

DESIGN OF AN INTEGRATED BUILDING SYSTEM

by

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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 Design of an Integrated Building System.

Respectfully,

Weldon Pries

**ACKNOWLEDGEMENTS**

**Professor Eduardo F. Catalano**

**Thesis Advisor and  
Professor in charge  
of Architectural Design**

**Professor Waclaw P. Zalewski**

**Structural Design  
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## STATEMENT OF INTENT

The purpose of this thesis was to design a structural and mechanical building construction system which would;

- provide for the accomodation of diverse uses and space requirements for education facilities which would include dimensions for offices, lecture rooms, seminar rooms, lounges, exhibition rooms, drafting rooms, work shops, entry spaces, auditoriums.
- allow flexibility of space use through the possibility of placing partitions on a modular system, and by combining, and using the inherent flexibility of the system in various ways either by eliminating portions of the secondary structure or by providing openings without critically affecting the structural properties of the system.
- provide for the possibility for growth and alteration or change of the building without altering the basic system.
- include the design of cores for stairs, passenger elevators, freight elevators, toilets, telephones, with the possibility for these elements to occur individuall, or collectifely as necessary, within but independent of the building system.
- allow for flexible circulartion patterns to occur; the possibility for corridors and the interconnection of cores.

- be of reinforced concrete and be constructed with a hierarchy of construction sequence corresponding to the breakdown of trades and the breakdown of spaces from the overall to the specific.
- provide for the necessary environmental control for flexible space use requirements with an exposed mechanical system layout with access for changes and flexibility.
- be an integrated system of structure, mechanical equipment, pipes, and lighting, with a flush ceiling for continuity of spaces, the services to occur within the structure, and to expose the services and concrete structure to their best visual qualities.
- to achieve a quality of "order" in the design of the parts, and in their relationship to each other and the whole.

SPECIFICALLY, THE PURPOSE OF THIS THESIS WAS TO DESIGN A STRUCTURAL FLOOR AND ITS SUPPORTING COLUMN TO REINFORCED CONCRETE AND TO DESIGN AN EXPOSED MECHANICAL SYSTEM WITHIN THIS FLOOR AND COLUMN.



## ARCHITECTURAL CONSIDERATIONS OF THE SYSTEM

### System of Space and Structure

The system is based upon the construction of specific structural components in sequence forming a basic building portion of "building unit" which can occur independently or can be repeated in a variety of ways to achieve continuity of space and variety of architectural character. This "building unit" is composed of one column which supports independently a structural floor area of 18 feet by 43 feet by a series of cantilivers constructed in sequence. Continuity of space is achieved in the combination of the basic "building units," and the introduction of infill structure between the "building units."

Variations in spaces including cores, courtyards, light wells, two-story spaces, and stairs can be achieved through openings in the structure. These openings are inherent to the system and are made possible by eliminating either portions of the infill structure or one or more of the "building units."

The cantiliver on the "basic building unit" allows for the possibility of offices to be located on the building periphery along a corridor at the column line. Diversity of the building periphery or "architectural character" is possible in the various combinations of the "building unit."

The column spacing is 66'-0" c.c. in the long direction and 36'-0" c.c. in the short direction. This provides an approximate 2:1 span ratio which allows for a flush ceiling or a constant structural depth in a one way structure. The outside face column dimensions are 6'-4" x 5'-8" which allow the column surfaces to correspond with the lines of the ceiling components. The clear span between columns is 60'-4" x 29'-8". However, the longest precast structural component is the 43'-0" beam. The reduction in span is made possible by the column "capital." The structural depth of the "capital" and beams is 3'-0" plus 4" slab and 2" topping.

## Planning Module

The planning module is 6'-0" by 6'-0". This dimension provides the possibility of placing partitions in two directions to obtain a minimum space of 12'-0" x 12'-0" or a small office of 12'-0" x 18'-0". The cantiliver of 18'-0" from the face of the column provides the possibility of locating offices with 18 foot depth along the building periphery or with a 24 foot depth including the width of the column.

Lighting is provided within each module and is located at the top of the structural ceiling component. Both supply and return air are provided for each module by means of the strip diffusers which are located between the structural ceiling components. The possibility for light and air to occur in each module increases the flexibility of space and use in the placing of partitions where necessary, and allows for the uniform ceiling design to be maintained.

## Design and Location of Cores

Passenger elevators, freight elevators, stairs, toilets, and telephones are designed to be located either independently or collectively within the system. These cores occur between the beams where the infill beams and ceiling components are eliminated. The cores are structurally independent from the structure of the system thus allowing lines and reveal the beams and ceiling components to be a continuous, unobstructed visual texture.

