

Grid Structure And Space

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May 10, 1999

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Thesis submitted to the faculty of Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Architecture

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“You employ stone, wood and concrete, and with these materials you build house and palaces. That is construction. Ingenuity is at work.

But suddenly, you touch my heart, you do me good. I am happy and I say: 'This is beautiful.' That is architecture. Art enters in.”

Le Corbusier
Towards a New Architecture
1927

To my wife, Su-Jen Pamela Chung,
my Parents ,Shen-Yo Sung and Mei-o Peng,
my Parents-in-law, Tien-Sung Chung and Hsueh-Chih Tseng
and other family members
for their unconditional support and love.
To my daughter, Claire, born two weeks after my defense. I believe that she brings me good luck.

Many thanks to Michael O'Brien for his guidance and help in many ways since I have studied in Virginia Tech; to William Brown for his support and trust;
to Heinrich Schnoedt for his patience and enlightenment; to William Galloway for his encouragement and wonderful discussion.
In addition, many thanks to all my classmates studying in "*March 12*" studio for their friendship.



GRID STRUCTURE AND SPACE

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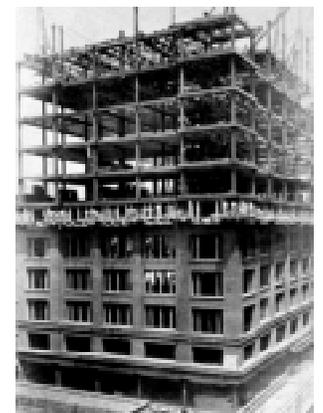
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A. Abstract

From the ancient times, people used various kinds of natural material to build architecture. Because of the characteristics of natural materials, there are many limits to challenge the possibility of the architectural structure.

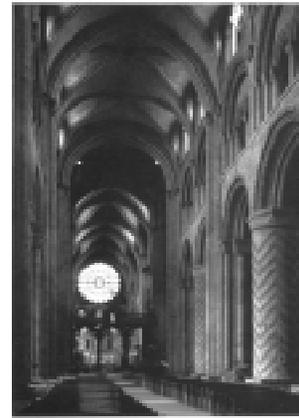
After the fire of 1871 in Chicago, there were many incentives to convince Chicago architects to use steel as the material in grid structure buildings. For example, rising real estate prices, the advent of the safety elevator and availability of cost effective steel members. After that, grid structures play a very important role in modern architectural history.



Now, construction technologies are improving and hundreds of structure types can be used. Architects have more power to build various kinds of amazing space. For instance, TWA terminal of J.F.K. International Airport. However, the grid structure still has several advantages that can not be substituted: (1) It costs less money due to repetition of components across similar bays. (2) It reduces the construction time, and (3) It possesses an inherent order, a good prerequisite for plan and section. In addition, new technology extends the span limits of grid structures. Thus, grid structures have more chances to take on different roles in the definition of space.



*Parthenon, Acropolis,
Athens 447-432BC*



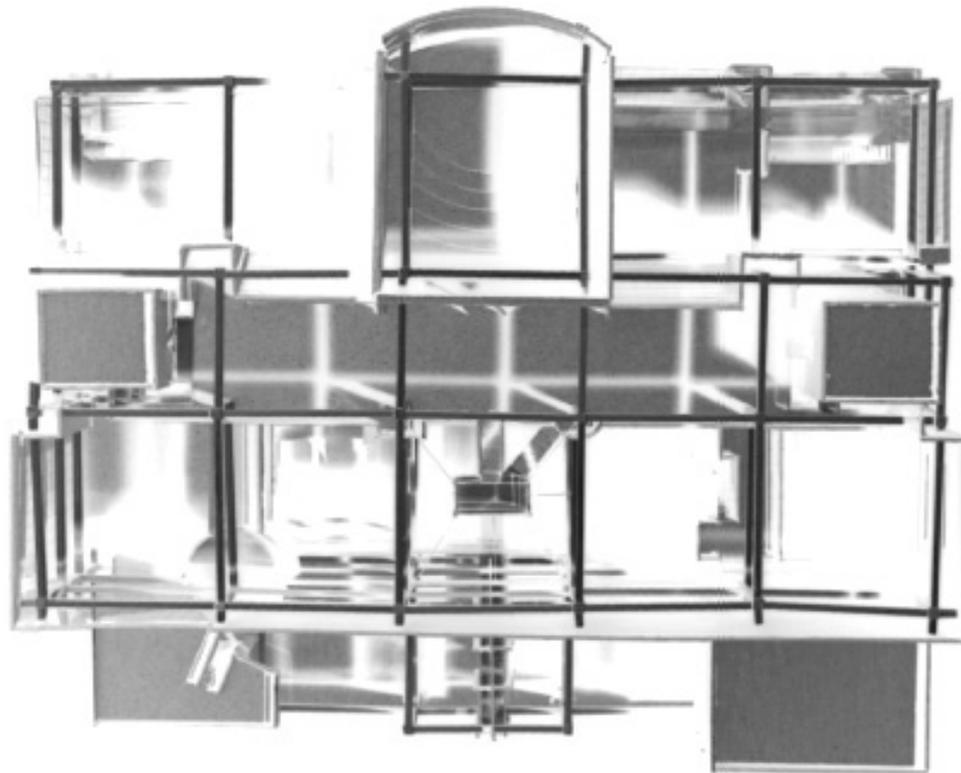
*Durham Cathedral,
Nave 1110-53*



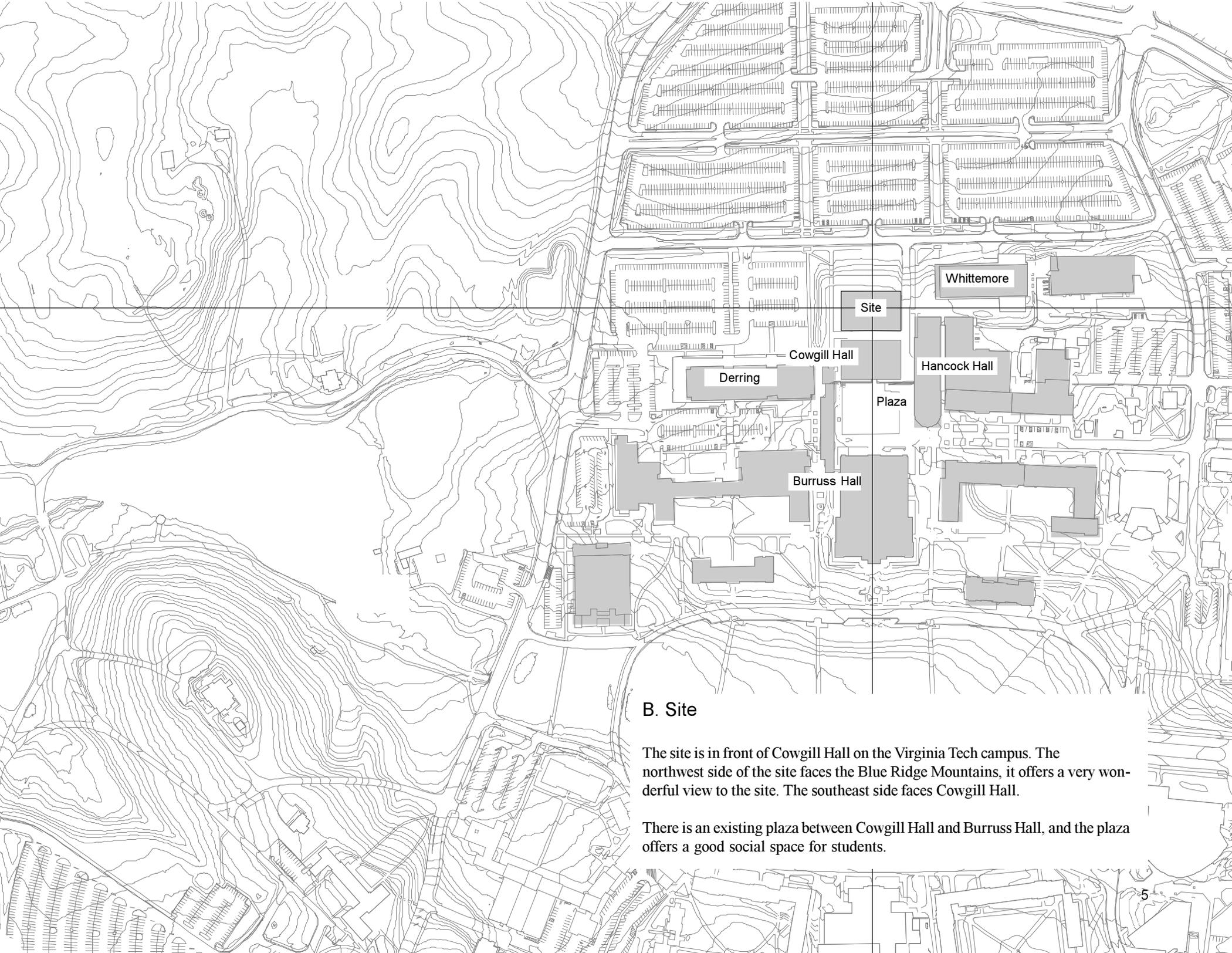
*Marquette Building,
Chicago 1895*



*TWA terminal, J.F.K. International Airport,
New York 1956-62*



This project is a study of the relations between structural grid and architectural space, and a search for several distinct spaces within the grid. In other words, the concept of the project is setting up a grid structure, then developing spacial ideas according to program. So, we can reserve the spirit of the grid structure, and it offers many chances to us to think about other roles that the grid structure can play.



B. Site

The site is in front of Cowgill Hall on the Virginia Tech campus. The northwest side of the site faces the Blue Ridge Mountains, it offers a very wonderful view to the site. The southeast side faces Cowgill Hall.

There is an existing plaza between Cowgill Hall and Burruss Hall, and the plaza offers a good social space for students.

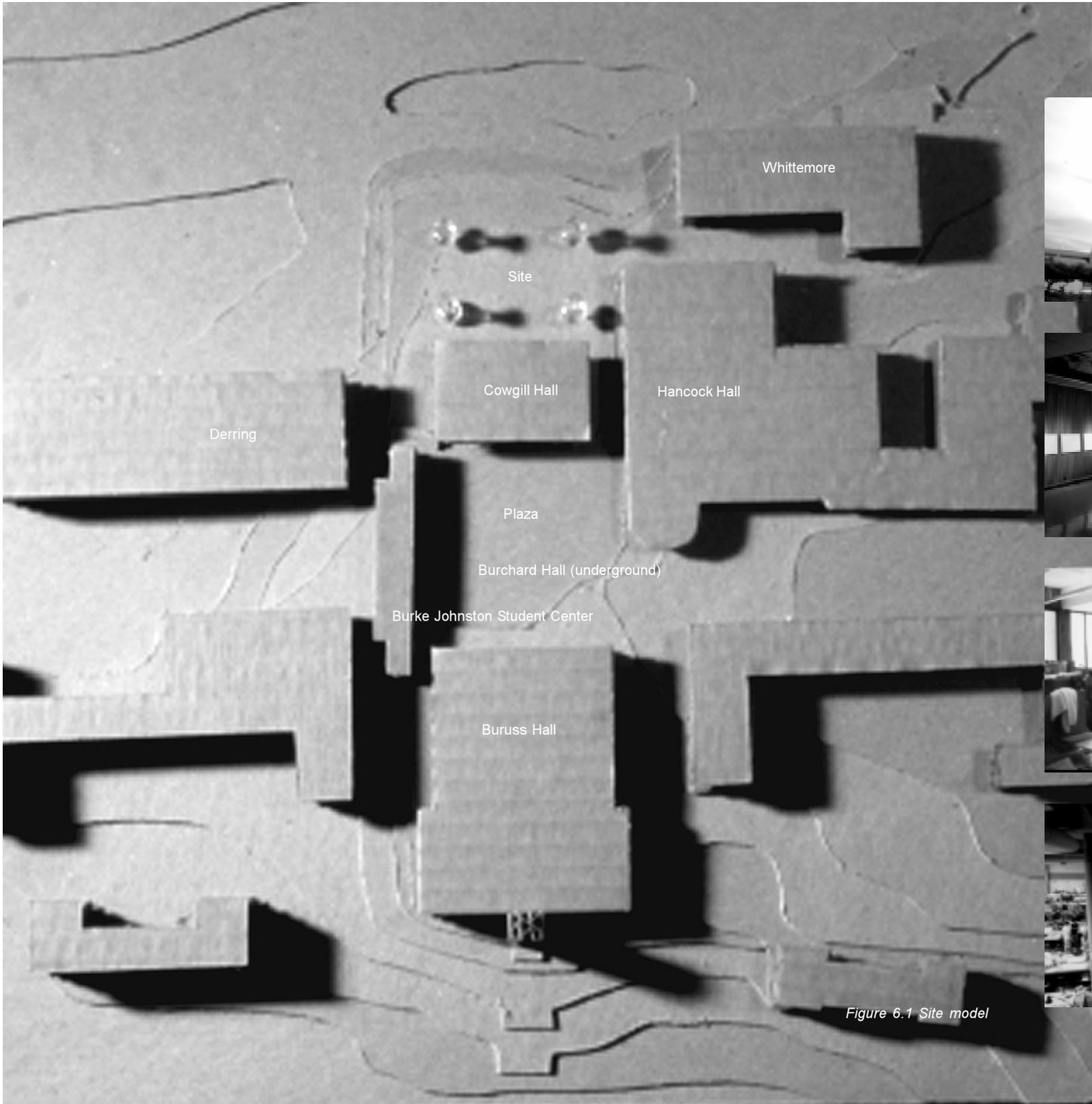


Figure 6.1 Site model



Figure 6.2 Cowgill Hall



Figure 6.3 Exhibition Lobby (Cowgill Hall)



Figure 6.4 Studio (Cowgill Hall)



Figure 6.5 Studio (Burchard Hall)



Figure 7.1 Cowgill Hall And Site



Figure 7.2 Plaza Between Cowgill And Burruss Hall

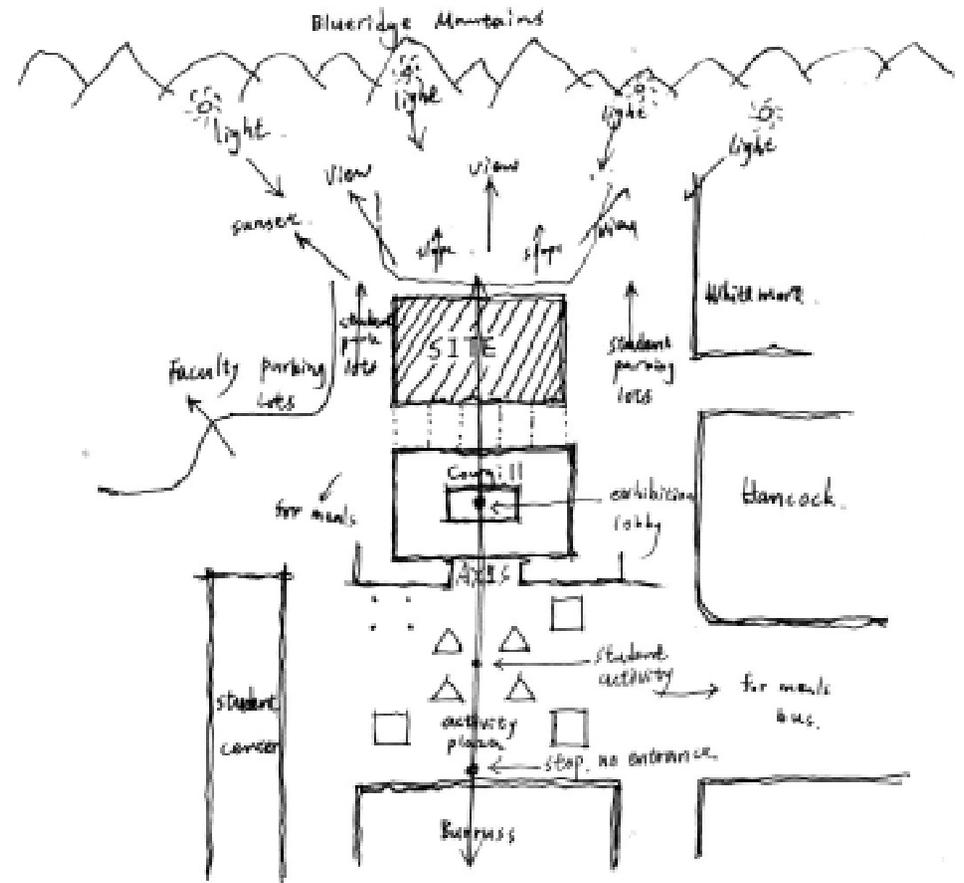


Figure 7.3 Blue Ridge Mountains

C. Program

The program of this project is an addition to Cowgill Hall, to house the graduate program of Architecture Department at Virginia Tech.

