AN INVESTIGATION OF THE PROCESS OF PLANNING FOR ADAPTABILITY

by

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(1960)

SUBMITTED IN
PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE
DEGREE OF BACHELOR OF ARCHITECTURE

at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
MAY, 1971

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ABSTRACT

A theory of Environmental Adaptability is developed for application to the process of planning the physical, man-made environment. The theory develops the notion that the built environment may usefully be conceived as composed of two components; spatial systems and material and service systems. These components may be considered individually in the application of the theory. The theoretical methods and conclusions are then applied to the programming and preliminary planning of a High Rise Office Building of 1,000,000 gross square feet. The conclusion outlines the further study required to apply the concept of adaptability to the final design, detailing and construction processes of such a building.

I. INTRODUCTION

This study is directed toward developing means by which to improve the planning and building process. "Improvement," in this context means an increase in the correlation between objectives and results, between "needs" and "performance." The topic label "Adaptability" is likely to set architects to thinking in terms of "megastructures," portable kitchen "modules," "plug-in-cities" and a whole host of more or less visionary (or at least graphically engaging) schemes for the configuration of the built environment. This investigation is not, however, oriented toward hardware as much as it is toward the planning process. That being the case, it is best to start, and digress, with a description of the author's general interests and particular prejudices so that the purpose of this study may be clear. The hardware we'll import later from England, Building E21, Kohler, Wisconsin or Detroit.

Areas of General Interest:

1. Commercial Building: Building facilities generated by "need" of investor to invest profitably or of user to produce profitably. Therefore, building projects in which the total capital costs and the cash flow generated by the economic use of the facilities become important design determinants.
2. Planning Process: Planning and building to minimize the physical, financial and intellectual resources required to accommodate activities in a man-made environment.
3. Urban Construction: Planning and building for dense aggregations of population and material.
4. Adaptability: Planning for the satisfactory accommodation of activities over time. Thus, provision in the physical, administrative and behavioral environment of adjustability to future needs and objectives.

For this study these areas of interest have been combined with the purpose of focusing on the latter. The provision of adaptability in the built environment is, it will say here, a particular necessity in the construction of high-rise commercial buildings in the urban core of large American cities. These structures, both through size and economic necessity, represent a model of rationalized general space accommodation. Thus they may serve both as an example of, and a test case for the notion of Adaptability.

Furthermore, planning for optimization of the physical and economic configuration of any project, if such planning is done at all, increasingly requires an explicit consideration of future costs (maintenance, conversion, financing, operating and demolition costs) because of the increasing rate of change in building user requirements. These costs may well be direct indices of the adaptability of the physical environment. When those costs are added to the undoubtable cost in public disturbance and danger that the massive reconfiguration of dense urban environments inevitably entails, the possible value of some theorizing on a subject as obscure as environmental adaptability becomes apparent.

To the task of rationalizing the building process the author brings a large collection of prejudices which there is neither space here to enumerate nor time to excuse. But a few deserve review because they bear directly on the utility of such a study.

Particular Prejudices:

1. Conviction that "generalized" and "rationalized" processes are required to accommodate the major portion of humanity's requirements for shelter. Thus a prejudice against the assumed value

of idiosyncratic, personal, intuitive approach to design which characterizes the traditional design process.

2. Conviction that until society codifies its stake in the activities of speculators (in this case speculators in land and buildings) the initial cost of commercial development will remain the paramount determinant of 80% to 90% of the built environment. Without enforcement of the publics' interest, we will be stuck with an increasingly "tacky" and eminently and continually obsolete stock of shelter. Thus, prejudice against the notion that the wisdom of the market place will produce a more useful physical environment.

3. Conviction that in the planning and design of buildings and social institutions, we must start from our present and provide for many alternative futures. Therefore, prejudice against a process of so called "visionary" investigation which assumes a particular future shape and rationalizes it.

Thus this study is developed as only a sub-set of considerations for use in the more inclusive consideration of the problem of resource allocation in the planning and building process. It is directed toward the development and preliminary testing of the many aspects of a generalized approach to planning physical environments for adaptability. This is the sort of consideration which cannot usually be intensively studied under the conditions of the project-by-project orientation of architectural practice and is thus particularly appropriate for an academic study.

II. OBSERVATIONS

In order to provide a context within which to define the concept of adaptability we may, and, according to prejudices already listed, must, start with a preliminary description of present conditions.

1. Predictions of the eminent demise of the central core of our older cities notwithstanding, high rise office buildings continue to be built in downtown areas of large older and middle-age U.S. cities (New York, Boston, Chicago, St. Louis, San Francisco) and in the commercial sub-centers of large younger cities (Houston, San Diego, Phoenix).[1] This is occurring because congenitally skeptical individual investors and financial institutions still believe that the prospect for economic gain is now, and will continue to be, high relative to the level of risk foreseen.

2. Such construction, making up approximately 80% of the sheltered floor area of the Central Business District is unavoidably permanent. Permanency is established when a structure retains physical value and structural capacity beyond the period of satisfaction of initially intended use. Provision of permanency, in downtown high rise structures, has little to do with analysis of the anticipated lifetime of the activity to be sheltered because:

    a. Massive, high-strength materials are necessary to support the building. They deteriorate very slowly if at all.

    b. The most stringent standards of public safety are applied by government and financing agencies.

c. High level of initial performance is required by the users and financing agents. This includes economic enforcement of users' desires to be associated with qualities designated "permanence," "stability," "prestige."

d. It is extremely expensive in terms of direct cost, and disturbance to surroundings, to demolish downtown structures. Thus they tend to be retained, beyond their economic usefulness, as a form of pollution.

e. Increasing rate of increase in all forms of construction costs from financing charges to demolition costs due to actual or contrived shortages of resources (Land, Materials, Labor, Capital) and increasing complexity of buildings gives economic advantage to existing structures. (Cost of replacement far exceeds capitalized income value which in turn exceeds depreciated physical value based on original cost.)

Thus, for almost all modern structures functional obsolescence rather than physical deterioration is the principal factor in declining building values. Helmut Schultz has expressed this in the diagram reproduced here as Chart A, Figure 1.[2] The resources applied to providing unused physical capacity or physical durability may be said to represent "overinvestment (waste of resources)"[3] to the extent to which the cost of providing that excess durability was originally greater than alternative solutions of lower durability. For narrowly adapted structures which reach a point of functional uselessness early in their potential physical life due to minor changes in the activity accommodated, the waste of resources is substantial (See Chart A). It is represented both by high initial cost and, as an exclamation point, high demolition costs, or as depressed real property value (See Chart A, Figure 2).

Similar efforts derive from the inadequacies of human intelligence applied to the initial configuration of buildings. The incidence of "mistakes" (failures to predict accurately) on the part of designers, building sponsors and users in establishing needs and building programs is generously documented. These failures result from:

a. Lack of knowledge of user requirements by designer through lack of information or inability to manipulate available information.

b. Unwillingness of building sponsor to finance study of actual rather than imagined requirements.

c. Stupidity and arrogance of planner and/or sponsor.

The point has been made that the rate of obsolescence of a physical environment defies prediction.[4] Obsolescence is not exclusively caused by a continuous and incremental state of flux such as that described by physical deterioration, but by random, even apocalyptic, events not amenable to the techniques of extrapolation or simulation.

As the rates of cultural and technological change increase, the costs of these effects go up exponentially. In a world increasingly aware of the limitations of its intellectual, financial and physical resources, this waste will become intolerable.

CHART IS
REPRODUCTION OF
STUDY BY
HELMUT C. SCHULTZ
SEE NOTE 1

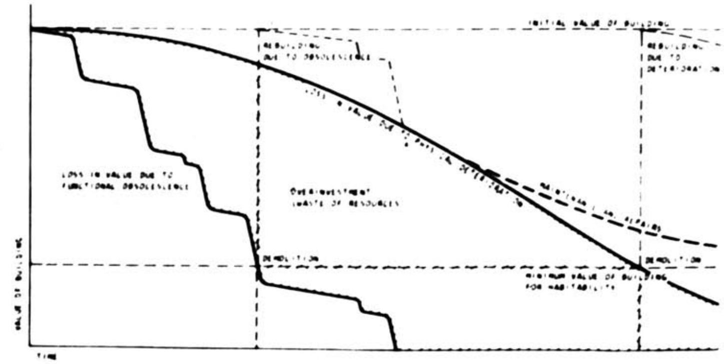


Figure 1. Redundancy in traditional buildings: discrepancy between functional obsolescence and physical deterioration as factors in depreciation

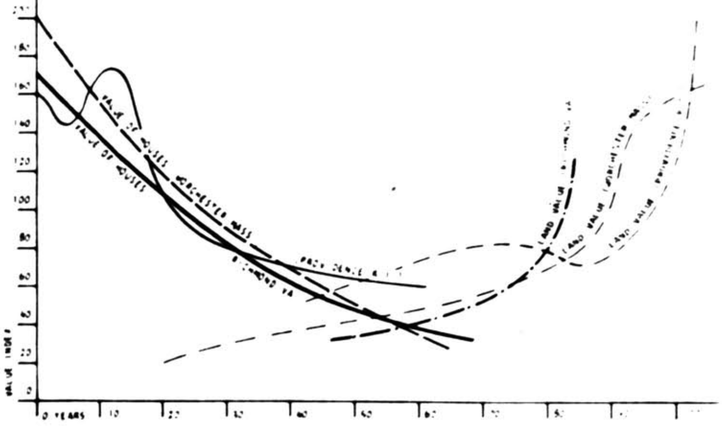


Figure 2. Depreciation of houses, appreciation of land (Source: Jean Gottman, **Megalopolis,** New York, 1961)

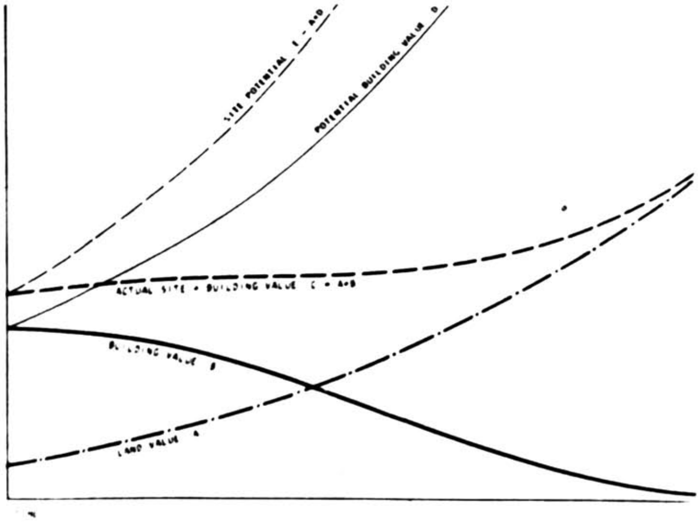
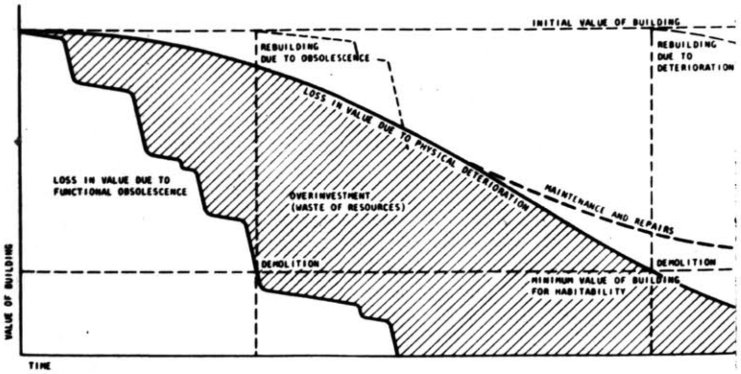


CHART A:

Figure 3 Property values, actual and potential



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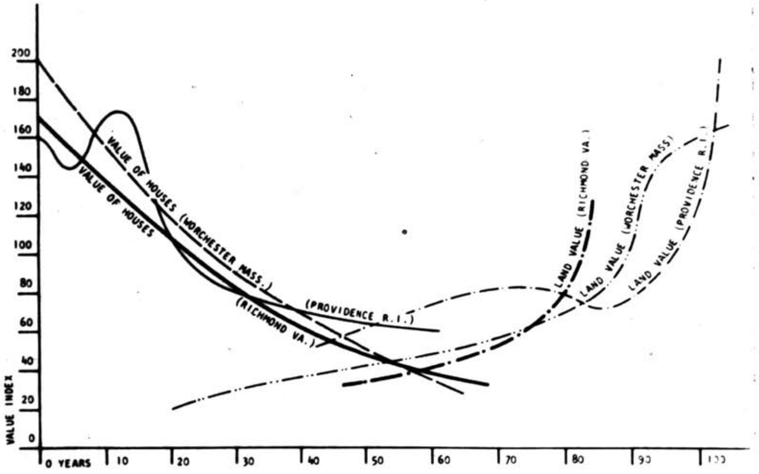


Figure 2. Depreciation of houses, appreciation of land (Source: Jean Gottman, Megalopolis, New York, 1961)

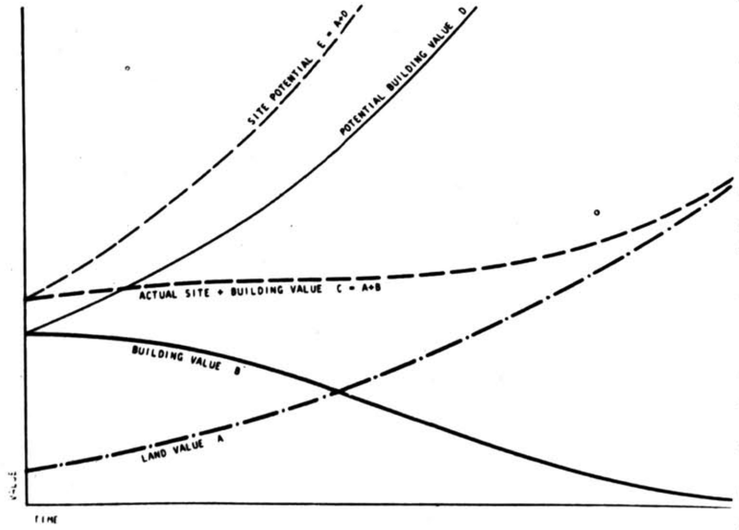


Figure 3. Property values, actual and potential

It is, therefore, necessary to establish measures of this waste and to develop the theory and application of the notion of generalized adaptability in the planning and building process. The economic aspects of this problem deserve greater definition than this study can give. This requires a greater competence in building economics than most architects, including this one, possess. But, we can at least locate the sources and indexes of these cost premiums. If the means are to be found by which a high level of adaptability may be provided for a particular structure, we must first establish at least a qualitative understanding of the meaning and measurement of adaptability and utility in building planning and design.

III. PLANNING FOR ADAPTABILITY: A THEORETICAL FRAMEWORK

"Adaptability," the word describes a characteristic of both the organism and the environment which is familiar but vague. Architectural synonyms include "flexibility," a word liberally and indiscriminately used by building planners to describe the lack of commitment they have chosen to make in developing an environment. Lynch, Aylward and others have discussed the inadequacy of the notion of environmental flexibility.[5,6] Essentially these arguments are focused on the imprecision of the concept in practice. "Flexibility" of which portions of the environment, for what purpose, over what time span, by which devices? The word adaptability is used here because of its relative obscurity and because it connotes a characteristic of organisms as well as environments. This requires that we define it and its application to built situations precisely. The following sets forth a definition of the concept of environmental adaptability based on the work of Lynch and Aylward with some modifications, extensions and simplifications developed to adapt a useful linguistic and conceptual notion to a useful planning tool.

A. The Concept of Adaptability

Preliminary Definition of the concept of Adaptability:

The adjustability of an organism, activity, space and/or material to predictable and unpredictable future needs, desires, or environmental conditions.

Components of the Environment: Definition for Planning:

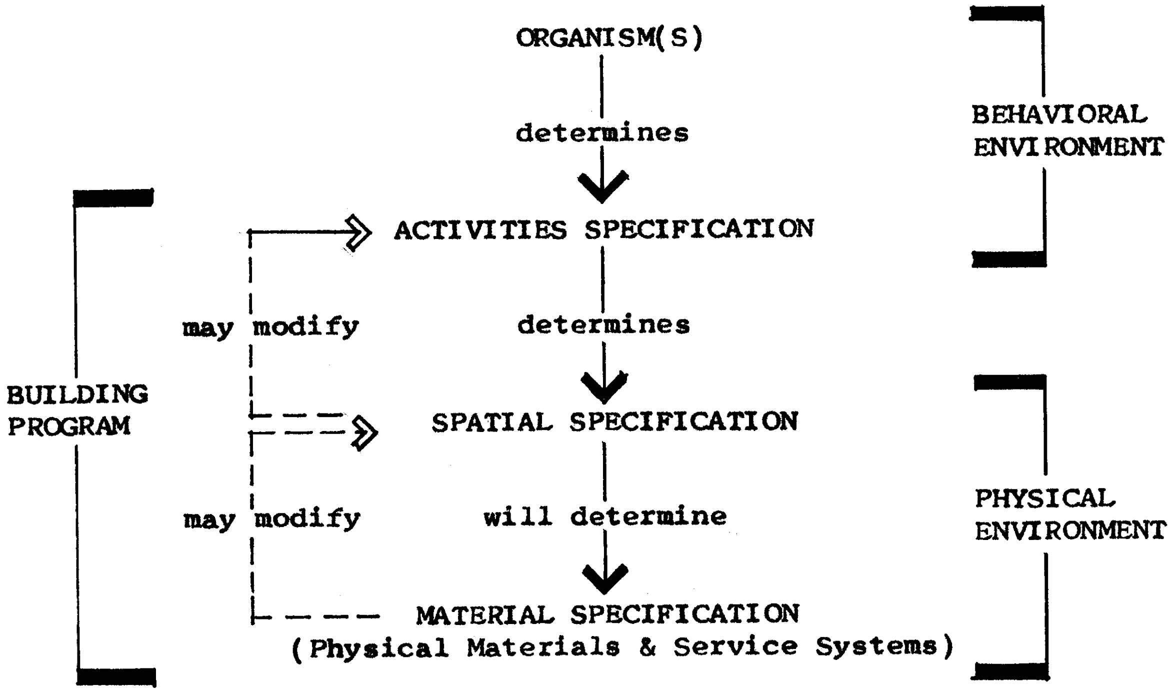
Organism:	User.
Activity:	Use or Purpose of User (an action).
Space:	Physical Volume within which user pursues activities.
Material:	Matrix by which space is defined, supported, serviced and finished.

It is necessary to distinguish these components to avoid some common and often expensive confusions. Change occurring in any one of these components may not require any change on the part of any other component. For example, a change in the character of an activity (increase in job absentee rate) will require administrative response (increase in fringe benefits, extension of coffee break time, bonus for good attendance record). Such a change represents a change in the character of the activity. No change in the spatial arrangement of the office or the materials supporting and sheltering the office need be undertaken. Similarly, and in contradiction to some favorite architectural myths, changes in spatial accommodation and materials (new offices and office furnishings) may have no effect on activities (productivity of office workers, ease of access to decision maker).

Furthermore, the adaptability of one component of an environment may substitute for changes in other components, even where such change is sub-optimal. An increase in the ambient noise level due to the introduction of more office equipment may be adapted to by the personnel after a brief period of discomfort without need for acoustical analysis and physical modification of space and materials.

