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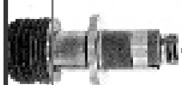
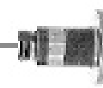
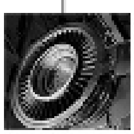
Program

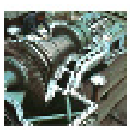
Focus

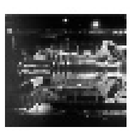


Facility For Industrial Technology and Power Generation









Old Main Plant Site

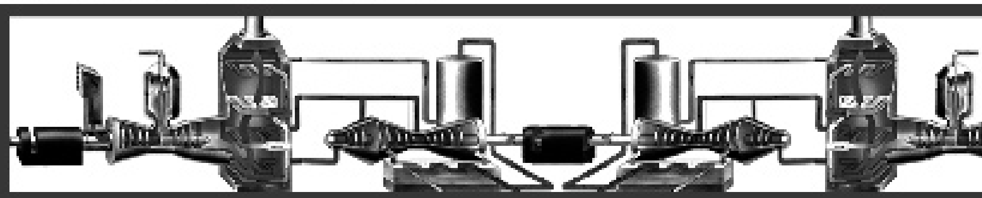
East River Road

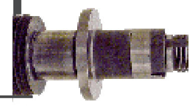
University of Minnesota

Architectural Thesis

Andrew E. Koedam

energy





THESIS PROJECT 05

FACILITY FOR INDUSTRIAL TECHNOLOGY
AND
POWER GENERATION

A Design Thesis Submitted to the
Department of Architecture and Landscape Architecture
of North Dakota State University

By

Andrew E. Koedam

In Partial Fulfillment of the Requirements
for the Degree of
Bachelor of Architecture

Primary Critic - Cindy Urness
Assistant Professor of Architecture

Secondary Critic - Angela Hansen
Assistant Professor of Landscape Arch

Blind Thesis Critic - Don't Know
Associate Professor of Architecture

Thesis Committee Chair - Don Faulkner
Department of Architecture

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Department of Architecture

Department Chair - Paul Gleye
Dept. of Arch and Landscape Arch

May 2005
Fargo, North Dakota

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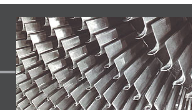

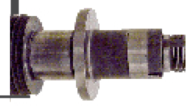

THESIS PROJECT 05

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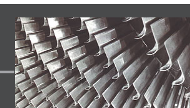

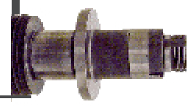

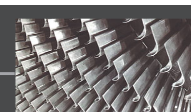

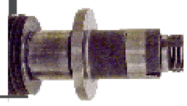

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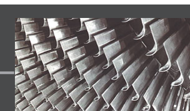

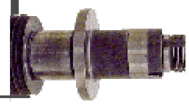

THESIS PROJECT 05

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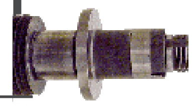
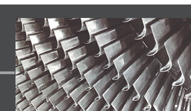
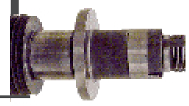


ABSTRACT

Reasoning and insight into a facility for industrial technology and power generation.



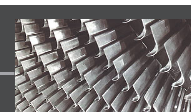


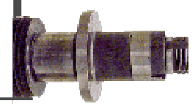
1.2 ABSTRACT

The University of Minnesota is currently among the top four leaders in the nation for industrial and mechanical engineering research. Their demand for innovative testing and research facilities grows as new discoveries are further being explored. The University is determined to utilize its ability to perform complex research, ultimately becoming one of the most advanced energy research elements in the world. The Facility for Industrial Technology and Power Generation will provide the essential means necessary to accomplish this goal. The 25 year 297 million dollar University facilities renovation project opened the door, allowing a facility of this typology to emerge. This development provides the University 55 million dollars in funding from the U.S. Department of Energy. It also provides a federal grant that will fund research into developing and testing new fuel sources and make coal burning more efficient and clean.

(Univ. of Minn., 2004, Steam Plant Facts Sheet)

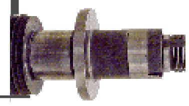
The importance of this research is invaluable to spatial environments, exterior/interior, natural environments, and the overall quality of life. This design thesis centers on solving the demand for larger, more adequate testing facilities, laboratories, and classrooms. These elements will support the advances in research along with the University's need for fuel storage and transport. The solution will create positive connections and relationships while meeting the needs of the University and its industrial/mechanical engineering department on campus.





ESSENCE

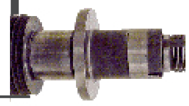
The heart of creating an advanced research facility for industrial technology and power generation.



2.4 ESSENCE

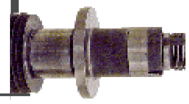
The exploration of power and energy comes from the minds drive to fulfill functional needs. This is ironic in the sense that the mind itself is powered by some incoherent energy that cannot be defined. Is all energy then created from the mind and its desire to fulfill functional needs? No, it is the energy within the mind that allows us to design energy and harness its power. The idea then is to create a sense of energy that harnesses and embraces the minds drive in fulfilling functional needs of foreseeable elements in power generation and industrial technology.

“We have only to speak of an object to think that we are being objective. But, because we chose it in the first place, the object reveals more about us than we do about it. What we consider to be our fundamental ideas concerning the world are often indications of the immaturity of our minds.” - G. Bachelard



BACKGROUND

Information and insight into a facility for industrial technology and power generation.



A6. BACKGROUND

PROJECT TITLE:

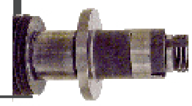
- Facility for Industrial Technology and Power Generation

PROJECT LOCATION:

- University of Minnesota Campus
  Old Main Power Plant
  East River Road

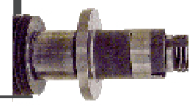
PROJECT BACKGROUND:

The University of Minnesota funds a large amount of technological research and development, aimed at improving mechanical functions HVAC and future means of power-heat generation. The importance of this research is invaluable to spatial environments exterior/interior, natural environments, and the overall quality of life. There is a demand for larger, more adequate testing facilities, laboratories, and classrooms to support the advances in research, fulfilling the needs of the engineering departments on campus.



TYPOLOGY

An architectural type. Typological precedents or analogous similarities to related buildings/projects.



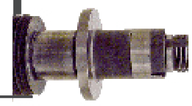
B8. TYPOLOGY

PROJECT TYPOLOGY:

1. The Focus on an architectural type. A building type the project is most closely related or associated to.

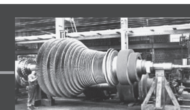
THESIS TYPOLOGY:

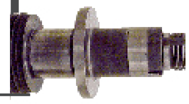
This design thesis will define the development of a Facility for Industrial Technology and Power Generation collaborated with the mechanical and industrial engineering programs on the University of Minnesota Twin Cities campus. The mixed-use building will identify testing facilities, laboratories, and classrooms integrated with an interpretive/recreation facility to encourage interaction among users. The design will also develop as an adaptive–reuse, utilizing the ruins still present from the Old Main Steam Plant and the non functioning Burlington Northern railroad bridge. The bridge currently has been converted into a pedestrian walkway connecting the east and west banks of the Mississippi River.



UNIFYING IDEA

A theoretical premise - an intellectual question the thesis researches and explores.





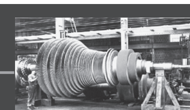
C10. UNIFYING IDEA

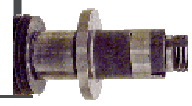
UNIFYING IDEA/THEORETICAL PREMISE:

1. The focus of design or the design exploration that will focus the solution to the problem.

UNIFYING IDEA/THEORETICAL PREMISE:

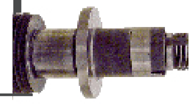
The design idea primarily focuses on satisfying functional needs to advance mechanical, industrial, and power generation research. Interactive research labs and classrooms provide the means necessary to progress research and developments. The design will create positive connections on campus with involved user interaction and provide a gateway to explore advanced systems and means utilized throughout the nation. The facility reacts to the users advanced needs while providing aesthetic appeal and relationships to the campus and community as a whole. The design's secondary function is providing a means of fuel storage and transport for the University's main steam supplier, SE Steam Plant, located one half mile up river. Function is the primary element that will drive the overall design, providing solutions to the needs of research, fuel storage/transport, and public connection.





JUSTIFICATION

Why the project defined is important personally and societally. A thesis demonstrating knowledge, skill and ability.



D12. JUSTIFICATION

PROJECT JUSTIFICATION:

1. Why the project is important (personal and societal). Project's ability to demonstrate knowledge and skill.

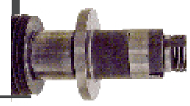
"The Mississippi River is a wonderful book that was not meant to be read once and thrown aside, for it has a new story to tell every day." - Mark Twain

Heating Plant Facilities:
- U of M
- SE Steam Plant
- Minneapolis Main
- St. Paul

Totaling 15 primary coal fired boilers, average age of 34 years, requiring 2.5 billion pounds of steam to be produced each year for the University of Minnesota campus.

(U of M, 2004, Steam Plant Facts Sheet)

The Facility for Power Generation and Industrial Technology is incubated by these statistics - offering a solution, or the means in finding a solution.



D13. JUSTIFICATION

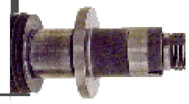
In 1988, a study was conducted of the University's utilities by CRS Sirrine, showing that the antiquated steam system required extensive renovation or replacement within ten years. The University set up a list of criteria in which contract proposals would be evaluated:

- Obtaining the lowest steam cost possible
- Ensuring fuel price protection through fuel flexibility of price guarantees
- Minimizing adverse environmental and health impacts
- Minimizing the financial risk for the University

In 1992, the University accepted a 25 year 297 million dollar contract with Foster Wheel which agreed to:

- Significantly reduce air pollution
- Produce energy through Cogeneration – convert excess steam into electricity
- Upgrade SE Steam Plant and St. Paul Plant
- Close the Old Main Steam Plant converting into fuel storage and transport to SE Steam Plant
- Allow flexibility in fuel choice, an environmental advantage

(U of M, 2004, Steam Plant Facts Sheet)



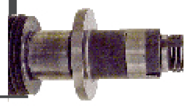
D14. JUSTIFICATION

The University also agreed to a voluntary participation in an Environmental Impact State (EIS) to ensure public health and safety. This agreement allowed the general public to have input on environmental consequences and review of environmental impacts.

(University, 2004, Services: Energy Oper.)

The benefits of the overall project are extremely valuable to the University and surrounding region. The addition of three, state-of-the-art boilers will encourage the use of fuel technology allowing the university to burn a variety of fuels such as: coal, natural gas, oil, and renewable resources, wood chips. This gives the university the ability to change fuels for economic and public health reasons, as new fuels are developed and research discovers more cost effective and environmentally sound energy sources. A secondary benefit is the use of cogeneration - passing the 2.5 billion lbs of steam over a turbine before heating the campus to produce an amount of electricity equal to the quantity used by the U of M campus.

(U of M, 2004, Board of Regents CW)



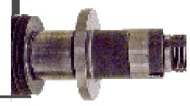
D15. JUSTIFICATION

The development of this project means a cost effective solution that reduces the amount of air pollution by 30% exceeding the UN goal of 20% by 2005. Financial stability is secured with 55 million dollars in funding from the U.S. Department of Energy Clean Coal Tech. Demonstration Program and an 86 million dollar capital investment in coal savings.

The University was honored with an undetermined federal grant that will fund research into developing new fuel sources and make coal burning more efficient and clean. Statistics show that nation wide, 60% of power production depends on coal, higher world wide, giving the University an opportunity to make a global “environmental” contribution.

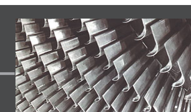
(U of M, 2004, Steam Plant Facts Sheet)

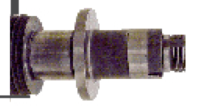
The Facility for Industrial Technology and Power – Generation will utilize the University’s decision to become one of the most advanced global energy research elements, providing the core for this design thesis. The facility is exceptional in its function, creating the explorations into finding a unique design solution.



USER/CLIENT

Defining specific identity of user/client groups involved with the facility for industrial technology and power generation, both quantitative and performance descriptions. Documentation of each user groups unique individual requirements including quantity, peak usage, and parking requirements.





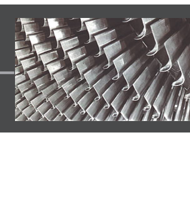
E13. USER/CLIENT

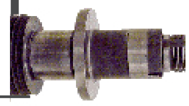
USER/CLIENT DESCRIPTION:

1. Identification and definition of users/clients involved.

The Facility for Industrial Technology and Power Generation will provide employment and research amenities to a variety of users while integrating a component of public involvement and interaction. Relationships developed through the University will support and encourage future developments leading to an additional user/clientele base: officials, industrial and power companies, and mechanical, industrial, and power generation research specialists.

- Students 50
- Faculty 10
- Lab Technicians 15
- Facility Staff 10
- Facility Maintenance 12
- Security 3
- Research Specialists 10
- Industrial/Power Companies 5
- General Public (Including Campus) 1000





E14. USER/CLIENT

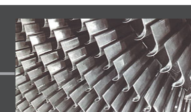
- STUDENTS: 50

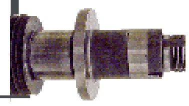
Students both undergraduate/ graduate will utilize all aspects of the facility. Collaborated education and research will allow students to explore and discover advanced means of fuel technology, power generation, and correlating systems. The University of Minnesota is among the top ten universities in the nation for industrial and mechanical engineering, awarding an average of 200 bachelor degrees, 50 master degrees, and 20 PhD's each year. This honorable recognition attracts 400 new students each year in the field of engineering.

(Dept. of Mech. Engin. at U of M, 2004.)

Of the 400, an average of 50 students will specialize in the study of industrial technology and power generation The addition of a new facility will attract more students each year and provide them with the necessary amenities for advanced education and research/ testing development.

(Industrial Engin. at the U of M, 2004.)



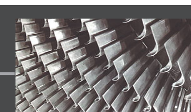


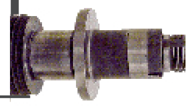
E15. USER/CLIENT

- FACULTY: 10

Faculty will have full use of the facility acting as a collaborative "hands on classroom". The facility becomes a tool for advanced education and research creating an interactive environment for students and faculty. The Facility for Industrial Technology and Power Generation will provide the technology and resources required for faculty and students to achieve viable research data. The University supports its Industrial and Mechanical Engineering programs with the help of 70 faculty members that provide means of higher education and advanced research background. Of the 70 faculty, 10 will perform research and testing procedures, including offices located within the facility. The facility only benefits because of the experience and determination of its faculty.

(Dept. of Mech. Engin. at U of M, 2004.)





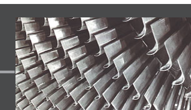
E16. USER/CLIENT

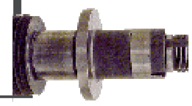
- LAB TECHNICIANS: 15

Lab technicians will provide support to advanced research and testing performed within the facility. The ability to assist and maintain research data is viable in achieving and discovering advanced means of industrial/ mechanical engineering and power generation. The facility will require a team of 15 full time lab technicians to provide the support and assistance to faculty and students. The quantity of lab technicians will vary slightly with the extent and length of each research and testing project.

- FACILITY STAFF: 10

Facility staff will perform office duties and handle public relations while managing overall operations of the facility. Staff and management will be in direct contact with the University facilities management and its college of industrial and mechanical engineering to make sure requirements are being met. A team of 10 personnel including management will be required to staff the facilities and its operations.





E17. USER/CLIENT

- FACILITY MAINTENANCE: 12

A team of 12 employees will manage and operate fuel storage and transport within the facility and to the SE Steam Plant while providing overall maintenance to the facility. Twelve employees are required with the University's renovation contract in order to assure no lay offs.

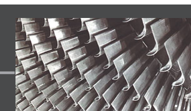
(U of M, 2004, Steam Plant Facts Sheet)

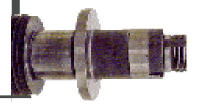
- SECURITY: 3

A team of 3 security guards will provide site and visitor access within the facility. Overall security measures will be handled in a manner not to discourage public interaction.

- RESEARCH SPECIALISTS: 10

Average rate 10 per month.
Officials and Specialists will be invited as guest lectures, consultants, and employees encouraged to perform collaborative research in support of the University and its mission to strive for national and global recognition.





E18. USER/CLIENT

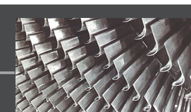
USER / CLIENT DESCRIPTION:

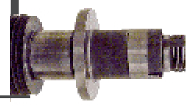
- INDUST./POWER COMPANIES: 5

Average 5 per month.
Industrial technology and mechanical engineering companies will be invited to observe and explore new technological advancements achieved by the University's respected departments. This idea offers increased clientele base for the University while providing employment and internship opportunities for students and faculty.

- GENERAL PUBLIC: 1000

Average 1000 per month.
The general public including campus will be encouraged to get involved and interact with the facility. The interpretive and recreational component will aid to utilize and inform the general public of advancements made in the industrial/mech. engineering and power generation fields. New research and discoveries will be accessible to the public in hopes of achieving environmental and economical benefits.

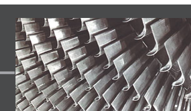


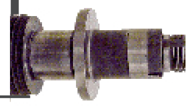


E19. USER/CLIENT

PEAK USAGE / ALLOWABLE ACCESS

Students:	Allowable Access: 24 hrs - 7 days a week Peak Usage: 7:00am – 10:00pm M-Su
Faculty:	Allowable Access: 24hrs - 7 days a week Peak Usage: 7:00am – 10:00pm M-Su
Lab Tech:	Allowable Access: 24 hours – 7 days a week Peak Usage: 7:00am – 10:00pm M-Su
Staff:	Allowable Access: 24 hours – 7 days a week Peak Usage: 7:00am – 5:00pm M-Su
Employees:	Allowable Access: 24 hours – 7 days a week Peak Usage: 7:00am – 5:00pm M-Su

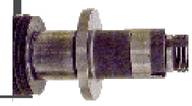




E20. USER/CLIENT

PEAK USAGE / ALLOWABLE ACCESS:

Security:	Allowable Access: 24 hours – 7 days a week Peak Usage: 12:00am – 12:00pm M-Su
Officials:	Allowable Access: 8 hours – 5 days a week Peak Usage: 7:00am – 5:00pm M-F
Specialists:	Allowable Access: 24 hours – 7 days a week Peak Usage: 7:00am – 10:00pm M-Su
Companies:	Allowable Access: 8 hours – 5 days a week Peak Usage: 7:00am – 5:00pm M-F
Public:	Allowable Access: 8 hours – 5 days a week Peak Usage: 7:00am – 5:00pm M-F



E21. USER/CLIENT

PARKING REQUIREMENTS FOR USER/ CLIENT:

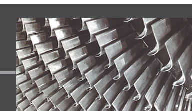
Parking Requirements are controlled under the University of Minnesota Parking Policy and ADA standards. Parking is determined at the discretion of the University.

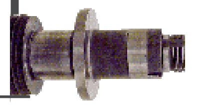
Students/Faculty:	25 stalls
Lab Tech/Employees:	30 stalls
Security/Staff:	15 stalls
Specialists/Companies:	10 stalls
General Public:	30 stalls
Total:	110 stalls

ADA Requirements:

1 - 25	1 van and 0 car stalls
26 - 50	1 van and 1 car stalls
51 - 75	1 van and 2 car stalls
76 - 100	1 van and 4 car stalls
100 - 200	1 van and 5 car stalls
201 - 300	1 van and 6 car stalls
301 - 400	1 van and 7 car stalls

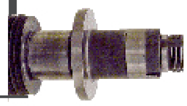
(AIA, 1994, Arch. Graphic Standards)





MAJOR PROJECT ELEMENTS

Principle and fundamental features of the thesis project.



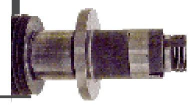
MAJOR PROJECT F23. ELEMENTS

MAJOR PROJECT ELEMENTS:

1. Principle and fundamental features of the project.

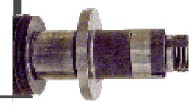
MAJOR PROJECT ELEMENTS:

The Facility for Industrial Technology and Power Generation will integrate a number of diverse spaces that will work together as one functioning unit. The relationships and connection between each space will fulfill functional requirements while providing users with aesthetic and enjoyable environments. Spaces within the facility need to have an element of flexibility, giving the ability to adapt with advancements made in research and the growing use of technology. This flexibility allows the facility to change with the growing needs of its users and their advanced testing and research.



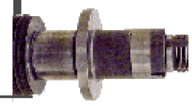
MAJOR PROJECT
F24. ELEMENTS

- Laboratories/Classrooms
- Testing Facilities
- Supporting Research Spaces
- Security Measures
- Locker rooms/Restrooms
- Employee Amenities
- Fuel Storage and Transport
- Fuel/Water Handling
- Waste Storage/Removal
- Mechanical/Electrical
- Connections/Transitions
- Circulation
- Conference/Meeting
- Interpretative/Recreation
- Facility Offices
- Parking



SITE INFORMATION

Site Data including information ranging from macro to micro scale. Why the specific site is important and appropriate for the facility. Site information including location, site history, site importance, demographics, and economic base.



G26. SITE INFO

SITE INFORMATION: MACRO TO MICRO

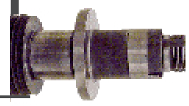
1. Information ranging from region, city, to the site.

Site Location: University of Minnesota Twin Cities Campus

Old Main Power Plant
- East River Road
- Mississippi River front

Minneapolis, Minnesota
- between University and downtown

Figure G.1 Aerial View Of Downtown Minneapolis, MN

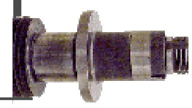


G27. SITE INFO

SITE HISTORY:

The site embraces a long historical background starting with Native American people. The land on which the site is located is known as the East River Flats where people have settled for thousands of years. The site is part of the last flat landing spots before the St. Anthony Falls, not bounded by high stone bluffs. This site is where the Dakota and other Native American tribes landed their canoes before carrying them around the falls. An 11,000 year old Clovis spear point provides evidence of this early human inhabitancy. The site evolved as an area of industrial manufacturing and production that took place along the Mississippi River during the Industrial Revolution. In the 1800's, immigrants migrated to the upper Midwest around the expanding Minneapolis area in search of work at these factories, allowing a variety of immigrants, predominantly Bohemian, to settle in along the East River Flats commonly known as the Bohemian Flats. The continued urban and industrial growth led to the development of river front facilities and the University. The negative effect of growth in industrial type facilities pushed out immigrants that had once settled on this land.

(Kiosk of University of Minnesota, 2004.)

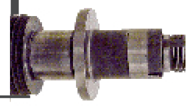


G28. SITE INFO

SITE IMPORTANCE:

Currently, the site includes ruins of the Old Main Steam Plant built in the early 1900's to supply the University with steam heat. This includes a non-functioning Burlington Northern railroad bridge that was used to transport, load and unload coal to the plant. The decommissioned bridge has since been converted into a pedestrian bridge that connects the east and west campuses of the University. The bridge also acts as a connection between downtown Minneapolis, the University of Minnesota TC, and Dinkytown, a village type pedestrian environment filled with small shops and restaurants.

The site location provides a context that encourages the utilization of industrial technology and power generation while providing a seam in which the general public can be integrated. The current SE Steam Plant, located only one half mile up river, additionally depends on the ability of the site to store and transport fuel for the University's primary source of electricity and heat. The site's current and historical background justifies and supports the development of a facility that will integrate research and testing of industrial technology/ power generation with the integration of the general public, including campus.



G29. SITE INFO

DEMOGRAPHICS:

- Provide quantitative values for economical stability and defining user groups.

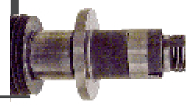
Based on 2004 college profile:
University of Minnesota - Twin Cities
College of Engineering and Industrial Technology

Dean:
Regents Professor H. Ted Davis
appointed in 1995

Faculty:
367 tenured and tenure-track faculty members, including 5 Regent Professors, 12 National Academy of Engineering members, and 1 National Academy of Sciences member.

Enrollment:
4,288 undergraduates, 2,358 graduate students
Freshman class: 792 students; average high school rank is 87th percentile; average ACT composite score is 28.1; average SAT total score is 1309

Degrees granted:
951 bachelor's degrees, 396 master's degrees, and 161 doctoral degrees

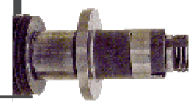


G30. SITE INFO

Departments:
Aerospace engineering and mechanics, astronomy, biomedical engineering, biosystems and agricultural engineering, chemical engineering and materials science, chemistry, civil engineering, computer science and engineering, electrical and computer engineering, geology and geophysics, mathematics, mechanical engineering, physics.

Major research centers:
Army High Performance Computing Research Center, Charles Babbage Institute of Computer History, Digital Technology Center, NSF Center for Earth-surface Dynamics, NSF Institute for Mathematics and IT Applications, NSF Materials Research Science and Engineering Center, NSF Multi-Axial Subassemblage Testing System.

Fields of related study and typology provide justifiable background in the university's ability to develop a full functioning facility for power generation and industrial technology. The defined user groups provide the mean on which a facility of this caliber would strive.



G31. SITE INFO

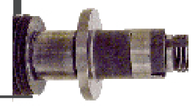
Alumni:
52,400 living alumni, including 214 University of Minnesota Outstanding Achievement Award winners, 17 National Academy of Sciences members, and 56 National Academy of Engineering members.

National ranking:
Eleven of IT's 19 undergraduate and 28 graduate programs are ranked among the top 20 in the nation, including

Aerospace Engineering	4
Astronomy	5
Biomedical Engineering	17
Biosystems and Ag Engineering	6
Chemical Engineering	1
Civil Engineering	13
Electrical Engineering	18
Geology and Geophysics	8
Materials Science	3
Mechanical Engineering	4
Mathematics	14

(Table G.1 U of M Colleges National Ranking)

(Dept. of Mech. Engin. at U of M, 2004.)

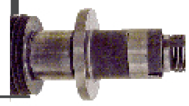


G32. SITE INFO

ECONOMIC BASE:

The facility for power generation and industrial technology is supported by a strong economic base within the site, region and nation. State allocations, donations, and investors support the University's decision to pursue advanced research in global scale technology. Together they supply 25% of the universities overall revenue. The installation of a large scaled research facility affects global power generation with the goal in reducing the amount of air pollution by 30%. This allocates 55 million dollars in funding from the U.S. Department of Energy Clean Coal Tech. Demonstration Program and an undetermined federal grant that will supply aid funds into research. The University of Minnesota will also see an 86 million dollar capital investment in coal savings alone.

(U of M, 2004, Steam Plant Facts Sheet)



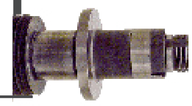
G33. SITE INFO

University of Minnesota Revenue Sources 2003

Sponsored Research $71.6 million (34%)	Tuition $44.8 million (21%)
State Allocations $52.3 million (25%)	Other Sources $43.9 million (20%)

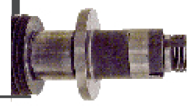
Table G.2 U of M Revenue Sources 2003

(Dept. of Mech. Engin. at U of M, 2004.)



PROJECT EMPHASIS

Areas of the thesis project that require more emphasis in relationship with the unifying idea/theoretical premise. Major points of focus within the facility.



H35. EMPHASIS

PROJECT EMPHASIS:

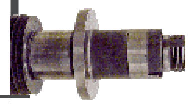
1. Specific areas of interest that relate to the thesis, and furthers the understanding of the theoretical premise.

ADAPTIVE REUSE:

The strong historical background of the site and Old Main Steam Plant ruins provide regional and cultural justification to an adaptive reuse facility. The ability to provide functional amenities such as advanced technological research, fuel storage / transport, and public interaction based off the site's historical foundation demonstrates quality architecture that carries unique value.

MIXED USE:

The integration of a variety of elements enhances the capability of advanced research and functional use by increasing the amount of vital resources available to the facility. The quality of work and research improves significantly when resources can easily be integrated and incorporated.



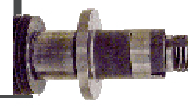
H36. EMPHASIS

CONNECTIONS:

Connections of spaces, users, and elements throughout the building are vital in constructing a facility that will rely on continuous interaction. The facility needs to be a well functioning system that offers users ease and flexibility. The integration of the general public is no exception in the connections to be made.

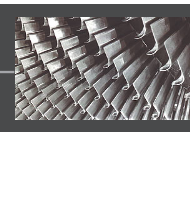
LAB/TESTING FACILITY DESIGN:

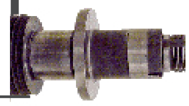
The design of these elements is the basis on which the facility will develop. The laboratories and testing facilities are the most important and prominent spaces throughout the facility, providing the core in which advanced research developments can be made. Supporting spaces and connections to other elements will derive from the design of the laboratories and testing facilities.



PLAN FOR PROCEEDING

A plan defining important steps in work to be done on the thesis project. A "Task Analysis" -tasks necessary to complete the project within a given time frame. Including definition of research direction, design methodology, documentation of the design process, and a specific schedule.





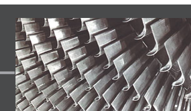
I38. PROCEEDING

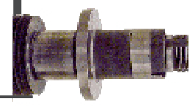
PLAN FOR PROCEEDING:

1. Tasks necessary to complete the thesis. How and when they will be done.

1. DEFINITION OF RESEARCH DIRECTION:

Research for the design thesis will focus on principles of industrial technology and power generation. The advanced laboratory and testing facility "Design and Methods" will be a primary focus of this research, initializing supporting elements that will aid in the process of advanced research and testing systems. Functional use of the building through connections and relationships of users and spaces will parallel with the laboratory research and testing. The integration of public use will also be explored to find essential components necessary in developing an informational and stimulating experience.

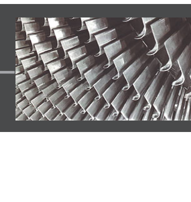


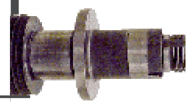


I39. PROCEEDING

2. DESIGN METHODOLOGY:

Research of industrial technology and power generation systems will lead to a precise set of standards required throughout the facility. General case studies can then be utilized in determining sufficient and insufficient qualities, public interaction, form, space, and user descriptions. Components of connection and relationships can next be explored based on the information and knowledge gained from specific research and case studies performed on existing research laboratories and testing facilities. The information acquired from these investigations will direct further exploration into fundamentals associated with construction details, building materials, equipment, sustainability, lighting, acoustics, etc…

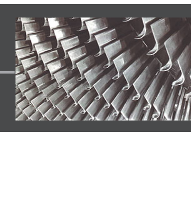


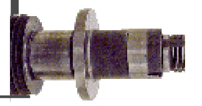


I40. PROCEEDING

3. DOCUMENTATION OF DESIGN PROCESS:

All research will be documented into a project log book. The log book will coincide with an organized collection binder that will be formatted by topic and date. This system will allow a quick reference corresponded with a complete account of all research. The design process will be equivalent to this type of system. All design related development will be documented and organized into a binder that will also be formatted by topic and date. Schematic design and research will be accounted for with the use of sketchbook and inserts, to be dated. Using this type of documentation system for research and design will create a complete and comprehensive reference tool mimicing the documentation process used with a laboratory.





I41. PROCEEDING

Fall Semester 2004

4. DESIGN THESIS WORK SCHEDULE:

Week #1: (August 24-27)……………………………………………...…………
August 24 Classes Begin
August 24 1st thesis meeting during ALA 561
August 27 1st draft of SOI due (3 copies)
Research

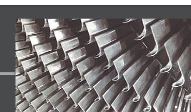
Week #2: (August 30-September 3)……………………………………...……....
September 1 SOI returned to office by faculty
September 2 SOI returned to students
Research

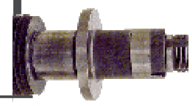
Week #3: (September 6-10)………………………………………………...…....
September 6 Labor Day holiday
September 9 Revised SOI due
Research

Week #4: (September 13-17)……………………………………..…………..…....
September 14 Application for Graduation due
September 16 Marked up SOI available

Week #5: (September 20-24)……………………………………………..……....
Revise SOI and correct mark ups
Research

Week #6: (September 27-October 1)…………………………………....………..
Research





142. PROCEEDING

Fall Semester 2004

Week #7: (October 4-8)……………………………………………………………
- October 7 Thesis Proposal due (2 copies)
- October 7 Thesis Abstract due
- October 7 Student faculty preference slips
- Research

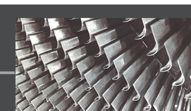
Week #8: (October 11-15)…………………………………………………………
- October 14 Student preference slips due
- Research

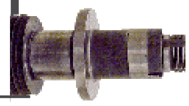
Week #9: (October 18 -22)…………………………………………………………
- October 21 Primary and Secondary Critics announced
- Define Program Layout (Outline)

Week #10: (October 25-29)…………………………………………………………
- October 28 Last day of ALA 561
- Research
- Program Development

Week #11: (November 1-5)…………………………………………………………
- Research
- Program Development

Week #12: (November 8-12)…………………………………………………………
- November 11 Veteran's Holiday
- Research
- Program – Rough Draft





I43. PROCEEDING

Fall Semester 2004

Week #13: (November15-19)…………………………………………………………
- Final week of Design Studio 561
- Research
- Program Draft

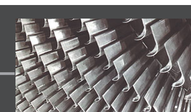
Week #14: (November 22-26)……………………………………………………
- November 24 Draft Thesis Program Due to Primary
- November 25 Thanksgiving Holiday
- November 26 Thank giving Holiday
- Research
- Program Revisions and Extensions

Week #15: (November 29-December 3)……………………………………………
- Research
- Program Revisions and Extensions

Week #16: (December 6-10)…………………………………………………………
- December 9 Final Thesis Program due to Primary
- December 10 Last day of classes
- Research

Week #17: (December 13-17)…………………………………………………………
- Finals week
- December 16 Program grade due
- Research
- Site Model

Week #18: (December 20-24)…………………………………………………………
- Research
- Site Model



Spring Semester 2004

Week #19: (December 27-31)……………………………………………
Research
Site Model

Week #20: (January 3-7)…………………………………………………
Research
Schematic Design

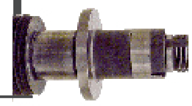
Spring Semester 2004

Week #21: (January 3-7)…………………………………………………
Research
Schematic Design

Week #22: (January 10-14)………………………………………………
January 11 Classes Begin
Concept
Form Design

Week #23: (January 17-21)………………………………………………
January 17 Martin Luther King Jr. Holiday
Concept
Base Map and Site Analysis

Week #24: (January 24-28)………………………………………………
Site Relationships



I45. PROCEEDING

Spring Semester 2004

Week #25: (January 31-February 4)……………………………………………
General Space (Planning)

Week #26: (February 7-11)……………………………………………………
Massing – Volume

Week #27: (February 14-18)…………………………………………………
Structural Systems -Sections

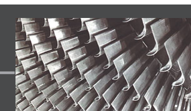
Week #28: (February 21-25)…………………………………………………
February 21 Presidents Holiday
Materials - Elevations

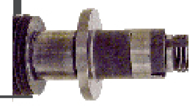
Week #29: (February 28-March 4)……………………………………………
Sections – Materials – Systems

Week #30: (March 7-11)………………………………………………………
Mid Semester Thesis Review
Design Development

Week #31: (March 14-18)……………………………………………………
Spring Break
Tie Up Any loose Ends

Week #32: (March 21-25)……………………………………………………
March 25 Easter Holiday
Revisit All Design Issues
Interiors





I46. PROCEEDING

Spring Semester 2004

Week #33: (March 28-April 1)……………………………………………
- March 28 Easter Holiday
- Story Boards
- Design Presentation Drawings

Week #34: (April 4-8)……………………………………………………
- Design Presentation Drawings

Week #35: (April 11-15)…………………………………………………
- Design Presentation Drawings

Week #36: (April 18-22)…………………………………………………
- Design Presentation

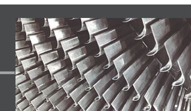
Week #37: (April 25-29)…………………………………………………
- April 25 Thesis Projects due MUB 4:30
- April 26 Annual Thesis Exhibit
- April 27 Annual Thesis Exhibit
- April 29 Draft of Thesis Document due

Week #38: (May 2-6)……………………………………………………
- May 6 Last day of classes

Week #39: (May 9-13)…………………………………………………
- Finals Week
- May 12 Final Thesis Document due 4:30
- May 13 Commencement 4:00 Fargo Dome

Primary and Sec. Critic Reviews to be schedule on a weekly basis.

Table I.1 Design Thesis Work Schedule



5. DESIGN THESIS CALENDER:

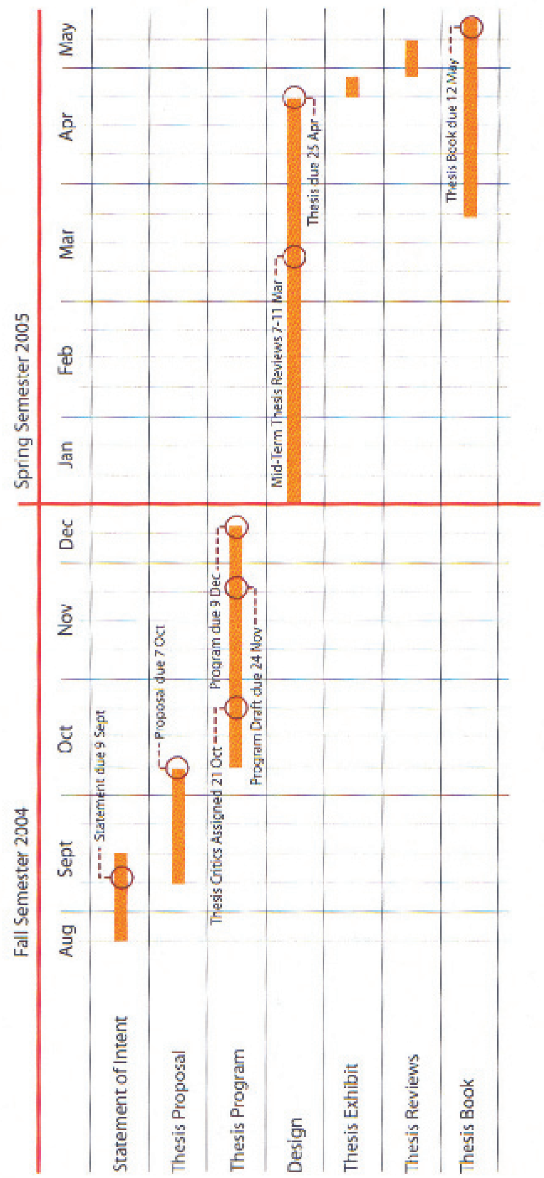
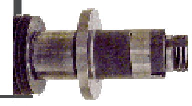
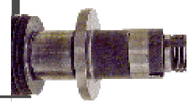


Table I.2 Design Thesis Calender



STUDIO EXPERIENCE

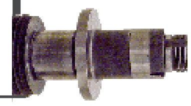
Previous studio experience - demonstrating ability and knowledge of architectural process.



J49. EXPERIENCE

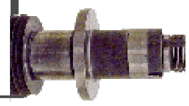
STUDIO EXPERIENCE:

Second year	Fall Semester 2000	Building Type:
Skull of Lucy		Museum
Mountain Retreat		Residential
Copenhagen School of Architecture		Education
Second year	**Spring Semester 2000**	
Downtown Fargo Pocket Vest Park		Cafe - Park
Prairie Green Passive Solar Home Design		Residential
CBA – NDSU Business College		Office
Montréal Footbridge		Bridge
Third year	**Fall Semester 2000**	
Ronald MC Donald House		Multi-Family
Implement Dealership – Heavy Timber		Dealership
Third year	**Spring Semester 2000**	
Fluid Motion Workout Facility		Gym - Studio
NDSU Great Plains Facility		Research Facility
Fourth year	**Fall Semester 2000**	
Urban Design – Fargo		Urban development
Fourth year	**Spring Semester 2000**	
Medium Density Housing		Medium density
Bioclimatic High Rise – San Francisco		High rise
Fifth year	**Spring Semester 2000**	
NDSU downtown – Addition		Education - Studio



RESEARCH RESULTS/GOALS

Results drawn from research and investigation into theoretical premise, typologies, and historical-physical-social contexts. Establishing a set for a project goals, focusing the design process imbuing the project with meaning.

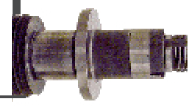


K51. RESULTS/GOALS

RESEARCH RESULTS AND GOALS:

1. RESULTS FROM THEORETICAL PREMISE RESEARCH:

The ability of a research facility to function properly relies on three main elements. The first and most important element is the ability and demand of users. The facility would not function without the dedication and persistence of its users. The second element is the functional ability of the building to allow for advancements in power generation and industrial technology. A properly programmed facility will allow users to operate efficiently and properly. The programmatic requirements will also incorporate interpretive features that encourage user interaction, not common with most industrial type facilities. The third element is the overall intention of the facility to provide advancements in power generation and industrial technology that will offer priceless benefits. The University of Minnesota supplies a user base of faculty and students that are among the top in the nation in mechanical engineering and industrial design. These users will experience ideas of connection, movement and interaction throughout the site, contributing to a positive "environmental" and global impact.



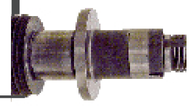
K52. RESULTS/GOALS

The benefits of the overall project are extremely valuable to the University and surrounding region. The addition of three, state-of-the-art boilers will encourage the use of fuel technology allowing the University to burn a variety of fuels such as: coal, natural gas, oil, and renewable resources, wood chips. This gives the University the ability to change fuels for economic and public health reasons, as new fuels are developed and research discovers more cost effective and environmentally sound energy sources. A secondary benefit is the use of cogeneration - passing the 2.5 billion lbs of steam over a turbine before heating the campus to produce an amount of electricity equal to the quantity used by the U of M campus.

(U of M, 2004, Board of Regents CW)

The development of this project means a cost effective solution that reduces the amount of air pollution by 30% exceeding the UN goal of 20% by 2005. Finical stability is secured with 55 million dollars in funding from the U.S. Department of Energy Clean Coal Tech. Demonstration Program and an 86 million dollar capital investment in coal savings.

(U of M, 2004, Steam Plant Facts Sheet)



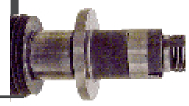
K53. RESULTS/GOALS

The University was honored a federal grant that will fund research into developing new fuel sources and make coal burning more efficient and clean. Statistics show that nation wide, 60% of power production depends on coal, higher world wide, giving the University an opportunity to make a global “environmental” contribution. The Facility for Industrial Technology and Power Generation will utilize the University’s decision to become one of the most advanced global energy research elements – providing the core for this design thesis.

(U of M, 2004, Steam Plant Facts Sheet)

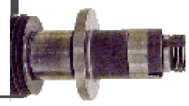
2. RESULTS FROM TYPOLOGY RESEARCH:

The multiple typologies: laboratory, testing facility, educational, office, and industrial allow the facility to explore a variety and combination of design elements. The non traditional typology allows freedom in exploring orientation, form, materials, scale, relationships, connections, and functional characteristics. Case studies with similar and non similar typologies offer an opportunity in exploring and aidingvarious design elements and decisions.



