Chapter 7

Technical Investigation

Material Selection

To arrive at a sustainable solution the building blocks of the project need to be sustainable. In order to select appropriate materials for various applications the relevant technical data regarding such a product needs to be compared with alternatives.

Although each application calls for strength in varying material aspects, there are certain factors such as embodied energy and life cycle costing that are always important in material selection

The use of recycled building materials is another practice widely recognized as sustainable. Due to the synergy between this design exploration and the proposed building material recycling yard adjacent to the proposed site, much of the proposed material selection derived out of an analysis of existing construction waste.

The boxes to the right aim to illustrate the selection of material relative to the required performance.

Wall Coating
Aqua Coat Paint

- Zero VOC Emissions
- Enhanced Thermal properties
- Non Toxic
- Locally Manufactured
- Weather Resistance

Wall Coating 2
In Situ Concrete

- Low Embodied energy
- Process creates Job Opportunities
- Locally Manufactured
- Long Life Cycle

Masonry Construction
Recycled Bricks

- Low Embodied energy
- Process creates Job Opportunities
- Locally Recycled

▲fig7.0a Material Selection (Author 2007)

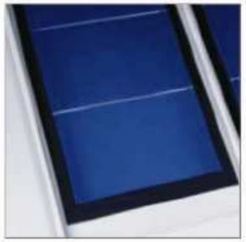
Roof Material 1
Concrete Roof
Covered with crushed
& rolled stone chips

- Shades roof surface
- Slows flow of stormwater
- Rainwater harvesting

Roof Material 2
Rheinzink

- Natural Material
- Low Embodied Energy
- 90% Recycle Rate
- Low Co2 Emissions in Production
- No toxic coating

Roof Material 3
Rheinzink PV
Sheeting



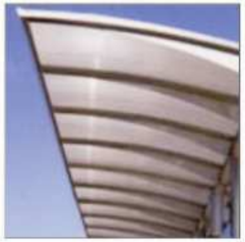
- Integrated Solar Power
- Natural Material
- Low Embodied Energy
- 90% Recycle Rate
- No toxic coating

▲fig7.0b Material Selection (Author 2007)

Glazing 1
Coolvue

- Reduces Heat gain by 50%
- Filters 99.5% UV Radiation
- Manufactured Locally

Polycarbonate
Multiwall



- Energy Efficient
- Filters 99.9% UV Radiation
- Manufactured Locally
- Transmits light & reduces heat gain
- Adaptable

Insulation
Thermocoustex

Recycled polyester board

- Energy Efficient
- Acoustic and thermal insulation
- Manufactured Locally
- 100% recyclable
- Low embodied energy

▲fig7.0c Material Selection (Author 2007)

Rainwater Managment
Rheinzink

- Natural Material
- Low Embodied Energy
- 90% Recycle Rate
- Low Co2 Emissions in Production
- No toxic coating

Rainwater Managment
Pervious Paving

- Low Embodied Energy
- Locally Manufactured
- Rainwater Harvesting
- Hard wearing surface

Sunscreen
Recycled Sunscreen

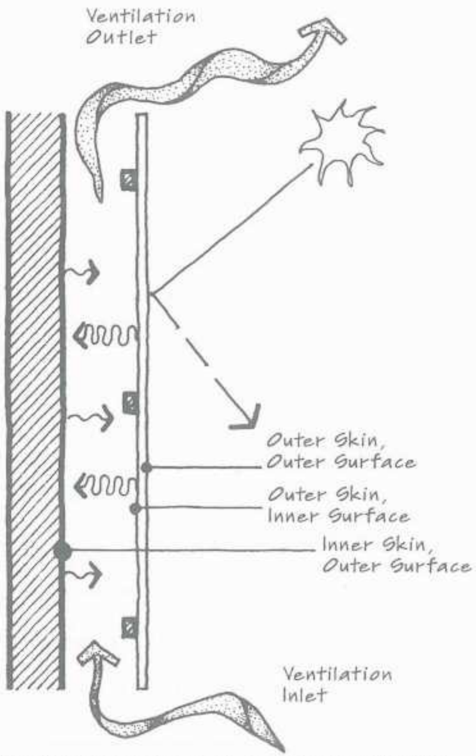
- Made from reclaimed scrap metal
- Process creates Job Opportunities

▲fig7.0d Material Selection (Author 2007)

