A case study in sustainability:

Designing studio spaces on the vertical within the recycled Armory Building

by

Hyung-Chan Kim

A thesis submitted to the graduate faculty

in partial fulfillment of the requirement for the degree of

MASTER OF FINE ARTS

Major: Interior Design

Program of Study Committee:
Çigdem T. Akkurt, Major Professor
Frederic Malven
David Arthur Block

Iowa State University
Ames, Iowa
2005

Graduate College
Iowa State University

This is to certify that master's thesis of

Hyung-Chan Kim

has met the requirement of Iowa State University

Signatures have been redacted for privacy

TABLE OF CONTENTS

LIST OF FIGURES	**v**
LIST OF TABLES	**viii**
CHAPTER 1. INTRODUCTION	**1**
Introduction	1
Purpose	2
Scope	3
Research Questions	3
Research Objectives	4
Methodology	4
CHAPTER 2. LITERATURE REVIEW	**6**
Background of Sustainable Design	6
Definition of Sustainability	8
Design for Sustainability	8
Sustainable Design Goals	9
LEED	9
Sustainable Materials	11
Sustainable Materials and Their Specifications	12
Summary	23
CHAPTER 3. DESIGN DEVELOPMENT	**24**
The Site	24
History of The Armory Building	24
Existing Conditions	24
Existing Plan	25
Existing Exterior Elevations	27
Health, Safety and Welfare Problems	28
Operational and Performance Problems	30
Design Program Statement	31
Design Objectives	31
Design Program and Development	31
Program Requirement for Each Floor	32
Perspectives	42
Sustainable Design in Studio Space	46
Sustainable Strategy	46
Space Planning	47
Floors	48

Walls 49
Ceiling and Lighting 51
Workstation 52
Common Space, Utility and Storage Units 53
Perspectives 54

CHAPTER 4. CONCLUSION **57**

Summary 57
Suggestions for Future Research 58

APPENDIX A. DRAWINGS OF THE ARMORY BUILDING **59**

APPENDIX B. PERSPECTIVES OF THE ARMORY BUILDING **73**

APPENDIX C. DRAWING AND PERSPECTIVES OF THE GRADUATE STUDIO **82**

BIBLIOGRAPHY **94**

ACKNOWLEDGEMENTS **97**

LIST OF FIGURES

Figure 1. Existing First Floor Plan (Scale=None) ↑N 25

Figure 3. Existing North Elevation (Scale=None) 27

Figure 4. Existing East Elevation (Scale=None) 27

Figure 5. Existing South Elevation (Scale=None) 27

Figure 6. Existing West Elevation (Scale=None) 28

Figure 7. Existing Conditions – Studio Spaces 28

Figure 8. Existing Conditions – Studio Work Space 29

Figure 9. Existing Conditions – Social Area 29

Figure 10. Existing Condition – Looking at Restroom 30

Figure 11. First Floor Plan (Scale=None) ↑N 32

Figure 12. Second Floor Plan (Scale=None) ↑N 34

Figure 13. Third Floor Plan (Scale=None) ↑N 36

Figure 14. Fourth Floor Plan (Scale=None) ↑N 38

Figure 15. Roof Plan (Scale=None) ↑N 40

Figure 16. Longitudinal (Scale=None) S - N 41

Figure 17. Transversal (Scale=None) W – E 41

Figure 18. Perspective – South Entry 42

Figure 19. Perspective – South View 42

Figure 20. Perspective – South View 43

Figure 21. Perspective – Roof Structure 43

Figure 22. Perspective – East View 44

Figure 23. Perspective – South Elevation 44

Figure 24. Perspective – Fourth Floor core facing North 45

Figure 25. Perspective – Atrium facing South 45

Figure 26. Floor Plan (Scale = None) ↑N 47

Figure 27. Wall Detail (Scale = None) 50

Figure 28. Steel Deck Section Detail (Scale = None) 51

Figure 29. L-shape Workstation 52

Figure 30. Components of Workstation	53
Figure 31. Utility storage units (Scale=None)	54
Figure 32. Perspective – Conference Space and Utility Units	54
Figure 33. Perspective – Conference Space and White Board and Screen	55
Figure 34. Perspective - Workstation	55
Figure 35. Perspective - Workstation	56
Figure 36. Perspective – Workstation	56
Figure 37. Existing First Floor Plan (Scale: 1/32" = 1'0") ↑N	60
Figure 38. Existing Second Floor Plan (Scale: 1/32" = 1'0") ↑N	61
Figure 39. Existing Exterior North Elevation (Scale: 1/32" = 1'0")	62
Figure 40. Existing Exterior East Elevation (Scale: 1/32" = 1'0")	63
Figure 41. Existing Exterior South Elevation (Scale: 1/32" = 1'0")	64
Figure 42. Existing Exterior West Elevation (Scale: 1/32" = 1'0")	65
Figure 43. Proposed First Floor Plan (Scale: 1/32" = 1'0") ↑N	66
Figure 44. Proposed Second Floor Plan (Scale: 1/32" = 1'0") ↑N	67
Figure 45. Proposed Third Floor Plan (Scale: 1/32" = 1'0") ↑N	68
Figure 46. Proposed Fourth Floor Plan (Scale: 1/32" = 1'0") ↑N	69
Figure 47. Proposed Roof Plan (Scale: 1/32" = 1'0") ↑N	70
Figure 48. Proposed Transversal Section (Scale: 1/32" = 1'0") B - B'	71
Figure 49. Proposed Longitudinal Section (Scale: 1/32" = 1'0") A – A'	72
Figure 50. South Entry	74
Figure 51. South View-1	75
Figure 52. South View-2	76
Figure 53. Roof Structure	77
Figure 54. East View	78
Figure 55. South Elevation	79
Figure 56. Fourth Floor Core – Facing North	80
Figure 57. Atrium – Facing South	81
Figure 58. Floor Plan (Scale: 3/16" = 1'0") ↑N	83

Figure 59. Reflected Ceiling Plan (Scale: 3/16” = 1’0”) ↑N 84

Figure 60. Elevations – North & East (Scale: 3/16” = 1’0”) 85

Figure 61. Elevations – South & West (Scale: 3/16” = 1’0”) 86

Figure 62. Utility Unit Detail (Scale: 1/4” = 1’0”) 87

Figure 63. Perspective – Conference Space and Utility Units 88

Figure 64. Perspective – Conference Space and White Board and Screen 89

Figure 65. Perspective – Workstation 90

Figure 66. Perspective - Workstation 91

Figure 67. Perspective - Workstation 92

Figure 68. Perspective - Workstation 93

LIST OF TABLES

Table 1. Space Usage of Armory Building 25
Table 2. First Floor Programming 33
Table 3. Second Floor Programming 35
Table 4. Third Floor Programming 37
Table 5. Fourth Floor Programming 39
Table 6. Product Analysis Chart 48

CHAPTER 1. INTRODUCTION

Introduction

In a period of scarce resources, this proposal presents a plan for adapting an existing facility for an optimum resource investment. The moral obligation of the interior designer is, not only to develop a design in a new space, but also to preserve previously built environments. The most important contemporary issue is environmentally friendly design. Therefore, the designer needs to consider environmental aspects, which are energy conservation, pollution prevention, resource efficiency, systems integration, and life cycle cost. This proposal will encompass a sustainable design, as well as functional, efficient and aesthetic environments.

The College of Design on the Iowa State University campus operates two buildings as design facilities: the Design Center and the Armory Building. The Design Center is home to the undergraduate students and the graduate programs of Architecture, Landscape Architecture, Community Regional Planning, and Art & Design. At the present time, the Armory Building, with studios and presentation space for freshmen of the Core Program (Pre-professional programs), is being used as a facility to support the Design Center. The College of Design occupies more than 40 classrooms throughout the campus for lectures. This is a clear sign that the Design building has outgrown its function, thus requiring newly organized and designed spaces to bring the scattered classrooms and studios together within the two buildings. Hence, it is proposed that some of the functions and the spaces in the College of Design be reassigned and reorganized by moving the lectures taking place outside the two buildings to the College of Design, into the spaces vacated by the graduate programs' move to the Armory Building.

The proposed four level designs for the Armory will occupy the central space of the building. It will house design studios for the graduate programs and Core program (The pre-professional undergraduate programs), faculty-student research spaces, computer and lighting labs, lecture and presentation spaces, plus an auditorium, activity space, and lounges. This proposed design would consider health and safety, welfare, fire and ADA codes; due to all of these needs, an elevator and three two-hour rated staircases will be included in the design.

It is of utmost importance to utilize ecological materials in the proposed project. Therefore, the purpose necessitates the use of sustainable materials, appropriate spaces where they are used, and the reasons they are so specified. It is believed that this design will make use of sustainable materials for reducing environmental impact based on a green building rating system, such as LEED (Leadership in Energy and Environmental Design).

Purpose

The main purpose of the present study is to design and develop an educational facility in the Armory Building, utilizing sustainable design materials. The proposed design will include preservation of the historical building, improvement of educational environment, and the utilization of the sustainable principles. This present proposal study is directed to achieving a design approach through the creation of a new conceptual design for the Armory Building. This study offers an opportunity to find sustainable materials for developing a new building as a test of the following:

1. Environmentally Responsible Design

2. Renewable Energy Focus
3. Economics

While these circumstances of sustainable materials will be discussed in Chapter II, the following information will provide the necessary background to introduce this study. The Armory Building as the site selected for the present study, has good potential for an educational facility for sustainable design based on the following reasons:

1. The preservation of the existing building offers some advantages
2. There is a need to improve educational facilities
3. A closer relation to sustainable theory is a moral responsibility

Therefore, there are some potentially desirable designs for an educational facility which includes sustainable approaches in the interior design field.

Scope

The nature of this thesis is to propose a re-design in an educational facility utilizing sustainable design. The focus will be on interior materials in additional to the function of space and programs of the new building.

Research Questions

This study, will attempt to answer following:

1. How would the Armory Building be used effectively as a home to graduate and core programs?
2. How would the Armory Building address sustainable design by the different uses of the building?

3. How would changes enhance sustainability in the Armory space?
4. What are the green materials, and what green materials should be used in the Armory Building?

Research Objectives

The research objective of this thesis is to find good sustainable materials for easy understanding of specification data regarding the following issues:

1. To consider opportunities to reuse an existing building over new construction
2. To make a commitment to consider environmental health impacts over the full life cycle when selecting materials and products
3. To identify which issues are of highest priority for the project
4. To make a commitment to reduce waste and promote recycling; establish and quantify waste reduction goals

Additionally, an interdisciplinary approach that this study focuses on includes three aspects of design: interior design, architecture, and facility management.

Methodology

There are many documents dealing with sustainable design. Information cited in this thesis is categorized into two parts: First part is recorded in drawings and photographic documentation, while the second part focuses on social and physical studies. The analysis starts with a literature review understanding sustainable buildings. Photographic documentation analyzes goals for a sustainable design, how sustainable design is attained, what kinds of materials are used, and what would be the following steps towards a good sustainable design.

The second part involves social and physical studies, including interviews and observations with architects and interior designers who participate in sustainable design and students who research sustainable design. Observations include site analysis and users' activities and behavior.

CHAPTER 2. LITERATURE REVIEW

Background of Sustainable Design

Mendler and Odell (2000) from HOK described the way that environmental issues moved into the mainstream of our culture. Growing environmental challenges face each new generation. As they move toward greater awareness of these issues, they are slowly building a collective momentum, not only toward solving these problems, but toward recognizing the opportunities these challenges offer us. These opportunities can lead to a new generation of responsible builders and communities that are healthy, productive, and able to enhance quality of life.

Interior designers are beginning to become conscious of the fact that the materials construction techniques they recommend all have an impact on the environment. There is in - creasing pressure from clients, both public and private, for environmental considerations to become a factor in design and in choosing materials.

A one focus of this review is to find and identify green design materials to apply to interior design spaces. Fox and Murrell (1989) purported that the first consideration when starting research should ask: how does one assess the environmental desirability of the product? Apart from considerations of energy consumed in its extraction and processing, there is the question of the human cost, such as the extraction of materials from the earth at great physical hazard. The amount of energy expended in transport to the site of consumption is also a major consideration: environmentally conscious designers endeavor to cut down the distance over which materials have to be delivered. McDonough and Braungart (1992) assert that designers should consider the interaction and implementation of diverse materials within the local climate and culture in a meaningful and productive way. Also they might consider the exclusive use of indigenous materials, utilizing practical and effective modern technology, including advanced glazing, energy efficient fixtures and appliances, and nontoxic water treatment systems.

McDonough and Braungart (1992) described that today the development of improved technologies and the emergence of new ideas are helping the field of green design grow by leaps and bounds. Whether applied to new construction or retrofitted into existing buildings, even ordinary homes and structures are beginning to employ green elements. Green design is evident in both creation and maintenance as more and more people realize the advantages. In fact, the day is probably not far off when every house will be as green as the world it calls home.

Examples of sustainability are not hard to find from the history of world culture. Most often they are small scale social solutions that involve a small number of people who acted to protect against damage to surrounding habitat, not to design activities. The interactions between people and nature have grown so complex, the rate and scale of change have become so overwhelming, and people can no longer rely solely on setting up situations and finding innovative solutions. McDonough and Braungart (1992) say that design has become crucial to future generations and to achieving any measure of sustainability; communities need designs that strike a balance between the local and global, traditional settlement, and the emerging planetary culture. Therefore, designers need to continue to develop sustainable theory for the sake of the next generation and those generations to come.

Definition of Sustainability

Sustainability represents a balance that accommodates human needs without diminishing the health and productivity of natural system (Mendler & Odell). In these times of rapidly rising world population, increased demand on scarce resources, and continued pollution, sustainability is quickly becoming the dominant issue of our time.

The concept of sustainability has been introduced to combine concern for the well-being of the planet along with continued growth and human development. McDonough and Braungart (1992) explained that though there is much debate as to what the word actually suggests, one can put forth the definition offered by the World Commission on Environment and Development: "Meeting the needs of the present without compromising the ability of future generations to meet their own needs."

In its original context, this definition was stated solely from the human point of view. In order to embrace the idea of a global ecology with intrinsic value, the meaning must be expanded to allow all parts of nature to meet their own needs now and in the future.

Design for Sustainability

Designing for sustainability requires awareness of the full short and long-term consequences of any transformation of the environment. Sustainable design is the conception and realization of environmentally sensitive and responsible expression as a part of the evolving matrix of nature.

Sustainable design contributes directly or indirectly to most of our environmental problems. The environmental impacts of buildings are eroding our very quality of life. Our open space is being consumed by sprawl, and our communities are being overcome with traffic and congestion. Sustainable design can lead to a variety of economic benefits. These include the economic benefits of energy, water, and material savings as well as reduced maintenance and other operational coasts (Fox and Murrell, 1989).

Sustainable Design Goals

The main goals for sustainable design are the three goals of sustainability in the design field. Kim (1998) explained the following issues:

1. Economy of Resources is concerned with the reduction, reuse, and recycling of the natural resources that are input to a building.
2. Life Cycle Design provides a methodology for analyzing the building process and its impact on the environment.
3. Humane Design focuses on the interactions between humans and the natural world. These principles can provide a broad awareness of the environmental impact, both locally and globally.

LEED

The mission of the U.S. Green Building Council is that USGBC will be the nation's foremost coalition of leaders from across the building industry working to promote buildings that are environmentally responsible, profitable and healthy places to live and work, (U.S. develop green building rating system which it calls LEED). The LEED (Leadership in Energy and Environmental Design) Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. Members of the U.S. Green Building Council, representing all segments of the building industry, developed LEED and continue to contribute to its evolution, (U.S. Green Building Council, www.usgc.org, 2003). LEED was created to:

- Define "green building" by establishing a common standard of measurement
- Promote integrated, whole-building design practices
- Recognize environmental leadership in the building industry
- Stimulate green competition
- Raise consumer awareness of green building benefits
- Transform the building market

LEED for New Construction and Major Renovations (LEED-NC) is a green building rating system that was designed to guide and distinguish high-performance commercial and institutional projects, with a focus on office buildings. Practitioners have also applied the system to K-12 schools, multi-unit residential buildings, manufacturing plants, laboratories, and many other building types. They introduced LEED rating of materials and resources which are:

1. Building Reuse (maintaining a percent of structure, shell and non-shell components) - Quantify structural elements in terms of cubic feet. Quantify shell and non-shell elements in terms of square feet
2. Resource Reuse (specify salvaged/refurbished materials) - Calculated as a percent of total cost of building materials
3. Recycled Content - Products with any recycled content
4. Rapidly Renewable Materials - Defined by LEED as resources that are planted and/or harvested within a ten-year cycle
5. Certified Sustainable Harvested Wood - Calculated as a percent of the cost of all

wood-based products used on the project

Sustainable Materials

The earth is both context and material - McDonough and Braungart

McDonough and Braungart (1992) reported that all materials could be considered in the following terms:

1. Buildings should be designed to be flexible enough to accommodate many human purposes, including living, working or craft, allowing the materials to remain in place while serving different needs. Design should include alternatives for how the site can be adapted to post-fair requirements.
2. Materials should be considered in light of their sustainability including their process of extraction, manufacture, transformation and degradation through proper resource management and biodiversity on a global and local scale. All materials should be considered in terms of their embodied energy and characteristics of toxicity, potential off-gassing, finish, and maintenance requirements.
3. Recycling of materials is essential. But recycled materials should not be encouraged if they are the result of a product designed for disposability. The manufacturer, if necessary, should make provision for the disassembly and re-use of all products. The reuse of entire structures must be considered in the event that a building fails to be adaptable to future human needs.
4. Materials should be chosen to minimize hazardous chemicals.

5. Solid waste left after maximal avoidance must be dealt with in a non-toxic manner. In nature, waste equals food. The aim is to eliminate any waste which cannot be shown to be part of a naturally sustainable cycle.
6. Life-cycle analysis of all materials and processes is important. Life-cycle assessment is a process in which the energy use and environmental impact of the entire life cycle of the product, process, or activity is catalogued and analyzed, encompassing extraction and processing of raw materials, manufacturing, transportation and maintenance, recycling, and return to the environment.
7. The design should qualify the environmental and economic costs such that the benefit of the project in relation to expense is understood in both the short and long terms.

Sustainable Materials and Their Specifications

Regarding the subject of sustainable materials and their specifications, this section will introduce the scope of green design, for easy understanding. Each one will be defined and evaluated by the LEED rating system.

Masonry Materials

Masonry productions have considerable environmental impact. They are high volume, high density materials, made from quarried non-renewable resources, mostly associated with high-energy input. New developments in greening the masonry materials industry seem, in the main, to be confined to making improvements to existing processes rather than developing new products or processes (Woolley 1997). The major expense of those industries is fuel costs. Therefore, masonry industries are continually looking for improvements in energy efficiency. Woolley (1997) surveyed that in the future, the supply of reclaimed masonry is unlikely to be enough to meet demand, especially if more care is not taken to reuse buildings rather than demolish them. New techniques, such as building with earth, will be one-way towards to a sustainable building industry.

Autoclaved Aerated Concrete (AAC): Builders in this country now can take advantage of an innovative concrete material that Europeans have time-tested and adopted. Autoclaved Aerated Concrete (AAC) is a pre-cast, manufactured building stone made of all-natural raw materials. It is an economical, environmentally friendly, cellular, lightweight but structural material that features thermal and acoustic insulation as well as fire and termite resistance. AAC is available in a variety of forms, ranging from wall and roof panels to blocks and lintels. Although it has been a popular building material in Europe for over 50 years, AAC has only been introduced to the U.S. in the past few years.

Concrete Masonry Units (CMU): Concrete Masonry Units (CMU) is made of hollow concrete formed blocks. There are concrete blocks available that contain pellets of expanded polystyrene and wood chips that help to reduce the amount of concrete used in the manufacture of the block and, as a result, improve the overall isolative value of the block. When this product is left exposed or plastered it can provide an opportunity to gain thermal mass to the interior but can be thermally inefficient if not protected from the exterior. It is necessary to verify product content and use local manufacturers to reduce transportation cost.

Insulated Masonry Units (IMU): Insulated masonry units (IMU) are manufactured in the same manner and of the same material as traditional Concrete Masonry Units. The difference between the two systems is in their assembled final form. IMU's are dry stacked and held together with reinforcing bars and cement surface bonding stucco applied to both sides. Interior cores that are not routed are filled with Expanded Polystyrene (EPS) foam cores (EPS is made using non- CFC and HCFC polluting processes). This creates an insulated thermal mass that performs structurally like the CMU.

Insulated Concrete Forms: Insulated Concrete Forms are a stay-in-place system that offers high thermal efficiency (R-26 to R-40 depending on thickness). The form materials are low-toxic and made of EPS foam. These systems are lightweight, easily assembled, and can have interior finishes applied directly.

Rastra: Rastra is a product name of another insulated concrete form. The difference is that this product is produced out of recycled post-consumer plastics, such as expanded polystyrene and mixed with concrete. It, like other forms, is filled with concrete and reinforcing bar to create a structurally and thermally efficient building.

Stone: Reclaimed stone is best; through it may well be expensive. If unsuitable or unavailable, newly quarried stone – especially if local – is sometimes a better buy than any other manufactured options.

Timber Materials

Potentially, wood is the ultimate environment-friendly building material. From an ecological point of view, one of its strongest credentials is that it derives from a renewable, living source and one that naturally reduces levels of carbon dioxide in the atmosphere (Wilhide, 2002). In addition, wood has low embodied energy. It does not require much in the way of processing, and it lends itself to recycling.

Composite Boards

Many types of preformed boards and sheets are now in common use in the building industry. They vary considerably in their environmental impact, which depends partly on their composition and partly on their potential for eco-friendly use in less-destructive construction methods (Fox and Murrell, 1989).

Plywood: Plywood is the most commonly used product for wall sheathing as it has excellent strength. Plywood that contains urea formaldehyde binders should be avoided, because of toxicity.

Oriented Strand Board (OSB): Oriented Strand Board (OSB) makes use of smaller, fast growing farm trees. The production process utilizes a maximum amount of wood fiber from each tree that is harvested, and because the process is very highly automated, the yield of finished product is very high (The Engineered Wood Associate).

Thermo-Ply: Thermo-Ply is made of 100 percent recycled material content (cardboard and office waste, and wood manufacturing waste) and is 99 percent recyclable. It does not use old growth, fast growing trees, or wood chips in the material content. The material is bonded by 100 percent polyvinyl alcohol (PVA), which is one of the safest bonding agents available (Landmark Products, 2000-2004).