## Circulation

Horizontal circulation occurs within the system to interconnect the cores and to provide access to the various spaces and parts of the building. Major circulation, interconnecting the cores, occurs alongside the columns, either as a 6 foot corridor or as an 18 foot passageway. Links between buildings or portions of buildings can be provided for by a linear combination of the basic "building unit," either 18 foot wide or 42 foot wide.

## STRUCTURAL COMPONENTS

The structural components of the building system are:

dual column

"capital" comprised of column arm and short girder beam

infill beam for continuity

structural ceiling component

chair

slab.

The dual column provides the space for the ducts and pipes. Vertical continuity and stability is achieved by welding the reinforcement to the column above and then grouting. Lateral stability occurs in the full width of each column in one direction and in the column arm in the other direction.

The Column "Capital" consists of two double structural components:

- 1) The column arm with dimensions 10 inches x 3 feet x 18'-10" long is supported across the dual column and secured to the dual column above and below by welding of the reinforcement in a specially provided groove.
- 2) The short girder with dimensions 10" x 3 feet x 18'-10" is supported on the end extensions of the column arm and positioned into place from the side, and secured by welding.

The column "capital" has an overall plan dimension of 17 feet 8 inches by 18 feet 10 inches and thereby reduces the span between columns from 60 feet to 48 feet.

The Beam with dimensions of 10 inches x 3 feet x 43 feet is the longest of the structural components. Although the distance of the columns are 66 feet c.c., the length of the beam is reduced due to the presence of the capital which makes possible the cantilever and the infill beam. The beam support directly the structural ceiling components and the precast floor slabs. The beam is supported symmetrically on the protruding lips at the ends of the short girders. It is placed into positions from the side and welded to the reinforcement of the short girders.

Infill beams 10 inches x 3 feet x 25 feet long. The infill beam is supported by the ends of the beams. It is dropped into place from above and its reinforcing welded to the reinforcing of the beams. The infill beam as a result provides the continuity of the beam from support to support and made possible the continuous horizontal structure. When the infill beam is not used, the resulting open space between the ends of the beams can be used either for cores, or a two story space.

Structural Ceiling Components are 15 inches deep, 4 inches width in concrete and 17'-2" long. They are double H shape which are lowered into position between the beams and are supported on the protruding ledge along the lower side of the beams H/H. The HH

components are 5 feet and 8 inches wide from outer edge to outer edge and are located between the 6 feet module lines. The 4 inch slot between adjacent ceiling components makes provision for the strip diffuser, supply and return alternating. The double H ceiling component assists in transferring slab loads to be beams from the "chairs." Moreover, the ceiling components make possible a continuous flush ceiling frame to which the wall partitions can be attached in any direction. Moreover, the ceiling components, to which the light fixtures are attached, create a continuous quality of reflected light texture from the concrete surfaces.

The "chairs" are precast structural components welded to the top of the structural ceiling components. Their function is to provide additional support for the precast slab thus dividing by three the span between the beams and thereby reducing the depth of slab necessary. A continuous free open space alongside the chairs between the slab and the ceiling components is provided for the mechanical ducts and pipes.

The precast floor slab is 6'-0" x 18' long x 4" deep. It is supported on the beams and chairs. The reinforcing from the beams and chairs extends and acts integrally with the topping through specially provided opening in the slab.

## MECHANICAL SYSTEM

The Mechanical System is designed integrally with the structural system.

The structural area supported by one column, that is, the "capital," beams, infill beams, and infill ceiling component and floor slab, corresponds to the mechanical area serviced by the vertical ducts in that column. The horizontal ducts and pipes are located within the structure in the space provided between the ceiling components and the floor slabs.

Flexibility for various temperature zones for specific use requirements is possible. Mixing boxes can occur either at the column within the "capital" or additional mixing boxes can occur where necessary. Horizontal ducts pass freely within the structure and are assessible from below for change, replacement, and adjustment. The free duct space allows for hot and cold supply and mixing boxes to be located at periphery and special locations.

The duct space within the column is designed to carry the vertical hot and cold supply and the return air necessary for the area supported by the column and five stories in height. An expansion of 30% is provided for possible future addition ducts.

The hot and cold supply vertical supply ducts are high velocity 4000 to 5000 feet per minute system. The vertical return ducts are designed for 2500 feet per minute. The horizontal mixed supply and the horizontal return has a velocity of 1200 feet per minute.



The strip diffusers are located between the structural ceiling components and provide supply and return air to each module with six air changes per hour.

The pipes, including, hot and cold water, waste, and ventilation are located in the structural floor between the ceiling components and the floor slabs. These are collected, with adequate slope, to the main vertical pipes which are located in the column.

## LIGHTING AND ACOUSTICS

### Lighting

Flourescent light fixtures are attached to the upper surface of the structural ceiling component providing direct light below each module and reflected light laterally from the sides of the exposed concrete ceiling component. The lighting is designed to create a continuous flush reflected light ceiling to the eliminate the sight of the light source except when seen directly above, and to provide a visual richness in the various intensities of reflected light from the exposed concrete components, above and below the light source.

