BUILDINGS AS SYSTEMS

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ABSTRACT

This thesis is concerned with the "design of a 'footprint' of structural, vertical circulation, and mechanical components from which different sizes of buildings, with different spatial qualities and character can be defined." The object is to develop through simultaneous study, "a typical structural and mechanical bay, with such behavior and geometry as to allow several organization patterns to form a system of growth."

The planning module of "the design presented" is an orthogonal grid alternating 15'0", 0'6", 15'0" in both directions; the 15 foot squares are subdivided into 5 foot square units. The structural bay, composed of precast concrete components, is 62 feet square with columns at the centerpoint of each side. The major components are centered on the 0'6" spacer of the 15 foot square grid. Secondary components span the 15 feet on a 5 foot square grid. Mechanical services are distributed within the limits of the structural section.
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DEVELOPMENT OF LINEAL AND TWO-WAY SYSTEMS

THERE ARE THREE BASIC SPACE MAKING CATEGORIES OF STRUCTURES: 1. THE CELLULAR TYPE FOR HOUSING REQUIRING INTRA-UNIT AS WELL AS INTER-UNIT PRIVACY. 2. THE MULTIPLE FUNCTION TYPE, FOR OFFICES, LABORATORIES, EDUCATIONAL FACILITIES, COMMERCIAL FACILITIES, AND INDUSTRIAL FACILITIES, REQUIRING A GREAT CAPACITY FOR CHANGE AND SOCIAL INTERCOURSE. 3. THE SPECIAL SINGLE SPACE, BUT SOCIAL FUNCTION TYPE, FOR THEATERS, STADIUMS, CHURCHES, AND AIRPLANE HANGERS, REQUIRING GREAT SPANS. THIS THESIS WILL BE LIMITED TO THE MULTIPLE FUNCTION TYPE, AND IS CONCERNED WITH THE "DESIGN OF A 'FOOTPRINT' OF STRUCTURAL, VERTICAL CIRCULATION, AND MECHANICAL COMPONENTS FROM WHICH DIFFERENT SIZES OF BUILDINGS, WITH DIFFERENT SPATIAL QUALITIES AND CHARACTER CAN BE DEFINED."

THE OBJECT IS TO DEVELOP THROUGH SIMULTANEOUS STUDY, "A TYPICAL STRUCTURAL AND MECHANICAL BAY, WITH SUCH BEHAVIOR AND GEOMETRY AS TO ALLOW SEVERAL ORGANIZATION PATTERNS TO FORM A SYSTEM OF GROWTH."

DIFFERENT ONE AND TWO-WAY STRUCTURAL SYSTEMS ARE STUDIED TO SEE WHICH ONE OFFERS MORE FREEDOM IN THE RELATION BETWEEN STRUCTURAL AND MECHANICAL ELEMENTS OF THE SYSTEM.
CERTAIN OBJECTIVES AND LIMITATIONS IN ADDITION TO THOSE
STATED ABOVE WERE SET UP AT THE BEGINNING OF THE PROGRAM:
1. THE PROJECT IS TO BE OF REINFORCED CONCRETE, EITHER
PRECAST OR POURED IN PLACE USING THE MOST ADVANCED TECH-
NOLOGICAL MEANS AVAILABLE. (THE STUDIES OF THIS THESIS
ARE LIMITED TO PRECAST CONCRETE.)
2. THE CONCRETE STRUCTURE IS TO BE EXPOSED TO THE SPACE
BELOW.
3. THE CEILING WILL BE FLUSH AT ALL POINTS TO ALLOW
MAXIMUM FLEXIBILITY OF THE SPACE AND STANDARD PARTITION
CONSTRUCTION.
4. THE MECHANICAL EQUIPMENT WILL BE POSITIONED HORIZON-
TALLY BETWEEN THE FINISHED FLOOR AND THE LOWEST POINT
OF THE STRUCTURE. (SEE DIAGRAM "A")
5. AIR CONDITIONING, LIGHT, AND PROPER SOUND CONTROL
WILL BE AVAILABLE AT ANY POINT IN THE SYSTEM.
6. THE SPACE-USE CHARACTERISTICS SHOULD ACCOMMODATE THE
INDIVIDUAL OFFICE, THE LARGE LECTURE HALL, AND ALL INTER-
MEDIATE SPACE REQUIREMENTS WITHOUT ANY CHANGES IN THE
BASIC SYSTEM.
7. LIMITED CONCERN IS GIVEN TO THE REMOVAL OF STRUC-
TUREAL ELEMENTS AFTER THE BUILDING IS CONSTRUCTED DUE TO
ABNORMAL LOADING CONDITIONS THAT WOULD HAVE TO BE AC-
COUNTED FOR.
(A joint study of past student work and construction standards was undertaken at the beginning of the term by the graduate class. This common background material is available for reference at the Department of Architecture, Massachusetts Institute of Technology.)

