ADAPTIVE REUSE: ANALYSIS OF BUILDING STOCK

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Abstract

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This project studies the process of building evaluation and design for reuse. The thesis presents a collection of tools and resources for that purpose, including a checklist for cataloguing physical conditions of existing stock and their implications for design solutions. In order to develop and test the process, two examples were used, a school and a hospital wing, as a context for analysis and design studies.

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I. INTRODUCTION

The implications of a decreasing energy supply coupled with rising costs of materials and production due to inflation are serious issues architects cannot ignore. These trends have led many designers to question the assumption that new buildings must always be constructed as society's needs change. New York architect Richard G. Stein points out in a recent energy study that the construction industry is responsible for 6.25% of all the nation's consumption. "The energy used to make a building is about sixteen times the energy it costs to operate it for a year," he told the New York Times, "so if you hold onto an existing building instead of replacing it, you are sixteen years ahead to start."

There are other arguments for recycling buildings. Reusing structures maintains a continuity in neighborhoods often favored over demolition and new construction, especially when the building saved is unusually handsome or has sentimental value to surrounding residents. Often older buildings were constructed with more expensive materials and attention to decorative detail than is financially possible today. Furthermore, the fact that rehab construction is often less costly than new building, more space can be afforded for the same amount of money. Or, more money can be spent on the quality and character of the adapted space.

Location and the demand for potential uses play significant roles in the feasibility of reuse. However, adaptability also depends on the physical structure and configuration of the building itself, and a rational approach toward assessing this aspect of feasibility is the goal of this thesis project. More specifically, I have been working toward a process which helps one (1) to understand the design potential of an existing building, and (2) to grasp the feasibility of various design possibilities, as a mechanism for working with the development process. Feasibility here is measured not in terms of dollar figures but in terms of the congruency or compatibility of an alternative with what is already there.

From the outset of this project the intention was to generate information about reuse of a building from many sources.

Sometimes the particular sequence of steps which examine the building are helpful, but in general this is a collection of resources, all important in context of each other. What emerged from the study as a most useful tool for analyzing existing building stock is a checklist of elements which is used to describe in a fairly exhaustive way, what is there to work with and the design implications of these existing conditions. This device was developed from a preliminary outline, presented at the beginning of Chapter II, to a more elaborated list suggesting design approaches, which can be found at the conclusion of Chapter II. Resources used either to contribute to formulation of the checklist or as supplementary tools for investigation of the building stock include a survey of literature, study of various potential programs, relevant case studies, discussion with consultants experienced in reuse, and a design process. All of these will be described in more detail and additional information is included in the Appendices.

To provide a context for this multidirectional analysis, I chose two structures which represented types of building stock increasingly becoming vacant and thus ripe for re-cycling. A school and one wing of a hospital selected with their differences (in age, construction, etc.) in mind in order to produce and test a procedure of investigation that has a general applicability.

II. RESOURCES AND PROCEDURE

A. Preliminary Checklist

As a first pass at grasping what are the physical conditions to be dealt with in a recycling situation, the preliminary checklist provides a general framework for a systematic examination. Some impressions about possible schemes for reuse may begin to emerge from this initial analysis. However, it is most likely that all the design implications may not immediately be clear. Therefore, the description organized around the checklist may also be useful for suggesting how to utilize other resources, to get at additional information about similar problems solved eleswhere which may be supplied by consultants, case studies, or literature. This checklist, then, provides the first layer of familiarity with the building, generates some ideas about potential, and focuses on how to direct additional inquiry.

Preliminary Building Analysis Checklist

Architecture

1. Character; image; special features of the building

2. Historic considerations
3. Configuration; depth and perimeter
4. Openings; frequency, height, width, sill height
5. Ceiling height
6. Bay size; location of columns
7. Location and construction of internal bearing walls
8. Location of circulation; stairs, corridors, elevators
9. Nature of roof construction; type, pitch
10. Materials
11. Availability of outdoor space

Structural

1. Nature of existing systems; location of members
2. Original loading of structural members, floors, foundations

Mechanical

1. Existing systems; degree of utility, nature of distribution, controls, load capacity
2. Capacity and location of utility lines in the street
3. Potential space to locate new systems (equipment, pipes, ductwork)
4. Thermal efficiency of building shell

Code Issues

1. Construction type
2. Building height and area

3. Location, size and materials of egress
4. Fire protection systems
5. Window openings: area of operable and fixed portions
6. Provisions for the handicapped
7. Earthquake resistance

Appendix A presents the above checklist used in context to describe two buildings, the Hancock School in Lexington, Massachusetts, and a portion of Charles Choate Memorial Hospital in Woburn, Massachusetts. The examples indicate the type of information implied by the list. Problems in obtaining this data may result if drawings of the buildings are unavailable, incomplete or incorrect, and/or if the structure is still being used, as in the case of the hospital, and thorough on-site investigation is impossible.

B. Literature Survey

Background reading can provide numerous examples of successfully recycled buildings which may have aspects which relate to a specific situation at hand. Existing literature also discusses the economics of reuse in terms of available programs of assistance and cost studies of completed projects.

Along other lines, the readings supply information about alternative uses for old buildings, which will be discussed further in the next section of program study.

The bibliography in Appendix B lists relevant sources which deal with adaptive reuse and information on potential new programs. However, since the entire built environment, old and new, can provide references pertinent to the specific problems or constraints of a reuse project, all architectural literature should be considered as possible resources.

C. Program Study

The purpose of the program study was to gain a clear understanding of the demands a new use is likely to make on existing buildings designed for other purposes. I concentrated on the needs of a selected range of programs: housing, retail, and office space, each of which has its own set of space, structural, mechanical, code and environmental requirements. In order to get at these requirements I used the readings, consultants and case studies. The product of studying the general needs of these programs is a compilation of descriptive material of varying specificity which can be found in Appendix C.

The significance of this study was its indication that, in terms of the physical structure itself (regardless of other factors such as location), housing places the most numerous and often most exacting demands on the building to be reused. This conclusion resulted in part from the fact that literature on these programs supplied more detailed and specific information on the needs of housing, whereas useful discussions of programs for office and retail spaces were more difficult to find and more general in nature. My conversations with consultants supported the conclusion (see Appendix E: Rector, Levinson) as did observations of case studies (see Appendix D).

The program study was useful in two ways. The first entails the utilization of the building analysis checklist. The program study contributed to development of the checklist, and when these are used together they can be helpful in the determination of appropriateness of a building for a particular use; the checklist outlines what the structure provides and the program study summarizes what a particular use might require. Secondly, the program study was useful in the subsequent design process as a basis for generating and organizing an environment for a new use. It furnished a set of specifications for the spaces required by new building functions. The programmatic complexity and availability of firm descriptive information led me to select housing as a prospective use in the design studies.

D. Case Studies

Case studies of projects — both rehab and new construction — can be helpful in gathering knowledge about the problems and potentials of recycling a particular building. I found this resource useful in several ways. From looking at relevant examples nearby I expanded the program study and verified what I had read about housing, retail and office space. This required visiting projects which contained these varied uses. Discussions with persons involved in the recycling process of these projects (architects and users) served to elaborate on the building analysis checklist. The case studies involving housing were of further use in the design process where plans of the buildings detailed actual built solutions to common problems in rehab which could be inspected and evaluated.

The projects I visited are discussed in Appendix B. They all occupy reused space. However, like references in literature, case studies should not be limited to recycled buildings. Any piece of building stock, regardless of use, which in some physical way resembles the project one is dealing with, can be a relevant analogue. Similarly, any built environment which supports the particular use with which one is concerned, can supply helpful information on how to satisfy the needs of that program. Therefore, case studies should be drawn from as wide a range of projects as possible to assist one in more fully understanding the potential alternatives in any project.

E. Consultants

A number of people with various kinds of experience in recycling assisted me with this project. Structural and mechanical engineers related recurring problems they encountered in dealing with reuse of old buildings and spoke about various solutions to these difficulties. Apropos of the checklist, they talked about what they looked for in evaluating a structure for reuse, and what implications those aspects had for occupying the building in a new way. They were also helpful in the design phase of this project by discussing the constraints and potentials of the systems in the two specific buildings I was dealing with. Finally, they contributed to the summary of the needs of various uses outlined in the program information (see Appendix C).

Another group of consultants gave additional assistance with the program study. These were mainly architects whose experience included various projects, developing housing, offices, and retail in older buildings. In some cases their involvement in design and project management roles led their conversations with me to center on the process of building conversion. Others dealt with planning and program development. One consultant from the Boston Building Department had contact with recycled buildings through building code review.

A final group of consultants did not work in the field of design or planning or construction. They were the users of some of the recycled buildings I visited as case studies. They assisted my in evaluating these projects, and notes on my discussions are included in Appendix D. All other information obtained from consultants is presented in Appendix E. The utility of these conversations becomes apparent as their advice shows up in other sections: the checklist, the program information, case studies, and the design schemes.

F. Design Studies

The work completed prior to this phase included (1) analysis of various programs for their essential (generalised) demands on a building, and (2) ongoing development of a checklist for analysis of a building to assess its adaptability to new uses. Together with these procedures, the case studies, consultants, and references in literature filled out the emerging process. The design studies were to test and develop this process by clarifying program requirements and by providing knowledge for evaluating the flexibility of structures. Moreover, the design work was initiated with the hope that issues dealing with the quality of the new environment, such as variety, sensitivity to user needs, and the character of the spatial exterience, would be dealt with.

The scope of this work encompassed several housing programs, with the school and the hospital wing as contexts for the problem. The exploration delved in more depth into the needs of the housing program by outlining schemes for different types of clients and different unit or building types. The task was to determine what characteristics make those buildings suitable for housing, and what types of housing fit them best. The building analysis checklist, in its earlier stages was used to determine what both buildings offered to work with at the outset of the design studies.

In the Hancock School, units for the elderly, family units, and small loft units were designed. Though most of the schemes have single loaded corridors because of the constraints, double loaded situations were attempted as well. Some units are flats, others have partial mezzanines. Some of the Hancock school schemes were generated without emphasis on preserving nonbearing partitions or plumbing locations in order to maintain as free a design approach as possible and maximize possibilities inherant in the building. One scheme retains most of the existing partitions and reuses plumbing connections.

The design studies of Choate followed a slightly more complicated procedure. Again, multiple schemes were sketched for varied users (elderly, families) and unit types (flats, duplexes). Like the Hancock studies, the first set of plans for Choate were designed considering only major architectural elements for reuse. Structure, stairs, and windows were utilized, but nonbearing partitions, interior doorways, and plumbing were ignored. In a second pass these schemes were all overlaid on drawings of the existing layout to determine which corresponded most closely with the given building organization. The one which seemed most compatible was redesigned to further minimize demolition and construction necessary to reuse the facility for housing.

It is necessary that design for reuse be judged by the same kinds of criteria with which new projects are tested. Therefore, in order to balance the emphasis on preservation, it seemed important to assess the efficiency of planning and the quality of the environment created by the schemes. Efficiency was measured in terms of unit sizes and ratios of net to gross area in the overall building. Presumably, there is some sacrifice in efficiency possible in a reuse project if construction costs are kept low from using what is there.

Quality was evaluated by means of another checklist which is presented below.

Quality Checklist

Image (suitability to projected use); materials, scale, detail.

Workability of layout; circulation, ajacencies, privacy of zones; suitability to specific user needs.

Through ventilation; multiple views (from how many places? simultaneously or sequentially?)

Light to the interior of the building.

Variety of spatial experience; two storey space, overlooks, nonrectilinear volumes.

Room proportions and sizes.

Private outdoor space.

Common space and amenities.

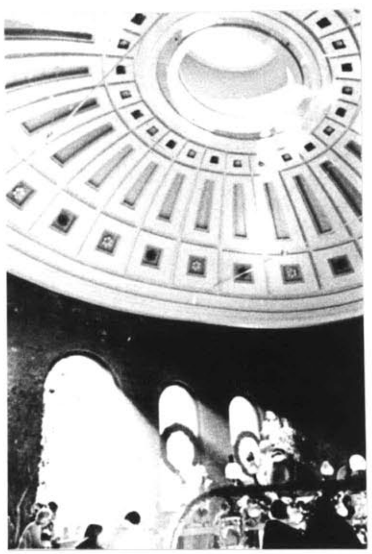
Variety of units.

This list begins to assess the livability of the environment in a reuse scheme. It can be applied to the building as a whole or to the individual units. The recycled building should also meet the code requirements for fire and safety, energy conservation, and provisions for the handicapped.

Plans and sections of the design schemes developed for both the Hancock and Choate are in Appendix F. Preceding the drawings for each building is a section of notes made during the design phase of this project to record discoveries which might contribute to the building analysis checklist. Also included there is an evaluation of two of the dwelling units using the quality checklist, and a summary of the efficiencies of the schemes.

G. Elaborated Checklist

A final and fundamental piece of the process developed in this thesis project is the building analysis checklist. This was presented as a skeletal outline earlier, and it was noted from time to time that various resources contributed to its complexity and elaboration. This section will present the checklist again, filled out to include some implications for design. In this way the checklist becomes a more useful tool enabling the architect to "prethink" the problem of reusing a particular building.



Architecture

1. Character, Image, Special Features

   This can be a positive or negative aspect of the building, depending on the program for reuse. The institutional character of the hospital wing is more acceptable for offices than for housing, though it is even rather sterile for a workplace. If a building's image needs change, and therefore money spent, then perhaps as many of its functional or organizational elements should be reused as possible to control total costs. Thus by utilizing existing partitions or plumbing, money is saved which can be spent to improve the exterior face of the building. If the character of the building is wonderfully suited to its new use, like the Hancock School, then more energy can be devoted to making the interior layout an exciting environment carefully crafted to the needs of the users. A reuse scheme should maintain the original integrity of a building, exploiting its positive aspects. Therefore it is important to grasp the essential character of a structure, which may be a subtle thing, and turn what may seem to be a constraint into a positive design determinant.

2. Historic Considerations

The implications of historic preservation relate to character. If a building is to be preserved, its image has been established as positive, and a use suitable to that image should be the program for reuse.

A major design implication related to historic preservation involves openings in the building shell. Since the facade must be maintained, intact, existing windows and entries must suffice. If these are not adequate to meet window requirements, the only alternative usually acceptable allows additional openings in areas of the roof not visible from the ground. Therefore, the roof type and structure takes on added significance. Facade preservation also has implications for the way windows are perceived from the interior. If sill heights are uncomfortably high, as in the Hancock, floors may have to be raised to adjust views from inside.

Another concern arising from historic preservation of windows deals with energy conservation and the double glazing requirement. One solution has been to make up new thermal pane windows which replicate original mullion patterns. Another useful approach is to add new sash inside the original window. This additional glazing may have mullions which accommodate new intermediate floor levels.

A final consideration related to historic restrictions involves mechanical systems. Air conditioning and ventilation equipment cannot be installed where it is visible on the exterior of the building; thus many types of systems using roof window units may be prohibited.

3. Building Configuration

The shape of a building can provide a quick indication of how it might be organized. This is especially true for housing, where more specific space and exposure requirements make it possible to estimate the number of dwelling units accommodated in a particular building configuration. In deep buildings, over 50 feet wide, where a double loaded corridor is a likely potential organization, the perimeter is significant in that exposure is required for each habitable room. In a shallow building the depth is a more critical dimension; perimeter use becomes a function of depth. Thus the configuration signals potential organization and provides a measure of maximum usage for evaluating the efficiency of an actual scheme.

4. Openings

In general for housing, the more window openings there are in an existing building, the better, since natural light and ventilation are required in all habitable spaces. For other programs the necessity diminishes; in offices windows are desirable but not required, in retail use they are sometimes unnecessary. Windows that extend high up on the wall are useful in bringing light deeper into the building. For housing, lower sill heights (three feet above the floor or less) are preferable.

Door openings are also significant, as it may be expensive to cut new ones and cover old ones acceptably. Moreover, in many old buildings the original doors are handsome and solid, increasing acoustical separation. These are worth reusing wherever possible.

5. <u>Ceiling Height</u>

The significance of this element lies in its indication of the potential for intermediate levels within one existing floor of the building. It may mean lofts or mezzanines which add more square footage to the usable area of the building. Or, if the height is insufficient for two use spaces but greater than 8 feet, variety and interest might be created by platforms raised a few feet above the floor. Note that this may solve the problem of high window sill heights. High ceilings also allow the possibility of varying the ceiling height, either to make mechanical spaces or to create a change in the spatial experience.

6. <u>Bay Size; Location of Columns</u>

Since columns generally are not desirable in the middle of rooms their spacing may indicate where potential walls should be located. Thus, if distances between columns correspond to reasonable room sizes or a multiple thereof, for whatever program will be introduced, the structural members will be easier to deal with in design for reuse. Once again, efficient residential planning makes more specific demands on these dimensions than offices or retail, though there is a range even in housing. This issue may be a low priority if plans with floating columns are acceptable or desirable.

7. <u>Location and Construction of Internal Bearing Walls</u>

Bearing walls have similar implications for design as those discussed above for columns; however, they are obviously more restrictive, and partitions in the new plan must coincide with existing structural walls. Though some openings are possible in bearing walls, it becomes expensive to substitute new structural elements extensively to carry the loads of the building, particularly in the lower floors of a building.

8. Location of Circulation

The location of existing circulation is significant in that most types of reuse will require some kind of circulation, and sometimes these requirements can be met by what is there. This is especially true with fire stairs, of which the function (and therefore size and location) does not change substantially with a change in program. Other vertical and horizontal circulation may or may not be suitable for a new use, however, it is costly to make new stair wells just as it is to fill in old ones with use spaces, so the utility of these should be examined. Often other elements of the building such as mechanical and structural systems have been organized around corridors and stairs, thus reinforcing the desirability of reusing existing circulation, particularly in newer structures where most systems can have utility for reuse. The hospital is an example of this situation.

9. Roof Type and Construction

The area on or under the roof of an old building can provide additional usable space or "found space." Attics under pitched roofs are often converted into interesting places with non-rectilinear

volumes, if enough windows can be provided. Skylights or dormers are often required. Cutting out larger pieces of a pitched roof can open up deck spaces and bring more light inside. Flat roofs, if strong enough construction, can also be useful in creating new private outdoor space, especially over lower extensions of the building (as in the hospital) where the roof is on the same level as an upper floor, and thus directly accessible.

Basements can also be sources of usuable "found space."

10. Materials

Quality, durability, fire resistance, and character are all important aspects of the materials of a structure that affect its suitability for reuse. Housing requires high quality materials which will withstand constant exposure to people (in some cases children). Residential use is not considered as high a fire hazard as some kinds of storage or manufacturing, though two hour fire ratings are required in some areas, and fire resistant materials are desirable. The discussion on character above (#1) emphasizes the importance of fitting the use with the image of a building, and materials play a major role in determining what that image is.

This is important both inside and outside a building. Wainscoting, wood trim, and paneled doors give an environment character, and ways to make them acceptable to code requirements are worth pursuing.

Materials are also significant in terms of their resistance to change. A concrete floor is more difficult to cut holes in than wood. The sound transmission or absorption quality of various materials is also important to consider, especially for housing or offices.

11. Outdoor Space

Outdoor space may be required for a number of programmatic uses. Housing is improved by such amenities as garden and play areas as well as simple quiet sitting places. On-site parking is frequently a necessity for housing, offices or retail space. The outdoor space around Faneuil Hall Marketplace in Boston takes on the qualities of a street and a park, absorbing overflow from the active retail center. Sometimes space around a building is useful as a buffer between the new use and the surrounding area, either protecting the recycled building if it is housing from a less hospitable environment, or shielding the neighborhood from a commercial concern in the reused structure.

Structure

1. Nature and Location of Existing Systems

As discussed above with reference to columns and bearing walls, the location of structure has implications for where space definition might occur or be added in a reuse scheme. It also affects where subtractions to the building might happen, in that they must avoid structural members. Floor construction may be a significant determinant of where and in what shape openings between floors are created. This becomes quite complicated with a concrete slab where the location of reinforcing, which might be unknown, must be taken into account.

2. Original Loading

Understanding what load the building can take is basic to deciding what uses are possible in terms of safety codes, and also in determining where additional loading from the construction of extra levels is possible. In general, institutional buildings can carry heavier loads than residential or office uses produce, so if ceilings are high enough, they are good candidates for mezzanines. Lower loads from new uses may mean that new floors can be added on to the top of the building. Often hospitals have been designed such that the foundations are strong enough to accept additional stories as a result of planning for the future. Sometimes these floors were never built, so the potential is there for new construction as well as rehabilitation.

Mechanical Systems

1. Existing Systems

According to several consultants, most of the existing systems in older buildings are not reusable. Electric wiring and plumbing pipes do not meet code requirements, and HVAC systems are often outdated and inefficient. However, these should be examined, for new ones are expensive, and if old ones can be used, especially in more recent buildings like the hospital, considerable money can be saved. Reusing these systems, especially plumbing may be a major determinant in the layout of new spaces. Housing requires the most extensive and complex systems, and thus is likely to need new mechanical equipment. The nature of distribution, control, and load capacity are all requirements which vary with the specific program planned for reuse, so these aspects of the existing systems should be checked as well as the condition of the equipment.

2. Capacity and Location of Utility Lines in the Street

Utility lines in the street are important if the demand on building services is expected to increase significantly with a change in the nature or intensity of the use of the building. This may be the result of additional area being added to the building or simply more people or processes requiring more water, electricity, gas, or waste removal.

3. <u>Potential Space to Locate New Systems</u>

New equipment might well be installed in the same place old equipment was located, however, in the case of large boilers easy access through sizable openings is important. If new mechanical space is needed, one would look to an area least desirable for other uses, unless for aesthetic reasons the equipment acquired a prominent place in the design. Existing risers and chase areas should be used if possible to avoid cutting additional holes in the floor. Extra ceiling height might be required for horizontal runs of pipes and ductwork. Mechanical equipment can be placed on the roof if there are no preservation restrictions, and this possibility might be examined carefully if solar energy could be utilized. Surrounding outdoor space is an alternative if equipment cannot go on the roof.

4. <u>Thermal Efficiency of the Building Shell</u>

The thermal efficiency of the building shell becomes an increasingly important issue as energy conservation is enforced by legislation. New code requirements will necessitate that any changes in exterior walls in a reuse project include bringing the U factor into line with a set of tough standards. Windows will also have to be tightened, requiring storm sash or double glazing.

Code Issues

1. Construction Type

The type of construction is significant in that it limits the height and floor area allowable under the code (see Program Information, Appendix C, for figures). The more fireproof the construction is, the greater the height and area permitted, therefore concrete structures can be larger than buildings of wood frame construction, without additional fire supression devices being required.

2. Height and Floor Area

See #1 above, "Construction Type."

3. Egress

The location, size and materials of exitways are important code issues in planning reuse of an existing building. Generally two means of egress are required from each floor (all levels covering more than 30% of the building area). As it was discussed under "Circulation," existing means of egress, especially fire stairs, should be reused if possible to avoid costs of new construction. If these are reutilized, their location will have some impact on the new organization of the building; for example, in housing, all units must be within 75' of an exitway.

4. Fire Protection Systems

The existence of fire protection systems may result in a broader allowance in height or floor area, or might make certain combustible materials important to the image of the building permissable. Fire supression systems are required if the new use for the building entails hazardous areas (such as certain kinds of storage), so the location of such systems may locate these parts of the new program in the building.

5. Window Openings

Required areas of operable and fixed portions of windows is determined by the code. Habitable rooms require a window area equal to 10 percent of the floor area and one half of that must be operable. To reiterate #4 in the "Architecture" part of this checklist, the more windows an existing building has, the better, if the new use is housing. This sometimes becomes problematic in attic and basement areas of the building. Any changes to existing windows must bring them in line with the energy part of the code, usually satisfied by storm sash or double glazing. Sometimes it is useful to add storm sash to the inside of the existing window rather than the outside, to preserve the fenestration details on the facade, or to deal with additional levels on the interior of the building.

6. <u>Provisions for the Handicapped</u>

Entry to the building must be on grade or gently ramped (1 in 10 slope). Thus if the entry to a building is quite distant from the ground, a substantial amount of area is required for a ramp, or else entry at a different level closer to grade must be part of the new design. An elevator must be provided if handicapped people are to reach upper portions of the building, and in the case of housing, there should be some units which are without changes in level. In public buildings toilet facilities must be sized and equipped for the accommodation of wheelchairs. Because they satisfy most of these code issues, hospitals require little money spent in this area.

7. <u>Earthquake Resistance</u>

The code requirements for earthquake resistance (Section 718.0) are almost never met by older buildings and a variance is needed.