The following spaces will be included in this building:

1. Exhibition Area--*Primary exhibition hall and secondary exhibition area*
2. Lecture Room--*For lecture classes and presentation of student work*
3. Library--*For students and faculty.*
4. Discussion Area--*Open space, welcomes others to join the discussion. Students and faculty can easily join or pass by.*
5. Studios--*For graduate students. Many levels in space, not only horizontal but vertical space.*
6. Thesis Defense Room--*The most important space of the building, like a sanctuary.*

D. Master Plan Ideas

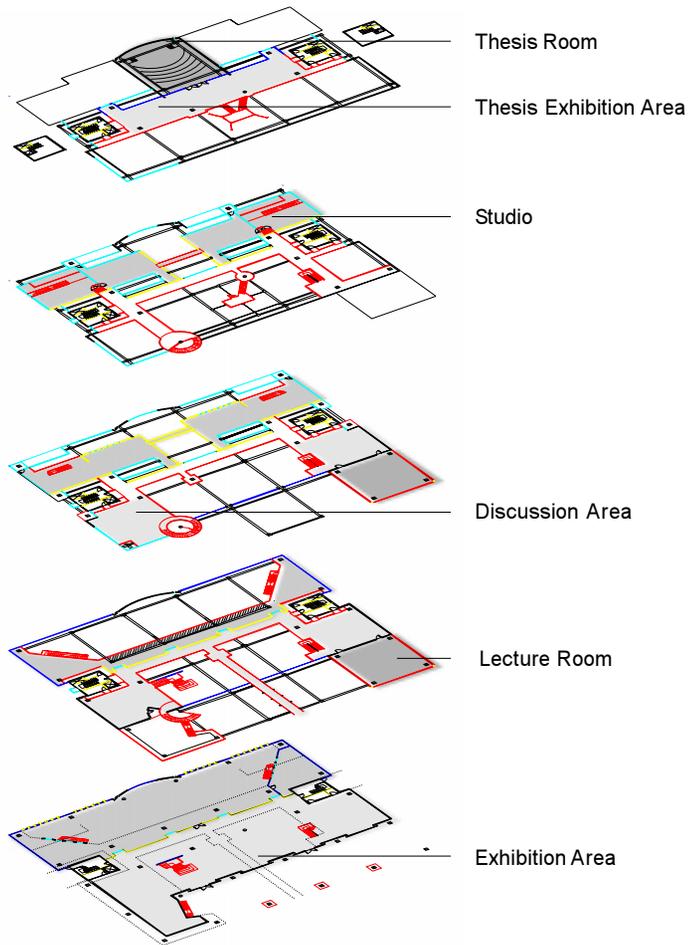


Figure 9.1 Plan Programming

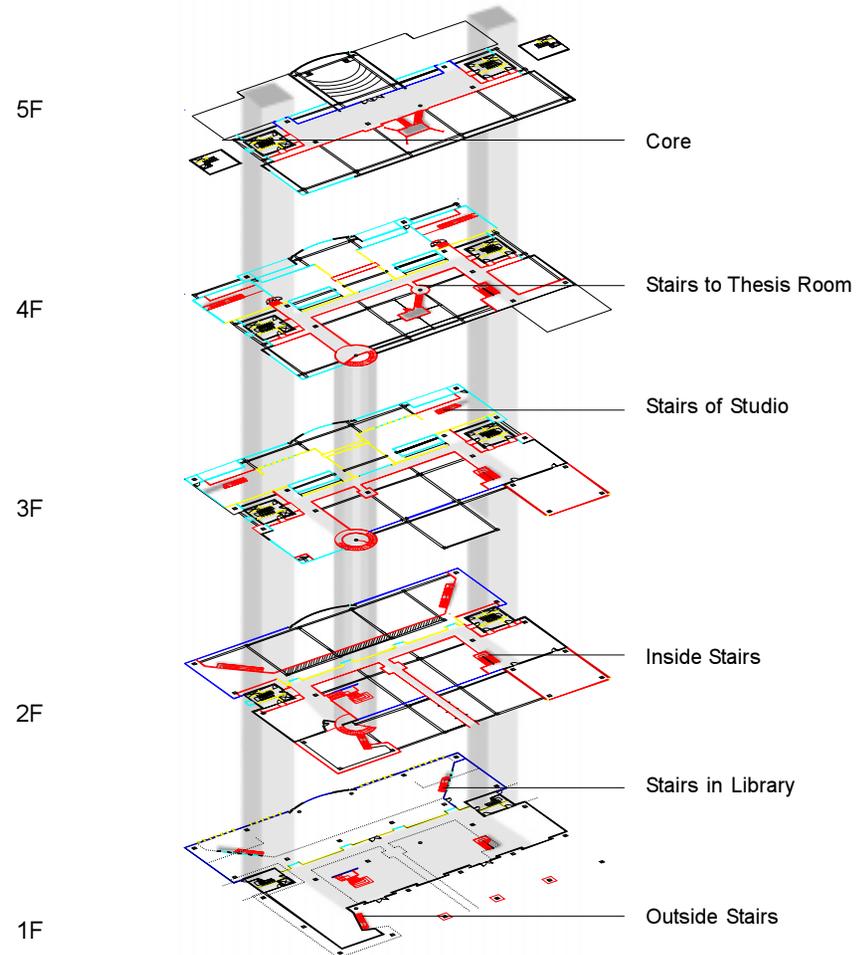


Figure 9.2 The Cores and Circulations

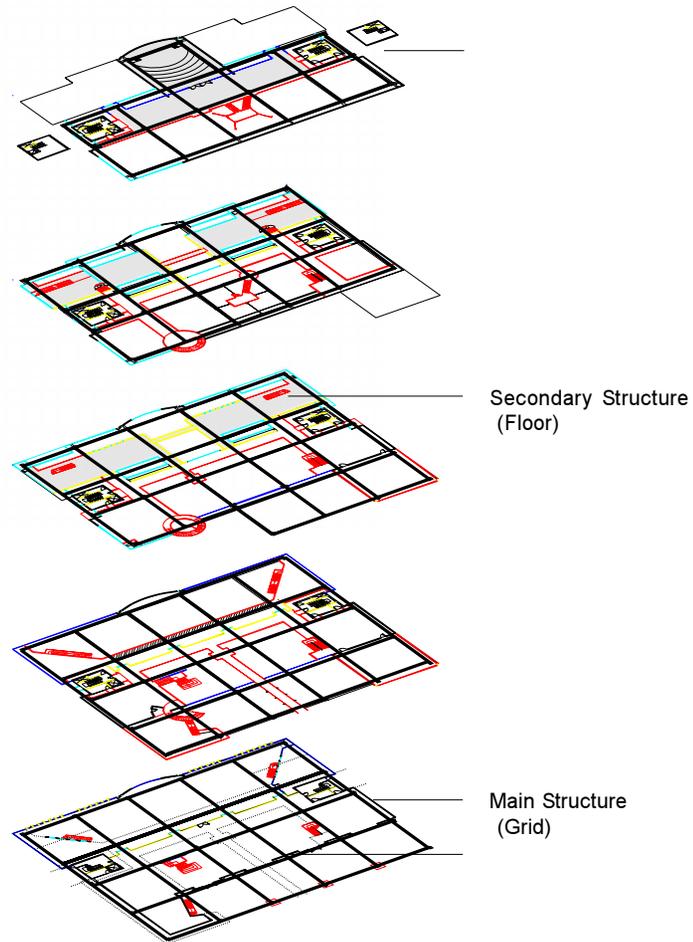


Figure 10.1 Main Structure and Secondary Structure

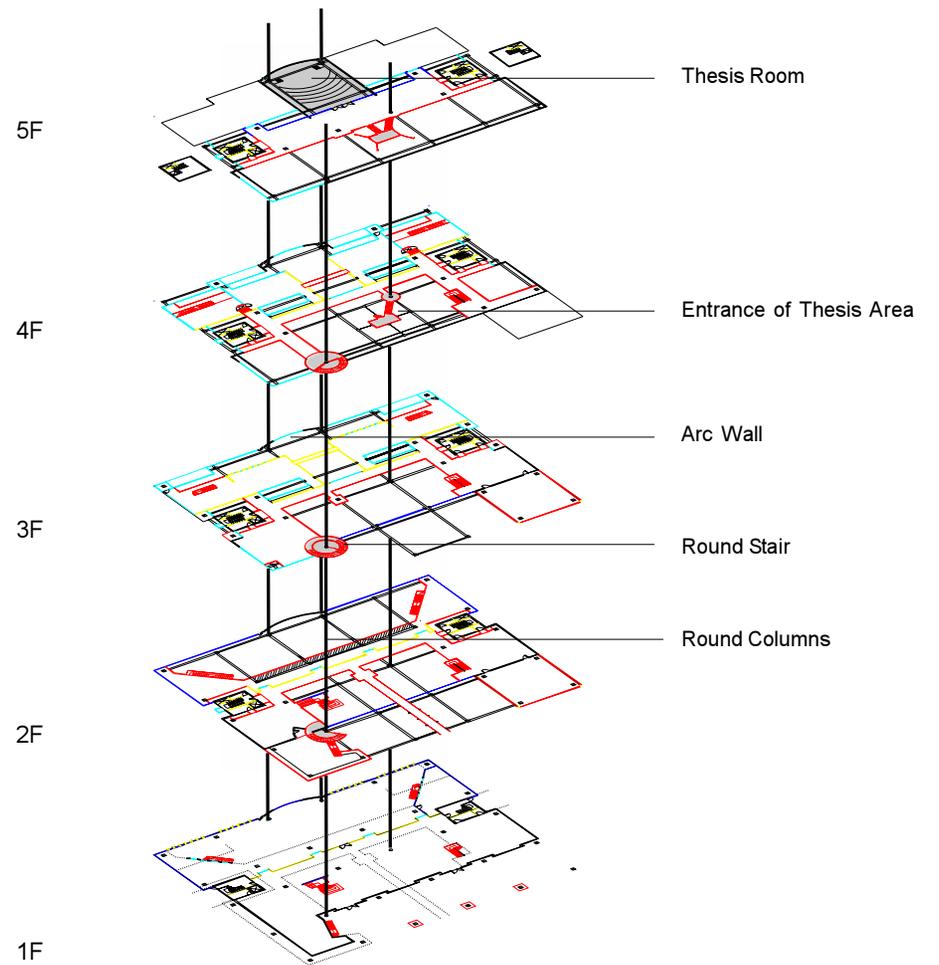


Figure 10.2 Round Columns and Space



Courtyard

Offering
an
interstitial
spatial
experience.

Figure 12.1 Cowgill Hall, the addition and courtyard



Figure 13.1 Proposed courtyard

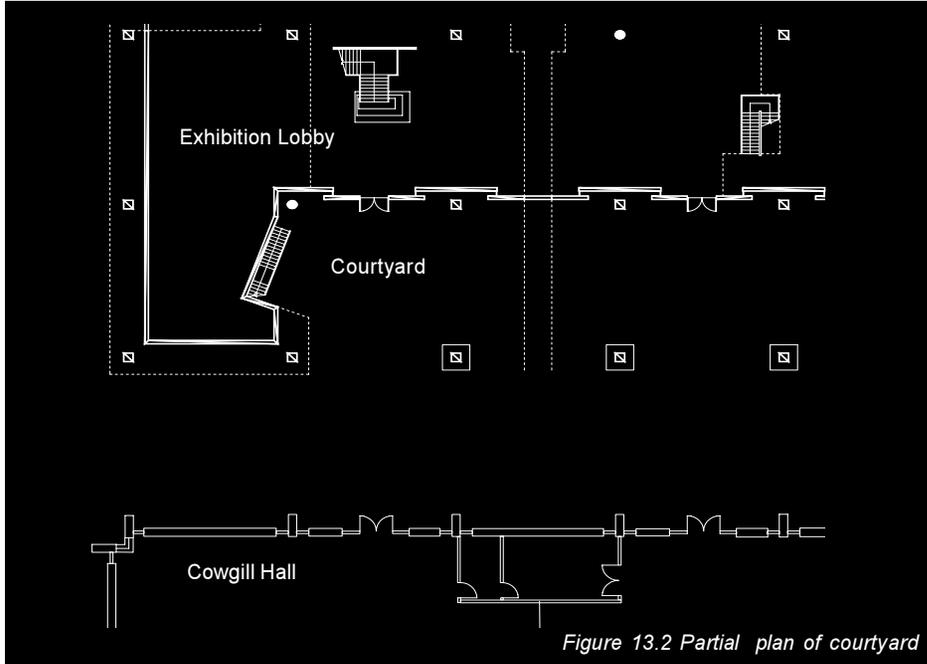


Figure 13.2 Partial plan of courtyard

1. Courtyard

In the current situation, the space facing this side of Cowgill Hall is not used very much by the students (Figure 13.3).

In this project, the mass of two buildings (Cowgill Hall and the Addition) form an open space (Figure 13.2). This space offers seats that are attached to the grid structure. Part of the structure and space (lecture room and connection bridge) are above and reduce the scale in the center of the space (Figure 13.1).



Figure 13.3 Current entrance of Cowgill Hall

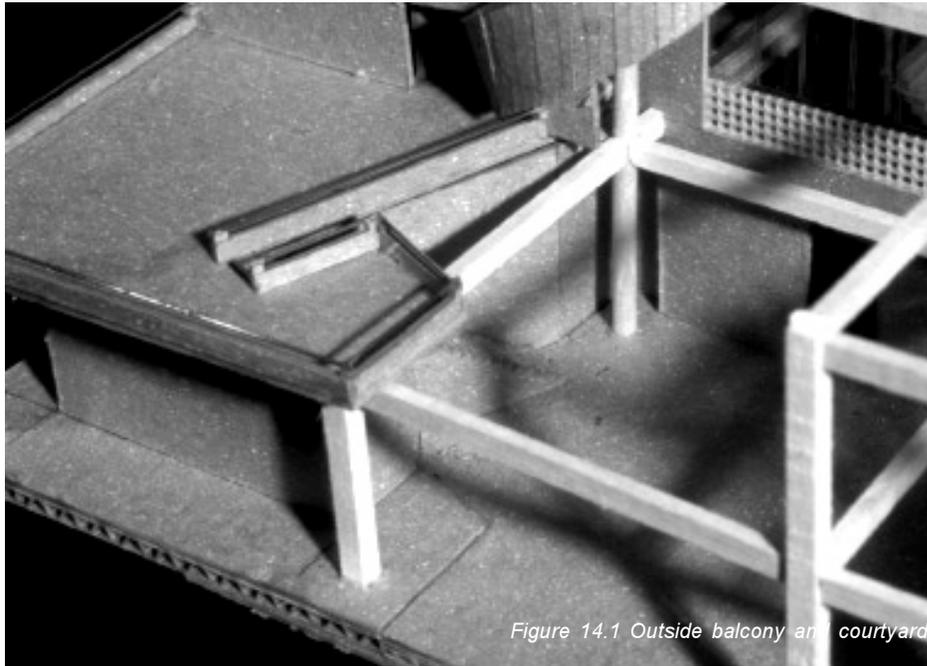


Figure 14.1 Outside balcony and courtyard

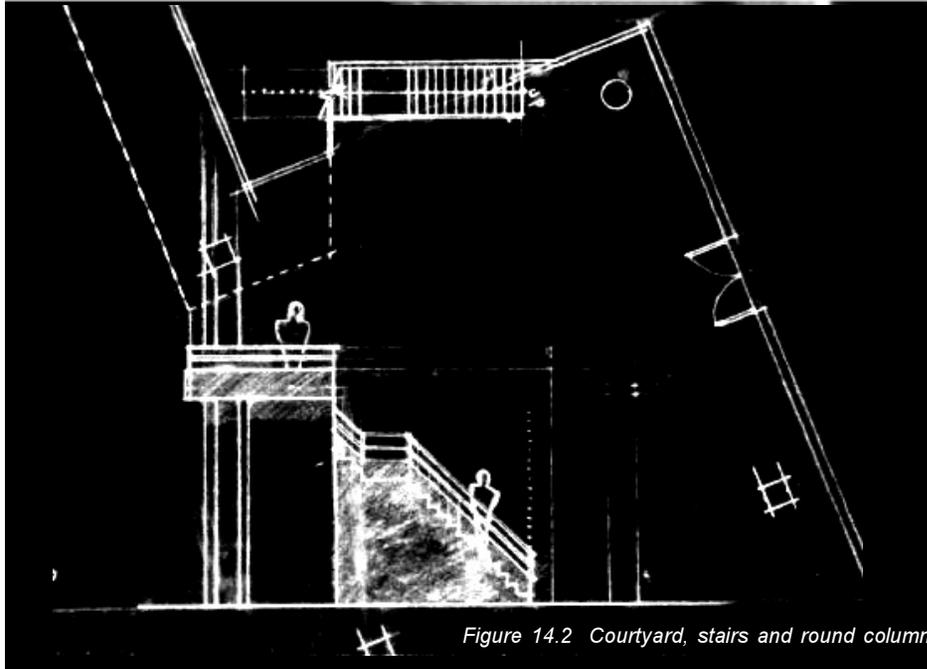


Figure 14.2 Courtyard, stairs and round column

On the west end of the courtyard, a stair leads from the courtyard space to a second floor outdoor space, this makes the courtyard space more dynamic (Figure 14.1). The vertical space offers a good chance to improve the contact among students not only in activities but also in the contact of vision. This will support the use of the courtyard as social space for students and faculty.

The courtyard area will be different from many spaces on campus. For example, the stairs leading to the outside balcony of the second floor changes direction toward a round column (whose shape is different from other outside columns) (Figure 14.2).



Connection

The bridge connects two inside exhibition spaces and one outside activity space.

Figure 15.1 The connection between Cowgill Hall and the addition



Figure 16.1 Connect bridge

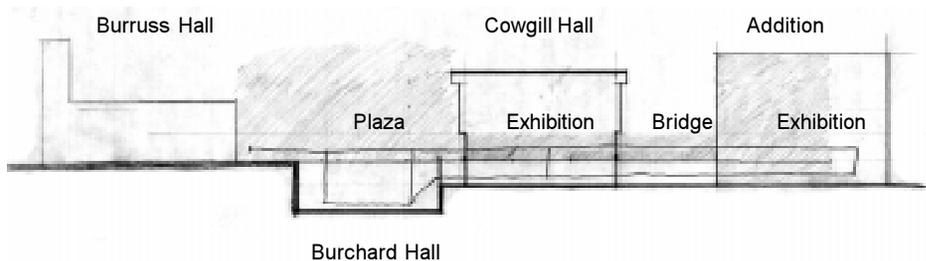


Figure 16.2 Relations among plaza and buildings

2. Connection and Activity Axis

2.1 Connection

The addition has two main links to Cowgill Hall: at ground level and second level with a bridge. The primary connection is on the ground. There are two main entrances of the addition facing the two entrances of Cowgill Hall. A new entrance to the architecture department is formed by the courtyard between these two buildings and the grid structure (Figure 17.1).

The second connection is with a bridge. There is a bridge at the second floor (exhibition area) to connect the addition to the lobby of Cowgill Hall and lead to the plaza that is between Burrus Hall and Cowgill Hall (Figure 16.1). The bridge connects two inside exhibition spaces and one outside activity space (plaza) and becomes a specific and important circulation path for the architecture department (Figure 16.2). Beside, the glass walls of the corridor are covered and etched with many famous sentences and images about architecture. When the light goes through the glass, the shadow of these images will project on the floor or the bodies of people walking (Figure 15.1).

2.2 Activity Axis

The bridge is located in the center of the second floor to connect the addition to Cowgill Hall. The beginning of the bridge is connected to the plaza (between Cowgill Hall and Burruss Hall) through the exhibition lobby of Cowgill Hall (Figure 17.2). It forms an activity axis to emphasize the starting point. The beam supporting the balcony (starting point) is designed differently from the others (Figure 17.3). To the exhibition lobby, the beam announces a very important location that is how these two buildings and plaza connect.