This thesis study began with one-way systems, the first of which was on a 4 by 8 foot module with a 32 foot by 48 foot bay. The girders ran in the short direction, with beams set flush at the bottom of the girders spanning the long direction. The girder was doubled and supported free of the column to allow for passage of mechanical equipment, to shorten the effective span of the beams, to simplify connections at the column, and to provide a building edge for possible expansion. (See diagram "B")

This bay was also studied with the double cantilevered girders running the long direction, with beams spanning a shorter distance and mounted flush at the bottom of the girders. (See diagram "C") Both systems using various beam shapes and girder designs allowed passage of mechanical equipment through the structure.

These systems were first studied with the mechanical risers in cores to eliminate major horizontal mechanical
RUNS ON THE ROOF OR IN THE BASEMENT. THIS METHOD PROVED TO LIMIT THE DESIGN FLEXIBILITY OF THE SYSTEM. THE MECHANICAL RISERS WERE THEN LOCATED IN THE COLUMNS AND WERE FOUND TO BE VERY SATISFACTORY FOR DESIGN FLEXIBILITY.

CERTAIN FACTORS WHICH BEGAN TO INFLUENCE CHANGES IN THE SIZES OF THE BAY WERE PARKING MODULES, AND STRUCTURALLY EFFICIENT BAY PROPORTIONS (1 TO 2 OR 1 TO 3 WERE MOST DESIRABLE) AND USE OF MATERIAL. THE ONE-WAY BAY STRETCHED TO 32 BY 64 FEET PLUS CANTILEVERS. THIS CREATED A GREAT DIFFERENCE BETWEEN THE SIZE AND WEIGHT OF ONE STRUCTURAL ELEMENT WHEN COMPARED TO ANOTHER.

THE ONE-WAY SYSTEMS WORKED SATISFACTORILY, BUT ACHIEVED DESIGN FLEXIBILITY IN ONLY ONE DIRECTION, DID NOT REQUIRE A PATTERN OF DIAPHRAGMS, DESIRABLE FOR ROOM DIVISION AND ACOUSTIC CLOSURE, AND HAD A GREAT VARIATION OF WEIGHT AND PROPORTION OF COMPONENTS.

FURTHER RESEARCH WAS CONCENTRATED ON FINDING A SYSTEM THAT WOULD EXPAND EQUALLY IN TWO DIRECTIONS, WOULD HAVE COMPONENTS OF MORE NEARLY EQUAL SIZE AND WEIGHT, AND WITH AS MUCH SPATIAL FLEXIBILITY IN BOTH DIRECTIONS AS THE ONE-WAY SYSTEM HAD IN ITS MOST FLEXIBLE DIRECTION.
A system which first attempted to include the above conditions had a 60 by 60 foot bay on a 5 by 5 foot module, with column capitals and linear spanning elements like those of the original one-way system. (See diagram "D") Theoretically the design achieved flexibility and allowed for expansion in two directions, however, it would require a certain amount of scaffolding during erection, and a great deal of complex post-tensioning to give the system continuity.

The 60 by 60 foot bay required large amounts of material at the column to resist increased stresses, the mechanical system was reaching its distribution limits in a building of from 5 to 6 floors, and the column itself was greatly increased in size.

Attention was directed towards structuring the 60 by 60 foot bay in the most efficient way possible in hopes of retaining the mechanical services in the columns.