III. CONCLUSIONS

An area of study which is fundamental to the question of reuse is the relation of a new use to the location of an existing building. The site was not dealt with in this thesis because it was necessary to limit the scope of the project to a reasonable size. However, marketing and location studies are most important to the success of a recycled building, and guidelines for planning in this area must precede evaluation of the adaptability of the structure itself. Once a location is judged appropriate to a set of development alternatives, then the structure itself can be analysed as a further step in the assessment of feasibility.

An original intent of this thesis project was to gain an understanding of the role of the architect in evaluating a building for reuse. The approach was to develop a process for cataloguing existing physical conditions and their implications for design. The result of an open and multidirectional attitude in examining this subject is a collection of tools and resources which can be used together, reinforcing and supplementing each other, as an evaluation and design process.

The study culminated in the generation of a building analysis checklist which can be used by the architect to produce an organized and systematically arrived at design for reuse which responds to the existing architecture. The procedure consists of grasping the positive aspects of the building and capitalizing on them, as well as identifying the constraints which must be turned into positive elements of interest. The integration of data from a variety of sources gives the overall process a flexible and expansive approach toward recognizing constraints in a building and finding acceptable design solutions. This might be illustrated by two examples.

A problem which surfaces in the evaluation of the hospital wing involves the inappropriate image of that structure for housing. The issue is identified at the outset in the building analysis checklist, and is emphasized again in the quality analysis segment of the design studies. Implications

for solutions which modify Choate's institutional character can then be sought in the other resources.

Since the problem stems in part from the large flat undifferentiated exterior of the building, housing projects with a similar aspect successfully treated can be examined for useful ideas. A project in the Boston area which can be considered a relevant case study is Sert's Peabody Terrace. Here the image of the large blocks is scaled down and humanized by a system of balconies and sunbreaks applied to the surface of the buildings.

The literature also provides some helpful references. For example, Ralph Erskine's Byker Wall housing in Newcastle, England, published in Jencks' The Language of Post Modern Architecture, shows another treatment of the same condition. The flat expanse of wall here was broken up and given residential scale by changes in materials (brick to metal and asbestos) and the addition of galleries and balconies of wood.

A more detailed program study involving knowledge of the potential users can provide information useful in designing the elements to be added to the slab. Details concerning dimensions and materials can be chosen with regard to residents' needs. Architects who have used such elements on their buildings might be helpful consultants, both in terms of design and cost estimates.

A major aspect of the Hancock School to be dealt with in reuse design is the existing circulation. As noted in the checklist analysis, there is a wide single loaded corridor along the back of the building which connects two large stairs. On one side of this hall is a bearing wall. The question is, what should the attitude of the designer be toward reusing these circulation elements?

The set of design studies examined double and single loaded schemes for organizing dwelling units in the building, i.e., maintaining the original location of the hall, and moving it to the other side of the bearing wall. (see Appendix F, Design Studies) The stairs were reused in all schemes because it was awkward to adapt them to apartments. One of the consultants experienced in reuse of schools, pointed out the financial advantage of reutilizing stairs, for it can be expensive to replace them with dwelling units.

Detailed understanding of program and users supported by the literature supplies information about the design and use of corridors in such a project. Elderly tend to appreciate more common indoor space where opportunities for socialization can occur, so larger hallways can be an asset. Moreover, the savings in construction expense from reusing existing organization can make up for a decrease in efficiency and thus allow larger units and public space. This information is supported by case studies, such as Central Grammar in Gloucester. The architects retained the large hall in this building; residents use it, and the economics of the building compare very favorably with new construction. Alternative options might use part of the large hall space for a kitchen and service core or storage for the dwelling, or, it might be used to give the units more generous entry areas.

The process of considering alternatives such as these in reuse projects is a dialogue between the constraints and the design goals. The already built environment contributes one set of information to the problem, which must be integrated with the user needs and form building issues. Consequently, the designer must work back and forth---sometimes preserving the existing architecture is a high priority and important constraint; other times the designer must look at the problem with a fresh viewpoint, relatively free of much of the already built context. The dynamic of this process became obvious in the design exercises. At first I analysed the buildings to understand what was there, then sketched with little more than the outline, windows and structure of the building as a base. Subsequent overlays examined the preliminary schemes in relation to more of the existing construction--partitions, doors, plumbing---and some changes were make to bring the new plans in line with these details. A further pass checked the plan for quality issues, and workability and form decisions were weighed against questions of reuse.

The image and circulation issues discussed above point to another set of information which would be a useful addition to the dialectic process. Cost data projecting expenses involved in solutions to common problems could be very instructive in predicting feasibility of solutions for reuse. Such a collection of data would follow a study of the recurring issues, like the image problem of the large slab, or the question of reusing stairs. This study might be organized around the building analysis checklist. Estimates could be collected on the basis of product information and existing projects where these solutions have been employed. The cost information would then become a further resource available in reuse design. It would be used not as a tool for generating alternatives, but rather as a measure of the relatvie feasibility of the solutions emphasizing various priorities which emerge in the dialogue.

Appendix A: Building Analysis Checklist

This appendix describes the two buildings studied in this thesis using the building analysis checklist. The analysis was a useful basis for the design studies, which in turn tested the completeness of the checklist.

THE HANCOCK SCHOOL, LEXINGTON, MASSACHUSETTS

I chose this building to study for adaptive reuse for several reasons. Appropriately, the school is presently empty and being examined for potential development as housing. Constructed in the 1880s, it is typical of many schools becoming vacant as a result of population shifts and new construction in the 1960s. The building is handsome and structurally sound. It contains a cafeteria in the basement and a large open meeting room in the attic, as well as standard classrooms, thus providing a variety of spatial conditions.

Architecture

1. Character, Image, Special Features

Though designed for an institution, the scale is suitable for residential or cellular offices, or could house small stores. Its image could be thought of as residential, with a pitched roof, gabled windows and porches. Arched windows of several sizes and handsome brickwork as well as interesting volumetric shapes (a semicircular stair) are special features of the building. Its frontality and general symmetry give it formality and dignity. Inside there is attractive woodwork, though it is painted institutional colors. Flues between classrooms might make fireplaces feasible. Classrooms have tin ceilings and some are equipped with built-in cabinets. Wood trusses frame a large open space on the third floor.

2. Historic Considerations

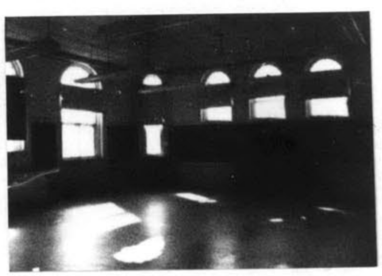
The Hancock School is located in a historic district (Lexington, Massachusetts) which prevents much change to the exterior of the building.

3. Configuration

Building depth: 45' - 50' (to outside of walls), suitable for double or single loaded corridor.

Perimeter: 440' excluding porches.

4. Openings



Large and frequent windows on the first and second floors extend to the ceilings and let light deep into the building. Windows in the basement are relatively small. The third floor (attic) has less window area and would require more for residential use. Most windows have large portions which are operable, though none have storm sash. All have quite high sills, 4' above the floors and sometimes higher, making them uncomfortably high for residential use. Since the facade cannot be changed, floors might be raised to adjust sill height.

5. <u>Ceiling Height</u>

Basement: 7 1/2' - 8 1/2'.

First and Second Floors: 13'-4".

Third Floor: up to 20'.

Upper three floors might accommodate intermediate levels.

6. <u>Bay Size, Column Location</u>

No columns. Classrooms are typically 31' wide, a suitable dimension for a dwelling unit.

7. <u>Internal Bearing Walls</u>

The single internal bearing wall runs longitudinally through the building about one-third of the way across the depth. (See plan of existing building.) Its masonry construction in the basement resists new openings — though some already exist — more than the wood stud construction above.

8. Circulation

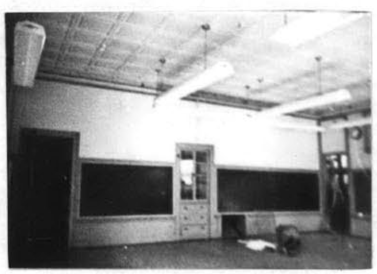
Two large, glass enclosed stairs are located at each end of a short hall which runs along the back of the building between the bearing wall and the exterior wall, and is single loaded. (See plan.) The stairs are suitably located for fire egress but might need additional enclosure. The hall is quite large: 14' wide.

9. Roof

The hip roof rises at a slope of 9 in 12 from the ends and 12 in 12 from the front and back. Large wood trusses support wood purlins and rafters; the roof is slate. Mezzanine could be built in the attic under the roof, though skylights would be needed.

10. Materials

The shell is brick faced with plaster inside. The bearing wall is brick with arched openings in the basement, 6" wood stud walls above which are plastered or finished with wood wainscotting below blackboards. Classrooms have tin ceilings which contribute to the character of the building. Floors in upper three floors are wood construction using large joists. Sound attenuation results from thick walls and floors. Basement floor is concrete, covered with asphalt tile.



11. Outdoor Space

Plenty of outdoor space is available for parking and green space.

Structure

1. Existing Systems

The system of joists does not change, always running from front to back. The original structure in the basement carrying the flues has been removed and replaced by steel WF beams. On the third floor, large wooden trusses carry the roof. Floor joists are 4" x 15" at 16" o.c. Stud walls are 2" x 6" at o.c.

2. Original Loading

The original loading was nominally 100 psf but the structure can most likely carry more than that. Additional wood frame structure can be carried on the floors if spread out or on the bearing and exterior walls if concentrated. Since the trusses in the attic act like arches structurally, additional loading should be symmetrical. Holes can be cut and framed, if necessary, almost anywhere except where the bearing wall is.

Mechanical

1. Existing Systems

The existing systems are obsolete (heating, ventilation, plumbing). There are sprinklers on the top floor which could be maintained. There is no standpipe; however, there is an alarm system which is connected to the fire department.

A 4" water main supplies the building and a 6" pipe connects the system to the city sewer. The waste pipe runs along the bearing wall beneath the floor of the basement with some supply and waste connections along the perimeter. The oil tank for the present heating system holds 5000 gallons; it is located on the west side of the building. The school was rewired in 1960, and power lines are available in the street for additional electricity.

2. Mechanical Space

The boiler room in the basement (500 s.f.), equipped with a masonry chimney flue and easy outside access, provides a good location for new mechanical system equipment. If large exterior air conditioning equipment is necessary, an installation on the ground is preferable to on the roof for reasons of historical preservation. Ample space is available near the building. Chase area for pipes and ductwork within the building is provided next to the flues and along the bearing wall.

3. Thermal Efficiency

U factor of walls, first and second floors = .21. Windows are single pane glass without storm sash. Third floor (attic) has fiber insulation in between rafters but it has settled and needs to be replaced. There is ample space for new insulation.

Code Issues

1. Construction Type

Presently 3C; masonry exterior wall, interior unprotected wood frame walls. (Plaster on interior walls may contain horsehair.) Interior walls need additional fire protection (gypsum) to improve fire rating.

2. Building Height and Area

Height: 4 floors; 50' Area: 6000 square feet per floor. With new plaster on the walls, the area on each floor could be increased to twice its size.

3. Egress

Multiple egress from each floor conforms to code requirements. Stairs are of sufficient size but may require additional fire enclosure protection.

4. Fire Protection

Sprinklers have been installed in the basement and on the top floor (dry system). There are alarm connections to the fire department. Fire resistance of some walls may be insufficient.

5. Openings

At present, window openings are adequate for use in a school. Residential use may require additional openings on the third floor.

6. Handicap Requirements

The school has no provisions for the hapdicapped; a ramp is needed for entrance on grade and an elevator must be installed.

7. Earthquake Resistance

Like all older buildings, Hancock does not meet the earthquake and mortar requirements of the code. A variance is needed.

CHARLES CHOATE MEMORIAL HOSPITAL, WOBURN, MASSACHUSETTS

In order to further develop and test the process being formulated to analyze buildings for recycling, an additional structure was chosen for study. I selected the hospital not only because it was designed for a program different from the Hancock School. The hospital is not designated for historical preservation and thus has no restriction on changes to the exterior. It is composed of several buildings or wings constructed at different times and having different configurations; I chose one piece to work on which was built in the 1960s and added to several years later, so the construction is very different from the school. Moreover, the section I am studying is a deeper building with lower ceiling heights, which presents a new set of constraints later on in the design studies.

Architecture

1. Character, Image, Special Features

The character and image of this wing of Choate are completely institutional. The materials and construction are sound and substantial, but the lack of ornamentation and plain, minimal detailing give the building an unwelcoming aspect which might be problematic if the hospital were to be converted to housing. Part

of the lower floor is covered with stucco and has few openings; its functions (laundry and receiving) have resulted in a bland, unattractive exterior. Interior finishes are hard institutional materials and colors. There are no special features to this part of Choate which invite emphasis or exploitation in rehab design.

2. Historic Considerations

There are no historic restrictions concerning preservation of the building. Therefore, the plan unattractive exterior could receive extensive change. Moreover, any alteration in wondow openings required by interior changes is possible.

3. Configuration

Building depth: basement: 68' first floor: 50' These figures imply a double loaded corridor organization. Perimeter: basement: 710' first floor: 590'

4. Openings

In most parts of the wing window openings are frequent; however, for conversion to housing the upper floor and parts of the basement would require additional windows. Windows in the basement have rather high sills which are at an uncomfortable height for residential use. To correct this, sills would have to be lowered or the floors raised. The windows are all relatively new and tight and thus suitable for reuse. Spacing of openings is irregular.

5. <u>Ceiling Height</u>

Ceiling height varies somewhat (9'-7" - 12') but all floors are too low for the addition of intermediate levels. There is substantial room, however, for running mechanical ducts and piping horizontally above a suspended ceiling.

6. <u>Columns</u>

There are columns on either side of the corridor (which might suggest maintaining the present location of the hall), and on the basement floor there is also a line of columns on one side between the corridor and the outside walls; in other places exterior walls are continuous bearing walls. Column spacing varies, but the irregularity, like that of the windows, is not a problem for the varied spaces required in housing. The system of columns is quite flexible in terms of alternative space organization, being less restrictive than bearing walls.

7. <u>Internal Bearing Walls</u>

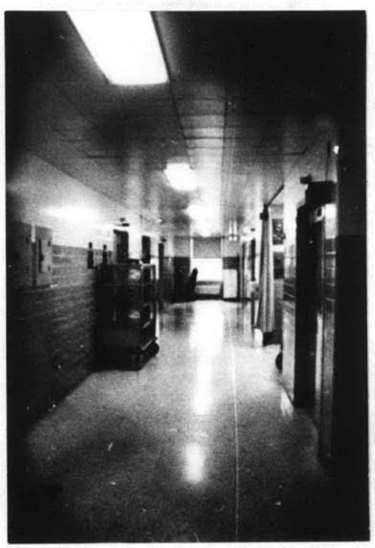
In a few places on the basement floor there are sections of bearing wall rather than the columns found above. These are along the corridor, and again suggest reuse of the existing corridor.

8. <u>Circulation</u>

There are interior double loaded corridors on all floors of this wing of Choate, with an elevator located in the center where the building joins the rest of the hospital. Along the hall there are fire stairs which are suitably sized, enclosed and located for residential use.

9. <u>Roof</u>

The roofs are flat concrete slabs covered with built up asphalt roofing. With suitable surfaces applied they could be used as deck areas, especially the section over the basement floor which extends out past the upper part of the building. Skylights installed in this part of the roof could be useful in bringing light into the deep interior of the basement level.



10. <u>Materials</u>

Exterior walls are brick and, on the basement, stucco. Floors are all concrete, and thus cutting through them is somewhat expensive and complicated. Partitions are mainly stud walls covered in gypsum or sometimes ceramic tile. Acoustic separation is substantial. Floors are covered in linoleum tile. Doors are solid wood; some have small windows. They are suitable for reuse. The materials strongly reinforce the institutional character of the place. Reuse plans might require softer materials to "minimize" the image.

11. Outdoor Space

There is considerable open space around the hospital presently used for parking.

Structural

1. The existing structural system of concrete columns is irregular, but the average span of the beams is 12' and the concrete slab spans 20', 16', and 8'. The thickness of the slab is generally 6 1/2", and 12" in some places under the corridor. Reinforcing of the slab is in one direction.
2. The original loading of the system was at least 60 psf, and 80 psf in corridors. When one storey of the wing was built in 1962, the foundations were designed and built for additional floors. Three more floors were added along with an extension in 1971, utilizing the extra strength in the foundations. This is a common sequence in hospital design; often foundations can hold more stories. New partitions can be built anywhere on the floor, even if they are constructed of clay tile or light block.

   Holes cut in the concrete must avoid the beams and the edge of the cut slab should be supported since reinforcing is in only one direction. Stair construction is reasonable since the sides of the stair could have walls to support the slab. Large two-storey spaces are more difficult unless the slab is removed from the whole span. Holes cut for chases or ductwork are not problematic but it is recommended that the long dimension of the hole runs parallel to the span of the slab.

Mechanical Systems

A study of Choate Hospital has been done by Block McGibony Associates, Inc., and Payette Associates, Inc., for the basis of future planning of the facility. The study was very complete, and portions of it dealing with the mechanical systems are included here.

1. Existing Systems

I. PLUMBING SYSTEMS

A. Domestic Cold Water:

1. Present Condition: A 4" cold water supply enters the basement of the 1960 building from Dows Lane and a 4" enters the administration building from Warren Avenue.

   The two services are looped through the basement with a 4" main so that the building can be fed from two streets.

   The water pressure varies from 50 p.s.i.g. in the winter to approximately 38 p.s.i.g. in summer, and is barely adequate to serve the top floors.

2. Adequacy and Future Considerations: The system is adequate for any foreseeable development. The city mains are an 8" on Warren Avenue and a 6" on Dows Lane. Any new construction which has an occupied floor higher than the existing top floor would require a booster water pump. The corrosion problem with the water supply would have to be addressed.

B. Domestic Hot Water:

1. Present Condition: Three 800 gal. domestic hot water storage heaters supply the Hospital.

   One located in the boiler room supplies the laundry with 180° water; one located in the boiler room supplies all but the 1960 building, and one located in the 1960 building supplies the 1960 building.

2. Adequacy and Future Considerations: System is adequate and would be capable of handling moderate expansion.

C. Sanitary Waste Systems:

1. Present Condition: There is a 6" sanitary waste to Warren Avenue, 1-6" and 1-8" sanitary waste to Dows Lane.

2. Adequacy and Future Considerations: The aggregate capacity of the 3 sanitary sewer lines is enough; however, the amount of expansion any one 6" waste line can handle is slight.

D. Storm Drainage System:

1. Present Condition: 8" storm drain to Dows Lane. 6" storm drain to Dows Lane.

2. Adequacy and Future Considerations: Existing lines adequately handle existing with slight spare for growth. Size of city lines unknown at this time by the city.

F. Gas:

1. Present Condition: 3" natural gas main enters from Warren Avenue and supplies kitchen, laboratory. Boiler Room is supplied from 3" gas from Dows Lane.

II. FIRE PROTECTION

A. Sprinklers:

1. Present Condition: 1950 building fully sprinkled. Original building fully sprinkled. Selected areas, i.e. shops and storage areas of basement in other buildings sprinkled.

2. Adequacy and Future Considerations: Low water pressure limits vertical expansion of system unless fire pump is used. Full sprinkling for various phases of construction can be avoided because top floor is less than 70 feet above grade.

3. Code Requirements: If 70 feet above grade, 100% sprinkled building required.

B. Standpipe System:

1. Present Condition: No fire line standpipe exists.

2. Adequacy and Future Considerations: Incoming sprinkler mains should suffice, although marginal, but fire pump will be required when standpipe is installed. All new construction shall have standpipes in stairwells and first aid stations throughout.

III. ELECTRICAL SYSTEMS

A. Service Capacity

1. Present Situation:

   a. Service #1: A 750 KW 120/208 V., 3 phase, 4 wire service in the boiler room supplies the third floor of the 1950 and 1960 building, all of the 1970 building and the boiler room.

   b. Service #2: A 500 KW 480 V., 3 phase X-Ray service in the boiler room supplies the special procedures room.

   c. Service #2: A 100 KW 208 V., X-Ray service located in the 1950 building supplies all X-Ray except special procedure room.

   d. Service #4: A 500 KW 120/208 V., 3 phase, 4 wire service in 1950 building supplies the original building and all of the 1950 and 1960 building except the third floor.

IV. HEATING, VENTILATING AND AIR CONDITIONING SYSTEMS

A. Boiler Plant:

1. Present Situation: Three - 150 H.P. low pressure steam cast iron boilers with rotary burners. There is space for a fourth 150 H.P. C.I. boiler.

   Two - 75 H.P. high pressure steam packaged Scotch Marine Boilers.

There are three stacks, one for low pressure boilers, one for high pressure boilers and one for the incinerator.

B. Air Conditioning Systems:

2. Radiant Heating - Cooling System:

a. Present Situation: The system is very poor. It doesn't provide adequate cooling and it produces indoor rain in the summertime operation.

2. <u>Capacity and Location of Utility Lines in the Street</u>

Water: 8" main on Warren Avenue; 6" main on Dows Lane.

Sewer: 6" pipe on Warren Avenue; 6" pipe on Dows Lane.

Storm Drains: size unknown by the City.

Gas: gas mains on both streets.

Electricity: do not foresee a need for additional power.

3. <u>Potential Space to Locate New Systems</u>

There is presently a power plant on the site adjacent to the wing under study. It is perfectly usable in the future.

Ceiling heights allow adequate room for a suspended ceiling above which ducts and pipes can be run. Some risers are available and should be reused. Since there are no historic restrictions on the building, air conditioning equipment can be mounted on flat roofs or through the wall. This is already the case in some areas of the hospital.

4. <u>Thermal Efficiency of the Building Shell</u>

Basement Floor: U = .28

Upper Floors: U = .24

<u>Code Issues</u>

1. <u>Construction Type</u>

Concrete construction, type 1.

2. Height and Floor Area

Building Height: 4 stories, 46'.

Floor Area: 22,160 square feet, ground floor; 12,532 square feet, upper floors (per floor).

There are no code limits on buildings of this type of fireproof construction.

3. Egress

There are two firestairs in the wing and a third at the place where it joins the older part of the hospital. No part of the corridor is further than 75' from an exit, and exits are no more than 150' apart, so using the present circulation in a residential scheme would meet egress requirements. There are doors in the corridor separating fire zones. The egress stairs and doors are all of sufficient size and materials.

4. Fire Protection Systems

Certain areas of the building are sprinkled, mainly shops and storage. No fire line standpipe exists; standpipe and fire pump may be required in a reuse project. The wing is tied into a central coded fire alarm system with one master box connected to the municipal fire alarm system.

5. Window Openings

Window openings, fixed and operable, are adequate for present use; however, in some areas, additional openings may be required for residential use of the building. The windows are relatively new.

6. Provisions for the Handicapped

Handicap requirements are met, since the building is a hospital.

7. Earthquake Resistance

Building does not meet earthquake requirements.

APPENDIX B: BIBLIOGRAPHY

APPENDIX B: BIBLIOGRAPHY

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Appendix C: Program Information

This appendix contains data compiled to outline program needs of housing, offices, and retail space. It is hoped that these notes might form a basis for determining whether a building is suitable for one of these uses. The intention was to cover major building requirements; more superficial details are not included.

For each type of use there are notes on space and environmental needs and structural requirements. Subsequent sections reproduced from the ASHRAE Applications Handbook (1974) deal with mechanical considerations. A final portion of the appendix contains excerpts from the Massachusetts code which cover important fire and safety issues.

The collection of program elements for housing was derived from the HUD "Minimum Property Standards for Multifamily Housing" (4910.10). Ohter program information was obtained from readings, consultants, and case studies.

HOUSING PROGRAM NEEDS

Structural loading requirements:	private apartments	40psf	live load
	public rooms	100psf	"
	corridors	80psf	"

The following section on housing needs is from HUD "Minimum Property Standards-Multifamily Housing"

Elevators shall be provided in buildings of:

(1) Five or more stories;

(2) Four stories where deemed necessary by the HUD field office to satisfy market considerations;

(3) Three or more stories in housing for the elderly;

(4) Two story housing for the elderly where central dining facilities are located on a floor level other than the floor level of living units which do not have cooking and dining facilities.

**(5) Two or more stories in housing with living units above the first floor intended for occupancy by wheelchair users.*

At least one of the required elevators shall be large enough to accommodate a wheelchair in accordance with ANSI A117.1.