Our concern here, however, is with the provision of adaptability in the built environment (Space and Material Systems) which may be taken advantage of when adaptation by organisms and/or activities cannot accommodate need. The discipline of architecture is capable of effecting only very minor and temporary changes in the organism. Thus we assume that changes in the organism are exogenous and are expressed in the environment through changes in the activity specification which, in turn, may affect the physical environment. The planners pre-occupation will be with the "fit" of the physical environment (space and material) to the activities accommodated. Thus:

DETERMINANTS OF THE PHYSICAL ENVIRONMENT



Measurement of Adaptability in the Physical Environment:

The index of what we shall call *specific adaptability* may be measured as the reciprocal of the cost of conversion of a physical environment from State A to State B where A and B are known and specified conditions. The index of *general adaptability* may be considered as the reciprocal of the average cost of conversion from any initial state to all others. The total costs of conversion, no matter how indirect and abstract, can probably be measured very closely in simple monetary terms provided that we learn where to look for indications of cost.

ECONOMIC COSTS:	Liquidated capital (including depreciation)
	Added Capital (demolition and remodeling)
	Income Lost During Conversion
PHYSICAL COSTS:	Material Wasted
	Pollution Produced by Conversion (Noise, Dust, Smoke, Ugliness, Hatred)
	Energy Resources Depleted by Conversion
FUNCTIONAL COSTS:	Interruption or Disruption of Adjacent Functions
	Loss of Efficiency or "Delight" in Activities.
	Loss of Utility

The costs of future conversions, once estimated, must be discounted to present value at the appropriate discount rate, a rate which will vary with each project. Such a procedure will then allow analysis of a particular project to optimize resources within the range of probable error generated. The fact that such estimates are bound to be approximate, at best, and bound to be thoroughly subjective, at first, does not diminish the value of assigning these future costs a role in determining present configuration. Once a more thorough and precise list of costs is developed and estimates made of the frequency and character of physical change these costs may be as accurately estimatable as material costs.

B. The Concept of Utility

The concept of adaptability may focus on the cost of conversion from one physical accommodation specification to another. It is assumed that the same level of satisfaction of needs may be accomplished in the initial state and converted state, an assumption that is infrequently valid. Thus we need a method for measuring the efficiency and the quality of a physical environment in the satisfaction of a specific set of needs established by the activity accommodated. We designate that quality of satisfaction as UTILITY. Utility may be defined as the economic, functional and physical efficiency of a physical situation at a particular time and for a specified use. The concept of utility is an extension and refinement of the notion of "fit," the correspondance between "needs" and physical accommodation of needs. In both cases the concepts are only useful to describe conditions at a point in time, since standards of performance for physical accommodation are constantly in flux. Where a particular physical accommodation may have high utility at time t, it may be designated as having low utility at time t + dt due simply to a refinement or re-valuation of the statement of "needs" or standards. This can occur without any change taking place in the activities or organisms accommodated. Thus, another definition of utility may take a superficially negative form: The degree to which the physical environment does not obstruct the procedural objectives of the users; the degree to which it stays out of the way.

The Measurement of Utility:

ECONOMIC UTILITY:

$$\text{Income Utility} = \frac{\text{Actual Rate of Return}}{\text{Prevailing Market Rate of Return}}$$

$$\text{Capital Utility} = \frac{\text{Actual Capital Costs/Unit}}{\text{Market Standard Costs/Unit}}$$

Note: Unit may be unit of production, consumption, transport or physical accommodation.

PHYSICAL UTILITY:

$$\text{Material Utility} = \frac{\text{Actual Quantity of Material Used}}{\text{Usual Quantity of Material Used to Achieve Same Result}}$$

$$\text{Spatial Utility} = \frac{\text{Actual Ratio of Usable to Service Space}}{\text{Usual Ratio of Usable to Service Space}}$$

$$\text{Energy Utility} = \frac{\text{Actual Ratio of Output/Input}}{\text{Standard Ratio of Output/Input}}$$

FUNCTIONAL UTILITY:

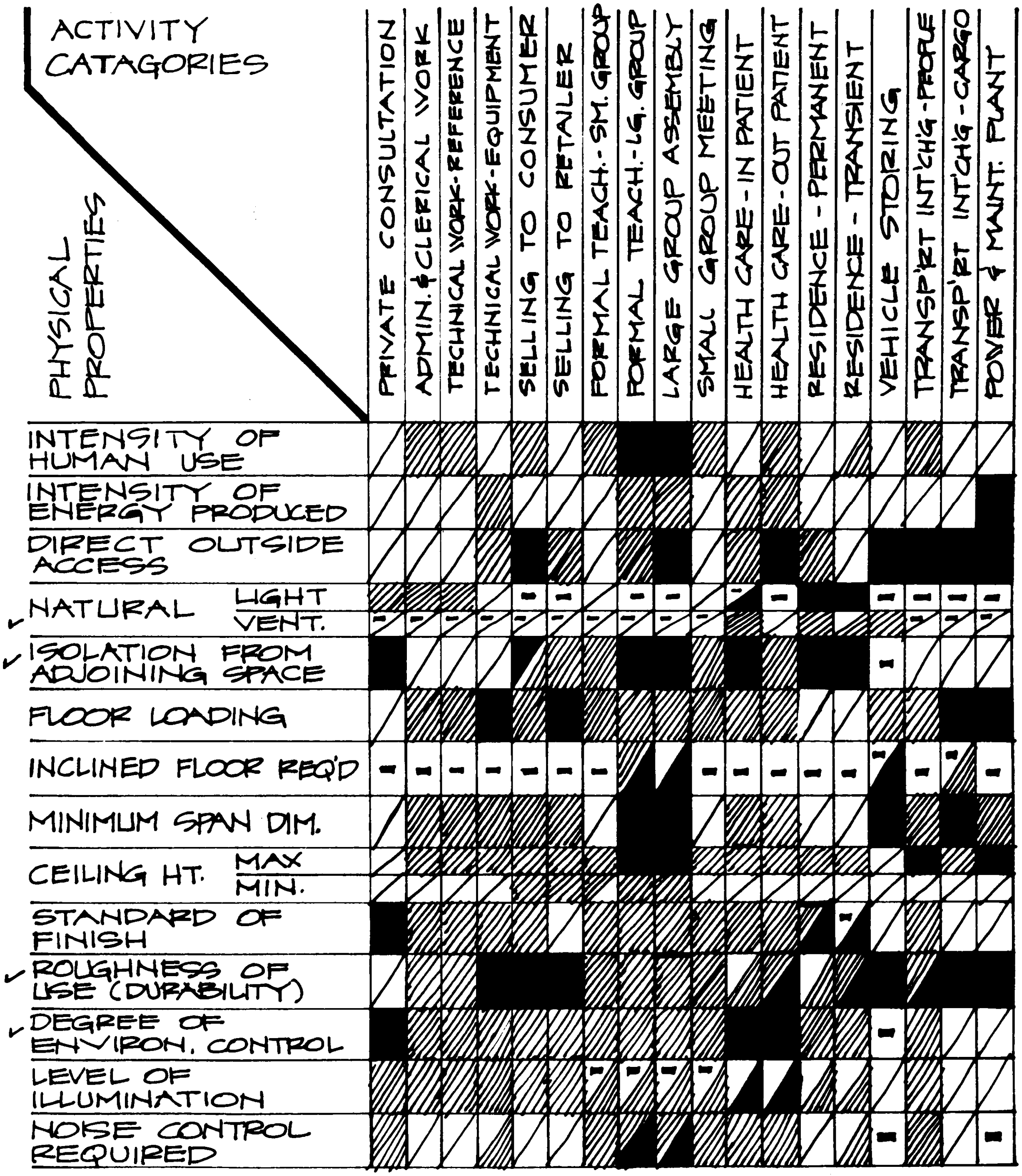
$$\frac{\text{Actual Level of Satisfaction of Needs}}{\text{Desired Level of Satisfaction of Needs}}$$

By such techniques of analysis the concept of utility may be quantified. Changes in the level of utility may then be assigned a monetary value and incorporated in the measurement of adaptability under the heading of Functional costs as shown above.

C. Specific Adaptability

By establishing a set of performance characteristics for the spaces and materials accommodating a range of known or postulated activities, we may rather easily examine the interchangeability of activities between accommodations. In the process we would be able to measure the loss or gain in the utility of the physical accommodation. We may also begin to establish the level of general adaptability of various given physical environments. As an example, we will use those activities most likely to request accommodation in the core of our cities in the next 10 to 25 years. These have been chosen based on the discussion following, in Section IV.A. We shall use categories of physical properties (Space & Material) similar to Aylwards.[7] (See Chart B.) The matrix shown here uses a qualitative notation to relate physical property requirements to various activity categories. Even at this low level of precision in the data supplied, it is possible to demonstrate which activities may exchange physical environments at low cost, as well as which activities cannot be housed by the same accommodation.

Once the straightforward but time consuming problem of establishing the appropriate categories of physical properties and the performance index units (preferred span, lighting level in foot-candles, permissible ambient noise level in decibels, etc.) is completed, we can determine more precisely the physical properties requiring adjustment for optimum and minimum utility in the exchange of one activity for another in a particular physical environment. The more detailed the data provided, and the more precise the list of both



ORDER OF NEED, OR DEGREE:

HIGH ■ MED. ▨ LOW ◸ NONE REQ'D [-] RANGE ◸

CHART B: SAMPLE "INTERFIT MATRIX BY PHYSICAL PROPERTIES

activity types and physical properties, the greater will be the differences exposed and the complexity of analysis. Even the primitive notation used in Chart B makes graphic the ease with which a low order activity may move to a space accommodating a more physically demanding activity, whereas a high order of need is shown to require an accommodation of relatively low adaptability. There is most likely a level of precision both in the specification of categories and the assignment of information where the marginal usefulness of the method for the planner becomes very low. I suspect that Chart B approaches such a level. We need not be more precise to document the fact that it will be expensive to accommodate auto parking and administration in the same structure.

The rewards of this approach lie in identifying those categories of activities which may exchange physical accommodations easily and may thus be accommodated economically in a single generalized structure. At the same time, those activities with rigid and unique physical requirements will be rigorously pinpointed.

The tedium of this technique is rewarded only if one is dealing with a constant set of performance standards and activity categories. To a high degree of probability, we may be able to identify those known activities which may trade spaces with one another easily without going into this degree of rigor. Thus this approach to identifying the adaptability of given specifications will only demonstrate its value by shocking us, by revealing easy interchangeabilities we had previously guessed to be difficult (expensive) or impossible.

Chart C attempts to identify and rank the interchangeability of functions in a less rigorous but quicker way. It deals with accommodated activities without the necessity of specifying all performance requirements. Once these qualities which make interchangeability difficult have been identified, we will have as precise a notion of which functions may be grouped together in one generalized structure at a low cost premium as in the more rigorous technique described by Chart B. Given a known and understood set of activity spatial and material specifications both of these techniques will emphasize that the modern office building will easily accommodate a wider range of existing building uses than, say, a parking structure or an apartment building, and may thus be designated as having a higher degree of specific adaptability. Thus adaptability can be enhanced by application of the notions of general, rather than specific, adaptability.

DESIRED USE (CONV. TO) / PRESENT USE (CONV. FROM)	LARGE OFFICES	SMALL OFFICES	RETAIL /COMM'L	WHOLESALE	THEATRE & MTG.HALL	LIGHT MFG. & PROCESS.	SPECIAL SCHOOL	CLINIC & LABORATORY	HOTEL	RESIDENCE (APT.)	AUTO PARKING	TRANSP'RT T'RM'N'L	MUSEUM & EXHIBITS	ENERGY PLANTS
LARGE OFFICES	■	■	▨	▨	⧄	▨	▨	⧄	⧄	⧄	⧄	⊟	⧄	⊟
SMALL OFFICES	▨	■	⧄	⧄	⊟	⧄	⧄	⧄	⧄	⧄	⊟	⊟	⧄	⊟
RETAIL /COMM'L	▨	▨	■	▨	⧄	⧄	▨	⧄	⧄	⊟	⧄	⧄	▨	⧄
WHOLESALE	⧄	⧄	▨	■	⧄	▨	▨	⧄	⊟	⊟	⧄	⧄	⧄	⧄
THEATRE & MTG.HALL	⧄	⧄	⧄	▨	■	⧄	▨	⧄	⊟	⊟	⧄	⧄	⧄	⊟
LIGHT MFG. & PROCESS.	▨	▨	▨	■	⧄	■	▨	▨	⊟	⊟	⧄	⧄	⧄	⧄
SPECIAL SCHOOL	▨	▨	▨	■	⧄	■	■	⧄	⧄	⧄	⧄	⊟	▨	⧄
CLINIC & LABORATORY	⧄	▨	⧄	▨	⧄	▨	▨	■	⧄	⧄	⧄	⊟	⧄	⧄
HOTEL	▨	■	⧄	▨	⧄	⧄	▨	⧄	■	■	⧄	⧄	⧄	⊟
RESIDENCE (APTS.)	⊟	▨	⊟	▨	⊟	⧄	⧄	⧄	▨	■	⧄	⊟	⊟	⊟
AUTO PARKING	⧄	⧄	⧄	⧄	⊟	⧄	⧄	⊟	⊟	⊟	■	⧄	⊟	⊟
TRANSP'RT T'RM'N'L	⧄	⧄	▨	▨	⧄	⧄	⧄	⊟	⊟	⊟	⊟	■	⧄	⧄
MUSEUM & EXHIBITS	⧄	⧄	▨	▨	▨	▨	▨	⊟	⊟	⊟	⊟	⧄	■	⊟
ENERGY PLANTS	⊟	⊟	⊟	⧄	⊟	▨	⧄	⊟	⊟	⊟	⧄	⧄	⧄	■

■ : EASY CONVERSION - PRINCIPALLY SPATIAL MODIFICATION & FINISH CHANGES

⧄ : MASSIVE CONVERSION INCLUDING SUBSTANTIAL STRUCTURAL & ENERGY SYSTEM REVISIONS WILL BE REQUIRED

▨ : EXTENSIVE CONVERSION INCLUDING MINOR STRUCTURAL REVISIONS WILL BE REQUIRED

⊟ : LIKELY THAT DEMOLITION OF EXISTING FACILITIES WILL BE NECESSARY

CHART C: SAMPLE "INTERFIT" MATRIX BY COMPARISON OF SPACE SPECS.

D. General Adaptability

The planning objective of most building projects today is to optimize initial utility while providing, in some cases, for programmed future modifications (Specific Adaptability). Little attention is paid to provisions for unpredictable changes in the physical environment. The ability of the Behavioral Environment to adjust to constraints imposed by the physical environment is frequently the only adaptability provided. Once the limit of tolerance is reached, the whole physical environment is replaced. (See Chart A.) Rather than concentrating on the specific adaptability of environments to known activities, we must deal generally with those qualities of any environment which must be prepared to accommodate unspecified change.

Categories of Change in the Physical Environment:

Spatial Specification Change:	Change in arrangement and connection of spaces
Material Specification Change:	Change in Arrangement, Connection and Performance of Material and/or Service Systems

Generators of Change in the Determinants of the Physical Environment:

Activities:	Changing Biological and Demographic Conditions Changing Market Demands Changing Administrative Policies Changing Production Techniques Experiment Changing Personal Interests
Space:	Major Changes in Activities Rigid and Highly Specific Form Changing Fashions in Modernity

<u>Material & Service Systems</u>: Major Changes in Spatial Specifications
Aging (Physical Deterioration)
Technological Change (Technical Obsolescence)
Changing Fashions in Modernity

Measurement of Change in the Physical Environment:

<u>Direction</u>: Expansion, Contraction, Transformation

<u>Character</u>: Progressive, Dialectic, Random

<u>Rate</u>: Frequency of Change

Measurement of Intermediate State:

<u>Duration</u> of Given Conditions (time units)

<u>Intensity</u> of Given Condition (Density, Energy level)

Response of Components of Physical Environment to Change:

1. Reaction of Space to Change in Activity
   a. Expansion of Activity - Minor:
      1) Intensification of Use (no modification in spatial configuration)
      2) Accretion of small spatial additions
   b. Expansion of Activity - Major:
      1) Addition of large spatial units
      2) Reconstruction of Existing Space (in addition to 1)
      3) Relocation to New Space
   c. Contraction of Activity - Minor:
      1) Re-intensification of Use
      2) Abandonment of small spatial units
   d. Contraction of Activity - Major:
      1) Relocation to New Space
      2) Reconstruction and Abandonment of major portion of existing space

- e. Transformation of Activity - Minor:
    - 1) Refinishing of all or portion of space
    - 2) Re-configuration of all or portion of space
- f. Transformation of Activity - Major:
    - 1) Relocation to more appropriate space
    - 2) Major Reconfiguration of space

2. Reaction of Materials to Changes in Activity
    - a. Expansion of Activity - Minor:
        - 1) Increased Intensity of use of materials
        - 2) Increased rate of physical deterioration
        - 3) Increase in maintenance required
        - 4) Use of initial over-capacity
    - b. Expansion of Activity - Major:
        - 1) Replacement of Materials with stronger or more durable components
        - 2) Frequent replacement with rapidly deteriorating "temporary" materials
    - c. Contraction of Activity - Minor:
        - 1) Decreased intensity of use (longer life implied)
        - 2) Decrease in Maintenance Required
    - d. Contraction of Activity - Major:
        - 1) Demolition, Abandonment or Liquidation of major portion or all of material assets
    - e. Transformation of Activity - Minor:
        - 1) Change in relative rate of deterioration of various components
    - f. Transformation of Activity - Major:
        - 1) Demolition, Abandonment or Liquidation of a portion or all of structure for replacement with more appropriate systems. (Systems of higher utility.)

3. Reaction of Materials to Change in Spatial Specification:
    - a. Expansion of Space - Major & Minor:
        - 1) Addition of Material and Service Systems
    - b. Contraction of Space - Major & Minor:
        - 1) Abandonment, Demolition or Liquidation (Sale or Lease) of a portion or all of Material & Service Systems

c. Transformation of Spatial Specification - Minor:

   1) Reconfiguration of portion of Material & Service Systems

   2) Demolition of and Addition to small portions of Material & Service Systems

d. Transformation of Spatial Specification - Major:

   1) Abandonment of Material & Service Systems

   2) Demolition and Replacement of Material & Service Systems

E. Adaptability in the Physical Environment

Lynch has suggested a set of properties of physical environments which are likely to provide for a high degree of adaptability. The following categories are his with the exception of the last two, which have appeared as a result of my consideration of the subject.[8]

1. Non-Specific Major Structure:
   - General and Repetitive Spatial and Material Typography
2. Growth Forms: Space and Material:
   - Perimeter Expansion by addition of enclosure units along minor axes
   - Internal Expansion by addition of enclosure units along major axes
   - Penetrability and Connectibility of present Peripheral Boundaries
3. Zoning and Structural Concentration:
   - Grouping of Static and Changeable Spaces
   - Grouping of Static and Changeable Material & Service Systems
   - "Course Grain" - zoning of spaces and materials in large or concentrated aggregations of space or structure
4. Over-Capacity:
   - Larger Spaces than required by initial specification
   - Greater structural capacity or mechanical system capacity than required by initial specification
5. Temporary Spatial or Material Units:
   - Mobile Units or Removable Units
   - For highly specific or short term use
6. Variety of Spatial Types in One Structure:
   - Through Original Provision, or
   - Through convertibility of minor Space Definition Systems
7. Diversity through Scale:
   - Concentration of Activities and Material and Service Systems in large aggregations allows intensification of use at one point to be offset by de-intensification of use at another point. Expansion at one point may likewise be accommodated by contraction at another.
8. Autonomy of Components: Space & Material
   - Systems <u>dis</u>-integration allows change in one component without disturbance to others

Single purpose component may be more specific in terms of lifetime or function at lower cost than multi-function component

Assembly of components to be as disassociated as possible to avoid procedural bottlenecks.

