

BUILDING AS A SYSTEM

by

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SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF  
MASTER OF ARCHITECTURE

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
June, 1966

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Thesis Supervisor

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Lawrence B. Anderson  
School of Architecture and Planning  
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Dear Dean Anderson:

In partial fulfillment of the requirements for the degree of  
Master of Architecture, I hereby submit this thesis entitled,  
"Building as a System."

Respectfully,

Hugo Garcia-Perez

June, 1966

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ACKNOWLEDGEMENTS

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I wish to thank

Professor Eduardo F. Catalano, Thesis Supervisor,

and

Professor Waclaw Zalewski, Structures Advisor,

for their guidance to the realization of this thesis.

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ABSTRACT

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The aim of this project was to design a footprint of structural, vertical circulation integrated with mechanical components, from which different sizes of buildings, with different spatial qualities, could be defined and also to achieve possibility of horizontal and vertical growth.

The central thought in the structural design was to achieve full flexibility in space, simplicity during construction and structural continuity in both directions.

The idea of applying systems in architecture is to put together all the components of the building in a unit of design, self sufficient by itself and achieving perfect control, order and hierarchy in the final product.

Definition of System - System is an order of things united by some form of interaction and interdependence of the parts to the whole.

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## DESCRIPTION OF THE SYSTEM DEVELOPED

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The system developed in this case is a linear system; it was chosen after a balance of advantages between this and the two directional system. The following advantages were achieved in a linear system over the usual two directional system.

- a) Easy removability of elements to create voids for spatial flexibility.
- b) No post-tensioning on site (no oversized elements).
- c) No use of scaffolding.
- d) Acoustical control.

The three major advantages of the two directional system over a linear one were also integrated satisfactorily in the system developed.

- a) The continuity of the structure in both directions.
- b) Flexibility in distribution of mechanical services.
- c) The organization of the inner space (partitions).

The parts of the structural system:

Criterion: The components of the structural system were developed with prefabrication, construction and erection process in mind; the final result is a system with simple structural components and a simple construction and erection process.

The column: The cruciform shape of the column is due to the fact that is composed of capital and column cast in one piece. The size of the capital is in turn determined by the inflexion points of the

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girder spanning between the columns. The vertical connection between the two columns occurs two feet higher than the floor level; it was done to reduce the shear moment at the connection point. (See Fig. #2). The columns were designed in a flat shape so that they could be mass produced by casting them horizontally, and pouring one on top of the other.

The link element: This is mainly used to transmit the compression forces due to the transverse continuity of the structure. The lower part has two ribs to match the visual aspect of the structure.

The girder: This element makes connection of the structure in the main direction and serves to carry the main branches of mechanical services. The ends of the girder are shaped so that they can be easily supported on the correspondingly shaped ends of the capital providing major area of support.

The slab over the girder: This element spans between the two beams of the girder and is an element comparatively less simple than the rest of the structure. The shape was designed in a manner to serve the following functions:

- a) To allow the mechanical services to pass through.
- b) To make welded connection for the reinforcement used to establish continuity in the secondary direction.
- c) To link the top slabs of the channels.

The channel: In linear systems, this element is used to cover the

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space between the main axis of the structure; in this case we carry further on this function by using this element to give structural continuity in the second direction and making the structure more economical. It requires two structural diaphragms. They were placed ten feet from each end and go from the bottom of the channel to six inches above the lower chord.

The cantilever: In the main direction the cantilever is achieved by means of the capital on the columns and an extra element also used to add half a module to the periphery. In the secondary direction the cantilever is achieved by using the continuity of the structure. The section remains the same, i.e., the channels.

#### THE FORM WORK

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As mentioned before, the structural components of the system were designed with a view to mass production, therefore the whole structure was thought precast. The form work would be in metal and all the casting process would be done in a factory for better results and maximum control. The figures in the following pages will show how the form work was planned.

#### ASSEMBLY

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All the members of the structure will be transported to the site from the plant and then laid in their proper positions by a crane. Each

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element is supported by the previous one, therefore scaffolding is not required except in a cantilever condition. (See construction sequence in photos.)

#### SPATIAL FLEXIBILITY

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The possibilities of spatial arrangements in this case are fairly numerous, with more emphasis in the main direction of the structure. In the secondary direction this flexibility is restricted by the variation in the size of the structural members used as a cantilevering element and by the main axis of the structure (as girders and columns).

#### EXPANSION AND REMOVAL OF PARTS

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The system was designed in such a way as to allow the easy removability of any of the structural elements without interfering with the distribution of the mechanical services. Each bay has been designed as a self-sufficient unit, structurally and mechanically. The expansion of the system must be done in units of one bay each of 35 x 65 feet. The peripheral services can early be changed into interior services.

#### THE CORES

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The core is an element which serves the following functions:

- a) Provide means of vertical circulation.
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- b) Create a pattern of horizontal circulation.
  - c) Create places of meeting around it.

Its sizes and characteristics are defined by its location within the building. Following this thought, the cores were designed as a system of growth with interchangeable elements; the elements to make by a particular core being chosen to serve definite functions. The growth of cores takes place in the main direction of the system. Each element of the core was designed as an independent element in itself and based on a five foot module. A ten foot wide circulation space surrounds each core so as to provide maximum flexibility of approach.

The core elements were grouped in two categories

- a) The basic elements.
- b) The complementary elements.

The basic elements are:

- 1) Passenger elevator
- 2) Fire stairs     single  
                      scissors
- 3) Toilets        men  
                      women

The complementary elements are:

- 4) Freight elevator
- 5) Closets        janitor  
                      electric  
                      telephones
- 6) Public telephones and drinking fountains.

Table #1 shows that with just six elements it is possible to get

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forty-eight different combinations of cores, and still these elements could in turn be varied in themselves. It shows the tremendous flexibility and variety achieved designing cores with this system.

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BASICS

COMPLEMENTARY

	D	E	G	DE	DG	EG	DEG
A	AD	AE	AG	ADE	ADG	AEG	ADEG
AB	ABD	ABE	ABG	ABDE	ABDG	ABEG	ABDEG
ABC	ABCD	ABCE	ABCG	ABCDE	ABCDG	ABCEG	ABCDEG
B	BD	BE	BG	BDE	BDG	BEG	ADEG
BC	BCD	BCE	BCG	BCDE	BCDG	BCEG	BCDEG
C	CD	CE	CG	CDE	CDG	CEG	CDEG

TABLE #1 DIFFERENT ARRANGEMENTS OF CORE ELEMENTS

## STAIRS

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Fire stairs: The design and location of fire stairs for this type of building were determined by the building code, which specified 175 feet (system with sprinkles) as the maximum distance between the farthest point of the building and a fire stair (along the path of circulation). Also it specifies an alternative means of escape for every space in the building. Scissor stairs were chosen in this case to increase the service and efficiency without increasing the area.