MINIMUM ROOM SIZES

*A. Minimum Room Sizes for Separate Rooms

Name of Space(1)	Minimum Area (Sq Ft) (7)					Least Dimension
	LU with 0-BR	LU with 1-BR	LU with 2-BR	LU with 3-BR	LU with 4-BR	
LR	NA	160	160	170	180	11'-0"
DR	NA	100	100	110	120	8'-4"
BR (primary) (2)	NA	120	120	120	120	9'-4"
BR (secondary)	NA	NA	80	80	80	8'-0"
Total area, BR's	NA	120	200	280	380	-----

B. Minimum Room Sizes for Combined Spaces

Combined Space (1) (4)	Minimum Area (Sq Ft) (7)					Least Dimension(3)
	LU with 0-BR	LU with 1-BR	LU with 2-BR	LU with 3-BR	LU with 4-BR	
LR-DA	NA	210	210	230	250	
LR-DA-SL	250	NA	NA	NA	NA	
LR-DA-K (5)	NA	270	270	300	330	
LR-SL	210	NA	NA	NA	NA	
K-DA (6)	100	120	120	140	160	

<u>Notes</u>

(1) Abbreviations:

LU = Living Unit
LR = Living Room
DR = Dining Room
DA = Dining Area
0-BR = LU with no separate Bedroom
K = Kitchen
NA = Not Applicable
BR = Bedroom
SL = Sleeping Area

(2) Primary Bedrooms shall have at least one uninterrupted wall space of at least 10 ft.

Baths

a. Each dwelling unit shall have one bathroom containing a lavatory, water closet, and bathtub. In other bathrooms showers may be substituted for bathtubs. Bathrooms shall provide for comfortable access to, and use of, each fixture. Bathrooms shall be convenient to the bedrooms.

Kitchen

a. Each living unit shall include adequate space to provide for efficient food preparation, serving and storage, as well as utensil storage and cleaning up after meals.

COUNTERTOPS AND FIXTURES

	Number of Bedrooms				
	0	1	2	3	4
Work Center	Minimum Frontages in Lineal In.				
Sink	18	24	24	32(1)	32(1)
Countertop, each side	15	18	21	24	30
Range or Cooktop Space(2)(3)(6)(7)	21	21	24	30	30
Countertop, one side (4)	15	18	21	24	30
Refrigerator Space (5)	30	30	36	36	36
Countertop, one side (4)	15	15	15	15	18
Mixing Countertop	21	30	36	36	42

Laundry

a. Where common laundry is not furnished, provide space in each living unit for a clothes washing machine equipped with power supply and water and waste piping or a laundry tray.

b. Where other drying facility is not furnished, provide space in each living unit for a dryer equipped with power supply and vent to the outside.

GENERAL STORAGE REQUIREMENTS

	Cubic Feet of Storage	
	Column 1 (1)	Column 2 (2)
0 BR	100	140
1 BR	150	200
2 BR	200	275
3 BR	275	350
4 BR or more	350	425

Notes

(1) This storage shall be located entirely within the living unit.

(2) At least one half of this storage shall be located within the living unit.

MINIMUM REQUIREMENTS FOR ARTIFICIAL AND NATURAL LIGHT
NATURAL AND MECHANICAL VENTILATION

Location	Artificial Light Footcandles (11)	Nat. Light Glazed Area As % of Floor Area	Natural Ventilation, Opening As % of Hor. Projection		Mechanical Ventilation Air Changes Per Hour (1)
***Public Areas**					
lobby (general)	10	--	5	or	4 supply(10)
dining	15	10	—		6 supply
corridors	10	--	--(2)		4 supply(10,12)
stairs	10	--	5	or	4 supply(10)
general storage	5	--	2	or	2
laundries	20	--	5	or	6 exhaust
garages (general)	5	--	see 615		
recreational areas	(3)				
arts and crafts	70	15	5	or	6 supply
game rooms	20	--	5	or	6 supply
Exterior Areas					
See 313-4					
Living Units					
living rooms	--	10	5		10(4)
dining rooms	--	10	5		10(4)
bedrooms	--	10	5		10(4)
kitchens	--	--	5	or	8 exhaust(8)
baths	--	--	5	or	5 exhaust (9)
laundry	--	--	—		(5)

NON-RESIDENTIAL SPACES

Community Social Rooms

Where community social and recreational rooms are provided, they shall be designed in accordance with the needs of the occupants and shall have adjacent toilet facilities for men and women. An adjacent storage area shall be provided. *Such spaces are required for housing for the elderly.*

Management and Maintenance Space

Space shall be provided commensurate with the number of living units served. Also, space shall be provided for necessary staff where social services are provided.

Common Laundries

Common laundry facilities containing space for automatic washers, dryers and sorting tables shall be located near the elevators or other pedestrian traffic center for the convenience and safety of the users. The space within the laundries shall be visable from an adjacent public area.

Project Storage

Space for storage of maintenance supplies and equipment such as paint, hand tools, lawn mowers, snow blowers, etc. shall be provided in accordance with the needs of the project.

Facilities for Trash and Garbage Disposal

a. Provide for the temporary sanitary storage of trash and garbage and for its subsequent disposal or removal.

PARKING AREAS

GENERAL

Adequate parking space shall be provided for residents, guests and service vehicles. Where practical, additional parking space shall be planned and reserved for future use.

Buildings required to be accessible to the physically handicapped shall have at least 5 percent of the parking spaces (with a minimum of 2 spaces) arranged for wheelchair users in accordance with ANSI A117.1.

Maximum walking distance from a parking space to a public entrance of apartment building served.

a. Non-elderly resident parking space - 250 ft

b. Elderly resident parking space - 150 ft

c. Guest parking space - 300 ft

Excerpts from ASHRAE Applications Handbook (1974)

DESIGN CONCEPTS AND CRITERIA

Low income rental apartment houses generally furnish only a central heating plant. However, even here it is prudent to design an adequate electrical distribution system to allow the use of window-type, self-contained air-conditioning units.

Medium income rental and cooperative-type apartment houses, almost without exception, will furnish at least adequate electrical capacity in most rooms to allow the installation of self-contained air-conditioning units. Often, unit wall sleeves and even the units may be supplied. Usually a separate heating system is furnished. Central systems are rarely considered for this class of occupancy, although in cooperative-type buildings, the cooperators might well be interested in considering the added initial cost of a central system if the total owning and operating cost factors were properly explained and evaluated.

It is in the high income and luxury apartment houses, of whatever classification, that central heating and cooling systems are usually installed. The vast majority of these apartment houses have been built with wall opening type fan-coil systems, but at present more thought is being given to other types of systems.

Both cooperatives and condominiums can provide common services to all dwelling units, but the condominium developer is often more inclined to design with independent HVAC, metered utilities, and unitary service hot water facilities for each apartment, in both low- and high-rise. Therefore, independent ownership in this type of condominium is paired with almost complete individual upkeep except for agreed-upon pooled expenses.

In the cooperative type apartment house, the maintenance and operation is more of a joint venture between the cooperators, so a suitable central system may be satisfactory, when considered in conjunction with all other factors.

Unlike commercial kitchens, those incorporated within a dwelling unit, for practical cost reasons, do not lend themselves to sophisticated comfort or ventilation treatment. Regardless of code requirements, mechanical exhaust is desirable, and make-up should preferably come through some air-conditioning apparatus, rather than by infiltration either through unitary systems inside the dwelling unit or a central building, air-conditioned ventilation system. Kitchen air conditioning, sometimes provided, is never sized for the loads from ovens, ranges, and washing facilities. These composite, general ventilation facilities may be advantageously employed for general dwelling unit vitiation during high occupancy periods, since exhaust requirements may be similar.

Flexibility in arrangement of furnishings is very important, particularly in apartments. Therefore, the location of air distribution devices along the exterior walls, usually under windows, is often not desirable. Where possible, an interior air-distribution system for cooling and ventilation, plus a perimeter heating system is preferred. This will also eliminate problems with window draperies and curtains.

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APPLICABILITY OF SYSTEMS

1. *All-Air Systems (Central or Unitary).*

A system may be classified as all-air, as far as an individual dwelling unit is concerned, whether the air is supplied from a central building air handler, a fan-coil unit for each dwelling unit, or a unitary system for each dwelling unit. Since all employ only air for cooling but may or may not switch over to a warm air heating cycle, the same considerations apply to the capability of each for independent control and flexibility for each room in a dwelling unit. Although single-exposure apartment layouts have less need for simultaneous heating and cooling capability than ones with multiple exposures, most buildings have apartments with more than one exposure, and it is difficult to conceive of any building with all apartments on the same exposure. Also, since apartments almost universally lack hung ceilings for duct distribution, dwelling units prevent ducted perimeter air supply under glass areas, which is desirable for colder climates. Therefore, even for double-glazing, below 30 F weather, some form of under-window heat is recommended. If all-air is employed with supplemental radiation in any of the three schemes, flexibility between rooms in any specific dwelling unit is not possible or economically practicable without room by room VAV control. Other all-air systems, although feasibile, are generally considered too costly to install or operate.

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The use of a single fan-coil unit per dwelling unit is all-air within the dwelling unit but either air-water or all-water with relation to the building. For full room-by-room flexibility, it must be applied with individual room VAV control, perimeter radiation for cold climates, and 3- or 4-pipe systems for flexibility between dwelling units. Central, conditioned or unconditioned outdoor air may be used, or outdoor air may be taken directly by each unit. Any VAV system which gangs all air outlets in a multiroom dwelling unit under the action of a single thermostat (*i.e.*, by modulation of the fan speed and self-actuated throttling of the outlet from reduced outlet static pressure) cannot handle variations between rooms nor can it shut off or reduce the cooling in unoccupied rooms while providing more cooling in an occupied room. Air volume control at fixed coil water temperature (characteristic of fan speed control) is better for overall dwelling unit humidity control than water throttling (higher surface coil temperature with fixed air flow), but it does nothing for room temperature flexibility or diversity.

From the air system standpoint, the use of a single unitary system per dwelling unit would have similar considerations, but it does not lend itself well to VAV in the absence of modulated cooling or heating. As a result, particularly when decentralized heating is also desired for each dwelling unit (with fuel or electricity to each air handler), these systems are more adaptable to milder climates where supply air heating is more acceptable, but there is a complete loss of room control flexibility. Unitary dwelling unit systems for cooling, combined with individual room electric resistance heaters, can preserve the desire for complete decentralization of each dwelling unit and also maintain room control flexibility. However, the designer would be obliged to incorporate a sequence of controls to avoid conflict between heating and cooling, or to control in essentially a pure reheat mode, if energy waste for anything but humidity control is to be avoided.

In addition to the reduced quality of on-off, summer-winter, temperature-humidity control, and lack of room flexibility, the restrictions on gas in many areas and the difficulties of piping fuel oil to such equipment (for individual utility services) may leave only electric heating as a possibility. If electric heat is chosen, better comfort and heating economy is obtainable with under-window radiation than with a common electric strip heater in the air handler.

Equipment for this system may be installed in a separate mechanical equipment room in the apartment or may be placed in a furred soffit or above a hung ceiling over a corridor or closet. Access to the equipment location should be through the service corridor or entrance. Except for possible differences in sources of heating and cooling effect, this system is identical to that in a deluxe single family residence.

Low capacity residential warm air furnaces may be used for this purpose but have the disadvantage of requiring some method of disposing of the products of combustion. In a one- or two-story structure it is possible to use individual chimneys or flue pipes but in a high rise structure it would be necessary to use a multiple vent chimney or a well designed manifold type of vent system. Local codes should be consulted on this latter type.

Sealed combustion type of furnaces have been developed for apartment house use. These units draw all the combustion air from outside and discharge the flue products outside through a windproof venting arrangement. This type of unit must necessarily be located near an outside wall. One- or two-story structures may also utilize outdoor units mounted on the roof or on a pad at ground level.

All of the preceding heating units can be obtained with cooling coils, either built-in or of the add-on type.

Maximum diversity benefits, as well as noise, vibration, air cleaning, and ventilation control are obtainable with the central building VAV system, although problems may arise with local codes and fire and smoke control. Since rent inclusion is mandatory with central building VAV its total energy consumption compared with unitary systems for each dwelling unit might be greater as a 24-hr operation without tenant turnoff incentive, despite a lower overall installed kw for HVAC. Compared with fan-coil units for each dwelling unit, its installed kw, as well as energy consumption, should be lower when both require rent-inclusion for all services.

2. *Air-Water Systems.*

This type can take the form of individual room or dwelling unit fan-coil units using central building primary conditioned air; room induction systems; or radiant panel systems; with all types having 2-, 3-, or 4-pipe hydronic systems. Refer to Chapters 4 and 8, 1973 ASHRAE Handbook & Product Directory for advantages and disadvantages of each.

Except for the single fan-coil unit per dwelling unit discussed previously, and for radiant panel systems, these systems locate individual room units at the perimeter in cold climates, and sometimes at ceiling interior locations in mild climates. To the extent that cold and hot water are simultaneously made available in each room, or cold primary air and warm water, or warm primary air and cold water, these systems all have room flexibility for temperature control. Flexibility of year-round humidity control depends upon the volume and dew-point of primary air. If central dehumidification and reheat is employed with it, during low dry-bulb, high wet-bulb weather, superior quality summer control is obtainable. (Unconditioned primary air would prohibit classifying such a system as an air-water system.) Winter humidity can also be raised through use of the primary air system.

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3. *All-Water Systems.*

This type may take the form of individual room units, located at the perimeter or interior; individual fan-coil units for each dwelling unit; 2-, 3-, or 4-pipe systems; valance systems, or 2-pipe systems with electric heat. Refer to Chapter 5 of the 1973 ASHRAE Handbook & Product Directory for further information.

The same considerations apply as were discussed for air-water systems, with the omission of primary conditioned air precluding the ability to control year-round humidity. All but two have no intermediate season temperature and humidity flexibility. The 4-pipe system, and 2-pipe systems with electric heaters, can be designed with complete temperature and humidity flexibility during summer and intermediate season weather, although none provides winter humidity control. Each of these systems can provide full dehumidification and cooling with chilled water, reserving the other two pipes or electric coil for as much heat as might be needed for space heating or reheat. The systems and controls needed for this are expensive, and only the 4-pipe system, with an internal-source heat recovery design for the warm coil energy, can lower the high operating costs. A 3-pipe system can provide temperature control flexibility, but alone it cannot provide humidity control during mild, muggy weather in dwelling units with characteristically low internal sensible heat loads.

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4. *Multiple Unitary Systems and Heat Recovery Systems.*

The type discussed in this section uses one unit or more per room and can take the form of window or through-the-wall units, or water-loop heat pumps. Refer to Chapters 6, 7 and 11 of the 1973 ASHRAE Handbook & Product Directory, and the discussion under Design Concepts and Criteria.

Despite the varying quality of comfort of the window and through-the-wall units, their wide popularity stems from avoidance of rent-inclusion or central operation responsibility, heating-cooling flexibility (even when combined with central heating), and low initial cost.

Without any greater zoning flexibility and with the assumption of additional responsibilities in central equipment maintenance, the higher initial cost of a water-loop heat pump is not easy to justify from an operating savings standpoint in this type of building, because of the minimal internal heat available for heat recovery. During heating periods, if no units are cooling, more electricity can be expended with the water-loop heat pump using electric supplementary heat than would be required with room-by-room electric resistance heating.

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5. ***Total Energy Systems (T.E.)***

Any type of multiple housing or domiciliary facility, with high year-round domestic hot water requirements, is one of the more attractive applications for total energy. The thermal profiles for HVAC and service hot water can match the electrical generating profile better than many other applications, and the 24-hr loads permit higher load factors and better equipment utilization. Refer to Chapter 10 of the 1973 ASHRAE Handbook & Product Directory.

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SPECIAL CONSIDERATIONS

Interior apartment house public corridors should have positive ventilation with at least four air changes per hour. Conditioned supply and exhaust air is preferable, but transfer into the apartments if necessary, through suitable acoustically lined transfer louvers to provide kitchen and toilet make-up air requirements has been used in some designs.

Special care must be taken to isolate air-conditioning equipment to reduce noise generation or transmission. Of particular importance is the design and location of the cooling tower to avoid disturbing not only occupants within the building but also their neighbors in adjacent buildings.

In large, luxury type apartment houses, a central panel may be provided from which the individual apartment air-conditioning system or units may be supervised for maintenance and operating purposes.

OFFICE SPACE - PROGRAM NEEDS

Office Types

"Organizations with a staff of less than forty and no outside contacts are recommended to chose conventional cellular offices. It is, in any case, not possible to do justice to any landscaped scheme in an area of less than 5,000 square feet. Nor is it possible to create a landscaped office where the overall dimensions are unsuitable.

Any interior measuring 18' from wall to window can be made only into a conventional cellular type office . . . Indeed, the minimum width considered necessary for open plan offices is 60' window to window, with a length 1.5 or 1.75 times greater, that is, 90 or 100 feet." (E. J. Browne, p. 21)

Space Needs

1. Workspaces - provide a range of sizes. Common examples:

40 - 60 s.f. minimum	Clerk, Typist
100 + s.f. minimum	Supervisors, Junior Management
140-200 s.f. minimum	Middle Management
200 + s.f. minimum	Executives

2. Storage

   Live: easily accessible from workspaces (files, supplies)

   Dead: may be separated from work spaces (files, bulk supplies, forms)

   Note: storage may have special structural requirements

3. Administrative Support

   Reception (near entry), telephone, library, reproduction (may need noise separation), mail.

4. Word Processing Center (Typing Pool)

    Noisy machinery needs acoustical separation from work spaces.

5. Computer

    Requires special mechanical equipment, often served by a raised floor (in tiles) for access to wiring and heat removal.

6. Conference Areas

    Some should be closed, even in open plan.

7. Toilets

    On each floor, equipped for handicapped.

8. Parking

    Varies with site and surrounding area, degree of public contact. Ideally one space per employee.

Personal Needs

Privacy, security, status.

Code Requirements

1. Windows

    None, artificial light and mechanical ventilation can be used. Windows are desirable.

2. Handicapped

    Entrance accessible from grade without stairs. Parking nearby this entrance. Interior access to all floors. Elevator sized for wheelchairs. Toilets equipped for wheelchairs.

3. Multiple Egress from Each Floor

   Length of travel to exitway cannot be over 200'. Maximum dead end corridor is 20'.

4. Two-Hour Fire Wall Rating

5. Height and Area Limitations

   See chart.

6. Structural Loading

Office Space	50 psf
Light Storage	125 psf
Corridors	80 psf
Lobby	100 psf

Possible Amenities

1. Lounge Areas

2. Cafeteria

   For large offices.

3. Recreation Facilities

4. Day Care Center

5. Auditorium

(NOTE: Some of these facilities can be shared with the community.)

Environmental Needs

1. Light - 20-50 footcandles (from Shoshkes)

Bookkeeping	50	Local Lighting
Typing	50	Local Lighting
Transcribing	40	Local Lighting
General Correspondence	30	Local Lighting
Filing	30	Local Lighting
Reception	20	Random Room Light

2. Sound - Acoustical Requirements

   Work area PNC (perceived noise criteria) ± 50.

   Noise producing machinery (typewriters, duplicators, etc., should be segregated or shielded by acoustical materials.

   Sound absorbing materials should be used where possible (carpet, tectum, acoustical tiles, etc.)

3. Mechanical - HVAC

   Outdoor Air Requirements (from ASHRAE 1967)

	Smoking Conditions in the Room	cfm per Person Recommended	cfm per Person Minimum	cfm per sq. ft. Floor Minimum
Meeting Rooms	Heavy	50	30	1.25
Offices, General	Some	15	10	0.25
Offices, Private	None	25	15	0.25
Offices, Private	Considerable	30	25	0.25
Toilets (Exhaust)				2.0

LOAD CHARACTERISTICS

Office buildings generally include both *peripheral* and *interior zone spaces*. The peripheral zone may usually be considered as extending from 12 to 18 ft *inward* from the outer wall toward the interior of the building and will have windows, frequently a large area. These zones may be rather minutely subdivided. Peripheral zone areas will have rapidly changing cooling loads in summer, due to shifting sun and weather, and they will require heating in winter. During intermediate seasons, one side of the building may require cooling while, at the same time, another requires heating. On the other hand, the interior zone spaces, whose thermal loads are derived almost entirely from lights, office equipment, and people, will require cooling at a ·y uniform rate throughout the year. Quite often, conditioning of these interior spaces is done by an independent system which has reheat or volume control for low- or no-load conditions.

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Occupancy will vary considerably. In accounting or other ·ons where clerical work is done, the maximum density is approximately one person per 75 sq ft of floor area. Where there are private offices, the density may be as little as one person per 200 sq ft. The most serious cases, however, are the occasional waiting rooms, conference rooms, or directors' rooms where the occupancy may be as high as one person per 20 sq ft.

The lighting load in an office building makes up a sizable part of the total heat load (25 to 60 percent).

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One of the largest sources of concentrated heat load in an office building is the computing and tabulating machinery which is increasingly used in large company operations. Although this type of equipment is still relatively new, its use is increasing rapidly. For now, as accurate an appraisal as possible should be made of the amount, size, and type of computer equipment anticipated for the life of the building in order to properly size the air-handling equipment, and make provision for the future installation of air-conditioning apparatus.

DESIGN CONCEPTS

The type of occupancy may have an important bearing on the air-distribution system to be used. If there is one owner or lessee for the entire building, his operations may be clearly enough defined so that a system can be designed which need not have the degree of flexibility required for a less well defined operation. However, the owner who occupies his own building may want to build considerable flexibility into his building since he will have to pay for all alterations. The speculative builder can generally charge off alterations to the tenants. Where different tenants may occupy different floors or even parts of the same floor, the degree of design and operation complexity increases in order to furnish proper environmental comfort conditions to any one tenant, group of tenants, or all of them at once. This problem is more acute where tenants have seasonal and varying overtime schedules.

Since stores, banks, restaurants, entertainment facilities, etc., may have hours of occupancy or design criteria which differ substantially from those of the office building, it is desirable that they have their own air-distribution systems, and, in some cases, even their own refrigeration equipment.

Some company cafeterias may be handled as part of the office building systems because their use is tied in closely with the offices. Main entrances and lobbies are sometimes placed on a separate system because they are the buffer zone between the outside and the interior. Some engineers prefer to have the lobby summer temperature 4 to 6 F deg above office design conditions in order to minimize the thermal shock experienced by many people when entering or leaving the buildings.

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APPLICABILITY OF SYSTEMS

The variables in design are so great that almost any given system available would be particularly suitable for some special building design or criteria. However, most office buildings use dual-duct, induction, or fan-coil systems, although variable volume air systems and *deluxe* type self-contained perimeter unit systems are becoming more common. Where fan-coil or induction systems are installed at the perimeter, separate all-air systems are generally used for the interior.

Smaller office buildings may find it economical to have perimeter radiation systems with conventional, single duct, low or medium velocity air-conditioning systems furnishing air from packaged air-conditioning units or multi-zone units. However, variations in design are manifold.

Some general comments can be made about the applicability of perimeter systems as a function of percentage of exterior glass.

Ductwork and piping may be run either vertically at the perimeter of the building or vertically in the interior of the building, with horizontal distribution at the ceiling for each floor. The latter is usually more costly, but the choice is dependent upon the architectural design of the building. The coordination and detailing of the relationship between perimeter unit location, perimeter wall glass, spandrel beams, piping, and ductwork are very often critical and must be carefully examined in the early stages of design in order to establish the most feasible and economical layout.

The higher the percentage of glass, the more air would be required for an all-air system. This means larger mechanical systems and rooms and duct shafts as compared to combination air-water systems.

From an architectural viewpoint, it is desirable to eliminate air-conditioning units from the perimeter of the building. In warmer climates and where the glass ratio is not high, the units may be located in the hung ceiling although this results in higher maintenance costs. Radiant panel ceiling systems may also be considered and have the added advantage that smaller air requirements will reduce the duct sizes and possibly even the floor-to-floor height, in comparison to other combination air-water and all-air systems.

The variety of uses to which the interior spaces may be put will usually require that the interior air-conditioning system allow modifications to handle all types of load situations. Ideally, a dual-duct system with hot and cold duct loops on each floor, will permit a simple means of connecting between main ducts and mixing units as required by changes in interior partitions. Where a large number of dual-duct mixing units are installed, the initial cost may be high, but if many tenant changes are anticipated, the higher initial cost may be justified and savings will be realized. Single duct reheat systems are most commonly used. Single duct ceiling induction systems are also used.

Few, if any, rental office buildings are now being designed without complete air conditioning. Coupled with the higher lighting levels now in use, this makes consideration of heat pump systems worthwhile, if electric rates are low enough.

