

Atrium Defines Form

Design Research project APG5058S

Design report submitted in partial fulfilment of the degree
Master Of Architecture (Professional)

by

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University of Cape Town

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The natural environment is deteriorating and electricity demand is outstripping supply partly due to our growing built environment and economy.

In response there is a need for energy efficient office space to accommodate economic growth and help with the conservation of the environment. The inner city is a perfect location to achieve this using already deteriorated land and increasing the inner city density to reduce urban sprawl. There is an urgent need for developers to invest into the idea of energy efficiency however this has been restricted because of our economic environment and the need for just usable space. The creation of energy efficient buildings is typically more expensive mainly due to the introduction of new technologies and materials.

Energy efficient buildings in South Africa are typically standard in form because they focus on the materials and technologies. This does not create an identity and does not speak a language of energy efficiency. The possibilities of energy efficiency are not only in the materials and making of the building but also possibly in the form which could give energy efficient buildings identity.

This Architectural thesis involves the Introduction of the atrium to office buildings as a method to increase building efficiency, spatial quality and identity in the context of Cape Town.

Many buildings In Cape Town are largely inefficient and have started to become retrofitted with technologies to increase building efficiency. The issue of deep floor plates which result in requiring more energy for artificial lighting and ventilation is a major engagement in this project. Deep floor plates also create large scale spaces with no connection to the exterior, resulting in people feeling anonymous and disorientated in the work environment

Over the course of the year this thesis has looked at the atrium, trying to find a balance between site and economic constraints, light quantities, creation of spatial links and creating identity through architectural expression in Cape Towns inner city.

The document starts off by introducing the site and its constraints, which led to first study models which looked at massing experiments. The following section briefly explains the macro and micro climate which is important in understanding passive heating and cooling strategies for the context of Cape Town. To further understand the implications that climate has on a building, an analysis on the effects of the Climate on a chosen mass was performed. This lead to a first design option 'Form Follows Efficiency'. The following chapter (Technology document) looks at the ways in which two different buildings reduce operational energy through passive design techniques. The following chapter (Theory document which was re-worked) focuses on atrium aesthetic, structure, function, natural lighting & ventilation, planning, materials, and economics.

The following chapter looks at a second exploration into atrium creating spatial quality and an identifiable form, keeping in mind light quality and bulk. The third design exploration looks at the expression of the form to create identity which lead to final design development ideas.

First set of study models

The construction a set of study models looking at methods of introducing natural light and ventilation into a deep site. The strategies involved introducing atriums, cutting away at the facade, stepping back the floors and varying the building height.

The layouts all followed a similar constraint of having a floor plate depth of no more than 15m and the height could not exceed 60m (the height restriction for the site).

In the study I could see that there was a relationship between the depth and width of the atrium. In the smaller atriums it appeared that not a sufficient amount of light was entering, thus either a large atrium is required to allow light to enter very deep or the height of the building must be reduced.



Model 1 (The Standard)



Model 2 (Tubular)



Model 3 (The Pitchfork-surface area)

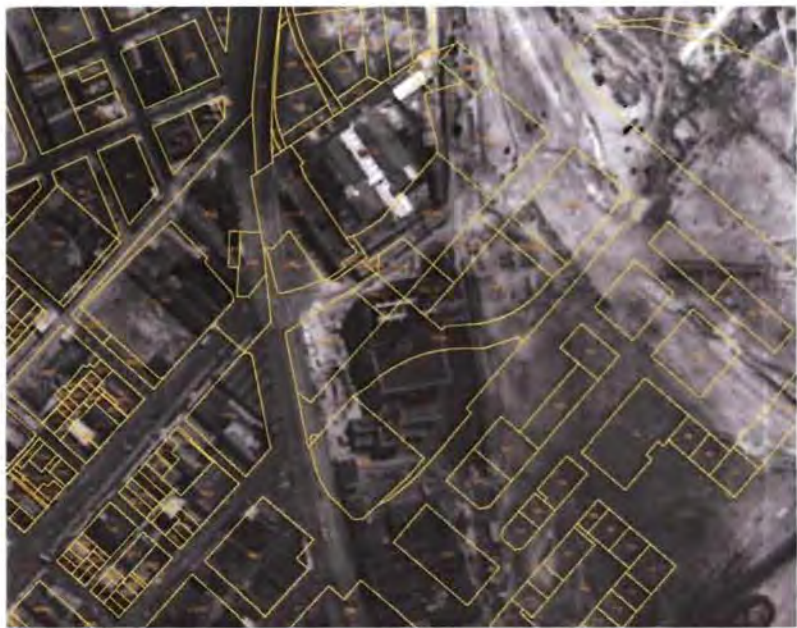


Model 3 (Porosity tapering down)

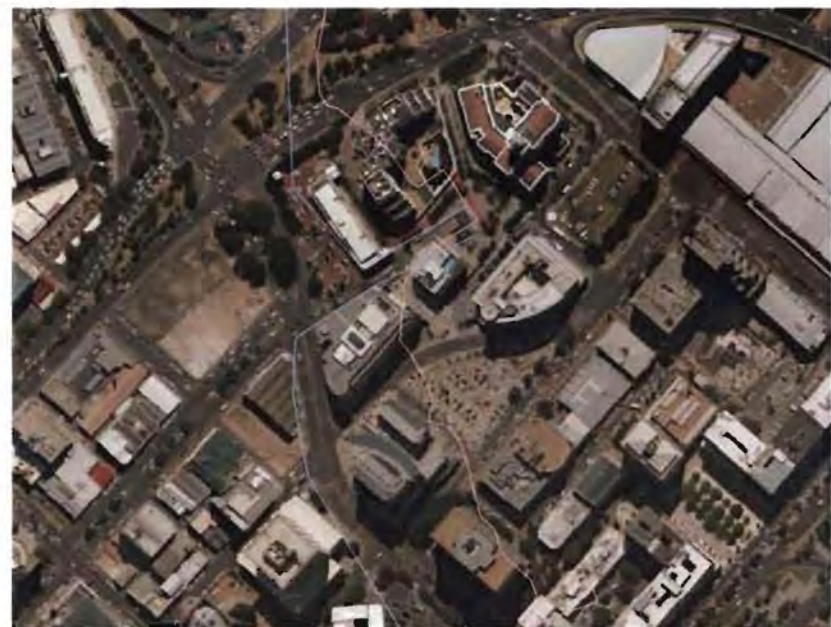


Model 5 (Tapering void)

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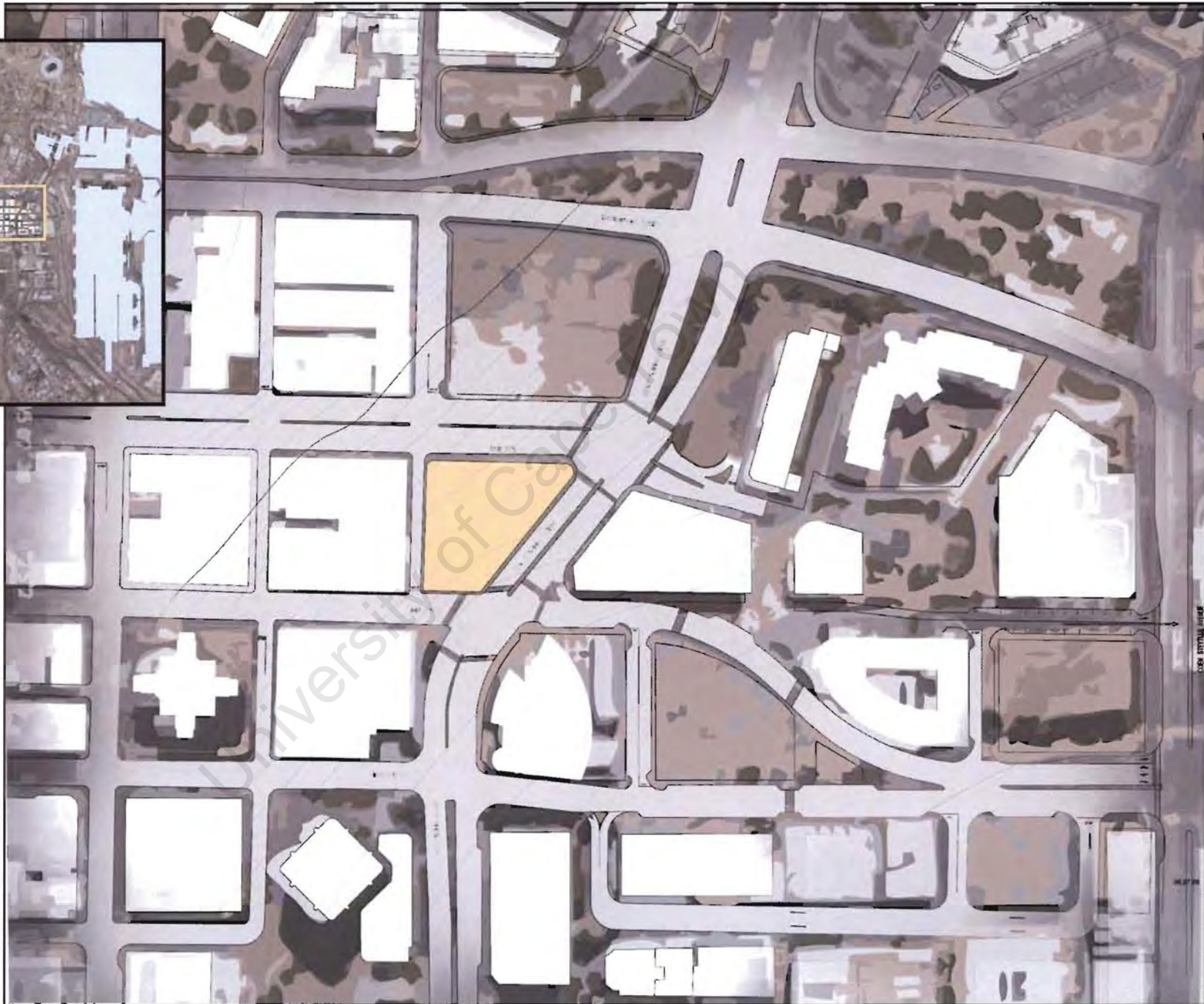


1945



2009

The site is located on the edge of Cape Towns CBD and used to be on the edge of the ocean in 1862. The building which is currently on the site appears to have been built pre 1945. Buildings in the area are constantly being renewed. The decision was made to demolish the existing two story building and rebuild a form with a new identity.



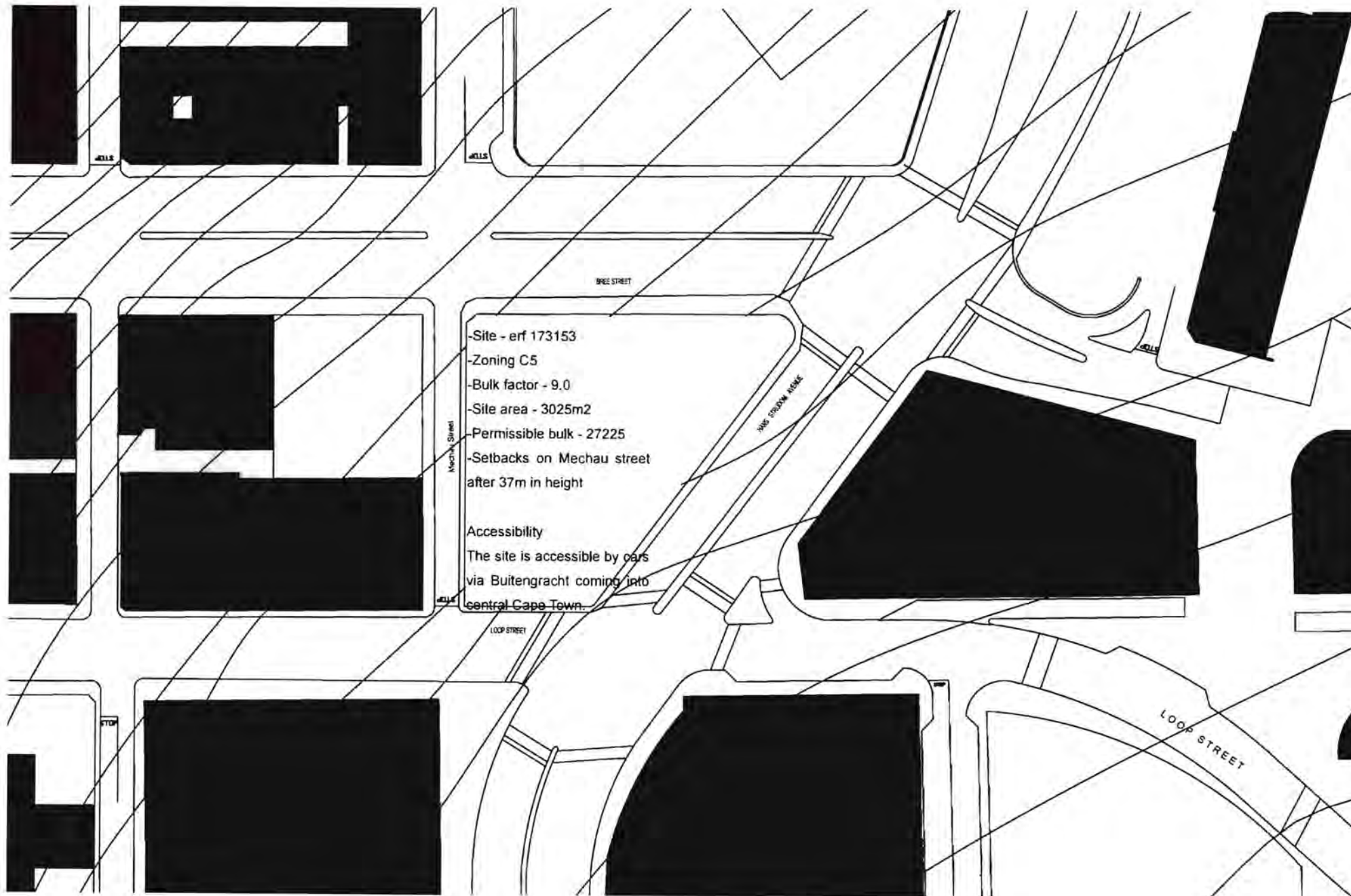
Site location plan
1:2500



View from South of Site



View from North of Site



-Site - erf 173153
-Zoning C5
-Bulk factor - 9.0
-Site area - 3025m2
-Permissible bulk - 27225
-Setbacks on Mechau street
after 37m in height

Accessibility
The site is accessible by cars
via Buitengracht coming into
central Cape Town.

Urban Study

Findings

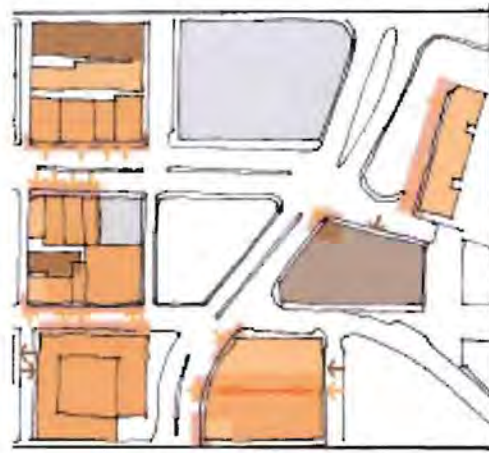
Entrances to retail / restaurants (Urban Activation) open onto Loop and Bree. Parking entrances open onto streets perpendicular to activated streets. The first floor accommodates less public activities such as offices and parking, above which is office space or parking on higher floors. After the fourth floor buildings are occupied by either offices or accommodation.

Buildings found to the South side of the site are skyscrapers whereas on the North edge buildings are low rise. The site is on the boundary of the CBD

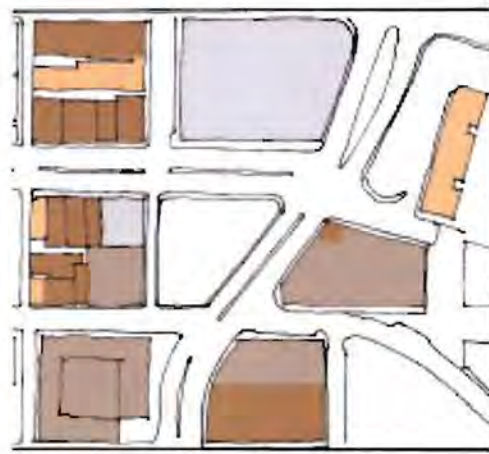
Key

-  Retail - Restaurant
-  Retail - Shops
-  Commercial - Office
-  Parking
-  Vacant
-  Parking Entrance
-  Building Entrance
-  Throughroute

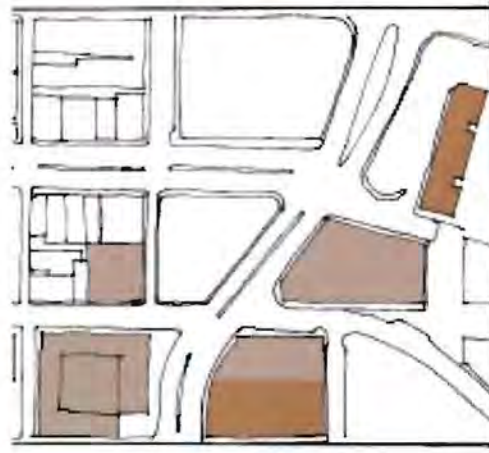
Ground floor



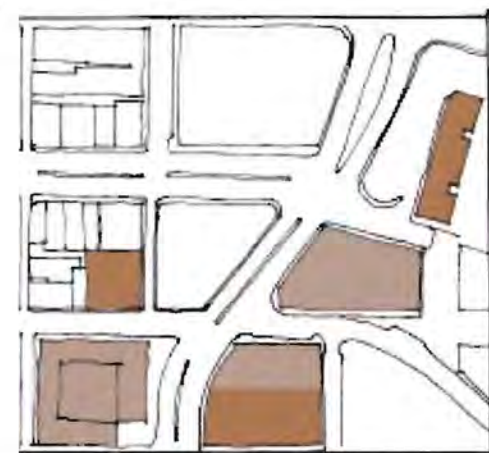
1st floor



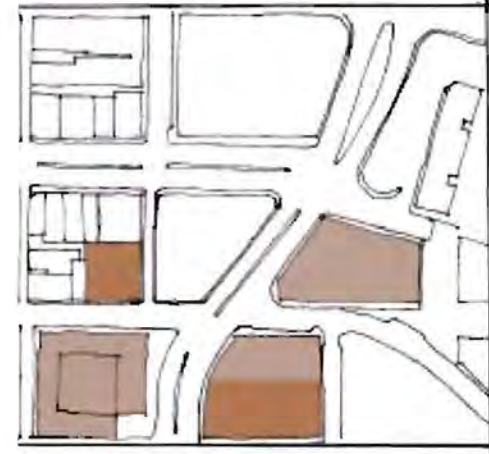
2nd floor



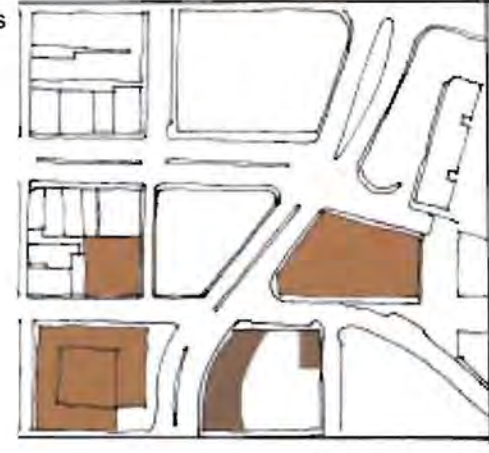
3rd floor



4th floor



5-... floors





Offices

Office building typologies develop and change over time, which must be accounted for. Office typologies continue to change as technology changes and thus the style of working. Designers can influence all aspects of the working environment, however it is important to create a space which has a good quality of space in order to increase productivity and work satisfaction

Approximately 65 percent of the working day is spent in individual work stations, 10% in extended work areas where shared spaces for equipment is becoming important, this results in the need for both individual and shared workstations.

New typologies of work stations are starting to take shape which incorporate interconnecting group offices with partially divided spaces, or the multiple workstation.

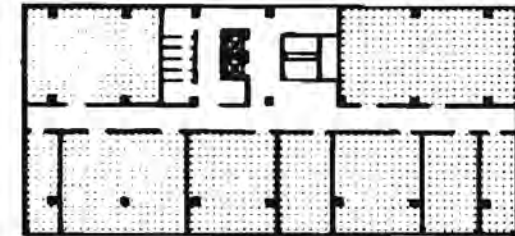
The floor area requirement in general for office space is roughly 8-10m² minimum for closed offices (this does not include circulation) and 12-15m² per worker which includes circulation space of 1.5m minimum.

The recommended ceiling heights for offices up to 50m² is 2.5m, 100m² is 2.75 and 250-2000m² of office the ceiling height can reach 3.25m. When trying to introduce more natural light however a higher ceiling may be appropriate.

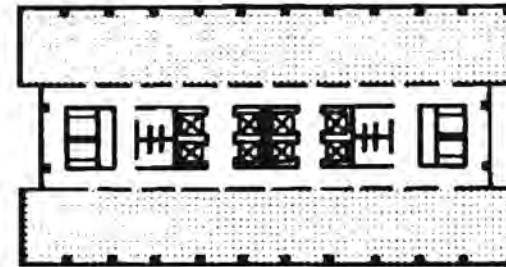
Depth of Space

The average depth of space is 4.5-6m deep. Daylight enters into a work station to a depth of approximately 4.5m from the window depending on the location of the window (there may be obstructions, or a different orientation)

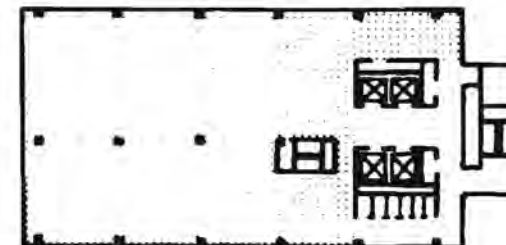
Offices require specific lighting quantities for various types of working environments. Technical drawing offices require large amounts of natural light up to 1000 lux where as general offices require no less than 300 lux



Double row layout



Three row layout



Open plan with corridor

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The massing studies were formed around the target of achieving a bulk of 23 000m², with a parking ratio of 2 bays per 100m².

Depending on the site coverage of each floor the height would vary. The objective was to find the best arrangement which allowed the most amounts of light to enter as well as experimenting with form, orientation, height, floor area and parking. All experiments had the same amount of bulk and followed the constraint that the floor plates could not be deeper than 15m otherwise sufficient amounts of light would not be achieved. This also made it possible to compare results in order to make a decision to the most desirable arrangement.

Option 1



Floor area - 820m²
 Number of floors - 33
 Orientation - North, South

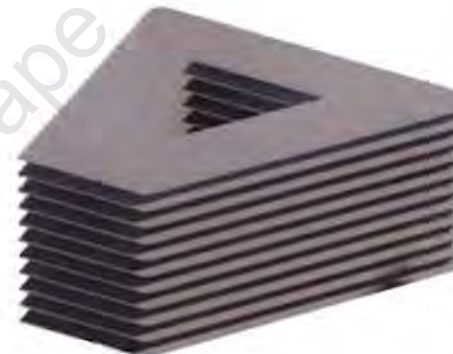
Height - Floor area is too small resulting in a tall building requiring a lot of structure.
 Atrium - No atrium required as ample light enters the space due to the floor plate depth.

Office, Circulation (excluding parking)

Circulation - 15% circulation of 820m²= 123m²
 Office space - 697m² of office Per floor, 23001m² of office space in total (**23%** of total site area)

Office space - 360m² per floor, 11880m² in total (**12%** of total site area)

Option 2



Floor area - 2500m²
 Number of floors - 11
 Orientation - North/West, North/east

Height - efficient usage of site area resulting in a lower building.
 Atrium - 28m X 32m diffusing light into 11 floors

Office, Circulation (excluding parking)

Circulation - 15% circulation of 2500m²= 375m²
 Office space - 2125m² of office Per floor, 23375m² of office space in total (**70%** of total site area)

Circulation, Parking, Office

Using the ratio of 2 parking bays per 100m² (parking of 22m² per bay)

Circulation - 375m² per floor
 Parking - 2125m² of usable office space= 935m² of parking per floor (42bays)
 Office space - 1190m² per floor, 13090 in total (**39%** of total site area)



June at 09:00am



June at 12:00pm



June at 03:00pm



June at 09:00am



June at 12:00pm



June at 03:00pm

Option 3

Height - Relatively economical site area usage thus a low number of floors.

Atrium - The atrium varies from 20m wide at the top to 18m wide at the base.

Office, Circulation (excluding parking)

Circulation - 15% circulation of average 1908m²= 286m²

Office space - 1640m² of office Per floor, 26240m² of office in total. (54% of total site area)

Circulation - 286m² per floor

Parking - 1640m² of office space= 721m² of parking per floor (33bays)

Office space - 919m² per floor, 14704m² in total (30% of total site area)



Floor area - 2231m², 2058m², 1907m², 1682m², 1605m²
 Number of floors - 4, 4, 3, 3, 2 (16)
 Orientation - North/West, North/east



June at 09:00am

June at 12:00pm

June at 03:00pm

Option 4

Height - Relatively economical site area usage, allowing ample light to enter the building

Atrium - Building has a waved facade to allow for north light to penetrate into the spaces, the atrium is 20m X 32m allowing ample light to penetrate.

Office, Circulation (excluding parking)

Circulation - 15% circulation of 2160m²= 323m²

Office space - 1837m² of office Per floor, 23881m² of office in total (61% of total site area)

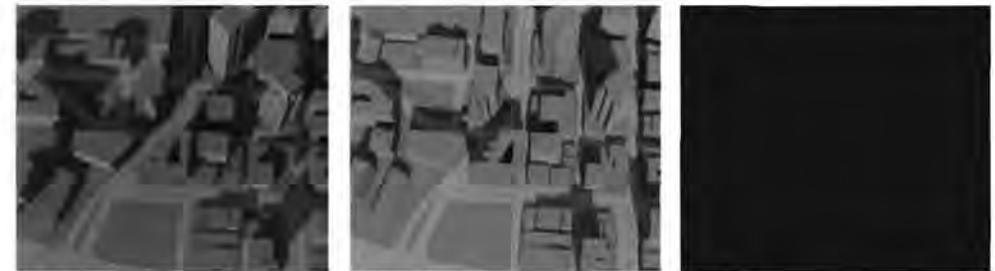
Circulation - 323m² per floor

Parking - 1837m² of usable office space= 824m² of parking per floor (38bays)

Office space - 1049m² per floor 13637m² total (35% of total site area)



Floor area - 2160m²
 Number of floors - 13
 Orientation - North/West, North/east



June at 09:00am

June at 12:00pm

June at 03:00pm

Option 5

Height - Relatively economical site area usage, the height is a result of the need to capture maximum North light.

Atrium - Building is separated into 3 segments creating the opportunity for natural light and ventilation.

Office, Circulation (excluding parking)

Circulation - 15% circulation of 2160m²= 260m²

Office space - 1470m² of office Per floor 23520m² of office space in total **(49% of total site area)**

Circulation - 260m² per floor

Parking - 1470m² of usable office space= 647m² of parking per floor (30bays)

Office space - 823m² per floor, 13168m² in total **(27% of total site area)**



Floor area - 420m², 820m², 490m²
 Number of floors - 7, 14, 26
 Orientation - North, South



June at 09:00am



June at 12:00pm



June at 03:00pm

Option 6

Height - Relatively economical site area usage thus a low number of floors.

Atrium - The atrium is 18m wide.

Office, Circulation (excluding parking)

Circulation - 15% circulation of 1584m²= 240m²

Office space - 1344m² of office Per floor, 22848m² of office in total. **(44% of total site area)**

Circulation - 240m² per floor

Parking - 1344m² of usable office space= 591m² of parking per floor (27bays)

Office space - 753m² per floor, 12801m² in total **(25% of total site area)**



Floor area - 1584m²
 Number of floors - 17
 Orientation -



June at 09:00am



June at 12:00pm



June at 03:00pm

Option 7

Height - Relatively economical site area usage, allowing ample light to enter the building on the south facade

Atrium - Building has a curved facade to allow for north light to penetrate into the spaces, this creates an atrium which is protected from the west light. The atrium is 27m wide allowing ample south light to enter the space.

Office, Circulation (excluding parking)

Circulation - 15% circulation of 1590m²= 240m²

Office space - 1352m² of office Per floor, 22984m² of office in total (**45% of total site area**)

Circulation - 240m² per floor

Parking - 1352m² of usable office space= 595m² of parking per floor (28bays)

Office space - 757m² per floor, 12869m² in total (**25% of total site area**)



Floor area - 1590m², 820m²
 Number of floors - 15, 3 (18)
 Orientation - North/West, North/east



June at 09:00am



June at 12:00pm



June at 03:00pm

Parking Arrangement



15 stories, 1 level - 2500m² retail, 10 levels - 22500m² office (excluding circulation), 4 levels - 10000m²- 2 parking bays per 100m² of office space (466 parking bays)

option 1 - parking above ground (reduces energy usage of excavating)

option 2 - parking is entirely under ground to reduce visual impact and disconnection between the ground floor public space and offices. Excavation use a lot of energy however the site is already half excavated, ventilation systems can be passive.

Preferable Massing Choice

The arrangement with the most floor area per floor resulting in the lowest building height became the most desirable choice. Option 2 allows for the largest atrium in relation to the depth which allows the most amount of light to filter into the space. The height of the building was low allowing the most amount of light to reach the street and neighbouring buildings.

It is the most simple arrangement which economically makes sense in that a simple structure, circulation and office arrangement can be imagined for this option.

Buildings are very site specific to the macro and micro climate, it is important to understand the geological location of the site in order to implement the most effective strategies to achieve comfort in a specific environment.

Macro

Cape Town resides in the temperate coastal zone, experiencing a subtropical Mediterranean climate which has warm, dry summers and mild wet winters. Winter occurs on average between the beginnings of June to the end of August, Cold fronts carrying heavy precipitation and strong North Westerly Winds come from the Atlantic Ocean. The majority of the annual rainfall occurs during the winter time, but due to the mountainous topography of the area precipitation can occur at various times of the year. Summer occurs on average between November and March which brings warm, dry conditions with strong South East winds, known as the Cape Doctor.

Micro

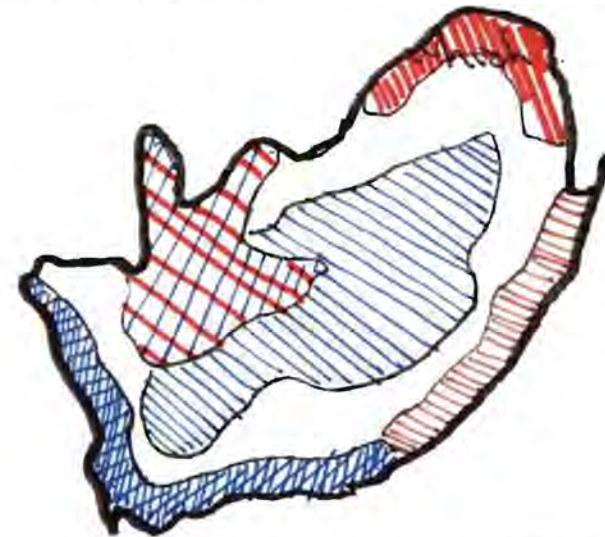
Cape Town Central Business District is influenced largely by its surrounding context and is an example of Compact urban form which effects the environment through man-made materials which conduct heat such as roof tops, roads and car parks. Cities in general are in response hotter than rural areas or spread urban areas. Buildings in central Cape Town can alter the wind patterns, which can affect the creation of heat islands, creating pockets of low and high pressure areas which also alter weather conditions.

Seasons

There are four different seasons in Cape Town, it is said that all four seasons can be experienced in one season and even within one day. It is important to consider when designing in Cape Town the fast changing environment the building has to deal with.

CLIMATIC ZONES

- Temperate coastal
- cold interior
- ARID INTERIOR
- SUB-TROPICAL COASTAL
- HOT INTERIOR
- TEMPERATE INTERIOR



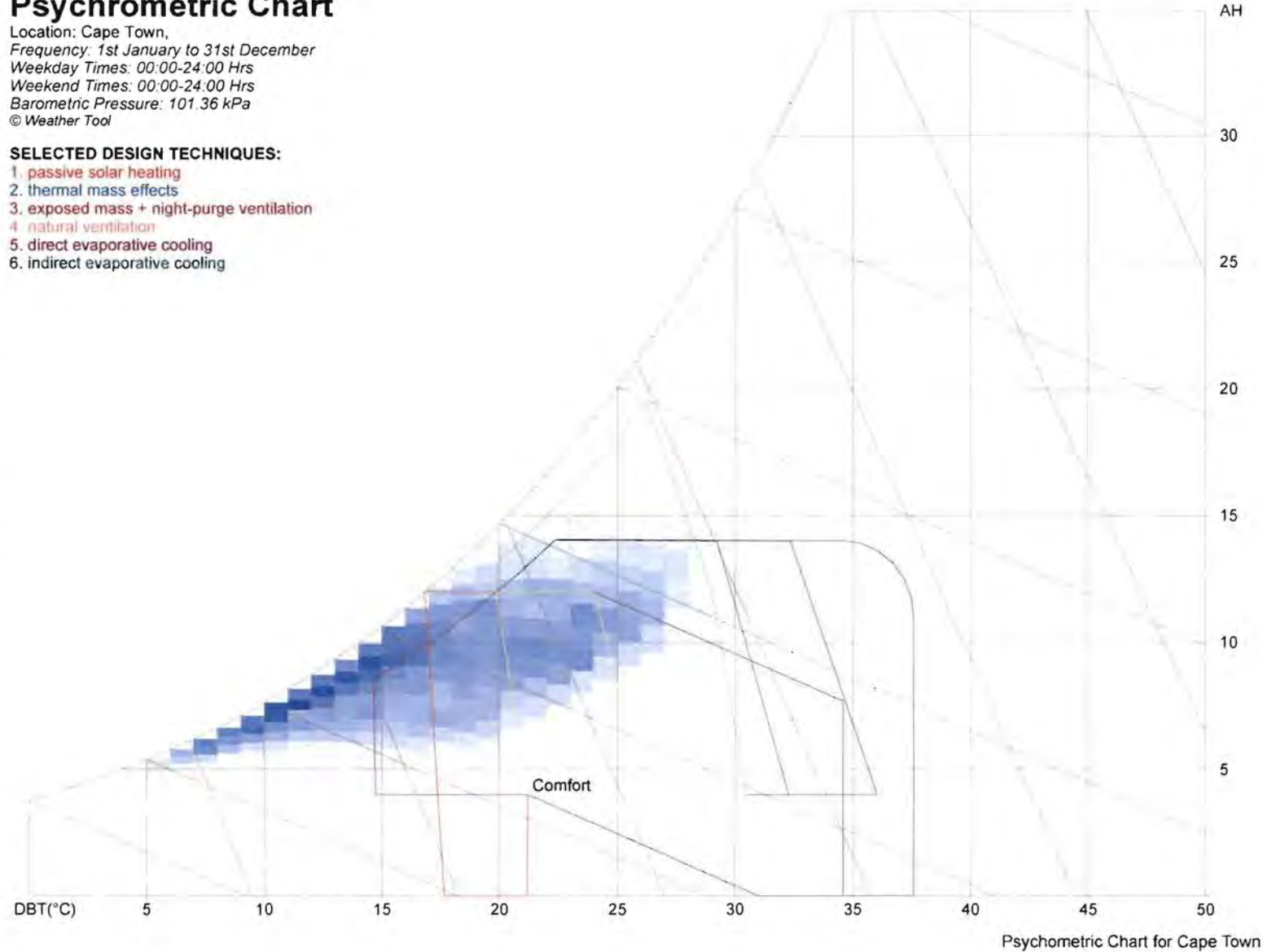
Climatic zones

Psychrometric Chart

Location: Cape Town,
Frequency: 1st January to 31st December
Weekday Times: 00:00-24:00 Hrs
Weekend Times: 00:00-24:00 Hrs
Barometric Pressure: 101.36 kPa
© Weather Tool

SELECTED DESIGN TECHNIQUES:

1. passive solar heating
2. thermal mass effects
3. exposed mass + night-purge ventilation
4. natural ventilation
5. direct evaporative cooling
6. indirect evaporative cooling

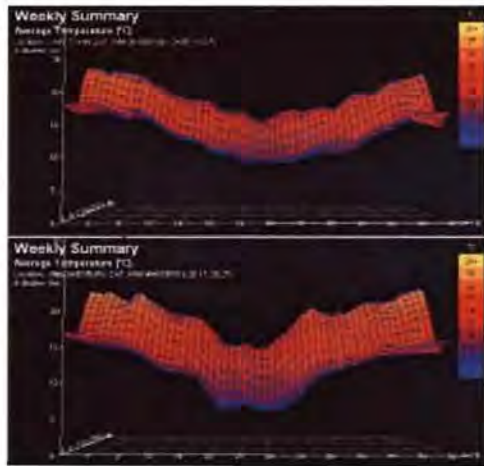
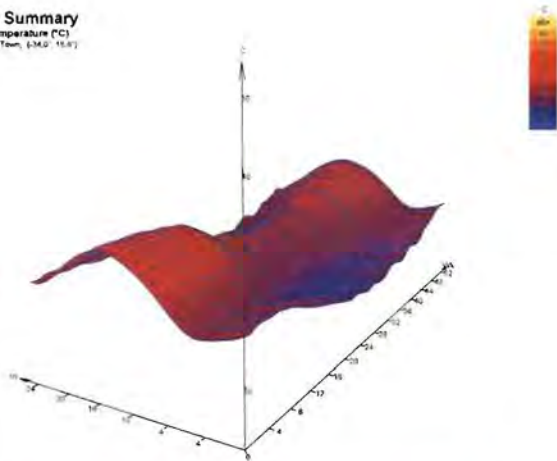


The Psychrometric chart

!1

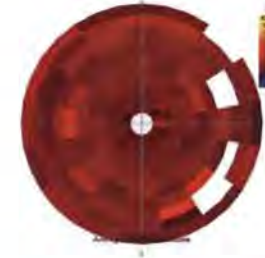
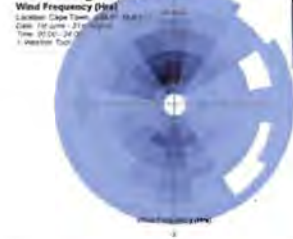
Indicates that with a good design, for a portion of the year a combination of natural ventilation and use of exposed thermal mass techniques and night purge ventilation may extend the comfort range for the building.