F. Adaptability and Assemblage

Adaptability as defined here is ultimately measurable only in terms of cost. The provision of adaptability through the implementation of the devices outlined above requires consideration of the most prosaic material and service components as well as the major spatial and structural hierarchy.

> "The method of assemblage is the key to making adaptability economically feasible. Homogeneous flexibility throughout a structure has proved to be very expensive, since it does not take into account differing degrees of adaptability required in different areas. Such a uniform level of adaptability might not be adequate to allow for rapid changes of some components (in daily or weekly cycles); conversely, it might be wasted where the need for change might not occur in the useful life of the components."[9]

The objective is to minimize the total resources wasted on the structure and its component spaces and materials. Thus, decisions regarding spatial arrangement and material components can be based on probabilistic projections of their useful life (frequency of conversion, durability required), and on methods of assembly that allow for changes to one component that minimize disturbance to other components (Autonomy).

The most long lived material component of any large structure is the major structural system. It must therefore receive the most careful consideration regarding its general adaptability. Conversely, the selection of the ceiling diffusers in office spaces need only be based on considerations of utility for a 5 to 10 year period. The diffuser need only be subject to tests for adaptability if 1) The rate of physical deterioration of the cheapest possible component provides for a physical life far in excess of its anticipated useful life, or 2) It is "integrated" with the major structure so that a change in air delivery requirements would make the structure as well as the diffuser functionally obsolete.

G. Adaptability for High Rise Structures

The balance of this study concentrates on the methods of providing for general adaptability in the major spatial and material configuration of large buildings in the centers of large cities. It is in these locations that buildings are most intensively built. Therefore, the provision of a high degree of adaptability to the construction of urban cores becomes most critical to minimizing the disruptions caused by rapid changes in the components of the environment in these locations. It is obvious that the urban cores of our cities are a single continuous structural aggregation of highly interdependent environments. The techniques developed here for the analysis of a single building will be extendable beyond one developer's property lines to find application to the entire urban situation. The re-assemblage of whole cities to maximize physical adaptability will contribute indispensably to making them humanly and economically tolerable once again.

Consideration and provision of general adaptability in the design and construction of these structures cannot avoid increasing their costs. Consequently, the value of the building to initial investors must be increased. This can be achieved to only a minor degree by increasing initial attractiveness (rentability) of space on the basis of its adaptability. This can be achieved by increasing the utility of the structure to a great range of future requirements thereby increasing the value of the building to a range of future purchasers or investors while representing only marginal initial cost.

If, however, maximum adaptability were to be achieved, it would only be provided in response to social fiat -- by society and/or government establishing the desirability of a high degree of adaptability in the environment and promulgating enforceable rules for its provision. (Market demand, building and zoning ordinances, title covenants, tax incentives, F.A.R. bonuses, etc.) Experiments with such government enforced devices are presently underway in New York City.

It is notable that the modern high rise office building has many of the qualities defined above for a high degree of adaptability:

Non-Specific Major Structure
Zoning and Structural Concentration
Diversity through Scale
Over Capacity
Autonomy of Space Definition Components

This adaptability is principally, often only, provided to that set of features the speculative developer must provide when he is building for as yet undetermined tenants -- namely in the area of provision for adjustability of the most short lived portion of the environment -- the "standard tenant improvements" (Tenant Space Definition and Finish Systems, Tertiary Mechanical, Electrical and Communications systems).

Some of the following qualities are usually provided in the modern high rise building. They are indicated by *.

Sample Application of Adaptability Attributes to High Rise Structures:

Non-Specific Major Structure:	* Undifferentiated structural and planning lattice * Undifferentiated Exterior Enclosure system

Growth Forms:	* Internal horizontal adjustability of space dimensions - Internal vertical adjustability of space dimensions * Penetrability of Exterior Envelope for connection to adjacent spatial units (seldom utilized) - Vertical Expansion through addition of structure and services (initial cost prohibits except for specific program)
Zoning and Structural Concentration:	* Aggregating continuous tenant space surrounding Aggregated core facilities - Concentration of Vertical Structure at periphery and core only * Concentration of Primary Service System spaces to minimize interference with tenant areas.
Over Capacity:	- Areas of Greater Structural Capacity for special loading conditions * Vertical Duct Shaft Space larger than volume occupied by ducts * Ceiling Plenum Space of larger volume than required for Service System Run Outs - Structural Capacity provided for Seismic loading
Temporary Spatial or Material Units	* Low Cost and/or Easily Removable Space Definition Components where Frequent Change is a Certainty * Disposable Paper Towels * Temporary Enclosure during Remodelling - Quickly erectable Enclosure for Outside or Roof-top Ceremonies or Tasks - Docks for attachment of and Access to Mobile Demonstration or Teaching Units (Air Borne Mobile Units included)
Variety of Spatial Types:	* Horizontal Variability - Vertical Variability - Provision for Major Intensification of Use of Spaces
Diversity through Scale:	<u>NOTE</u>: A principal adaptability attribute of Large High Rise Structures * Aggregation of many units of use - Transferability of Energy Distribution to points of demand and away from points of under utilization of capacity

Autonomy:

NOTE:

Potentially the most important attribute for an adjustable environment. Components may be developed to narrowest possible specification with minimum interdependence with other components.

- Makes Lay-In Ceilings preferable to Concealed Spline Ceilings (cost saving) and Discontinuous floor structure preferable to structural continuity of floor structure (cost premium)
- If exterior wall element may be removed, modified or replaced while disturbing only the space enclosed by that element, such change is less disturbing to whole building, is likely to be less expensive than if structure and neighboring units are disturbed or endangered and is thus more likely to occur.

To establish a more rigorous and useful specification of adaptability in high-rise structures the preliminary design of a single prototype building was undertaken. Both an initial program and an adaptability program have been developed to test the utility of the preceding analysis.

IV. DESIGN INVESTIGATION

To establish design requirements, assuming the foregoing analysis and the possibility of achieving economy as well as adaptability, the development of design studies for a high rise loft structure located in the urban core and initially serving today's market requires the following investigations:

A. Initial Design Specification
   1. The forseeable future for space demand (activity accommodation) in the C.B.D.
   2. Initial Building Program and Basic Building configuration

B. Spatial Adaptability Specification

C. Material and Service Systems Adaptability Specification

D. List and Cost Ranking of Programmed Adaptability Provisions

E. Design Studies

F. Cost Comparison Estimates and Feasibility Studies

G. Final Design Specification

H. Building Development Activities

In the period allotted to this study we have only begun this process and have concentrated on A. through E. above, since the last three steps require a high level of definition of particular project circumstances not convenient to an academic situation.

A. Initial Design Specification

Present conditions and the predictable future demands of the users of downtown space are considered here simultaneously for the obvious reason that we are building for the near future, not the present. The specification of the initial spatial and material requirements for a downtown structure will be developed directly from these considerations. The planning method used here will then include the addition of specifications for adaptability to the initial spatial and material specifications from which we shall proceed to the development of a prototype structure for the purpose of demonstrating how these specifications may be applied.

1. Initial Conditions -- the Present and Near Future of "Downtown." The predominant present uses of downtown space in older and middle-age cities are tabulated on Table No. 1. A rough indication of the proportion of space dedicated to the various activities is indicated there, as well as prediction of the trends of near future spatial requirements of the activities shown. It must be emphasized that both the data and projections are rough. They have been developed quickly from several sources and are based on the extrapolations and expectations of the sources referenced. Since my objective here is to develop a technique for physical planning, time would not allow a more rigorous exercise of the demographer's function.

   Furthermore, this analysis assumes that we are generally familiar with the spatial and functional relationship of activities and spaces in the existing city without further elaboration here.

This study is developed in consideration of the existing cores of older and middle age American cities with populations in excess of 500,000. "Older" in this context means that the city reached a population of 500,000 previous to 1900, "middle age" means that it reached a population of 500,000 between 1900 and 1930. Predicting the near future of these areas has been a favorite game for the students of many disciplines over the past 10 to 15 years, the result being that a concensus of opinion seems to have been reached. The sources referenced in the Bibliography are remarkably unanimous in the view of the near future they represent. Their conclusions and qualifications are summarized here.

TABLE NO. 1

Partial List of the User Activities of The Central Business District by U. S. Census Department Category

		PRESENT % of USABLE SPACE	TREND:	
CATEGORY	SUB-CATEGORY		1980-1990	AFTER 1990
RETAIL TRADE:	Metropolitan	2	-	-
	City	3	-	0
	* Local	4	+	0
WHOLESALE TRADE:	Metropolitan	1	-	-
	City	1	-	-
MANUFACTURING:	Headquarters & Sales	10	-	-
	Plants & Labs.	0.5	0	0
	Distribution	1	0	0
SERVICES:	Financial			
	Insurance & Real Estate			
	Government			
	Consultant Professionals			
	Others			
	Total Services	55	++	+
EDUCATION:	K-12	N	0	0
	Resident College	N	0	0
	Commuter College	N	+	0
	Special Training & Adult Education	0.5	++	+
HEALTH SERVICES:	Hospital	0.5	-	-
	Clinic	N	0	0
	Laboratories	N	0	0
	Doctors Offices	2	-	-
RESIDENTIAL:	Hotels & Transient	3	0	-
	Apartments	8	0	0
	Private Residences	N	0	0
ENTERTAINMENT & CULTURAL:	Restaurant-Night Club	.5	0	-
	Movie Theatre	1	-	-
	Cultural	.5	0	0
TRANSPORTATION INTERCHANGE:	Rail (Passenger)	1.5	0	+
	Rail (Cargo)	1	0	0
	Bus	1	0	0
	Auto (Parking)	3	+	0
	Truck (Terminal)	1	-	-

TABLE NO. 1 (Continued)

CATEGORY	SUB-CATEGORY	PRESENT % of USABLE SPACE	TREND: 1980-1990	AFTER 1990
COMMUNICATIONS:	Radio, T.V., Telephone	2	+	++

KEY TO TABLE NO. 1

N:	Negligible
+:	Increase in % of Usable Space
++:	Large increase in % of Usable Space
-:	Decrease in % of Usable Space
--:	Large Decrease in % of Usable Space
O:	No significant change

Assuming no massive social, physical or economic discontinuity, but counting on increasingly frequent technological changes, the following future seems likely for the Central Business District.

a. Increasing specialization in service industry accommodation (See Table No. 1). Such uses will still benefit from:

   1) Physical Proximity for communication and exchange.

   2) External Economies of Scale through Aggregation.

   3) Minimization of the cost of uncertainty through aggregation.

   4) Accessibility of C.B.D. to all parts of metropolitan region.

b. Small and Medium size "elite" service industries to predominate in downtown usable area utilization. They will be served by local commercial, health, entertainment and transportation services. Metropolitan Commercial and entertainment functions will tend to follow the population to the suburbs, as will large corporate headquarters' activities.

c. Younger cities, with less rigidly established radial transportation systems, will further develop into constellations of intensively developed sub-centers one of which may be original "C.B.D." The density of development at each node is not likely to reach that of present centers of New York, Philadelphia, Chicago, etc.

d. C.B.D. land will continue to increase in value but at a lower rate than land cost increases in other parts of metropolitan area. This indicates the declining dominance of the C.B.D. as the most accessible and desirable location.

e. Capacity of existing utility and transport systems to absorb expanded use and expanding expectations for better service will be exceeded, requiring substantial and prolonged re-construction of the connective tissue of the central city. The most shocking initial event in this revision will be the prohibition of private vehicular traffic from major portions of the C.B.D.

f. Allocation of materials, labor, capital and land will be subject to more extensive public control as the supply of each declines in proportion to demand and as society acknowledges and enforces its interests in public and private investment.[10]

These seem to be the most likely future changes of significance to the building planner, but they must be further qualified. The growth and health of the center of older and middle aged cities depend on a substantial increase in the social and physical mobility of the present urban poor. It also depends on amelioration of the most prominent physical problems caused by the present forms of urban aggregation.

1. Congestion caused by admission of all traffic to C.B.D.
2. Rigid and deteriorated public transportation
3. Lack of Dirt Pollution Control
4. Lack of Noise Control
5. Inadaptability of existing downtown structures and energy systems to changes in use and changes in appearance.

Conclusions for Planning High Rise Structures:

a. Larger aggregations of land will be available
b. More public control of uses of land and structures will occur
c. Greater emphasis will be placed on the controlled design and construction of urban energy and transport systems and their connection to existing and future structures

d. Increased interest (economic motivation) in using existing stock of structures to satisfy present needs
e. Concentration of private vehicle storage at the periphery of C.B.D. or along axis through C.B.D. will take the car out of the office building.

These conclusions begin to indicate to what degree buildings built today should be designed to accommodate changes in their surroundings.

1. Major changes in the size, spatial complexity and material specification of pedestrian, vehicular and energy transmission systems will require major response in the spatial and material systems at the base of tall buildings while having little affect at upper levels.

2. Major changes in the size of individual building sites aggregated by private developers or civic action will have affects on the utility of existing structures. In order to adapt to an altered spatial environment as well as an altered activity environment, the intersection between one existing building and its environment should be modifyable.

   Changeable Skin Components
   Changeable External Zone HVAC capacity
   Connectability to nearby structures by high level
      bridges carrying people and/or energy and
      communication system umbilicals

3. Major change in energy transmission and conversion systems as well as frequent and random changes in communications technology will require that high rise structures built today be provided with accessible and modifyable facilities for these systems. For example, a building which cannot be cheaply adapted to a conversion in energy source for the heating system is likely to become economically obsolete very rapidly.

Likewise, a building system which cannot inexpensively and incrementally accept a massive qualitative and quantitative change in communications systems is likely to retain utility only if used as a warehouse.

4. Negligible change in the character of major activities demanding accommodation, except that changes in the mechanics and spatial relationships of movement systems may affect interface between "building" and "surroundings."

2. Initial Building Program

In order to apply considerations of adaptability to other building requirements, the following program was developed. It is intended to be representative of a speculatively developed approximately 1,000,000 gross square foot high-rise office structure on a representative site in a major downtown area of an older American city. The qualification that it be a "speculatively" developed building is included to preclude consideration of the idiosyncracies of large corporations or other individual developers preoccupied as much with the public relations aspects of monument making and labelling as with the utility of the structure.

a. SITE:

1/4 Block at Corner: 38,000 S.F.

1/2 Block : 76,000 S.F.

Full Block : 160,000 S.F.

Block is 400 feet square with 20' Alley bisecting it in one direction

F.A.R. Range: 12 to 30
(Floor Area Ratio)

Adjacent Uses: Office and Commercial Buildings 5 to 50 years old, built to property lines. 150' to 300' tall.

Streets:
80' R.O.W.
Undifferentiated Grid
4 lanes (one way)

Utilities:
Gas Main
Water Supply
Fire Main
Sanitary Sewer
Storm Sewer
Electric Main
Telephone Trunk
C.A.T.V.

All available adjacent to site - under street

Land Cost: $65.00 to $80.00 per S.F.

b. Activities to be Accommodated -- Initial Tenancy:

Administrative & Clerical Offices
Small to Medium Service Industry Offices
(2,500 - 15,000 S.F.)
Small Corporate Headquarters
(5,000 - 10,000 S.F.)
Retail and Commercial spaces
(Ground Associated)
Energy and Circulation Services

Parking: NOT TO BE INCLUDED
May be provided in separate parking structure

Loading Facilities: Initially at grade:
six 10' x 25' berths.

c. Tenancy Date: Market Survey Results

See Tenancy Profiles (Chart D and Chart E)

Building to be planned for tenancies ranging from 1,000 gross rentable square feet to 25,000 gross rentable square feet (G.R.S.F.) with preferred range between 5,000 and 20,000 G.R.S.F.

Tenancy Module: Approximately 5,000 G.R.S.F.
4,000 to 4,500 usable S.F.

Proportion: 2 to 1
45' x 90' to 50' x 100'

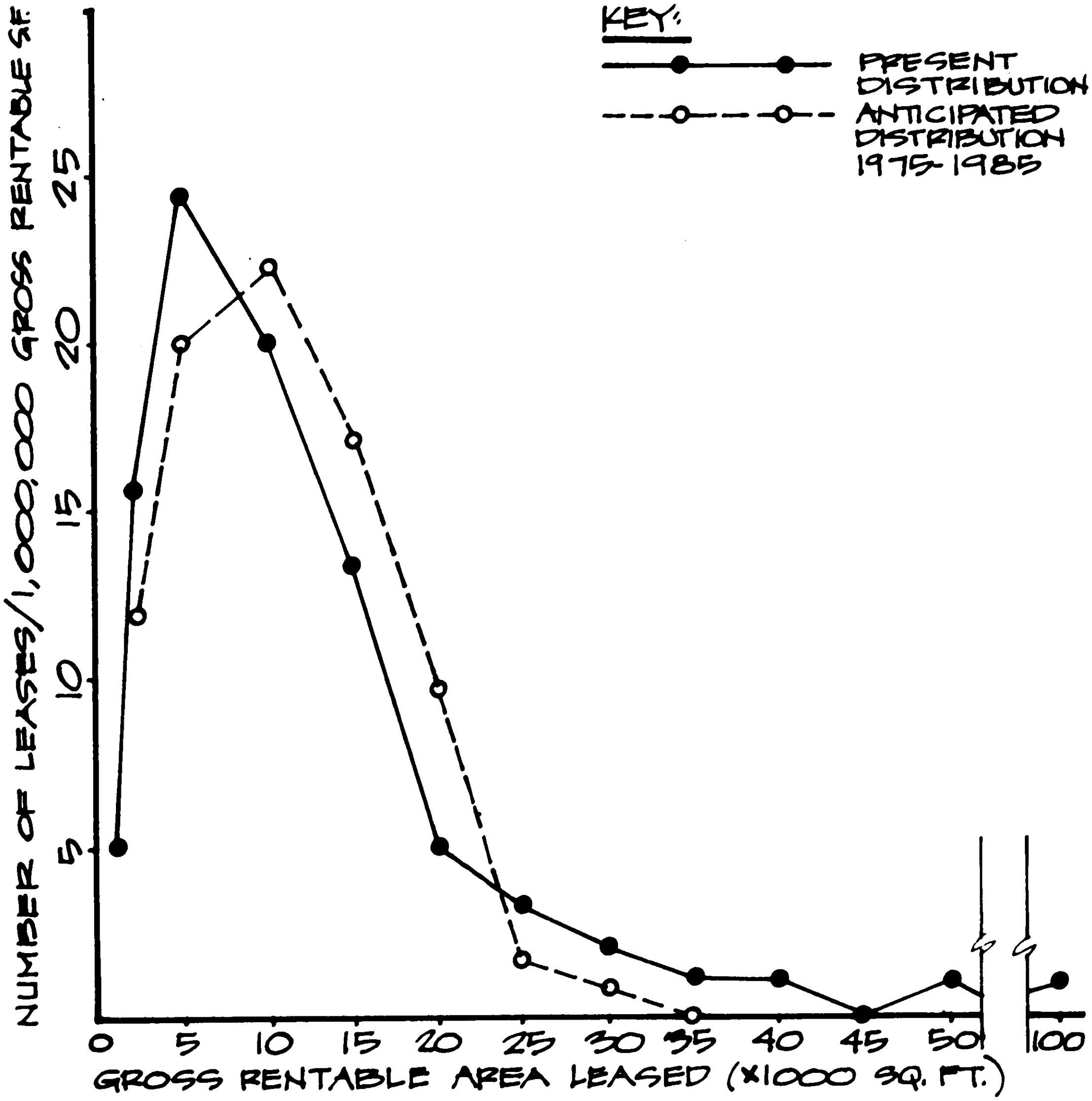
Maximum Depth of Tenant Space: 45' - 50'

Minimum Depth of Tenant Space: 30' - 35'

Typical Ceiling Height: 8'-6" Min.