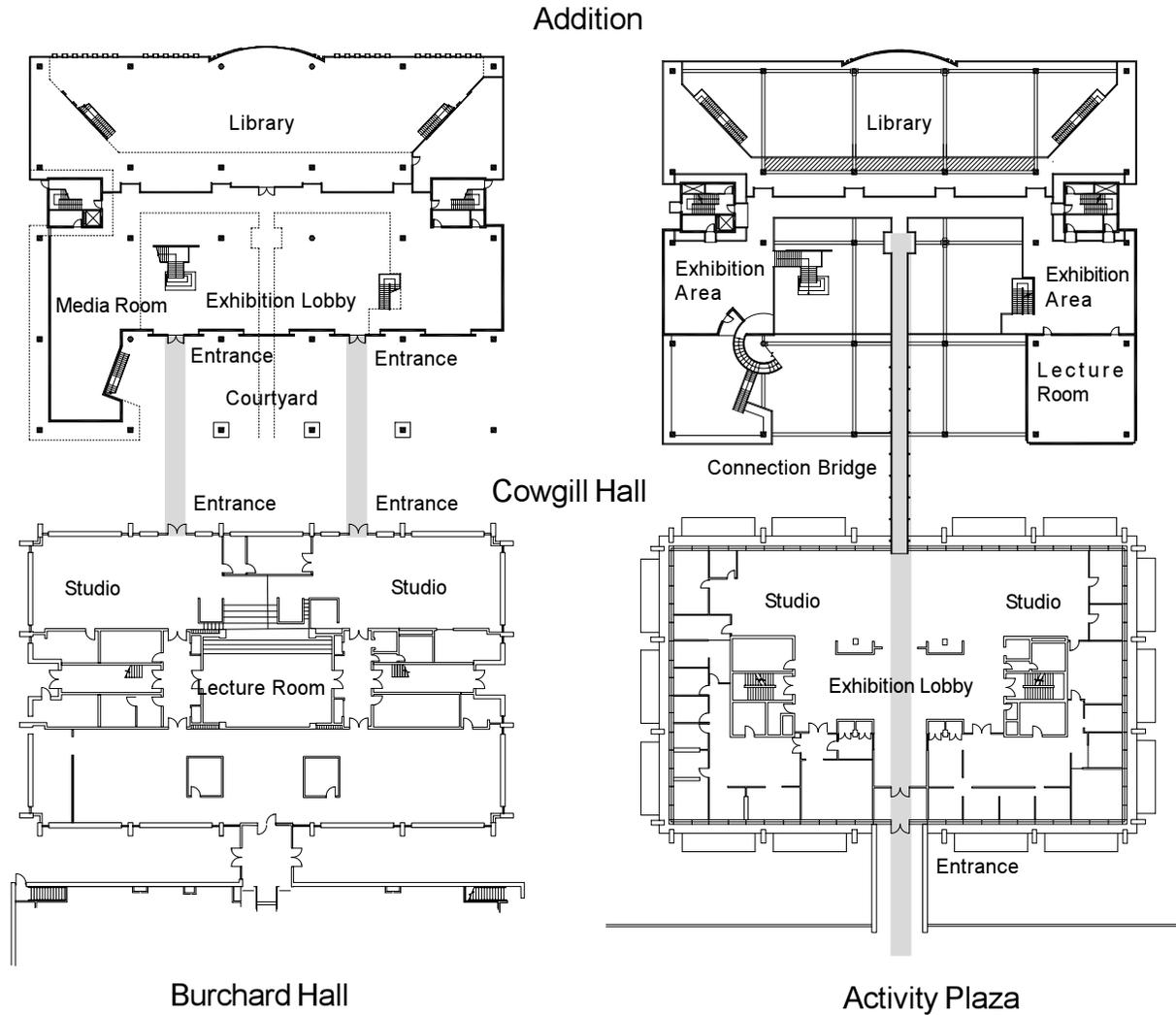


Figure 17.1 Relations between Cowgill Hall and the Addition on the first floor

Figure 17.2 Relations between Cowgill Hall and the Addition on the second floor

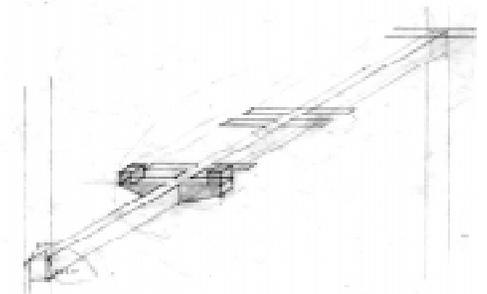
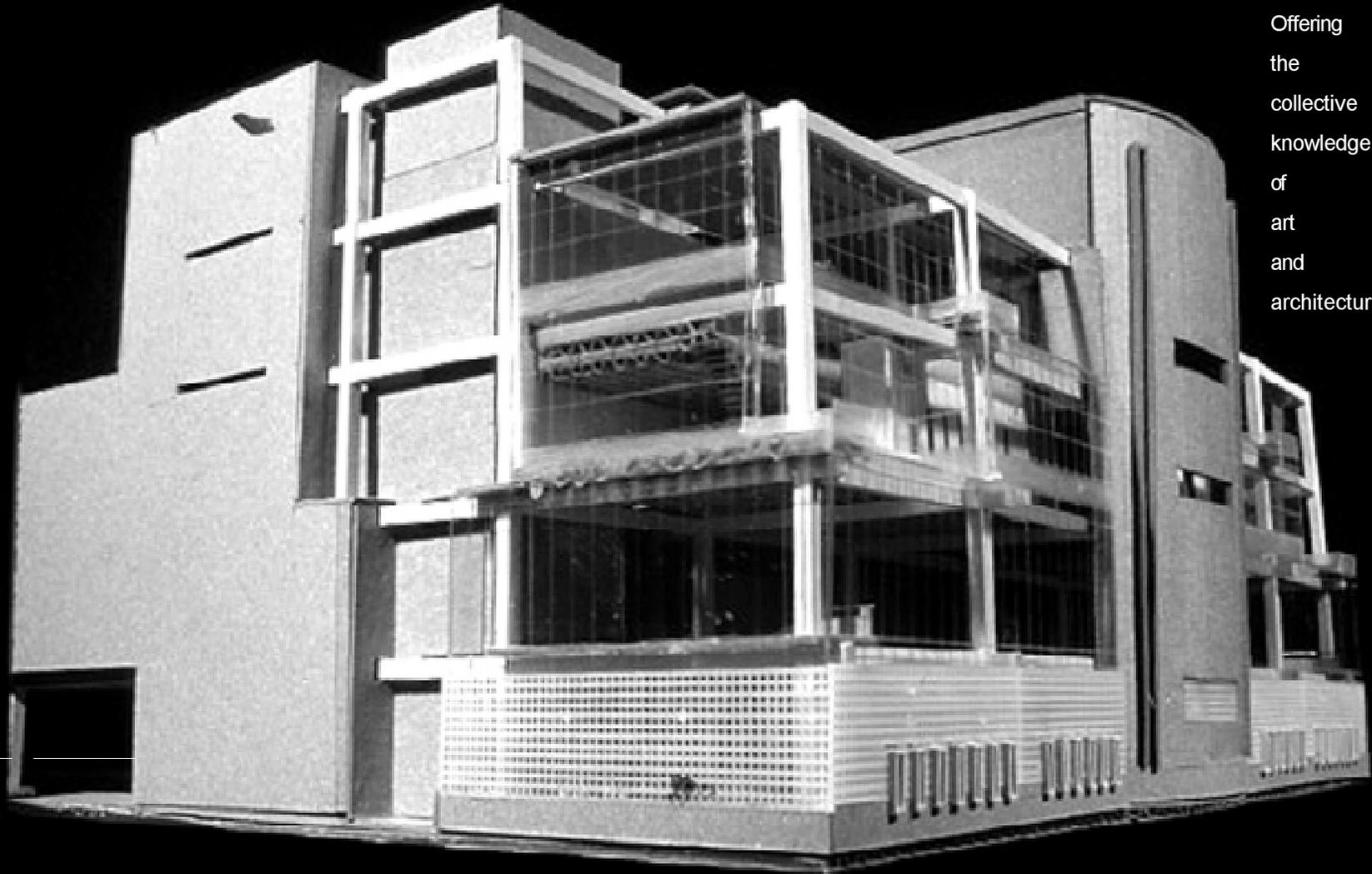


Figure 17.3 The beam supporting the balcony



Library
Offering
the
collective
knowledge
of
art
and
architecture.

Figure 18.1 North elevation of the addition

3. Library

The library is developed to not only offer the knowledge of art and architecture, but also offer a special experience of the space. When people are walking in the library, they will face two tall round columns of the grid structure. Because of the long narrow opening beside the columns, the sunlight will project on the back and spread on the columns. The light image on the columns will change in the result of the movement of the sun (Figure 19.1). When the people raise their heads, they will see the steel truss supporting the studio area and laying on the grid structure. Thus, people can enjoy how the main structure (the grid structure) supports the secondary structure (the steel truss) (Figure 19.3).

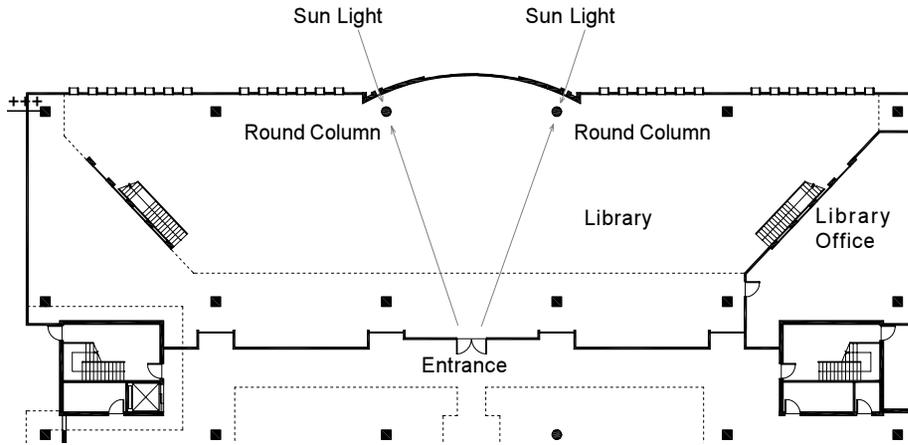


Figure 19.1 1F Plan of the library (partial)

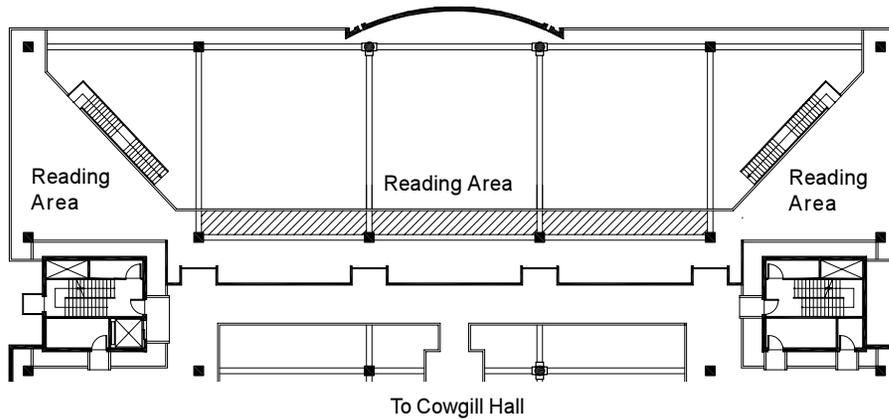


Figure 19.2 2F Plan of the library (partial)

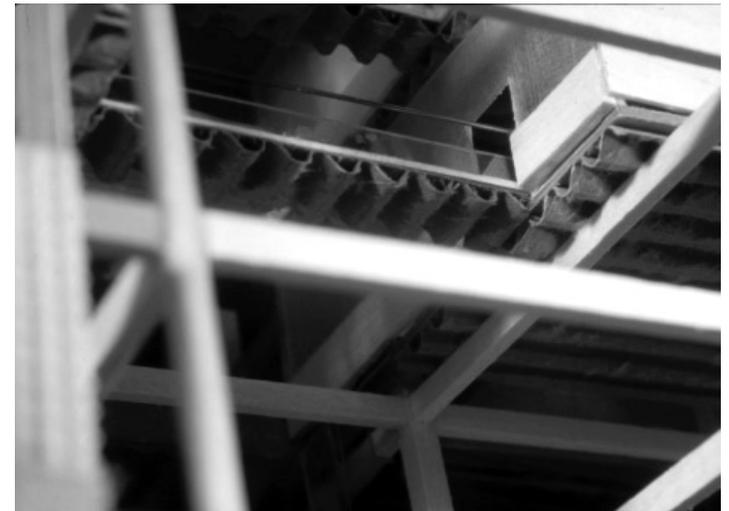


Figure 19.3 Grid structure supports steel truss

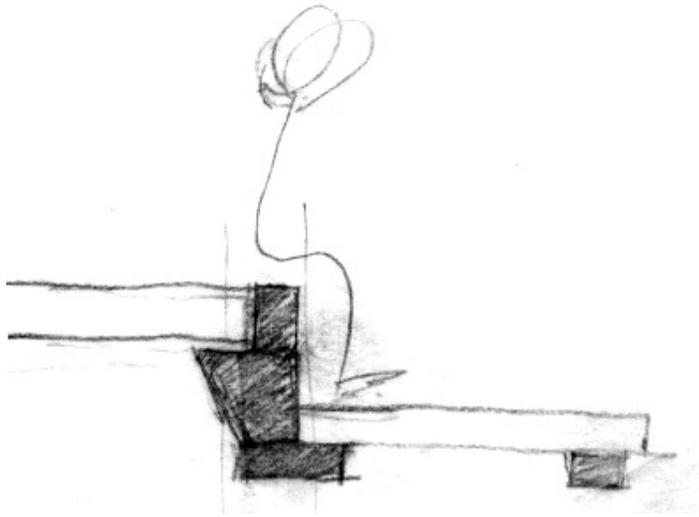


Figure 20.1 Beams become seat

The reading area of the library is on the second floor. The floor in this area is below the beams but still supported by beams, so beams become seats (*Figure 20.1*). Here, structure is not just structure, it can become a kind of furniture. There are more relationships between the structure and people. There are windows above this area, so natural light comes in. The light makes the reading area brighter, and emphasizes the different spacial qualities of the library (*Figure 20.2*).



Figure 20.2 Sunlight projects on reading area

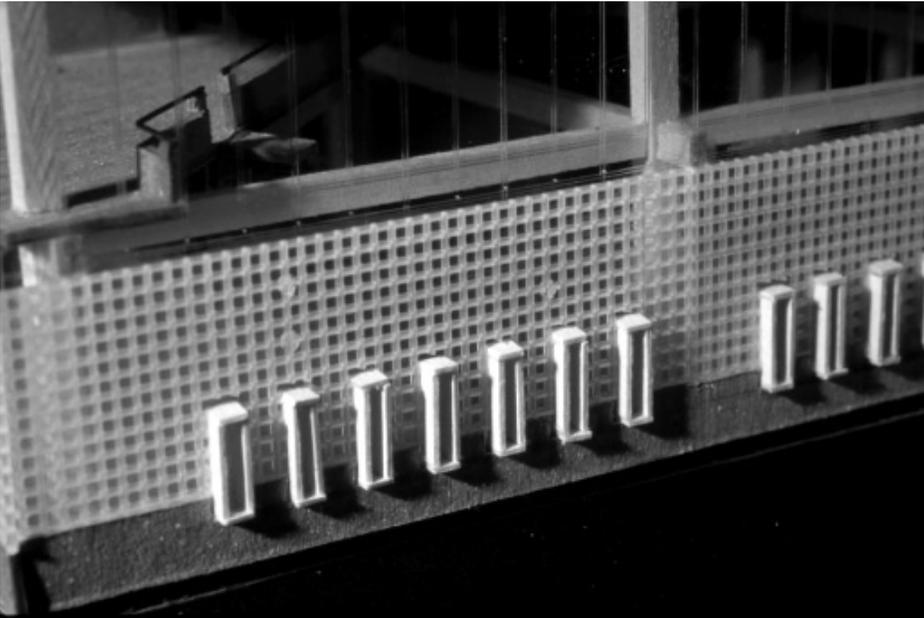


Figure 21.1 The first floor facade of the library

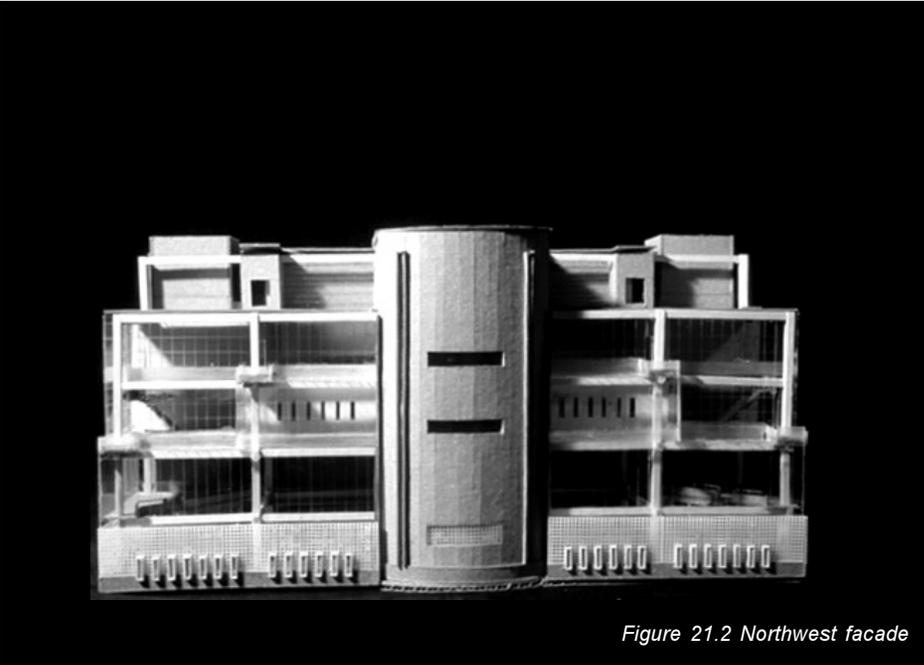


Figure 21.2 Northwest facade

The material of the facade in the first floor is glass block. The natural light can go through but people cannot see through. In addition, there are several wood frames with glass are inserted as windows. So, the long narrow view blocked by wood frame becomes a kind of beautiful painting (Figure 21.1). A different idea at the second floor, the whole facade of the second floor is made of a steel frame and large pieces of glass (Figure 21.2, 21.3). The view of the sky and mountains is very expansive. This offers the second floor a totally different and contrasting feeling from the view of the first floor.

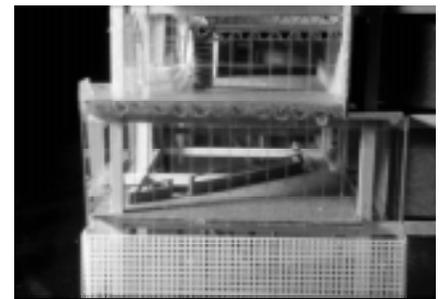


Figure 22.3 The second floor facade of the library



Discussion Area
Offering
a
space
for
presentation
and
discussion.

Figure 22.1 Sunlight projects on the beams and reflects to the walls (Dark discussion area)

4. Discussion Areas

There are two discussion areas on the third floor. Both of them have the same function: they offer a space for presentation or discussion. The location of the space is near to the two main vertical circulation stairs. People can easily enter or pass by. It means that the space welcomes everybody to join the activity or just take a look. The discussion area offers more chances for different groups to communicate their projects and ideas. It is worth mentioning that those two discussion areas have different light condition: bright and dark.

