

1.

AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS.

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER IN ARCHITECTURE,
MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

GAJINDER SINGH,
BACHELOR OF ARCHITECTURE, 1959,
UNIVERSITY OF DELHI, INDIA.

DEAN L.B. ANDERSON,
SCHOOL OF PLANNING AND ARCHITECTURE,
MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
CAMBRIDGE, AUGUST 1966.

DEAN L.B.ANDERSON,
SCHOOL OF ARCHITECTURE AND PLANNING,
MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
CAMBRIDGE, MASSACHUSETTS.

DEAR DEAN ANDERSON,

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER IN ARCHITECTURE, I HEREBY SUBMIT MY THESIS
ENTITLED " AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS".

SINCERELY YOURS,

GAJINDER SINGH

AUGUST 1966.

FOR THEIR GUIDANCE IN THE PREPRATION OF THIS
THESIS, I WISH TO SINCERELY THANK

PROF. EDUARDO CATALANO,

PROF. WACLAW ZALEWSKI,

PROF. LEON GRISSE.

CONTENTS.

TITLE.....1.

APPLICATION FOR SUBMISSION.....2.

ACKNOWLEDGEMENTS.....3.

THE ABSTRACT.....5.

THE OBJECTIVES.....7.

THE ONE WAY SYSTEM.....9.

THE MODULE AND THE SPAN.....10

THE STRUCTURAL CONCEPT.....13

THE SYSTEM DESCRIBED.....15

THE ELEMENTS.....15

THE FORMWORK.....20

THE CORES.....21

MECHANICAL SERVICES CONCEPT.....23

AIR DISTRIBUTION SYSTEM.....25

LIGHTING.....30

PLUMBING.....31

ACOUSTICS.....32

THE ABSTRACT.

LOOKING AT THE HUMAN PROBLEMS AROUND US AND THEIR CONSEQUENT DEMANDS ON ARCHITECTURE, IT IS QUITE CLEAR THAT WE HAVE TO REORIENT OUR BASIC APPROACH. IN THIS AGE OF TECHNOLOGY, AND MASS PRODUCTION, IT IS NO LONGER POSSIBLE TO USE THE AGE OLD METHODS. MOREOVER, THE PURELY EMOTIONAL APPROACH TO ARCHITECTURE HAS TO BE ABANDONED IN FAVOUR OF A MORE RATIONAL, LOGICAL AND SYSTEMATIC APPROACH.

AS THE DESIRE TO CONTROL THE PHYSICAL ENVIRONMENT INSIDE THE BUILDING IS ON THE INCREASE, AND THE MEANS TO ACCOMPLISH WITHIN OUR REACH, THE MECHANICAL SERVICES ARE PLAYING AN IMPORTANT PART IN THE ORGANIZATION OF STRUCTURE. WITH THIS IN MIND THE SUBJECT CHOSEN FOR THE THESIS WAS TO DEVELOPE A SYSTEM OF CONSTRUCTION, WHICH NOT ONLY SUCCESSFULLY INTEGRATES THE VARIOUS MECHANICAL SERVICES REQUIRED FOR AN EDUCATIONAL BUILDING, BUT ALSO HAS THE FLEXIBILITY FOR ANY FUTURE CHANGES. THERE ARE A FEW SELF-IMPOSED RESTRICTIONS FOR THE PURPOSE OF THIS STUDY WHICH ARE AS FOLLOWS:

i) THE SYSTEM SHALL BE DESIGNED FOR EDUCATIONAL BUILDINGS AT A COLLEGE LEVEL.

ii) THE MATERIAL USED SHALL BE PRE-CAST CONCRETE, WHICH SHALL BE CAST AT A PLANT, AND THE ELEMENTS SHALL BE CAPABLE OF EASY TRANSPORTATION.

iii) THE MAXIMUM NUMBER OF FLOORS IN THE BUILDING SHALL NOT BE MORE THAN SEVEN.

THE OBJECTIVES

IT IS NO DOUBT TO BE ACKNOWLEDGED THAT ALL FORMS OF DISCIPLINE IMPOSE CERTAIN RESTRICTIONS. BUT IN DEVELOPING A FORM OF DISCIPLINE OR IN THIS CASE A SYSTEM OF CONSTRUCTION, ONE HAS TO REMEMBER THAT THERE CAN BE NO COMPROMISE AS FAR AS THE QUESTION OF FLEXIBILITY IS CONCERNED. DURING THE DEVELOPMENT OF THIS THESIS, THE FOLLOWING WERE THE MAIN OBJECTIVES:

1. THAT WITHIN THE FRAMEWORK OF MODULE AND THE SPAN, THERE SHALL BE NO COMPROMISE ON FLEXIBILITY, AND THE SYSTEM SHALL LEND ITSELF EASILY TO THE CREATION OF BUILDINGS OF VARIOUS SIZES AND VARIOUS ARCHITECTURAL SPACES.
2. THAT THE FORM OF THE BASIC ELEMENTS AND SYSTEM OF CONSTRUCTION SHALL BE EXTREMELY SIMPLE.
3. THE NUMBER OF BASIC COMPONENTS SHALL BE MINIMUM POSSIBLE.

CONTINUED.....

4. THAT THERE SHALL BE NO ARBITRARINESS IN THE DESIGN OF THE STRUCTURAL ELEMENTS, IN ORDER TO INTEGRATE THE MECHANICAL SERVICES.

5. A COMPLETE FLEXIBILITY OF VARIOUS MECHANICAL SERVICES, SO THAT SPACES COULD BE INTERCHANGED EITHER AT DESIGN STAGE OR ALTERATIONS COULD BE MADE WHEN THE BUILDING IS IN OPERATION.

THE LINEAL OR THE ONE WAY SYSTEM.

AFTER A PRELIMINARY STUDY OF THE ADVANTAGES AND DISADVANTAGES OF THE ONE WAY AND THE TWO WAY SYSTEMS, IT WAS DECIDED TO DEVELOPE THIS THESIS ON THE BASIS OF ONE WAY SYSTEM. THE REASONS WHICH FAVOURED THIS DECESION ARE :

1. FOR A SYSTEM BASED ON THE ASSEMBLY OF PRE-CAST ELEMENTS, A ONE WAY SYSTEM LENDS ITSELF MORE EASILY THAN A TWO WAY SYSTEM.
2. NO SCAFFOLDING IS REQUIRED DURING CONSTRUCTION.
3. POST TENSIONING OPERATIONS CAN BE AVOIDED.
4. AS THE STRESSES ARE ACTING ONLY IN ONE DIRECTION AT A TIME, THE CONNECTIONS BETWEEN THE ELEMENTS ARE MUCH SIMPLER.

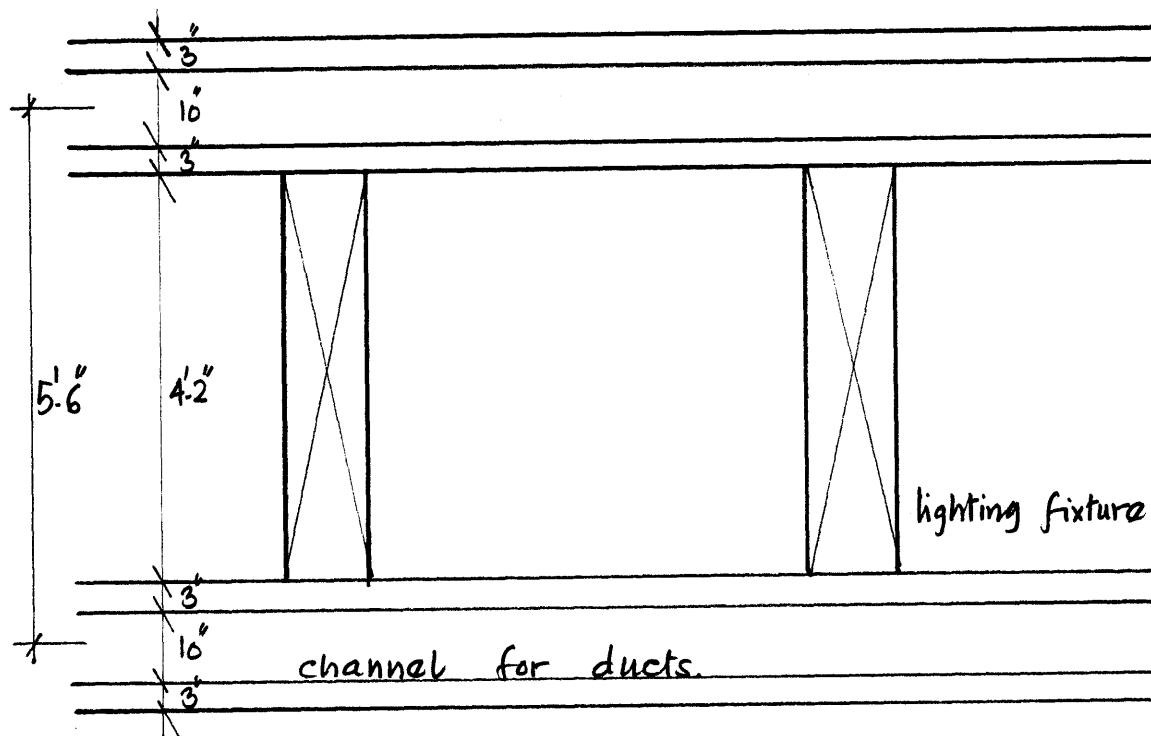
THE MODULE AND THE SPAN :

THE MODULE:

THE DETERMINATION OF THE MODULE IS THE FIRST IMPORTANT STEP IN THE CREATION OF ANY SYSTEM OF CONSTRUCTION. A NUMBER OF PRELIMINARY STUDIES WERE DONE FOR THIS PURPOSE KEEPING IN MIND SUCH PROBLEMS AS

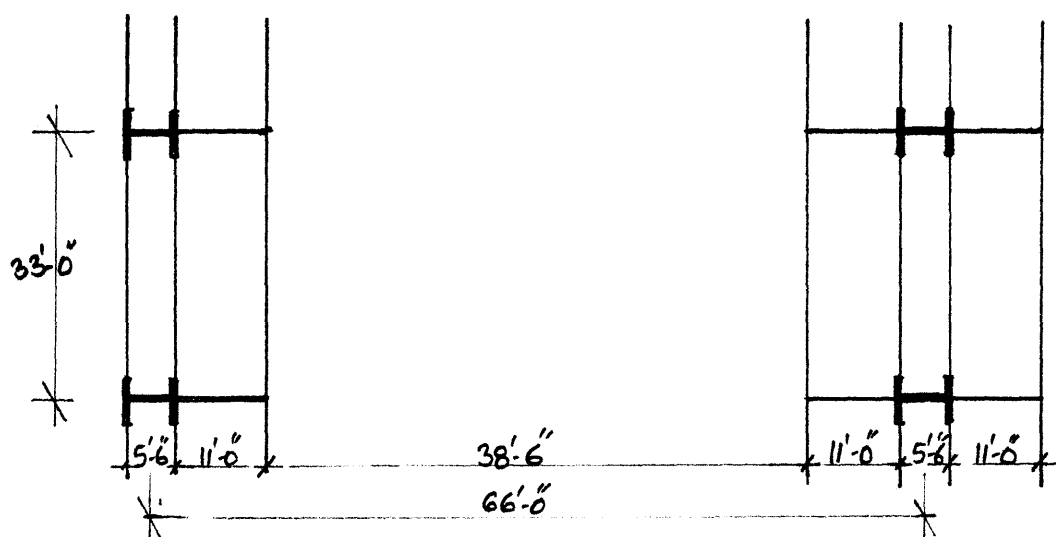
1. DISTRIBUTION OF LIGHT. IT WAS CONSIDERED IMPORTANT TO PROVIDE AN EVEN GENERAL BACKGROUND LIGHTING BY THE USE OF FLUORESCENT FIXTURES. ADDITIONAL LIGHTING FIXTURES COULD BE ADDED TO CREATE SPECIAL CONDITIONS.
2. THE SIZE OF THE FIXTURE, WHETHER STANDARD OR NOT, AND THE RESULTANT EFFECT ON ECONOMY.
3. A BALANCED SUPPLY AND RETURN AIR SYSTEM THROUGH A REGULAR DISTRIBUTION OF DIFFUSERS.
4. PARTITIONING OF SPACES, ITS EFFECT ON LIGHTING CONDITIONS, AIR DISTRIBUTION AND THE CREATION OF SMALLEST HABITABLE ROOMS.
5. THE RATE OF GROWTH OF SPACES, WHICH IS A DIRECT FUNCTION OF THE MODULE.
6. CORRIDOR SIZES TO SERVE A VARIETY OF SPATIAL CONDITIONS.