Open stairs: Because of the flexibility achieved in this system, there exists the possibility of placing open stairs in any position wanted or required. They should be placed where main activities occur in the building. This will help reduce the number of stops for the elevators, as people will use stairs for short runs. The stairs also provide points of recognition because open spaces and perspectives. Their size will depend upon their importance and amount of activity.

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SECOND PART

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DESCRIPTION OF MECHANICAL SYSTEM

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The system adopted covers a variety of conditions and offers complete flexibility. The main distribution comes from mechanical rooms through horizontal bridges, connecting columns which carry the vertical distribution. The secondary branches of horizontal distribution are located in between main girders; and modular distribution in the space created between two channels every five feet. (See Board #3). In case there are two adjacent rooms, one needs more volume of air than the other, the problem will be solved with a special connector above the partition. The main return air system is located in the same places as the supply, but in alternate columns and girders; the modular distribution for return air occurs in all spaces created between the channels.

Type of System: The type of air supply system adopted is dual duct high velocity (4000 f.p.m.) with mixing boxes serving a bay of 35 x 50 feet each. The speed in the secondary branches is reduced to 1500 f.p.m. and 900 f.p.m. in modular distribution branches. The air return system is low velocity (1200 f.p.m.). The fifteen foot width along periphery is controlled by a mixing box which serves a bay of 15 x 70 feet.

Air Diffusers: These are located within the structure along the

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space created by joining two channels every five feet. In the periphery zone air diffusers are located either in the ceiling or window wall for supply. Return grids are placed in the ceiling.

#### PLUMBING

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The plumbing system is divided into two groups:

- a) The toilets and mechanical rooms.
- b) Extra pipes of secondary services.

The first ones are located in the cores and shafts and the secondary but general service in the columns. Each pipe group in a column serves a bay of 35' x 125' and is composed of

- a) Water supply, hot and cold.
- b) Waste.
- c) Vent pipes.

Waste and vent horizontal runs are provided with a slope of one inch to a foot.

#### LIGHTING

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The lighting system is located within the channels. The variation of foot candle intensity will be given by the type of space to be illuminated. The range achieved is:

66 F.C. with 1/40 watt lamp

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132 F.C. with 2/40 watt lamps

198 F. C. with 3/40 watt lamps

The type of lamps to be used are fluorescent tubes, 40 W, nine feet long to match with the rectangular module of the structure and for economy.

