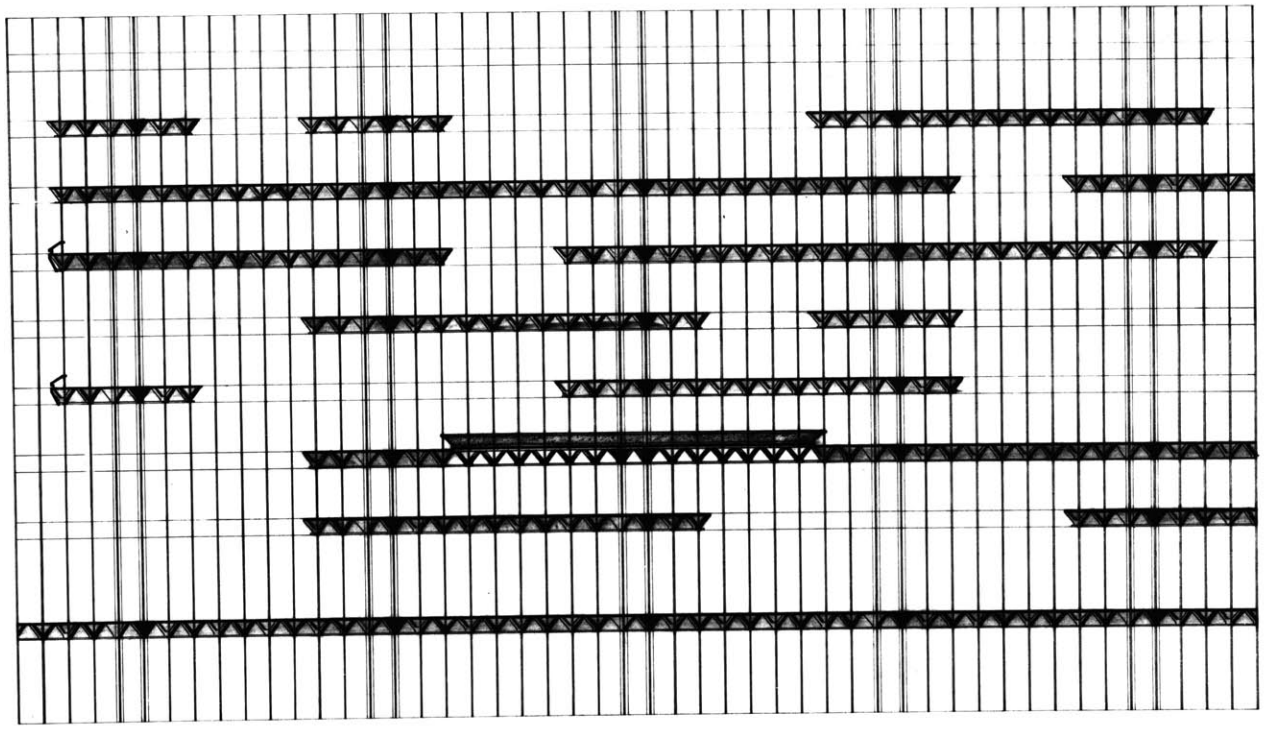

Section

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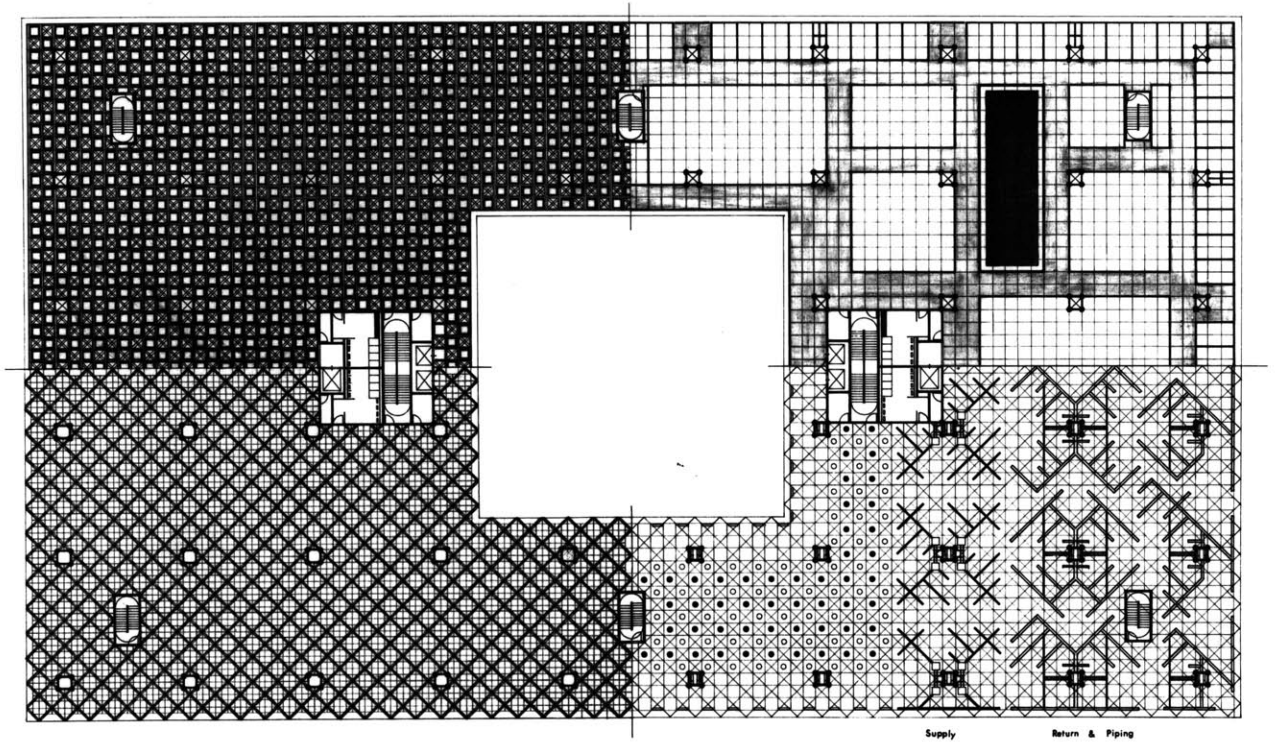
Lighting

Rooms



Supply

Return & Piping