THESE STUDIES REVEALED THAT A MODULE OF 5'0" BEST SERVED MOST OF THE REQUIREMENTS ENUMERATED ABOVE. HOWEVER, A MODULE OF 5'6" WAS ADOPTED FOR THE PRESENT DESIGN, AS SPACES CARRYING THE AIR CONDITIONING DUCTS WERE CREATED BETWEEN THE TWO CHANNELS.



THE SPAN:

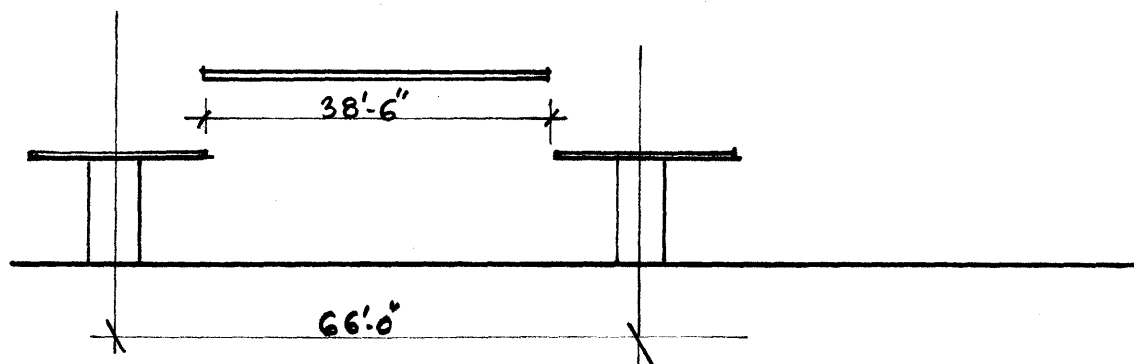
THE SPAN IS PRIMARILY A FUNCTION OF THE BASIC REQUIREMENTS OF SPACE IN A BUILDING. BEFORE DECIDING ON THE ACTUAL DIMENSIONS OF A TYPICAL BAY, STUDIES WERE DONE ON THE DIMENSIONS REQUIRED FOR THE FIRE-ESCAPE STAIRCASE, THE ELEVATOR AND THE TOILET ROOMS. THE ELEMENTS WERE DESIGNED AS ADDITION SERIES ON THE BASIS OF A UNIT 7 MODULES LONG AND 1 MODULE WIDE i.e. 38'6" X 5'6". THIS IN TURN DICTATED A DIMENSION OF 66'0" FOR THE MAIN SPAN, LEAVING TWO CIRCULATION SPACES OF 11'0" ON EITHER SIDE OF VERTICAL CORES.



THE SECOND DIMENSION OF 33'0" (HALF OF THE MAIN SPAN) IS THE MOST ECONOMICAL DIMENSION FOR A ONE WAY SYSTEM, BEING IN THE RATIO OF 1:2, AND IS QUITE A REASONABLE DIMENSION FOR MOST PURPOSES IN THE TYPE OF BUILDINGS UNDER CONSIDERATION.

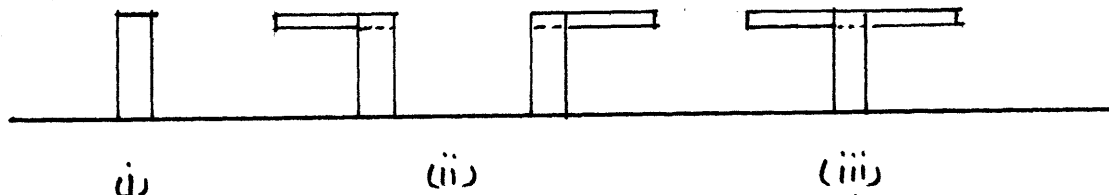
THE STRUCTURAL CONCEPT.

AS FLEXIBILITY IN THE CREATION OF A VARIETY OF ARCHITECTURAL SPACES WAS THE MAIN OBJECTIVE THOUGH KEEPING IN MIND THE OTHER POINTS ALREADY ENUMERATED ABOVE, THE WHOLE DESIGN CONCEPT WAS ORIENTED TO THAT END. IT IS VERY DIFFICULT TO ANALYSE IN RETROSPECT THE VARIOUS STAGES ONE PASSES THROUGH DURING THE PROCESS OF DESIGN, AS IT IS A LONG SERIES OF TRIALS AND ERRORS. HOWEVER, THE FINAL RESULT CAN BE SAID TO HAVE BEEN CONCEIVED PRIMARILY AS A ONE WAY SYSTEM IN WHICH STRUCTURAL ELEMENTS 38'6" LONG AND 5'6" WIDE WERE SIMPLY SUPPORTED ON TWO SETS OF CANTILEVERS FROM THE COLUMNS ON EITHER SIDE.



THE MAIN ADVANTAGES OF THIS APPROACH ARE

1. THE MIDDLE ELEMENTS CAN BE REMOVED AT A DESIGN STAGE TO INSERT VERTICAL ELEMENTS.
2. OPENINGS CAN BE CREATED SO AS TO HAVE SPACES OF DOUBLE THE NORMAL FLOOR TO FLOOR HEIGHT OR TO CREATE COURTS WITHIN THE BUILDING.
3. BY BREAKING THE LONGITUDNAL ELEMENTS, AND THE CREATION OF NEGATIVE BENDING MOMENTS AT THE COLUMNS (BECAUSE OF CANTILEVERS) ONE HELPS TO CREATE CONTINUITY IN THIS DIRECTION WHICH HAS ITS RESULTANT ECONOMIC ADVANTAGES.
4. FURTHERMORE, BY A VARIATION IN THE DESIGN OF THE MAIN CANTILEVER ELEMENTS i.e. A ONE SIDED CANTILEVER OR EVEN NO CANTILEVER AT ALL, ONE CAN GREATLY INCREASE THE POSSIBLE COMBINATIONS AND ALSO VARY THE END CONDITIONS.



THE SYSTEM DESCRIBED.

THE ELEMENTS:

REFER PHOTOGRAPH 1. IN ALL THERE ARE ONLY SIX DIFFERENT TYPES OF ELEMENTS THAT HAVE BEEN DEVELOPED FOR THE SYSTEM. THEY ARE FROM LEFT TO RIGHT

1. THE CHANNELS.
2. THE COLUMN.
3. THE GIRDER.
4. THE SECONDARY BEAMS.
5. THE SLAB OVER THE SECONDARY BEAMS.
6. THE MAIN BEAM TYPE A

NOT SHOWN IN THE PICTURE IS MAIN BEAM TYPE B

HOWEVER, THESE ELEMENTS HAVE BEEN DESCRIBED BELOW IN ORDER OF THEIR IMPORTANCE IN THE SYSTEM, WHICH ALSO FOLLOWS THE SEQUENCE OF CONSTRUCTION.

THE COLUMN:

H SHAPED IN PLAN, 5'6" X 6'3" X 12'10" IN HEIGHT. THE FLOOR TO FLOOR HEIGHT IS 13'0", BUT A TOLERANCE OF 2" IS ALLOWED FOR ADJUSTMENT WHEN ONE COLUMN IS PLACED ON TOP OF THE OTHER. A TYPICAL COLUMN CARRIES A NOTCH 1'4" WIDE X 2'10" DEEP FOR THE CANTILEVER

GIRDER. THE COLUMNS SHALL BE CAST WITHOUT A NOTCH IN CASE IT TO BE USED WITHOUT A GIRDER IN A TWO STOREY SPACE.

THE GIRDER:

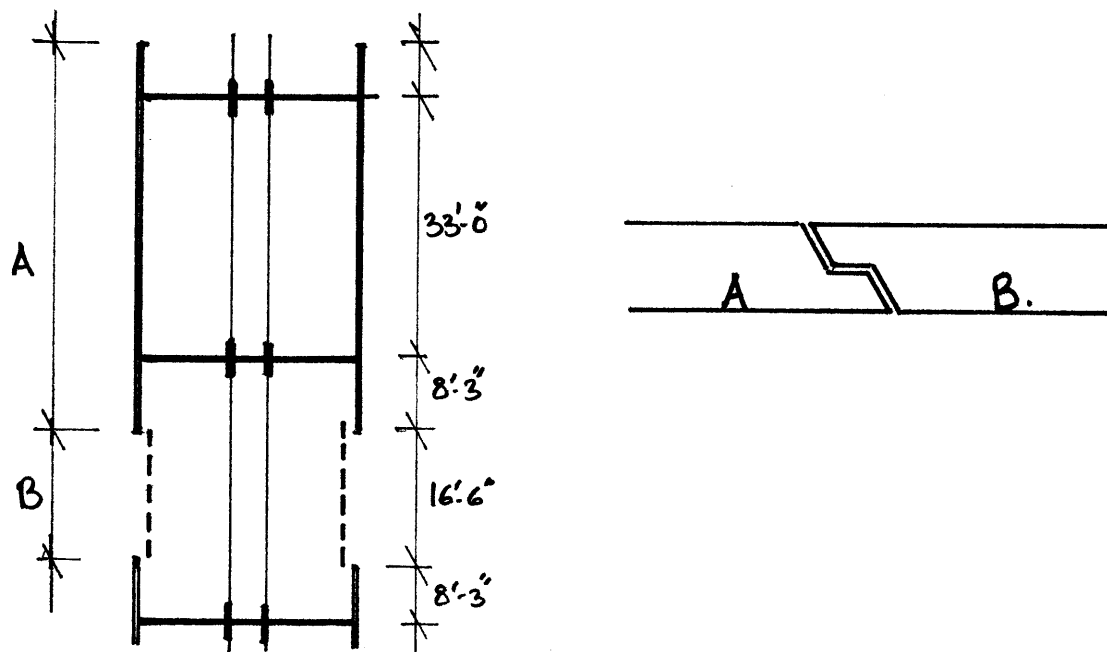
IT HAS BEEN DESIGNED AS TWO L TYPES, SINGLE OR DOUBLE. IN EITHER CASE THE RESULTANT CANTILEVER IS 11'0" ON ONE OR EITHER SIDE. THE GIRDERS ARE 1'4" WIDE X 2'10" DEEP. THESE ARE PLACED BY THE CRANE INTO THE NOTCH PROVIDED IN THE COLUMN, AND AFTER PROPER ADJUSTMENT ARE WELDED TO THE COLUMN, THROUGH A STEEL PLATE AT THE BOTTOM OF THE GIRDER, AND CEMENT GROUTED.