### Acoustics

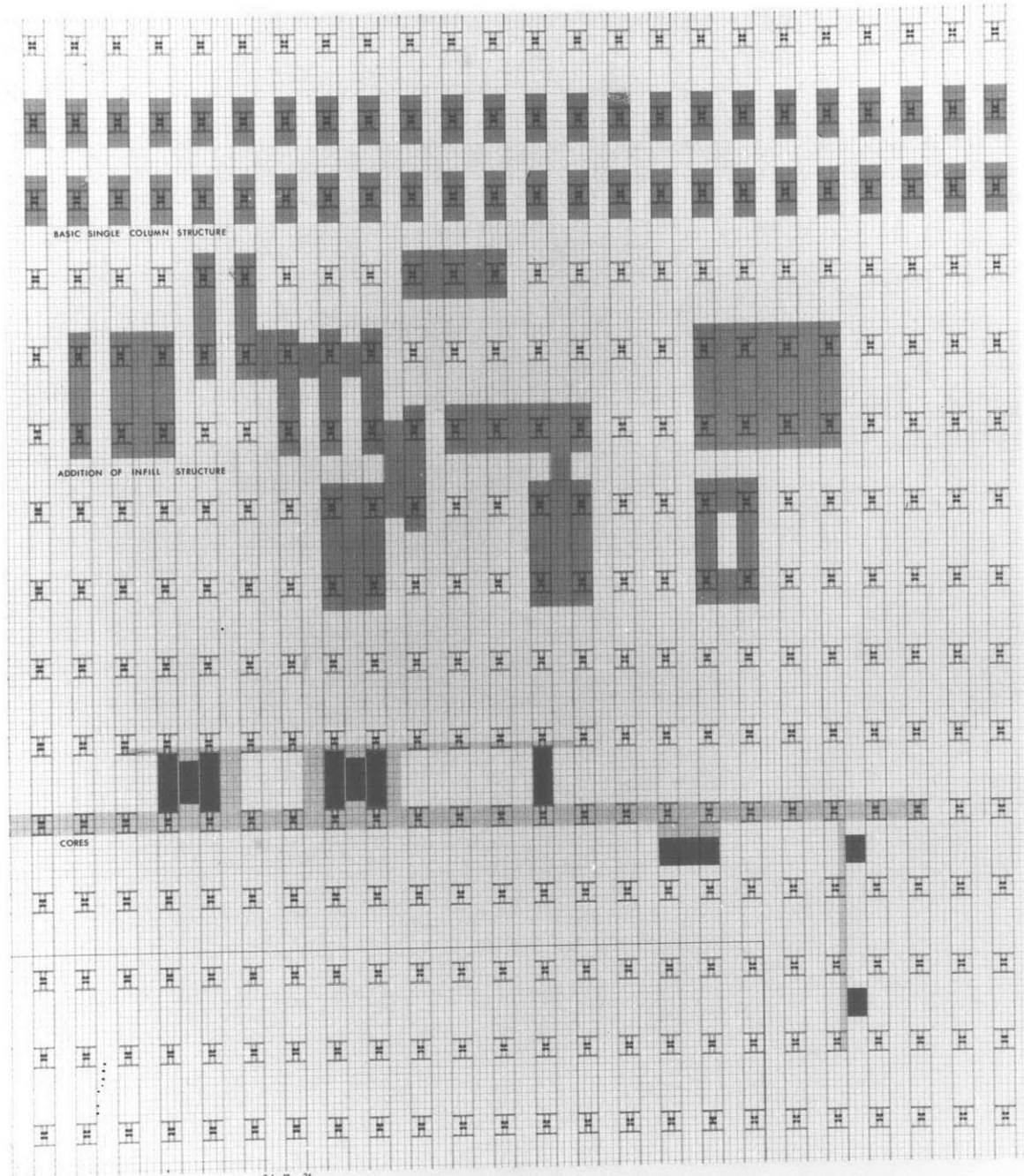
Acoustical sound absorption and acoustical privacy is achieved by acoustic panels which are supported on top of the structural ceiling components, in order to least interfere with the lighting and mechanical systems and the visual quality of the light reflecting concrete ceiling components.

## CONSTRUCTION SEQUENCE

- 1) The dual column positioned and secured to the arm and column below by welding of there inforcement.
- 2) The arms are placed on the ledges provided in the dual column.
- 3) The dual column above is placed. The reinforcement is welded joining the two columns and arm.
- 4) The short girders are positioned on to the end lips of the column arms and welded.
- 5) The beams are positioned on the end lips of the short girders and welded.
- 6) The infill beams are positioned on and between the ends of the beams and welded to the ends of the beams.
- 7) The structural ceiling components are lowered into position resting on the beam ledge and are secured by welding.
- 8) The chairs are set on the ceiling components and welded.
- 9) The precast slabs are positioned with the reinforcing of the chairs extending up through the holes provided in the slabs.