Fiberboard: Since U.S. production of particleboard began after World War II; this practical and inexpensive alternative to solid wood has become one of the nation's leading building materials. Particleboard (PB) and Medium-density fiberboard (MDF) are currently manufactured primarily from wood residues from production of lumber and plywood; there is now the opportunity to utilize post-consumer waste wood and waste paper and agricultural residues as raw materials. Use of these materials can divert wastes from land filling or burning. These alternative materials include straw residue, which is the stem of a grain crop, such as rice and wheat, and bagasse, the residue from sugar cane processing. The amount of agricultural waste fiber far exceeds present and future fiber requirements for production of PB and MDF. Most residual straw and bagasse is now burned, which contributes to air pollution and global warming (Green building, 2002).

From an environmental standpoint it is also important to make sure that the recycled content of wood-fiber-based PB and MDF is as high as possible and that little, if any, virgin wood is used. Obviously, recycled content saves trees. This report evaluates various methods of producing PB and MDF and the associated environmental and health impacts. It also makes recommendations that will inform consumers and guide them to environmentally preferable—and safer—PB and MDF products (Landmark Products, 2000-2004).

Insulation

Insulation is an integral part of any comfortable, energy-efficient building. Factors to consider when choosing an insulation material include resistance to heat flow (R-value) resistance to air infiltration, cost, toxicity, resistance to moisture and rot, fire resistance, and availability.

Cellulose Fiber: one hundred thousand million tons of cellulose polymer are produced annually, with no pollution and with a beneficial effect on global warming. Cellulose fiber insulation is made from processed waste paper, made into a fluff that can be placed by hand or sprayed. It is usually treated with borax (sodium tetraborate) for fire and insect resistance. Cellulose fiber insulation can be used in 'breathing wall' type timber frame construction, and in lofts, but it is not suitable in positions where it might encounter moisture (Woolley 1997).

Wool Insulation: Wool is a natural fiber derived from a fully renewable resource. Wool insulation is breathable and it can absorb moisture with no loss of thermal efficiency. This is one reason why it is so effective at keeping buildings warm in winter during warm conditions. Wool insulation releases moisture, which actually helps with the cooling effect. Wool insulation is truly environment-friendly. Its production takes a fraction of the energy required to produce glass fiber insulation. Wool insulation is completely safe to handle. Wool insulation has a life expectancy of more than 50 years and is recyclable (Green Building Store).

Icynene: Icynene is a sprayed foam insulation made from petroleum that creates very little pollution during its manufacture or installation. The R-value is 3.6 per inch; it adheres well to most materials, and is flexible so that it remains airtight with seasonal building movement. Icynene contains no formaldehyde, is non corrosive, and no volatile organic compounds (VOCs) are detectable after 30 days of curing. This product can also be installed in existing wall cavities for retrofit projects. Icynene has been certified as contributing to improved indoor air quality (The Icynene Insulation System, 2004).

Natural Fiber Insulation: Natural fiber insulation is 100% recyclable, so it helps to reduce overall landfill waste. Made from mostly recycled cotton, the manufacturing processes apparently use far less energy than non-decomposable fiberglass insulation. Because it is made from natural fibers, it feels softer to the skin, and it may be less irritating (Eco-Wise, 2002).

BioBase Spray Insulation: BioBase spray-in-place, foam insulation is a soybean based polyurethane. This specially developed product has excellent thermal and sound insulation properties, when applied by trained and certified installers. BioBase expands in the wall or roof cavities to completely fill all spaces and is therefore a highly efficient seal against air infiltration, the number one source of energy loss. In direct comparison to products using conventional insulation, BioBase provides superior quality and performance. It is ideal for use in both residential and commercial construction applications. BioBase insulation is an open cell, semi-rigid foam that provides a sealed thermal envelope that can simplify construction practices. BioBase adheres to any clean, dry surface, and it completely fills any cavities and forms a continuous barrier against any potential air leaks. It provides any domestic or commercial building with substantially reduced energy costs combined with a cleaner, more comfortable environment. Using BioBase insulation systems also allows for the use of smaller, less expensive heating and cooling equipment. Use of properly sized HVAC equipment reduces energy consumption and prevents moisture buildup within the structure. The resulting increased energy efficiency is a significant cost-reducing factor in most buildings. BioBase provides a healthier indoor environment, having no harmful emissions that can cause allergic reactions. It can eliminate building warp, caulking and taping, and the labor-intensive work associated with air-tightness detailing required when insulating with conventional products. Proper ventilation of a tightly sealed building allows, for the first time, the ability to control indoor air quality. (Bio Based Chemicals, LLC, 2003)

Paints & Stains

Volatile organic compounds (VOCs) are currently a key issue in paint manufacturing; not only as a consideration, for environmental effects, but also for the health of workers using solvent-borne paints indoors. Water-borne paints have been increasing in popularity. According to Woolley (1997) it was reported that through safer methods for users, and with less VOCs emitted to the environment, these paints possibly use less toxic petrochemicals than conventional solvent-based paints. Alternatives exist in the 'organic' or plant-based paints from specialist environmental suppliers. These are made from ingredients derived from processes that are inherently less damaging to the environment than petrochemical production.

Plant-Based (Solvent-Borne): Organic oil-based paints also use solvents, but usually ones derived from plant sources rather than petrochemicals. Typical solvents are gum turpentine, from the oil of the balsa tree, and citrus peel oil. The actual drying oils are also plant based, such as linseed oil, often grown on organic farms. The waste products from the manufacturing processes are all biodegradable. This paint production process is low energy compared to synthetic oil- based paints. Plant-based chemicals are not necessarily non-toxic. Wastes from plant-based production processes are much less of a problem than with petrochemical processes. One company claims that all its wastes are composted and returned to the land. Although organic paint solvents are derived from plant sources, these are still volatile organic compounds that contribute to photochemical smog. The solvents in organic paints can still pose a health hazard similar to the petroleum-based solvents in conventional paints, most importantly if used without adequate ventilation (Autonomous Building, 2003).

Plant-Based (Water-Based): Plant-based water-borne coatings for timber are rare, but can be found. We have found none listed as being suitable for exterior use. The rating is similar to that for solvent-borne plant based coatings. These paints involve the least toxics in production and the VOCs ratings are low. Non-solvent-borne paints are less of a hazard whilst being applied and afterwards (Autonomous Building, 2003).

Floor Coverings

Common floor coverings are most often cited as primary contributors to indoor air contamination. This is due to the VOC constituents (volatile organic compounds) present in the binders used in the fabrication of material, such as carpet padding, carpeting, and adhesives used to apply carpet padding and tile. Since homes are now constructed tightly in order to conserve energy, chemicals out gassing from building materials are more potent and harmful. Formaldehyde out gassing is a primary threat from commonly used floor coverings. Airing a home before it is occupied will dilute the chemicals during their most potent initial stage; however, high levels of VOC's will outgas for months and, in many cases, will continue to outgas for years. Reducing the application of VOC's in the home can be achieved through alternatives - mainly associated with the use of carpeting. This section identifies recycled-content materials which are durable, high quality, and attractive floor coverings. The use of these materials strengthens the viability of our recycling efforts and greatly benefits our resource and energy conservation. Linoleum and natural carpets use renewable resources and offer durability without compromising aesthetics. The cork used in linoleum is harvested from the cork tree on an ongoing basis without harming the tree. Along with cotton and wool, carpet-type floor coverings are available from grasses and reeds. Ceramic tile offers outstanding durability and maintainability. It also has high aesthetic value (Sustainable Source Book, 2004)

Bamboo Flooring: bamboo is a grass, not a wood. Bamboo produces new shoots each year and is individually harvested from controlled forests reproducing within three to five years. Because bamboo has an extensive root system constantly growing underground it replenishes itself naturally (Sustainable Source Book, 2004). By using bamboo people help to preserve the habitat of endangered wildlife, unlike the results of harvesting of other hardwoods. Bamboo flooring is harder than maple and red oak, and now comes in over 30 colors, complimenting any interior design. During the manufacturing process the product is treated to prevent insect and mildew damage and to conform to both residential and commercial fire prevention standards. Most manufacturers produce this product pre-finished, ready for installation, whether nailed down or glued directly to a concrete surface, as it is a laminated (engineered) product. Maintenance for this product is the same as most pre-finished products, requiring a light damp mop on occasion, with frequent sweeping and/or vacuuming (Wood Floor Online, 2004)

Cork Flooring: Cork flooring stands out in many ways. Unlike vinyl and other synthetic materials it does not release toxic fumes. It is insulated and therefore ideal over concrete slabs and other cold sub floors. It is durable, anti-static, and noise absorbent with a pleasant amber color. Styles vary, with rolls and planks in various widths and finishes. Pre-finished and unfinished flooring is available (Green building, 2002).

Linoleum: linoleum is made from a linseed oil and natural resin 'cement' mixed with cork, wood flour and powered limestone (Woolley, 1997). It is a tough yet visually striking floor covering, highly resistant to foot traffic. Because linoleum is an organic product, its performance is enhanced by time, as exposure to air serves to harden and increase its durability, while remaining quiet and comfortable under foot (Green Building, 2002).

Carpet: Both synthetic and natural fibers have their advantages and drawbacks, and both create different types of environmental impacts. In the case of synthetic fibers, the manufacturing impacts, such as energy use and air emissions generated prior to carpet making, are typically more significant. All synthetic fibers are petroleum based and, for that reason, they bring with them the environmental impacts associated with petroleum exploration and refining. Petroleum is a non-renewable resource, and using it to produce synthetic fibers requires large amounts of energy and generates considerable pollution. On the other hand, agricultural impacts (and grazing impacts in the case of sheep's wool) result from use of natural fibers. Wool also involves the use of water and energy for washing, and water pollution and solid wastes are generated from the wool-washing process. Additionally, methane releases from sheep could contribute to global warming. Wool, however, is a renewable resource and requires less energy to produce than synthetics (Choose Green Report, 2001).

Consumers should check to ensure that new carpet meets indoor air quality standards. The Carpet and Rug Institute (CRI) has an Indoor Air Quality Carpet Testing Green Label which sets carpet standards. Adhering to the CRI standards is recommended, but requiring the CRI Label in specs may eliminate certain carpet manufacturers. Carpet can be a major source of indoor air contamination, although some tests show that carpet is one of the lowest emitters of VOCs among various interior products. The adhesives used to install carpets and the latex rubbers used by some manufacturers to adhere face fibers to backing materials generate volatile organic compounds (VOCs). Carpet can be purchased treated with anti microbial agents that resist the growth of micro-organisms. Installing carpets in strict accordance with the Carpet and Rug Institute guidelines, as well as additional measures such as requiring suppliers to unroll and air-out carpets in the warehouse before bringing them into the buildings will minimize the risks of indoor air quality problems resulting from the carpet. Commercial carpets can be installed with water based low VOC adhesives or the products can be purchased with pre-applied adhesive. Rubber-based recycled padding is commonly used and can outgas. Recycled padding from carpet fibers may be more suitable for environmentally sensitive persons (Environmentally Responsible Carpet Choices, 2002)

Summary

The review of literature provides the principles of sustainable design, specifically, of sustainable materials. The production and consumption of building materials have diverse implications on the local and global environments. It involves extraction, processing, manufacturing, and transporting building materials; all cause ecological damage to some extent.

The strategy of this chapter is to find and select sustainable materials following these guidelines:

1. Adapt existing buildings to new uses
2. Incorporate reclaimed or recycled materials
3. Use materials that can be recycled
4. Reuse non-conventional products as building materials

CHAPTER 3. DESIGN DEVELOPMENT

The Site

History of The Armory Building

The Armory Building was built between 1920-1991. This building was used to meet the needs of the expanding college facility; it included a gymnasium, shooting galleries, and horse stalls. Commencement activities were held in the new Armory, in addition to circuses, plays, dances, and concerts. In December of 1922, a fire completely destroyed the building. In 1923-1924 an exact copy was built, with the exception of the fireproof materials used to build the second Armory. An addition on the west side was built in 1941 to match the existing east wing, which provided additional classroom space. Beginning in 1946, home men's basketball games were held in the Armory, and shortly after, varsity wrestling followed. In 1956, the Armory was remodeled to add classrooms and to make the building more suitable for concerts, indoor athletics, and graduation ceremonies by increasing seating capacity from 3500 to 8500. During the 1970's, the building was mainly used for general recreation - basketball, tennis, badminton, volleyball, etc. In 1990 twelve design studios were built in the building as additional facilities for the College of Design (Iowa State University Library, 2000).

Existing Conditions

The location of the Armory is north-west of Iowa State University main campus. The space usage by department is:

	Sq/ft
College of Design	17,445
ROTC	16,010
Department of Public Safety	9,864
ISU General	42,682
Space Unallocated	91
Total	84,586

Table 1. Space Usage of Armory Building (Facility planning & management, Iowa State University, 2005)

Existing Plan

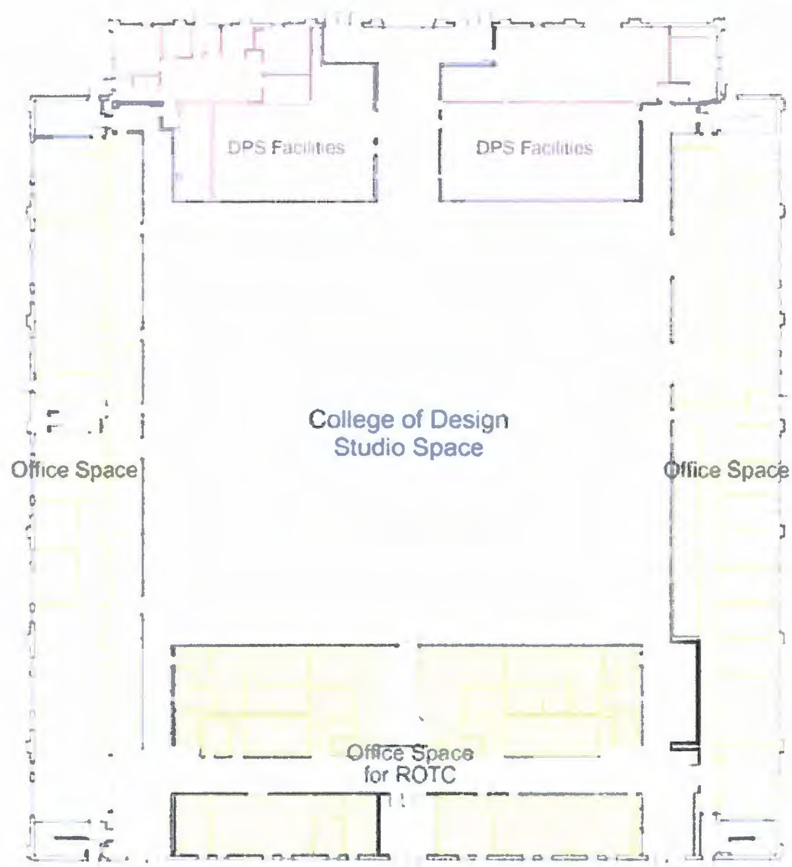

Figure 1. Existing First Floor Plan (Scale=None) ↑N

The central space of the Armory Building is used by the College of Design twelve studios for the undergraduate foundation courses and core program. The outside space of the Armory Building is used by other department offices and classrooms for the Department of Public Safety Office, ROTC classroom and office space, parking division offices and other administration offices.

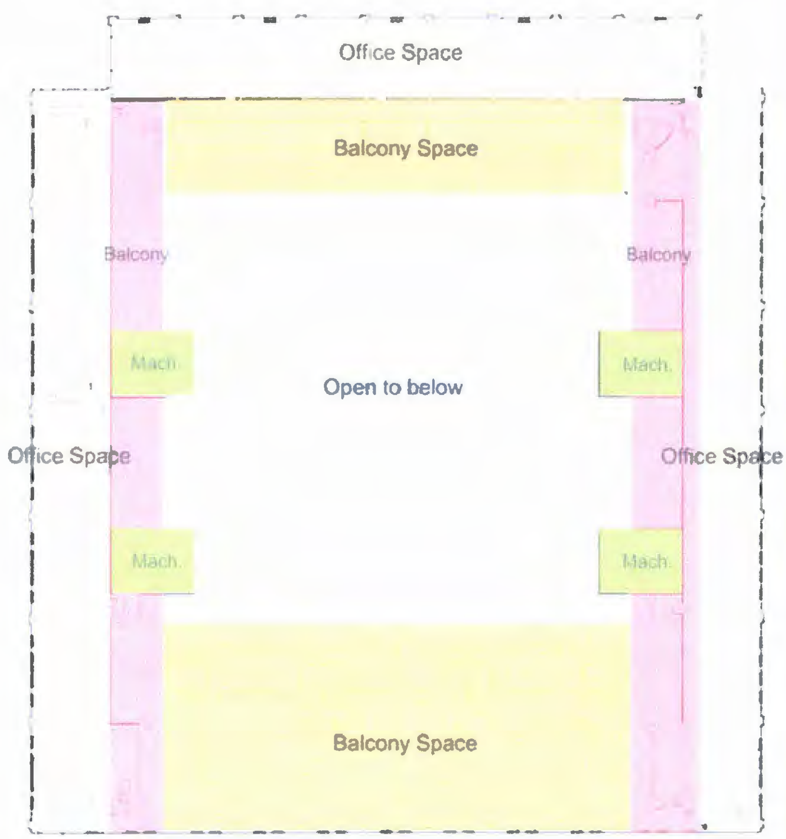

Figure 2. Existing Second Floor Plan (Scale=None) ↑N

Existing Exterior Elevations

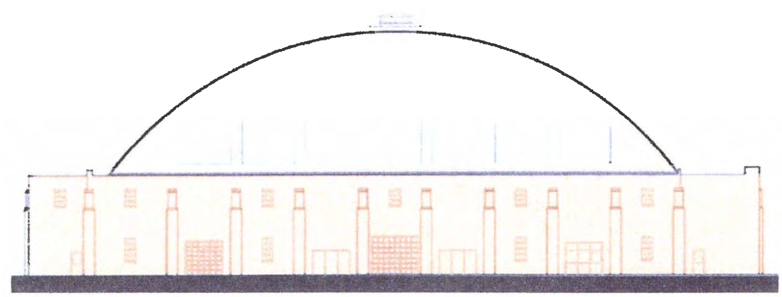

Figure 3. Existing North Elevation (Scale=None)

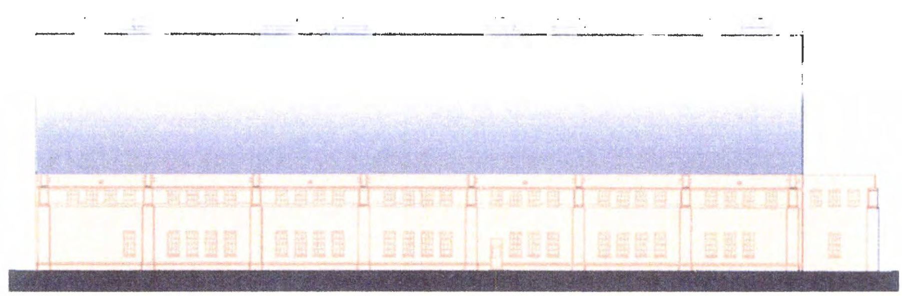

Figure 4. Existing East Elevation (Scale=None)

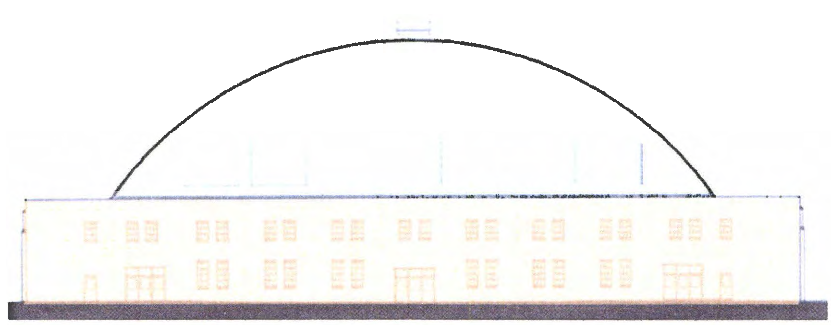

Figure 5. Existing South Elevation (Scale=None)

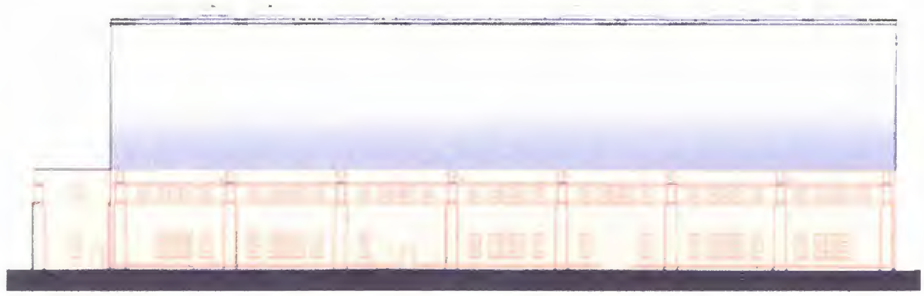

Figure 6. Existing West Elevation (Scale=None)

Health, Safety and Welfare Problems

The studio space of the existing Amory Building has several problems related to health, safety, and welfare factors. Problems arise because individual studio spaces do not have security doors and ceilings. These spaces need visual and acoustical privacy, more comfortable social spaces for users, and more personal storage spaces for students.

Figure 7. Existing Conditions – Studio Spaces

Figure 8. Existing Conditions – Studio Work Space

Figure 9. Existing Conditions – Social Area

Operational and Performance Problems

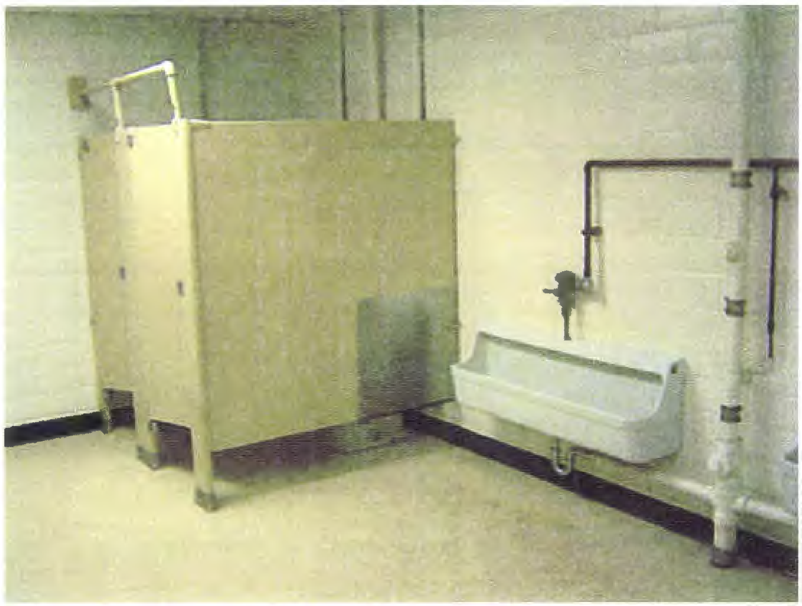

Figure 10. Existing Condition – Looking at Restroom

The overall condition of existing Armory Building also has problems which affect operations and performance factors. The fact that the Armory Building has only one restroom space for the entire building is a testament to the need for remodeling. The condition of this sole restroom indicates that the time has come for redesigning. The Armory Building space also needs a more comfortable environment for the computer lab and presentation area. The existing space is totally open, and therefore has many visual and acoustical problems. The Armory Building also needs workshop space for creative activities such as a model workshop, wood workshop, photo studio, and lighting simulation lab.