Weekly Summary
Average Temperature (°C)
Location: Cape Town, (34.0, 18.4)
Weather: Sun

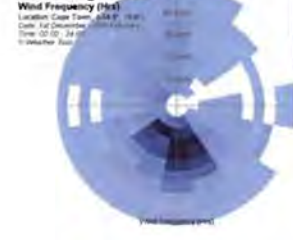


Average temperature

Prevailing Winds

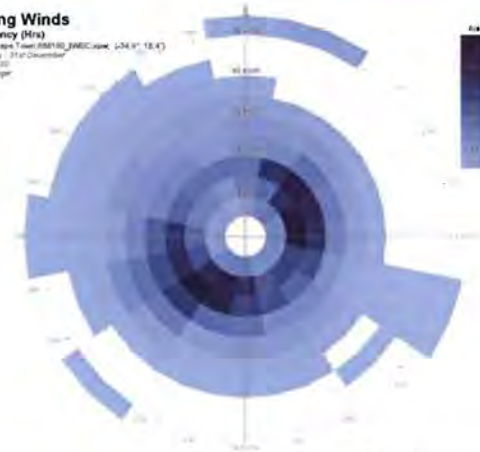


Prevailing Winds



Prevailing Winds

Wind Frequency (Hrs)
Location: CAP_Cape Town 00100_0000Cape, (34.0, 18.4)
Date: 1st January - 31st December
Time: 00:00 - 24:00
Weather: Sun

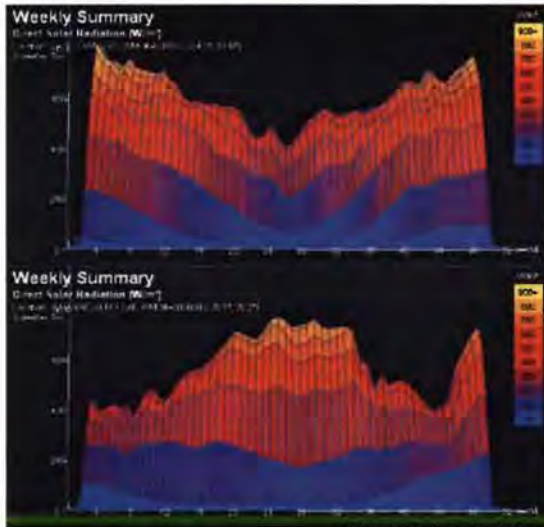
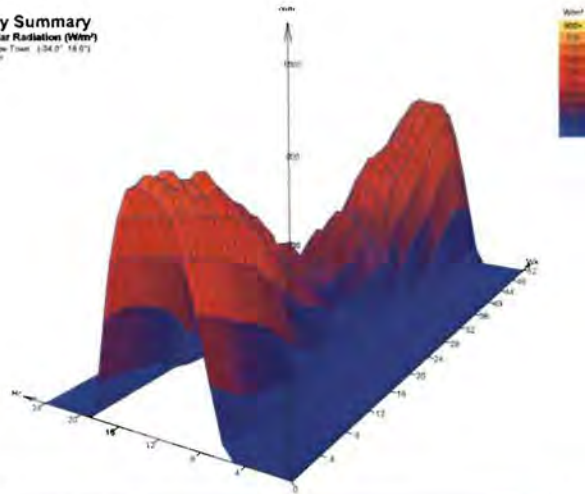


Prevailing wind

The temperature needs to be controlled in summer due to it being too hot and in winter due to it being too cold. Cape Town has less temperature fluctuations than Johannesburg (low diurnal temperature variations) thus day to day thermal mass strategies will not work as well in Cape Town, however seasonal thermal massing may be appropriate

- Prevailing wind from North West and South East
- North and South façade have to accommodate this.
- Cape Town average wind speed +/- 45 km/hr
- Warm winds in summer months thus natural ventilation can be useful.
- The wind is less humid in summer than in winter

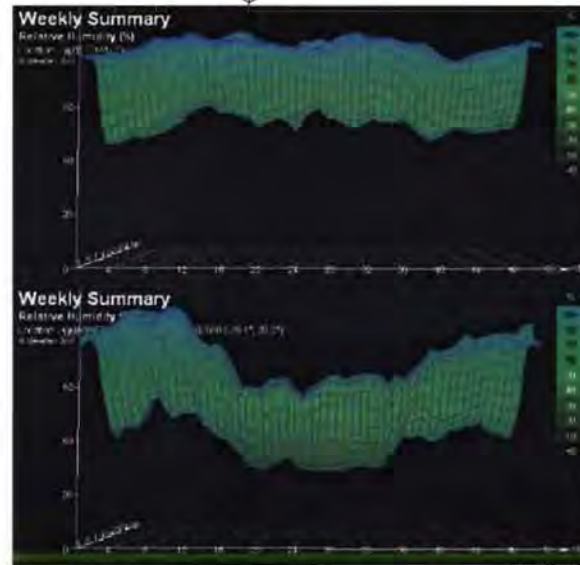
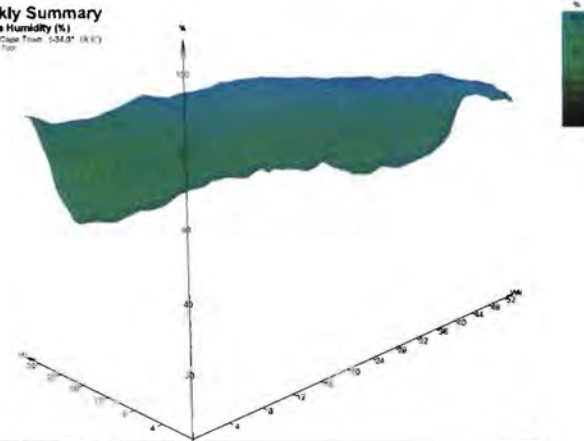
Weekly Summary
 Direct Solar Radiation (W/m²)
 Location Cape Town (-34.0° S 18.8° E)
 11/01/2017 - 17/01/2017



Direct Solar Radiation

- Radiation levels are very low in winter due to very high levels of humidity and overcast skies.
- Opportunity for the use of solar radiation for passive heating and as source of renewable energy.
- Harvest heat and storage thermal mass control system. In Cape Town high solar radiation during the summer months creates excessive heat gains when it is least needed.

Weekly Summary
 Relative Humidity (%)
 Location Cape Town (-34.0° S 18.8° E)
 11/01/2017 - 17/01/2017

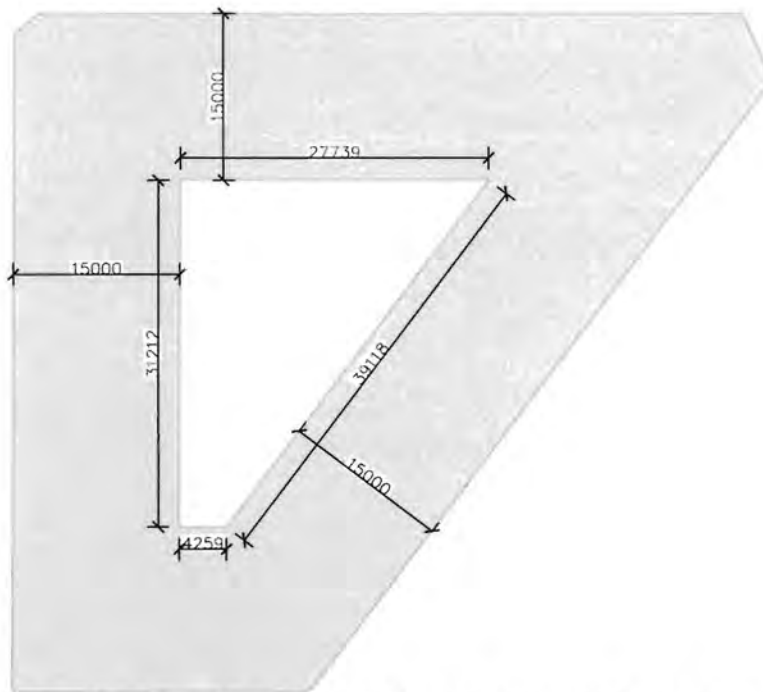


Humidity

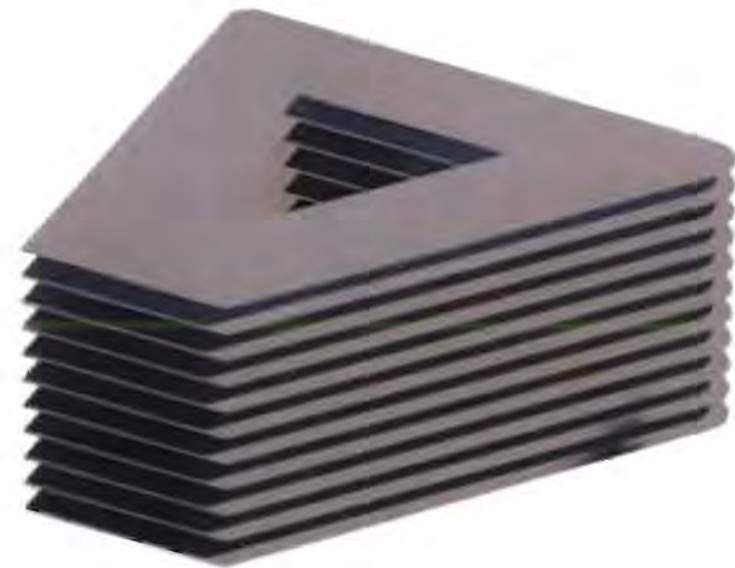
- Humidity is very high in winter months.
- Average humidity is consistently low during the day and very high both in afternoon and morning hours throughout the year.
- Evaporative cooling will be less successful in Cape Town than in Johannesburg due to the higher humidity levels

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An Ecotect model of option 2 from the massing experiments was conducted in order to better understand the implications of the climate on a building. The model consists of concrete floors, void and single glazing on the facades and in the atrium. The atrium size is in relation to the 15m offset from the site boundary. The atrium depth is 11 floors or 44m making up the targeted bulk. This study does not include any parking.



Physical model with the introduction of circulation, parking and form adjustments



Option 2 from the massing studies

Sun Studies

Sun studies were performed to see what shadows are cast on the site and to see the impact a mass has on the neighbouring buildings. It can be seen that the new Portside development which is going to be constructed opposite my site of Bree street will not create shadows over my site at any time in summer, however may cause shadows in winter when the sun is lower. The Invectec building on the other side of the road of Hans Strijdom avenue shadows the mass in the early mornings and the buildings along mechau street shade parts of the site in the afternoon when the sun is in the West. The small service road is too narrow to have a building abutting up to the boundary, not enough light is entering that area, the building may have to be lower on this edge.



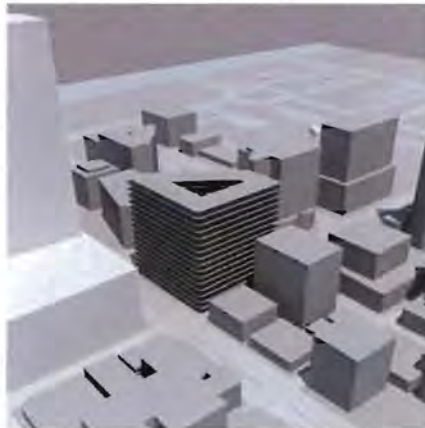
East view at 08:00am (mid summer)



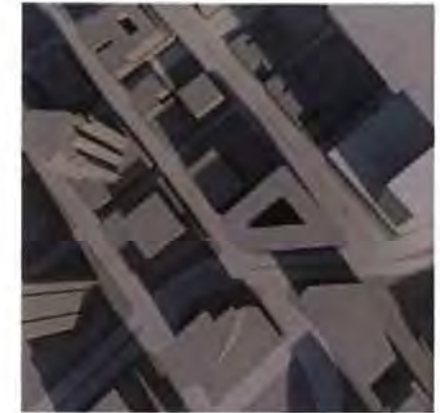
East view at 12:00pm (mid summer)



West view at 12:00pm (mid summer)



West view at 03:00pm (mid summer)



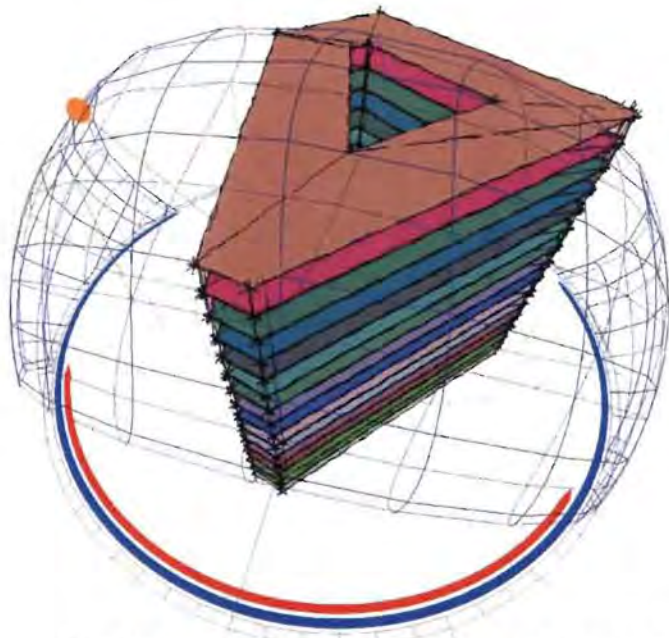
Plan view at 08:00 (mid summer)



Plan view at 12:00 (mid summer)



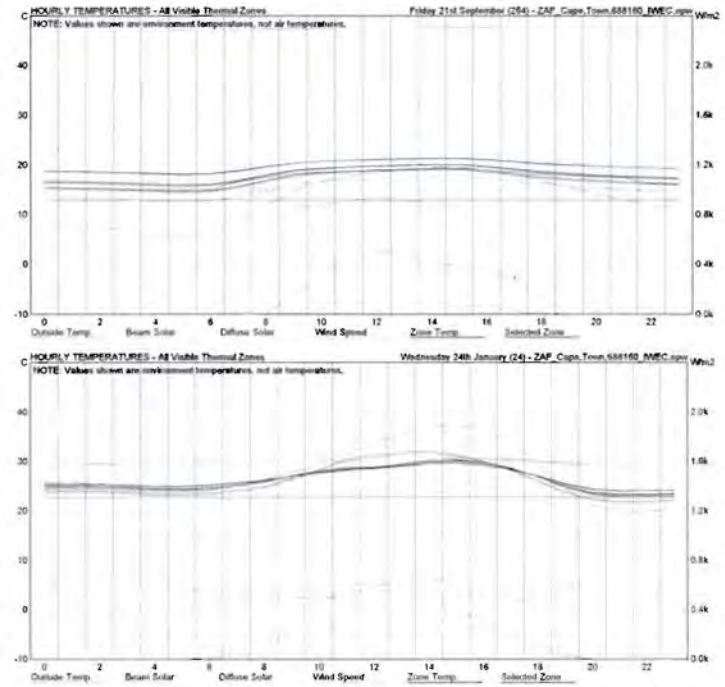
Plan view at 03:00 (mid summer)



Different 'zones' in the building model with the daily and annual sun path.



Physical model with the introduction of circulation, parking and form adjustments

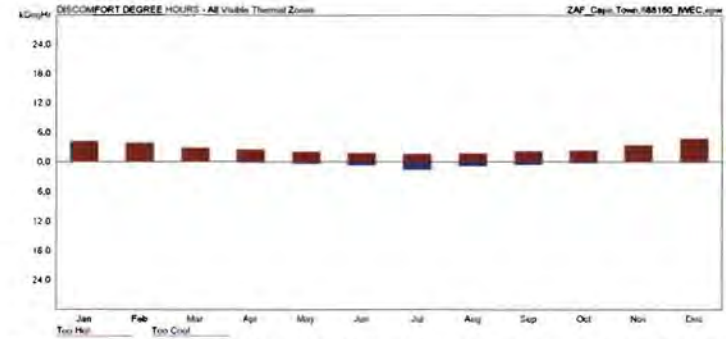


The graphs above show the temperature of different 'zones' in my building in relation to the outside temperature of particular days. It can be seen that the temperature of the spaces follow the temperature of the exterior. This is due to the lack of shading and insulation

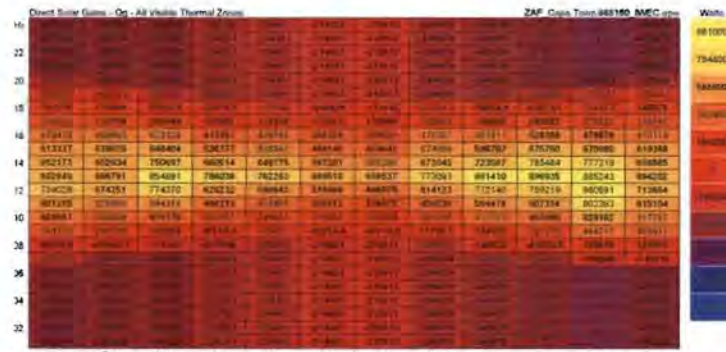
Thermal Comfort

In the mid summer months in the current model it can be seen that there is excessive heat gain and radiation in the months between November- February. This is due to the North-West and East facing facades. In the morning between 8-12 and in the afternoon between 4-6pm this occurs (which could be considered the hot spots) which created discomfort. Through the use of shading devices to reduce the amount of heat gain and insulation this could reduce the discomfort.

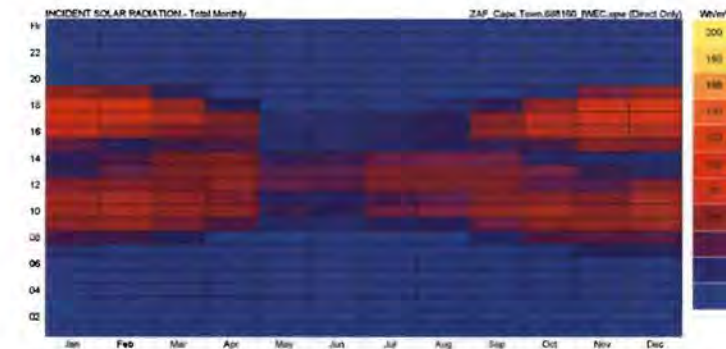
Sun positioning can be used to identify the angle of shading to protect a building at specific times.



In summer the building becomes too hot for approximately four hours of the day which if read hand in hand with the solar radiation impacts one can determine the times at which this occurs.



Solar gains are excessive in the mid day when the sun is at a high angle and therefore does not enter spaces as much as in the mornings and afternoons



Solar radiation impacts on the building. It can be seen that excessive solar radiation occurs in the mornings and afternoons when the sun is at an angle thus entering and heating internal spaces

Shadow Study

Taken every hour during the course of the day at different times of the year



21 December - 0800-1800



21 March - 0800-1800



21 June - 0800-1800



21 September - 0800-1800

Equidistant Projection

Location: -33.9°, 18.4°
 Sun Position: 108.0°, 15.8°
 HSA: 108.0°
 VSA: 137.4°
 Time: 07:00
 Date: 22nd Dec (356)
 Percentage Shading: [Behind]

Equidistant Projection

Location: -33.9°, 18.4°
 Sun Position: 100.8°, 27.9°
 HSA: 100.8°
 VSA: 109.5°
 Time: 08:00
 Date: 22nd Dec (356)
 Percentage Shading: [Behind]

Equidistant Projection

Location: -33.9°, 18.4°
 Sun Position: 84.8°, 52.8°
 HSA: 84.8°
 VSA: 88.1°
 Time: 10:00
 Date: 22nd Dec (356)
 Percentage Shading: 83%

Equidistant Projection

Location: -33.9°, 18.4°
 Sun Position: 45.8°, 75.8°
 HSA: 45.8°
 VSA: 80.0°
 Time: 12:00
 Date: 22nd Dec (356)
 Percentage Shading: 100%

Stereographic Diagram

Location: -34.0°, 18.8°
 Sun Position: 51.5°, 11.2°
 HSA: 51.5°
 VSA: 17.8°
 Time: 09:00
 Date: 22nd Jun (173)
 Percentage Shading: 19%

Stereographic Diagram

Location: -34.0°, 18.8°
 Sun Position: 27.8°, 27.1°
 HSA: 27.8°
 VSA: 30.1°
 Time: 11:00
 Date: 22nd Jun (173)
 Percentage Shading: 46%

Stereographic Diagram

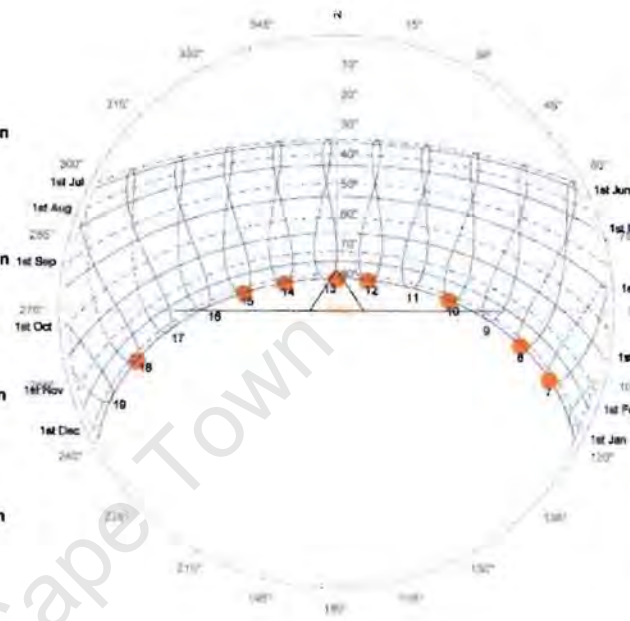
Location: -34.0°, 18.8°
 Sun Position: 0.7°, 32.8°
 HSA: 0.7°
 VSA: 32.0°
 Time: 12:45
 Date: 22nd Jun (173)
 Percentage Shading: 54%

Stereographic Diagram

Location: -34.0°, 18.8°
 Sun Position: -19.3°, 30.0°
 HSA: -19.3°
 VSA: 31.5°
 Time: 14:00
 Date: 22nd Jun (173)
 Percentage Shading: 57%

Stereographic Diagram

Location: -34.0°, 18.8°
 Sun Position: -45.5°, 16.6°
 HSA: -45.5°
 VSA: 23.0°
 Time: 16:00
 Date: 22nd Jun (173)
 Percentage Shading: 26%



Equidistant Projection

Location: -33.9°, 18.4°
 Sun Position: -0.3°, 79.6°
 HSA: 0.3°
 VSA: 79.6°
 Time: 12:45
 Date: 22nd Dec (356)
 Percentage Shading: 100%

Equidistant Projection

Location: -33.9°, 18.4°
 Sun Position: -82.6°, 70.5°
 HSA: -82.6°
 VSA: 80.8°
 Time: 14:00
 Date: 22nd Dec (356)
 Percentage Shading: 99%

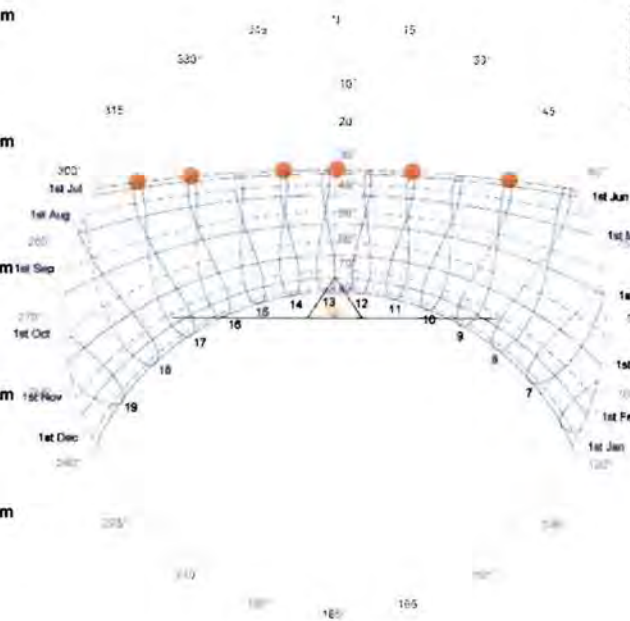
Equidistant Projection

Location: -33.9°, 18.4°
 Sun Position: -79.5°, 58.7°
 HSA: -79.5°
 VSA: 83.7°
 Time: 15:00
 Date: 22nd Dec (356)
 Percentage Shading: 87%

Equidistant Projection

Location: -33.9°, 18.4°
 Sun Position: -104.5°, 21.8°
 HSA: -104.5°
 VSA: 122.3°
 Time: 18:00
 Date: 22nd Dec (356)
 Percentage Shading: [Behind]

BRE VSC: 14.4%
 Overcast Sky: 11.4%
 Uniform Sky: 16.4%



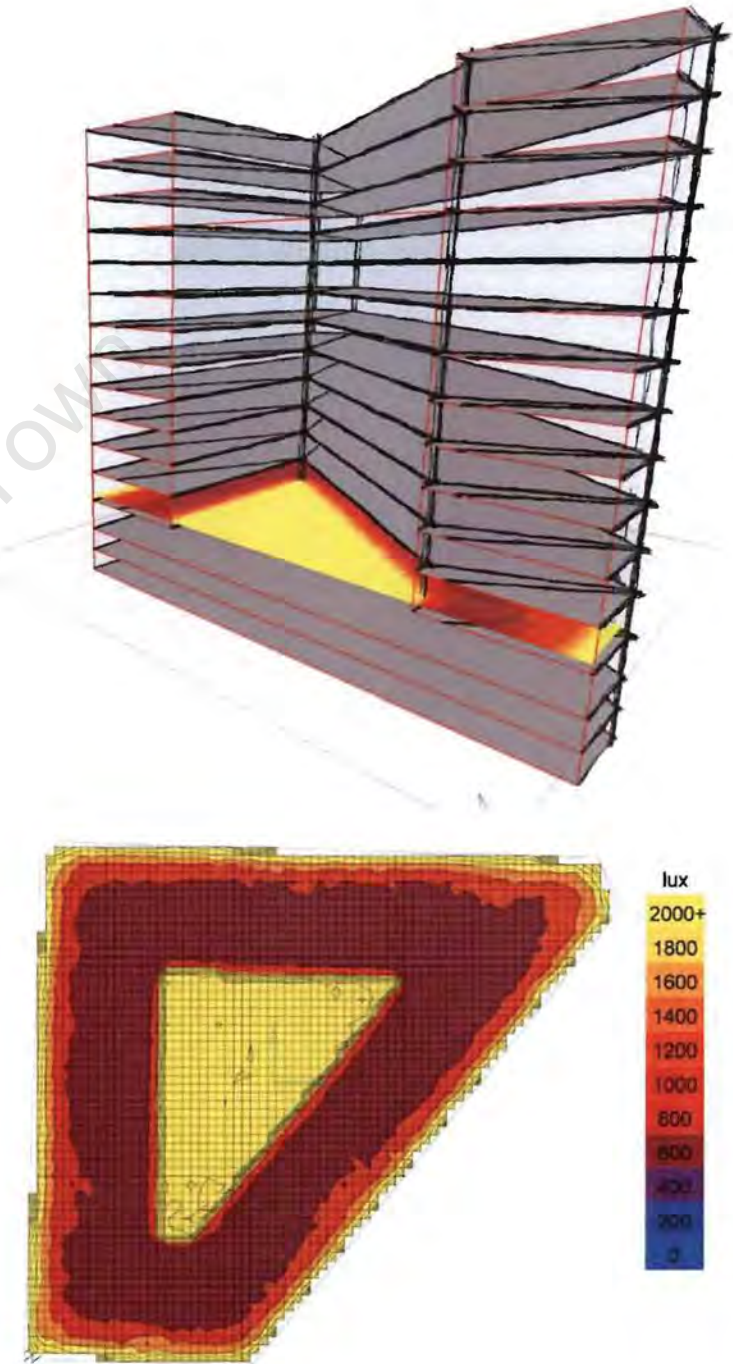
Stereographic Diagram

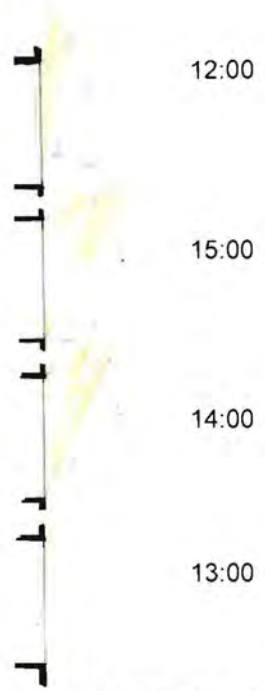
Location: -34.0°, 18.8°
 Sun Position: -55.8°, 7.0°
 HSA: -55.8°
 VSA: 12.2°
 Time: 17:00
 Date: 22nd Jun (173)
 Percentage Shading: 9%

BRE VSC: 14.4%
 Overcast Sky: 11.4%
 Uniform Sky: 16.4%

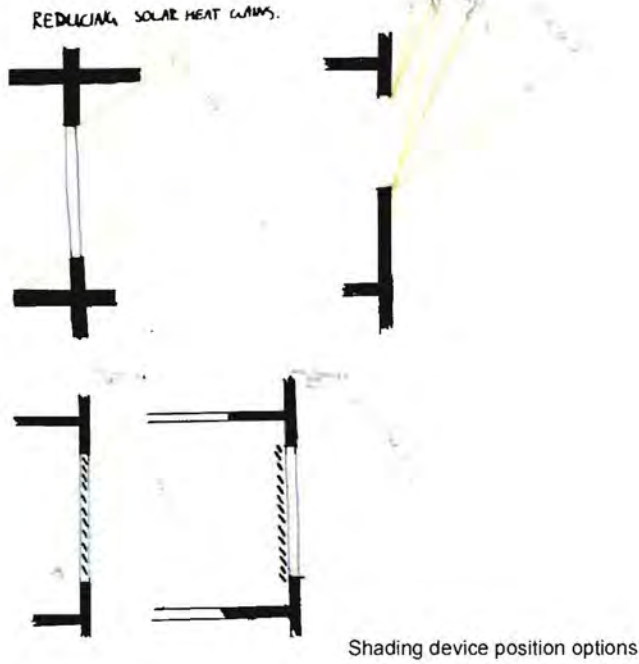
Daylight Analysis

A Daylighting study was conducted on option 2 of the massing studies. It results show that sufficient amounts of light would enter the atrium 11 floors deep and provide more than a sufficient amount of light (no less than 400 LUX) in the office space at the deepest level. The analysis also shows that there is the least amount of light in the corners of the atrium, but the most amounts of light enters on the corners of the facades to the exterior. The analysis grid was set at desk height of 800mm and used a grid of determining the light quantities every 1m (shown in the daylight analysis plan below). The lighting study was conducted using the worst case scenario (a clouded winters day). In response to the high light levels which enter the atrium a solar control device would have to be introduced otherwise the large amounts of light would create glare in the offices.

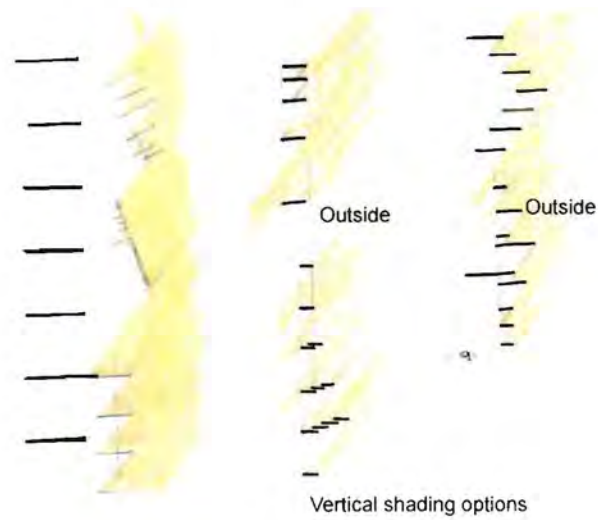




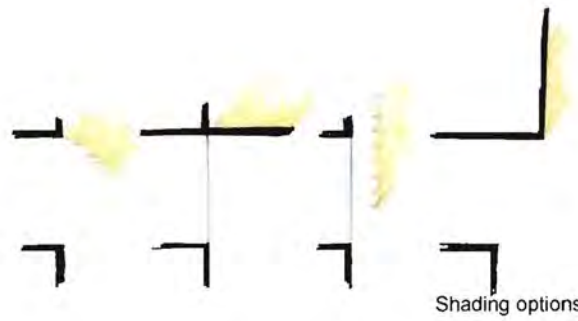
Sun angles in summer and winter



Shading device position options



Vertical shading options



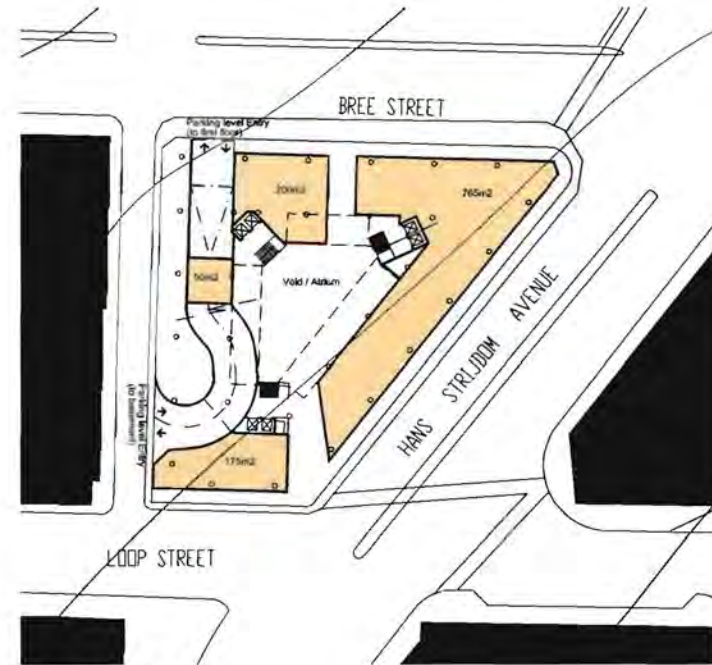
Shading options



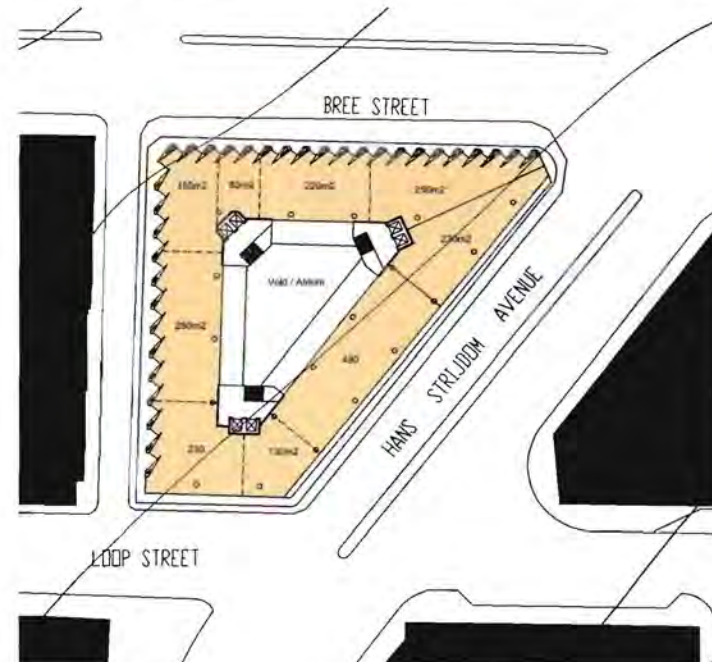
Mid Day Summer and Winter Sun Angles

DESIGN DEVELOPMENT 1

1 Form follows Efficiency.



Ground Floor plan (NTS)



3rd Floor plan (NTS)

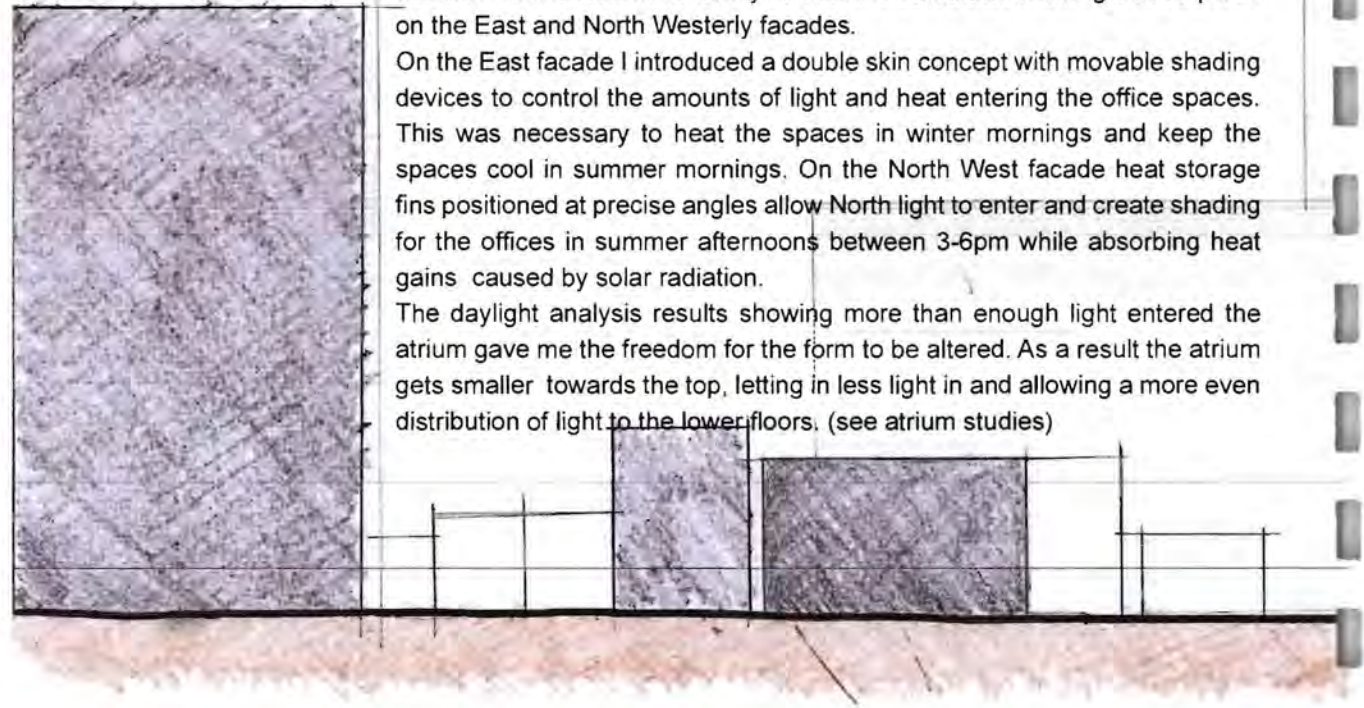
The first development of ideas was a result of the massing studies, case studies (shown in the next section), climate study and the model analysis results.

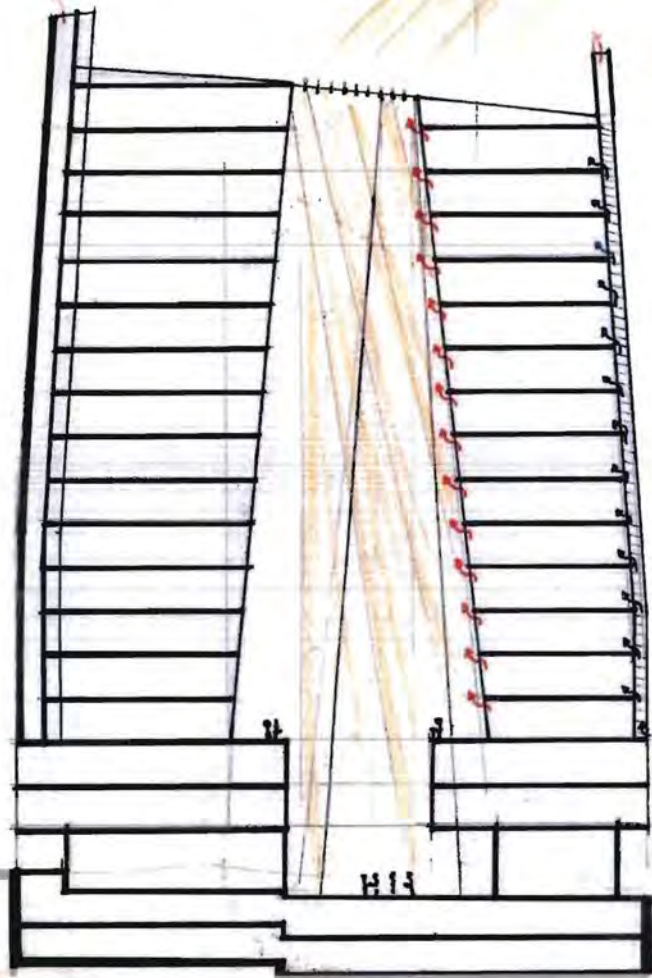
Vehicular access to the site was positioned along Michau street while pedestrian access was positioned along Bree and Loop streets. Vertical circulation cores were positioned in the corners of the atrium where there is the least amount of light.

The massing studies showed that the most economical form would be of a floor plate of 15m deep setback from the boundary of the site with a central atrium. The climate study suggested that natural ventilation would be successful in the summer months, however a double skin facade enabled me to introduce natural ventilation all year. Night purge would also occur with the use of a large ceiling depth to help keep the spaces cool in summer and warm in winter. The model analysis data indicated that shading was required on the East and North Westerly facades.

On the East facade I introduced a double skin concept with movable shading devices to control the amounts of light and heat entering the office spaces. This was necessary to heat the spaces in winter mornings and keep the spaces cool in summer mornings. On the North West facade heat storage fins positioned at precise angles allow North light to enter and create shading for the offices in summer afternoons between 3-6pm while absorbing heat gains caused by solar radiation.

The daylight analysis results showing more than enough light entered the atrium gave me the freedom for the form to be altered. As a result the atrium gets smaller towards the top, letting in less light in and allowing a more even distribution of light to the lower floors. (see atrium studies)





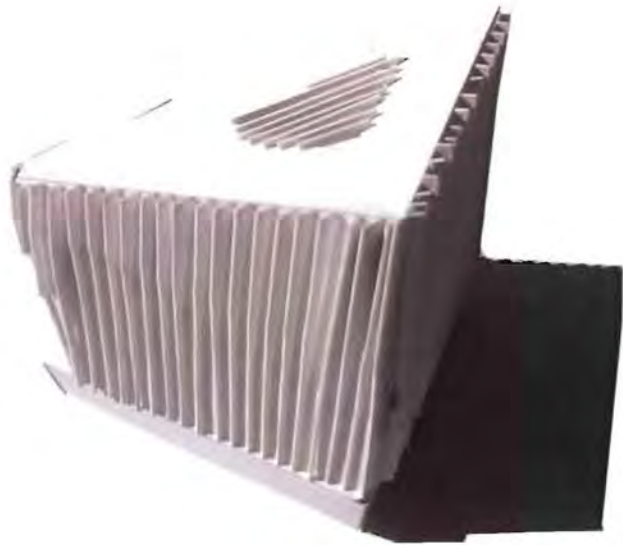
Atrium Perspective



The problem with the form follows efficiency option is that the atrium does not create a nice spatial quality. It is a deep space which focused mainly on light quantities. Qualities such as the interaction between people and orientating of ones self in relation to other spaces in the building and the urban context were not taken into account.