The Envelope

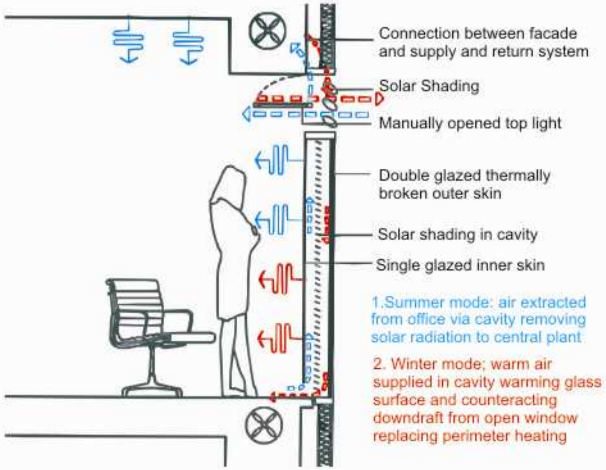
Precedent Studies

The use of a double skin ventilated wall system evolved out of a response to the problem of creating thermal mass in a light transmitting surface. The workshop's orientation is east west, making it difficult to make use of the natural light without allowing the build up of too much heat gain and excessive glare.



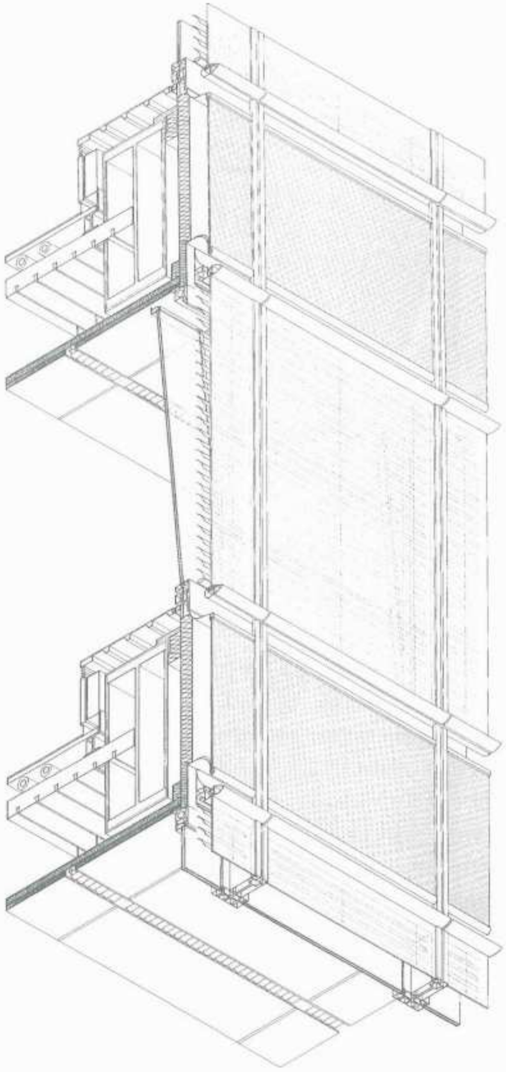
▲fig7.1Diagrammatic Section of Double Skin Wall (Brown, GZ, DeKay, M 2001, p. 102)

Due to the climatic variances the wall needs to be able to react differently under different situations. The heat gain has to be directed inwards during winter and outwards during summer months in order to provide year round comfort. The facade detail developed for the Commerzbank in Frankfurt by Norman Foster in conjunction with facade engineer Josef Gartner is designed to be able to adapt, allowing the interior environment to be manipulated by the user. This affording the user the opportunity to interact with the building and with nature.



▲fig7.2 Sketch Of "Breathing Wall" (Jacks 2007, p.9) edited by author

Due to this dissertation proposing an educational facility this interaction, and the users control over the systems form an integral part of the learning process. Therefor the mechanical ventilation assistance will have a direct user interface in order for the occupants to have a hands on experience of ventilation principles and passive design.



▲fig7.3 Commerzbank Facade - 3D Detail (Lechner 2001, p.557)

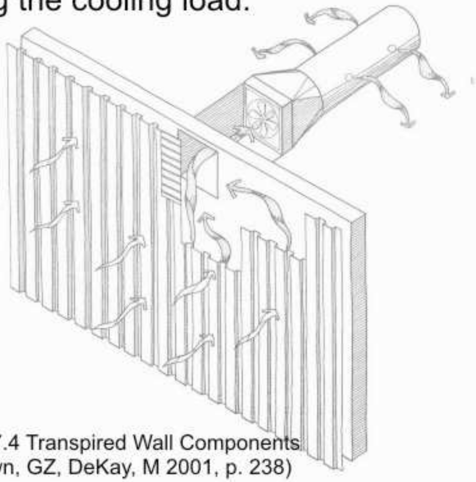
Envelope Exploration

The aim of this disertation, as stated earlier, is to look at existing sustainable building principles in order to develop an array of systems responding to the specific context of the proposed site.