A study was made to understand the assemblage of a large bay with relatively small pieces using no scaffolding. (See diagram "E")
THE COLUMNS WERE THEN LOCATED AT THE CENTER OF EACH SIDE OF A 60 FOOT SQUARE BAY WITH THE UNDERSTANDING THAT A GREATER LOAD WOULD BE MORE DIRECTLY TRANSFERRED TO THE COLUMN. THIS COLUMN SPACING ALLOWED THE PIECES WHICH COMPOSE THE BAY TO BECOME VERY SIMILAR IN SIZE AND WEIGHT. (SEE DIAGRAM "F")

FURTHER STUDY OF THE COLUMN PLACEMENT RESULTED IN A SOLUTION FOR VARIOUS EDGE AND CORNER CONDITIONS, SYSTEM ASSEMBLAGE, AND SIZE OF MAJOR AND MINOR MEMBERS. (SEE DIAGRAM "G")

THE FINAL DESIGN PRESENTED ACHIEVED MOST OF THE ORIGINAL OBJECTIVES: GREAT FLEXIBILITY IN TWO DIRECTIONS, SOLVED MANY EDGE AND CORNER CONDITIONS, MADE POSSIBLE A GREAT VARIETY OF VOID SPACES, RESOLVED THE MECHANICAL AND STRUCTURAL INTEGRATION, AND ACCOMPLISHED A UNIVERSALITY OF SPACE-USE WITH FLUSH CEILINGS AND DIAPHRAMS EVERY 5 FEET SQUARE. (SEE DIAGRAM "H")
DESCRIPTION OF "THE DESIGN PRESENTED"

THE DESIGN IS ORIENTATED TO GROWTH AND FLEXIBILITY. MANY BUILDING PROGRAMS MAY BE RESOLVED WITHIN THE FRAMEWORK OF THE SYSTEM, AND MANY SITE GEOMETRIES CAN BE ACCOMMODATED.

THE PLANNING MODULE IS AN ORTHOGONAL GRID ALTERNATING 15'0'', 0'6'', 15'0'' IN BOTH DIRECTIONS; THE 15 FOOT SQUARES ARE SUBDIVIDED INTO 5 FOOT SQUARE UNITS.

THE STRUCTURAL BAY IS 62 FEET SQUARE WITH COLUMNS AT THE CENTERPOINT OF EACH SIDE. WHEN THIS SINGLE BAY IS MULTIPLIED OVER A MUCH GREATER FLOOR AREA, THE PATTERN OF COLUMNS BECOMES A 44 FOOT SQUARE BAY ON THE DIAGONAL TO THE SPACE-USE GRID. (FURTHER REFERENCE TO THIS SYSTEM WILL BE CALLED "THE DESIGN PRESENTED")

THE STRUCTURE IS DESIGNED WITH A HIERARCHY OF COMPONENTS. THE MAJOR COMPONENTS (COLUMNS WITH CANTILEVERED GIRDERS AND CROSS GIRDERS) ARE CENTERED ON THE 0'6'' SPACER OF THE 15 FOOT SQUARE GRID. SECONDARY INTERSECTING BEAMS SPAN THE 15 FEET ON A 5 FOOT SQUARE GRID. PRECAST FLOOR SLABS ARE SUPPORTED BY THE SECONDARY BEAMS.
THE CONFIGURATION OF GIRDERS AND THE DIAGONAL LOCATION OF COLUMNS MAKE POSSIBLE THE ASSEMBLAGE OF THE STRUCTURE WITHOUT SCAFFOLDING, ALLOWS FOR GREAT FLEXIBILITY IN SPATIAL PLANNING, AND PROVIDES MANY STRUCTURAL ADVANTAGES.

THE BUILDING EDGE CAN OCCUR AT THE COLUMN LINE, OR MAY CANTILEVER 15 FEET OUT FROM THE COLUMN LINE. THE EDGE MAY UNDULATE 15 FEET EVERY 30 FEET OF LENGTH. CORNER CONDITIONS FOLLOW THIS THEME AND MAY BE SEEN ON THE DRAWING TITLED "FOOTPRINT - CORES AND EDGE CONDITIONS."