Design Program Statement

The main goal of this design is to improve the educational environment, to utilize sustainable design theory, and to preserve an historical building.

Design Objectives

This design will consider several objectives, they are:

1. To improve the educational environment in the Armory
2. To expand vertical space in the existing central open space
3. To preserve the historical character of the building
4. To apply sustainable materials
5. To utilize passive solar energy to conserve energy
6. To provide adequate and secure studio space for undergraduate graduate students
7. To provide spaces for faculty and graduate student research collaboration
8. To provide classrooms for lectures
9. To create an ecological environment in the south atrium space

Design Program and Development

Proposed design considers the possibility of a four-story building within the existing Armory Building. The central area is consisted of open space from the first floor to fourth floor, one elevator, and staircase in four different locations. Each floor has barrier-free restrooms for both genders. Every studio and lecture space can be accessed both by west and east side entrances and hallways. The proposed design includes glazing on the south side for direct solaration in addition to a skylight system. Each floor has a specific function. The first floor provides a common space. The second floor provides foundation core studio spaces for the undergraduate foundation program. The third floor provides studios for the graduate programs studio space and faculty research spaces. The fourth floor provides research labs for both students and faculty and several additional faculty research spaces.

Program Requirement for Each Floor

First Floor: This floor is to be considered common space for all users.

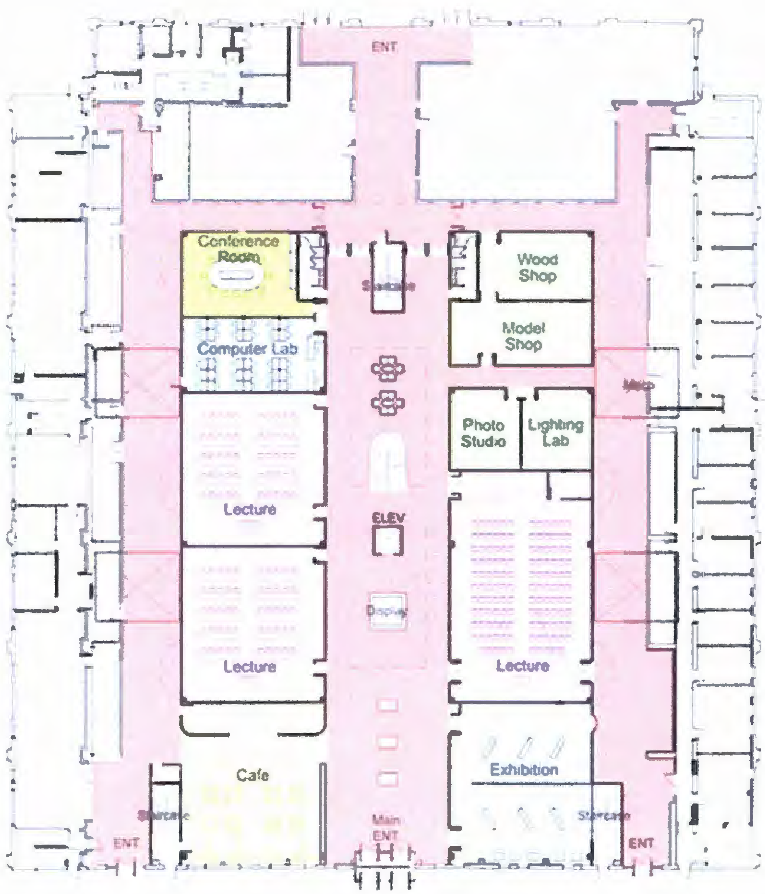

Figure 11. First Floor Plan (Scale=None) ↑N

First Floor			
Space	Capacity	EA	Sq/f
Large Lecture Space	160	1	2,560
Middle-Size Lecture Space	50	2	3,360
Activity Room	N/A	1	2,456
Gallery	N/A	1	1,800
Computer Lab	28	1	800
Conference Room	12	1	736
Café	40	1	1,800
Restroom	N/A	2	288
Common Space	N/A	1	5,980
Total			19,750

Table 2. First Floor Programming

It includes different sizes of lecture spaces, computer lab, conference space, activity spaces (Photo studio, model shop, lighting lab, and wood shop), gallery, café, and a lounge space. The central hallway space of the first floor is to provide a multipurpose space for both personal use, i,e, studying, reading, computer, chatting etc. and academic purposes such as discussions, presentations, and exhibitions etc.

Second Floor: This floor is to provide eight studio spaces for the core program of the undergraduate program. Some foundation courses consist of two sections. Therefore, this design provides connected passageways between two studios for easy access. The studio spaces have high individual working tables 36"d x 60"w x 37"h. Most studio activities require drafting and drawing work rather than computer work; therefore, the studio space provides a 37 inch high working table for easy exchange with the instructor. Each studio has two entrances, on west and east side, for easy evacuation in an emergency situation. The south side of second floor provides atrium space for the building users.

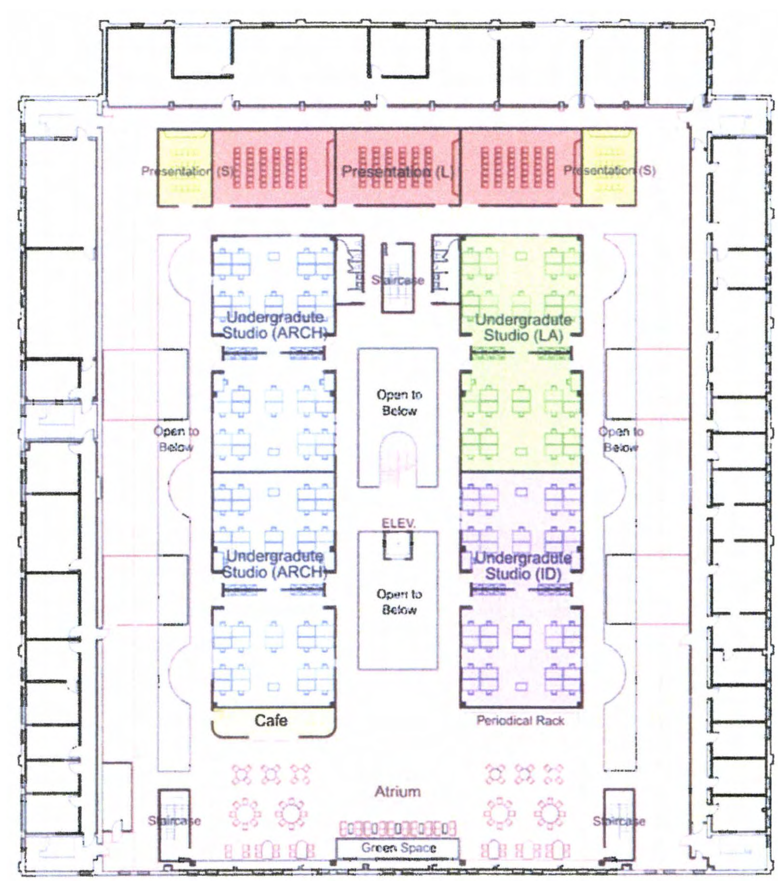

Figure 12. Second Floor Plan (Scale=None) ↑N

Second Floor			
Space	Capacity	EA	Sq/f
Studio (Undergraduate)	18	8	8,704
Social Space	100	1	3,795
Middle-Size Presentation Space	20	2	600
Large Size Presentation Space	42	3	1,980
Café	N/A	1	272
Periodical Rack	N/A	1	272
Restroom	N/A	2	288
Common Space	N/A	1	4,403
Total			20,314

Table 3. Second Floor Programming

Atrium space is for personal use and academic purposes similar to the first floor central hallway. Also, this space provides plant space, periodical rack, and café for the users' pleasure. The north side of the second floor provides two different sizes of multi-media presentation spaces providing equipment for digitalized presentations, overhead projections, Elmo etc.

Third Floor: This floor is to contain eight studio spaces for graduate programs. The space planning of the third floor is almost the same as the second floor studio space. In the next passage details of a typical graduate studio will be discussed. The south side of the third floor will include open space to allow direct sunlight to benefit the second floor and central hallway and provide a half circle of lounge space as social area. The south side of third floor also provides four faculty research spaces. These faculty spaces have south facing windows and doors. The north side of third floor provides multi purpose rooms with two different sizes of presentation spaces, copy center, and design supply shop.

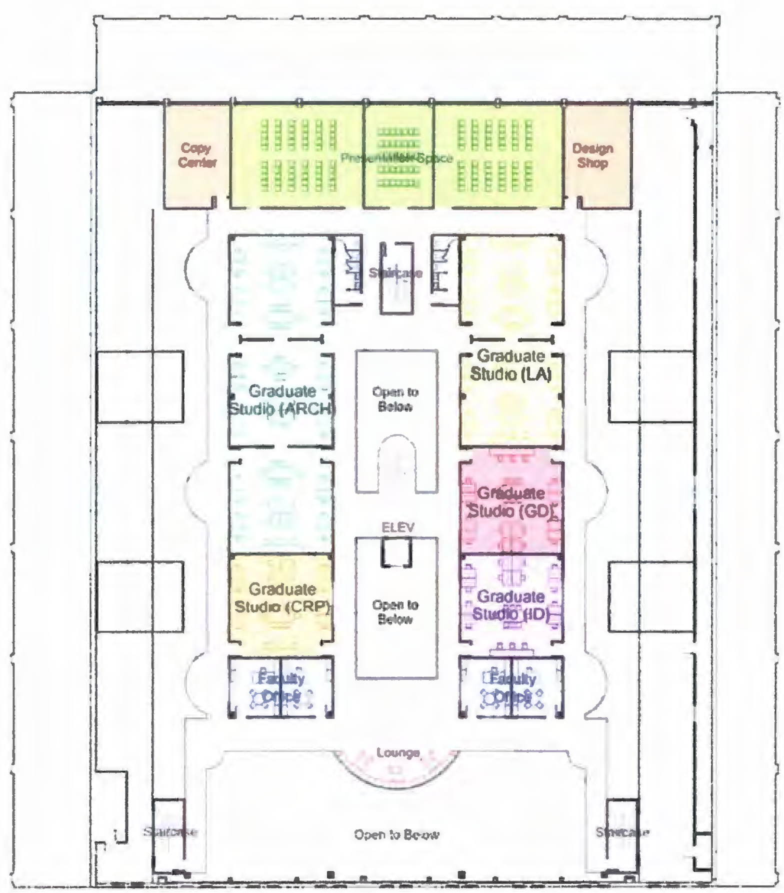

Figure 13. Third Floor Plan (Scale=None) ↑N

Third Floor			
Space	Capacity	EA	Sq/f
Studio (Graduate)	12	8	5,832
Faculty Research Space	N/A	4	840
Middle Size Presentation Space	35	1	486
Large Size Presentation Space	60	2	1,890
Copy Center & Supply Shop	N/A	1	918
Restroom	N/A	2	288
Common Space	N/A	1	5,024
Total			15,278

Table 4. Third Floor Programming

Fourth Floor: This floor is to contain eight graduate research lab spaces for both faculty and students. These spaces will have flexible functions according to the character of the research. On the south side of fourth floor, open space will allow direct sunlight to filter down to the second and third floors and central hallway, where a half circle of lounge space provides a social area. The south side of fourth floor also provides faculty research spaces. The reason these faculty research spaces are located on fourth floor is to foster close relationships between graduate students and faculty.

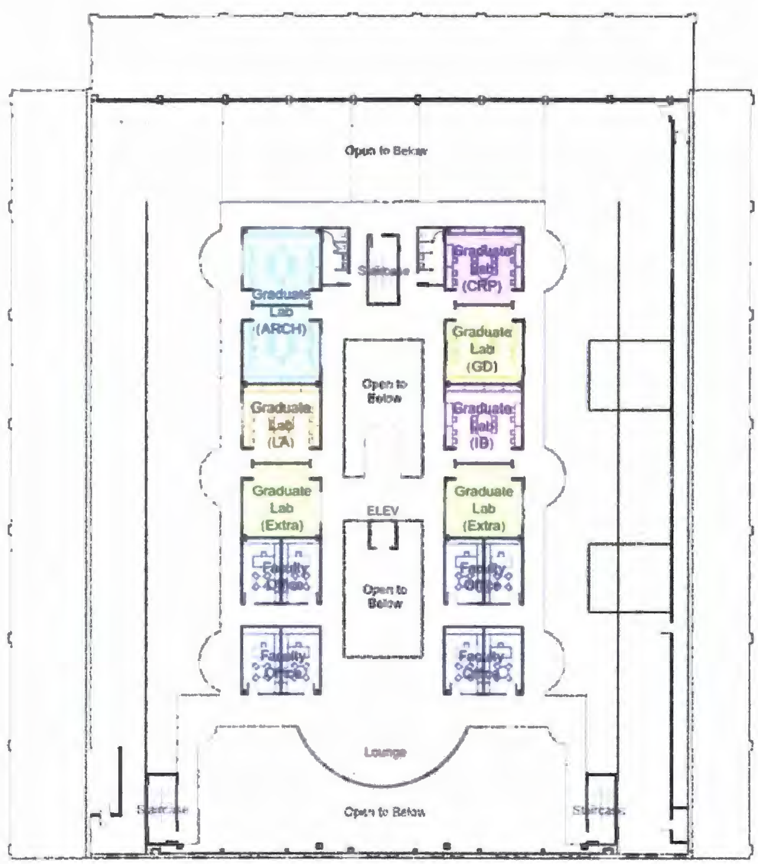

Figure 14. Fourth Floor Plan (Scale=None) ↑N

Fourth Floor			
Space	Capacity	EA	Sq/f
Research Lab	N/A	8	3,528
Faculty Research Space	N/A	8	1,360
Middle Size Presentation Space	35	1	486
Restroom	N/A	2	240
Common Space	N/A	1	5,238
Total			10,366

Table 5. Fourth Floor Programming

Sections and Roof Plan: This roof design features a skylight system which allows for direct sunlight from the roof into the first floor open space.

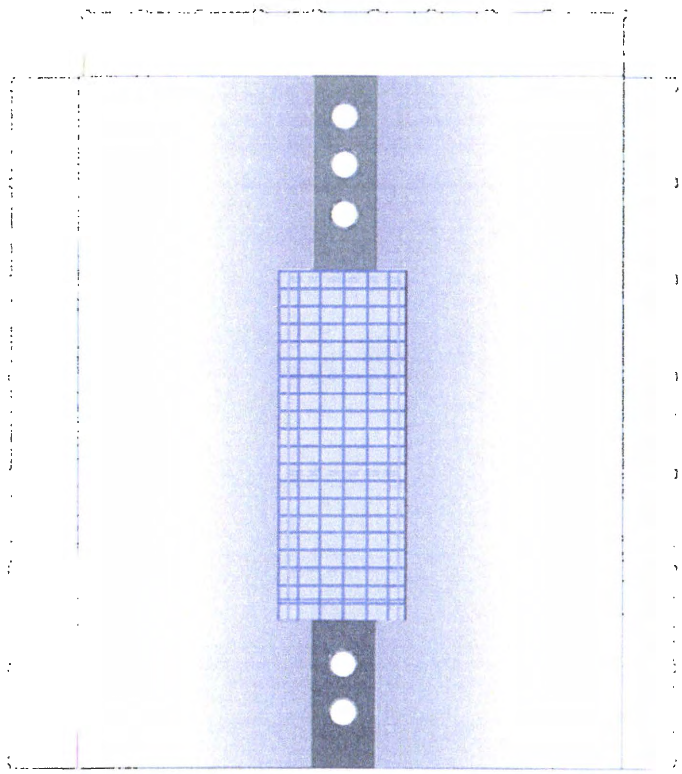

Figure 15. Roof Plan (Scale=None) ↑N

Sunlight will bring natural light to each studio space as well as other spaces. The skylight system can provide UV protecting glass and steel frames, and also natural ventilation system windows on both sides as vertical element for reducing indoor temperature in summer time.

In the longitudinal section, the existing wall of the south side can provide natural light for the inside of the building. South wall contains a motorized shading device for summer time and the noon sun.

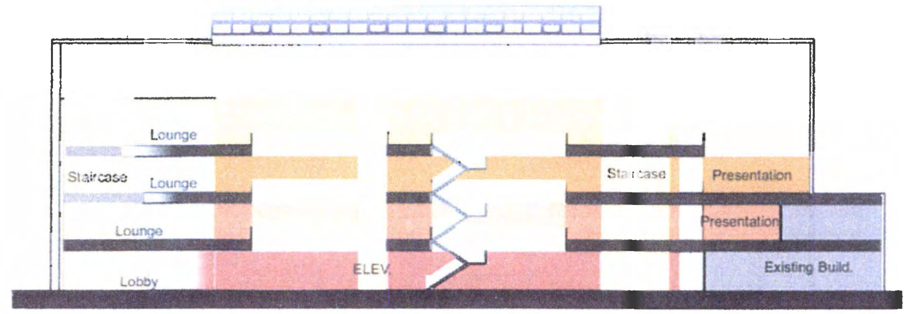

Figure 16. Longitudinal (Scale=None) S - N

The transversal section, central part of the design is open to the skylight. The proposed building shape will get a smaller size as it rises, because of existing roof line and the existing mechanical system. The outside hallway of second, third, and fourth floors provide balcony spaces creating social spaces on each floor.

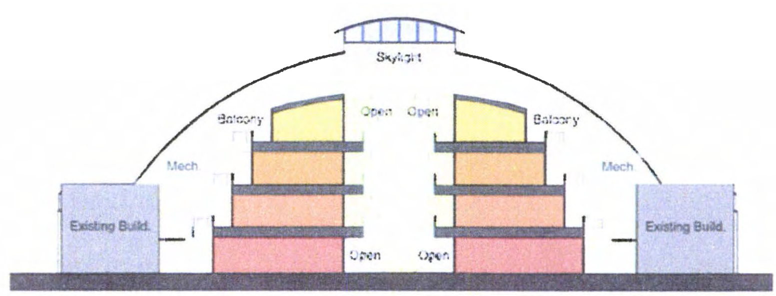

Figure 17. Transversal (Scale=None) W – E

Perspectives

In this section, perspectives are included for the understanding of proposed design.