In small to medium size office buildings, air source heat pumps may be employed. In larger buildings internal source heat pump systems (water-to-water) are feasible with most types of air-conditioning systems. Heat removed from the core areas is either rejected to a cooling tower or is utilized in the perimeter circuits. The internal source heat pump can be supplemented by a boiler to assist on extremely cold days or over extended periods of limited occupancy. Excess heat removed may also be stored in hot water tanks.

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SPECIAL CONSIDERATIONS

Areas in office buildings which have special ventilation requirements are elevator machine rooms, electric and telephone closets, electrical switchgear, plumbing rooms, refrigeration rooms and mechanical equipment rooms. The heat loads in some of these rooms may be so high as to require the installation of air-conditioning units for spot cooling.

If a boiler plant is required for an office building, its location will be partially predicated upon the type of fuel and the value of basement space. For coal or oil firing, the problems of fuel transport to a penthouse boiler plant must be considered for feasibility and cost. Gas will often present less of a transport problem than oil or coal for a penthouse boiler plant location. The possibility of a gas outage must be considered and suitable measures taken to provide heat in an emergency. This may be done by means of emergency oil storage or electricity, a duplicate gas line or possibly other means which may be unique to a given application.

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Mechanical Equipment Rooms

The total electro-mechanical space requirements for office buildings range from about 8 to 10 percent of the gross area. The clear height required for fan rooms will vary from about 13 to 18 ft depending upon the complexity of the distribution system and the equipment involved. On typical office floors, the perimeter units take up about 1 to 3 percent of the gross floor area, whereas interior shafts require about 2 percent more. Therefore, on each floor, ducts, pipes, and equipment require about 3 to 5 percent of the gross floor area. Electrical

If fewer floors are served by an equipment room, then more equipment rooms will be required to serve the building. This allows greater flexibility in serving changing floor or tenant requirements. It will often be found that the use of one mechanical equipment room per floor and the complete elimination of vertical shafts will require no more total floor area than will the use of fewer mechanical equipment rooms plus the necessary shafts. Mechanical equipment rooms, especially when they are relatively frequent, can often be the same heights as typical floors, and equipment will be smaller, but maintenance costs will be higher.

Equipment rooms located on upper levels generally cost more to install due to rigging and transportation logistics, but this must be balanced against lower level revenue and desirability of space by tenants.

In any case, mechanical equipment rooms must be thermally and acoustically isolated from office floors above, below, or around them.

Cooling Towers

Cooling towers are the largest single piece of equipment required for the air-conditioning systems. As a rough approximation, the cooling tower requires about 1 sq ft of floor area per 400 sq ft of total building area and is from 13 to 40 ft high, usually located on the roof. The building structure must be capable of carrying the cooling tower and dunnage, the full load of water (about 120 to 150 psf), and the wind load stresses.

Where the possibility exists that cooling tower noise may affect neighboring buildings, the tower should be designed to allow the inclusion of sound traps or other suitable noise baffles. This may affect tower space and weight requirements, and probably also motor horsepower.

The cooling tower is sometimes enclosed in a decorative screen for esthetic reasons, and calculations should be made to ascertain that the screen has sufficient free area to enable the tower to get its required air quantity. If the tower is placed in a rooftop well or near a wall or split into several towers at various places or levels, the engineering becomes much more complicated and the initial and operating costs of the tower will generally increase substantially. The possibility of hydraulic problems is increased when towers are split and placed on different levels. This practice should be avoided.

COMMERCIAL SPACE - PROGRAM NEEDS

Sizes

Variable. A combination of different sizes is desirable from the point of view of leasing (interesting variety). Shops are often long, thin rectangles, as not much frontage is necessary and displays require closed wall space. (This is a general rule. Note Design Research building, Harvard Square, Cambridge, as an exception.) Examples of sizes are shown on attached sheet. Flexibility in organization of rental space is desirable.

Structure

Clear floor space is often desirable, i.e., less structure to permit flexibility, which is very important in retail planning.

Load Requirements

Retail, Light Merchandise	100 psi
Storage (Light)	125 psi
Restaurants	100 psi
Corridors	80 psi

Mechanical

For small stores, individual units are desirable. Restaurants require special ventilation equipment with larger ducts, and toilets are often required.

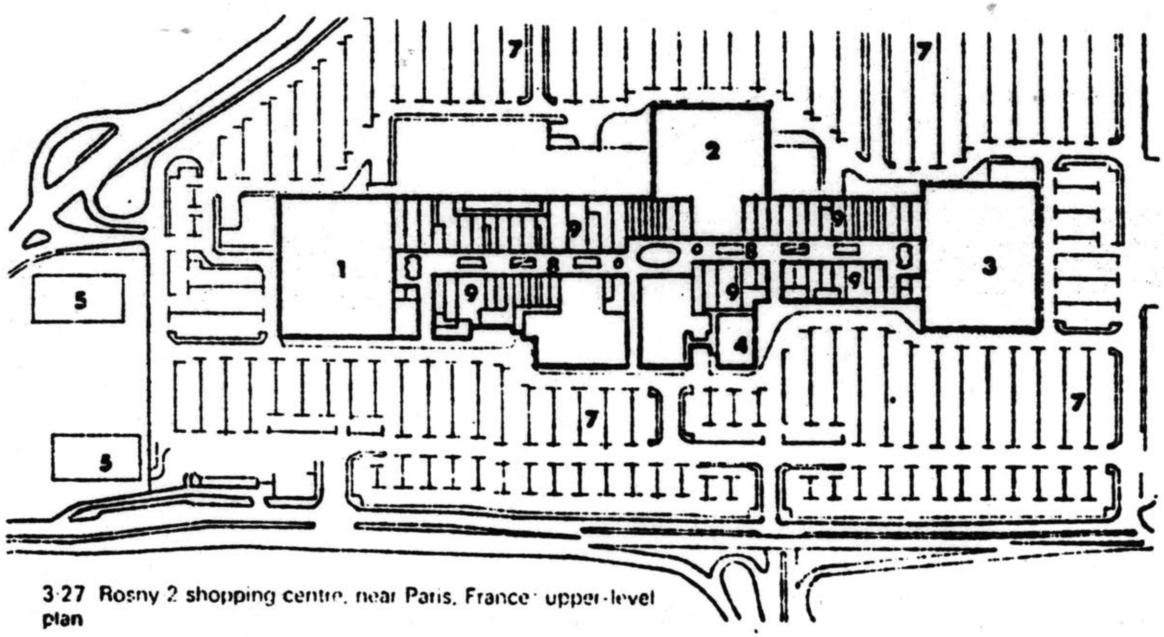
In general, less plumbing is required in commercial space making it more similar to offices rather than residential. Moreover, less chase area is required, in case it is difficult to cut through floor slabs. See ASHRAE discussion.

Special Needs

Storage is sometimes needed which can be away from display area. Delivery access is often required. It may be desirable to isolate large truck access from the main pedestrian access to the building. Parking is generally desirable. Additional outdoor space can be a useful amenity to accommodate spillover, vending, and rest areas.

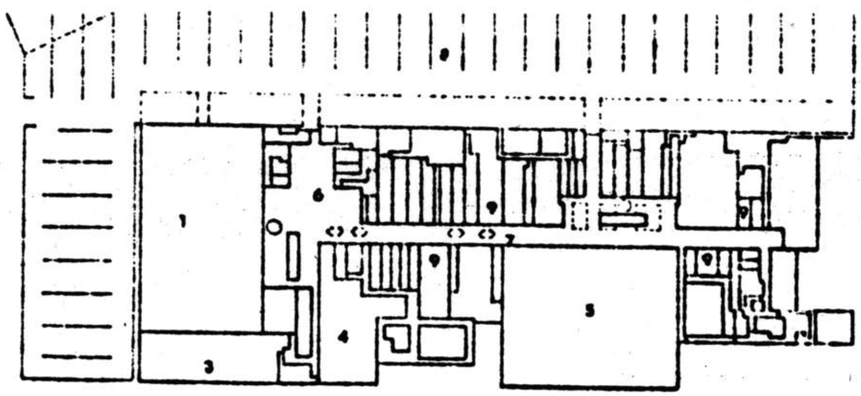
Code Requirements

Generally the same as for offices, except that fire wall separations must be three-hour rated, and some exitways must be sized slightly differently, depending on occupancy load.



Key:
1 Samaritaine department store (3 levels)
2 La Redoute department store (1 level)
3 B H V department store (3 levels)
4 Cinema
5 Office building
6 Railway station
7 Car parking
8 Shopping mall
9 Shops
Scale. 1:4000

3·27 Rosny 2 shopping centre, near Paris, France: upper-level plan



Key:
1 Penney's department store
2 Macy's T B A
3 Ice rink
4 Cinema
5 Macy's department store
6 Main Square
7 Mall
8 Parking
9 Shops
Scale 1 4000

3 11 Sun Valley, California USA: lower-level plan

PART I: SMALL STORES

Air conditioning in modern small stores has become more of a necessity rather than just a convenience to provide comfort for the customer. With the advent of greater lighting intensities in show windows and sales areas, and with internal fixture layouts discouraging use of windows for internal ventilation, air conditioning has become a prime requirement of modern store design.

The requirements for air-conditioning design and installation in small stores are fairly uniform with variations as to location of equipment, services, and air distribution.

Generally, in small store air-conditioning design, unitary equipment should be considered. Ease of installation, economy in initial costs, minimum space requirements, factory warranties and relocation of equipment are some of the advantages of unitary equipment.

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EQUIPMENT SELECTION

Modern unitary equipment is offered in many types and models as discussed in Chapter 42 of the 1972 GUIDE AND DATA BOOK, while unitary systems (multiple units) are discussed in Chapter 6 of the 1973 ASHRAE HANDBOOK & Product Directory. Free standing types are most commonly used where floor space is available. The units are readily adapted for installation within the store fixture work. Units also can be installed remote from the conditioned areas, in utility of basement spaces, with distribution through ductwork.

Where floor space is not available, suspended unitary equipment can be installed. Existing stores with small cooling loads often use room air conditioners installed in transoms above the doors or through walls where space is available.

The use of single-package rooftop equipment is very common in store air conditioning. The units are factory-assembled in a weathertight case; the refrigerant system is factory-charged and sealed, and internally wired; thus installation is greatly simplified. The use of multiple units to condition the store can mean less ductwork and can minimize problems in the event of equipment failure. Mounting supports can be built in the roof to provide a secure, waterproof platform on which to place the equipment.

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Water-cooled unitary equipment is available in all capacities required for small store air conditioning. However, communities in the United States have placed restrictions on the use of city water for condensing purposes which require installation of a cooling tower and circulator pump.

Where roof areas, yard areas or equipment areas with outside walls are available adjacent to the conditioned spaces, air-cooled equipment may prove to be an economic and efficient system. Water-cooled equipment generally provides for most efficient operation, ease of installation, and economy of operation when the equipment room or conditioned spaces are remote from the required conservation equipment.

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PART II:

EATING AND ENTERTAINMENT CENTERS

Air conditioning of restaurants, cafeterias, bars, and night clubs presents all of the usual problems encountered in comfort conditioning, with the addition of several factors specifically pertinent to this type of application. Some of these are:

1. Extremely variable loads with high peaks occurring in many cases twice a day.

2. High sensible and latent heat gains due to gas, steam, and electric appliances.

3. High concentration of food, body, and tobacco-smoke odors, necessitating adequate ventilation with proper exhaust facilities.

4. Localized high sensible and latent heat gains in dancing areas.

5. Unbalanced conditions in restaurant area adjacent to kitchens which, although not a part of the conditioned space, require attention.

6. Heavy infiltration of outdoor air through doors, due to high usage factor during rush hours.

DESIGN CONCEPTS

Some of the factors which will influence system design and equipment selection are:

1. Outlet design should not permit drafts on patrons.

2. Provision should be made for step control of refrigeration plants serving no other loads, to give satisfactory and economical operation under reduced loads.

3. Air should be exhausted at the ceiling for removal of smoke and odors.

4. Building design and space limitations very often favor one type of equipment as against another. For example, in a restaurant having a vestibule with available space above it, a system with the high-side equipment located remotely and the low-side equipment above the vestibule may be satisfactory. Such an arrangement saves valuable space, even though self-contained units located within the conditioned space may prove somewhat lower in initial cost. In general, small cafeterias, bars, etc., with loads up to 10 tons can be most economically conditioned with package units, while the larger and more elaborate establishments would require built-up central plants.

5. If not required for kitchen exhaust, the air required by an air-cooled or evaporative condenser may sometimes be drawn from the conditioned space, thus eliminating the necessity for operating additional exhaust fans and also improving the overall efficiency of the plant due to the lower temperature of air entering the condenser. Proper water treatment is necessary. It also may be necessary to bypass air when it is not required.

6. The usual practice for the smaller restaurant with an isolated plant has been to use direct-expansion systems.

Large establishments are often handled by circulating chilled water through spray type or finned-coil surface dehumidifiers. In such cases, reheat control is preferred, with face-and-bypass dampers a second choice.

7. Solid adsorption dehydration equipment, while usually more costly, produces superior results where latent heat loads are especially high. This is particularly true of dance floors, where it is difficult to maintain humidities below 60 percent with conventional refrigerating equipment alone.

8. The odor and smoke problem in many restaurant and kindred applications can be mitigated either by ample ventilation or by odor absorption equipment. The economics of the latter may be quite favorable where sufficient ventilation air is not readily available, since it permits selection of a smaller refrigerating plant, and achieves a reduction in both summer and winter operating cost.

Height and area limitations

USE GROUP

Mass. State Code

TYPE OF CONSTRUCTION

N.P. - NOT PERMITTED
[-] UNLIMITED

USE GROUP			TYPE 1 Fireproof Note b		TYPE 2 Noncombustible			TYPE 3 Exterior Masonry Walls			TYPE 4 Frame	
					Protected		Un-protected	(HT) Mill	Ordinary Joisted Protected	Ordinary Joisted Un-protected	Protected	Un-protected
			1A	1B	2A	2B	2C	3A	3B	3C	4A	4B
A	HIGH HAZARD	Notes f and j.	5 ST 65' 16,800	3 ST 40' 14,400	3 ST 40' 11,400	2 ST 30' 7,500	1 ST 20' 4,800	2 ST 30' 7,200	2 ST 30' 6,600	1 ST 20' 4,800	1 ST 20' 5,100	N.P.
B-1	STORAGE-Moderate	Notes a, c, d, g and h.			5 ST 65' 19,950	4 ST 50' 13,125	2 ST 30' 8,400	4 ST 50' 12,600	3 ST 40' 11,550	2 ST 30' 8,400	2 ST 30' 8,925	1 ST 20' 4,200
B-2	STORAGE-Low	Notes a, c and d.			7 ST 85' 34,200	5 ST 65' 22,500	3 ST 40' 14,400	5 ST 65' 21,600	4 ST 50' 19,800	3 ST 40' 14,400	3 ST 40' 15,300	2 ST 30' 7,200
C	MERCANTILE	Notes a, c and d.			6 ST 75' 22,800	4 ST 50' 15,000	2 ST 30' 9,600	4 ST 50' 14,400	3 ST 40' 13,200	2 ST 30' 9,600	2 ST 30' 10,200	1 ST 20' 4,800
D	INDUSTRIAL	Notes a, c and d.			6 ST 75' 22,800	4 ST 50' 15,00	2 ST 30' 9,600	4 ST 50' 14,400	3 ST 40' 13,200	2 ST 30' 9,600	2 ST 30' 10,200	1 ST 20' 4,800
E	BUSINESS	Notes a, c and d.			7 ST 85' 34,200	5 ST 65' 22,500	3 ST 40' 14,400	5 ST 65' 21,600	4 ST 50' 19,800	3 ST 40' 14,400	3 ST 40' 15,300	2 ST 30' 7,200
F-1-A	ASSEMBLY THEATRES	With stage and scenery		6 ST 75' 14,400	4 ST 50' 11,400	2 ST 30' 7,500	1 ST 20' 4,800	2 ST 30' 7,200	2 ST 30' 6,600	1 ST 20' 4,800	1 ST 20' 5,100	N.P.
F-1-B	ASSEMBLY THEATRES	Without stage (Movie theatres)			5 ST 65' 19,950	3 ST 40' 13,125	2 ST 30' 8,400	3 ST 40' 12,600	3 ST 40' 11,550	2 ST 30' 8,400	1 ST 20' 8,925	1 ST 20' 4,200
F-2	ASSEMBLY - Night clubs and similar uses			4 ST 50' 7,200	3 ST 40' 5,700	2 ST 30' 3,750	1 ST 20' 2,400	2 ST 30' 3,600	2 ST 30' 3,300	1 ST 20' 2,400	1 ST 20' 2,550	1 ST 20' 1,200
F-3	ASSEMBLY - Lecture halls, recreation centers, terminals, restraurants Note c.				5 ST 65' 19,950	3 ST 40' 13,125	2 ST 30' 8,400	3 ST 40' 12,600	3 ST 40' 11,550	2 ST 30' 8,400	1 ST 20' 8,925	1 ST 20' 4,200
F-4	ASSEMBLY - Churches, schools Notes k and l.				5 ST 65' 34,200	3 ST 40' 22,500	2 ST 30' 14,400	3 ST 40' 21,600 Note e	3 ST 40' 19,800	2 ST 30' 14,400	1 ST 20' 15,300 Note e	1 ST 20' 7,200 Note e
F-6	ASSEMBLY - Schools (Schoolhouses) Notes m and n				5 ST 65' 34,200	3 ST 40' 22,500	2 ST 30' 14,400	3 ST 40' 21,600	3 ST 40' 19,800	N.P.	1 ST 20' 15,300	N.P.
H-1	INSTITUTIONAL - Restrained			6 ST 75' 18,800	4 ST 50' 14,250	2 ST 30' 9,375	1 ST 20' 6,000	2 ST 30' 9,000	2 ST 30' 8,250	1 ST 20' 6,000	1 ST 20' 6,375	N. P.
H-2	INSTITUTIONAL - Incapacitated			8 ST 90' 21,600	4 ST 50' 17,100	2 ST 30' 11,250	1 ST 20' 7,200	2 ST 30' 10,800	2 ST 30' 9,900	1 ST 20' 7,200	1 ST 20' 7,650	N. P.
L-1	RESIDENTIAL - Hotels				9 ST 100' 22,800	4 ST 50' 15,000	3 ST 40' 9,600	4 ST 50' 14,400	4 ST 50' 13,200	3 ST 40' 9,600	3 ST 40' 10,200	2 ST 35' 4,800
L-2	RESIDENTIAL - Multi-family				9 ST 100' 22,800	4 ST 50' 15,000	3 ST 40' 9,600	4 ST 50' 14,400	4 ST 50' 13,200	3 ST 40' 9,600	3 ST 40' 10,200	2 ST 35' 4,800
L-3	RESIDENTIAL - 1 & 2 family				4 ST 50' 22,800	4 ST 50' 15,000	3 ST 40' 9,600	4 ST 50' 14,400	4 ST 50' 13,200	3 ST 40' 9,600	3 ST 40' 10,200	2 ST 35' 4,800

TABLE 2-5. FIRE RESISTANCE RATINGS OF STRUCTURAL ELEMENTS IN HOURS

The following section on code requirements is from the Massachusetts State Code

TYPE OF CONSTRUCTION

	Notes on Page 2-33		TYPE 1		TYPE 2 NONCOMBUSTIBLE Note b			TYPE 3 EXTERIOR MASONRY WALLS			TYPE 4 FRAME	
	STRUCTURAL ELEMENT		FIREPROOF		PROTECTED		Unprotected	Heavy Timbers (Mill)	Ordinary Protected	Ordinary Unprotected	Protected	Unprotected
	EXTERIOR WALLS	Note a	1A	1B	2A	2B	2C	3A	3B	3C	4A	4B
1	On street lot lines or with fire separation of 30' or more from interior lot lines or any building	Bearing	4	3	2	3/4	0	2	2	2	3/4	0
		Non-Bearing	0	0	0	0	0	0	0	0	3/4	0
	On interior lot lines or less than 6' therefrom, or from any building	Bearing	4	3	2	1 1/2	Note c 3/4	2	2	2	3/4	3/4
		Non-Bearing	2	2	1 1/2	3/4	Note c 3/4	2	2	2	3/4	3/4
	6' or more but Less than 11'	Bearing	4	3	2	3/4	0	2	2	2	3/4	0
		Non-Bearing	2	2	1 1/2	3/4	0	2	2	2	3/4	0
	11' or more but Less than 30'	Bearing	4	3	2	3/4	0	2	2	2	3/4	0
		Non-bearing	1 1/2	1 1/2	3/4	3/4	0	See Sec217	1 1/2	1 1/2	3/4	0
2	Interior bearing walls and partitions		4	3	2	3/4	0	2	3/4	0	3/4	0
			←—— Noncombustible ——→									
3	Fire walls		4	3	2	2	2	2	2	2	2	Note d
			←—— In No Case less than Fire Grading of Use Group — (See Table 16) ——→									
4	Fire Divisions		←—— Fire Resistance Rating corresponding to Fire Grading of Use Group — (See Table 16) ——→									
5	Fire Enclosure of Exitways, Elevator Hoistways, Exitway Hallways and Stairways Note e		2	2	2	2	2	2	2	2	3/4	3/4
			←—— Noncombustible ——→									
6	Shafts other than Stairways		2	2	2	2	2	2	2	2	3/4	3/4
			←—— Noncombustible ——→									
7	Exitway Access Hallways & Vertical Separation of Tenant Spaces		3/4	3/4	3/4	3/4	0	3/4	3/4	0	3/4	0
			←—— Noncombustible ——			Note h ——→						
	Other Non-bearing Partitions (See Art. 9)		←—— Noncombustible ——			Note h ——→		0	0	0	0	0
8	Columns, Girders, Trusses (other than roof trusses) and Framing	Supporting one Floor or Roof	3	2	1 1/2	3/4	0	See Sec217	3/4	0	3/4	0
		Supporting more than One Floor	4	3	2	3/4	0	See Sec217	3/4	0	3/4	0
9	Structural Members Supporting Wall		←—— Required Fire Resistance of Wall Supported but not less than Fire Resistance Rating for Type of Construction ——→									
10	Floor Construction including Beams Note g		3	2	1 1/2	3/4	0	See Sec217	3/4	0	3/4	0
11	Roof Construction including Beams Note g, 15' or Less in Height		2	1 1/2	3/4	3/4	0	See Sec217	3/4	0	3/4	0
					←—— Note h ——→							
12	Roof Trusses and Framing including Arches & Roof Deck Note f	More than 15' but less than 20' in height to lowest member	3/4	3/4	3/4	0	0	See Sec217	0	0	3/4	0
			←—— Note h ——→									
		20' or more in height to lowest member	0	0	0	0	0	See Sec217	0	0	0	0
			←—— Note h ——→									

SECTION 902.0 FIRE HAZARD CLASSIFICATION

The degree of fire hazard of buildings and structures for each specific use group as defined by the fire grading in Table 9-1 shall determine the requirements for fire walls, fire divisions and the segregation of mixed uses as prescribed in section 213 and all structural members supporting such elements, unless otherwise provided in this Code.

TABLE 9-1 - FIRE GRADING OF USE GROUPS

Class	Use Group	Fire grading in hours
A	High hazard	4
B-1	Storage - Moderate hazard	3
B-2	Storage - Low hazard	2
C	Mercantile	3
D	Industrial	3
E	Business	2
F-1	Assembly - Theatres	3
F-2	Assembly - Night Clubs	3
F-3	Assembly - Recreation centers, lecture halls, terminals, restaurants	2
F-4	Assembly - Churches, schools	1½
H-1	Institutional - Restrained occupants	3
H-2	Institutional - Incapacitated occupants	2
L-1	Residential - Hotels	2
L-2	Residential - Multi-family dwellings	1½
L-3	Residential - 1 and 2 family dwellings	3/4

HABITABLE ROOM: a room or enclosed floor space arranged for living, eating, and sleeping purposes (not including bathrooms, water closet compartments, laundries, pantries, foyers, hallways and other accessory floor spaces).

HABITABLE ROOM, MINIMUM HEIGHT: a clear height from finished floor to finished ceiling of not less than seven and one-half (7½) feet, except that in attics and top half-stories the height shall be not less than seven and one-third (7-1/3) feet over not less than one-third (1/3) the area of the floor when used for sleeping, study or similar activity.

HABITABLE ROOM, MINIMUM SIZE: a room with a minimum dimension of seven (7) feet and a minimum area of seventy (70) square feet, between enclosing walls or partitions, exclusive of closet and storage spaces.

503.2 WINDOW SIZE: Windows and exterior doors may be used as a natural means of light and when so used their aggregate glass area shall amount to not less than one-tenth (1/10) of the floor area served.