The atrium could only be used for orientation by knowing where the atrium is, however it does not create varying identifiable spaces which would orientate people as to where they are in relation to other spaces or places in the building. The form of the atrium is too regular and each facade within the atrium is indifferent. Orientation to the urban context is as a result not possible.

Furthermore the spatial arrangement in the offices does not allow for interaction between workers through spaces within the atrium. This option I think is close as to what would be produced in our current economic environment.



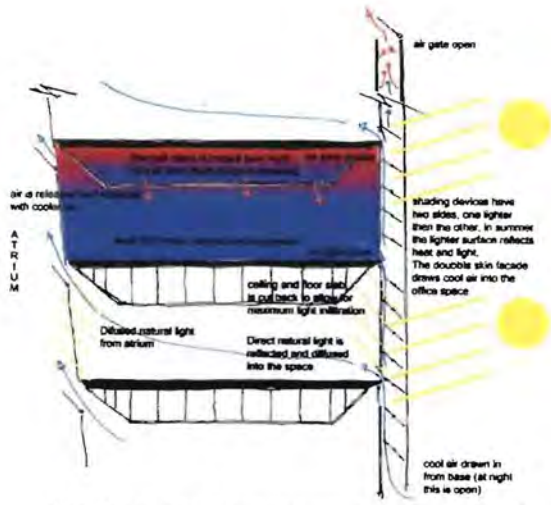
West view - heat storage, shading fins and atrium roof with light reflectors



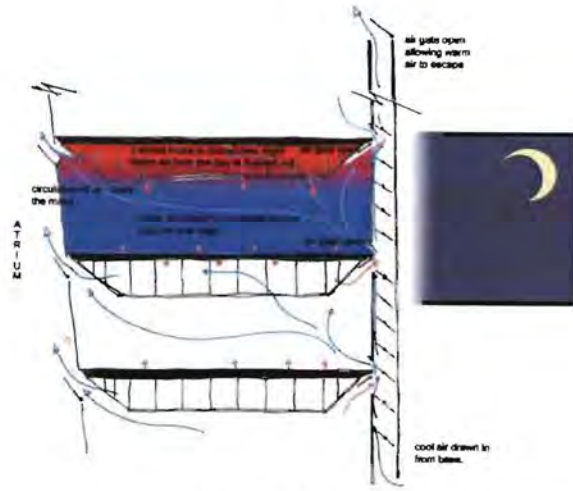
East view - Double skin movable shading.



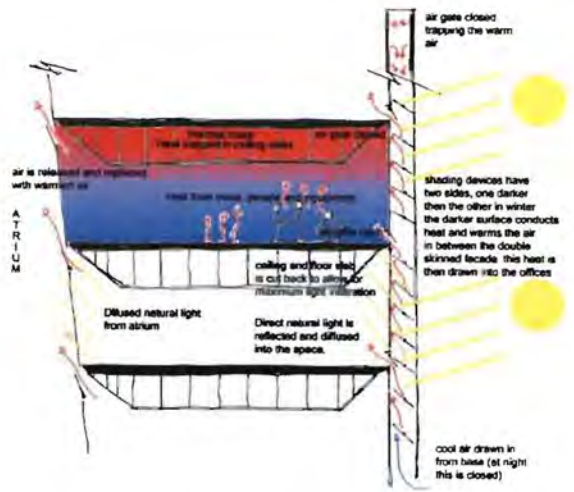
View in atrium from ground floor - The taper upwards allows for an even distribution of light into all the floors as well as a higher light coefficient on the bottom floors in relation to a standard straight atrium ..



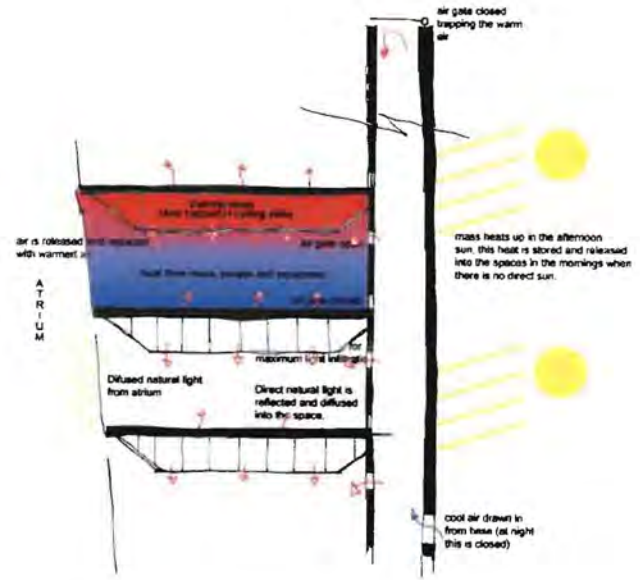
Cooling strategy in Summer mornings on East facade



Cooling strategy in Summer evenings



Heating strategy for winter mornings on East facade



Heating and cooling strategy for winter mornings on West facade

Case studies : Energy Efficiency

There are varying aspects which influence the energy usage in buildings. In this document I will be focusing on strategies and technologies to reduce the operational energy.

With improvement of technological advancements in heating, cooling and ventilating combined with the economic success margins required in making office space in the CBD, efficiency is often related to achieving maximum bulk with minimal spatial qualities other than creating workable space. This often results in the creation of deep floor slabs with no natural light and ventilation.

The case studies presented are two examples which focus on efficiency and share the same programmatic function of office space. Office space can be seen as a key element to feasibility and the economical success of a building in the CBD area. The examples shown are ones which take into account the environment and strive to have minimal impact by reducing energy consumption.

Case Study
Kruger Roos Architects
 2005
BP Building, Cape Town



Bp building North-East facade and main entrance.



Bp building's Interior atrium , skylights and circulation.

Program:

The new headquarters for BP offers A-grade office space.

Structure:

Load bearing cavity walls which act as thermal massing and allow for deeply recessed windows

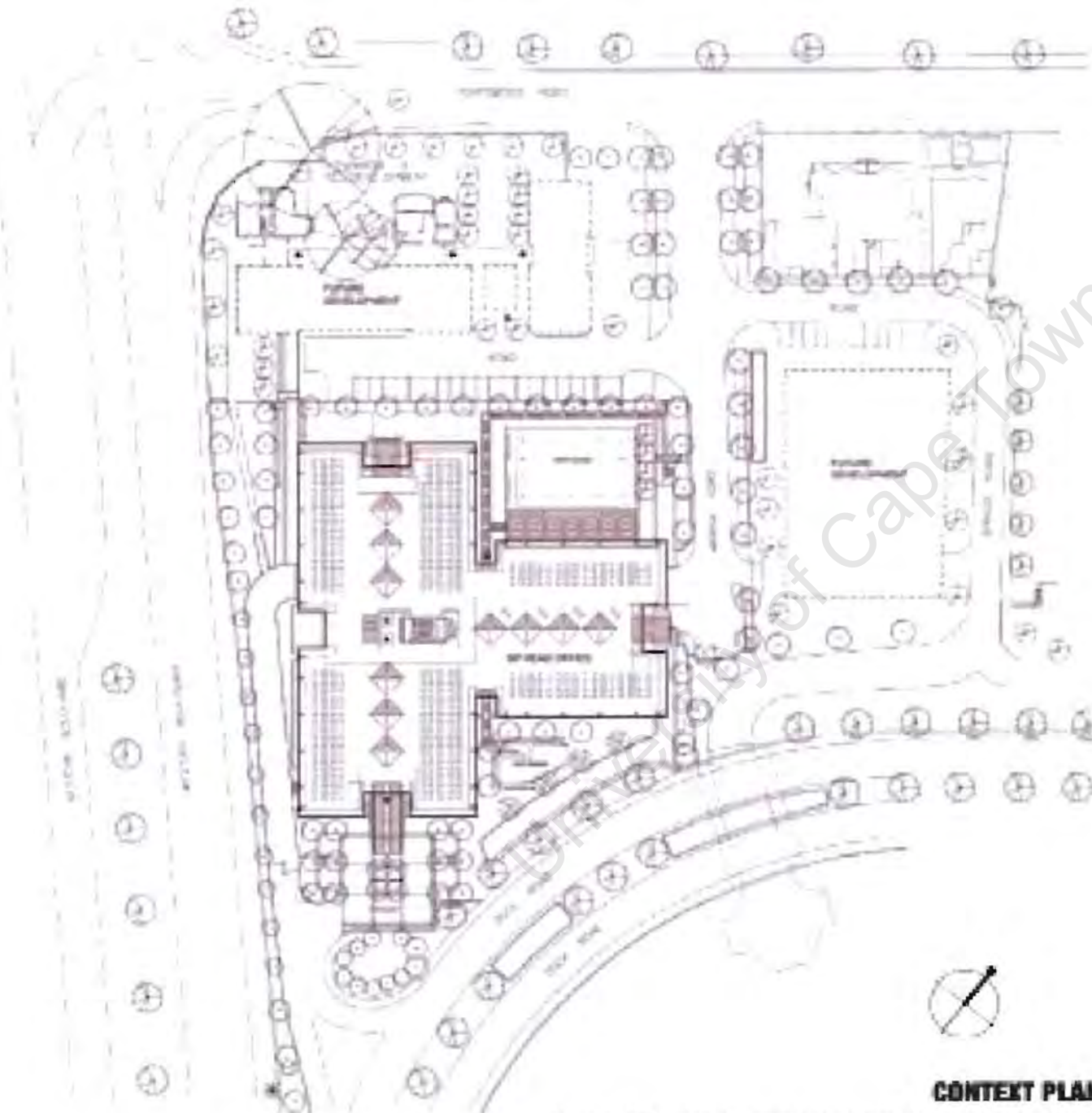
Energy efficiency techniques:

Deep windows, reducing thermal heat gain in summer and allowing sun to penetrate in winter. Use of light shelves and skylights for natural lighting. Light shelves located on the North, North-East and North-West facing Facades. Skylights act as thermal ventilation ducts, thermal solar panels. Photovoltaic panels generate 10% of the overall energy requirements.

Floor Plate Depth, Natural Light Strategies, Circulation and Orientation

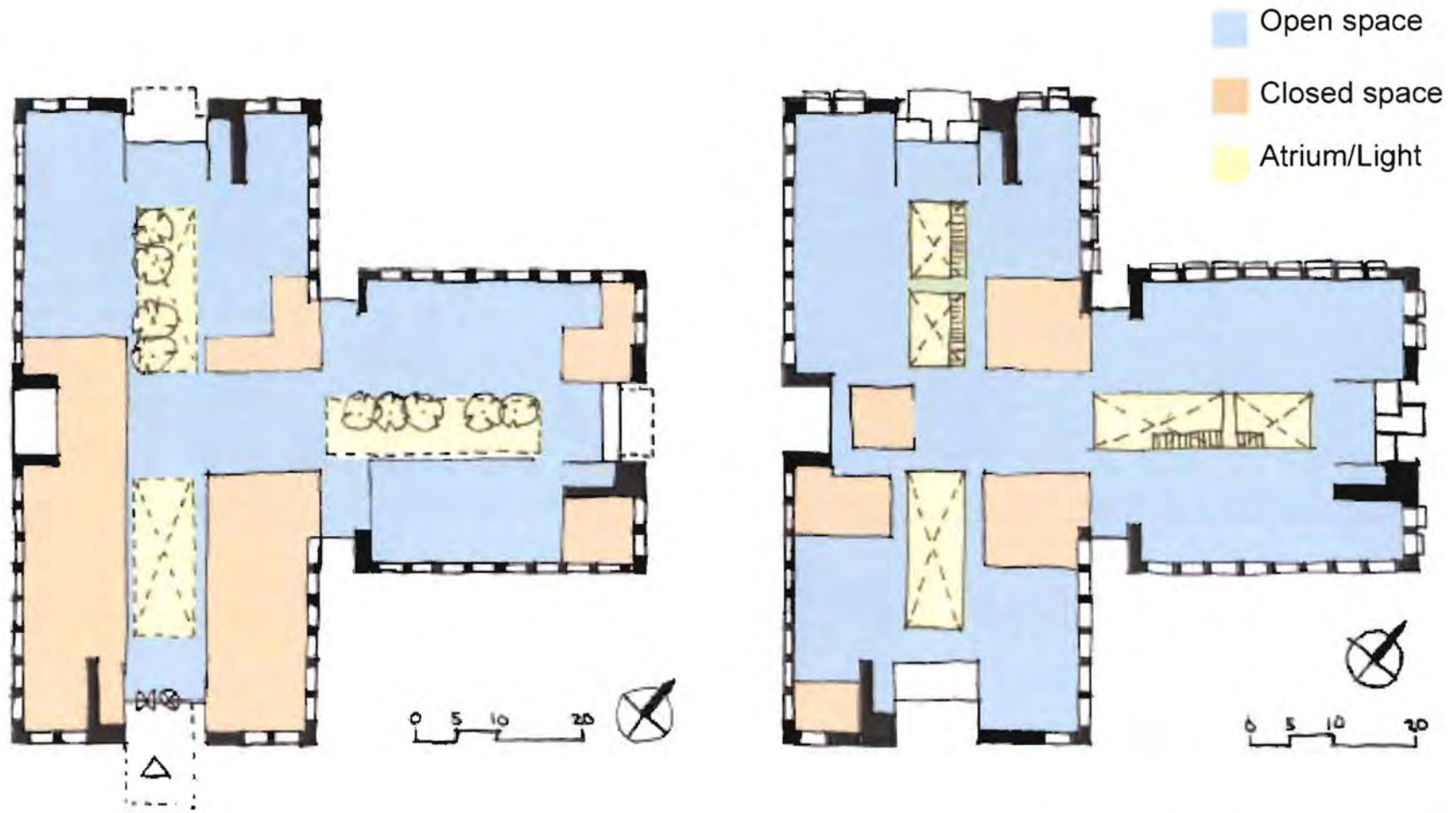
Strategic building orientation at a 45 degree angle to the north allows for maximum light and solar heat gains in winter

The BP building is accessed from North-East and South East the entrance, opens into a centralised atrium of 26X7m which allows light and ventilation to enter the public space and the working environment. Circulation is linked to the central atrium space and located on the North-East and North-West legs of the building. Glass pyramids which have shading devices allowing natural defused light to enter the building run along the centre of the roof above the atrium providing light for three levels of offices in the three legs of the building. The floor plate depth reaches +/-12m from the external facade to the centralised atrium. Two of the atriums of 182 m² have three pyramids whereas the main entrance atrium has four. The floor to ceiling height is +/-3.7m allowing more light to penetrate into the deep windows. Deep windows are used reducing thermal heat gain in summer and allowing sun to penetrate in winter. Light shelves located on the North, North-East and North-West facing Facades are also used to let light penetrate deeper into the floor plate.



CONTEXT PLAN

Site plan. The building is orientated 45 degrees to maximise on North light.



Plans showing the general distribution/arrangement of space.



Section illustrating how light penetrates into the office space and Ventilation occurs through the skylights.



Section through main leg of building.



Image taken from the roof showing the solar panels and the 'lanterns'.

Main Efficiency Strategies

Water consumption had to be 20% better than an equivalent conventional building..

To achieve an optimum lighting installation within the work space, a combination of natural daylight harvesting, via skylights and light shelves was used. Lanterns or light wells along the circulation route provide natural light to the open plan offices inside where as light shelves shade windows according to the season and reflect light into the deep plan. Ventilation stacks are used allowing the windows to be deeply recessed reducing solar heat gain in summer and allowing sun penetration in the winter. Double glazing contributes to the further reduction of solar heat gain through reduced conductivity.

Thermal solar panels which are used to heat up the water and photovoltaic cells, which generate 10% of the building's electricity help in the efficiency of the building.

The roof garden's moderating effect on climate by retaining heat energy from the sun rather than reflecting it and, through evaporation of moisture, helps to cool the air therefore saving on air-conditioning and heating costs.

The low degree of ownership and space per person is countered with collaborative and breakout spaces and a high degree of collective ownership of all parts of the building



Light enters through the lanterns and is defused into the office space via the atrium.

Facade Design and engineering

Full three dimensional solar modelling of the façade module was undertaken for each façade orientation. This enabled finite dimensioning of shading devices, light shelves and the macro positioning of the façade glazing.

Each facade is treated differently relating to its orientation. Double glazing contributes to the further reduction of solar heat gain during summer and heat loss during winter through reduced conductivity. Furthermore direct sunlight is eliminated by orientating glazed sides to the southeast. Light shelves shade windows according to the season and reflect light deep into the plan.



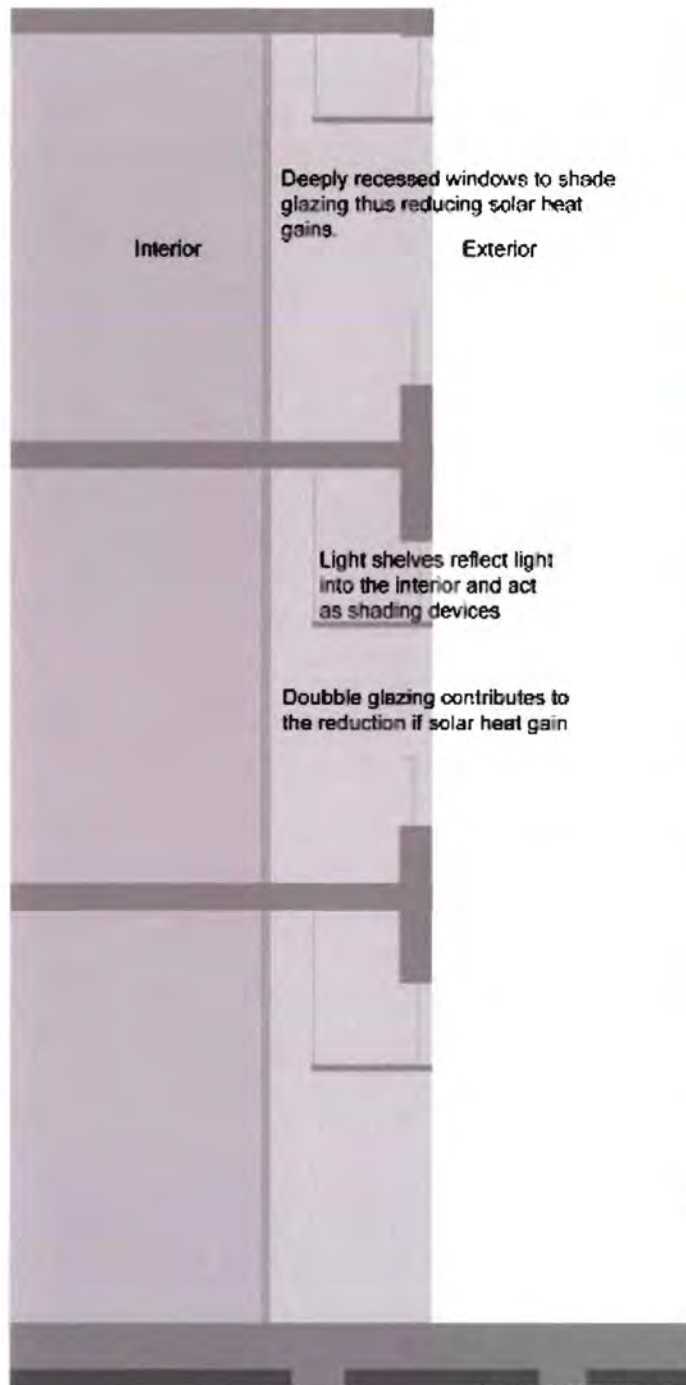
Large light shelves, deeply recessed glazing.



Smaller light shelves less recessed glazing.



Entirely open facade to allow maximum light intake.



Section through facade.

Interior

Deeply recessed windows to shade glazing thus reducing solar heat gains.

Exterior

Light shelves reflect light into the interior and act as shading devices

Double glazing contributes to the reduction of solar heat gain

Case Study Mick Pearce

1996

Eastgate Centre, Harare



Eastgate building external 'heavy' expression is responding to nature, Eastgate interior atrium creates a public space and accommodates appropriate resources and attending to cultural language. culation - a mix of delicately detailed lattice girders make up the sky light roof.

Program:

Retail consists of the first two floors relating to the public space created by the atrium. Flexible office space occupies the next five floors above.

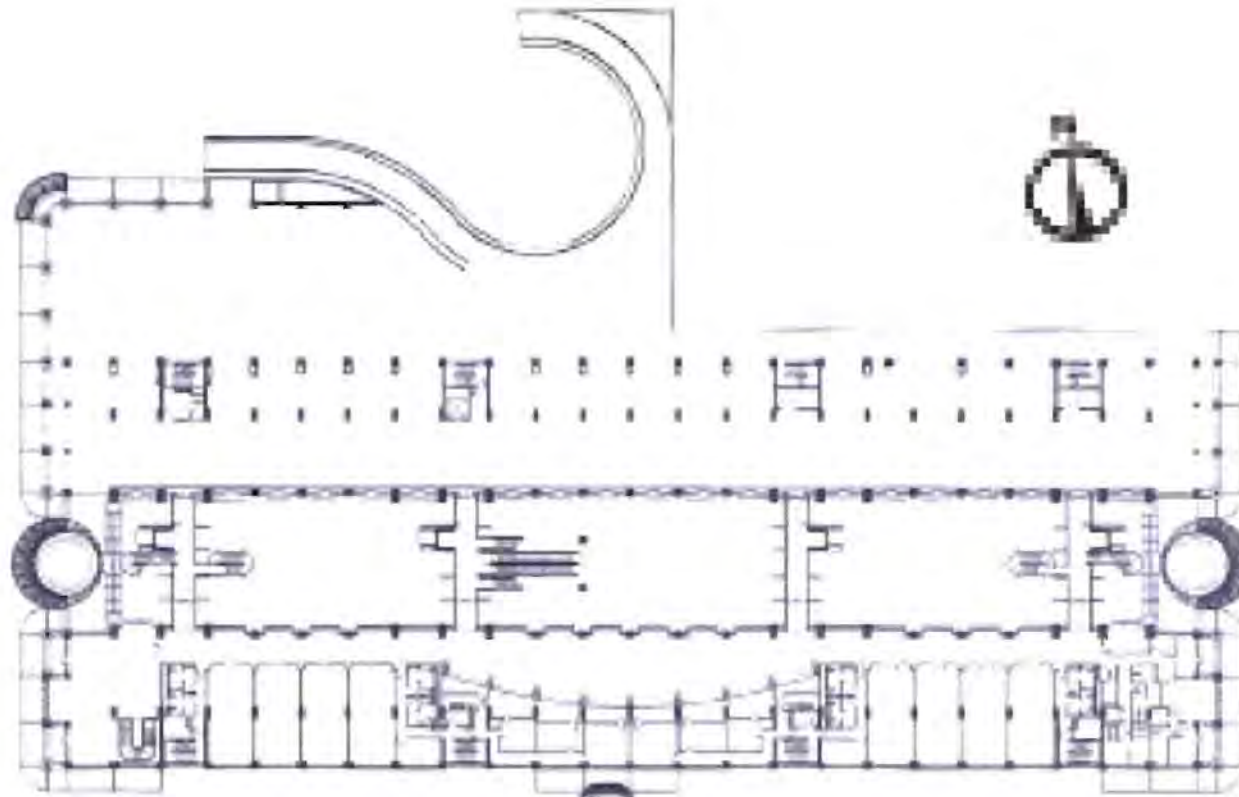
Structure:

Cast in-situ reinforced concrete beams and slabs

Energy efficiency techniques:

Passive cooling, through thermal massing due to tropical climate. The building uses 10% of the energy needed by a similar conventionally cooled building.

Access, Circulation, Orientation, Depth of floor plate, Light, and Services



The Eastgate centre is divided into two long narrow tower blocks with public space wedged in-between the two and accessed via four main entrances on street level; from the centre of the longitudinal edges and the short edges. This leads to the main atrium space which serves as vertical circulation, allows the users in the building to have physical connections with each other and with the first two floors of shops. The atrium is covered by a steel truss configuration and covered with a frosted glass allowing light to filter into the space below.

The proportions of the atrium (18mx145mx 6 floors deep) in relation to the depth of the space allow for sufficient amounts of light to filter into the office spaces and create natural lighting.

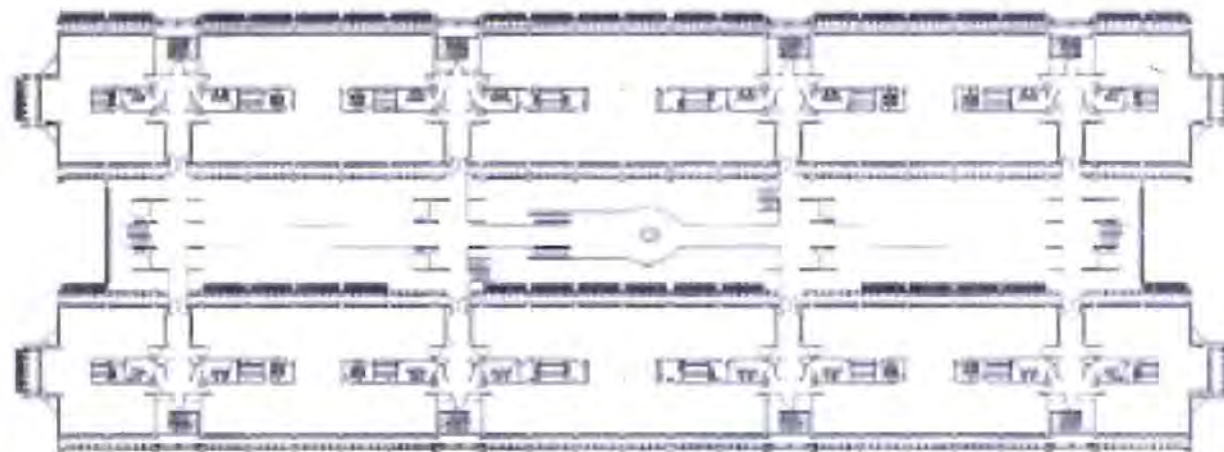
There is a skywalk on the second floor which allows light to travel through to the ground floor shopping area, but also provides access to all office spaces via linking vertical circulation cores.

Office space located on the edges of the floor plates and bathrooms located in the centralised cores so as to maximise on natural light. The Floor plate depth is 16m inclusive of the centralised cores with an atrium of 18m wide natural light thus only has to penetrate +/- 8m into the space.

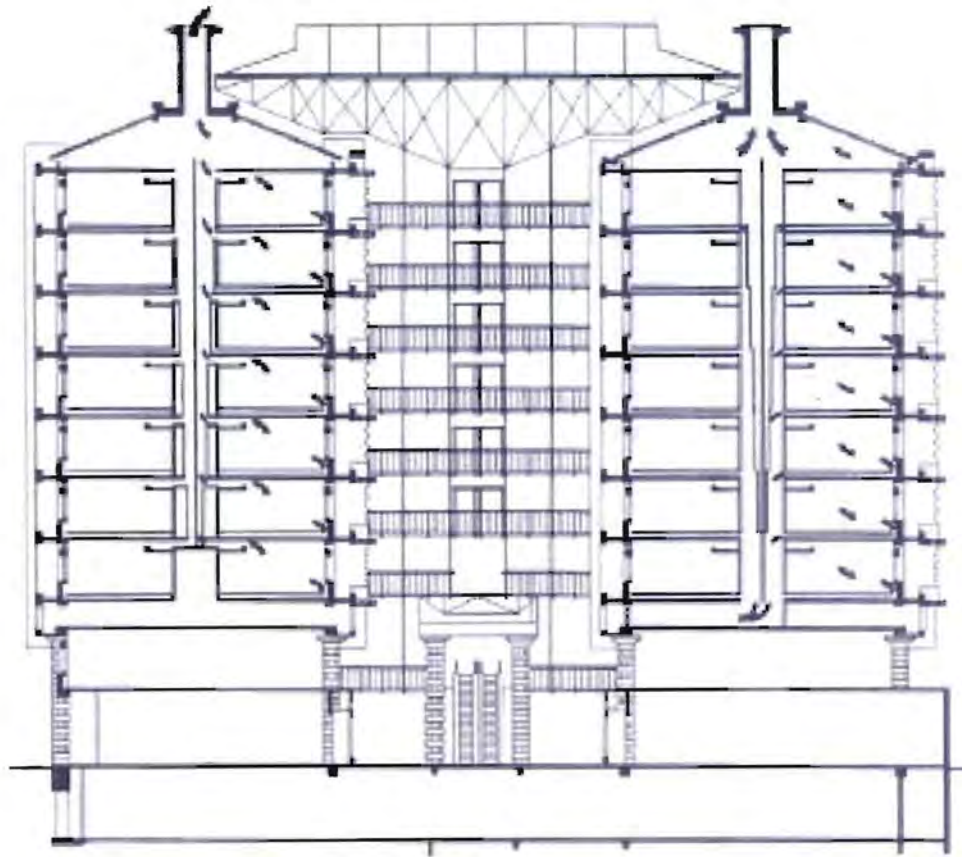
The two parallel tower blocks are facing North on which these facades additional shading devices are attached but still allows natural light to penetrate into the spaces.

Furthermore central circulation minimises the need for corridors. Centralised atrium which acts as vertical circulation space, visual and physical interaction

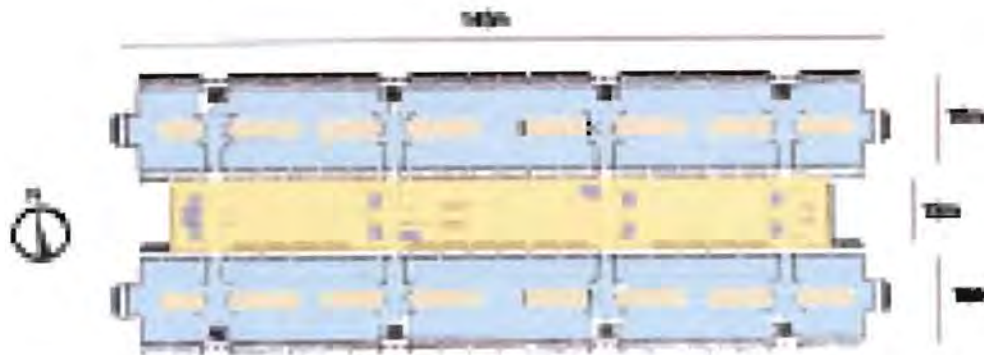
First floor plan (above); and second floor plan (below)



Floor plans.



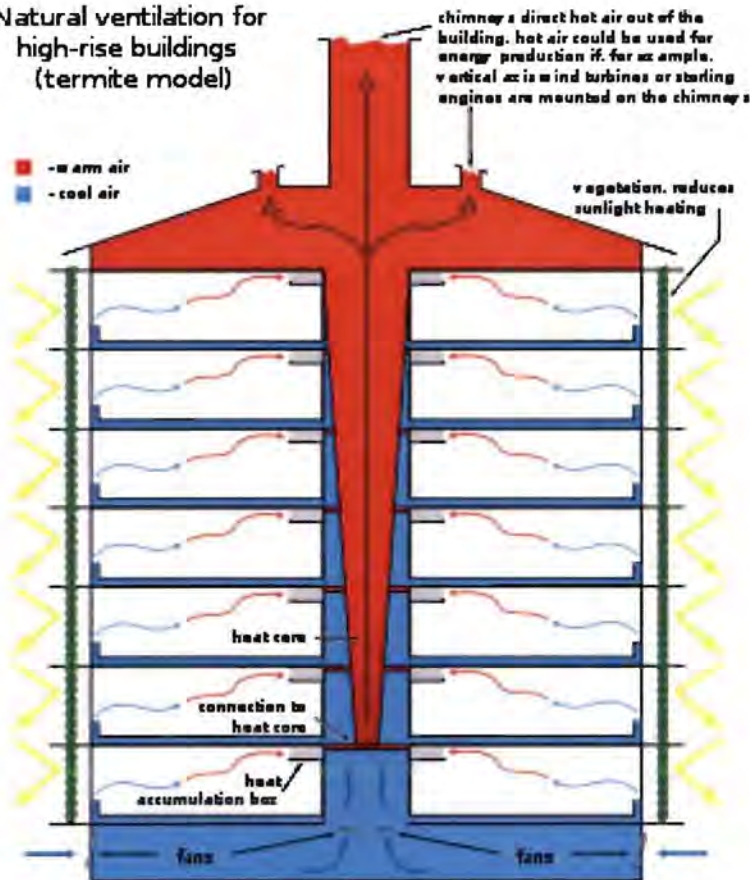
Section.



Spatial arrangement plan.

The office space in this instance is located on the edges of the floor plates to allow for natural light to filter into the spaces, the exterior is heavily shaded against excessive heat gains due to the Harare tropical climate. The need for high flexibility of office space resulted in the bathroom and inner-office circulation cores are spread out in many small cores along the entire 145m length of building. The main vertical circulation is also spread out at regular intervals along the entire length, however they are located in the centre of the public space/atrium.

Natural ventilation for high-rise buildings (termite model)



Cooling strategy.

Thermal Comfort analysis

The graph shows the temperature fluctuations within the Eastgate centre. In the typical day in Harare a maximum temperature of 27 degC and a daily swing of 10 degC. Heights above floor level vary from: low level - 1m; mid level -1.8m; high level - 2.3m (Piet de Beer, 1997). The peak internal office temperature at desk height is approximately 3.5 degrees cooler than the external ambient temperature, and the internal peak temperature occurs approximately one hour after the external peak temperature (due to thermal mass). the results also show that there is a temperature difference of about 1.5 degrees between high and low levels.

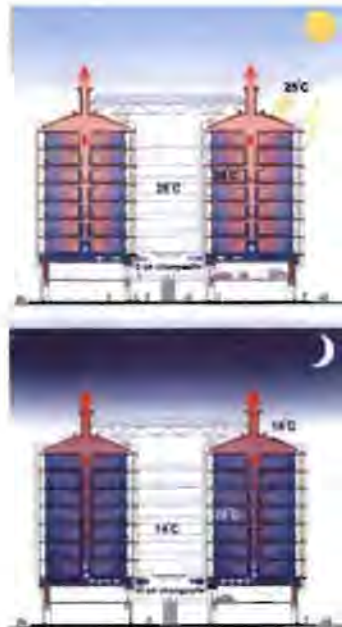
Heat Transfer

During the day low volume fans circulate the under floor cool air which is up to 4,5 degC cooler than the outside temperature and peaks approximately three hours after the external air temperature peak. During the night the high volume fans run and the under floor temperature cools by 2 degC. The heat loads from the transfer of heat through the building fabric, occupants, lights and equipment contribute the increasing temperature of about 1,5 degC. On days when there is a high diurnal temperature swing, building cooling performance is at its best, and on days with low diurnal temperature swings cooling performance is reduced. (Piet de Beer, 1997)

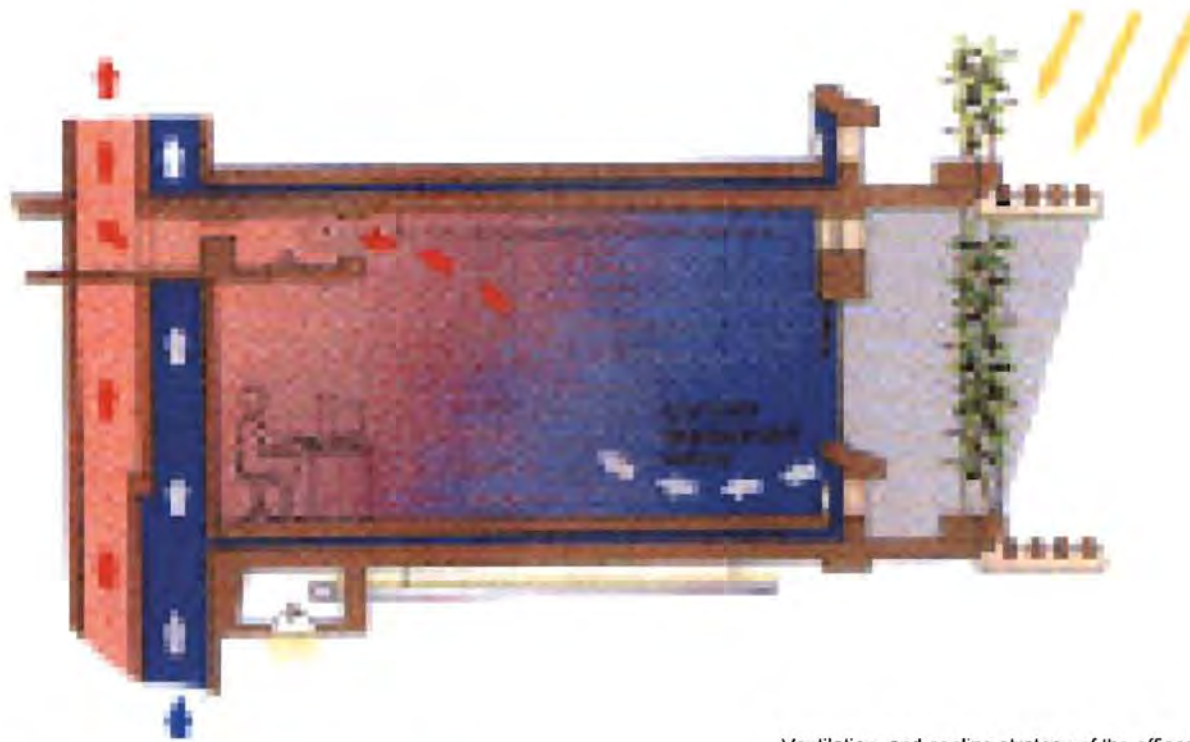
Main Efficiency Strategy

The buildings primary efficiency strategy is the heating and cooling system. Harare has large diurnal and seasonal temperature fluctuations thus thermal massing was the most appropriate technique to use. This system was further inspired by using the same heating and cooling principles as a local termite mound.

The building is partly ventilated by low intake fans which are housed above the first floor. The fresh air is distributed through 32 vertical air ducts along the length of the building. Raised floors allow air to flow under the offices and enter the building through grills situated below the windows. These floors have been created by placing precast concrete stools which a cast in situ slab is placed on and screed. The stools have dentilations on the underside in order to increase surface area by which the transfer of heat from the mass occurs. The predicted temperature of the concrete is to remain around 20 degC which allows for cooling and heating of the office space. The concrete slab has a wave profile section to increase the surface area increasing the slabs ability to absorb heat gains and for an efficient structure which extrudes out the building creating balconies which have additional shading devices attached to the ends. The window surfaces are small and the facades are thick and deep allowing no direct sunlight to enter the building.



Ventilation, and cooling strategy of East-gate centre.



Ventilation, and cooling strategy of the offices.

Hot air which is heated by the occupants, lighting and electronic equipment enters high level Bulkheads and passes through vertical chimneys. These chimneys have large cross sectional areas and allow air to flow at a limit of 2m/s. The air is discharged from the chimneys at roof level. The performance of this system at its peak achieves a fresh supply of air twice an hour during daytime, during the night large fans are used and the supply of air is accelerated to 7 fresh supplies per hour in order to accelerate the cooling of the slab. Fans used during the day are smaller than those used at night. The timing of the day/night fan usage varies with the season to take advantage of the changing ambient temperatures (Piet de Beer, 1997).