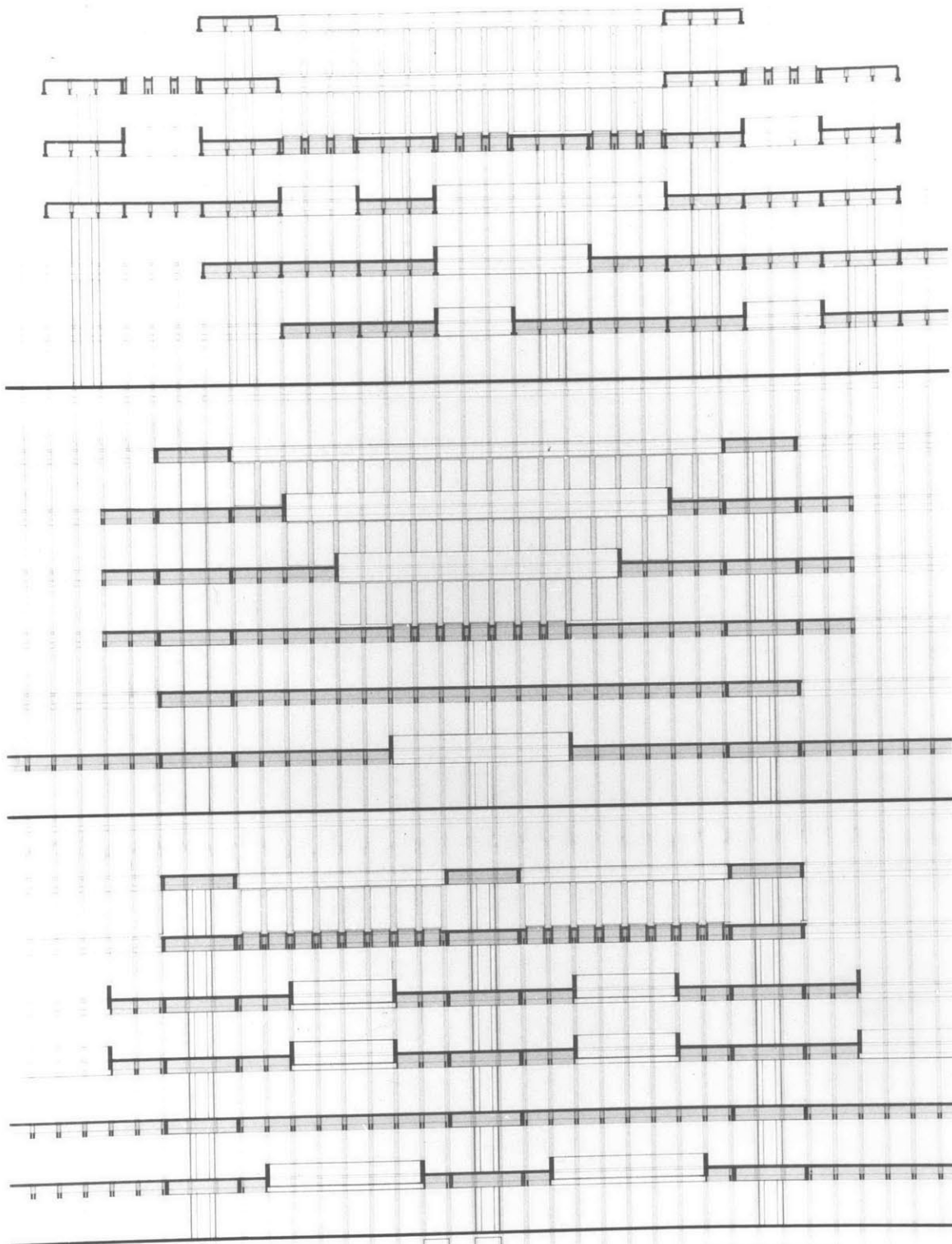
- 10) Two inch topping is poured over the slabs which bonds the chairs, slabs, beams and slabs.
- 11) Mechanical duct work and pipes are placed vertically in the column.
- 12) Mixing boxes within the structural depth of the "capital." Ducts and pipes are positioned within the space provided between the ceiling components and the floor slabs.
- 13) Diffusers are placed between the ceiling components and connected to the horizontal ducts.
- 14) Fluorescent lighting fixtures installed and secured to the ceiling components.
- 15) Acoustic panels placed on ceiling components and sealed to the ceiling components for acoustic privacy and acoustic absorption.
- 16) Room partitions positioned to requirements and attached to ceiling components and finished floor.

