

BUILDING SYSTEMS DESIGN FOR HIGHER EDUCATION FACILITIES

by

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June, 1967

Lawrence B. Anderson, Dean
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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 Systems Design for Higher Education Facilities".

Respectfully,

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Laszlo Imre Nemeth

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The new age is indeed a challenge to the architect. Rapid growth with its concomitantly rapidly changing value systems make the architect face formidable problems which demand the exploration of new and meaningful solutions. This project is concerned with the development of an organic set of systems reproducible in any juxtaposition relative to the variability of three factors - site, program, existing structures.

Programmatic requirements applied to the system are the accommodation of college and university functions, normally found in classroom, lecture hall and laboratory. The final intent of the second semester is to test this set of requirements in a real situation, that is, to subject the system to utilization that will improve the contemporaneous haphazard blossoming of educational facilities. Ultimately, as it is inherent to it, the system will direct further growth.

PROGRAM.

The problem advanced is the design of a building system of construction that is capable of flexible expansion, growth and change that would accommodate the various departments of a college or university. This system is to accommodate any type of space up to a medium sized auditorium or cinema.

The programmatic restrictions are self- imposed, or set secondarily (by consideration of width, parking space under the building, elevator and fire exit regulations, etc.); therefore, the building which will arise can take any size or form. On the other hand, certain restrictions are evident from the outset. In accordance with code requirements, the exits, elevator capacities and toilets are calculated on (150 ft²) gross area per person. In addition to these requirements, the building would have to provide space suitable for the following activities:

1. classrooms
2. laboratories - industrial
research
testing
3. workshops
4. seminar rooms
5. small auditoriums
6. studies
7. drafting rooms
8. departmental libraries
9. administrative and staff areas

10. faculty and assistants' offices
11. lounges
12. restrooms
13. exhibition spaces
14. storage
15. maintenance
16. mechanical equipment
17. parking

CONCEPT

The resultant design is limited in its height by one factor - the size of support.

Internal flexibility and ability to expand are major considerations. Large and small spaces could be used for a variety of purposes at any given time. Expansion may occur within the building itself, that is, there may be shifts in the spatial needs of various departments within the building. Consequently, it must be possible to introduce partitioning into large spaces. The design of systems of this nature are rooted in the modular proportioning of spaces. The module developed in this project is dependent upon a number of considerations. Primary consideration was its fitness to function, in this case, that of educational facilities. The module was obliged to respect the ordering influence of systematic development, to accord fully with today's technology of construction and to recognize the demands on mechanical services (air conditioning, illumination, communications, power) as

use of spaces change.

SOLUTION

Construction and Structure. Inherent in the very nature of the university is the fact that its growth can have no finite limits. This idea was an important factor in the solution. The basic unit has a self sufficiency - geometrically, structurally, and mechanically. This unit is based on the core which is the permanent element in the building. There is a hierarchy in the components of the structure. Columns, girders, main mechanical branches are more permanent than the secondary elements - beams, joists, mechanical fixtures. The secondary elements are readily accessible for service. That the buildings permit their easy expansion and removal is essential.

Construction speed was kept in mind as an economic consideration in view of two factors - limited human resources and interference with the existing life around the building. The system is designed to be built entirely in precast concrete, except for special situations such as footings, cores and topping. Precast, prestressed concrete was chosen for the best appearance and most efficient use of materials. It can cope better with shrinkage and creep; the minimized effect of stress variation prolongs the life of the material. Its high

cost relative to other materials will be balanced, however, over an assumed large quantity of units needed.

A one-way system was selected for the following reasons: a one-way system is more flexible inasmuch as structural continuity is not required; a one-way system is more efficient over a given way and uses less materials; moreover, the one-way system has less critical connections than the two-way system.