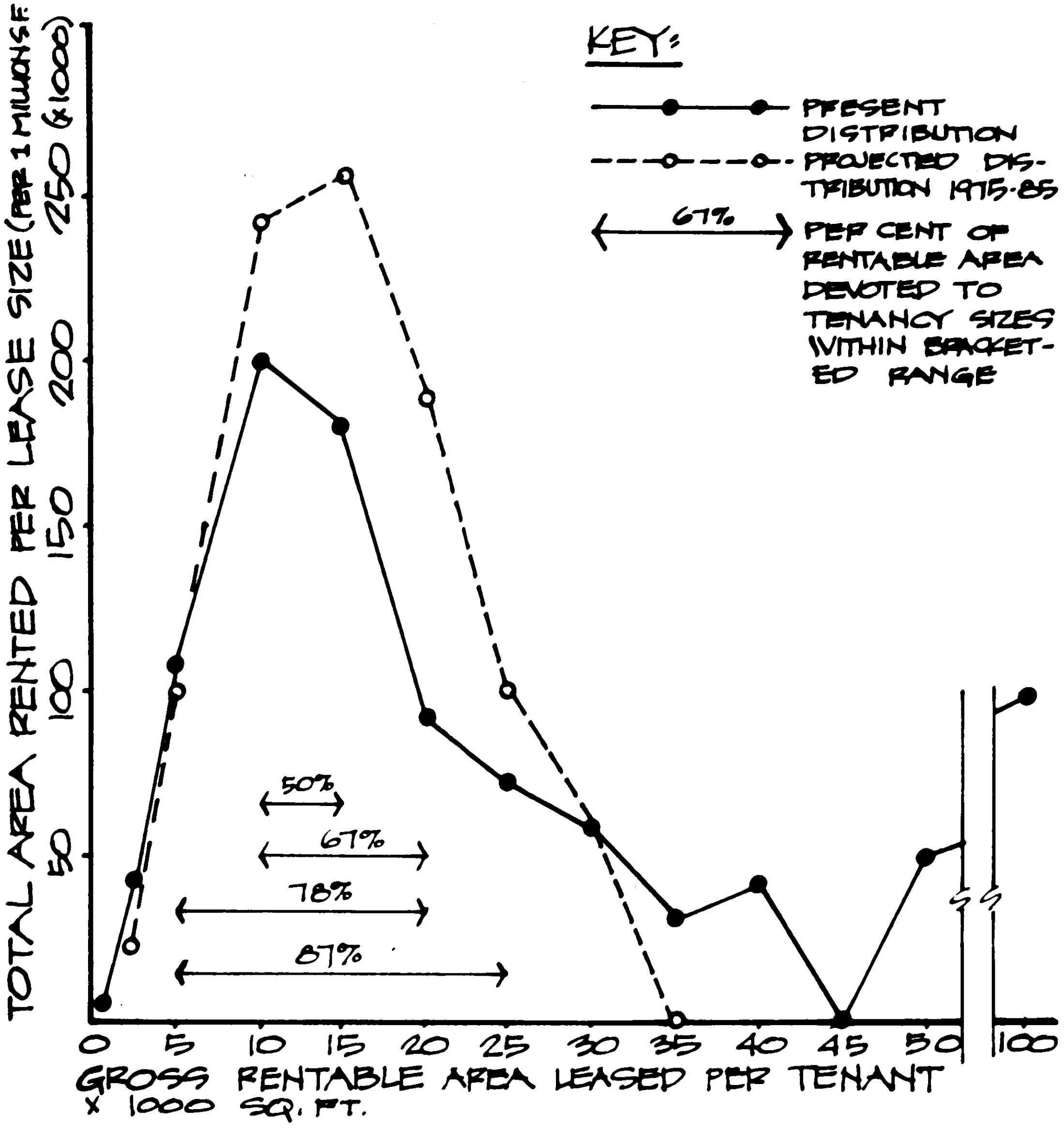
d. Tenant Services: Per Building Code and Present Practice

Each Floor: Exit Stairs
Elevators



NOTE: PROFILE BASED ON DATA SUPPLIED BY FARNSWORTH, PALMER & CO., REAL ESTATE CONSULTANTS, CHICAGO, ILL., FOR DOWNTOWN OFFICE SPACE IN 700,000 SQ.FT. TO 1,500,000 SQ.FT. SPECULATIVELY DEVELOPED BUILDINGS.

CHART D: TENANCY PROFILE I: NUMBER OF LEASES BY SIZE OF RENTED AREA (PER 1 MILLION S.F.)



NOTE: SEE CHART D FOR SOURCE AND QUALIFICATIONS TO DATA.

CHART E: TENANCY PROFILE II: TOTAL RENTABLE AREA BY SIZE OF RENTED AREA (PER 1 MILLION S.F.)

Toilet Facilities
Receiving and Freight Closet
Maintenance Closet
Communications and Electric Closets
Mechanical Spaces
"Wet Columns" - @ core
Mail Chute (no closet)

Ground Related: Building Lobby and Directory
Loading Area
Mail Vault

e. Economic Objectives: Per Feasibility Studies

Rental Rates: $9.00/G.R.S.F.

Land Cost: 12% to 15% of Project Cost

Building Construction Costs (Chicago):

Base Building:	$24.00/S.F.G.
Standard Tenant Improvements:	5.50/S.F.G.
Total	$29.50/S.F.G.

Pre-Tax Cash Flow Rate of Return:

15% minimum on initial equity using following factors:

Vacancy Rate: 5%

Operating Expenses:
(incl. Taxes) $3.10/G.R.S.F.

Debt Service: 11.0% Constant

Equity (Book): 15%

Initial Occupancy:

December 1, 1973

f. Initial Physical Property Specification: Sample for Tenant Spaces:

(See Chart B) May be used to compare other possible tenancies for compatibility

Direct Outside Access:

Interior Public Corridor

Natural Light:	Window Area approximately 10% of Usable Area (min.)
Natural Ventilation:	None - all mechanical 5% fresh air supply (min.)
Intensity of Human Use:	Per Code: 100 G.R.S.F./person Actual: 150 G.R.S.F./person
Intensity of Machine Use:	5-10 Watts/G.R.S.F.
Intensity of Bulk Use (Per Code):	Tenant Areas 50 p.s.f. (min.) Service Areas 100 p.s.f. Lobbies & Receiving 100 p.s.f. Mechanical Areas 100 p.s.f.
Inclined Floors Required:	No
Ceiling Height: Office Areas	Maximum: 10'-0" Minimum: 8'-6"
Optimum Structural Span:	40'-0" minimum 50'-0" maximum
Standard of Tenant Finish:	Not Included
Durability of Tenant Finishes:	See Adaptability Program
Degree of Environmental Control:	Zoned: 2 Peripheral zones/floor 1 Interior zone/floor Peripheral zone to have 20'-30' long thermal control zones Interior to have 1,000 S.F. thermal control zones
Isolation from Adjoining Space: (S.T.I.)	Visual: Complete Acoustical: 50 db S.T.C. Fire: 1 hour rating
Illumination Level (S.T.I.; 2'6" above floor):	75 foot candles
Permissible Ambient Noise Level:	10 decibels

g. Design Performance Indexes: ("Rules of Thumb")

$$\frac{\text{Vertical Surface Area}}{\text{Gross Floor Area Above Grade}} = .35 \text{ (max.)}$$

$$\frac{\text{Gross Rentable Area}}{\text{Gross Floor Area}} = .85 \text{ to } .90$$

Approximate weight of Structural Framing and Floor Slabs per Gross Square Foot (Steel) =

0.75 x Number of Floors + 3.0

$$\frac{\text{Height from Ground}}{\text{Narrowest Dimension of Building at Ground}} = 2.5 \text{ to } 3.0 \text{ (max.)}$$

$$\text{Gross Area per Typical Floor} \times \frac{2}{1000} =$$

maximum number of floors

h. Building Configuration Chosen (See Design Studies)

Total Area: 900,000 to 1,000,000 G.S.F.

F.A.R. on 1/4 Block Site: 26.3

F.A.R. on 1/2 Block Site: 13.2

Full Block to have multiple buildings

Building Area Breakdown:

33 Typical Floors @ 29,600 = 845,000 S.F.
1.5 Mechanical Floors @ 25,600 = 33,400
1 Lobby Floor @ 20,000 = 20,000
Penthouse & Roof-top Mechanical = 4,000
2 Basements @ 25,600 = 51,200
953,600 S.F.

Building Height:

36 to 37 Floor Levels above grade @ 12'-6" = 450 feet to 462.5 feet

Typical Floor: 184' x 137'

Planning Module: Base 4'-6"
Alternates: 1'-6"
3'-0"
9'-0"

i. Building Code Applicable:

Municipal Code of Chicago, Chapters 13, 39 to
78.1, relating to Buildings, as Amended to
January 1, 1967

The above is the basis for the design studies in Section IV.D. It has been developed to be typical of specifications for a speculative office building in downtown Chicago, but has general application to all other downtown situations.

B. Spatial Adaptability Program

The initial spatial and material configuration of the project is also to be programmed for adaptability. The categories of considerations are based on the previous discussion of the changes to which spatial and material systems are subject. Here the attempt is made to quickly characterize the frequency, type and direction of change. The frequency of change is characterized by application of probability notation, whereas the type and direction of change are broken into sub-categories so that likely requirements may be simply indicated. Finally, a durability specification is placed on each spatial category indicating the range of time beyond which it is unlikely that the initial space will need to retain high utility (See Chart F).

The exercise of establishing such a shorthand program emphasizes the possibilities available for providing an adaptable environment. It also helps to indicate which spatial categories require specific sorts of considerations. A few examples should illustrate the point.

The great majority of the building space is initially to be devoted to the accommodation of office activities. These activities, in aggregation, are likely to remain the principal users of the structure but both the character of the activity and spatial requirements of individual users are going to fluctuate substantially. Tenants want to be able to move in and out of the building over a fairly short term. If an individual tenant remains, his spatial requirements will change with fairly high frequency. Certainly

INDICES OF CHANGE CATAGORIES OF SPACE	FREQUENCY OF SPATIAL CHANGE (PROBABILITY)					TYPE OF CHANGE					REQUIRED PERIOD OF USE (YEARS) (LT=LONGTERM)
	UNDER 1 YEAR	1-2 YEARS	2-5 YEARS	5-10 YEARS	LONG TERM	CHG. IN INTENSITY OF USE	CHG. IN ACTIVITY TYPE	CHG. IN SPATIAL CONFIG.	EXPANSION	CONTRACTION	DURABILITY
USER SPACES:											
A. TYP. OFFICE SPACE	.2	.4	.5	.8	1.0	■	■	■	■	■	5-10
B. TYP. COMM'L SPACE	.1	.3	.6	.9	1.0	■	■	■	■	■	5-10
SERVICE SPACES:											
A. CENTRAL SERVICES											
LOBBY	0	0	.1	.4	1.0			■			10-20
RECEIVING	0	.1	.1	.2	.5	■		■	■		10-20
STAFF & WORK SHOPS	0	.1	.1	.2	.5			■			10-20
STORAGE	0	.1	.1	.2	.5	■	■	■	■	■	15-25
PRIMARY MECH. & ELEC.	.1	.3	.5	.7	1.0	■		■	■		LT
B. TENANT SERVICES											
EXIT STAIRWAYS	0	0	0	.2	.5	■			■		LT
PASS. ELEV. SHAFT	0	0	0	.2	.5	■			■		LT
FREIGHT EL. SHAFT	0	0	0	.1	.4	■			■		LT
TOILET ROOMS	0	.1	.3	.4	.8	■		■	■		10-20
MAINT. CLOSETS	0	0	.2	.3	.4						LT
ELEC. & COMM. CLOS.	.1	.2	.5	.8	1.0	■		■	■	■	5-10
UTILITY SHAFTS	.1	.1	.1	.3	.5	■		■	■	■	10-20

CHART F: SPATIAL ADAPTABILITY PROGRAM within a ten year period major spatial reconfiguration for any remaining initial tenant is next to certain. This change can manifest itself through

a. Intensification or Reintensification of Use of Tenants' Space

b. Expansion or Contraction of Tenants' Space

c. Relocation of Tenants' space in Building concurrent with a. or b.

d. Change in Activity of Tenant

The building material and service systems capabilities will be the condition limiting the degree to which these changes may economically occur and thus the spaces provided for these services must be configured to be adaptable to changes taking place in tenant areas. The critical parameter here is likely to be changes in the intensity of use of the tenant spaces. Intensity of use may be simply expressed in three categories:

Intensity of Human Use of Space: Square Foot/person
Intensity of Energy Produced: Watts (Btuh)/S.F.
Intensity of Bulk Use: lbs/S.F.

Changes in intensity of Energy Produced and in Bulk Use have direct and obvious effects on the mechanical, electrical and structural systems and will be discussed below. Changes in the intensity of human use directly effect the spatial configuration and use of service spaces as well. If the population density of the building were to gradually decrease over time because clerical people are gradually being replaced by machinery, the need for elevator, exit stair, toilet room and lobby spaces would also decline. At some point of very low population density, the conversion of elevator shaft space to computer memory bank space, for instance, might be economically desirable. More likely and of greater economic significance is a substantial increase in the intensity of human use in the building. To accommodate such a desired change it will be necessary to minimize the cost of: 1) Adding exit stairway(s) shafts of the height and exit dimension required (possibly throughout the height of the building), 2) Adding elevator capacity by reconfiguring the lobby while providing for double deck elevator cabs, or by adding additional shafts. These shafts could be best located near the core and thus require that floor structure be cheaply removable, or they could be added at the exterior surface of the building thus requiring addition of structure and modification of existing enclosure. Likewise, toilet rooms would have to be added beyond the initial core of the building. This might take the form of the addition of several executive toilets near peripheral executive offices.

Because of the vertical spatial configuration of the structure, it is obvious that the least desirable location for increases in intensity of use is high in the building. The addition of service shafts to these areas is most expensive and disturbs all lower level activities. Since the structure accommodates a great range of tenancies, it may be possible to concentrate the most intensive at the lower levels where additional service spaces may be provided more economically. Less intensive uses are then gradually accumulated at the upper levels. This reinforces the previous conclusion that the lower, ground associated, levels of the building are likely to be subject to greater specification changes by the surrounding uses than the upper levels.

The most frequently changing spatial requirements are those of tenants. Since there are no buffer areas between tenant spaces which could accommodate incremental changes in the area requirements of tenancies, growth (or shrinkage) of any tenant space should be able to occur vertically as well as horizontally. Thus it should be possible to provide for the insertion of a stairway or escalator at many points in the tenant areas without the necessity of rebuilding the major structure.

Spatial Adaptability Program Summary: In Order of Increasing Cost:

Provide for Addition of Exterior Stair and Service Shafts

Provide for Expansion of Core Facilities into Tenant Areas

Provide for insertion of Vertical Access ways in Tenant Areas

Provide for multiple floor height spaces at base of building

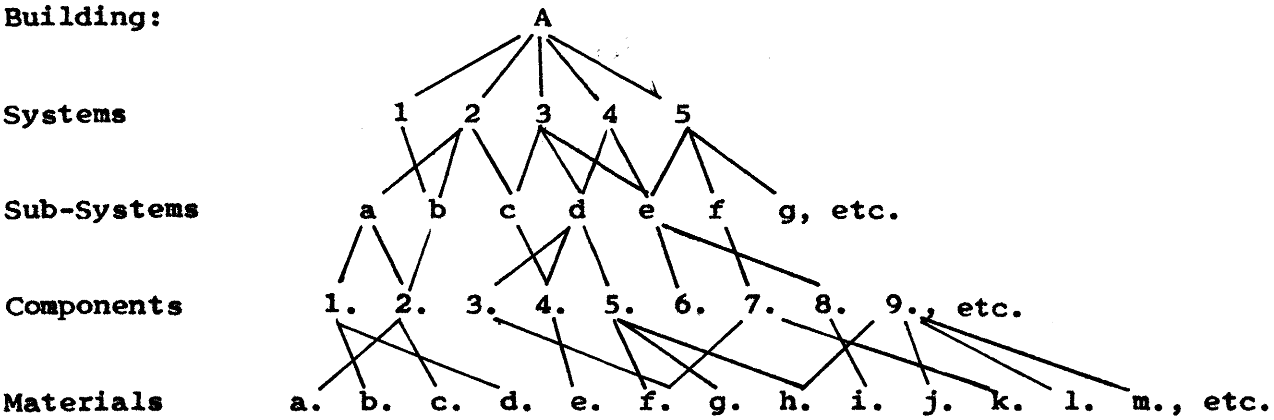
Provide for multiple floor height spaces throughout building

Provide for Re-construction of low intensity spaces at top of building

Provide for Removal and Reconstruction of lower 4 to 6 floors of building (50-70 feet)

C. Material and Service Systems Adaptability Program

The initial spatial specification, a general building configuration and an outline specification for the spatial adaptability have been established. The same techniques of analysis may be applied to the material and service systems as were applied to the spatial specifications. The results of this analysis will guide the selection, combination and detailing of the anatomical elements of the building. CHART G demonstrates a technique for establishing the adaptability requirements of the component systems and sub-systems. The technique could be applied to a higher degree of complexity of analysis by including categories of components and materials.



Adaptability specifications could be produced for each level in the systems hierarchy, but without much utility, I suspect, beyond the component level. Again the frequency and type of change are indicated for each category, a degree of durability is specified for each sub-system.