K54. RESULTS/GOALS

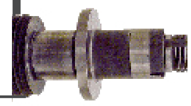
The most important aspect of each building and structure studied, is the ability to explore. A typology doesn't define a set of design rules or guidelines. It defines perceived functional characteristics encouraging a cookie cutter type relationship with people's ability to relate to type. Each case study explored its own characteristics of what the designer felt was important to the function and context. The case studies show the exploration of materials, historical use, technology, environment, surrounding context, advanced construction methods, ideas of connection, etc.. The ability of a designer to explore this underlying importance, without stereotyping, leads in the direction of pure design, pure Architecture. Typology integrate a limit of control before the ability of exploration takes place. The ability to learn from an example is important but cannot be followed as a rule or guideline controlling the ability of exploration and new discovery. A more functional or aesthetic solution always lies in the beyond, it is the architects role to explore the beyond. Guidelines can only be driven from codes and zoning ordinances that are required by law for the health, safety, and well being of the public.



K55. RESULTS/GOALS

3. HISTORICAL CONTEXT OF THESIS:

The site and facility form a relationship historically congruent with the nature of the thesis. The ideas of industry and production run along the Mississippi riverfront telling the story of technological advancements made throughout time. The riverfront embraces a variety of industrial aspects that relate to the physical and social context. Location on the riverfront near the historical birthplace of Minneapolis, the project is an example of turn of the century industrial architecture and a symbol of the areas working river heritage. The existing structure of the Old Main Steam Plant is another element proving the integrity of the project and its ability to have purpose. The facilities capability to provide advanced industrial technology and power generation research while incorporating user/public interaction allows a sense of fit. The U of M hydrological facility located up river is an example of a research facility's capability to fit within its physical and social context. Social trends and development in efficiency and clean air provide support to the intentions of the research facility.



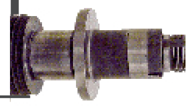
K56. RESULTS/GOALS

4. GOALS OF THESIS PROJECT:

The thesis project goal is to primarily focus on satisfying functional needs to advance mechanical engineering, power generation, and industrial technology research. Interactive facilities, laboratories, and classrooms provide the means necessary to progress research and developments. The design will create positive connections on campus with involved user interaction and provide a gateway to explore advanced systems and means utilized throughout the world. The facility reacts to the users advanced needs while providing aesthetic appeal and relationships to the campus and community as a whole. The secondary function is providing a means of fuel storage and transport for the University's main steam supplier, SE Steam Plant located one half mile up river.

Function is the primary element that will drive the overall design, providing solutions to the needs of advanced research, fuel storage/transport, and physical/public connection.

Exploration - is used as a design tool in finding a solution to the thesis goals.



SITE ANALYSIS

A complete and comprehensive site analysis of the site chosen for the facility documenting existing conditions with analysis of current conditions providing useful information to the design process.

L58. SITE ANALYSIS

SITE ANALYSIS:

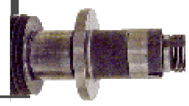
1. Comprehensive site analysis of thesis project site

Site Location: University of Minnesota
Twin Cities Campus
Old Main Power Plant

- East River Road
- Mississippi River front

Minneapolis, Minnesota
• between the university and downtown

Figure G.1 Aerial View of Downtown Minneapolis, Minnesota



L59. SITE ANALYSIS

SPECIFIC SITE LOCATION:

Figure L.1 Detailed Aerial View of Specific Site - University of Minnesota

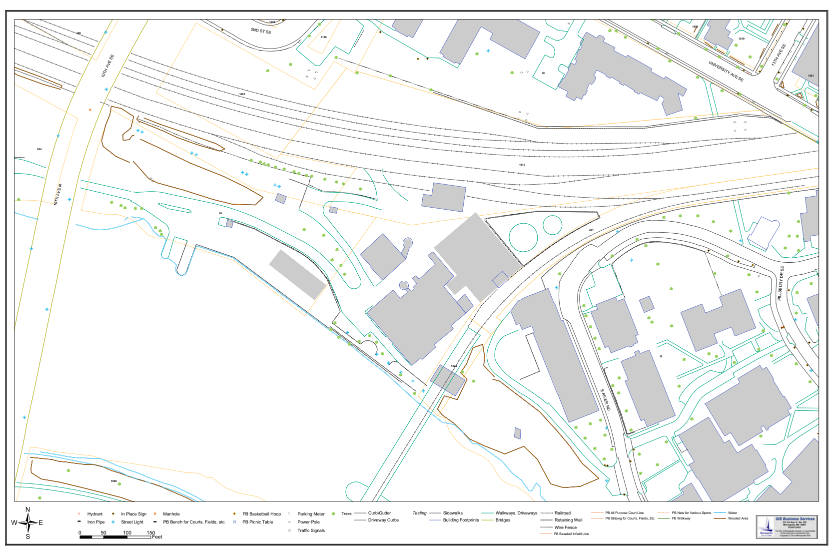
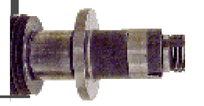


Figure L.2 Plat Map of Specific Site - University of Minnesota



L60. SITE ANALYSIS

MAJOR LANDMARKS:

The location near downtown Minneapolis, MN offers many historic and modern landmarks. The mill district is also located directly across the river expressing the industrial nature of the site.

Appendix C.2 - Minneapolis Major Landmarks Map

SITE / ENVIRONMENTAL ISSUES:

The site location and characteristics are extremely important in the development of the Facility for Industrial Technology and Power Generation. Located on the riverfront near the historical birthplace of Minneapolis, the site is an example of turn of the century industrial architecture and a symbol of the areas working river heritage. The site also fall in the 72 mile Mississippi National River and recreation development area running through the twin cities. This requires an element of preservation to the riverfronts historical, natural, recreational, and cultural significance. The integration of a public interpretive and recreation center will encourage public interaction with the site and improve public access to the riverfront.

(U of M, 2004, Steam Plant Facts Sheet)

L61. SITE ANALYSIS

SITE TOPOGRAPHY / HYDROLOGY:

The topography of the site shows the dramatic elevation changes which directly affects the flood plain and hydrology of the site. According to Minneapolis city officials, the site lies in a historic floodplain now diverted by a series of dams and locks built a half mile up river. The lower elevation park area of the west bank receives most of the flood waters when they occur. The steep topography significantly increases the amount of runoff additionally enlarging the amount of site drainage. These elements need careful consideration during early design phases, insuring the prevention of site flooding and erosion during heavy rainfalls.

(City of Minneapolis,MN, 2004)

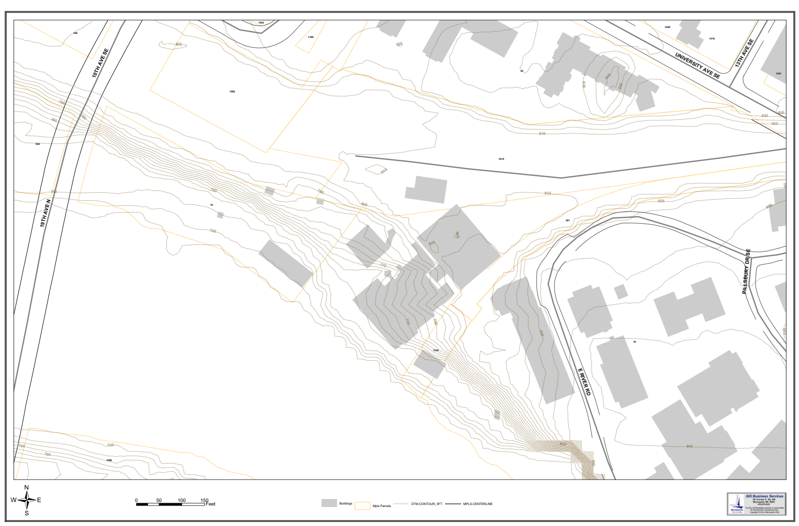
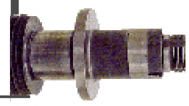


Figure L.3 Topographic Map of Specific Site



L62. SITE ANALYSIS

SITE GEOLOGY / VEGETATION:

The geology of the site dates back thousands of years during glacial movements. The site is composed of 50 - 100 foot glacial till deposits, mostly consisting of limestone deposited from the Mississippi River. The deposits are covered with an average of one foot of topsoil and 4 feet of subsoil allowing for abundant amounts of vegetation. The effects of erosion sporadically affect the layers of topsoil and subsoil apparent by the clumps of vegetation along the banks of the river. Vegetation also becomes apparent on the flats within the site topography.

(US Dept. of Agriculture, 1971, Soil Survey)

EXISTING ELEMENTS:

The site includes existing elements that carry defined characteristics of aesthetic value and function.

Old Main Steam:
- Masonry office building
- Steel siding storage building
- 2 Steel fuel tanks
- Other Coal Equip. and storage

Pedestrian Bridge:
- historical iron bridge

University Buildings
- 3 surrounding campus buildings

L63. SITE ANALYSIS

SITE TRANSPORTATION / LINKAGES:

The site offers a wide variety of transportation/circulation within its urban and institutional environment. Pedestrian friendly and vehicular connections are made between three major elements surrounding the site. The connections include access to the downtown Minneapolis, Dinkytown, and the University campuses.

(University of Minnesota, 2004, U of M TC)

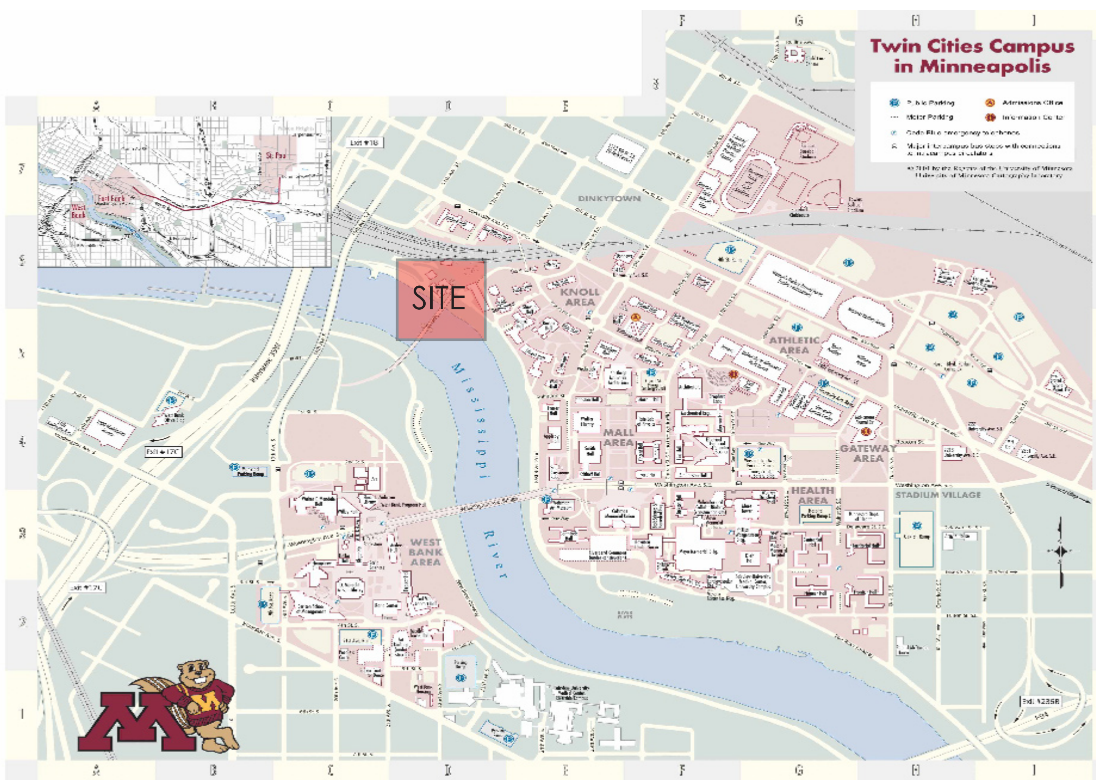
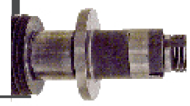


Figure L.4 Transportation Map of U of M

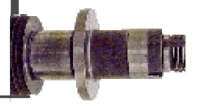


L64. SITE ANALYSIS

SITE VIEWS:

The site location provides many spectacular views of its surrounding context and history. The site's west edge is lined with views of the historical river front including the series of locks and dams that control river levels, along with water traffic barges that are vital to riverfront industries. Viewable directly across from the site is part of the historic Bohemian Flats that have been adapted into public park use since they lie within the flood plain. The eastern edge of the site provides views on to the University along with historical structures and railroad yards. The site's most definable view is the overlook onto historic and modern day Minneapolis with its connecting stone arch and steel bridges.

Figure L.5 Views Looking Out From Site



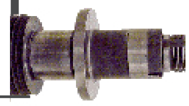
L65. SITE ANALYSIS

CLIMATE DATA:

Minneapolis, Minnesota
Lat / long: 44 53 N – 093 13 W
Altitude: 834 feet above sea level

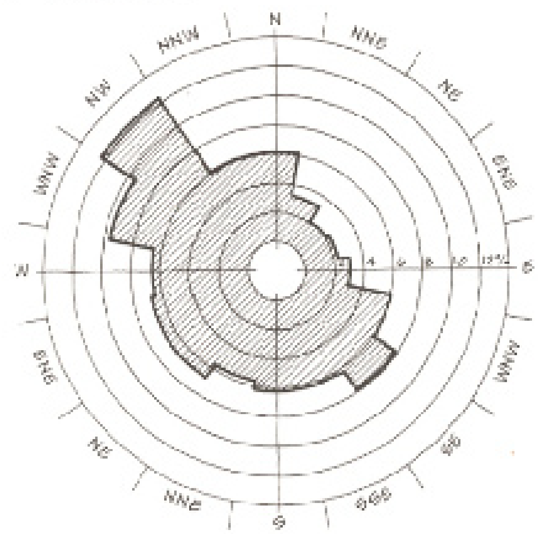
	Yearly
High temperature (avg.) degrees F	54
Low temperature (avg.) degrees F	35
Days warmer than 90 deg. degrees F	16
Days colder than 5 deg. degrees F	45
Precipitation (avg.) inches	27.1
Snow (avg.) inches	52
Days with some precipitation.	113
Days with thunderstorms	37
Humidity (3 pm) % relative	55
Windspeed (avg.) knots	11

Table L.1 Climate Data

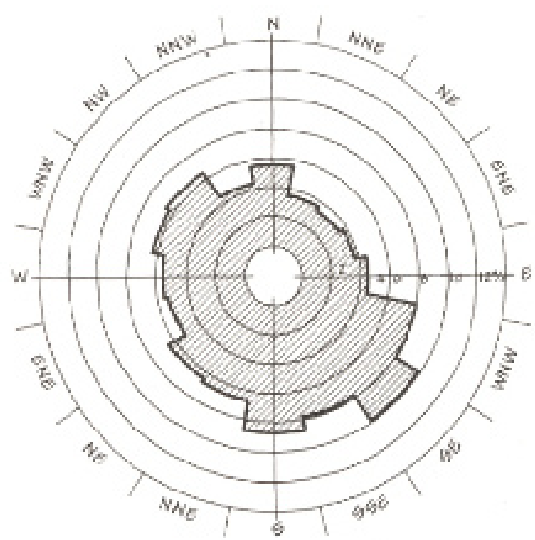


L66. SITE ANALYSIS

WIND ROSES:



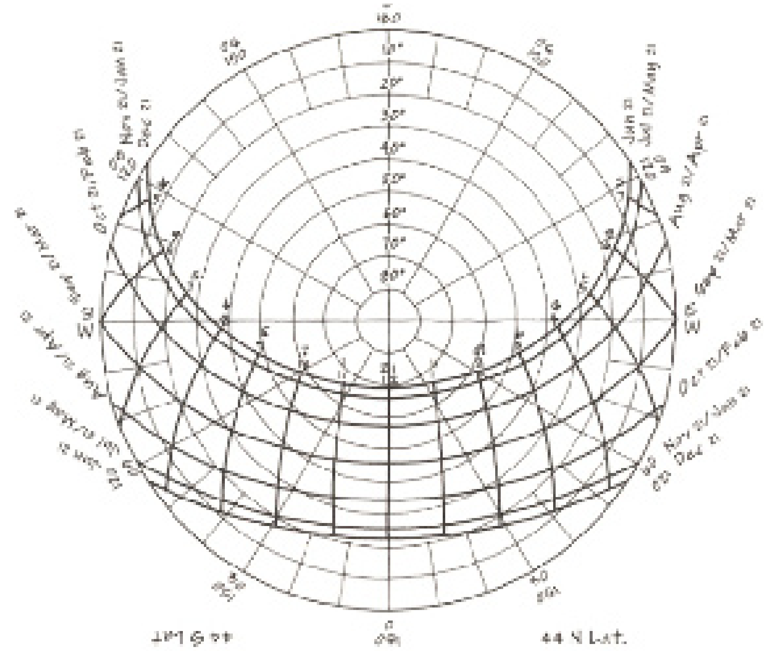
December Wind Rose, Minneapolis



June Wind Rose, Minneapolis

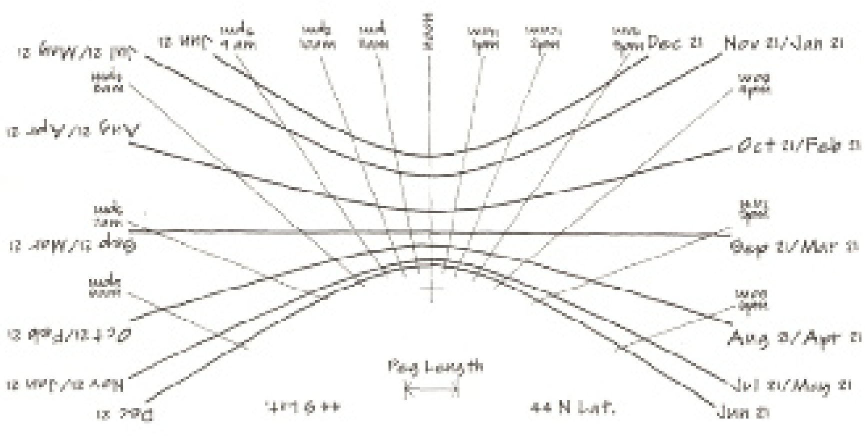
Diagram L.1 Wind Roses

SUN DIAL / DIAGRAM:



Sun Path Diagram, 44° Latitude

1 SUNDIAL



44° Latitude Sundial

Diagram L.2 Sun Diagrams

L68. SITE ANALYSIS

SITE ANALYSIS:

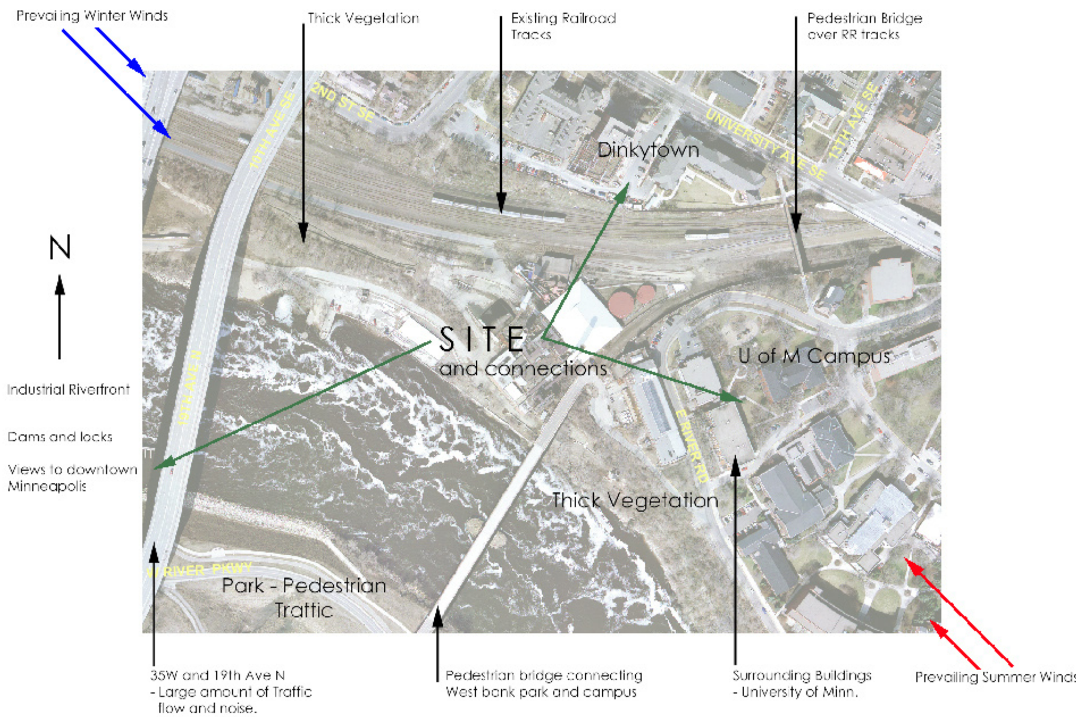
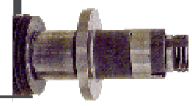


Figure L.6 Site Analysis

SITE CHARACTERISTICS INFLUENTIAL TO THE DESIGN PROCESS:

PHYSICAL CONTEXT:

The site's dominant feature is its riverfront edge. The location was vital in the operation of the once functioning steam plant. This characteristic now carries a historical value of the industrial importance along the Mississippi River. The dramatic topography of the site is an element with direct relationships to this riverfront edge.



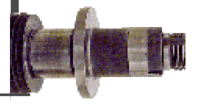
L69. SITE ANALYSIS

The historic Burlington Northern bridge is another major element in the context of the site. It provides connection between the site and three major elements: downtown Minneapolis, Dinkytown, and the University of Minnesota. The ideas of connection are formed between large and small scale, providing exploration in the process and design of movement.

The non-functioning rail yard located throughout the site becomes a common element to the physical context. The rail road tracks form a sense of historical linkage and relationships between physical elements.

SITE BUILDABILITY/OPPORTUNITIES:

The site's physical and historical context provides inspiration and feasibility in the construction of a facility for power generation and industrial technology. The physical features of the site are suitable for construction and draw interest to the design process.



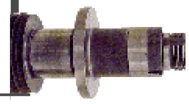
L70. SITE ANALYSIS

SITE BUILDABILITY/OPPORTUNITIES:

The riverfront edge, dramatic topography, downtown, U of M, Dinkytown, bridge, historical background, industrial importance, and existing building (including existing equipment) all provide conceptual design ideas. The ability to explore these elements will provide solutions in developing a facility with a similar typology to its historical and present context.

IMPACTS OF DEVELOPMENT:

The facility for power generation and industrial technology will offer positive impacts to its surrounding context. The design will begin a revitalization of a desolate area, strengthening the idea of connection at a pedestrian level. The building itself will incorporate technological advances in the use and storage of hazardous materials. Noise, vibrations, and other physical impacts will be allocated within the design process; limiting the impacts they have on their surrounding. The facility will provide a safe atmosphere to users while providing an aesthetically pleasing environment.



L71. SITE ANALYSIS

SITE RELATIONSHIPS:

The site forms relationships at a macro and micro scale. The location near downtown Minneapolis, MN and on the University of Minnesota TC campuses provides a common link in which distant users can relate. This also give the facility a means to be identified by location and by exposer. This is important because the goal of the facility is to provide efficient and cleaner ways of producing and distributing energy, affecting people from a regional standpoint and intentionally towards a global view.

The site also embraces the ability to respond to users with a direct relationship. The location on campus and near downtown establishes the site as part of a main connection axis between the three major city elements.

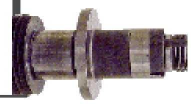
The site offers a means in which the facility will strive. It offers historical context to the industrial atmosphere while providing a function to a variety of users that relate with the sites location and context. The site allows a process of design and function that will have a regional and global affect.

SITE VIEWS/RELATIONSHIPS:

Figure L.7 Views of Site - set1

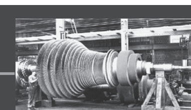
Figure L.8 Views of Site - set2

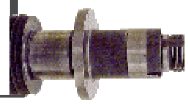
Figure L.9 Views of Site - set3



PROGRAMMATIC REQUIREMENTS

The process of establishing the specific spatial requirements for the thesis project. Detailed information includes descriptions of spaces, quantitative, qualitative, and technical information, and relationships between project spaces and surrounding environment, and impacts of spatial requirements.





PROGRAM
M74. REQUIREMENTS

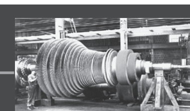
PROGRAMMATIC REQUIREMENTS:

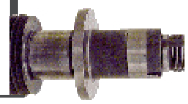
1. Specific spatial requirements and relationships for thesis project.

PROGRAM SPACES:

The idea and creation of space is crafted by an architects ability to form space while altering limitations into ideas of design inspiration, exploring the element of creativity. This process defines components of function with the integration of aesthetic beauty in form, material, construction, etc.. Architecture extracts on the creation of space, developing coherent spatial relationships and connections. These relationships offer the design a medium in which to explore architecture, the ideas of form, function, aesthetics, and overall design.

The Facility for Power Generation and Industrial Technology shall be a medium of design exploration demonstrating the ability to create architecture based on the principle of form following function. This allows the creation of well-designed space, creating functional and aesthetic connections within its specific environment that provide interest and usability.





SPACE ALLOCATIONS

RESEARCH BASED:

- Power Generation Lab
- Research Labs
- Byproduct Removal
- Power Conversion
  Heat Distribution

Lab support for research based spaces

- Emergency Backup
- Equipment Storage
- Hazardous mat. storage
- Electrical
- Mechanical HVAC
- Engineering Systems
- Write Up Offices
- Locker room / Toilets
- Breakout Rooms
- Conference Rooms
- Technology Learning
- Offices

FACILITY BASED:

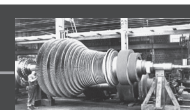
- Solid Fuel Storage
- Solid Fuel Handling
- Hydrology Handling
- Mechanical HVAC
- Electrical
- Waste Management
- Custodial Services
- Research Library
- Drafting/Operations
- Security
- Pedestrian Bridge
- Parking

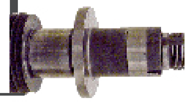
PUBLIC BASED

- Lobby
- Gallery
- Interpretive
  Recreation office
- Auditorium
- Administration
- Conference
- Office Supplies Storage

EDUCATION BASED

- Classrooms
- Computer Lab
- Breakout rooms
- Offices
- Library
- Departmental Office

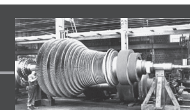


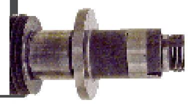


RESEARCH BASED SPACE ALLOCATION

- Power Generation Lab..................................10000 sqft
- Research Labs..5200 sqft
- Power Conversion/Heat Distribution..............3000 sqft
- Byproduct Removal..3500 sqft
  (hazardous and non-hazardous)

SUBTOTAL 21700 sqft





PROGRAM
M77. REQUIREMENTS

PROGRAM SPACES: RESEARCH BASED

POWER GENERATION LAB

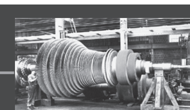
NET AREA: 10000 SQ FT
OCCUPANTS: 20 - 30

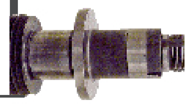
FUNCTION:

The power generation lab will be the core element within the facility providing the functional ability to perform large scale research and testing procedures. This requires the space to consist of a flexible plan, incorporated around stationary equipment, indicated below. The space will create the most adverse impact on the overall building and surrounding context, producing high volumes of noise, vibrations and byproduct.

CONSIDERATIONS:

- Requires a large amount of safety and hazardous control elements defined by the UBC 2003. Type I construction
- Ability in supporting increased equipment load.
- Efficient work lighting with the incorporation of direct sunlight.
- Specific fire retardant clothing required with eye and hearing protection. Medical and Wash stations also required.
- High-Bay design for use of testing research and equipment.
- Incorporated crane hoist and sec. load bearing members.
- Increased HVAC and mechanical systems with consideration towards ventilation, exhaust, and fire suppression.
- Structural stability against movement and vibrations.
- Open space for the fabrication, repair, and installation of new components.
- The design has to allow for expandability and flexibility while maintaining spatial relationships.
- Clearly defined circulation and egress.
- Positive social interaction amongst users.





PROGRAM
M78. REQUIREMENTS

PROGRAM SPACES: RESEARCH BASED

POWER GENERATION LAB

EQUIPMENT:

Multi-Fuel Boiler	2000 sq ft	250 mw Steam Turbine	1200 sq ft
Condensing Unit	500 sq ft	Fuel Handling	500 sq ft
Energy Circ. Unit	750 sq ft	Byproduct removal	2500 sq ft
Crane Hoist	500 sq ft	Tool/Part storage	1000 sq ft

USAGE:

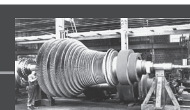
The focus of the power generation lab is the research and testing of advanced components in fuel burning systems that center on steam heat and electricity production. Students and faculty will use the space as an interactive classroom/laboratory where hands on learning is integrated with the study of advanced procedures in research and testing.

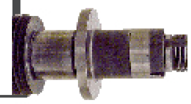
OPERATION:

The power generation lab will be monitored and maintained by a full time staff of operators and mechanics. Students, faculty, and research experts will have full access to the lab 24 hours - 7 days a week. Access will be restricted to authorized personnel monitored by 24 hour security.

ENVIRONMENT:

The interior environment has to be properly marked as to exits, hazards, and safety/emergency locations. Industrial type materials (1 hour fire rating min) and markings are required for the nature of the space. Functional aspects and ease of usability are the two primary components.





PROGRAM
M79. REQUIREMENTS

PROGRAM SPACES: RESEARCH BASED

RESEARCH LABS

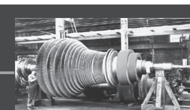
NET AREA: 5200 SQ FT
OCCUPANTS: 1 - 15 per lab

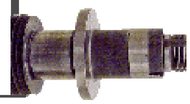
FUNCTION:

Supporting labs will consist of both dry and wet labs that will aid in smaller scale research and testing. The lab spaces will provide specialized lab equipment along with standard equipment necessary for the research being evaluated. The labs will be effective within themselves, but will also provide the means for research and testing at a larger scale.

CONSIDERATIONS:

- Requires a large amount of safety and hazardous control elements defined by the UBC 2003. Type I construction
- Ability in supporting increased equipment load.
- Efficient work lighting with the incorporation of indirect sunlight.
- Specific fire retardant clothing required with eye and hearing protection. Medical and Wash stations within proximity.
- Sensitive security with authorized access control.
- Increased HVAC and mechanical systems with consideration towards ventilation and exhaust.
- Protected storage space sufficient for hazardous materials
- Emergency exhaust and fire suppression systems.
- The design has to allow for flexibility while maintaining overall spatial relationships.
- Two means of egress from each lab no greater than 75 feet.
- Clearly defined circulation and means of egress.
- 3-4 ft mechanical clearance and 2’ structural clearance.
- Team based labs creating positive social interaction.





PROGRAM SPACES: RESEARCH BASED

RESEARCH LABS

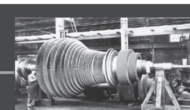
SPECIFIC RESEARCH LABS:

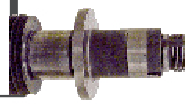
	FUEL SOURCE	ADDMIXTURE	GENERATION
Closed Dry Labs:	1 @ 150 sqft ea.	1 @ 150 sqft ea.	1 @ 150 sqft ea.
Open Dry Labs:	1 @ 250 sqft ea.	1 @ 250 sqft ea.	1 @ 250 sqft ea.
Closed Wet Labs:	2 @ 200 sqft ea.	2 @ 200 sqft ea.	2 @ 200 sqft ea.
Open Wet Labs:	2 @ 500 sqft ea.	2 @ 500 sqft ea.	2 @ 500 sqft ea.

Total:	Closed Dry Labs:	3	450 sqft
	Open Dry Labs:	3	750 sqft
	Closed Wet Labs:	6	1200 sqft
	Open Wet Labs:	6	3000 sqft
			5200 sqft

The combination of labs work together in providing the means in which faculty, students, and specialists can perform research and testing procedure in the development of cleaner and more efficient fuel sources. Each lab will focus on one of the tree aspects in research: fuel sources, addmixture and combinations, and industrial means of generation.

- Fuel source research focuses on new means of fuel and energy used in power generation.
- Addmixtures and combinations focuses on existing fuel sources and the ability to manipulate properties offering more efficient and cleaner burning.
- Industrial means of generation focuses on the design of equipment and production of energy.





PROGRAM
M81. REQUIREMENTS

PROGRAM SPACES: RESEARCH BASED

RESEARCH LABS

EQUIPMENT:

Closed Dry Lab: Equipment per Lab

Casework:	50 sqft
Electric:	25 sqft
Storage:	50 sqft
CPU:	25 sqft

Open Dry Lab: Equipment per lab

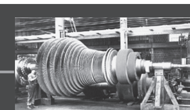
Casework:	75 sqft
Electric:	50 sqft
Storage:	50 sqft
CPU:	75 sqft

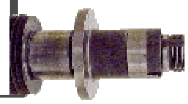
Closed Wet Lab: Equipment per lab

Casework:	50 sqft
Electric:	25 sqft
Engineering:	50 sqft
Docking:	25 sqft
HVAC Exhaust:	50 sqft

Open Wet Lab: Equipment per Lab

Casework:	100 sqft
Electric:	50 sqft
Engineering:	125 sqft
Docking:	75 sqft
HVAC Exhaust:	150 sqft





PROGRAM SPACES: RESEARCH BASED

RESEARCH LABS

USAGE:

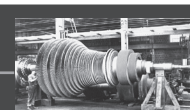
The focus of each lab space works as a component or as an element of space that completes the whole. Students, faculty, and specialized researchers will use each lab space as an interactive classroom and fully functional component in research and testing. Research lab spaces are a key component in achieving the scope of the facility. The lab spaces flexibility will also allow change with the necessities of research.

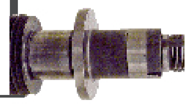
OPERATION:

Research lab spaces will require certified and authorized personnel only, monitored by 24 hour security. Labs will be accessible and under the responsibility of these personnel 24 hours - 7 days a week. Research labs will operate under the guidelines of the research being performed.

ENVIRONMENT:

The interior environment has to be properly marked as to exits, hazards, and safety/emergency locations. Industrial type materials (1 hour fire rating min) and markings are required for the nature of the space. Functional aspects and usability are the primary components involved with the nature of each lab space. Research labs also carry the responsibility of safe research and testing practices with all safety measures being in place.





PROGRAM
M83. REQUIREMENTS

PROGRAM SPACES: RESEARCH BASED

POWER CONVERSION AND HEAT DISTRIBUTION

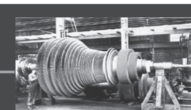
NET AREA: 3000 SQ FT
OCCUPANTS: 1 - 5

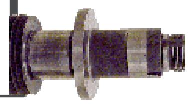
FUNCTION:

The power conversion and heat distribution space houses equipment used in converting raw steam into energy, electricity and distributing heat. This space uses positive byproducts from research and testing done within the facility, redirecting it back into the facility itself and throughout campus as a secondary means energy.

CONSIDERATIONS:

- Requires a large amount of safety and hazardous control elements defined by the UBC 2003. Type I construction
- Ability in supporting increased equipment load.
- Efficient work lighting with the incorporation of indirect sunlight.
- Specific fire retardant clothing required with eye and hearing protection. Medical and Wash stations within proximity.
- Sensitive security with authorized access control.
- Increased HVAC and mechanical systems with consideration towards ventilation and exhaust.
- Emergency exhaust and fire suppression systems if internal.
- The design has to allow for flexibility
- Equipment can be located on the exterior separated from the facility.
- Connection to facility has to be in direct relationship with the power generation laboratory.
- Security and Access at maximum





PROGRAM SPACES: RESEARCH BASED

POWER CONVERSION AND HEAT DISTRIBUTION

EQUIPMENT:

POWER CONVERSION		HEAT DISTRIBUTION	
Main Generator:	500 sqft	Flow Station:	250 sqft
DC / AC Converter:	500 sqft	Blowers:	250 sqft
Switch Yard:	1000 sqft		
Transmission Station:	250 sqft		
Control Room:	250 sqft	- used for both	

USAGE:

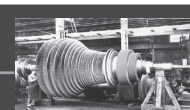
The focus of the power conversion and heat distribution space is to effectively use positive byproducts from facility research and testing as supplemental energy to the University of Minnesota campus. This space will be maintained by the maintenance employees and specialists only. Any research and testing of the systems will be under strict regulation.

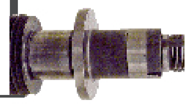
OPERATION:

The operation of the space will be as continuous as possible under maximum security. Only authorized maintenance and control room operators will be allowed within the space.

ENVIRONMENT:

The impact of this space will require dampening of loud noise and vibrations to the surrounding context. Danger and security signage will also be required around the perimeter of the space.





PROGRAM SPACES: RESEARCH BASED

BYPRODUCT REMOVAL

(HAZARDOUS AND NON-HAZARDOUS)

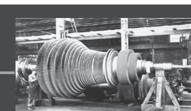
NET AREA: 3500 SQ FT
OCCUPANTS: 1 - 15

Function:

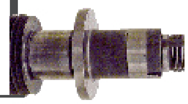
The byproduct removal space will provide a means in which the facility can move and maintain negative byproducts (hazardous or non-hazardous) created by research and testing. The byproducts will be maintained by periodic removal, with the idea of containing the negative byproducts from polluting the environment and surrounding context. The space will house special containment devices along with transport equipment used in the removal of the byproducts. Continued research and testing within the facility will strive to eliminate as much of the negative byproducts as possible.

CONSIDERATIONS:

- Requires a large amount of safety and hazardous control elements defined by the UBC 2003. Type I construction
- Specific fire retardant clothing required with eye and hearing protection. Medical and Wash stations also required.
- Increased HVAC and mechanical systems with consideration towards ventilation, exhaust, and fire suppression.
- Structural stability against movement and vibrations.
- The design has to incorporate a means of separation from the main facility.
- Clearly defined safety, circulation and egress.



PROGRAM
M86. REQUIREMENTS



PROGRAM SPACES: RESEARCH BASED

BYPRODUCT REMOVAL
(HAZARDOUS AND NON-HAZARDOUS)

EQUIPMENT:

Hazardous Contain.:	500 sqft	Byproduct Storage:	500 sqft
Hazard Cleanup:	100 sqft	Transport equipment:	400 sqft
Non-Hazard. Contain.:	500 sqft	Vehicle Storage:	1000 sqft
Non-Hazard. Cleanup:	100 sqft	Other Equipment:	400 sqft

USAGE:

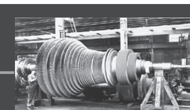
The byproduct removal space will be used by trained maintenance staff only. The byproducts of research and testing will be contained within this space until complete removal. The space will also house vehicle transports: forklifts, front end loader, etc.. which will also serve the entire facility's needs.

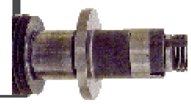
OPERATION:

The space will operate under required circumstances and be readily available in case of emergency 24 hours - 7 days a week. Maximum security will be maintained on the space because of stored hazardous materials.

ENVIRONMENT:

The design has to take special consideration in the location of this space. The location is limited to within 150 ft of the river with 100% sealed construction to prevent contamination and pollution. The space also needs to consider its visual characteristic, not to destroy the facility's relationships and connections with the surrounding context.

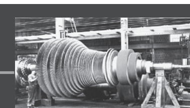


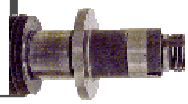


RESEARCH SUPPORT SPACE ALLOCATION

- Emergency Backup..500 sqft
- Equipment Storage..500 sqft
- Hazardous Material Storage...........................600 sqft
- Electrical...1000 sqft
- Mechanical HVAC..2500 sqft
- Engineering Systems.....................................2500 sqft
- Write Up Offices..900 sqft
- Locker rooms / Toilets...................................4200 sqft
- Breakout Rooms..1200 sqft
- Conference Rooms..500 sqft
- Technology Learning.....................................500 sqft
- Offices...1500 sqft

SUBTOTAL 16400 sqft





PROGRAM
M88. REQUIREMENTS

PROGRAM SPACES: RESEARCH SUPPORT

EMERGENCY BACKUP

NET AREA: 500 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The space supplies the facility with backup generators that produce electricity and power in case of emergency or shutdown. Research and testing within labs requires fail safe systems for the safety of users and integrity of research projects. The facility itself also requires these backup systems for means of egress, hazardous ventilation, and fire suppression.

CONSIDERATIONS:

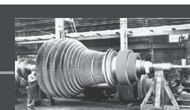
- Ability to support large equipment load, and stability against movement and vibration.
- Increased HVAC and mechanical systems with consideration towards ventilation, exhaust, and fire suppression in case of emergency - Automated System.
- Type I construction for safety and reliability of equipment

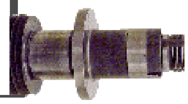
EQUIPMENT:

4 Generators:	50 sqft ea. - run backup systems
Fire Suppression system:	50 sqft
Lighting:	25 sqft
Ventilation / Exhaust:	200 sqft
Electrical:	25 sqft

OPERATION / USAGE:

The Emergency Backup space operates only in time of need.





PROGRAM SPACES: RESEARCH SUPPORT

EQUIPMENT STORAGE

NET AREA: 500 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The power generation and research lab spaces use a majority of the same equipment and tools. These tools are inventoried and stored within the equipment storage space to minimizes confusion and provide ease of use.

CONSIDERATIONS:

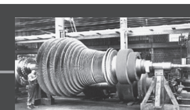
- Shelving system for inventory and count.
- Location near both labs - connection
- Properly organized and charted
- Properly maintained - safety tested

EQUIPMENT:

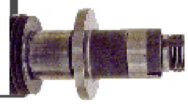
Tools, parts, and supplies - non hazardous

OPERATION / USAGE:

The equipment storage will be controlled with security access by authorized personnel 24 hrs - 7 days a week



PROGRAM
M90. REQUIREMENTS



PROGRAM SPACES: RESEARCH SUPPORT

HAZARDOUS STORAGE

NET AREA: 600 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The hazardous storage space houses hazardous materials used in research and testing. Materials of this nature are used primarily by wet labs, but will be allowed within all power generation and research spaces. The hazardous storage space needs to allow for safe material containment and a properly marked inventory storage system.

CONSIDERATIONS:

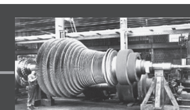
- Shelving system for inventory and count.
- Location near both labs - connection
- Properly organized and charted
- Safety and containment
- Emergency equipment and wash stations
- Spill containment system

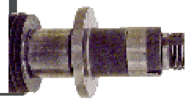
EQUIPMENT:

Hazardous Liquids/Gas:	250 sqft
Hazardous Solids:	250 sqft
Spill Containment:	100 sqft

OPERATION / USAGE:

The hazardous storage will be controlled with security access by authorized personnel 24 hrs - 7 days a week.





PROGRAM SPACES: RESEARCH SUPPORT

ELECTRICAL

NET AREA: 1000 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The focus of the electrical space is to provide specialized equipment in supporting the electrical load of lab spaces. Electricity produced from research and testing will be directed into the facility providing components of self sufficiency. Electrical space will include telephone, internet, cable, microwave systems, digital satellite, and fiber-optic controls.

CONSIDERATIONS:

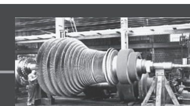
- Specific dress required - working with electrical components
- Location near both labs - primary use of controls
- Properly organized and charted
- Safety and containment

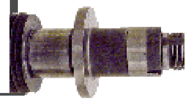
EQUIPMENT:

Lighting Systems:	100 sqft	Safety Systems:	250 sqft
Telephone / Fax:	100 sqft	Microwave System:	50 sqft
Cable:	100 sqft	Digital Satellite:	50 sqft
Fiber Optics:	100 sqft	Mechanical Power:	250 sqft

OPERATION / USAGE:

The electrical space will operate 24 hours - 7 days a week with only qualified maintenance and research specialists allowed access.