504.1 AREA OF NATURAL VENTILATING OPENINGS: Natural ventilating openings from habitable spaces shall have a free area when open of at least 5 percent of the floor area of the space ventilated.

MEANS OF EGRESS: a continuous and unobstructed path of travel from any point in a building or structure to a public space and consists of three (3) separate and distinct parts: (a) the exitway access, (b) the exitway and (c) the exitway discharge; a means of egress comprises the vertical and horizontal means of travel and shall include intervening room spaces, doors, hallways, corridors, passageways, balconies, ramps, stairs, enclosures, lobbies, escalators, horizontal exits, courts and yards.

605.32 EXISTING EXITWAYS: In all buildings (other than one and two-family dwellings) exceeding three (3) stories or forty (40) feet in height, or having more than seventy-five (75) occupants above or more than forty (40) occupants below grade floor, all existing enclosed stairways shall be enclosed with partitions and opening protectives of two (2) hour fireresistance rating complying with article 9; doors shall be self-closing. Existing enclosures of substandard fireresistive construction shall be covered on the stair side only with the component materials required for a two (2) hour fireresistive assembly.

607.1 ARRANGEMENT: All required exitways shall be so located as to be visible and readily accessible with unobstructed access thereto and so arranged as to lead directly to the street or to an area of refuge with supplemental means of egress that will not be obstructed or impaired by fire, smoke or other cause.

607.2 SEPARATION OF EXITWAYS: Whenever more than one (1) exitway is required from any room, space or floor of a building, they shall be placed as remote from each other as practicable, and shall be arranged to provide direct access in separate directions from any point in the area served.

607.3 LENGTH OF TRAVEL: All exitways shall be so located that the maximum length of exitway access travel, measured from the most remote point to an approved exitway along the natural and unobstructed line of travel shall not exceed the distances given in table 6-2; except that in buildings of residential, mercantile or institutional use groups where the area is subdivided into rooms or compartments, and the egress travel in the room or compartment is not greater than fifty (50)* feet, the distance shall be measured from the exitway access entrance to the nearest exitway.

* May be increased to 100 feet, in use groups equipped with automatic sprinklers.

607.4 FLOORS BELOW GRADE: In buildings of all use groups the permissible length of exitway access travel on any floor more than one (1) story below grade shall not exceed seventy-five (75) feet.

TABLE 6-2 MAXIMUM LENGTH OF EXITWAY ACCESS TRAVEL (FEET)

USE GROUP	LENGTH	LENGTH WITH FIRE SUPPRESSION SYSTEM
High Hazard (A) ...	--	75
Storage (B)	100	150
Mercantile (C)	100	150
Industrial (D)	150	250
Business (E)	200	300
Assembly (F)	150	200
Institutional (H)..	100	200
Residential (L) ...	100	150

612.1 NUMBER OF DOORWAYS: Every room with an occupancy load of more than fifty (50) or which exceeds one thousand five hundred (1500) square feet in area shall have at least two (2) egress doorways and the doors shall be hung to swing in the direction of exit travel without obstructing the required width of exitway.

SECTION 609.0 NUMBER OF EXITWAYS

The following general requirements apply to buildings of all use groups. More restrictive requirements that may be provided in article 4 for special uses and occupancies shall take precedence over the general provisions of this section.

609.1 MINIMUM NUMBER: Except in one and two-family dwellings, there shall be two (2) or more approved independent exitways serving every floor area above and below the grade floor, one (1) or which shall be an interior enclosed stairway. Exitways in dwellings shall be so arranged that they may be reached without passing through another living unit.

609.11 EXITWAYS IN RESIDENTIAL USE GROUPS: In all multi-family residential use groups (L-2), except as provided in section 609.12, each apartment shall have access to at least two (2) independent exits which are remote from each other; such exits shall be so arranged that to reach either exit it will not be necessary to pass through a public corridor which serves the other.

609.12 EXITWAYS IN TYPE 1-A AND 1-B, L-2 USE GROUPS: In buildings of type 1-A or type 1-B construction a single exitway shall be permitted for every room, or group of less than four (4) rooms used for residential occupancy on multi-family floors, provided that elevator lobbies on all floors except the ground floor are enclosed with self-closing fire doors, and providing that all public corridors are zoned by self-closing fire doors, so that no entrance door of any room or apartment shall be more than fifty (50) feet from the nearest egress or segregating fire partition. Doors from elevator lobbies, doors in segregating fire partitions, and doors to stair enclosures, shall not be over two hundred (200) feet apart. Sleeping facilities shall be limited to not more than six (6) persons beyond the enclosed stairs. Rooms other than bedrooms connected with the same living unit may be permitted.

SECTION 616.0 INTERIOR EXITWAY STAIRWAYS

616.1 CAPACITY OF EXITWAY STAIRS: The capacity of stairways and doors per unit of exit width shall be computed in accordance with section 608.

616.2 MINIMUM DIMENSIONS

616.21 WIDTH: All required interior stairways shall be at least forty-two (42) inches in width except that such width may be reduced to thirty-six (36) inches in buildings of use group L-3 (one and two-family dwellings) or in exitways from boiler rooms and similar service spaces not open to the public or in general use by employees.

616.22 HEADROOM: The minimum headroom in all parts of the stair enclosure shall be not less than six and two-thirds (6-2/3) feet.

616.23 RESTRICTIONS: No stairways shall reduce in width in the direction of exit travel.

603.4 BUILDING ACCESS FOR HANDICAPPED: All buildings and parts thereof classified in use groups C (Mercantile), D (Industrial), E (Business), F (Assembly), H (Institutional), L-1 and L-2 (Residential) shall have at least one primary entrance accessible to and usable by the handicapped. Such entrance shall provide access to a level that makes elevators available in buildings where elevators are provided. Where ramps are used to comply with this requirement, they shall have a slope not greater than one (1) in ten (10) and comply with the other provisions of this article for access to the handicapped.

615.2 LANDINGS: On ramps required for the use of handicapped persons, landings shall be provided at all ramp points of turning, entrance, exitway and doors at a minimum of thirty (30) foot intervals. All landings shall provide a clear distance of forty-two (42) inches from any door swinging to the ramp. Minimum landing length shall be forty-two (42) inches and the bottom landing of any ramp or set of ramps and landings of a straight run shall be a minimum length of seventy-two (72) inches.

612.2 SIZE OF DOORWAYS: The minimum width of single doorways shall be thirty-two (32) inches and the maximum width shall be forty-four (44) inches with the following exception:

Access for the handicapped: In all buildings and parts thereof subject to the provisions of section 603.4 primary entrance and access doorways shall be thirty-six (36) inches or greater in width.

Appendix D; Case Studies

This appendix contains a sample of the buildings I looked at and a brief discussion of the aspects of each I found instructive in the framework of this thesis project. All of the buildings were converted to uses I investigated in the program study. Those adapted to housing were useful in the design portion of this project as well.

ELDERLY HOUSING, BEACON HILL, BOSTON, MASSACHUSETTS

Architect: Boston Architectural Team

Project Manager: Robert Verrier

This building was of interest to me because it has much in common with the Hancock School, for which I was designing housing. A discussion with Mr. Verrier and a visit to the building provided the basis of these notes.

Programming

Input from the neighborhood through the Beacon Hill Civic Association contributed to program development for the housing project, in terms of unit types and amenities.

Financing

A HUD insured load provided financing for the project through MHFA and FHA. Though a finance program for family housing was used (D4) to supply more money, the project was geared toward elderly. Section 8 subsidies cover 75 percent of the rents. Maximizing the number of units in the project (there are 35) was important to making the cononmics work. A large amount of money was spent on fire protection and the elevator alone cost $65,000.

Construction Type

The building was not consistent in its construction. Masonry walls, cast iron columns, steel girders and mill construction all support the building. However, they all have a sufficient fire rating (two hours). The school, like most others, was designed to carry twice the load of residential use.

Space Issues

The third floor gym was converted to two floors of units (flats). New stairs to the top floor were put in in addition to the elevator. The top floor units were complicated by the timber trusses holding up the roof, which in some areas required redesign.

Amenities

The project has a lounge, laundry, and small yard area.

Mechanical

Air conditioning was required for the loan. A central HVAC system (vertical fan coil, three-pipe system) was installed which used a unit on the roof. The exterior unit had to be placed carefully for historic preservation of the facade. Verrier pointed out that in his experience with recycling buildings, existing mechanical systems had never been reused.

Fire Protection

The building is sprinkled up and down. That is, the large (over 18") structural/mechanical space above the ceiling is sprinkled as well as the use space. There is an emergency fire pump and smoke detectors. The necessity of the extensive protection resulted from the fact that the building was 72' high.

Image

In comparison with the Gloucester Elderly Housing, I found the Bowdoin project disappointing. The exterior of the building was intact and is quite handsome, but the public space inside (entry, stairs, corridor), as well as the units, retain little or none of the historic character of the building. All original finishes are replaced by white gypsum. Detailing is new and undistinguished.

SENTRY MINUTEMAN INSURANCE COMPANY, CONCORD, MASSACHUSETTS

Architects: Day and Ertman, Boston

Note: Renovations of the high school had begun under these architects for another company, which Sentry bought, along with the building.

I examined this building primarily with reference to the Program Study in which I was developing information on office space.

Size

Sentry has over 500 employees. The office space, excluding the gym, auditorium, and cafeteria is about 100,000 square feet.

Sentry removed all partitions from the school (built in 1962) to make an open office landscape plan. The main issues behind this decision were flexibility and standardization. A few offices are closed; most all other work areas are open. A word processing center collects noisy machines in one area, and low acoustical panels help there.

Work spaces vary in size within a range of standards: 5' x 6 1/2'; 5' x 9'; and 10' x 15'. A few closed offices are larger. Some of the workspaces are larger. Several workspaces are shielded by freestanding panels 5' high.

Storage (files) is mostly decentralized, though in some cases collected to a zone running down the center of each large room where the structural span is shorter (formerly a hall). Supplies are bulk stored in the basement; a mail system connected these with employees.

Also in the basement is mechanical, locker room, and cafeteria. Lounge areas are scattered and open, except for a "quiet room."

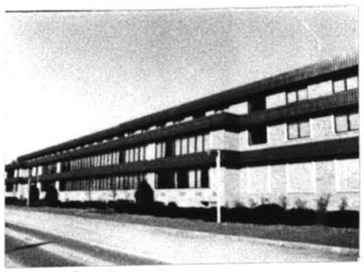
A meeting room can be useful to offices, but the auditorium in this former school is too big, seating well over 500. It is sometimes used by the community. The lobby of the auditorium is used as a conference area.

The gym is not used as much as it should be. Noise transfer through the floor to the office below is a problem.

Heating and ventilation units are spaced frequently under windows (which are fixed sash) with individual control. There is also a core system in which delivery is through a plenum in the ceiling. Mr. Baldinelli, the physical plant manager, criticized the individual units and control as inappropriate to an open plan.

Code issues were not a problem in the reuse of the building due to the fact that it was a school which provided adequate egress. However, there is a problem in supporting file storage areas with existing structure, except where the corridor had been. A special area for computers is equipped with a raised floor to allow for wires and heat removal. There is extra space there for expansion.

Parking (480 spaces) necessitated the use of the athletic fields. Office space in the basement of the building was outfitted to resemble offices above as much as possible. Only the smaller high windows are different.



A ramp was added to a rear entrance for the handicapped. The building has two elevators. One toilet on each floor is equipped for wheelchairs.

The image of this modern building was suited to the rather institutional character of Sentry, which emphasized standardization. I found it somewhat dehumanizing.

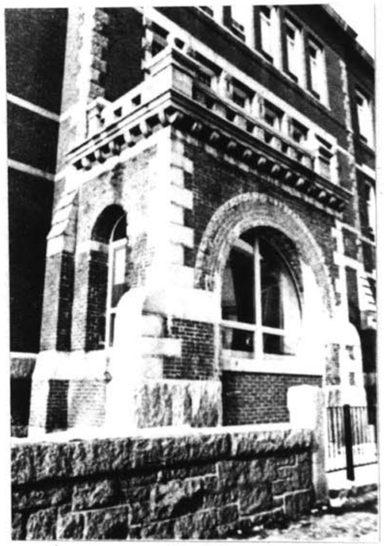
ELDERLY HOUSING, CENTRAL GRAMMAR, GLOUCESTER, MASSACHUSETTS

Architects: Anderson, Notter, Finegold Associates, Boston

I was interested in this building because it is similar to the Hancock in character and has many of the same constraints, such as historic preservation of the exterior. The layout of the units was a useful reference in my design work, as was the nature of the public space, the way light was dealt with in relation to depth, and the use of the attic. When I visited the building I was taken around by the superintendent, Jeanine Poirer.

Image

The preservation of the character of this building contributes a great deal to its success as a housing project for the elderly. The beautiful detailing on the exterior was maintained with little effort. However, special pains were taken to preserve aspects of the interior as well. The original wainscoting was stripped and painted with a fire retardant varnish. Some of the original bookcases and closet doors and hardware are still there and are of a quality which could not be duplicated without great expense. Many of the people who live in this building were pupils or teachers at Central Grammar, and they very much appreciate the preservation of these meaningful details.



Variety

There are several basic unit types. However, almost all of the apartments, even within a type, are slightly different. This gives them individuality, and the tenants can feel more of a sense of ownership. The variety also contributes interest to the building and the lives of the residents.

Common Space

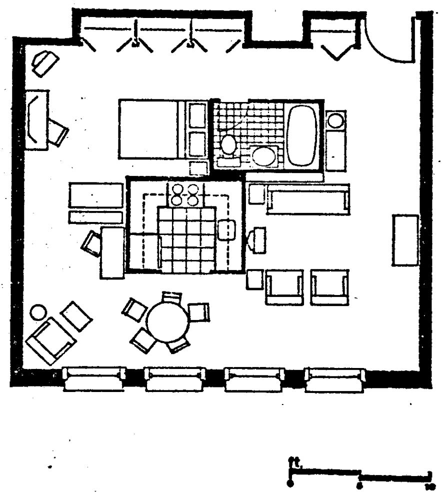
The common spaces in Central Grammar include a large community room equipped with kitchen facilities, a laundry room, entry lobby, and large corridors which encouraged extension of residents' homes into the hall with door mats and furniture. The common spaces were well used.

Handicapped

The building accommodates the handicapped with on grade entry, an elevator, and some special units which have bathrooms and kitchens equipped for wheelchairs.

Attic

The attic space was used for additional dwelling units, some flats and a few duplexes. Several of the apartments at the top of the building have terraces cut into the roof, from which there is a wonderful view. This alteration to the exterior of the building was possible because it was not visible from the street.



Basement

The basement apartments also have small yard spaces associated with them. The basement has somewhat high windows which limit the light entering the units; this makes them seem rather dark to me. However, elderly with sight problems may appreciate the lack of glare.

Parking

There are 28 spaces for 80 units. Only one resident was on the waiting list for a space.

Unit Design

One interesting unit which was designed to bring light deeper into the building and thus use floor space more efficiently has an open plan with no high walls. The low partitions around the central plumbing core allow light to pass above them to the area designated in plan as a bedroom. This plan is unusual for elderly housing but is quite successful.

MERCANTILE WHARF BUILDING, BOSTON, MASSACHUSETTS

Architects: John Sharratt Associates, Boston

I looked at Mercantile Wharf to observe one solution to the problem of a very deep building. Here the architects cut a large area out of the center of each floor to form a skylight atrium space as a focus for the project. This eliminated the dark interior of each level which would have been difficult to utilize in the housing units.

The ground floor is occupied by shops and a restaurant, and the center space has been made into a garden. Greenery in built-up planters grows under the large glass roof, and small seating areas are provided for strolling visitors. Circulation happens mainly along the sides of this space under a series of brick arches which emphasize the quality of the original masonry. The atrium is punctuated by elevators taking residents to the apartments on upper floors.

This building is an example of a situation where the architects made a major change in an existing structure to give the building an exciting formal element and to deal with a primary constraint: the building depth. This would be an excellent solution in a building which was already open vertically (such as a large power station or factory). In Mercantile Wharf, the designers subtracted already built square footage; presumably they thought it was not useful space. The cost in demolition and in loss of rentable space must be considered carefully in such a decision. It is always important in a reuse situation to examine all possible uses for the interior space in a deep building.

The Garage, Cambridge, MA.

Architects: ADD, Inc.

The aspect of this project most interesting to me is the circulation, which contributes to the success of the building in three ways. First, the architects reused the existing ramp which distributed cars through the structure; thus the character of the place is enhanced by exploiting an original feature, and continuity is maintained between the old and the new.

Second, the relationship of the retail goods and the circulation area is a dynamic one in which visitors walking through the building find little separation between themselves and the merchandise for sale. This is accomplished by various means. Large openings in shop wall definitions invite potential customers in more readily than ordinary glass shop windows. In some establishments which sell things to eat, tables and chairs are set up cafe style in the circulation space, rather than in the shop. In some cases the merchandise itself has moved out into the circulation area, either as a spillover from a store, or, as with the kites, as an entirely unenclosed vending operation. These relationships between shoppers and goods not only encourage sales, but also visually enliven the interior of the building.

A final aspect of the garage which works well is the high degree of flexibility. Many of the retail operations have light partitions defining their spaces. These are easily moved to accommodate changes in space needs, and this change sometimes occurs in relation to the circulation area. Several shops have expanded into the area next to the ramp which is large enough to be flexible. Sometimes the extra space is in the stores, sometimes it is public and contains benches for stopping and sitting.

Faneuil Hall Marketplace
Architects: Ben Thompson Associates

I looked at this project which houses offices and retail space in search of program information on these uses. The success in planning terms seems not to be a precise design fit to a specific program, but rather a flexibility to the varied needs of different tenants. Another architectural aspect which contributes to the success of the project is the emphasis on the positive elements of the original buildings. The designers capitalized on the fine materials and the special features of the waterfront buildings, and went to considerable expense to make the quality of the new construction equal to the old.

The surrounding outdoor space has been fully exploited and receives heavy use. The photo at the left was taken on a cold January day. In the summer larger crowds stroll along the storefronts or sit and watch the others parade, relaxing from shopping and consuming food from the numerous eateries in the Quincy Market Building.

For more extensive notes on this project see Appendix E, Consultants: Mark Rector.

Appendix E: Notes on Consultants

These notes summarize my conversations with various consultants who have experience with recycling builidngs. They provided information about architectural, structural, mechanical, financial, and programming aspects of reuse.

APPENDIX E: CONSULTANTS

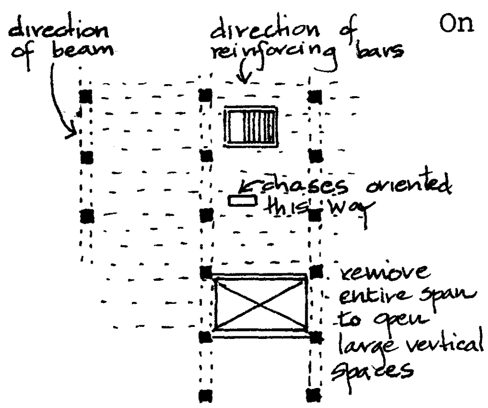
Structure

Leon Groisser, Structural Engineer

On adding intermediate structure (mezzanine, loft, etc.) to an existing floor level:

In general, adding additional structure (dead and live loads) for residential use is okay if the original building was a school or hospital, since these were designed for heavier loads than housing produces. They were built to carry book storage areas, assembly, or laboratory equipment, and they usually can carry over 60 - 100 psf, often twice the loading requirement for housing. Additional structure would be made most likely of wood which is relatively light and thus would not strain the existing system.

The new load should not be concentrated on one point but rather brought down on several of the floor joists if possible. If a new load is carried by an arch, or arch-like truss, the arch should be loaded as symmetrically as possible.



On cutting holes in concrete flooring:

Cutting holes in concrete is okay for stairs, for there can be enough structure around the stair to hold up the edge of the slab. Holes can be cut for larger architectural spaces if the whole span is removed (see sketch). Basically when holes are cut, the edge of the slab where it was cut must be held up.

Holes can be cut for chases if the small dimension of the hole is only a few feet long and runs parallel to the beam or bearing wall.

David Berg, Structural Engineer

Look at the building as a whole. Where will it deform with new loading? Look at the deflection patterns and relative stiffnesses.

In checking the structural condition of the building:

Look at joints and connections to ensure that movement or separation is not occurring. Check concrete for cracking. Inspect wood members for excessive checking or splitting and rotting. Note any significant deflection.

Gutting buildings is seldom done because the large costs of building up new structure inside. There are great problems of adding new foundations for new points of support under the center of the building. Seismic requirements of the code are rarely met by older buildings. A variance must be obtained.

Removing all stud walls which seem to be nonbearing partitions is not always wise. Often systems of stud walls which cross each other from floor to floor act like trusses and do transfer load down through the points where they cross over one another. Adding new partitions in this way can sometimes be used as a network to carry new loads. Post tensioning is sometimes used to strengthen masonry walls.

If head room is a problem, structure (joists, beams) can be cut into and reinforced (at some expense) to accommodate increased height.

Cutting holes in concrete necessitates determining the pattern of reinforcing. If reinforcing is radial, it is quite problematic, in terms of where holes can be cut. If reinforcing is two-directional, the best place to cut holes is in the center of the slab. It is advisable to reinforce the edge of the cut slab.

Mechanical Systems

Dan Levinson, Mechanical Engineer

Common problems encountered in rehab projects:

Compliance with code requirements for systems.

Knowing where and how big existing lines are, especially water, which is necessary for fire protection systems.

Accessibility to mechanical space for removal and installation of equipment (especially boilers).

Placement of air handling equipment in buildings under historic preservation restrictions. Solutions: work within existing window system (see Franklin Square House) or use a unit separate from the building.

Suggestions:

Line up plumbing as much as possible in reuse scheme to avoid the expense of many vertical shafts.

Use existing risers or holes where possible, especially in the roof where flashing adds expense, particularly in slate roofs.

Cutting small holes in a concrete slab is not problematic. The more holes cut, the cheaper each hole is.

Allow a 6' x 8' opening from the outside to the mechanical space for boiler installation.

Common systems:

In housing the systems required are more complex than those used in office or retail space, mainly because more plumbing is needed. The nature of the system used, in terms of control, depends on the kind of development (condominium, section 8 rent subsidy, etc.). The two most commonly used heating systems in housing are (1) baseboard radiation, used mostly in buildings up to four stories, and requiring separate air conditioning, and (2) a vertical fan coil system, which is less expensive in higher buildings. The fan coil system is largely preassembled and thus cuts down on on-site labor. This system requires a certain amount of stacking, but it provides both heating and cooling and is quite flexible.

In offices controls depend on the nature of the organization. Cellular offices should have individual controls and open plan offices are better with central control.

In retail (small shops) individual units are most desirable, particularly in air conditioning.

Code Issues

Paul Folkins, Structural Engineer, Boston Building Department

Section 105 (change in occupancy) and section 106 (extent of alterations) largely determine how structly a reuse project must comply with code requirements. If alterations cost over 50% of the worth of the building, based on replacement cost less repair, it must conform as if it were a new building. If there is a change in use, the project must also comply, in this case with the new occupancy requirements.

Major code issues which are frequently troublesome in rehab projects:

Earthquake and mortar requirements, which always need a variance.

Height and area with respect to type of construction.

Multiple egress requirement.

Enclosure of stairwells for fire exits.

Access to the roof.

Height of parapet.

It was recently decided that circulation to the two means of egress from a dwelling unit could not be through the same exitway. This results in having fire doors which swing in both directions frequently along a corridor which connects apartments to the fire stairs. The necessity for two oppositely swinging doors, each 40" side with a jamb in the middle, means that the corridor must be quite wide.

Article 22 requires several strict energy measures including conformity of the U value of the building envelope with a set of standards, control of wattage used (based on square footage) increasing the value of natural light, and storm sash or double glazing on all the windows. There are other standards requiring energy efficient mechanical systems, which will make replacement of existing systems a likely expense.

Retail Planning

Marcus Rector, Architect, Benjamin Thompson & Associates, Inc.

Understanding merchandising is essential to retail planning. The design should make people interact with the goods being sold. Psychologically or physically, there should be minimal separation between the people and the merchandise. This entails active connection between shops and circulation.

The program aspects of retail space are less specific than the demands of housing, for location is the main determinant of success. There is a range of requirements needed by different stores, but they are less rigid than those of residential development.