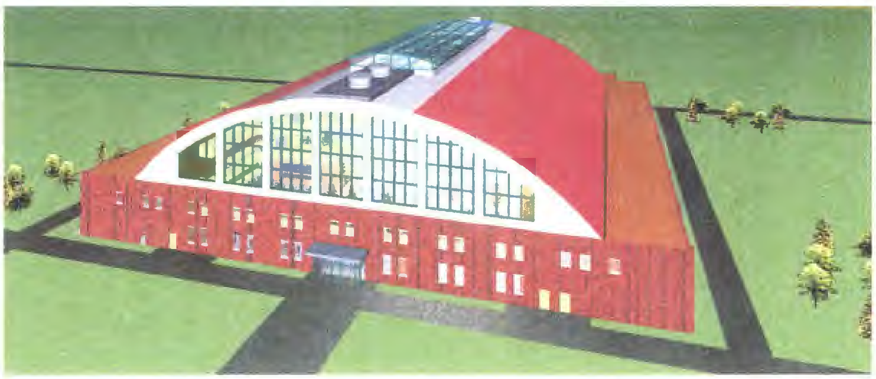

Figure 18. Perspective – South Entry

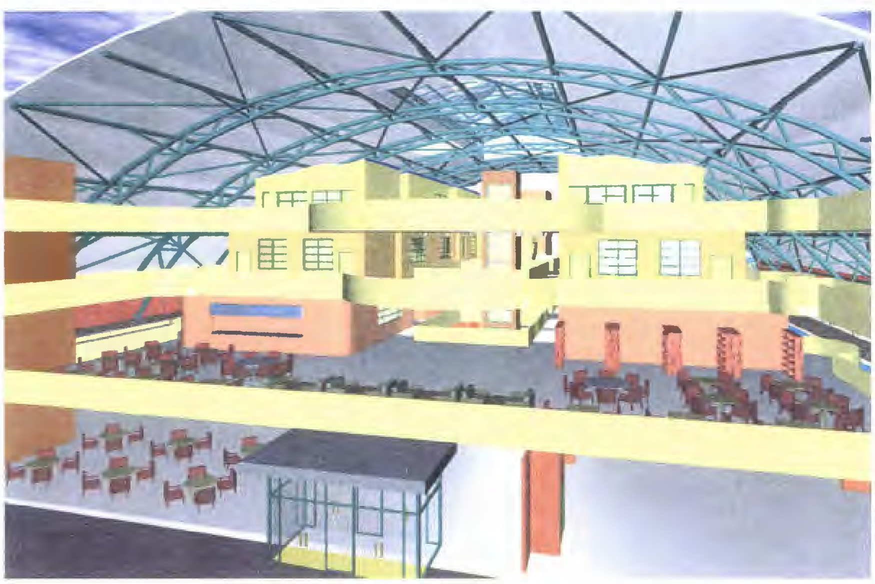

Figure 19. Perspective – South View

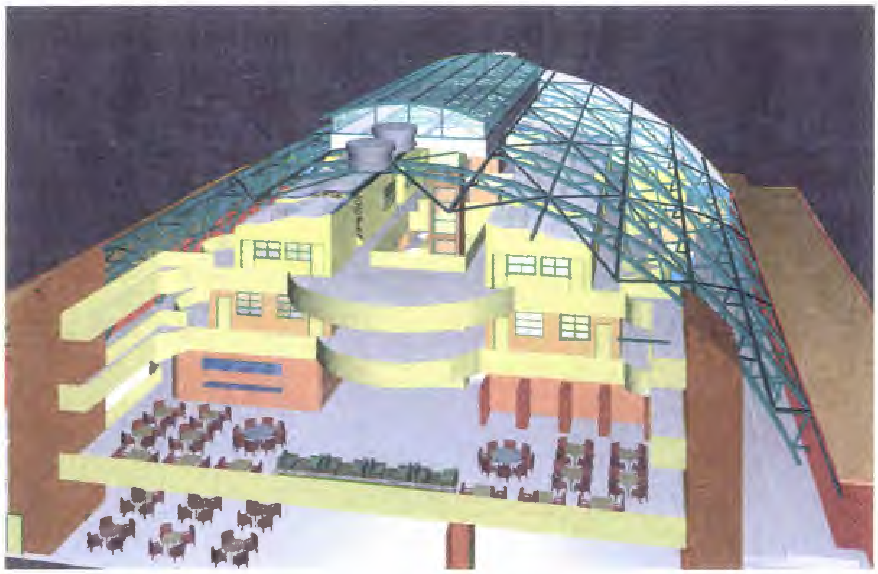

Figure 20. Perspective – South View

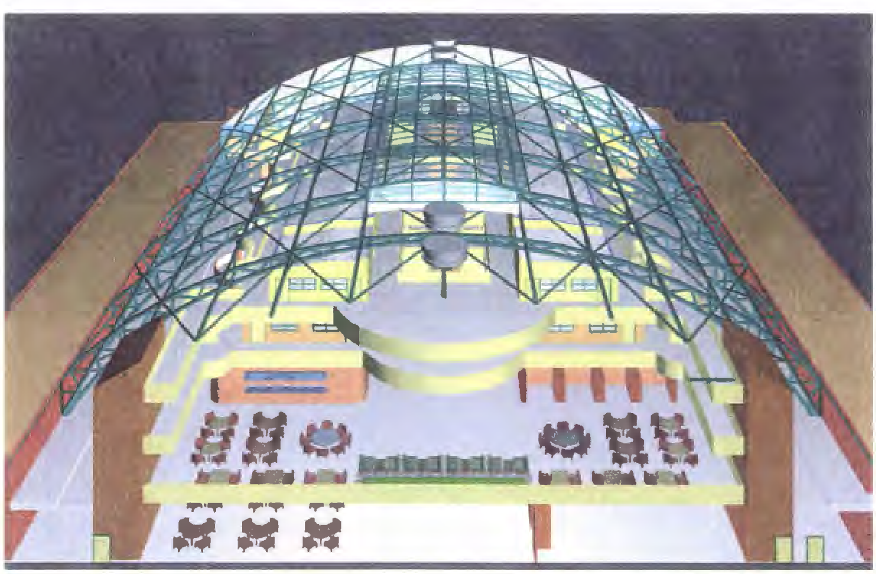

Figure 21. Perspective – Roof Structure

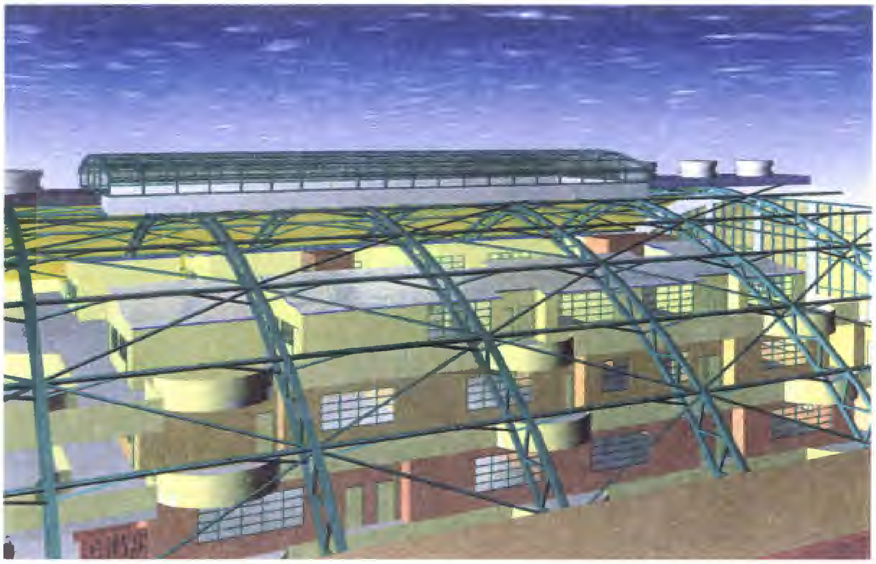

Figure 22. Perspective – East View

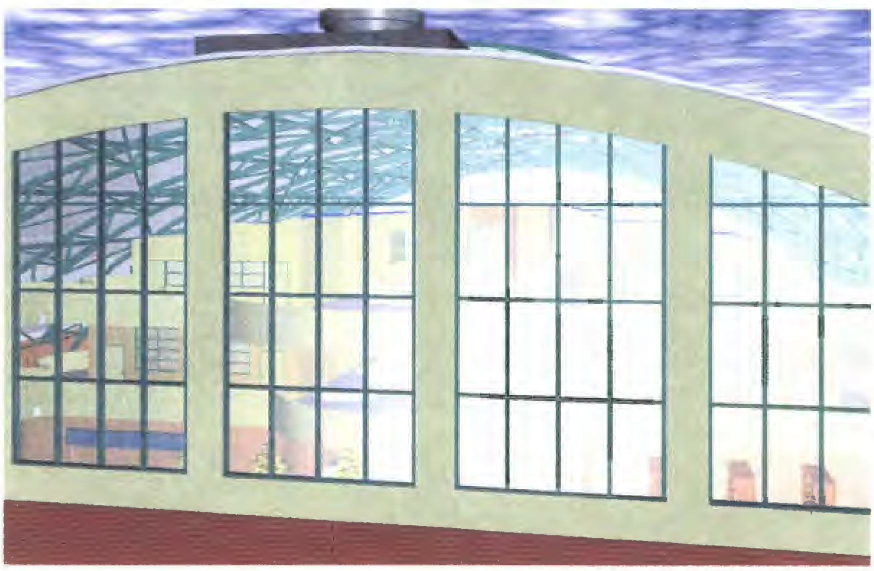

Figure 23. Perspective – South Elevation

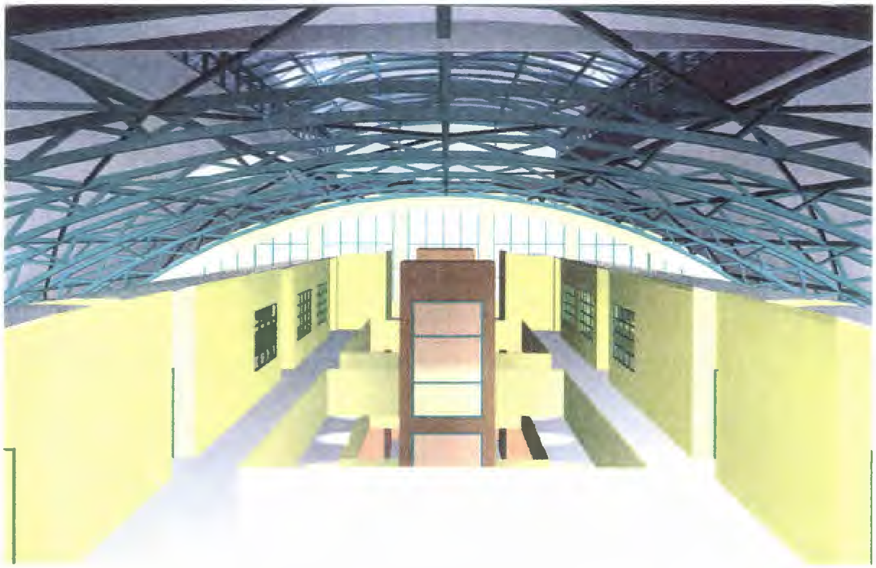

Figure 24. Perspective – Fourth Floor core facing North

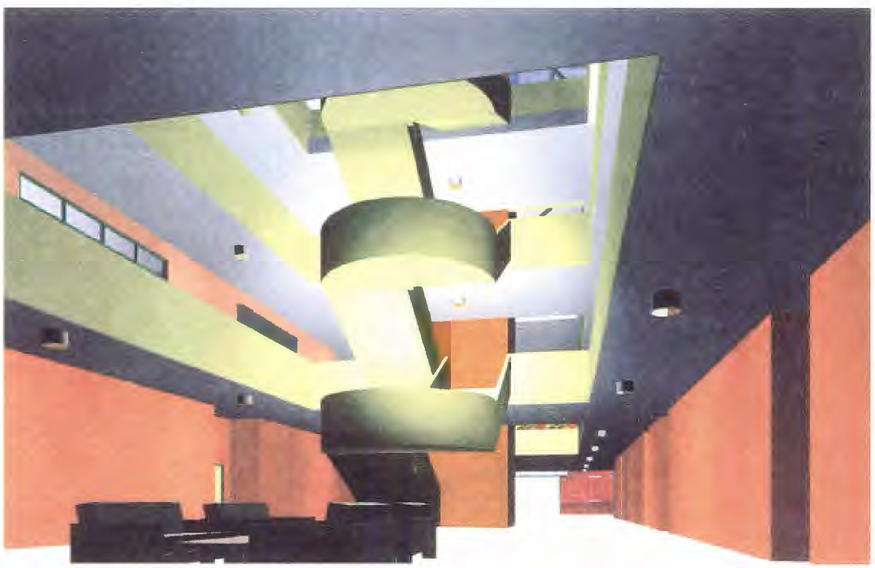

Figure 25. Perspective – Atrium facing South

Sustainable Design in Studio Space

In this section, graduate studio designs relating to the following issues are explained:

1. Sustainable design in design studio
2. Improvement of design studio environment
3. Suggested future studio environment

Most design major students spend long hours in studios and labs. Over the past decade the value of the computer as an aid to create design has increased rapidly. Therefore, future design studio environments need to be developed to implement and include computer technology. Moreover, this proposed design is an example of how a studio environment can be related to sustainable strategy.

Sustainable Strategy

The design of the graduate studio considers the following issues:

1. To apply flexible layout in a floor plan for applying many kinds of function and purposes
2. To apply sustainable construction methods in walls, ceilings, and floors for low maintenance
3. To apply sustainable materials for achieving an environment - friendly studio space
4. To apply health and safety issues in a studio environment
5. To apply high technology systems for future studio environments

Space Planning

The floor plan of a graduate studio provides a maximum of twelve L shaped work stations for both computer work and general design study such as research and sketching etc. Low dividers on these work stations allow for communication among students.

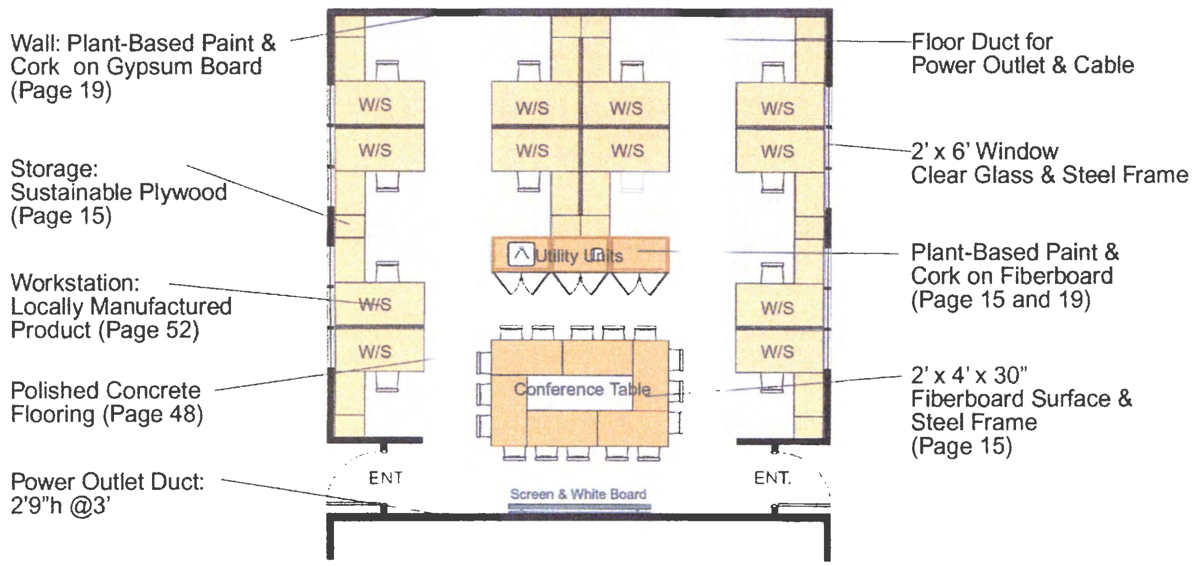

Figure 26. Floor Plan (Scale = None) ↑N

Each work station has a storage unit and ten inch high partition for defining one's territory. The central part of this studio provides a conference table to be used for lectures and seminars. This area also provides three-parts of cabinet units. The two parts of the cabinet will house a small kitchenette, including a refrigerator, microwave, storage space, and a sink. Another cabinet unit will provide electrical equipment storage space, including LCD projector controller, DVD & VTR, ELMO, and other digitalized presentation equipment. Studio space will access the wireless internet system; they will use power outlets in both walls and floor duct systems.

Floors

The material of floor is Polished Concrete Flooring. The advantage of this finish material is low installation cost, no annual maintenance cost, and no replacement. Under the finished floor a floor duct providing easy access to power outlets and other electrical functions in each workstation.

Polished Concrete Flooring					
Costs Per Square Foot	Installed Cost	Annual Maint'	Year AV. Life	Replace' Cost	Total Exp. 20 Years
Vinyl Sheet Flooring	$2.72	$1.39	9	$3.43	$38.14
Vinyl Tile Flooring	$1.23	$1.47	15	$1.60	$32.76
Ceramic Mosaic Tile	$6. 48	$1.22	20		$30.88
Quarry Tile	$5.78	$0.58	20		$30.18
Cement Terrazzo	$8.50	$0.46	20		$20.10
Granit -Glaze	$6.50	$0.46	20		$15.70
Polished Concrete	$3.98	$0.00	20		$3.98

Table 6. Product Analysis Chart (PolishedCreate, 2005)

Walls

Wall system consists of three parts: general wall part, chair rail, and pin-up space. Both west and east side walls provide two window spaces (2 feet x 6 feet each) for getting natural light from the skylight system and south facing window. The materials of the wall part are consisted of three parts, so that floor level to ceiling has plant-based paint on gypsum board. The 2'3" to 2'8" height for the chair rail also has plant based paint on a solid wood panel to protect walls from damage alone by furniture. The 2'9-1/2"' to 7' high of pin-up space is covered with natural composition cork; Dividing the chair rail and pin-up space is 3' of power outlet duct. The color selection of the studio wall utilizes natural colors, such as earth and plant colors. These colors create natural relaxation spaces providing environmental friendly materials like natural cork for pin-up space for making green environment and using a sustainable approach.

Natural cork has many kinds of sustainable material advantages which address following issues:

1. **Environmentally friendly**- Cork material is produced using all natural cork products which are harvested with no waste materials produced.
2. **Durability**- Cork is remarkably resistant to wear, as it is less affected by impact and fiction than other hard surfaces because of its cellular composition.
3. **Resiliency**- When cork is subjected to pressure, the gas in the cells is compressed and volume reduces considerably. When released from pressure cork recovers quickly to its original shape.

4. **Insulation**- Because 90% of the tissue consists of gaseous matter, the density of cork is extremely low giving the material wonderful insulating properties, thermal as well as acoustical.
5. **Fire retardation**- A natural fire retardant, cork does not spread flames and does not release toxic gases during combustion.
6. **Hypoallergenic**- Cork does not attract dust and consequently does not cause allergies.
7. **Electrically dissipative**- Cork material does not produce static electricity making it suitable for rooms with electronic equipment and appliances.
8. **Easy to clean**- Cork material can be easily maintained by vacuuming and damp mopping with approved cleaners.
9. **Easy installation**- Cork materials are easily installed without the use of special tools.

(Black River Cork Flooring Corp., 2004)

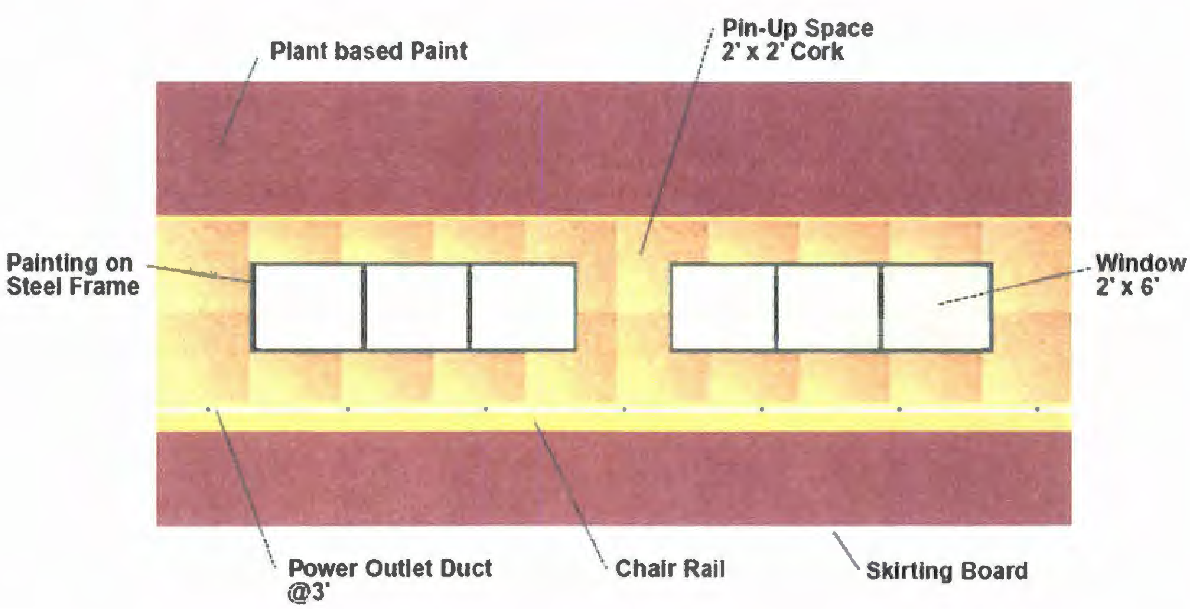

Figure 27. Wall Detail (Scale = None)

Ceiling and Lighting

The ceiling is constructed with a steel deck system. The advantage sof this ceiling system are:

1. **Versatility**: this system can use various depths and rib spacings, with or without stiffening elements, with or without acoustical material, cellular and non-cellular, and in varying material thicknesses. This extensive choice makes steel deck applicable to a wide range of projects and structural designs.
2. **Attractive appearance**: Steel deck is primarily a structural component, it is visually attractive when left exposed in other applications. With the properly specified factory and field coatings, steel deck is easy to maintain, durable, and a esthetically pleasing.
3. **Durability**: Steel deck in place and performing satisfactorily for more than a half century is indicative of the product's durability.
4. **Economy and value**: Low life-cycle cost. (Steel Deck Institute, 2002)

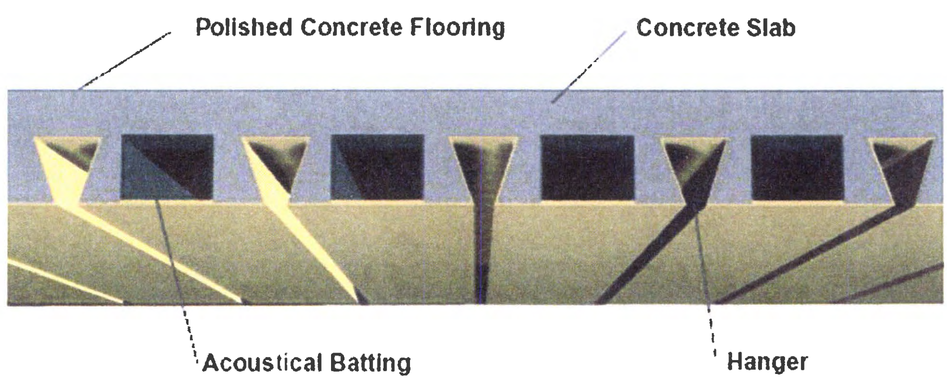

Figure 28. Steel Deck Section Detail (Scale = None)

The light plan for this studio utilizes a total of eighteen hanging – type, energy efficient two 40watt fluorescent lights. This lighting plan provides 16 inches HVAC space between lighting and ceiling.

Workstation

Each workstation provides a 6' by 6' module and an L-shaped working table. The manufacturer of the workstation they are local industry HON Office Furniture. The furniture maker's products were selected because it is local, which means that it requires low transportation cost remaining faithful to sustainable principles. They are also light weight thus easy to move to rearrange space plans. The focus of this workstation is:

1. To provide an individual, private working environment
2. To provide flexibility for both computer and paper work
3. To provide low height partition for dividing and defining territory
4. To provide self storage space under table surfaces for practicality

Figure 29. L-shape Workstation (HON Office Furniture, 2005)

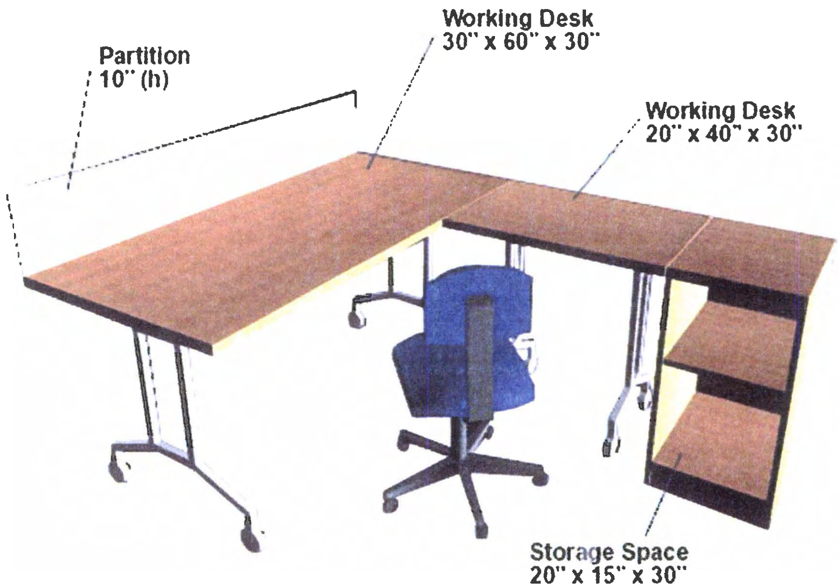

Figure 30. Components of Workstation

Common Space, Utility and Storage Units

The front central part of the common space of the graduate studio provides conference tables and seats, utility storage units, and white board and screen. This space can be used as common space for both academic use and personal interaction.