THE MAIN BEAM:

1'4" WIDEX 2'4" DEEP. THIS BEAM SPANS ACROSS THE MAIN GIRDERS AND PROVIDES A POINT OF BREAK IN THE 66'0" SPAN. IT CARRIES HOLES 12" X 12" AT 5'6" CS. TO ALLOW THE DUCTS TO PASS THROUGH. TO PROVIDE CONTINUITY IN THE BEAM, IT IS DESIGNED AS A SERIES OF TWO ELEMENTS "A" AND "B", THE POINT OF BREAK BEING THE POINT OF INFLECTION.

BEAM TYPE IS "A" IS SUPPORTED BY THE GIRDER THROUGH A PROJECTION 1'4" X 1'4" X 1'0" THAT SLIDES INTO THE BEAM; IS TACK WELDED AND CEMENT GROUTED. THE ENDS

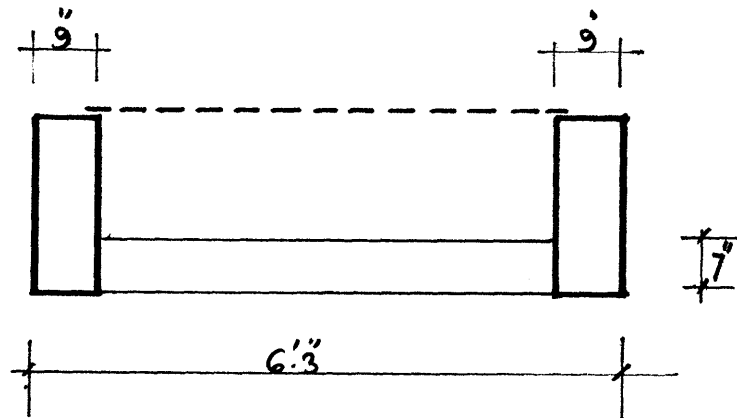
OF THE BEAM TYPE "A" ARE SHAPED TO RECEIVE BEAM TYPE "B" WHICH SIMPLY RESTS ON IT , AND IS WELDED ON TOP AND BOTTOM TO PREVENT SLIDING.



THE SECONDARY BEAMS:

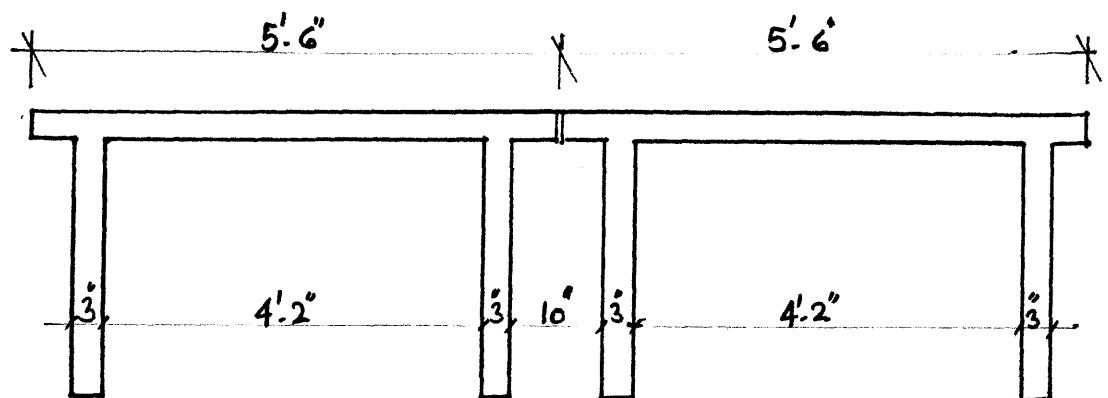
THESE BEAMS 9" WIDE X 1'9" DEEP SPAN BETWEEN THE COLUMNS ACROSS THE 33'0" SPAN, BUT THE ACTUAL SPAN OF THE SECONDARY BEAMS IS ONLY 28'6". THESE ARE DESIGNED TO BE SIMPLY SUPPORTED ON THE BRACKETS 9" X 9" X 12" PROVIDED AT THE ENDS OF THE COLUMNS. IN THE CASE OF CANTILEVER END CONDITION, THE SECONDARY BEAMS ARE FIRST PROPPED AND THEN POST-TENSIONED THROUGH THE COLUMN AT THE MIDDLE OF THE NEXT SIMPLY SUPPORTED SPAN.

THESE BEAMS ARE CAST IN PAIRS, AS THEY ALWAYS OCCUR IN PAIRS. THE CONNECTING ELEMENTS ARE 1'4" WIDE X 7" DEEP AND CARRY A GROOVE IN THE MIDDLE TO MATCH THE END OF THE CHANNELS. TO PREVENT THEM FROM OPENING APART DURING TRANSPORTATION AND HELP LIFT THEM WITH A CRANE TWO STEEL RODS CONNECT EACH PAIR AT THE TOP.



THE CHANNELS:

THE OVER ALL WIDTH OF A CHANNEL IS 5'6", BUT THE VERTICAL SIDES ARE AT A CLEAR DISTANCE OF 4'2" APART. WHEN TWO CHANNELS ARE PLACED NEXT TO EACH OTHER, THERE IS A CLEAR DISTANCE OF 10", WHICH IS USED FOR CARRYING DUCTS.



THE CHANNELS ARE CAST IN TWO SIZES:

1. 38'6" LONG FOR THE MID-SPAN.
2. 11'0" LONG FOR THE SIDE SPAN.

THE CHANNEL WITH ONLY ONE VERTICAL SIDE IS TO BE USED NEAR THE COLUMN. THE OTHER SIDE OF THE 5'6" SLAB RESTS ON THE MAIN GIRDER.

THE SLAB OVER THE SECONDARY BEAM:

THIS IS COMPARATIVELY THE LEAST IMPOTANT ELEMENT IN THE WHOLE SET. IT IS A PIECE OF SLAB 3" THICK, 5'6" WIDE THAT SPANS ACROSS THE SECONDARY BEAMS. BUT AS THE DUCTS AND PIPES PASS BETWEEN THE LOWER SIDE OF THE SLAB AND UPPER SIDE OF THE SECONDARY BEAM, THE SLAB CARRIES TWIN BEAMS 3" WIDE AT 5'6" CS. AND HAS SMALL LEGS AT THE ENDS (SECTION 1-1 drg. no.5) THE SLAB GOES 6" INTO THE COLUMN AT EVERY FLOOR LEVEL TO PROVIDE BEARING FOR THE VERTICAL PANEL TO COVER THE DUCT ON THE FACE OF A COLUMN. THIS ALSO HELPS TO STOP THE VERTICAL TRANSFERENCE OF NOISE FROM ONE FLOOR TO THE OTHER.

THE FORMWORK.

AS THE SYSTEM IS COMPOSED OF PRE-CAST ELEMENTS ,
MASS PRODUCED AT A PLANT FOR QUALITY CONTROL, IT IS
ESSENTIAL THAT THE ELEMENTS BE SIMPLE IN SHAPE,
AND EASY TO CAST. THE FORMWORK SHALL BE IN METAL
FOR REPITITIVE USE WITH THE REQUISITE SLOPE ON ALL
THE PLANE SURFACES FOR EASY REMOVAL OF FORMS AFTER
CASTING.

THE CORES:

REFER DRAWING NO 2.

THESE ARE THE PERMANENT VERTICAL ELEMENTS IN A BUILDING, WHICH BY THEIR VERY NATURE ARE USED FOR VERTICAL CIRCULATION, AND CONSEQUENTLY SET UP A PATTERN FOR HORIZONTAL CIRCULATION. THEY ARE PRIMARILY COMPOSED OF PASSENGER AND FREIGHT ELEVATORS AND FIRE-ESCAPE STAIRCASES. BUT IN THEIR SECONDARY ROLE, ALSO CARRY OTHER ELEMENTS OF HORIZONTAL CIRCULATION LIKE THE TOILET ROOMS, JANITORS CLOSETS, TELEPHONE BOOTHS ETC. AS TO THE SIGNIFICANCE OF THE CORES IN THE OVERALL SYSTEM, IT HAS BEEN MENTIONED BEFORE THAT THE MAIN SPAN OF 66'0" IS THE RESULT OF THE DESIRE TO PLACE THE CORE ELEMENTS AT THE DESIGN STAGE, BY THE REMOVAL OF THE MIDDLE ELEMENTS.

THE VARIOUS CORE ELEMENTS WERE DESIGNED ON A BASIC UNIT OF 5'6" WIDTH X 38'6" LENGTH ON CS. BY COMBINING THE ELEMENTS TOGETHER IN DIFFERENT WAYS ONE GETS A LARGE VARIETY OF CORES.

MECHANICAL SERVICES

MECHANICAL SERVICES.

THE BASIC ISSUE IN THE DESIGN OF THE TOTAL SYSTEM WAS TO ACHIEVE A COMPLETE SYNTHESIS OF MECHANICAL AND STRUCTURAL SYSTEMS, SO THAT INSTEAD OF EXISTING SIDE BY SIDE THEY BECOME COMPLEMENTARY TO EACH OTHER. THAT THIS HAS BEEN ACHIEVED IS EVIDENT BY THE FACT THAT STRUCTURAL ELEMENTS WHILE PERFORMING THEIR NATURAL FUNCTIONS CREATE SPACES FOR THE VERTICAL AND HORIZONTAL RUNS OF THE MECHANICAL SERVICES, PROVIDING COMPLETE FLEXIBILITY FOR ANY KNOWN OR UNKNOWN CHANGES.

THE CONCEPT.

THE IDEA OF A SELF-SUFFICIENT STRUCTURAL BAY HAS BEEN CARRIED TO THE MECHANICAL SERVICES ALSO, SO THAT AT THE DESIGN STAGE OR EVEN IN LATER ADDITIONS TO A BUILDING, EACH BAY IS A COMPLETE FUNCTIONING UNIT IN ITSELF. WITH THIS IN MIND, THE STRUCTURAL COLUMNS HAVE BEEN DESIGNED AS HOLLOW COLUMNS (HSHAPED IN PLAN) SO AS TO CARRY THE VERTICAL RUNS OF MECHANICAL SERVICES THE COLUMNS ARE FED FROM THE MECHANICAL ROOMS EITHER BY TUNNELS OR BRIDGES DEPENDING UPON THE LOCATION OF THE MECHANICAL ROOMS i.e. BASEMENT OR ROOF LEVEL. THE VERTICAL RUNS FROM THE COLUMNS IN TURN FEED INTO MAJOR HORIZONTAL CHANNELS CREATED BY THE SECONDARY BEAMS

SPANNING ACROSS THE COLUMNS ON 33'0" CS. SPAN. FURTHER DISTRIBUTION AT MODULAR LEVEL TAKES PLACE THROUGH THE SPACES BETWEEN THE CHANNELS AT 5'6" CS.

THE AIR DISTRIBUTION SYSTEM IN THE EXTERIOR ZONE OF A BUILDING, WHICH IS ABOUT 15' IN WIDTH, REQUIRES A DIFFERENT TREATMENT FROM THAT OF THE INTERIOR ZONE, AS THE EXTERNAL CONDITIONS VARY CONSIDERABLY DURING THE COURSE OF THE DAY. CONSEQUENTLY THE SELF-SUFFICIENT BAY WAS DESIGNED SO AS TO ACCOMMODATE EITHER OF THE TWO TYPES. THIS PROVIDES FLEXIBILITY FOR THE ADDITION OR REMOVAL OF A TYPICAL BAY AT DESIGN STAGE OR AFTER CONSTRUCTION.