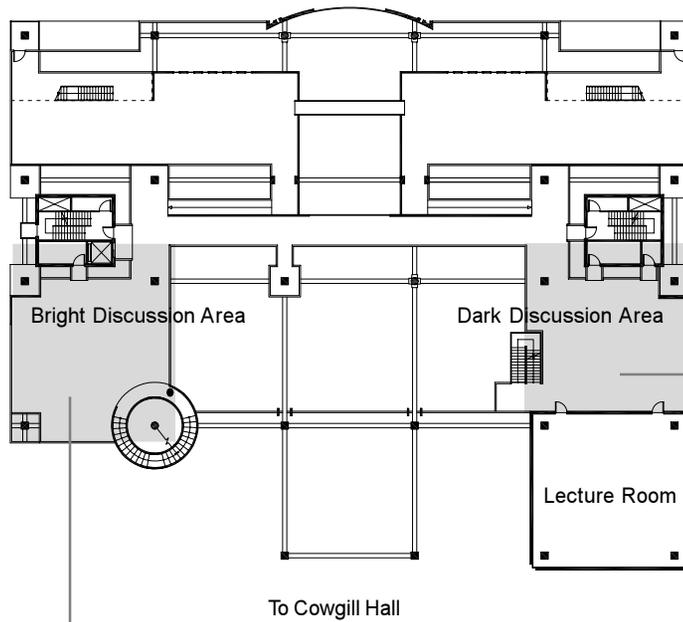


Figure 23.1 3F Plan

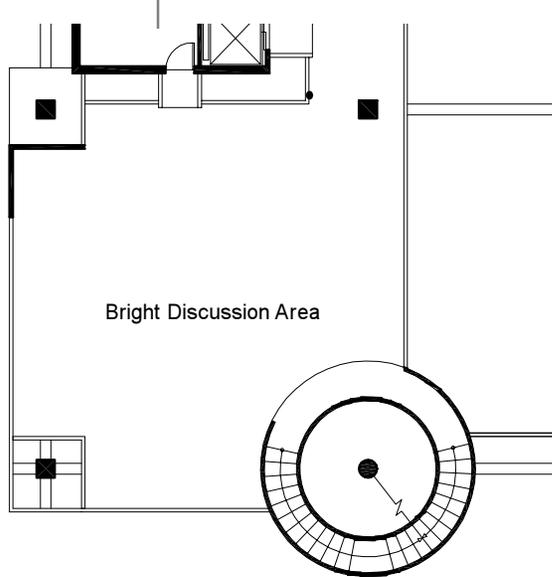


Figure 23.2 Bright Discussion Area

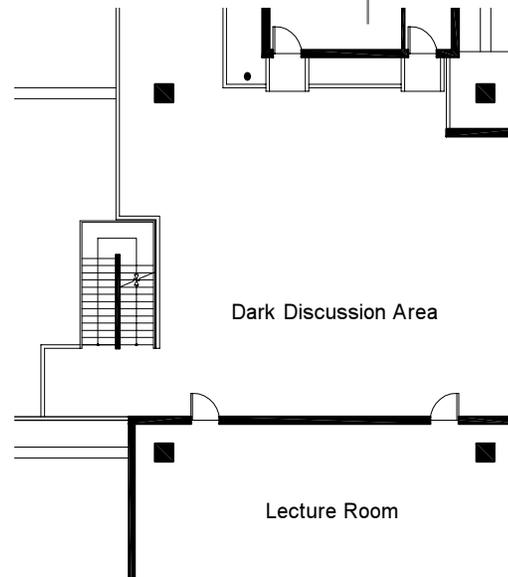


Figure 23.3 Dark Discussion Area



Figure 24.1 Dark discussion area



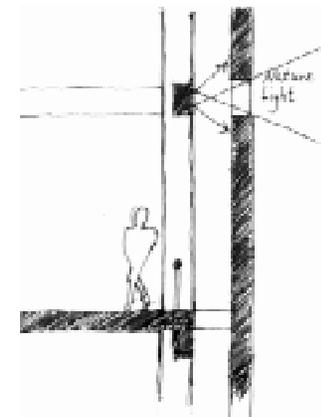
Figure 24.2 Natural light appears the textures of the cores



Figure 24.3 Horizontal slots behind the beams

4.1 Dark Discussion Area

The walls of the dark discussion area are made of concrete panels. There are three horizontal slots on the wall behind the beams (Figure 24.3). When the sunlight goes through the horizontal slots of the walls, it will project on the beams and reflect on the wall (Figure 22.1). In addition, because the core doesn't touch the main structure and walls, there is a vertical opening between the core and the main structure. Natural light can project into the space on the surface of the core (Figure 24.2). It can appear on the textures of the cores and make the cores become the background of the grid structure. People in the space can see the structure by the reflection of light. For functional reasons, we can set up some artificial light on the beams of the third floor, so the discussion space is brighter than the balcony on the fourth floor. Obviously, the discussion area (main event) will be like a bright stage, and the people at the balcony of the fourth floor are spectators.



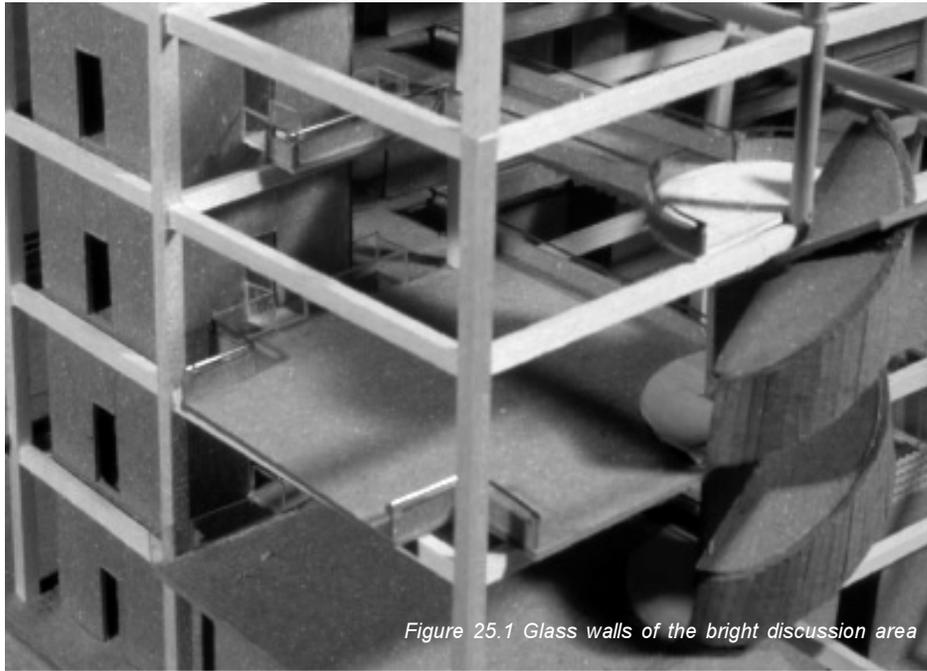


Figure 25.1 Glass walls of the bright discussion area



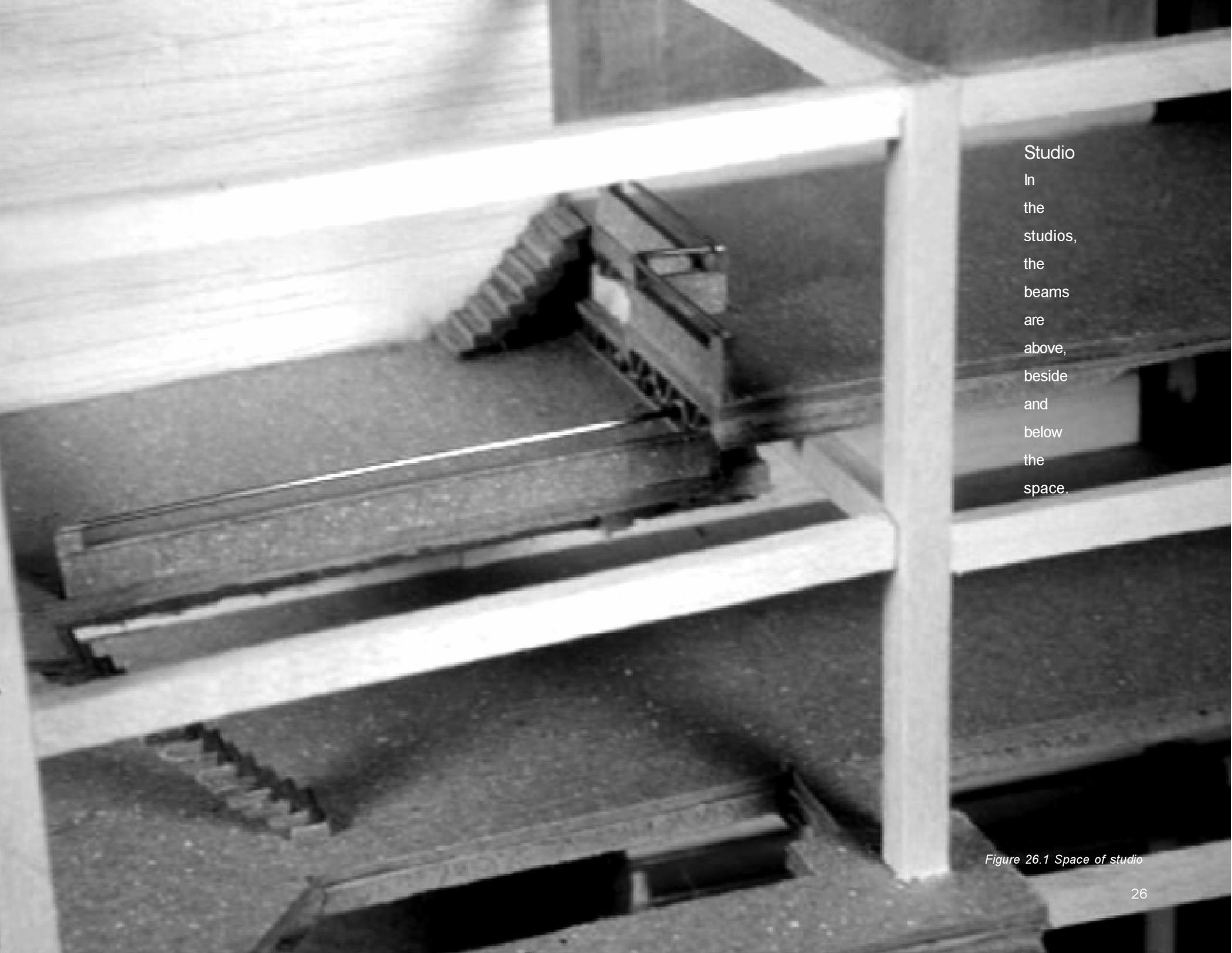
Figure 25.2 Circular stairs and the bright discussion area



Figure 25.3 The grid structure and the bright discussion area

4.2 Bright Discussion Area

The elevation of the wall in the bright area is composed of big pieces of glass (Figure 25.2). A lot of sunlight or natural light will go into this area, so the shade of the grid structure will project on the floor (Figure 25.3). On the other hand, the sky and mountains will be the best background of this area. The circular stairs connect the discussion area to other floors. When people pass the fourth floor stairs, they still have chance to see what is happening in the area (Figure 25.1).



Studio
In
the
studios,
the
beams
are
above,
beside
and
below
the
space.

Figure 26.1 Space of studio



Figure 27.1 Space of the studio

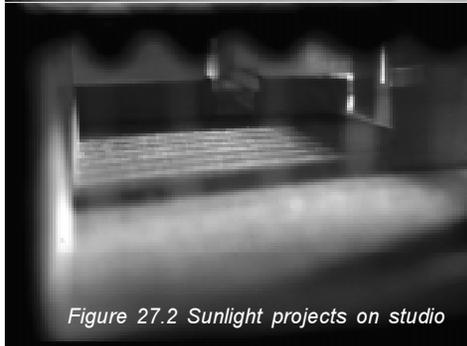


Figure 27.2 Sunlight projects on studio



Figure 27.3 Sunlight projects on studio

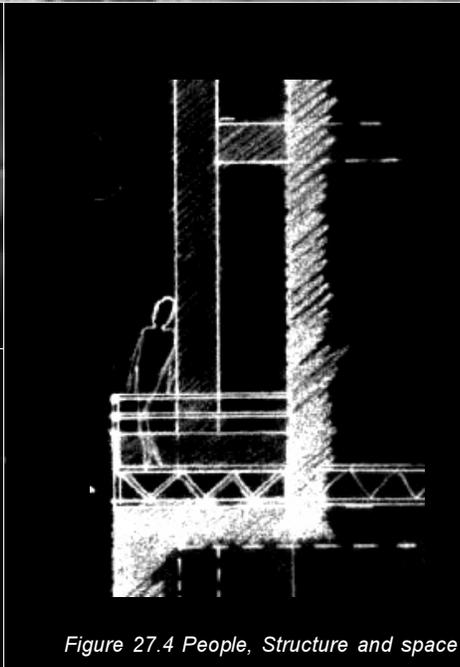


Figure 27.4 People, Structure and space

5. Studio and Secondary Structure

5.1 Studio

The relations of spaces in the studios are not just horizontal but also vertical (Figure 27.1). All the floors of the studios do not just lay on the grid structure. Steel trusses are supported the floor by the grid structure. The floors are located on different levels. So, in the studios, the beams are above, beside and below the space. In addition, people can go to the outside balcony which is a small space (1m x 1m) and there is a column standing in the center (Figure 27.2, 27.3).

Most of the spaces are covered by glass for getting natural light and more views. However, there are two areas which are covered by wood for some people who prefer to work in darker condition. Besides, there are a few long narrow openings on the wood walls, so the sunlight can project into the dark space and make beautiful shade in the studios (Figure 27.4).

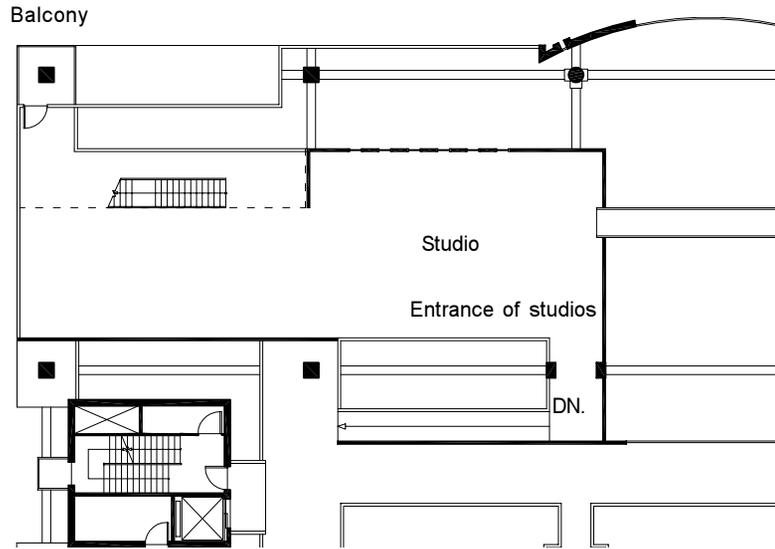


Figure 28.1 Entrance of studios

Every entrance of the studio is defined by a column. To propose a stronger entrance, the columns are cut into two thinner columns and moved to each side of the entrance. That is the only place in this building where the main structure breaks (Figure 28.1).

5.2 Main Structure And Secondary Structure

To emphasize the stability of grid structure, the studio space is located at the third and the fourth floor and supported by the secondary structure (steel truss) across the main grid structure (Figure 28.3). Because of the lively and changeable characteristics of the studio space, the secondary structure can be easily changed to fit the requirement of the construction, and doesn't need to change the main structure (Figure 28.2).



Figure 28.2 Grid structure and Secondary Structure

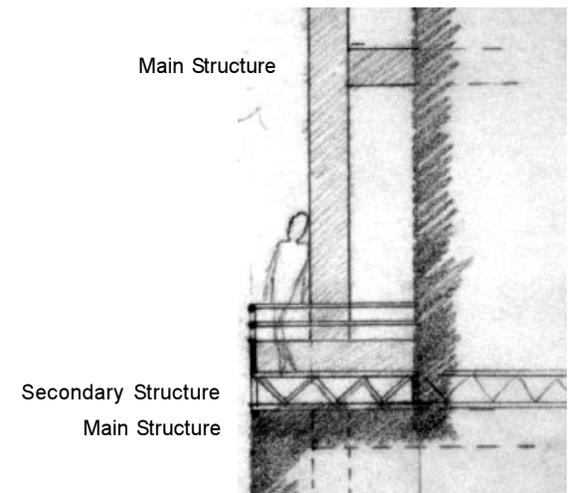


Figure 28.3 Main structure and secondary structure

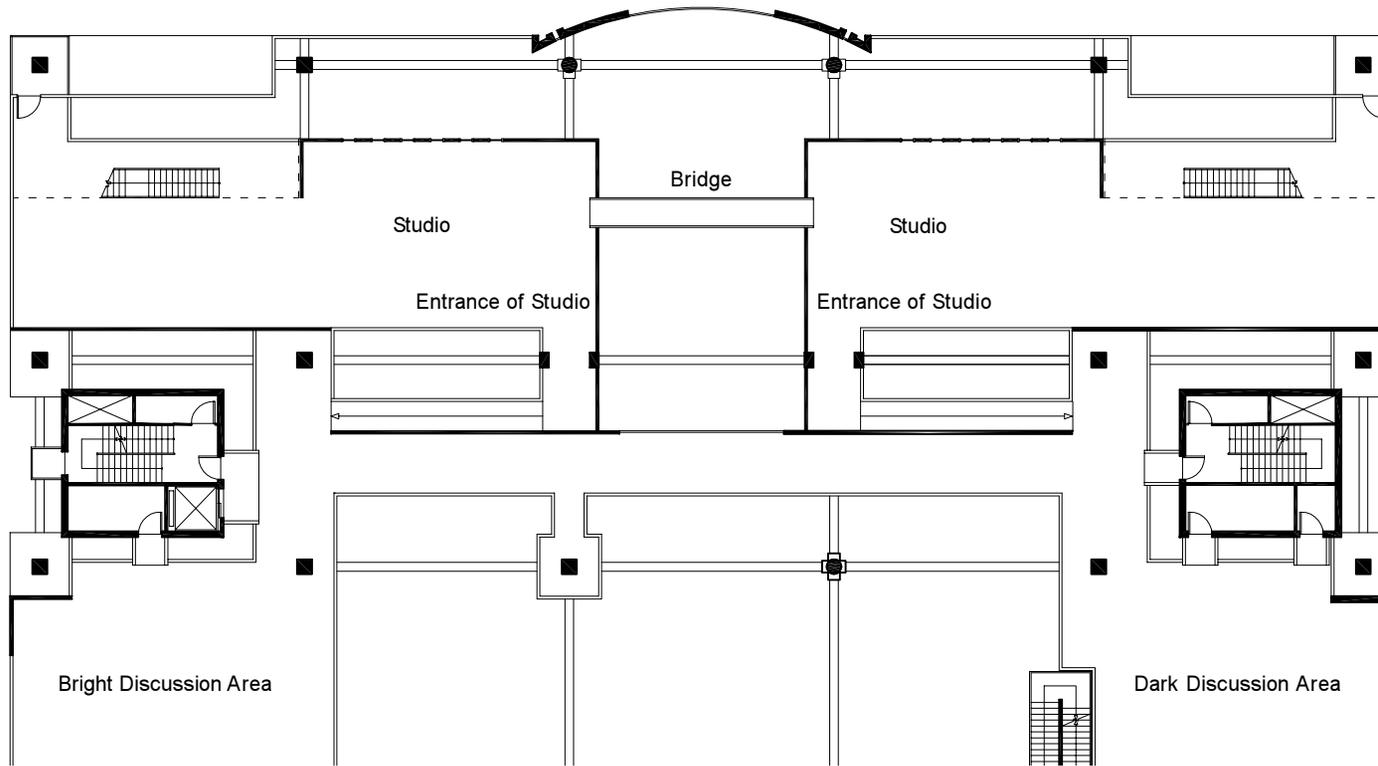


Figure 29.1 3F Plan (partial)