Structure

Mechanical Systems

5 50 80

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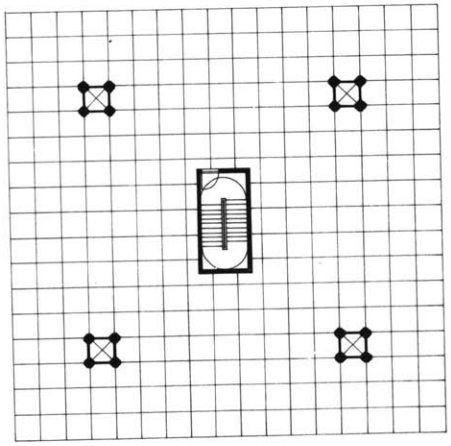
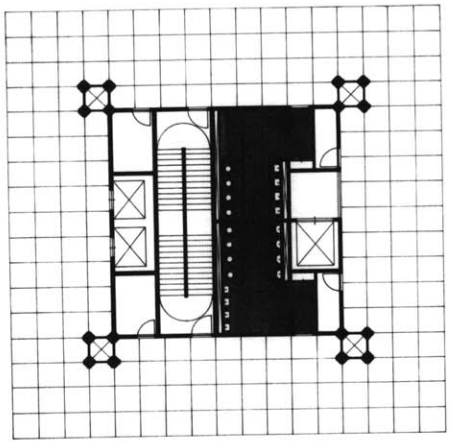