AIR DISTRIBUTION SYSTEM

INTERIOR ZONE:

AS A VERY LARGE PERCENTAGE OF THE SPACES IN AN EDUCATIONAL BUILDING DO NOT REQUIRE SPECIAL CONDITIONS OF TEMPERATURE OR HUMIDITY, THE INTERIOR ZONE WHICH IS UNAFFECTED BY THE EXTERNAL CHANGES HAS BEEN TREATED WITH A "ONE DUCT HIGH VELOCITY VARIABLE VOLUME SYSTEM". THE AIR IS TREATED TO L PRE-DETERMINED SPECIFICATIONS IN THE MECHANICAL ROOM AND BROUGHT BY DUCTS THROUGH THE HOLLOW COLUMNS AT A VELOCITY OF 4000 F.P.M. THE HIGH VELOCITY HELPS TO KEEP THE SIZE OF THE DUCTS AND IN TURN THE SIZE OF THE HOLLOW COLUMNS TO THE MINIMUM AS THE AIR MOVES ALONG THE MAJOR CHANNELS HORIZONTALLY BETWEEN THE SECONDARY BEAMS, THE SPEED IS REDUCED TO 1000 F.P.M. THROUGH THE INTRODUCTION OF HEAVILY LINED ATTENUATING BOXES. SMALLER DUCTS TAKE OVER FROM HERE ON AND THESE ARE PLACED IN THE 10" WIDE SPACE BETWEEN THE CHANNELS. THE DISTRIBUTION AT MODULAR LEVEL TAKES PLACE THROUGH STRIP DIFFUSERS $\frac{1}{2}$ " WIDE X 4'0" LONG ATTACHED TO THE LIGHTING FIXTURES, AND INSULATED TO PROTECT THE AIR FROM THE HEAT GENERATED BY THE ILLUMINATING SOURCE.

THE SUPPLY AND THE RETURN AIR FORM A CHECKER BOARD PATTERN WITH DIFFUSERS AT 5'6" CENTRES, SO THAT THERE ARE TWO SUPPLY AND TWO RETURN AIR DIFFUSERS EVENLY SPACED IN AN AREA OF 11' x 11'. THE RETURN AIR DUCTS CARRYING AIR AT 1000 FPM ARE PLACED IN THE SAME MODULAR CHANNELS AS THE SUPPLY DUCTS. SINCE THEY COME FROM OPPOSITE DIRECTIONS, AND LOADS VARY INVERSELY, THEY LIE ONE ABOVE THE OTHER LIKE TWO WEDGES.

AS THE RETURN AIR MOVES FROM THE MAJOR HORIZONTAL CHANNELS INTO THE VERTICAL DUCTS, THE VELOCITY INCREASES TO 3000 FPM, BUT THE SIZE OF THE DUCT REMAINS THE SAME AS THE RETURN AIR VOLUME IS ONLY 70% OF THE SUPPLY AIR. THE COLUMNS CARRYING THE VERTICAL RUNS OF THE RETURN AIR ALTERNATE WITH THOSE OF SUPPLY ON THE 66'0" SPAN, BUT ALL THE COLUMNS ON THE 33'0" SPAN BELONG TO THE SAME TYPE.

THE FLEXIBILITY IN THE SYSTEM IS PROVIDED BY THE FACT THAT THE SUPPLY AND RETURN AIR DUCTS TOGETHER OCCUPY ONLY THE ALTERNATE CHANNELS. THE OTHERS COULD BE USED FOR SUCH PURPOSES AS

1. MEETING EXTRA LOAD DEMANDS ON THE AIR SYSTEM;
IN CASE A PARTICULAR ROOM HAS A MUCH LARGER
CONCENTRATION OF PEOPLE.
2. CREATING SPECIAL CONDITIONS OF TEMPERATURE AND
HUMIDITY. THIS CAN BE DONE BY TREATING THE AIR
SUPPLY BEFORE PASSING IT ON TO THE DIFFUSERS, USING
PIPES WHICH CARRY CHILLED WATER OR STEAM.
3. CARRYING EXHAUST AIR DUCTS FROM SPECIAL EXPERIMENTS
CONDUCTED IN A CHEMISTRY LABORATORY.

EXTERIOR ZONE.

THE NATURE OF THE PERIPHERAL ZONE ABOUT FIFTEEN FEET IN WIDTH REQUIRES A CONTINUAL ADJUSTMENT, AS THE ATMOSPHERIC CONDITIONS OR THE POSITION OF THE SUN KEEPS ON CHANGING. TO ACCOMPLISH THAT, A THREE PIPE "INDUCTION SYSTEM" HAS BEEN ADOPTED FOR THE EXTERIOR ZONE. THE AIR COMES AT A HIGH VELOCITY OF 4000 FPM FROM THE MECHANICAL ROOM THROUGH THE HOLLOW COLUMNS, AND THE MAJOR CHANNELS TO THE 5'0" WIDE INDUCTION UNIT BELOW THE WINDOW SILL LEVEL (REFER DRAWINGS NOS 5 AND 6) THREE PIPES CARRYING HOT, COLD AND RETURN WATER SUPPLY ARE ALSO BROUGHT THE SAME WAY TO THE INDUCTION UNITS. THE HIGH VELOCITY AIR IS ALLOWED TO ESCAPE THROUGH VERY FINE NOZZLES, THEREBY CREATING TURBULENCE. THE RETURN AIR FROM WITHIN THE ROOM GETS SUCKED INTO THE UNIT THROUGH A GRILL, PASSES THROUGH A FILTER, GETS MIXED WITH THE TURBULENT FRESH AIR FROM THE DUCT (25% OF THE TOTAL SUPPLY) AND FINALLY PASSES OVER THE COIL CONTAINING HOT OR CHILLED WATER. THE TEMPERATURE OF THE WATER IN THE COIL IS CONTROLLED BY A THERMOSTAT THROUGH A VALVE THAT REGULATES THE PROPORTION OF HOT AND COLD WATER.

THE INDUCTION SYSTEM HAS THE FOLLOWING DISTINCT ADVANTAGES.

1. NO MECHANICAL PARTS TO HANDLE.
2. NO RETURN AIR DUCTS TO GO BACK TO THE CENTRAL PLANT IN THE MECHANICAL ROOMS.
3. AS THE INDUCTION UNITS ARE ONLY 5'0" WIDE, EVERY STRIP OF 5'6" WIDTH X 15'0" DEPTHA CAN BE THEORATICALLY TREATEATED SEPERATELY IF SO DESIRED.

BOTH THE INTERIOR AND EXTERIOR ZONE SYSTEMS ALLOW FOR COMPLETE FLEXIBILITY OF PARTITIONING, ENSURING A VERY EVEN DISTRIBUTION OF AIR AT ANY PARTICULAR TEMPERATURE OR LOAD CONDITIONS.

LIGHTING.

FOUR FEET LONG HIGH OUTPUT FLUORESCENT TUBES SHALL BE USED IN FIXTURES THAT CARRY THE ATTACHMENTS FOR STRIP TYPE AIR DIFFUSERS. THE FIXTURES ARE PLACED AT 5'6" CENTRES SO AS TO GIVE AN EVEN DISTRIBUTION OF LIGHT IN A LARGER SPACE OR WHEN SUCH SPACE IS FURTHER SUBDIVIDED INTO SMALLER PARTITIONS. ONE TUBE OF 40 WATTS HIGH OUTPUT IN EACH FIXTURE AT 5'6" CENTRES GIVES AN INTENSITY OF 90 FOOT CANDLES.

SPECIAL CONDITION OF LIGHTING CAN BE CREATED BY VARYING THE NUMBER OF TUBES IN A FIXTURE OR BY THE USE OF TUNGSTEN LAMPS.

PLUMBING.

SEE DRAWINGS NO. 3 AND 5.

AGAIN THE SAME PRINCIPLE OF FLEXIBILITY HAS BEEN APPLIED TO PLUMBING ALSO. AT THE MODULAR LEVEL, EACH OF THE CHANNELS AT 5'6" CS. IS CAPABLE OF CARRYING ALL THE PIPES GENERALLY NEEDED IN A LABORATORY. THESE PIPES RUN ABOVE THE LIGHTING FIXTURES IN THE MIDDLE OF THE 5'6" SPAN AND ARE CONCEALED FROM VIEW BY THE ACOUSTIC PANEL. ALONG THE 66'0" SPAN, WASTE AND VENT PIPES SLOPE FROM THE MIDDLE IN EITHER DIRECTION. THE PATTERN REPEATS ITSELF WHEN THE PIPES REACH THE MAJOR HORIZONTAL CHANNEL, SO THAT HALF THE PIPES GO IN EITHER DIRECTION. CONSEQUENTLY, EACH OF THE H SHAPED COLUMNS CARRIES TWO SETS OF 5" DIA WASTE AND VENT PIPES. THESE CAN BE INTERCHANGED DEPENDING UPON THE LOADING CONDITIONS IN A PARTICULAR CASE. MOREOVER, EACH HOLLOW COLUMN CARRIES RISERS OF 1½" DIA COLD WATER SUPPLY, 3" DIA O.A. INSULATED HOT WATER SUPPLY AND ONE 4" DIA RAIN WATER PIPE.

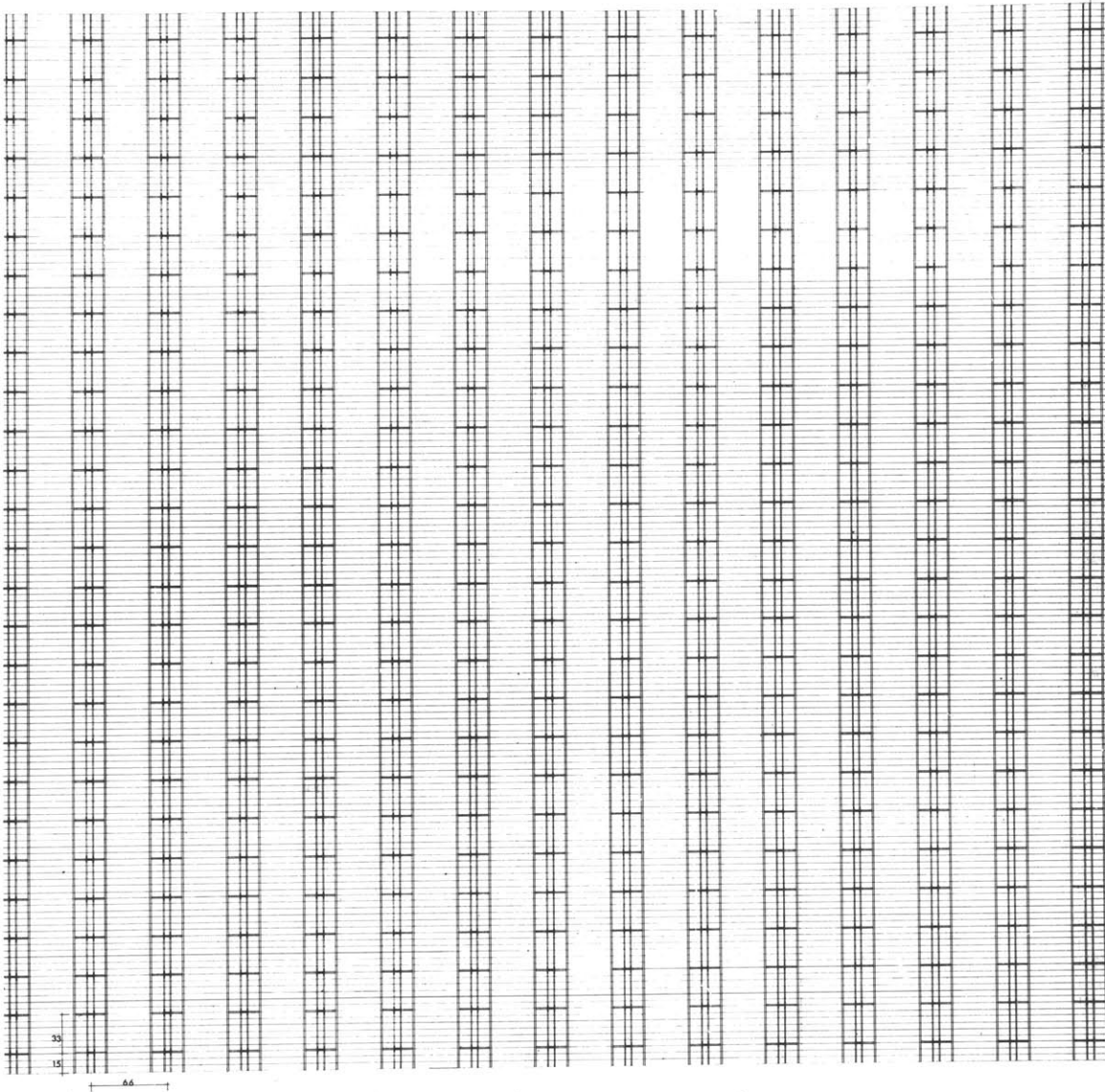
THE LOCATION OF THE TOILET ROOMS WITH WATER CLOSETS, URINALS AND WASH BASINS HAS BEEN CONFINED TO THE VERTICAL CORES. ■■■■■ ■■■■

ACOUSTICS

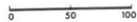
THE AIR DISTRIBUTION SYSTEM CARRIES WITH IT THE RISK OF TRANSMITTING THE SOUND FROM ONE ZONE TO THE OTHER. HOWEVER, IF TREATED CAREFULLY THERE IS NO CAUSE FOR CONCERN. ALSO A CERTAIN AMOUNT OF ACOUSTICAL MATERIAL IS NEEDED IN EVERY BAY SO AS TO ABSORB THE SOUND REFLECTED BY THE HARD SURFACES.