It has been impossible to give much attention to service systems beyond the establishment of this program, but one conclusion is

INDICES OF CHANGE		FREQUENCY OF MATERIAL SYSTEM CHG. (PROBABILITY)					TYPE OF CHANGE						REQUIRED PERIOD OF USE (YEARS) (LT=LONGTERM)
SYSTEMS	SUB-SYSTEMS	UNDER 1 YEAR	1-2 YEARS	2.5 YEARS	5-10 YEARS	LONGTERM	CHANGE IN INTENSITY OF USE	CHANGE IN SPATIAL SPEC.	CHG. DUE TO OBSOLESCENSE	CHG. DUE TO DETERIORATION	EXPANSION	CONTRACTION	DURABILITY
STRUCTURE	FOUNDATIONS	0	0	.1	.1	.4	■			■	■		LT
	VERTICAL STRUCT.	0	0	.1	.4	.5	■	■		■			LT
	FLR. STRUCT-UPP. LEVEL	0	0	.1	.2	.5	■	■	■			■	LT
	FLR. STRUCT-LOW LEVEL	.1	.1	.2	.4	.7	■	■	■		■	■	30
ENCLOSURE	EXTERIOR WALLS	0	0	.1	.2	.6		■	■	■			20-30
	ENTRIES & STORE FRONT	.1	.2	.3	.5	1.0		■	■		■	■	10-15
	ROOFING & MOIST. PROT.	0	0	.1	.2	1.0		■		■			20-30
	PLAZA DECK	0	0	.1	.4	.6	■	■			■	■	20-30
	SOFFITS	.1	.1	.4	.6	1.0		■			■	■	10-20
SERVICE CORE SPACE DEFINITION	EXITWAY ENCLOSURE	0	0	0	0	.2					■		LT
	PASS. ELEV. SHAFT	0	0	0	.1	.2					■		LT
	FR. ELEV. SHAFT ENCL.	0	0	0	.1	.2					■		LT
	TOILET ROOM ENCL.	0	.1	.3	.4	.7		■			■		10-20
	MAINT. CLOS. ENCL.	0	0	.1	.1	.4		■					LT
	ELEC./COMM. ENCL.	.1	2	.4	.7	1.0		■			■		10-20
	UTILITY SHAFT ENCL.	0	.1	.4	.6	.8		■			■		10-20
	CENTRAL UTILITY ENCL.	0	0	.1	.2	.5		■					LT
	RECEIVING ENCLOS.	0	0	.1	.3	.9		■			■	■	LT
BLDG. FINISHES	LOBBIES	0	0	.1	.3	1.0	■	■	■	■			10-20
	ELEVATOR CABS.	0	0	0	.2	1.0	■		■	■			10-15
	TOILET ROOMS	0	.1	.3	.5	1.0		■	■	■			10-20
	MAINT. CLOSETS	0	0	.1	.5	1.0				■			10-20
	ELEC/COMM. CLOS.	0	.2	.5	.7	1.0	■	■		■			5-10
	CENTRAL UTILITY AREAS	0	0	.1	.4	1.0		■		■			10-20
	RECEIVING AREA	0	0	.1	.3	.9		■		■			LT

CHART G: MATERIAL & SERVICE SYSTEM ADAPTABILITY PROGRAM - "A"

INDICES OF CHANGE		FREQUENCY OF MATERIAL SYSTEM CHG. (PROBABILITY)					TYPE OF CHANGE						REQUIRED PERIOD
SYSTEMS	SUB SYSTEMS	UNDER 1 YEAR	1-2 YEARS	2-5 YEARS	5-10 YEARS	LONGTERM	CHG. IN INTENSITY OF USE	CHG. OF SPATIAL SPEC.	CHG. DUE TO OBSOLESCENSE	CHG. DUE TO DETERIORATION	EXPANSION	CONTRACTION	DURABILITY OF USE (YEARS) (LT = LONGTERM)
STD. TEN. IMPRV'MT.	SPACE DEFINITION	.1	.2	.5	.8	1.0	□	■	■	□	□	□	5-10
	FINISHES	.1	.2	.5	.8	1.0	□	■	■	■	□	□	5-10
	TERTIARY H.V.A.C.	.1	.2	.5	.8	1.0	□	□	□	□	■	■	5-10
	TERTIARY ELEC.	.1	.3	.8	1.0	1.0	■	■	■	□	■	□	5-10
	TERTIARY COMM.	.1	.3	.8	1.0	1.0	■	■	■	□	■	□	5-10
H.V.A.C.	PRIMARY	0	0	0	.1	.6	■	■	■	■	■	■	LT
	SECONDARY	0	.1	.3	.5	1.0	■	□	■	■	■	■	10-20
	BLDG. SERV. TERTIARY	0	0	.1	.2	1.0	■	■	□	■	□	□	LT
PLUMB.	SUPPLY	0	0	0	.2	.6	■	■	□	■	■	□	LT.
	FIRE PROTECTION	0	.1	.2	.4	.6	□	■	■	□	■	□	LT.
	FIXTURES	0	.1	.3	.5	1.0	■	■	■	□	□	□	10-20
	SANITARY DRAIN.	0	.1	.2	.4	.6	■	■	□	■	■	□	LT
	STORM DRAIN	0	0	.1	.4	.8	□	□	□	■	□	□	LT
ELEC.	PRIMARY	0	0	.1	.5	1.0	■	□	■	□	■	□	10-20
	SECONDARY	0	.1	.4	.6	1.0	■	■	■	□	■	□	10-20
	BUILDING TERTIARY	.1	.2	.4	.6	1.0	■	■	■	□	■	□	10-20
	EMERGENCY	0	.1	.2	.5	1.0	□	■	■	□	□	□	10-20
COMM.	TELEPHONE DISTR.	.2	.4	.5	.8	1.0	■	□	■	□	■	□	5-10
	TV/RADIO/C.A.T.V.	.1	.2	.4	.6	.8	■	□	■	□	■	□	10-20
	ALARM & DETECTION	.1	.1	.2	.5	1.0	□	■	■	□	■	■	10-20
MAJOR EQUIP.	PASS. ELEVS.	0	0	.1	.2	.5	■	□	■	■	■	□	20-30
	FREIGHT ELEV.	0	0	.1	.1	.3	■	□	□	■	■	□	20-30
	WINDOW WASHING	0	0	0	.2	.5	□	■	□	■	□	□	20-30
	MAINT. (VACUUM, ETC.)	0	0	0	.2	.3	■	□	■	□	□	□	10-20
	CONVEYOR (MAIL, PNUE.)	0	0	0	.2	.5	■	□	■	□	■	□	LT

CHART G (CONT.) MATERIAL & SERVICE SYSTEM ADAPTABILITY PROGRAM - "B" emphasized by this analysis: the most likely candidates for quick radical change among the material and service systems are the Electrical and Communications Systems. The provision of initial over-capacity and substantial expandability in the spatial and material accommodation of these systems is likely to be a very good gamble, and one that can be undertaken at low cost. Doubling the size of the typical electrical and communications closet, for example, reduces gross rentable area by only approximately 0.5%.

As in the case of spatial systems, potential contractability of de-intensification of use causes few planning problems. Systems will simply develop over-capacity by de-intensification of use and thereby become, perhaps, more adaptable to subsequent changes and at zero cost.

Adaptability to major intensification of use, particularly intensification of use of the major structural system seems to be particularly difficult to accommodate. It is possible to conceive of systems developments which would allow reinforcement of the vertical structural system (additional row of vertical supports and foundations added between core and outside wall and/or addition of horizontal structure between core and outside wall), but not without tremendous cost and reduction of the utility and adaptability of the building. It is entirely feasible, however, to provide for the complete reconfiguration of the upper levels of the building (top 5 or 6 floors) by partial demolition of the building. The top few floors of a high-rise structure may be considered as simply a low-rise building if wind bracing systems and primary mechanical systems do not require the presence of major structure and fixed enclosure at the top.

Similarly, the high probability of major changes in spatial and material configuration at the lowest levels of the building indicate that increasing the concentration of structure at these levels will maximize the utility of the structure over time.

For the purposes of detailing, it is obvious that short term or frequently changed sub-systems and components should have a high degree of autonomy from long term, infrequently changed elements.

Material and Service Systems Adaptability Program Summary: (Partial)
In Order of Increasing Cost:

1. Provide for frequent Removal and Replacement of Standard Tenant Improvement Sub-systems.

2. Provide for Intensification of Human Use through provision for removal of floor structure or enclosure units and extension of plumbing lines, increase in elevator capacity through double decking, etc.

3. Provide for major intensification of machine use by maximizing accessibility and replaceability of primary and secondary service system components.

4. Provide for demolition and reconstruction of entire systems at top of building through making this area as physically autonomous as possible.

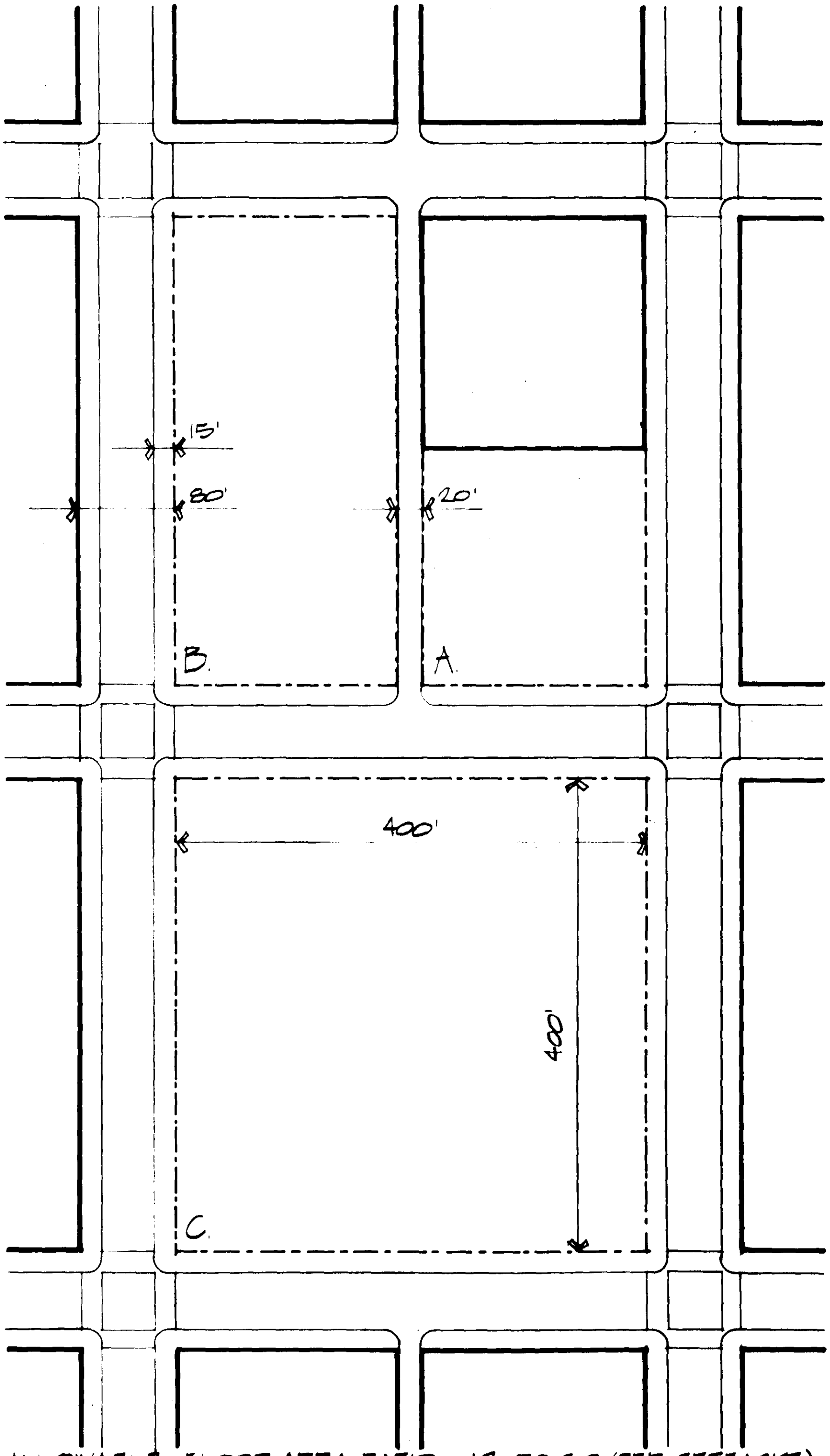
5. Provide for demolition and reconstruction of all systems at base of building through concentration of major structure (circulation and service systems as well as load bearing systems) and autonomy of tenant zone material and service systems in this area.

Finally, the ultimate in planning for adaptability is designing and detailing a major permanent structure for maximum ease of demolition. It should be possible to design structures so that they may be taken down their own elevator shafts, so to speak. The objective would be to use the existing enclosure and perimeter structure as an envelope to horizontally contain the noise, dirt and unsightliness of the process of demolition. At the same time the ever lowering roof could be an inflatable or membrane structure that encloses and isolates the work from the top.

D. Design Studies

On the following plates will be found the graphic results of this study and the development of the preliminary design for a high-rise structure of 1,000,000 square feet.

SITE PROGRAM:



ALLOWABLE FLOOR AREA RATIO = 12 TO 30 (PER SETBACKS)
SITE A: 190' × 200' = 38,000 SQ.FT.
SITE B: 190'×400' = 76,000 SQ.FT.
SITE C: 400'×400' = 160,000 SQ.FT. (FOR MULTIPLE BLDGS.)
UTILITIES (ALL BELOW GRADE UNDER STREET): GAS MAIN,
WATER • FIRE MAINS SANITARY • STORM SEWERS,
ELECTRIC MAIN, TELEPHONE, C.A.T.V.

BUILDING PROGRAM SUMMARY:

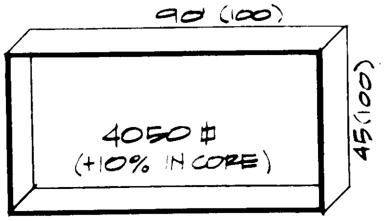
F.A.R: 12 TO 30

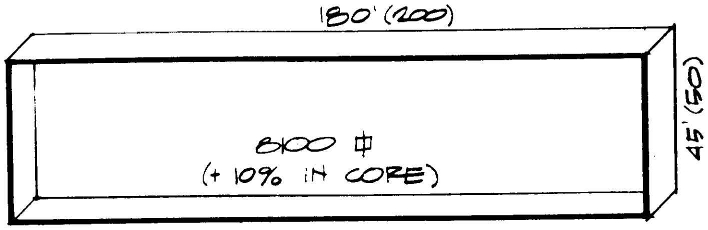
BUILDING AREA:

- TOTAL GROSS BUILDING AREA: 700,000 - 1,500,000 #
- BASED ON F.A.R: 12 × SITE "B" = 913,000 SQ.FT.
  30 × SITE "A" = 1,145,000 SQ.FT.
- GROSS BUILDING AREA SELECTED: 950,000 SQ.FT.

TENANCY MODULE:

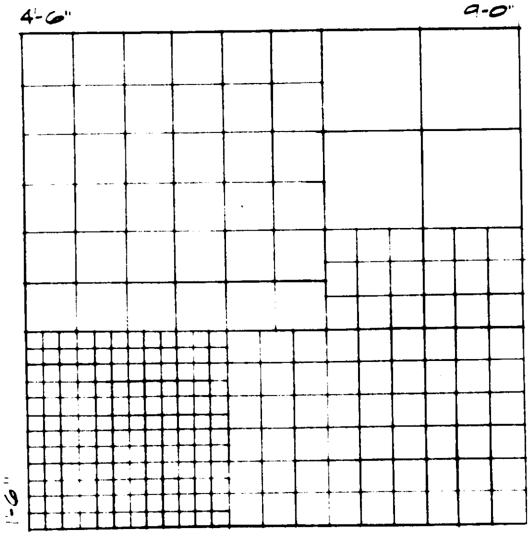
- SEE TEXT FOR ACTIVITY SPECIFICATION
- MODULE BASED ON PRIME TENANCY RANGE OF 4500 GROSS RENTABLE SQ.FT. TO 22,500 G.R.S.F. (85% OF DEMAND)
- LIMITING PROPORTIONS OF TENANT SPACE:
  CEILING HEIGHT: 8'-6" MINIMUM
  SMALL TENANTS (4500 G.R.S.F):
  2.0 FRONT FT./FT OF DEPTH
  LARGE & MED TENANTS (10 - 20,000 G.R.S.F)
  4.0 - 6.0 F.FT/FT. OF DEPTH
- TENANCY MODULE:

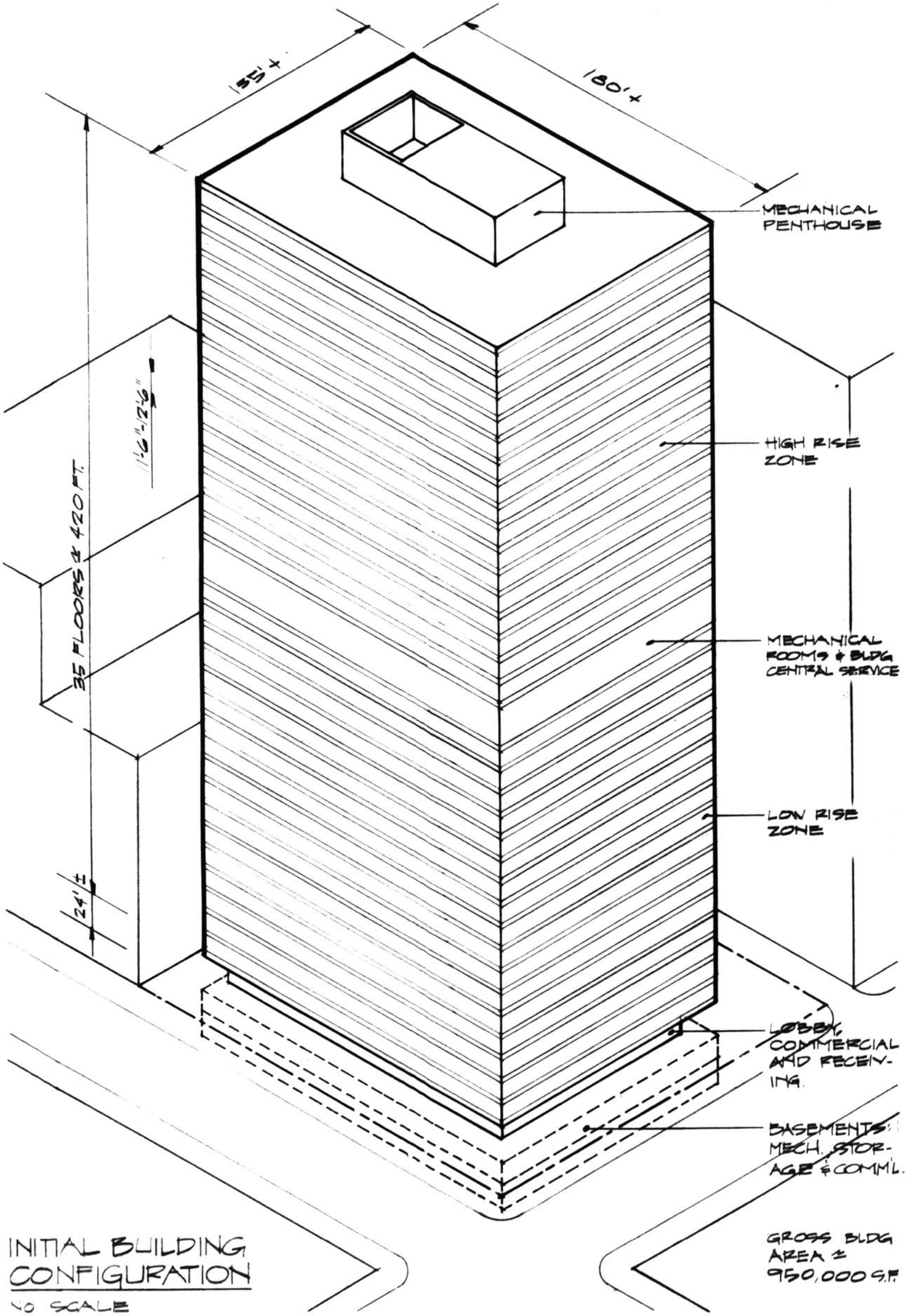
- 

- 

PLANNING MODULE:

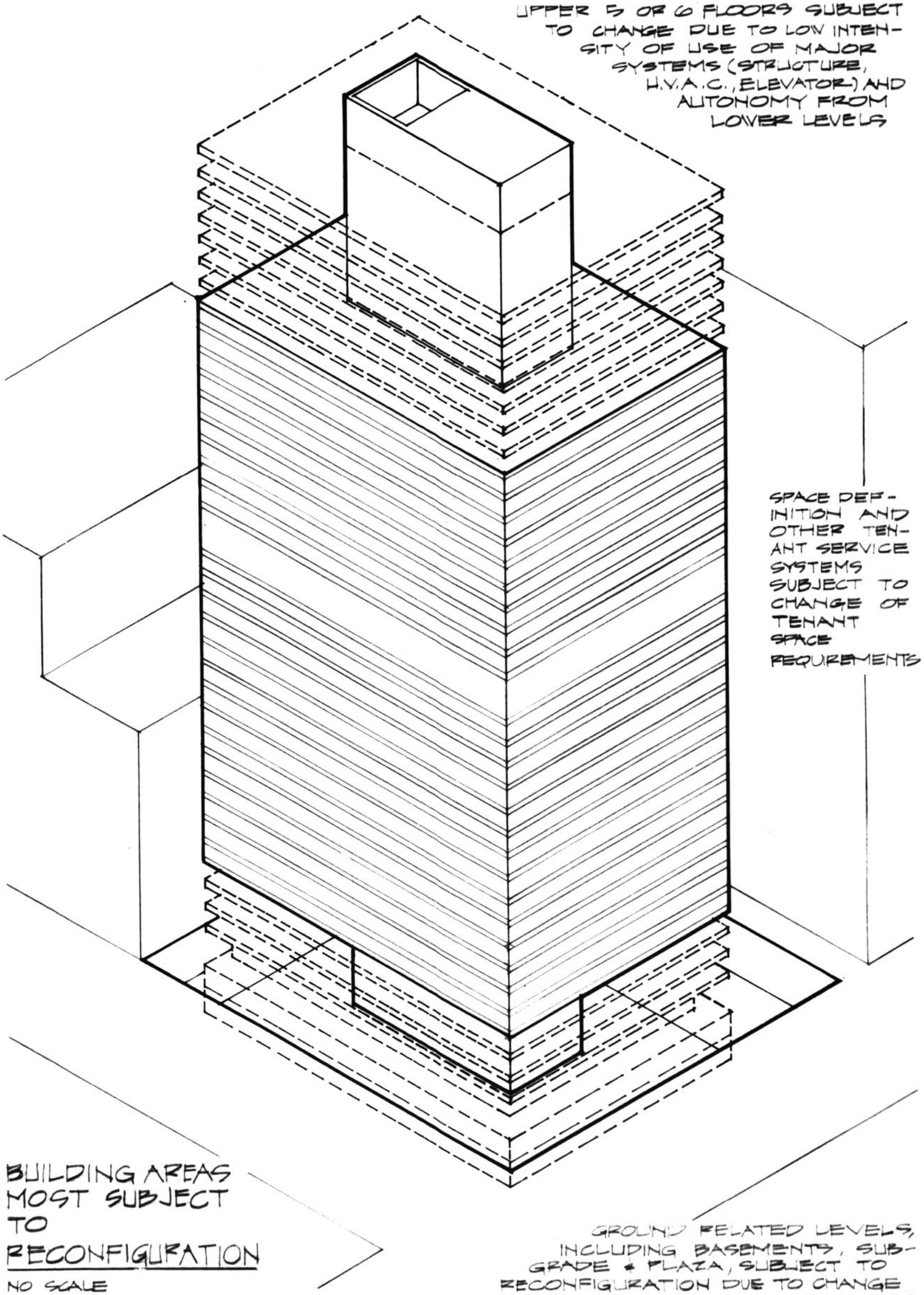
- BASE: 1'6" × 1'-6"
  9'0" × 9'0"





INITIAL BUILDING CONFIGURATION

NO SCALE



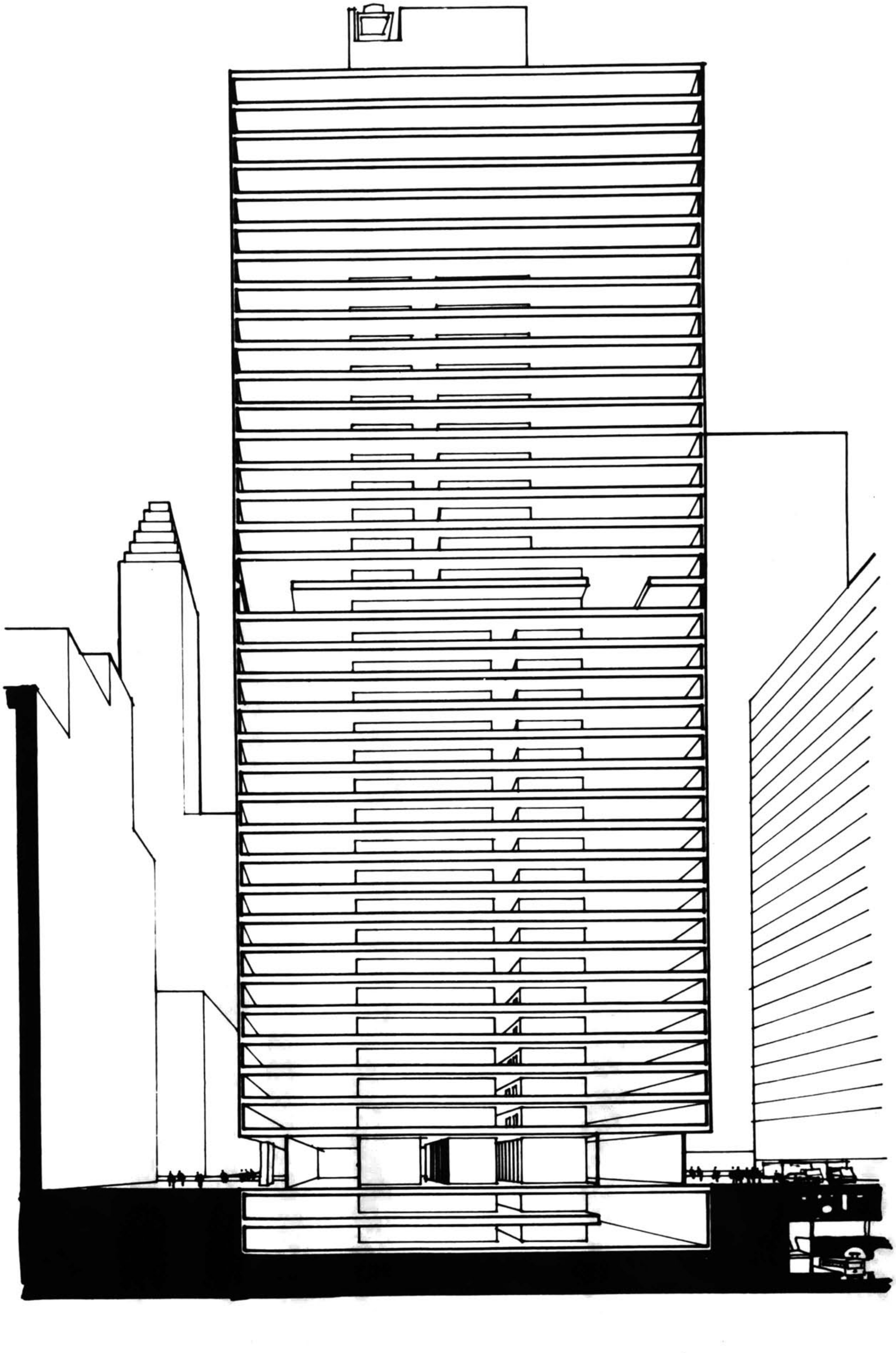
UPPER 5 OR 6 FLOORS SUBJECT TO CHANGE DUE TO LOW INTENSITY OF USE OF MAJOR SYSTEMS (STRUCTURE, H.V.A.C., ELEVATOR) AND AUTONOMY FROM LOWER LEVELS

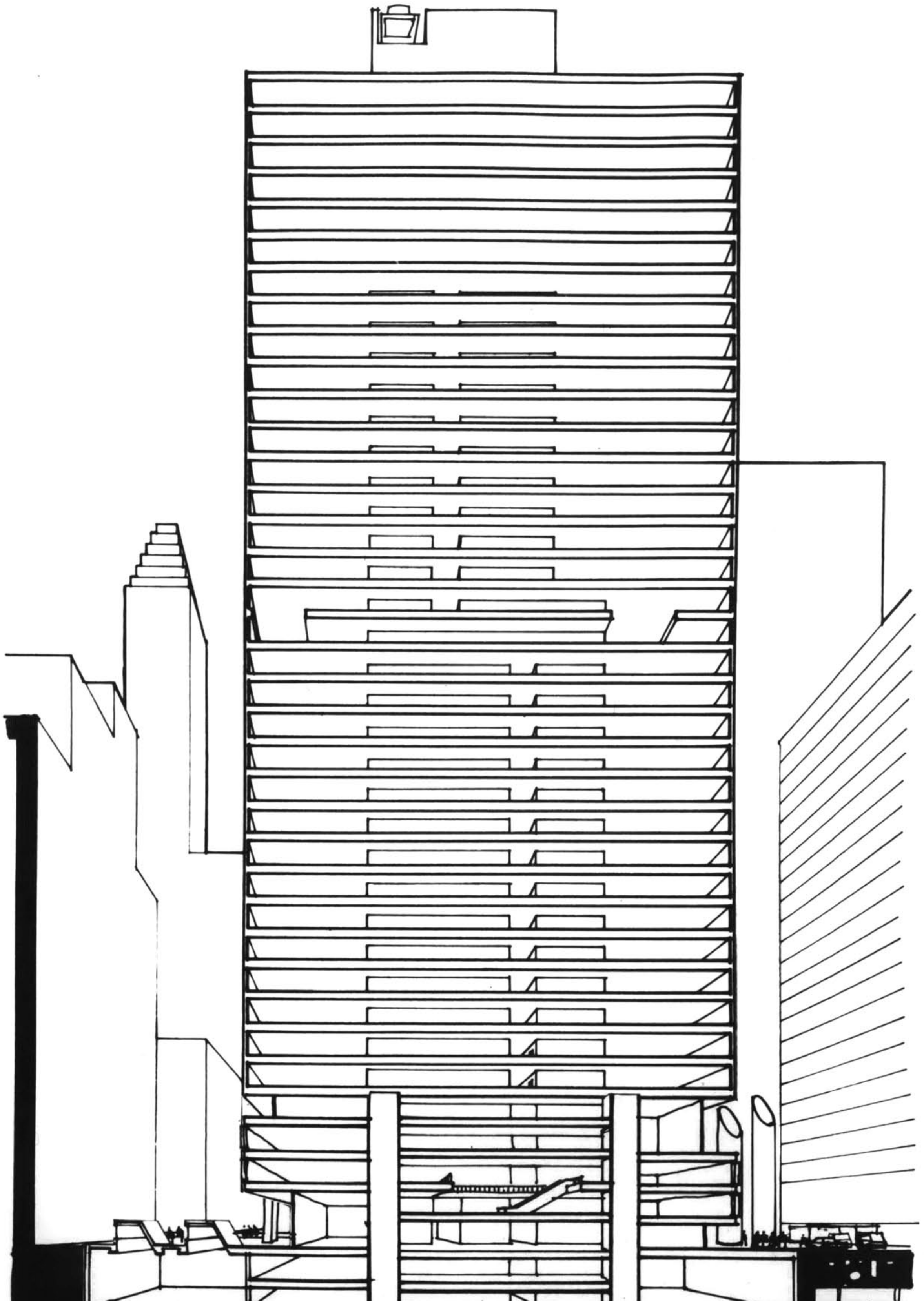
SPACE DEFINITION AND OTHER TENANT SERVICE SYSTEMS SUBJECT TO CHANGE OF TENANT SPACE REQUIREMENTS

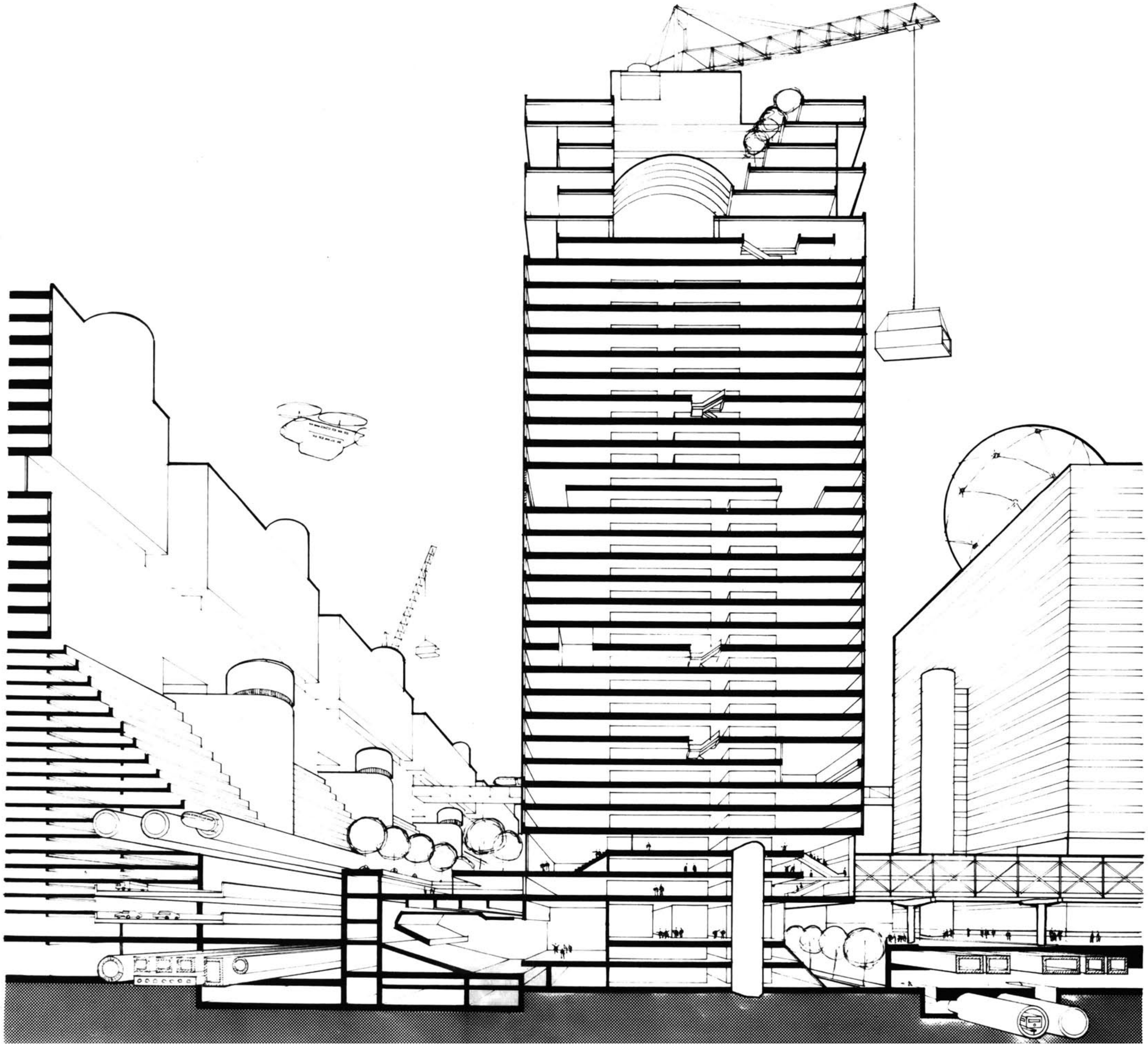
BUILDING AREAS MOST SUBJECT TO RECONFIGURATION

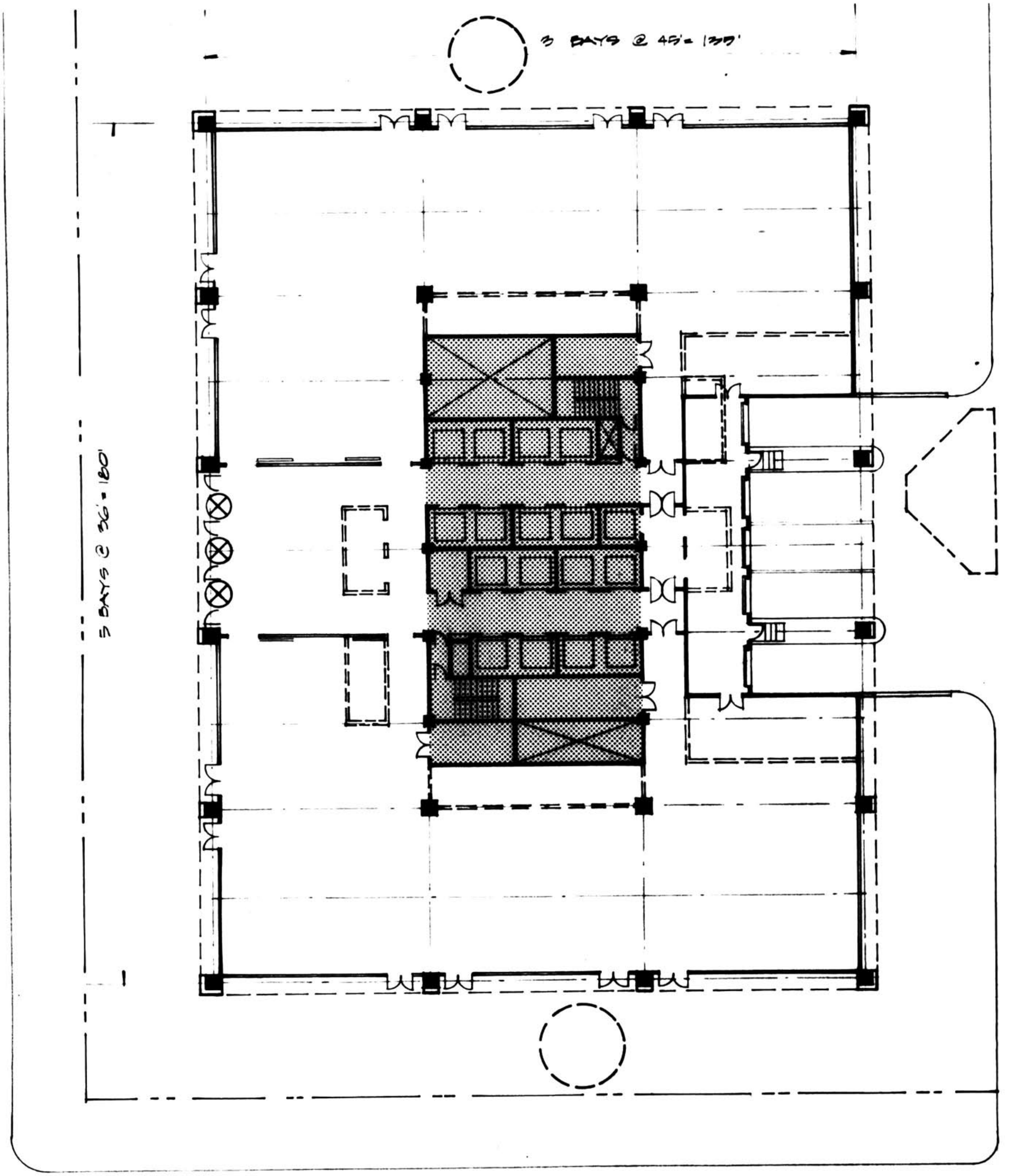
NO SCALE

GROUND RELATED LEVELS, INCLUDING BASEMENTS, SUB-GRADE & PLAZA, SUBJECT TO RECONFIGURATION DUE TO CHANGE OF SPACE USE & ADJACENT LAND USE