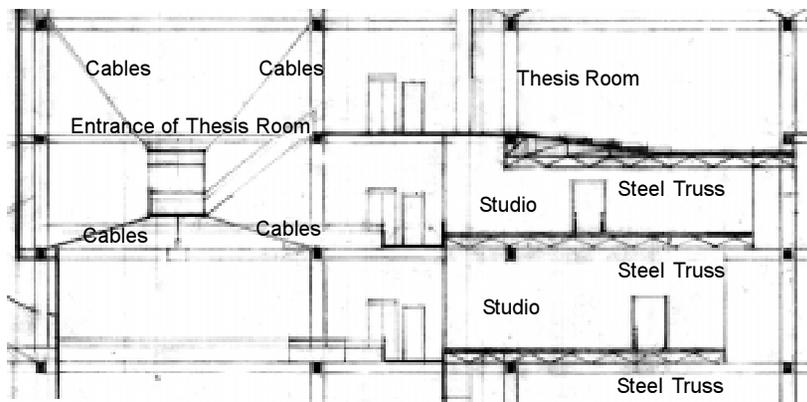


Figure 29.2 Section of studio (partial)

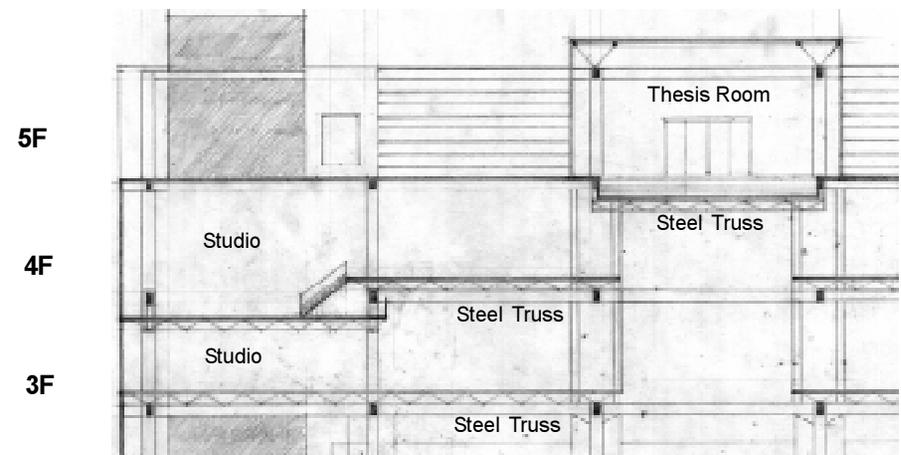


Figure 29.3 Section of studio (partial)



Frame and Enclosure

To emphasize and respect the grid structure, walls will be separated from the columns.

Figure 30.1 The walls are separated from the grid structure

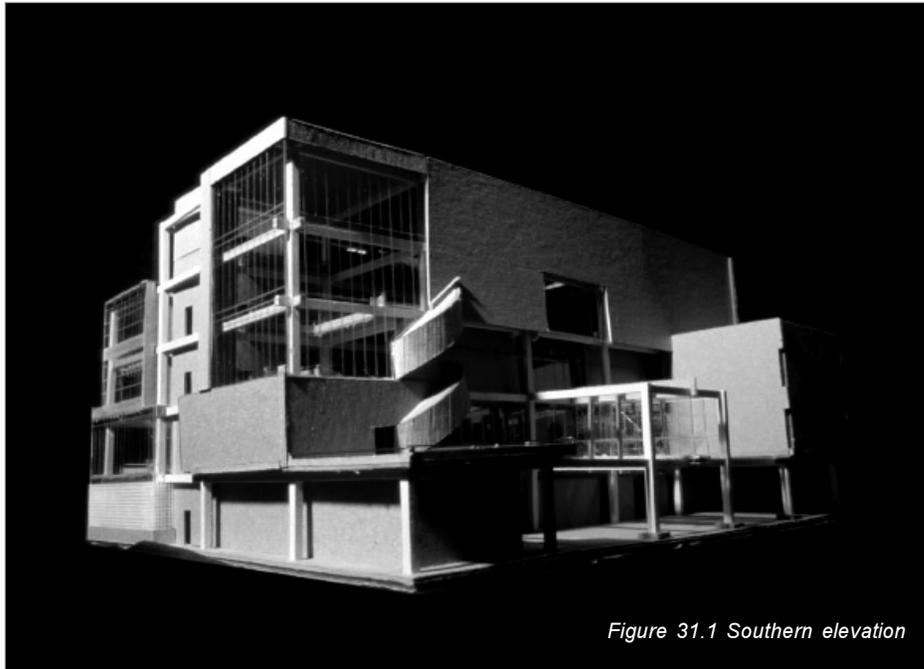


Figure 31.1 Southern elevation



Figure 31.2 Western elevation

6. Frame and Enclosure

To emphasize and respect the structure, all the walls will be separated from the columns. The columns will be visible in every space. In some space, the beams will show up, too. By these means, the structure has a stronger relation with the space. Furthermore, we have more chances to control the artificial light and natural light to project on the structure and walls. This way, the space is defined not only by walls but also by structure and light.

The structure in the courtyard between the addition and Cowgill Hall is exposed and is not covered by walls, so people can easily understand the main structure of the building (Figure 31.1).

On the northwestern side of the addition, the structure is enclosed with transparent material (glass), and the structure is exposed in some places. People still can experience the main structure (Figure 31.2).

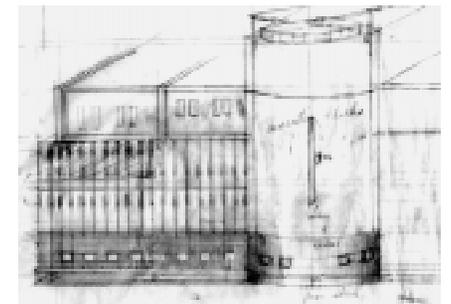
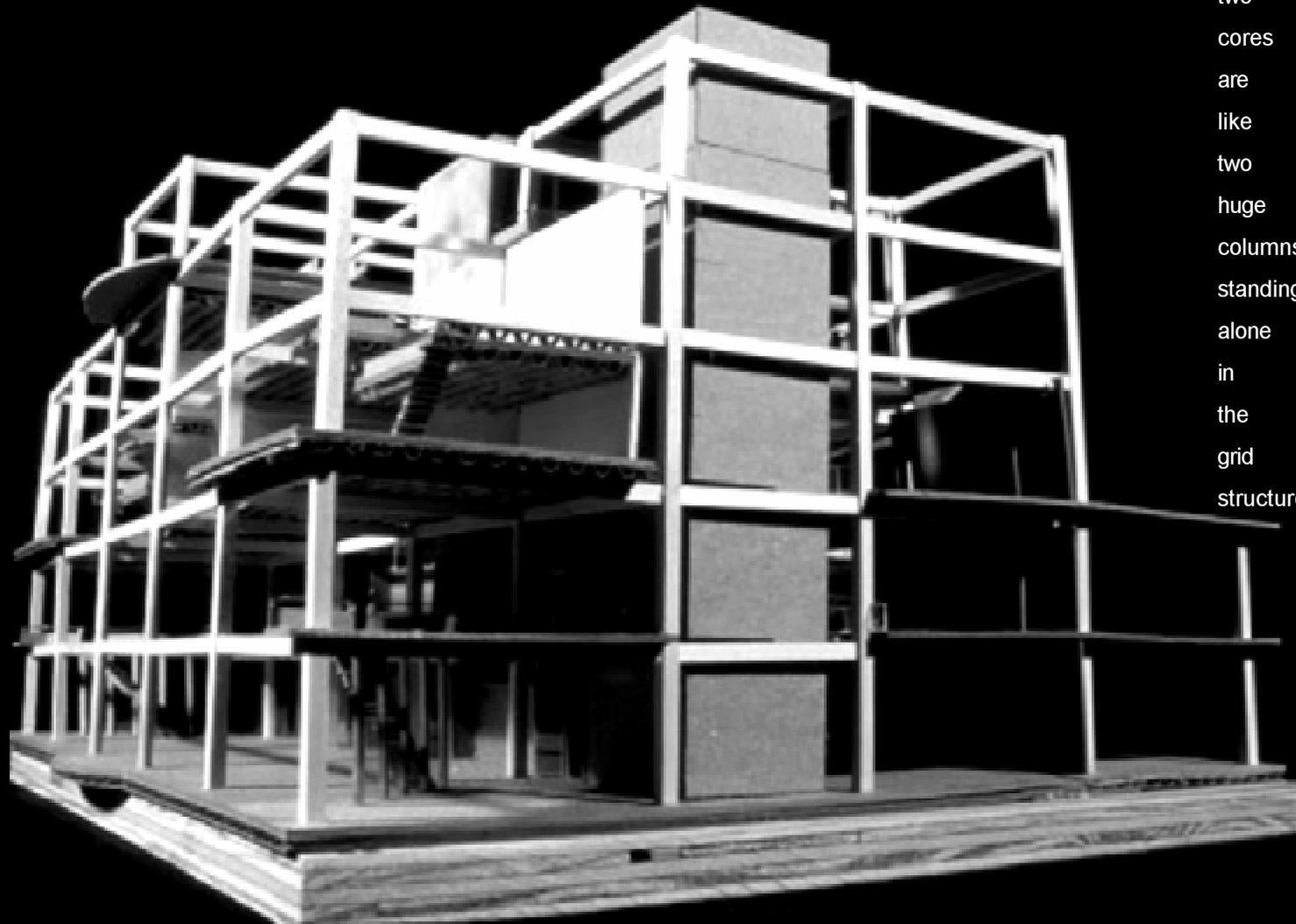


Figure 32.3 Draft drawing of elevation



The Cores
The
two
cores
are
like
two
huge
columns
standing
alone
in
the
grid
structure.

Figure 32.1 Relations between cores and grid structure

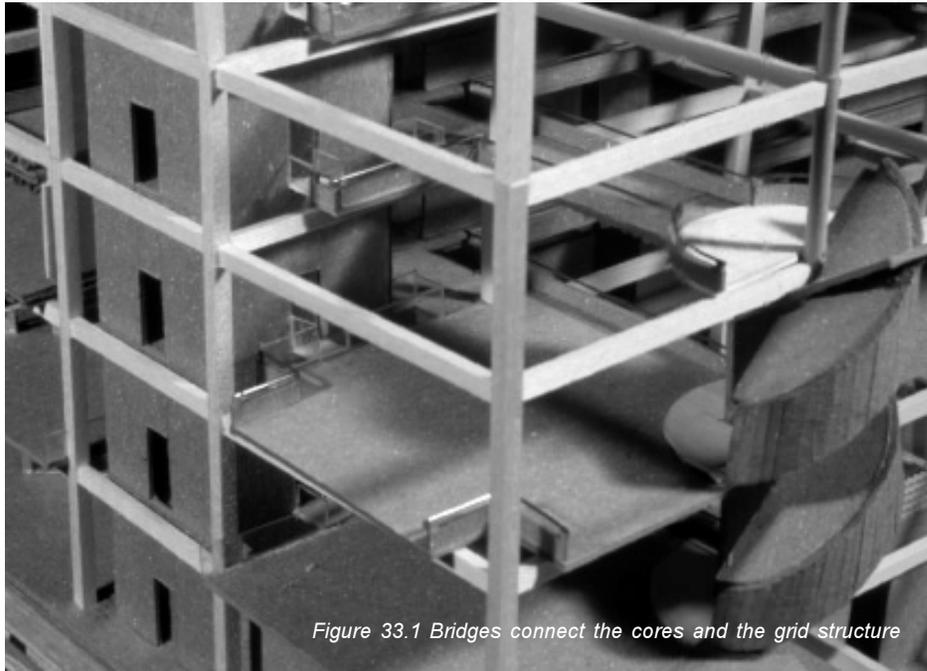


Figure 33.1 Bridges connect the cores and the grid structure

7. Cores

The structures of the two main cores fit into two separate grid spaces. They accept the heaviness of their own structure. The cores do not attach to the main grid structure. Viewed as part of the structure, the two cores are like two huge columns standing alone in the grid structure (Figure 33.1), but the inside of the column is empty. It houses toilets, fire stairs and all mechanical functions. (Figure 33.3)

All circulation between the cores and grid structure is by bridges connecting the different spaces (Figure 33.3). A straight path connects the two cores on every floor. This is the main horizontal circulation which connects the left and right side spaces (Figure 33.2).

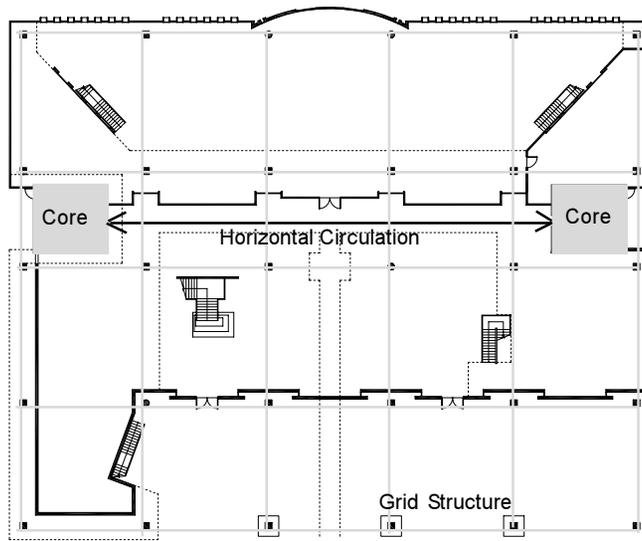


Figure 33.2 The cores and grid structure

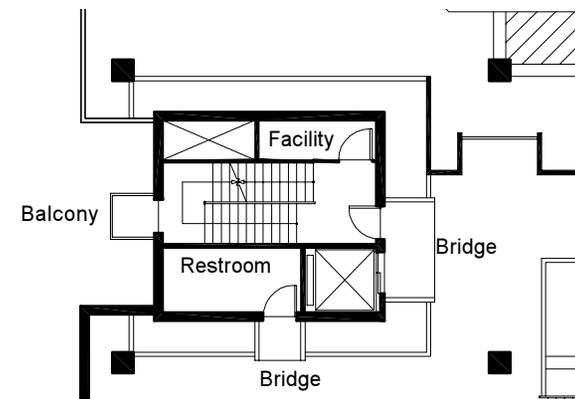


Figure 33.3 Plan of the cores

Thesis Room

Every
time
they
gather
in
the
thesis
room
to
discuss
a
student's
thesis,
they
are
lighting
a
little
spark
of
knowledge.

Figure 34.1 Outside wall of the thesis room



Figure 35.1 Entrance of the thesis room



Figure 35.2 Natural light makes the balcony very bright

8. Thesis Room

The thesis room is the most important space in the building. Thesis projects are the research results of students and faculty after studying for many years. Thesis defense is a ceremony, and the feeling of this room should support this educational climax.

The entrance of the thesis room is supported by a round column (the only round column in this lobby) and separated from the two main stairs (Figure 35.1). The balcony is suspended (by cables) from the grid structure (Figure 35.2). There is a small opening above the balcony, so natural light will make the balcony very bright (Figure 35.2). Following the stairs will lead people to the fifth floor and toward the outside wall of the thesis room. Because of the slot above the wall, sun light goes into and spreads over the whole wall (Figure 34.1).

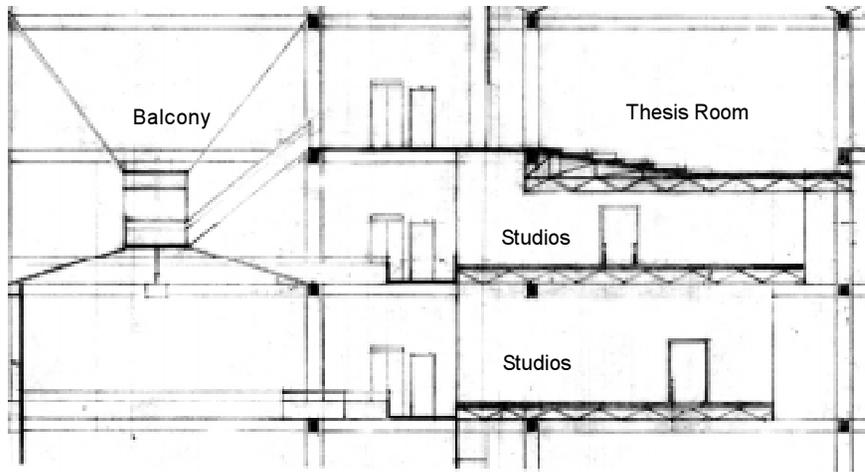


Figure 36.1 Section of the thesis room

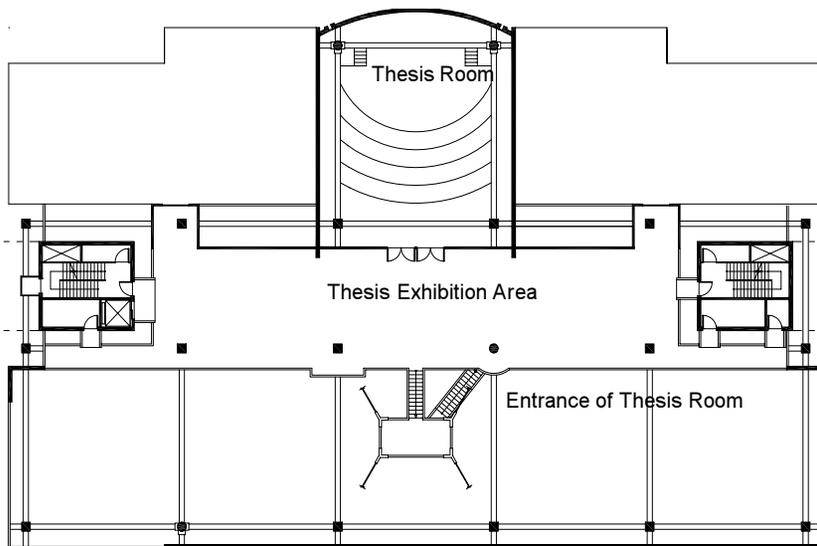


Figure 36.2 Plan of the thesis room

After opening the doors and walking in the room, people will find that the main structure only supports the roof and the walls. The floor is a terrace, and the grid structure is exposed (Figure 36.1). In addition, the exposed beams become part of the exhibition set and stage. There are four small openings above the joints of the columns and beams on the roof (Figure 36.3). The sunlight projects on the joints and the walls, making shadows and reflecting light from the structure (Figure 36.4).

