



A BUILDING SYSTEM BASED ON GROWTH

by

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B. Arch (Hons) University of Roorkee (India) 1964

Submitted in Partial Fulfillment
of the Requirements for the
Degree of Master in
Architecture
at the
Massachusetts Institute of
Technology
June, 1965

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Accepted by.....
Chairman, Departmental Committee
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Submitted to the Department of Architecture on June 15, 1965
in partial fulfillment of the requirement for the degree of
Master in Architecture.

The objective of this thesis was to study the building
as an integrated system of space, structure and services.

The factors influencing this study of buildings as
systems was analysed and the constants determined. The
emphasis was then to study the integration of these factors
into evolving an organisational unit; an organisational
unit which recognised the factors of expansion and growth.
Detailed study was carried out on the individual elements
thereupon arriving at a "building system based on growth,"
for a prototype space research and development building.

Thesis Supervisor: Eduardo F.Catalano.
Title: Professor.

June 15, 1965

Pietro Belluschi, Dean
School of Architecture and Planning
Massachusetts Institute of Technology
Cambridge, Massachusetts

Dear Dean Belluschi:

In partial fulfillment of the requirements for the degree
of Master of Architecture, I hereby submit this thesis
entitled "A Building System Based On Growth."

Respectfully,

Jasbir Sawhney

ACKNOWLEDGMENTS

The author wishes to thank the following
whose assistance and advice contributed
substantially to the thesis project:

Mr. W. Zalewski

Prof. Eduardo F. Catalano

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INTRODUCTION

"Despite man's unprecedented progress in industry, education, and the sciences, the simple refuge affording privacy and protection against the elements is still beyond the reach of most members of the human race.

One reason for this lag is the population surge that has more than doubled the world's numbers in a century, a population rising by fifty to sixty million annually, where by the year 2000 A.D. an estimated six to seven billion people will somehow have to be housed."
Charles Abrams

Along with this formidable Herculean onrush of people, we also have a rapidly industrialising world. Although this industrialisation does bring progress to man it also unloads numerous problems for the architect. We have yet to cope with the automobile, the rapid urbanisation with the new influx of peoples, the rapid growth and decay of our cities, the suburban sprawl. With further economic progress new undertakings have sprung up at phenomenal rates - thus today all at once the architect is plagued by a constant stream of problems and to a great extent is confused as to how to approach them. For now members of society have begun to voice dissatisfaction.

"...breathing foul air, swimming in polluted waters, suffocating in crowded subways, enervation in traffic jams and so many nuisances of our civilisation make life not only unpleasant but also detrimental to the physical and mental well being." Progressive Architecture

With this host of problems it is not difficult to deduce that we have an inadequate approach towards

solving our problems.

Traditionally the architect was a member of the elite, trained to serve that particular section of society. With both the industrial revolution and social changes our society and mode of thinking has altered greatly, but architecture yet is practiced in the same manner. Individuals (architects) are yet trying to serve the individual at that particular level, in contrast to serving the whole society.

In the world today the total building activity controlled by the architect is around 2%. This inevitably indicates two things:

1. The acute shortage of architects around the world
2. The need for the architect to enlarge his sphere of influence and activity.

The architect yet continues to perform his duties in a manner antiquated by industrialisation. The architect handles each problem of construction as a unique problem - namely, custom designed. Such a process not only means a continued wastage of time and effort, but also the added expense involved in both design and construction. This attitude can only be financed by the privileged few of society, thereby permitting the other members to contribute chaos to the scene by engaging lesser trained individuals.

In order to fully realise the potentials of the age it is imperative to recognise the merits of industriali-

sation. This involves design and research leading to standardisation, modular coordination and mass production. Thereby available to the consumer as good design, in available supply at adequate prices. This seems to be the only manner in which architecture can have a wide enough influence.

As we undertake to industrialise the building industry, we notice the dire necessity to bring architecture to the realm of a scientific order, organisation or system.