In terms of organization, flexibility is valuable. South Market (Faneuil Hall Marketplace, Boston) used modular space planning three dimensionally (20' bays, basement, first and second floors) to organize retail rental space. Some tenants needed high visibility and no storage, and rented the first floor space only; others, such as the restaurant, needed a great deal of basement space (for food preparation and storage) and also first and second floor space for the eating area. Rents are higher per square foot in small gallery and arcade (internal circulation) stores, and lower in large areas with plaza entry. Retail spaces in Quincy and South Markets vary from 600 to 1000 square feet.

In terms of mechanical systems, offices combine well with retail since they have similar mechanical requirements. Old buildings assimilate new systems best when the designer takes a clear attitude about the equipment. For example, Hardy, Holzman, Pfeiffer expose and emphasize pipes and ductwork with color. In the Marketplace, BTA lets it show but does not let it compete as a thematic element with the strength of the original building, using muted and neutral colors which blend with the fine materials of the existing building.

Retail Planning

Paul Dietrich, Architect, Cambridge Seven Associates, Inc.

Flexibility is the most important aspect of designing retail space, since tenants of small stores generally change frequently (every 5-10 years). Different tenants treat the same space in different ways. They take what they can get, and often mold what they have to sell to the size of the space they are in. Location is more of a key to their success than the architecture.

Restaurants have more specific program needs. There are stringent code requirements concerning toilets, ventilation, and exhaust. Windows are often totally unnecessary if artificial ventilation can be used.

Program Development

Doris Cole, Massachusetts Institute of Technology

At MIT program development comes after deciding where the use will be located. Buildings are analyzed for suitability using the following checklist of conditions:

Current occupants
Architecture, interior and exterior
Circulation: pedestrian, handicapped, vertical, service, security, and control
Structure
HVAC
Plumbing
Electrical
Fire projection
Operating costs

The areas of concern outlining the process of programming and installing a particular use into an existing building at MIT is as follows:

1. Site analysis in terms of program needs.
2. Other general emphases, such as flexibility, or special aspects of the environment needed, are projected.

3. Functions (types of spaces) and circulation are outlined.
4. A detailed list with square footages is made for all areas. Net assignable area is multiplied by 1.6 to get gross, which covers mechanical, structural, circulation, and custodial.
5. A detailed program in the form of "facility sheets" describes special requirements (mechanical, acoustical, furnishings, etc.).
6. Performance specs which are somewhat standard cover finishes, color code, graphics, etc.
7. Building services are described.
8. A budget is detailed.
9. Schedule for the work is formulated.
10. Submittal requirements are listed.

Development

Dennis Walsh, Developer

Advantages of using old schools for housing:

Classroom dimensions often make reasonable units, thus walls can be reused.

Solid, heavy construction provides substantial noise attenuation.

High windows let light into the interior of the building.

Beautiful detailing gives the project quality and character.

Often unused attics become "found space" and can be converted to more dwelling units, especially if the cost of conversion of the classrooms is low.

Location and setting of schools is often perfect for housing.

Penalties for using open warehouse space for housing:

Everything must be built, including sound barriers, fire walls and stairs, partitions, etc.

Common costs: $3,000 - 5,000 for unit acquisition; $20,000 per unit for construction (and demolition). 60-70% of the income from the building supports debt service.

Efficiency: When are additional construction costs justified if the money spent increases the efficiency of the building? For example, if there are large existing stairwells, should they be converted to units and smaller fire stairs put in, thus increasing rentable space? Probably not, for filling in the stairs may be very costly since stairs must be removed, complete new floors must be constructed, and windows may be in the wrong places, especially in terms of sill height. In general, if much of the existing architecture is used, minimizing demolition and construction, and thus lowering cost per square foot, the efficiency of a building in terms of rentable space is not as important. Financial analysis can determine these kinds of questions.

Appendix F: Design Studies

This appendix includes various housing schemes designed for the Hancock School in Lexington, MA, and one wing of Charles Choate Memorial Hospital in Woburn, MA. These design explorations were used as a tool to examine the feasibility of reutilizing the two buildings for housing and to determine what type of housing best fit the existing conditions. Other purposes of the studies were to discover major constraints encountered in the process, as a test for the building analysis checklist, and to investigate the program demands of housing.

The program needs varied with different users:

Elderly: Level changes are not advisable in the majority of the units; all units require one bedroom on or near the level of the rest of the apartment (living, dining, kitchen, bath). A bathroom should be ajacent to this bedroom. Slightly larger baths and open kitchens are needed in some units to accommodate wheelchairs. Some common space is desirable, possibly laundry, lounge, etc.

Families: More bedrooms (two, three or four), and larger living, dining, and kitchen areas are needed. More than one bathroom is required, as is more storage. Separation of rooms for privacy is desirable; a largely open plan is not appropriate. Spaces for children may be smaller than spaces for adults.

Young adults: These units are for one or two persons, without children, who can negotiate stairs. Communication is permitted, or even desirable between spaces since privacy is not as important as in family units. Room dimensions are similar to elderly (smaller than family units in living, kitchen and storage areas).

Different organization and unit types were explored as well as different users. Flats, duplexes and mezzanine or loft units are included, and double and single loaded corridors are examined. Other organizations were studied but turned out to be unsuitable to the existing architecture.

The following sections present a summary of notes taken with the design sketches. The intent was to record major obstacles or constraints the building presented in order to draw conclusions about its relative intractibility for certain uses or organizational schemes.

The Hancock School

Architecture: Building depth and ceiling height were the most important physical constraints encountered in the design process. The building is about 42 feet side. If outside access to units is ruled out for historical reasons, a corridor is necessary, and this building shape made a double loaded hall almost impossible. Where it is tried (elderly units, first floor), units are less efficient in their use of space. Because of the size of the units, a double loaded corridor is ruled out entirely for family apartments.

The ceiling height measures 13' 4". A general assumption used from the first was that it would not be economically practical to gut one of the floors and use the two storey space for three levels. With some difficulty, a second level was inserted into the original single floor level, squeezing head room in some parts of the units, though other parts are left open the full 13'. This gives variety to the dimensions of the spaces, though some are technically not "habitable". Because the upper level could only go over kitchen, bathroom, storage, or hall spaces, these rooms had to be clustered in order to aggregate space for the loft; thus the configuration of the unit is largely determined. In some cases a further level with only 5' headroom was built over the corridor for a sleeping platform. This space was a result of the effort to get light into the unit from the corridor windows.

Original stairs and access were important organizing elements in the design of the residential schemes. Two of the three entrances were maintained; the third seemed unnecessary. Both original stairs were used because the locations were good in terms of efficient circulation. The possibility of using these stairwells for units was pursued, however, the awkward results did not seem worth the required demolition and construction costs.

Because the Hancock School is in a historic district, limitations are placed on alteration to the outside of the building. This contributes to problems with windows and conditions of access.

Location and spacing of windows presents quite a significant limitation in the design of living units. On the third floor skylights must be added because there are simply not enough openings to use the space efficiently for housing. On other floors spacing is not a serious problem. A general conclusion may be that for housing, the more windows there are the easier the building is to reuse. The problem becomes more serious when historical preservation prevents change to the facade.

A further problem of the windows to be taken into account is the height of the sills, which in this building is about one

one foot too high for the residential use. In some cases this is solved by raising all or part of the floor of the unit, though this is expensive. Because the windows extend to the ceiling, complications arise in inserting a second level up to the outside wall of the building. A second sash inside the original one, with appropriately located mullions might solve this and respond to the energy requirement as well. The sill height in the basement is shown in the drawings lowered with the ground cut out for a few feet and then bermed up to its original level. This solution does not appreciably alter the facade of the building, and it provides a small piece of territory belonging to the unit where flowers can be tended and enjoyed from the inside.

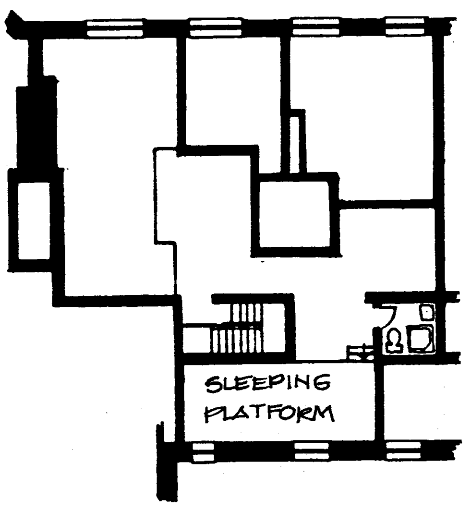
The roof plays a major role in determining the usable space at the top of the building. The hip roof here severely limits second level space on the third floor, however, some mezzanines have been projected in the plans.

Handicap requirements: Because the original building was not designed to accommodate the handicapped, ramped access, an elevator, and some single level units had to be provided. These constraints were not found to be significantly restrictive. Ramped entry is on the basement level, which is closest to the ground.

Structure: The single interior bearing wall, masonry in the basement and stud construction above, is located one third of the way across the span of the building. The assumption used was that it could receive limited openings on the lower floors and more extensive openings higher up. The bearing wall was used to organize plumbing, as it was continuous through three floors of the building and its location ended up being suitable for windowless spaces. Moreover, some pipe space already exists around the wall in the basement. The wall was a primary constraint but generally could be used in a positive fashion.

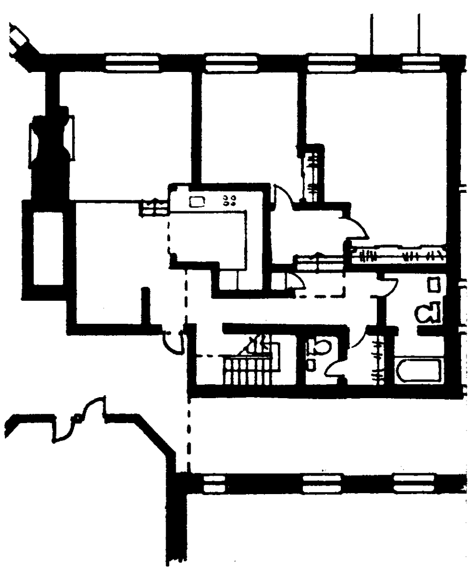
Trusses on the third floor posed another structural constraint. These happen to be wood and very handsome, and therefore can be seen as a plus as well as a constraint. Hopefully the combination of their large dimensions and the sprinkling system already installed would prevent the need for encasing them. It was the spacing of these trusses and the limitations on headroom which were constraints, but again not insurmountable obstacles. It is important to note that the trusses represent a change from the bearing wall system below, and therefore it is likely that unit configuration changes on the top floor.

Mechanical: The two major mechanical considerations dealt with were the mechanical room for equipment in the basement, and the two chimney flues. It seemed logical to assume that mechanical equipment (boilers) stay in the same place, as it is easily connected to a flue, and access from the outside



is convenient, an important consideration if new equipment needs to be installed. The flues were useful in a positive sense to carry risers or chases, and might make fireplaces easily feasible, an amenity for some units. On the other hand, they are quite large and get in the way of efficient planning.

Materials: The brick masonry in the basement can be viewed as a desirable finish, but as **slightly less** flexible in the bearing wall than stud construction. The wood construction of the floors makes it relatively easily penetrated, however, this was not necessary since existing stairs were used. The handsome finish materials (wood wainscoting, tin ceilings) encourage extensive reuse of the existing layout.



Quality evaluation: The following discussion examines the quality of the environment in a scheme for the Hancock School. One of the family units is used as an example; it is examined using the quality checklist.

1. Image. The family units utilize much of the original layout of the school, therefore the materials and built-in cabinets can remain intact. The image is also enhanced by the handsome windows and the exterior detailing. The building has a wonderful character which is very appropriate to housing.

2. Workability of layout. An attempt was made to give bedroom zones privacy from living areas. The private rooms can be entered without passing through the public rooms, and

circulation between the bedrooms and the bathrooms is also segregated form the public living spaces.

The dining area is ajacent to the kitchen, which is big enough for a small eating area as well, though there is a circulation path in between. The kitchen and dining are on the same level for ease of serving. The kitchen, dining, and living areas are all ajacent to promote communication between these spaces.

3. Through ventilation was possible in this scheme by building the sleeping platform over the corridor. Multiple views are only possible simultaneously from the loft.

4. Light comes quite deep into the building by virtue of its high windows. The dining area will get natural light through the open living area, however, the hall in the bedroom zone will be dark.

5. A variety of spatial experience was created by the construction of new levels in the single floor space. A platform 18" up from the original floor level raises the living room and some of the bedroom areas to a more comfortable relation to the window sill height. A mezzanine level for additional children's bedrooms has an even higher sleeping platform. Thus there are four different levels in the unit. The ceiling over the living area is over 11 feet high, whereas in the kitchen it is only 6' 9".

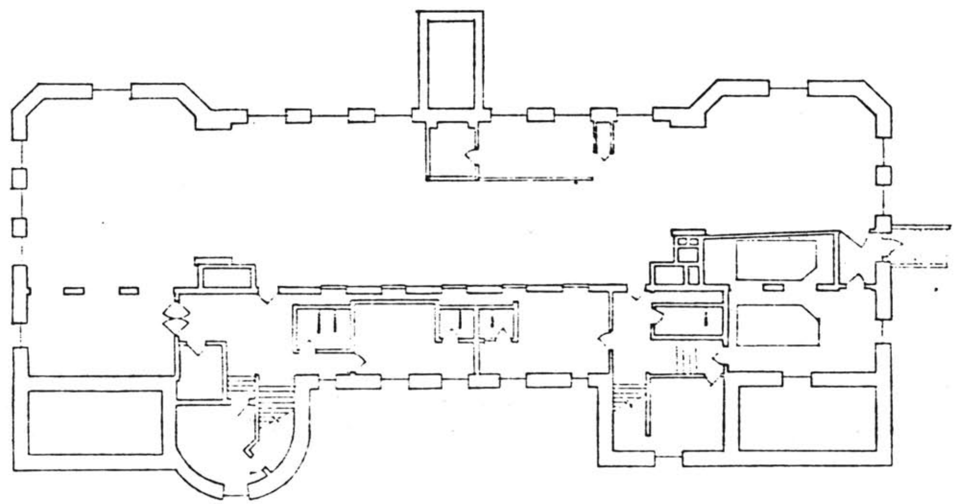
6. Room proportions and sizes. Rooms are often quite large and proportions reasonable. The only dimension that was squeezed is the headroom under the mezzanine. This is not a problem on the third floor where there is more vertical space.

7. Private outdoor space. The project has abundant space available which could be shared by the units, however, it would not be privately accessible to the apartments.

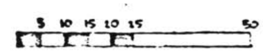
8. Common space and amenities. There is ample space for parking, gardens and recreation. Inside there is room for laundry facilities either in the units or in a common area. The building has three porches and large well lit stairs. The halls also have plenty of windows and are quite spacious.

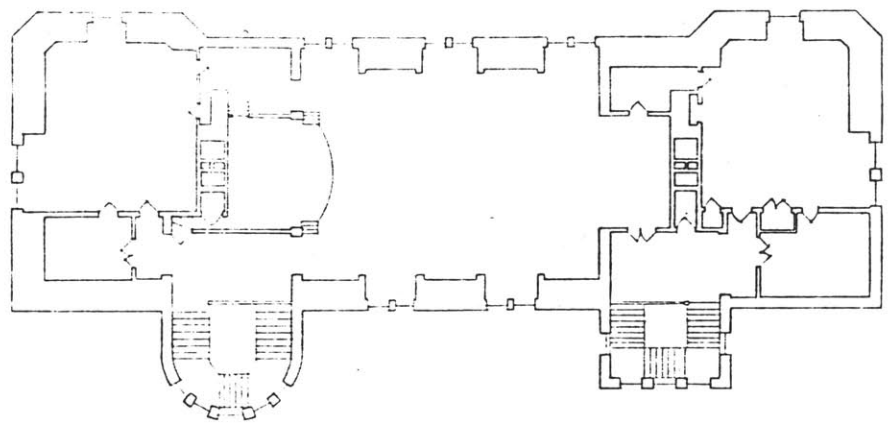
9. Variety of units. Out of 14 units, 9 are different.

Plans of the Hancock School as it exists are included here. The second floor is omitted, as it is almost identical to the first.

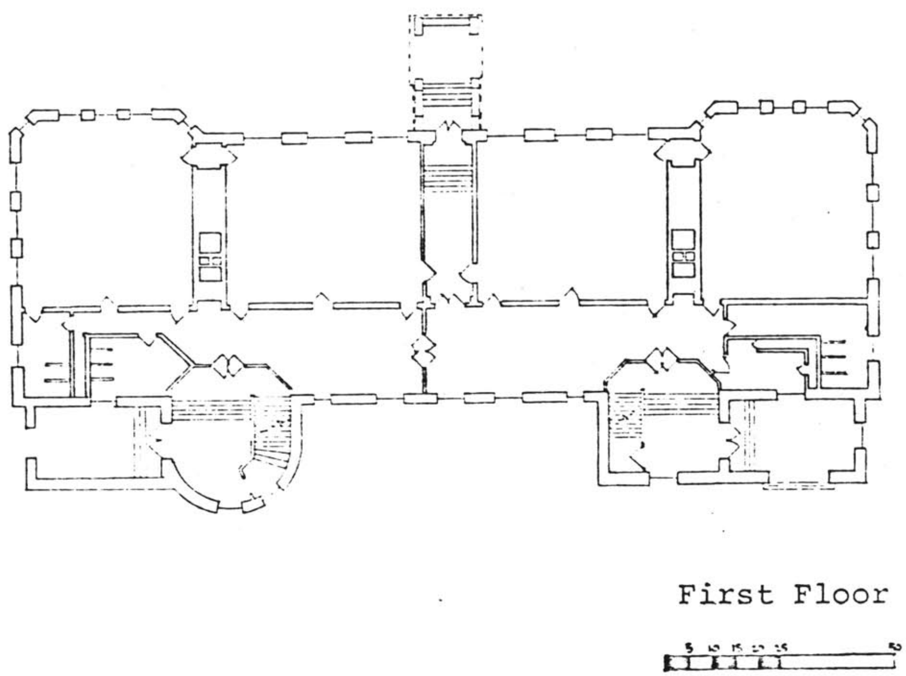


Basement



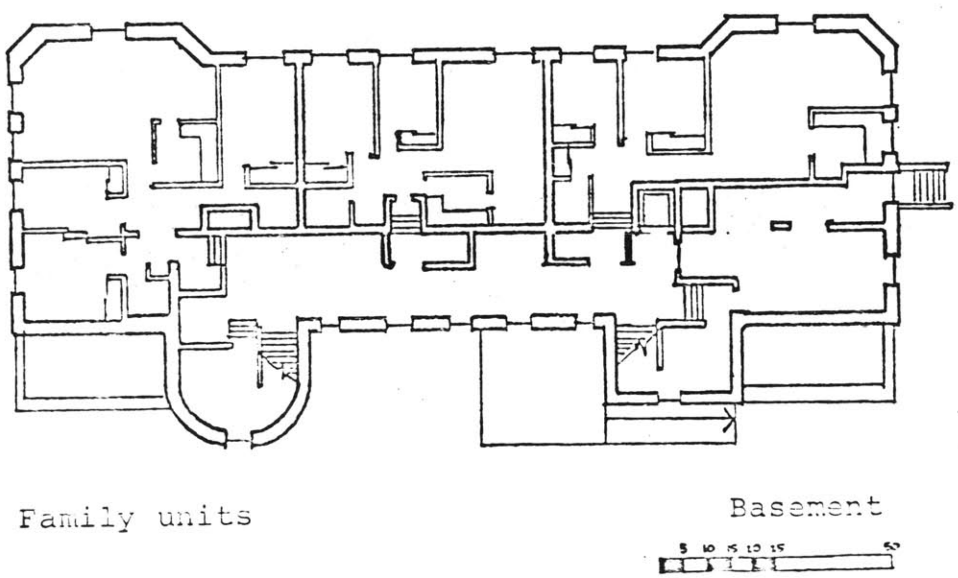


Third Floor



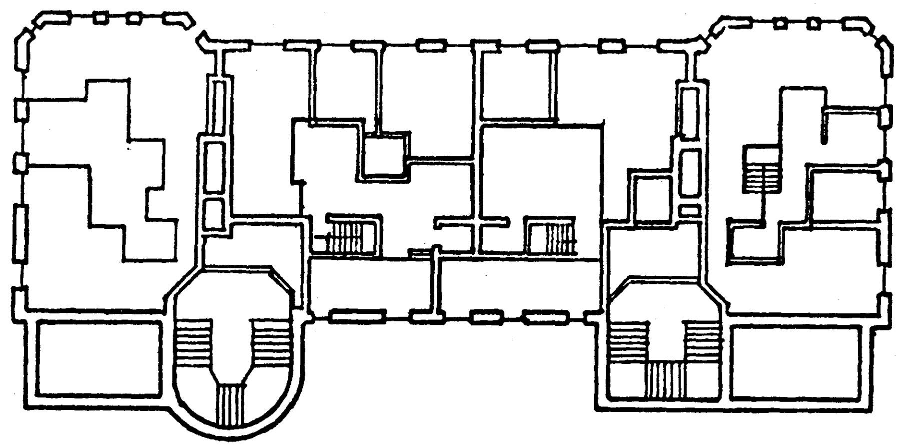
First Floor

The next group of drawings presents the three types of housing schemes for the Hancock, family, loft, and elderly units.