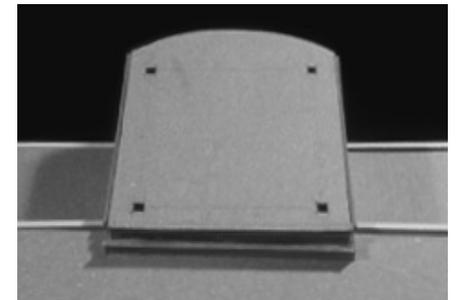


Figure 36.3 Roof of the thesis room

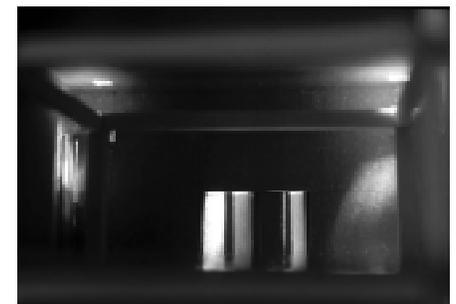


Figure 36.4 The sunlight projects on the joints and the walls

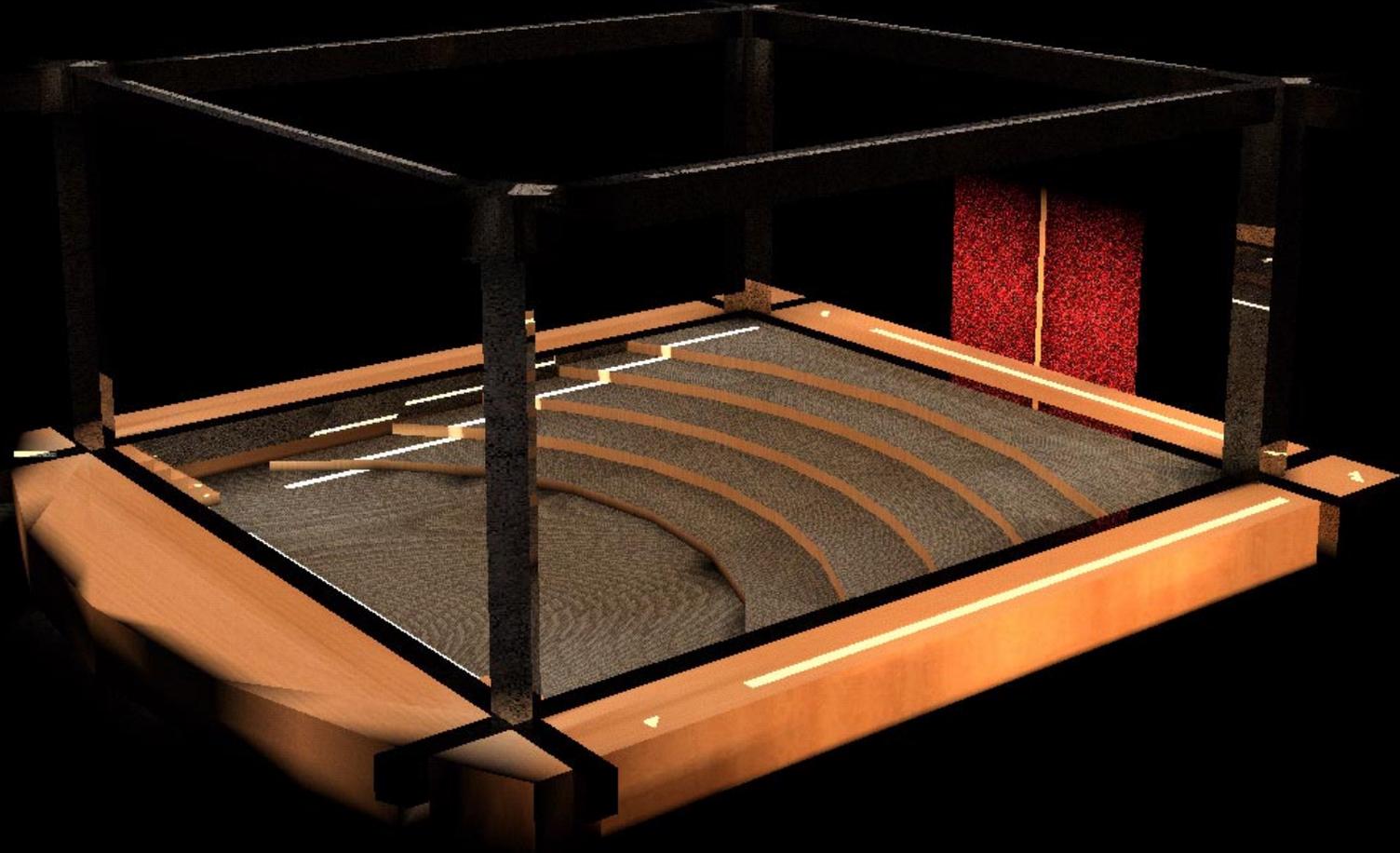


Figure 37.1 The grid structure in the thesis room



When designing a building of grid structure, putting ceilings on the beams to conceal lights and air conditioning ducts is the most simple and common idea. It will be easier for construction and save money. However, the thesis room is the most important space in the whole building, and its characteristics should not be covered by economy. So we have more choices to think about how to control the openings and the material to research more about space feeling of the thesis room.

In this project, ceilings, floors and walls are separated from the main structure. Thus, the one-unit grid has been reserved in the whole space of the thesis room. In addition, using a secondary structure helps to fit the requirement of construction by the actual function. This is the main design idea of the thesis room.

Many openings follow the order of grid structure on the ceiling and walls to make natural light enter inside. The majority of the light projects on the columns and beams and reflects to become diffused light. Then, the grid structure is a protagonist above the background of light. Besides, the structure becomes a sort of source of light.

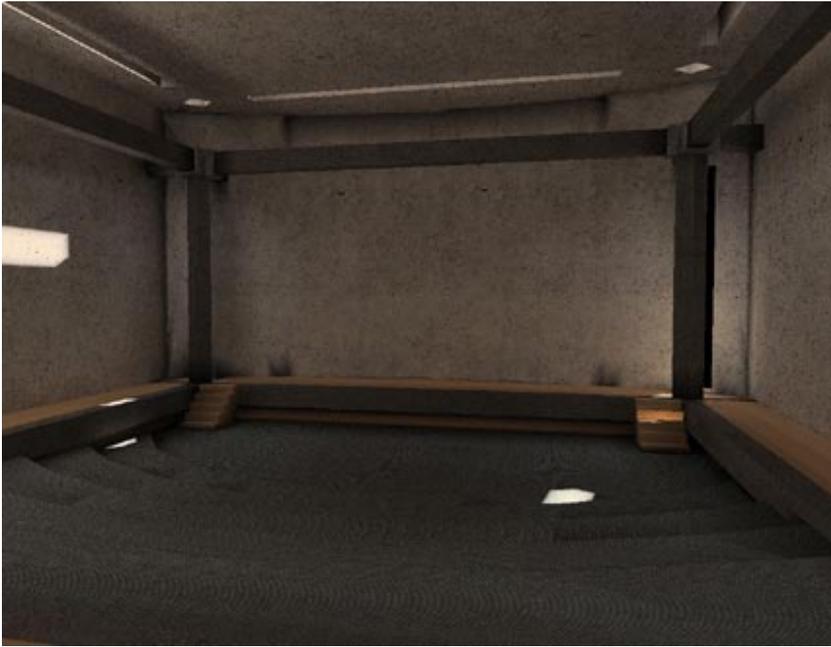


Figure 39.1 Front side view, Morning sunlight, Structural material: Concrete



Figure 39.2 Back side view, Morning sunlight, Structural material: Concrete

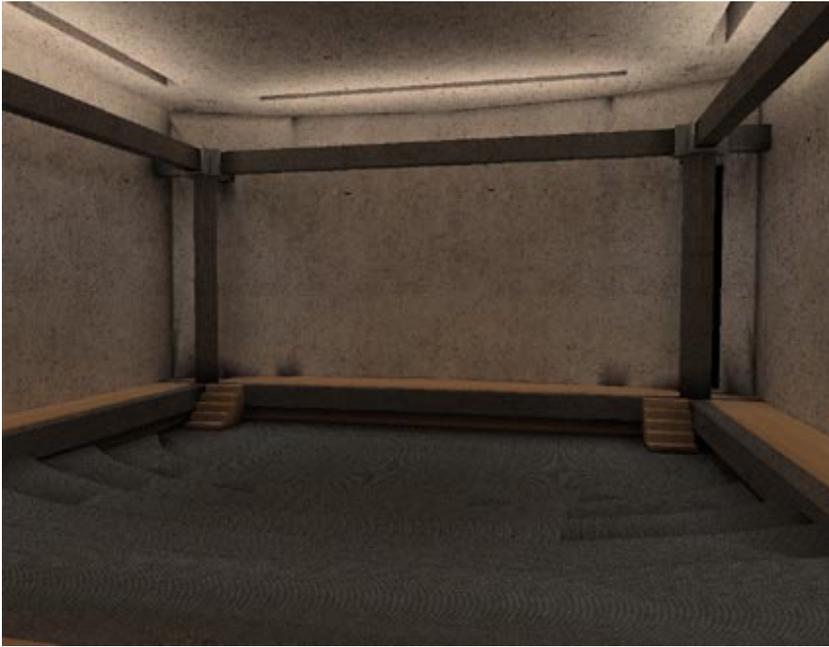
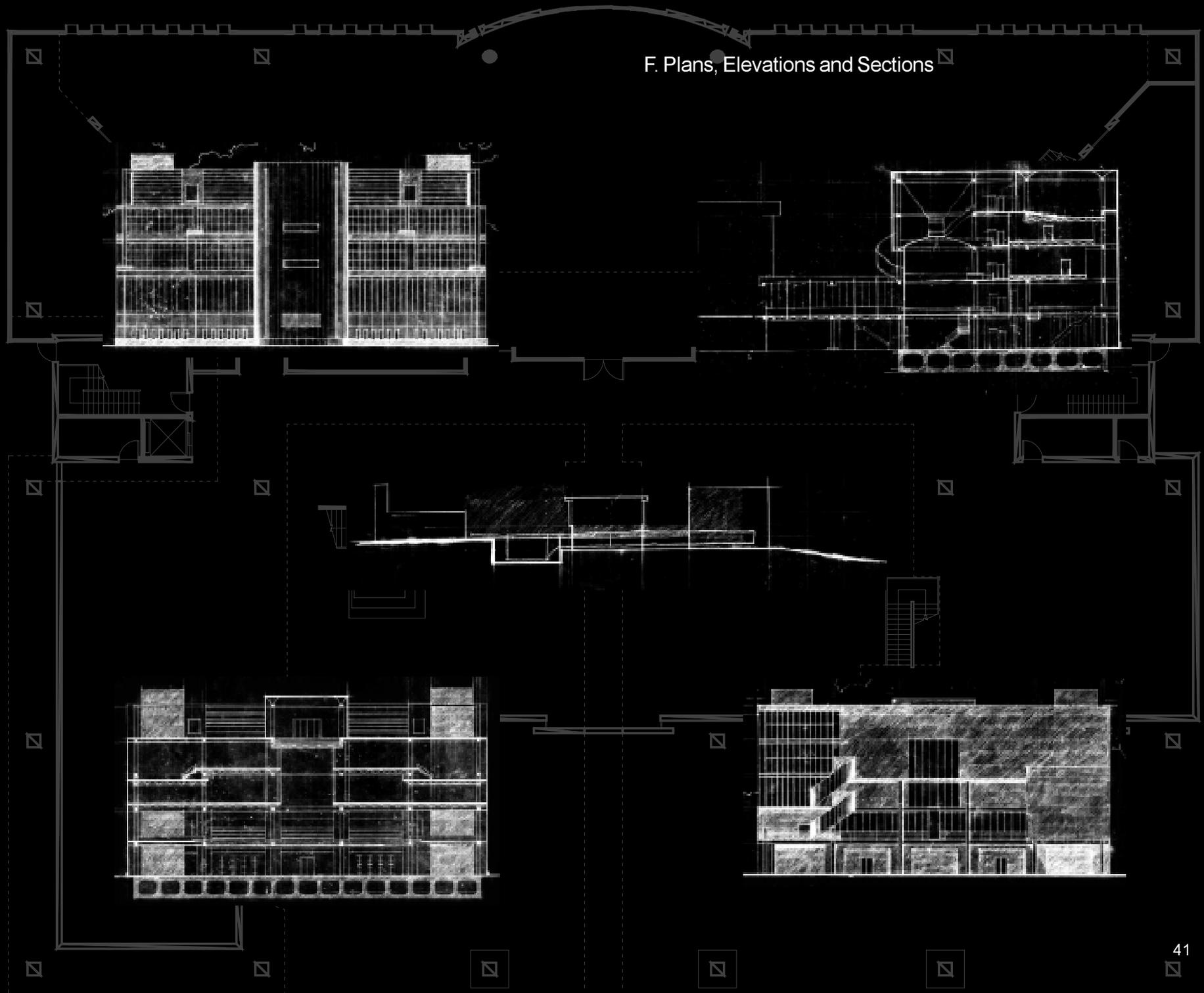


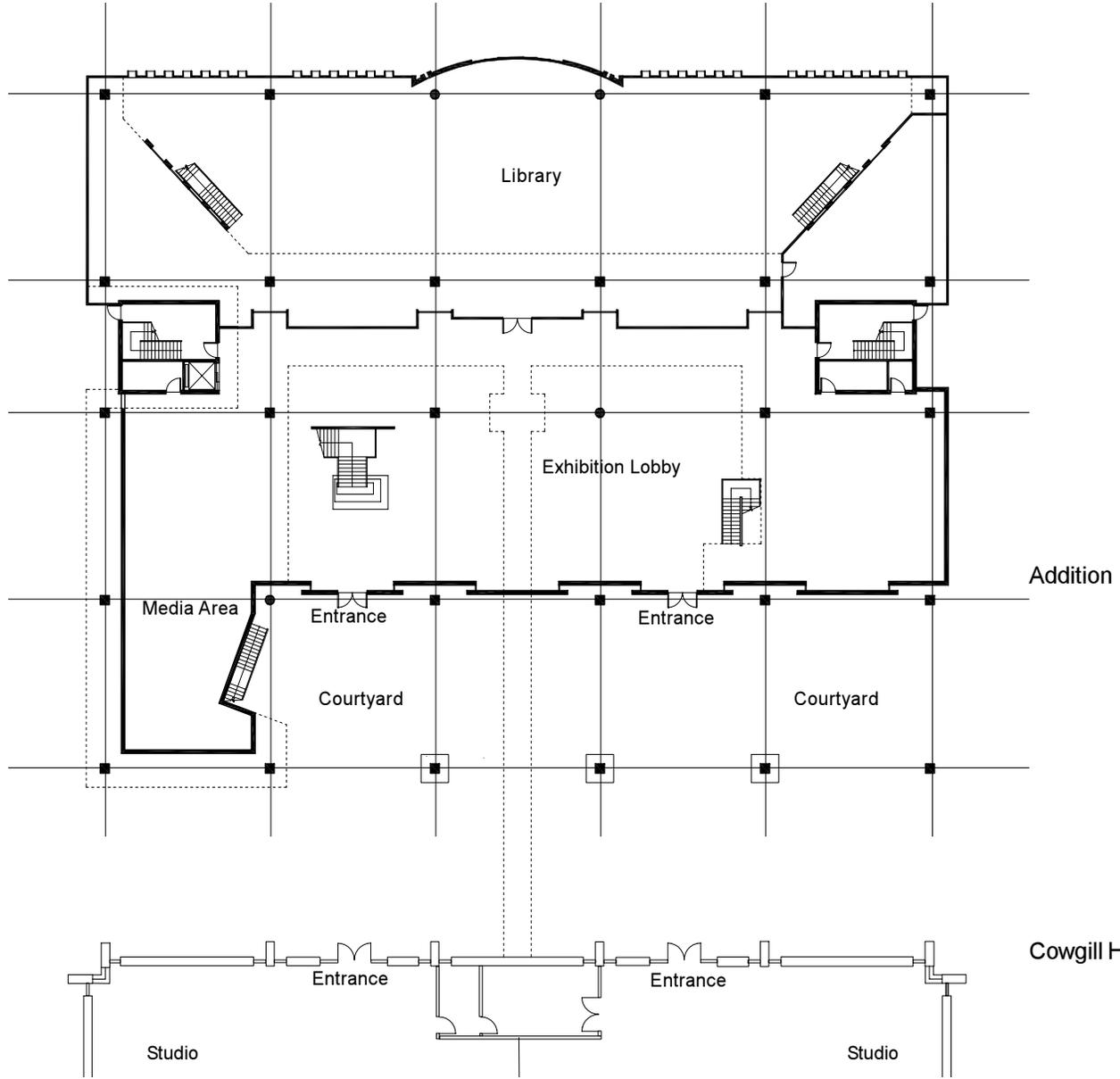
Figure 40.1 Front side view, Noon sunlight, Structural material: Concrete



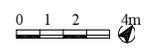
Figure 40.2 Back side view, Noon sunlight, Structural material: Concrete