The existence of a system in the world is at once obvious to every observer of nature, no matter whom. Upon examining a plant, we see the organisation of its various parts, we study it under a microscope and see its organisation of cells. Similarly upon examining crystals we notice a similar organisation. The cell is the basic unit of the organisation at a particular hierarchial level.

In all systems we come across this particular phenomenon; therefore upon approaching architecture it also becomes necessary to define its cell, or a unit. This cell is usually defined by certain forces which are prevailing (in equilibrium). Similarly we need to bring to realisation the forces which would determine the principles of organisation in buildings.

In buildings we find three distinct constants (forces) - space, structure and services.

Thus studying buildings in a more organised sense

we see them as an integrated system of space, structure and services.

With the vast explosion of knowledge and the research available in all spheres of science and technology, it is expressly important to undertake greater strides towards creative engineering to advance building technology.

We are well aware that certain forces come into play and the embodiment of these forces we call form. Thus in order to create new forms we must understand these forces, the mechanics, the structure. There exists an order and we must comply with it, we need to understand the validity of our forms as a system of forces.

The master mason of historic times understood the forces which governed his materials, this gave him insight into the forms he had to create. With the advent of steel and concrete the architect lost contact with this aspect of his training, he became an artist, far removed from the forces which determine his forms. He left this to the engineer. Today we have an acute specialisation of the architect. He is less aware of construction and technology, and thus it becomes difficult for him to communicate with the engineer.

Thus I believe there is a great future for architecture if we give way to these two cultures of the humanities and science - for we need to bridge the gap.

Franklin Ford says of culture

"implies the most ambitious and most exacting intellectual effort and aesthetic endeavours in every discipline. Thus defined it also presupposes at least some exchange among the disciplines, some reciprocal curiosity and appreciation. In short, it necessarily involves a continuous tension between the centrifugal thrust of specialisation and a centripetal tug towards synthesis, towards the central area of shared concerns, what is worrying us now? Is it not precisely the suspicion that the centrifugal has triumphed over the centripetal, that the essential tension has disappeared and with it culture."

And this brings us to the important fact, said by Dr. Radhakrishnan, President of India, "Today we have knowledge, but no wisdom."

Wherein architecture must emerge as a more comprehensive undertaking, out of the mists and myths of the aesthetic.

BUILDING TYPE

To design a prototype 'research and development' building requires the allocation of space for both simple and complex uses. In particular it means the flexibility of space, structure and services. By flexibility of space we mean large areas unobstructed by fixed elements, subdivided by partitions into modular increments. Structural flexibility allows both major and minor revisions to occur in the building. Flexibility of services encounters the modular supply and complete control of all services throughout the building.

This type of building requires a large area devoted to parking of automobiles, which means the spacing of columns should be sympathetic to automobile dimensions.

In consideration of the unpredictable nature of much of today's research, with respect to the work being performed, the principal shortcoming in the design is that as additional space is added to the building it is usually in large increments. This creates a situation in which there is a lack of adequate space before the expansion takes place and a surplus after. This is a primary problem - to provide for their growth due to new spatial needs.

PROPOSAL

The site for the prototype 'research and development' building was assumed to be in open country.

Research establishments, especially of this size, have found it a popular choice to move away from congested urban areas.

The building is due to be a low development varying from one to five stories, the emphasis being on horizontal growth.

To begin with it was necessary to choose a module as the basic of a planning grid. It is found that a five foot square module would be most effective. This would provide adequate flexibility in planning of spaces and partitions and also would provide adequate space for fixtures and services.

In order to incorporate the finding that such a building must have the facility to grow, it became imperative to study growth forms. The contemporary 'box' type building is one which does not lend itself to additions, the only addition being one of another new building. When one studies nature, as mentioned before, one notices the conglomeration of cells or units. There is a basic unit or element which groups itself in various ways to form various types of plants. Similarly it should be possible to create a unit in buildings, which when grouped with others in various ways would form various buildings, with a growth potential.