**GRAPHICAL MATERIAL**



BUILDING FOOTPRINT

06 18 36

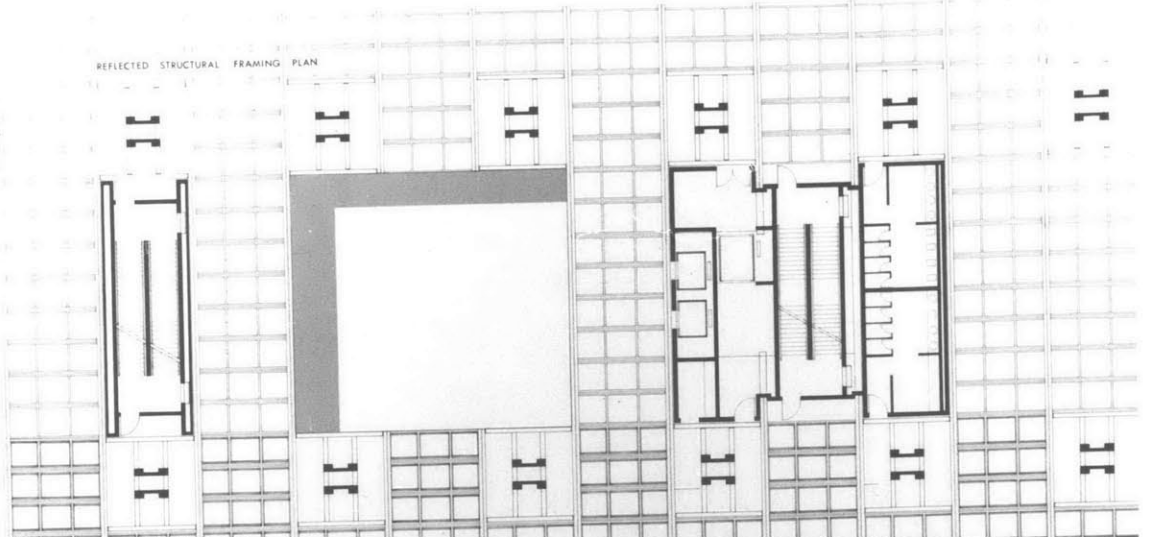


BUILDING SECTIONS

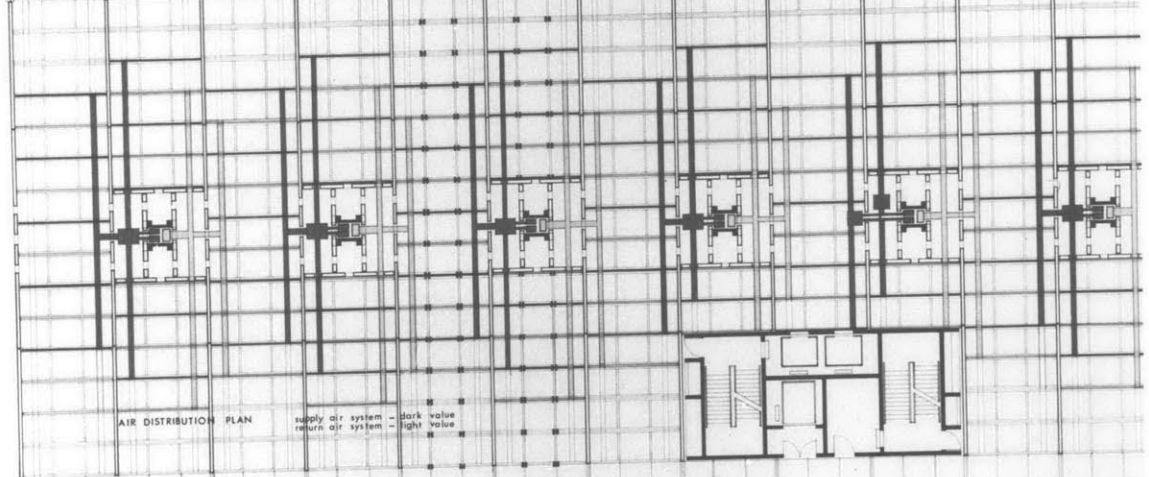
0 6 12 18

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REFLECTED STRUCTURAL FRAMING PLAN