VOID POSSIBILITIES RANGE FROM A SINGLE 15 FOOT SQUARE OPENING TO A 60 FOOT SQUARE OPENING, WITHOUT REMOVING A COLUMN OR DISTURBING THE PATTERN ON THE FLOOR ABOVE OR BELOW. INTERMEDIATE Voids ARE 15' BY 30', 30' BY 30', AND 30' BY 60'. (SEE DRAWING TITLED "FOOTPRINT - CORES AND VOID POSSIBILITIES") CORES, OPEN STAIRS, COURT YARDS, AND FUNCTIONS REQUIRING A GREATER HEIGHT THAN ONE FLOOR CAN BE PLACED AS REQUIRED BY DESIGN OR CODE AT ANY POINT IN THE SYSTEM ON THE 15 FOOT MAJOR GRID.

CORES CONTAIN VERTICAL CIRCULATION (STAIRS AND ELEVATORS), TOILETS, PLUMBING RISERS, TOILET VENT STACKS, MAIN ELECTRIC FEEDS AND THEIR SERVICE ROOMS, TELEPHONE SERVICE ROOMS, MAINTENANCE ROOMS, AND SPACE ALLOCATED TO TELEPHONES, WATER FOUNTAINS, MAIL CHUTES, AND VENDING MACHINES.
COLUMNS (THE STRUCTURAL SUPPORT) CONTAIN VERTICAL AIR RISERS AND RETURNS, WET RISERS FOR PLUMBING OUTSIDE THE CORES, AND ROOF DRAINS.
COMPARATIVE FRAMING SYSTEMS


AN INTERIOR COLUMN OF THE DESIGN PRESENTED CARRIES A FLOOR AREA OF 44 FEET BY 44 FEET, OR 1,936 SQUARE FEET. EACH ONE OF THE GIRDER, TRANSFERRING LOAD TO THE COLUMN, CARRIES ONE FOURTH THIS AREA WITH A MAXIMUM MOMENT AT THE COLUMN OF APPROXIMATELY ONE MILLION POUNDS PER SQUARE INCH. THE MAXIMUM SPAN OF THE SECONDARY MATERIAL, CANTILEVERING FROM THE GIRDER, IN THIS FRAMING PATTERN IS 15.6 FEET. (SEE DIAGRAM "I")

AN INTERIOR COLUMN OF A 62 FOOT BY 62 FOOT BAY WITH THE MAJOR GIRDER ARRANGED DIRECTLY BETWEEN COLUMNS, CARRIES A FLOOR AREA OF 62 FEET BY 62 FEET, OR 3,844 SQUARE FEET. EACH ONE OF THE GIRDER, TRANSFERRING LOAD TO THE COLUMN, CARRIES ONE FOURTH OF THIS AREA WITH A MAXIMUM MOMENT AT THE COLUMN OF APPROXIMATELY TWO MILLION
POUNDS PER SQUARE INCH. THE MAXIMUM SPAN OF THE SECONDARY MATERIAL, CANTILEVERING FROM THE GIRDER, IN THIS FRAMING PATTERN IS 31 FEET. (SEE DIAGRAM "J")

AN INTERIOR COLUMN OF A 44 FOOT BY 44 FOOT BAY WITH THE MAJOR GIRDERS ARRANGED DIRECTLY BETWEEN COLUMNS, CARRIES A FLOOR AREA OF 44 FEET BY 44 FEET, OR 1,936 SQUARE FEET. EACH ONE OF THE GIRDERS, TRANSFERRING LOAD TO THE COLUMN, CARRIES ONE FOURTH OF THIS AREA WITH A MAXIMUM MOMENT AT THE COLUMN OF APPROXIMATELY ONE MILLION POUNDS PER SQUARE INCH. THE MAXIMUM SPAN OF THE SECONDARY MATERIAL, CANTILEVERING FROM THE GIRDER, IN THIS FRAMING PATTERN IS 22 FEET. (SEE DIAGRAM "K")

A COMPARISON OF THESE FRAMING SYSTEMS SHOWS THAT, ALTHOUGH "THE DESIGN PRESENTED" ALLOWS FOR A 62 FOOT SQUARE USE SPACE IN SINGLE INCREMENTS, EACH COLUMN SUPPORTS ONE HALF THE LOAD, AND HAS ONE HALF THE MAXIMUM MOMENT, OF THE 62 FOOT SQUARE BAY WITH THE GIRDERS ARRANGED DIRECTLY BETWEEN COLUMNS. IT ALSO HAS TWICE THE NUMBER OF COLUMNS IN A FOOTPRINT OF MANY BAYS.