It was necessary to consider units of growth following a rectilinear geometry, so as to facilitate the use of contemporary elements of buildings. In defining a unit it was necessary to arrive at certain distinct criterion, such as size and shape along with services and structure.

The size was found to be approximately 20-30,000 square feet which would be adequate as an increment to an existing building. Such an element also would be able to support the essential services necessary, and contain its own independent structure with moderately large spans to incorporate flexible spaces.

With the services in the centre, from where they would be equidistant to all points, we needed to define a limit to their served area. This became obvious considering the fire stair code regulations - whereby a radius of 120 ft. was chosen. Thus the unit was now a circle of 240 ft. in diameter with the services in the centre.

In order to once again relate to the rectilinear geometry it became necessary to further define the circular unit, and it came to be decided to choose the pin-wheel. (The pin wheel is a form which facilitates growth, especially due to its assymetrical form.)

One of the requirements of the growth pattern was to execute an addition with the minimum alteration to

an existing condition. This condition was also adequately satisfied by the 'pinwheel' form.

Upon finalising the choice of the pinwheel as the form of the unit, it became necessary to give it structural embodiment, with service facility. The centre would be the location of the core which would be a self-supporting element containing vertical transportation and circulation elements, service rooms, duct and shaft space and rest rooms.

The building was designed as a composition of these units. In such a building the space allocation is in constant flux, also the services are due to change from time to time. Thus it is concluded that the elements of construction remain as the true expression of the architecture and determine its character.

STRUCTURAL SYSTEM

The structural system is a two-way cast-in-place and precast, prestressed structure. The floor system is made up of precast elements while the columns are cast-in-place. It became necessary to choose a cast-in-place system for columns due to their varying thickness on floors and the avoidance of heavy lifting equipment. The precast floor units facilitated easy handling with ^{out} heavy lifting equipment.

In a unit the self-supporting core occupies the centre, the structure around it is a continuous floor system on a 5'-0" modular grid with columns spaced at 45'-0". At the periphery a 15'-0" cantilever is used for two benefits:

1. It reduces the positive bending moment at mid span.
2. It permits additions (growth) to take place adjacent to the existing building without interfering with existing column foundations. It eradicates the duplication of columns at a point which would occur upon an immediate expansion.

Prestressed concrete was chosen as the material and the use of prefabricated elements was encouraged. The advantages of prefabrication for a building of the nature are numerous. This being a prototype building, it would be

used extensively over a region, and this would encourage centralised production of components. Also the quality control and efficiency of production at a prefabrication plant are greater than at site.

A prefabricated system for 45'-0" spans in two directions was to be designed; it was necessary therefore to subdivide the bay into smaller subdivisions. 5'-0" was suitable for such divisions because it would provide an adequate structural module for the position of partitions. Thus it was necessary to design an element of a 5'-0" x 5'-0" dimension.

For a prestressed concrete structure of 45'-0" span it was found necessary to limit the depth of the structure to 1/15th of span. We therefore require a 3'-0" deep structure. This depth is somewhat shallow for the volume of services due to be run within the system. Thus it became necessary to design a mechanical system in conjunction with the 3'-0" deep structure. In such a case it was necessary to provide maximum sized openings at the midspan and lines joining columns. These would carry the main ducts.

In arriving at a solution the emphasis was upon recognising the

1. Direction of forces
2. 5'-0" modular subdivision

3. Use of maximum repetitive units
4. The position of main ducts
5. Simplicity of elements in casting and erection.

A simple and effective system was evolved which recognised these factors, where the units around the column express by their shape and direction the transfer of loads to the column. The load is a maximum at the column, therefore the units at the column have more concrete. This implies the use of two types of units. The shear is minimum at midspan, therefore enabling the facility for the largest void for the services.

The unit is simple to cast and the erection procedure is time saving. The unit is so designed so as to avoid threading of post tensioning cables. In this way the erection is carried out in three phases.