The structural system is a very simple arrangement of double girders and columns, which can either be precast on the site or be delivered from the factory and assembled by cranes. First, the upside-down L-shaped column girders are erected with a long central connecting unit which serves as a guide for attachment and reaches a few stories in height. When the column girders are in place, a simple supported girder 30'0" long is placed between them. The connection is made at zero moment, at the length of the L-shaped rigid column girder. This arrangement facilitates longer column-to-column spans as well as lighter cross sections of the girders.

With the columns and the girders in place, the simple spanning members are lowered onto the two parallel girders and the erection of the floor is completed.

The 60'0" long spanning members are in the shape of an inverted "Y". The shape is the result of the analysis of the relationships of the supporting and service elements. The

standard "T" section affords an equal amount of depth to both the visual and the service parts of the ceiling. The inverted "Y" shape reduces the visual part while greatly increasing the mechanical service part of the floor structure. The shape is derived from the structural analysis of the "T" shape where the lower leg of the "T" is simply spread and pretensioned with high strength steel wires. As for the upper part, it remains practically the same as the "T" when the topping diaphragm is poured, only to become stronger by forming a series of parallel box beams all integrally connected. At every 5'0", the dimension which is the optimum condition for the structural and modular breakdown of the interior spaces, the spanning member occurs. To prevent further spread, there are diaphragms inside the spread legs of the "T". This diaphragm creates a modular ceiling pattern, which incorporates all mechanical and lighting equipment, and receives the interior partitioning. The cores are cast in place as the permanent elements of the structure. They act as wind bracing with the reinforced topping slab which acts as a diaphragm against the cores.

The building height is limited only by the size of supports. The ten stories are considered as the optimum condition.

Mechanical Systems. The primary aim of the design was to develop an integrated framework of structures and services that would permit the use of several different mechanical systems depending on the development of the technology of the future. The mechanical system is fed from the cores, independent of the structural system. This I felt was necessary because of the changeable nature of the structural system. The design premise was based on the minimum planning module of 5'0" X 10'0", the smallest room that would require supply or return of air, light, plumbing, power and communications, and acoustical control.

The source of all these services would be the mechanical room adjacent to the core, either in the penthouse or in the basement.

Air Conditioning. The overall system is based on a high velocity dual duct system which is brought up vertically through the cores, distributed horizontally between pairs of girders and fed into diffusers through the mixing boxes between the spanning members. The diffusers would be part of a panel that fits into the openings in the side walls of the inverted "Y's". These panels are easily removed for servicing. Furthermore, they incorporate the acoustical control. All air

supply and return ducts were calculated as to the necessary size under the given velocities. The perimeter is controlled with the same HVDD system forcing the air upward through floor diffusers.

Plumbing. All plumbing is supplied from the cores and runs in much the same pattern as the air distribution in alternate chases with the air ducts.

Lighting. Each module carries its own diffuser light fixture containing two 4 foot, 30 watt fluorescent lamps generating a 65 foot candle light level in an average classroom. Additional light can be obtained individually from the floor mounted power supply. Natural lighting is also possible by large skylight areas taken from absent flanges of spanning members.

Power. Normal 110 AC power will be distributed from the garage mechanical room vertically in core chases with a breaker panel at each floor serving each typical bay. Horizontal distribution goes through major ducting between girders to secondary conduits in the floor which run at the center of every module so as to remain free of partitioning.

Communications. Telephone distribution will be similar to electrical, using a panel board in the core for an individual bay with distribution in the floor conduits. Telephone equipment rooms would be located in the mechanical floors. Special signal, intercom and television wiring will be distributed from the cores in conduits as piping.

Acoustics. The demand for reverberation noise control is extremely important in an exposed concrete building. Reverberation is controlled by the acoustically absorbent panels in the spanning members. There will a great deal of sound diffusion inasmuch as the ceiling is not a flat plane but an irregular surface which has different sized components that operate at sound levels roughly equivalent to the wavelength of normally spoken and machine made noises.