The conference area consists of six 2' by 4' module tables and sixteen chairs. It can be possible to create any layout according to purpose. Chairs can be stacked away to clear space.

Utility storage units provide two different functions: Equipment storage space for LCD projector controller, DVD & VTR and other computerized presentation equipment and units for a small kitchenette which includes refrigerator, microwave, trash, sink, and shelves. This storage unit would contain waterproof and self ventilation systems inside wall and the top of the unit to protect electrical equipment heating. These units have doors with surface to be used as pin-up space when they are closed during class or presentations.

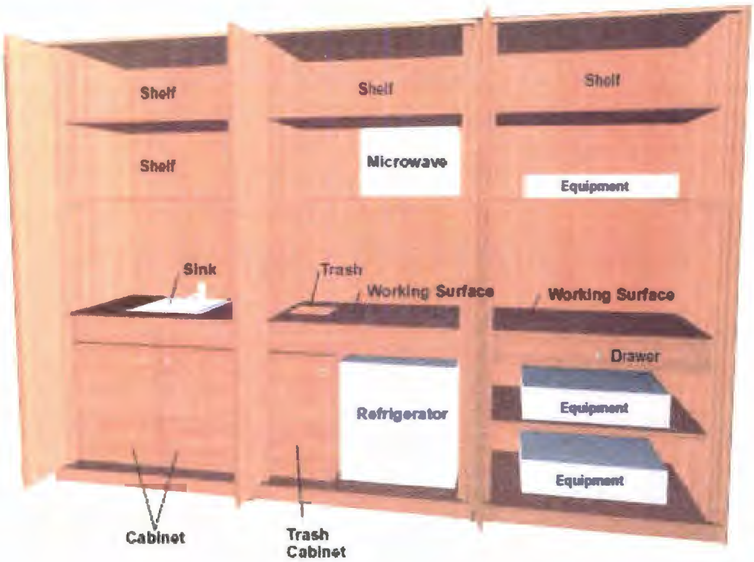

Figure 31. Utility storage units (Scale=None)

Perspectives

Figure 32. Perspective – Conference Space and Utility Units

Figure 33. Perspective – Conference Space and White Board and Screen

Figure 34. Perspective - Workstation

Figure 35. Perspective - Workstation

Figure 36. Perspective – Workstation

CHAPTER 4. CONCLUSION

Summary

Because of deteriorating environmental conditions, sustainable design is becoming an important field in interior design. It is not only for our lives, but also for next generations. As it was mentioned before, sustainable design issues can be attained in our ordinary lives. Therefore, we need to figure out global issues of sustainability to understand and resolve our environmental problems.

The case study and design achieved to use sustainable design in an historical old campus building: The Armory Building. The proposed design also utilized sustainable principles in the Armory Building which meant to consider selecting environmentally friendly materials and construction methods to enhance the educational environment of the students and other users. The proposed design revived an historical building to emphasize the importance of preservation. It demonstrated how to renovate an existing building as adaptive-reuse thus making it a cost-effective endeavor and included the knowledge of sustainable materials used and to be used in other projects. To design studio spaces based on sustainable design issues promoted understanding of sustainable design in an educational facility in addition to suggestion of management option for the College of Design in finding a solution to facility operation problems. This created a more contemporary studio design for a computerized studio environment utilizing sustainable design.

The author believes that implementing these ideas will benefit both the provider and users thus, having an impact to sustainable design in an educational facility.

Suggestions for Future Research

This study is limited to architectural and the interior design applications. It does not represent the engineering solutions, such as mechanical and/or structural applications.

This study does not include other sustainable issues, such as indoor air quality, water conservation and quality, and energy consumption which could be studied even under the proposed conditions. The database for sustainable materials should be revisited periodically to acknowledge and to include the new innovations. Further research objectives for understanding sustainable design issues are needed.

APPENDIX A. DRAWINGS OF THE ARMORY BUILDING

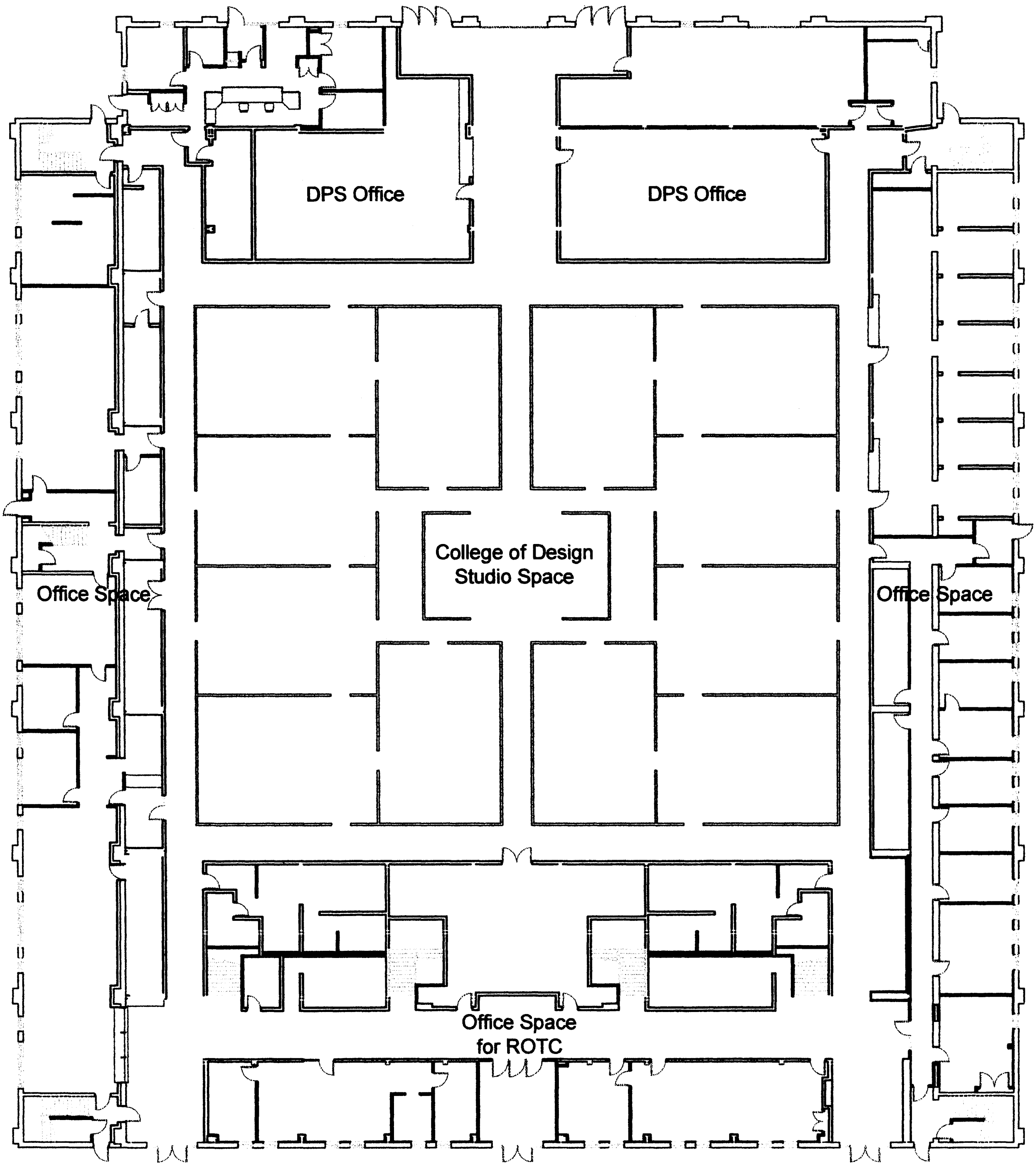

Figure 37. Existing First Floor Plan (Scale: 1/32" = 1'0") ↑N

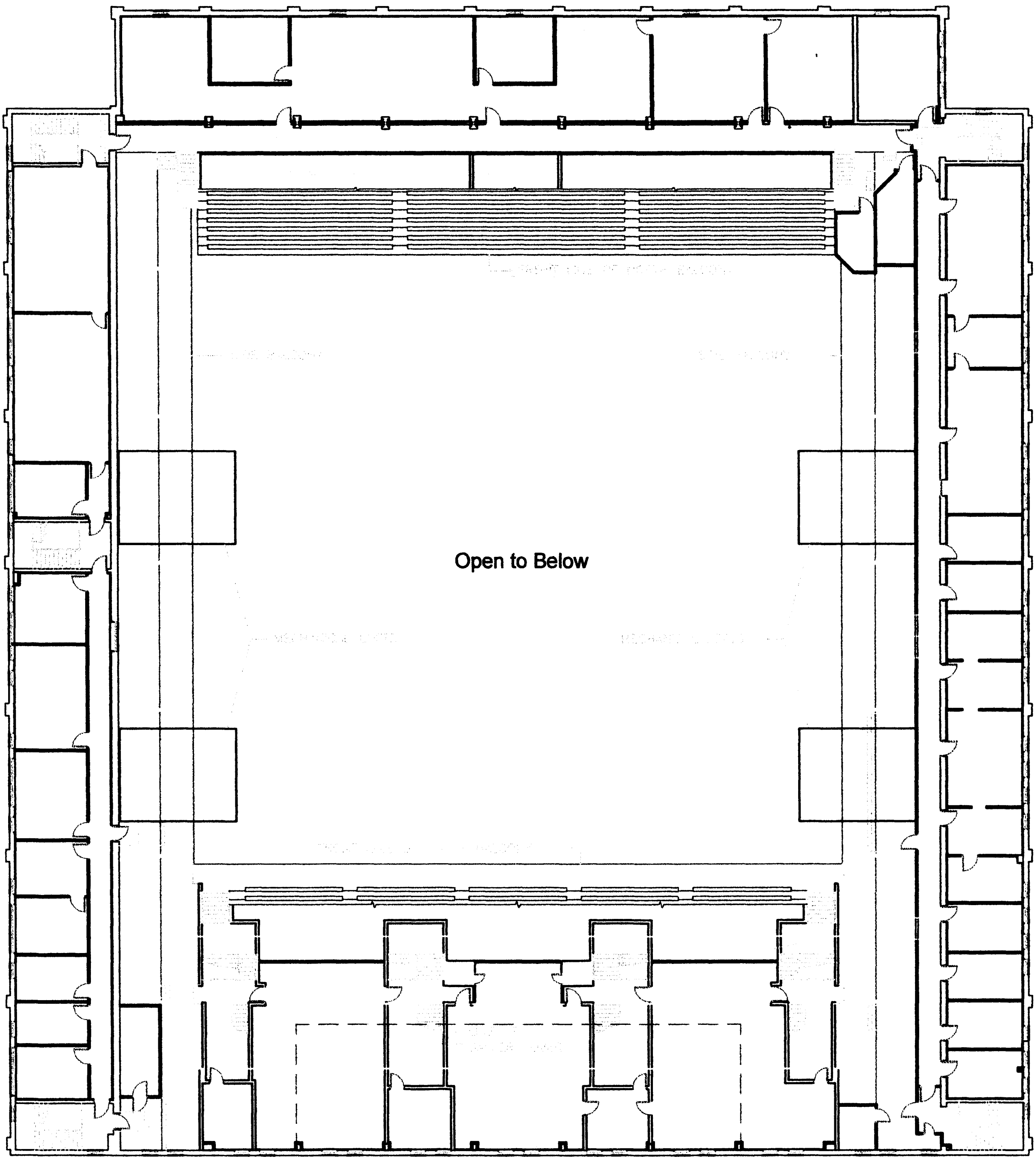

Figure 38. Existing Second Floor Plan (Scale: 1/32” = 1’0”) ↑N

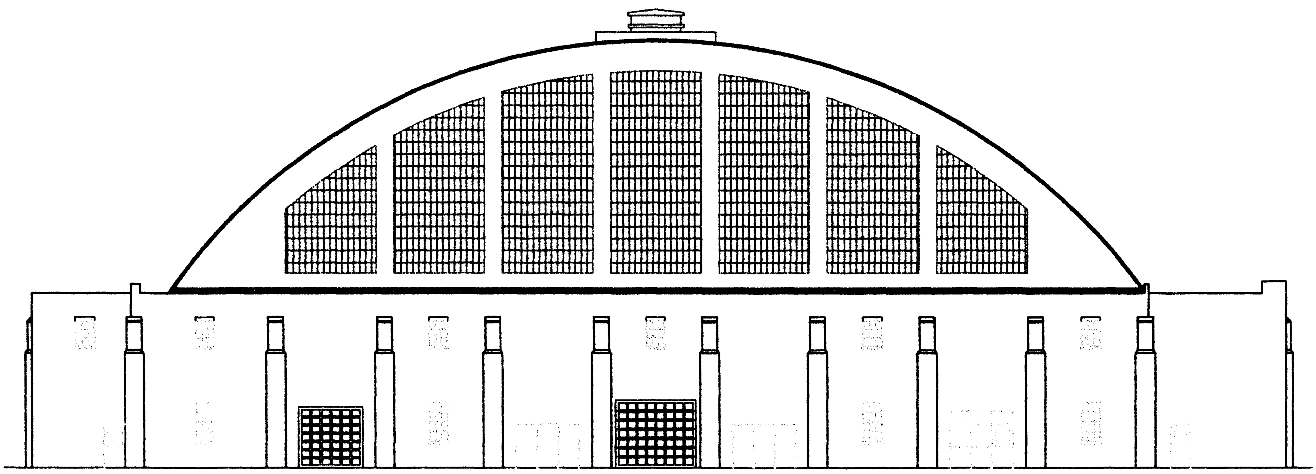

Figure 39. Existing Exterior North Elevation (Scale: 1/32” = 1’0”)

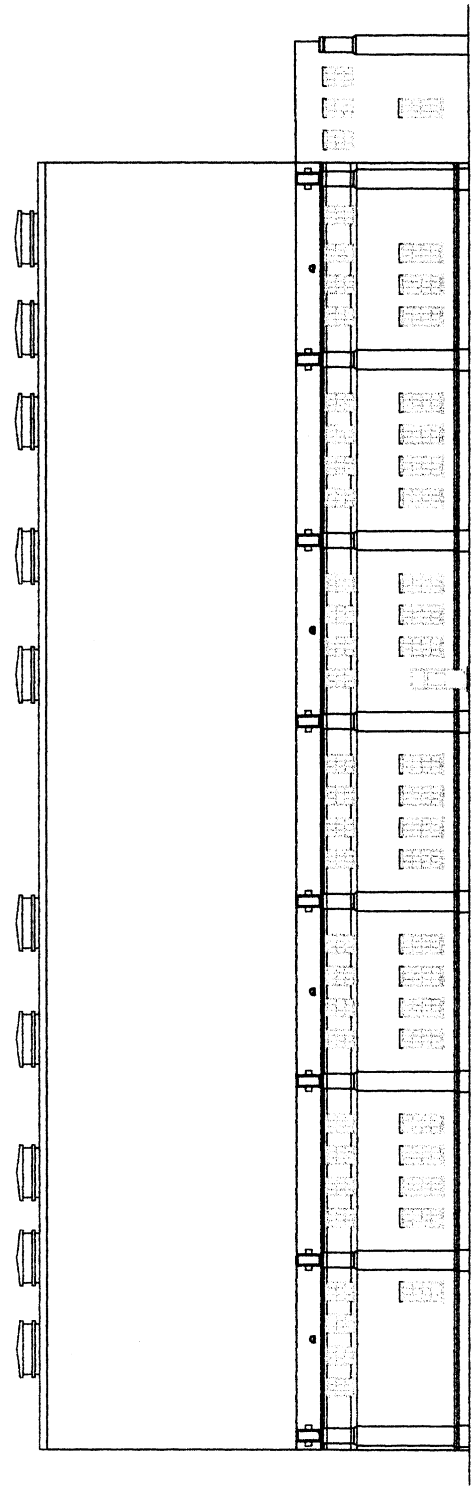

Figure 40. Existing Exterior East Elevation (Scale: 1/32 = 1'0")

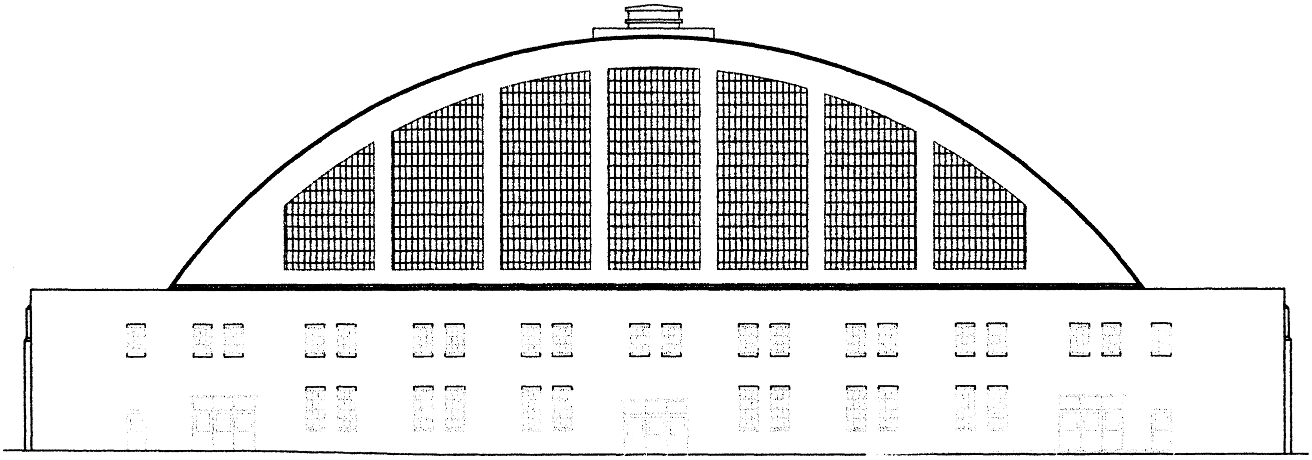

Figure 41. Existing Exterior South Elevation (Scale: 1/32" = 1'0")

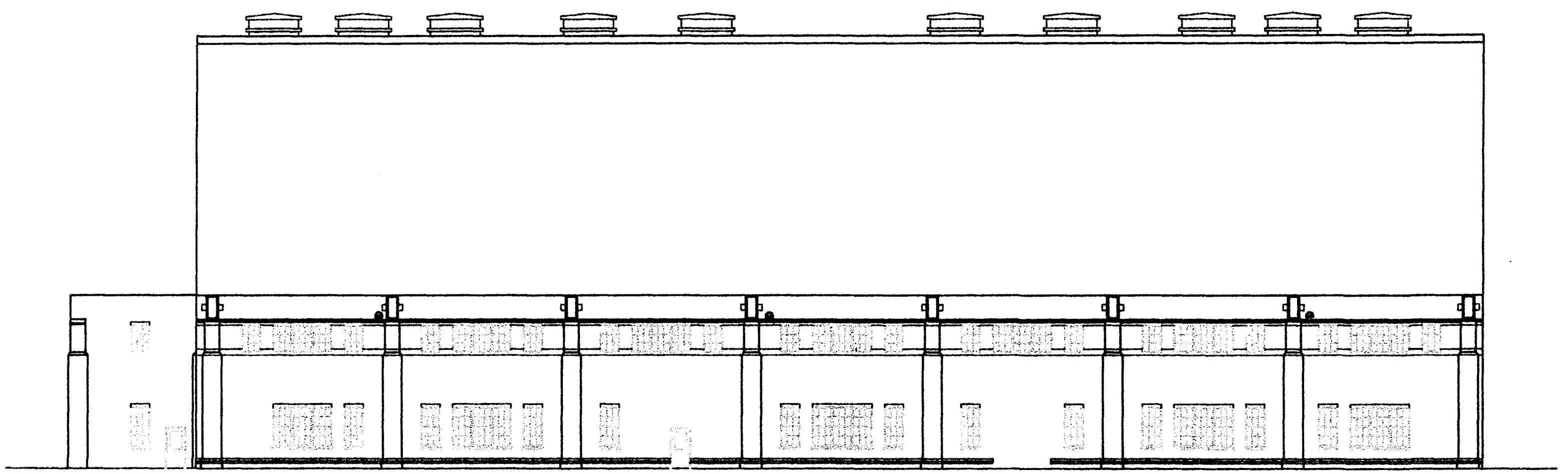

Figure 42. Existing Exterior West Elevation (Scale: 1/32" = 1'0")