1. A flat scaffolding is erected (which can be transferred to the next bay) upon which the module is marked at 5'-0" intervals. The lower chord units are positioned within each 5'-0" x 5'-0" square. The cables are laid out. The floor units are then positioned.
2. The system is post tensioned.
3. The top slab is poured and the structure is grouted.

MECHANICAL SERVICES

AIRCONDITIONING

The system used was the use of columns as supply shafts and return ducts via the core. The columns were found suitable for supply ducts in this type of building due to its extended periphery. To use the column for return ducts would require 10'-0" x 10'-0" columns which was too large for a 45'-0" span. Therefore the return ducts are in the cores.

The air handling units are placed in the basement, since the building is of varying heights and plans, and feed is via columns.

The high velocity supply system can be fed to a diffuser at every alternate module, similarly the return grille is at every alternate module.

PLUMBING

Flexibility of location of plumbing services, both supply and removal is provided with the use of wet column. Each column serves an area of 45'-0" x 45'-0".

ELECTRICAL and TELEPHONE SERVICES

The electrical and telephone shafts are provided in the core, from which they serve every 5'-0" x 5'-0" module using raceways in the floor.

The artificial lighting is also provided, as in airconditioning, for every alternate module.

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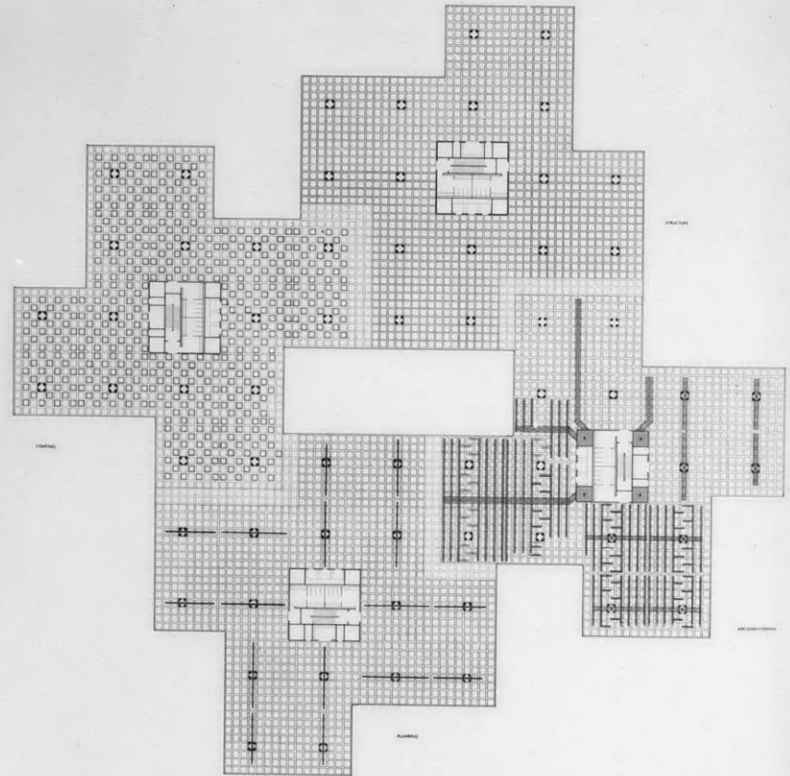
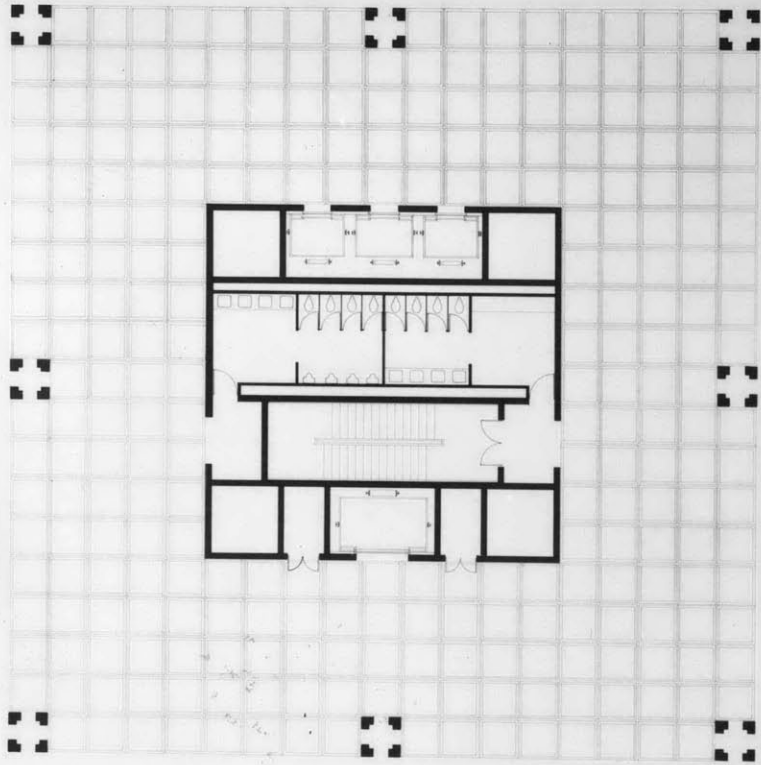
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ENTRANCE LEVEL PLAN