PROGRAM
M92. REQUIREMENTS

PROGRAM SPACES: RESEARCH SUPPORT

MECHANICAL HVAC

NET AREA: 2500 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The focus of the mechanical space is to provide lab spaces with heat, ventilation, exhaust, and air conditioning. The space allocated is doubled for the intensive amount of mechanical equipment required for research and testing. The space will house this equipment vital to the facility, using energy and heat produced from research and testing.

CONSIDERATIONS:

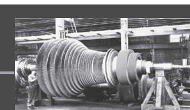
- Ability in supporting increased equipment load.
- Specific fire retardant clothing required with eye and hearing protection. Medical and Wash stations also required.
- High-Bay design for use of testing research and equipment.
- Advanced mechanical systems with consideration towards ventilation, exhaust, and fire suppression.
- Structural stability against movement and vibrations.

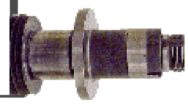
EQUIPMENT:

Air Intake:	500 sqft	Exhaust system:	500 sqft
Filtration:	250 sqft	Ventilation System:	500 sqft
Extractor:	250 sqft	Cooling System:	500 sqft

OPERATION / USAGE:

The mechanical HVAC space will operate 24 hours - 7 days a week with only qualified maintenance and research specialists allowed access.





PROGRAM
M93. REQUIREMENTS

PROGRAM SPACES: RESEARCH SUPPORT

ENGINEERING SYSTEMS

NET AREA: 2500 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The focus of engineering system is to provide wet lab spaces with vital materials involved with research: natural gas, propane, oxygen, refrigeration, water, and vacuum systems. These elements work on a separate system because of the need for user access. Flammable, hazardous, and non hazardous materials will be centrally located within the space, being distributed (piped) into wet labs. The engineering space will also house a heating and refrigeration systems of containment for specific uses needed by research and testing.

CONSIDERATIONS:

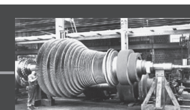
- Properly organized and charted
- Emergency equipment and wash stations
- Spill containment system (Emergency)
- Ability in supporting increased equipment load.

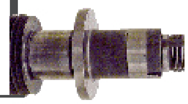
EQUIPMENT:

Natural Gas :	100 sqft	Heating containment:	500 sqft
Propane:	100 sqft	Refrigeration:	500 sqft
Oxygen:	100 sqft	Water Supply:	500 sqft
Vacuum System:	200 sqft	Exhaust (Emerg.):	500 sqft

OPERATION / USAGE:

The engineering systems space will operate 24 hours - 7 days a week with only qualified users and specialists allowed access.





PROGRAM SPACES: RESEARCH SUPPORT

WRITE UP OFFICES

NET AREA: 900 SQ FT
OCCUPANTS: 1-2

FUNCTION:

Write up rooms allow users privacy and quietness for charting results and hypothesis developed by research. The space is used on a temporary basis but offers convenience and efficiency of documentation for users.

CONSIDERATIONS:

- Office typology
- Ability to allow natural daylight
- Sound proof spaces for focused documentation
- Provide means of communication throughout facility
- Adjacent to lab spaces - connection, efficiency, ease of use

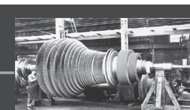
EQUIPMENT:

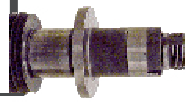
6 write up rooms: 150 sqft ea.

Desk / Equipment :	50 sqft
Chart storage:	50 sqft
Shelving:	25 sqft
PA Electrical:	25 sqft

OPERATION / USAGE:

Write up rooms will be accessible 24 hours - 7 days a week with access to all users. The spaces will provide necessary means of research and testing documentation while allowing users to communicate with the entire facility through a pa system.





PROGRAM
M95. REQUIREMENTS

PROGRAM SPACES: RESEARCH SUPPORT

LOCKER ROOMS / TOILETS

NET AREA: 4200 SQ FT
OCCUPANTS: 1-50 per locker room

FUNCTION:

Locker rooms provide showering units, toilets, and lockers for users of the facility. These spaces are provided for users to enhance the functional character of the facility. The idea is to provide user amenities creating a high quality, efficient work environment.

CONSIDERATIONS:

- Social Interaction amongst users
- Ability to allow natural daylight
- Informational posting
- Personal Storage

EQUIPMENT:

2 locker rooms: 2100 sqft ea. one male and on female

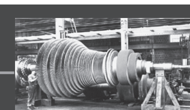
Shower space:	500 sqft	Laundry Stations:	50 sqft
Sink / Hand Washing:	250 sqft	Locker / Storage:	500 sqft
Benches / Seating:	300 sqft	Toilets / Urinals:	500 sqft

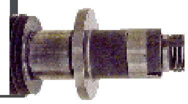
Research based Toilets 150 sqft ea. (total on average 1500 sqft)

Toilets will be provided throughout the facility - minimum of one male and one female facility per floor. This is dependent on design including combination of occupancies and floors.

OPERATION / USAGE:

Locker room facilities and toilets will be accessible by all users and ADA compliant 24 hours - 7 days a week. Maintained by custodial staff.





PROGRAM
M96. REQUIREMENTS

PROGRAM SPACES: RESEARCH SUPPORT

BREAKOUT ROOMS

NET AREA: 1200 SQ FT
OCCUPANTS: 1-25 per room

FUNCTION:

Breakout rooms are provided for user relaxation, offering a means of social interaction. The spaces offer comfort and lounging for all facility users.

CONSIDERATIONS:

- Food and Beverage equipment
- Natural daylight and views
- Sound proof spaces for privacy
- Entertainment and lounging.

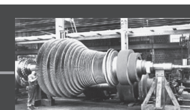
EQUIPMENT:

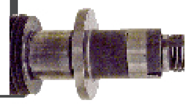
4 break rooms: 400 sqft ea.

Kitchenette :	100 sqft	Entertainment (TV):	10 sqft
Dining Furniture	100 sqft	Casework:	100 sqft
Lounging Furniture:	50 sqft	Information board:	30 sqft
PA Electrical:	10 sqft		

OPERATION / USAGE:

Breakout rooms will be used periodically throughout the day by all users dependent on break times. The spaces will be most heavily occupied during scheduled break times 9:15 am., 12:00pm., and 3:15 pm. Break rooms can also provide temporary meeting and conference space.





PROGRAM SPACES: RESEARCH SUPPORT

CONFERENCE ROOMS

NET AREA: 500 SQ FT
OCCUPANTS: 1-25 per room

FUNCTION:

Lab conference rooms are dedicated to research and testing presentations only, offering large amounts of gathering space. Business and educational type conference will allow for group discussion and decision making.

CONSIDERATIONS:

- Proximity to lab spaces - views
- Natural daylight
- Sound proof spaces for privacy
- Multimedia links and hookups

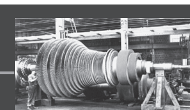
EQUIPMENT:

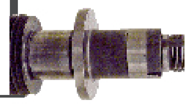
2 lab conf. rooms: 250 sqft ea.

Discussion Table:	75 sqft	Multimedia (CPU):	40 sqft
Projector and Screen:	50 sqft	Casework:	75 sqft
Information board:	10 sqft	PA Electrical:	10 sqft

OPERATION / USAGE:

The conference rooms will be used sporadically throughout the working day 7:00am - 5:00pm depending on meeting schedules. The spaces will be available anytime to facility users based on a scheduling requirement. The conference rooms also provide ample room for class lectures and small scaled guest presentations.





PROGRAM
M98. REQUIREMENTS

PROGRAM SPACES: RESEARCH SUPPORT

TECHNOLOGY LEARNING

NET AREA: 500 SQ FT
OCCUPANTS: 1-25

FUNCTION:

Technology learning space is similar to a formal classroom with the equipment provided to explore advanced mean of research and testing. The space is computer based allowing users full access to a wide range of information while allowing demonstration and presentation of procedures. The space also encourages group discussion with social interaction amongst users.

CONSIDERATIONS:

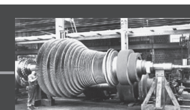
- Ability to allow natural daylight and views
- Sound proof spaces for privacy
- Multimedia links and hookups
- Flexible plan for allowing for change in layout

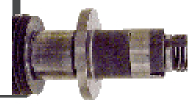
EQUIPMENT:

25 User Stations:	10 sqft ea.	Multimedia (CPU):	50 sqft
Projector and Screen:	50 sqft	Casework:	100 sqft
Information board:	40 sqft	PA Electrical:	10 sqft

OPERATION / USAGE:

The technology learning space will only be accessible during the business day for all users of the facility. The space has multi functions and uses in analyzing and presenting research information.





PROGRAM SPACES: RESEARCH SUPPORT

OFFICES

NET AREA: 1500 SQ FT
OCCUPANTS: 1-2

FUNCTION:

Office space will be provided for primary research personnel including faculty and graduate students. These spaces provide users with privacy and a focus work type atmospheres where day to day business is handled.

CONSIDERATIONS:

- Ability to allow natural daylight and views
- Sound proof spaces for privacy
- Multimedia links and hookups
- Flexible plan for each office

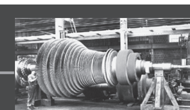
EQUIPMENT:

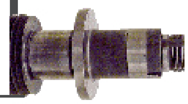
10 offices	150 sqft ea.

Work Desk:	25 sqft
Multimedia (CPU):	5 sqft
Casework:	100 sqft
PA Electrical:	10 sqft
Storage:	10 sqft

OPERATION / USAGE:

Each office space will be personalized by the specific user, accessible 24 hours - 7 days a week. Office hours shall be arranged by each user based on their schedule.

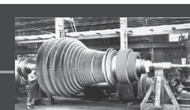


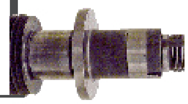


FACILITY BASED SPACE ALLOCATION

- Soiled Fuel Storage..10000 sqft
- Solid Fuel Handling...2000 sqft
- Hydrology Handling...2000 sqft
- Mechanical HVAC...2500 sqft
- Electrical...1000 sqft
- Waste Management..1000 sqft
- Circulation.............................15% of Total.....10000 sqft
- Security..200 sqft
- Pedestrian Bridge...5000 sqft
- Parking..20000 sqft

SUBTOTAL 44700 sqft





PROGRAM SPACES: FACILITY BASED

SOLID FUEL STORAGE

NET AREA: 10000 SQ FT
OCCUPANTS: 1-25

FUNCTION:

The facility requires large amounts of varieties of fuel sources that will be researched and tested. The fuel storage space gives the facility and its users access to readily available materials: coal, barley hulls, corn husks, natural compost, and wood chips. The space will also provide solid fuel storage for the SE plant.

CONSIDERATIONS:

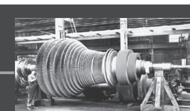
- Exterior design - limited protection
- Ease of accessibility - hauling equipment
- Ability to handle increased amount of load
- Adaptable for varieties of fuel

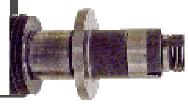
EQUIPMENT:

Coal:	2000 sqft
Barley Hull:	2000 sqft
Corn husks:	2000 sqft
Natural compost:	2000 sqft
Wood chips:	2000 sqft

OPERATION / USAGE:

Each storage unit will be operated and maintained by maintenance staff with periodic refilling, depending on research and studies being performed. The use of the storage spaces need to allow for large equipment and the ability to move large amounts of fuel.





PROGRAM
M102. REQUIREMENTS

PROGRAM SPACES: FACILITY BASED

SOLID FUEL HANDLING

NET AREA: 2000 SQ FT
OCCUPANTS: 1-25

FUNCTION:

Solid fuel handling is in control of moving fuel sources into the power generation lab area. This includes having a continuous mechanism or conveying system from each unit of storage within the boiler unit of the power generation lab, required for long duration studies. Solid handling will also convey fuel from the solid fuel storage to the SE plant located one half mile up river.

CONSIDERATIONS:

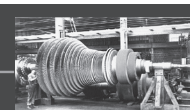
- Interior / exterior connection
- Ease of accessibility - large scaled equipment
- Ability to handle increased amount of load
- Adaptable for varieties of fuel

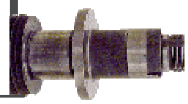
EQUIPMENT:

Conveying system: 1500 sqft
Operating Station: 500 sqft

OPERATION / USAGE:

The solid fuel handling space will be operated 24 hour - 7 days a week or dependent on research or testing study. The space will be operated by maintenance crew only under the supervision of the specific researcher.





PROGRAM
M103. REQUIREMENTS

PROGRAM SPACES: FACILITY BASED

HYDROLOGY HANDLING

NET AREA: 2000 SQ FT
OCCUPANTS: 1-25

FUNCTION:

Hydrology handling takes water from the Mississippi river bringing it into the facility for production and cooling processes. The secondary purpose is to filter and extract the used water back into the river. This space is vital in maintaining steam production for the use of heat and electricity purposes.

CONSIDERATIONS:

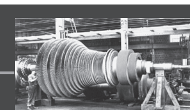
- Interior / exterior connection
- Ease of accessibility - riverfront
- Ability to handle increased amount of load
- Water filtration - intake and outlet

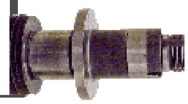
EQUIPMENT:

Water intake:	500 sqft
Water outlet:	500 sqft
Filtration:	500 sqft
Operating station:	250 sqft
Emergency Backup:	250 sqft

OPERATION / USAGE:

The hydrology handling space will be operated 24 hour - 7 days a week or dependent on research or testing study. This space is vital in the production of energy requiring 24 hour security and monitoring. Access will only be allowed to maintenance and specialist.





PROGRAM
M104. REQUIREMENTS

PROGRAM SPACES: FACILITY BASED

MECHANICAL HVAC

NET AREA: 2500 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The focus of the mechanical space is to provide the facility, excluding labs with heat, ventilation, exhaust, and air conditioning. The space allocated is doubled for the intensive amount of mechanical equipment required for research and testing. The space will house equipment vital to the facility and self sufficiency, while using energy and heat produced from research and testing.

CONSIDERATIONS:

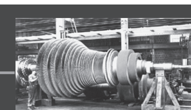
- Ability in supporting increased equipment load.
- Specific fire retardant clothing required with eye and hearing protection. Medical and Wash stations also required.
- Advanced mechanical systems with consideration towards ventilation, exhaust, and fire suppression.
- Structural stability against movement and vibrations.

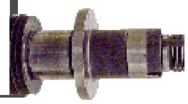
EQUIPMENT:

Air Intake:	500 sqft	Exhaust system:	500 sqft
Filtration:	250 sqft	Ventilation System:	500 sqft
Extractor:	250 sqft	Cooling System:	500 sqft

OPERATION / USAGE:

The mechanical HVAC space will operate 24 hours - 7 days a week with only qualified maintenance and research specialists allowed access. The system is separated from labs to prevent contamination.





PROGRAM SPACES: FACILITY BASED

ELECTRICAL

NET AREA: 1000 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The focus of the electrical space is to provide standard equipment in supporting the electrical load of the entire facility, excluding lab spaces. Electricity produced from research and testing will be reused allowing the facility to provide components of self sufficiency. Electrical space will include telephone, internet, cable, microwave systems, digital satellite, and fiber-optic controls.

CONSIDERATIONS:

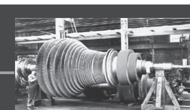
- Specific dress required - working with electrical components
- Properly organized and charted
- Safety and containment

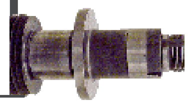
EQUIPMENT:

Lighting Systems:	100 sqft	Safety Systems:	250 sqft
Telephone / Fax:	100 sqft	Microwave System:	50 sqft
Cable:	100 sqft	Digital Satellite:	50 sqft
Fiber Optics:	100 sqft	Mechanical Power:	250 sqft

OPERATION / USAGE:

The electrical space will operate 24 hours - 7 days a week with only qualified maintenance and research specialists allowed access. Electrical spaces are separated from lab areas to prevent total failure. The system directs excess electricity to labs in case of emergency.





PROGRAM
M106. REQUIREMENTS

PROGRAM SPACES: FACILITY BASED

WASTE MANAGEMENT

NET AREA: 1000 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The waste management spaces are allocated for all custodial services and nonhazardous waste produced by the facility, excluding plumbing. The waste includes day to day trash and custodial cleaning separating and compacting all trash for recycling and hauling purposes.

CONSIDERATIONS:

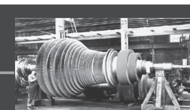
- Separation of waste material - recycling
- Properly organized and compacted
- Muti-Locations for ease of use

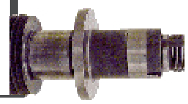
EQUIPMENT:

5 custodial rooms:	100 sqft ea.
Handling:	200 sqft
Compactor:	100 sqft
4 System separation:	25 sqft ea.
(glass, plastic, paper, aluminum)	

OPERATION / USAGE:

The waste management space is required for the amount of waste produced by the facility. It will be operated 7:00am - 5:00pm by custodial staff.





PROGRAM
M107. REQUIREMENTS

PROGRAM SPACES: FACILITY BASED

CIRCULATION

NET AREA: 10000 SQ FT 15% OF TOTAL SQ FT

FUNCTION:

Total Facility Circulation: 10000 sqft 15% of total square footage.

Total Square Footage 58300 sqft - minus 20000 sqft for parking

Included:

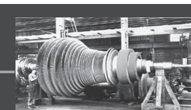
Horizontal Circulation - corridors, hallways, transitions
Vertical Circulation - stairs, elevators, ramps
Spatial Circulation

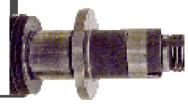
CONSIDERATIONS:

- 5’ minimum width
- 20’ maximum dead end corridors
- Access relationships towards space allocation - connection
- Properly marked - safety and emergency egress

OPERATION / USAGE:

Circulation will provide direct connections and movement throughout the facility spaces. Design consideration will be important because of the importance in everyday usage.





PROGRAM SPACES: FACILITY BASED

SECURITY

NET AREA: 200 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The security space will provide the facility with protection and safety. This will ensure secure access throughout the site and within restricted areas. A team of security personnel are trained to operate the space and perform security measures as needed.

CONSIDERATIONS:

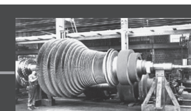
- Authorized site access
- Restricted space allocations
- Surveillance of facility and its perimeter
- Safety of Users

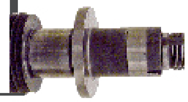
EQUIPMENT:

Authorization Window:	100 sqft ea.
Surveillance Cameras:	50 sqft
Detention:	50 sqft

OPERATION / USAGE:

The security space will be operated 24 hours - 7 day a week by a properly trained crew. The idea is to prevent any wrong doing with the ability to control any measures affecting users health and safety.





PROGRAM
M109. REQUIREMENTS

PROGRAM SPACES: FACILITY BASED

PEDESTRIAN BRIDGE

NET AREA: 5000 SQ FT
OCCUPANTS: 1-1000

FUNCTION:

The pedestrian bridge is an existing historic element providing connection from the west bank of the Mississippi river to the east bank, running directly through the facility's site. This connection provides a main artery of circulation from downtown Minneapolis, U of M campus, and Dinkytown. The design incorporates the bridge within the site to attract users. The primary connection of the bridge is maintained with the focus on revitalization.

CONSIDERATIONS:

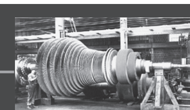
- Aesthetic appeal
- Facility integration
- Multi-functional aspects
- Proper lighting
- Security near facility
- Safety of Users

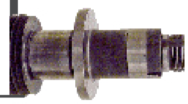
EQUIPMENT:

Existing

OPERATION / USAGE:

The pedestrian bridge is accessible to the public 24 hour - 7 days a week with periodic maintenance controlled by the facility and University.





PROGRAM
M110. REQUIREMENTS

PROGRAM SPACES: FACILITY BASED

PARKING

NET AREA:	20000 SQ FT
OCCUPANTS:	1-1000

FUNCTION:

Parking is defined by the building type and the amount of occupancy based on the UBC 2003. The facility for power generation and industrial technology requires 110 off street parking stalls including visitor parking with 1 van and 4 car stalls being ADA accessible. Separate drop off and loading zones will be provided based on design layout.

CONSIDERATIONS:

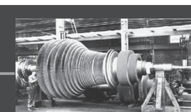
- Proximity to facility
- Enclosed access
- Delegated parking stalls
- Proper lighting
- Security

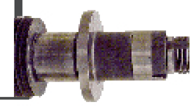
EQUIPMENT:

100 Parking Stalls:	17000 sqft
1 ADA van Stall:	250 sqft
Loading / Unloading:	1000 sqft
Drop off zones	250 sqft

OPERATION / USAGE:

Parking is accessible to the facility users 24 hour - 7 days a week with periodic maintenance and security controlled by the facility. Public access will not be allowed after 5:00pm for security reasons.

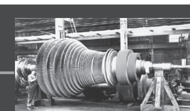




PUBLIC BASED SPACE ALLOCATION

- Lobby..1000 sqft
- Gallery..2000 sqft
- Interpretive / Recreation Office......................2000 sqft
- Auditorium..3500 sqft
- Administration..3000 sqft
- Conference rooms...500 sqft
- Office Supplies Storage.......................................500 sqft

SUBTOTAL 12500 sqft



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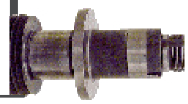

M112. REQUIREMENTS

PROGRAM SPACES: PUBLIC BASED

LOBBY

NET AREA: 1000 SQ FT
OCCUPANTS: 1-500

FUNCTION:

The function of the lobby is to create public entry into the facility while directing user/visitor function. The public space provides opportunity for users to socially interact while interpreting the spatial layout of the facility.

CONSIDERATIONS:

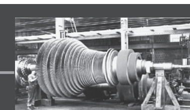
- Interior colors and materials that are pleasing
- Allowing natural daylight and views
- Informational Center - Direction on Layout
- Inviting character

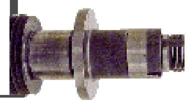
EQUIPMENT:

Front Desk:	500 sqft
Information center:	250 sqft
Lounging Furniture:	250 sqft

OPERATION / USAGE:

The lobby space will be used throughout the day by the staff and general public. The lobby will only be operated during business hours 7:00am - 5:00pm. The space has to display inviting characteristics that are pleasing and informational to all users. The lobby immediately directs users/visitors throughout the facility.





PROGRAM
M113. REQUIREMENTS

PROGRAM SPACES: PUBLIC BASED

GALLERY

NET AREA: 2000 SQ FT
OCCUPANTS: 1-500

FUNCTION:

The function of the gallery is display the valuable efforts of the facility's research and testing. The gallery acts as an interpretive space for visitors demonstrating the function and operations of the facility. A historic riverfront walking trail is also incorporated for visitors. Display areas expose valuable information on the advances in power generation and industrial technology that affect everyone. The gallery space will also act as a gathering space for special presentations and press releases.

CONSIDERATIONS:

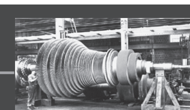
- Interior colors and materials that are pleasing
- Allowing natural daylight and views
- Informational displays of research and testing
- Views into Lab ares - visual understanding
- Large amounts of wall and floor display

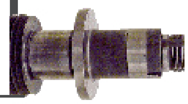
EQUIPMENT:

Display Equipment: 1000 sqft
Informational / Visual effects : 250 sqft

OPERATION / USAGE:

The gallery space will be used throughout the day primarily by the general public. The gallery will only be operated during business hours 7:00am - 5:00pm. The gallery will change periodically with new break through in technology.





PROGRAM
M114. REQUIREMENTS

PROGRAM SPACES: PUBLIC BASED

INTERPRETIVE / RECREATION OFFICE

NET AREA: 2000 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The interpretive and recreation office will provide support to the gallery space. Questions and concerns generated by the public will be handled along with periodic updating of the gallery. The office will also control the historic riverfront walking trial with directional and information stands throughout the site. The idea of the interpretive and recreation office is to integrate public interaction, exposing the general public to advancements made at the facility.

CONSIDERATIONS:

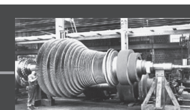
- Office typology
- Allowing natural daylight and views
- Informational displays of research and testing - maps

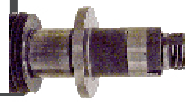
EQUIPMENT:

Office Furniture: 100 sqft
Informational cpu units: 100 sqft

OPERATION / USAGE:

The interperative/recreation office will be used throughout the day primarily by the general public. The gallery will only be operated during business hours 7:00am - 5:00pm. The office will provide answers to questions and concerns and provide directional service of historic walking trail.





PROGRAM
M115. REQUIREMENTS

PROGRAM SPACES: PUBLIC BASED

AUDITORIUM

NET AREA:	3500 SQ FT
OCCUPANTS:	150

FUNCTION:

The function of the auditorium is to hold large scale public and private presentations, lectures and meetings. Guest lectures and other special events will also be held within the space.

CONSIDERATIONS:

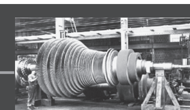
- Interior colors and materials that are pleasing
- Allowing natural daylight and views
- Ease of Access from lobby
- Discrete lighting

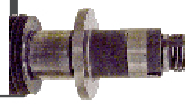
EQUIPMENT:

Seating:	150
Seating Area:	2500 sqft
Presentation Area:	500 sqft
Storage A/V Room:	500 sqft

OPERATION / USAGE:

The auditorium will be used periodically by the staff and the general public. The auditorium will operate based on scheduled time of use usually 7:00am - 9:00 pm.





PROGRAM SPACES: PUBLIC BASED

ADMINISTRATION

NET AREA: 3000 SQ FT
OCCUPANTS: 1- 5 per room

FUNCTION:

Administration spaces include receptionist, offices, and utilities with focus work type atmospheres where day to day business is handled. The administration space takes care of facility requirements and business issues.

CONSIDERATIONS:

- Ability to allow natural daylight and views
- Sound proof spaces for privacy
- Multimedia links and hookups
- Flexible plan for each office

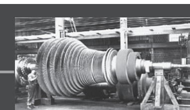
EQUIPMENT:

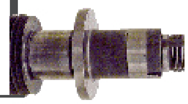
15 offices	150 sqft ea.	PA Electrical:	50 sqft
Receptionist:	100 sqft	Mail Room:	100 sqft
Multimedia (CPU):	50 sqft	Waiting:	200 sqft
Copy Room:	100 sqft	kitchenette:	150 sqft

Office layout - same as research based offices

OPERATION / USAGE:

All administration space will be personalized by the specific user, accessible 24 hours - 7 days a week. Administration hours shall be arranged by each user based on their schedule with public operation only during the business day 7:00am - 5:00pm.





PROGRAM SPACES: PUBLIC BASED

CONFERENCE ROOMS

NET AREA: 500 SQ FT
OCCUPANTS: 1-25 per room

FUNCTION:

Facility conference rooms are dedicated to administration type meetings. Conference spaces allow for group discussion and decision making necessary for the facility.

CONSIDERATIONS:

- Proximity to Administration spaces
- Natural daylight - views
- Sound proof spaces for privacy
- Multimedia links and hookups

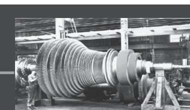
EQUIPMENT:

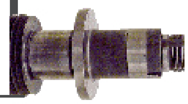
2 lab conf. rooms: 250 sqft ea.

Discussion Table:	75 sqft	Multimedia (CPU):	40 sqft
Projector and Screen:	50 sqft	Casework:	75 sqft
Information board:	10 sqft	PA Electrical:	10 sqft

OPERATION / USAGE:

The conference rooms will be used sporadically throughout the working day 7:00am - 5:00pm depending on meeting schedules. The spaces will be available anytime to facility users based on scheduling requirements. The conference rooms also provide ample room for class lectures and small scaled guest presentations.





PROGRAM SPACES: PUBLIC BASED

OFFICE SUPPLIES STORAGE

NET AREA: 500 SQ FT
OCCUPANTS: 1-5 per room

FUNCTION:

The overall facility requires large amounts of office supplies. The storage space inventories and organizes a system in which office supplies can be distributed throughout the entire facility.

CONSIDERATIONS:

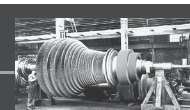
- Shelving system for inventory and count.
- Location near both labs - connection
- Properly organized and charted
- Proximity to Administration spaces

EQUIPMENT:

Shelving System: 250 sqft
Casework: 150 sqft

OPERATION / USAGE:

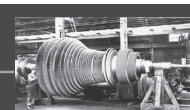
The equipment storage is accessible with security access by all facility staff 24 hrs - 7 days a week.



EDUCATION BASED SPACE ALLOCATION

- Classrooms..1500 sqft
- Computer Lab...500 sqft
- Breakout Room...500 sqft
- Offices..1500 sqft
- Library..1500 sqft
- Departmental Office...200 sqft

SUBTOTAL 5700 sqft



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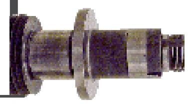

M120. REQUIREMENTS

PROGRAM SPACES: EDUCATION BASED

CLASSROOMS

NET AREA: 1500 SQ FT
OCCUPANTS: 1-25 per room

FUNCTION:

The facility is used as a full functioning hands on classroom within itself. Formal education classrooms are also provided for specific engineering and industrial technology courses. The classrooms provide lecture based education.

CONSIDERATIONS:

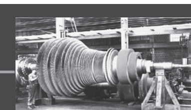
- Natural daylight and views
- Location near both labs - connection
- Flexible layout for in class demonstrations

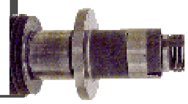
EQUIPMENT:

3 classrooms	500 sqft ea.
Seating Capacity:	25
Seating Area:	300 sqft
Presentation Area:	100 sqft
Equipment storage:	100 sqft

OPERATION / USAGE:

Classrooms are accessible 24 hours - 7 days a week by faculty and students by means of security access. The spaces will be primarily used from 7:00am - 5:00pm but will allow students and faculty the ability to use the classrooms as study spaces.





PROGRAM
M121. REQUIREMENTS

PROGRAM SPACES: EDUCATION BASED

COMPUTER LAB

NET AREA:	500 SQ FT
OCCUPANTS:	1-25 per room

FUNCTION:

The computer lab provides students and faculty with computer access with advanced research and testing software. The ability to learn computer based technology is vital in modern day research and education. The space also provided muti-media link hook ups, printers, and internet access to increase quality of education.

CONSIDERATIONS:

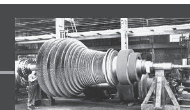
- Natural daylight and views
- Location near classrooms
- Flexible layout for demonstrations

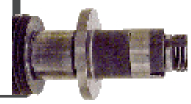
EQUIPMENT:

25 CPU workstations:	15 sqft ea.
4 printers:	25 sqft
Multimedia:	50 sqft
Equipment storage:	50 sqft

OPERATION / USAGE:

The computer lab is accessible 24 hours - 7 days a week for faculty and students by means of security access. The space will be primarily used from 7:00am - 5:00pm but will allow students and faculty the ability to use the computer lab for after class work.





PROGRAM SPACES: EDUCATION BASED

BREAKOUT ROOM

NET AREA: 500 SQ FT
OCCUPANTS: 1-25 per room

FUNCTION:

Breakout rooms are provided for students and faculty to engage in social interaction and discussion. The space provides a means of relaxation offering comfort and lounging for users.

CONSIDERATIONS:

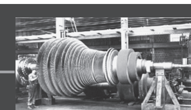
- Food and Beverage equipment
- Natural daylight and views
- Sound proof spaces for privacy
- Entertainment and lounging.

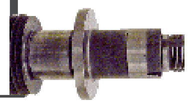
EQUIPMENT:

Kitchenette:	50 sqft	Entertainment (TV):	10 sqft
Dining Furniture	50 sqft	Casework:	100 sqft
Lounging Furniture:	100 sqft	Information board:	30 sqft

OPERATION / USAGE:

The breakout room will be used periodically throughout the day by faculty and students dependent on break times. The breakout rooms will also provide informal meeting and conference spaces for users.





PROGRAM
M123. REQUIREMENTS

PROGRAM SPACES: EDUCATION BASED

OFFICES

NET AREA: 1500 SQ FT
OCCUPANTS: 1-2

FUNCTION:

Office space will be provided to faculty and graduate students. This space provides users with privacy and focus work type atmospheres where day to day business is handled.

CONSIDERATIONS:

- Ability to allow natural daylight and views
- Multimedia links and hookups
- Flexible plan for each office

EQUIPMENT:

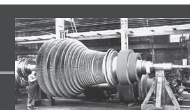
10 offices 150 sqft ea.

Office Layout

Work Desk:	25 sqft
Multimedia (CPU):	5 sqft
Casework:	100 sqft
PA Electrical:	10 sqft
Storage:	10 sqft

OPERATION / USAGE:

Each office space will be personalized by the specific user, accessible 24 hours - 7 days a week. Office hours shall be arranged by each user based on their schedule.



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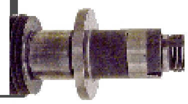

M124. REQUIREMENTS

PROGRAM SPACES: EDUCATION BASED

LIBRARY

NET AREA: 1500 SQ FT
OCCUPANTS: 1-50

FUNCTION:

A library space will offer special reference materials on advanced power generation and industrial design to all facility users including general public. Research and testing data, methods and detailed study reports will be filed within the library for educational purposes. The library space offers students, faculty, facility staff, and the general public a medium to explore advanced means of research and testing.

CONSIDERATIONS:

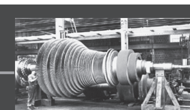
- Ability to allow natural daylight and views
- Sound proof spaces for privacy
- Multimedia links and hookups
- Flexible plan for each office

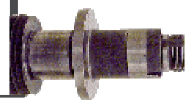
EQUIPMENT:

Librarian Desk:	25 sqft	Storage:	100 sqft
Multimedia (CPU):	25 sqft	15 Study Desks:	150 sqft
Casework:	200 sqft	2 Group Work Stations:	250 sqft
Shelving:	500 sqft		

OPERATION / USAGE:

The library space will be accessible 24 hours - 7 days a week by all facility users including the general public.





PROGRAM SPACES: EDUCATION BASED

DEPARTMENTAL OFFICE

NET AREA: 200 SQ FT
OCCUPANTS: 1-5

FUNCTION:

The departmental office space will be provided for faculty and students with any concerns related to the college of engineering and industrial technology. The office is specific for the facility location secondary to the head departmental office on campus. This space provides users with privacy and focus work type atmospheres where day to day business is handled.

CONSIDERATIONS:

- Ability to allow natural daylight and views
- Multimedia links and hookups
- Flexible plan for each office

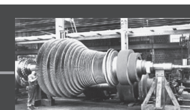
EQUIPMENT:

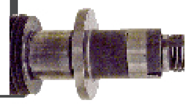
Departmental Chair Office	150 sqft
Receptionist:	50 sqft

Office Layout - same as educational based offices

OPERATION / USAGE:

Departmental office space will be personalized by the specific user, accessible 24 hours - 7 days a week. Office hours shall be arranged by each user based on their schedule.





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

RESEARCH BASED:

- Power Generation Lab..10000 SQFT

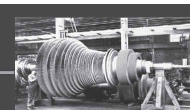
Multi-Fuel Boiler	2000 sq ft
250 mw Steam Turbine	1200 sq ft
Condensing Unit	500 sq ft
Fuel Handling	500 sq ft
Energy Circ. Unit	750 sq ft
Byproduct removal	2500 sq ft
Crane Hoist	500 sq ft
Tool/Parts storage	1000 sq ft

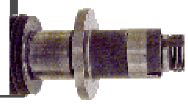
- Research Labs..5200 SQFT

Closed Dry Labs:	3	150 sqft ea.
Open Dry Labs:	3	250 sqft ea.
Closed Wet Labs:	6	200 sqft ea.
Open Wet Labs:	6	500 sqft ea.

- Power Conversion/Heat Distribution....................................3000 SQFT

Main Generator:	500 sqft
Flow Station:	250 sqft
DC / AC Converter:	500 sqft
Blowers:	250 sqft
Switch Yard:	1000 sqft
Transmission Station:	250 sqft
Control Room:	250 sqft





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

RESEARCH BASED:

- Byproduct Removal..3500 SQFT

Hazardous Contain:	500 sqft
Byproduct Storage:	500 sqft
Hazard Cleanup:	100 sqft
Transport equipment:	400 sqft
Non-Hazard. Contain.:	500 sqft
Vehicle Storage:	1000 sqft
Non-Hazard. Cleanup:	100 sqft
Other Equipment:	400 sqft

LAB SUPPORT FOR RESEARCH BASED:

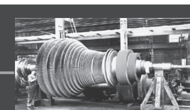
- Emergency Backup (UPS)...500 sqft

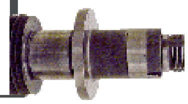
4 Generators:	50 sqft ea.
Fire Suppression system:	50 sqft
Lighting:	25 sqft
Ventilation / Exhaust:	200 sqft
Electrical:	25 sqft

- Equipment Storage..500 sqft

- Hazardous Material Storage...600 sqft

Hazardous Liquids/Gas:	250 sqft
Hazardous Solids:	250 sqft
Spill Containment:	100 sqft





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

LAB SUPPORT FOR RESEARCH BASED:

- Electrical..1000 sqft

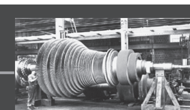
Lighting Systems:	100 sqft
Safety Systems:	250 sqft
Telephone / Fax:	100 sqft
Microwave System:	50 sqft
Cable:	100 sqft
Digital Satellite:	50 sqft
Fiber Optics:	100 sqft
Mechanical Power:	250 sqft

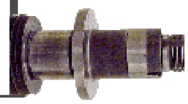
- Mechanical HVAC..2500 sqft

Air Intake:	500 sqft
Exhaust system:	500 sqft
Filtration:	250 sqft
Ventilation System:	500 sqft
Extractor:	250 sqft
Cooling System:	500 sqft

- Engineering Systems...2500 sqft

Natural Gas :	100 sqft
Heating containment:	500 sqft
Propane:	100 sqft
Refrigeration:	500 sqft
Oxygen:	100 sqft
Water Supply:	500 sqft
Vacuum System:	200 sqft
Exhaust (Emerg.):	500 sqft





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

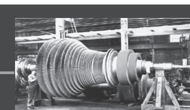
LAB SUPPORT FOR RESEARCH BASED:

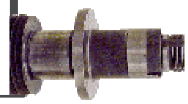
- Write Up Offices..900 sqft

6 Write Up offices:	150 sqft ea.
Desk / Equipment:	50 sqft
Chart storage:	50 sqft
Shelving:	25 sqft
PA Electrical:	25 sqft

- Locker rooms / Toilets..4200 sqft

2 locker rooms:	2100 sqft ea.
Shower space:	500 sqft
Laundry Stations:	50 sqft
Sink / Hand Washing:	250 sqft
Locker / Storage:	500 sqft
Benches / Seating:	300 sqft
Toilets / Urinals:	500 sqft
Facility Based Toilets	150 sqft ea.