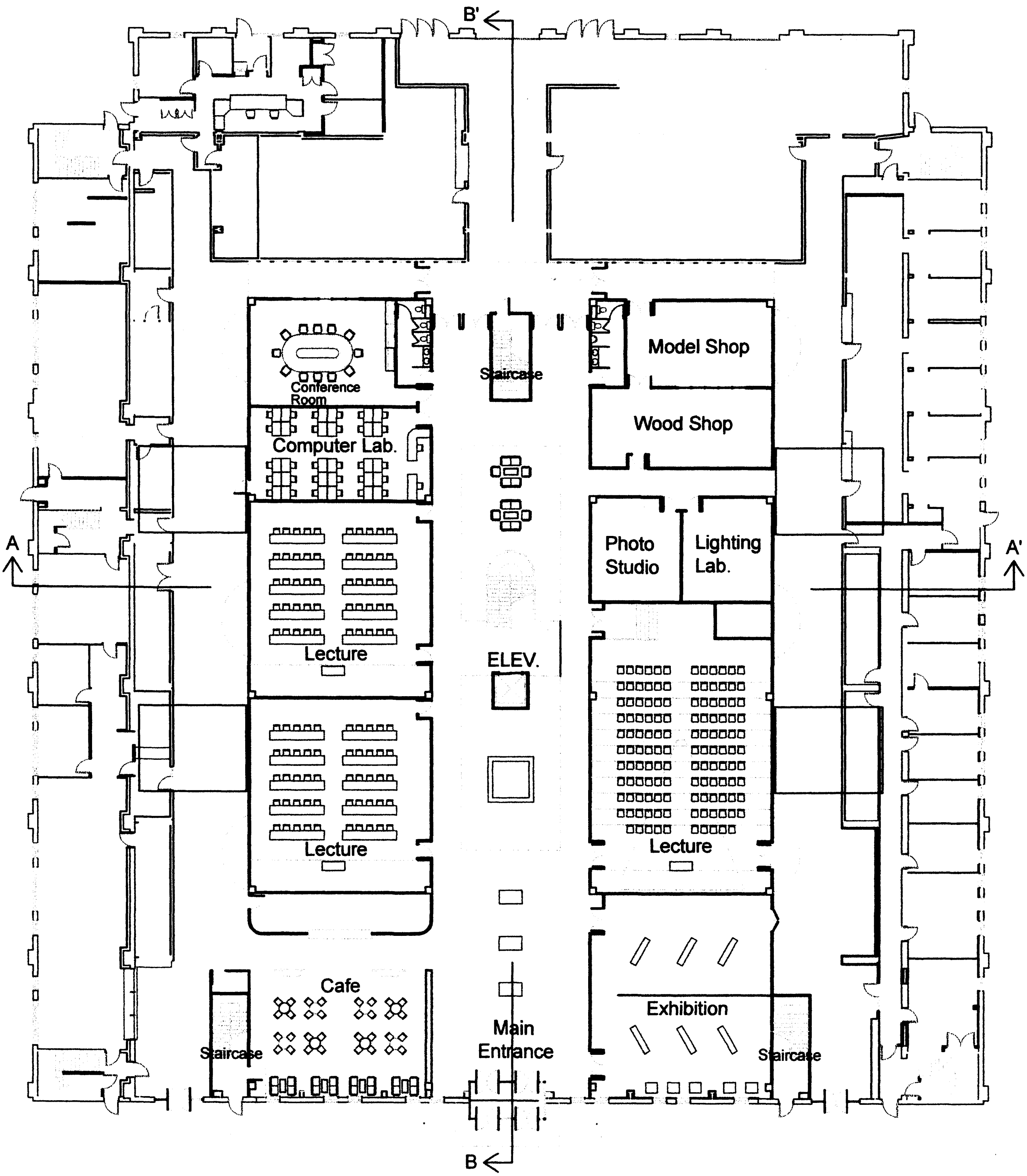

Figure 43. Proposed First Floor Plan (Scale: 1/32" = 1'0") ↑N

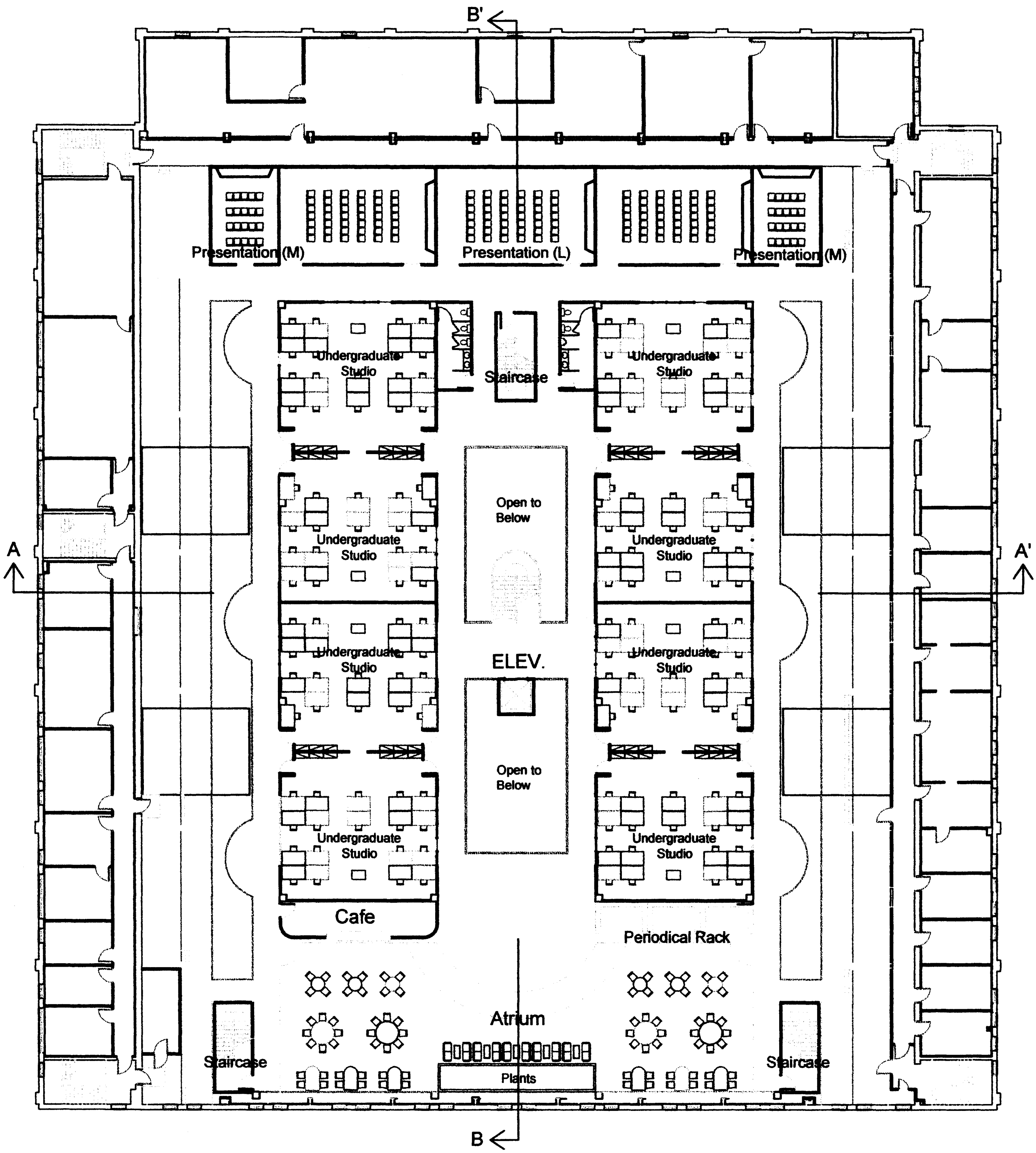

Figure 44. Proposed Second Floor Plan (Scale: 1/32" = 1'0") ↑N

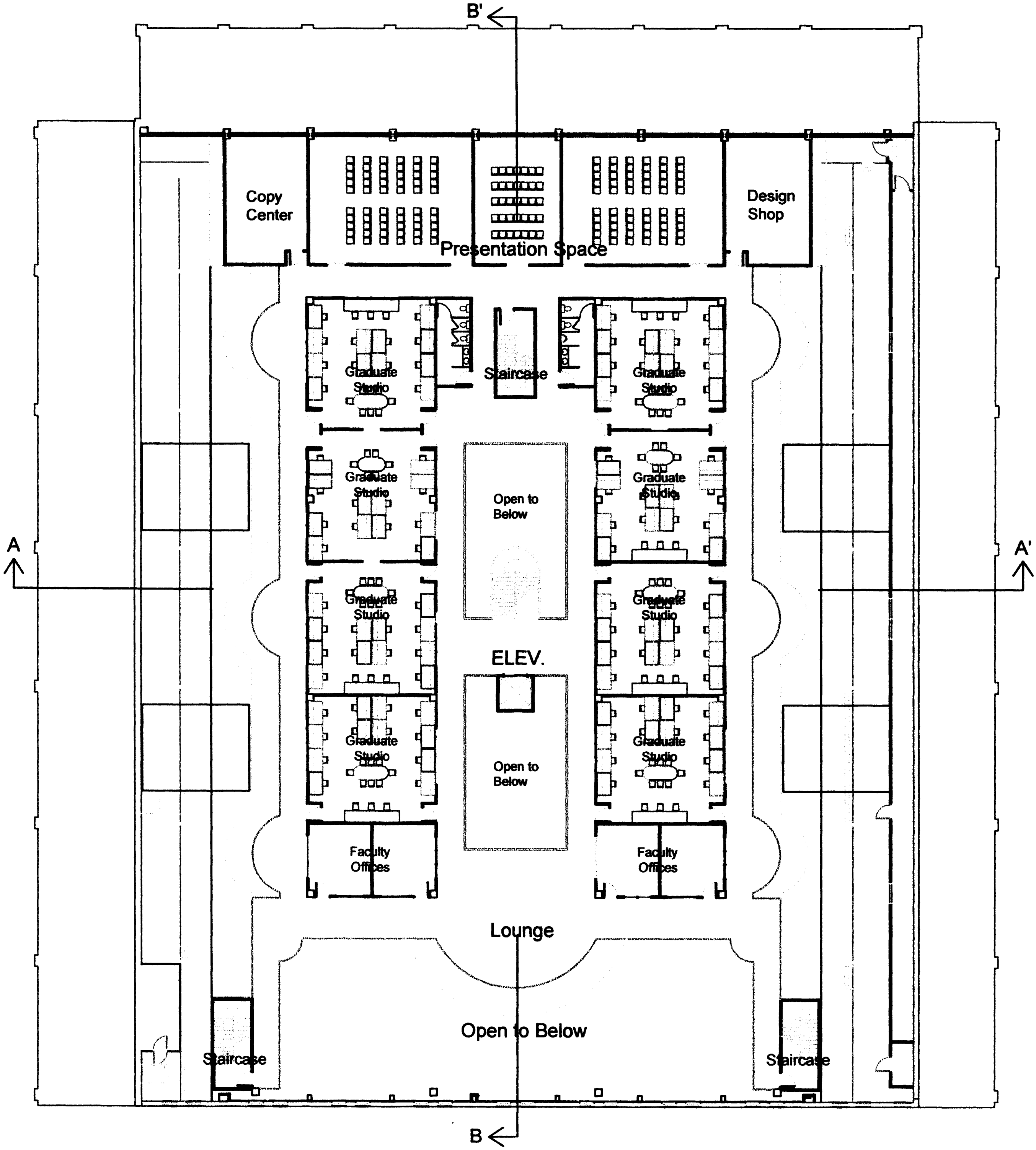

Figure 45. Proposed Third Floor Plan (Scale: 1/32" = 1'0") ↑N

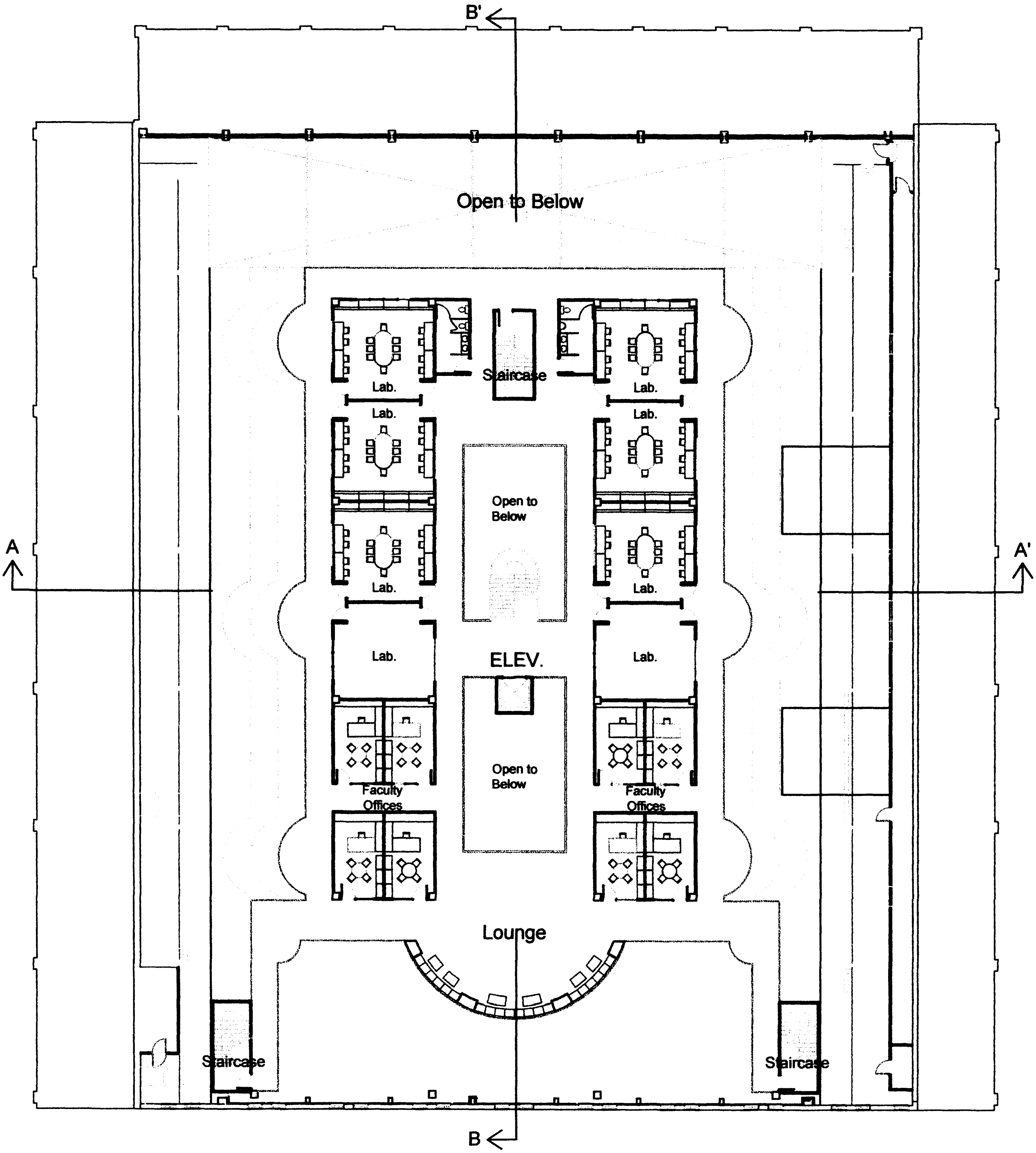

Figure 46. Proposed Fourth Floor Plan (Scale: 1/32" = 1'0") ↑N

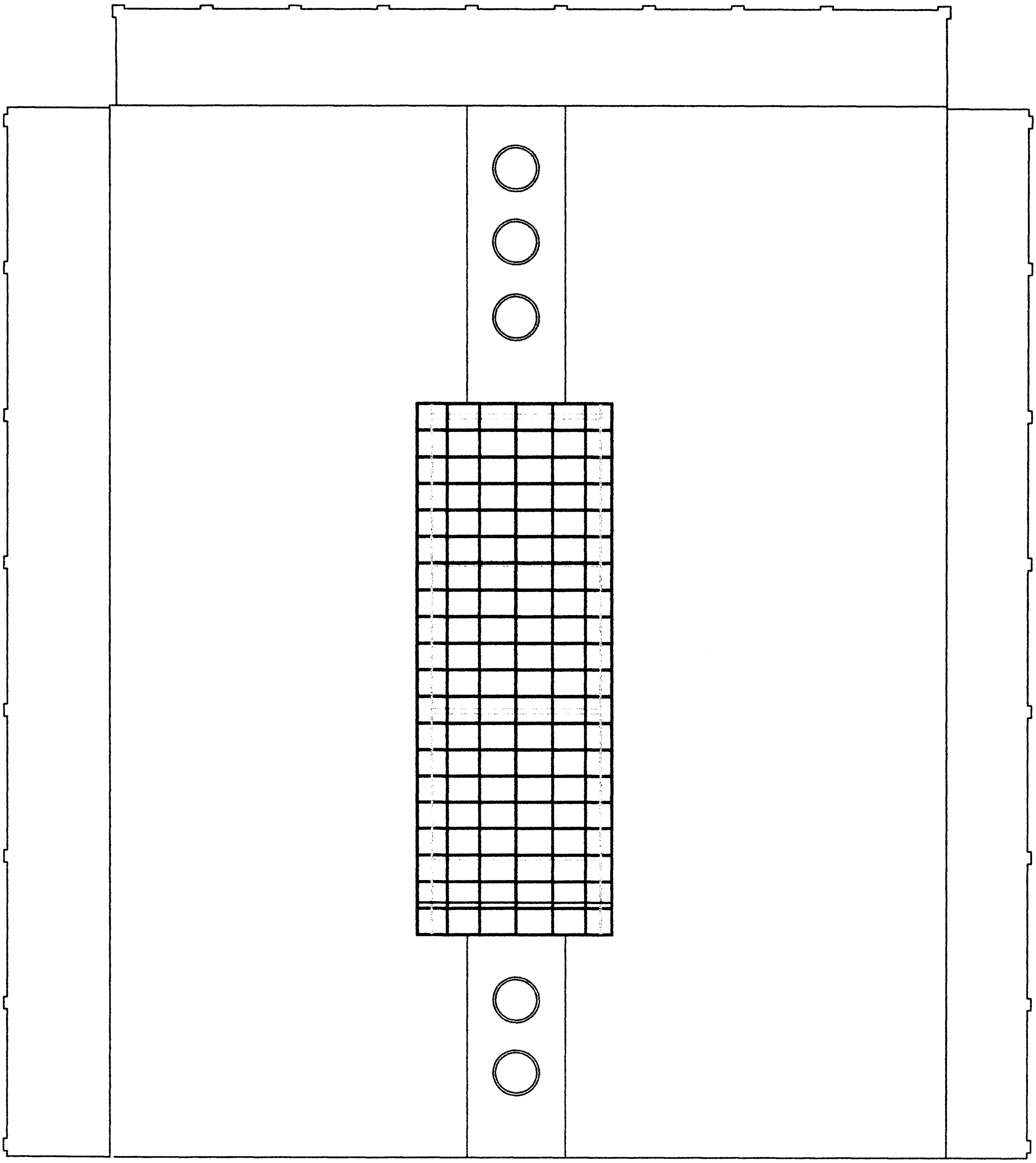

Figure 47. Proposed Roof Plan (Scale: 1/32” = 1’0”) ↑N

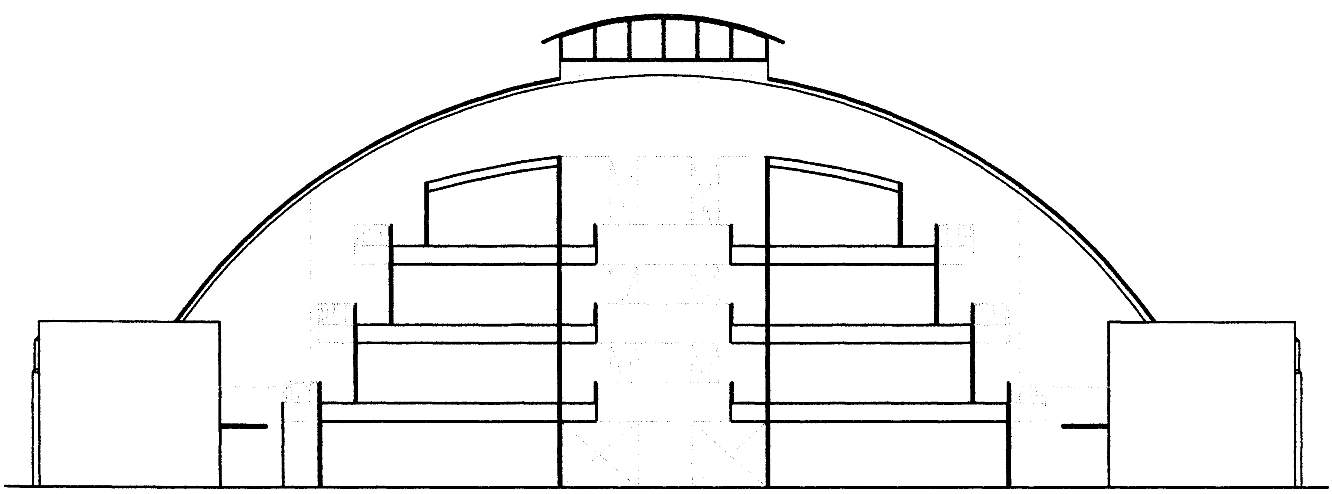

Figure 48. Proposed Transversal Section (Scale: 1/32" = 1'0") B - B'

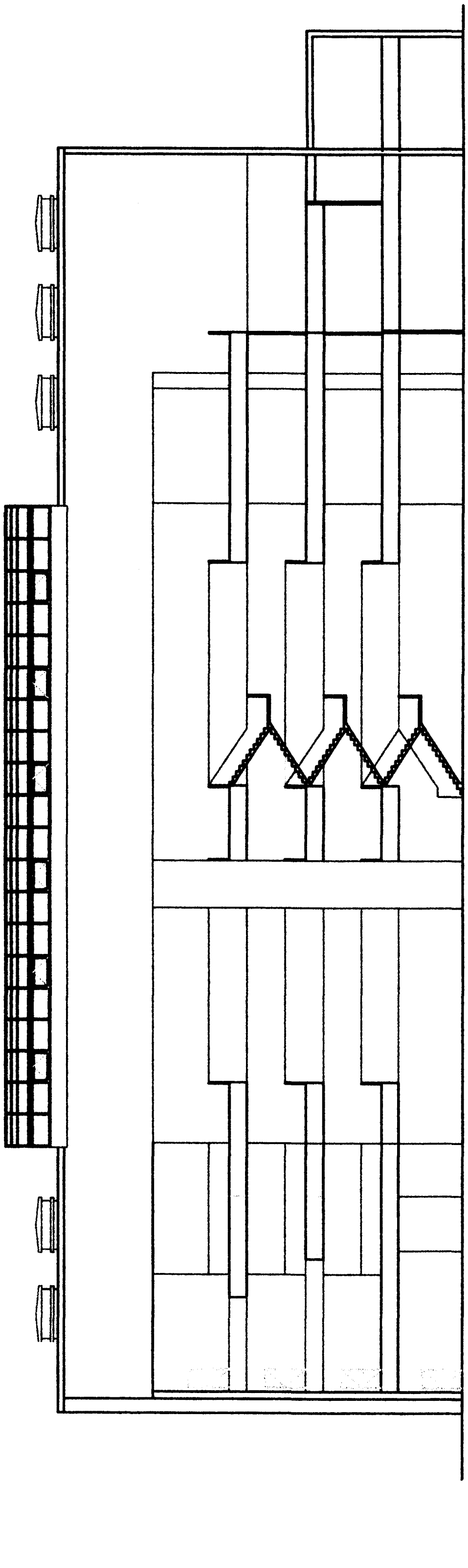

Figure 49. Proposed Longitudinal Section (Scale: 1/32" = 1'0") A – A'