"THE DESIGN PRESENTED" HAS A MAXIMUM MOMENT PRACTICALLY EQUAL TO THAT OF THE 44 FOOT SQUARE BAY WITH THE GIRDERS ARRANGED DIRECTLY BETWEEN COLUMNS; BOTH MAJOR GIRDERS CARRY THE SAME LOAD, BUT THE LOAD CONFIGURATION IS
DIFFERENT IN EACH CASE.

"THE DESIGN PRESENTED" HAS MUCH GREATER EFFICIENCY IN USE OF MATERIALS IN THE SECONDARY SPANNING MEMBER, SINCE IT REQUIRES ONLY 0.7 THE SPAN OF THE 44 FOOT SQUARE BAY WITH THE GIRDERS DIRECTLY ARRANGED BETWEEN THE COLUMNS.
FORMS ONLY.

1. Stack cross-shaped beams spanning 15 feet and 4 inches thick. AERI STACK CAST USING SLIPPED SIDE.

2. Place slabs of reinforced concrete, 15 feet squares.

3. Place beams at their points of intersection.


5. Double cross-shaped beams spanning 15 feet and a diagonal type.

6. Column, a longitudinal type and a diagonal type.

7. Connections at either end.

8. Transferring stages of construction.

9. Column component with 15 foot cantilever beam. The column component is of reinforced, precast concrete.

These elements are:

(Structural Components) (See Drawing titled "Sections Through"

On Two Of Them) Are Five Basic Components Of The System. With Variations

The Structure Is Of Reinfroeced, Precast Concrete. There
THE FOLLOWING MATERIAL IS CONCERNED WITH THE STRUCTURAL BEHAVIOR OF THE SYSTEM.

THE NEGATIVE MOMENT OF A CANTILEVER AFFORDS AN ADVANTAGE BY THE SAVINGS IN THE USE OF STEEL. (SEE DIAGRAM "L")


EDGE CONDITIONS - WITH THE BUILDING EDGE AT THE COLUMN LINE NO SPECIAL GIRDER REQUIREMENTS ARE NECESSARY, BUT THE SPECIAL OUTER-MOST COLUMN ELEMENT MUST RECEIVE THE POST-TENSIONING OF THE OPPOSITE COLUMN AND CANTILEVER ELEMENT. (SEE DIAGRAM "N")
WITH THE BUILDING EDGE CANTILEVERED 15 FEET FROM THE COLUMN, NO SPECIAL COLUMN IS NECESSARY, BUT THE CENTER PROJECTING GIRDER MUST BE SPECIALLY REINFORCED TO HANDLE THE LOAD REVERSAL. (SEE DIAGRAM "O")

TO COMPLETE CERTAIN CORNER CONDITIONS, AN ADDITIONAL ELEMENT SUPPORTED ON A NORMAL CROSS GIRDER IS REQUIRED. (SEE DIAGRAM "P")
STEPS OF CONSTRUCTION

1. POUR FOOTINGS ABOUT PRESET SLEEVE WHICH WILL RECEIVE THE TWO STORY COLUMN STABILIZER; THE STABILIZER ASSURES VERTICAL CONTINUITY.

2. SET FIRST COLUMN COMPONENT WITH 15 FOOT CANTILEVER; TACK WELD TOP AND BOTTOM. SET OPPOSITE COLUMN COMPONENT AND TACK WELD AS BEFORE. REPEAT SAME PROCESS FOR THIRD AND FOURTH ELEMENTS OF COLUMN. WHEN ALL FOUR COLUMN COMPONENTS ARE PLACED ABOUT STABILIZER, THREAD POST-TENSIONING CABLES. POST-TENSION BOTH SETS OF CABLES SIMULTANEOUSLY, BUILDING UP EQUAL TENSION AT A SLOW RATE.