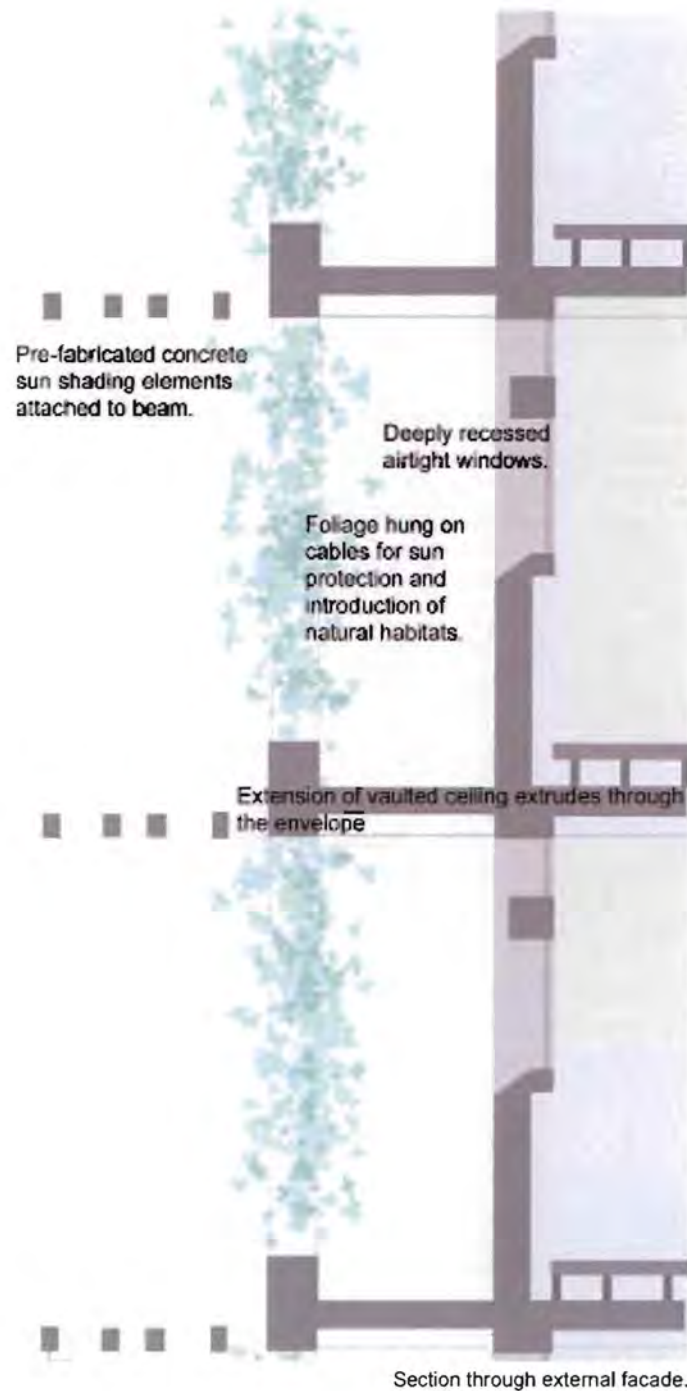


Heat which the lighting generates is directly absorbed into the vaults. Vaults extrude through the envelope to create balconies.

Materiality And Facade

Exterior Facade

The internal vaulted ceiling extrudes through the envelope of the building creating space for balconies and acts as a shading device. A reinforced concrete beam extends the length of the building at the end of the balconies from which precast concrete shading elements are fixed. Brick and concrete panels act as infill of the reinforced concrete structure. Small sealed windows puncture the infill to reduce the amount of heat gain that large openings usually suffer from. The windows are sealed because the heating, cooling and ventilating occurs by the 'termite mound' system.



External facade.

using low speed fans to drive the air through the building.

The Three buildings all use climatically responsive facades which vary due to the orientation and the location of the project. The facades are all layered and respond to the specific climatic conditions.

There are different methods of energy efficiency successful to for varying climates. Different forms are produced due to the different climates and contexts.

The two projects use make use of atriums to service the building and help with the passive techniques of lighting, heating and cooling the building.

among the choices of energy efficiency arose the topic of aesthetic and imagery. Cape Town is an international city which followed international culture of modernist style buildings, the bottom section of my building pays tribute to this era, remembering that this is now a part of our culture, the Hyperbuloid elements which protrude out of this element is a form which can be easily recognised by people in Cape Town. Class members have given comments already that it reminds them of large drums or the cooling towers which were once situated at the gateway into Cape Town. The reason for choosing this type of form was partly because Capetonians can identify the form easily, and it gives the remembrance/ imagery of energy or creating energy which is the focus of the project in a sense that

For this particular site and focus of thesis the solution which arose was one which required me to separate the volumes to allow for sufficient amounts of natural light, however there are many other possibilities to allow natural light to enter into a space, which is all relative to the depth to which it is required to reach and the width of the atrium. On a larger site for example there may have been the possibility of just using an atrium to allow for natural light to enter.

Conclusion

All three buildings studied share a similar programmatic function of office space. The study shows that despite the varying heights and geographical locations of the three buildings the floor plate depth stays relatively constant. The Eastgate and Bp building both use atriums to introduce natural light and thus reducing energy consumption. Varying atrium sizes are used; the Eastgate centre has a large 18m x 145m atrium allowing natural light to defuse into the 7 story (approximately 30m) high complex. The 26m X 7m atrium of the Bp building allows light to diffuse down three stories (approximately 13m) into the office space. This leads to the belief that the depth of space which natural light has to enter is linked to the atrium size. The smaller the atrium or opening in the slab the shallower the light will travel into a space.

The floor depth allowing sufficient natural light to enter the building for office space does not become less than 6m (as in the Bp building) and does not exceed 10m deep. The floor plate depth has a lot to do with the facade treatment; The Eastgate centre and Bp building have small punctured openings which result in the response to climatic conditions reducing heat gains. In turn this reduces the amount of light entering the space resulting in a shallower floor plate. The Bp building however introduces light shelves which reflects light deeper into the space thus less lighting is required.

Circulation cores in the two buildings are positioned similarly, the principle behind them is similar. Circulation is positioned in the centre of the atrium or space so as to not obstruct the natural light. In both instances the circulation is positioned in the central atrium

Atriums are often used for many other purposes other than letting natural light to enter. Atriums are also key techniques other passive techniques such as the ventilation. The Bp building uses the atrium to achieve stack effect, the lantern skylights which allow natural into the atrium also acts as a chimney, letting hot air rise through the atrium and exit via these skylights. The Eastgate centre uses the same system as the Bp building, however only used for the ventilation of the central public space.

The Eastgate centre uses a system of thermal massing in order to keep the interior temperatures at a constant level. The Eastgate center introduces a ventilation system

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Energy efficient architecture involves using natural forms of energy such as the sun, wind and water to make a building comfortable for inhabitation and reduce the effects on the environment through increasing energy efficiency.

Strategies implemented into buildings using energy from the surrounding environment to reduce the energy consumption are passive strategies and differ due to the climate of a Geographical location. Buildings implement different techniques such as natural lighting, ventilation, heating and cooling which are essential in reducing energy and creating comfort.

Passive strategies that are implemented into a design, have architectural consequences of form, aesthetic and space. One of the most essential influences of a building design is natural lighting levels appropriate for the activity. Light is an essential component to space-making, form-making and the aesthetics of a building, and provide endless possibilities in controlling it. Light, due to the complex nature of Architecture, plays an important roll that directly and indirectly influences the heating, cooling and ventilation of a building.

Light enters a space through the facades, but penetrates only up to a certain depth depending on the orientation, size of opening and shade of wall surfaces, thus allowing varying light levels into a space. In instances where the space is too deep for natural light to enter, a space needs to be lit artificially or an atrium is created allowing natural light to enter a void. This results in the introduction of another spatial quality which has endless possibilities in aesthetic, form and size.

The atrium is an important component in design, and

one that assists in the resolution of some of the challenges in creating an energy efficient building, especially in the case where a large site create deep space. The atrium influences and assists important aspects of a buildings design such as: **aesthetic, structure, function, natural lighting & ventilation, planning, materials, and economics**, all of which combine to create the harmonious **spatial identity** of a building

Toyo Ito

1995-2000

Sendai Mediatheque, Japan

University of Cape Town

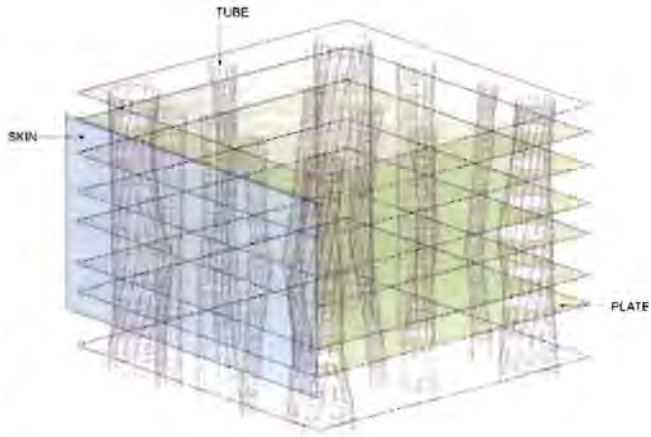


"Place" structured by tubes and plates and a redefinition of the grid derived from the modernist "domino" construction, by having tubular structural members of different sizes at varying intervals

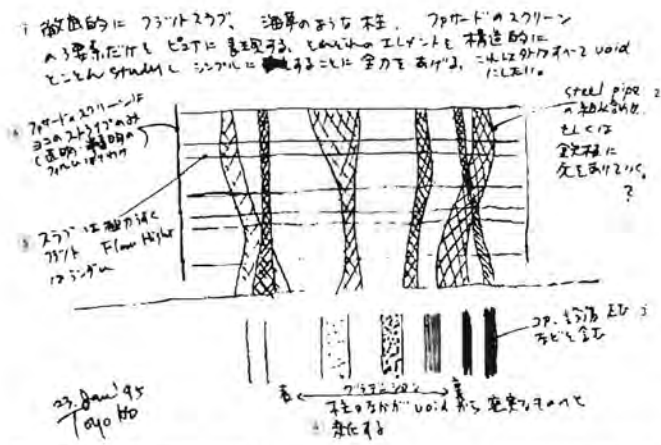
Project Description

What characterises the Mediatheque is the thirteen tubular atrium columns that support the floors. The steel slabs measuring about fifty meters on each side are supported by the atriums acting as the structure. Each tubular atrium comprised of thin steel structural pipes that define the tubular form. Each tube is of a different size and contains **vertical circulation** routes comprising elevators, stairways, ducts for air conditioning and energy supply. The tubes are essentially supposed to be empty, allowing for daylight to enter from the top, however internal functions had to accommodate these spaces defining the size of the tubes and the amount of light able to diffuse into the spaces below.

The tubes and the floor plan are connected, in that the tubes allow the internal space to be free and have fluid movement routes and the tubes are organic and free flowing, just as in nature. Toyo describes the idea of the tubes by saying "The tubular columns are conceived as something that sways and dances in the water just like seaweed."

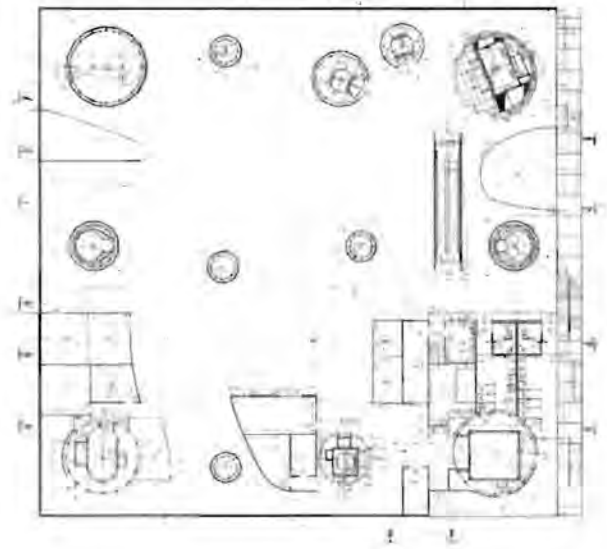


Elements which make up the Mediatheque



Sketch by Toyo K0 from the competitive phase • 1 assumed the organic form, the commonalities between these three elements • 2 the perfect size of the tubes • 3 the organic form of the tubes • 4 the perfect size of the tubes • 5 the perfect size of the tubes • 6 the perfect size of the tubes • 7 the perfect size of the tubes • 8 the perfect size of the tubes • 9 the perfect size of the tubes • 10 the perfect size of the tubes

Concept Sketch of free flowing tubes



Fluid spatial arrangements and movement routes which relate to the organic form of the tubes.

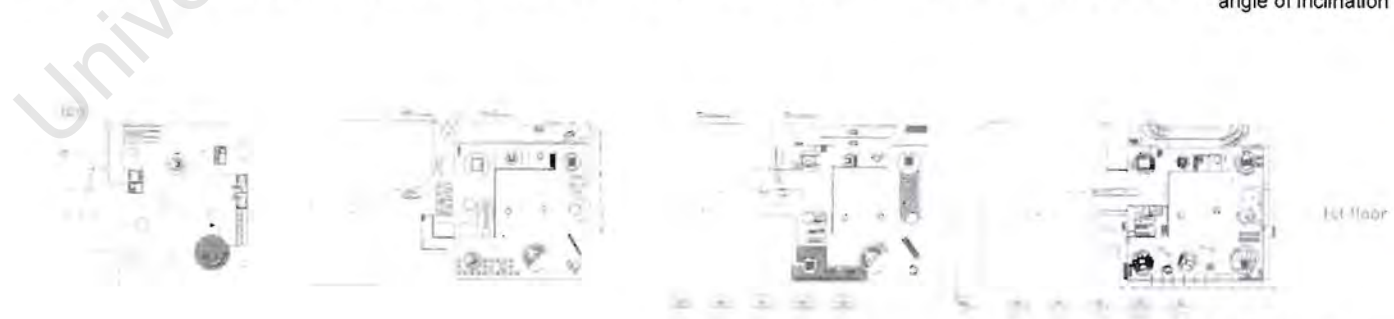
Spatial links and Organisation

The thirteen tubular atriums in the Sendai are important to the **aesthetic** and **function** of the building. The program variety which inhabits the spaces on different levels are linked to each other by the tubes. The tubes are also elements that service the building through ducts for air conditioning, energy supply and water. The tubes act as structure holding up the floor plates and give the **building identity**.

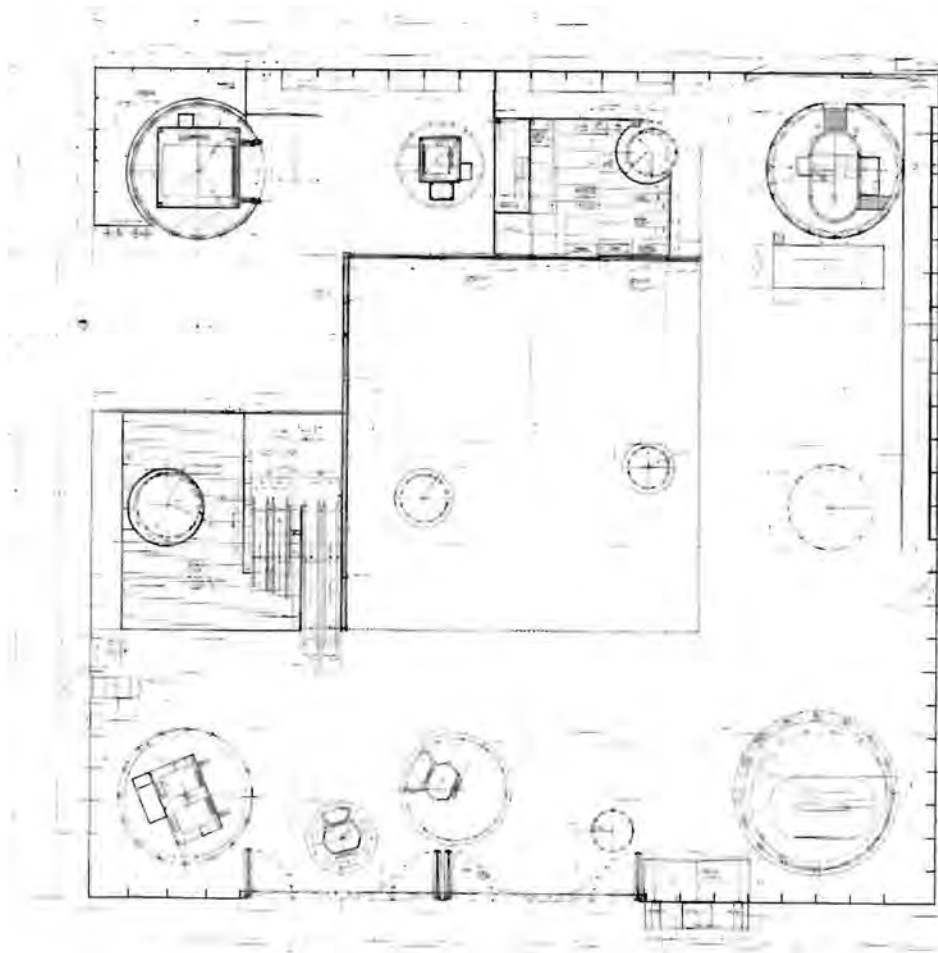
The tubes are different in size, form and angle of inclination which puncture through variable height floor plates consisting of different programs making every level in the Sendai different and identifiable. The tubes relate to nature in that there are no two which are identical, the spacing between them is irregular and almost random. It can be seen that there is a complex interplay between the **sculptural aesthetic**, structural logic and **functional** requirements.



Seemingly irregular spacing of tubes inhabited by different functions. The different structural patterns can be seen due to the tubes location, size and angle of inclination



Floor plan development

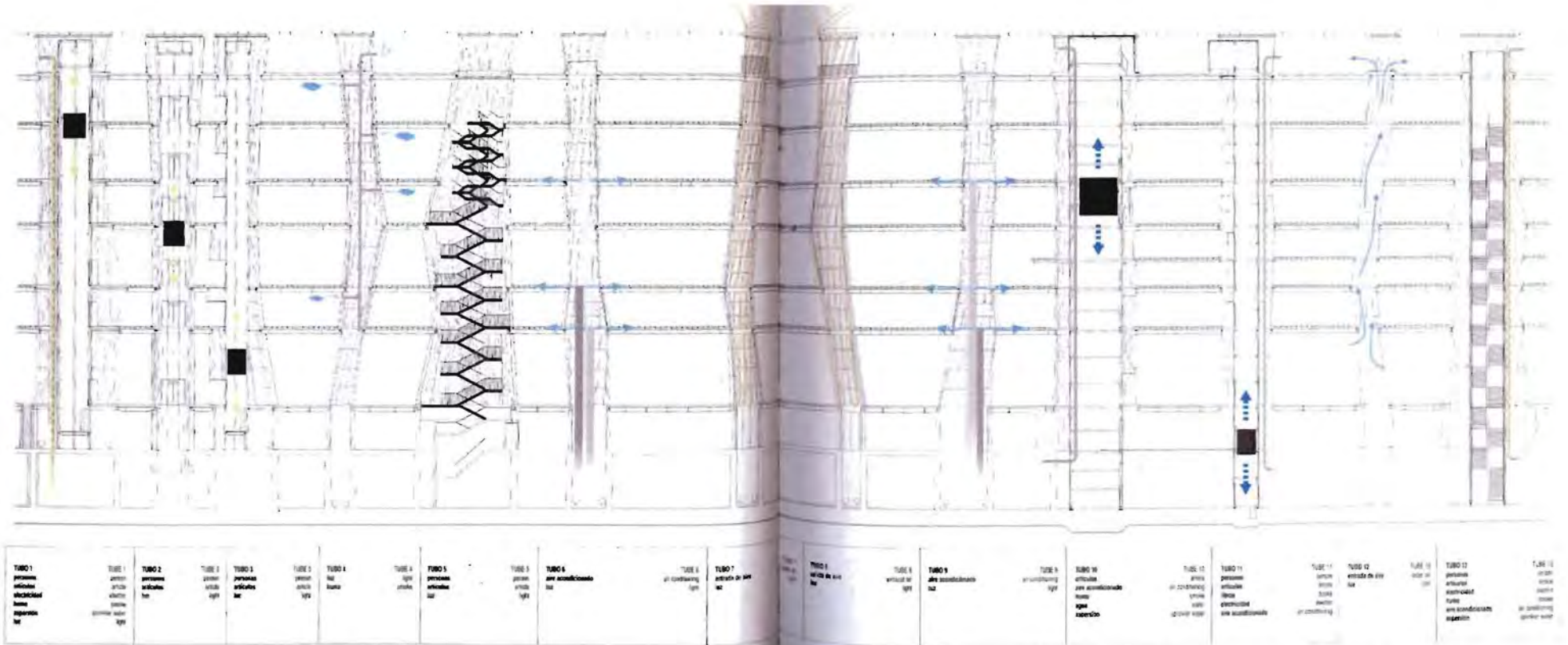


Ground floor plan

The size and positioning of the tubes are not random. From the ground floor it can be noticed that tubes with public **vertical circulation** consisting of staircases and elevators are positioned close to the main entrance.

The second row of tubes, positioned in the centre of the three rows, accommodates **services** of air conditioning and **daylighting**. The tubes which allow for **natural light** to enter the building are positioned in the centre of the floor plate letting **light into the deep space**. The air conditioning ducts are positioned in the centre of the building which reduces the distance needed for ducts to travel. The depth of the floor plate from the façade to the centre is twenty five meters and the floor to ceiling height ranges between four to seven and a half meters, this may not allow sufficient light to enter the space resulting in the two central tubes being allocated to supplying light to be small. The tubes allowing light and ventilation to enter are smaller than the tubes on the main façade because they do not need to accommodate people.

The third row of tubes located at the back of the building is used for servicing the spaces and escape routes. Like the front of the building these consist of primarily staircases and elevators.



Section through the function of all thirteen tubes. Tubes act as structure holding up the floor plates. In section the different size, form and angle of inclination can be seen puncturing through the floor plates.



Main entrance facing the street on which the first row of columns are positioned.

Back of the building, used for servicing the spaces and escape routes.

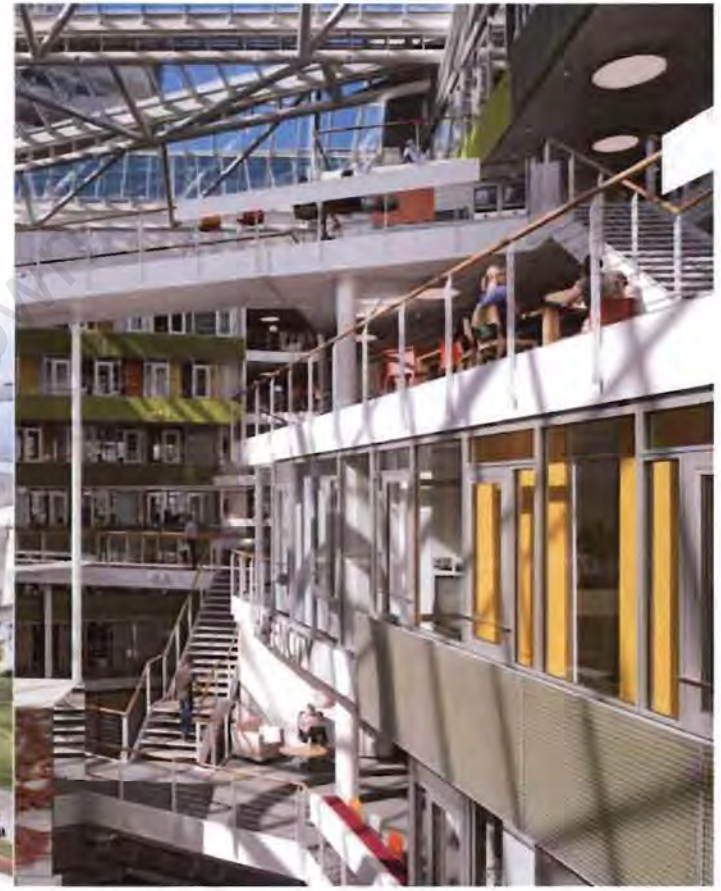
Gunter Behnisch
2007-2009
Unilever Headquarters,
Germany

Design

The building expresses the ideas which Behnisch architecture stands for by expressing and incorporating interesting form, materials and light into the building, and creating a focus on the **interaction and networking of people**, these are fundamental aspects to the **spatial arrangement** and give the building formal and **spatial identity**. The building also creates an identity of being environmentally designed and reduces the amount of energy through natural lighting, insulation and ventilation techniques this becomes an important aspect to the formation of internal space.



Form of the building



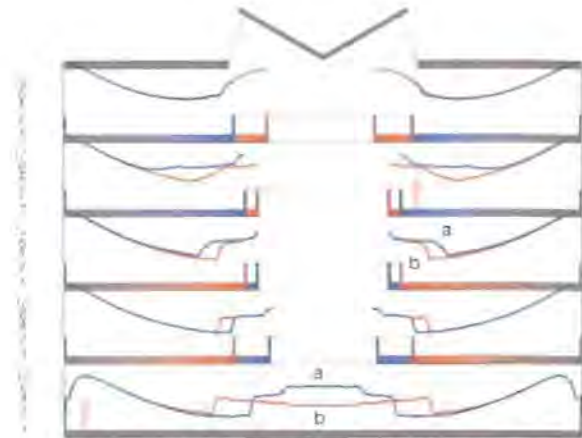
Natural light filtering into the atrium which incorporates meeting places to create interaction between employees



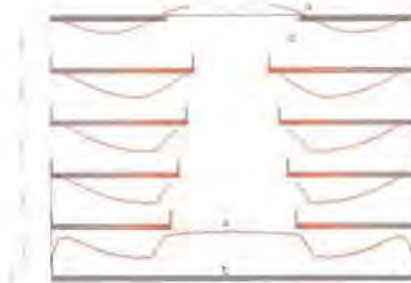
Result of the atrium space

Daylighting

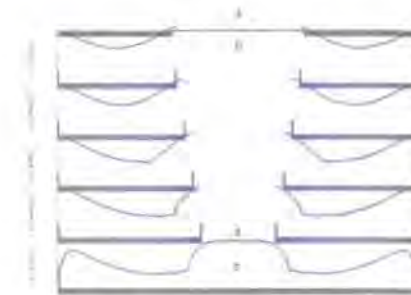
The atrium of this building has been designed to allow large amounts of daylight to flood the space. Daytime lighting experiments were conducted on various cross sectional configurations with the building tapering either upwards or downwards and roof configurations looking at the difference between all glass and saw tooth roof with north facing glazing. The results were that the void that tapers at the top allows for a higher average daylight coefficient with more even day time illumination on the lowest floors. A saw tooth roof with north facing glazing also had its advantages in allowing the eye to adjust easier by letting natural light to filter into the space reducing the contrast between the bright atrium space and the darker working areas. A sculptural element in the centre of the atrium further helps to diffuse light into the space



Daylight factors for two cross section versions
a- widening towards the top
b- widening towards the bottom



Daylight factors for atrium widening towards the bottom
a- all glass roof
b- saw tooth roof



Daylight factors for atrium widening towards the top
a- all glass roof
b- saw tooth roof



The saw tooth nature of the roof structure is such that it creates a sculptural folding feature. The roof structure and ramps expresses the idea of connectivity and networking between people.

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Conclusion

The Mediatheque and the Unilevers building derived from two different approaches in methods of designing. The Mediatheque was derived from a concept of creating natural organic forms which sway in a virtual water tank and the Unilevers building was formed with a focus on creating a brand identity of networking and energy efficiency. The two different approaches resulted in different atrium forms. The Unilevers building resulted in the form of a large atrium allowing natural light to flood the space which gives the building its energy efficient identity, the Mediatheque has thirteen, small in comparison, tubular atriums which were formed by the conceptual idea and act more as sculptural elements giving the building identity. The structure is an important factor in determining the aesthetic and identity. The Unilever building is partly defined by the roof structure which expresses an idea of networking whereas the Mediatheque tubes are formed by the structure and define the atrium space. The amount of natural lighting which enters the space through the atriums is an important aspect of creating an efficient building. The Unilever building studied the lighting intensities which entered the space resulting in a comfortable balance allowing sufficient light for the program. The Mediatheque has a larger floor to ceiling height than the Unilever headquarters, however the space is also much deeper allowing limited amounts of light into the space which does not make the building flexible for programmatic change unless the space is artificially lit. The tubes which allow light to enter in the centre of the floor plate do not allow for sufficient light to enter the space and only reduces the amount of lighting needed by a small percentage. The function of the atriums is different in the two buildings. Differences between the atriums lie in that the Unilever Headquarters allows for the connection

of people through the space and allows for sufficient natural light to serve the spaces connecting to the atrium. The Mediatheques tubes do not accommodate for this, however they do form the structure for the building. Similarities which lie within the atriums are; vertical circulation of people and services, variation in special relationships and they both create an interesting form.

The idea which the Mediatheque incorporates does not create efficiency however it is important to note that it is inspirational to incorporate natural forms within a building. The Mediatheque is too imbalanced on the scale of being sculptural and creating contradictions with passed eras. Lessons are meant to have been learnt that deep spaces are inefficient and I believe with today's environmental and energy issues these lessons are far too valuable to be ignored at the expense of creating organic form. The building is however interesting and I hold onto the belief that the form does however inspire people to recognise and appreciate organic natural form. In turn this may inspire people to preserve the environment.

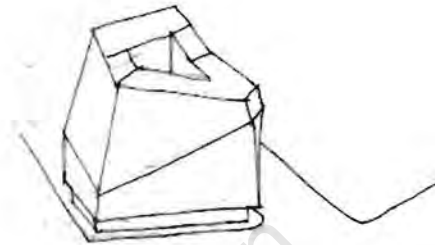
The main difference between the two atriums is that the Mediatheque focuses on the sculptural aspect and the Unilever building focuses more on the functional formation of an atrium. The Mediatheque has ideas which are very interesting and inspirational to incorporate into my design however more lessons can be learnt from the Unilevers building in relation to creating efficient spaces which is my design focus.

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The drive to find an arrangement incorporating previous ideas and new ones led me to producing exploratory sketches. I imagined different spatial arrangements in the search to find a balance or compromise between creating an atrium with sufficient amounts of natural light, reached my set bulk goal, creates spatial quality in an atrium and an identifiable form.

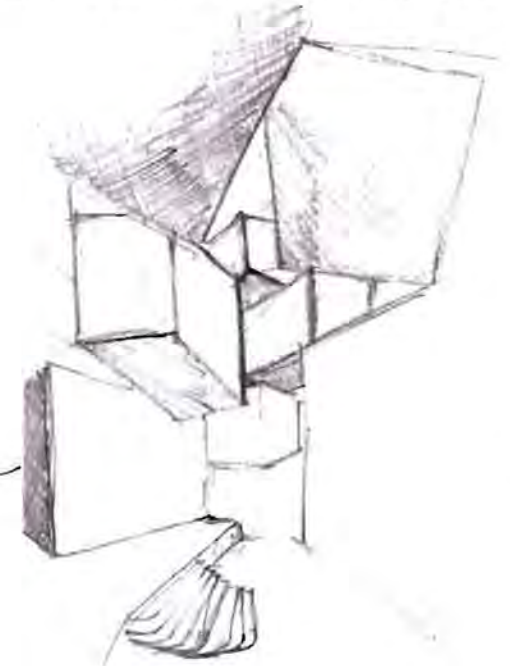
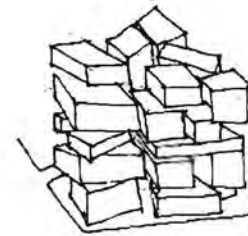
An important part to this study was to imagine spatial organisations which would create various visual and spatial links to people and places within the atrium.

The office building has to accommodate approximately 1300 people working eight hours a day for five days of the week, which means that they spend half the time that they are awake in the office environment. Consequently the workers must feel at ease in their work environment and part of the working community without making people feel namelessness with a large scale.



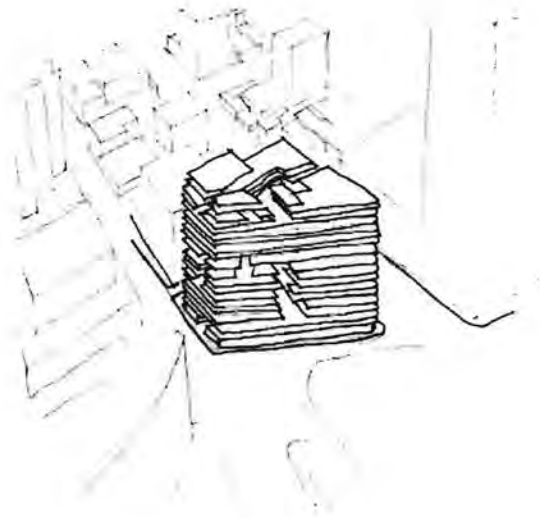
1

One central atrium allowing light to filter 14 floors. The atrium tends to be a bit too deep even with extra openings on the sides of the atrium to allow for more light to enter.



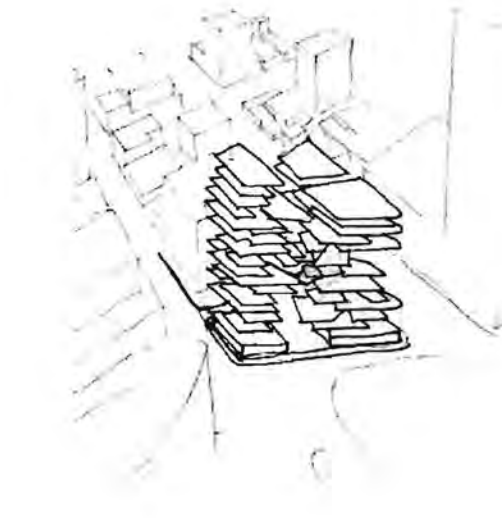
2

Smaller masses for work groups. These boxes are angled in different directions to create varying spatial relationships and connections into different spaces. The gaps between the boxes allow for natural light and ventilation. This arrangement creates interesting facades. There may however be too many angles making different spaces appear similar, as a result becoming confusing and disorientating.



3

Floors are cut at varying levels creating smaller atriums as well as one larger atrium in the centre. The smaller atriums are focused on linking views from the urban context into the atrium and interaction between workers. The atrium however did not integrate the idea of the atrium being the structure for the building.



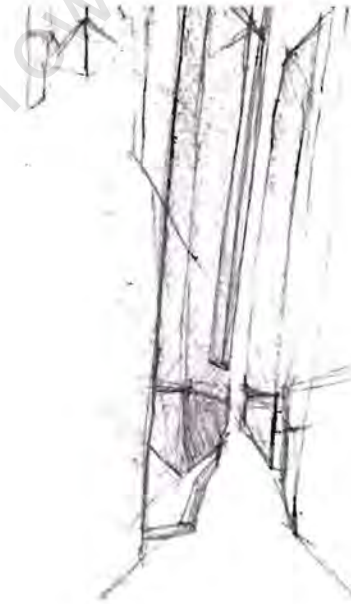
4

An atrium which consists of spaces being hung from a central core enclosed by a facade. The spaces are rotated at irregular angles creating variation in the views and spatial relationships between different work areas. This option may be spatially inefficient and the target bulk would be hard to achieve.



5

Shifted larger floor plates than the previous exploration making the space a bit less busy. The divisions are larger than the previous option making some overlap creating more connections between the circulation cores and less unusable space.



6

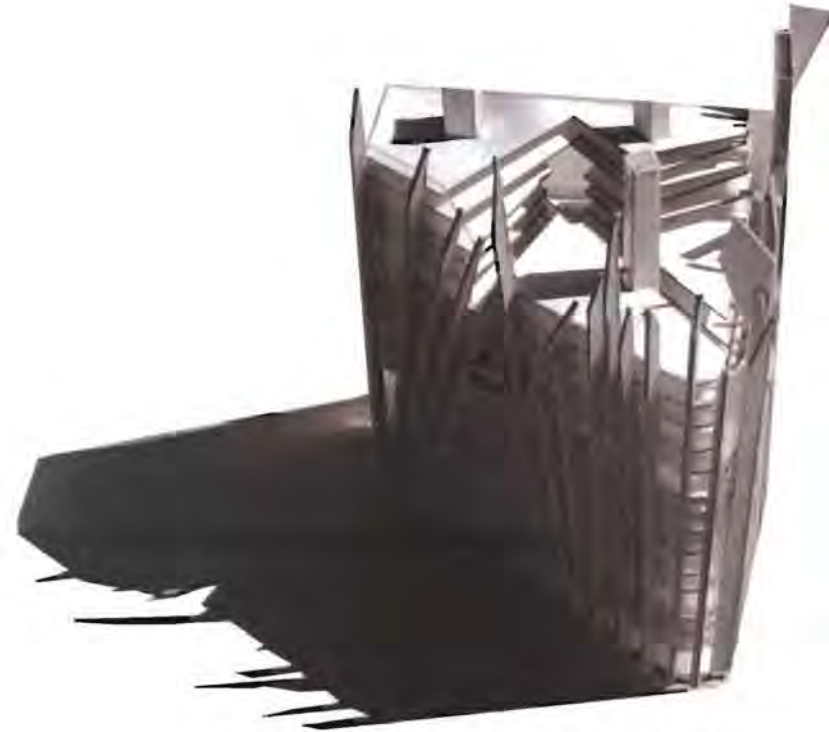
Atrium which is formed by cutting void through the mass. These voids create visual links to the urban context as well as create connections between spaces, however just as the 'safeguard version' the void is too high and narrow creating an unpleasant space for an office environment.

2 Spatial Connection

The study model looks at creating connections between spaces in the building and the urban context. There are different views out to signal hill, the Atlantic ocean, the city centre and Table view. Views can help with orientation in the urban context. The facade has openings in the shading device which creates focus to particular views. The spatial arrangement is organised with shifting floor plates to allow for interaction of people between the spaces in the building. The shifting floor plates create a series of smaller atriums which make visual connections to the urban context. The idea of having a variety of smaller atriums is that it creates more intimate smaller identifiable areas within a larger whole. This means that occupants will benefit from feeling part of smaller more intimate areas where they can become part of a working community without feeling the anonymity of large scale office environments. The arrangement allows for people to build close relationships as well as see and meet new people in other areas of the building.



All atriums linking to the exterior intersect at a point in the middle of the mass creating one larger central atrium. The floor plates in the atrium are cut back differently to maximise connections between spaces.



North East view - The shading facade frames the visual axis, is structural and expresses the idea of connectivity through its pattern which also imitates a natural pattern like a forest and its view ports connecting people to other spaces.

Drawbacks

The problem with the design is that the structure which supports the floor plates does not create the form of the atrium.

The atrium is the main focus of this thesis and the expression of form could be created by the atrium.

In the spatial connection option the structure comes from the vertical circulation cores and columns placed where required to hold up the floor plates. The structure does not follow the atrium form and give the building a strong identity.

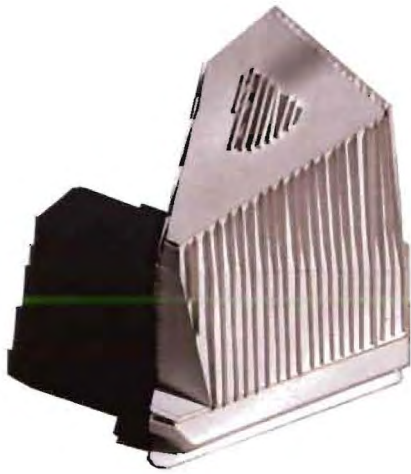


Visual connections from the site into the natural and urban context



Visual connections from the spaces in the building to the urban context and spaces in the building

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DESIGN DEVELOPMENT 3

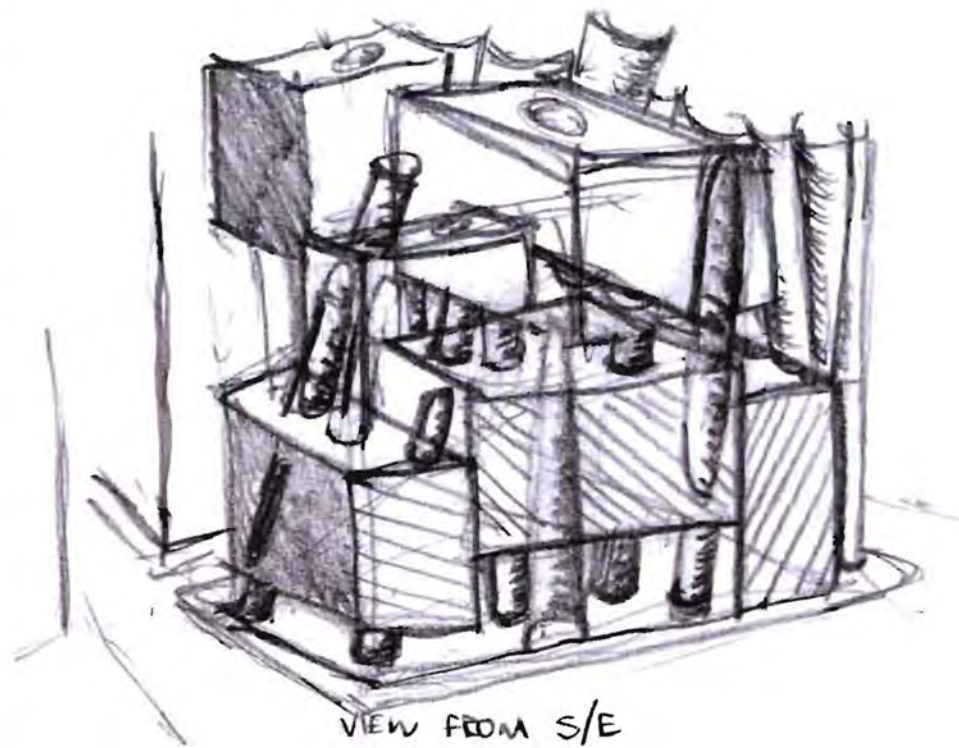
Expressing the Atrium to form Identity

In my next steps led me to the decision to choose a circular atrium form which would create interaction, become the structure, allow natural light and ventilation to enter and house the vertical circulation and services.