Added absorption can be obtained by means of floor carpeting and soft furnishings. Drapery and wall coverings are also feasible. Longitudinal and transverse sound transmission is secured by the floor structure and by the exposed webs of the spanning members which provide the anchorage point for the top of the partitions attached there with resilient mounting clips.

CONCLUSION

The challenge to the architect lies only partially in the analysis of the use of various supporting facilities and the resolution of their interrelationships, as it was attempted in this project. The further challenge lies in the shaping of an environment which is efficient in, and around the building, and which will eloquently state, to those who use it and to those who only see it, that the purposes of education and the benefit of mankind are inextricably linked.

We are at the beginning of a new and revolutionary era. It is for architecture - the mirror of man's achievements and aspirations - to interpret and to interpolate the needs and the means of the era in terms of function and of form, and to combine in a unique way both the highly aesthetic and the fully practical in one working whole.

It is hoped that the system developed will be a useful tool - not a dictator - in attaining these goals.

An Urban University in Downtown Montreal

A contemporary urban university acquires sixty-five acres of land proximal to the heart of Montreal. Its purpose is to develop a new campus.

Today confronts us with a tremendous challenge - the task of the provision of a cultural and intellectual focal point for the entire community. Things that happen in a university are analogous to occurrences in a city. For example, a university is comparable to a city inasmuch as it is a place where many people work. It is a place, moreover, for research, for continuous communication, for the development of social contacts, and for the simultaneous movement of many people in many directions by many varied means. To the extent that the university emulates the functions of the city, it may serve as a laboratory for the testing of multifarious design concepts which subsequently will be applicable to all future magna scale complexes, including cities, that must be built if mankind is to survive.

In this particular instance, the development will provide the urban university the opportunity of more meaningful participation in the life of the city. In a similar way, the city will benefit from its involvement with the university. This intent - meaningful confrontation - will be accomplished not only by

psychological attitude but by the physical fact of the university as well.

The area where the university for 5,800 students is to locate is in a dense, extremely urban section of downtown Montreal. It is surrounded by four major arteries (Sherbrooke, Saint Catherine's, Peel and Guy Streets). It straddles a presently underdeveloped section of Burnside Street. The buildings located on the periphery of the site are of considerable historic importance. They are part of the long tradition of Montreal, and, more important, they establish the 'image' of the streets which they border. These buildings that sustain the life of the streets and help to structure the city will be retained under university control in their present form. Essentially, the university will occupy the area over Burnside Street, between the buildings that are being preserved.

The first floor of the university will be utilized for activities which contribute to the life and to the economic health of the city, at the same time as they fulfill the academic functions of the university. Here, commercial areas, professional offices, and services, along with public educational facilities, libraries and galleries will provide student-"city people" melting pots. To support this intention physically, this area will be a purely pedestrian one, with great variety in the character of outdoor spaces.

The complex is served by the existing subway stations at both ends of Burnside Street. Burnside Street will become a linear spine, which, like a backbone links all the various elements without itself being impeded in respect of enlargement - unlike the rigid system of various satellite centers around a concentric core. It will become a new kind of "Street" that will not rupture the texture of the city but enhance it with playful variations. There are two levels of parking under the whole complex providing facilities not only for the whole university but for the immediate neighborhood in urgent need of them.

The upper level of parking is considered a potential area of expansion for the university. The ceiling height is greater therefore on the upper level.

The first level above the ground floor is considered a platform for the major part of student movement. It is the level where students arrive directly through bridges which connect the surrounding blocks and residential districts with the university and which traverse the streets and their motor traffic. This student level will contain all the essential major spaces necessary for student academic functions but will, at the same time, be acutely aware of the availability of these functions to the general public. By comparison, certain activities tend to be located peripherally in both horizontal and vertical

positions. These are:

- 1) Teaching facilities with low density and low frequency of change-over; those which are peculiar to specialized courses of study or dependent upon frequent delivery of bulk equipment and supplies.
- 2) Such non-teaching facilities as research laboratories and offices for faculty members.