THE FIRST OBJECT HAS BEEN ACHIEVED BY USING DUCTS INSTEAD OF A PLENUM FOR THE RETURN AIR, AND THE SECOND BY FIXING A 4' WIDE SHEET OF ACOUSTICAL MATERIAL IN EVERY CHANNEL, ABOVE THE LIGHTING FIXTURE AND BELOW THE PIPES. THE SMALLER 10" WIDE SPACES BETWEEN THE CHANNELS THAT CARRY THE DUCTS HAVE ALSO BEEN COVERED BY ACOUSTICAL PANELS. AS THE OPENINGS IN THE BEAMS TO LET THE AIR DISTRIBUTION DUCTS PASS THROUGH OCCUR ABOVE THE ACOUSTICAL PANEL, THERE IS NO NECESSITY TO CLOSE THESE OPENINGS. TO STOP THE SOUND GOING FROM ONE PARTITIONED AREA TO THE OTHER DIAPHRAGMS SHALL BE PLACED IN THE GROOVES WHICH OCCUR AT EVERY 5'6" CS. ALONG THE LENGTH OF THE CHANNEL.

A THIRD SOURCE OF NOISE THAT CAN BE A NUISANCE IS CAUSED BY THE CHANGE OF VELOCITY. TO OVERCOME THIS HEAVILY LINED ATTENUATING BOXES SHALL BE USED.

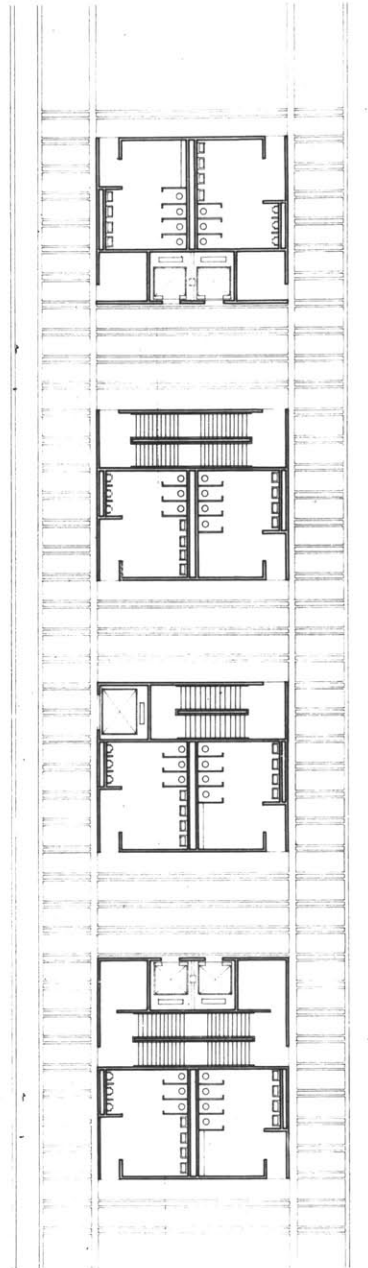
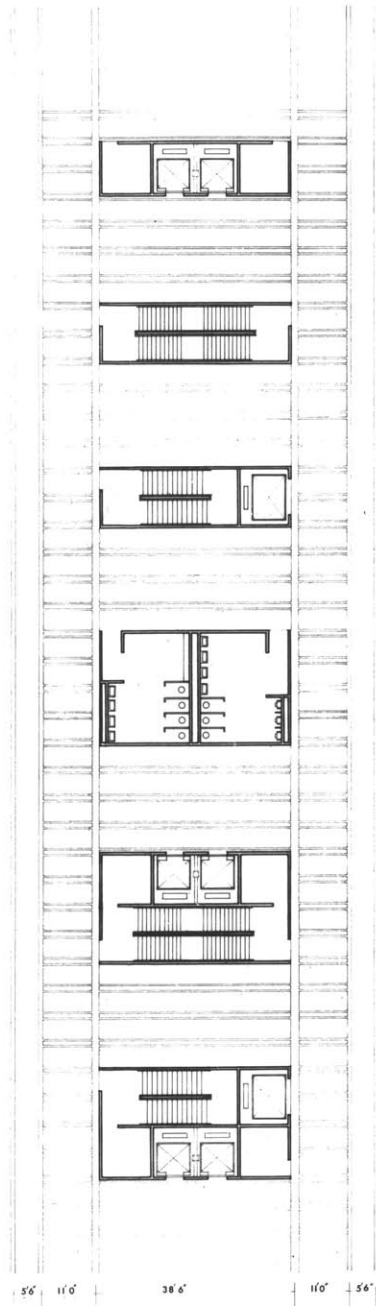


THE GENERAL GRID
SCALE



AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS

GAJINDER SINGH MASTERS THESIS 05.06

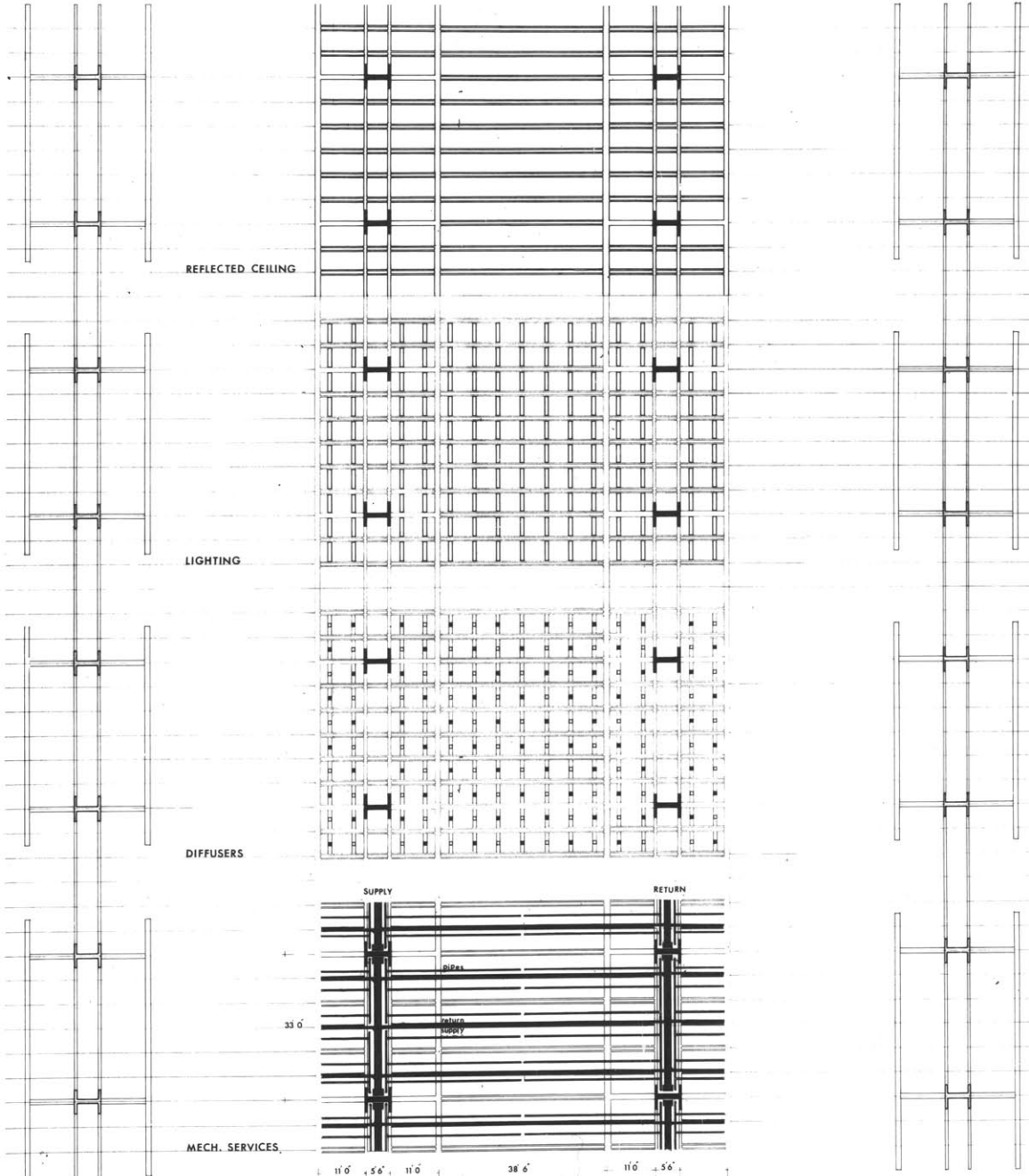


VARIATIONS OF CORE ELEMENTS

SCALE

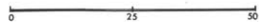


AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS

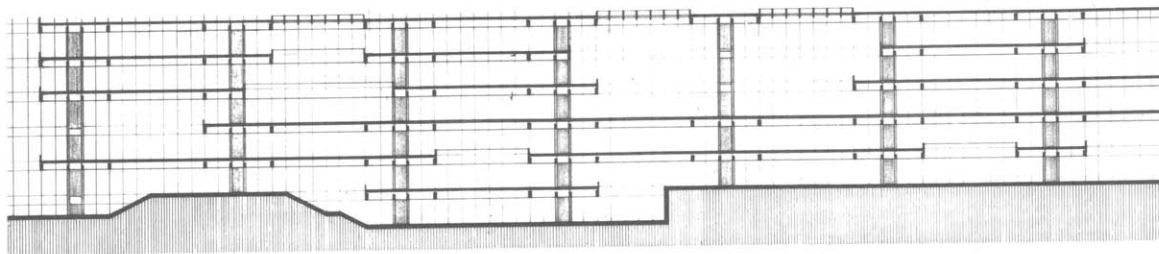
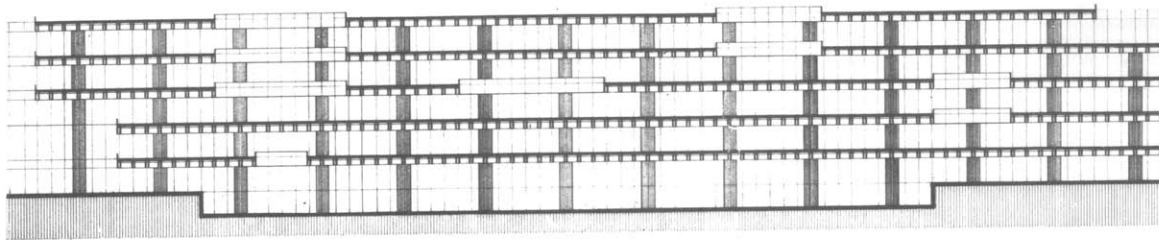
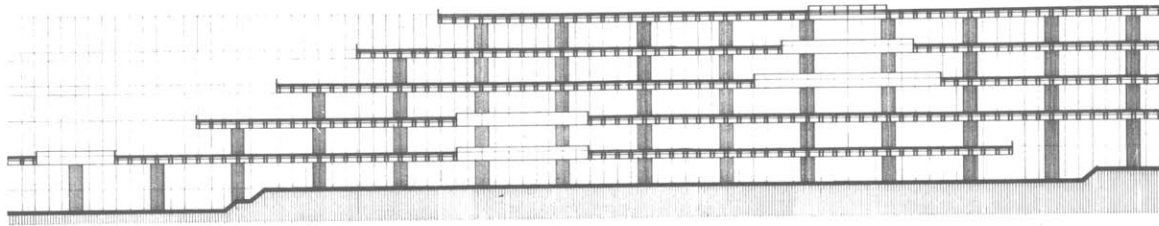


AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS

SCALE



GAJJINDER SINGH MASTERS THESIS 65.66



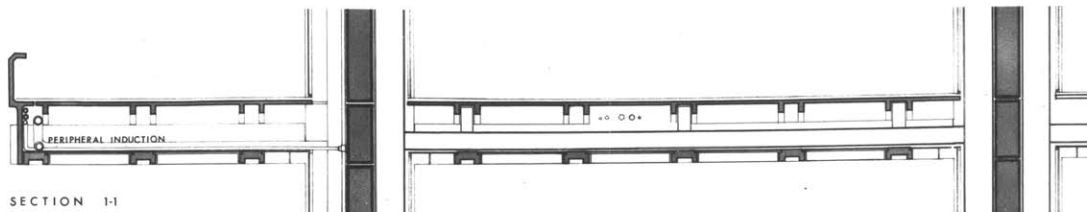
GENERAL SECTIONS

SCALE

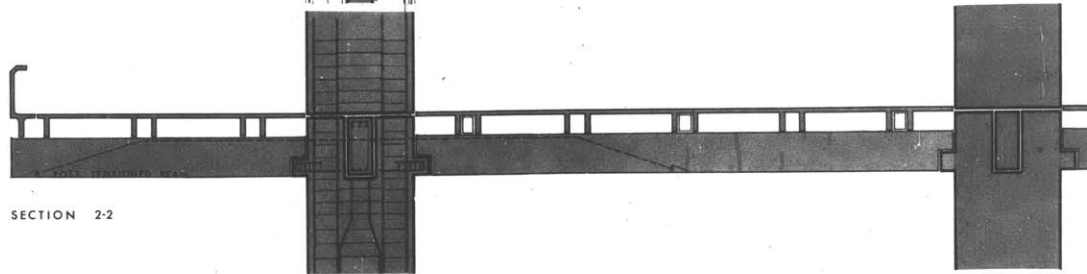
0 25 50

AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS

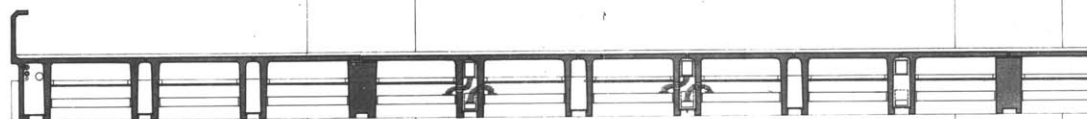
GAJINDER SINGH MASTERS THESIS 65-66



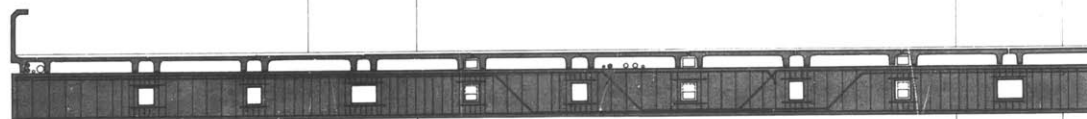
SECTION 1-1



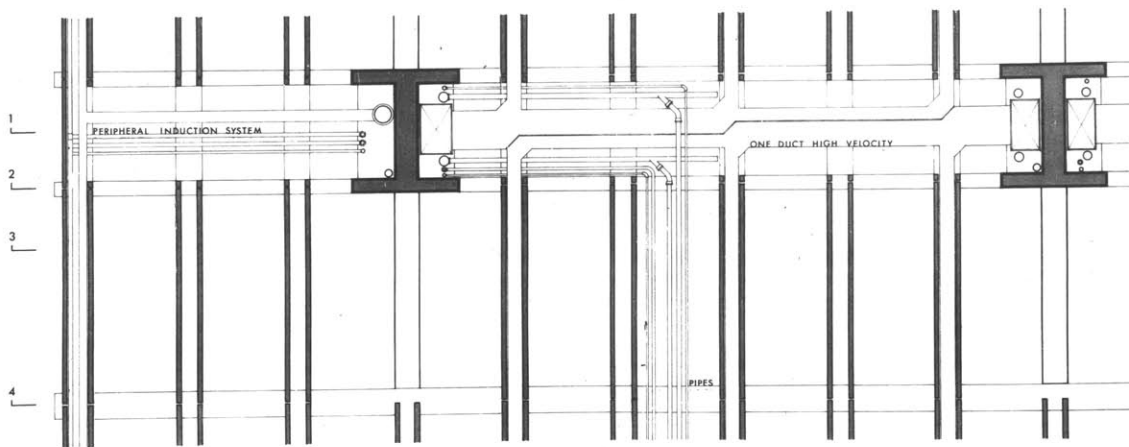
SECTION 2-2



SECTION 3-3



SECTION 4-4

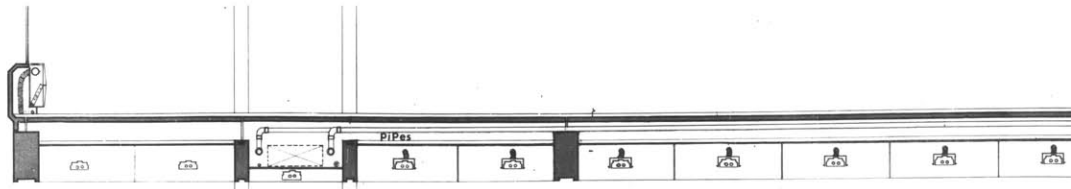


STRUCT. & MECH SECTIONS

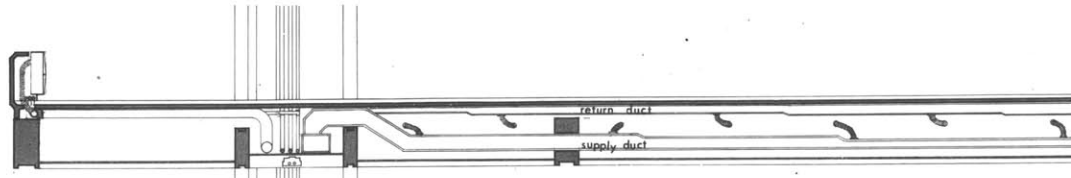
AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS

SCALE
0 5 10

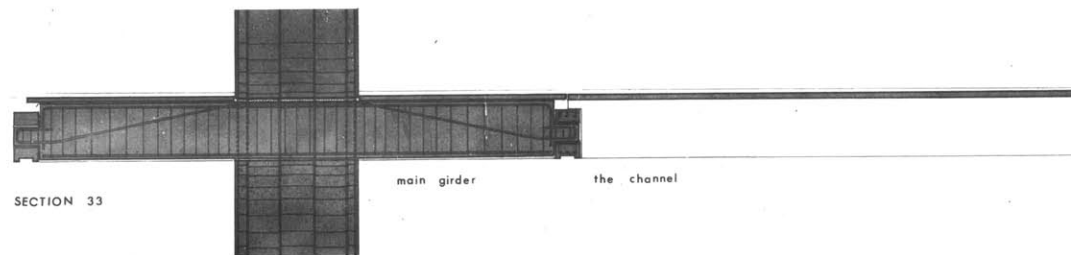
GAJINDER SINGH MASTERS THESIS



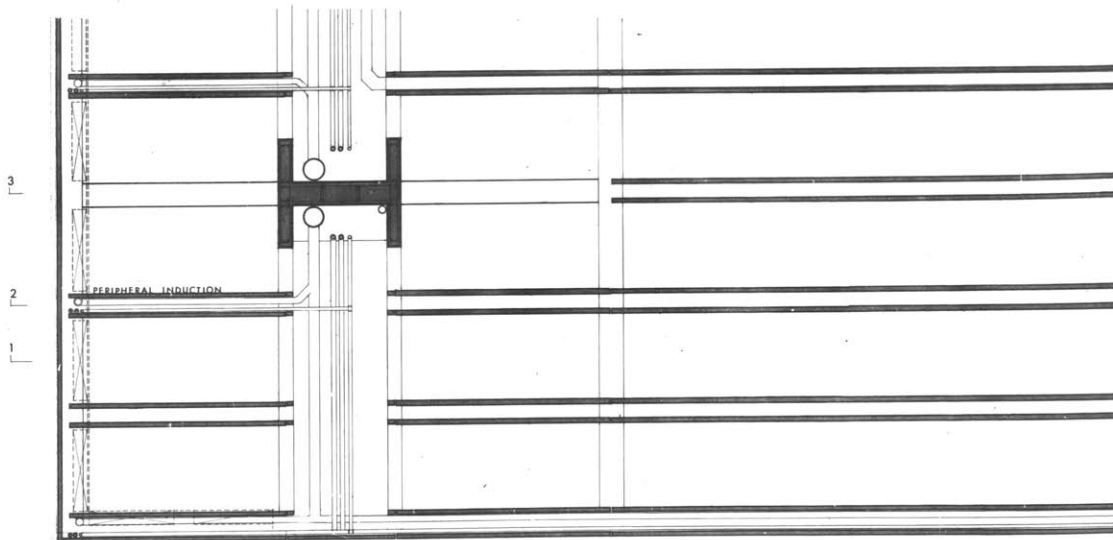
SECTION 11



SECTION 22



SECTION 33

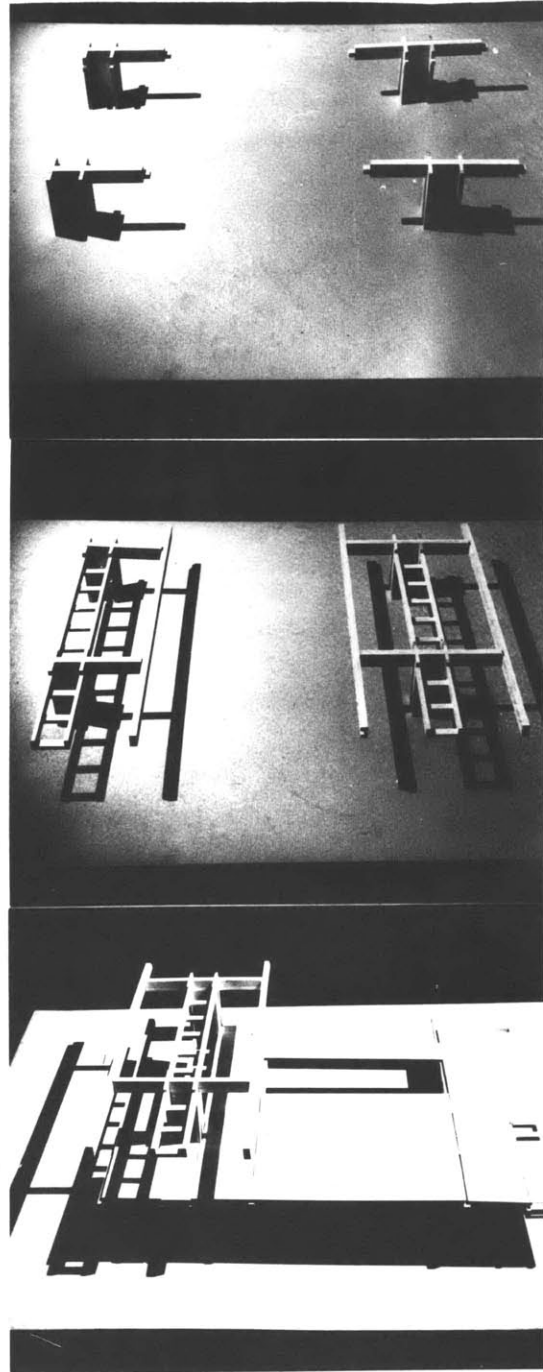
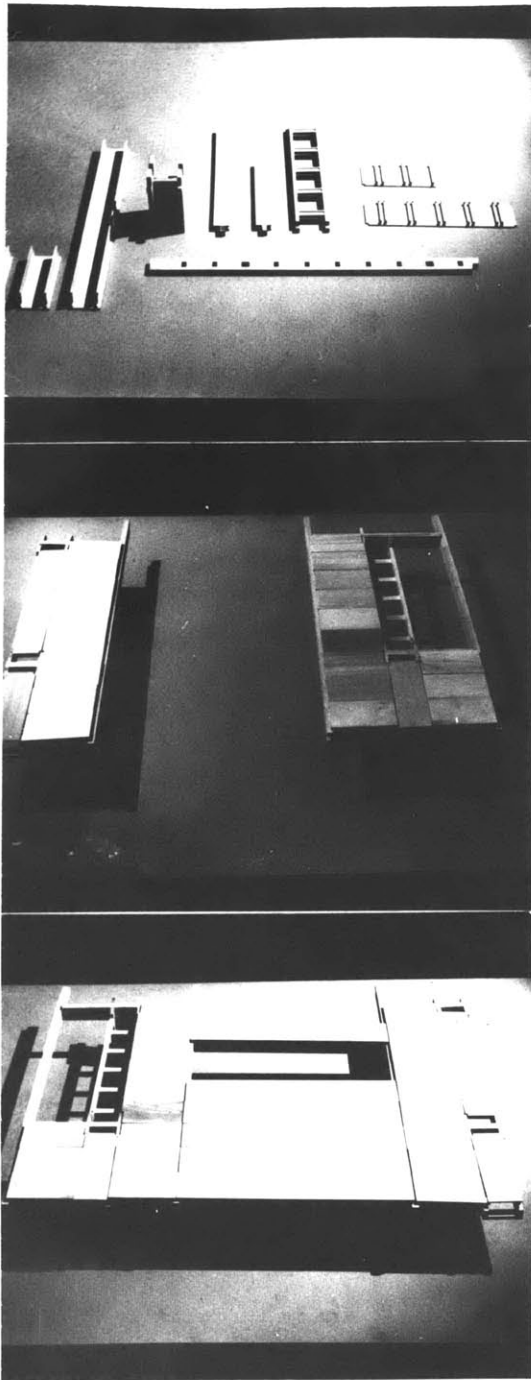


STRUCT. & MECH SECTIONS.

AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS

GAJINDER SINGH MASTERS THESIS

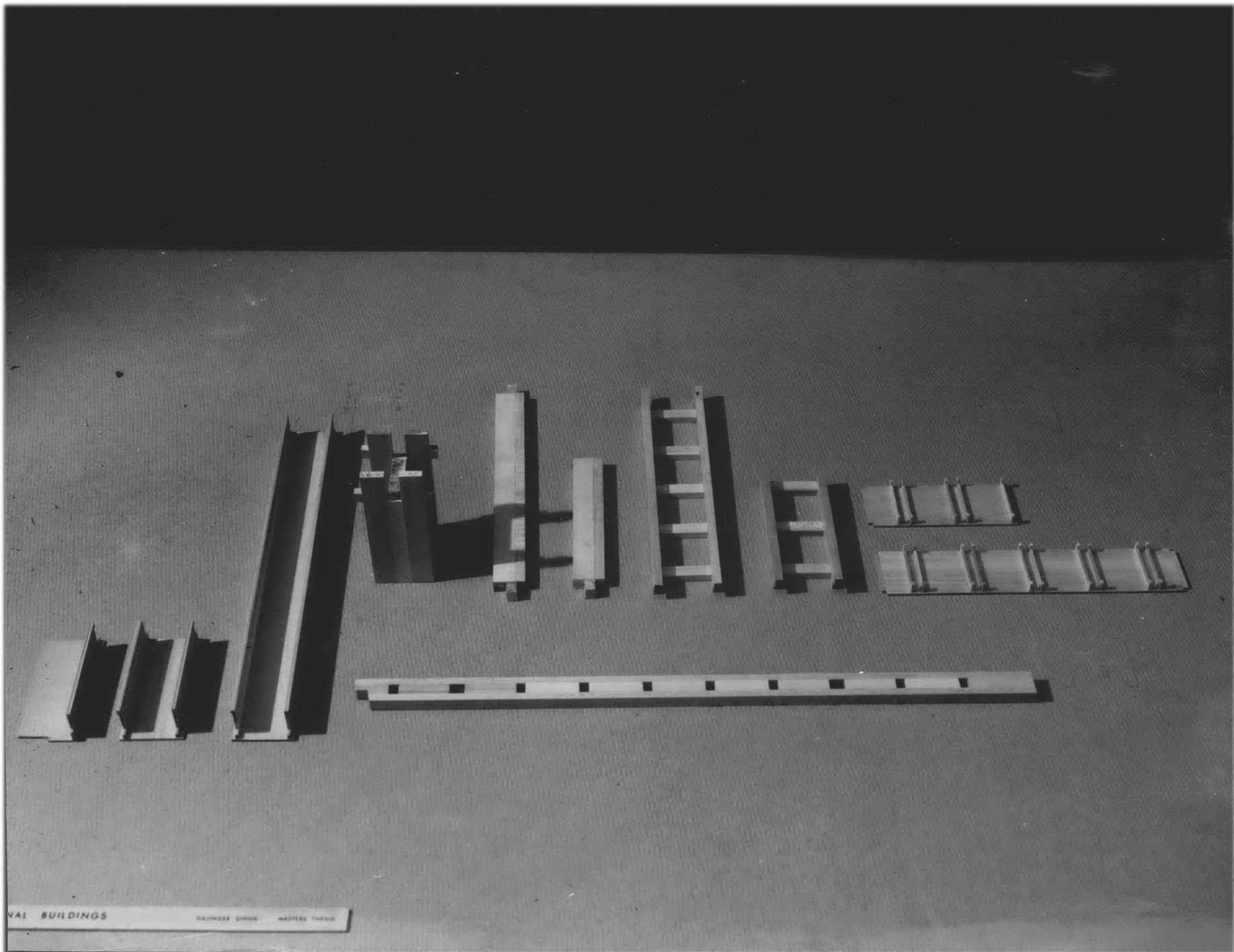




THE ELEMENTS & CONSTRUCTION SEQUENCE

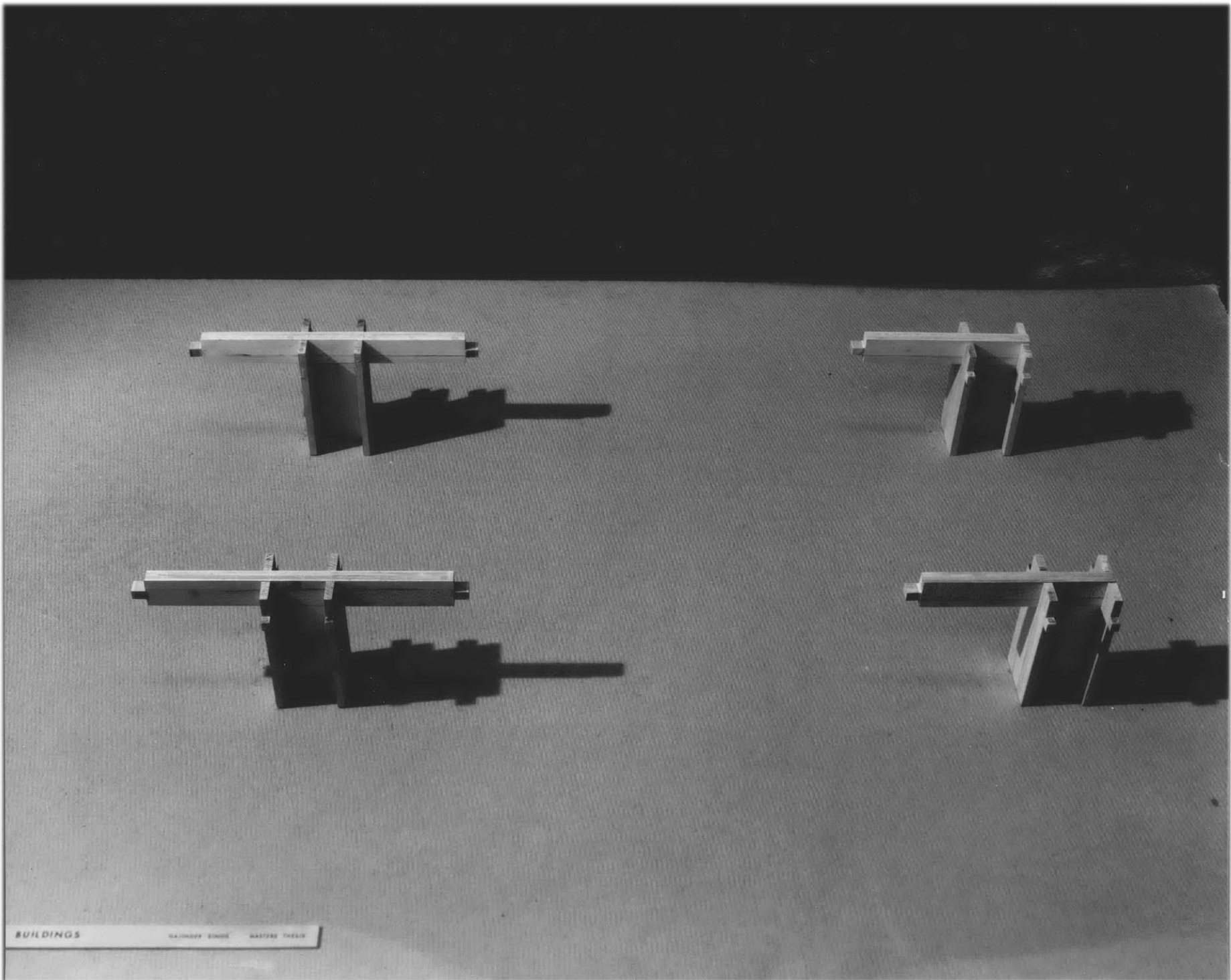
AN INTEGRATED SYSTEM FOR EDUCATIONAL BUILDINGS