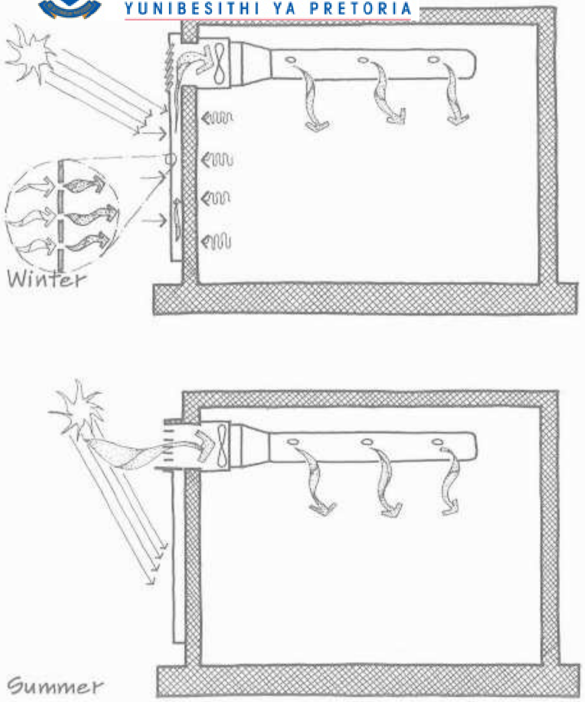
Transpired Wall System

A ventilated wall system usually used to reduce heating and cooling loads by using the cavity to act thermal mass or direct airflow.

In the case of a transpired wall, solar energy is utilized to regulate internal temperatures. In winter fresh air is preheated before it is pumped into the building, and the cavity aids in reducing heat losses. In summer months an intake bypass damper is used to bring in untempered fresh air, while the preheated air in the cavity naturally ventilates the heated air to the outside insulating the building from excessive heat gain thereby reducing the cooling load.



▲fig7.4 Transpired Wall Components
(Brown, GZ, DeKay, M 2001, p. 238)

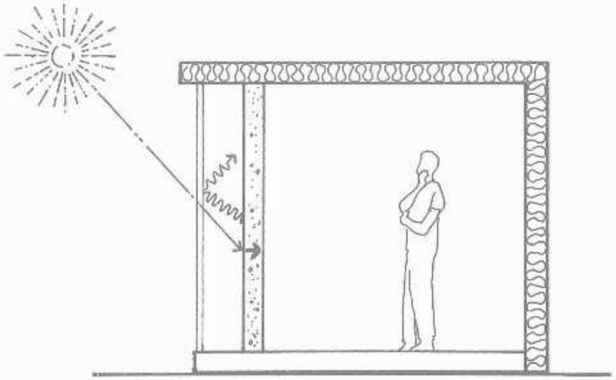


▲fig7.5 Transpired Wall Section
(Brown, GZ, DeKay, M 2001, p. 238)

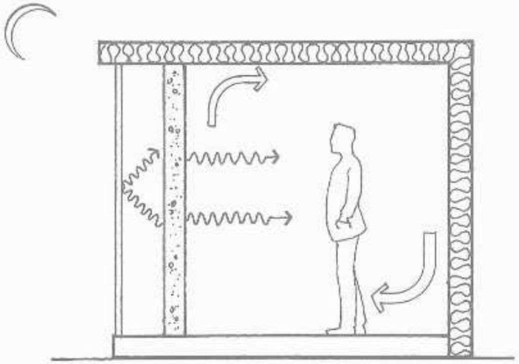
▲fig7.6 An Example of a Transpired Wall
(Brown 2001, p.238)

Trombe Wall

A simple architectural device where a pane of glass is placed just in front of a wall with a dark coating. The solar radiation is trapped in the cavity due to the greenhouse effect. The wall is in turn heated, then that heat is then slowly released into the space by convection. This regulates and stabilizes interior temperature, thereby reducing the heating or cooling load.



▲fig7.7 Trombe wall building up heat gain in day
(Lechner 2001, p.152)



▲fig7.8Trombe wall releasing heat gain at night
(Lechner 2001, p.152)

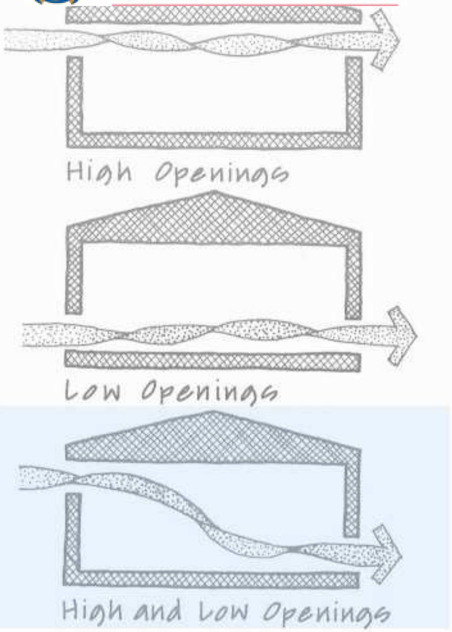
Openings in the Envelope

Considerations

An essential component when planning any space is the sizing and locations of the openings. Optimizing the orientation, layout, sizing and relation of openings to one another can have a drastic impact on the effectiveness of a cross ventilation strategy.