1

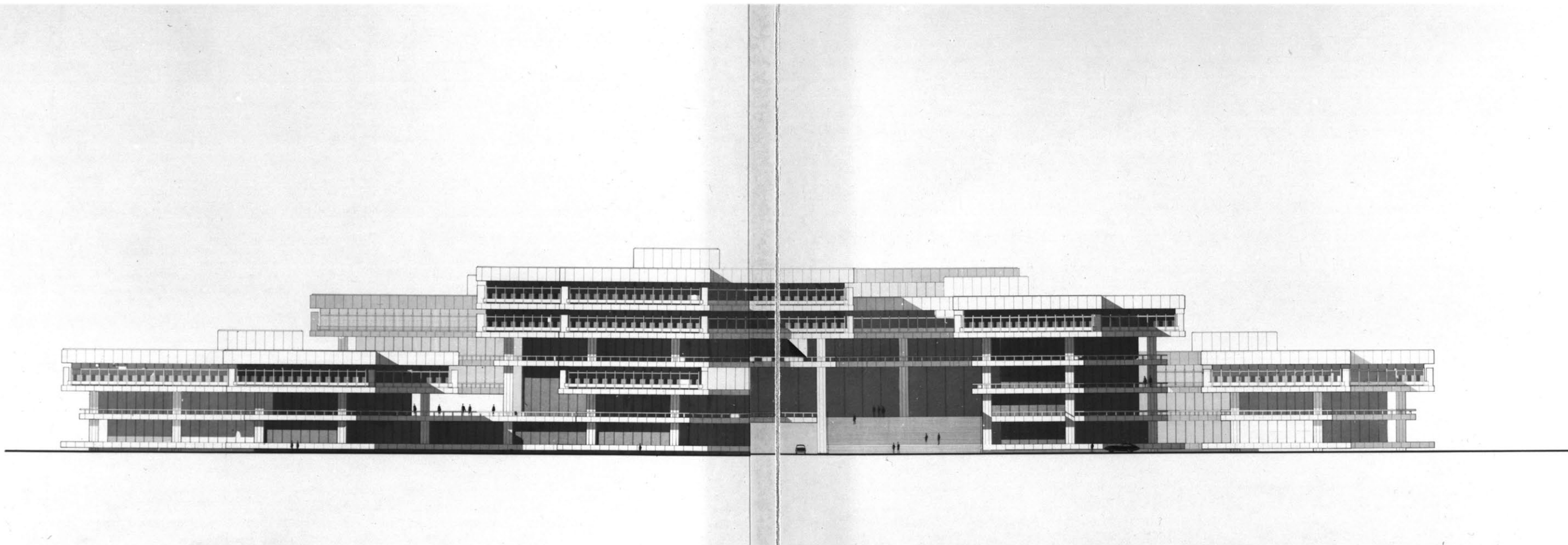
A BUILDING SYSTEM BASED ON GROWTH FOR SPACE RESEARCH LABORATORIES
MASTER IN ARCHITECTURE, THESIS ONE MASSACHUSETTS INSTITUTE OF TECHNOLOGY JULIUS SHARINNY