3. WHEN A SUBSTANTIAL NUMBER OF COLUMNS WITH CANTILEVERS ARE IN PLACE, GIRDERS, WHICH HAVE BEEN PREPARED IN THE CROSS OR "T" FORM, ARE PLACED. NO SCAFFOLDING IS REQUIRED TO ASSEMBLE THE SYSTEM. EITHER ORTHOGONAL OR DIAGONAL GIRDERS MAY BE PLACED INDEPENDENTLY AND TACK WELDED. IF BOTH ARE PLACED, ORTHOGONAL GIRDER IS PLACED FIRST. THE TACK WELDING PREVENTS THE TOPPING FROM CRACKING.

4. DOUBLE CROSS BEAMS WITH PRE-ATTACHED CHAIRS ARE THEN PLACED IN GIRDER GRID.

5. PRECAST SLABS ARE SET ON THE CHAIRS. SLABS ARE PREPARED WITH OPENINGS TO RECEIVE STEEL RODS. THESE RODS
ARE BENT DOWN AND SECURED TO A METAL MESH UPON WHICH A TOPPING IS Poured. THE RESULTING SLAB SPAN IS AN ALTERNATE 10'0", 5'0" MODULE.

6. BEGIN AGAIN WITH NUMBER 2, REPEATING PROCEDURE FOR THE SECOND AND FOLLOWING FLOORS, WITH A MAXIMUM HEIGHT OF SIX STORIES.
DESCRIPTION OF THE MECHANICAL SYSTEM

AIR HANDLING

THE DESIGN FOR THE AIR HANDLING IS A HIGH VELOCITY DUAL DUCT SYSTEM; WITH THE AIR BEING SUPPLIED AND RETURNED AT EACH COLUMN. THE INTERIOR AS WELL AS EXTERIOR ZONES OF THE BUILDING ARE HANDLED BY THE SAME AIR SYSTEM. THIS SYSTEM AFFORDS GREAT FLEXIBILITY IN INITIAL DESIGN, AND IN LATER ADDITIONS OR CHANGES TO THE CONSTRUCTED BUILDING WITHOUT ANY SPECIAL MECHANICAL ALTERATIONS.

THE MECHANICAL DISTRIBUTION ZONE IS 31 BY 62 FEET. EACH COLUMN HAS TWO COLD, TWO HOT SUPPLIES, AND TWO RETURN DUCTS AT EACH FLOOR. EACH SET OF SUPPLY DUCTS ENTERS ONE OR TWO MIXING BOXES WHICH REDUCE THE VELOCITY AND CONTROL THE TEMPERATURE OF THE AIR. THE TEMPERATURE OF THE ZONE CAN BE CONTROLLED IN HALVES OR FOURTHS, AND WILL ALWAYS PROVIDE SEPARATE CONTROL FOR THE EDGE CONDITIONS. TWO SUPPLY AND RETURN BRANCHES RUN SIDE BY SIDE ACROSS EACH ZONE SERVING LINEAR COMBINATION DIFFUSER-RETURN FIXTURES, WHICH IN TURN SERVE EVERY 5 FOOT SQUARE MODULE. DUCT WORK IS LOCATED IN THE FOUR QUADRANTS OF THE CROSS SHAPED COLUMN, WHICH SIMPLIFIES THE VERTICAL MECHANICAL INSTALLATION; SINCE THE SHALLOW POINT OF THE GIRDERs
HAS NO VERTICAL SLAB SUPPORT, A LONGER MAXIMUM HORIZONTAL DUCT LENGTH CAN BE USED SIMPLIFYING HORIZONTAL INSTALLATION. (SEE DRAWINGS TITLED "MECHANICAL DISTRIBUTION PLAN" AND "SECTIONS THROUGH MECHANICAL AND STRUCTURAL COMPONENTS")

THE SYSTEM IS DESIGNED FOR SPACES WITH 10 FOOT HIGH CEILING OR LESS, AND NINE AIR CHANGES PER HOUR. THE SUPPLY VELOCITY IN THE COLUMN, FOR BOTH HOT AND COLD AIR DUCTS, IS 4,000 FEET PER MINUTE. THE HOT AIR SUPPLY REQUIRED IS 70 PER CENT OF THE COLD. THE RETURN VELOCITY IN THE COLUMN IS 2,500 FEET PER MINUTE. THE RETURN AIR REQUIRED IS 75 PER CENT OF THE SUPPLY.