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

LAB SUPPORT FOR RESEARCH BASED:

- Electrical..1000 sqft

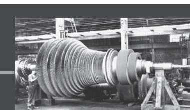
Lighting Systems:	100 sqft
Safety Systems:	250 sqft
Telephone / Fax:	100 sqft
Microwave System:	50 sqft
Cable:	100 sqft
Digital Satellite:	50 sqft
Fiber Optics:	100 sqft
Mechanical Power:	250 sqft

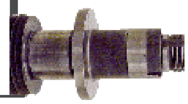
- Breakout Rooms...1200 sqft

4 break rooms:	400 sqft ea.
Kitchenette:	100 sqft
Entertainment (TV):	10 sqft
Dining Furniture	100 sqft
Casework:	100 sqft
Lounging Furniture:	50 sqft
Information board:	30 sqft
PA Electrical:	10 sqft

- Conference Rooms...500 sqft

2 lab conf. rooms:	250 sqft ea.
Discussion Table:	75 sqft
Multimedia (CPU):	40 sqft
Projector and Screen:	50 sqft
Casework:	75 sqft
Information board:	10 sqft
PA Electrical:	10 sqft





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

LAB SUPPORT FOR RESEARCH BASED:

- Technology Learning..500 sqft

25 User Stations:	10 sqft ea.
Multimedia (CPU):	50 sqft
Projector and Screen:	50 sqft
Casework:	100 sqft
Information board:	40 sqft
PA Electrical:	10 sqft

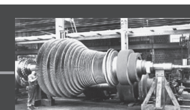
- Offices...1500 sqft

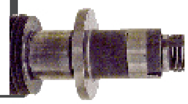
10 offices:	150 sqft ea.
Work Desk:	25 sqft
Multimedia (CPU):	5 sqft
Casework:	100 sqft
PA Electrical:	10 sqft
Storage:	10 sqft

FACILITY BASED:

- Soiled Fuel Storage..10000 sqft

Coal:	2000 sqft
Barley Hull:	2000 sqft
Corn husks:	2000 sqft
Natural compost:	2000 sqft
Wood chips:	2000 sqft





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

FACILITY BASED:

- Solid Fuel Handling..........2000 sqft

Conveying system:	1500 sqft
Operating Station:	500 sqft

- Hydrology Handling..........2000 sqft

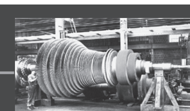
Water intake:	500 sqft
Water outlet:	500 sqft
Filtration:	500 sqft
Operating station:	250 sqft
Emergency Backup:	250 sqft

- Mechanical HVAC..........2500 sqft

Air Intake:	500 sqft
Exhaust system:	500 sqft
Filtration:	250 sqft
Ventilation System:	500 sqft
Extractor:	250 sqft
Cooling System:	500 sqft

- Electrical..........1000 sqft

Lighting Systems:	100 sqft
Safety Systems:	250 sqft
Telephone / Fax:	100 sqft
Microwave System:	50 sqft
Cable:	100 sqft
Digital Satellite:	50 sqft
Fiber Optics:	100 sqft
Mechanical Power:	250 sqft



EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

FACILITY BASED:

- Waste Management..1000 sqft

    5 custodial rooms: 100 sqft ea.
    Handling: 200 sqft
        Compactor: 100 sqft
        4 System separation: 25 sqft ea.
        (glass, plastic, paper, aluminum)

- Circulation..10000 sqft

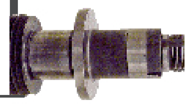
- Security...200 sqft

    Authorization Window: 100 sqft ea.
    Surveillance Cameras: 50 sqft
    Detention: 50 sqft

- Pedestrian Bridge..5000 sqft

- Parking...20000 sqft

    100 Parking Stalls: 17000 sqft
    1 ADA van Stall: 250 sqft
    Loading / Unloading: 1000 sqft
    Drop off zones 250 sqft



EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

PUBLIC BASED:

- Lobby...1000 sqft

Front Desk:	500 sqft
Information center:	250 sqft
Lounging Furniture:	250 sqft

- Gallery...2000 sqft

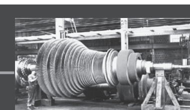
Display Equipment:	1000 sqft
Informational / Visual effects :	250 sqft

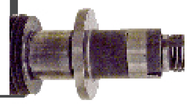
- Interpretive / Recreation Office..2000 sqft

Office Furniture:	100 sqft
Info. cpu units:	100 sqft

- Auditorium...3500 sqft

Seating:	150
Seating Area:	2500 sqft
Presentation Area:	500 sqft
Storage A/V Room:	500 sqft





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

PUBLIC BASED:

- Administration..3000 sqft

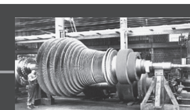
15 offices:	150 sqft ea.
PA Electrical:	50 sqft
Receptionist:	100 sqft
Mail Room:	100 sqft
Multimedia (CPU):	50 sqft
Waiting:	200 sqft
Copy Room:	100 sqft
Kitchenette:	150 sqft

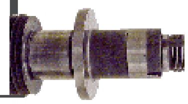
- Conference rooms...500 sqft

Discussion Table:	75 sqft
Multimedia (CPU):	40 sqft
Projector and Screen:	50 sqft
Casework:	75 sqft
Information board:	10 sqft
PA Electrical:	10 sqft

- Office Supplies Storage..500 sqft

Shelving System:	250 sqft
Casework:	150 sqft





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

EDUCATION BASED:

- Classrooms..1500 sqft

3 classrooms	500 sqft ea.
Seating Capacity:	25
Seating Area:	300 sqft
Presentation Area:	100 sqft
Equipment storage:	100 sqft

- Computer Lab..500 sqft

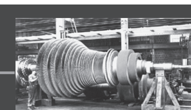
25 CPU workstations:	15 sqft ea.
4 printers:	25 sqft
Multimedia:	50 sqft
Equipment storage:	50 sqft

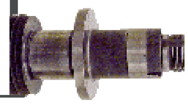
- Breakout Room..500 sqft

Kitchenette:	50 sqft
Entertainment (TV):	10 sqft
Dining Furniture	50 sqft
Casework:	100 sqft
Lounging Furniture:	100 sqft
Information board:	30 sqft

- Offices..1500 sqft

10 offices	150 sqft ea.
Work Desk:	25 sqft
Multimedia (CPU):	5 sqft
Casework:	100 sqft
PA Electrical:	10 sqft
Storage:	10 sqft





EXECUTIVE SUMMARY OF SPACE ALLOCATIONS:

EDUCATION BASED:

- Library..1500 sqft

Librarian Desk:	25 sqft
Storage:	100 sqft
Multimedia (CPU):	25 sqft
15 Study Desks:	150 sqft
Casework:	200 sqft
2 Group Stations:	250 sqft
Shelving:	500 sqft

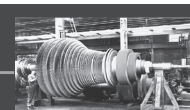
- Departmental Office..200 sqft

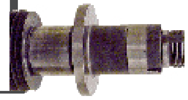
Dept. Chair Office:	150 sqft
Receptionist:	50 sqft

SPACE ALLOCATION:

Research Based:	21700 sqft
Lab Support	16400 sqft
Facility Based:	44700 sqft
Educational Based:	5700 sqft

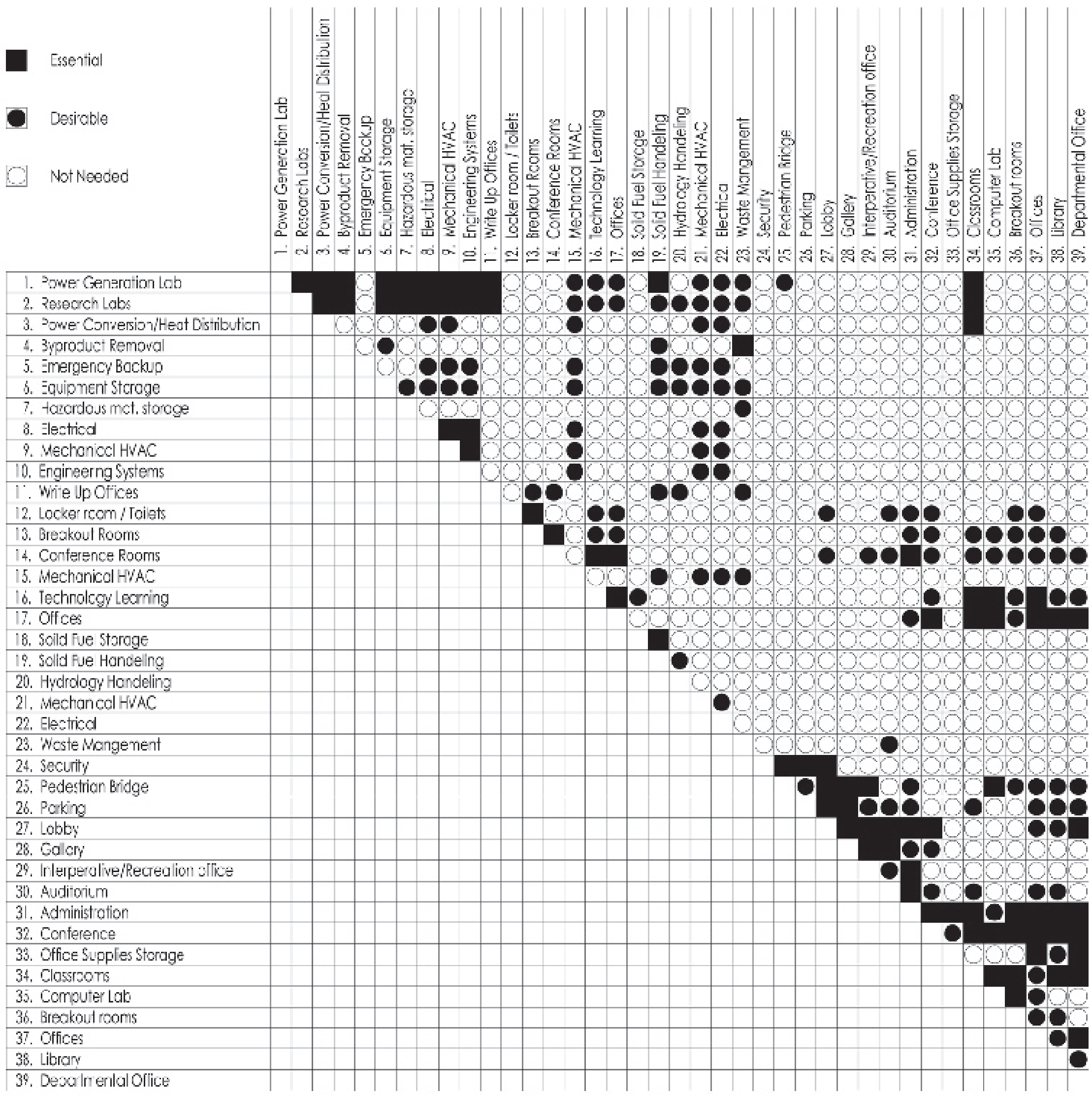
TOTAL SQFT..88500 SQFT

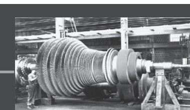


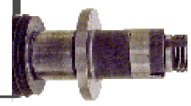


PROGRAM
M138. REQUIREMENTS

INTERACTION MATRIX:

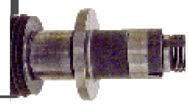






CODE SEARCH

Research and investigation of building and construction practices. Demonstrating knowledge and ability to locate and interpret required design elements at a professional standard.



N140. CODE SEARCH

CODE SEARCH AND ZONING:

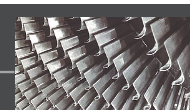
PROJECT NAME:	Facility for Power Generation and Industrial Technology
LOCATION:	Minneapolis, MN U of M campus
ZONING:	Minneapolis Code of Ordinances (Appendix C.1)
BUILDING CODE:	UBC - 2003 Minnesota State Building Code

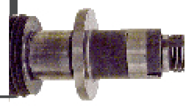
ZONING REQUIREMENTS:

PROPERTY CLASS: I3 - General Industrial District

SET BACKS: - ONLY IF LOCATED NEAR OFFICE OR RESIDENTIAL

FRONT YARD:	300 feet
SIDE YARD E :	300 feet
SIDE YARD W:	300 feet
REAR YARD:	Riverfront - 0 feet
SCREENING:	not less than 8 feet not less than 95% opaque along property line adjacent to office or residential





N141. CODE SEARCH

CODE SEARCH AND ZONING:

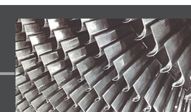
ZONING: INDUSTRIAL DISTRICTS

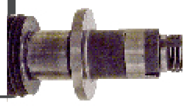
The industrial districts are established to provide locations for industrial land uses engaged in production, processing, assembly, manufacturing, packaging, wholesaling, warehousing, or distribution of goods and materials. Regulations for the industrial districts are established to promote industrial development and maintain and improve compatibility with surrounding areas. In addition to industrial uses, limited commercial uses, parking facilities, institutional and public services and utilities are allowed.

CLASS: I3 - General Industrial District

General industrial uses include high impact and outdoor uses which are likely to have a substantial adverse effect on the environment or on surrounding properties and which require special measures and careful site selection to ensure compatibility with the surrounding area. General industrial uses often include processing of raw materials and production of primary materials. General industrial uses include petroleum and coal product.

(City of Minneapolis,MN, 2004, Zoning)





N142. CODE SEARCH

CODE SEARCH AND ZONING:

ZONING REQUIREMENTS:

HEIGHT LIMIT:	4 stories or 56 feet permit for exceptions

No shading of office or residential building. Preserve surrounding area and views.

FLOOR AREA RATIO:	(2.7) maximum permit for exceptions

MIN LOT AREA:	2 acres

MAXIMUM FLOOR AREA ALLOWANCES PER OCCUPANT:

Group B (office)	100 gross
Group H-5 (industrial)	100 gross

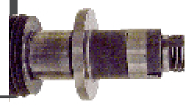
MIN EXITS: based on occup. load

1-500	2
501- 1000	3
> 1000	4

MINIMUM WIDTH

CORRIDORS:	5 ft
STAIRS:	3.5 ft

Exits not to exceed 75 ft from exit corridor.
Dead ends not to exceed 4 ft.
Not less than 2 exits per floor including 1/2 to travel into workstation / lab areas.



N143. CODE SEARCH

CODE SEARCH AND ZONING:

BUILDING CODE COMPLIANCE:

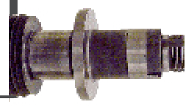
BUILDING OCCP:	Mixed - Use
	Adaptive Reuse
Section 309	Group B
Section 307	Group H-5
Section 406	Parking Garage

Separation walls are needed as per Chapter 3 of the UBC, defining each area separately allowing limitations only to apply within each specific area.

Requirement for fire zones and sprinkler systems:

Group H-5:	Sprinkler system installed throughout building. Where the design area of the sprinkler system consists of a corridor protected by one row of sprinklers. (max sprinkler - 13)
Group B:	Sprinkler systems are not required but allow modification to floor area and building height.

CONSTRUCTION TYPES:	Type I
	Type II
	Type III



N144. CODE SEARCH

CODE SEARCH AND ZONING:

GROUP H-5:
TYPE I:

ALLOWABLE HEIGHT:	unlimited
INCREASES ALLOWED:	non
ALLOWABLE STORIES:	unlimited
AREA LIMITATIONS:	unlimited
AREA MODIFICATIONS: (if sprinklered)	non

GROUP H-5:
TYPE II:

ALLOWABLE HEIGHT:	65 ft
INCREASES ALLOWED:	non
ALLOWABLE STORIES:	3 stories
AREA LIMITATIONS:	37,500 ft PF
AREA MODIFICATIONS: (if sprinklered)	200% TFA

GROUP H-5:
TYPE II:

ALLOWABLE HEIGHT:	65 ft
INCREASES ALLOWED:	non
ALLOWABLE STORIES:	3 stories
AREA LIMITATIONS:	28,500 ft PF
AREA MODIFICATIONS: (if sprinklered)	200% TFA

N145. CODE SEARCH

CODE SEARCH AND ZONING:

GROUP B:
TYPE I:

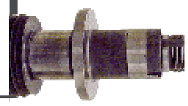
ALLOWABLE HEIGHT:	unlimited
INCREASES ALLOWED:	20 ft - 1story
ALLOWABLE STORIES:	unlimited
AREA LIMITATIONS:	unlimited
AREA MODIFICATIONS: (if sprinklered)	non

GROUP H-5:
TYPE II:

ALLOWABLE HEIGHT:	65 ft
INCREASES ALLOWED:	20 ft - 1 story
ALLOWABLE STORIES:	5 stories
AREA LIMITATIONS:	37,500 ft PF
AREA MODIFICATIONS: (if sprinklered)	200% TFA

GROUP H-5:
TYPE II:

ALLOWABLE HEIGHT:	65 ft
INCREASES ALLOWED:	20 ft - 1 story
ALLOWABLE STORIES:	5 stories
AREA LIMITATIONS:	28,500 ft PF
AREA MODIFICATIONS: (if sprinklered)	200% TFA



N146. CODE SEARCH

RELEVANT CODE REQUIREMENTS:

CHAPTER 3 - USE AND OCCUPANCY CLASSIFICATION

SCOPE: The provisions of this chapter shall control the classification of all buildings and structures as to use and occupancy. (UBC 2003)

CHAPTER 4 - SECTIONS 414 AND 415 SPECIAL REQUIREMENTS

SCOPE: Storage and use of hazardous materials in excess of the maximum allowable quantities per control area listed in Section 307.9. Buildings and structures with an occupancy in Group H shall also comply with the applicable provisions of section 414 and the International Fire Code. (UBC 2003)

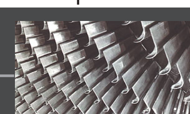
CHAPTER 12 - SECTIONS 1202-1203 INTERIOR ENVIRONMENTS

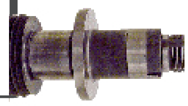
SCOPE: The provisions of this chapter shall govern ventilation, temperature control, lighting, yards and courts, sound transmission, room dimensions, surrounding materials, androdent proofing associated with the interior spaces of buildings. (UBC 2003)

VENTILATION:

Inlet and outlet ducts shall provide min. of 1 sq in for each 1 sq ft of floor area.

Separate duct systems are required for each workspace or lab - creating flow min of 1 cubic foot per min per sqft.





N147. CODE SEARCH

RELEVANT CODE REQUIREMENTS:

CHAPTER 16 - SECTIONS 1601-1623
STRUCT. DESIGN (LOADS)

SCOPE: The provisions of this chapter shall govern the structural design of the buildings, structures, and portions thereof regulated by this code. (UBC 2003)

CHAPTER 31 - SECTIONS 3104 - 3108
SPECIAL CONSTRUCTION

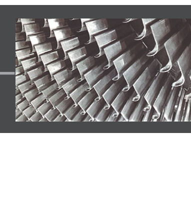
SCOPE: The provisions of this chapter shall govern special building construction including membrane structures, temporary structures, pedestrian walkways and tunnels, awnings and canopies, marquees, signs, and towers and antennas. (UBC 2003)

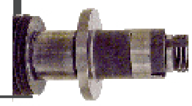
CHAPTER 34 - SECTIONS 3401 - 3410
EXISTING STRUCTURES

SCOPE: The provisions of this chapter shall control the alteration, repair, addition, and change of occupancy of existing structures. (UBC 2003)

All explored design measures will comply with the 2003 UBC and Minnesota State Building Code. Along with any referenced material within either document.

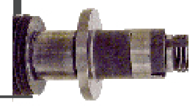
(Internat. Code Council, 2002, UBC 2003)





CASE STUDIES

Learning from the built environment, aiding in the design and process of the facility for industrial technology and power generation.



O149. CASE STUDIES

CASE STUDIES:

1. a. A detailed, intensive study of a unit, such as a corporation or a success or failure.

   b. An exemplary or cautionary model; an instructive example.

CASE STUDIES - Explored and Examined

1. Prittard & Sullivan Building
   - Eric Owen Moss
2. Arizona Science Center
   - Antoine Predock
3. Jewish Museum
   - Daniel Liberskind
4. Felix Nussbaum Museum
   - Daniel Liberskind
5. Cinema Palace
   - Coop Himmelblau
6. Mummers Theater
   - John Johansen
7. Mill City Museum
   - Meyer, Scherer, & Rockcastle
8. Center for Biotech. and Bio Engin.
   - Bohlin, Cywinski, Jackson
9. Banque Populaire de L'Ouest
   - Decq & Cornette
10. Cartie Foundation for Contemp. Art
    - Nouvel, Cattani, & Associates
11. Bridge Collaboration
    - An exploration

Prittard & Sullivan Building

Culver City - California
(A.Betsky. 1997. 80-89)

Figure O.1 PSB Envelope

Architect: Eric Owen Moss
Typology: Electronic Graphics Lab
Style: Late Modern

The PS building is an expression of "residual memory." The fragmented design encompasses remnants of what was once a bow-string-trussed warehouse. Design elements: trusses, masonry walls were left, respecting the existing ordering system and linear orientation. The use of industrial type materials: concrete, steel, glass, and wood trusses adds to the composition of the overall experience.

Influential Design Elements:

- Industrial material use
- Linear composition - orientation
- Residual Memory - to existing site
- Fragmented form - composing whole
- Connections - Direct and Indirect
  Interior and Exterior
- Form relating to function
- Environment expresses creativity and exploration.

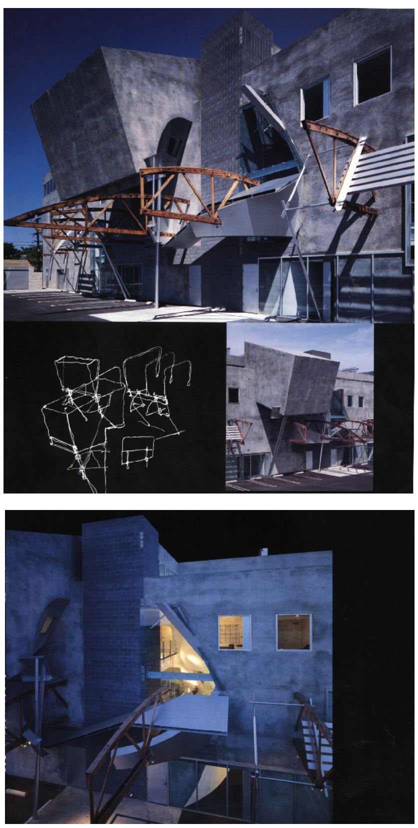


Figure O.2 PSB Details

Figure O.3 PSB Interior

Prittard & Sullivan Building

Culver City - California
(A.Betsky, 1997, 80-89)

Figure O.4 PSB Connections/Bridges

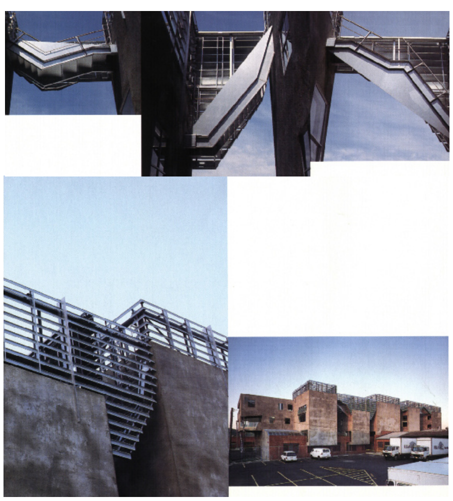


Figure O.5 PSB Exterior

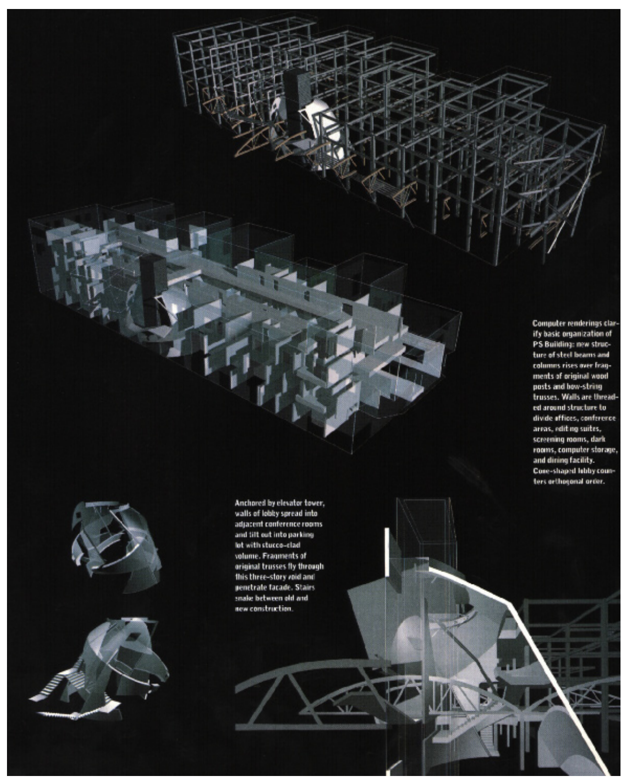


Figure O.6 PSB Plan/Sections

Arizona Science Center

Phoenix - Arizona
(J. Giovannini, 1997, 94-101)

Architect: Antoine Predock
Typology: Science Center
Style: Post Modern

The Arizona Science Center is rooted from elements of land, sky, and depth of time. The design responds to the natural desert context and its diverse surroundings. Large scale forms refer to the cosmos through the land creating connection, an experience of entry, breaking the common datum relationship. Strong visual aspects with the use of concrete, aluminum, and glass help in defining the exterior and interior functions along with their defined relationships

Figure O.7 ASC Entry

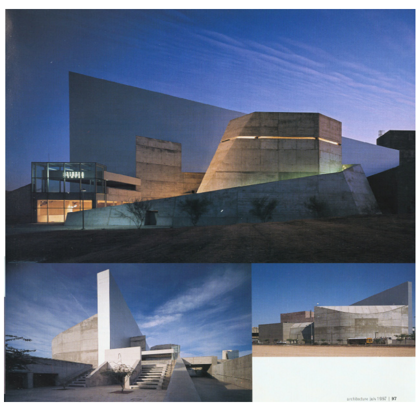


Figure O.8 ASC Envelope

Influential Design Elements:

- Industrial material use
- Linear elements - relationships
- Expression of the surrounding context
- Defining forms - controlled by function
- Connections - Direct and Indirect Interior and Exterior
- Use of light - creating cool and warm spaces
- Ideas of movement and experience

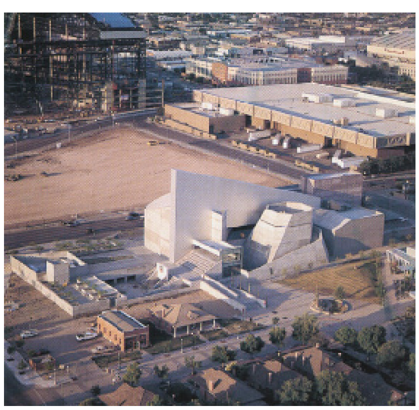


Figure O.9 ASC Aerial Site View

Figure O.10 ASC Interior/Exterior

Arizona Science Center

Phoenix - Arizona
(J. Giovannini, 1997, 94-101)

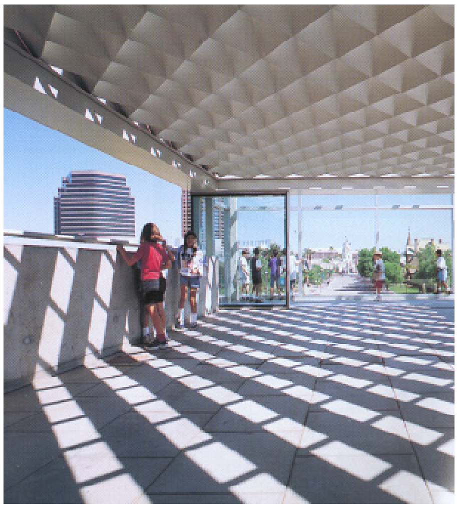


Figure O.11 ASC Observation Deck

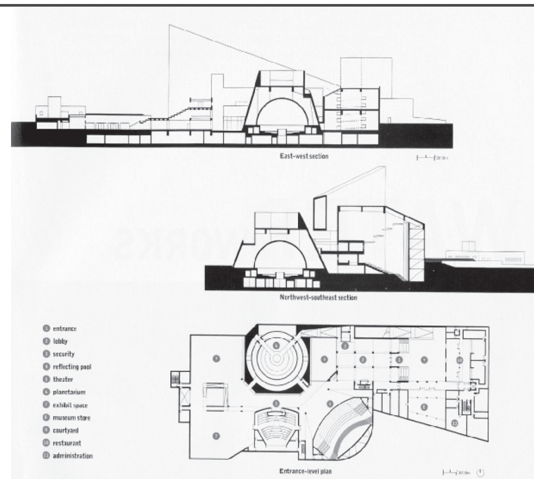


Figure O.14 ASC Plan/Sections

Figure O.12 ASC Interior Circulation

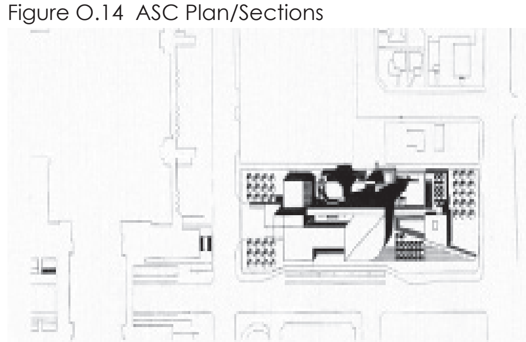


Figure O.15 ASC Site Plan

Figure O.13 ASC Interior

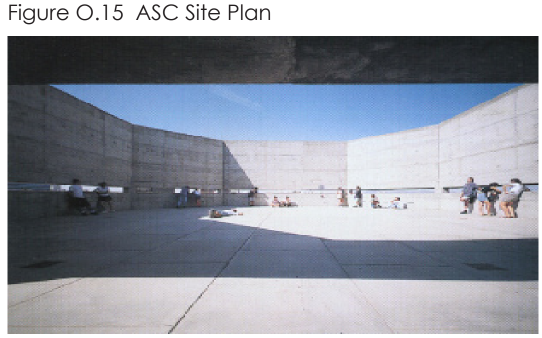


Figure O.16 ASC Exterior Courtyard

Jewish Museum

Berlin - Germany
(A. Betsky, 1998, 104-107)

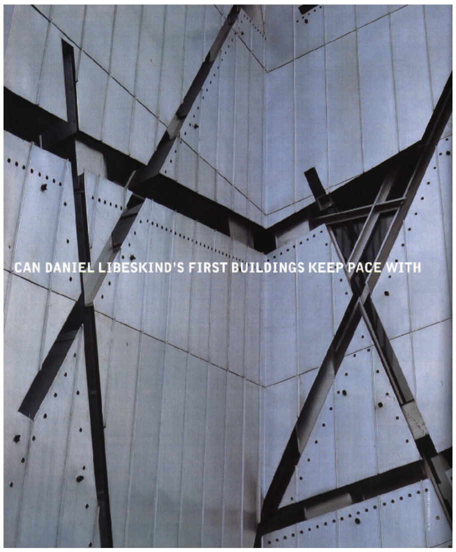


Figure O.17 JM Exterior/Material Detail

Figure O.18 JM Aerial Site View

Architect: Daniel Libeskind
Typology: Museum
Style: Post Modern

The Jewish Museum expresses Daniel Liberskind's idea of Architecture being literal changing the space in which it is built - not just in the present, but in the foreseeable future. One thing is now gone and an what takes its place enforces order, form, and presence on its culture. The questions of space, light, and material are what make this buildings great. The Jewish Museum is creates inaccessible space that relates to the emotional and spiritual meaning, its purpose.

Influential Design Elements:

- Industrial material use
- Linear elements - relationships
- Expression of meaning spiritual - emotion
- Defining forms -transcending local issues
- Connections - Direct and Indirect
  Interior and Exterior
- Use of light - supporting the meaning
- Ideas of movement and experience interaction that is memorable and influential - Void carrying meaning

Jewish Museum

Berlin - Germany
(A. Betsky, 1998, 104-107)

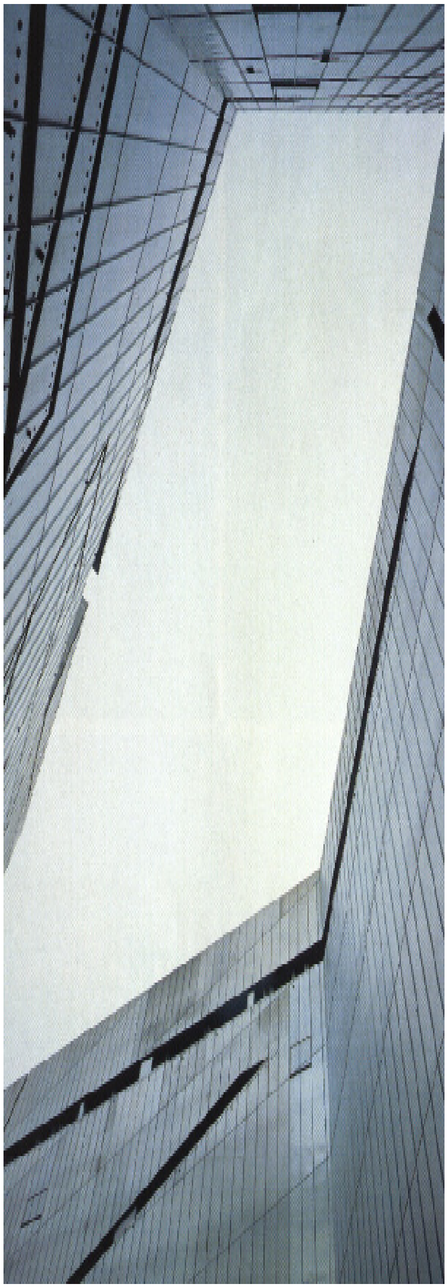
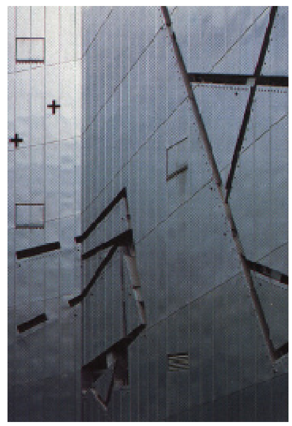


Figure O.19 JM Exterior Courtyard



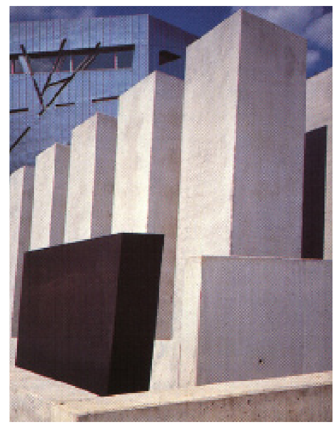


Figure O.20 JM Details/Entry

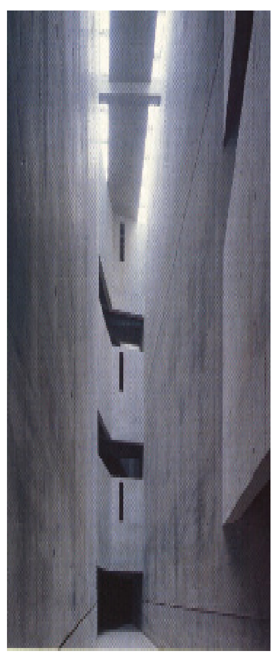


Figure O.21 JM Interior

Felix Nussbaum Museum

Osnabruck - Germany

(R. Ingersoll, 1998, 110-117)

Architect: Daniel Libeskind

Typology: Museum

Style: Post Modern

Figure O.22 FNM Aerial Site View

The Felix Nussbaum Museum carries an idea of criss-cross style, orientation, and materiality. This idea is expressed with the canted intersections of the building's volume, oblique slots, and scored elevations; its also an indictment of Liberskind's mastery of the technical imperatives of building. The design is created as a narrative that intertwines the history of the city, site, and the tragic denial of Jewish presence in German culture. Its an expression of meaning, purpose.

Influential Design Elements:

- Industrial material use
- Criss-Cross elements - relationships
- Expression meaning - purpose
- Defining forms - controlled by function
- Connections - Direct and Indirect
  Interior and Exterior
- Use of morphias spaces - openings
- Ideas of movement and experience created by the meaning of the space not controlled by function.

Figure O.23 FNM Exterior/Material Details

Felix Nussbaum Museum

Osnabruck - Germany

(R. Ingersoll, 1998, 110-117)

Figure O.24 FNM Exterior Courtyard

Figure O.25 FNM Exterior

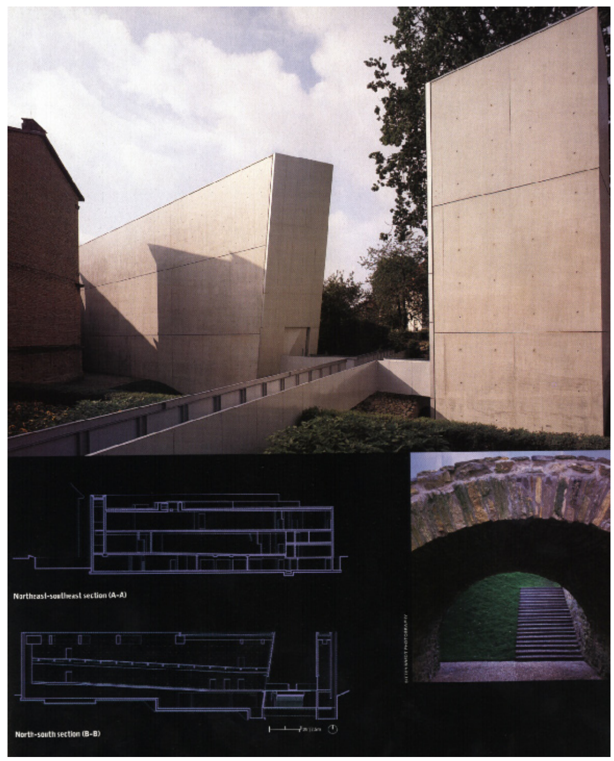


Figure O.27 FNM Entry/Sections

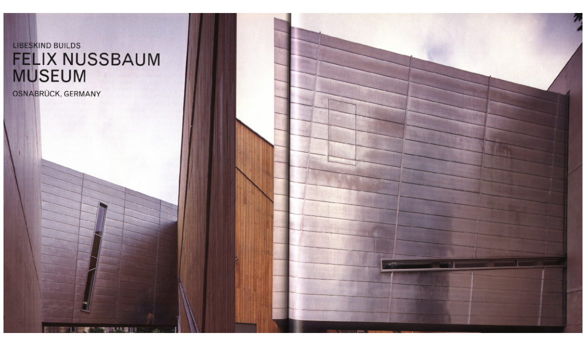


Figure O.26 FNM Details

Figure O.28 FNM Interior

Cinema Palace

Dresden - Germany

(J. Giovannini, 1998, 52-61)

Architect: Coop Himmelblau

Typology: Theater

Style: Post-Stalinist Modern

The Cinema Palace an expression of new technologies and construction. The building responds to its soporific, Stalinist, surrounding by energizing the urban feel with an over scaled individuality. The aesthetic constructability offers a sculptural vision. It breaks the Euclidean geometry of Communist-era planners with a floating spatial plan. The circulation spaces morph around the concrete mass, function driven creating a sense of freedom with its construct.

Figure O.29 CP Entry

Influential Design Elements:

- Industrial material use - technology
- Morph, fluidity, movement, irregularity
- Expression of freedom to context
- Defining forms - controlled by function
- Connections - Direct and Indirect
  Interior and Exterior
- Use of light - to enhance spaces and
  freedom throughout
- Ideas of movement and experience

Figure O.30 CP Envelope

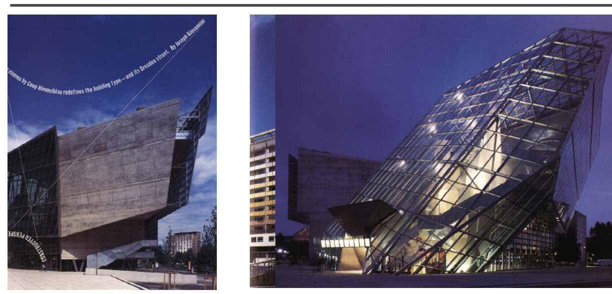
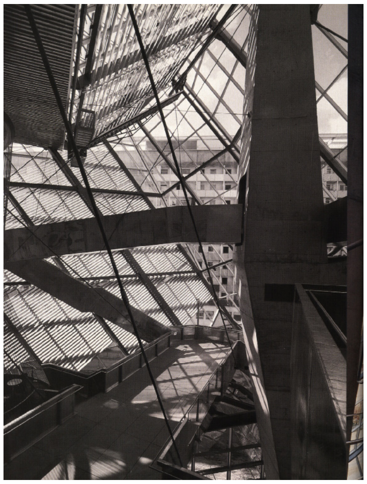


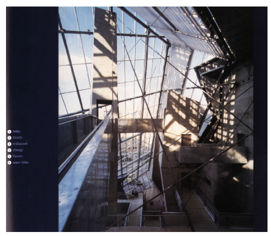
Figure O.31 CP Atrium

Cinema Palace

Dresden - Germany

(J. Giovannini, 1998, 52-61)





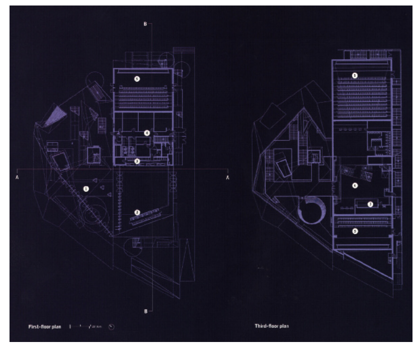


Figure O.34 CP Plans

Figure O.35 CP Aerial Site View/Plan

Figure O.32 CP Atrium Interior

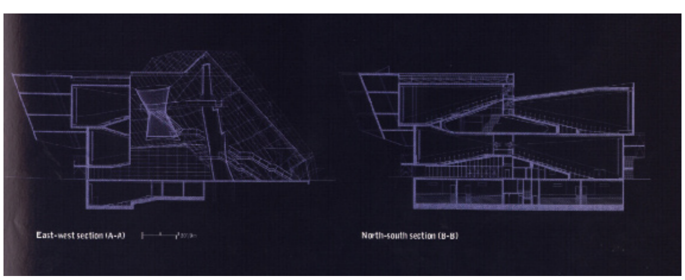


Figure O.33 CP Sections

Figure O.36 CP Elevation

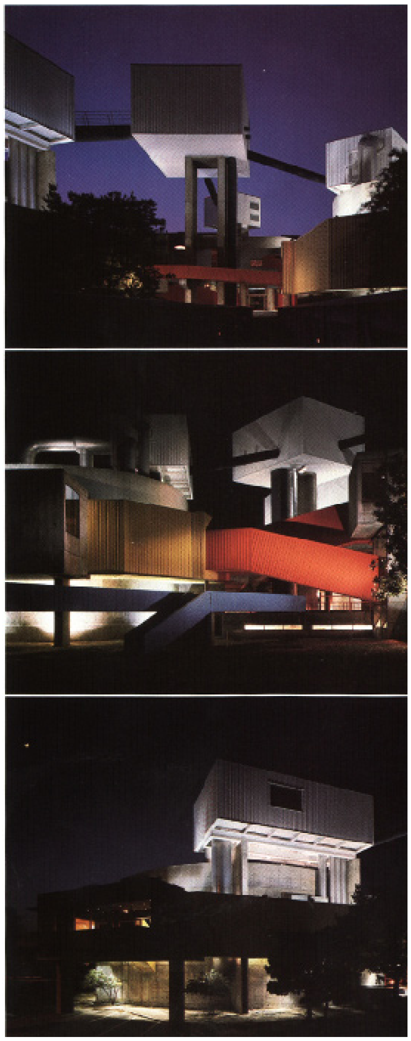


Figure O.37 MT Exterior

Mummers Theater

Oklahoma City - Oklahoma
(D.Dillon, 1992, 62-69)

Architect: John Johansen
Typology: Museum
Style: Modernist

Mummers Theater was built in an acrobatic way to be altered. The idea broke traditional theater design by riding formality and incorporating brashness and calculated imperfections. The conceptual idea follows the increments involved in electronics and circuit boards. The three concrete pods act as terminals with the ramps and bridges as the wiring. The use os industrial materials adds to the character of the defined spaces expressing intimacy and playfulness.

Influential Design Elements:

- Industrial material use - playfulness
- Modular pods - kinetic composition
- Indust. forms - components (character)
- Defining forms - controlled by function
- Connections - Direct and Indirect
  Interior and Exterior
- Minimal use of fenestration - function
- Ideas of movement and experience
  elevation changes - fluidity

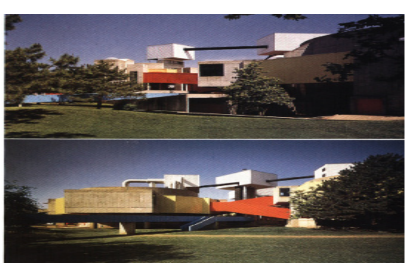


Figure O.38 MT Exterior Elevations

Figure O.39 MT Entry/Interior

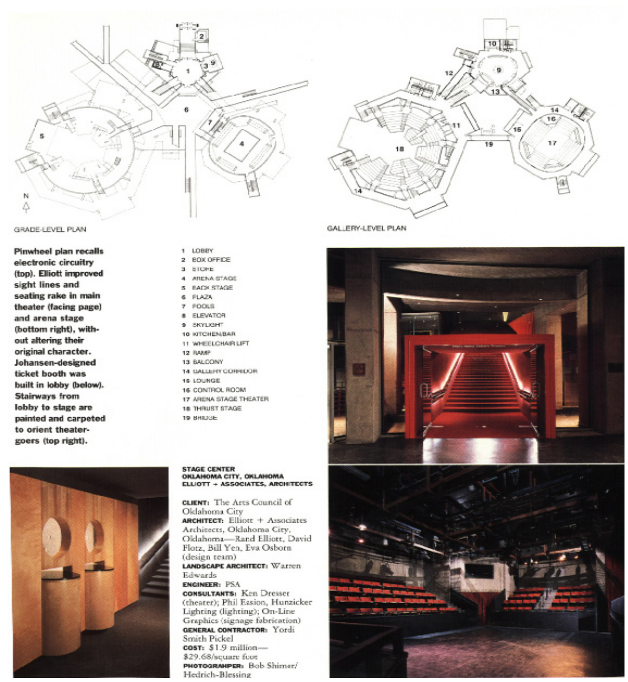
Mummers Theater

Oklahoma City - Oklahoma
(D.Dillion, 1992, 62-69)

Figure O.40 MT Exterior Circulation

Figure O.42 MT Interior/Oculus

Figure O.41 MT Entry Bridge



GRADE-LEVEL PLAN

GALLERY-LEVEL PLAN

Pinwheel plan recalls electronic circuitry (top). Elliott improved sight lines and seating rake in main theater (facing page) and arena stage (bottom right), without altering their original character. Johansen-designed ticket booth was built in lobby (below). Stairways from lobby to stage are painted and carpeted to orient theatergoers (top right).