The vertical circulation is the essential connector of the movement platforms with the parking levels and the upper levels serving academic and research functions. The cores occur at regular intervals creating a strong, clearly understandable spine for the university. These cores carry the network of utilities from the mechanical rooms for horizontal distribution.

In developing this concept for the university full use was made of the structural system developed in the first semester. The flexibility of the system to adapt to full three-dimensional changes can be utilized most efficaciously in the university which is active, dynamic and responsive to the changes not only of the academic life therein, but also to the changes in society. Such a university can be a testing ground experimentation in urban environments, a manifestation of the idea of a continuous and responsive building as opposed to the fixed, object buildings of yesterday. This is one way that the university can contribute

to the progress of humanity through the exploration of physical and psychological connotations of the environment.

Growth and change will reflect a hierarchical system in the structure of the university. The cores and the circulatory system are the most permanent elements. The academic and city life is closely linked to these modes of circulation. Within the hierarchical ordering, the resulting circulation system in terms of both size and location becomes a reflection of desire lines. Like the transportation arteries of the metropolis they become more dense, more prominent and more space consuming at the core.

Sizes of the buildings around the periphery of the university, directly juxtaposed to the preserved structures will retain the existing architectural character by their sizes, their bulk and by the open spaces which they create. Moreover, the use of materials will reflect a continuation of the city texture.

All roofs are accessible as public or private terraces.

The entrances to the university are defined by architectural events which are varied in character. At the main parking entrances there is a visual connection between motor and pedestrian levels, and between these and the exterior spaces through means of light penetration. There are numerous pedestrian entrances between the new and the existing buildings which are outgrowths of plazas created from formerly useless and rather unsightly

back lanes. Irregardless of this ready accessibility, there is obvious predominance of the important arrival point, which leads to the center of gravity, the central square of the complex. This center is determined not only by its physical size and location but by the general collective activities that it serves. The hierarchy of spaces leading to the central square as the pedestrian circulation reflects the life intensity that it directly supports.

The delight and special flavor of an urban environment derive from its compaction and its contrast, established by the composition, variety and the sequence of the exterior spaces created by the buildings. The sequence of stations or plazas can serve as stations or plazas, shorten distances, provide elements of reference, provide appropriate intensity or serenity, transform lineal circulations into multidimensional movements as climaxes and subclimaxes. The spatial sequence can facilitate a maximum interaction between the life and movement of the city and the university campus.

This scheme is an attempt to discover structuring principles which might be applicable to the organization of the physical environment, The university as a place and as an active operation. Many of its functions are known; others are not. My supposition is that its principal function is to encourage exchange between people in different disciplines with a view to enlarging the field