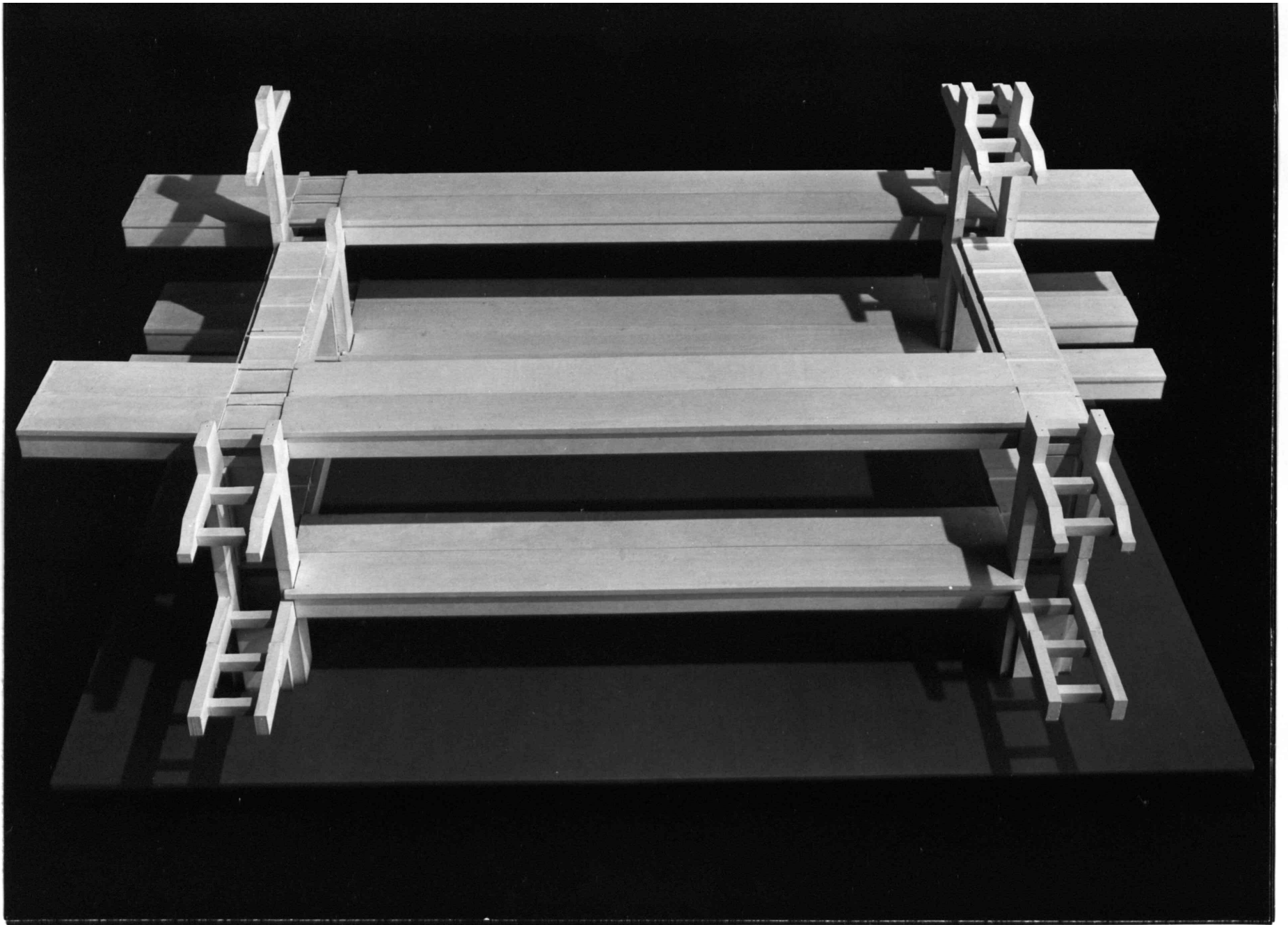
#### ACOUSTIC

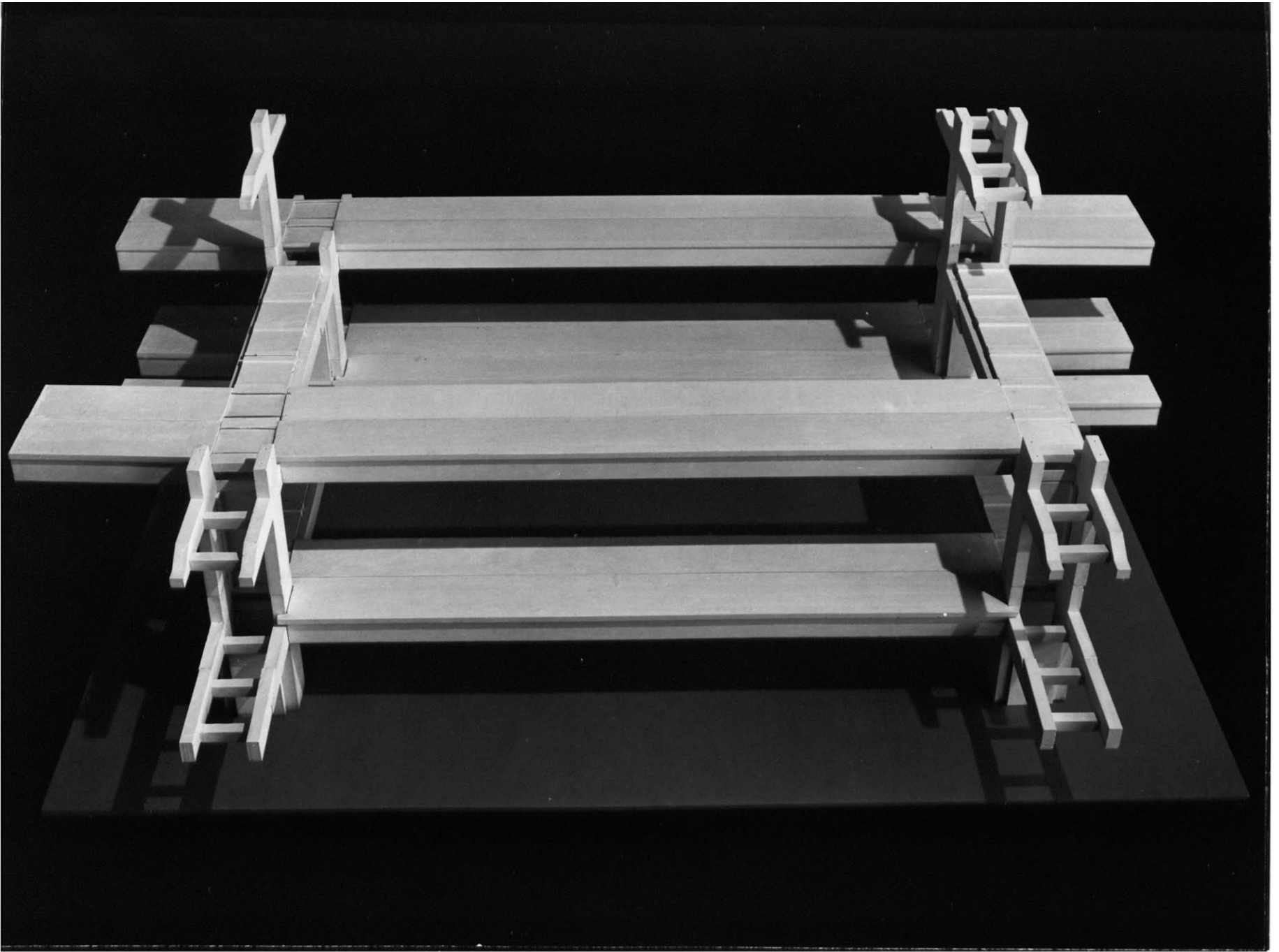
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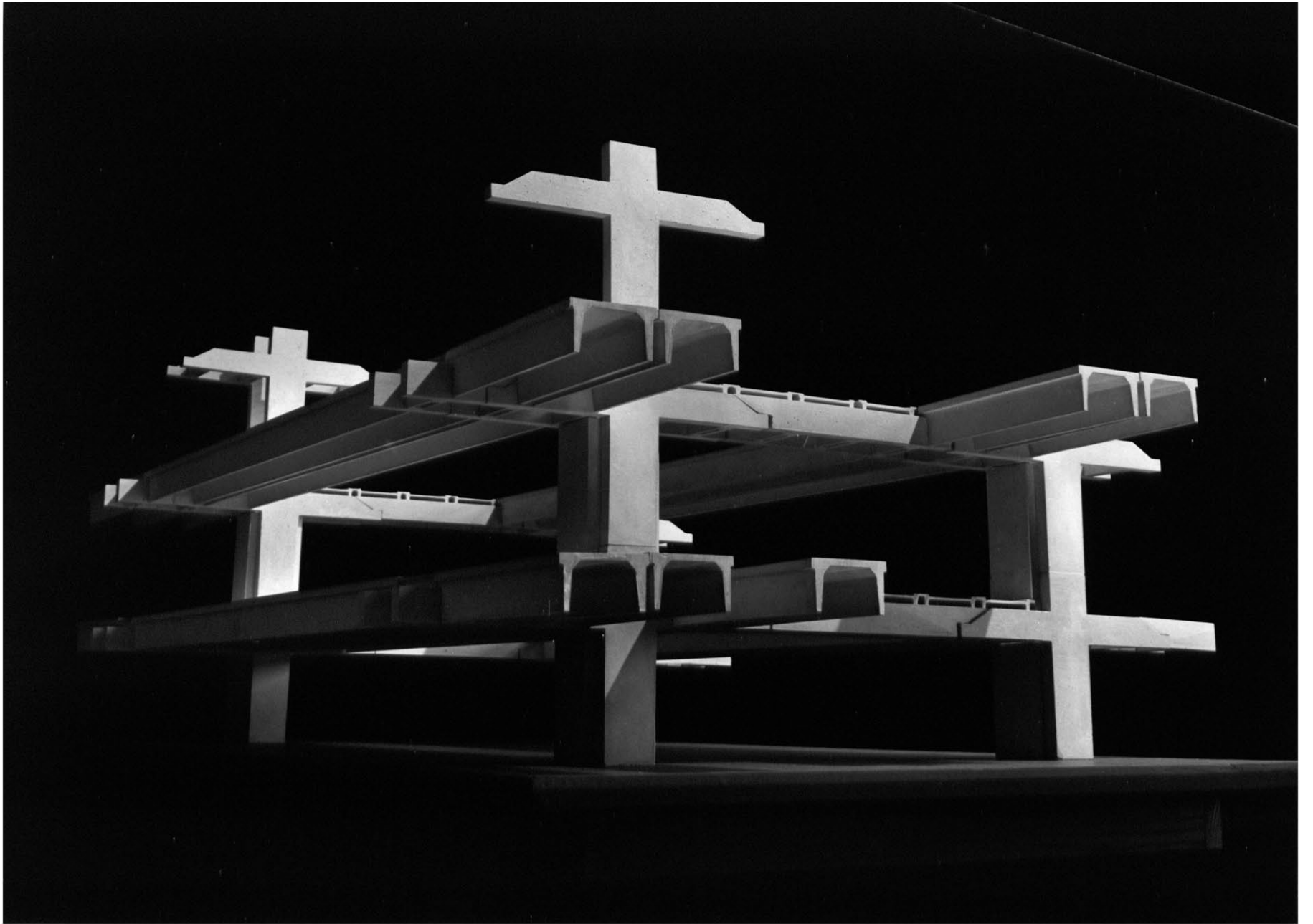
The structure was designed without perforations to eliminate problems of sound transmission. In the secondary direction whenever a partition occurs, a contact diaphragm will be placed. As a general treatment, an acoustical panel shall be placed at the bottom of the channels.