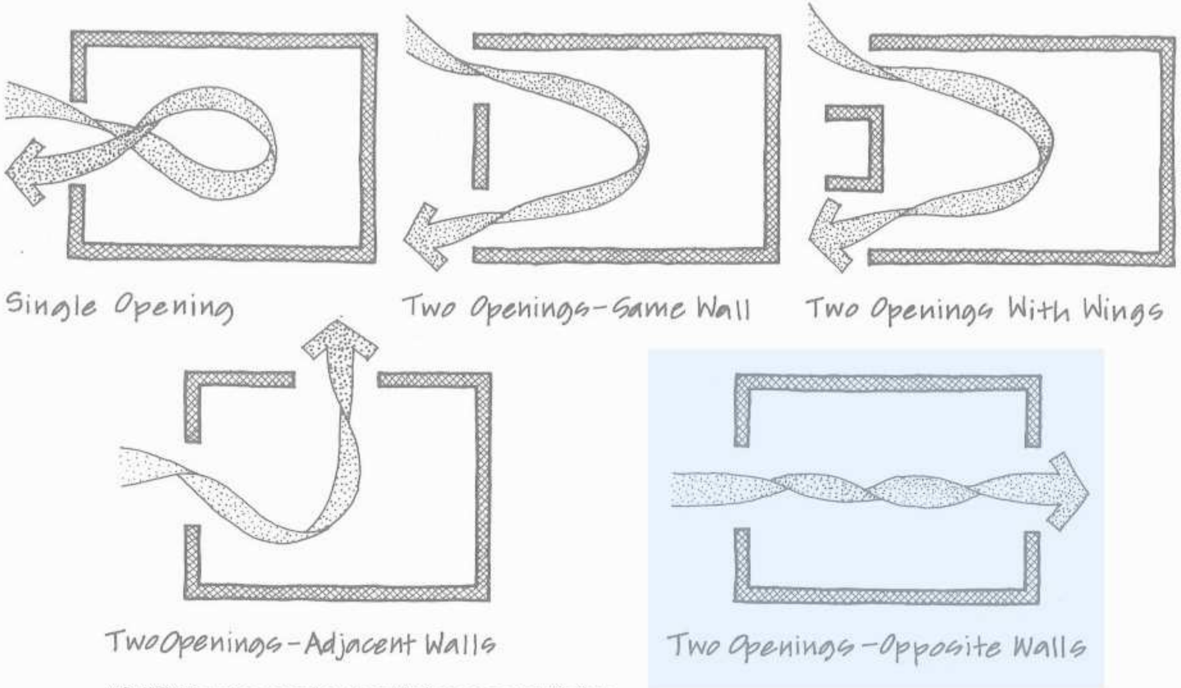
The ideal situation for opening is highlighted on the image to the right, where openings are placed on opposite walls at different heights from one another.

The implementation of this strategy combined with orientating the openings in order to utilize the prevailing summer winds ensures effective and optimal use of the potential of natural ventilation.



window height as a fraction of wall height	1/3	1/3	1/3
window width as a fraction of wall width	1/3	2/3	3/3
single opening	12-14%	13-17%	16-23%
two openings in the same wall	----	22%	23%
two openings in adjacent walls	37-45%	37-45%	40-51%
two openings in opposite walls	35-42%	37-51%	47-65%

Average Interior Air Velocity as a Percentage of the Exterior Wind Velocity
range = wind 45° to perpendicular to opening



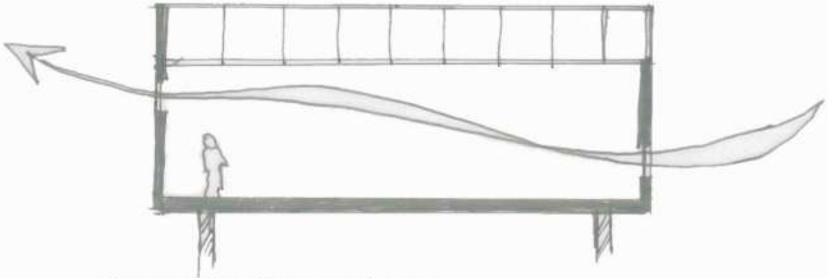
▲fig7.9 Planning opening to optimize cross ventilation (Brown 2001, p.242)