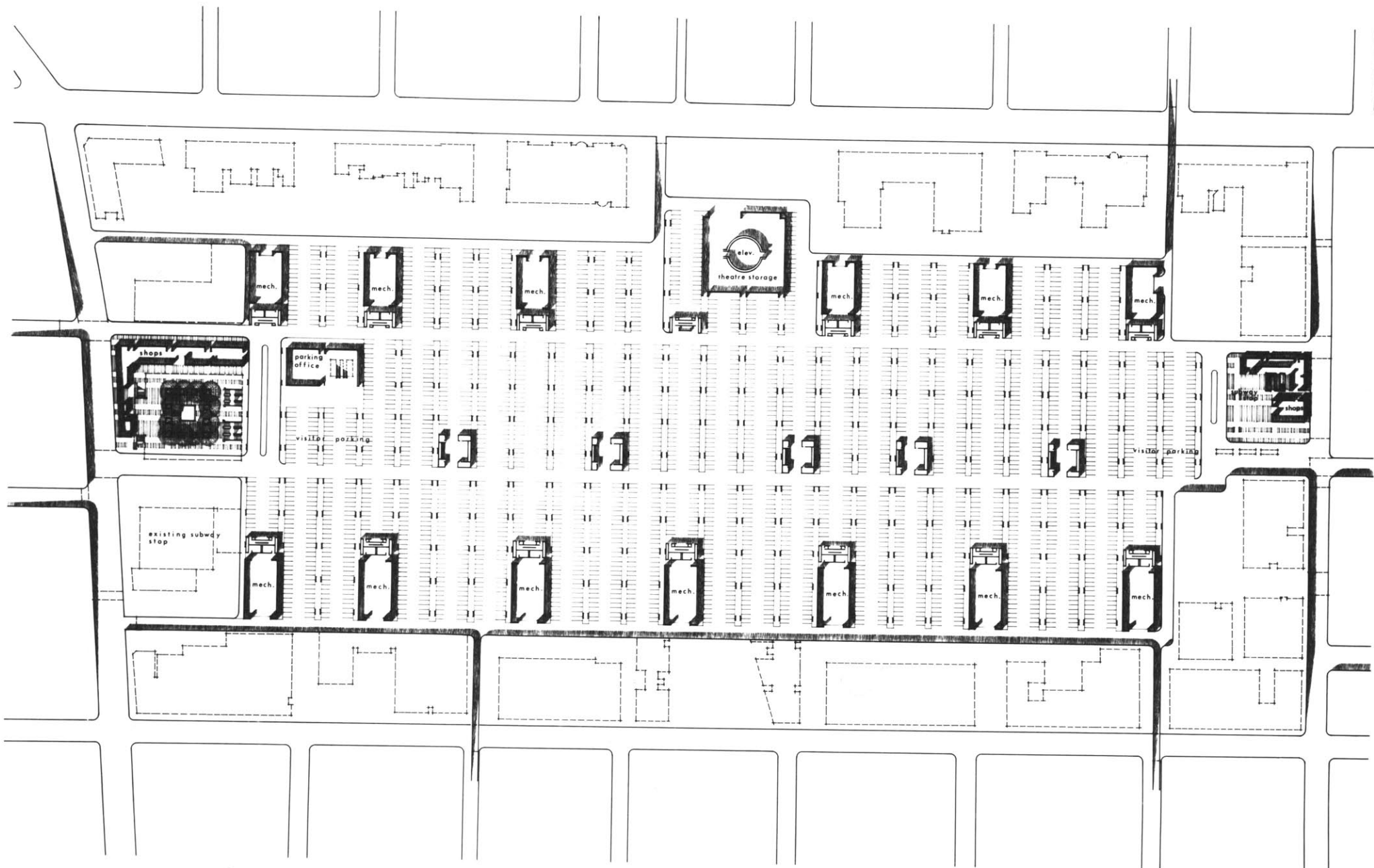
of human knowledge. I have tried to imagine a synthesis where all the faculties would be associated and where the psychological barriers that separate one from another would not be reinforced by physical barriers, where the identity of the whole would not be subjugated to the identity of the parts.

The design of the university is not intended to show precisely the location of each room. This is a temporary condition. In conformity with contemporary research, the new university must enable a many-sided collaboration of the various branches of science and arts. Consequently, in the structural planning demarcation lines between faculties have not been taken into account. The solution tends to show that the building system is flexible enough to permit within its free envelope the location and the number of rooms requisite for various purposes at any time in its life span. Experience has shown that the constant changes in educational systems - growth and the creation of new disciplines - demand a flexible system.