Circular atriums poses new spatial qualities which could be seen as a fresh new outlook to office buildings and the working environment. The thought that a circular form would be efficient in many different ways. A circular form has less spatial efficiency than a square, however my thesis involves creating a target bulk and not spatial efficiency. A circular tube is strong in all axis leading to a variety of new spatial arrangements, it creates more surface area than a square and like a natural process, creates a closed loop system that is never ending and has no corners.

The focus of this exploration was to express the atrium in the buildings form to give the building identity through the introduction of atriums .

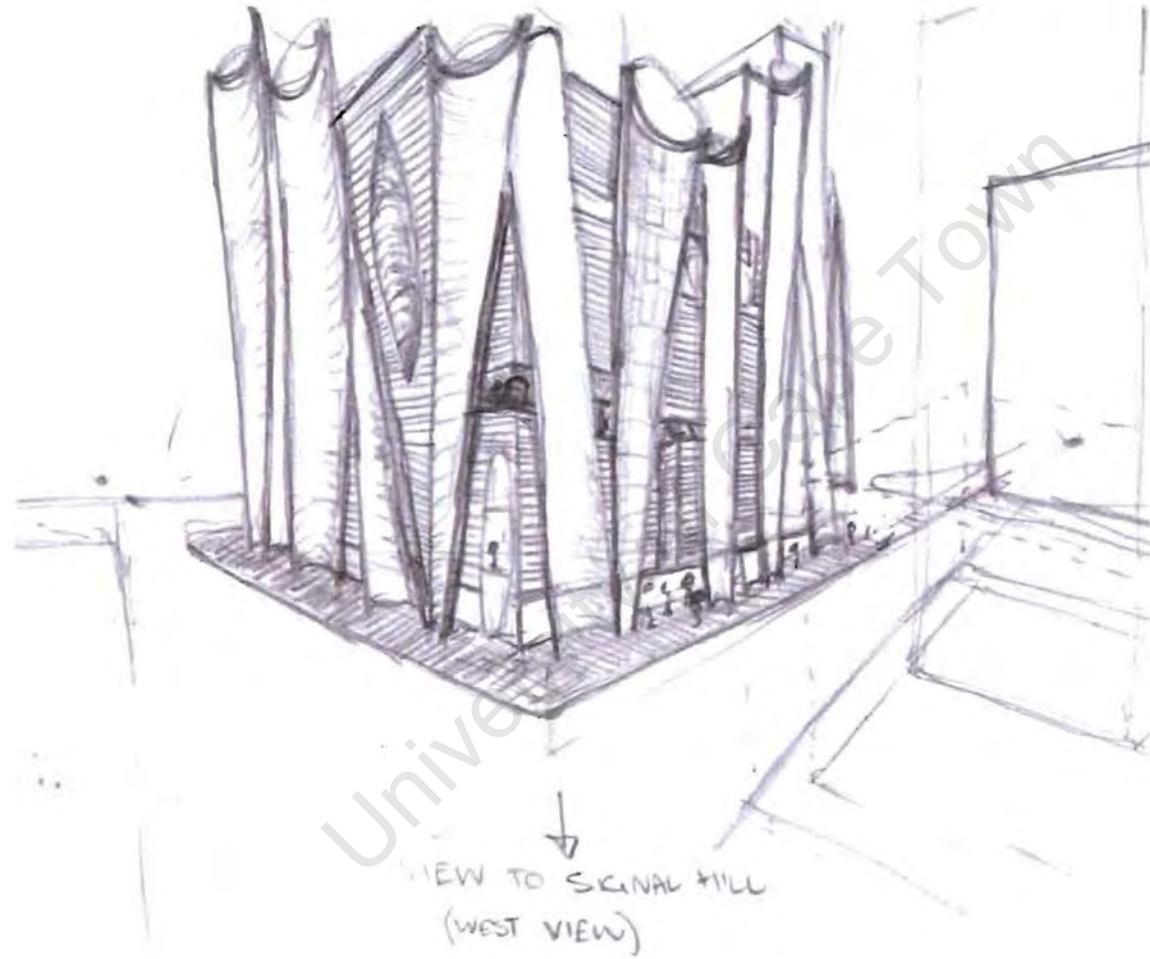
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Circular structural atriums which serve as the vertical circulation, ventilate the spaces and separate a series of masses creating the atrium



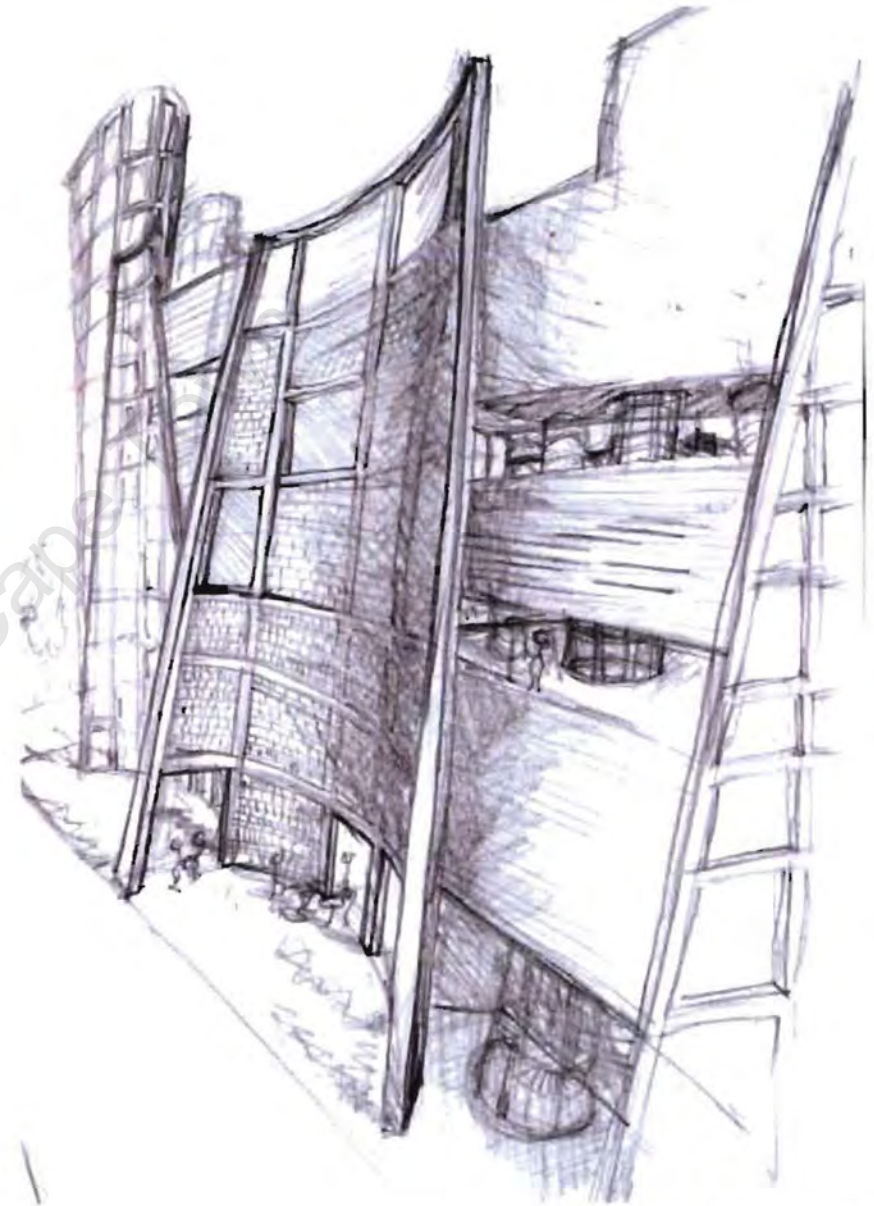
Perspective sketch - Mass Punctured by circular voids in random positions creating interesting forms when they intersect other circular and straight voids.



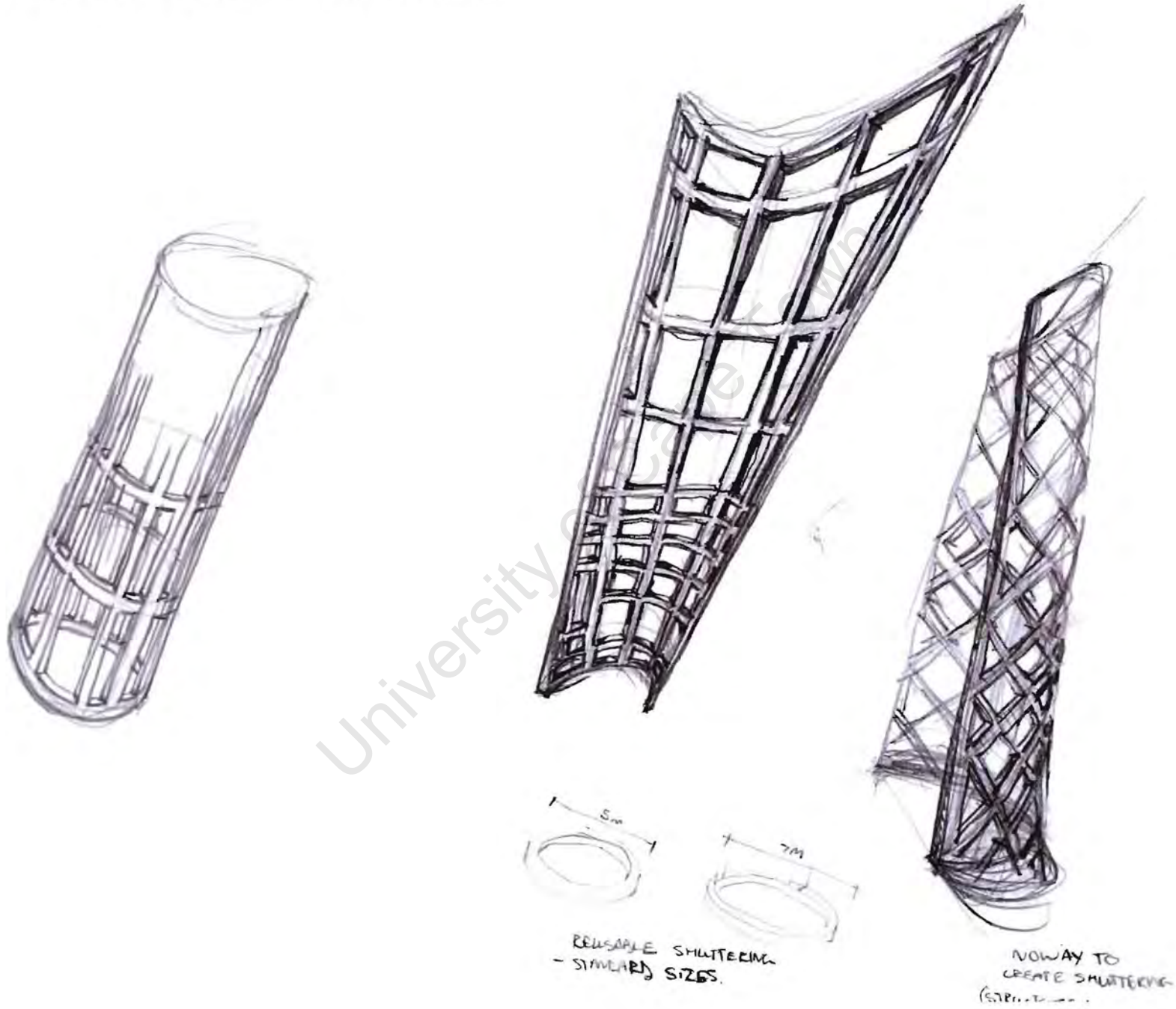
Exterior view conceptual sketch

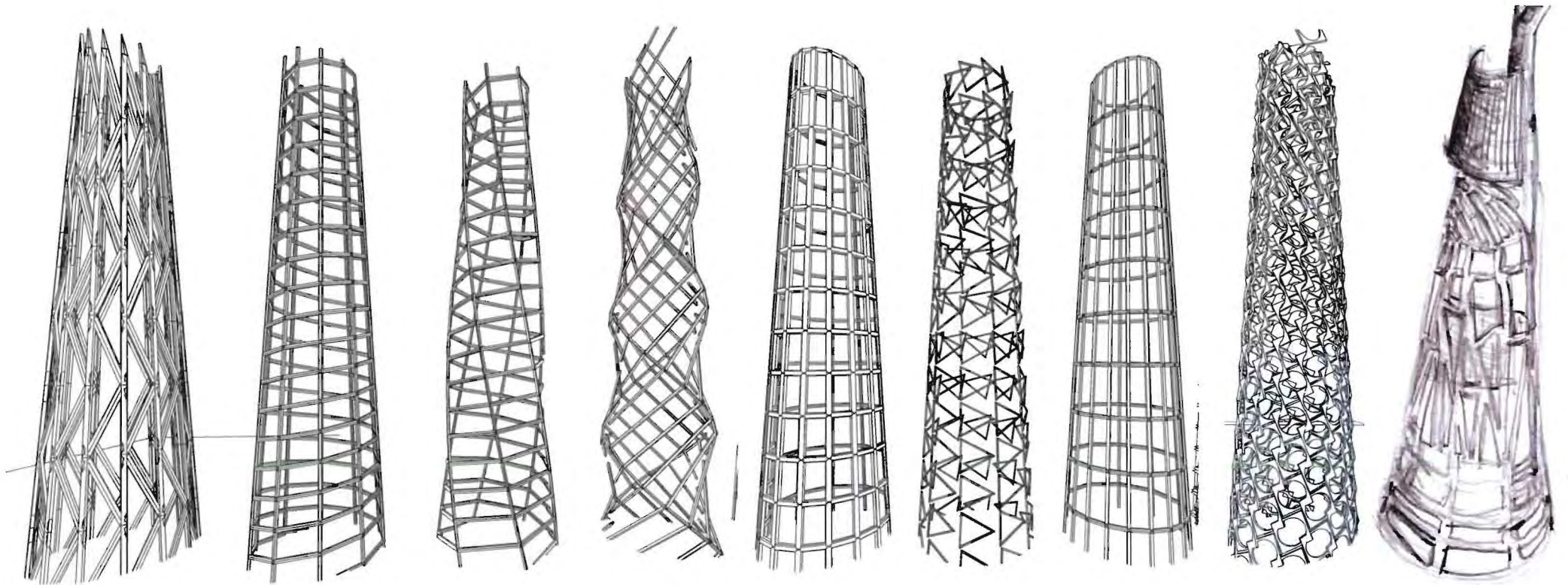


Atrium view Conceptual sketch

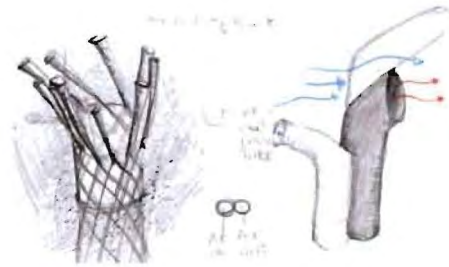


Street view Conceptual sketch

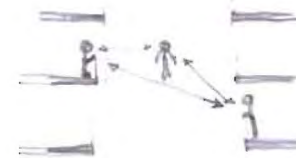




Each atrium can perform a different function relating to the arrangement



STRUCTURE



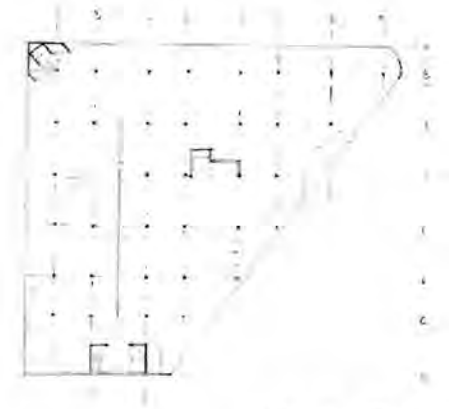
CONNECTIONS BETWEEN PEOPLE



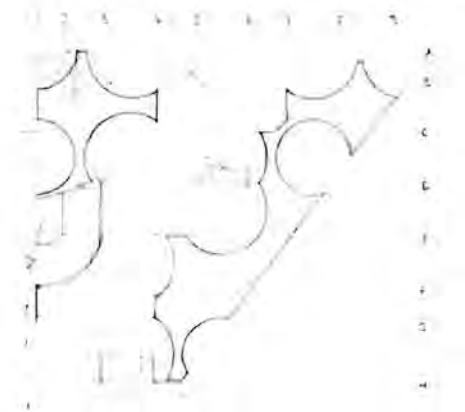
Initial Consolidation

Atriums are placed at regular intervals, relating to the structural parking grid. Where the structural grid falls close to the facade an 'atrium' becomes the facade which is cut by the constraints of the site boundary.

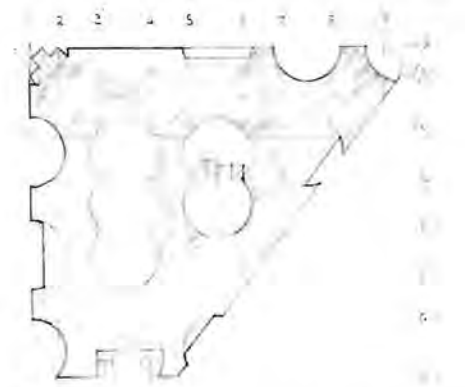
The tubular atriums in the centre are grouped together creating two larger atriums to allow for more light to enter, however the amounts of light entering still may be too small with too much structure blocking the light entering the atrium instead of reflecting it into the office spaces. The deep narrow spaces are also an issue discussed previously.



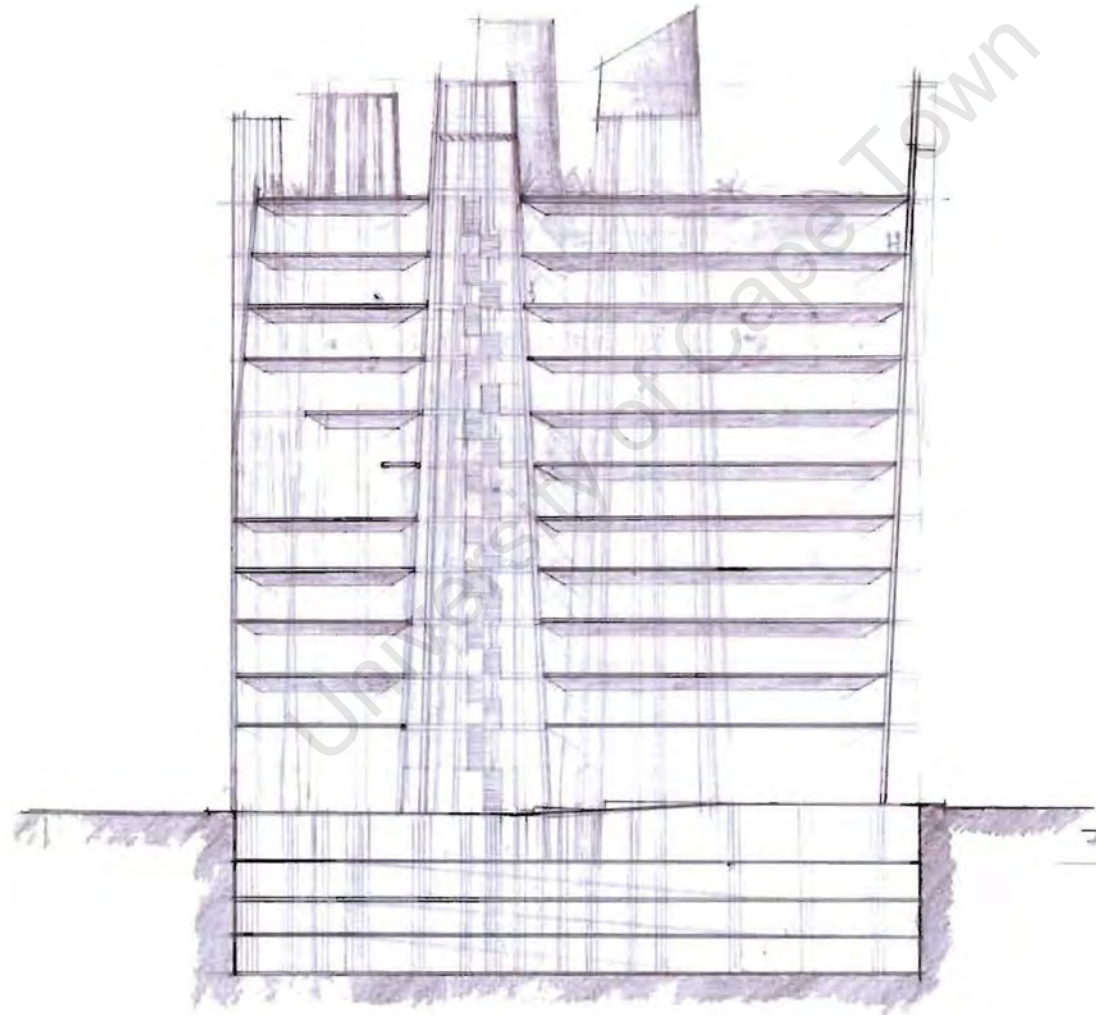
Basement Parking



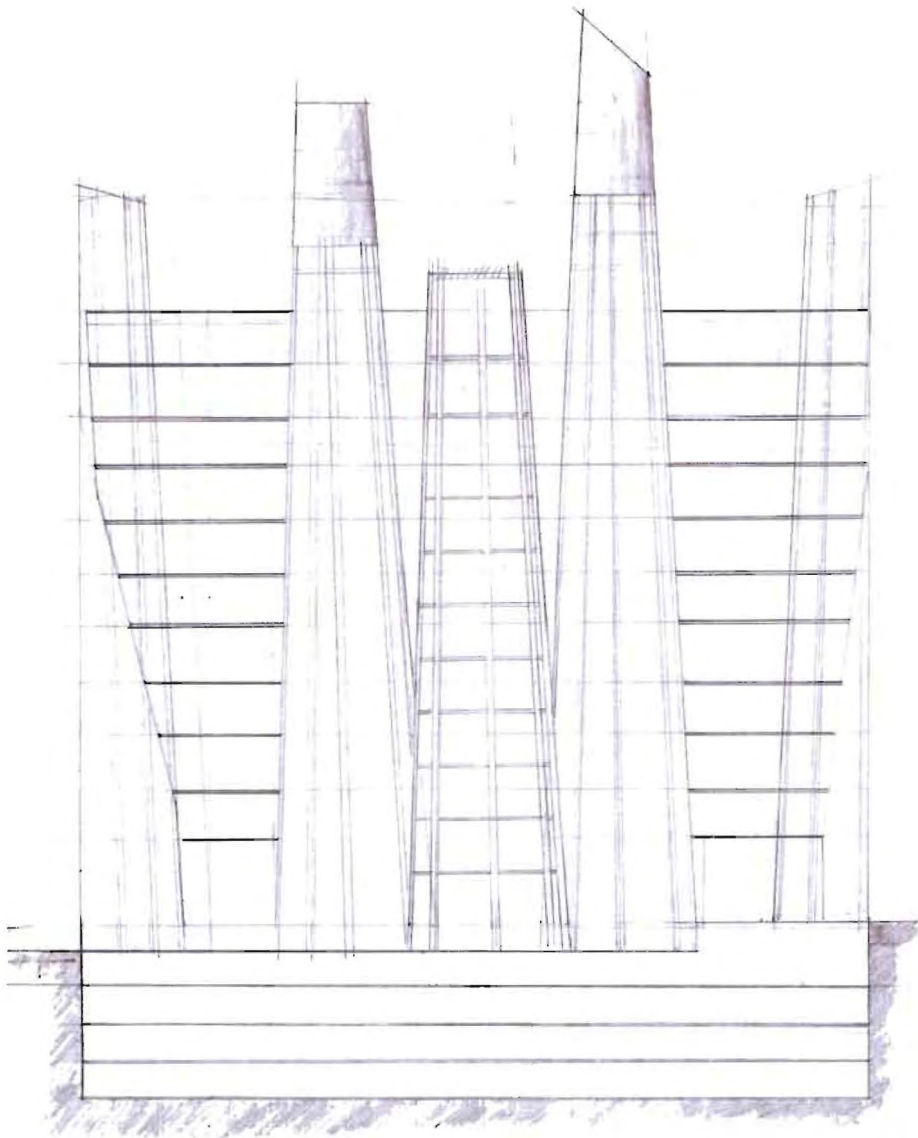
Ground Floor



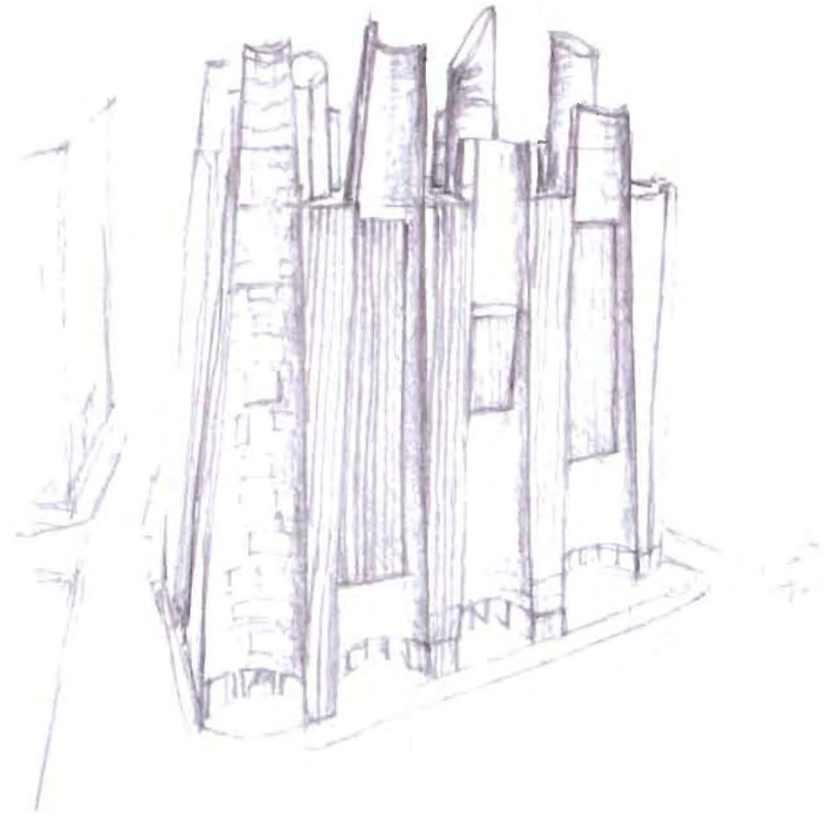
Typical Floor Plan



East West Section



North West - South East Section



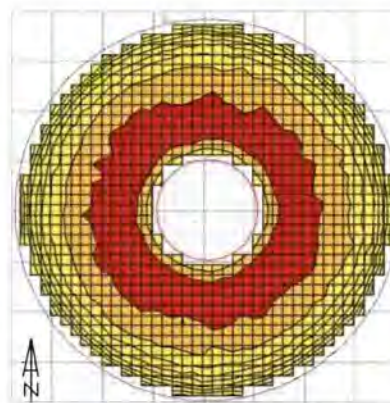
Perspective sketch from North edge

Atrium Daylighting Analysis

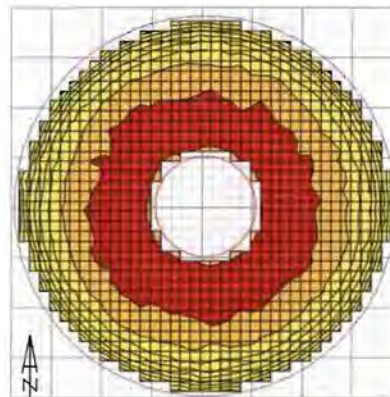
Parameters of study

In these studies fixed parameters were implemented in order to allow for comparable results throughout all the studies. The base model to which the studies were conducted introduce a floor to floor height of 4.3m, a distance of 14m from atrium to exterior facade, single glazing in the atrium and facade and 0.2m thick concrete floor slabs. Within the Analysing software the geographic location was set for Cape Town and an overcast sky condition was selected to see how much natural light would enter the spaces in the worst case scenario. This setting meant the maximum lux levels in the sky was 8000lux, and an average window cleanliness was selected. From the environment settings, results were shown over the analysis grid which calculated the light levels at every node of 1m over the surface of study. The level of the analysis grid was offset at 0.8m above the floor plate to calculate the lux levels which would be received at desk height.

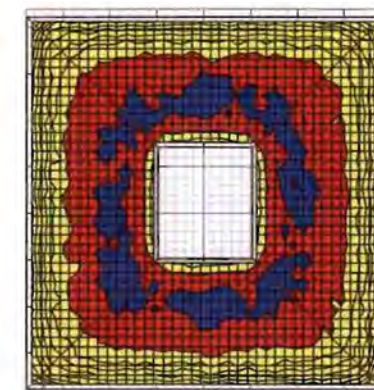
The Lux levels were calculated at 1m intervals throughout the analysis grid.



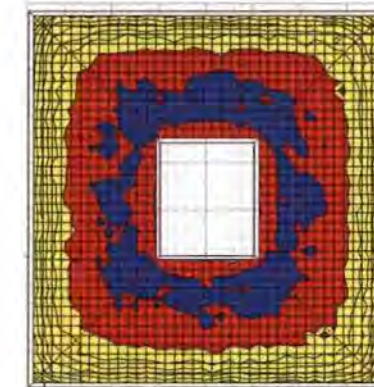
DEPTH:
7.8m



DEPTH:
40.8m



DEPTH:
7.8m



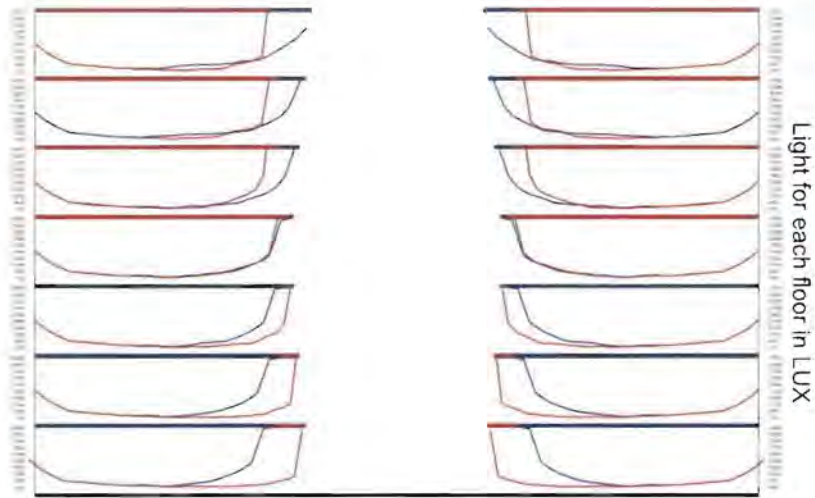
DEPTH:
40.8m



Daylight analysis for round atrium and form

Daylight analysis for square atrium and form

In the images it can be seen that there is a more even distribution of light throughout the floor plate with a circular atrium. The rectangular atrium has a slightly higher light intensity entering the space at the boundaries of the atrium to the floor plate. The circular atrium has lower lux levels of light entering the space from the atrium but allows for a deeper more consistent distribution of light resulting in higher average light intensities within the space. The circle allows for higher light levels into the offices



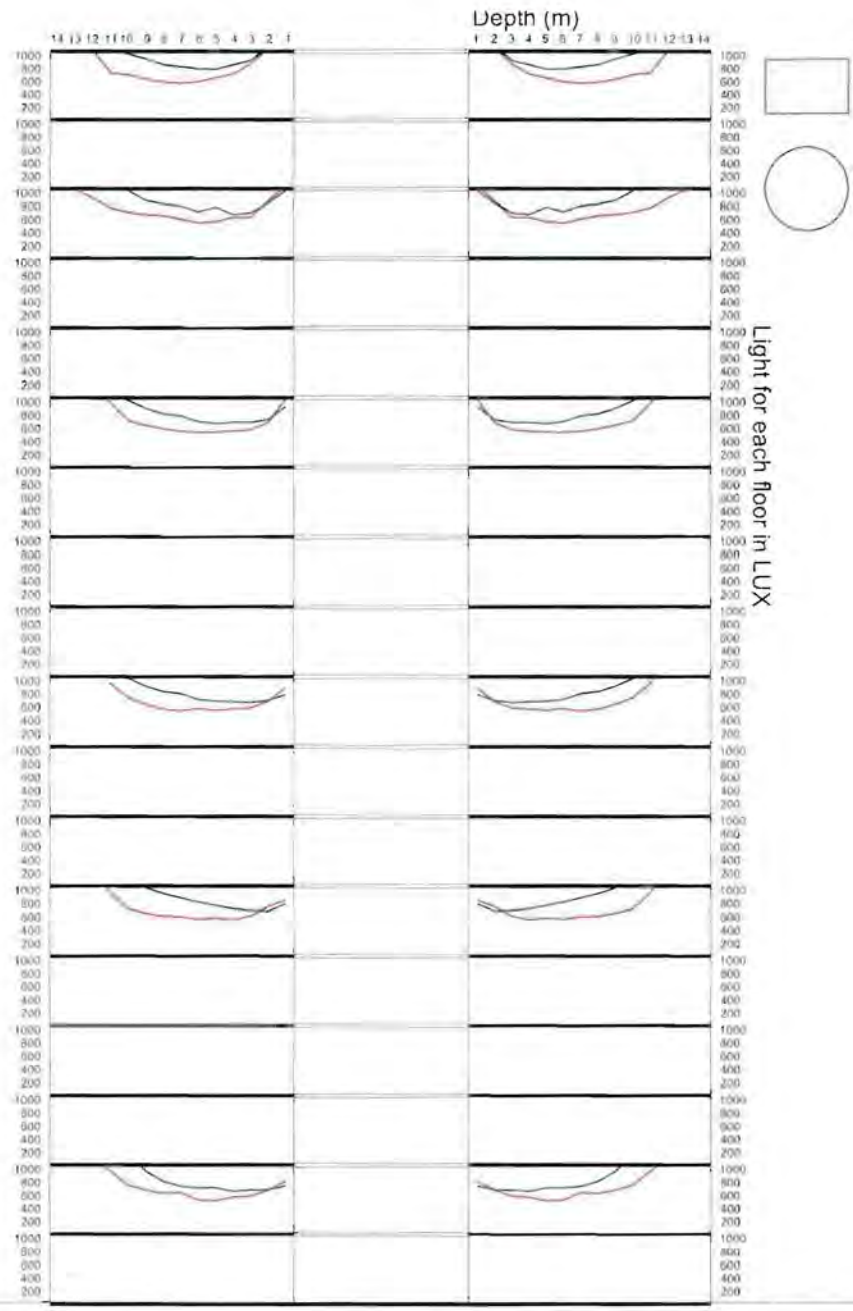
Light for each floor in LUX

Tapering up and down

An atrium which tapers up (gets progressively smaller towards the top) allows for a more even distribution of light into each level, for example at the boundary of the atrium on each floor there is the same amounts of light entering the space at the same depth. The atrium which Tapers up lets in larger amounts of light at the top of the atrium and allows progressively less light to enter in the lower levels. The atrium which tapers down also lets more light reach the lower floors.

Conclusion to daylighting analysis

The most efficient atrium to have which allows for the best lighting quality is a circular atrium which tapers up.
 An atrium which is 10m wide allows for sufficient light to enter into the lower levels of 68m deep with the aid of light coming from the facade of the building 14m from the atrium.
 The decision was made that the depth of floor plate would not be greater than 16m with the aid of an atrium. In consultations with PJC consulting, (an energy efficiency orientated firm) who were working on the amounts of light which enter an atrium suggested that with an atrium of 10m wide sufficient light only reaches seven stories into the atrium or roughly 24m. This suggests that my daylighting studies for the depth to which light can enter may be incorrect, however the results use consistent modelling techniques and still indicates that more light is brought in by a circular form rather than a square form. With the help of precedent, daylight studies and advice the atrium depth, width and form was established.



Light for each floor in LUX

10m wide atrium

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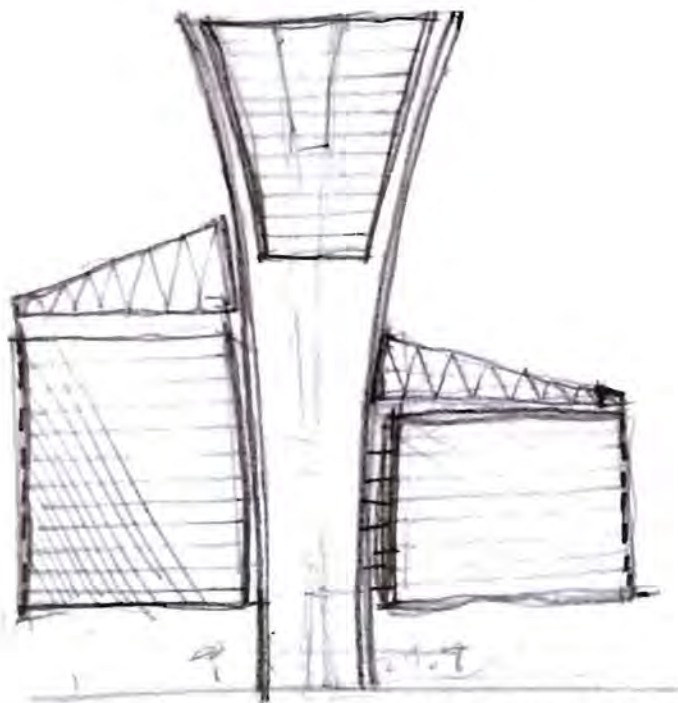


The use of hyperbolas to form the atriums structure and give the building identity.
The separation of the mass into two blocks of mass which would reduce the scale of the atrium and allow for more light to enter through the void in the middle of the masses.

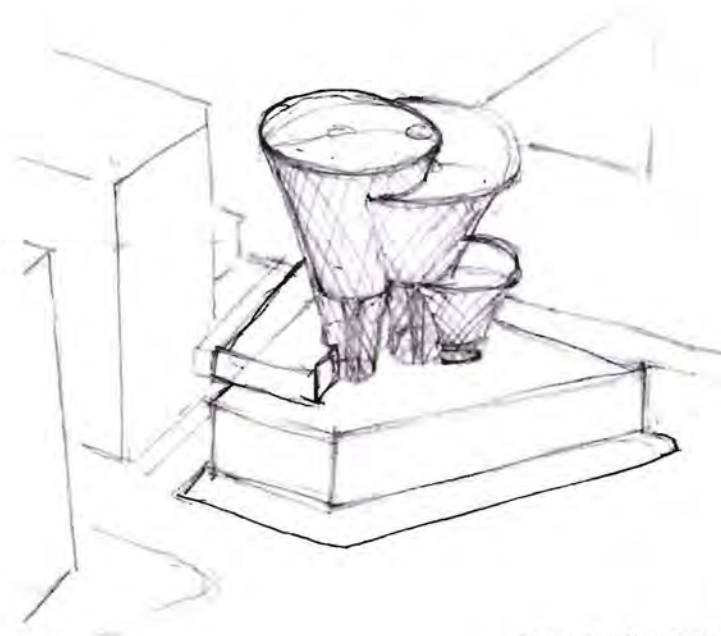


Exploration of arrangement... What will the atrium form become and how can they be arranged to create spatial qualities? The hyperbaloid acts like a funnel drawing large amounts of light in at the top and evenly distributing the light to the lower floors (due to its widening at the base)

The use of a hyperbaloid structure becoming the atrium and supporting the floor plates. The masses making up the office spaces are separated reducing the large scale of the atrium. There are also only three Hyperbaloids making up the structure which allows for a large central atrium, but also a sense that there are three smaller, more intimate atriums. The ground floor is open to the public allowing them to experience the space.



Conceptual spatial organisation section



Conceptual Perspective

Hyperbaloids

Hyperbaloid structures are created with doubly ruled surfaces creating a lattice of straight elements. Hyperbaloids are hence easier to build and more efficient than curved surfaces that do not have a straight ruling. Hyperbaloids create a Gaussian curvature (curves inward) and are superior in stability to outside forces than straight structures. Hyperbaloids are often used for water storage (large loads at a high level) and are not used because of their spatial inefficiency.

The choice to use a hyperbaloid structure was to create an efficient structure, an iconic building, taper towards the middle allowing for an even distribution of light into the lower floors and creating a angled top section which the hyperbaloid creates allowing light to enter the void below.

The idea of a hyperbaloid is interesting because it also still speaks about creating an even structure, but it is twisted on an axis creating an elegant curvature which draws attention to the form of the atrium.



Hyperbaloid model image imagining the elegant interior perspective that the void can become...



Study model to understand the nature of hyperbaloids. Straight elements rotated on a central axis.