Evolution of Envelope

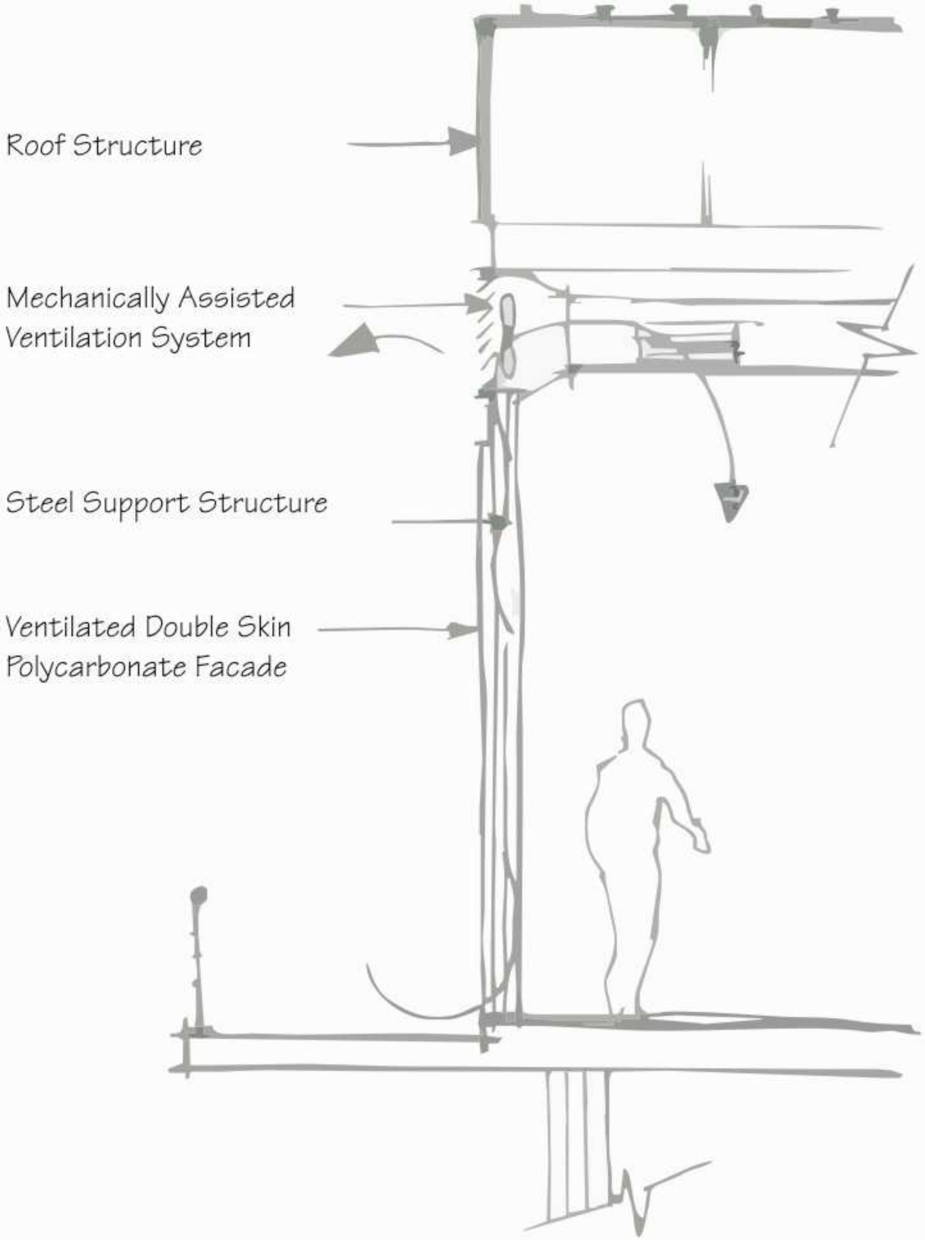
The interaction between user and building again becomes a defining concept in the evolution of the ventilated wall system.

The ventilated wall system is a combination of the envelope precedent walling systems and Shigeru Ban's *Naked House*. Elements of the transpired wall system have been combined with a double skin polycarbonate system that is easily adjustable in different climatic conditions to create a comfortable working environment.

▲fig7.10 Shigeru Ban's Naked House
(Hawthorne 2005, p.85)



▲fig7.11 Section Illustrating Opening
Positions for optimal cross-ventilation



▲fig7.12 Ventilated Wall Concept
(Author 2007)

Roofing Exploration

In attempting to choose a direction for a roofing structure, the initial task was to set out parameters that the roofing system or structure needed to achieve.