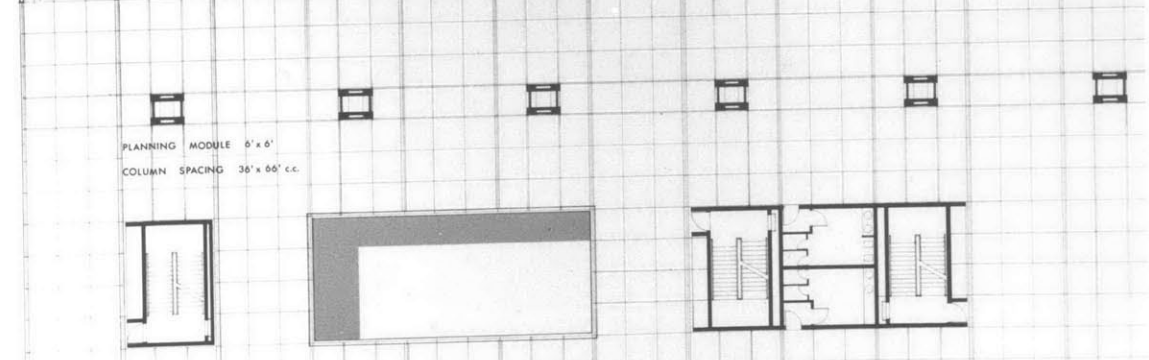
REFLECTED CEILING PLAN



AIR DISTRIBUTION PLAN

supply air system - dark value  
return air system - light value

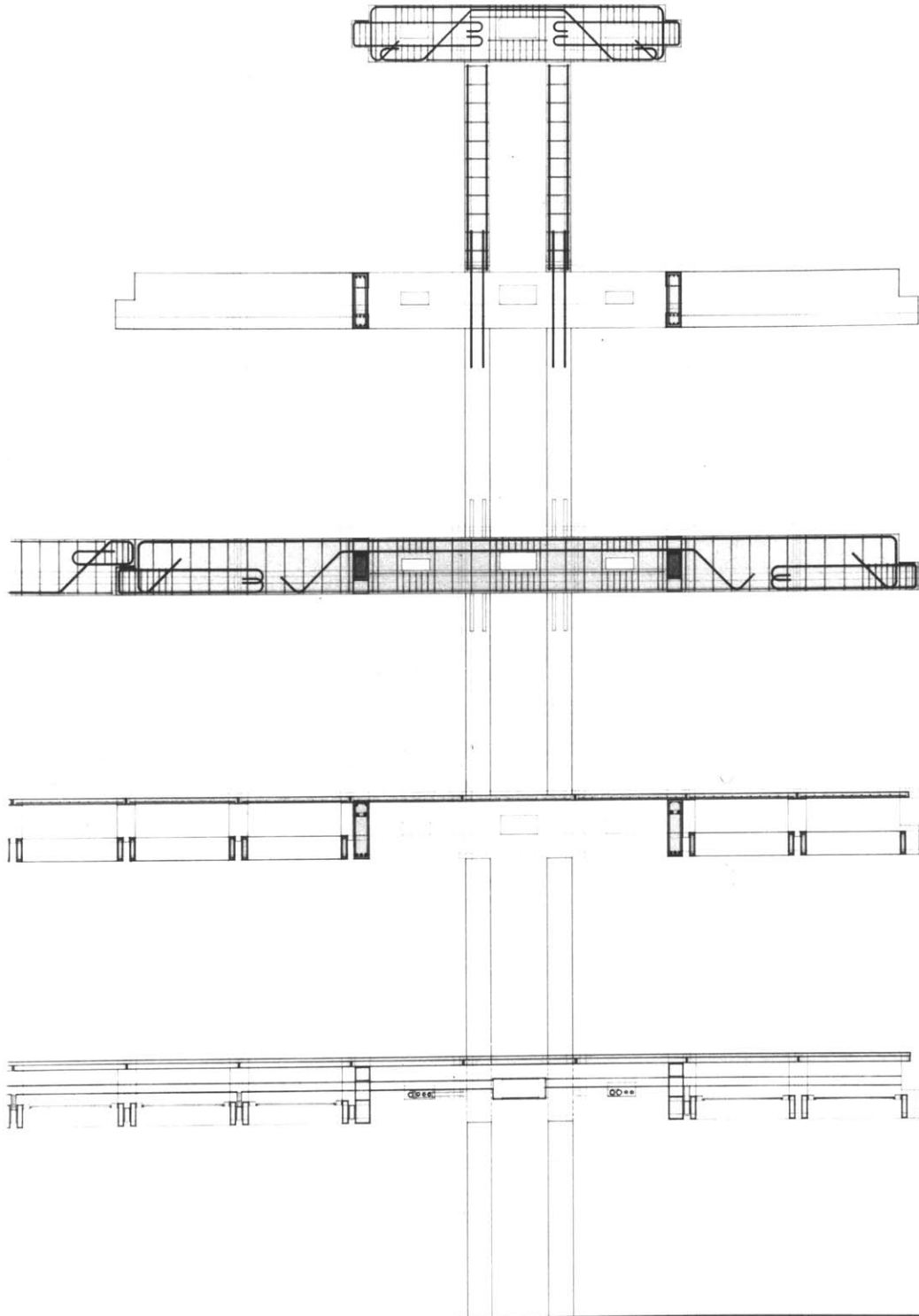
PLANNING MODULE 6' x 6'  
COLUMN SPACING 36' x 66' c.c.