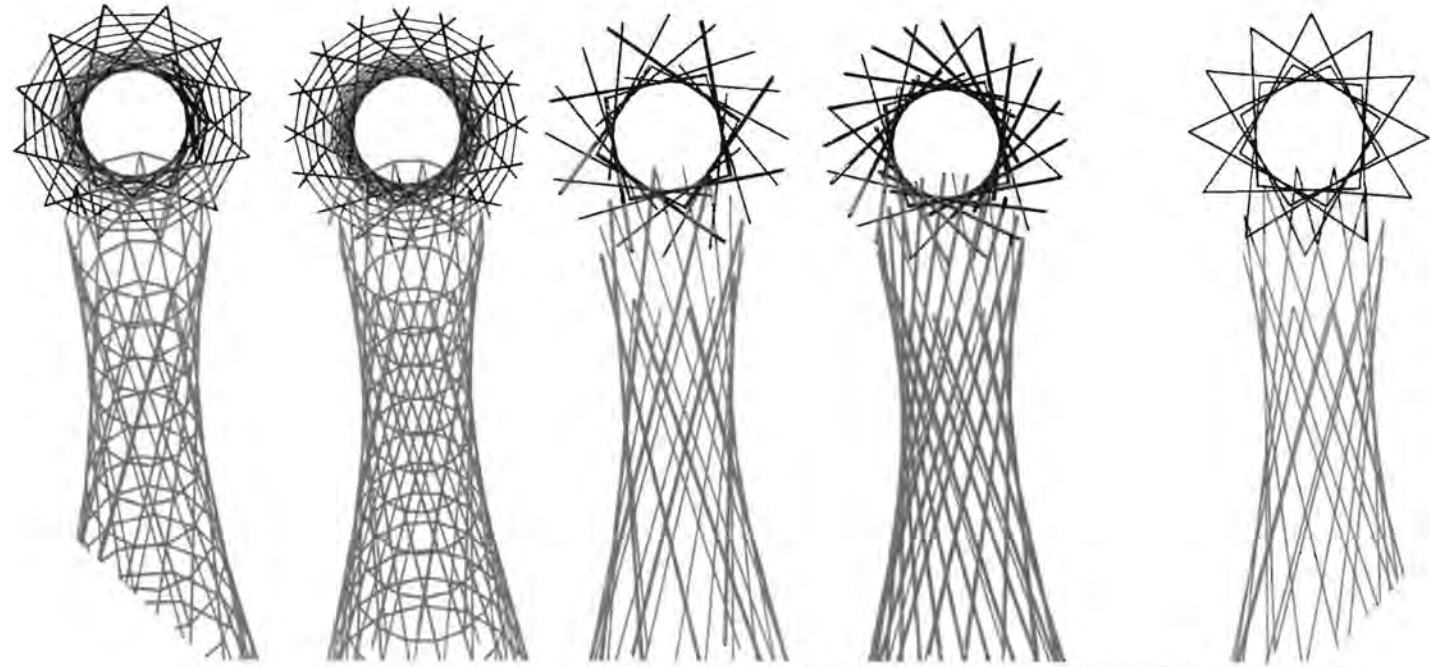
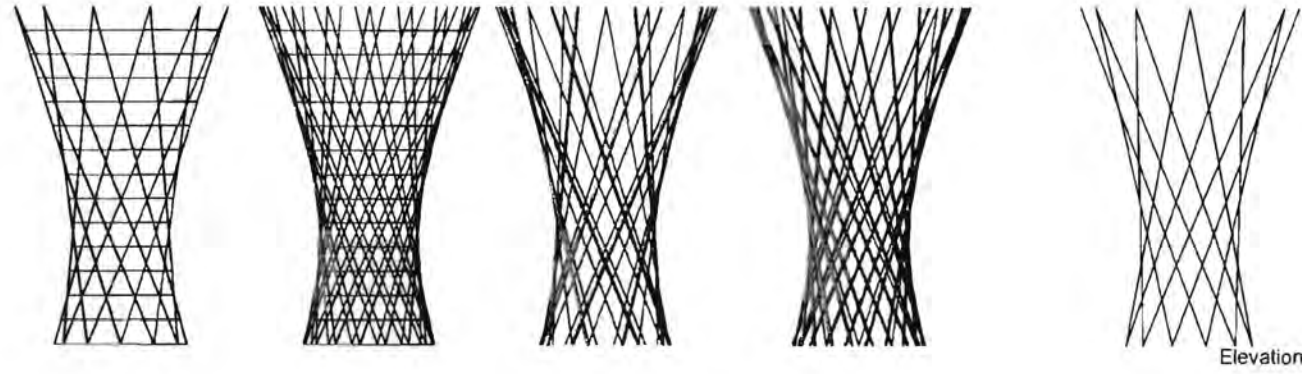
Explorations in the spacings between the structural members. The structure presented the issue of being able to get circulation from the void, through the structure into the office spaces. A system of platforms was used which gave flexibility as to where the entrance from the service cores leading to the offices could be.



Physical model explorations to the structural arrangement trying to find an interesting expression and arrangement of member spacings.

Structural Preference

The option on the far right is the most desirable because it blocks the least amount of light entering the atrium and the office spaces. A uniform thickness to the structure is also desirable to reduce the spiralling effect in the atrium which may be sickening when viewed in a moving elevator. The choice to hide the circular elements tying the structure together (seen in the first two options) was also a choice to achieve an aesthetic of structural simplicity.

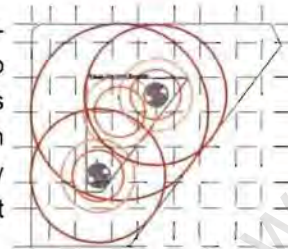
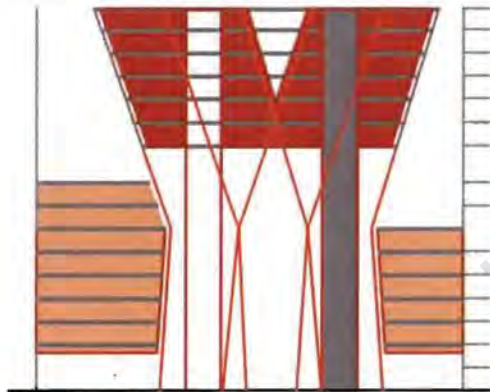


Top view with shadows that will be cast from the structure into atrium.

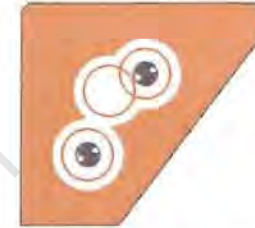
Atrium arrangement and bulk

After deciding on the massing arrangement I performed a series of study plans and sections to determine the number of hyperbaloid atriums, the arrangement, size (creating no more than a 15m deep floor plate) and the amount of floor area. After a few of the studies I decided that the atriums must be all connected to one another at the smallest point which would result in one larger atrium comprising of the hyperbaloids joining. This resulted in only small adjustments to the arrangement to try create the maximum bulk and best arrangement to allow light to enter.

Sectional Legend



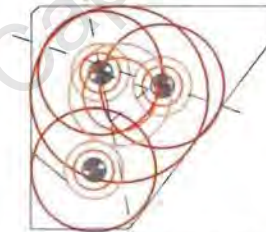
All hyperbaloid sizes at the top, smallest point and bottom.



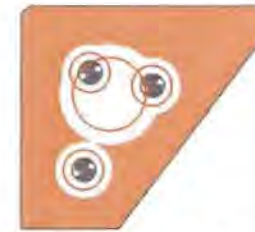
Bottom level Minimum floor area: 2207m²
Atrium area: 818m²



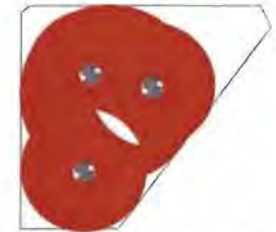
Top level Maximum floor area: 2249m²
Atrium area: 184m²



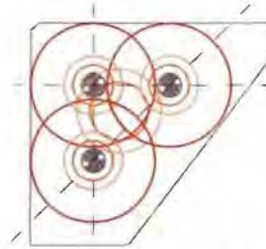
All hyperbaloid sizes at the top, smallest point and bottom.



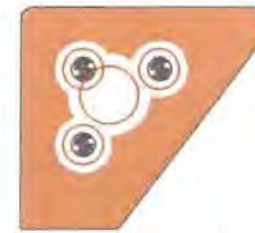
Bottom level Minimum floor area: 2127m²
Atrium area: 903m²



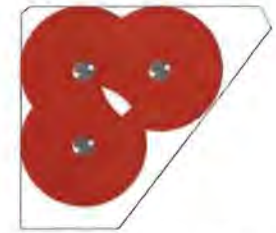
Top level Maximum floor area: 2354m²
Atrium area: 46m²



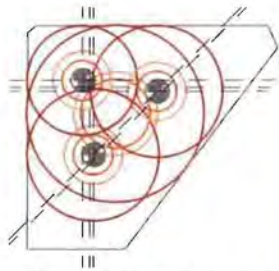
All hyperbaloid sizes at the top, smallest point and bottom.



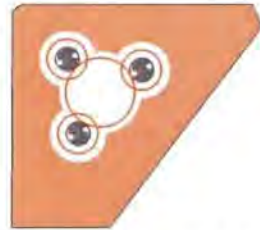
Bottom level Minimum floor area: 2127m²
Atrium area: 840m²



Top level Maximum floor area: 2151m²
Atrium area: 35m²



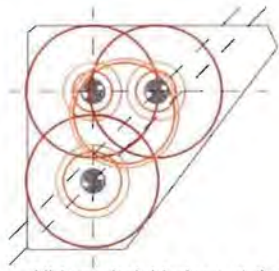
All hyperboloid sizes at the top, smallest point and bottom.



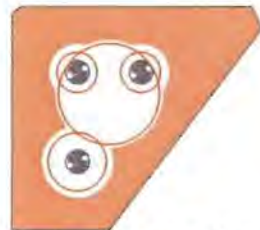
Bottom level Minimum floor area: 2225m²
Atrium area: 805m²



Top level Maximum floor area: 2202m²
Atrium area: 83m²



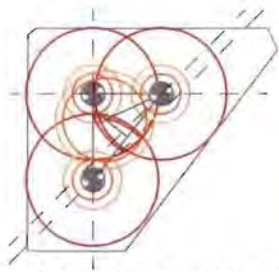
All hyperboloid sizes at the top, smallest point and bottom.



Bottom level Minimum floor area: 1990m²
Atrium area: 1040m²



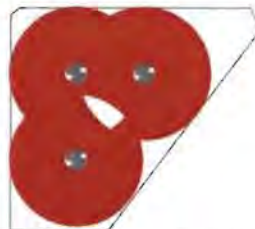
Top level Maximum floor area: 2342m²
Atrium area: 58m²



All hyperboloid sizes at the top, smallest point and bottom.



Bottom level Minimum floor area: 1990m²
Atrium area: 906m²



Top level Maximum floor area: 2342m²
Atrium area: 58m²



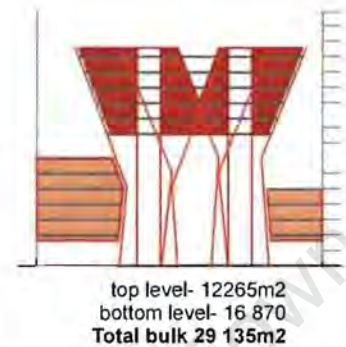
By cutting the bottom mass back on the North edge increasing the amount of light entering the atrium. With three intersecting hyperboloids the atrium structure became too busy with multiple intersecting members.



This organisation creates the best balance between allowing light to enter and floor area. The arrangement reaches the full site bulk which is over my target. The organisation however presented structural problems.

The hyperbaloid structures were overlapping and intersecting at many occasions, and if viewed from the top the angled path to which the structures follow intersect and creates a birds nest pattern (see plans to the right). This birds nest is extremely difficult to work with and restricted the position of service cores and spatial arrangement to a large extent.

In a meeting with a structural engineer Brian Richardson at KWF Wilkinson Consulting Engineers he mentioned that there are many unknown forces where the hyperbaloid structures meet and extensive structural modelling would have to be performed. I then queried the option of cutting the hyperbaloids where they intersect to free the plan. As a result large columns would have had to be placed where they intersect and the three forms would have to be tied together at each of the connection points. By cutting the hyperbaloids this Brian said I would be breaking the structural purity and it would no longer be a hyperbaloid. Hyperbaloids are also quite fragile when distributing the loads, as a result forces have to be evenly distributed along in the structure. As a result the uneven forces which the bottom levels would inflict on the structure would cause it to warp and become uneven

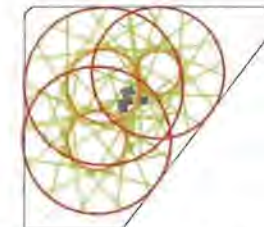


In section the North facing edge is stepped down to allow light to enter the atrium and to create visual connections to the urban context. This option creates the full bulk of the site and is over my targeted bulk. I can thus adapt the building to allow more light to enter, expose the hyperbaloid elements and have more visual connections from the atrium into the urban context



Perspective of mass

Structural Exploration - the consequence of cutting the structural members where they intersect



Structural arrangement viewed from the top level



If hyperbaloids are cut where they intersect this is the amount of members that would be lift uncut

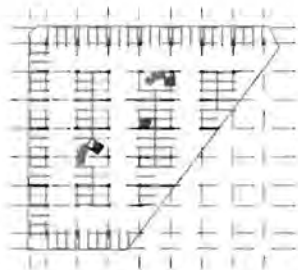


Plan showing all the members conditions. Green are the uncut structural members, red are the members cut at the base (the structure does not continue to the floor and would have to be transferred) and purple are the members that would be cut above the base (reaching the ground)

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The result of my final arrangement was due to the structural difficulties which three intersecting hyperbaloids created. The choice to keep the structural purity but reduce the number of hyperbaloids to two so that the structure allows for more spatial flexibility and less unknown forces. The third atrium structure was still needed to allow light to enter the bottom levels. It became a concrete grounded structure which helps support the bottom floor plates and is cut at intersections to the hyperbaloid structures to reduce the amount of unknown forces and make the atrium space less busy than if there were three intersecting hyperbaloids.

Atrium size with the precedent and daylight analysis studies the size of the circular atriums are between 16m (where the hyperbaloid is at its smallest)-24m wide. I had to take into account that the structure above would shade the atrium a lot as a result it became no more than 7 floors deep and no less than 16m wide to allow for sufficient amounts of light to enter.



Parking layout with structural grid



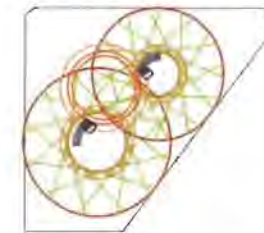
Structural grid overlaid with the position of the hyperbaloids and circular concrete atrium.



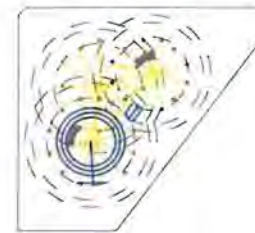
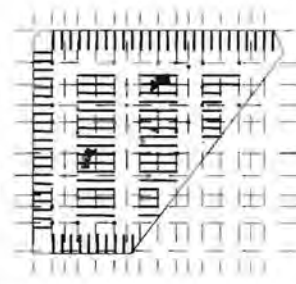
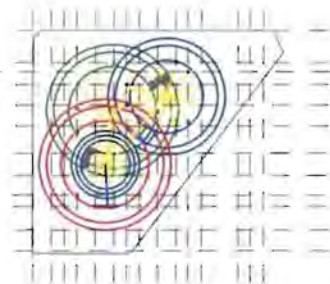
Bottom level Maximum floor area: 2130m²
Atrium area: 890m²



Top level Maximum floor area: 2050m²



Structural arrangement/pattern of the hyperbaloids viewed from the top with position of circulation.



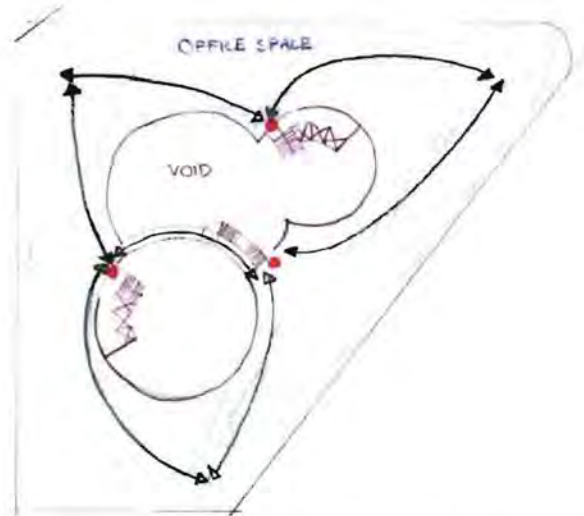
An attempt to create a structural grid which was a mix between a radial and standard grid in an attempt to reduce the amount of transfer beams. Columns are as a result positioned sometimes in the middle of parking bays and in the centre of the circulation for cars. This may become problematic for parking and reversing cars. A decision was made that transfer beams would be the best option with the standard parking grid layout.



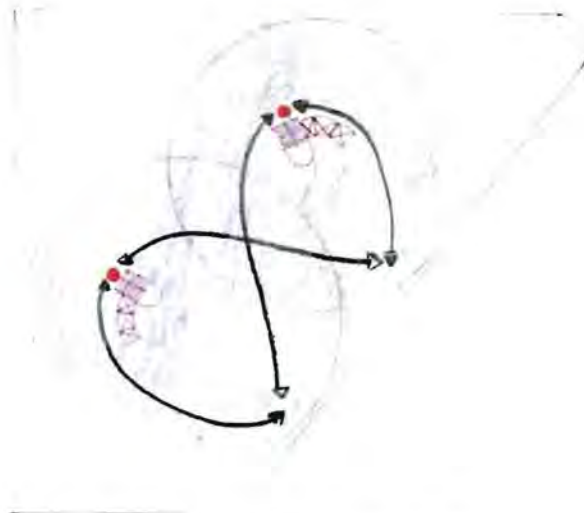
Central circulation
 makes the space look busy with many land-
 ings
 -Central circulation can act as an element re-
 flecting light into the office space



Circulation on the side of atrium
 -Frees the void
 -Can act as shading from the morning/after-
 noon sun.



Circulation and escape routes on bottom levels

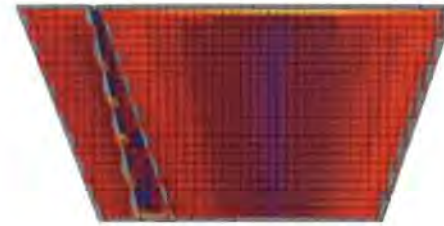


Circulation and escape routes on top levels

Development of top section facade



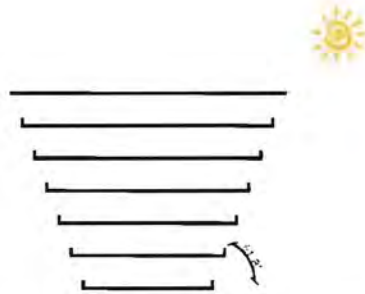
Angle of the buildings facade shades the building in-between November and mid February between 11:45 to 13:15



South facade total radiation



West facade total radiation

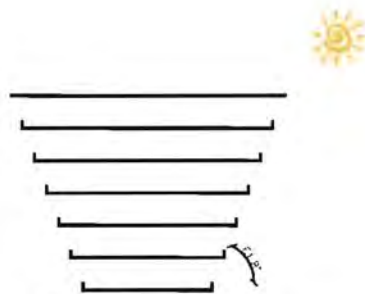


The increasing size of floor plates shades the building in-between November and mid February between 11:00 to 14:00

- No shading- building shades itself
- Intermediate zones of shading intensity
- Shading to protect entire facade

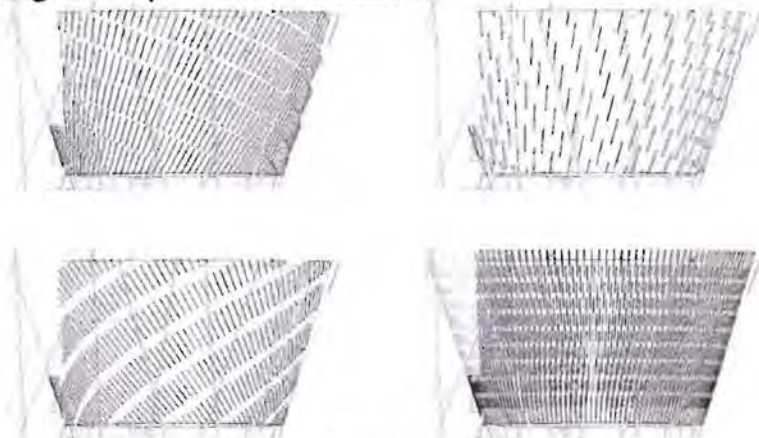


Visualisation sketch of top section



The increasing size of floor plates with a service walkway shades the building in-between November and mid February between 10:15 to 14:30

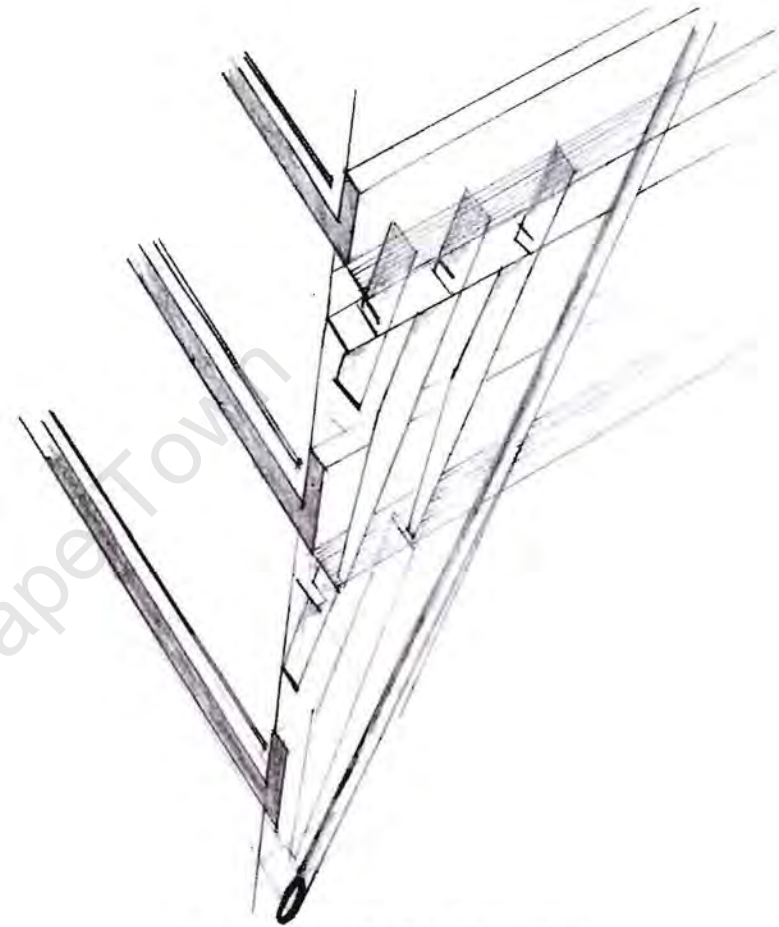
Shading on Top Facade Section



Shading pattern development



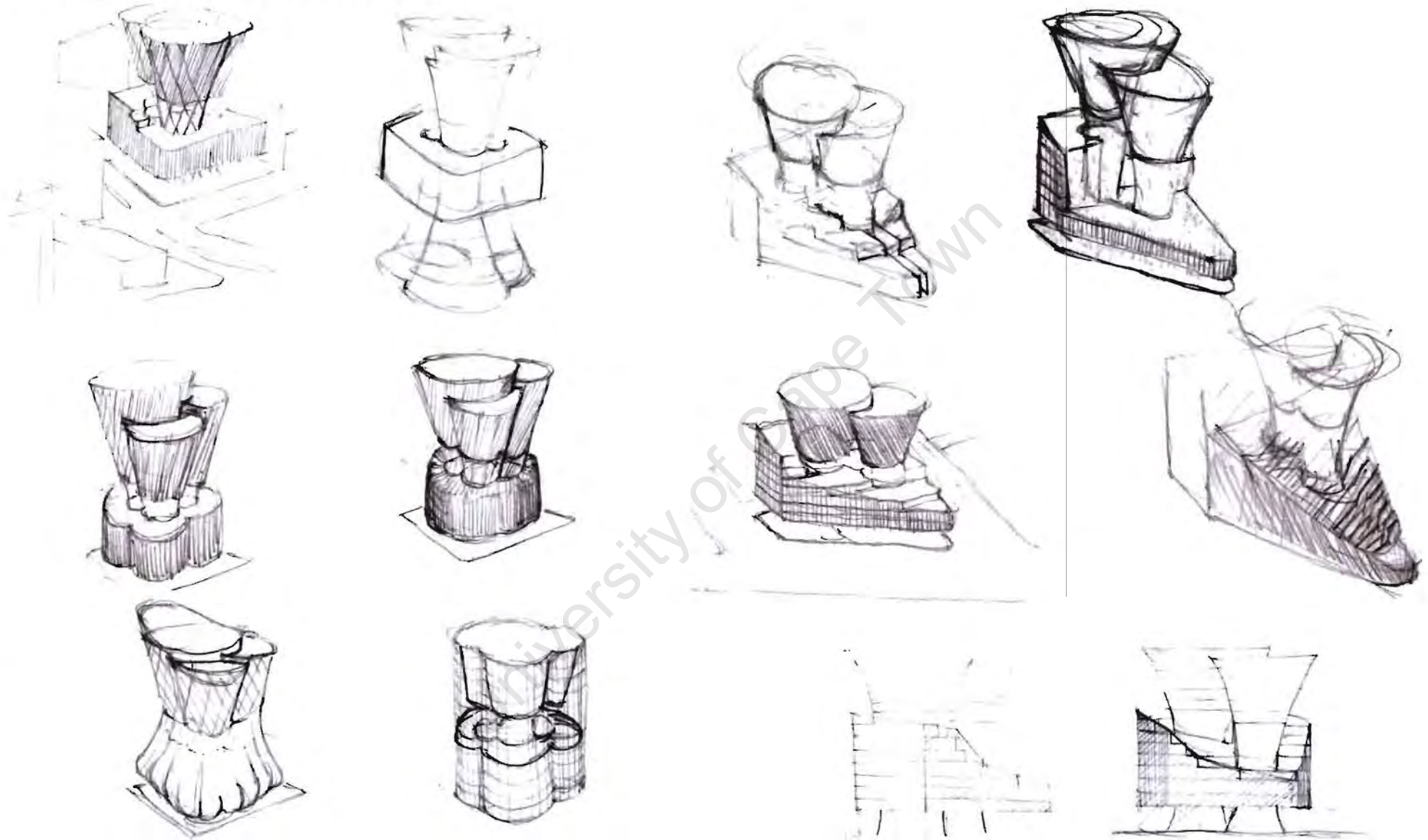
Shading follows line of structure to exentuate the structural direction and form of the mass



Sectional perspective through top section

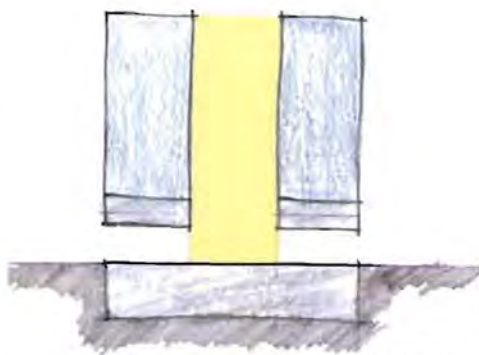
Facade includes the structure which is expressed on the exterior. Floor plates are supported by beams which come off the primary hyperbaloid structure, vertical shading is attached to the service walkways. Light shelves attached to the main structure. An up stand beam on the edge of the floor plate is in tension tying the hyperbaloid members together and supporting the floor plates. the floor slab has a gap allowing ventilation to enter the offices. The choice of vertical shading came from the need to only shade the facade when the sun were at low angles. This would result in large horizontal shading devices. Movable vertical shading is in response better for sun protection on east and west facades.

Development of Bottom Form

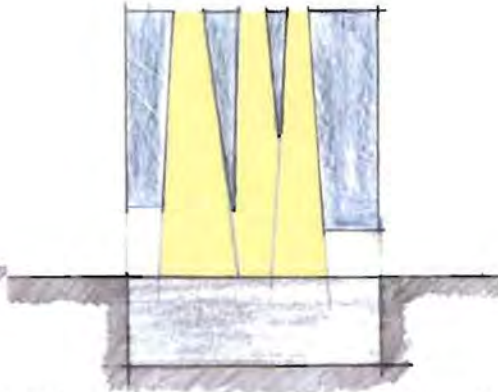


Development of mass

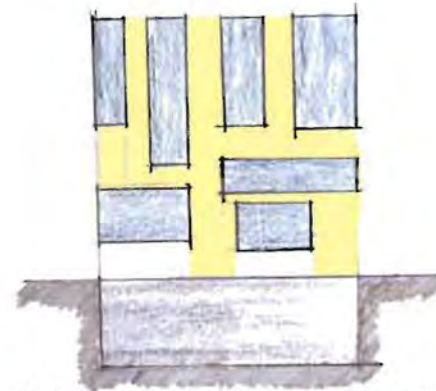
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Central Atrium allowing natural light



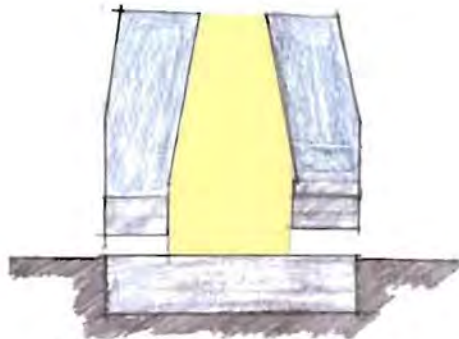
Tubes - intersecting at base creating a large public open space



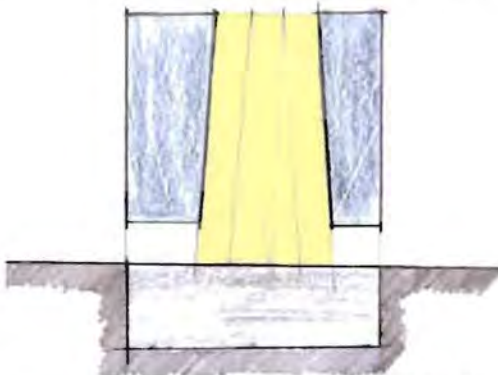
Many blocks of mass - creating multiple smaller office environments. Focusing on connections between people and spaces in the building



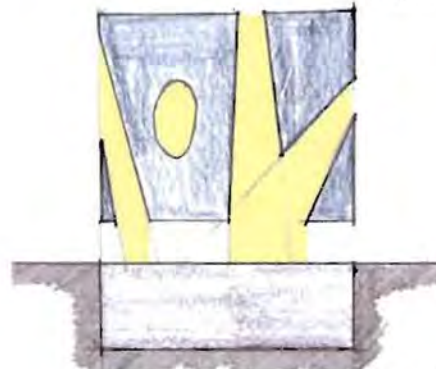
Separation of floor plates to reduce the scale of the atrium



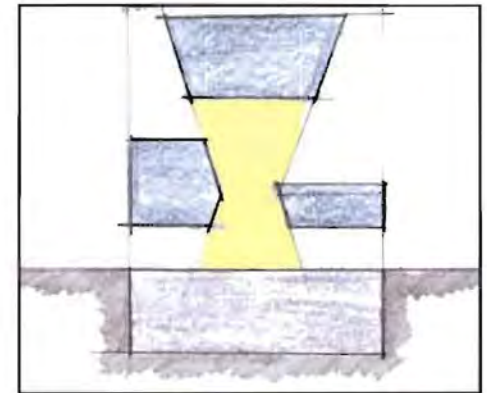
Tapered Central - atrium allowing an even distribution of light



Bunch of tubes to increase light quality

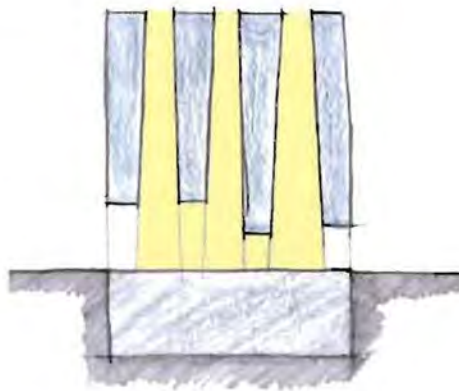


Tubes at angles - light Entering from side and top.

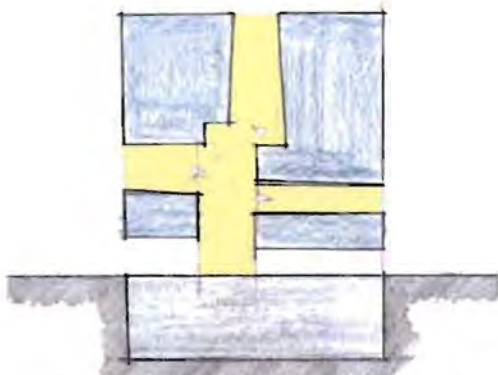


Final Arrangement

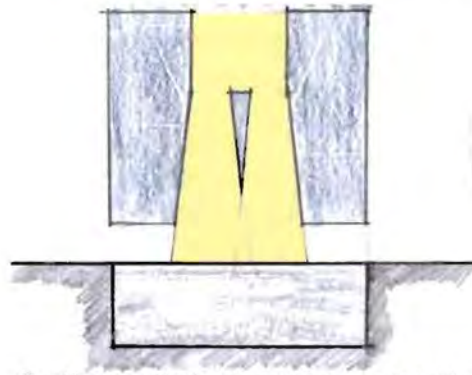
Separation of masses reducing the scale of the atrium. Top mass cut back to allow light to enter the atrium below. North edge lowered to allow light to enter atrium and create visual connections from the atrium to the urban context. Atrium becomes structure for the floor plates. Creates variation in the types of office spaces. Atrium tapers allowing an even distribution of light to the lower floors



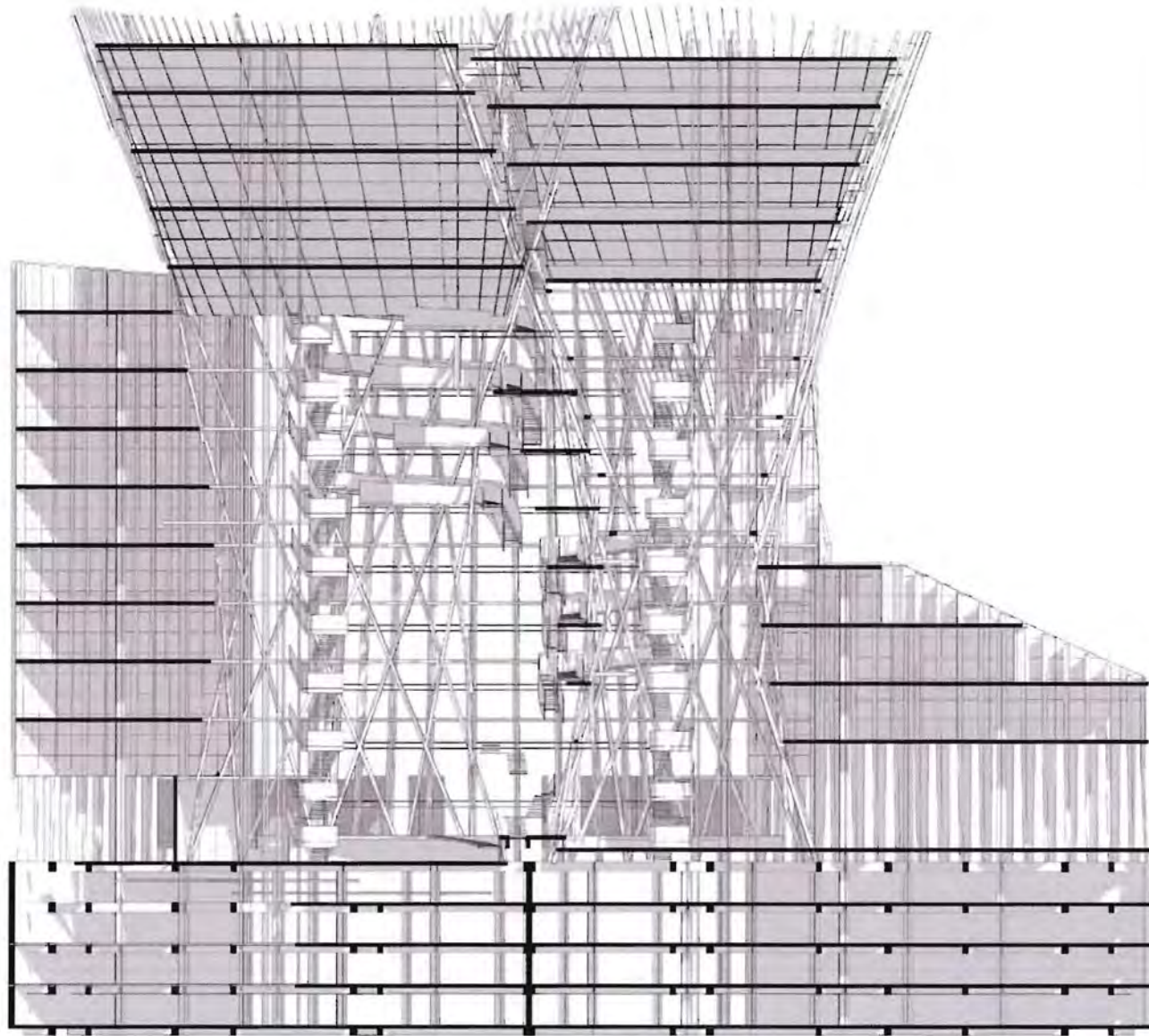
Tubes - becoming the structure



Interaction of people and connections to context

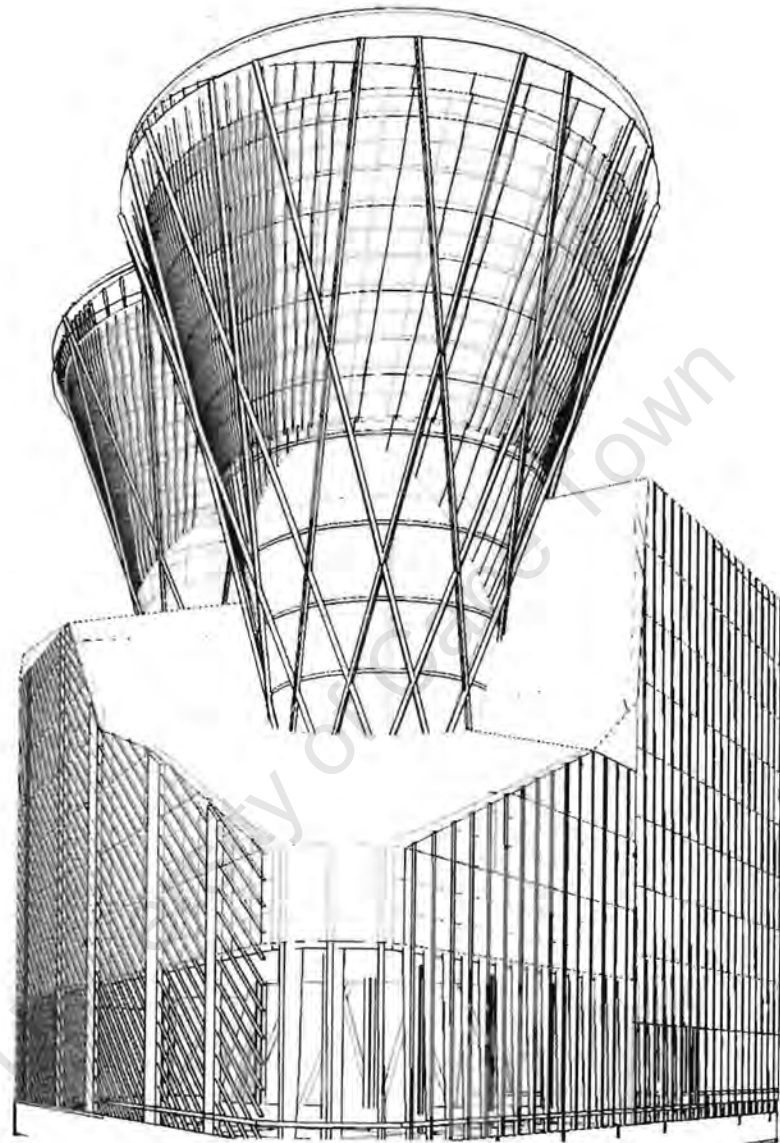


Combination of both tubes and large central atrium



Section through North South axis

The height of the bottom section not only talks about increasing natural light qualities, but also that to the urban context. On the south side of the site buildings are high rises and to the north edge the buildings are low rise. The building relates to this and speaks to both edges of the site.