APPENDIX B. PERSPECTIVES OF THE ARMORY BUILDING

Figure 50. South Entry

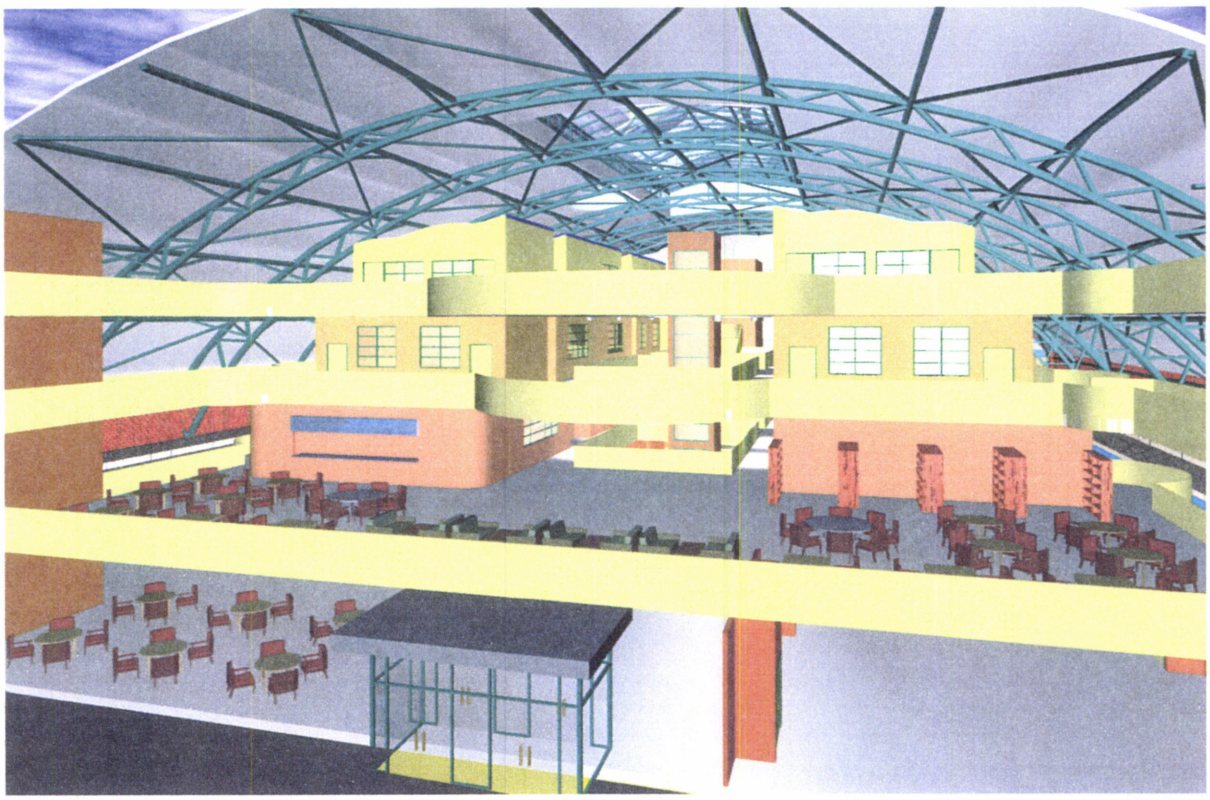

Figure 51. South View-1

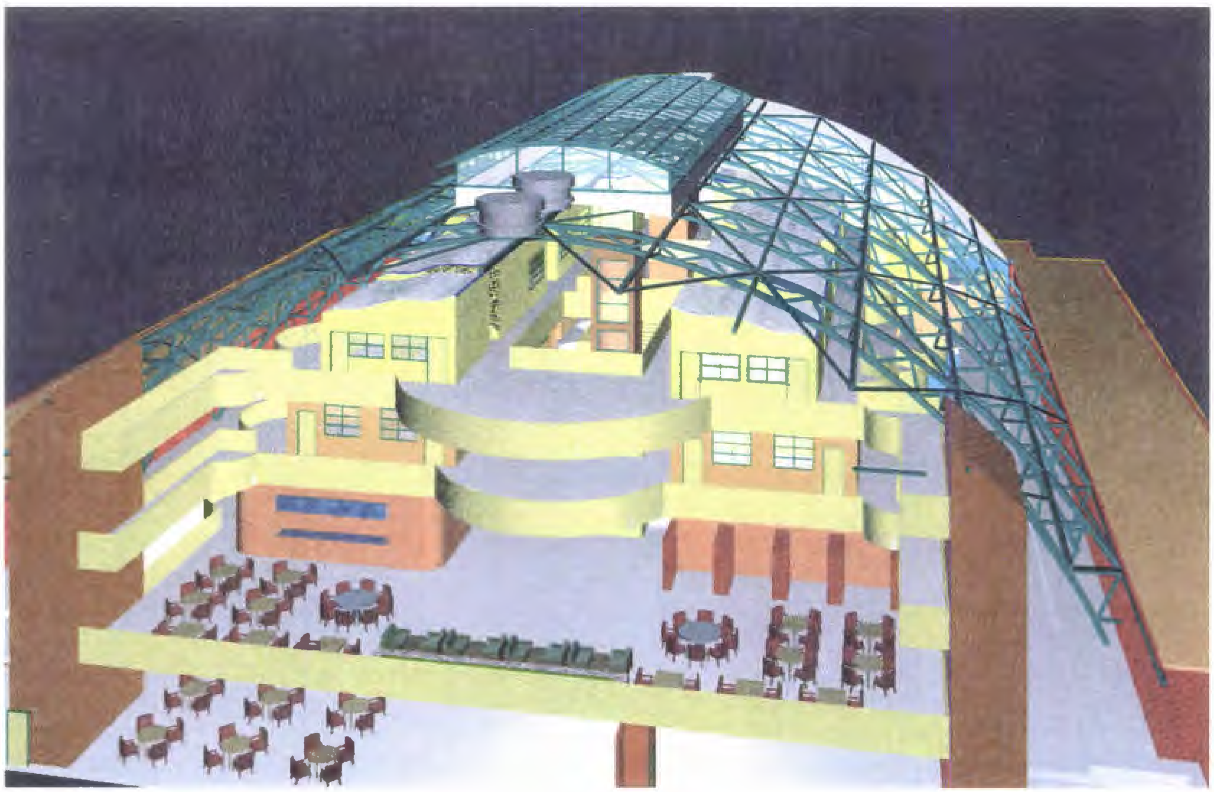

Figure 52. South View-2

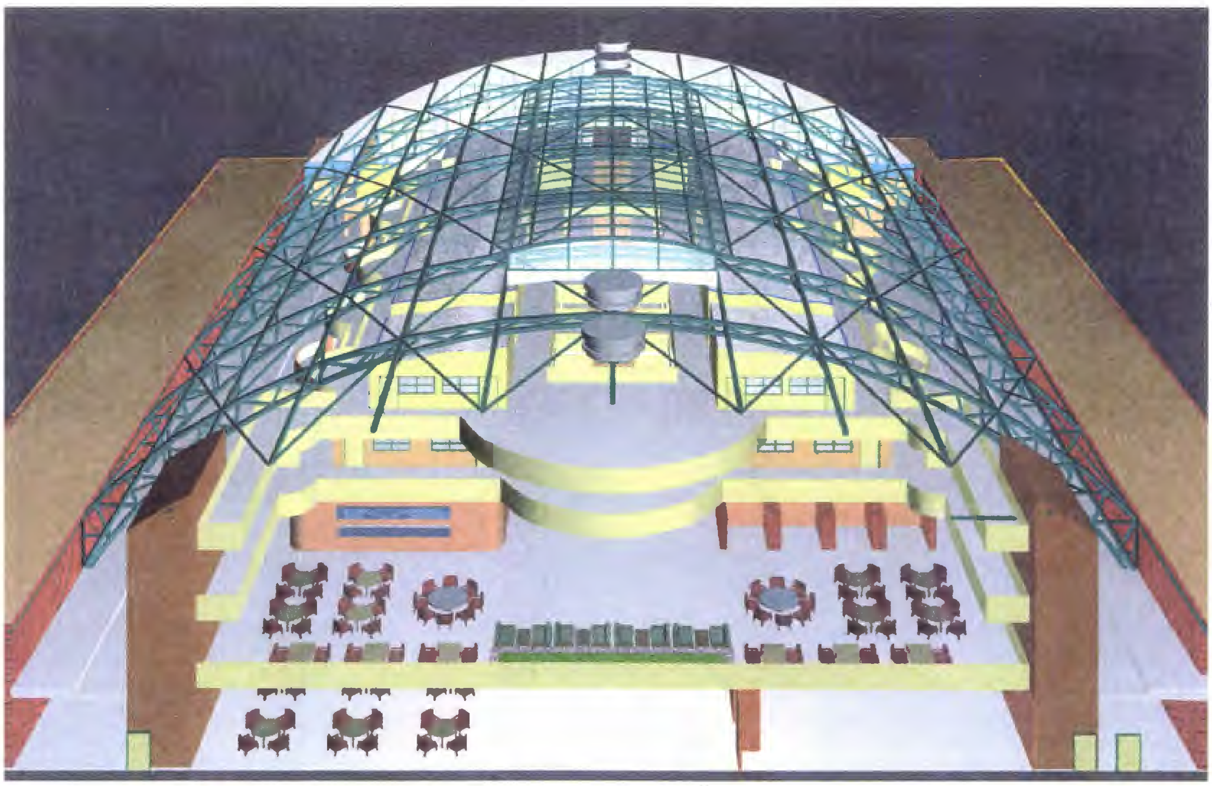

Figure 53. Roof Structure

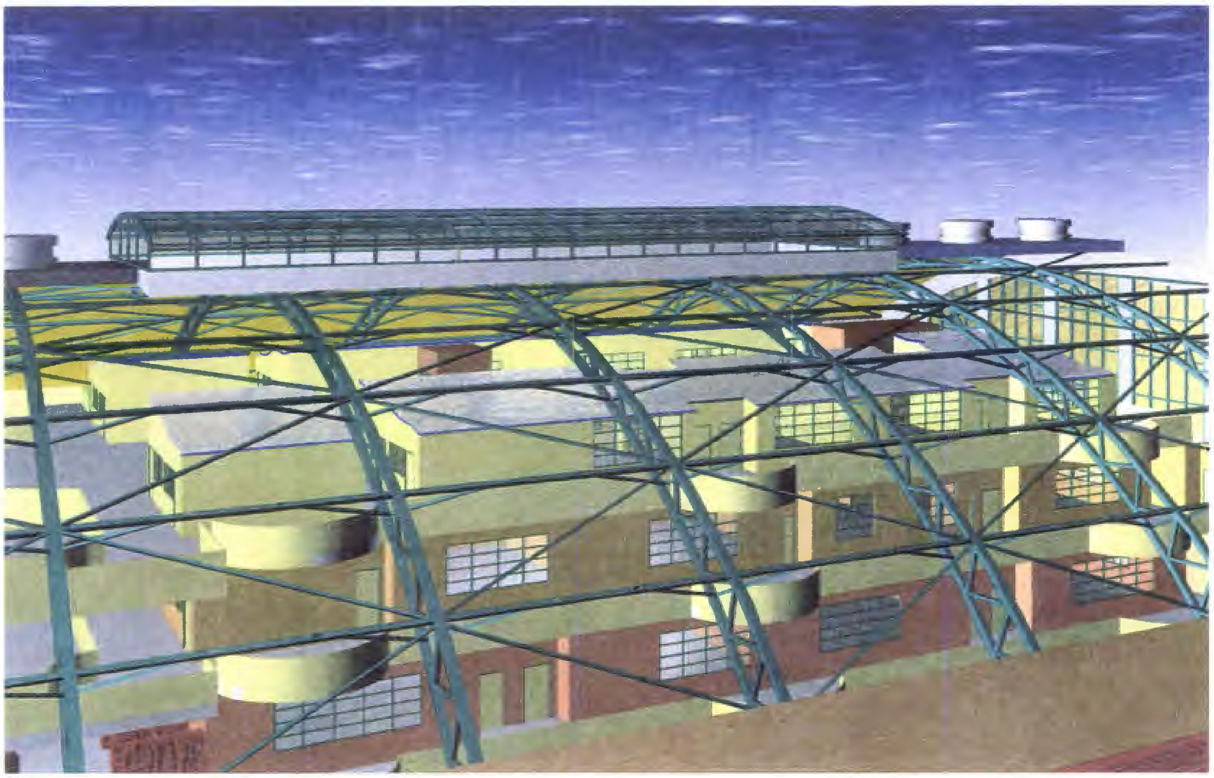

Figure 54. East View

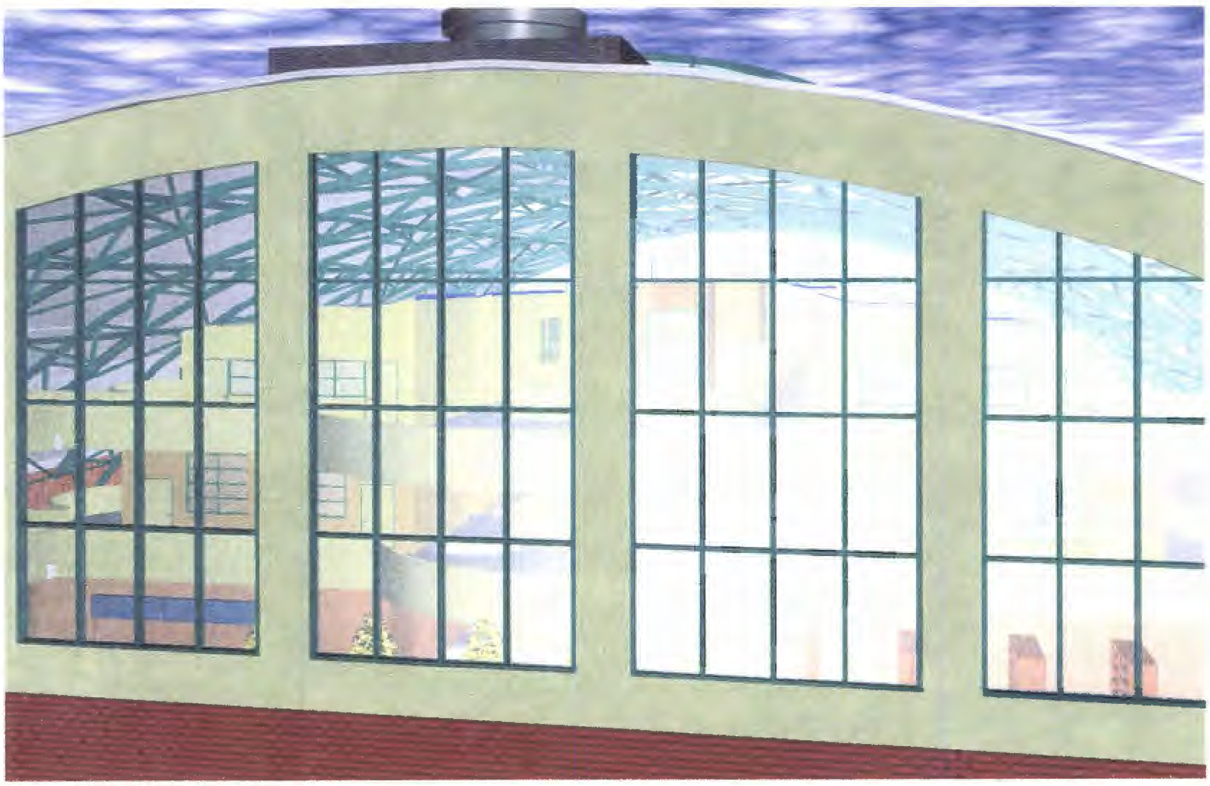

Figure 55. South Elevation

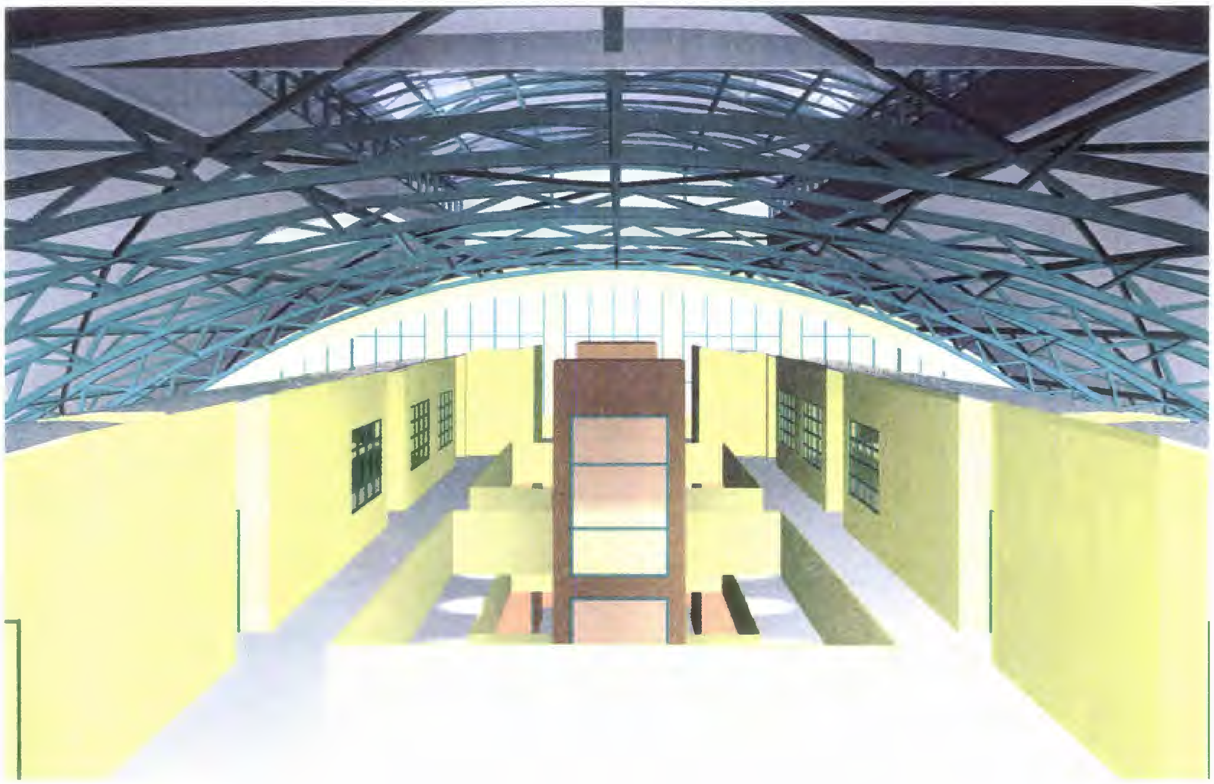

Figure 56. Fourth Floor Core – Facing North

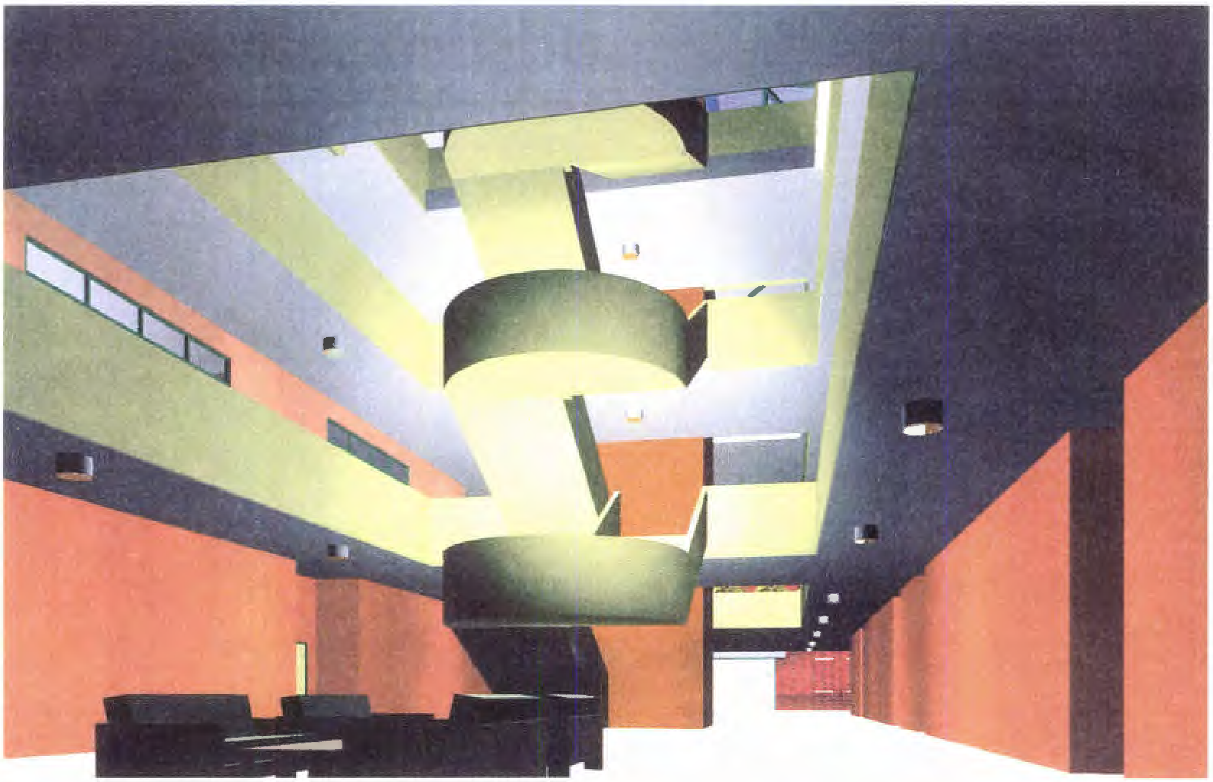

Figure 57. Atrium – Facing South

APPENDIX C. DRAWING AND PERSPECTIVES OF THE GRADUATE STUDIO

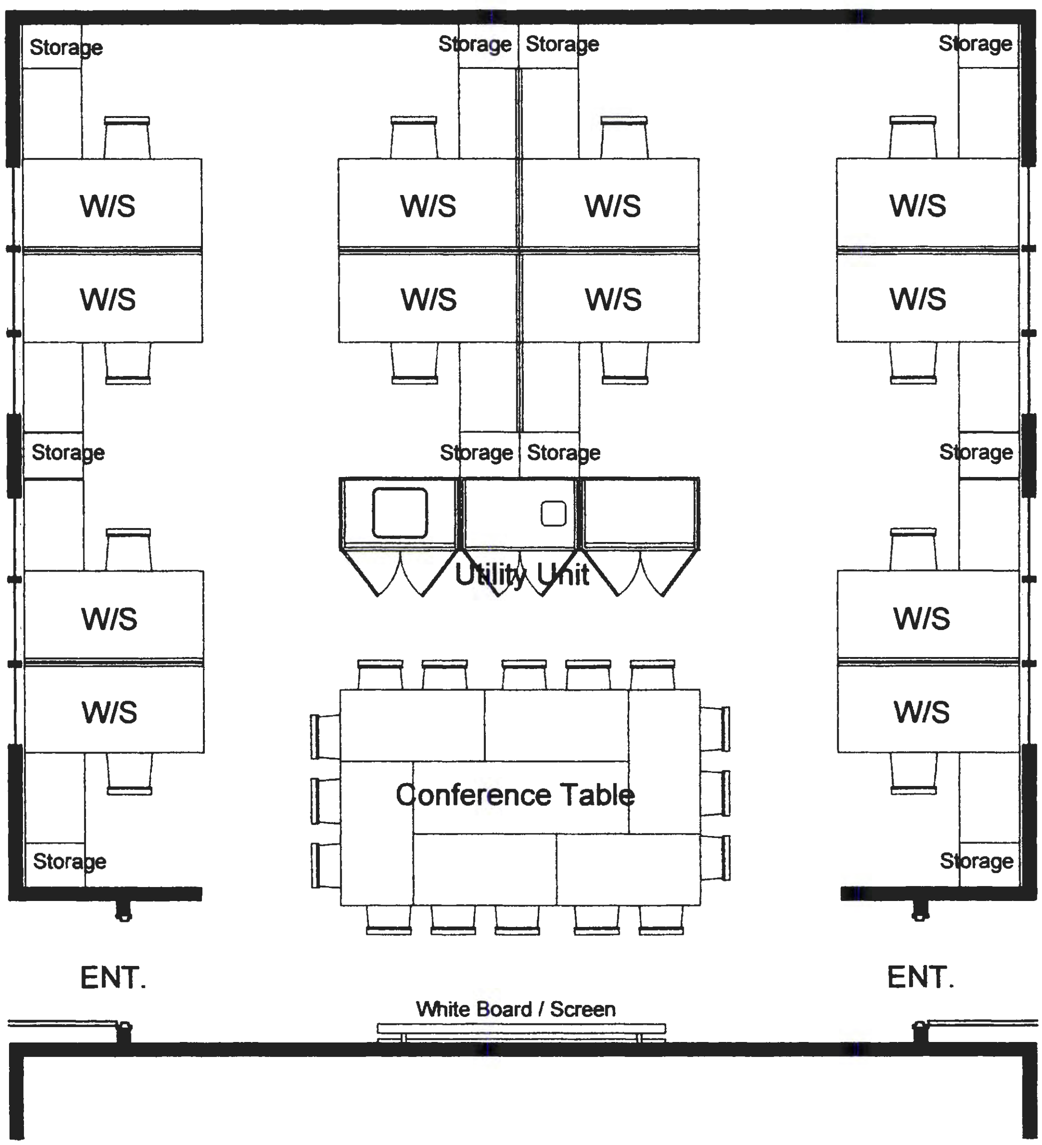

Figure 58. Floor Plan (Scale: 3/16" = 1'0") ↑N

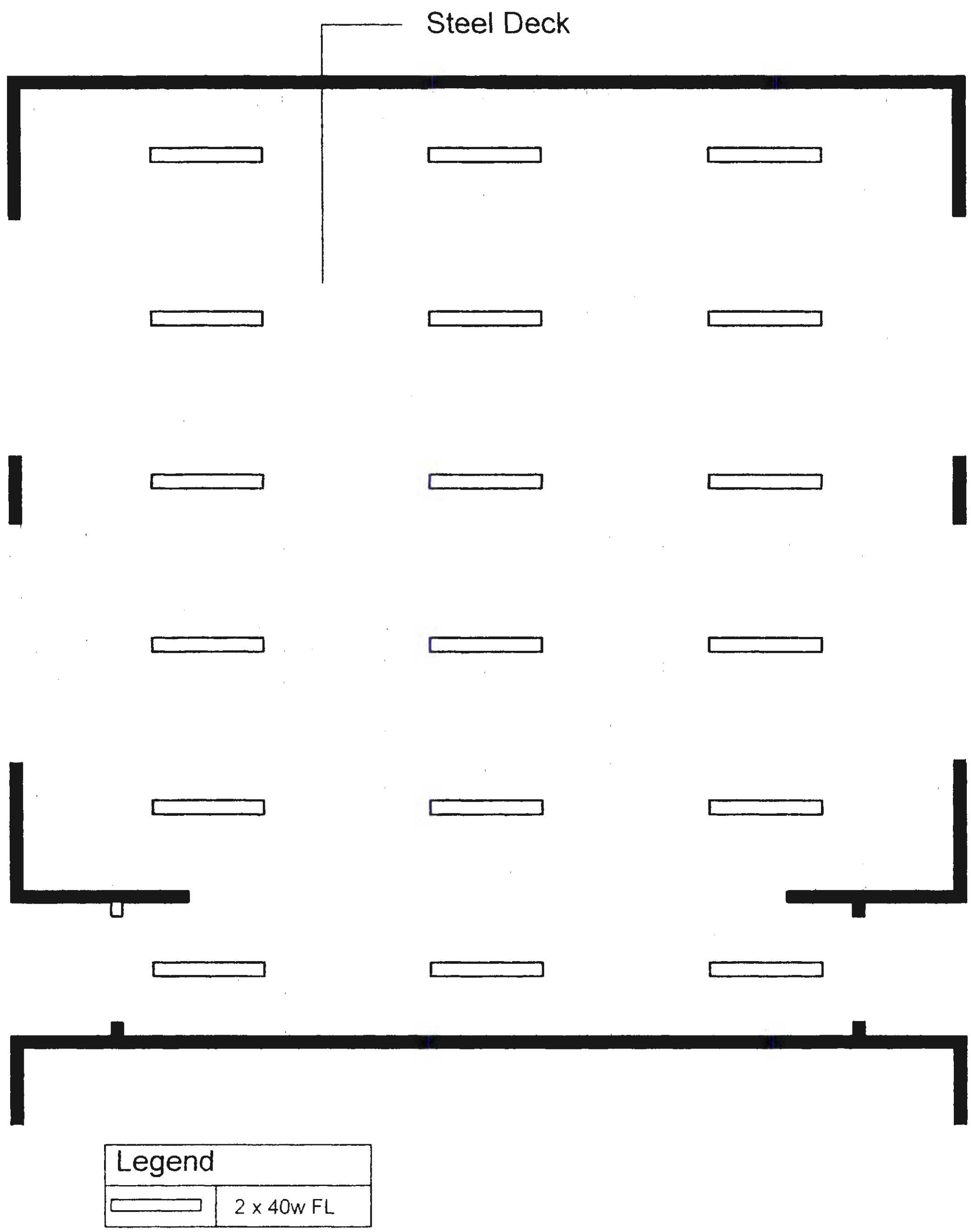

Figure 59. Reflected Ceiling Plan (Scale: 3/16" = 1'0") ↑N

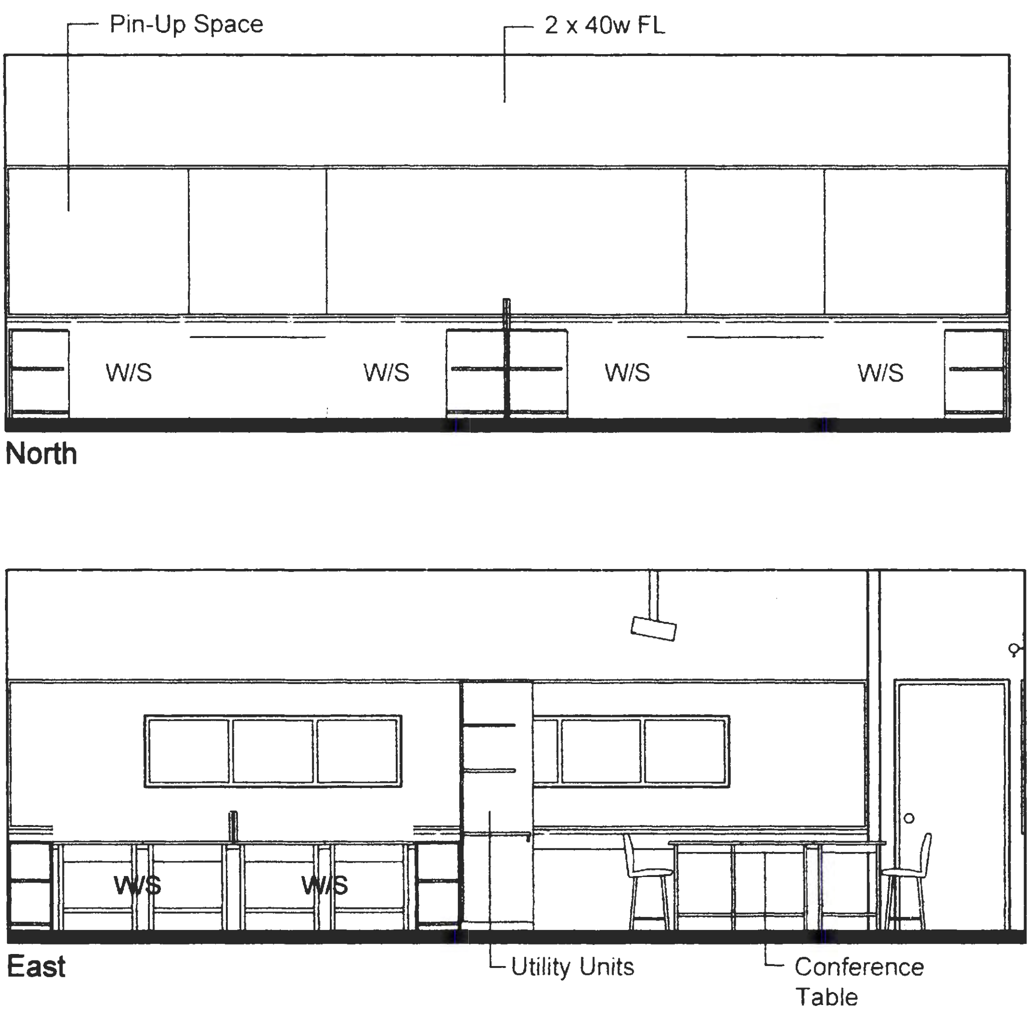

Figure 60. Elevations – North & East (Scale: 3/16" = 1'0")

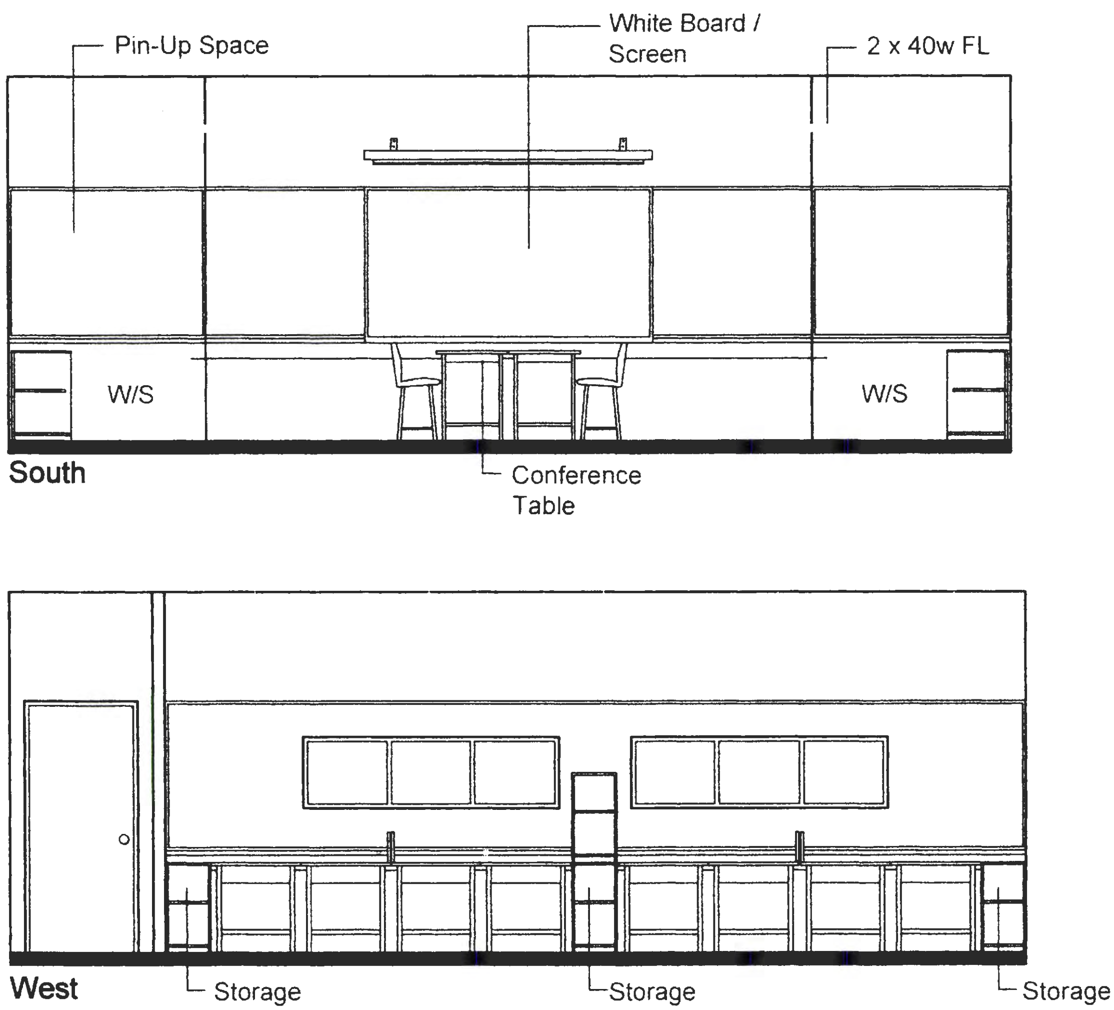

Figure 61. Elevations – South & West (Scale: 3/16” = 1’0”)

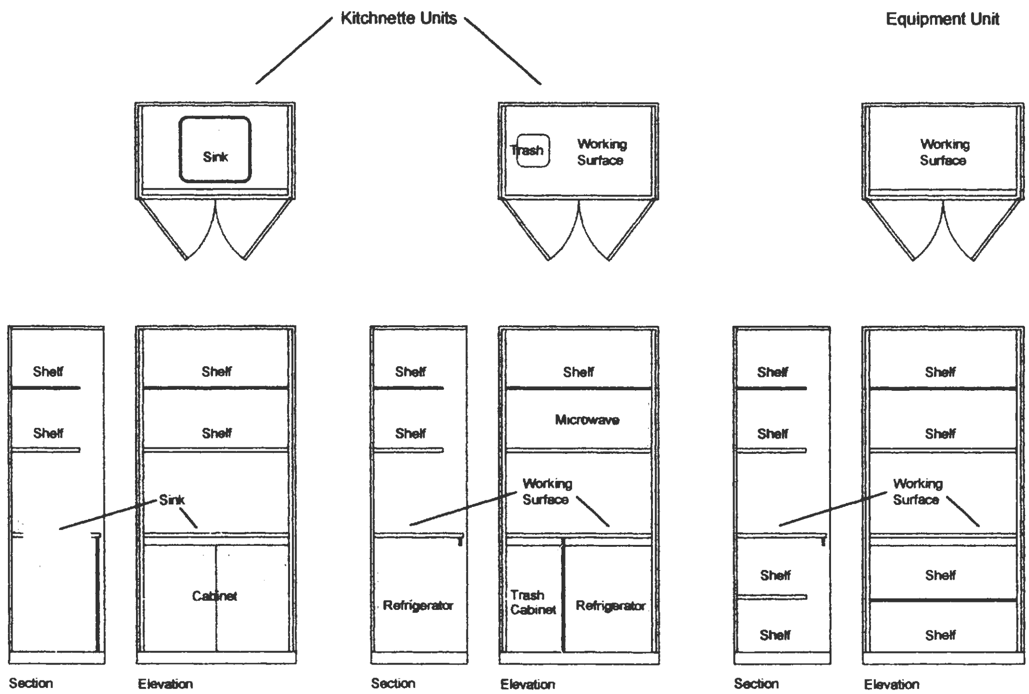

Figure 62. Utility Unit Detail (Scale: 1/4" = 1'0")

Figure 63. Perspective – Conference Space and Utility Units