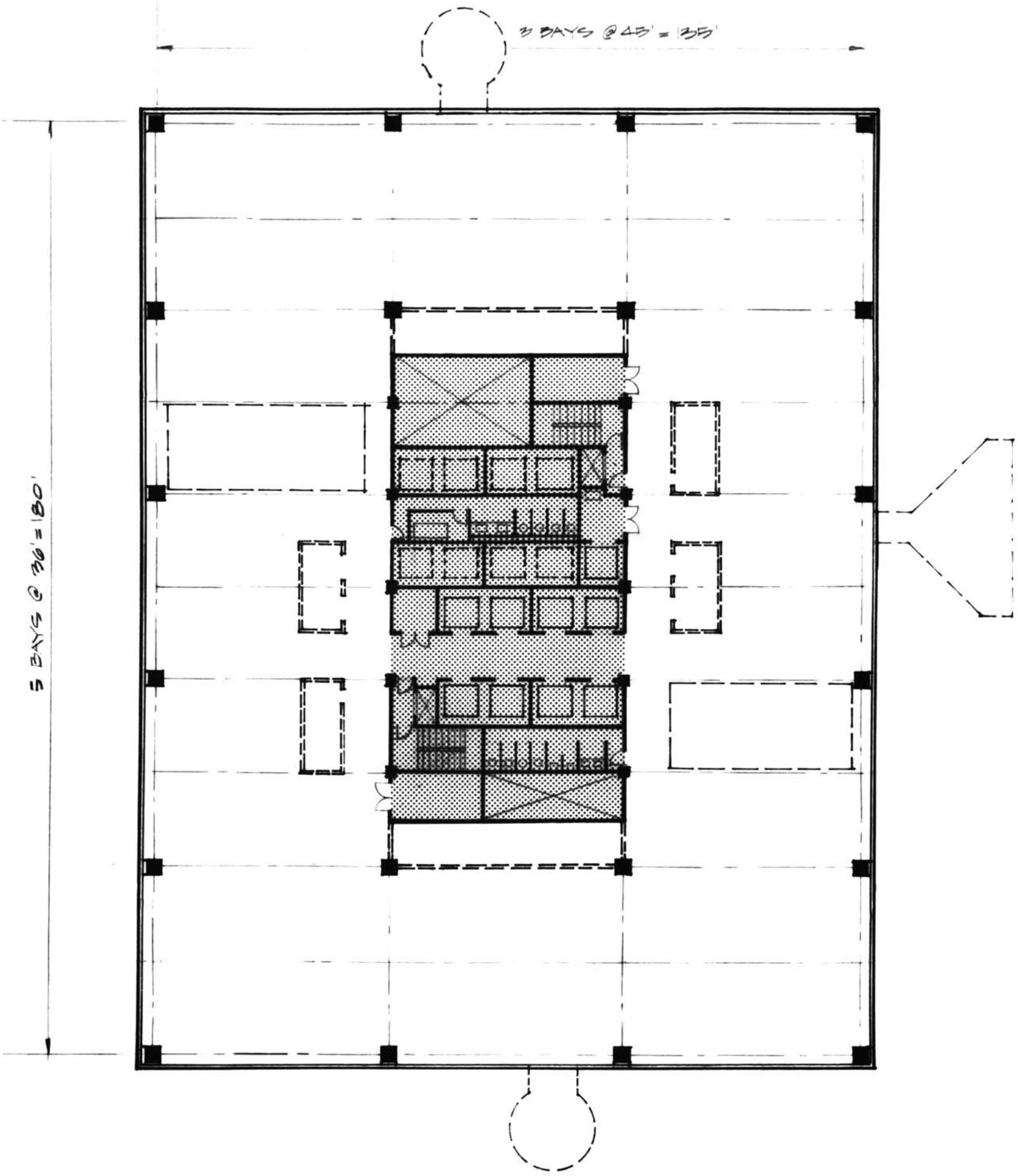




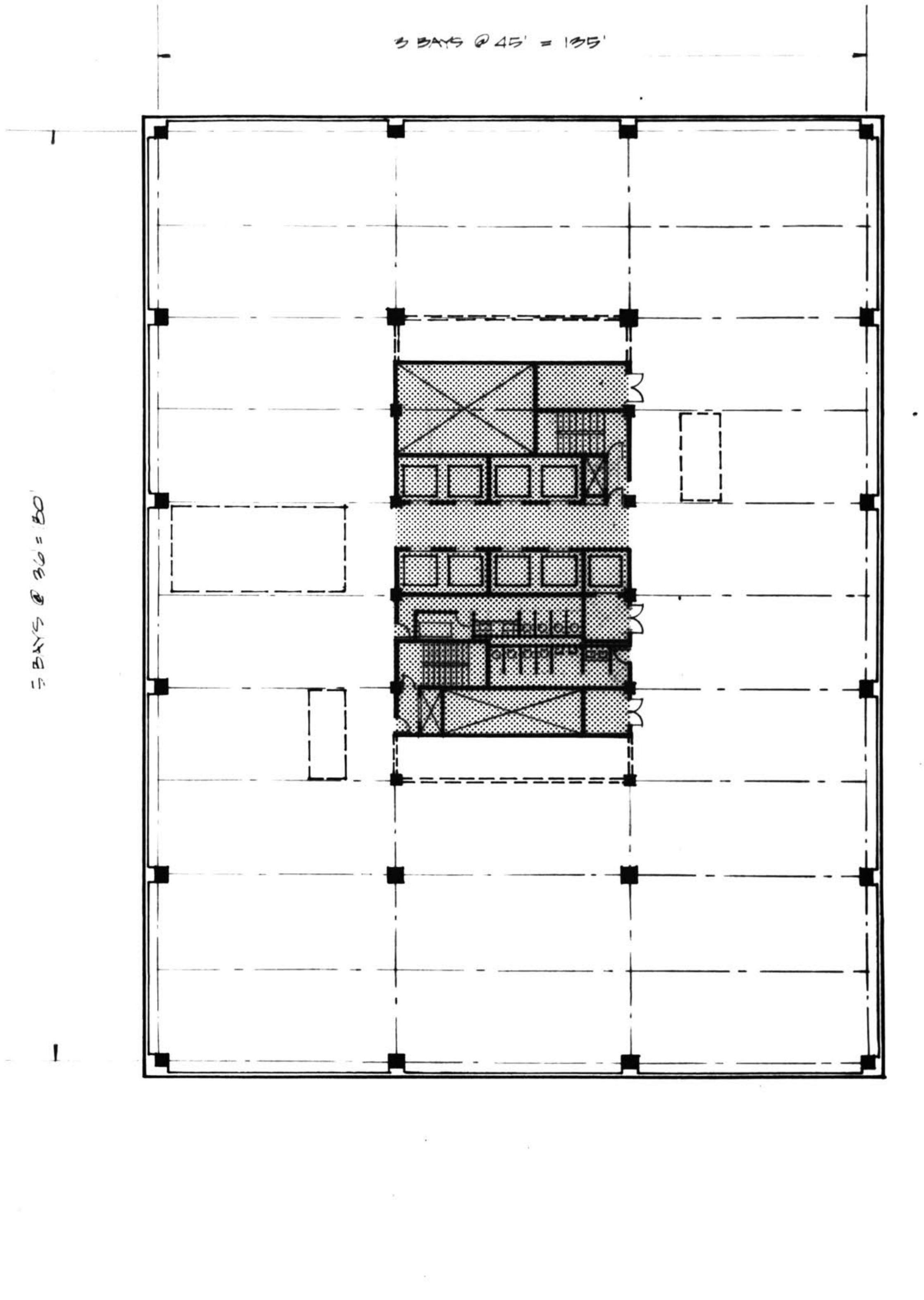




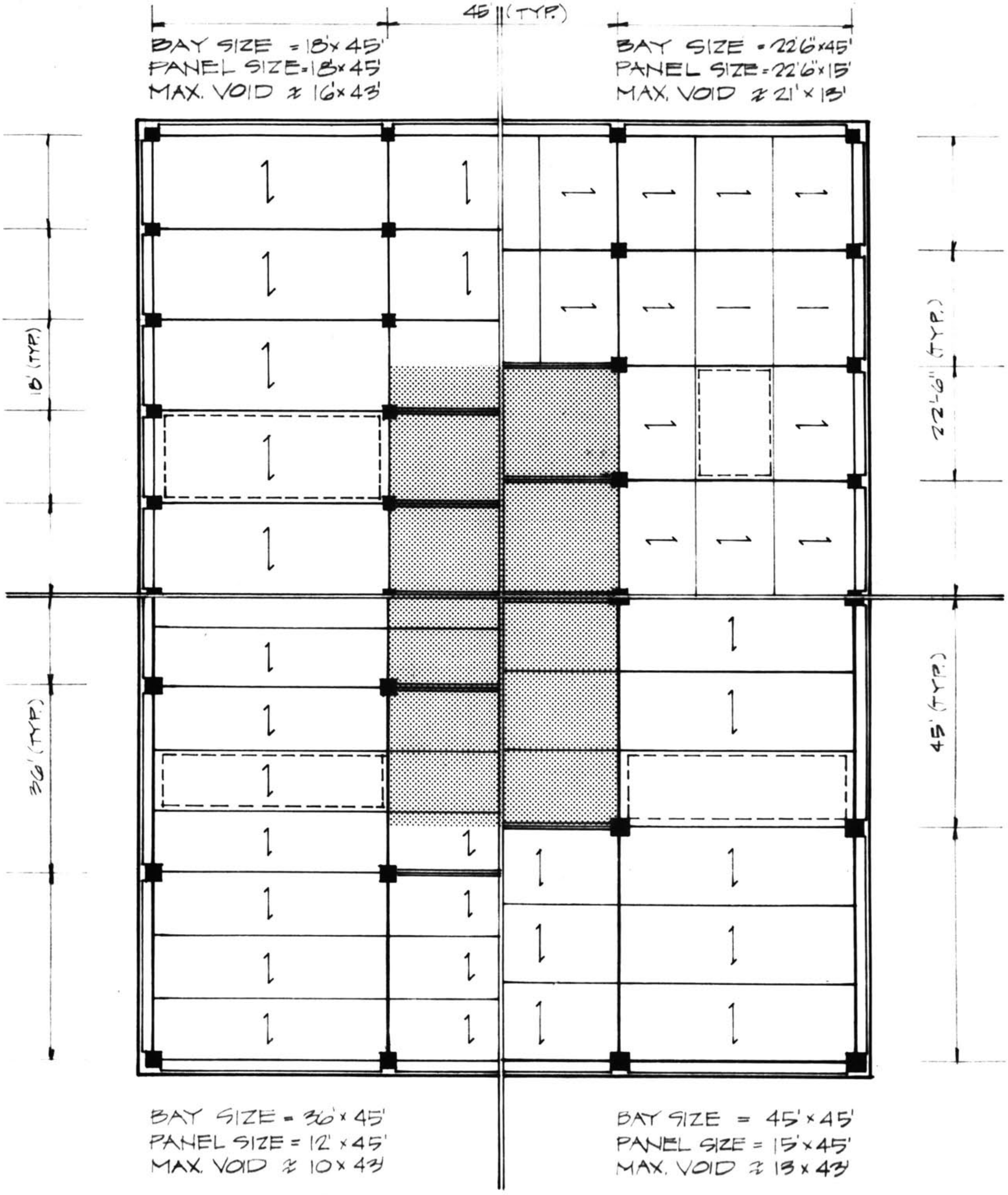
GROUND FLOOR PLAN



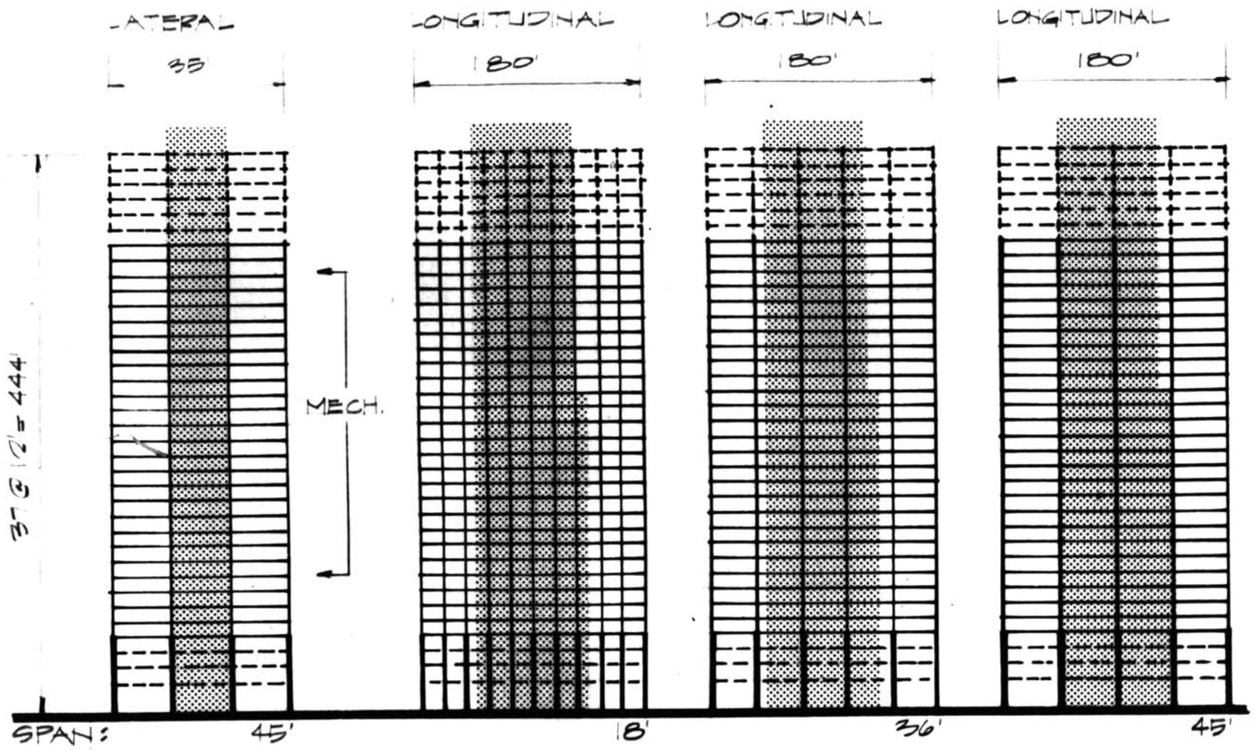
LOW RISE FLOOR PLAN



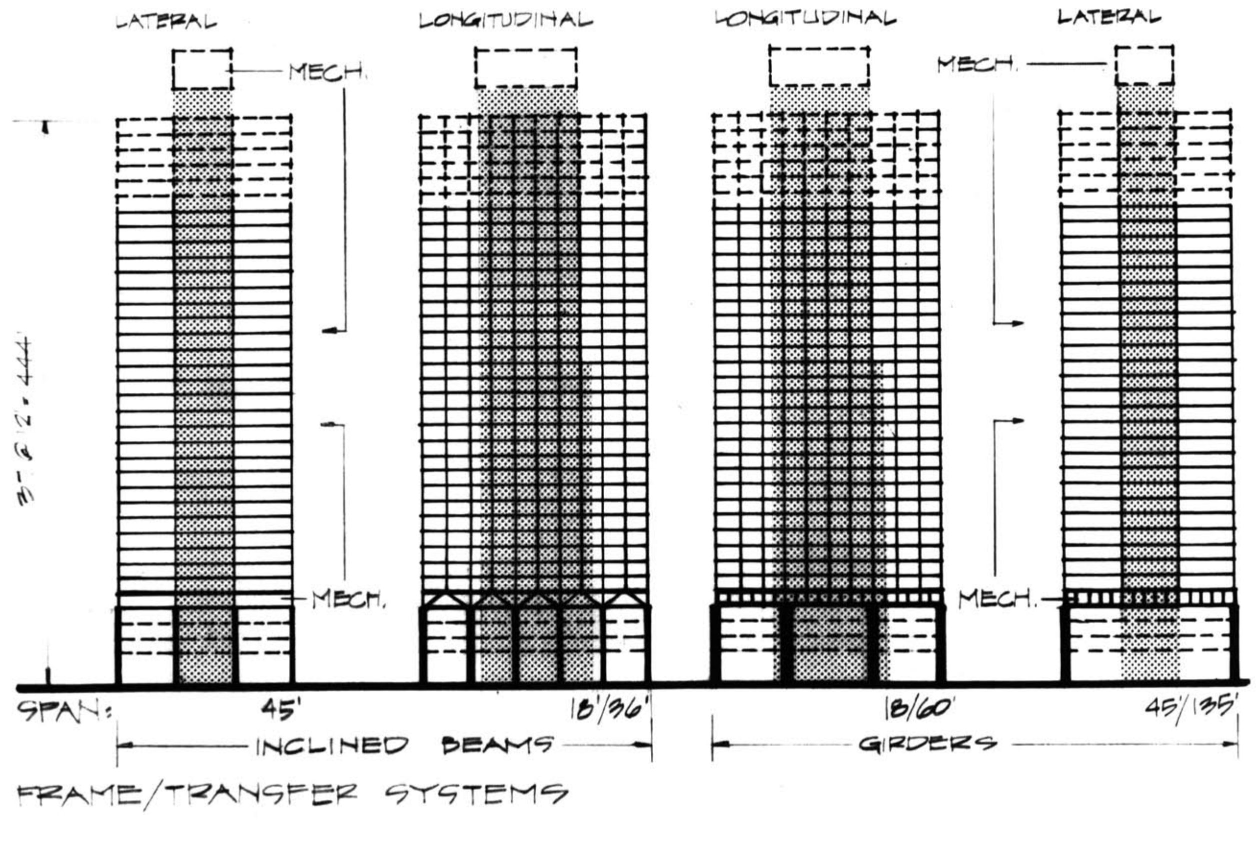
HIGH RISE FLOOR PLAN



FLOOR FRAMING STUDIES

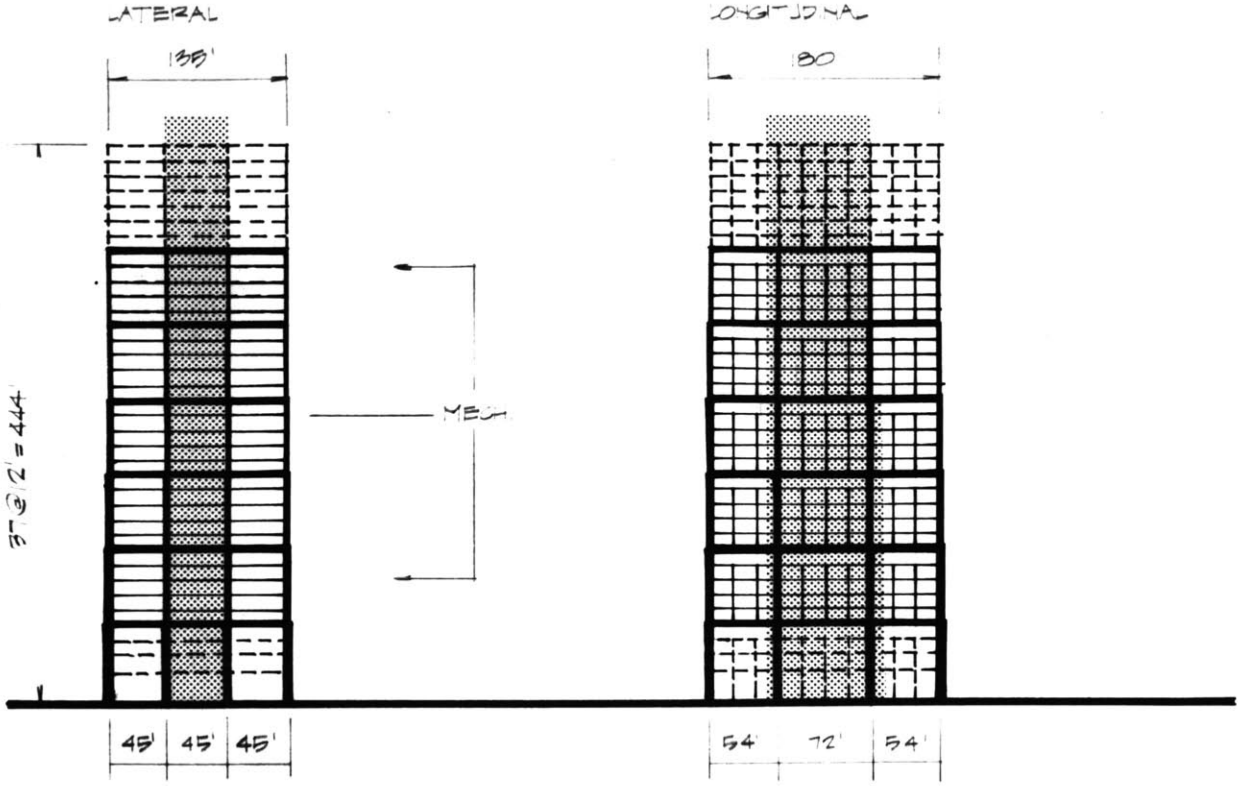


FRAME SYSTEMS

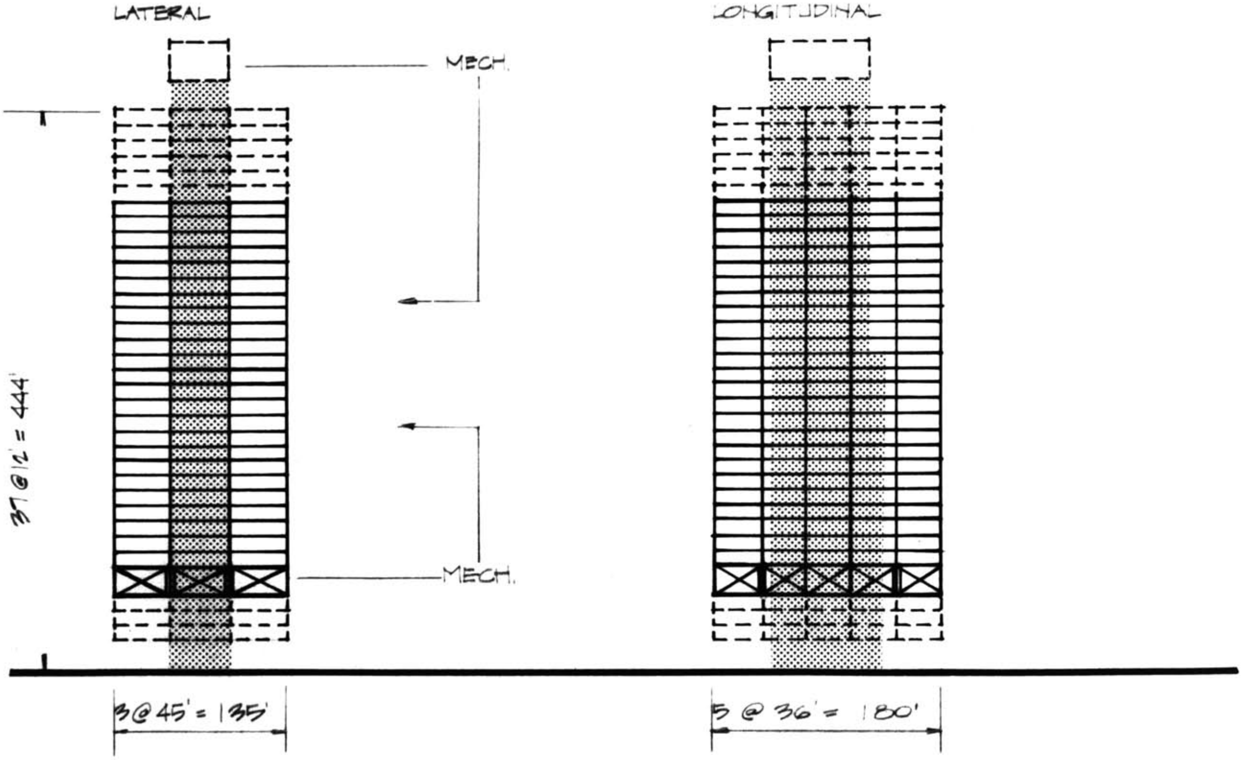


FRAME/TRANSFER SYSTEMS

VERTICAL STRUCTURE STUDIES

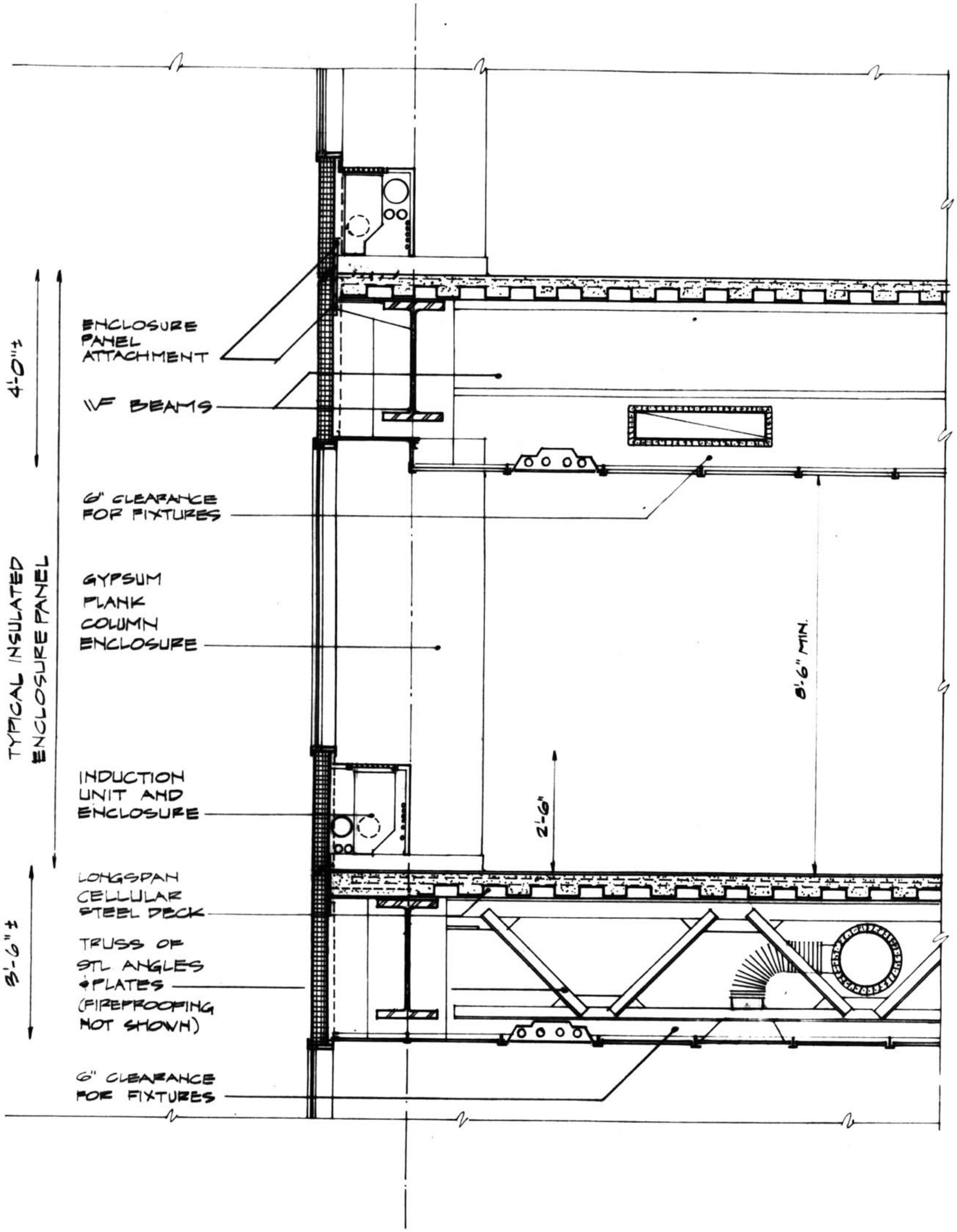


MEGAFRAME

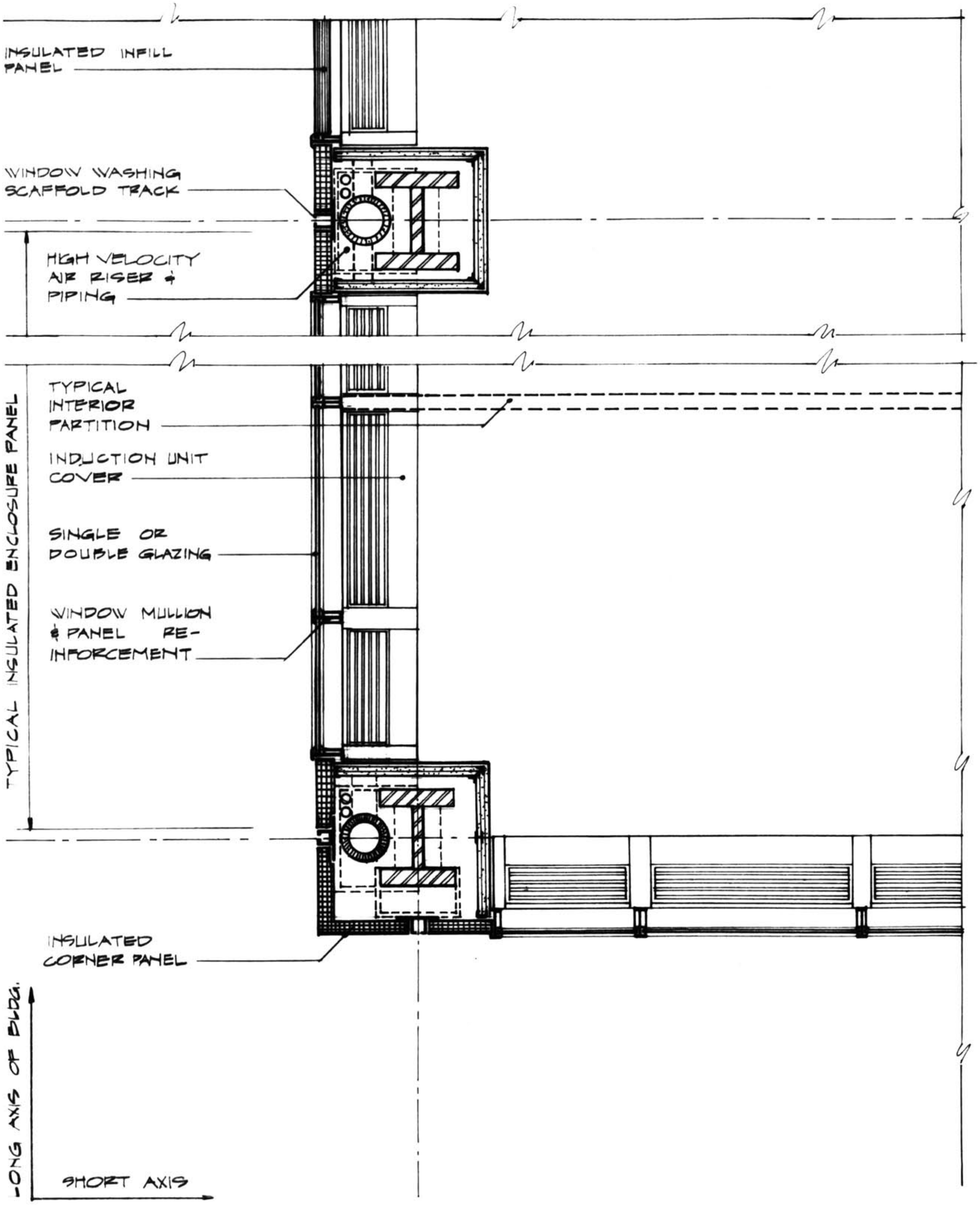


CANTILEVERED FRAME (WITH SUSPENDED LOWER FLOORS)

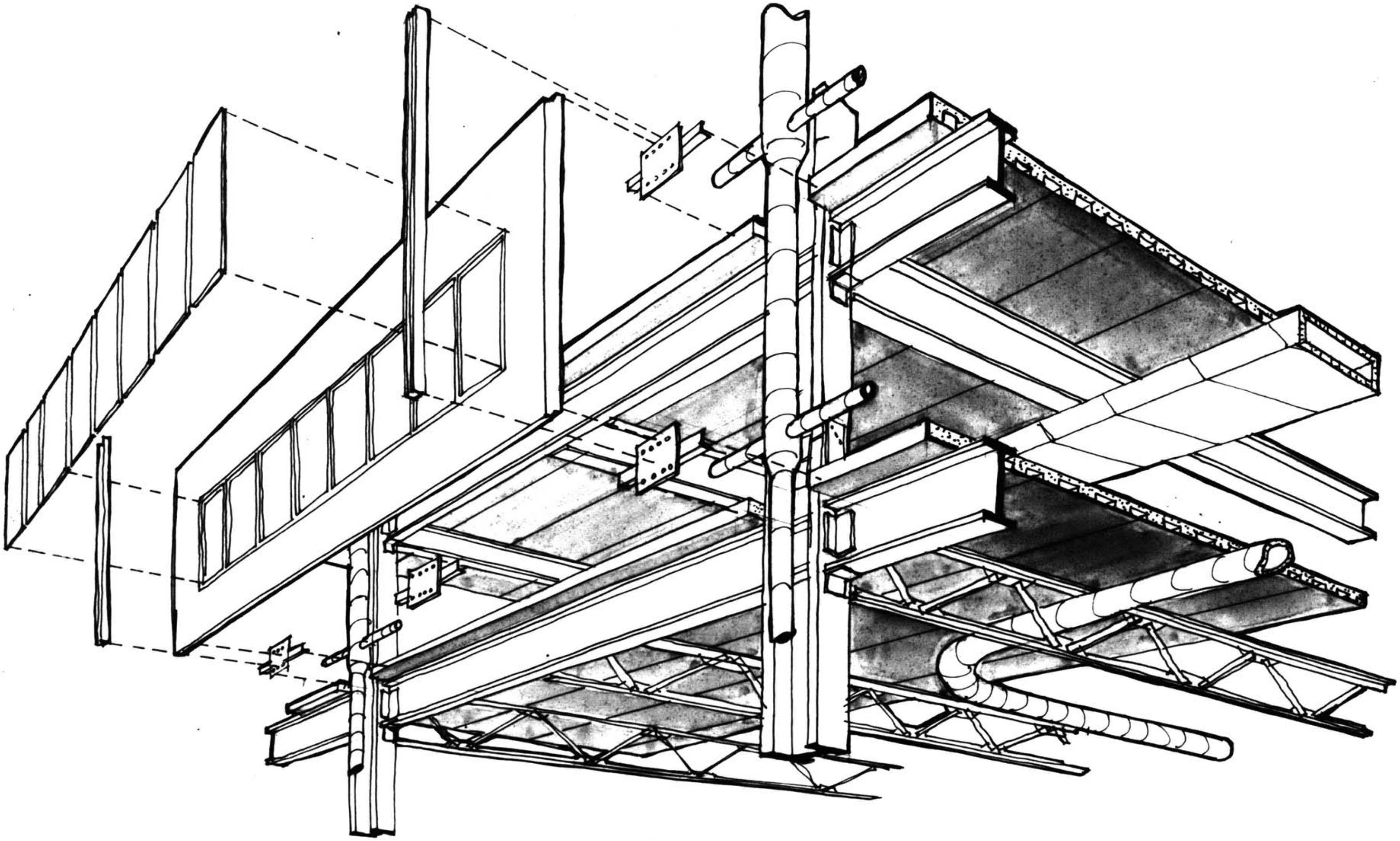
VERTICAL STRUCTURE STUDIES



WALL STUDY - SECTION



WALL STUDY - PLAN



WALL STUDY

V. CONCLUSION

The techniques and concepts suggested here are, obviously, inadequate to the task of economically and accurately analyzing the adaptability requirements of the built environment. The first and principal inadequacy of this study is that it avoids coming to grips with the details of the problem of quantifying adaptability provisions so that cost-benefit decisions may be made as easily about these provisions as about the initial structural configuration. Secondly, considerable and skeptical work needs to be done on further developing a set of physical properties (CHART B) for the comparative evaluation of activities and accommodations that is at once precise, brief and broadly applicable. Thirdly, the detailed means by which adaptability may be provided to material and service systems needs a study of its own.

This study was initiated to introduce the author to the theoretical and practical aspects of the problem. Having surveyed and begun to test these here, there is perhaps, something more productive that may be done in this area as this preliminary exposure is applied and tested in architectural practice.

NOTES TO THE TEXT

1. U. S. Bureau of the Budget defines these loaded words as follows:

Older Cities:	Cities which qualified as Standard Metropolitan Statistical Areas (S.M.S.A.'s) before 1900.
Middle Age Cities:	Cities which qualified as S.M.S.A.'s between 1900 and 1930.
Younger Cities:	Cities which qualified as S.M.S.A.'s after 1930.