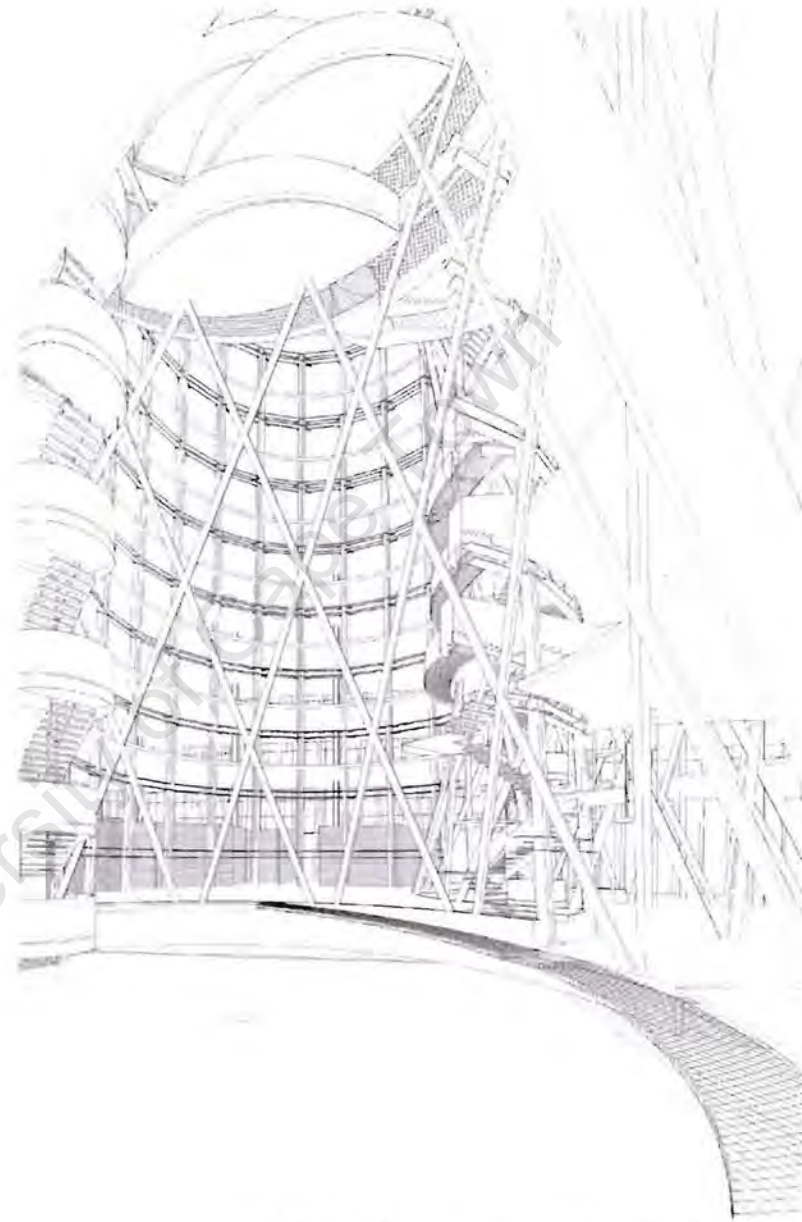


Perspective from North edge

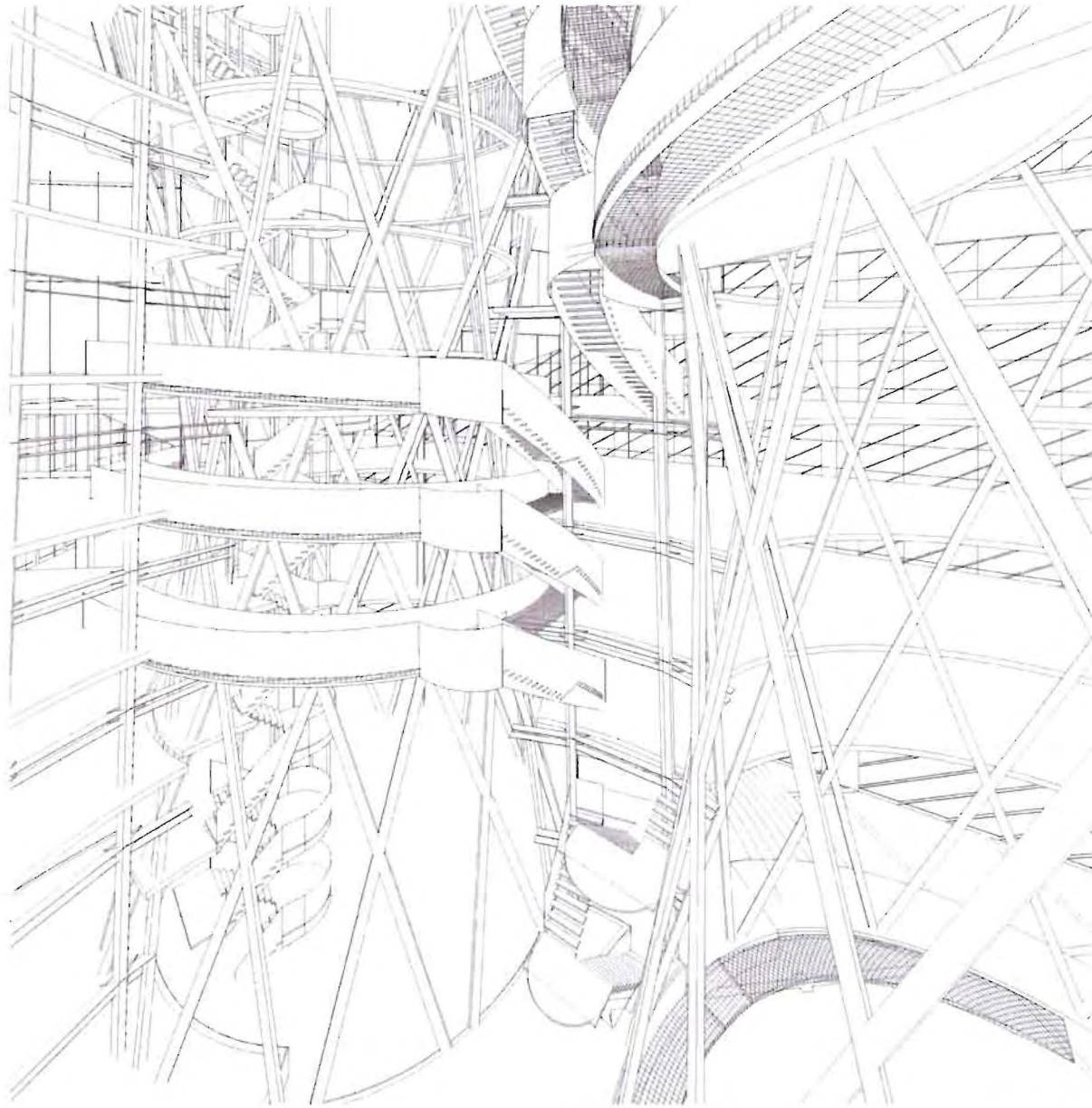
The decision to ground the bottom mass with shading and structure because the hyperboloids cannot deal with uneven loads. It also encloses the public space on the ground floor making different interior environment. The top structure is round allowing wind to flow around it giving good ventilation to the offices and reducing the impact of heat islands.

The atrium forms the structure for the floor plates and gives the building identity

The ramps and vertical circulation are housed and expressed in the atrium. The circulation forms a feature and become elements which reflect light into the office spaces, create a sense of security for people walking along them (due to the heights of these staircases and ramps in the atrium), emphasise the idea of connection between spaces and people and are elements which calm the space with their simplicity, making the twisting structure less dominant.



Perspective from ground floor looking into the south Atrium



Perspective looking out from the office spaces into the atrium

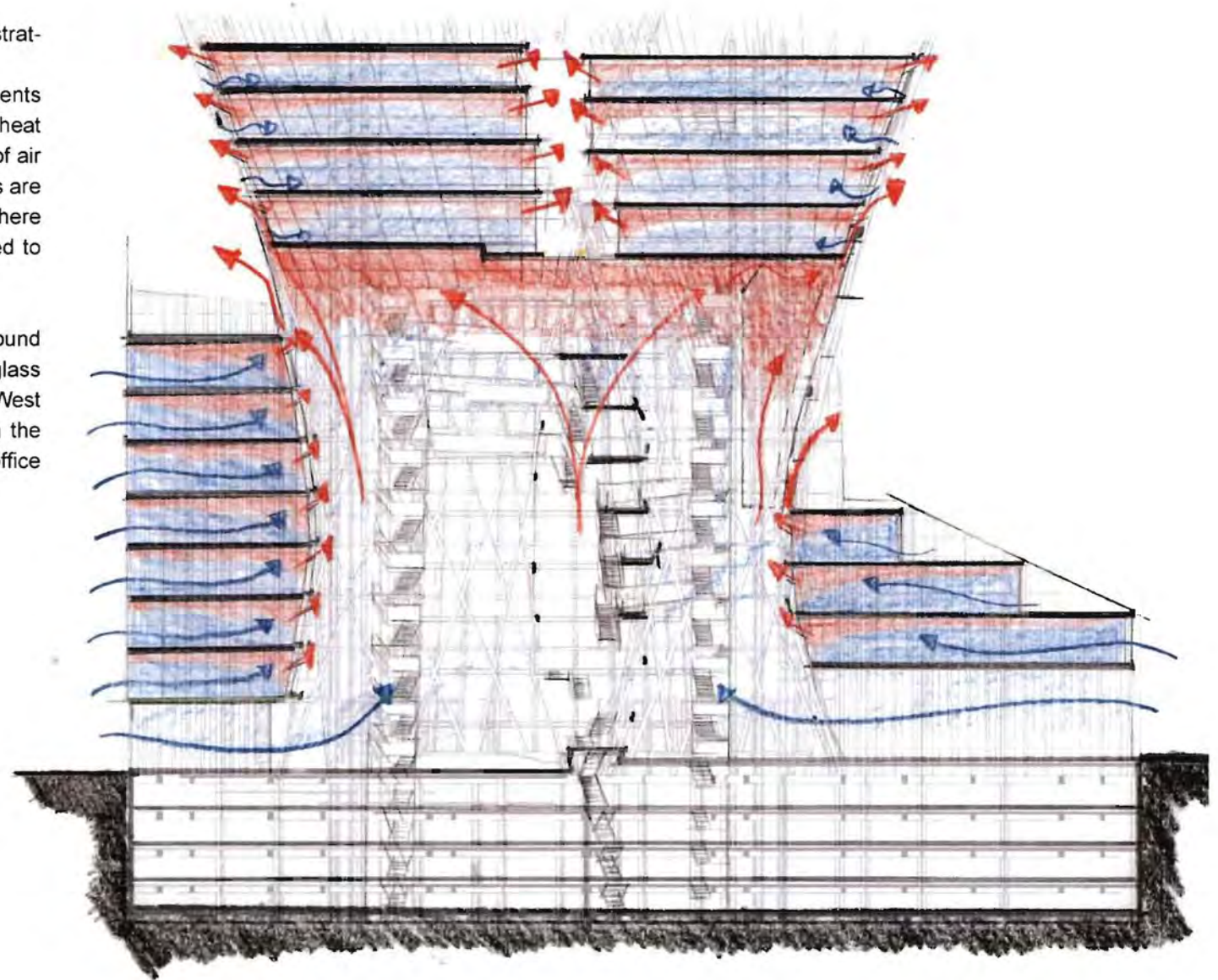
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Ventilation Strategy

The atrium acts as a passive heating and cooling strategy.

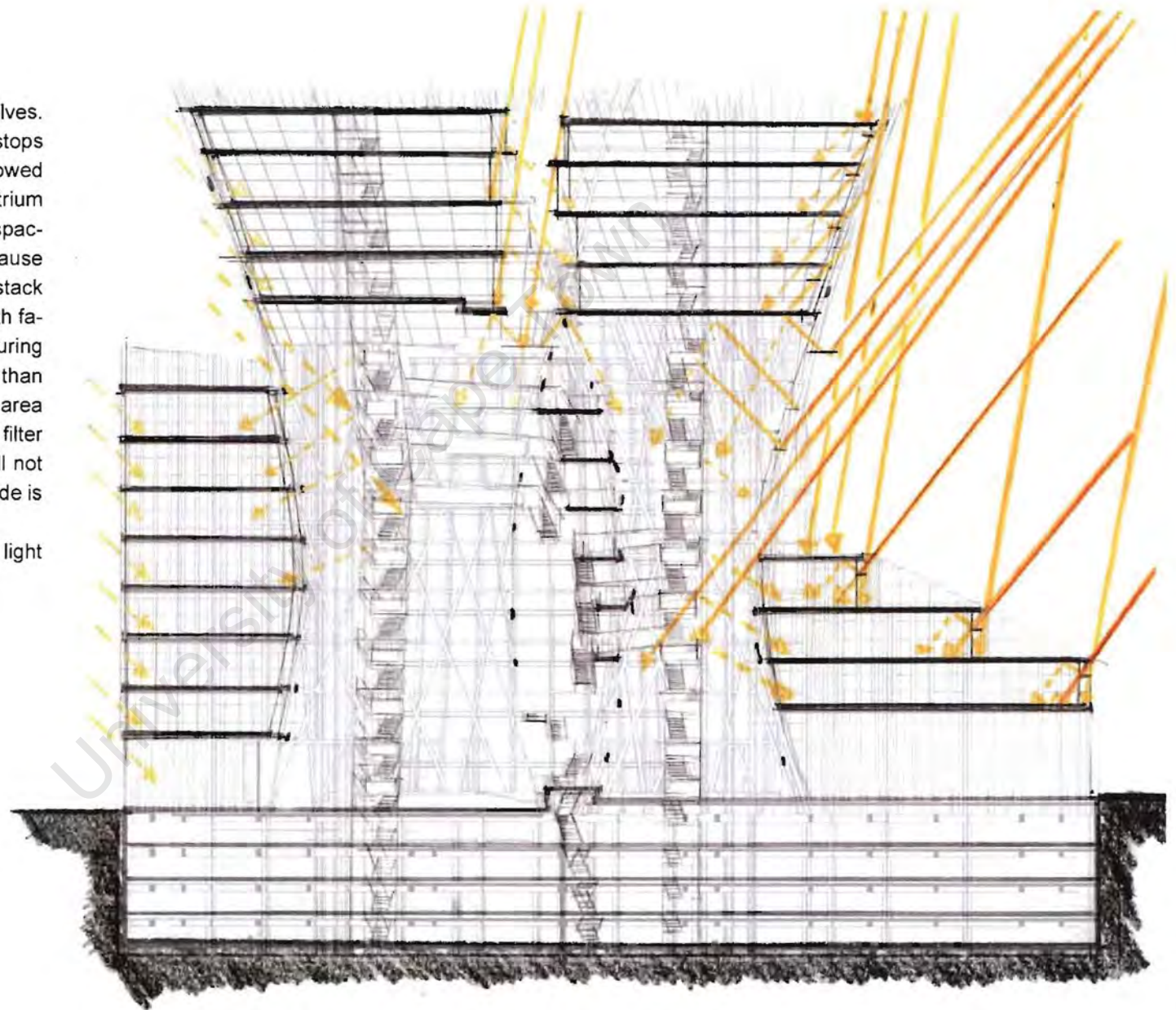
Hot air accumulates at the top and escapes via vents in the atrium. The vents are dark in colour which heat up in the summer sun helping with the extraction of air by creating a suction effect at that point. The vents are mainly heated up in the summer months when there are large amounts of solar radiation and the need to circulate air faster.

Fresh air is brought in through the facades and ground floor which then exits at the top of the atrium. A glass enclosure is positioned on the North, East and West facing edges of the atrium which heats up air in the winter months and can be distributed into the office spaces for the too cold discomfort hours.



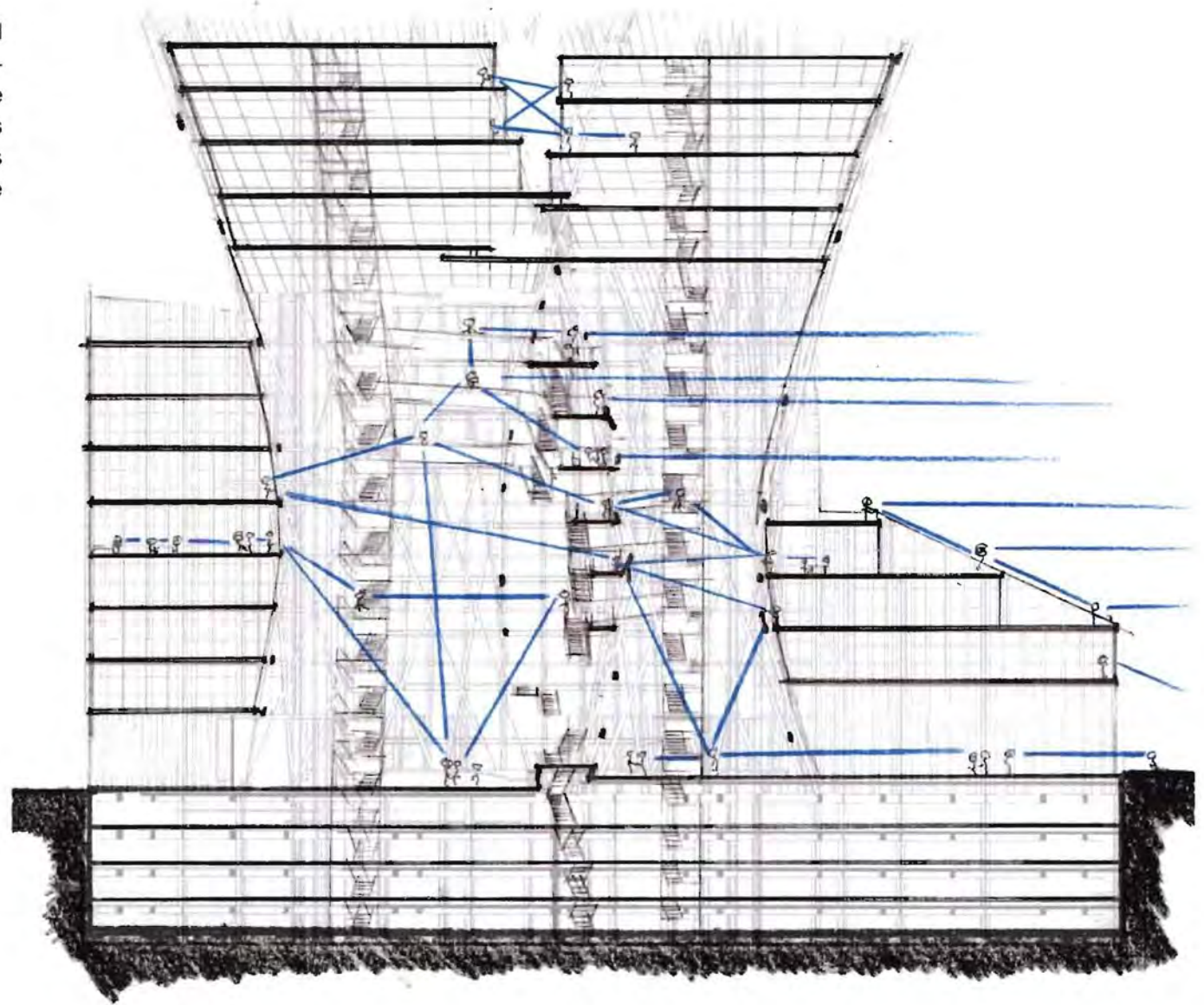
Daylighting

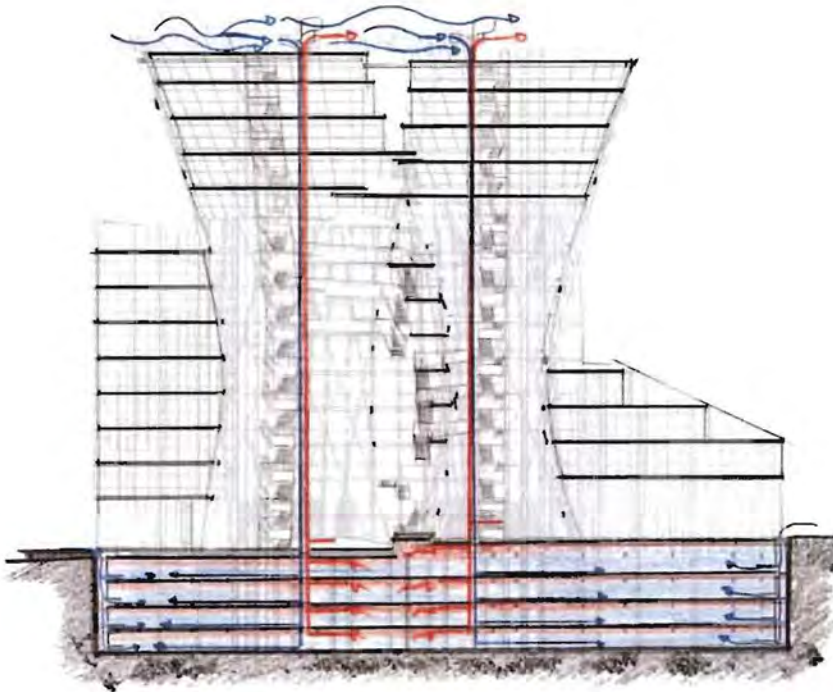
Winter sun is reflected into the atrium by light shelves. Light shelves increase the light intensity and stops glare which is created by direct sunlight. I have allowed however for some direct sunlight to enter the atrium during the winter months in order to heat up the spaces. The atrium should be cool during summer because of the constant movement of air created by the stack effect in the atrium. The atrium closest to the south facade which does not have direct light entering it during times of the day (due to its orientation) is larger than the atrium on the North edge. The south atrium area also widens towards the top allowing more light to filter deeper into the space. This part of the atrium will not be effected by heat gains because the atrium facade is shaded by the floor plates above. Furthermore the circulation is designed to reflect light into the office spaces.



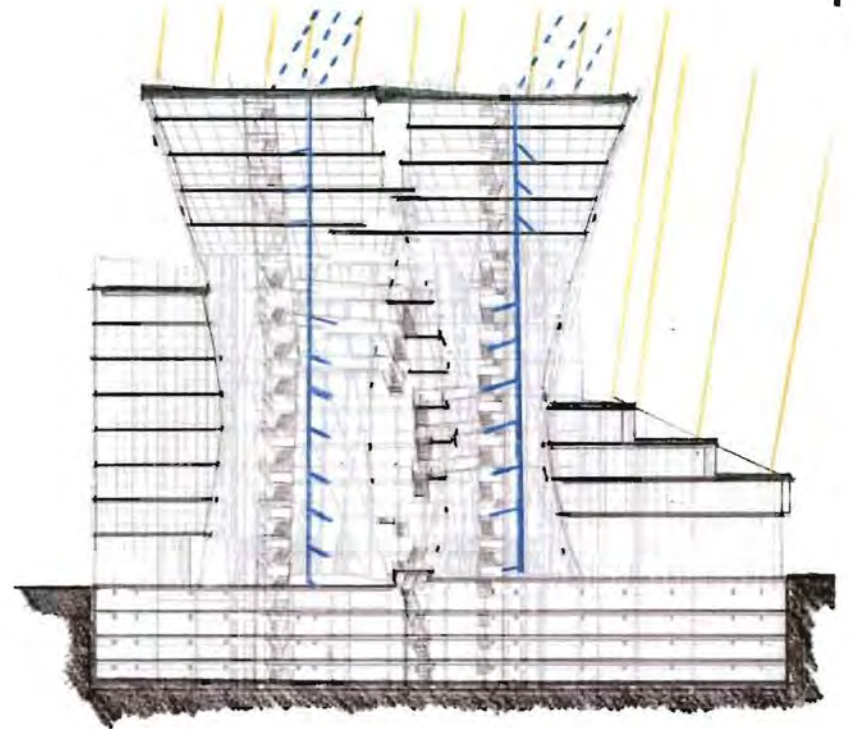
Connections in Atrium

Connection between people and places visually and spatially. Views to the urban context help people orientate themselves. The three atriums connect people through the social spaces located where the atriums intersect. The choice to have three smaller atriums creates more intimate spaces while still becoming one larger atrium to allow sufficient amounts of light.

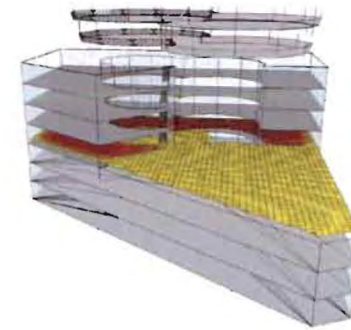
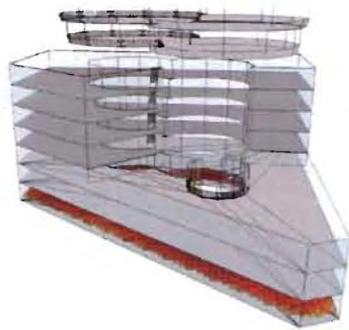
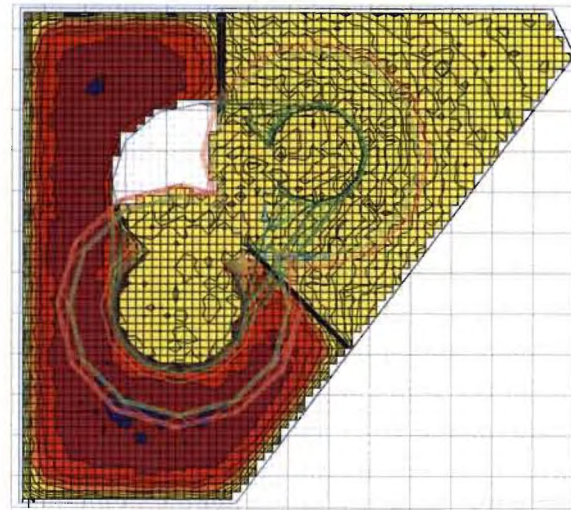
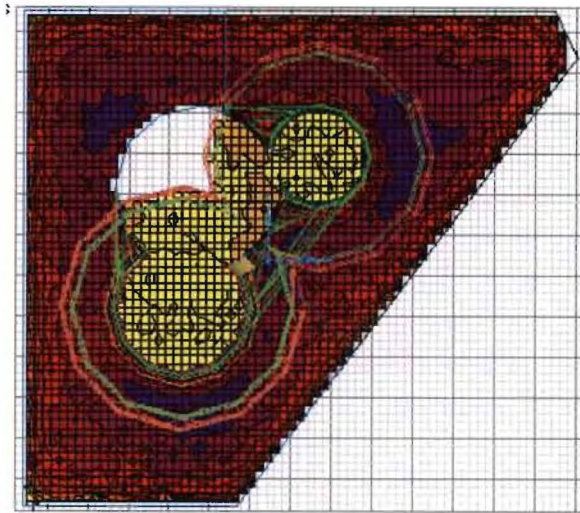




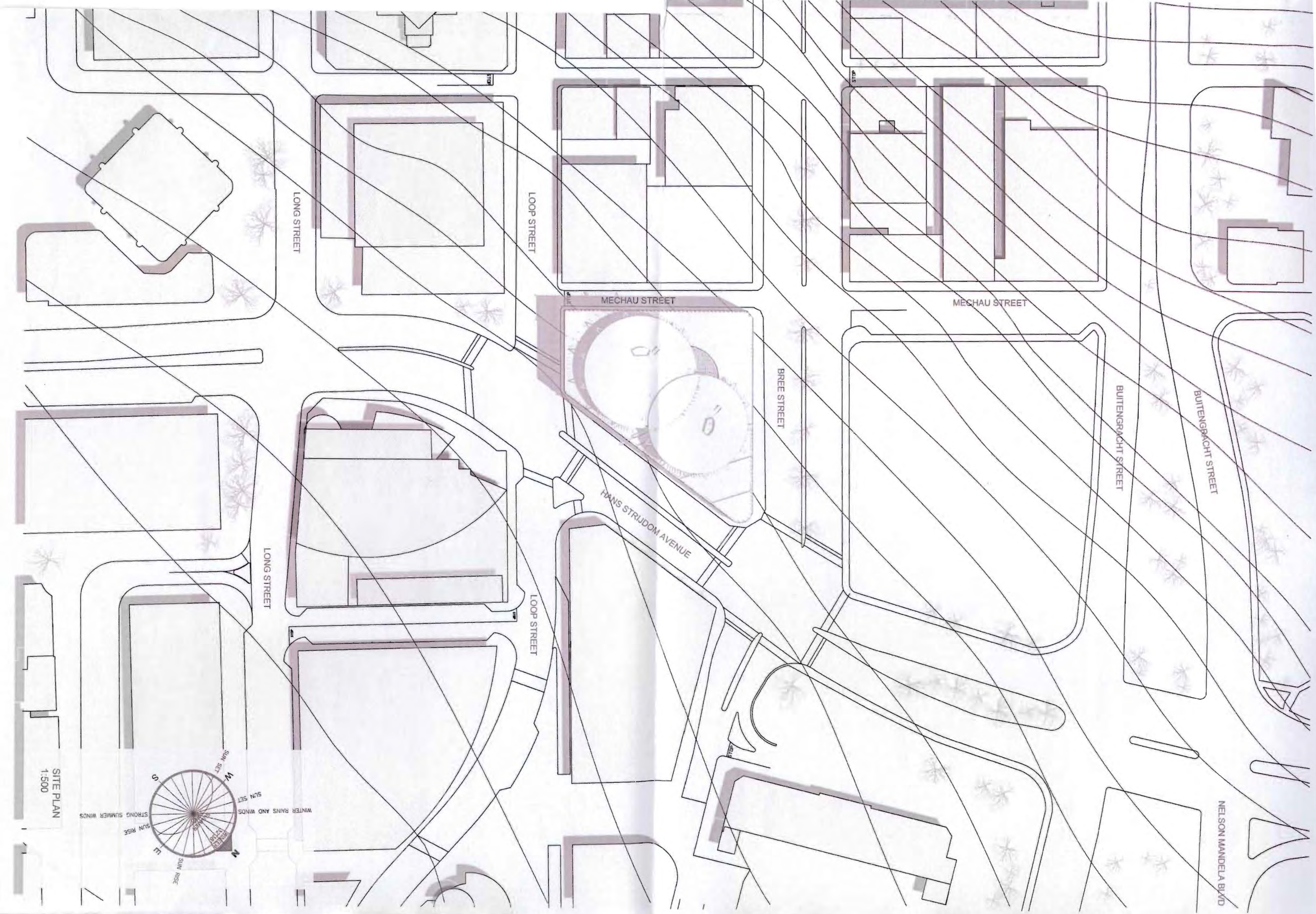
Ventilation system for basement parking is drawn through the ducts in the atrium and exits at roof level.



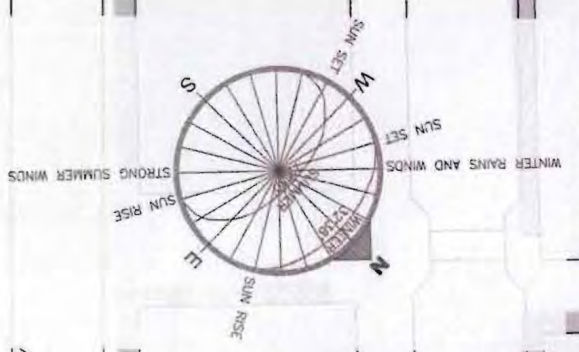
Planted roofs help with insulation properties. The roof also collects water and used for flushing toilets and washing.



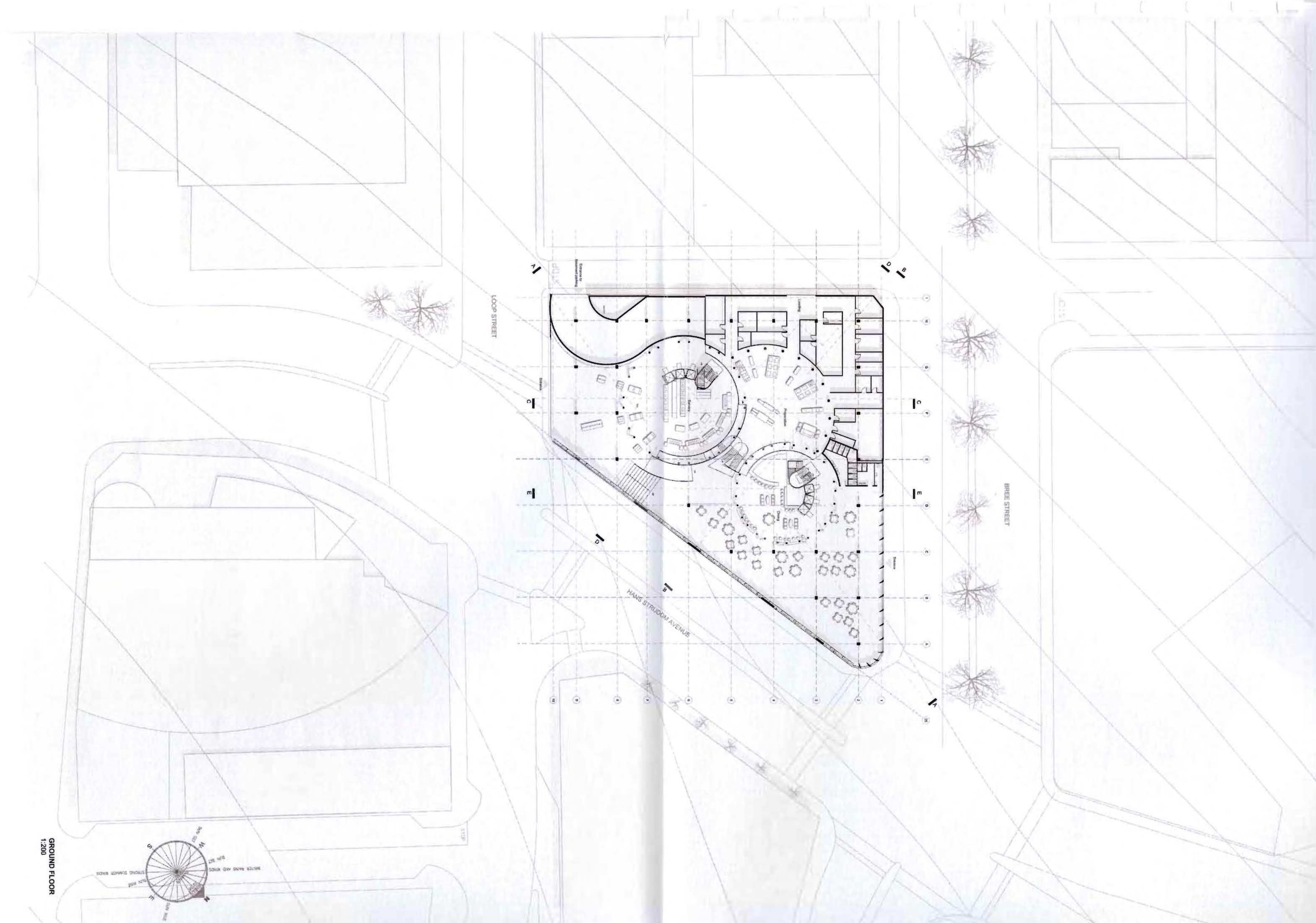
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SITE PLAN
1:500



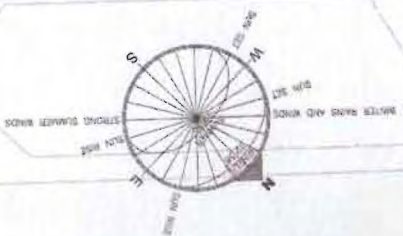
NELSON MANDELA BLDG



LOOP STREET

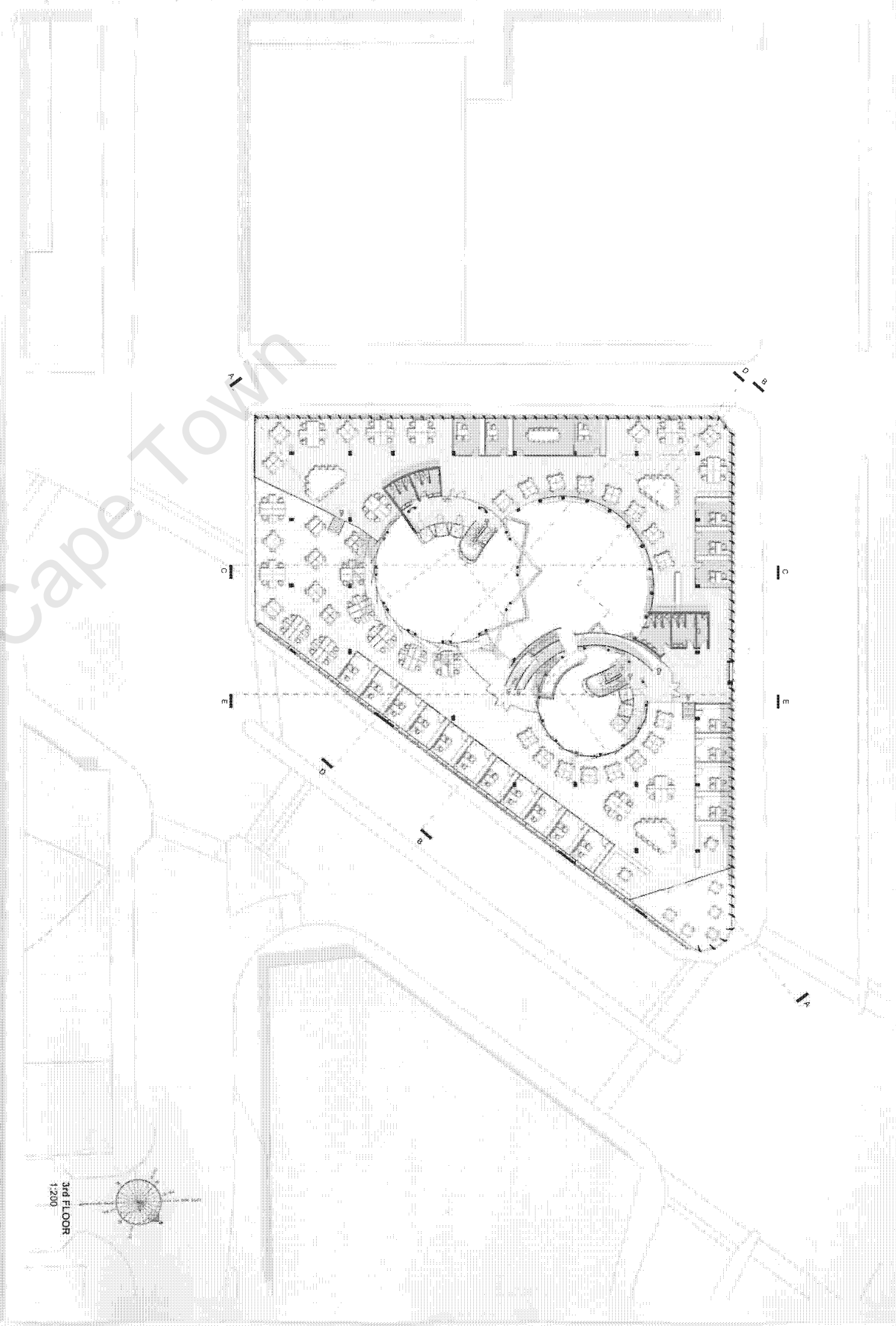
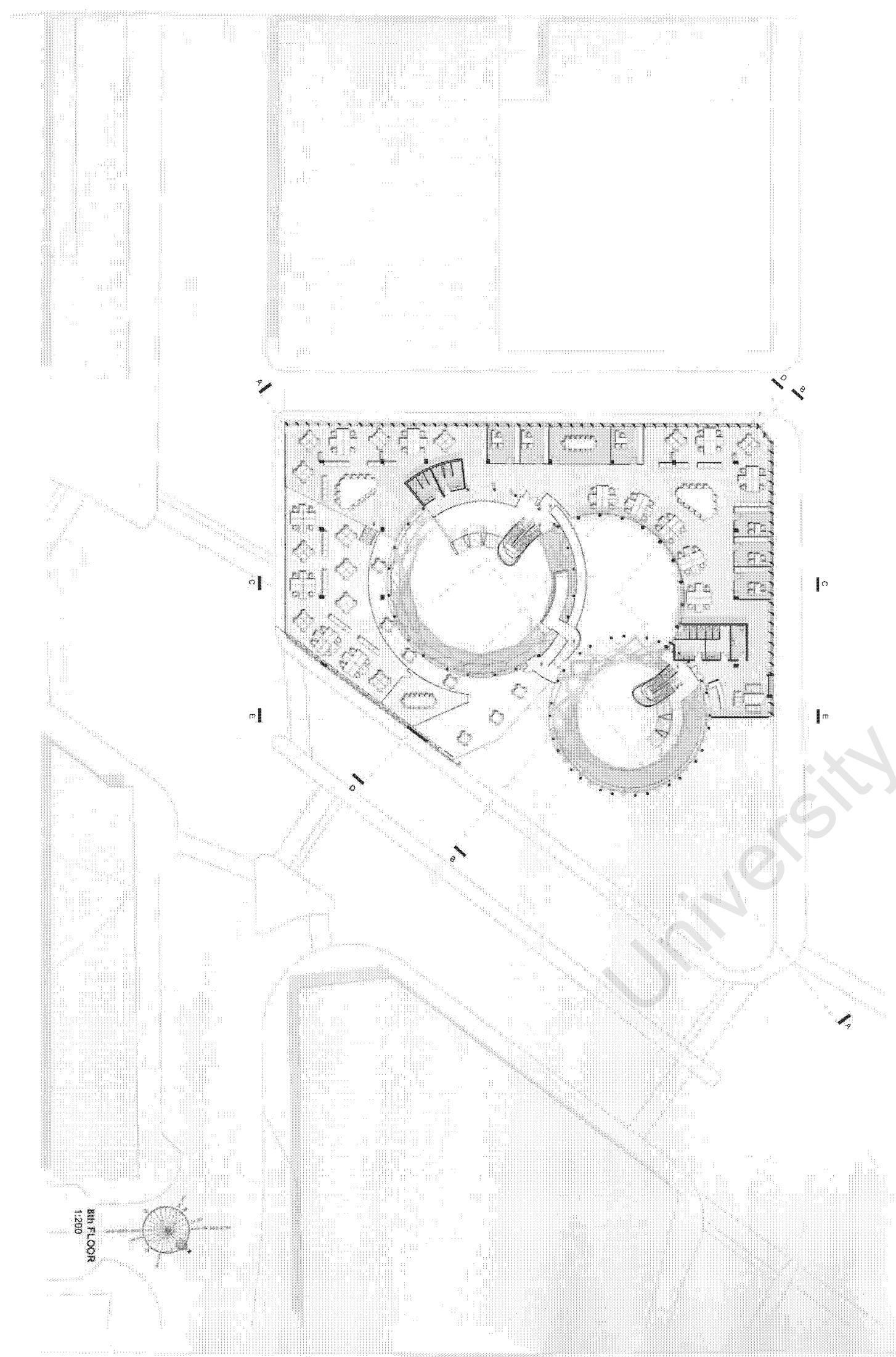
BREE STREET