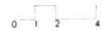
PLAN OF BUILDING SYSTEM COMPONENTS

0 6 12 18

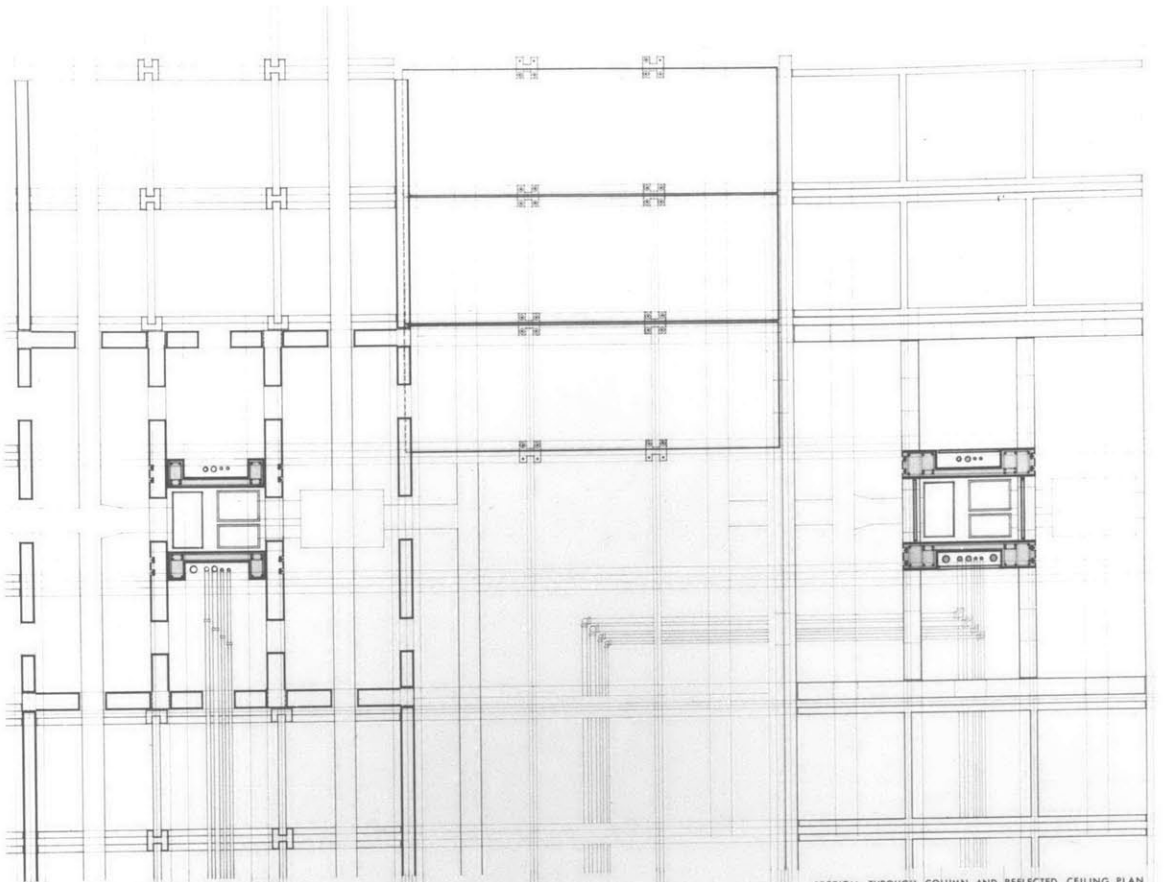




STRUCTURAL COMPONENTS AND CONSTRUCTION SEQUENCE

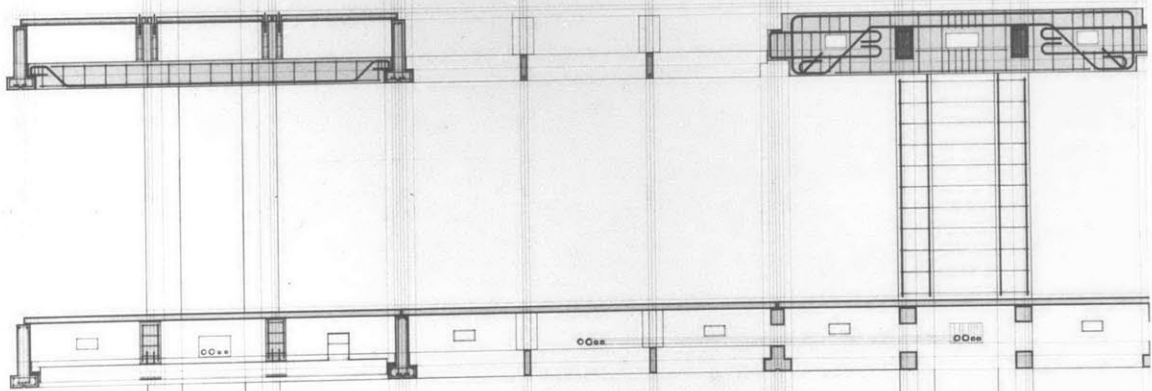


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PLAN SECTION THROUGH STRUCTURE