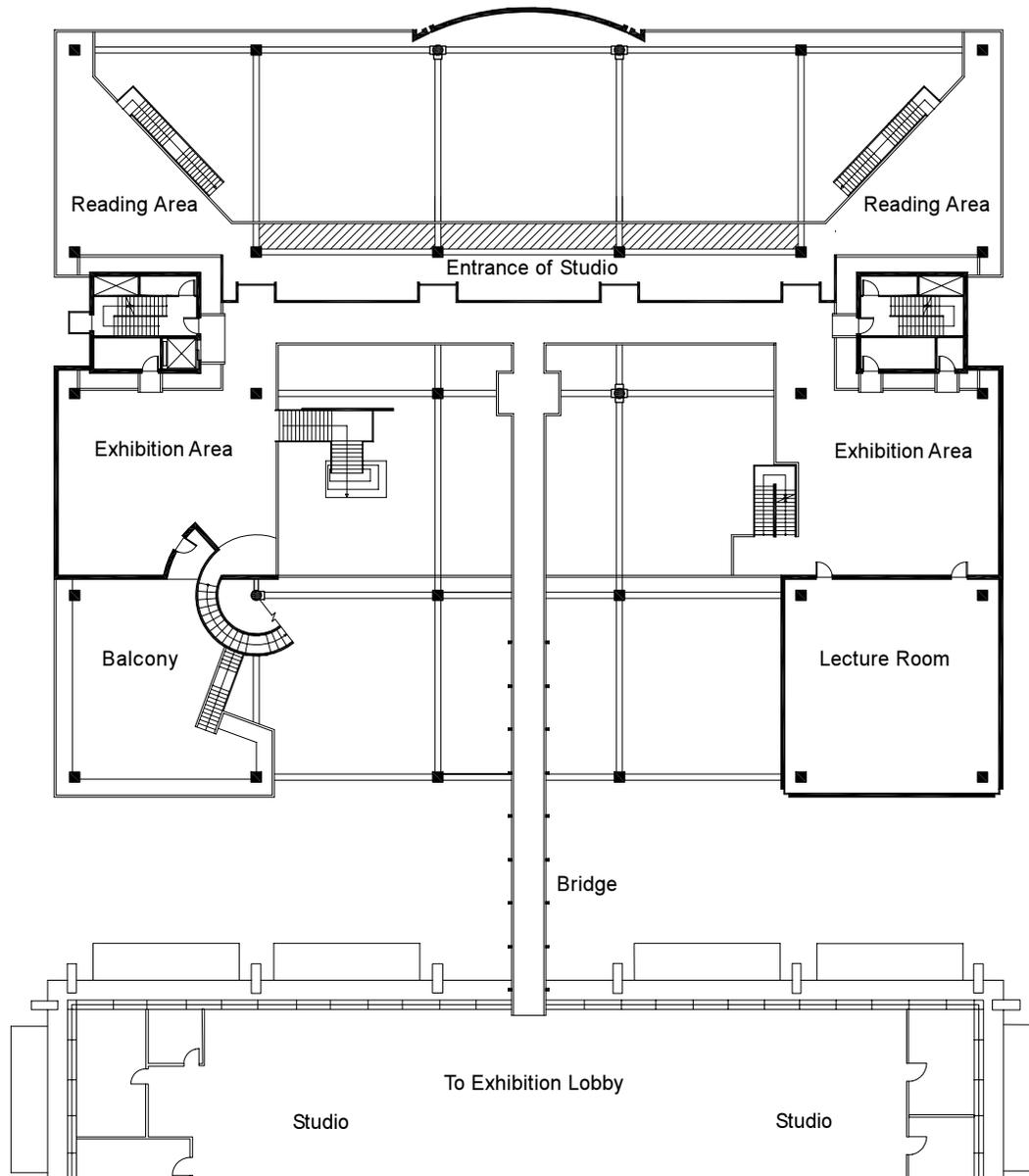
F. Plans, Elevations and Sections





1F Plan



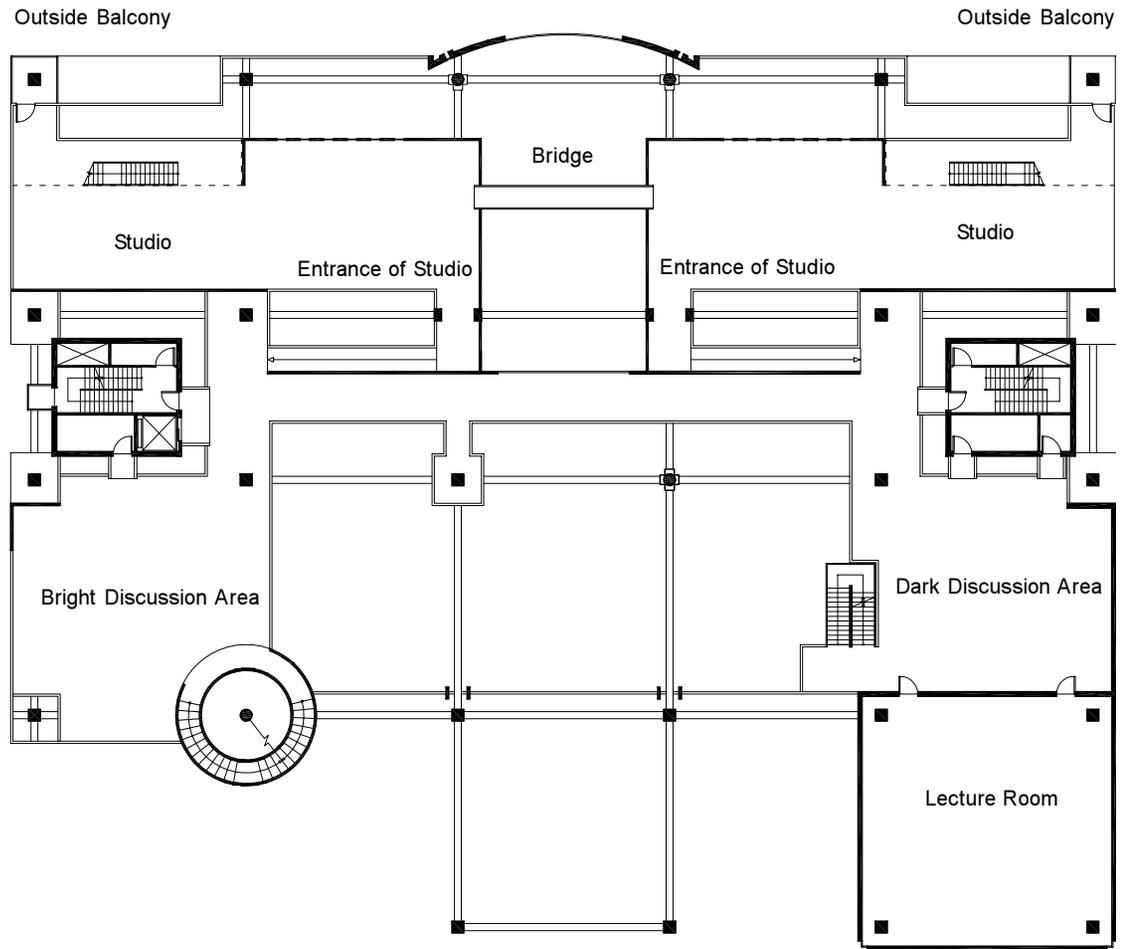


Addition

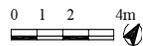
Cowgill Hall

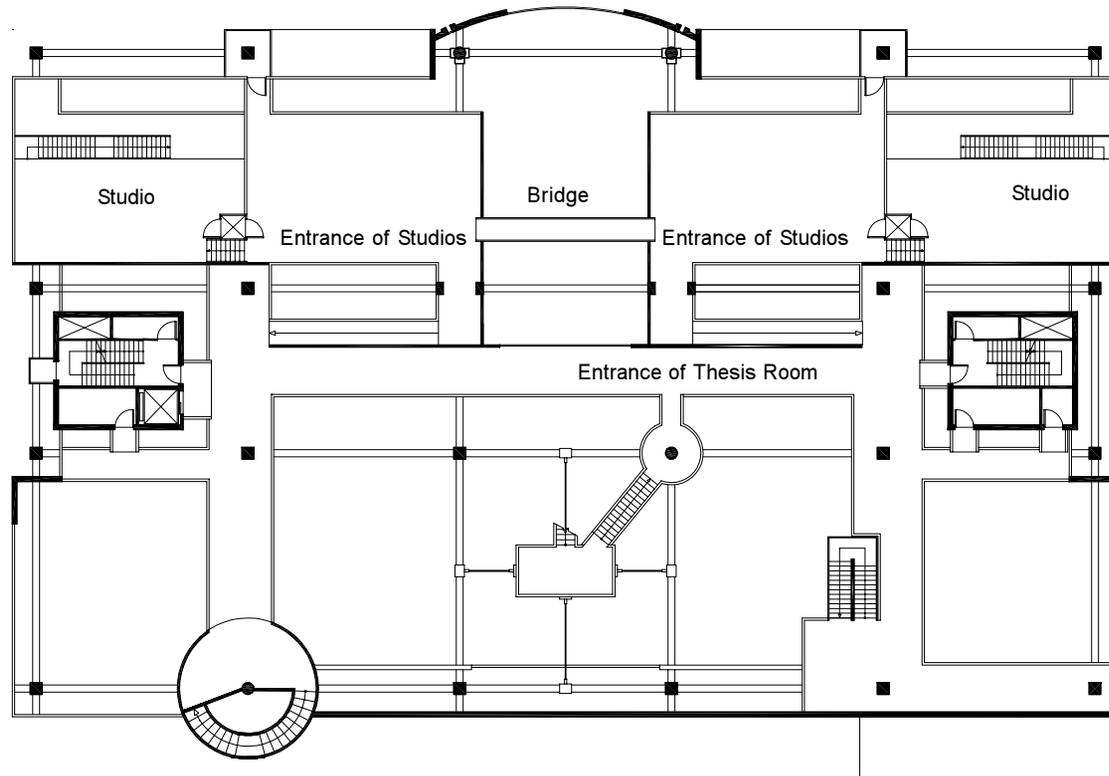
2F Plan





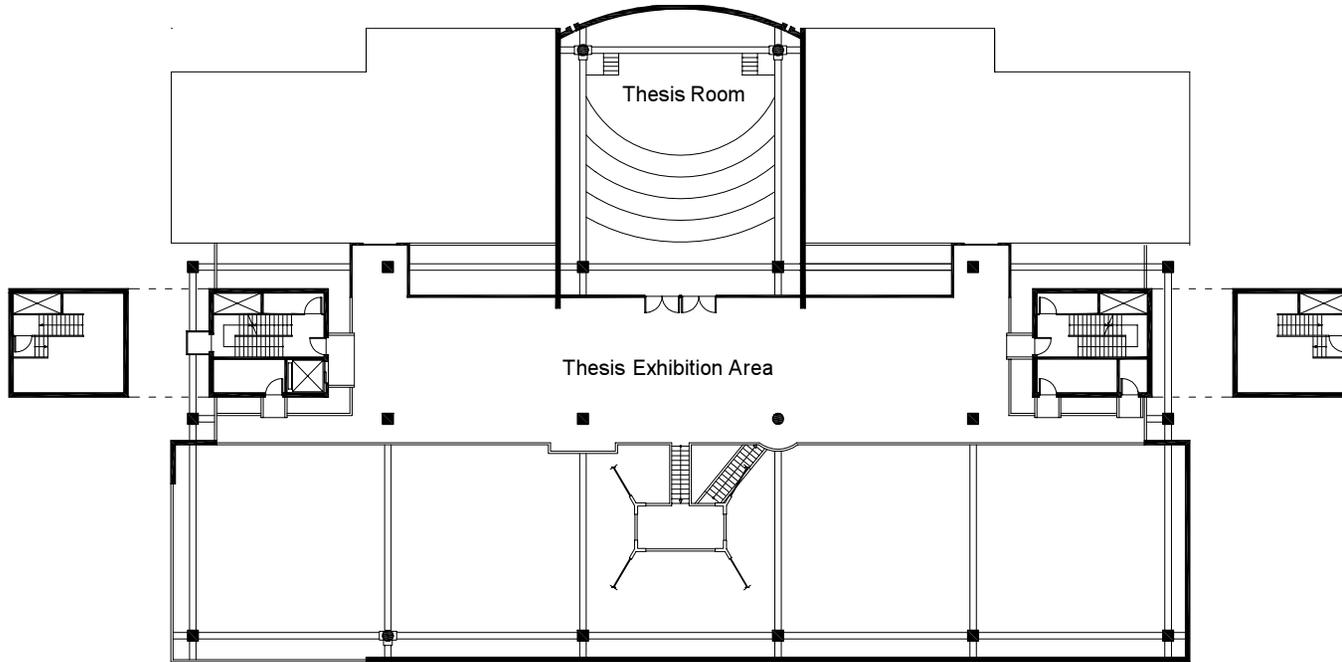
3F Plan





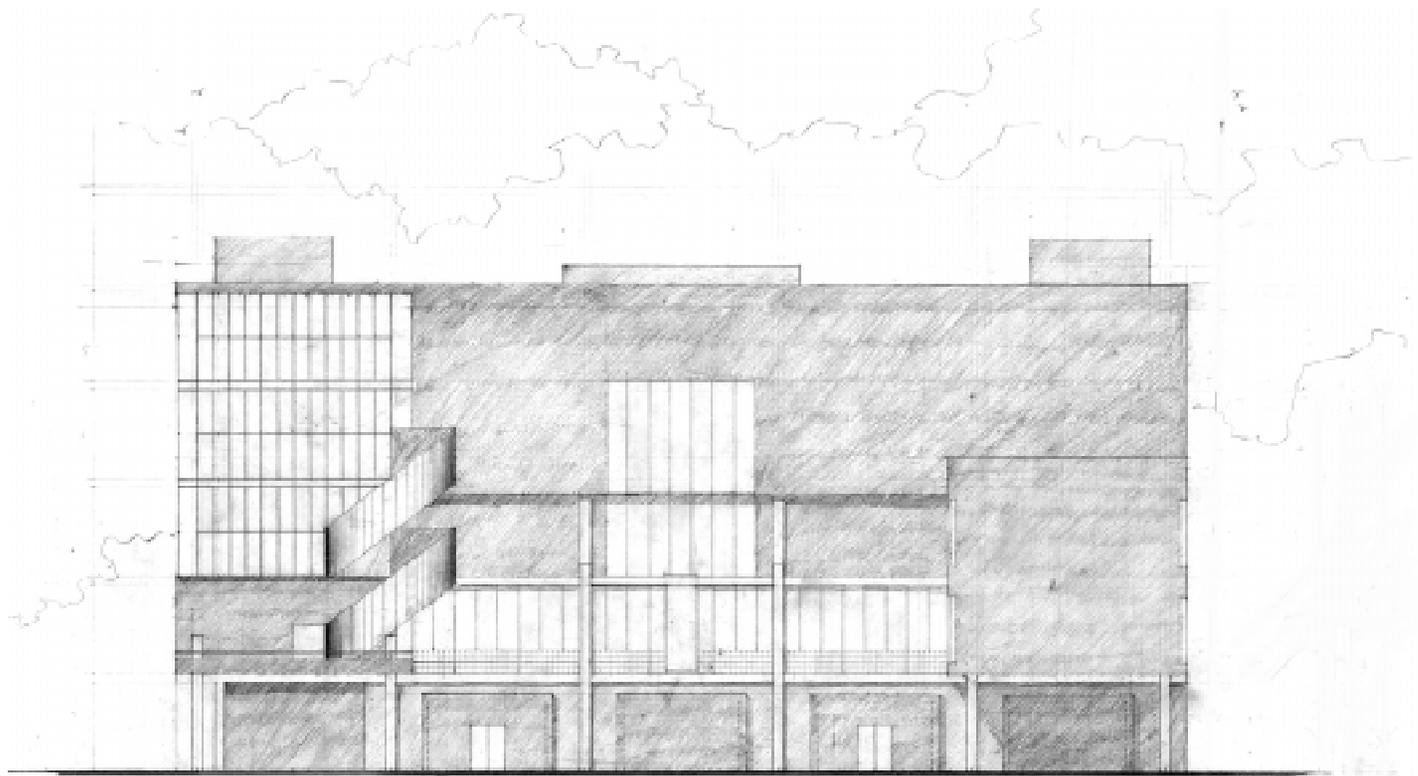
4F Plan



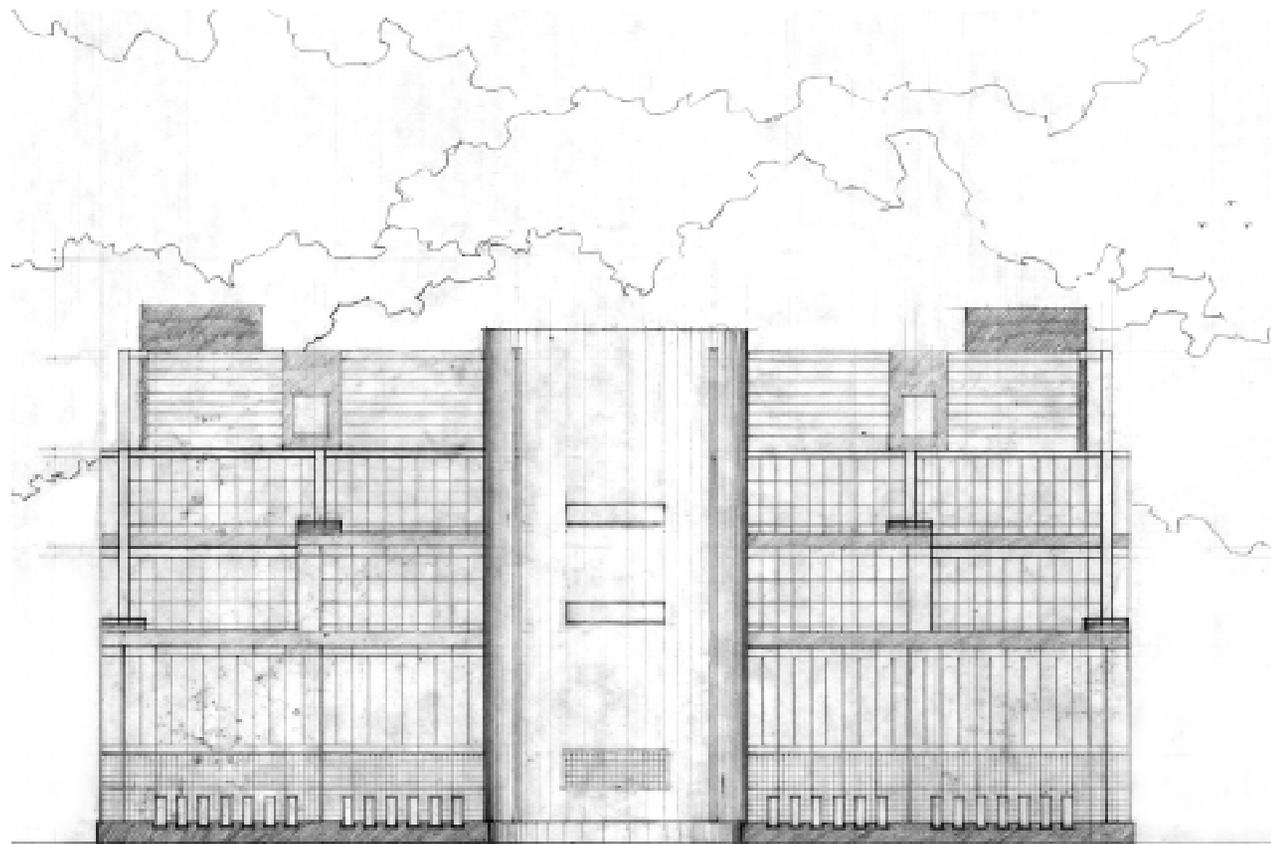


5F Plan

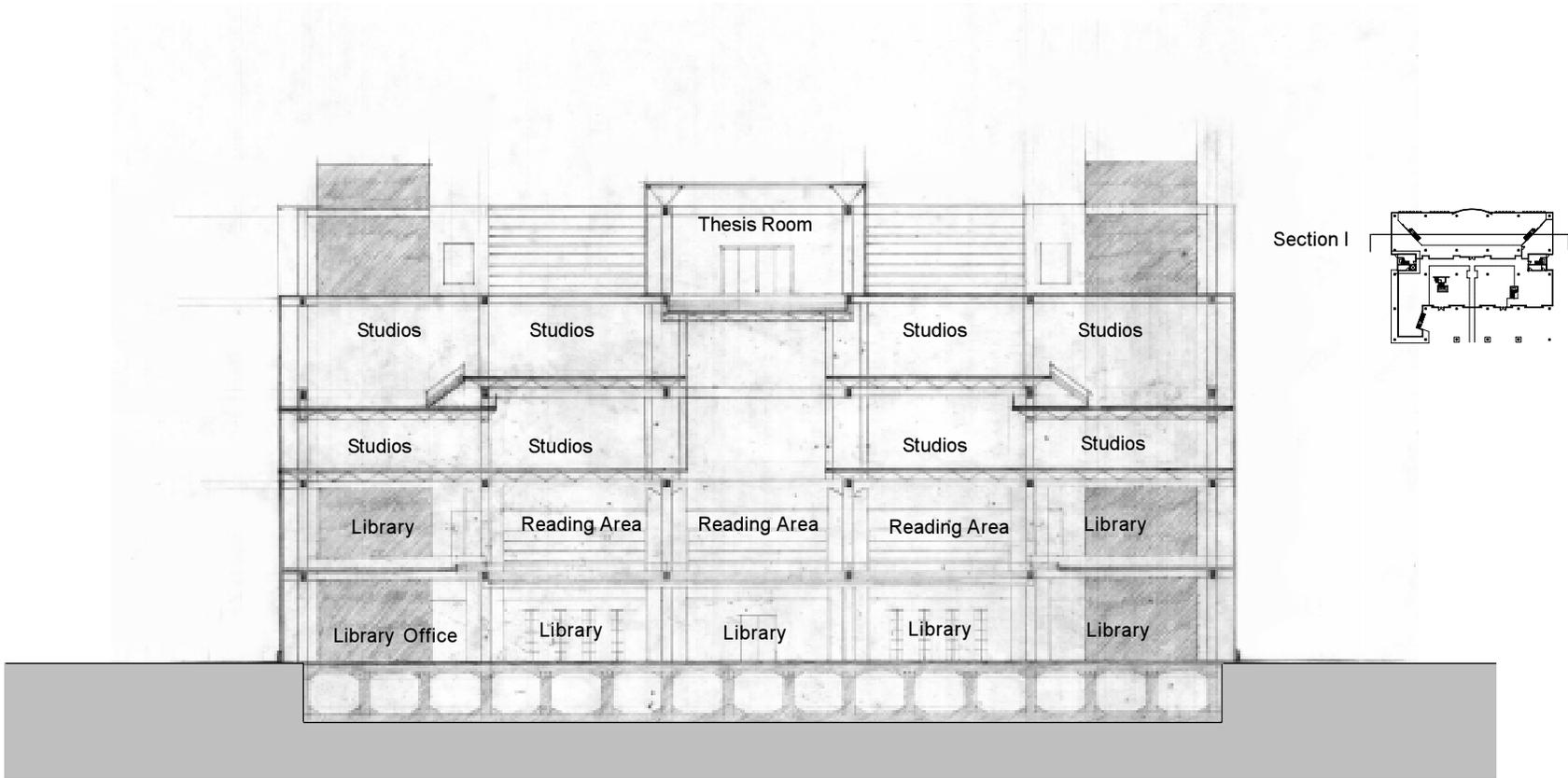




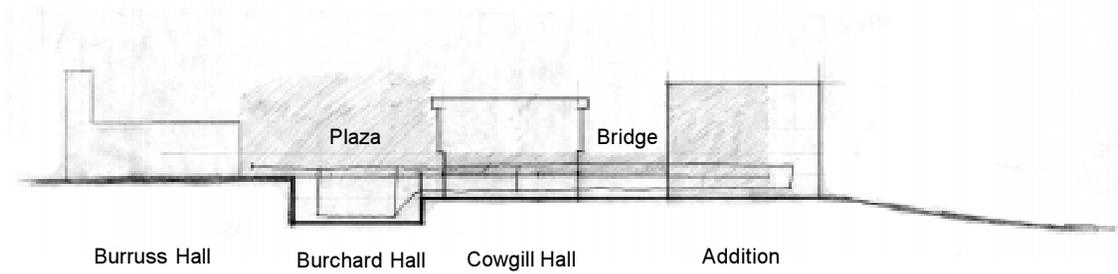
Southeast Elevation



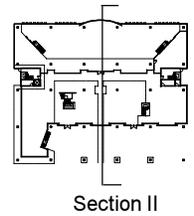
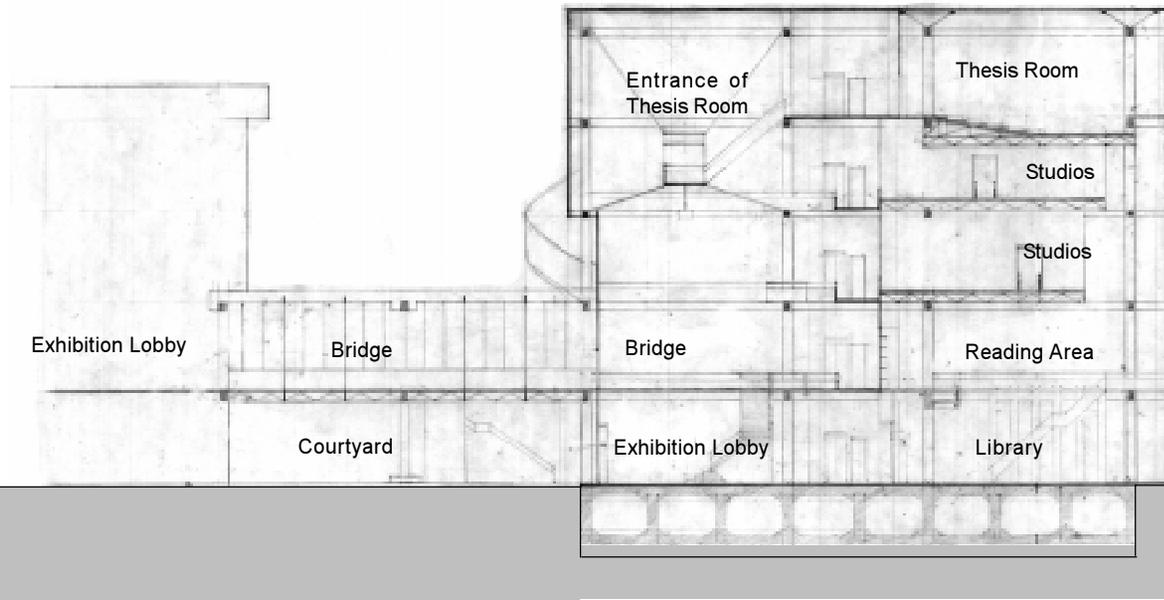
Northwest Elevation



Section I



Site Section



Section II

Cowgill Hall

Addition

Section II

G Photos

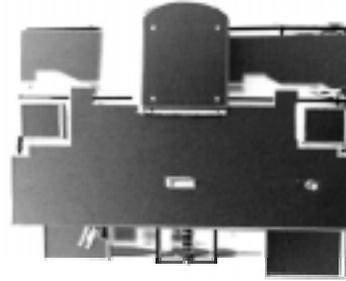
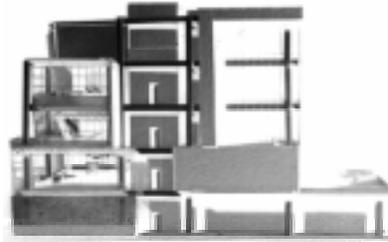
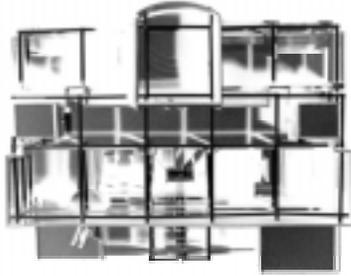




Figure 52.1 Southern view of Cowgill Hall and Addition

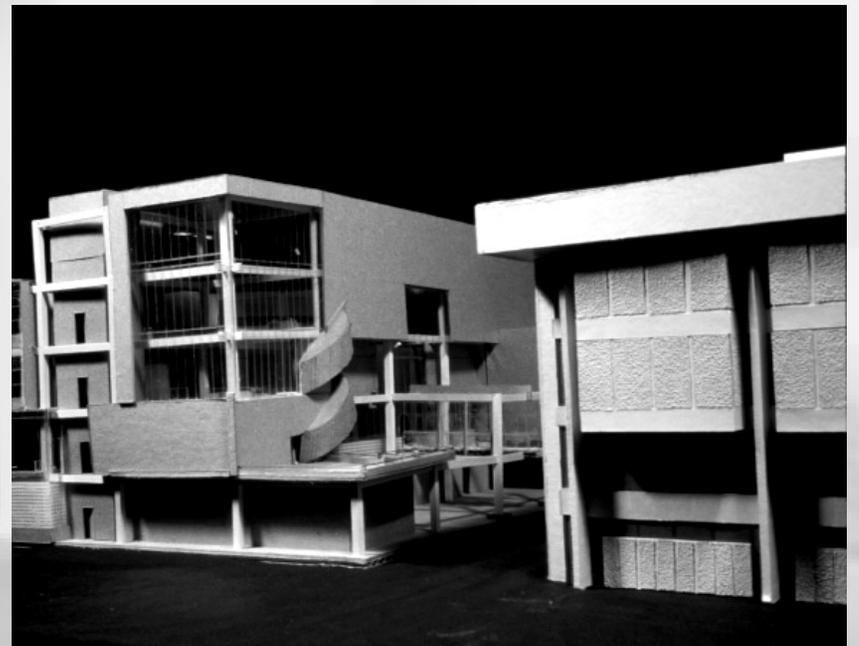


Figure 52.2 Southern view of Cowgill Hall and Addition



Figure 53.1 Eastern view of Cowgill Hall and Addition

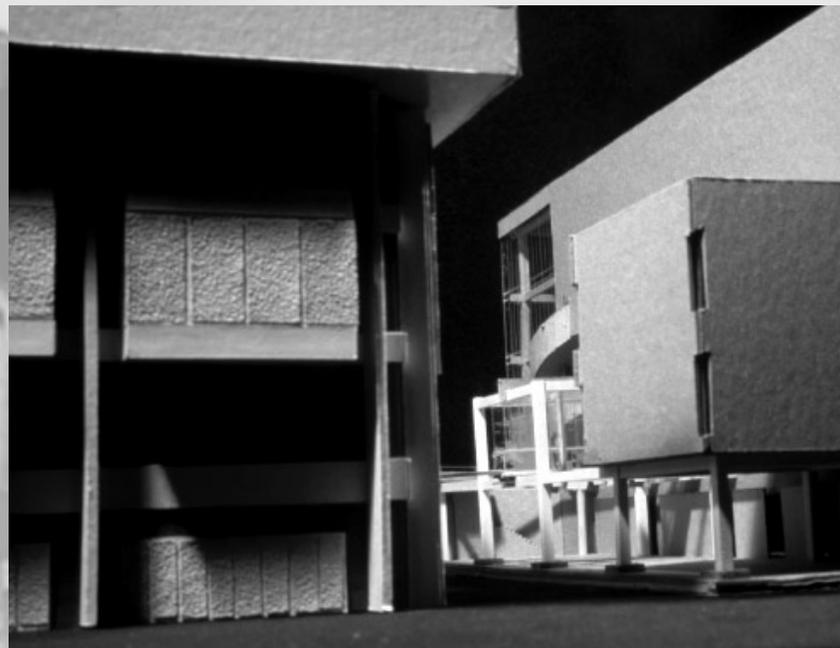


Figure 53.2 Western view of Cowgill Hall and Addition



Figure 54.1 Northeastern view of Cowgill Hall and Addition