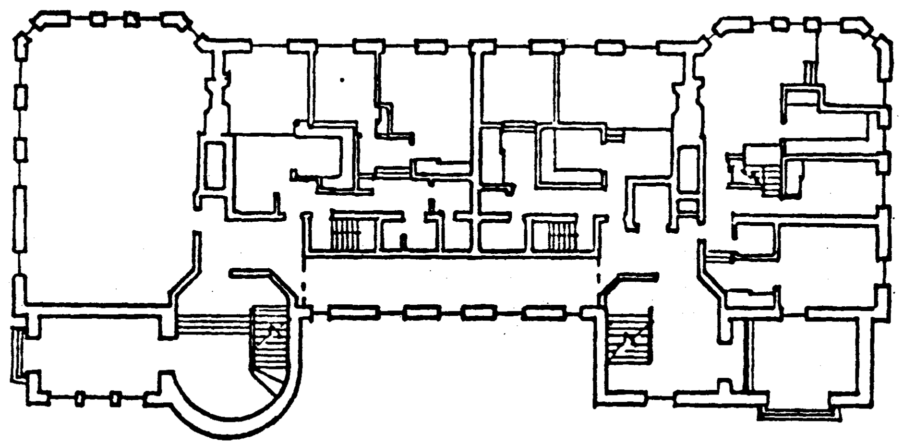


Family units

Basement

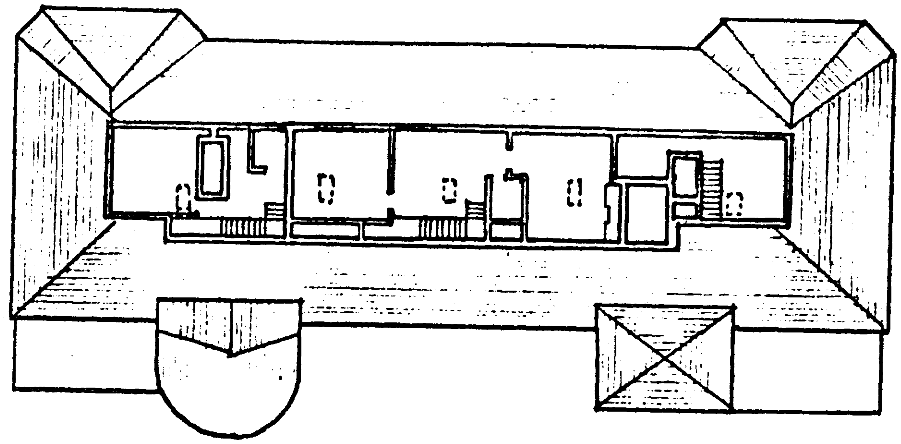


First Floor: upper level

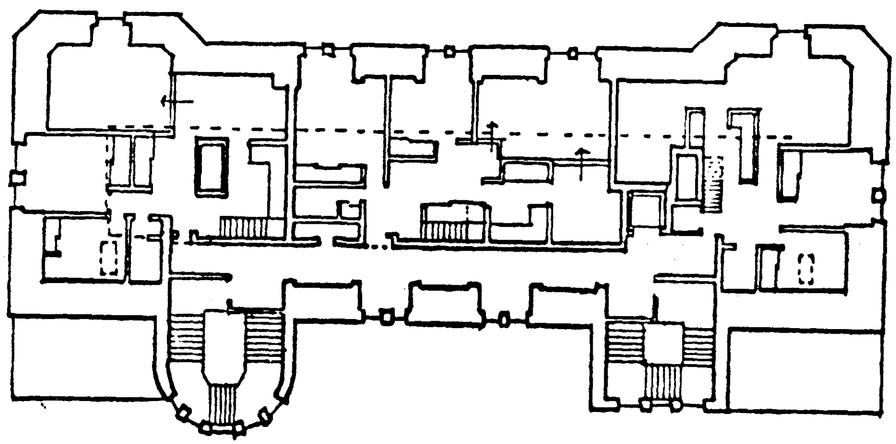


Family units

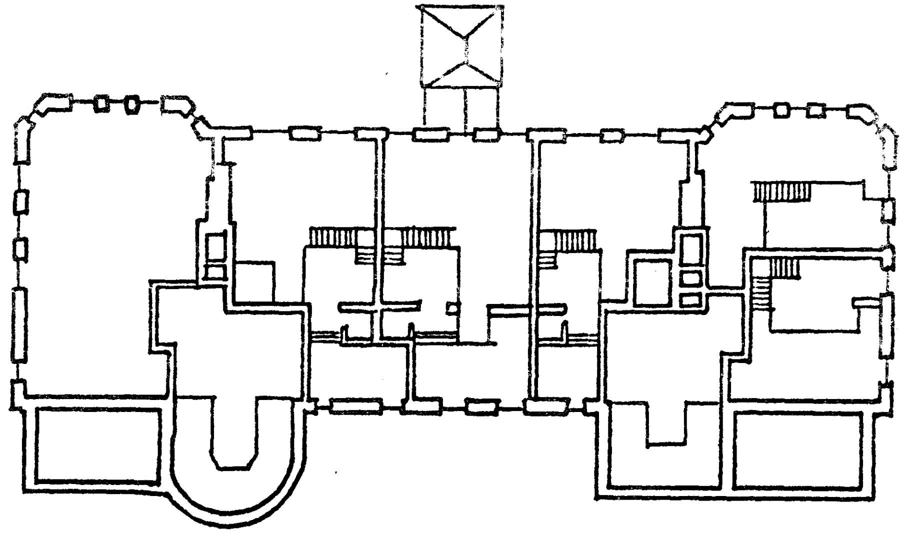
First Floor



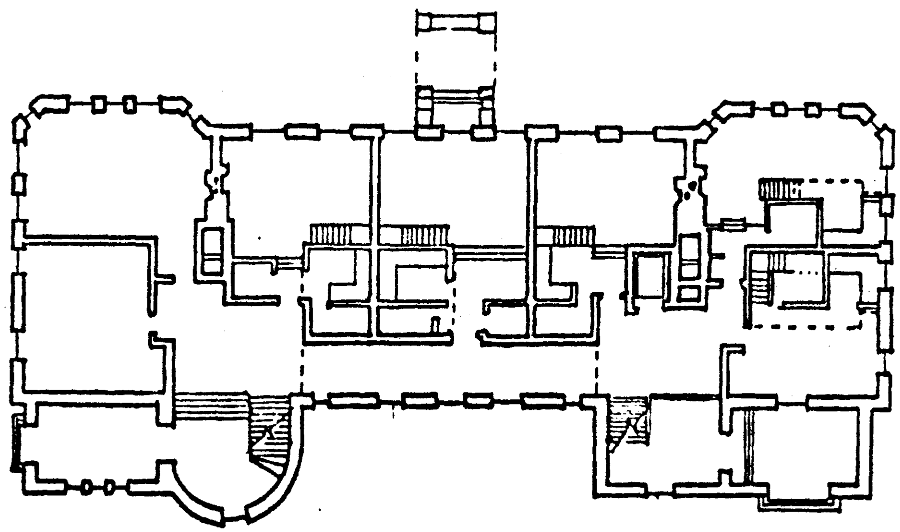
Third Floor: upper level



Family units Third Floor

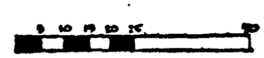


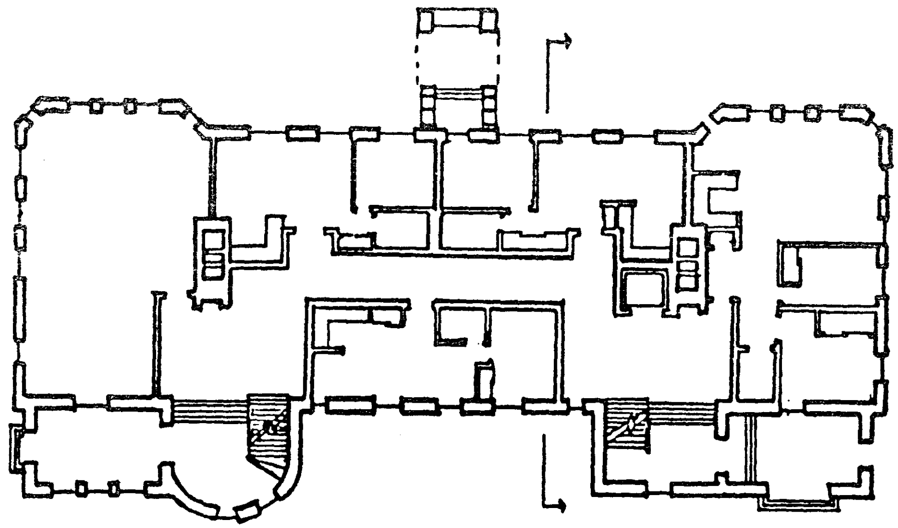
First Floor: upper level



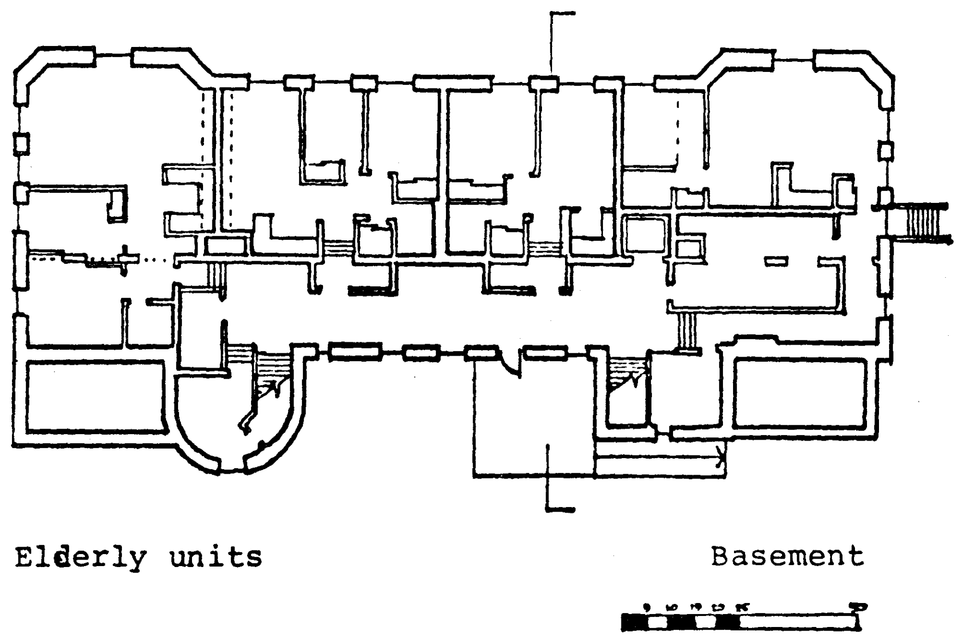
Loft units

First Floor



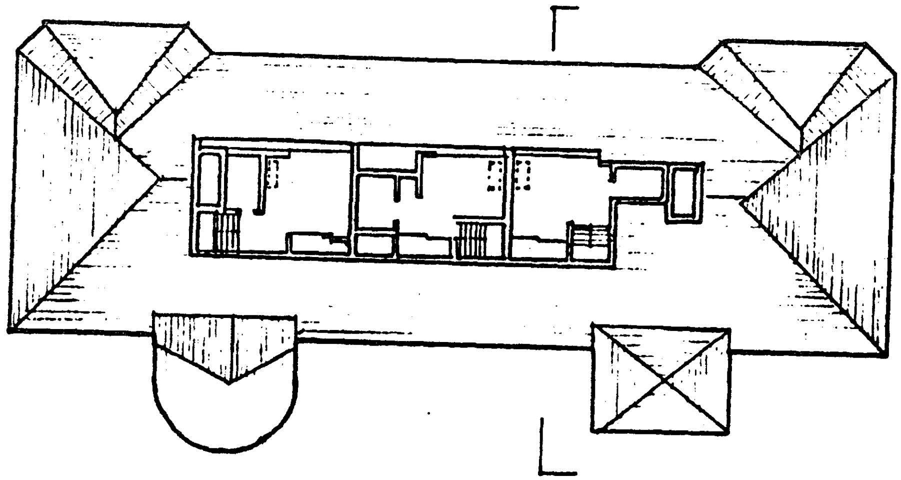


First Floor

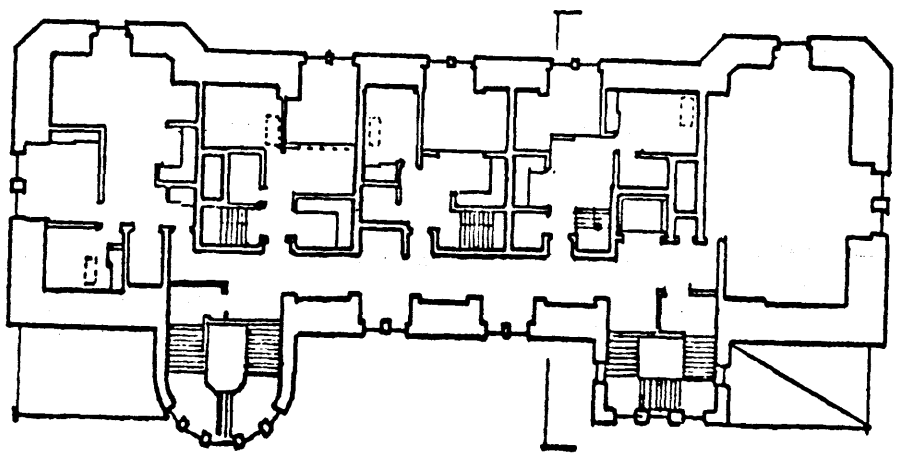


Elderly units

Basement



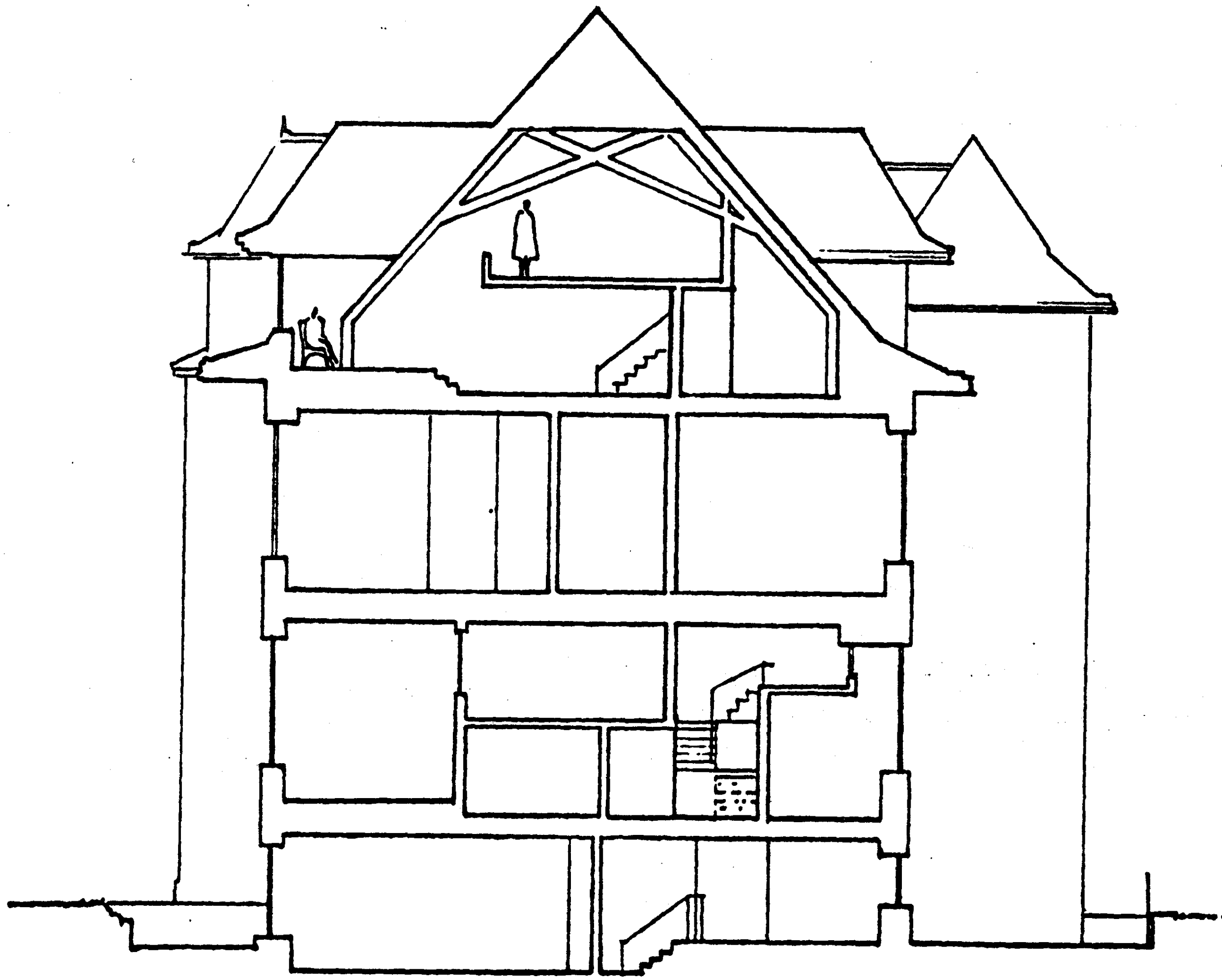
Third Floor: upper level



Elderly units

Third Floor

The basement and top levels of this section are typical of all schemes. The first floor represents family units (loft units are similar) and the second floor is typical of elderly units.



Charles Choate Memorial Hospital

This wing of the hospital is a relatively deep building particularly on the bottom floor (68'). This condition makes a double loaded corridor the most likely solution, and one which is reinforced by the existing organization. I considered omitting the hall on the ground floor and designing back-to-back units entered from the outside, but all that was gained from that was some dark space at the back of each unit. This did not seem worth the expense of demolishing the corridor system. I also tried moving the interior space of the dwellings away from the existing wall, thus forming a garden/terrace area in front of each entry, behind the facade. However, this extra outdoor space seemed superfluous since outdoor space is abundant.

Furthermore, since the building is fairly new and many of its systems, which are organized around the corridor, are reusable, it was reasonable to base the new schemes on the existing circulation. The ground floor of the elderly units is the only plan which varies the location of the hall somewhat to mitigate the long straight corridor.

As the lower floor extended out farther than the upper levels, it was possible to bring light deeper into the units by means of skylights. This provided natural light in some secondary bedrooms, thus increasing efficiency of planning. Few other windows had to be added to the two lower floors of the wing; more would be needed on upper floors.

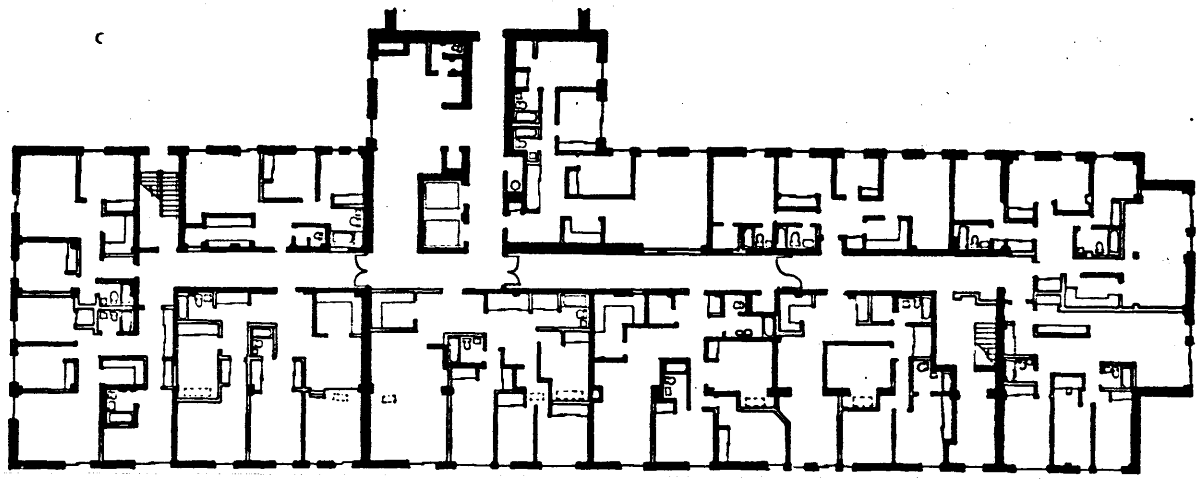
Since the ceiling height is between 9' 7" and 12' in this building, there is no possibility for mezzanine livels. Floors and ceilings can be varied, however. There is also a scheme for duplex units, but openings between floors are limited to stairs on account of the concrete floor.

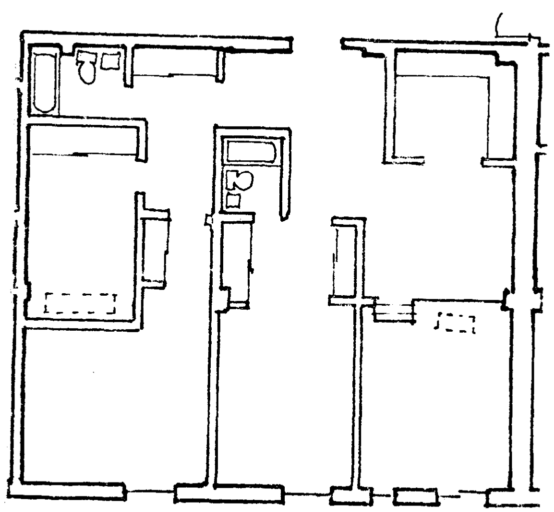
Other materials are problemmatic in the image they create. They tend to reinforce the hard, sanitary character of the building.

The flat roof over the ground floor can provide private outdoor space associated with the second floor. This amenity encourages flats on the lower two floors of the building. Trellises and other light construction on this roof as well as balconies from upper floors might be used to improve the image of the structure from the exterior.

The frame structure of this wing is a very minor constraint. Column spacing corresponds to reasonable room dimensions in many cases. Moreover, sometimes columns in rooms can be acceptable.

The following discussion examines the ground floor family flats with regard to the Quality checklist.

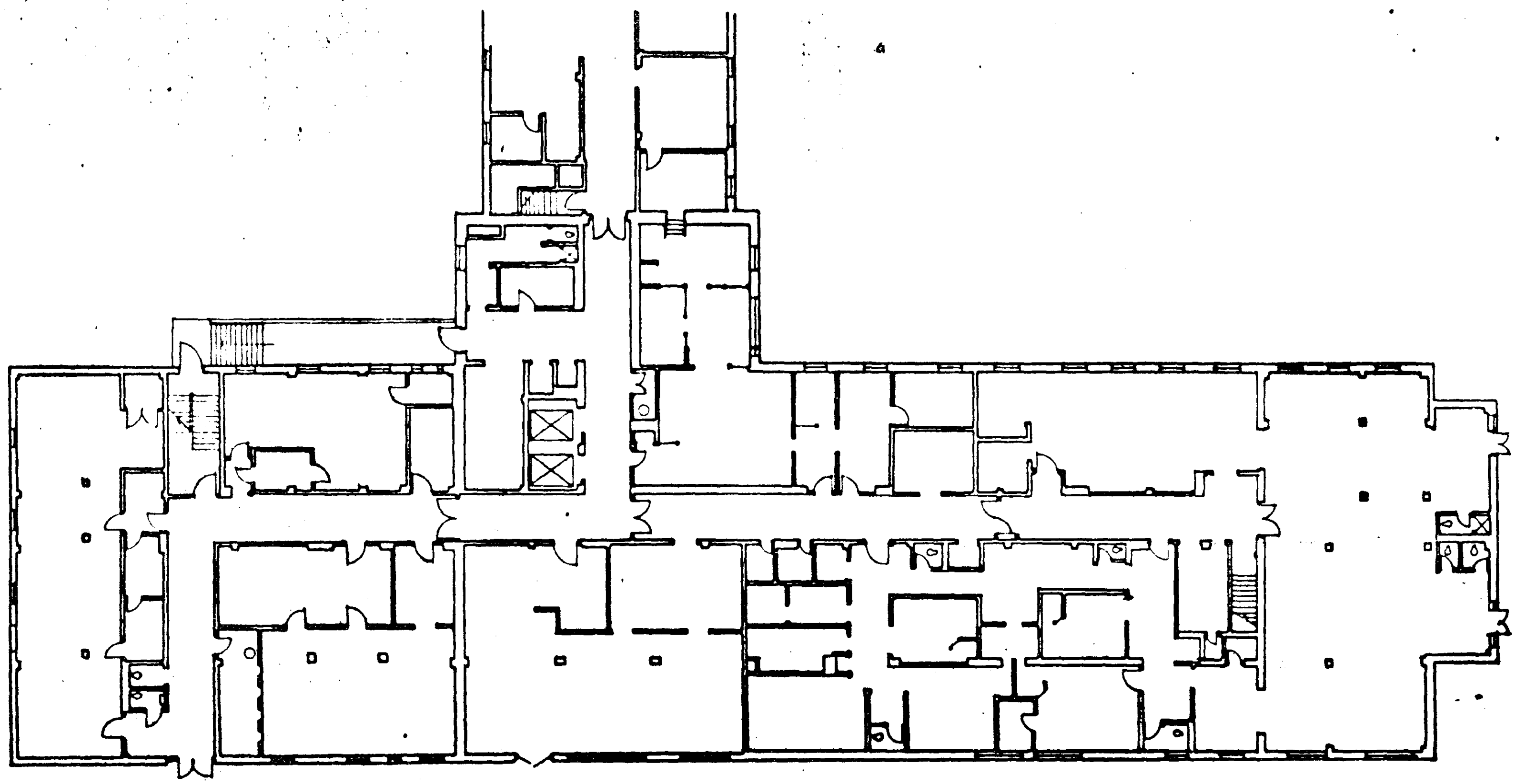




1. Image: The image of this wing of Choate is ill suited to housing. The facade should be broken up with balconies and projections, and materials should be replaced with warmer colors and soft or varied textures. An effort has been made in several of the schemes to break up the long, straight dark corridor. Here the public space is opened up around the elevator to let some light in and interrupt the linearity of the hall.
2. Workability: As in the Hancock units, an effort was made to separate public and private zones of the apartment. Bedrooms can be entered without passing through living, dining, and kitchen areas, and circulation between bedrooms and bathrooms is also shielded from the public zone. There are two baths, one for children and guests and one entered from the master bedroom. The kitchen is large, and it is adjacent to the living/dining area.