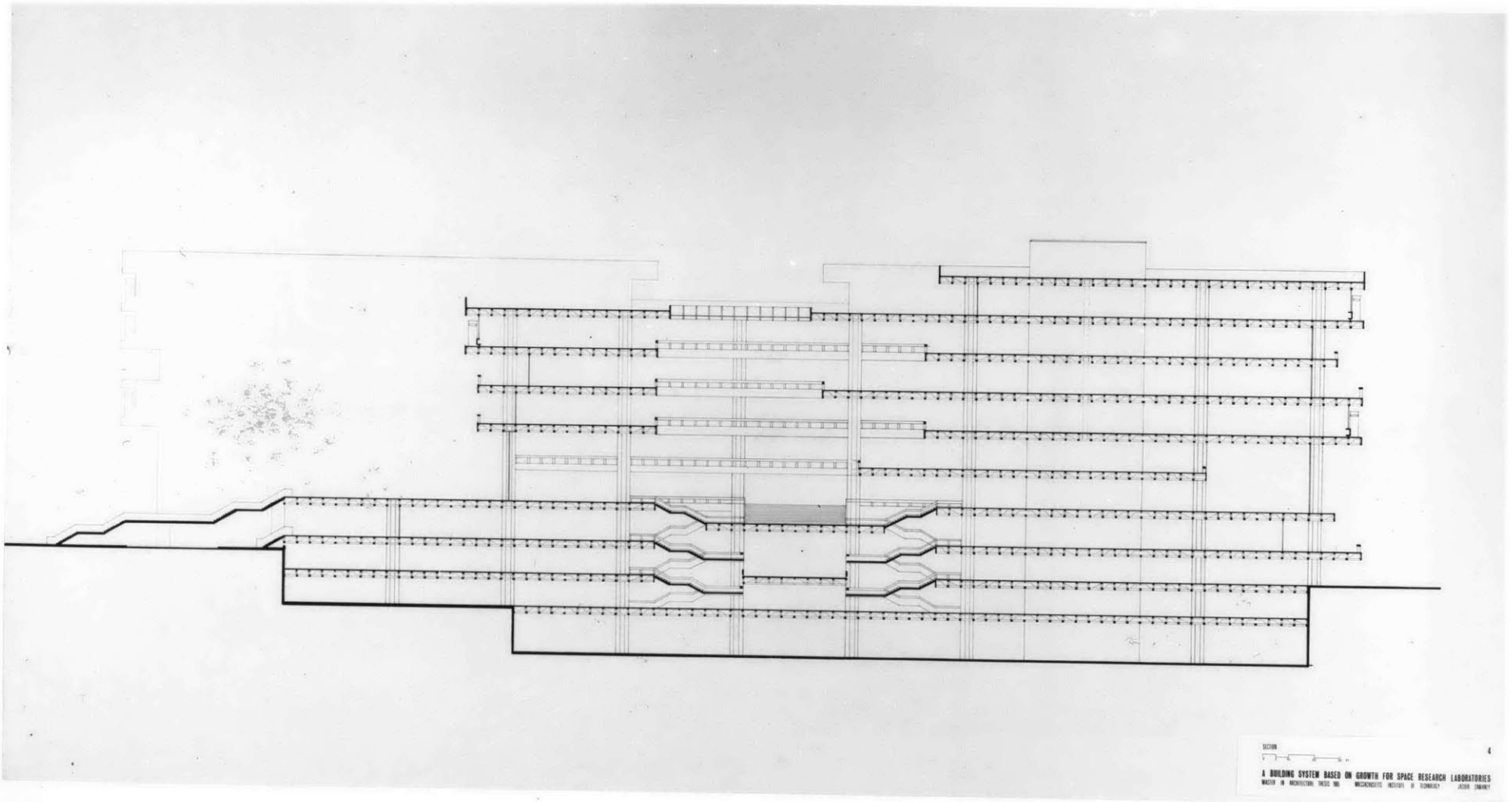


UNIT OF SYSTEM



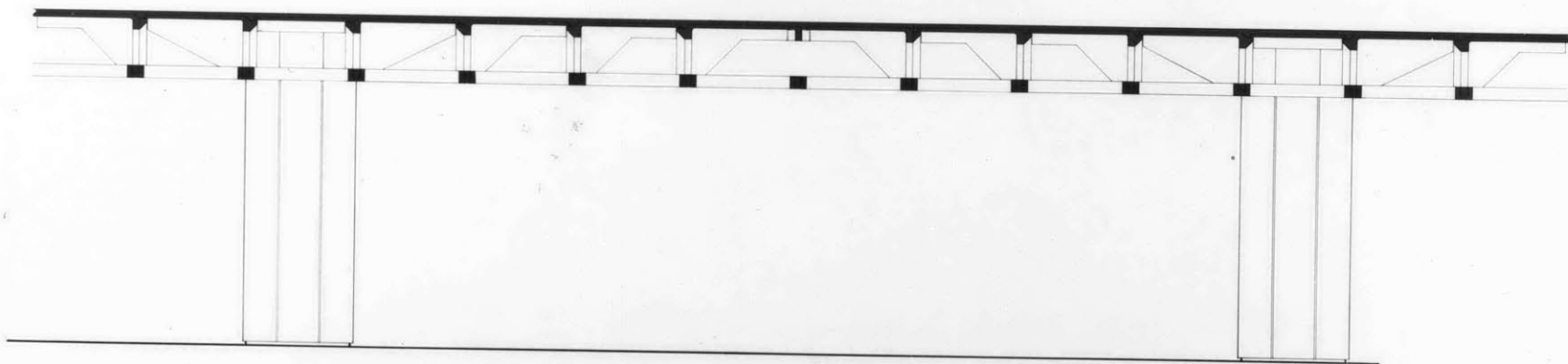
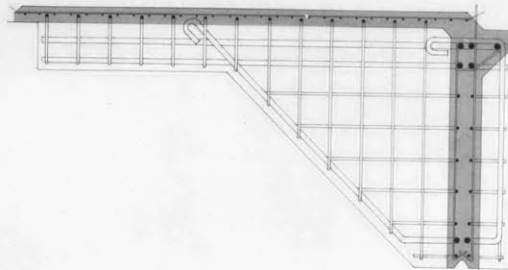
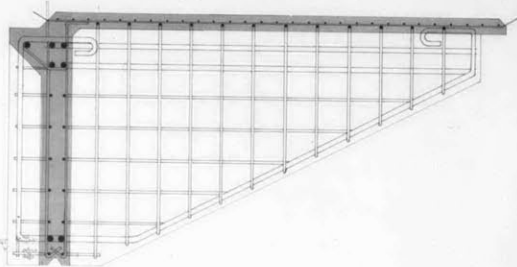
A BUILDING SYSTEM BASED ON GROWTH FOR SPACE RESEARCH LABORATORIES
 WITH A MODULAR CELL IN BACKGROUND METHOD OF CONSTRUCTION JOHN JARVIS





SCALE

A BUILDING SYSTEM BASED ON GROWTH FOR SPACE RESEARCH LABORATORIES
MADE IN AMSTERDAM, 1963 NO. ARCHITECTURE SECTION 10 UNIVERSITY JOHN VAN DER



STRUCTURAL DETAIL
A BUILDING SYSTEM BASED ON GROWTH FOR SPACE RESEARCH LABORATORIES
MADE IN BRITAIN