Fire Stair



Multi - Core

CORE DETAIL

5 10 15 20 50

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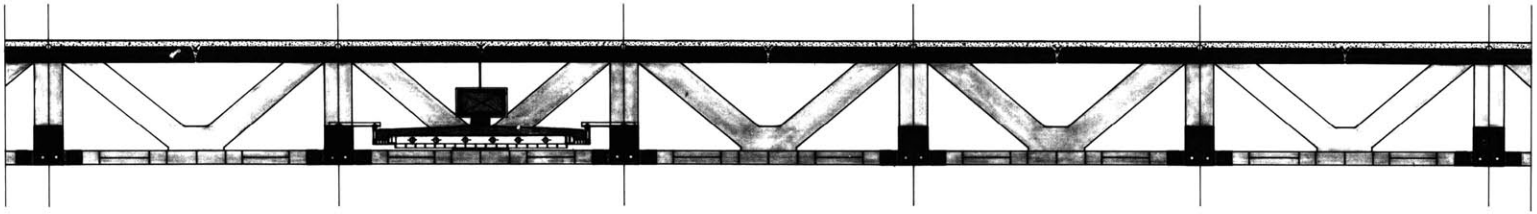
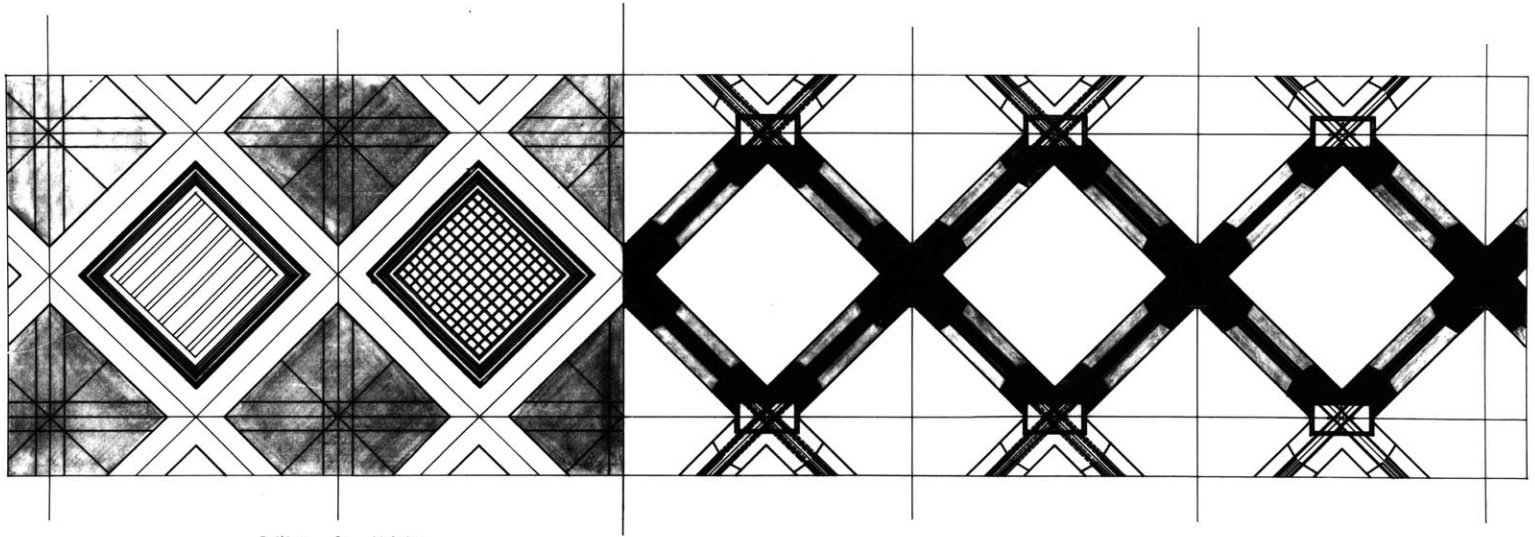