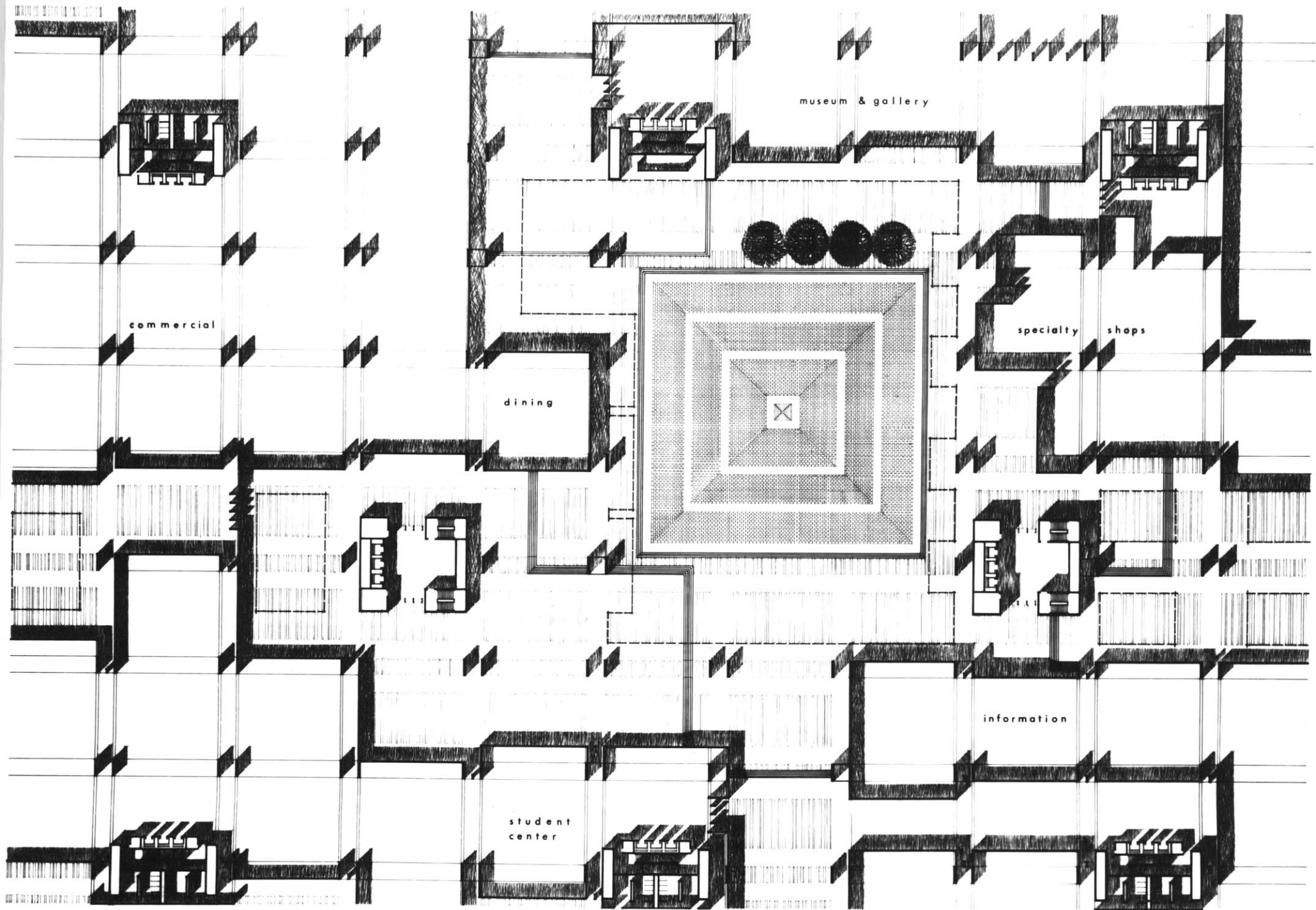
SITE PLAN

MASTER OF ARCHITECTURE
M. I. T. SPRING 1967
LASZLO IMRE NEMETH
0 50 100 500



PARKING LEVEL

MASTER OF ARCHITECTURE
 M. I. T. SPRING 1967
 LASZLO IMRE NEMETH
 0 10 50 100 300



MAIN PLAZA DEVELOPMENT