Figure 54.1 Southwestern view of Cowgill Hall and Addition

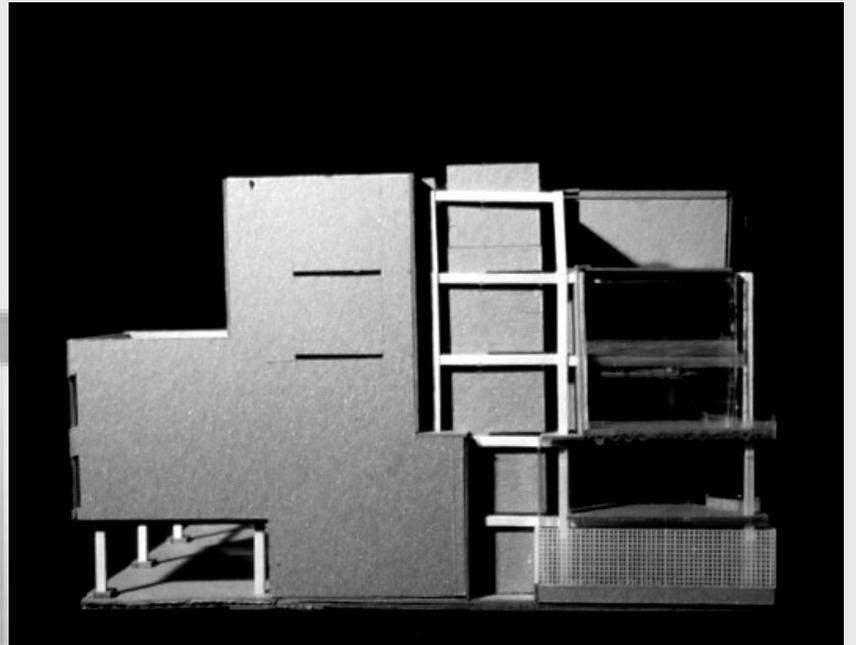




Figure 55.1 Top of the Addition (with roof)

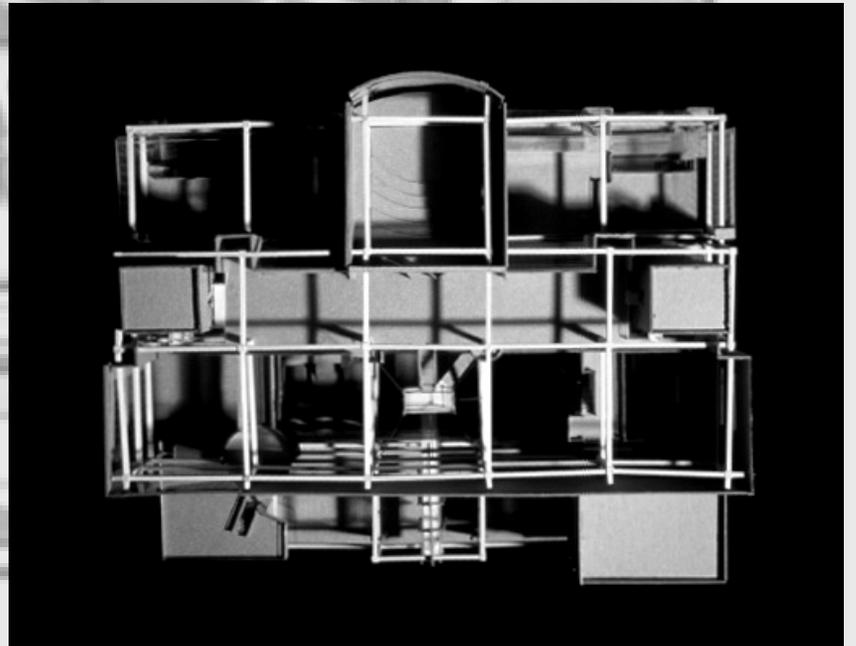
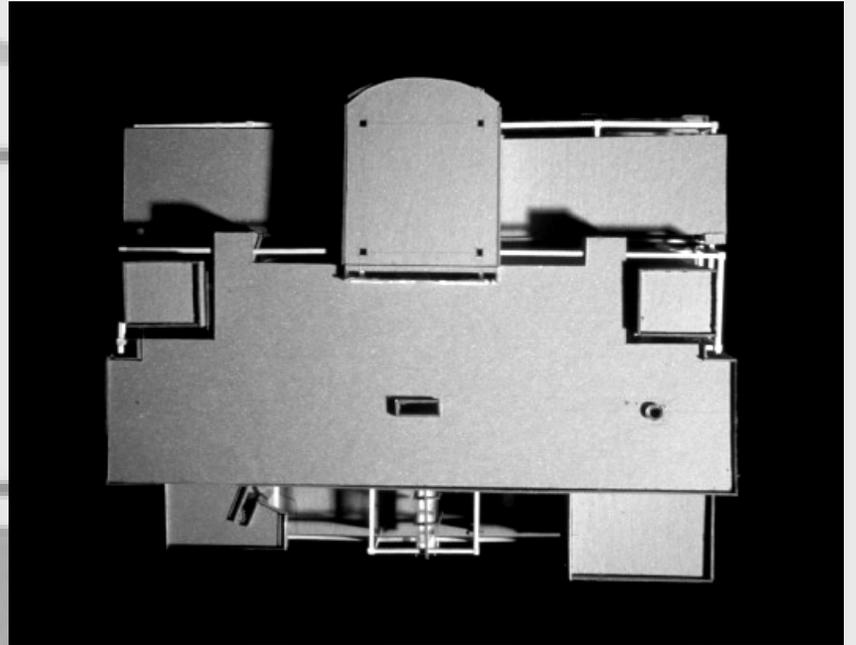


Figure 55.1 Top view of the Addition (without roof)

Photography Credit

- The Chapel of Ronchamp, Patrick Nuttgens, The Story of Architecture, Phaidon Press Limited, Page 270
- P. 2 Marquette Building, Hugh C. Miller, The Chicago School of Architecture, Department of The Interior-National Park Service U.S, Page 17
- P. 3 Parthenon, Patrick Nuttgens, The Story of Architecture, Phaidon Press Limited, Page 97
- P. 3 Durham Cathedral, Patrick Nuttgens, The Story of Architecture, Phaidon Press Limited, Page 133
- P. 3 TWA Terminal of J.F.K. International Airport, Patrick Nuttgens, The Story of Architecture, Phaidon Press Limited, Page 286
- P. 3 Marquette Building, Hugh C. Miller, The Chicago School of Architecture, Department of The Interior-National Park Service U.S, Page 17
- P. 5 1999 Topographic & Base Maps, Capital Design And Construction Department, Virginia Polytechnic Institute and State University. <http://www.cdcd.vt.edu>

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