DETAIL OF BEAM SECTION



Ceiling & Lighting

DETAIL OF CROSS SECTION

1 2 3 5 7

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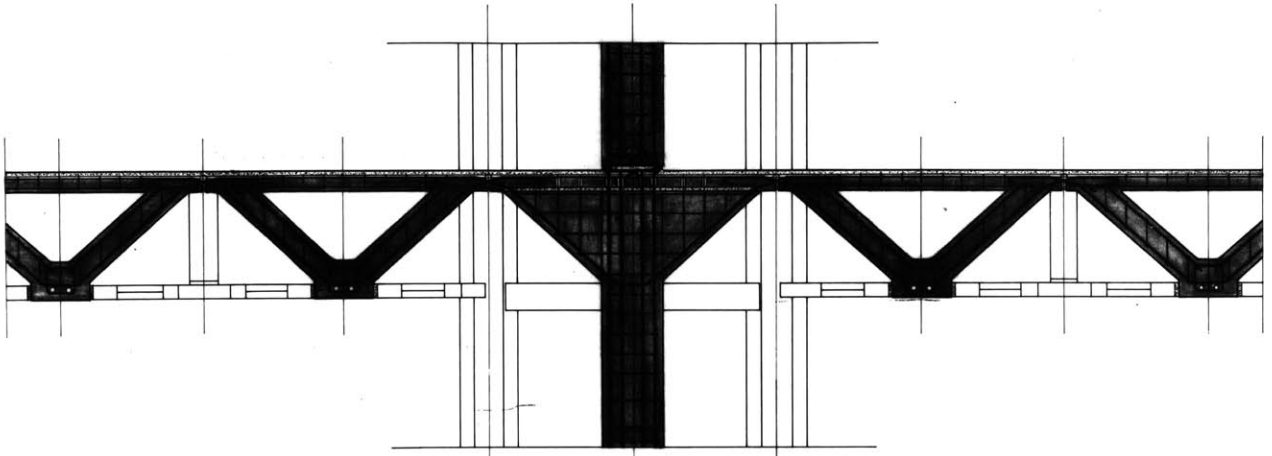
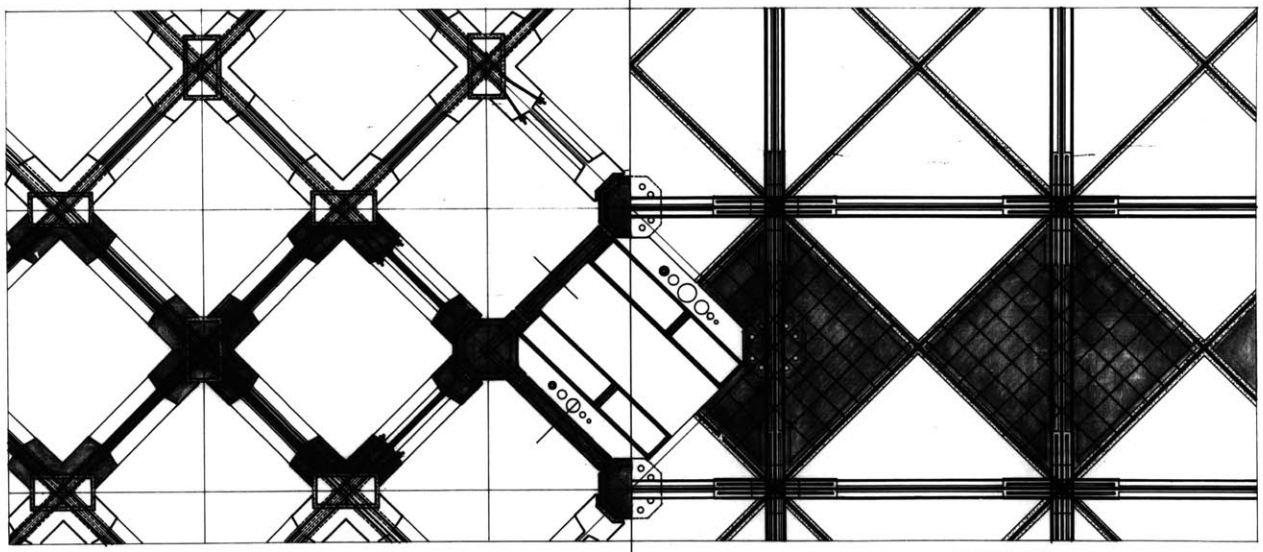


DETAIL OF COLUMN SECTION



DETAIL OF CROSS SECTION

1 2 3 5 7

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