1 LOBBY
2 BOX OFFICE
3 STORE
4 ARENA STAGE
5 BACK STAGE
6 PLAZA
7 POOLS
8 ELEVATOR
9 SKYLIGHT
10 KITCHEN/BAR
11 WHEELCHAIR LIFT
12 RAMP
13 BALCONY
14 GALLERY CORRIDOR
15 LOUNGE
16 CONTROL ROOM
17 ARENA STAGE THEATER
18 THRUST STAGE
19 BRIDGE

STAGE CENTER
OKLAHOMA CITY, OKLAHOMA
ELLIOTT + ASSOCIATES, ARCHITECTS

CLIENT: The Arts Council of Oklahoma City
ARCHITECT: Elliott + Associates Architects, Oklahoma City, Oklahoma—Rand Elliott, David Flotz, Bill Yen, Eva Osborn (design team)
LANDSCAPE ARCHITECT: Warren Edwards
ENGINEER: PSA
CONSULTANTS: Ken Dresser (theater); Phil Easion, Hunzicker Lighting (lighting); On-Line Graphics (signage fabrication)
GENERAL CONTRACTOR: Yordi Smith Pickel
COST: $1.9 million—$29.68/square foot
PHOTOGRAPHER: Bob Shimer/Hedrich-Blessing

Figure O.43 MT Plan/Interior Material Details

Figure O.44 MCM Entry

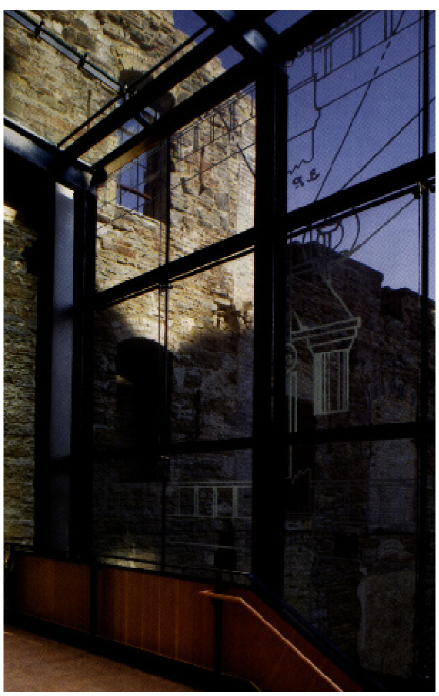


Figure O.45 MCM Material Details

Mill City Museum

Minneapolis - Minnesota
(D. Lefever. 2004, 122-126)

Architect: Meyer,Scherer,& Rockcastle
Typology: Museum
Style: Post Modern
Adaptive Reuse

The Mill City Museum acts a multi layered exhibition about the city's history. The purpose of the design was to draw the meaning and essence out of the building, orchestrating the element; not trying to create them. The design tells the life story of a once most technologically advanced mill (1878), through its life of disaster, to what is now an exploration of new construction symbolizing its unique value.

Influential Design Elements:

- Industrial material use
- Multi leveled orientation - relationships
- Expression of the surrounding context and historical meaning to the city
- Forms - controlled by historical function
- Connections - Direct and Indirect
  Interior and Exterior
- Use of glass and etching - elements
- Ideas of movement and experience historical and present purpose

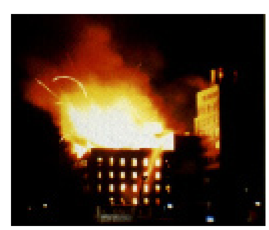


Figure O.46 MCM Elevation/Historic Fire

Mill City Museum

Minneapolis - Minnesota
(D. Lefever, 2004, 122-126)

Figure O.47 MCM Aerial Site View

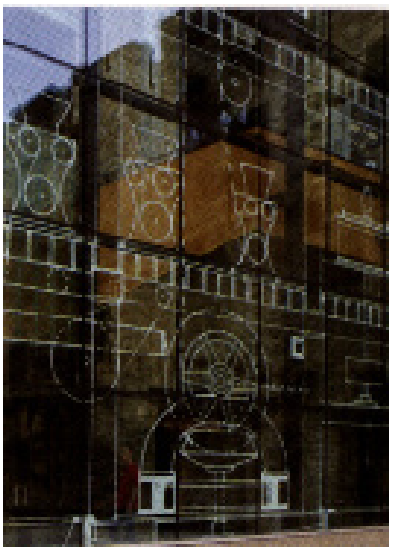


Figure O.48 MCM Glazing Detail

Figure O.50 MCM Plan/Sections

Figure O.49 MCM Interiors

Center for Biotechnology and Bioengineering

Pittsburgh - Pennsylvania
(V. Mays, 1994, 76-80)

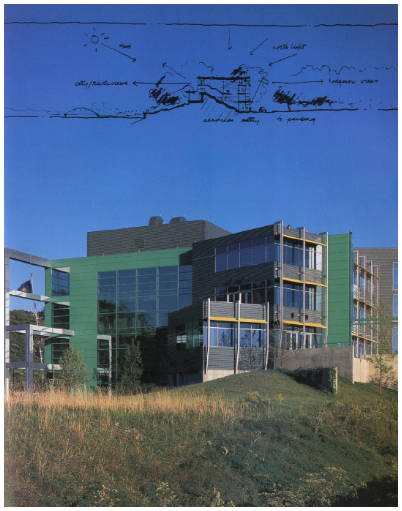


Figure O.51 CBB Exterior

Architect: Bohlin, Cywinski, Jackson
Typology: University - Laboratory
Style: Post-Modern

The Center for Biotechnology and Bioengineering rises from its ruins of the steel industry. It becomes a new symbol in the recovery from a dependence on rust belt economics. The center becomes a standard for the universities research park. The design integrates a modular system of 400 - 600 sq. ft. labs allowing for ever shifting spatial configurations. The envelope uses industrial materials at different scales and forms due to limitations of lab spaces.

Influential Design Elements:

- Industrial material use - scale and form
- Linear elements - relationships
- Expression of technology - factory laden
- Defining forms - controlled by function
- Connections - Direct and Indirect - linear
  Interior and Exterior
- Industrial process creates structures that mimic machines - instead of buildings.
- Contextual relationship to industrial river front manufacturing - tough, rigid exper.

Figure O.52 CBB Material Details

Figure O.53 CBB Aerial Site View/Elevation

Center for Biotechnology and Bioengineering

Pittsburgh - Pennsylvania
(V. Mays, 1994, 76-80)

Figure O.54 CBB Circulation Detail

Figure O.55 CBB Exterior Details

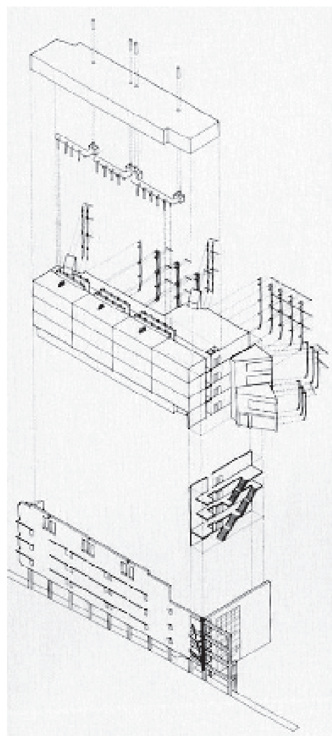


Figure O.56 CBB Plans/Sections

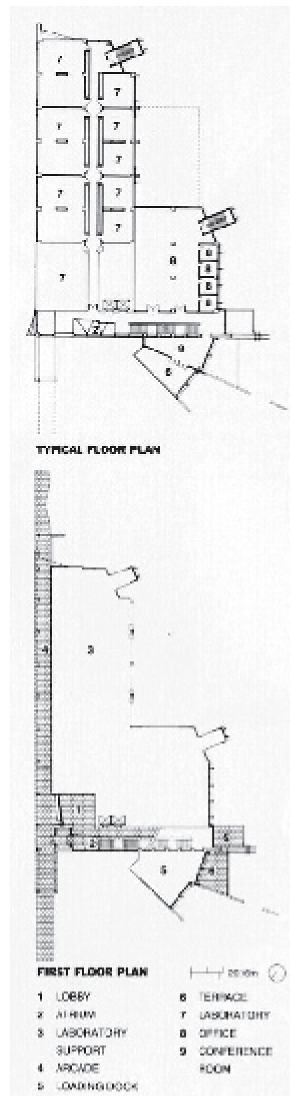


Figure O.57 CBB Interior

Cartie Foundation for Contemporary Art

Paris - France

(B.Shortt, 1994, 64-68)

Architect: Nouvel, Cattani, & Assoc.
Typology: Museum - Studio
Style: Post-Modern

The Cartie Foundation for Contemporary Art masters the use of transparency creating an environment of lightness. It carries an apparent simplicity built upon the elegant high-tech sensibility expressed with the use of stainless steel and glass. The ideas of visual clarity respect the historical background of the site while providing users with a variety of intense views. A series of glass walls and chesnut trees create volume of the site giving the building a 3D quality.

Influential Design Elements:

- Industrial material use
- Linear orientation - relationships
- Controlled visual elements overlap
- Sense of construction - frag. series
- Connections - Direct and Indirect
  Interior and Exterior
- Use of glass and light to define space
- Ideas of physical and visual movement and experience

Figure O.58 CFCA Exterior Courtyard

Figure O.59 CFCA Exterior

Figure O.60 CFCA Entry

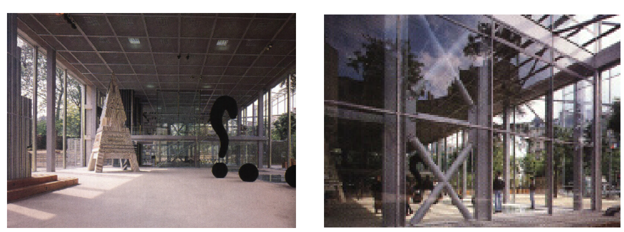


Figure O.61 CFCA Interior/Entry

Figure O.62 CFCA Material Details

Cartie Foundation for Contemporary Art

Paris - France

(B.Shortt, 1994, 64-68)

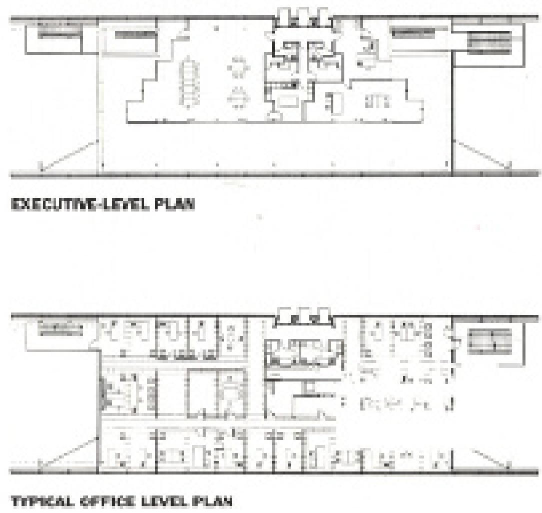


Figure O.65 CFCA Plan

Figure O.63 CFCA Glazing Detail

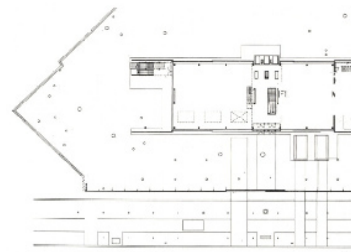


Figure O.64 CFCA Entry Detail

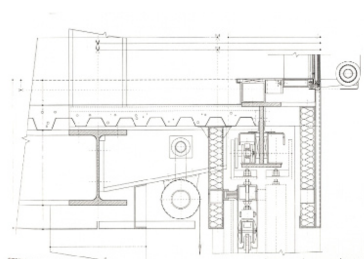


Figure O.66 CFCA Plan/Interior

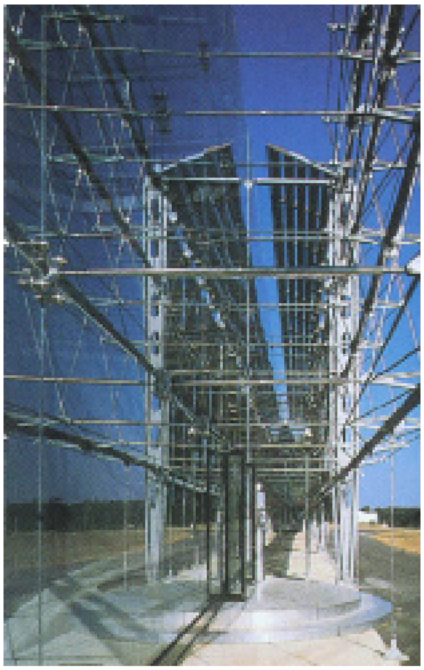


Figure O.67 BPL Entry Detail

Figure O.68 BPL Entry

Banque Populaire de L'Ouest

Rennes - France
(R.A.Barreneche, 1994, 117-124)

Architect: Decq and Cornette
Typology: Bank Administration
Style: Post-Modern

The Banque Populaire de L'Ouest offer complete views of the surrounding courtside through a complexity transparent facade, with out the use of mullions or internal frames. The design idea is a response to the elements of light, air, and views. The use of steel members is used to laterally stabilize the glass facade. Alumin louvers and motorized fiberglass sunshades help reduce the amount of solar gain. The building is a great example of light weight material use.

Influential Design Elements:

- Industrial material use
- Linear elements - relationships
- Expression of the surrounding context
- Openness - creating movement
- Connections - Direct and Indirect
  Interior and Exterior
- Use of light - to define space and used
  to change the experience
- Ideas of movement with the use of light
  and materials

Banque Populaire de L'Ouest

Rennes - France

(R.A.Barreneche, 1994, 117-124)

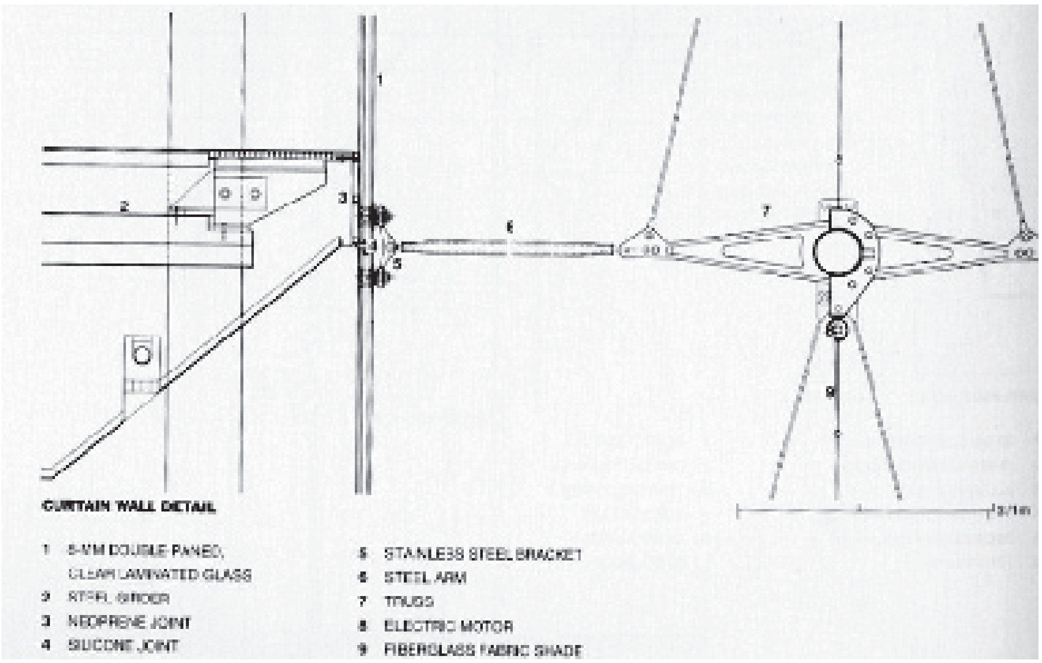


Figure O.69 BPL Glazing System Details

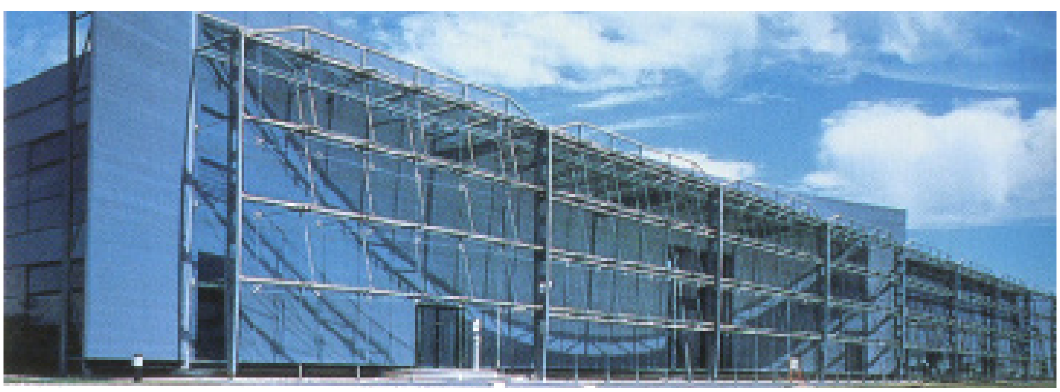


Figure O.70 BPL Exterior

Bridge Collaboration

A exploration of Historical and Modern Design - Function

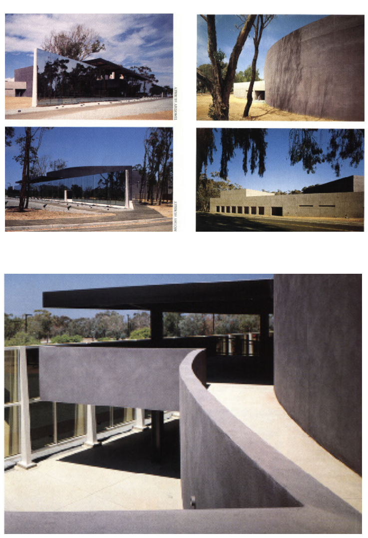
Influential Design Elements

Each bridge explores its own defining characteristics as an element of connection. The ability to span a void for the purpose of movement and circulation. The bridge is an element that carries a meaning coherent to both spaces in which it spans. It holds aesthetic and functional elements of both spaces while defining it own characteristics. A bridge is driven by function, but the examples shown demonstrate its ability to fit in with its context while maintaining an identity of its own with characteristics only true to its spanning abilities.

Bridges:

1. Holocaust Mem. Museum (M.F.Schmertz, 1993, 58)
   - Pei, Cobb, Freed, & Partners
2. Mandell Weis - Land Bridge (E.Posner, 1991, 48)
   - Antoine Predock
3. BioMed. Info. Comm. Center (D.K.Dietsch, 1992, 60)
   - GHA Architects
4. Doernbecher Child Hospital (B.J.Novitski, 1999,129)
   - Zimmer, Gunsul, Frasca partnership
5. MetroPont (D.K.Dietsch, 1994, 33)
   - Bernard Tschumi Architects
6. Fort Point Bridge (P.Vanderwarker, 1994, 45)

1. Figure O.71 HMM Connection Bridge



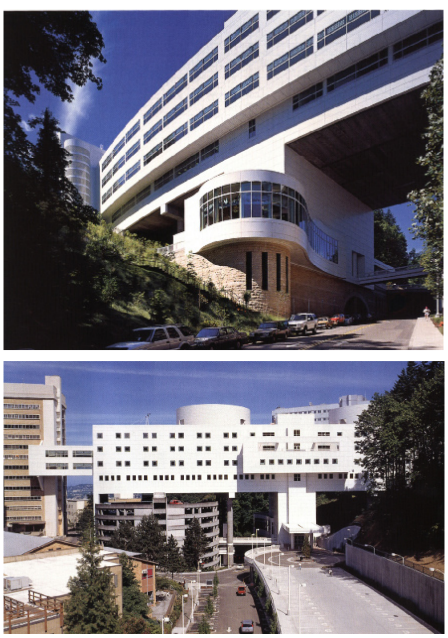
2. Figure O.72 MW Land Bridge

Figure O.73 MW Land Bridge Details

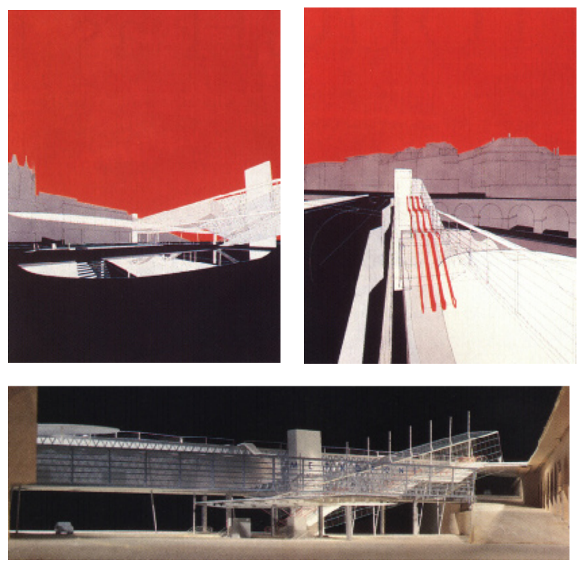
Bridge Collaboration

A exploration of Historical and Modern Design - Function

3. Figure O.74 BICC Connection Bridge

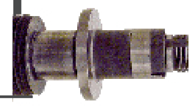


4. Figure O.75 DCH Spatial Bridge Design



5. Figure O.76 MetroPont Pedestrian Bridge

6. Figure O.77 FP Historic Lift Bridge



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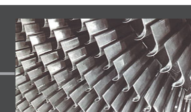

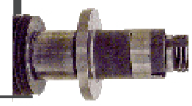

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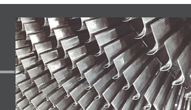

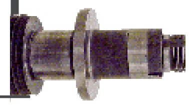

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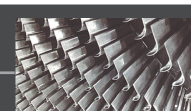

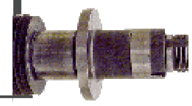

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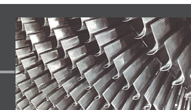
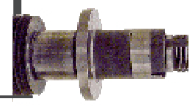
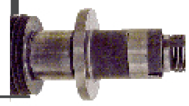




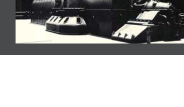
APPENDIX A

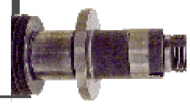
Statement of Intent .



APPENDIX B

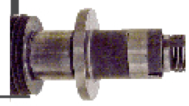
Thesis Proposal.





APPENDIX C

Maps and photos referenced from program document.



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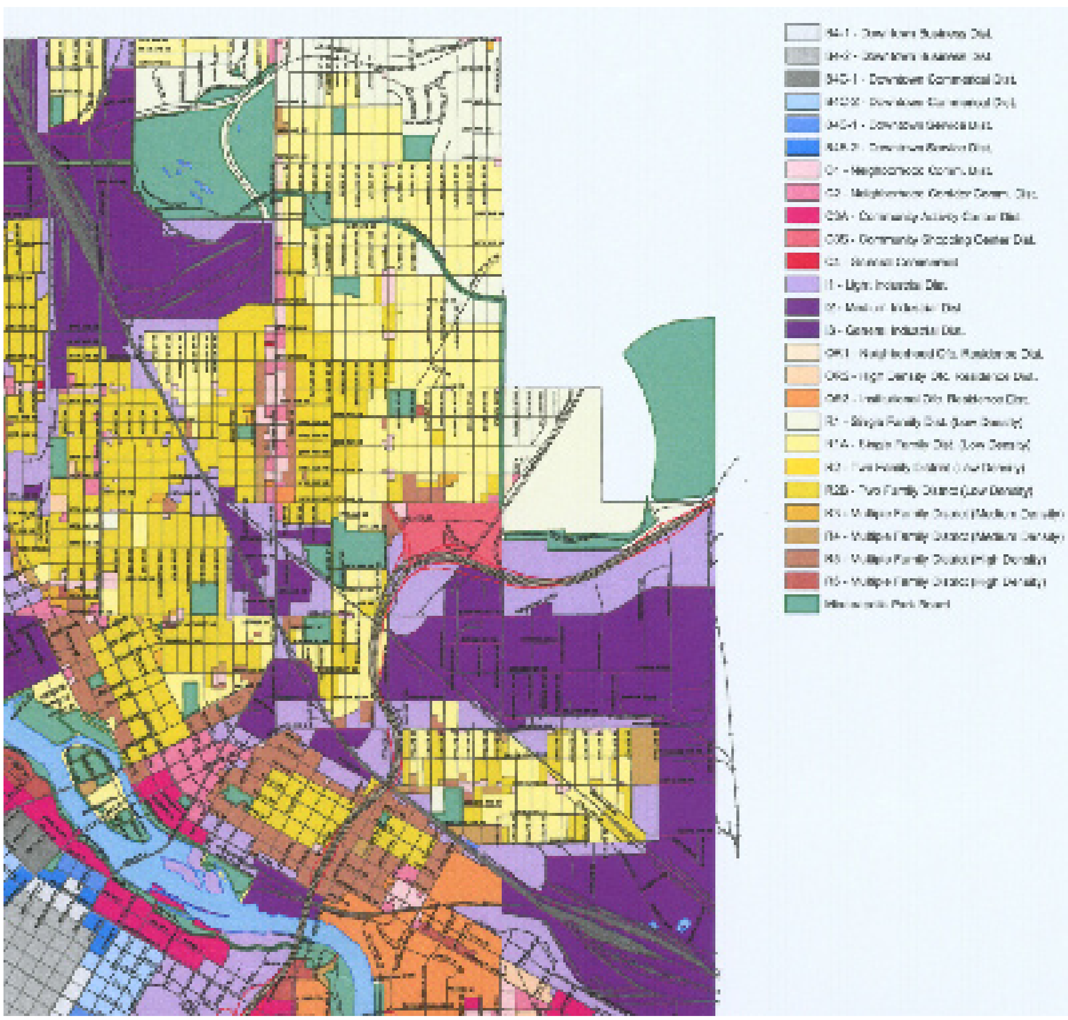
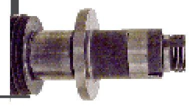
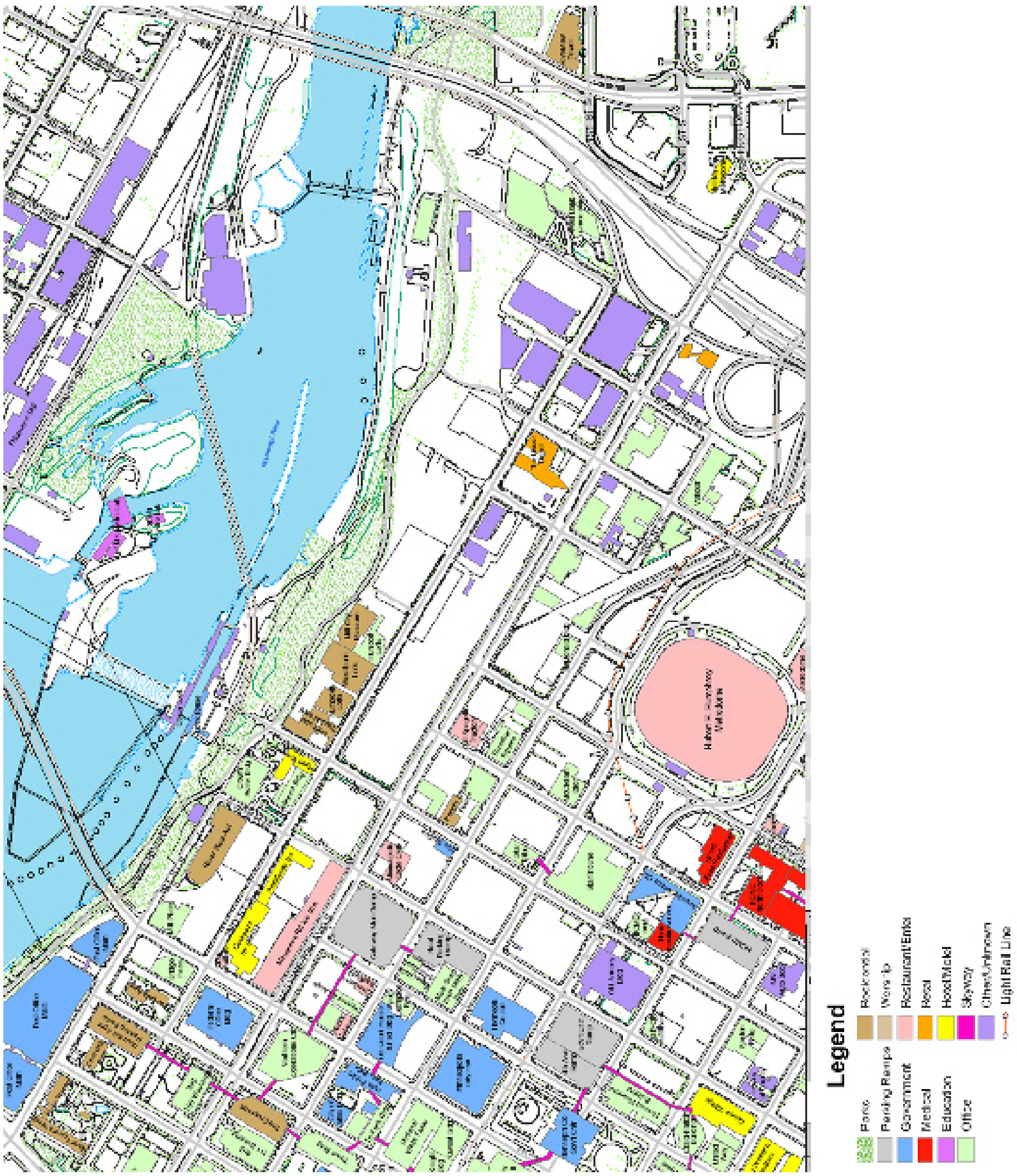
APPENDIX C.1 - Minneapolis Zoning Ordinance Map.

Minneapolis, Minnesota
Site - I3 General Industrial District





APPENDIX C.2 - Minneapolis Major Landmarks Map. Minneapolis, MN

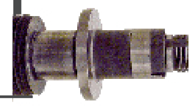


APPENDIX C.3 - Additional Views of Site

University of Minnesota Campus
Minneapolis, Minnesota





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Tables/Diagrams - Reference List.

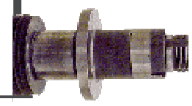

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Table G.2 U of M Colleges National Ranking

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Table L.1 Climate Data

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Diagram L.1 Wind Roses

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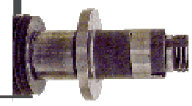
Diagram L.2 Sun Diagrams

Brown and DeKay. Sun, Wind, and Light. New York: John Wiley & Sons Inc., 2001



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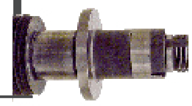
Figures - Reference List.



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City of Minneapolis,MN. 26 September 2004.
http://www.ci.minneapolis.mn.us/zoning/maps/.html

Figure L.1 Detailed Aerial View of Specific Site, Univ. of Minnesota
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Figure L.7 Views of Site - set1
Koedam, A. 2004. Photos. September

Figure L.8 Views of Site - set2
Koedam, A. 2004. Photos. September

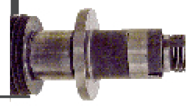

Figure L.9 Views of Site - set3

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Figure O.1 PSB Envelope

Betsky, A. (1997, July). Urban Construct. Architecture, 80-89.

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Betsky, A. (1997, July). Urban Construct. Architecture, 80-89.

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Figure O.10 ASC Interior/Exterior

Giovannini, J. (1997, July). Land Forms: Arizona Science Center. Architecture, 94-101.

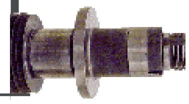

Figure O.11 ASC Observation Deck

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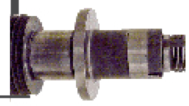

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Giovannini, J. (1998, August). Constructed Perspective. Architecture, 52-61.

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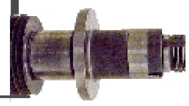
Giovannini, J. (1998, August). Constructed Perspective. Architecture, 52-61.



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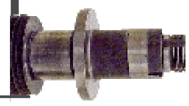

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Figure O.64 CFCA Entry Detail
Shortt, B. (1994, September). Parisian Jewel. Architecture, 64-68.

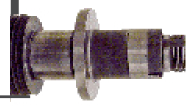

Figure O.65 CFCA Plan/Interior

Shortt, B. (1994, September). Parisian Jewel. Architecture, 64-68.

Figure O.66 CFCA Exterior Courtyard

Shortt, B. (1994, September). Parisian Jewel. Architecture, 64-68.

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Figure O.71 HMM Connection Bridge

Schmertz, M.F. (1993, July). In Remembrance. Architecture, 54-65.

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Posner, E. (1991, September). California Civic Pride. Architecture, 48.

Figure O.73 MW Land Bridge Details

Posner, E. (1991, September). California Civic Pride. Architecture, 48.

Figure O.74 BICC Connection Bridge

Dillon, D. (1992, November). Staging a Comeback. Architecture, 62-69.

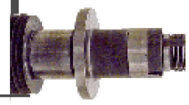


Figure O.75 DCH Spatial Bridge Design

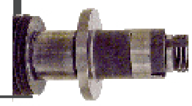
Novitski, B.J. (1999, July). Doernbecher Children's Hospital, Portland, Oregon. Architectural Record, 128-133.

Figure O.76 MetroPont Pedestrian Bridge

Dietsch, D.K. (1994, August). On the Boards. Architecture, 33.

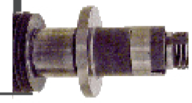
Figure O.77 FP Historic Lift Bridge

Vanderwarker, P. (1994, March). Protest: Save a Boston Bridge. Architecture, 45.



APPENDIX F

Other reference material - aiding in the design development of the facility for industrial technology and power generation.



'The Most Critical Division' Between Inside and Out

The special demands of laboratories as a building type.
By Michael J. Crosbie

If architecture and building are a veil that is drawn between inside and outside, separating a natural and uncontrolled exterior environment from a carefully modulated interior world, then laboratories represent the most critical division that architects can design today. Labs for research and product development, and labs for manufacturing microscopic objects such as microelectronics, are considered by their designers first and foremost as highly controlled environments for the performance of a specific task, supported by sophisticated mechanical equipment and monitored by other systems that regulate temperature, humidity, and air pressure and protect the lab's inhabitants from highly toxic substances and processes. Secondarily they are places for human work, and must offer some respite from their hard-edged technical nature in the form of softer spaces where people can gather and relax.

Compared with any other common building type, labs are designed and built to exacting specifications uncommon for most buildings, and their environmental controls are expected to perform with consistent precision. In laboratory design, "there is a low tolerance for error," says Mario J. Loiacono, director of engineering for the Cambridge, Mass., firm Symmes Maini & McKee, which has designed dozens of research and production labs around the country. "The cost of business interruption is usually very high, so labs perform to tighter specifications, their environmental impact is more significant, they have more interrelating parts, all of the building's components form an integral unit to satisfy process needs, and flexibility is typically important."

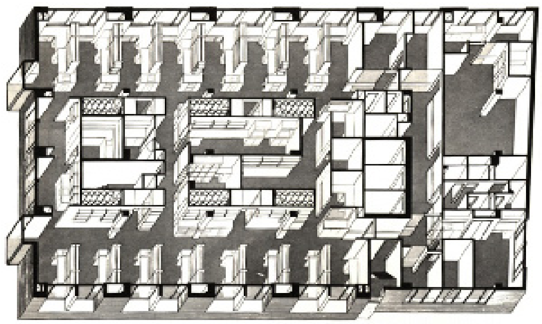
The demands of a lab's environmental controls are evident in the relative cost of such equipment compared with that for other building types. "The budgets for lab buildings, mechanically, are somewhere between 35 and 40 percent of the total building cost, as compared with office buildings or schools, where it's around 20 percent," comments Jeff Burke, AIA, of Payette Associates, a Boston firm that has built a reputation for its expertise in lab design. David Rowan, AIA, also of Payette, adds that between 50 and 65 percent of a lab's volume can be dedicated to mechanical equipment. Electrical demands for microelectronics labs can be 50 to 100 watts per square foot; a typical office load is five to eight watts per square foot.

The process of designing such buildings often is focused on how to meet the lab's technical requirements. "Right from the beginning of a project, we think in terms of mechanical systems and how they will serve the building," says Leevi Kiil, AIA, of Haines Lundberg Waehler in New York City, a firm involved in lab design for half a century. "We begin to formulate very early in the design what the solution might be mechanically. In our programming interviews, mechanical and electrical engineers are often with us so that they can begin to think about the building early in the process."

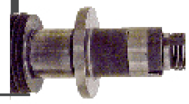
The location and distribution of mechanical equipment will depend primarily on the lab's use. The irony of such large and powerful environmental systems is that their size and strength often threaten to disrupt the very activities they are designed to support. For example, in its design for the National Center for Physical Acoustics at the University of Mississippi, Haines Lundberg Waehler (in association with Mockbee Coker Howorth Architects of Jackson, Miss.) located mechanical equipment in a separate building wing far from the lab spaces. "We used large ductwork buried below the corridors of the lab, and the air had to be moved at a very low volume to avoid noise," explains Kiil. The 30 lab spaces are housed at the center of a one-story wing to isolate them from noise and vibrations above and below and from around the building's perimeter.

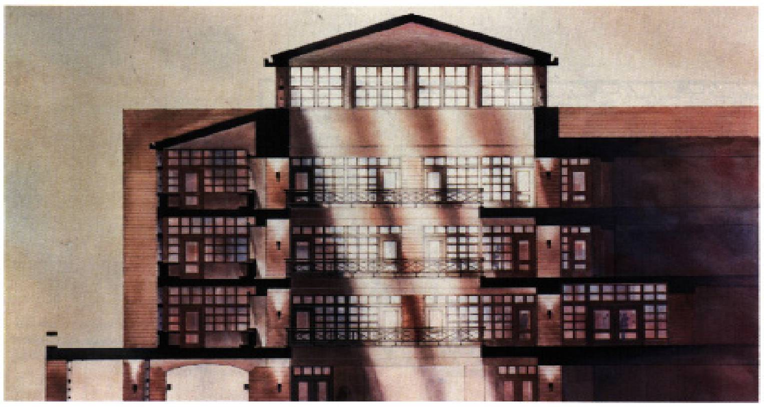
In micro-electronics labs known as "clean rooms," air changes can be in the range of 600 to 720 per hour, whereas in a typical office air changes might be five to 10 per hour. Clean rooms are classified in magnitudes of 10. Class 10 labs are common, in which a cubic foot of air contains no more than 10 particles greater than 0.5 microns in size. (For comparison, a hospital lab might be classified at 1,000, an office building at 1 million.) Class 1 labs are now being built. "A clean room, where you're trying to place 100 million transistors on a chip, is very sensitive to any vibration," says Loiacono. Symmes Maini & McKee's design for the Microsystems Technology Laboratories at MIT had to accommodate 3,500 square feet of Class 10 labs, 3,000 square feet of Class 100 labs, and 9,000 square feet of Class 10,000 labs, all within an existing building with a tight height limit. Using a vertical chase space, entire floors of the building were devoted to mechanical equipment, which had special dampening features to limit vibration and noise. In new construction, stiff structural systems are used to minimize vibration. "Typically, a lot of concrete mass is used," explains Loiacono. "With 400 to 600 pounds per square foot of floor loading you can successfully limit vibration."

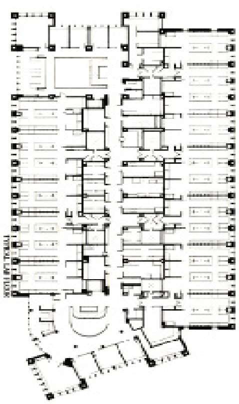
Tied to the issue of mechanical equipment placement is flexibility. Labs for research and development put a premium on flexibility as research goals change, while labs dedicated to production require a certain latitude in design for replacing outdated equipment. HLW's Kiil notes that ideas about flexibility in lab design have changed. "In the 1950s and '60s," he says, "lab design was approached by creating modular laboratories, virtually identical, and providing all the services and utilities that you might



The Wellman research building at Mass. General has open lab spaces and shared instrument areas.







Rutgers University lab design shows intent to incorporate both daylight and casual meeting places.

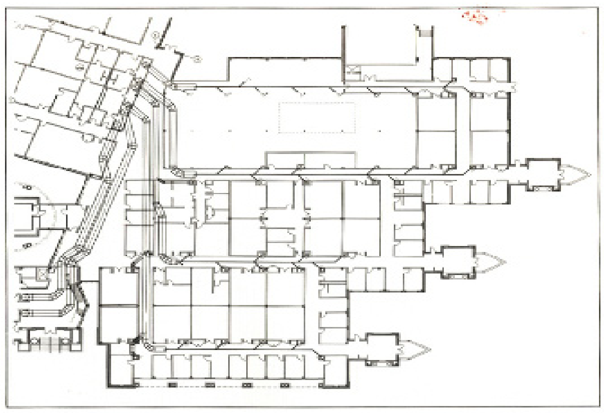
ever need in every one of those modules. Utilities usually were brought up in shafts. If you made a large lab out of a series of small modules, the modules would always be interrupted by a shaft wall and they became a physical impediment to lab layout. The approach we've been following recently is to create large, uninhibited laboratory space—a loft type of space—and collect the services in one end or opposite ends of the building." In HLW's design for the Miles pharmaceutical research center in West Haven, Conn., shaft spaces are located at the ends of the L-shaped building, with additional shafts toward the plan's bend. From the shafts, air ducts and plumbing are distributed through six-foot-deep hung ceilings to labs located at the building's periphery. Lab support areas and storage are placed in the plan's spine.

Kill adds that, in general, mechanical systems tend to share spaces in labs, adding to flexibility. "Very often we provide spaces for systems, but we don't build in all of the systems. Sometimes its economical not to build everything in, but to provide space for it so that at a later date when you need more complex systems they can easily be added."

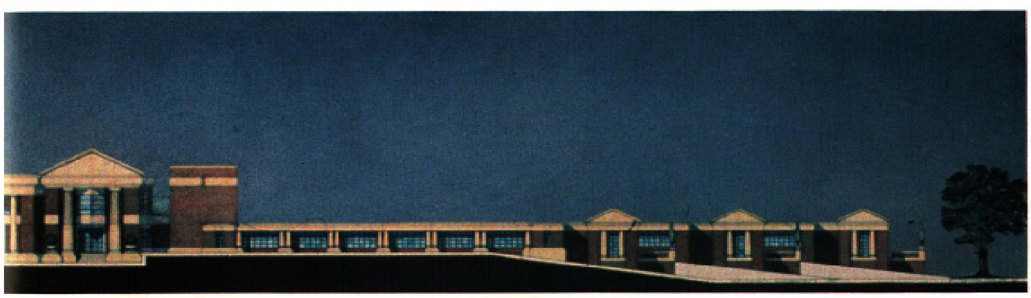
Flexibility in a lab designed for production requires equipment that can be modified without disrupting the manufacturing process. Says Loiacono, "In micro-electronics, a piece of equipment may have a life of only 18 months. You have to have flexibility in terms of space and available utilities so a new piece of equipment can be moved in and connected in the shortest possible time."

Another Symmes Maini & McKee project, Serono Laboratories in Randolph, Mass., had a great number of technical demands to be accommodated in an existing one-story building of 12,000 square feet. The biotechnology lab allows research and development of new therapeutic products through recombinant DNA technology to be tested before being put into large-scale commercial production. Thus the lab had to be flexible enough to respond to the changing direction of biotech research. "Probably the biggest challenge was to provide for the use of gaseous materials and the removal of liquid waste by gravity within this single-story warehouse," says James Polando, Symmes Maini & McKee's chief process engineer. The mechanical room for this kind of lab, normally housed in a two-story space, had to work in a one-story space.

Maintaining mechanical systems and the facility itself is essential for research that requires an environment where conditions must be consistent over long periods of time for experimentation. For production of pharmaceuticals and biological matter, FDA approval rests on the repeatability of the manufacturing process. Every step—and the environmental conditions in which

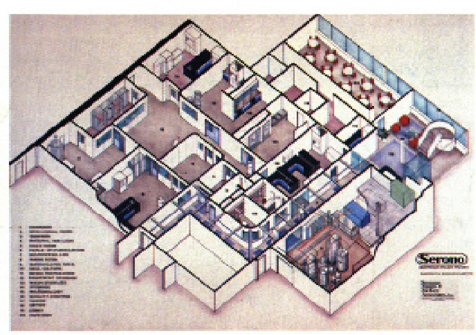


NCPA building, right and below, isolates mechanicals in a separate building (left) from lab spaces.