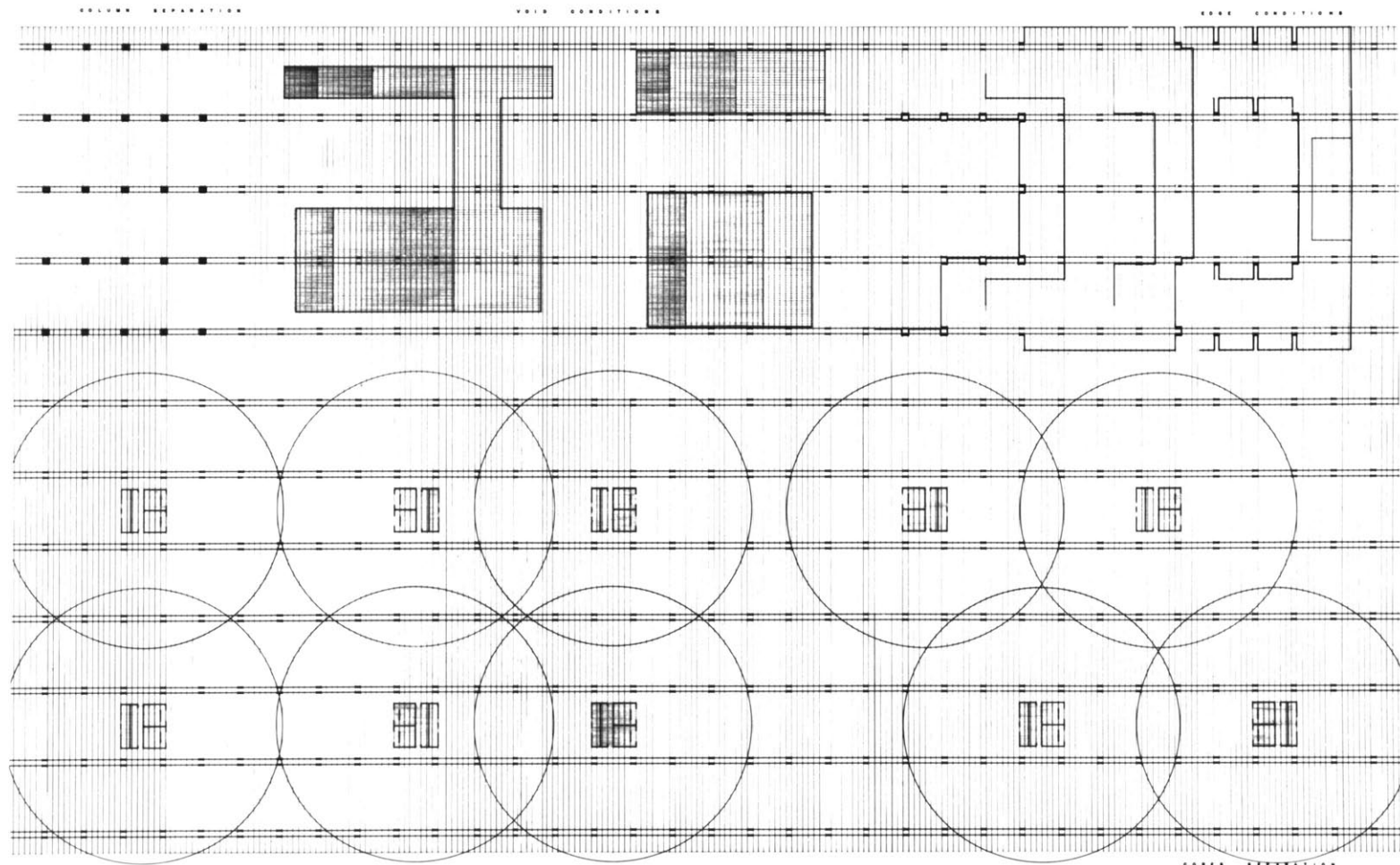
The same acoustical panel serves to cover electrical wires and pipes wherever they occur.