Large Cities:	S.M.S.A. population of 500,000 people or more.
S.M.S.A.:	Distinguishable population and market center, as established by U. S. Bureau of the Budget. Definition involves two considerations: 1) Definition of Central City and County by Population (50,000 minimum). 2) Definition of Economic and Social relationships with contiguous counties and cities that are "metropolitan in character." Metropolitan characteristics include per cent of labor force in non-agricultural work, population density and land use.

See: United States Bureau of the Budget, *Standard Metropolitan Statistical Areas*, Washington, D.C., United States Government Printing Office, 1964, pp. 1-3.

2. Helmut C. Schultz, "Structure for Change and Growth," *Forum*, Vol. 134, No. 2, March, 1971, pp. 60-63.

3. *Ibid.*, p. 61.

4. *Ibid.*, p. 61.

5. Kevin Lynch, "Environmental Adaptability," *Journal of the American Institute of Planners*, Vol. XXIV, No. 1, 1957, pp. 16-24.

6. Graeme M. Aylward, *Environmental Adaptability*, M.C.P. Thesis, M.I.T., June, 1966.

7. Graeme M. Aylward, "Towards a Theory for Describing and Designing Adaptability in the Built Environment," Transactions of the Bartlett Society, Volume 7, 1968-69, pp. 132.

8. Kevin Lynch, op. cit., p. 19-23.

9. Helmut C. Schultz, op. cit., p. 62.

10. The foregoing are my own observations and conclusions but are significantly influenced by the sources listed in the Bibliography, particularly:

    a) Articles by I. C. Jarvie, Jungk, H. Moller, Barnett, Mazlish and C. Price in S. Anderson, ed., Planning for Diversity and Choice, Cambridge, Mass., M.I.T. Press, 1968.

    b) David L. Birch, The Economic Future of City and Suburb, CED Supplementary Paper Number 30, Committee for Economic Development, New York, 1970.

    c) John Allpass, "Changes in the Structure of Urban Centers," Journal of the American Institute of Planners, Vol. XXXIV, No. 3, May 1968, pp. 170-173.

    d) Grace Milgram, U. S. Land Prices - Directions and Dynamics, Washington, D.C., U. S. Government Printing Office, 1968.

    e) David Bayliss, "Developing Patterns of Urbanisation: Forecasting and Technology," Transactions of the Bartlett Society, Volume 7, 1968-69, pp. 77-97.

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