Parameters\ concerns the roofing structure\ system must address include:

1. User Interface - The roofing structure must be operated and controlled by the users, whether this be automatic or manual.

2. Thermal Performance - Consideration of insulation and roofing material in terms of thermal mass.

3. Natural Ventilation - Roofing to include or create opportunities to introduce height level clerestory ventilation.

4. Day lighting - Roofing to accommodate introduction of high levels of natural diffused day lighting.

5. Solar Power - Roofing system to accommodate building integrated photovoltaic cells.

6. Integration - Roofing to be seamlessly integrated into the supporting structure.

▲fig7.13 British Pavilion, Seville
(Steele 2005, p.122)

Nicholas Grimshaw's British Pavilion uses an independent shading device above the roof structure that incorporates photovoltaic cells that power the water pumps that cool the eastern facade.

▲fig7.14 South Elevation depicting the floating glass roof (Christian Richters)

Renzo Piano's Beyeler Foundation Museum untilised an almost all glass roof. Layers of glazing shaded by sloped panes of opaque glass. The building uses the roof as a mechanism to introduce and control natural day lighting. Given that the roof is almost entirely glass the roof performs surprisingly well thermally, due mainly to precise engineering. (Buchanan 2005, p.41)

▲fig7.15 Red Location Apartheid Museum
(Steele 2005, p.122)

The Red Location Apartheid Museum employed a saw-tooth roof, which utilizes natural light and creates opportunities for natural ventilation, The image of the saw-tooth roof is also strongly symbolic as the trade unions who provided the only voice for the disenfranchised under apartheid used the image of the saw-tooth widely in their posters and it is also a roofing form strongly associated or even synonymous with industry or production.