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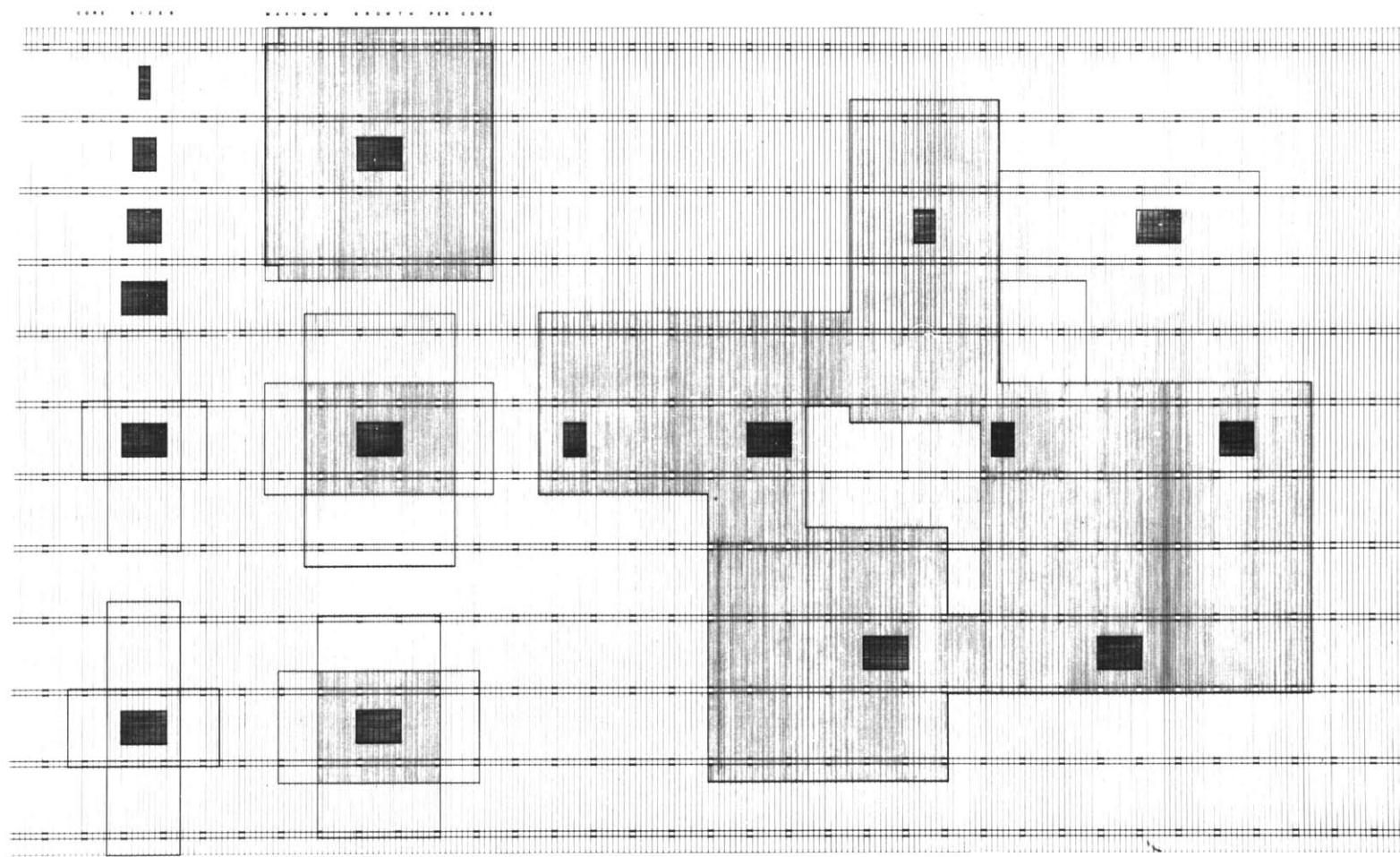




VARIABLES OF DESIGN

B U I L D I N G    A S    A    S Y S T E M

..... INSTITUTE OF TERRACOTTA



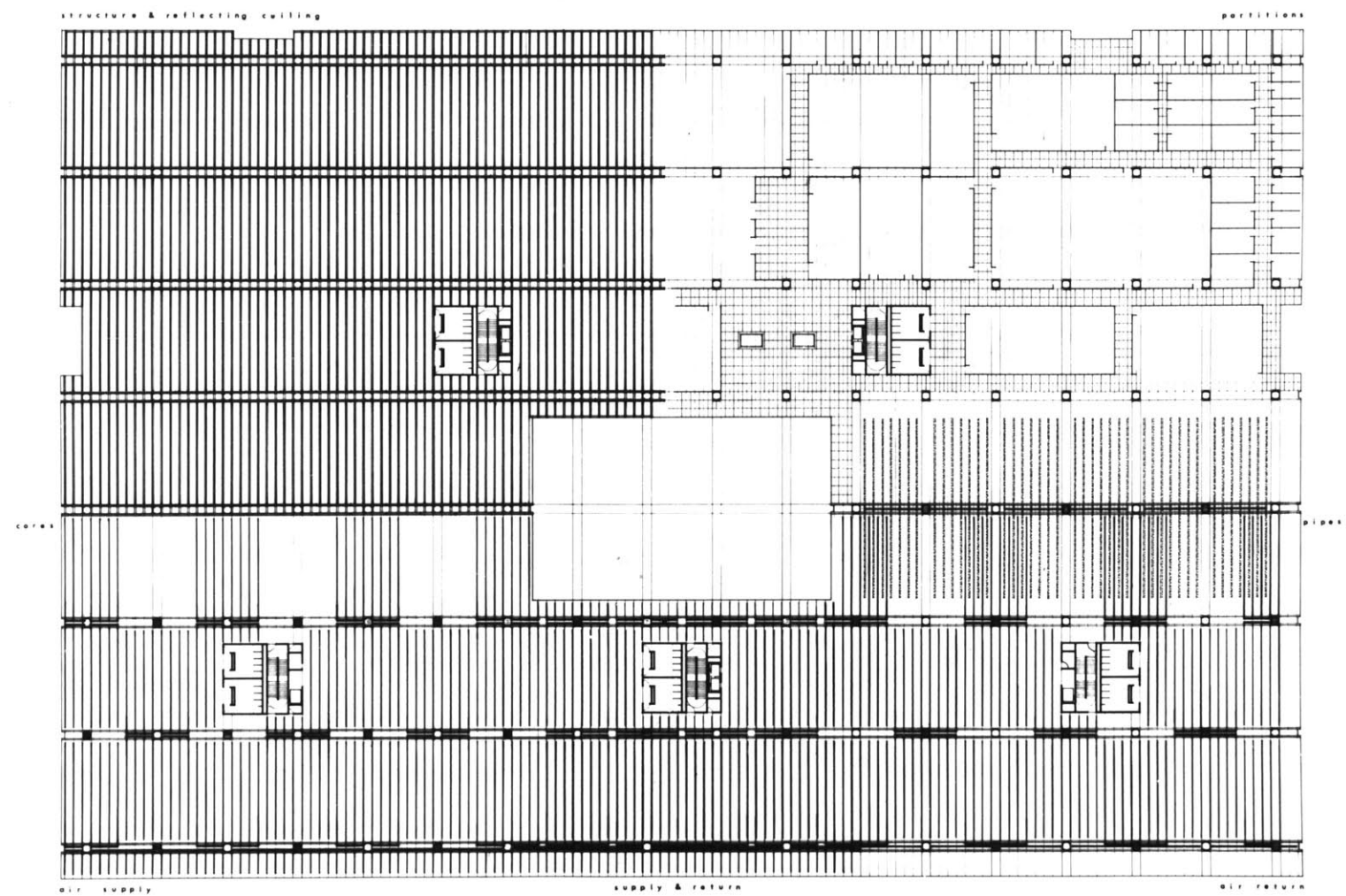
THE ORGANIZATIONAL PATH OF ARCHITECTURE      ARCHITECTURE PERCEIVED WITHIN SYSTEM SPACE