Below, flexible HVAC system of the Serono DNA lab allows a wide variety of lab types. Note observation corridor.

Wayne Soverns



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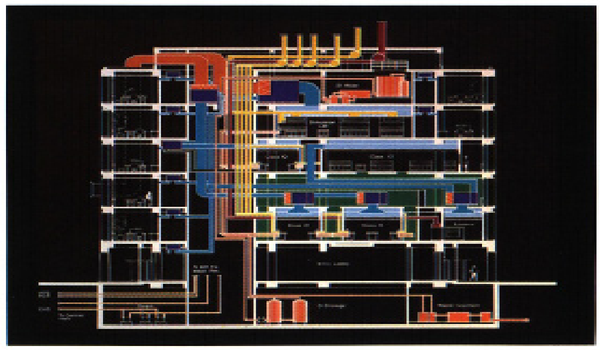
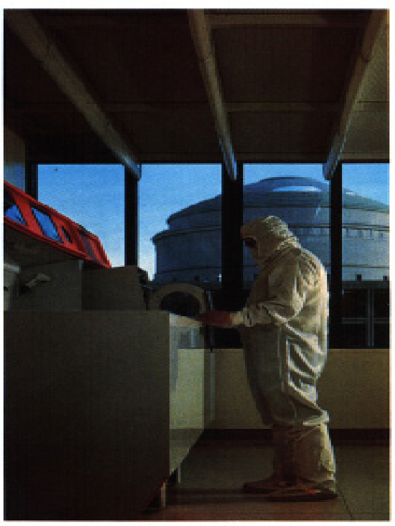




Above and top, MIT's microsystems technology lab is an adapted building housing clean rooms up to Class 10.

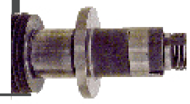
it is carried out—has to be identical to assure the product's safety. Says David Rowan of Payette: "I think maintenance is a big problem. Very few institutions have knowledgeable maintenance departments that really know how to adequately maintain the equipment. You try to keep things as simple as possible."

Loiacono observes that, with the increasing complexity of laboratories, "there's a trend toward more sophisticated maintenance staff. You can't design a system that's maintenance free, but the systems should be simple. If the systems are overly complicated, they'll be shied away from by the maintenance staff. It's a combination of simplicity in design and good-quality monitoring systems that will encourage their maintenance."

The lab spaces themselves have to be designed for durability and cleaning. "You have to consider a lab in the same way you'd consider a commercial kitchen," says James Polando. "You want to maintain it in sparkling condition. Biotech labs often have to be steam-cleaned daily, so you choose finishes and construction techniques that allow you to scrub down a room."

Emphasis on a lab's mechanical and technical performance needs to be matched with concern for the lab's inhabitants—their physical and mental comfort and settings for the casual exchange of information. Intensely controlled lab spaces need a counterbalance in soft, quiet, daylighted retreats where technicians and scientists can refresh their energies and discuss their work. "We've been trying to merge the productive and reflective spaces in a lab by creating a third environment where you can have great interaction," says Payette's Burke. "Interaction is important in labs right now because the boundaries of specialties and disciplines are breaking down—there's a much greater sharing of interdisciplinary knowledge. This sharing can be promoted by sharing services, resources, and facilities."

At Payette's Wellman research building at Massachusetts General Hospital in Boston, which is the world's largest facility committed to laser research, a typical floor of the 12-story building has wide-open laboratories and shared instrument areas. Another Payette project, the Rutgers University Center for Advanced Biotechnology and Medicine, a facility to be used by both commercial and university-based scientists, has large stair atriums on either end that serve as casual gathering spaces. Offices with glazed interior walls are grouped around the atriums to encourage eye contact and interaction. The building will be connected to others on campus, another gesture toward interdisciplinary melding. "Many research buildings are being connected to each other," comments Payette's William Wilson, AIA, "because that's the nature of research." □



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Miles pharmaceutical lab distributes services vertically at the ends of the building, then horizontally to peripheral labs.

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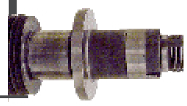
Crosbie, M.J. (1989, March). The Most Critical Division Between Inside and Out. Architecture, 94-99.



T&P Practice

Laboratory Innovations

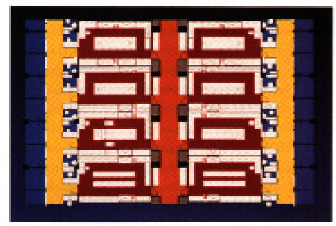
As corporations and universities race for new ideas, architects experiment with interactive formulas for research facilities.

Bell Laboratories in bucolic Murray Hill, New Jersey, was for decades the paradigm of laboratory design. Conceived in the late 1930s by Voorhees, Walker, Foley and Smith of New York, the research complex consisted of repetitive laboratory modules flanked by shared corridors. Within the discrete laboratories, senior scientists, supported by small teams of junior investigators, independently pursued their research. The building's organization did little to encourage interaction among scientists or between scientists and corporate management. In essence, "AT&T allowed very intelligent scientists to think interesting thoughts, hoping new products might evolve from them," explains Janet M. Brown, director of facility planning at CUH2A, a Princeton-based specialist in laboratory design.

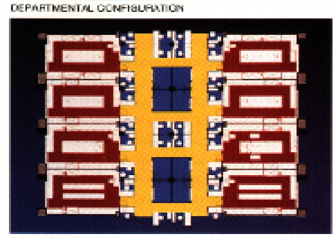
If Bell Labs represents the first generation of modern American laboratories, then Louis Kahn's Salk Institute, completed in 1965, represents the second. According to Stanley Stark, partner of New York-based Haines Lundberg Waehler (HLW), "Although most remembered for its majestic siting, Salk's fundamental contribution to laboratory design was its introduction of interstitial space." By routing utilities through an intermediary level between laboratory floors, rather than through wall cavities, Kahn freed up the plan. Salk's labs were still primarily laid out along corridors in repetitive units, but they could be expanded or contracted to meet the changing nature of research. This more flexible approach has dominated lab design for the past 30 years.

New research models

Bell Labs and the Salk Institute advanced scientific knowledge and spurred other corporate and institutional clients to follow suit; but rapidly changing economic, cultural, and technological conditions have conspired to shape a new research model for the 1990s and beyond. "Today, there is a much tighter relationship between science and business," contends Brown. Corporations are asking researchers to develop ideas that can be converted into marketable products more quickly; universities are tailoring their research toward applied, rather than theoretical, work in order to receive private funding; and campus laboratories are being sponsored and occupied by private companies, so that the distinction between academic and corporate labs is becoming blurred.



DEPARTMENTAL CONFIGURATION



TEAM CONFIGURATION

- MECHANICAL SPACE
- PERSONNEL CORRIDOR
- SERVICE CORRIDOR
- RESEARCH OFFICE
- LAB OR LAB SUPPORT

1 ENCLOSED OFFICE FOR SENIOR SCIENTIST
2 WORKSTATION FOR JUNIOR SCIENTIST

TOP: By introducing two secondary corridors between the labs and enclosed offices, architects retain a traditional departmental configuration while separating staff from hazardous materials. **ABOVE:** By inverting the plan, architects cluster scientists' offices together. This arrangement encourages interaction among different disciplines, an important ingredient as research becomes more multidisciplinary.

The pressure to produce profitable ideas, coupled with the complexities of today's research, is forcing scientists to interact with their peers, with scientists from other disciplines, and with the business world at large. Such increased interaction means that the research laboratory of the future, whether industrial or academic, may more closely resemble a corporate beehive than a monastic retreat. And this shift is already evident on every scale—from the basic lab module to the overall building program.

Office versus lab

Traditionally, a scientist and a technician worked together in the lab; the senior investigator would be assigned an enclosed office at the far end of the room, while the technician would be allocated a few linear feet of bench space near the experiment. Essentially all aspects of their work took place in this laboratory—from running experiments to analyzing results over a cup of coffee.

Today, scientists spend more time in an office environment, simulating experiments on computers. Hypotheses are often tested electronically before experiments are conducted in real life. And more often than not, the actual experiment is undertaken by specialized equipment, rather than by human hands. "You don't even have to go to the lab to get your results," explains Brown. "They appear on your computer screen."

This automated research, coupled with a concern for worker safety, has prompted architects to pull scientists' offices out of the lab so that researchers need not walk through experiments to get to their desks. In separating office and lab spaces, architects now have the opportunity to congregate scientists more closely to encourage the exchange of ideas.

Not only are offices being removed from the generic lab, so is sophisticated analytical equipment. Architect Mariano Rodriguez of The Hillier Group in Princeton estimates that the amount of instrumentation in research facilities is doubling every seven years. Because today's high-tech instruments are expensive and require special placement, most complex machinery, such as mass spectrometers and electron microscopes, are being located in dedicated labs, to be shared by a specific group of investigators. Even less complicated processes, such as glass washing, are located in shared support rooms. In addition to saving the cost of duplicating equipment and space, these dedicated areas free up the lab module so that it can remain as generic, and therefore as flexible, as possible.

JEFF GOLDBERG/ESTO

U.S. Headquarters
Rhone-Poulenc Rorer
Collegeville, Pennsylvania
CUH2A, Architect

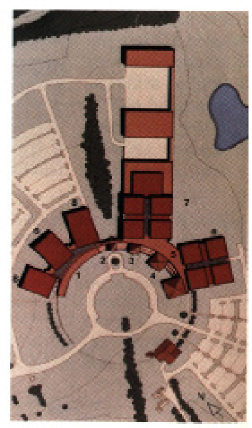
Rhone-Poulenc Rorer was formed in July 1991 as an alliance between the United States-based Rorer Group and the French pharmaceutical and chemical company Rhone-Poulenc. The new company quickly set out to assemble 2,000 researchers, managers, and support personnel—formerly located at dispersed sites—within a new, 1.1 million-square-foot headquarters (site plan). The client believes that combining the corporation's scientific, business, and marketing divisions will spark creativity.

Princeton-based CUH2A designed the U.S. Research and Development Center and Administrative Offices as a series of laboratory and office pavilions linked by a curved circulation spine. The connecting zone includes common functions such as the library, auditorium, and fitness center. The architects provided opportunities for casual interaction both within hallways in the spine (center left) and in the laboratory block (plan). Natural light is emphasized throughout the facility. An atrium in a lab wing illuminates interior research spaces (top left).

TYPICAL LABORATORY FLOOR

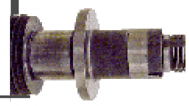
- LABORATORY
- LAB SUPPORT
- RESEARCH OFFICE
- ADMINISTRATION
- MEETING AREA

1 SKYLIT ATRIUM
2 CONFERENCE ROOM
3 BREAK-OUT AREA



SITE PLAN

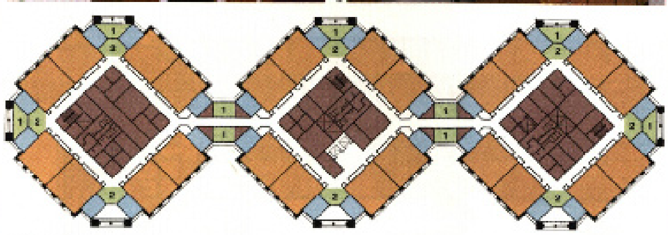
1 FITNESS CENTER
2 LOBBY
3 AUDITORIUM
4 LIBRARY
5 DINING
6 CHEMISTRY
7 BIOLOGY
8 CORPORATE OFFICE



Biological Sciences Complex
University of Georgia
Athens, Georgia
CRSS Architects

Eager to be part of the state's emerging biotechnology industry, the University of Georgia constructed the Biological Sciences Complex (top right) in 1991 to house both biochemical and genetic research. The Houston-based firm of CRSS designed the 250,000-square-foot building as three interconnected octagonal blocks (plan). Within each block, the architects placed laboratories and offices on the building perimeter to maximize natural light; support spaces are clustered at the center. The architects also designed a flexible floor plan to promote interaction among project team members while preserving a sense of individual territory within particular departments. Discussions among faculty and research assistants, for example, can take place within centrally located instrumentation rooms or adjacent to corner offices. The laboratories (center right) can be subdivided into a number of configurations. Technician workstations (bottom right), generously sized to accommodate complex computer equipment, are positioned next to windows, far away from fume hoods (below).

FRED MARTIN JR PHOTOS



Break-out areas

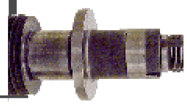
Because of the complexity of today's research, interaction among scientists is critical. Many researchers are working in multidisciplinary teams; the more ideas are shared, the more likely these joint projects will bear fruit. "Architects and managers must be very sensitive to the need for cross-fertilization," explains HLW's Stark. But the solid walls required for shelving and utilities, the protected areas for hazardous materials, and the hard surfaces for cleanliness typical of most labs are not conducive to such socialization. To overcome these barriers, architects are emphasizing shared functions through staircases and atriums that invite exchanges between floors, glazing between labs that promote interior views of research activity, and carefully placed conference areas to facilitate both scheduled and casual discussions.

Today's laboratory designers are quick to distinguish these informal meeting spaces from the "interaction spaces" popular during the 1970s and 1980s. Many of these earlier attempts took the form of lounges tacked onto the ends of corridors in out-of-the-way places. Instead, the most forward-thinking designers subtly weave these kinds of spaces—now often referred to as "break-out areas"—into the normal work flow. "The best exchange of information often happens in or near work areas," observes Chris Cowansage, director of laboratory planning at the Washington, D.C., office of CRSS. Architects can encourage this communication by strategically locating a blackboard, bulletin board, coffeepot, or mailbox outside an office or lab as a magnet to attract discussions.

Adaptable lab modules

Scientific research is changing so rapidly—responding virtually daily to new diseases, new discoveries, fluctuating funding, business priorities, and staff mobility—that academic and corporate clients want some assurance that a building will meet their needs into the next century. "I see more and more clients saying that flexibility is now a big issue, given the first costs of the projects," observes Cowansage. "They are taking a longer-term view, even if it does cost a little more money upfront."

One response to this demand for flexibility is the generic lab module. Architects develop such units from a basic geometry that can accommodate a variety of configurations—from a hood-intensive chemistry lab, for example, to an instrument-intensive electronics lab. Typically, the width of a standard module is based on a 10-foot dimension to ac-



commodate 30-inch-deep casework and 5-foot-wide aisles. The length of a lab module depends upon the specific work being undertaken by the researchers. Architects frequently work with manufacturers to develop casework and bench "kits-of-parts" so that layouts can be easily removed or reassembled.

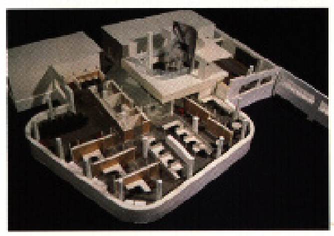
While an architect will always strive to develop a lab module from which to organize a coherent plan, Stark predicts even greater flexibility in the near future. "In older labs, a lot of time went into creating the perfect module, and then it was repeated ad infinitum," explains Stark. "In the future, we will see more forgiveness in the base module; it will be invested with qualities that allow it to grow and change." This ability to adapt the laboratory is critical if facilities are to accommodate the organizational volatility inherent in research. "Teams are reconstituted with remarkable rapidity during projects," Stark observes. "They need to be able to create dedicated support or additional office space to accommodate these changes. We have come to expect this in general office environments. The same pressures exist in labs."

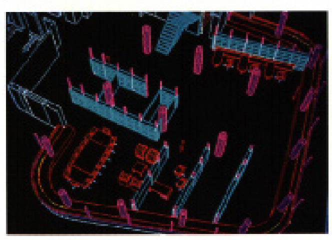
The fact that architects are frequently being called upon to design lab space for an unidentified tenant is symptomatic of this volatility. "There are instances," describes Cowansage, "when management says they are not going to assign a user to the space during design because they want a generic lab. They want to be able to decide three years from now who is going into it."

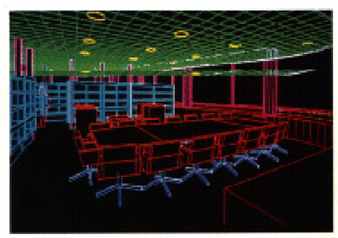
Organizing the team

Once the lab module, support space, and office needs are defined, the architect must develop the research block according to an organizational strategy based either on departments, such as biology and chemistry, or on the project team. Ideally, the two approaches are carefully balanced. According to CUH2A's CEO Ronald A. Thompson, "A critical mass is needed within each discipline—there needs to be enough of a coalition between people of similar specialties so that they can talk to each other in a way that only they can understand—but there also needs to be a connection between different disciplines working on joint projects."

But achieving the correct mix of labs and offices, of generic and dedicated spaces, and of departmental and team areas is no longer enough for the most up-to-date research labs. Today, architects are also being asked to integrate research and business functions under the same roof to foster closer ties between sci-





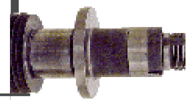


Skirball Institute and Residential Tower
New York University Medical Center
New York City
Polshek/Payette Associates

Inserted between two buildings on New York University's urban medical campus, the new 23-story building (top left) comprises an institutional and residential enclave. The lower five stories, known as the Skirball Institute of Biomolecular Medicine, house research labs and faculty offices, while the upper levels provide apartments and medical offices. A curved, five-story pavilion containing research administration, conference rooms, and lounges (center left, bottom left, and below) will connect the institute to Tisch Hospital. By locating an open staircase within this pavilion, and alternating shared instrumentation and conference rooms between floors, the architects invite scientists to socialize within this public element.

The laboratories are organized along a double-loaded corridor (plan). The lab module is divided into a primary bench and desk zone along the perimeter wall, and a secondary support zone along the corridor. Between the zones lies a "ghost corridor"—an aisle that runs continuously between adjacent labs to provide a second means of egress.

TYPICAL LABORATORY FLOOR

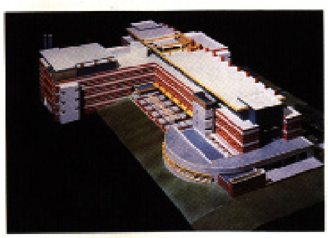


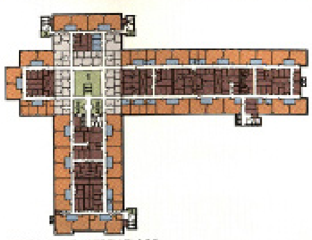
Walter Reed Army Institute of Research
Forest Glen, Maryland
Haines Lundberg Waehler, Architect

Like many older, urban research centers, Walter Reed Army Institute of Research had long outgrown its Washington, D.C., headquarters. Having relied on satellite campuses for years, Walter Reed is now consolidating its services within one state-of-the-art building in suburban Maryland. Construction of the 485,000-square-foot building and adjacent parking garage will begin this year.

The new facility (below) is divided among seven departments that focus on viruses, bacteria, parasites, medicine and surgery, psychology, animal care, and vaccine and drug development respectively. Research conducted at Walter Reed primarily involves infectious diseases, so HLW developed a basic repetitive laboratory module that can be easily reconfigured as one division expands and another contracts (plan). In addition, the architects provided a large central zone of support space that's accessible to all the labs.

Administrative offices ring the three-story building's atrium, which marks the crossing of the two wings, and encourages communication between division chiefs and researchers.





TYPICAL LABORATORY FLOOR

- LABORATORY
- LAB SUPPORT
- RESEARCH OFFICE
- ADMINISTRATION
- MEETING AREA

1 SKYLIT ATRIUM
2 CONFERENCE ROOM
3 LOUNGE

Walter E. Foran Hall
Rutgers University
New Brunswick, New Jersey
Haines Lundberg Waehler, Architect

As science becomes more sophisticated, financing research facilities is becoming more complicated. Rutgers University, for example, is relying on a trio of sponsors to pay for the construction of Foran Hall on the shared campus of Cook and Douglass colleges. Each of the funding sources is tied to a specific portion of the building. A state revenue bond administered by the State Commission on Science and Technology will pay for the Center for Agricultural Molecular Biology. Federal grants from the U.S. Department of Agriculture will finance the Plant Science Department. And money appropriated by the New Jersey legislature will cover the shared research and teaching portion of the building, Cook/Douglass Science Center.

Because construction money was tied to specific entities, and funding commitments were uncertain, HLW Architects designed the building so that certain functions could be added or eliminated as necessary. Fortunately, all three portions of the building are now funded, and the entire 140,000-square-foot facility (below) will be completed in 1994.

TYPICAL LABORATORY FLOOR

- LABORATORY
- LAB SUPPORT
- RESEARCH OFFICE
- ADMINISTRATION
- MEETING AREA

1 PLANT SCIENCE
2 SCIENCE CENTER
3 MOLECULAR BIOLOGY
4 CONFERENCE ROOM
5 BREAK-OUT AREA

ence and business in the corporate environment. Explains Thompson: "The research team has dramatically expanded to include not just the scientists but the whole business team." This change can be seen in the size of new research facilities: 10 years ago, the average industrial complex might have been 300,000 square feet; today, many are 1 million square feet. And new university facilities are often strategically positioned to link a vast array of existing laboratory spaces together into one dynamic complex.

Research amenities

Nonlaboratory facilities that serve all of a complex's tenants are also receiving increased scrutiny. As scientists spend less time in the lab, they are required to spend more time in meetings—so seminar rooms, auditoriums, conference areas, and high-tech training rooms are taking on greater significance.

Connections to the outside are also being strengthened. The library, always an important ceremonial space in a research facility, is increasing in size and usefulness—and tying scientists electronically to new research being developed around the world. "Today, with the globalization of knowledge, no single research entity can do everything on its own. There is a good deal of collaboration and sharing of information," explains Stark.

To recruit and retain well-qualified staff, a critical issue for both academic and corporate laboratories, research clients have broadened their program requirements. Large-scale research complexes are incorporating consumer services, such as newsstands, cash machines, food carts, dry cleaners, and video rentals. On-site day-care centers are becoming commonplace. Fitness centers, which were integrated into the corporate environment several years ago, are now considered essential to research facilities.

These amenities are not just altruistic gestures on the part of management. While employees may appreciate the convenience, corporate strategists recognize that they keep scientists more focused on their research. And many of these functions encourage conversation that leads to scientific breakthroughs. According to Peter Hoyt, CUH2A's director of design, scientists will not share technological or business knowledge until and unless a social relationship is established.

"There is nothing like scientists spending 20 minutes next to each other on the Stairmaster to help break the ice in a meeting later that day," Hoyt says with a laugh. ■

—*Nancy B. Solomon*

Researching Laboratory Trends

As technology changes and dollars for R&D facilities shrink, new strategies for designing labs have emerged in both the public and private sectors.

1

Carnegie Mellon University's Undergraduate Chemistry Laboratories (1) encourage cross-discipline collaboration by creating an open working environment. Relocatable lab tables replace traditional fixed casework. Exposed overhead utilities maximize system flexibility (2). Utility drops occur only as required at workstations, facilitating future connections, while lowering costs for moving, maintenance, and service. Angled lab benches delineate multiple work zones within a larger space (3). Lab sinks are located at the ends of work stations for greater user access. Safety considerations include separation of student and chemical paths, unobstructed sight lines, and ease of movement around work surfaces and utility drops (4).

By Barbara A. Nadel

From California's academic medical centers to New Jersey's pharmaceutical corporate-office parks, a new generation of research laboratories is on the rise. Technology and science, along with competitive market forces and dwindling federal grant money, are driving research facilities toward generic, modular lab spaces with more public amenities. Experts predict the demand for laboratories will remain strong within research and development, academic, and corporate environments.

In mid-1995, an architectural trade magazine that has since ceased publication, sponsored a juried competition for all types and sizes of laboratory projects, both new construction and renovation. Three national lab experts reviewed over 200 submissions. The jurors were: Bruce Carmichael, Sc.D., executive director, facilities development and operations, Yale School of Medicine, New Haven; Steve Copenhagen, CEO, McLellan & Copenhagen Inc., Cupertino, Calif.; and Don Raney, AIA, director, architecture, planning and design/real estate services, Hoffmann-La Roche Inc., Nutley, N.J.

Barbara A. Nadel, AIA, is a principal of Barbara Nadel Architect in New York City, specializing in the programming and design of health, correctional, and institutional facilities.

According to the judges, only a handful of projects successfully integrated technical parameters, programmatic needs, and inspired design solutions. Overall, however, the substantial number of lab projects from both academia and the corporate arena reflect the wide variety of programs and laboratory types being built in this active market segment.

"Architects who direct lab design without understanding the issues force compromises that impair building performance."

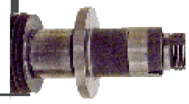
—Janet Baum, AIA, Health, Education + Research Associates, Inc.

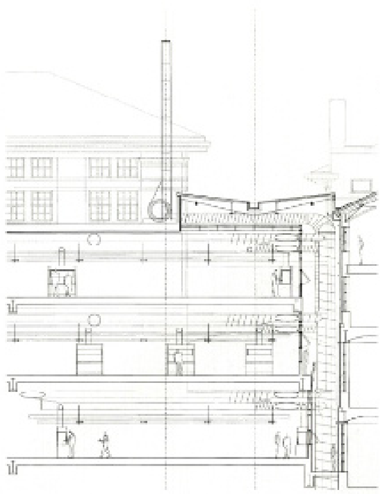
Academic research

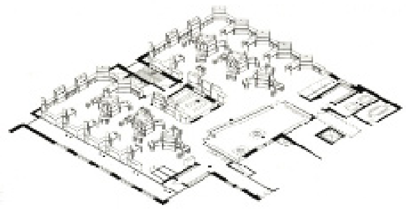
"There's a revitalization of science on campus, with more long-range strategic planning for these very complex facilities," says veteran lab planner Janet Baum, AIA, principal of St. Louis-based Health, Education + Research Associates, Inc. (HERA).

In the past, as prestigious academic medical centers scrambled to recruit top talent, researchers called the shots, asking for—and often getting—cavernous labs and office areas. Today, as federal medical research money becomes scarcer, organizations justify expenditures by examining occupancy patterns and densities. No longer do researchers have a blank slate or a blank check where facilities are concerned. Benchmarks and data bases now measure sq ft per person and quantify productivity per sq ft.

Occupancy patterns in technical building types change frequently. Lab design must anticipate different types of research and building systems, placing greater burdens on architects to understand the nature of research to be conducted and the related engineering processes. "Architects who direct lab design without adequately understanding the issues force compromises that impair







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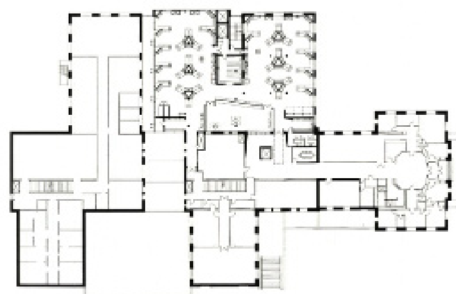

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critical building performance," says Baum.

Yale's research facilities contain standardized lab modules, with carrels at the end of wet benches. "After a while, the labs start to look alike," states Carmichael. "More academic research is genetic and cellular, across multiple disciplines. The nature of this scientific research is driving the design consistency."

Corporate research and development
The highly competitive, market-driven pharmaceutical industry fosters entrepreneurial activity by outsourcing basic research to small start-up labs and universities. These nimble, profit-oriented research incubators develop new products. They need generic lab space designed for flexibility and multi-use applications, with minimal fixed equipment, blank walls, and low fit-up costs.

Although co-locating scientists of different disciplines is difficult due to the nature of fume-hood and mechanical-system requirements, a team-based facility trend is emerging. Chemists have greater hvac needs than biologists; both disciplines need separate labs to guard against cross-contamination. Still, building a single building for each is expensive.

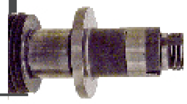
"The trend is toward a small, fragmented group of people managing the R&D process. Discovery yields great promise for biotechnology," says Hoffmann-La Roche's Raney. To further cut costs and boost efficiencies, round-the-clock computerized testing can operate without lab personnel, vacations, or benefits. Within the pharmaceutical industry, the bottom line forces the acceleration of product development and getting new items to market before the competition. One month of sales can pay for an entire facility's project cost. Recruiting and retaining the select, highly-mobile group of top researchers around the country is part of the R&D game. Environmental design and the quality of space are viewed as recruitment tools and employment perks. "University research facilities have raised quality-of-life expectations, through well-designed conferencing facilities, gathering areas, and offices located close to labs, allowing social interaction," Raney adds.

Return on investment
Corporate entities seeking return on investment insist on economic feasibility studies before building new labs. In contrast, government organizations, such as the National Institutes of Health, are subject to congressional oversight, and thus remain acutely sensitive to spending taxpayer money wisely, by not building what one feisty senator terms "gold plated" facilities.

While government agencies and academia do not demand a profit-oriented return on investment, they need their own criteria to assess the value of these facilities. Budgets are increasingly tied to productivity, with grant-dollar production used to determine allowable construction costs per sq ft. While the amount varies by each institution, some use a rule of thumb, applying between $200 and $400 of grant money per sq ft as a goal for academic project construction. This rule is not the sole benchmark, but is a growing factor influencing overall space allocations.

Lab retrofits
"The science community is looking at improved environments. Academic research centers want architectural design qualities carried throughout their projects," says Copenhagen. These qualities—logical organization, public amenities, people spaces, design touches in corridors, a pleasant palette of colors and textures—enhance a lab building. When they are not included, purely

Continues on page 117



Laboratory Architecture and Design Projects Voted Most Progressive

In 1995, an architectural magazine sponsored a juried competition for laboratories. Over 200 projects were submitted for judging by three prominent lab experts; 18 projects received awards. The magazine closed in early 1996, before publishing the winning projects. RECORD is pleased to belatedly acknowledge the winners, below. Projects are listed alphabetically, by architectural firm.

Anshen + Allen. Cecil H. and Ida Green Earth Sciences Research Laboratory, Stanford University, Palo Alto, Calif. New earth sciences research labs.

William N. Bernstein and Associates, Architects. Biotechnology Incubator; Audubon Business & Technology Center, Columbia University, New York City. Biotechnology lab modules and offices.

Burt Hill Kosar Rittelmann Associates. Undergraduate Chemistry Laboratories, Carnegie Mellon University, Pittsburgh. Chemistry teaching labs, support spaces.

Centerbrook Architects and Planners. Neuroscience Center, Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y. Research labs, housing, parking garage.

Davis, Brody & Associates, LLP, Architects. Warren Alpert Research Building, Harvard Medical School, Boston. Research labs; animal facility, parking garage.

Ellenzweig Associates, Inc. Joslin Diabetes Center, Boston. Labs, animal facilities and public areas added atop existing building.

Ellerbe Becket Company. Earth Sciences and Materials Engineering Building, University of Minnesota, Minneapolis. Teaching labs, offices.

Garikes Wilson Karlsberger Inc. JMGR/ Lyons & Hudson. The J. Bennet Johnston Health and Bioenvironmental Research Building, Tulane University Medical Center, New Orleans. Environmental research labs and offices.

The Hillier Group. Du Pont Merck Pharmaceutical Co. Medicinal Chemistry Building, Wilmington, Del. Research labs, offices, library, public spaces.

Kallman McKinnell & Wood Architects. Bass Center for Molecular Biophysics and Biochemistry, Yale University, New Haven. Research labs, classrooms.

Kling-Lindquist Partnership, Inc. Glaxo Wellcome Research and Development Headquarters, Research Triangle Park, N. C. Research labs, auditorium

Kornberg Associates. Tananbe Research Laboratories, USA, San Diego. Chemistry and biology research labs, vivarium.

MBT Architecture. Biomedical Sciences Research Building, University of Washington School of Medicine; Seattle. Genetic research labs, vivarium, offices.

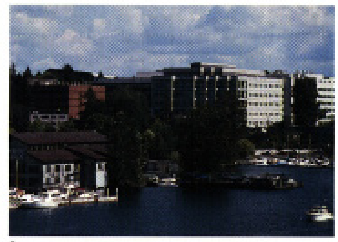
Payette Associates, Inc. Biotech Research Facility, Biogen, Inc., Cambridge, Mass. Biomedical research labs, offices, auditorium, public areas.

Payette Associates, Inc. Stevenson Chemistry Building., Vanderbilt University; Nashville. Synthetic chemistry research and teaching labs.

Payette Associates, Inc. Undergraduate Science Center, Washington and Lee University; Lexington, Va. Teaching and research labs, classrooms.

Robbie/Young + Wright Architects Inc. Chemistry and Computer Science Building York University, North York, Ontario, Canada. Chemistry and computer science labs, offices, classrooms.

Zimmer Gunsul Frasca Partnership. Fred Hutchinson Cancer Research Center, Seattle. Biomedical research laboratories, offices.



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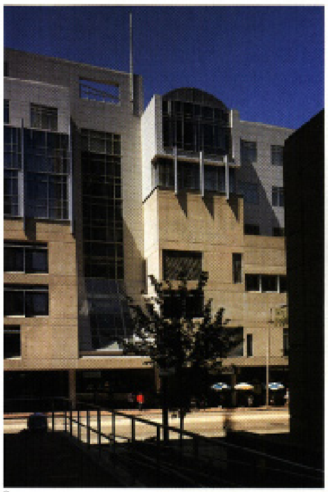
Biomedical Sciences Research Building *Urban context and outdoor connections remain important design elements for research facilities. The laboratory (5) is sited to complement adjacent buildings and maximize magnificent waterfront views in labs and conferencing areas.*

Tananbe Research Laboratories *The lab (6) is a research refuge for talent in the competitive drug-discovery business. Lab views overlook canyons, the ocean, and mountains. To overcome language barriers in the lab's international staff, a corridor (7) concentrates researchers' traffic patterns.*



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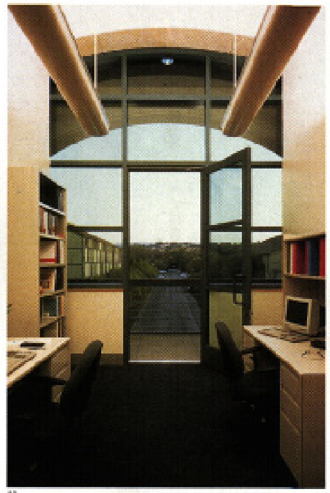

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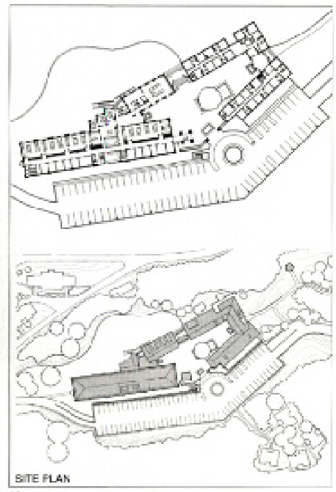

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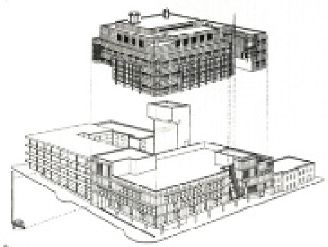

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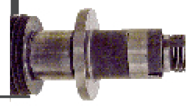
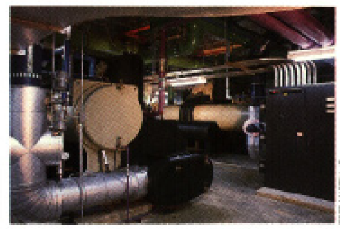
Joslin Diabetes Center Research and Clinical Facility Expansion *Capacity was doubled by adding three stories and a penthouse atop a 1974 exposed-concrete building on a restricted urban site—while maintaining operations below (8, 9). Expansion space includes labs for 64 researchers, administrators, diabetes patients, and staff from around the world. The design resolves three entrances on two levels, and accommodates an Eye Institute by raising an existing courtyard 12 ft. A new skylit atrium, elevated landscaped courtyard, and renovated lobby provide daylight while transforming the character of the original building.*

Green Earth Sciences Research Laboratory, Stanford University *The laboratory is designed as a pavilion (10, 11) with a central portal opening onto a plaza, and serves as a gateway to the north/south axis of the near-west campus. To balance the height limitations, campus-plan plaza requirements, and programmatic criteria, 50 percent of the space is below grade. A submerged plaza courtyard provides daylight to surrounding offices and labs. Partial interstitial space at the concourse level facilitates lab renovations without interrupting researchers in adjacent spaces.*

Neuroscience Center, Cold Spring Harbor Laboratory *Located on a steep hill in a residential neighborhood (12,13), the laboratory overlooks the research campus and Long Island Sound. The structure integrates three stories of labs, 60 guest rooms for visiting scientists, and a 150-car parking garage. Each workspace and lab has a harbor view. Outdoor study areas and public spaces are protected from the noise of a nearby highway. Energy conservation measures balance guest room heating and cooling demands with those in the labs.*

Nadel, B.A. (1996, December). Researching Laboratory Trends. Architectural Record, 50-53.





FRED MARTIN JR.

Venting the Laboratory

Improving air quality in laboratories requires integration of mechanical and structural systems.

ABOVE LEFT: Placement of HVAC services affects even the rooftop, where exhaust fans and stacks are located.
ABOVE RIGHT: Basement-level air handlers in the University of Georgia Biological Sciences complex reveal the tremendous space required by mechanical equipment to provide fresh air.

"It acts as a giant lung." That is how Vice President Howard Weiss characterizes Anshen + Allen's new laboratory addition to California State University, Fullerton's sciences building (page 115). Weiss's metaphor aptly describes what is required of mechanical systems installed in research laboratories today. Forty to 50 percent of the total design and construction budget of a laboratory is typically dedicated to HVAC equipment, in order to ensure a healthy environment for scientific researchers who must work with toxic substances.

According to Eugene Bard, principal of the Boston-based mechanical engineering firm BR+A, greater public awareness about airborne contaminants and stringent regulations restricting their discharge are prompting the installation of improved air-filtration systems. Such measures require more space dedicated to air-handling services in laboratories.

Fumes and heat

Likewise, researchers' concerns for their own safety while working with hazardous airborne toxins is leading architects to increase the number of internal fume hoods; these separately ventilated, negatively pressurized cabinets limit the spread of unwanted toxins and exhaust them away from bench tops. Fume hoods are now commonly installed at individual workstations, further increasing the rate of air exchange within laboratories. As a consequence, added fume hood duct and sash requirements have elevated floor-to-floor heights in laboratories.

While such mechanical systems successfully boost the volume of air to better dilute toxins, the ever-increasing number of computers and electronic instruments necessary for recording and analyzing lab data generate large quantities of heat. Since air-handling systems consume energy and produce the lion's share of operating expenses, a greater number of efficient heat-recovery systems are being added to HVAC equipment in order to offset increasing loads.

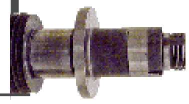
The demand for mechanical services has heightened the need for architects to consider how they will integrate such equipment into a building structure at the conceptual design stage. They are learning to take better advantage of ceiling plenums, to avoid overlapping separate supply and return air ducts that could cause cross-contamination; and to limit critical floor-to-floor dimensions, especially for projects restricted in height by local zoning regulations.

Distribution diversity

Horizontal distribution is the most economical air-circulation solution since a low-rise structure—three stories or less—offers the advantage of a higher roof-to-floor-area ratio, allowing greater freedom in locating and routing mechanical penthouses and exhaust stacks. Vertical shafts punched through floors, on the other hand, consume valuable square footage that could be devoted to labs. An exoskeletal approach, permitting ventilation shafts to be pulled outside the building envelope, also reduces the space requirements of mechanical systems, as illustrated by the University of Arizona's agriculture school (pages 116-117).

Another height-reducing approach is exemplified by Haines Lundberg Waehler's new Drug Discovery Facility in New Jersey, in which labs are serviced by a central corridor. Such a strategy requires a larger building footprint, but physically separates waste, supplies, and utility services from the actual lab and allows for changes and maintenance of HVAC systems with far less disruption than if these services were located in the ceiling plenum. Some buildings devote an entire floor to utility services between or above lab levels; this interstitial approach offers the most flexibility in changing lab configurations, but is usually reserved for those buildings in which the demand for frequent mechanical system alterations overrides concerns about height limitations and added costs.

Intake and exhaust distribution routes are primary considerations in determining a



lab facility's eventual structure and expression. Hansen Lind Meyer Principal Martin Meisel reveals that when designing a lab project, "My closest associate is a mechanical engineer." Even a lab's initial siting and orientation have implications for locating stacks, thereby influencing the eventual profile of the roof line. Flad & Associates Vice President Ralph Jackson explains that such decisions determine the direction and height at which fumes are discharged. Air exhaust tends to roll back down the sides of the building, producing a "wake cavity" effect. Fumes must therefore be exhausted away from and above adjacent structures to avoid reintrainment. Architects must also decide early in the design process where fresh-air intake grills are best placed, ensuring that they are sufficiently below rooftop exhaust and away from potential polluting vehicle emissions at ground level.

Modeling systems

In addition to early consultation with mechanical engineers, architects involved in lab projects must work closely with owners and users during design development. The complexity of integrating mechanical and utility services within equipment-intensive buildings makes the three-dimensional modeling of proposed projects vital for conveying design strategies to clients and for eliciting decisions from owners, who often cannot visualize plans. Full-scale mock-ups of a typical lab station are frequently constructed. But the rendering capabilities and sophisticated graphics of computer-aided design systems are proving a faster, more effective tool for communicating three-dimensional ideas at earlier stages in the design process.

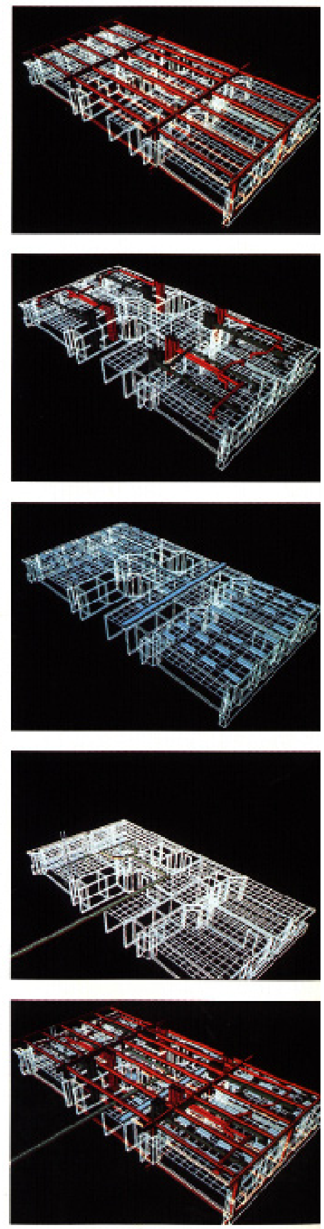
In designing the University of Maryland at Baltimore's new health research facility, for example, CUH2A and Ayers Saint Gross created a series of computer-generated lab perspectives (right), which convinced their skeptical clients of the scheme's flexibility.

Client demands for better air quality with more adaptable mechanical services are therefore fueling the increased role of HVAC systems in the earliest stages of the design process. The examples on the following pages illustrate the dictum of Stanley Stark, a principal at Haines Lundberg Waehler: "The configuration of the air-handling system has its own 'architecture' in the way that it is delivered, strongly influencing the architecture of the laboratory as a whole." ■

—*Marc S. Harriman*

University of Maryland at Baltimore
Health Sciences Facility
Baltimore, Maryland
CUH2A and Ayers Saint Gross, Architects

A new, 200,000-square-foot facility for conducting biomedical research will serve as the hub of the University of Maryland at Baltimore's medical center when completed in 1995. Constructed on an urban site in downtown Baltimore, the building will connect the hospital, adjacent medical research and teaching facilities, and a shock trauma center to encourage the collaboration of specialists from the medical, nursing, pharmacy, and dental schools. Baltimore-based Ayers Saint Gross and Princeton-based CUH2A therefore designed the building to accommodate biomedical research laboratories in flexible spaces. The six-story building's attachment to adjoining facilities at each floor level dictated a lower-than-optimal, 13-foot, floor-to-floor height. To maintain ceiling clearances, the architects minimized overhead mechanical services by routing supply and exhaust ducts from the labs to vertical shafts that run to a rooftop penthouse, where system control elements are located. Polluted air from a nearby incinerator and downdrafts from helicopters arriving and departing from the adjacent shock trauma center placed additional burdens on the building's exhaust system. Such constraints led the architects to design a brick-clad tower stretching above the northwest corner of the building to house exhaust stacks. This tower not only discharges toxins, but creates an architectural marker to enhance the school's previously undistinguished presence on the cityscape.