LIGHTING AND ACOUSTICS

ONE FOUR FOOT FLOURESCENT LIGHT IS MOUNTED ON THE DIFFUSER FIXTURE EVERY 5 FOOT MODULE. HORIZONTAL CLOSURE PANELS FORM A COFFER BY ATTACHING TO BOTH SIDES OF THE LINEAR DIFFUSER FIXTURE. THE COFFER IS PROVIDED WITH A LIGHT REFLECTING SURFACE, PERFORATED AND BACKED WITH SOUND ABSORPTIVE MATERIAL TO GIVE ACOUSTIC TREATMENT TO THE IMMEDIATE SPACE, AND PROVIDES SOUND SEPARATION FROM SPACE TO SPACE. HORIZONTAL CLOSURE WAS DECIDED UPON BECAUSE OF THE VARIETY OF
DUE TO THE PATTERN OF THIS GRID, WATER PIPETTES MAY BE LOCATED AT ANY POINT IN THE SYSTEM. HORIZONTAL RINGS ON A GRID OF 30 FEET SQUARE. VARIOUS PLUMBING RISERS IN EACH COLUMN WHICH SERVE PLUMBING AND STRUCTURAL COMPONENTS.

SEE DRAWING TITLED "SECTIONS THROUGH MECHANICAL" PROPER ILLUMINATION WITH FOUR GREAT DARK AREAS IN THE CELL AND THE NECESSITY FOR PROPER ACOUSTIC TREATMENT AND OPEN STRUCTURAL SHAPES REQUIRING ADDITIONAL CLEARANCE.
CERTAIN ALTERNATIVES AND FURTHER DEVELOPMENT OF "THE DESIGN PRESENTED"

CERTAIN ALTERNATIVE SOLUTIONS TO VARIOUS PARTS OF "THE DESIGN PRESENTED" WERE CONSIDERED. FOR EXAMPLE: COLUMN STABILIZER METHOD OR ERECTION AND VERTICAL CONTINUITY SEEMED COSTLY, AND MAY HAVE BEEN REMOVED BY USING A LIMITED AMOUNT OF SCAFFOLDING DURING ERECTION AND METAL INSERT BARS FOR VERTICAL CONTINUITY. THE COLUMN AND CANTILEVER GIRDER MAY HAVE BEEN SEPARATE COMPONENTS ELIMINATING SPECIAL TRANSPORTATION EQUIPMENT, BUT INTRODUCING ANOTHER CRITICAL CONSTRUCTION CONNECTION.

FURTHER DEVELOPMENT OF "THE DESIGN PRESENTED" MAY LEAD TO GREATER EFFICIENCIES. THE 15 FOOT GRID OF GIRDERS OFFERS A MUCH MORE EFFICIENT USE OF THE STRUCTURAL MATERIAL THAN THE FINAL 5 FOOT GRID. IF THESE GIRDERS WERE RE-SHAPED TO CARRY THE SLAB DIRECTLY, AND THE SLAB DEPTH INCREASED TO SPAN THE 15 FEET SQUARE, THE DOUBLE CROSS SHAPED BEAMS MAY BE ELIMINATED. THE 13 FOOT SLABS ARE EASILY STACK CAST ON THE SITE, HOWEVER, THE DOUBLE CROSS SHAPED BEAMS ARE DIFFICULT TO CAST ON THE SITE AND WOULD REQUIRE SPECIAL SUPPORTS DURING TRANSPORT IF CAST IN A PLANT.
SUMMATION

THE BASIC PROGRAM SET UP FOR THIS STUDY IS LIMITED IN ITS SCOPE, HOWEVER, ITS IDEALS ARE BROAD AND DIRECTED TOWARDS THE DEVELOPMENT OF AN ATTITUDE AND THE ORGANIZATION OF A THINKING PROCESS WHICH WOULD ENABLE AN INDIVIDUAL TO BETTER SOLVE THE COMPLEX ENVIRONMENTAL PROBLEMS OF MAN.

THE PROCESS OF SYSTEMATIC SYNTHESIS OF CONSTRUCTION COMPONENTS, AND OBJECTIVE APPROACH TO THE DESIGN OF BUILDINGS IS THE GREAT LESSON OF THIS STUDY.