0 10 20 30 40 50 60 70 80 90 100

GROWTH OF THE SYSTEM

B U I L D I N G      A S      A      S Y S T E M

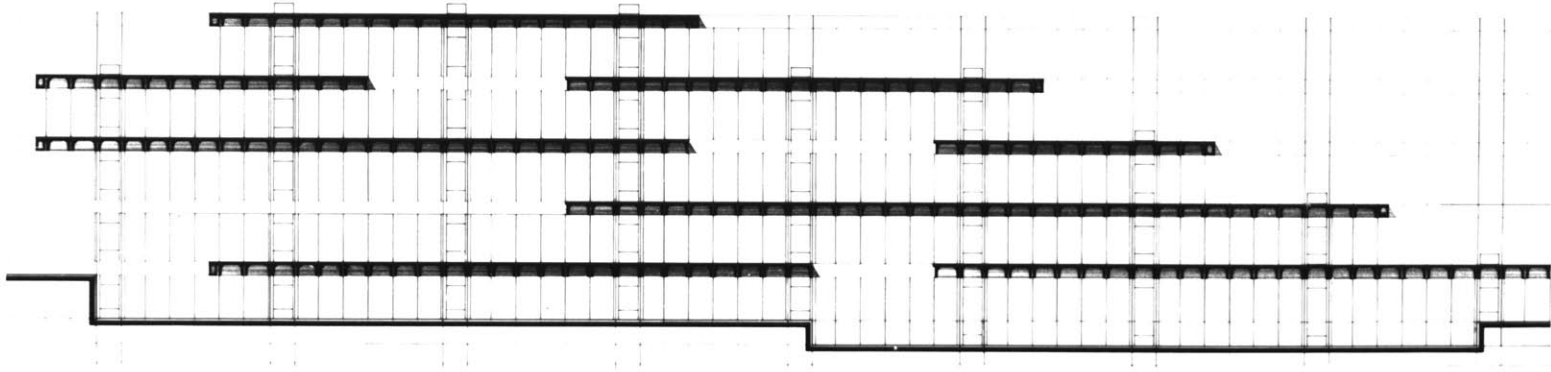
LECTURE TABLE IN ARCHITECTURE      MARSHFIELD INSTITUTE OF TECHNOLOGY      1964



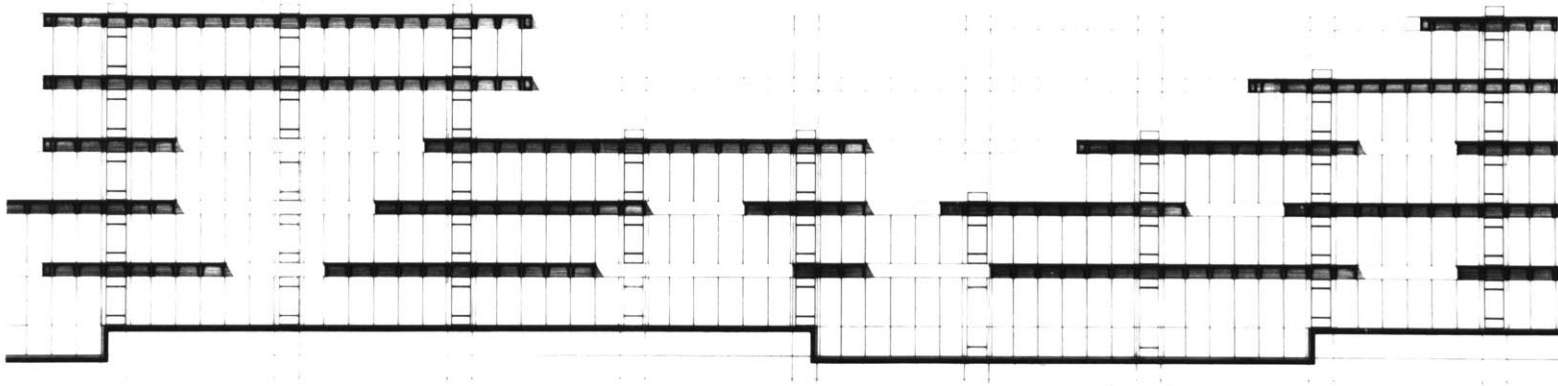
FOOT PRINTS

B U I L D I N G A S A S Y S T E M

\*\*\*\*\* THREE IN ARCHITECTURE \*\*\*\*\* UNIVERSITY OF TECHNOLOGY \*\*\*\*\* THREE IN ARCHITECTURE \*\*\*\*\*



double span opening

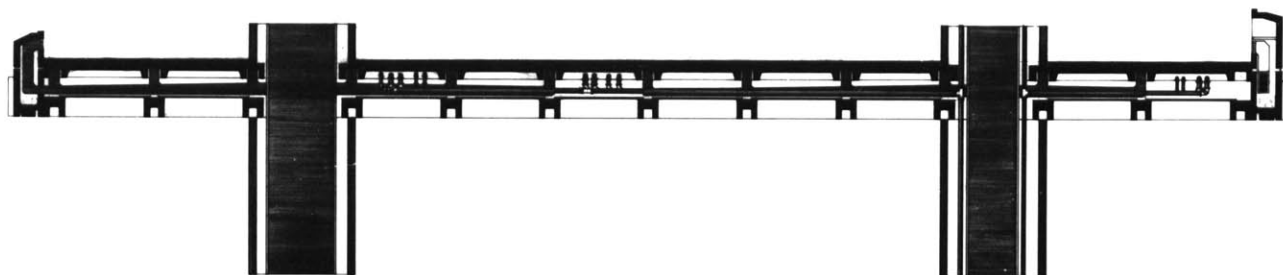


single span opening

S E C T I O N S

B U I L D I N G A S A S Y S T E M

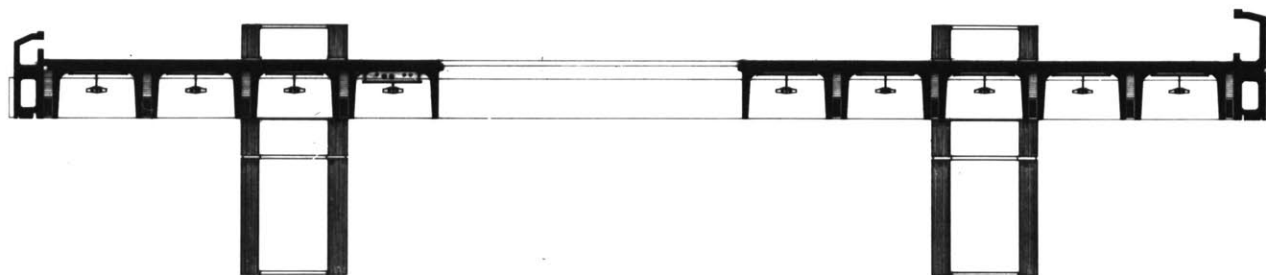
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s e c t i o n t h r o u g h A A'