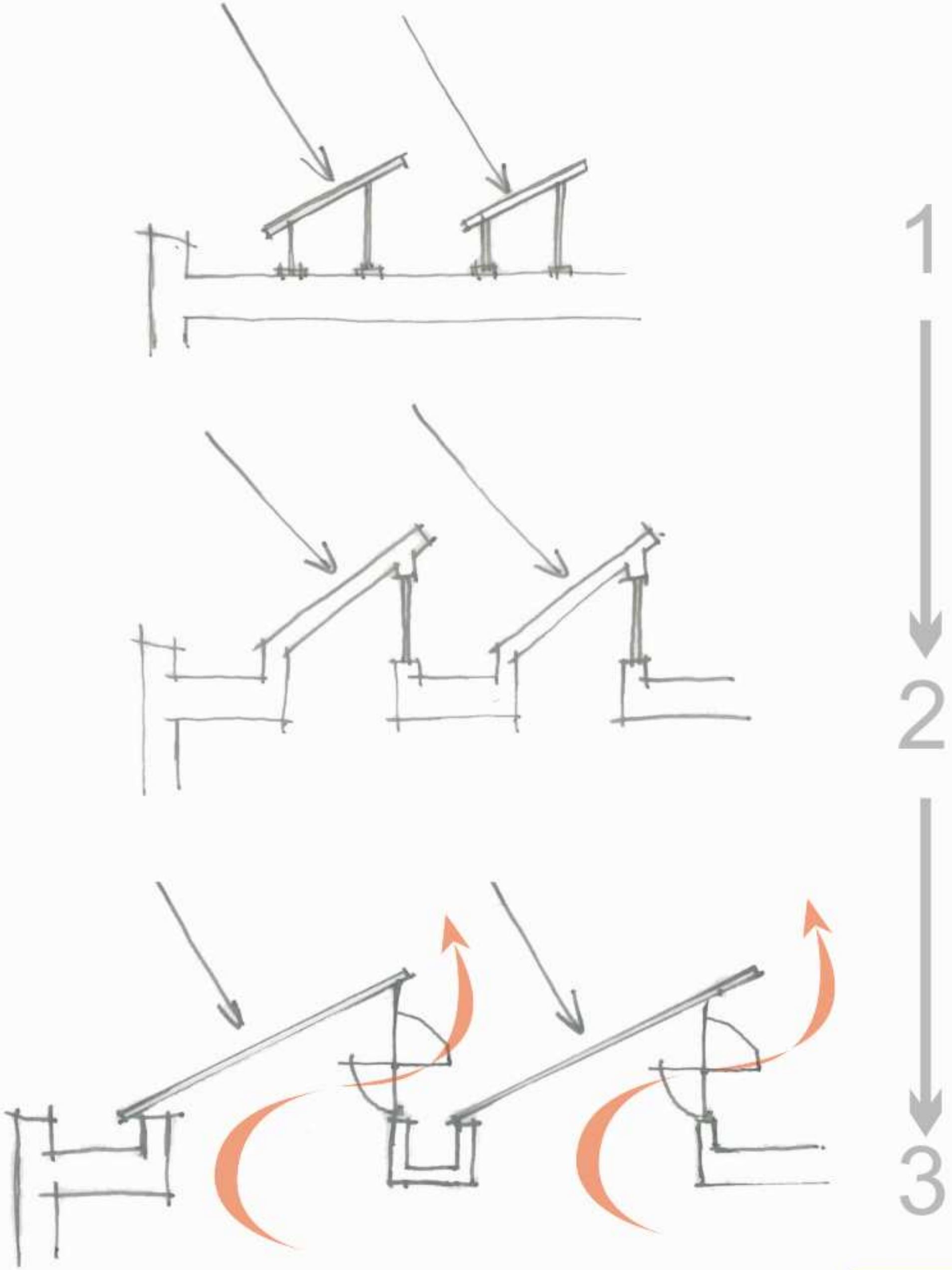
Evolution of Roofing Syst

The choice of form in terms of roofing is critical to the energy efficiency of a roof structure. An vast amount of heat gain and loss could occur due to poor detailing, material choice or insulation.

The proposed roof evolved out of a understanding of micro-climatic data, a desire for energy efficiency and social concerns.

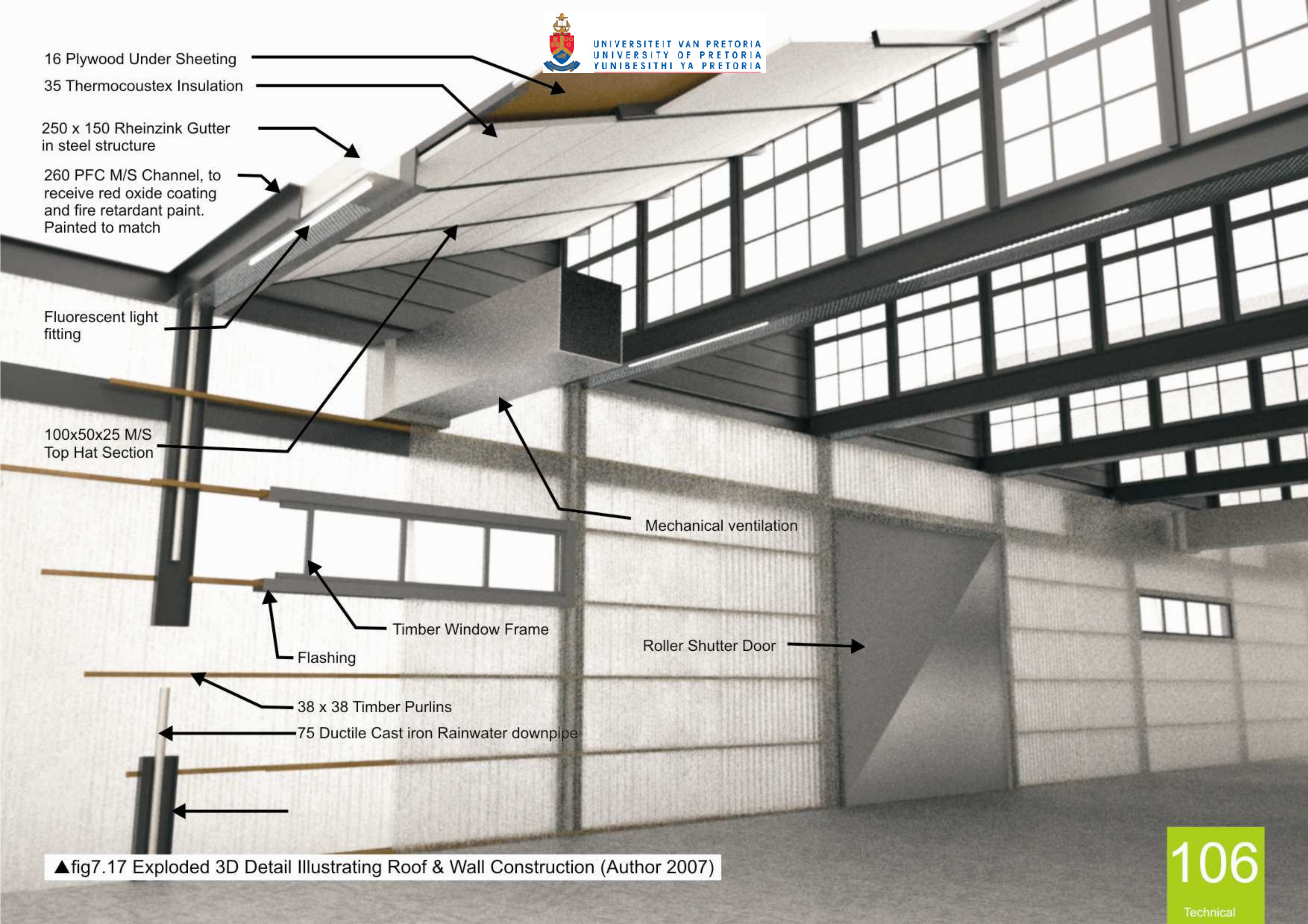
The resulting saw-tooth roof construction encompasses all of the parameters initially set, and has given the architecture a legibility related to the program.