TOP LEFT: Proposed Health Sciences Facility
RIGHT AND FACING PAGE: Computer images of the Health Sciences Facility depict location of separate building systems—structural (top row, left to right), HVAC (second row), electrical (third row), plumbing (fourth row)—and their integration (bottom row). The drawings allow clients to envision the organization of each system and the design of individual laboratories (facing page, far right, top to bottom).

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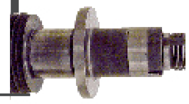
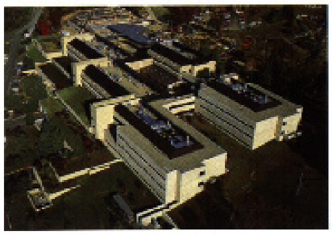
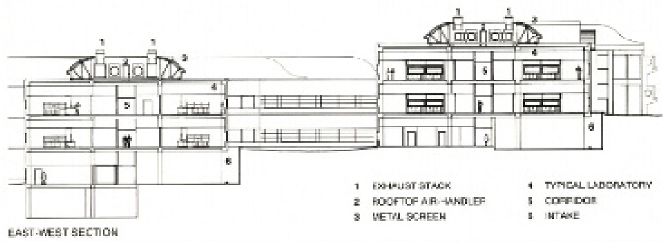




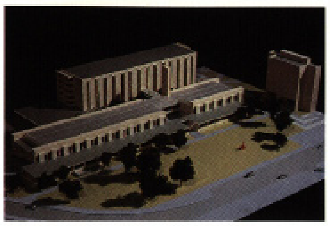


STEVE TURNER

Boehringer Ingelheim Pharmaceuticals
Ridgefield, Connecticut
Flad & Associates, Architects

Two linear laboratory wings added to the south end of Boehringer Ingelheim Pharmaceuticals' 20-year-old campus in rural Connecticut mark the completion of a second construction phase for the German-based company's growing North American headquarters. The new buildings provide an additional 100,000 square feet of chemistry- and biology-based research space for developing new drugs. In the new labs, Flad & Associates distributed mechanical equipment along double-loaded service corridors that continue the circulation spine established by the original structures. The architects maintained the three-story height of the existing research facilities and extended supply ductwork from basement air-handlers through two fresh-air supply shafts flanking one end of the hallway. Two more shafts flanking the opposite end of the corridor remove fume hood exhaust. Ducts then branch out laterally from the central corridor to individual labs; this main hallway efficiently doubles as circulation for occupants and as a plenum for overhead air-handling services. The wind-tunnel-tested, aerodynamic profiles of curved, perforated metal screens atop the buildings' flat roofs shield penthouse mechanical equipment from view and from prevailing winds. Their sloped configuration, engineered so that the path of airflow closely follows the panels' streamlined contours, limits the deflection of swirling outside air from the building facades and permits rooftop exhaust to be discharged from relatively short stacks without risk of reintrainment.

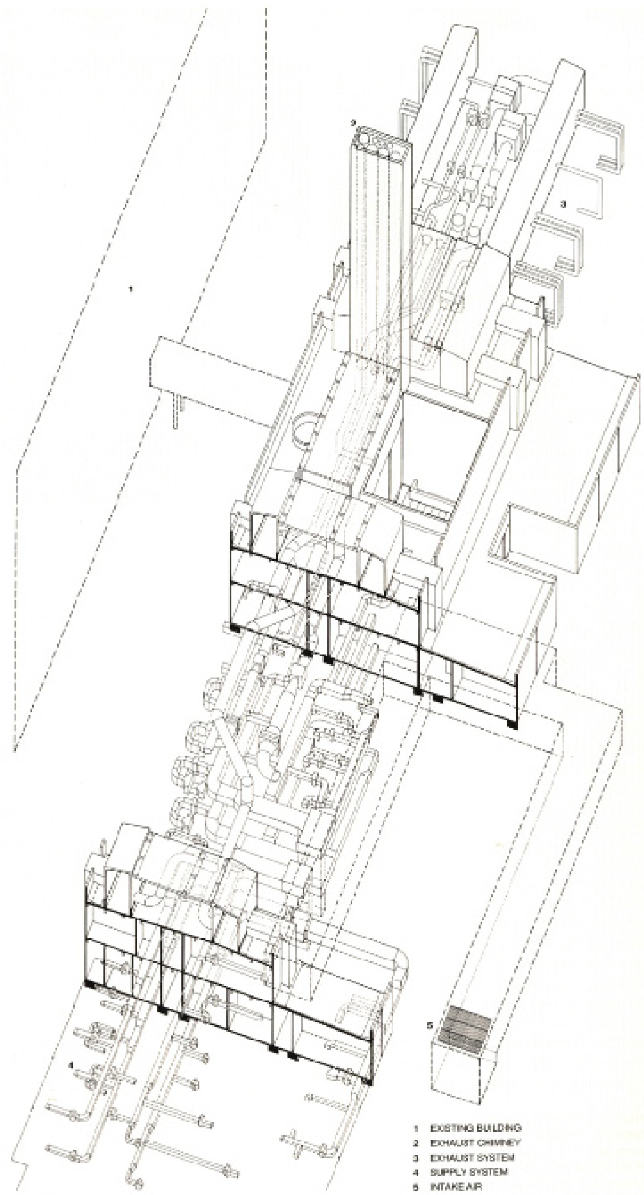
TOP: Aerial view of two new laboratory wings.
SECTION: Profile of metal-panel windscreens for rooftop exhaust stacks.
ABOVE RIGHT: Typical laboratory with fume hoods along rear wall.
BOTTOM RIGHT: Basement-level air-handlers.



Sciences Building Addition
California State University, Fullerton
Fullerton, California
Anshen + Allen, Architects

A new addition to California State University, Fullerton's School of Natural Sciences and Mathematics building now provides the faculty with improved indoor air quality and an additional 60,000 square feet of teaching and research laboratories. Anshen + Allen's linear, two-story structure allows support spaces and equipment to be shared by the university's biology, chemistry, geology, and physics departments. The architects specified 16-foot floor-to-floor heights to accommodate the air-handling services required in each of the department's labs. To conserve interior space, they pulled fume hood exhaust ducts from each lab to the outside of the building at every 22-foot-wide structural bay and extended them upward to a rooftop plenum above the building's central circulation spine. Since the university did not want mechanical services to be visible, the architects wrapped exterior ductwork, rooftop equipment, and exhaust stacks within an uninsulated, metal-paneled shell. A previous retrofit of the original building added fume hoods to existing labs, but also expelled exhaust too close to existing intake grills, causing reintrainment of chemicals previously discharged into the atmosphere. To correct the situation, Anshen + Allen located the new structure's fresh-air supply at the southwest corner of the building, as far as possible from the original laboratories. Furthermore, aeronautical engineering studies of wind patterns helped the architects determine that new stacks must force exhaust upward at least 25 percent above the original six-story structure to avoid possible reintrainment; this led Anshen+Allen to house the stacks within a single, 100-foot-tall chimney.

MODEL: Addition with 100-foot-tall exhaust chimney.
DRAWING: Mechanical system distribution.

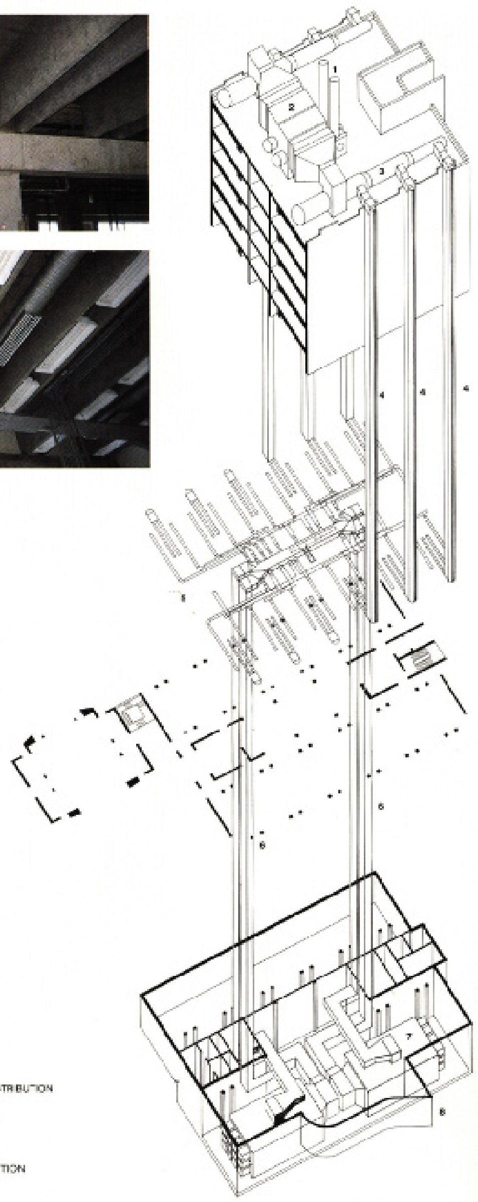


MECHANICAL SERVICES DISTRIBUTION

Marley Agricultural Laboratory
University of Arizona
Tucson, Arizona
Anshen + Allen, Architects

A new, seven-story research and teaching facility for the University of Arizona's plant sciences, plant pathology, entomology, and biotechnology departments greatly expands the school's agricultural college. Sited between adjacent one- and three-story buildings, the 123,000-square-foot Marley Agricultural Laboratory was designed by Anshen + Allen with carefully threaded mechanical and utility systems to minimize its imposing height. Basement-level air-handlers take in fresh air at ground level, supplying it to the labs through two vertical risers within the core of the building. The architects specified poured-in-place concrete slabs above the central corridors and support areas to provide room for deep horizontal distribution trunks overhead. These ducts then branch into supply ducts running between precast-concrete, double-T members to lab stations, providing ample 10-foot-6-inch effective ceiling heights within shallow, 13-foot-6-inch floor-to-floor dimensions. Exhaust ducts run between alternate precast-concrete T-beams to avoid crossovers with supply services; exhaust ducts also lead from each of the 11-by-33-foot lab module fume hoods to seven metal-clad vertical shrouds running lengthwise up the east- and west-facing exterior walls. These risers then feed into a single rooftop plenum, where frames are expelled through shared stacks. By interlocking supply and exhaust ducts within the structure, Anshen + Allen clearly relegates HVAC services to distinctly separate zones, facilitating their installation, future adapeation, and maintenance.

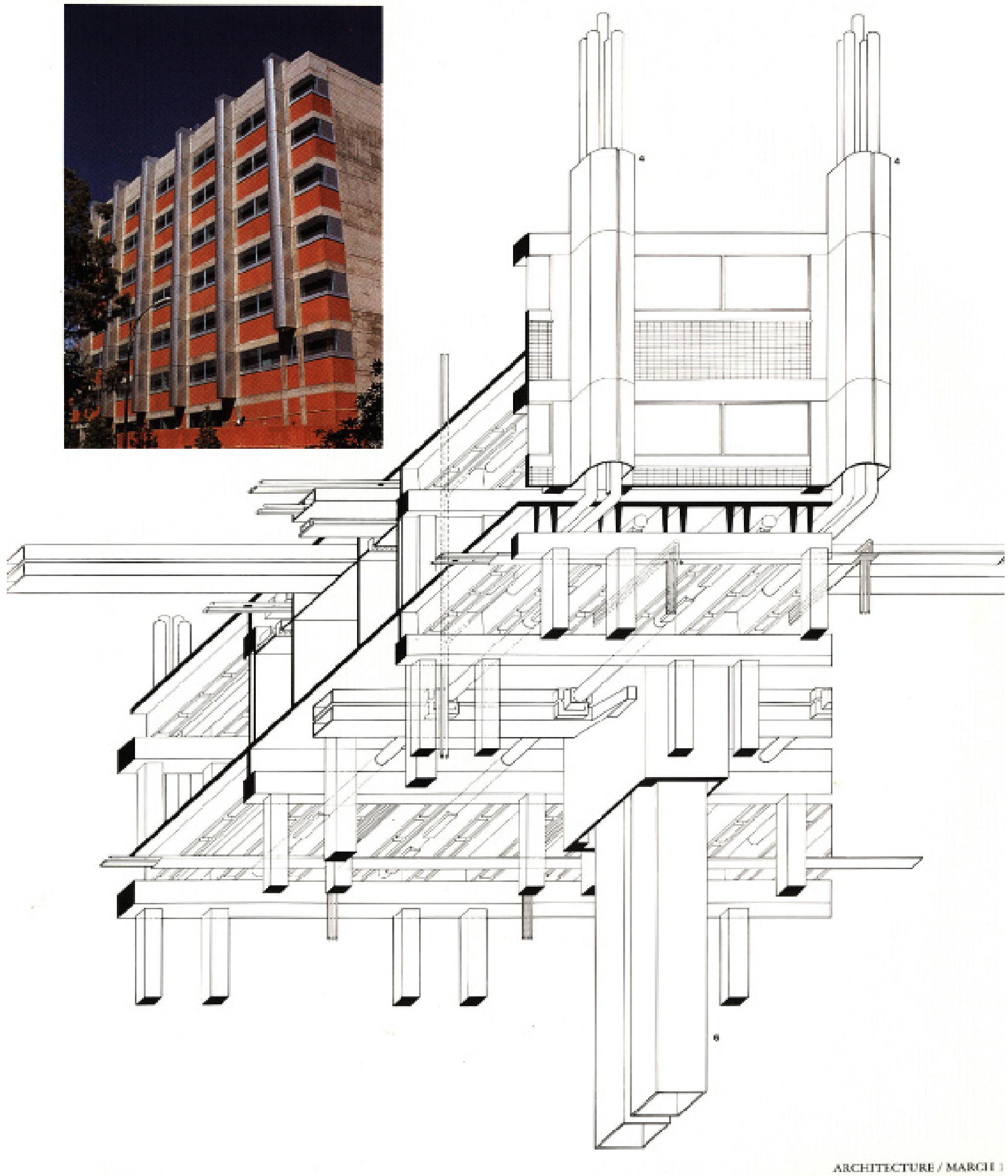
MODEL AND FACING PAGE: Duct risers run up facade.
TOP RIGHT: Typical concrete T-beam.
ABOVE RIGHT: Utilities placed within structure.
ISOMETRIC, RIGHT: Duct distribution.
ISOMETRIC, FACING PAGE: Integration of mechanical and structural systems on typical floor.



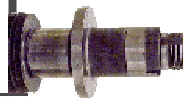
1 EXHAUST STACK
2 EXHAUST PLENUM
3 EXHAUST MANIFOLD
4 EXHAUST RISER
5 TYPICAL HORIZONTAL FLOOR DISTRIBUTION
6 SUPPLY RISER
7 BASEMENT AIR-HANDLING UNIT
8 GROUND-LEVEL INTAKE

MECHANICAL SERVICES DISTRIBUTION

116 ARCHITECTURE / MARCH 1993



Harriman, M.S. (1993, March). T&P Technology: Venting the Laboratory. Architecture, 111-112.



Betting on biotech: One of the largest construction projects underway in Boston, the $650 million University Park, comprises 27 acres of research and office buildings, four housing complexes, restaurants, stores, and a high-tech-sounding hotel called Hotel@MIT.

FOR THE BIOTECH INDUSTRY, PLACE MATTERS

The biotech field presents "clusters" of growth for enterprising lab designers. by C.C. Sullivan

Architects seeking work in the biotechnology market might find that their business-development efforts are a bit like biological specimens: The closer you get to them, the more complex they appear.

Just two years ago, it was a different story. After the dot-com bubble burst, the fast-growing biotech industry was a savior to investors and real estate developers with high hopes for high-tech. In 2001 and 2002, companies using genetic research to develop everything from drugs to pesticides were investing more than $3 billion annually in laboratories and office space, a figure that was growing by 20 percent a year in some places, according to the U.S. Department of Commerce.

Today, the fast growth is over. "Since 2001, when the industry was peaking, company values and venture-capital sources have tapered off very dramatically," says Joseph Cortright, principal of the Portland, Oregon–based economic consulting firm Impresa. "The firms are mostly very small companies that are losing money, and even the big ones are cutting back on their burn rates to save money, or looking for mergers." And while the U.S. biotech industry numbers about 1,450 establishments employing 190,000 people, almost all of its revenues come from sales of fewer than a dozen products.

Still, many developers and architects are committed to this segment, which some call "the brightest spot" in the economic picture. "Right now the commercial market in general is in a trough, but we have every confidence that it will grow again," says Peter Calkins, an executive in the Boston office of real estate developer Forest City Enterprises. "There's a great deal of activity on the institutional side." Others are even more upbeat. "The market's still more robust than anything else at the moment," says Dan Winny, director of design and planning with Hanover, New Hampshire–based Lyme Properties, a developer specializing in biotech. "That's why everybody has become a lab developer or a lab architect."

BIOTECH: A CLUSTERING ORGANISM

So why is making costly labs for companies with zero sales revenue a good business? Besides our aging populace and high demand for better drugs, the main reason is steady growth in National Institutes of Health (NIH) grants for bioscience research. (Total grants doubled between 1995 to 2001 but are now growing more moderately.) But the key factor for building construction is where you happen to be: As with politics, all biotech is local. "The top nine biotech centers average about $800 million annually, and the bottom 42 get about $100 million" in NIH funds, Cortright explains. "And the disparity is much wider in all measures of commercialization: For example, 47 of the 51 most active venture capitalists, who play very hands-on roles in companies, are in one of the nine leading areas."

Not only are investors very location-sensitive, but so are talented young scientists and PhDs, say biotech experts. They're drawn to locales with lots of opportunities—in particular, San Francisco and Boston, which have dominated biotech since its early days in the 1970s. Top challengers include San Diego, Seattle, and the Research Triangle Park area of North Carolina—the latter has seen the most growth in startups since 1997—and other hot spots include Los Angeles; Washington, D.C.; and the pharmaceutical centers of metropolitan New York City and Philadelphia.

Yet despite the ingrained "clustering" of this quirky industry, state

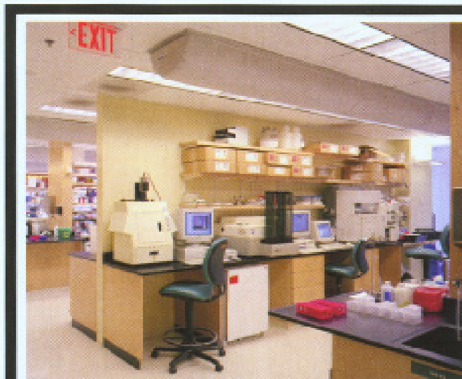
and local governments are battling fiercely to lure companies away from the centers. At least 40 states have official magnet programs, and 83 percent of municipal development agencies list the biosciences among their top two growth priorities. And recently, a few places have made Herculean and, some would argue, hubristic attempts to create biotech momentum out of thin air. The city of Phoenix, for example—a place Cortright says is "bereft of all biotech"—announced its start-up funding of the ambitious Translational Genomics Research Institute, or TGen, whose first phase is the $46 million Phoenix Bioscience Center at Copper Square designed by the SmithGroup, set to open in November. And the state of Florida recently committed 100 acres in North Palm Beach County and a jaw-dropping $500 million to entice The Scripps Research Institute, based in La Jolla, California, to establish a large new drug-design outpost there. Scripps will occupy temporary lab space while it constructs its 364,000-square-foot facility to open in 2006. (Proposals from architects and project managers are due this month.)

MIGHTY HUBRIS

Such projects outside the main biotech clusters can't gain critical mass without big institutional support—a major medical school, for example—argues Calkins. But even then, the springboard to private-sector activity might be a pipe dream. "It takes a confluence of things for that to happen successfully: NIH funding, access to venture capital," he says. And they'll compete for people, investors, and grants with huge projects adjacent to major institutions in the hottest clusters, such as Catellus Development's Mission Bay project in San Francisco, which is plowing $1.5 billion of University of California and private money into 300 acres of research buildings, housing, and stores. In Cambridge, Massachusetts, Forest City is completing the final phases of University Park, a $650 million research campus next to the Massachusetts Institute of Technology that includes 2.3 million square feet of private-sector labs, offices, residences, stores, and a hotel. (The P/A Award-winning plan is by Koetter Kim.)

In the diffuse biotech world, however, there are many more small projects than massive master plans. Wherever NIH money goes, so too go developers planning new labs or adapting suburban "flex buildings" and urban lofts. But in the last two years, the most robust segments have been large pharmaceutical companies and universities, say developers. "Corporate and institutional buildings are about 80 to 90 percent of the market; then there's the smaller slice of intensive commercial wet-lab research," Winny notes.

Whether commercial or institutional, all segments compete for the same thin talent pool, which explains why biotech firms are seen as design-focused clientele, says Edward T.M. Tsoi, principal of Cambridge-based Tsoi/Kobus & Associates, an architecture firm known for its lab projects. "Their buildings become recruiting tools to attract the best and brightest, and they must have more sex appeal than their competitors' facilities," says Tsoi. "They also have to offer amenities like cafeterias, exercise rooms, daycare—even concierge services." Other design issues include creating comfortable and creative environments, with plenty of meeting places for spontaneous cross-disciplinary collaboration—a vital tool in a field that bridges biology, chemistry, and others. "They want to erase the boundaries of specialties," says Tsoi.

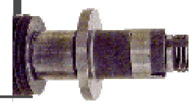


LABS, UNDER THE MICROSCOPE

USE As with most specialty typologies, the commercial biotech lab building is a well-studied niche. Base buildings for biotech occupants tend to cost about 25 percent more to build than office structures, mainly because of the need for higher floor-to-floor dimensions, stronger floors (a minimum of 100 pounds of load per square foot), double the typical available electrical service, and HVAC systems that can churn out six complete air changes or more per hour. Fortunately for developers, however, their tenants stay longer and renew their leases more frequently than office end-users, mainly because of the time-consuming, costly build-outs that the occupants usually underwrite.

COSTS The cost differentials are surprising. According to the real estate firm Meredith & Grew, the core and shell of a lab building in Boston, for example, might average $200 per square foot, versus $125 for an office building. Tenant improvements might add a mere $25 for the office user, while the biotech firm pays a whopping $150 to $300 per square foot.

CONVERSIONS Another option preferred by many developers is converting existing warehouses or office structures into biotech labs. For example, Lyme Properties of Hanover, New Hampshire, has found success in renovating mill buildings in New England, either brick and heavy-timber structures or the concrete-framed versions that emerged between 1910 and 1920. The structures have high floor-to-floor heights, and ideal column bays of 20 to 25 feet. While Meredith & Grew notes that office structures can be adapted for biotech labs at a cost of about $100 per square foot—mainly to reinforce floors and upgrade M/E/P systems—many developers contend that few office buildings are worth converting, in part due to the costs of M/E/P retrofits and the limitations of the steel structures.



practice

FROM BIO TO NANO?

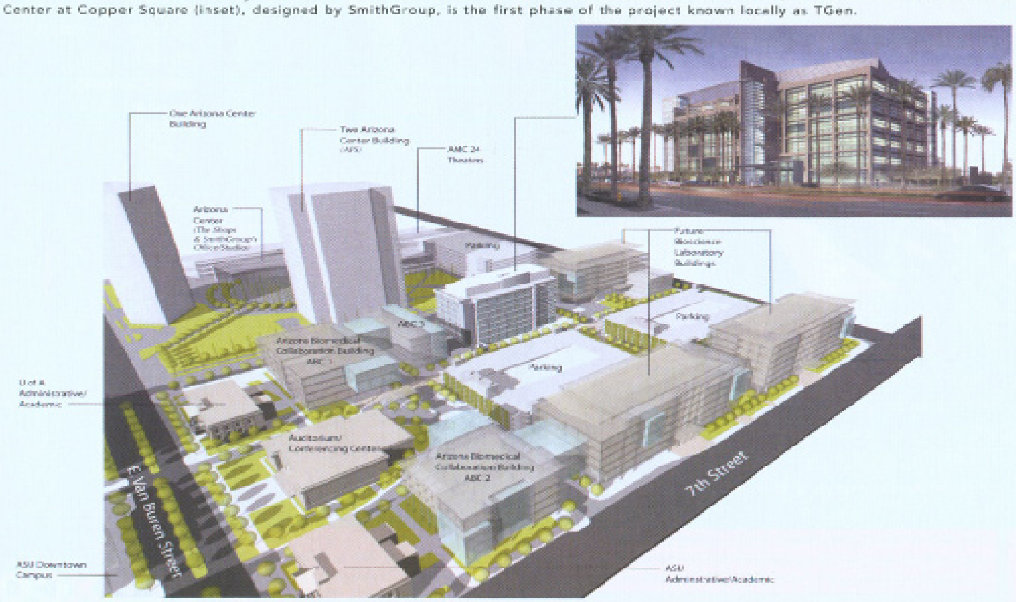
Architects expect demand for such spaces to continue to grow—a study by one design-builder, Rochester, New York–based Sear-Brown, shows that the global biopharmaceutical industry could expand by 60 percent in five years—and many firms are betting their marketing budgets on it. Plus, there's the nanotechnology wild card: This emerging field of microscopic materials and machines has been catapulted by huge research grants and fast-flowing venture capital. (And late last year, the Nanotechnology Research and Development Act earmarked $3.7 billion for research and another $710 million for use across ten federal agencies in 2004 as part of the National Nanotechnology Initiative—an increase of $100 million over 2003.) Not surprisingly, many developers of biotech properties have quietly begun angling for their claim on this market, working with universities and government agencies on their nanotech building needs.

Whether for bio or nano, expensive and highly engineered research laboratories are the focal point of the projects (see "Labs, Under the Microscope," page 26). But the demands on nanotechnology facilities are stricter, with unique requirements for controlling contamination, vibration, and electromagnetic interference, says Michael O'Halloran, director of technology with Portland, Oregon–based Industrial Design & Construction, a unit of CH2M-Hill. The needs of generic biotech lab spaces are a known quantity—mainly robust HVAC and electrical systems—and thus easier for developers to build speculatively. "Still, that's why the choice of engineer is even more important for us than the choice of architect," says Lyme Properties' Winny. "We have a very strong preference for engineers."

Architects active in biotech tend to have tight alliances with M/E/P firms or, in many cases, staff engineers, but they are unlikely to admit that the architecture is secondary. "There's no question that the mechanical engineering is incredibly important, but no one sees the ductwork," says Tsoi. "They see how light comes in, how convenient the equipment layout is, how scientists can interact in halls. We hear that most breakthroughs are the result of specialists that come together and collaboratively attack a challenge." No-nonsense biotech leaders are hard to impress, however, even when the budget is large. "While we're interested in creating beautiful environments; our architecture tends to be relatively utilitarian," says Keith McKeown, a spokesperson for The Scripps Research Institute, which is located a stone's throw from Louis I. Kahn's Salk Institute (1965) and the Neurosciences Institute (1995) by Tod Williams and Billie Tsien, a project funded in part by Scripps.

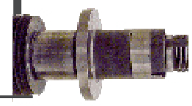
"We're looking for architects with experience in biotechnology and biomedical research," adds McKeown. "We're not necessarily looking for cutting-edge design."

In some places, the stakes are high for attracting commercial biotech business. The city of Phoenix, which experts say has almost no biotech activity, has pinned its hopes on its recently announced Translational Genomics Research Institute, a huge development that used $150 million in seed money to draw the International Genomics Consortium to the location. The $46 million Phoenix Bioscience Center at Copper Square (inset), designed by SmithGroup, is the first phase of the project known locally as TGen.



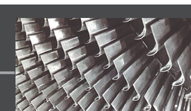
28 03 | 2003

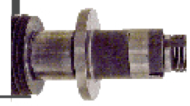
Sullivan, C.C. (2003, March). For The Biotech Industry, Place Matters. Architectural Record, 25-28.



PROCESS

Evolution of design response, conceptual work, and decision making process.





R221. PROCESS

1. Concept

CONCEPTUAL
DESIGN

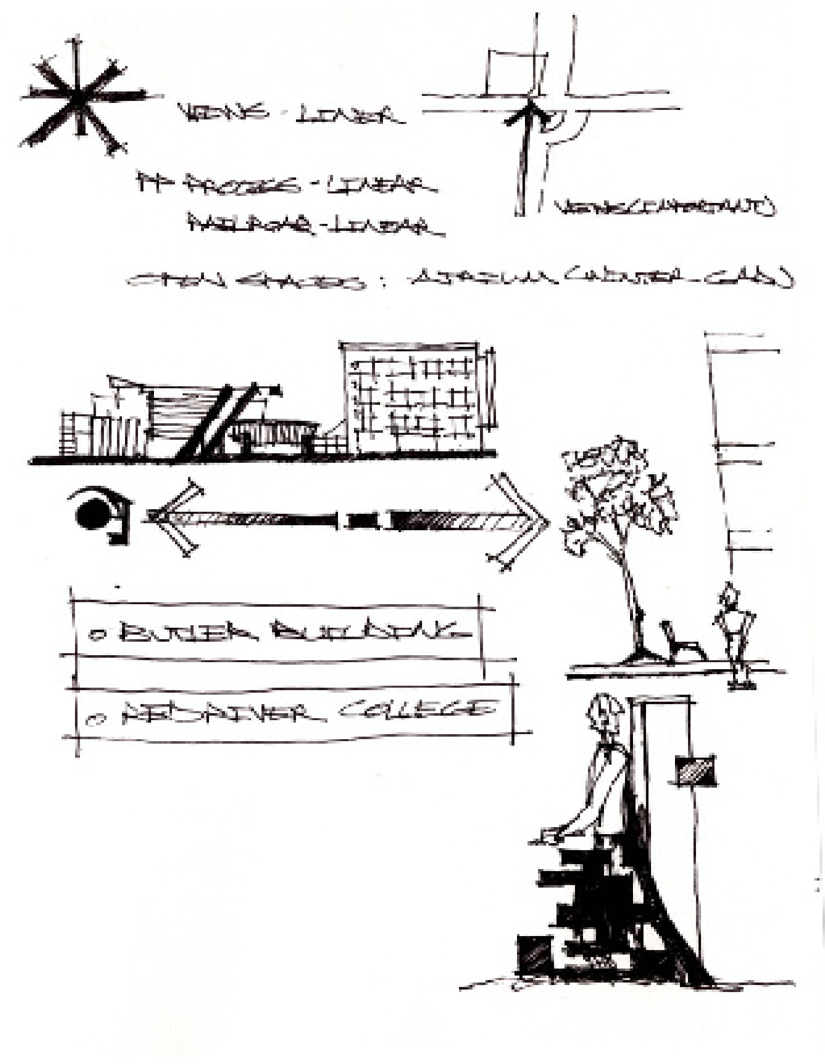
COAL STORAGE/ HANDLING
CONVEYER SYSTEM
BOILER
WATER
REACTION - PRODUCING STEAM
TURBINE
PRODUCTION OF ELECTRICITY

STUDENTS = COAL (MAIN COMPONENT)
NDSU DOWNTOWN = COAL STORAGE
FACULTY = CONVEYER SYSTEM (MEANS OF COAL SUPPLY)
ART DEPARTMENT - ADDITIVES TO COAL
ARCHITECTURE = BOILER WHERE THE REACTION HAPPENS
TURBINE = COLABORATION

PRODUCING ELECTRICITY => QUALITY/VALUABLE ARCHITECTURE
STAFF/PUBLIC = POWER LINES SUPPLYING WORLD WITH "ELECTRICITY"
IMAGINATION = WATER (REUSABLE)

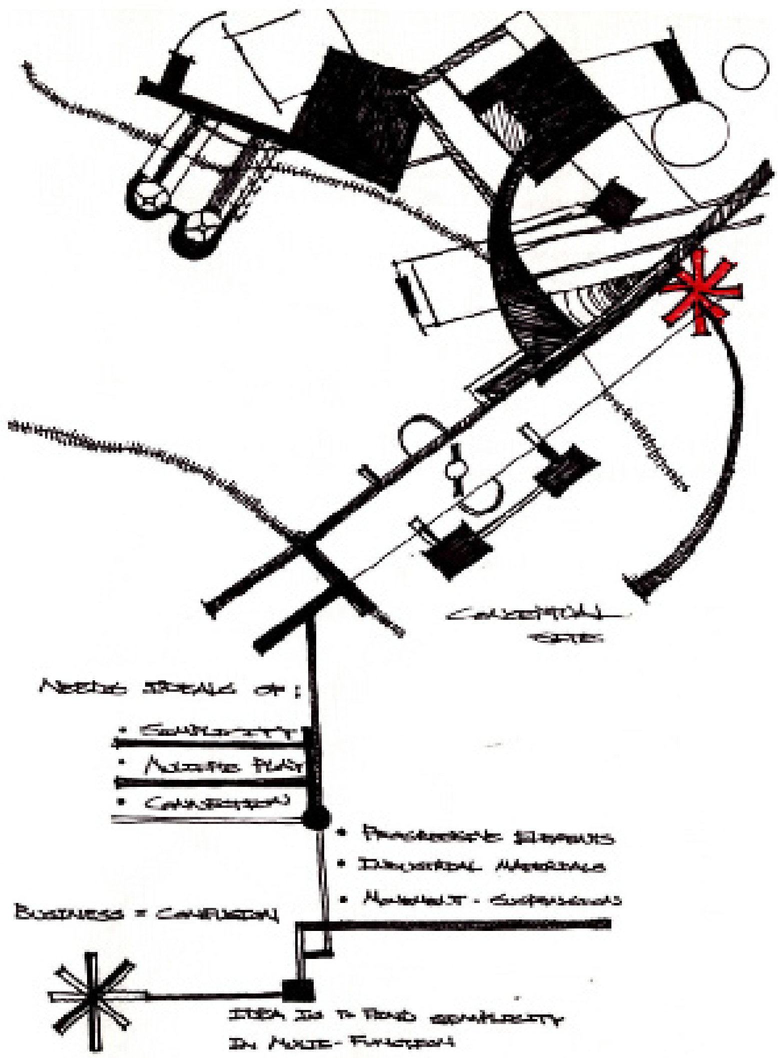
R222. PROCESS

1. Concept

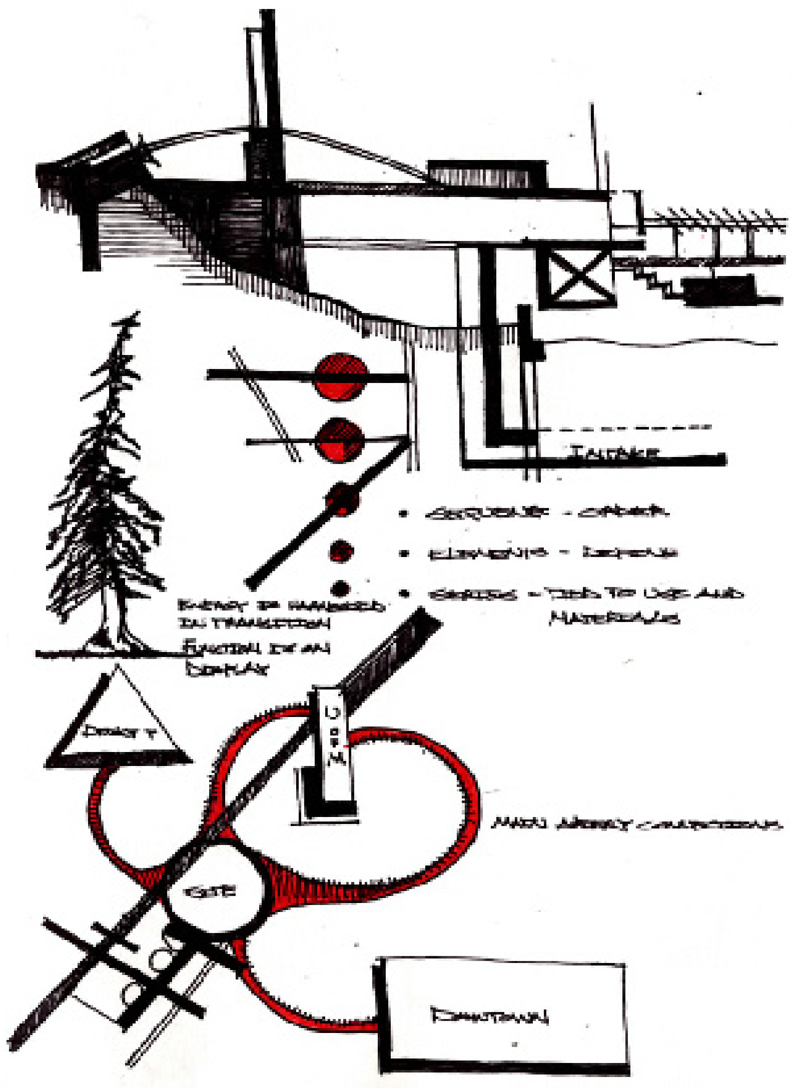


R223. PROCESS

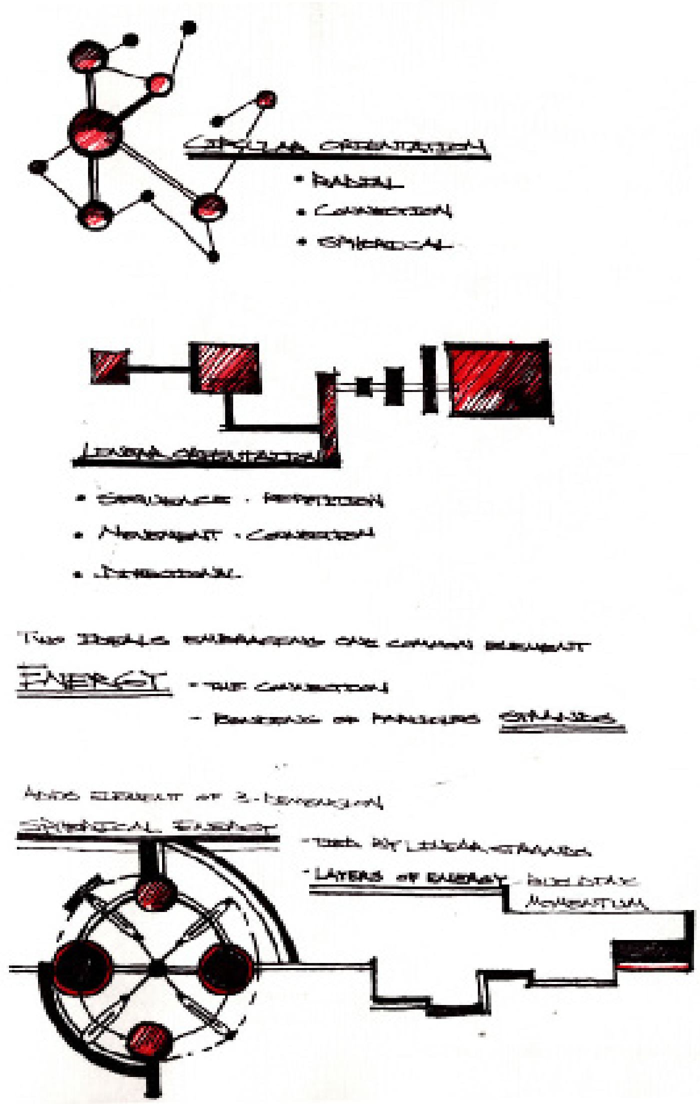
1. Concept



1. Concept

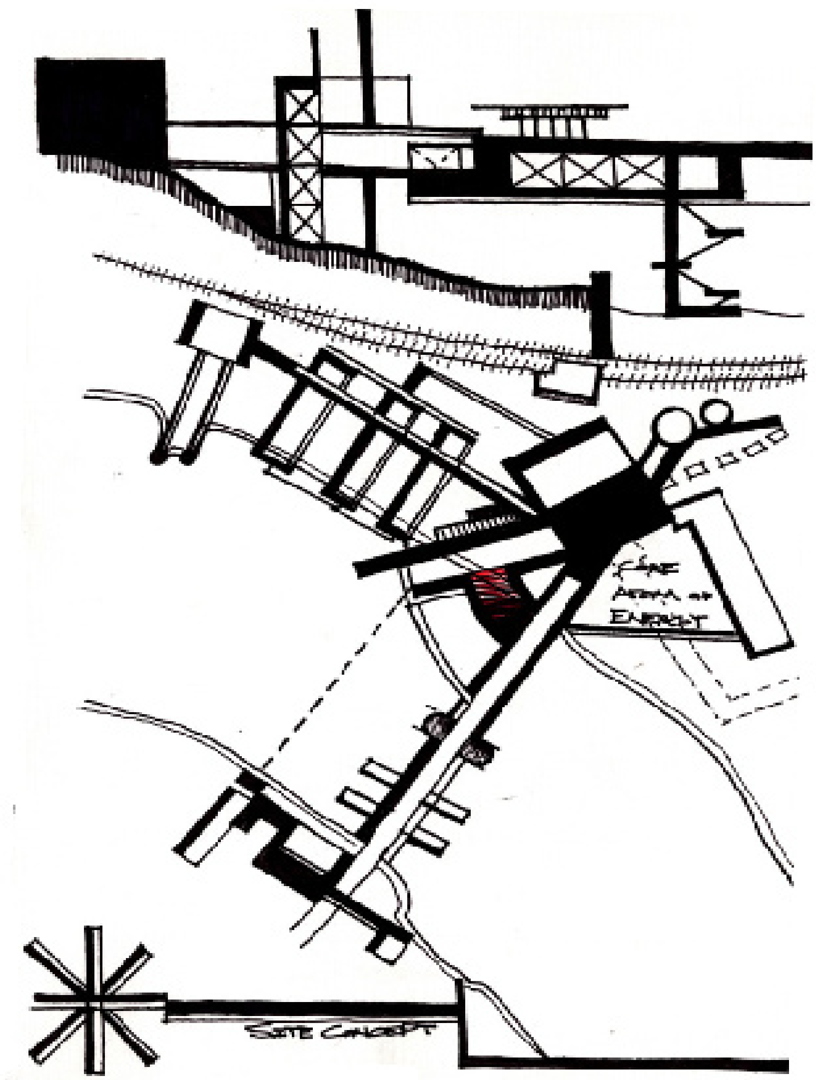


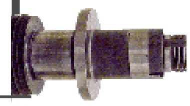
1. Concept


CIRCULAR ORIENTATION
• RADIAL
• CONNECTION
• SPHERICAL
LINEAR ORIENTATION
• DIRECTIONAL
ENERGY
- THE CONNECTION
SPHERICAL ENERGY
LAYERS OF ENERGY
MOMENTUM