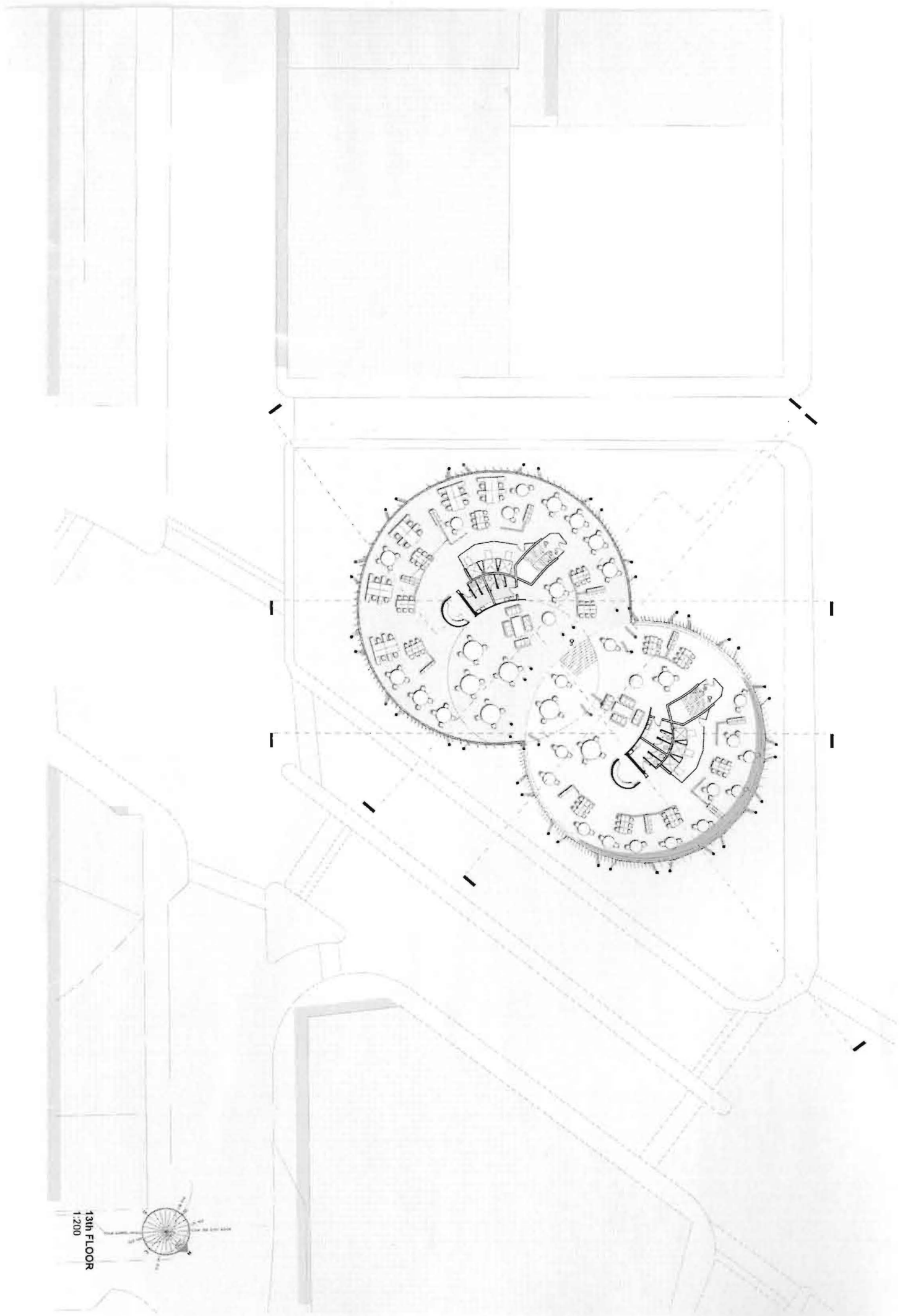
HANS STRUDON AVENUE



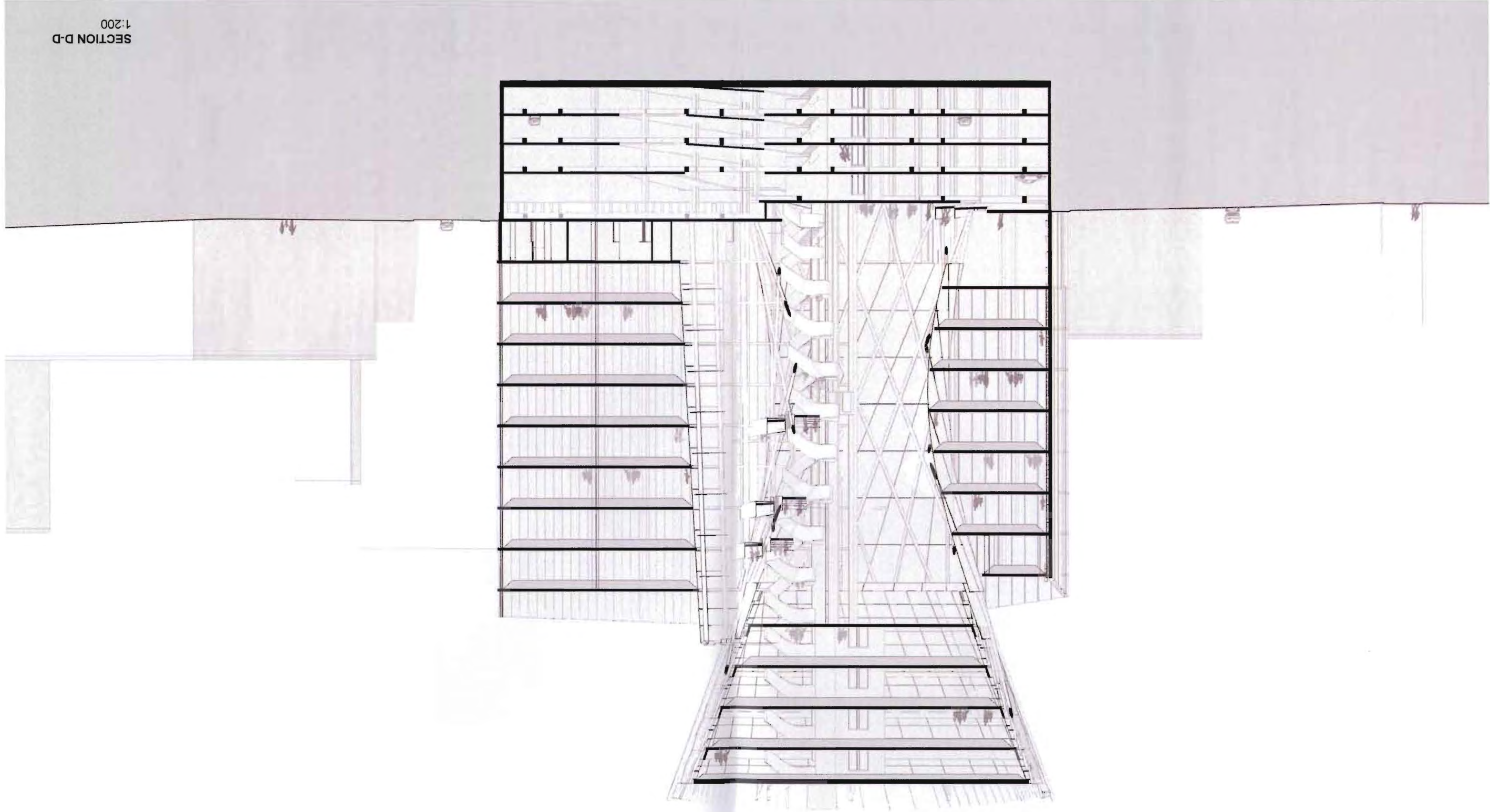
GROUND FLOOR
1:200

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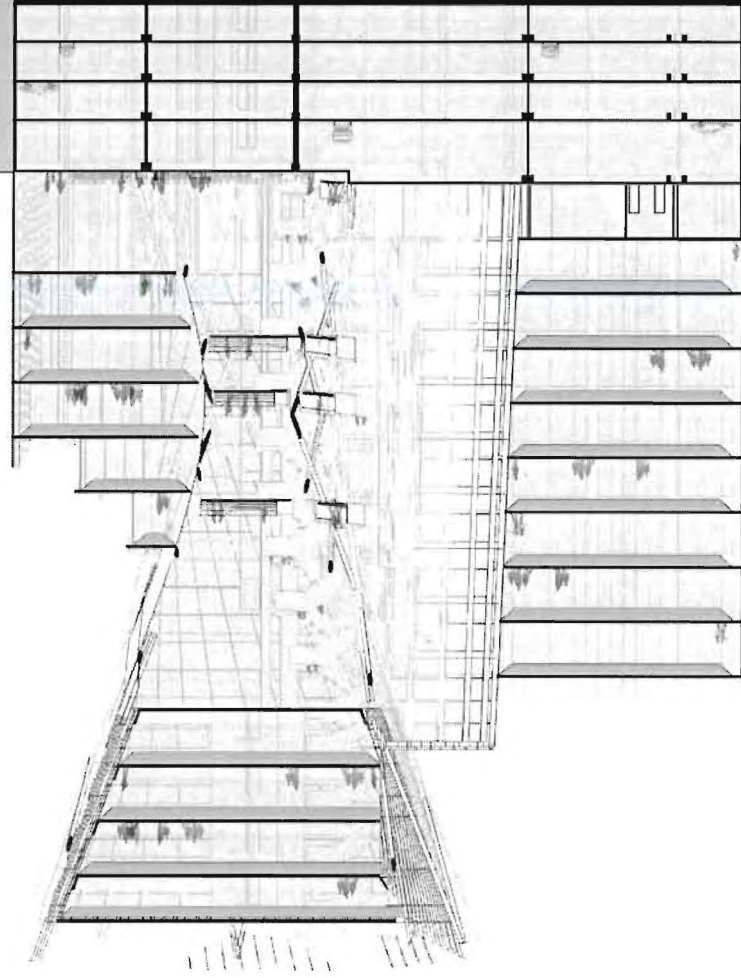




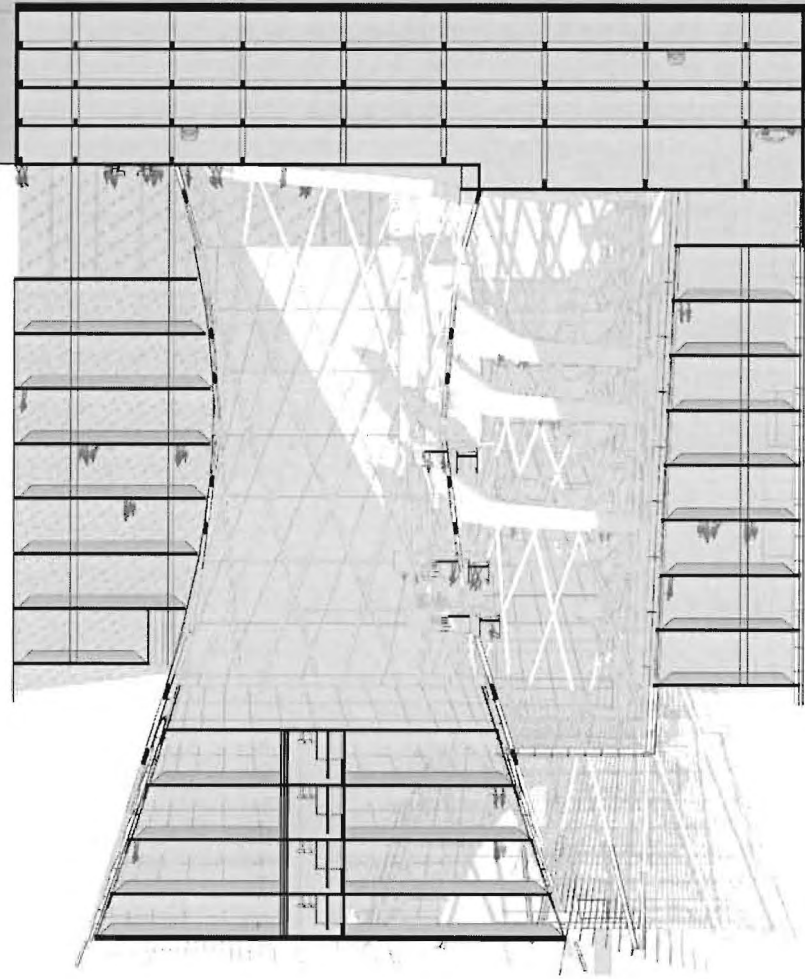
SECTION D-D
1:200



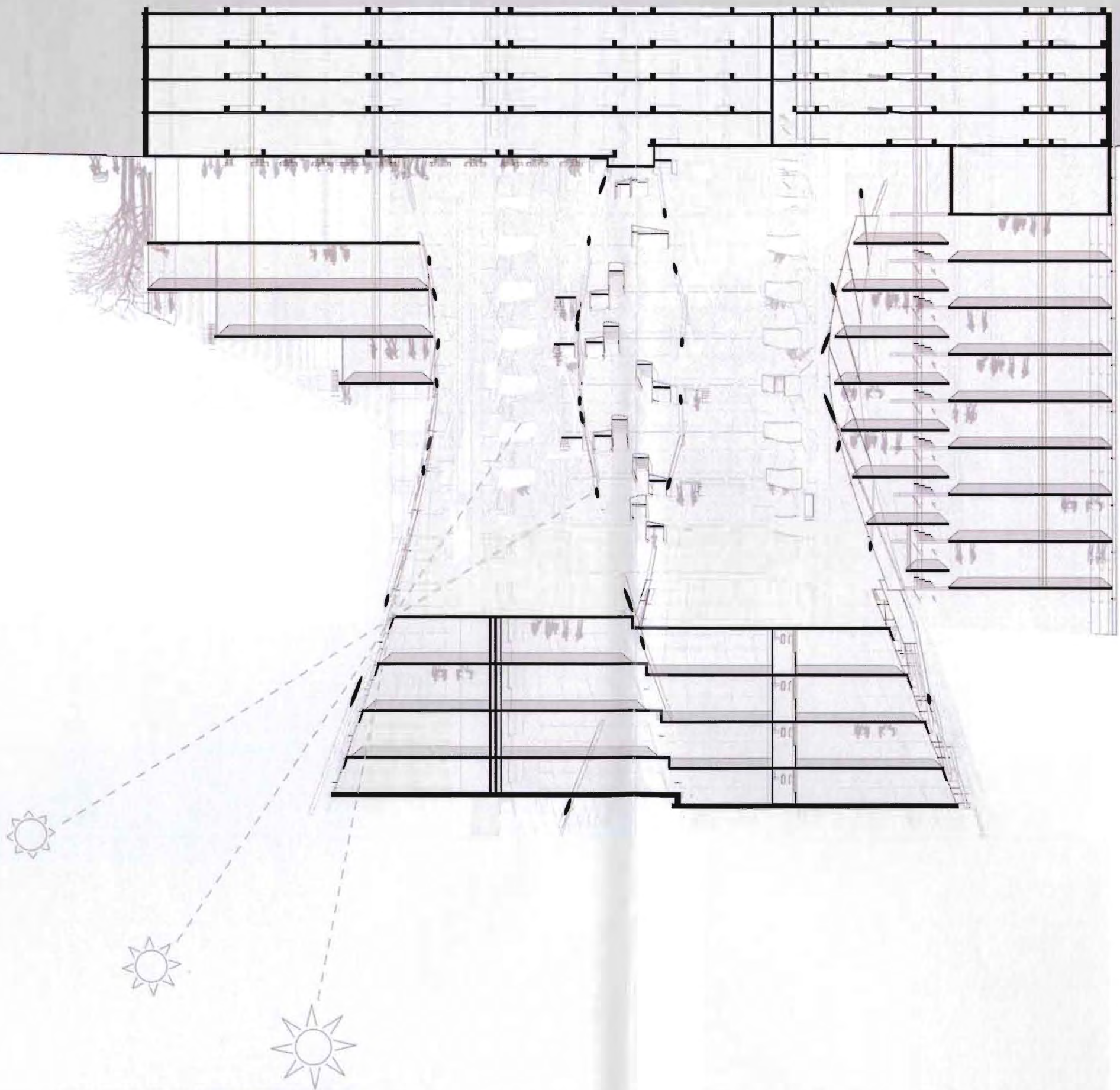
SECTION B-B
1:200



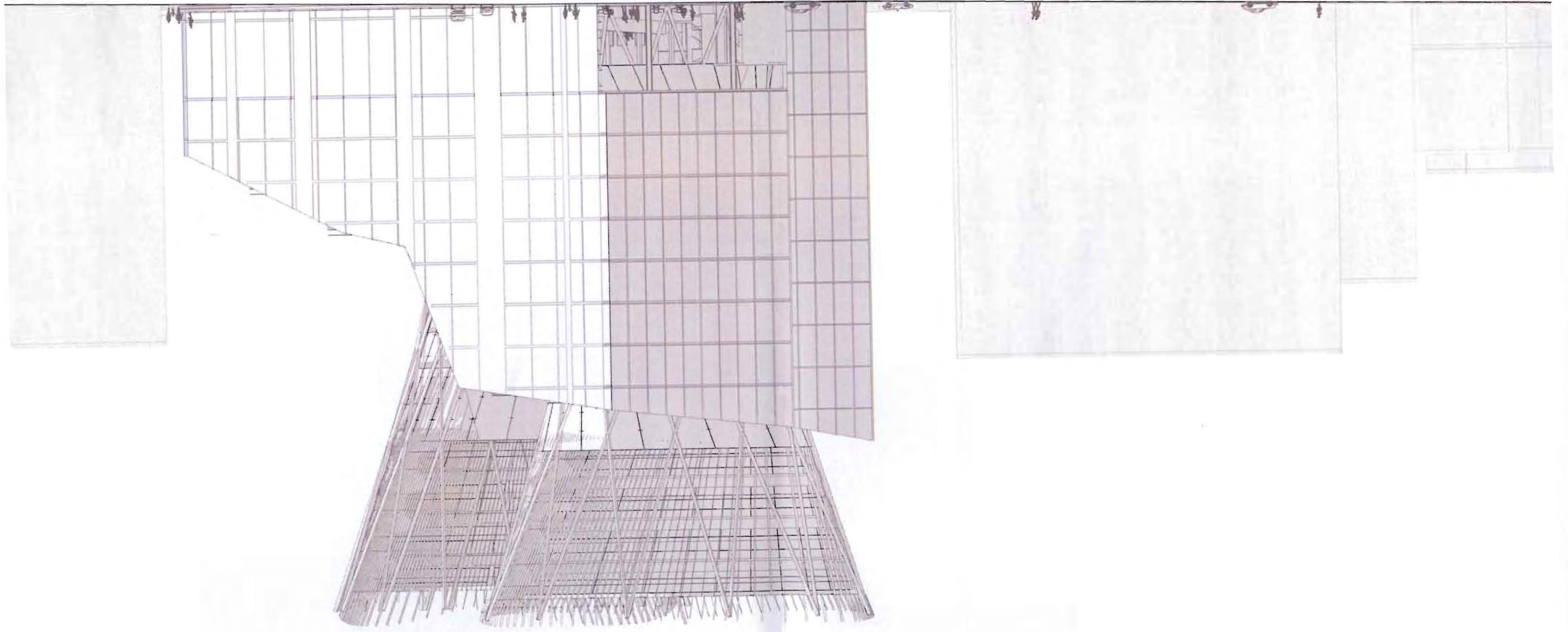
SECTION C-C
1:200



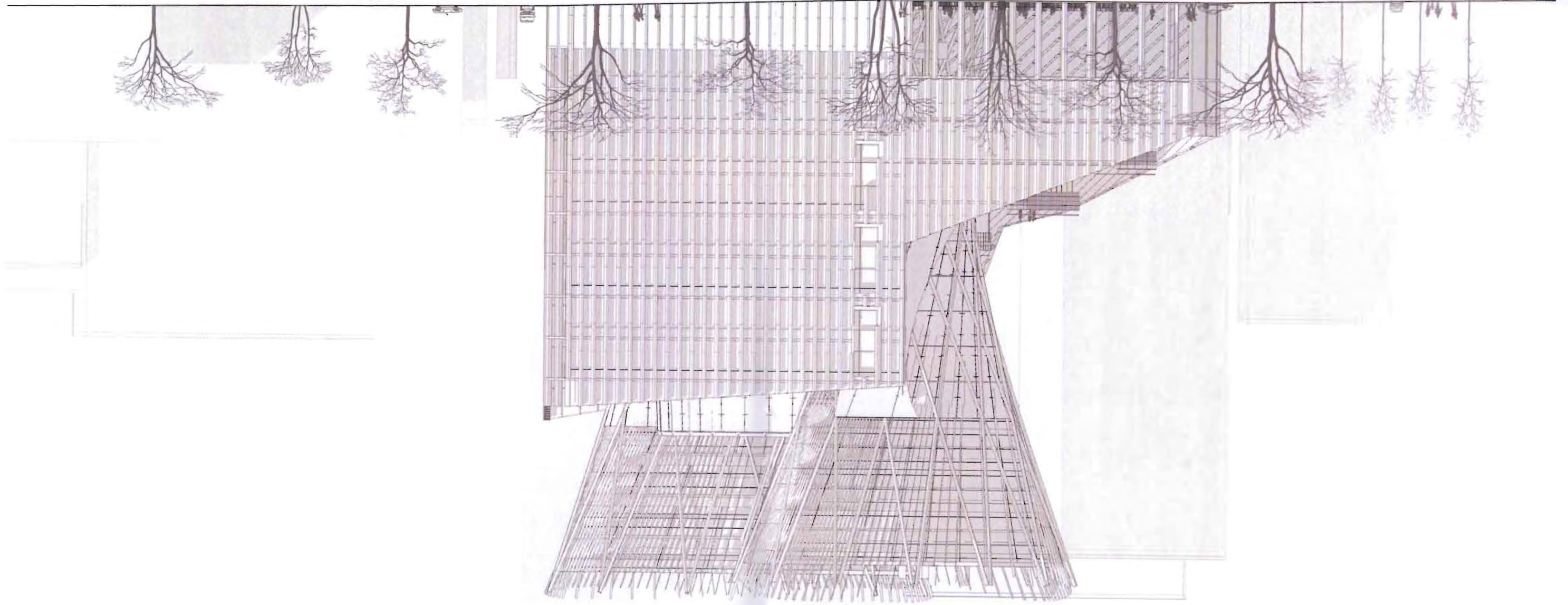
SECTION A-A
1:200



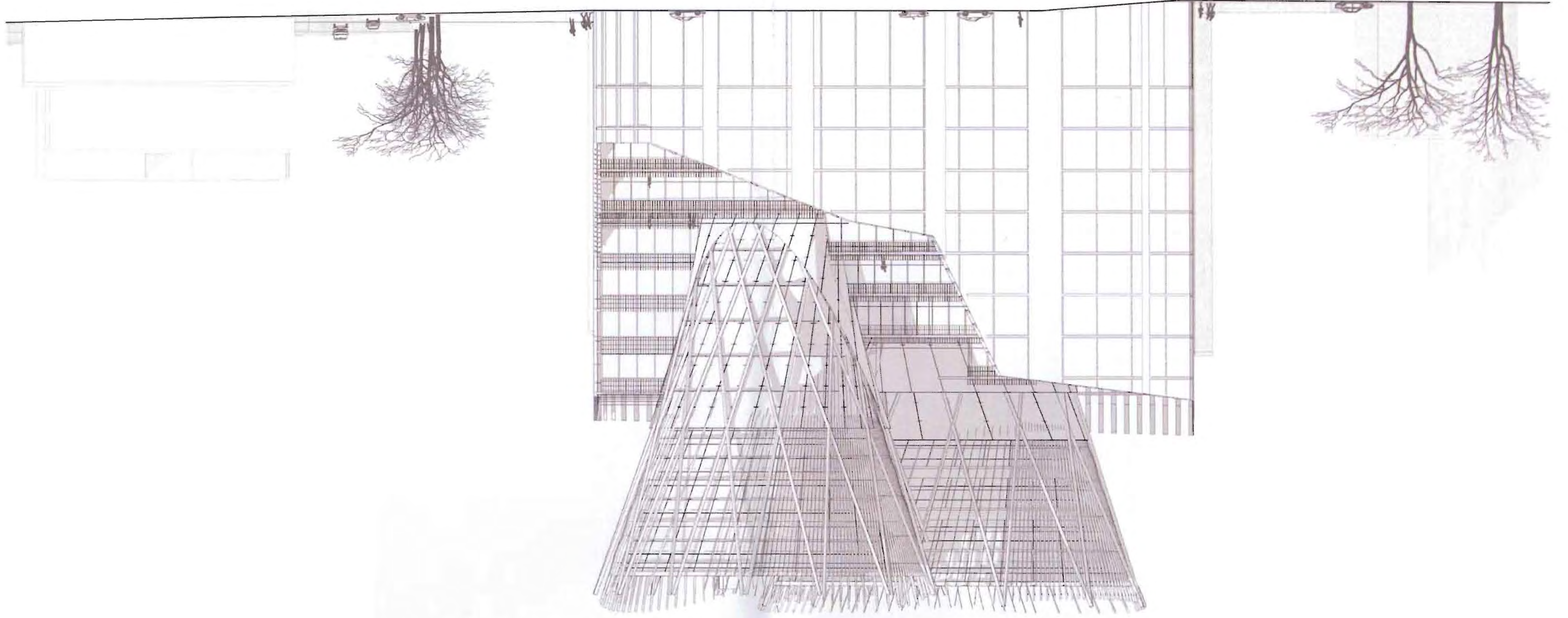
SOUTH EAST ELEVATION
1:200

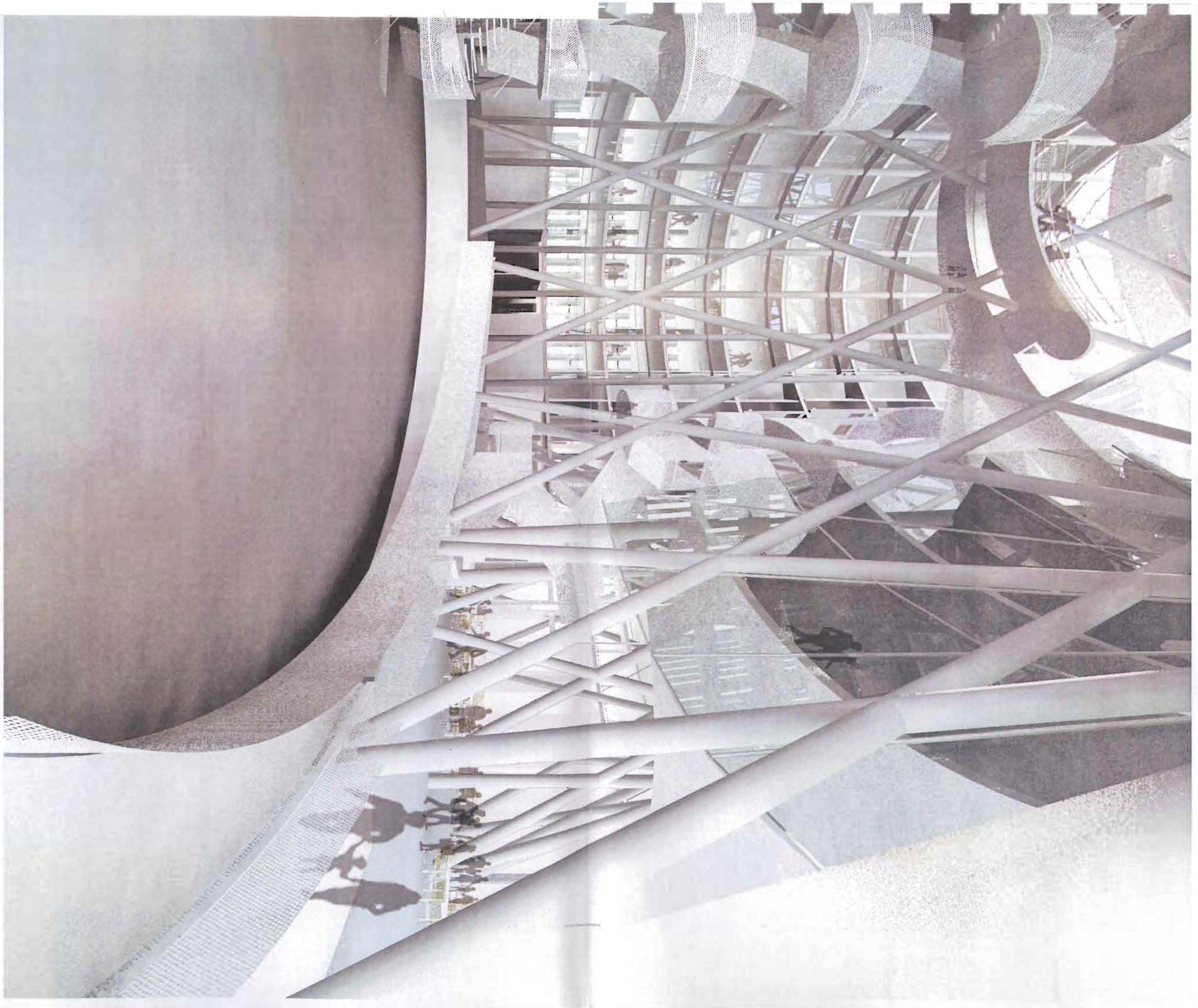


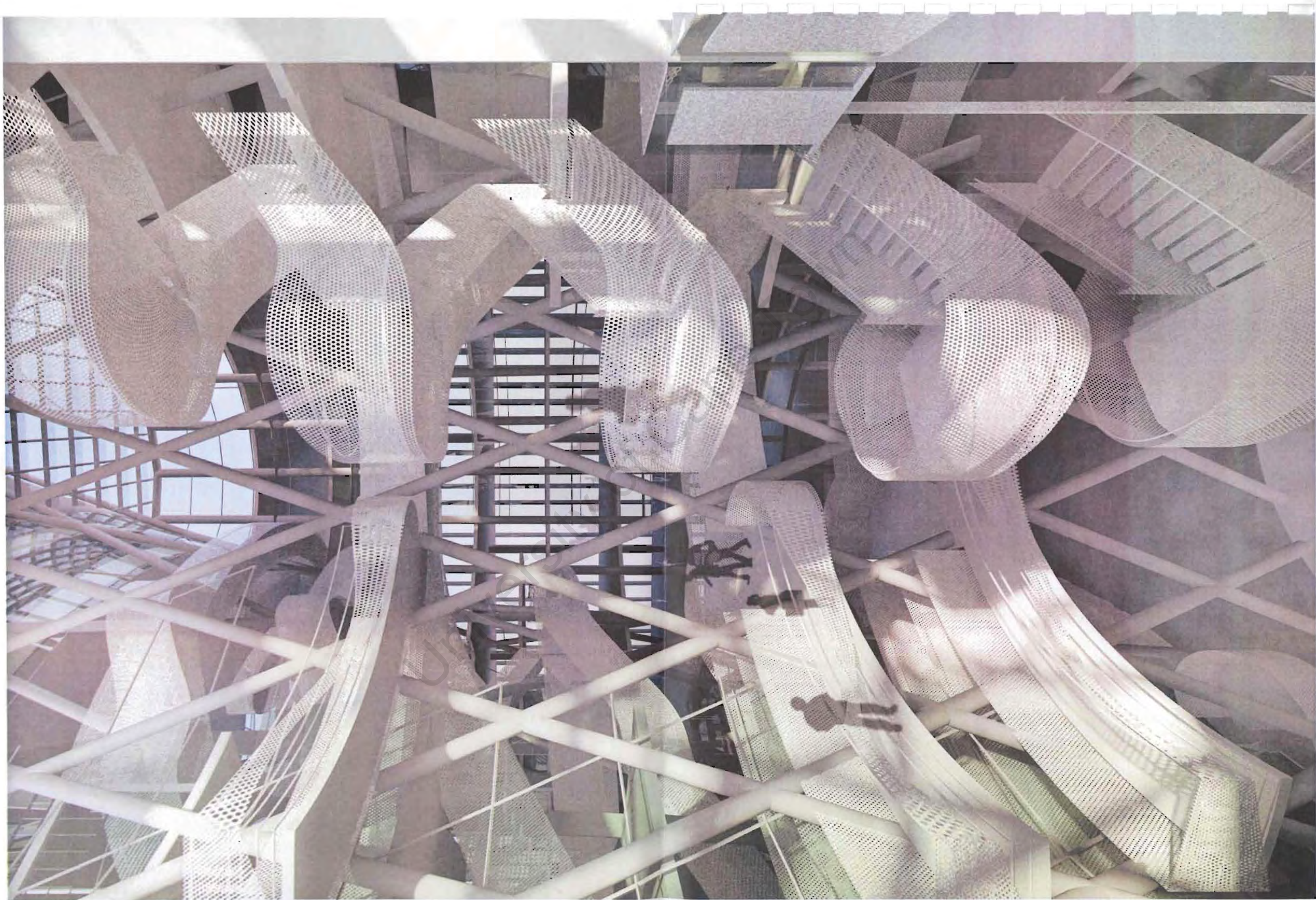
NORTH WEST ELEVATION
1:200

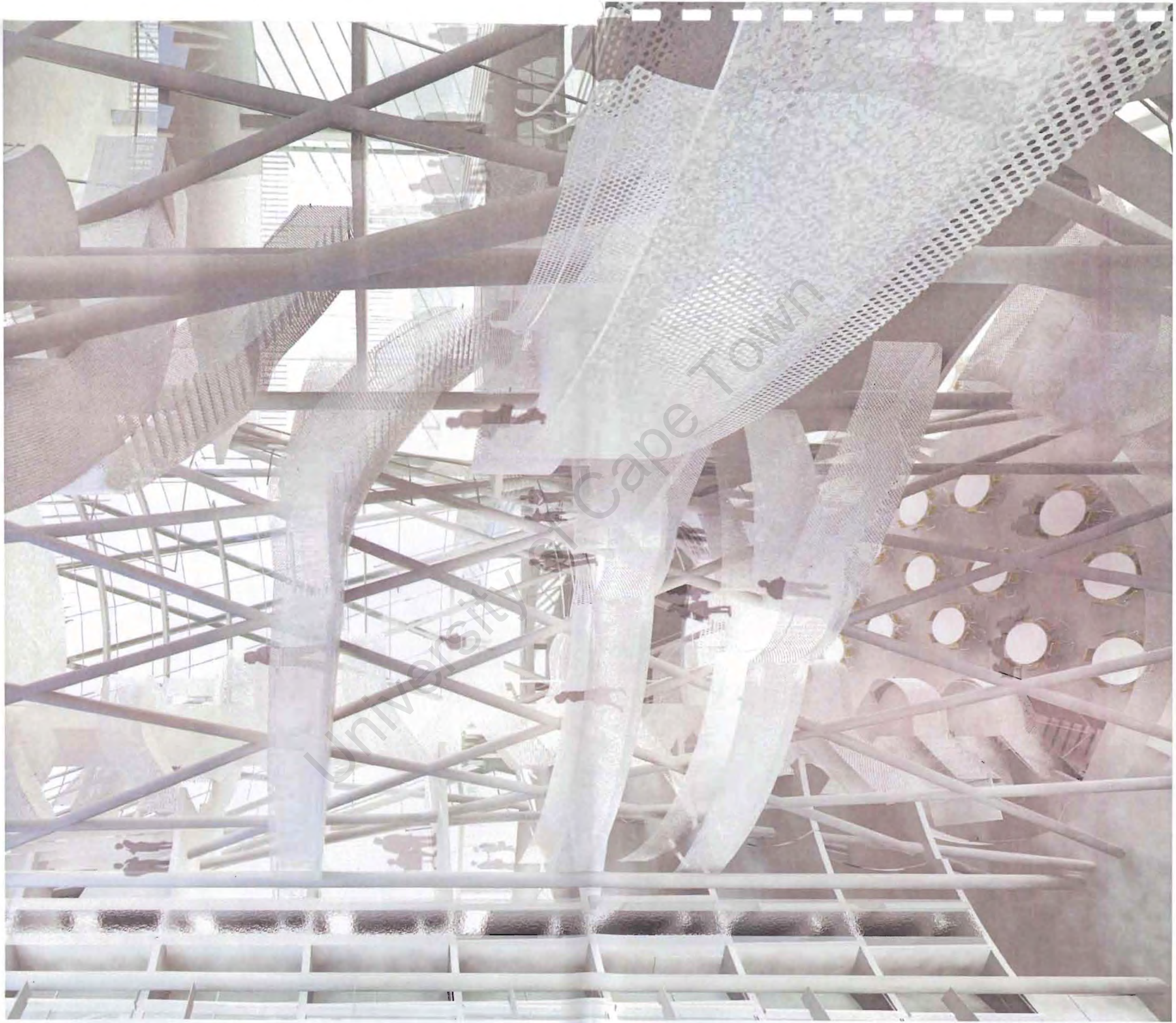


NORTH EAST ELEVATION
1:200











The atrium is used to increase building efficiency to a large extent. Passive heating and cooling techniques are applied to make the office spaces comfortable. The atrium accommodates communal meeting spaces which are equal distances from all the offices. These spaces have seating areas and shared kitchens. The working community involves the interaction between people who they work with and the expansion of their networks through interacting with people from other offices. The communal spaces in the atrium will allow for this networking to happen and will create opportunity for people to interact.

The building is created in response to the climate in Cape Town. Strategies to increase comfort were taken through creating passive heating and cooling techniques which would best suit our climate. These techniques would be used to reduce the operational energy

For this particular site and focus of thesis the solution which arose was one which required me to separate the volumes to allow for sufficient amounts of natural light. There are many other possibilities to allow natural light to enter into a space, all relative to the depth to which it is required to reach and the width of the atrium. On a larger site for example there may have been the possibility of just using an atrium to allow for natural light to enter.

My aim was to impose a new identifiable architecture to the inner city which has an identity of efficiency the method to which I created this form was through the atrium. The atrium gives the building its identity without forgetting about our modernist context. The expression which has arisen has 'roots' in modernism and 'stems' of efficiency where the efficient structure of the atrium feeds the building with natural light, passive heating and cooling strategies.

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