GAJINDER SINGH MASTERS THESIS 05 06



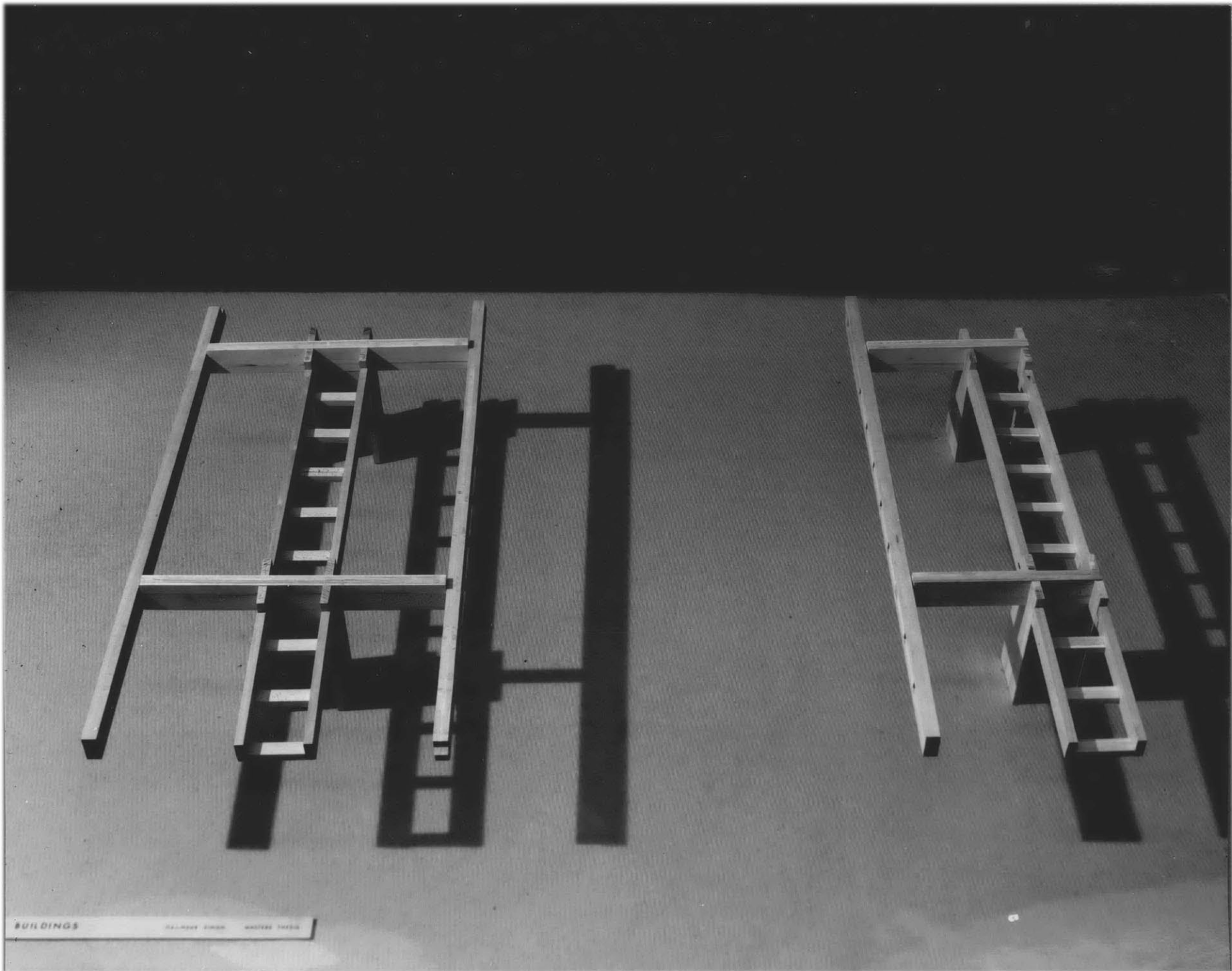
VAL BUILDINGS

GAJINDER SINGH WATERS TAPAL



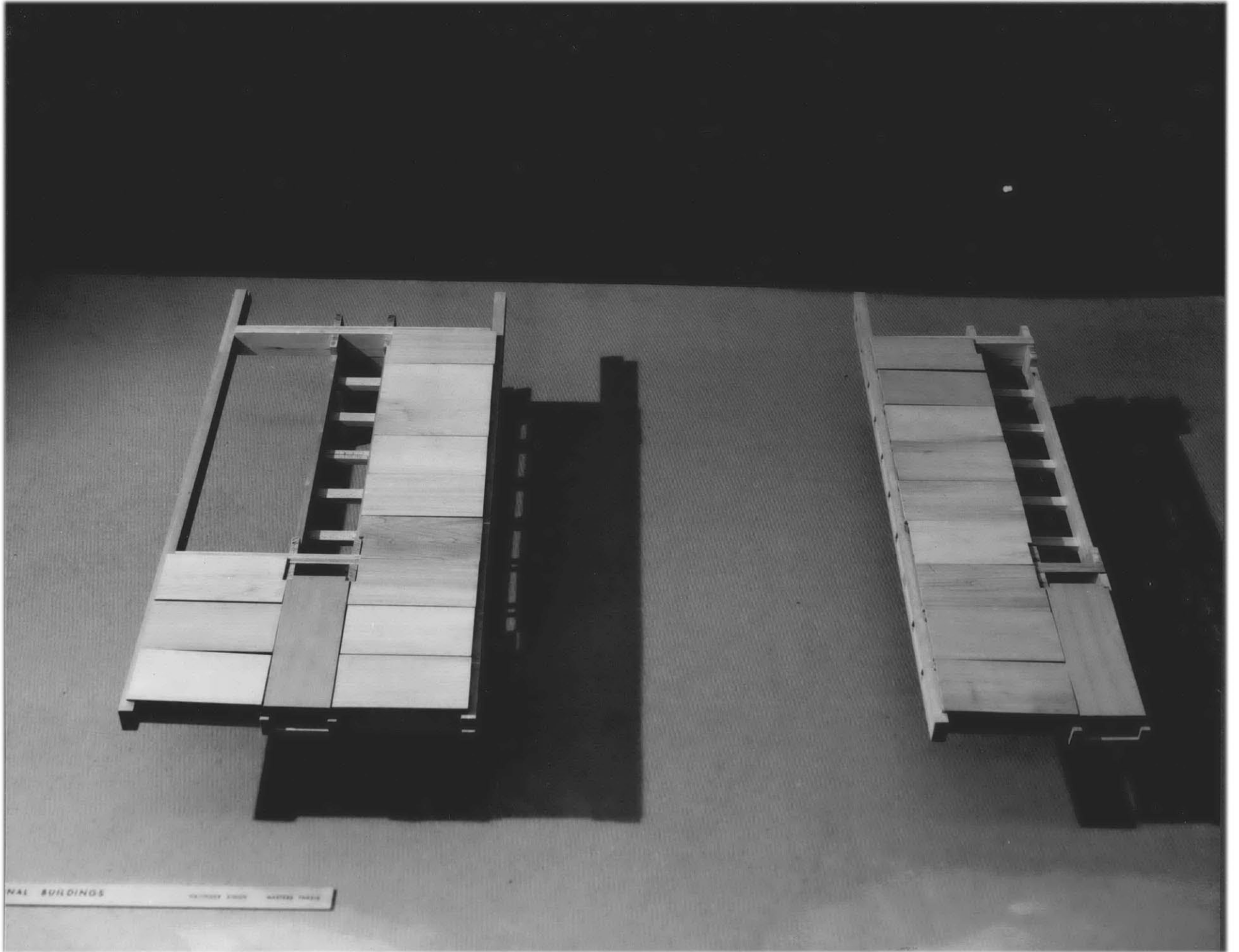
BUILDINGS

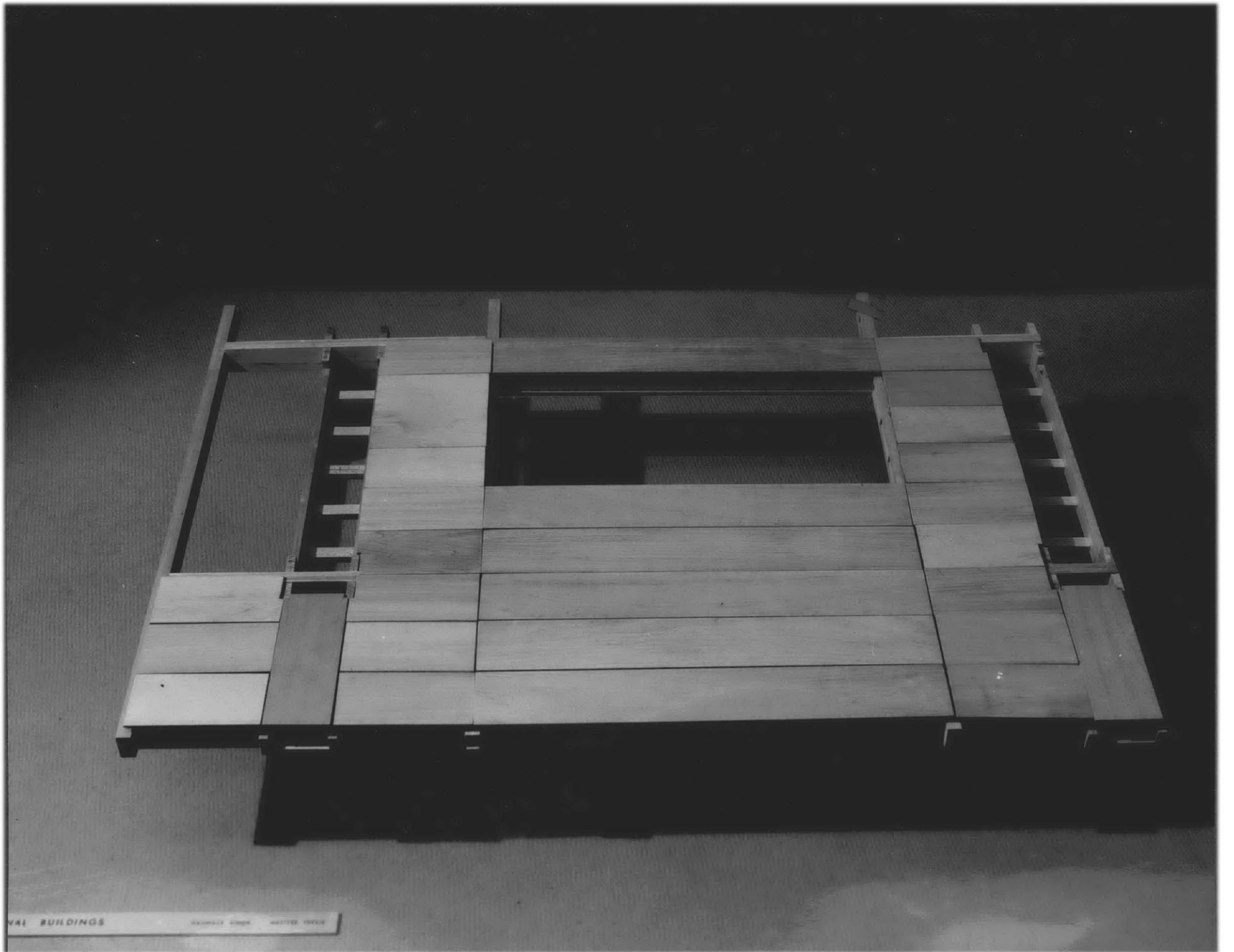
WALTER GROSCH WALTER TRULY



BUILDINGS

WALTER GUNDEL WALTER GUNDEL





VAL BUILDINGS

BRUNNEN STRASSE 100 10000 BERLIN