s e c t i o n t h r o u g h B B'

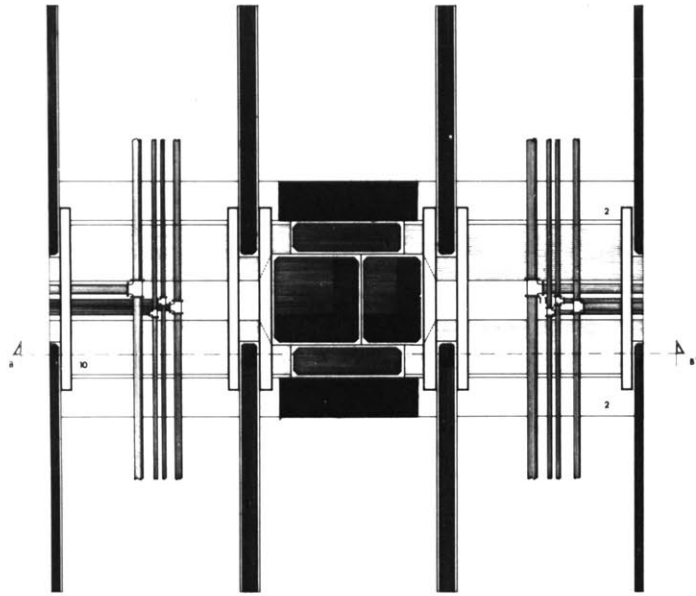


s e c t i o n t h r o u g h C C'

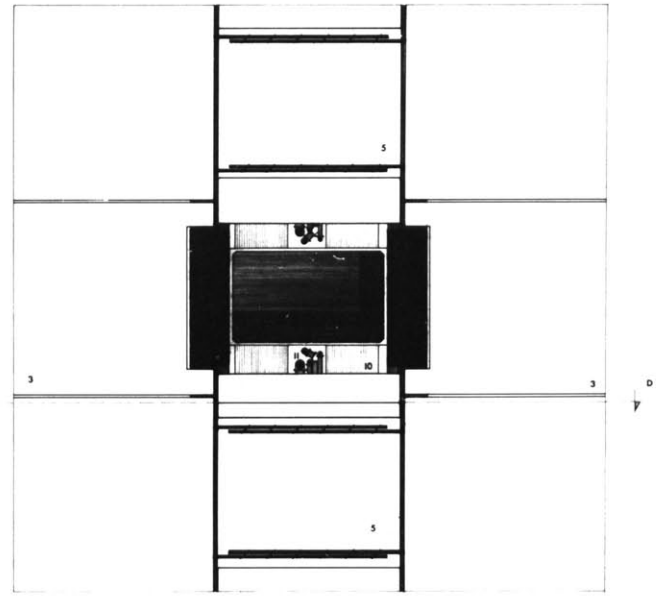
S E C T I O N S



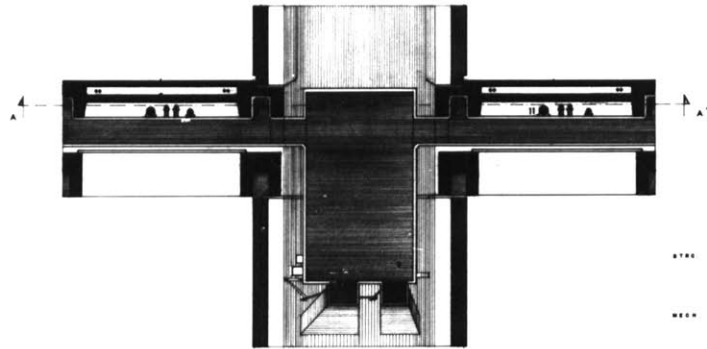
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MARTIN'S THEORY IN ARCHITECTURE ..... INSTITUTE OF TECHNOLOGY ..... 1922



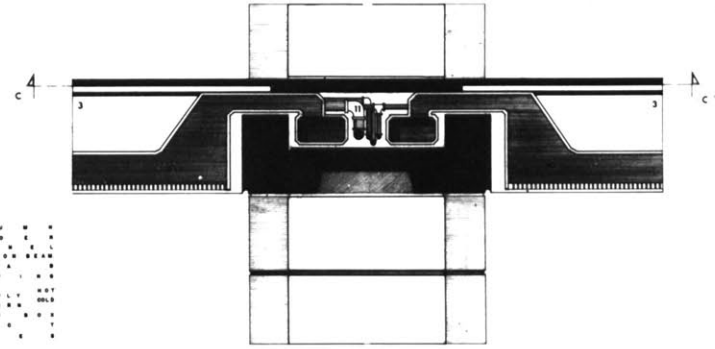
horizontal section AA'



horizontal section CC'