Figure 64. Perspective – Conference Space and White Board and Screen

Figure 65. Perspective – Workstation

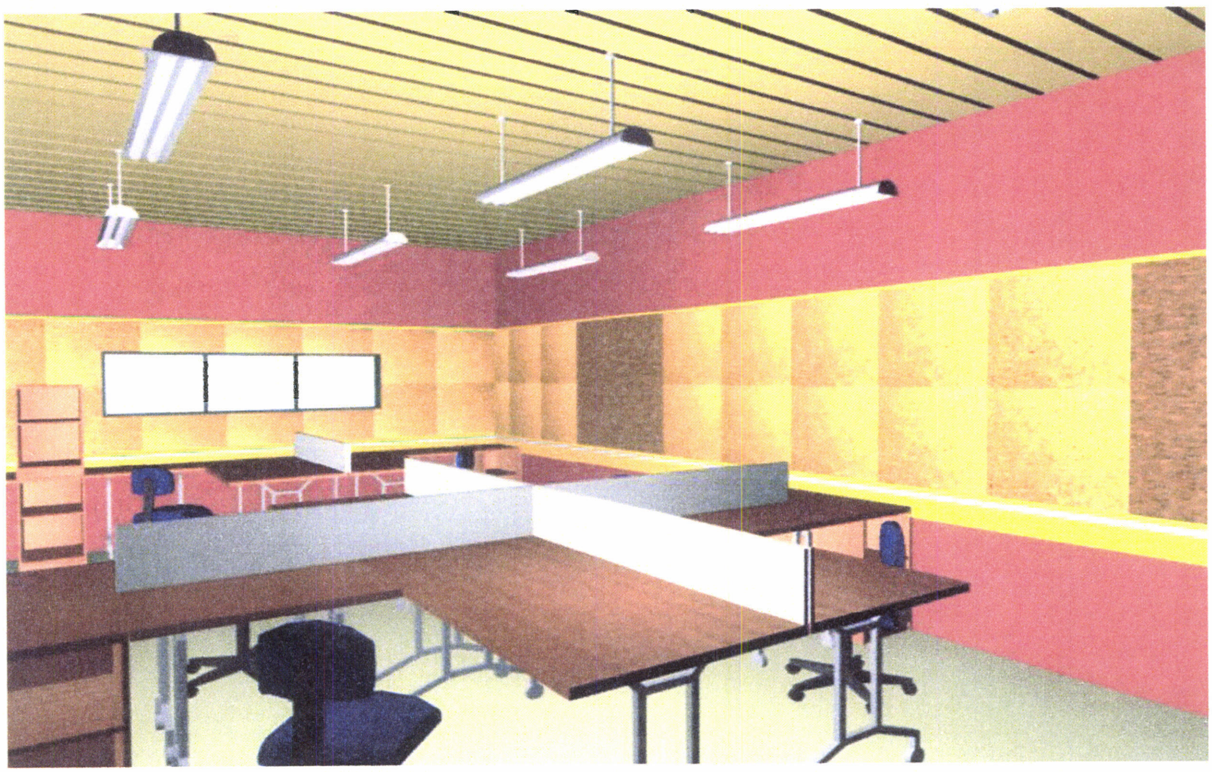

Figure 66. Perspective - Workstation

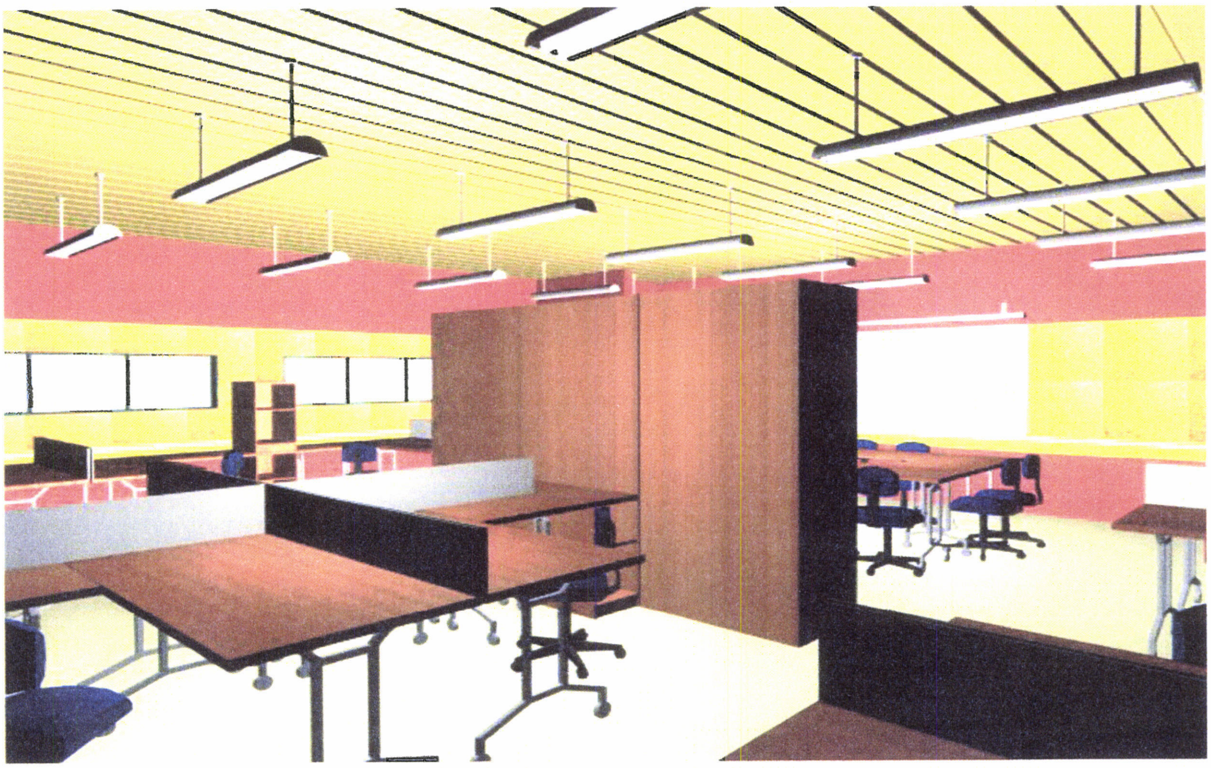

Figure 67. Perspective - Workstation

Figure 68. Perspective - Workstation

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ACKNOWLEDGEMENTS

Several people have been particularly helpful to me in the completion of this thesis. I extend my sincere gratitude to my committee members, Professors David A. Block and Frederic Malven, for their invaluable advice and commitment. I also express my utmost appreciation to my major professor, Professor Çigdem T. Akkurt. I am grateful for her enthusiastic interest, suggestions, and patience with me in completing this study.

I thank Dorothy Dake for her time and assistanace in editing this paper. I am also in debted to Hasan Akkurt, for his contious support in the realization of this study.

Finally, I thank my wife and lovely kids for their encouragement and their generous support ehich have been the source of my inspiration throughout. Without them, I would not have realized my dream. And, I thank my parents for their unconditional love and support.