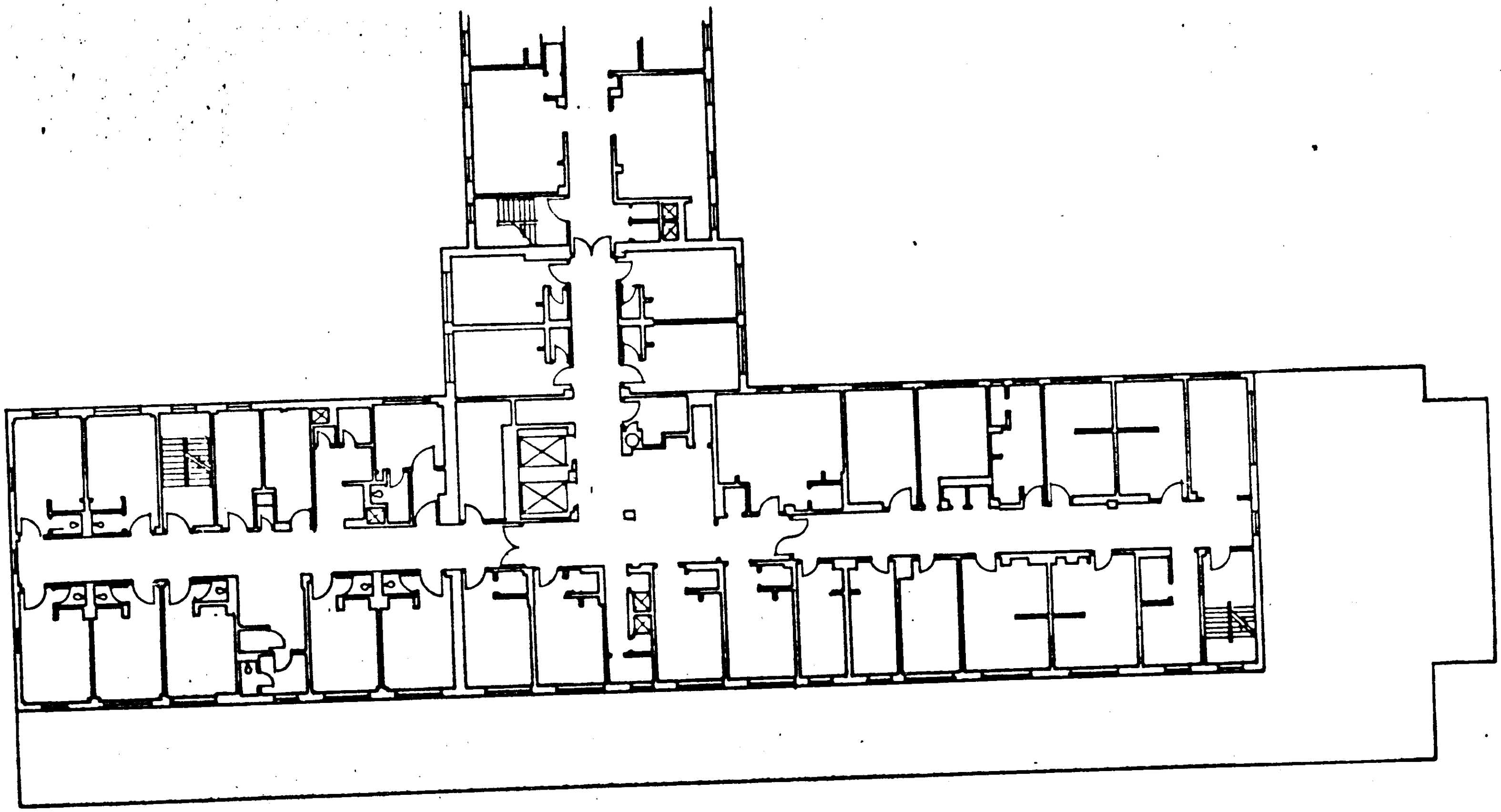
3. Through ventilation and multiple views are impossible in the double loaded corridor layout, except in corner units.
4. Light is brought deeper into the unit by means of skylights (which are the only source of natural light in one bedroom).
5. A variety of spatial experience was difficult to create in this scheme as a result of the concrete floors and the ceiling height. Small changes in floor and ceiling heights might help vary the space.
6. Room proportions and sizes are suited to family tenants. As the frame structure did not pose a significant constraint (as a bearing wall system might have), room shapes and dimensions were only controlled occasionally by existing partitions.
7. Private outdoor space is available adjacent to the unit.
8. Common Space and Amenities: The site offers extensive space for parking and outdoor activities. The building is large enough, moreover, to have laundry and lounge areas, and reuse of relative new systems as well as a substantial number of dwelling units will economically allow for the provision of some nonrentable space.
9. Variety of Units: All 11 units on the ground floor are slightly different, and more than half are very unlike each other.

This group of drawings presents existings plans of the hospital and schemes for reuse.

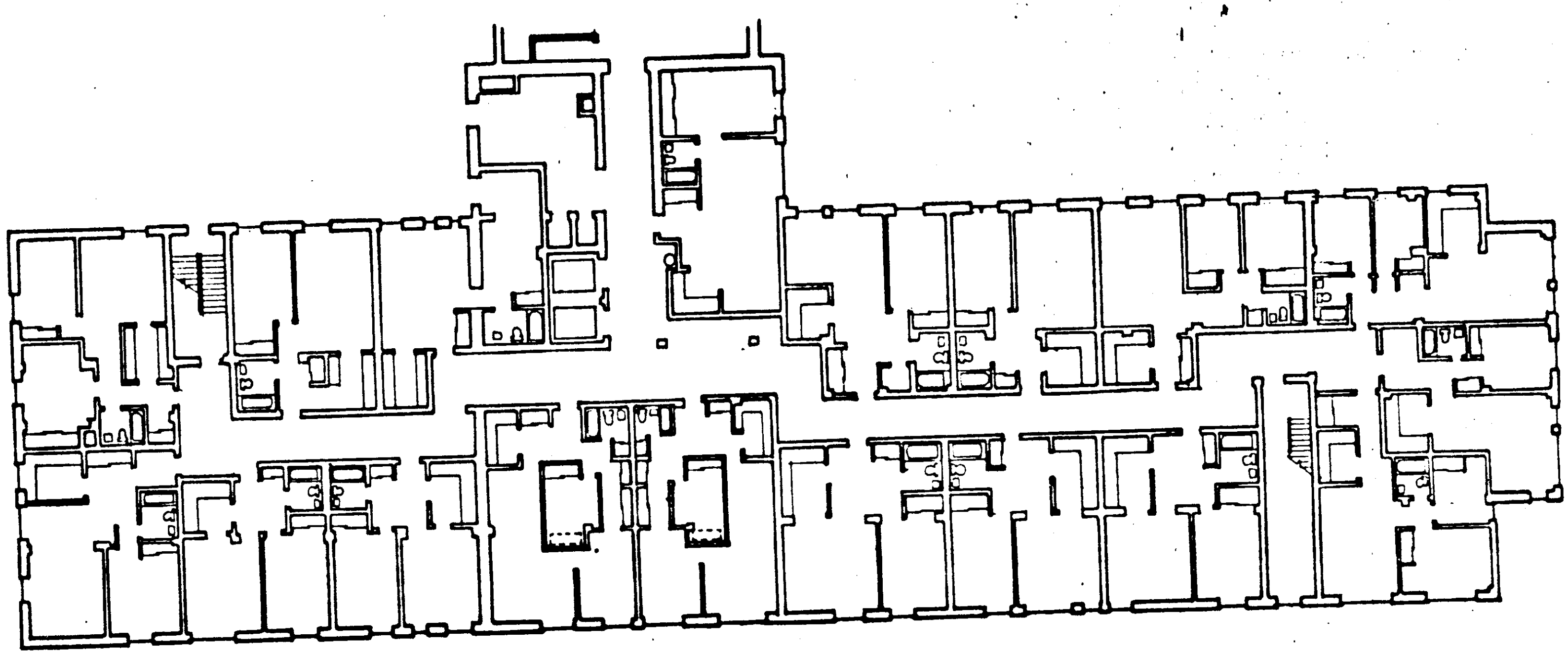


Charles Choate Memorial Hospital

Ground Floor



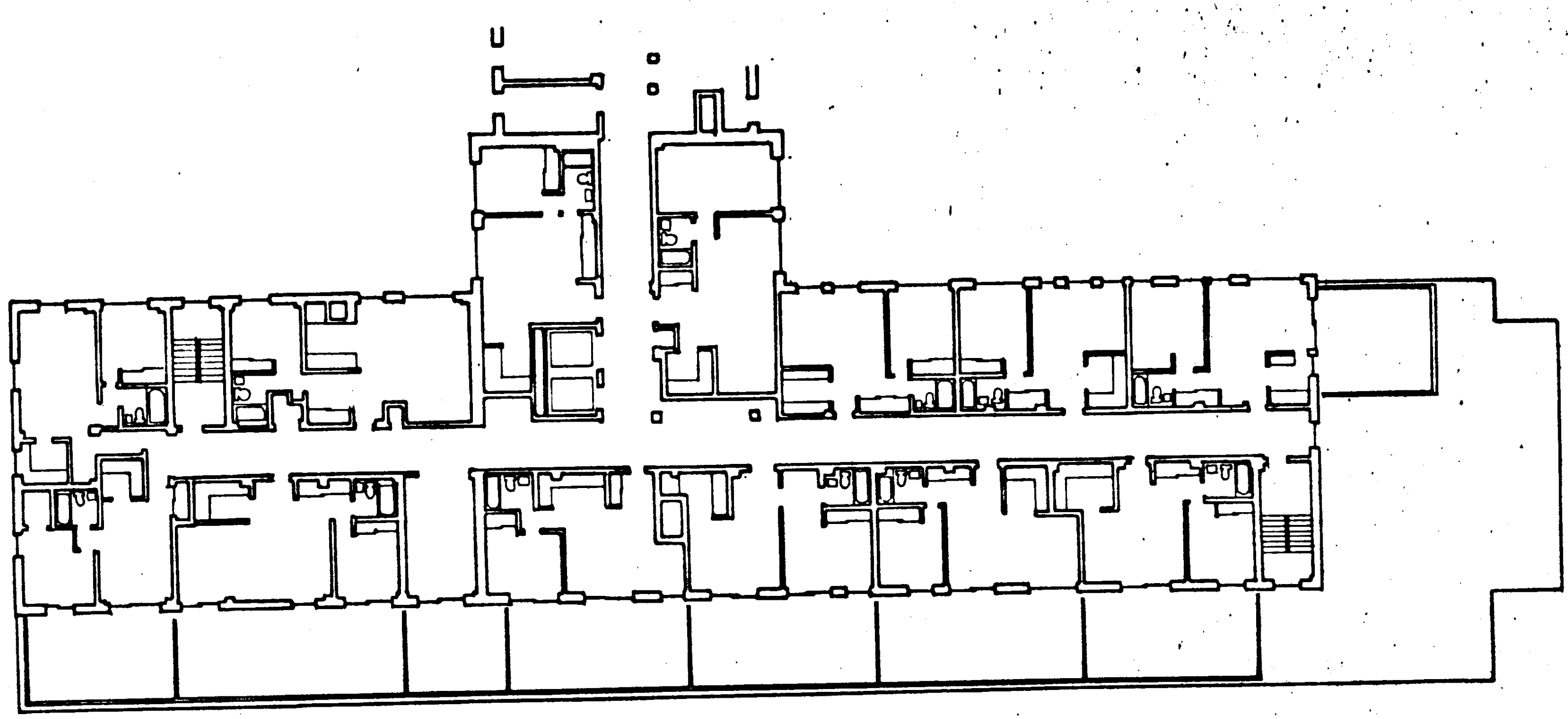
Existing Plan: First Floor



Ground Floor

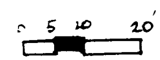
Elderly Units

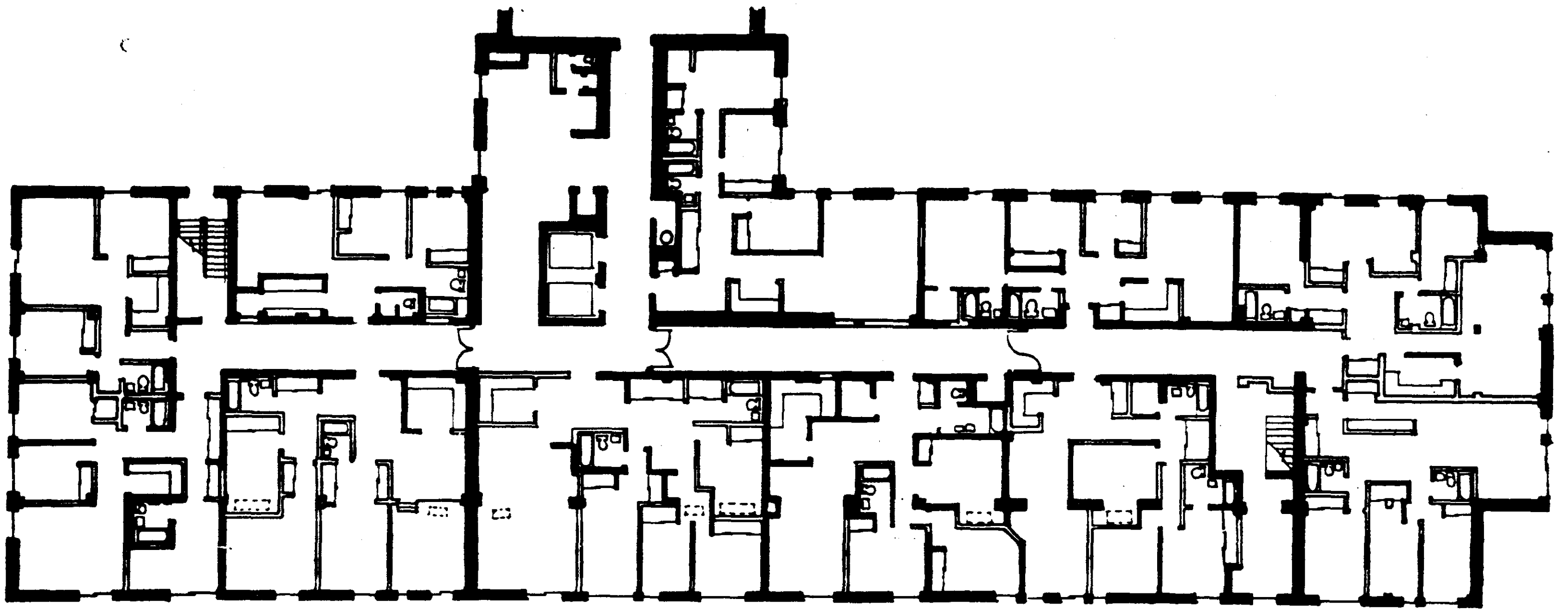
0 5 10 20



Elderly Units

First Floor

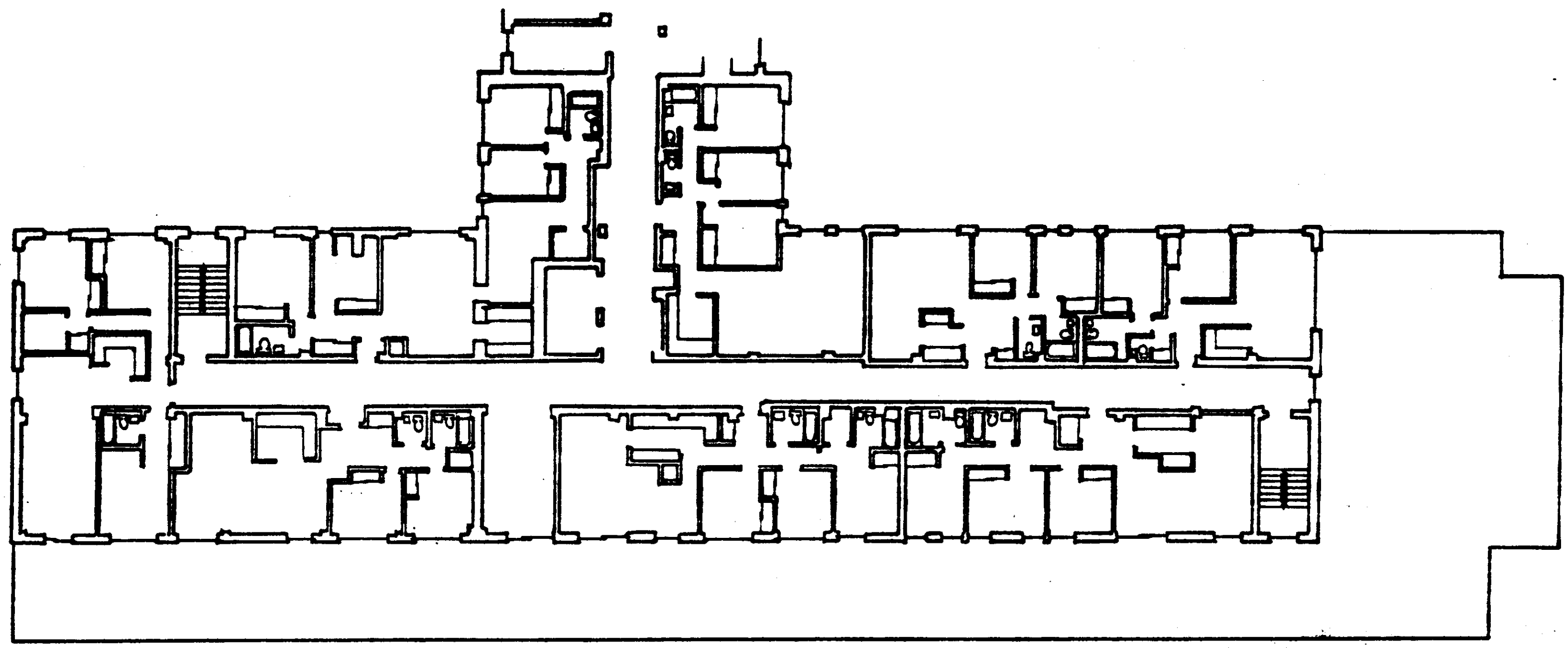




Family Units (Flats)

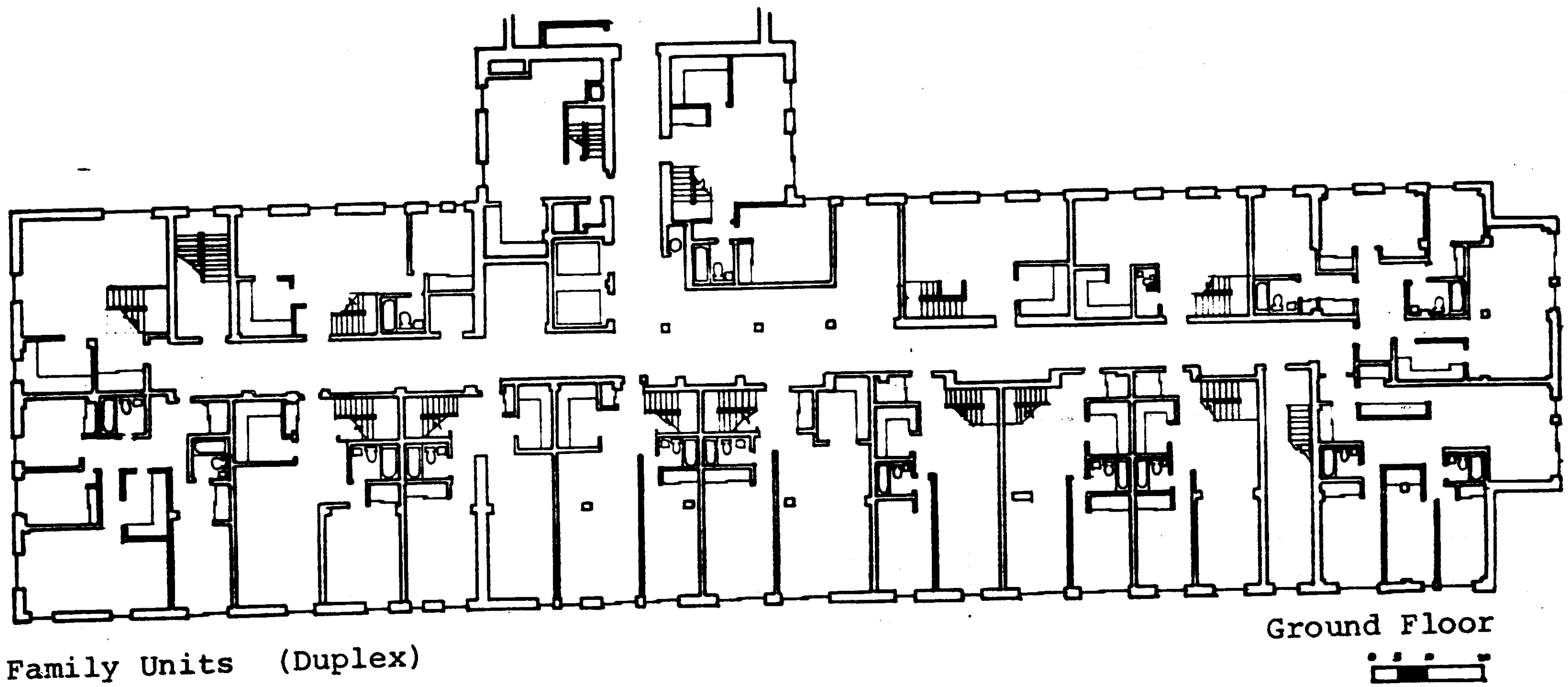
Ground Floor

Note: Walls shaded black indicate reuse of original construction. Existing plumbing and door locations were also used where possible.

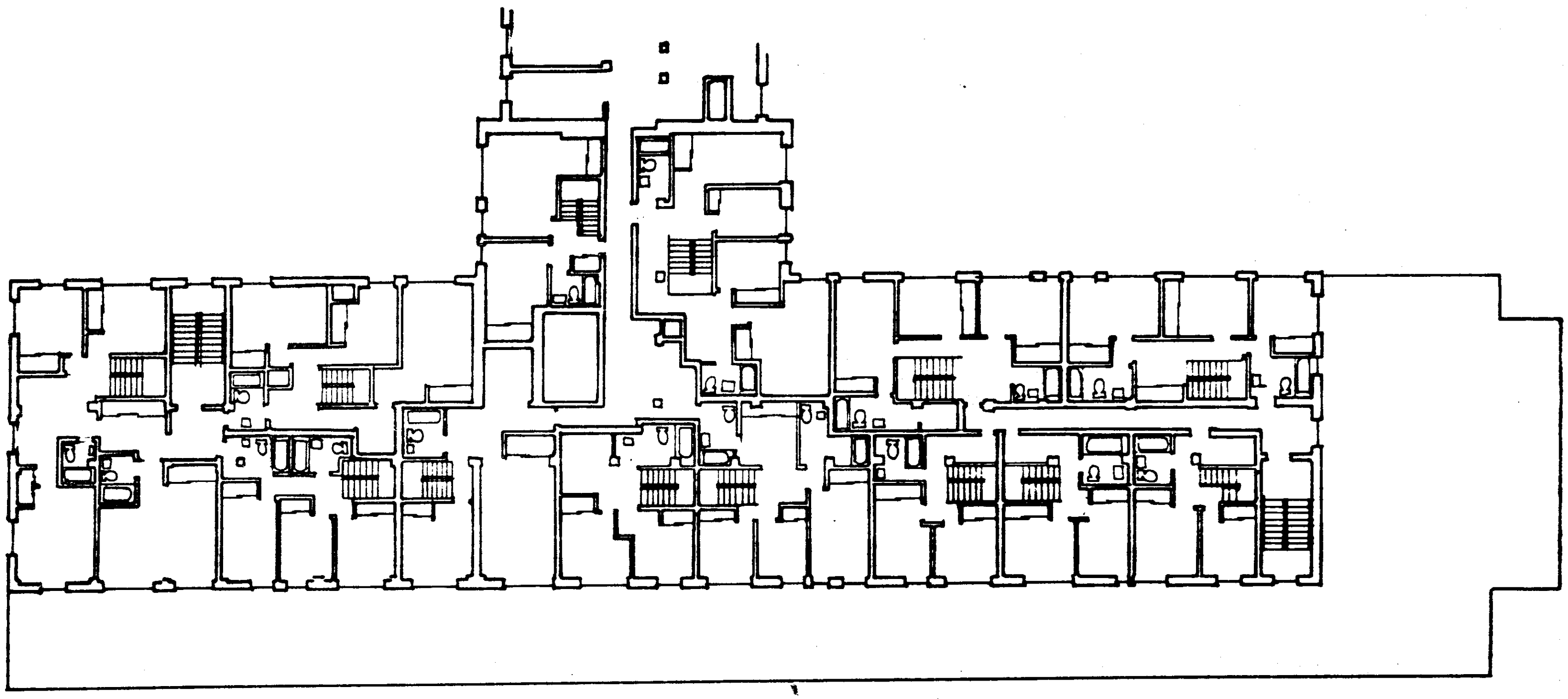


Family Units (Flats)

First Floor



Family Units (Duplex)



Family Units (Duplex)

First Floor

Summary of efficiency of planning for the preceding design studies:

			net s.f. / gross s.f.
Hancock School			
Elderly units:	1 BR	620-900 s.f. (mostly 600's)	
	2 BR	920-1180 s.f. (mostly 900's)	.70
Family units:	2 BR	1014-1240 s.f. plus 200-425 s.f.loft	
	3 BR	1517-1742 s.f. "	
	4 BR	2340 s.f.	.73
Loft units:	1 BR	504-768 s.f. plus 150-190 s.f. loft	.80
Choate			
Elderly units:	1 BR	590-800 s.f.	
	2 BR	730-884 s.f.	.83
Family units: (flats)	2BR	785-1200 s.f. (mostly 700-900)	
	3BR	1100- 1512 s.f. (mostly 1200-1400)	
	4 BR	1525, 1800 s.f.	.83
Family units: (duplex)	2 BR	1140	
	3 BR	1150-1780 s.f. (average 1425 s.f.)	
	4 BR	1590-1800 s.f.	.87