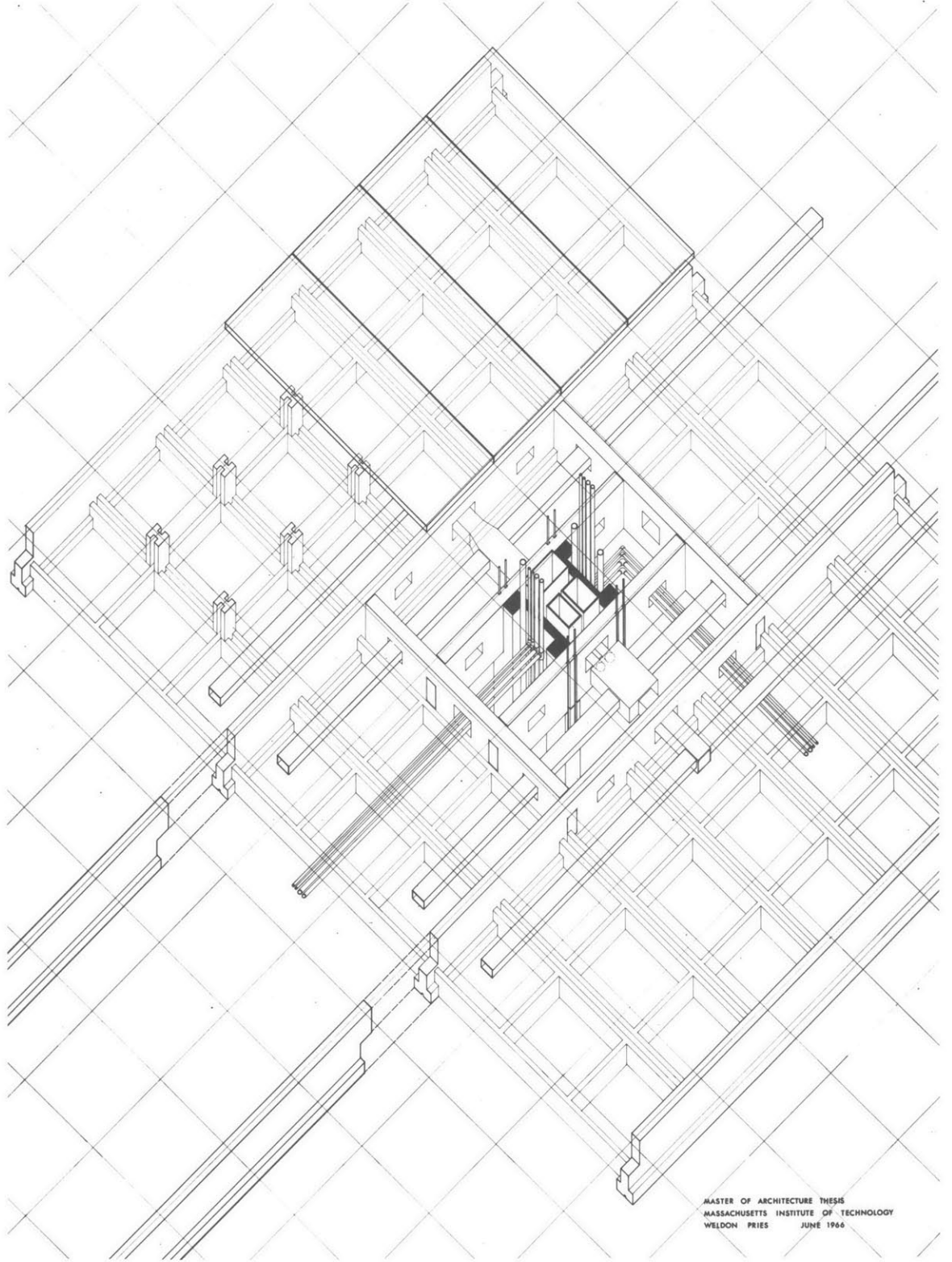
SECTION THROUGH COLUMN AND REFLECTED CEILING PLAN



STRUCTURAL AND MECHANICAL COMPONENTS



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