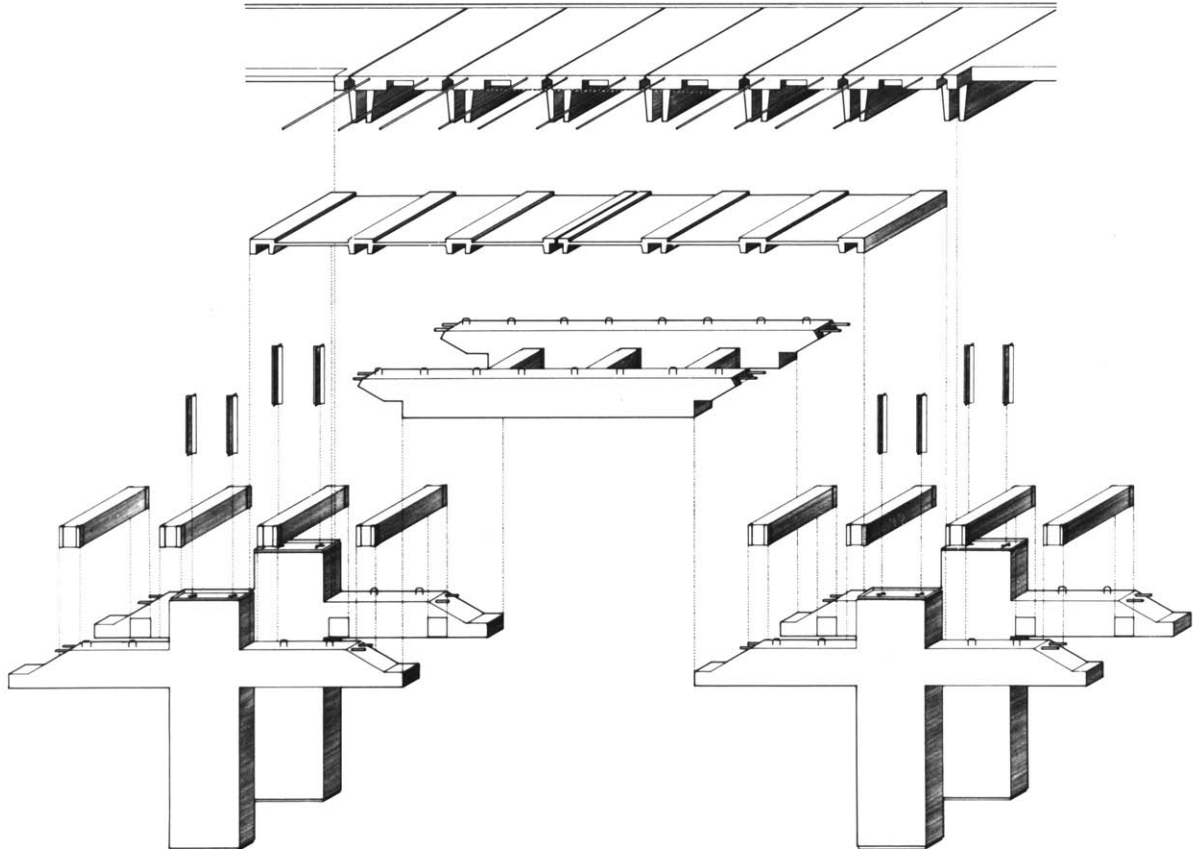
section BB'



section DD'



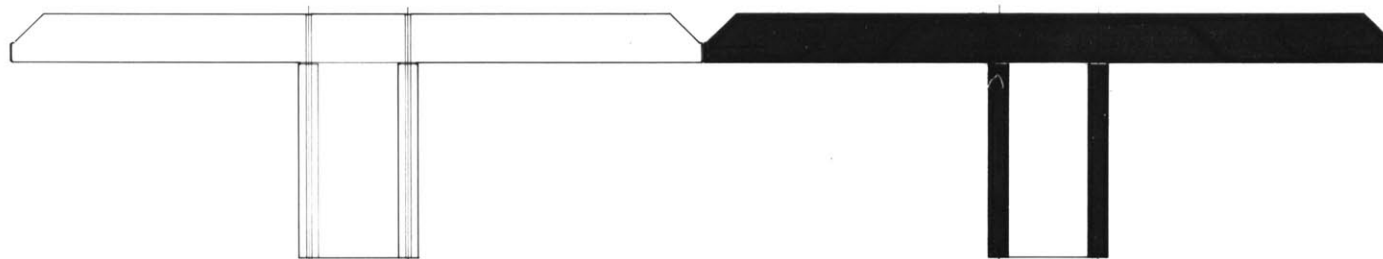
CONCRETE TOPPING  
 CHANNELS  
 CONCRETE SLAB  
 REINFORCING  
 CONCRETE  
 COMPRESSION BELLS  
 COLUMN



CONSTRUCTION SEQUENCE

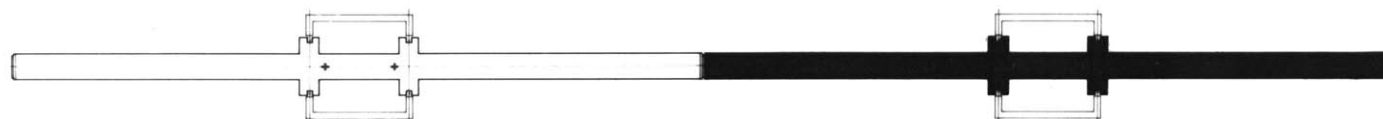
B U I L D I N G   A S   A   S Y S T E M

MADEIRA TABRIZ DE ARQUITECTURA   INSTITUTO DE TECNOLOGIA   1968



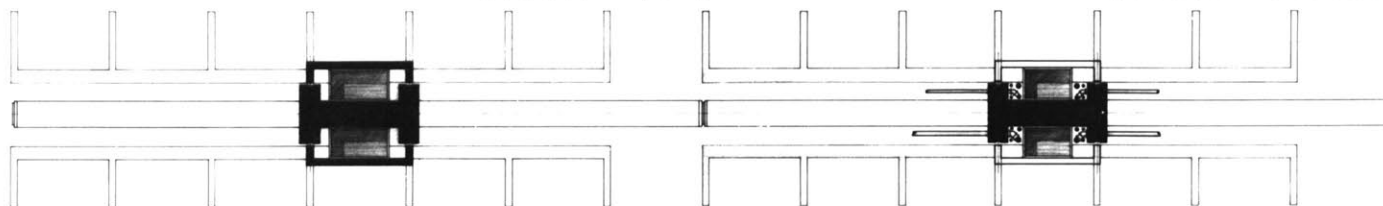
elevation

section



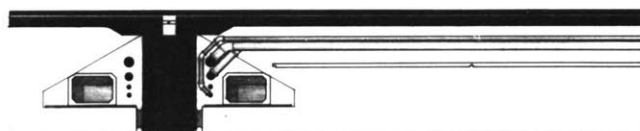
girder plan

girder section

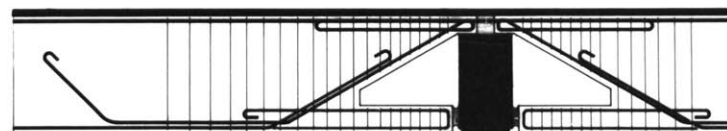


column plan

mechanicals plan



mechanicals



channels reinforcement



ALTERNATE