R226. PROCESS

1. Concept





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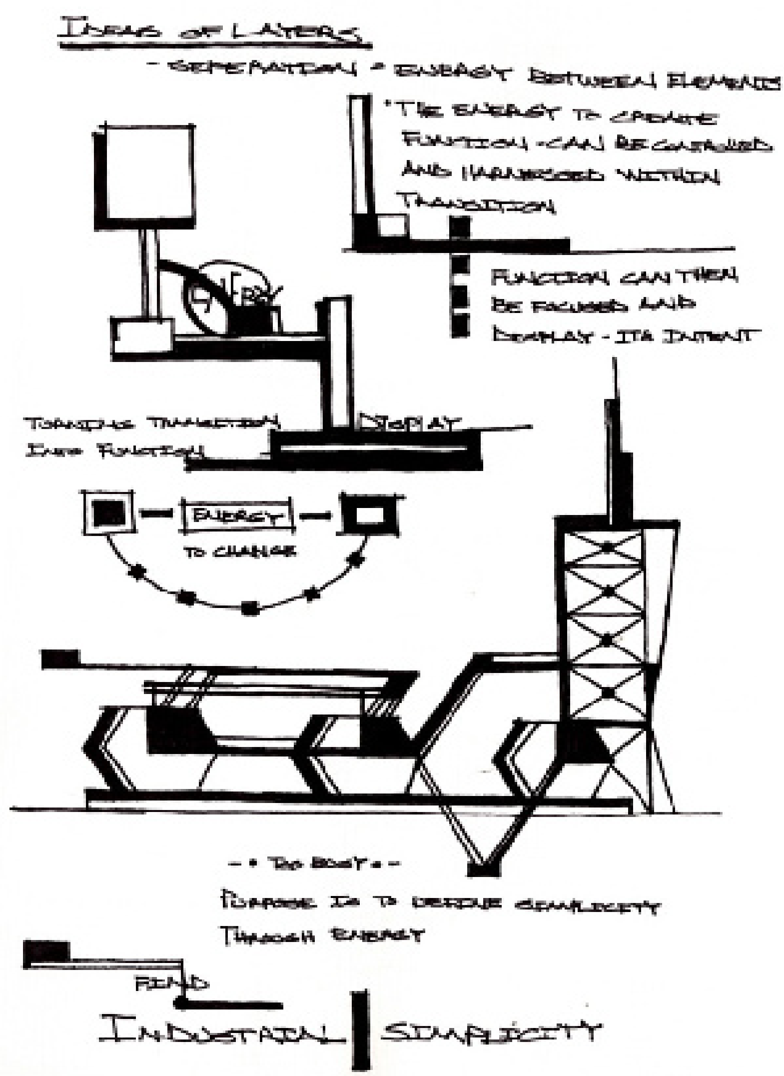

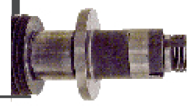

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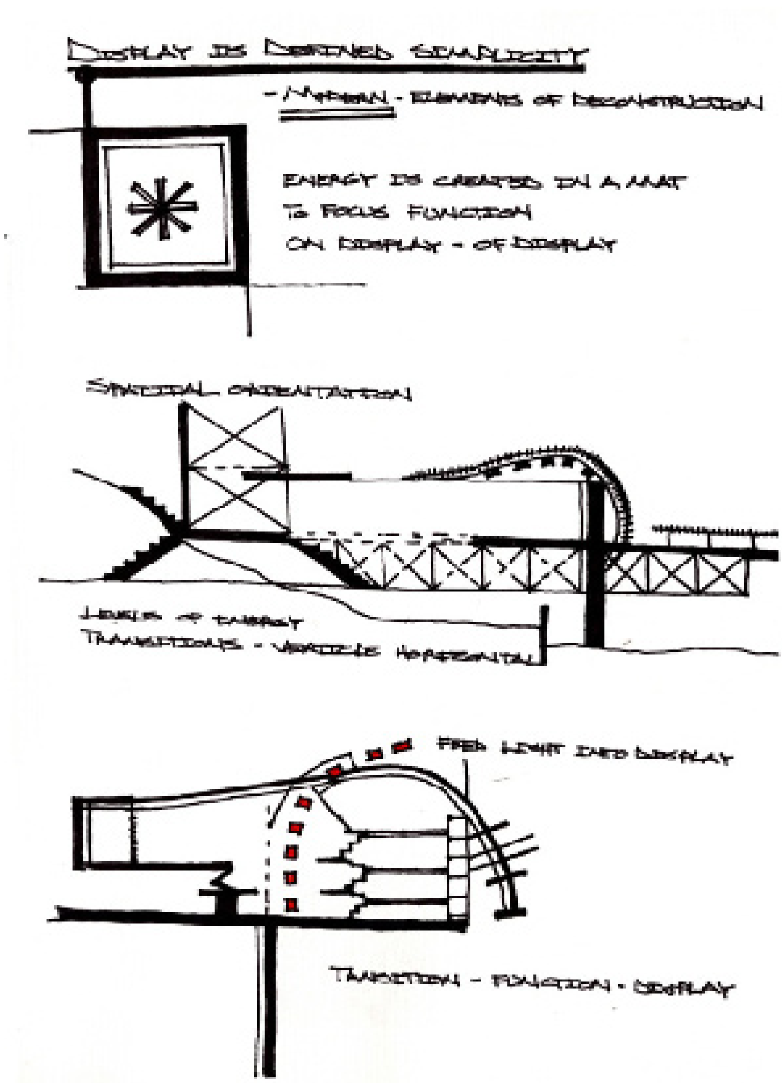

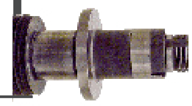

R229. PROCESS

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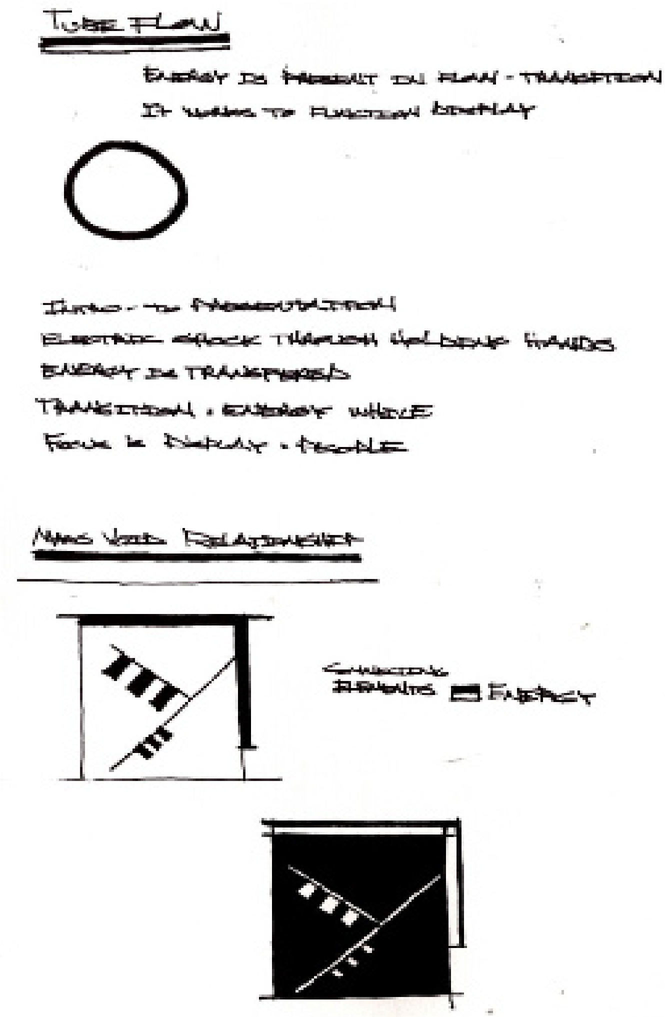
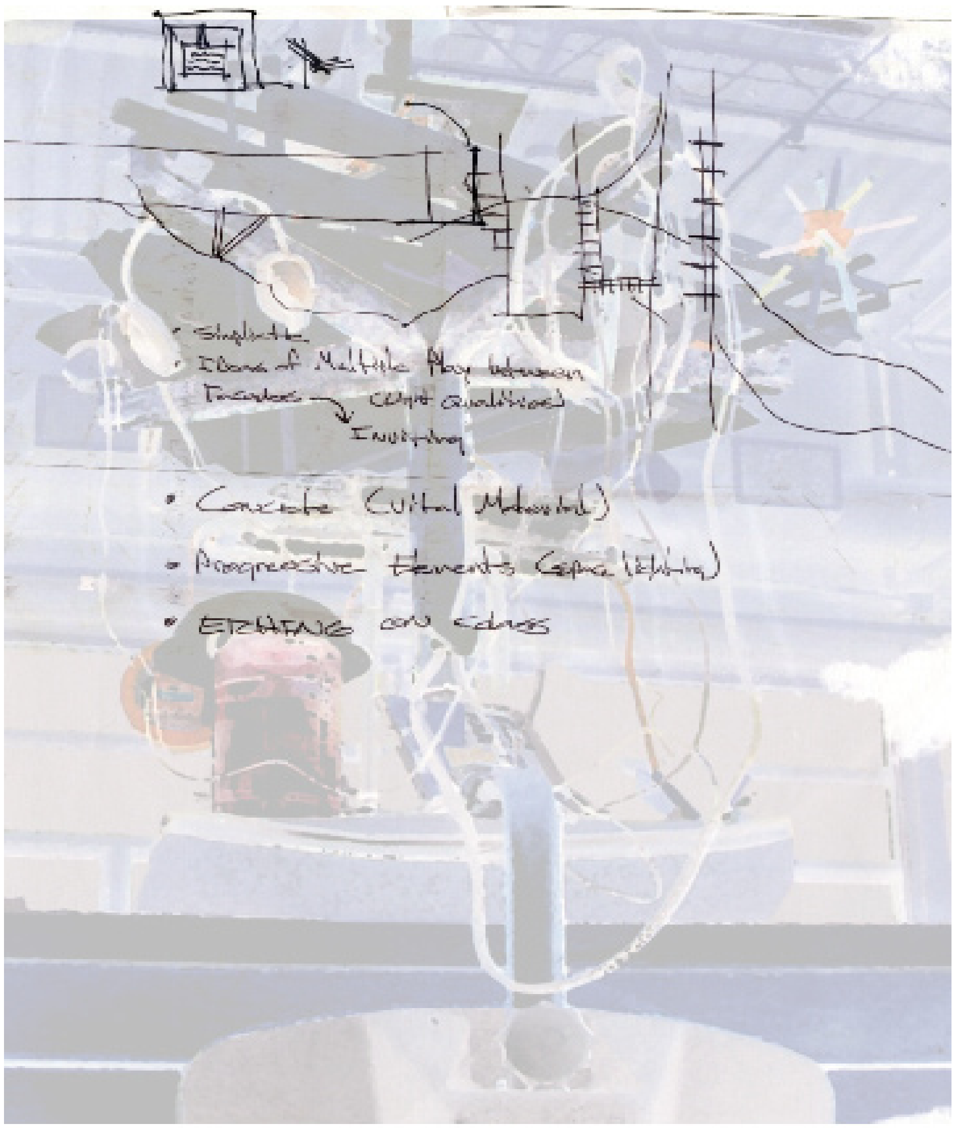


R230. PROCESS

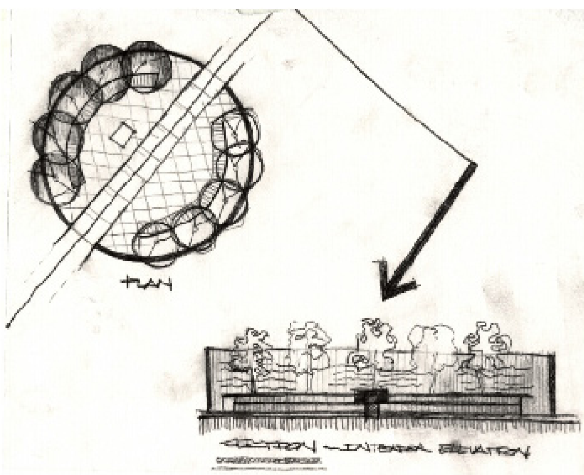
1. Concept

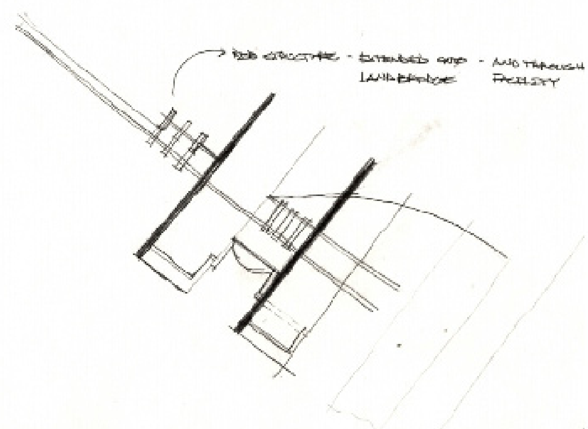
1. Concept



R232. PROCESS

2. Form





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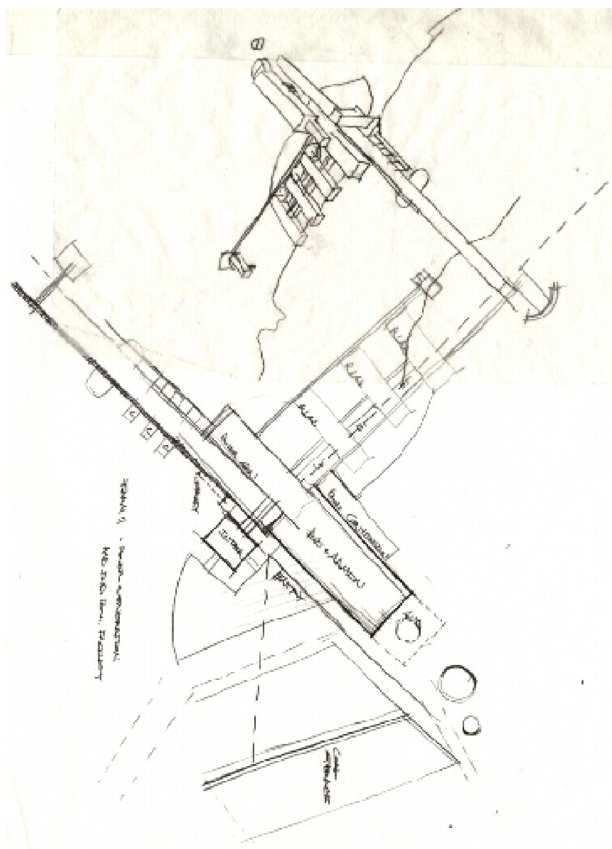

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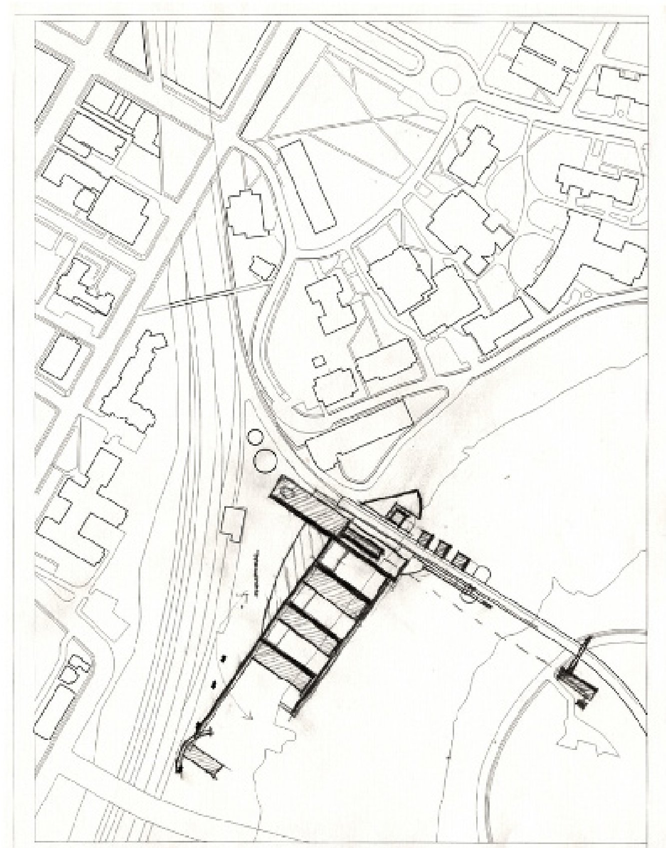

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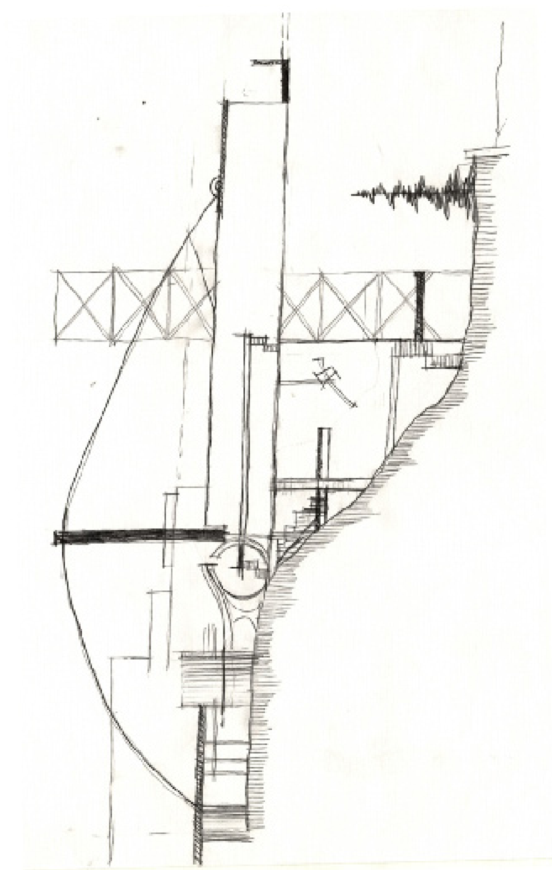

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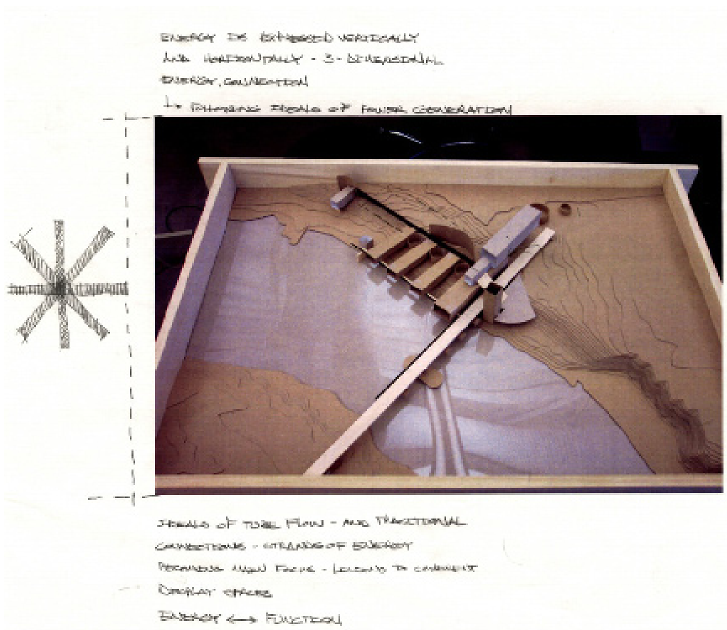
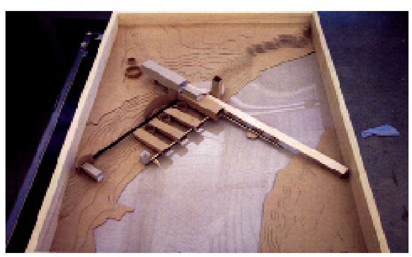
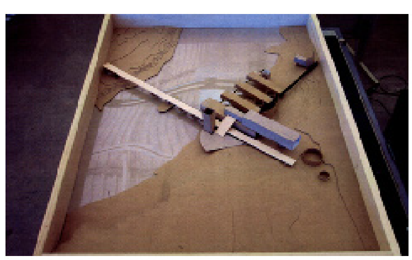

ENERGY IS EXPRESSED VERTICALLY
AND HORIZONTALLY - 3-DIMENSIONAL
ENERGY, CONNECTION
CONNECTIONS - STRANDS OF ENERGY
DISPLAY SPACE
ENERGY ↔ FUNCTION





R237. PROCESS

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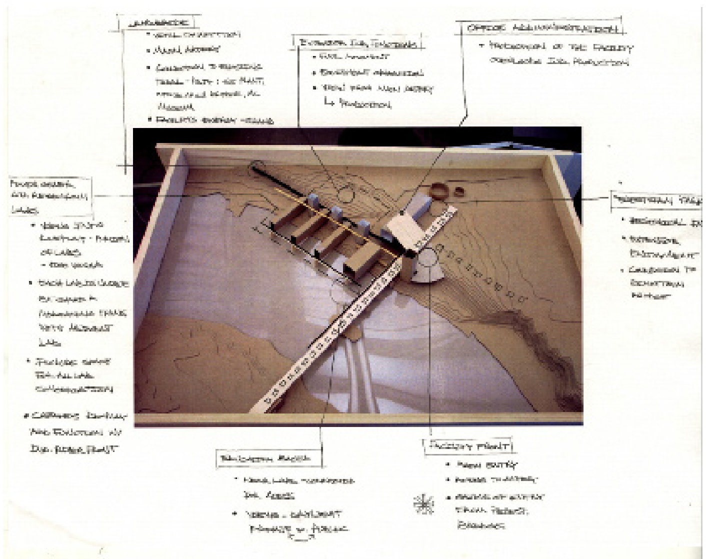

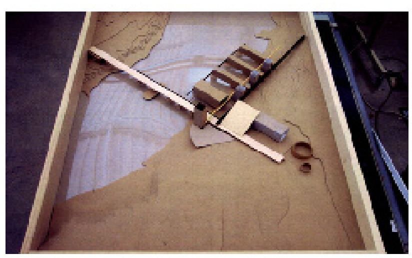

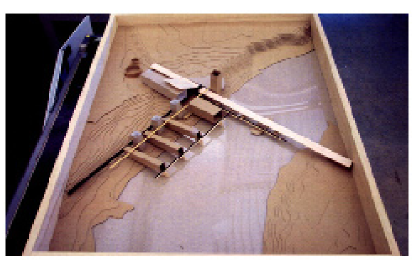

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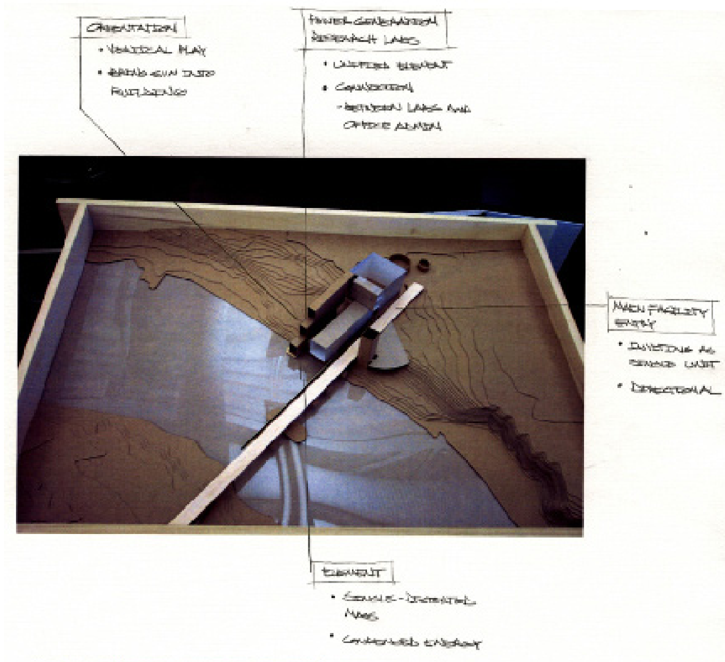
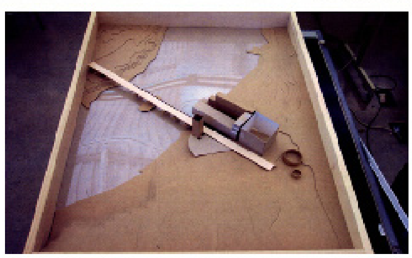
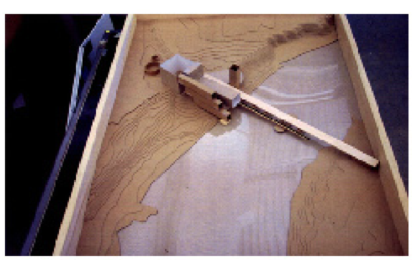

ORIENTATION
VERTICAL PLAY
POWER GENERATION RESEARCH LABS
CONNECTION
OFFICE ADMIN
MAIN FACILITY ENTRY
DIRECTIONAL





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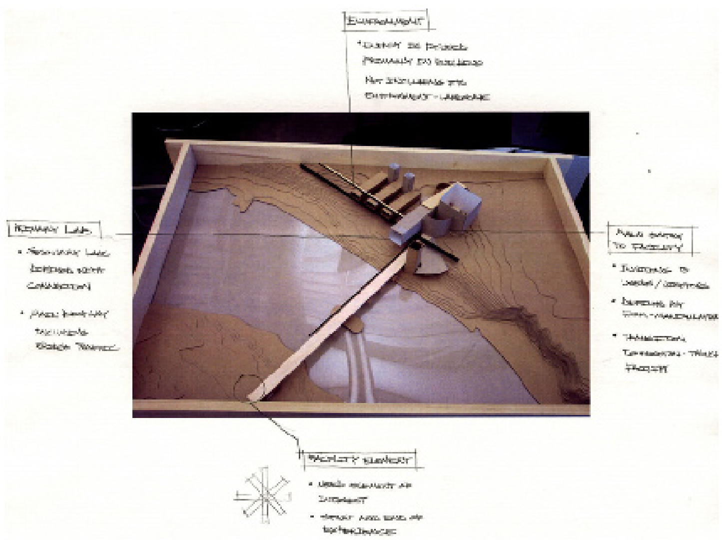
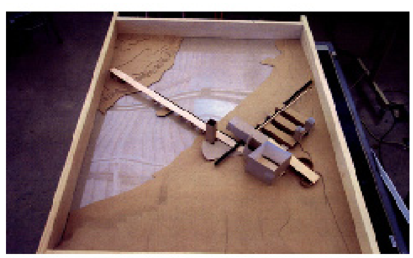
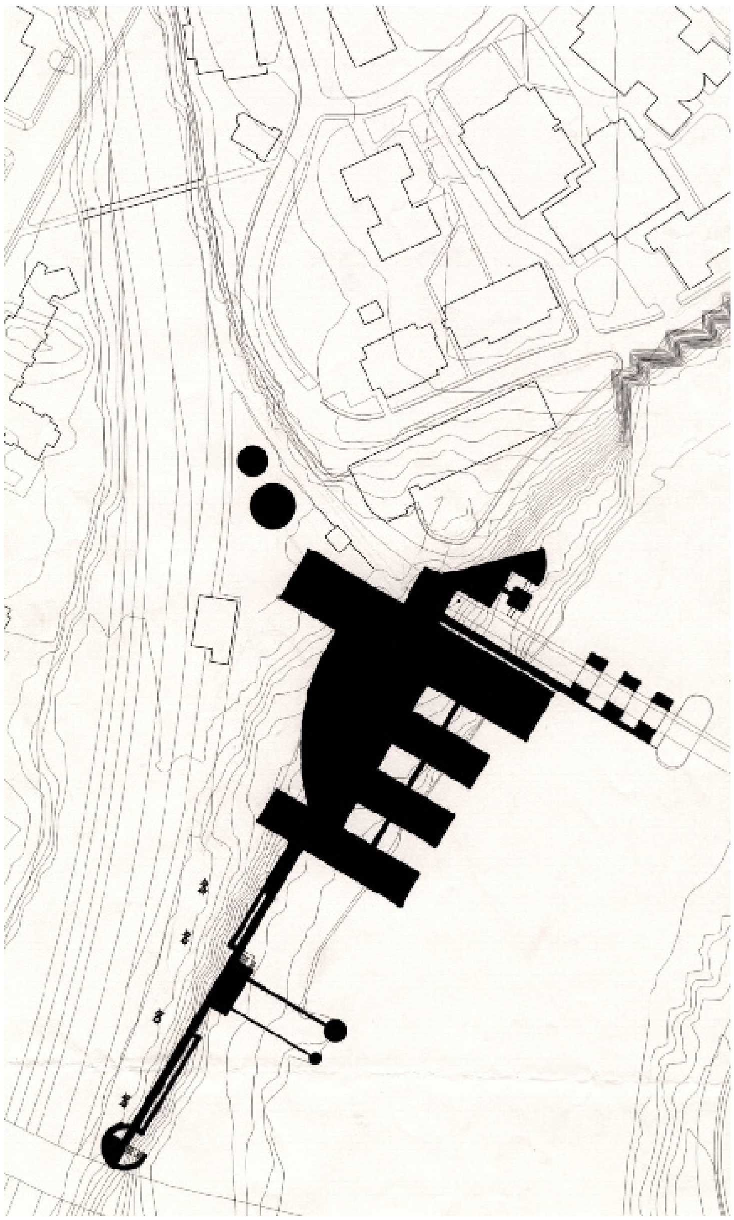
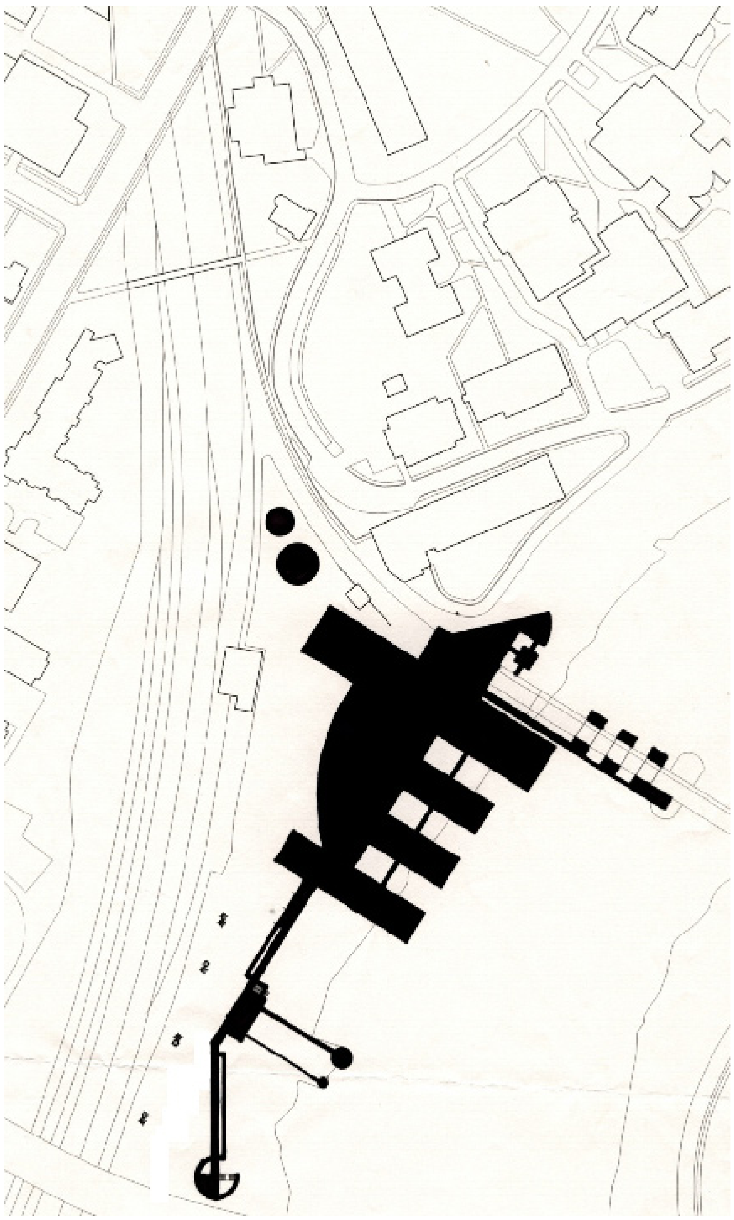

ENVIRONMENT
PRIMARY LINE
MAIN ENTRY TO FACILITY
FACILITY ELEMENT



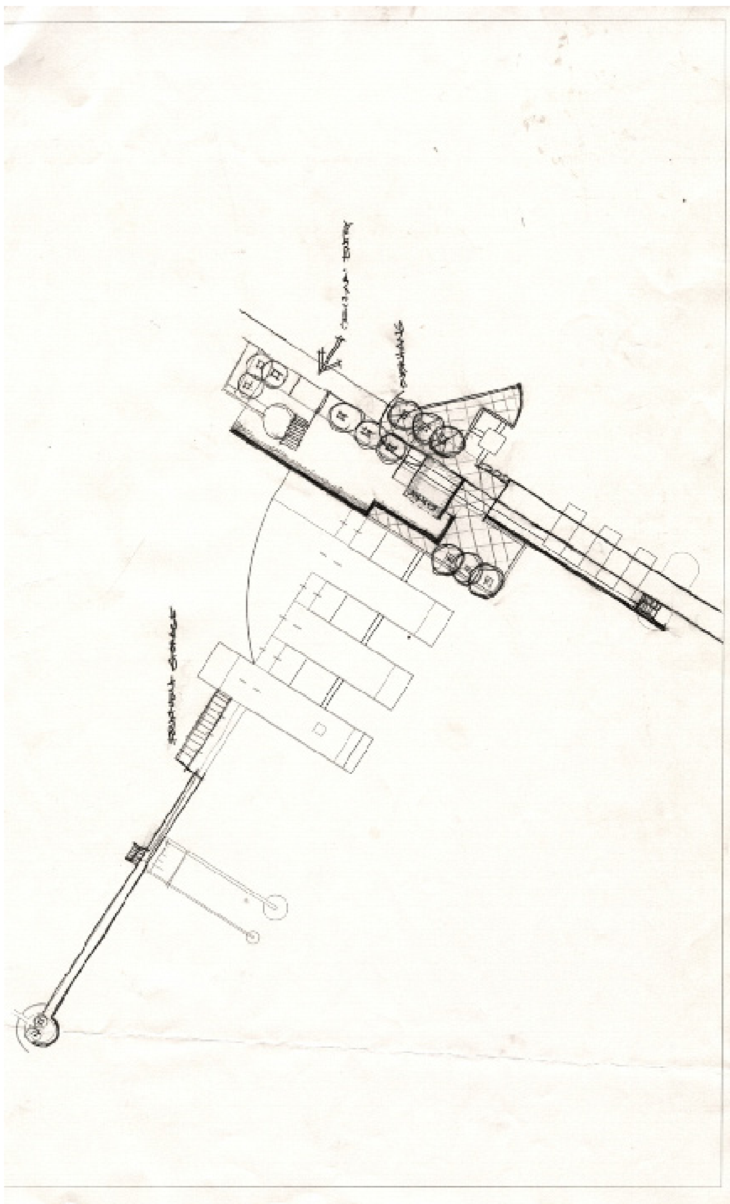
3. Function



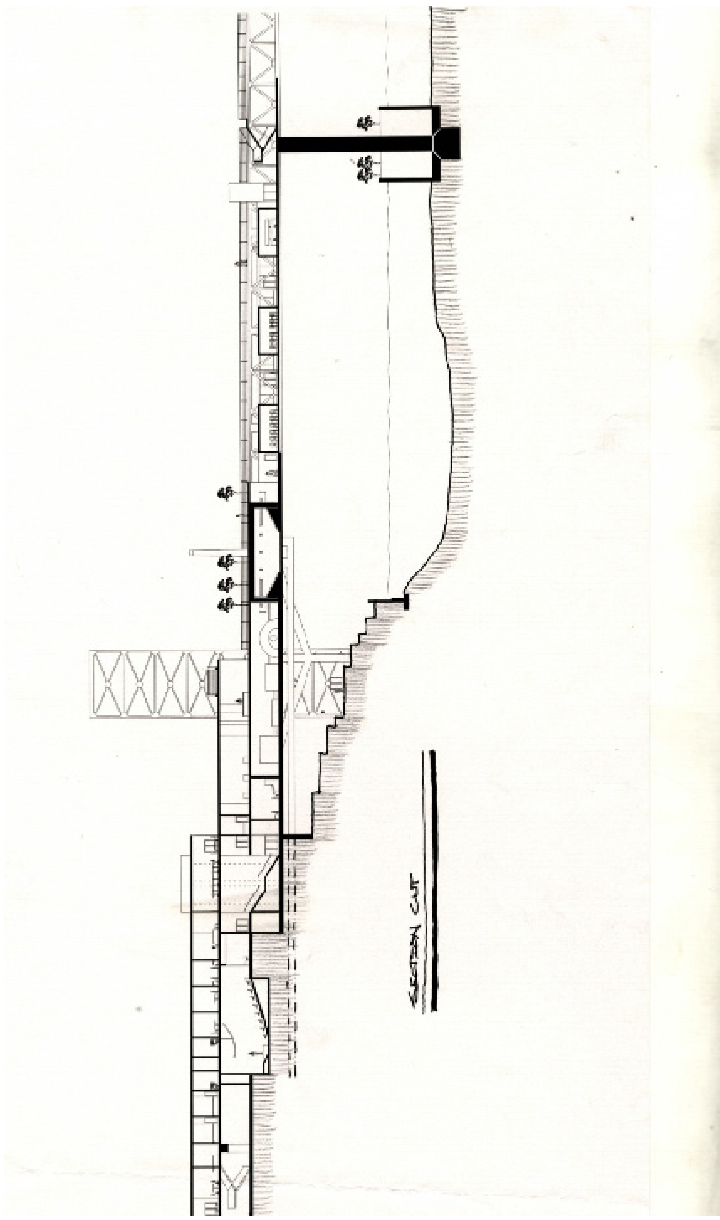
3. Function



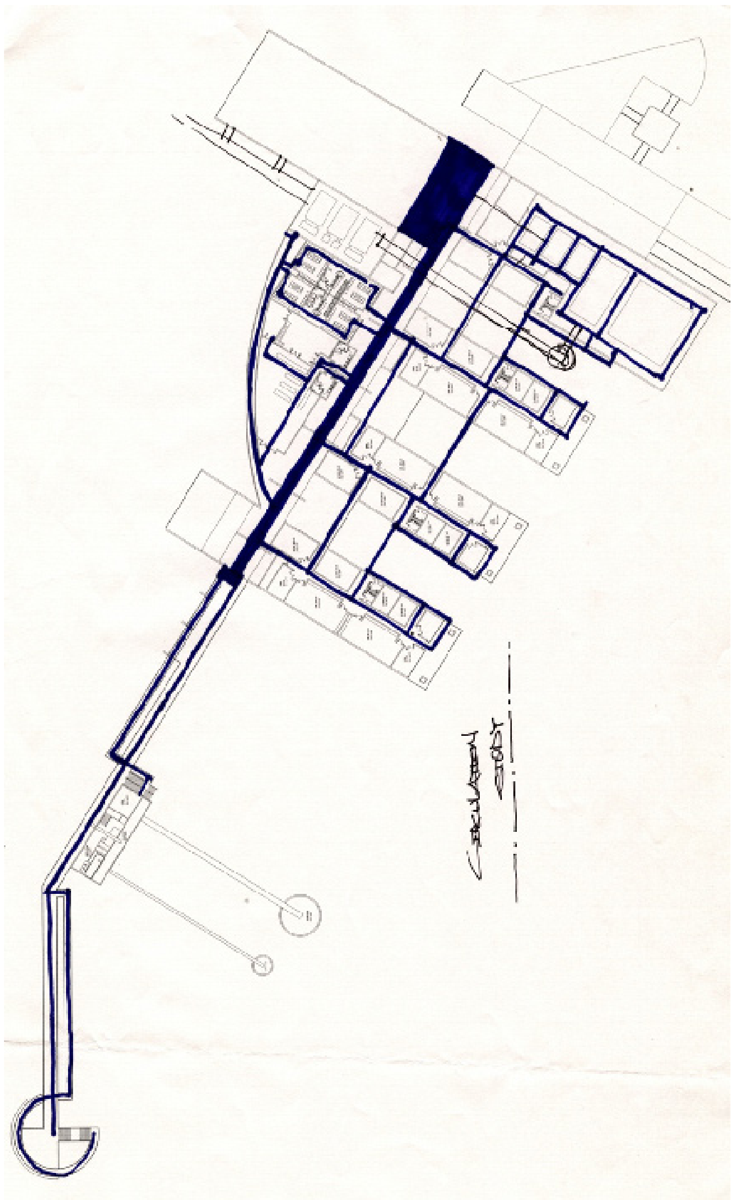
3. Function



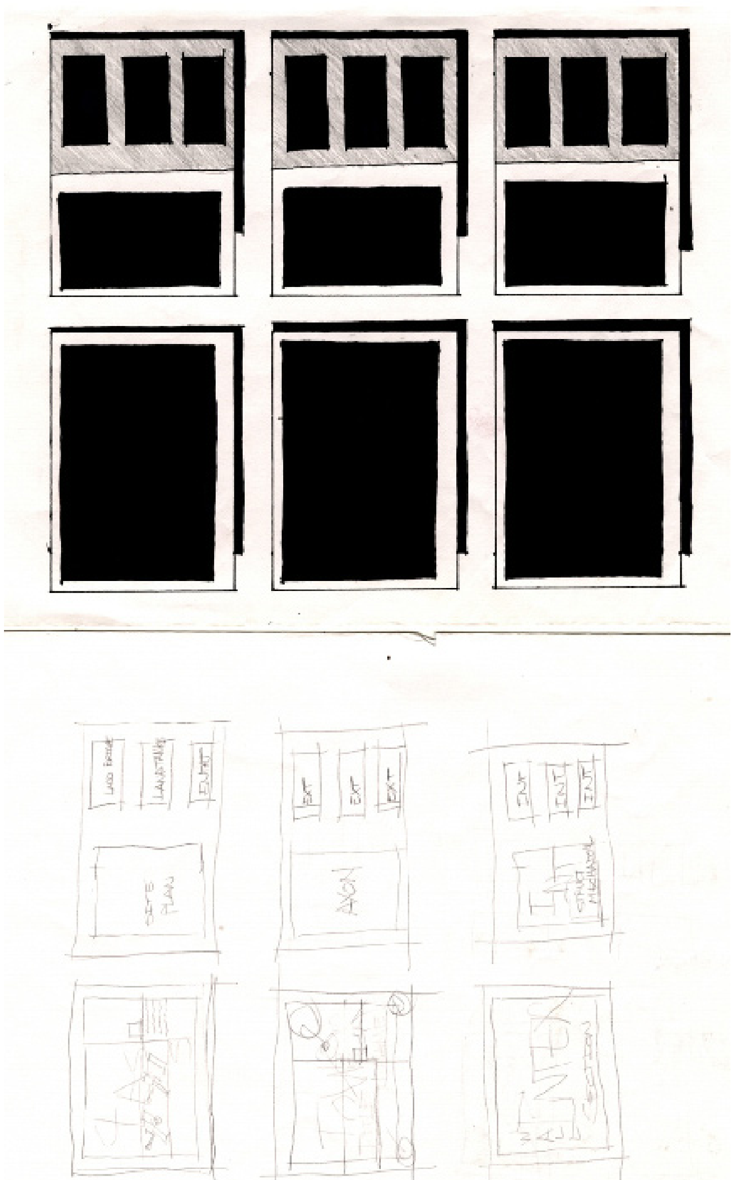
3. Function

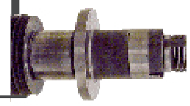


3. Function



3. Function





DESIGN THESIS

Design solution presentation and model.

IDENTIFICATION

Andrew Evan Koedam

You go to school, study architecture, you get a master's degree, and you wind up being famous for plastic glasses.

DIGITAL FORMAT

CD including - Thesis Program
Thesis Presentation
Animation