The conceptual evolution of the roofing form is illustrated to the right. Initial investigations included shading the concrete roof structure with retrofitted solar panels. This was later adapted to a concrete roof structure optimally inclined for solar radiation. As the design progressed the roofing component changed to a lighter modular steel structure, based on the sizes of Wispeco steel school type pivot windows, was implemented to allow users to interact with the building and allow excess heat gain to escape.



▲fig7.16 Evolution of the Roofing Structure
(Author 2007)

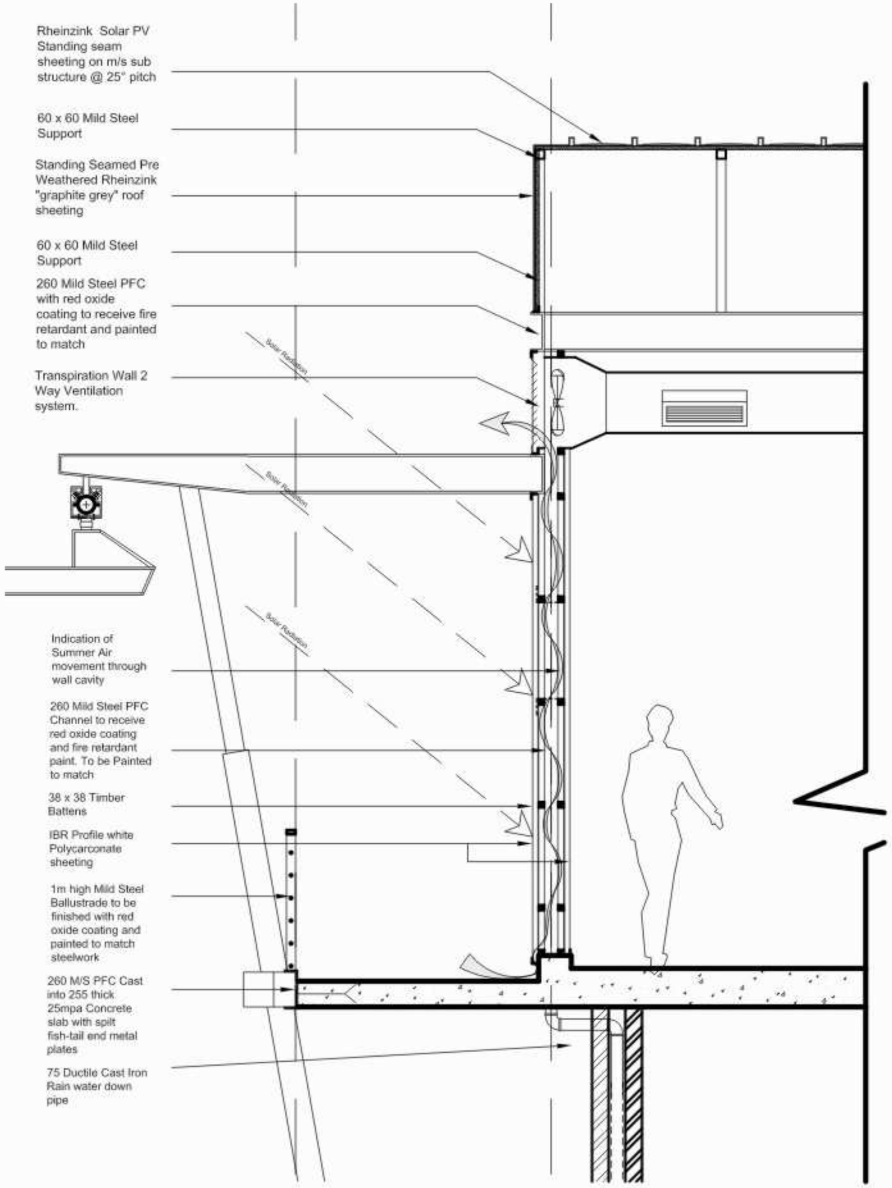
Integrated Envelope & Roofing Solution



▲fig7.17 Exploded 3D Detail Illustrating Roof & Wall Construction (Author 2007)

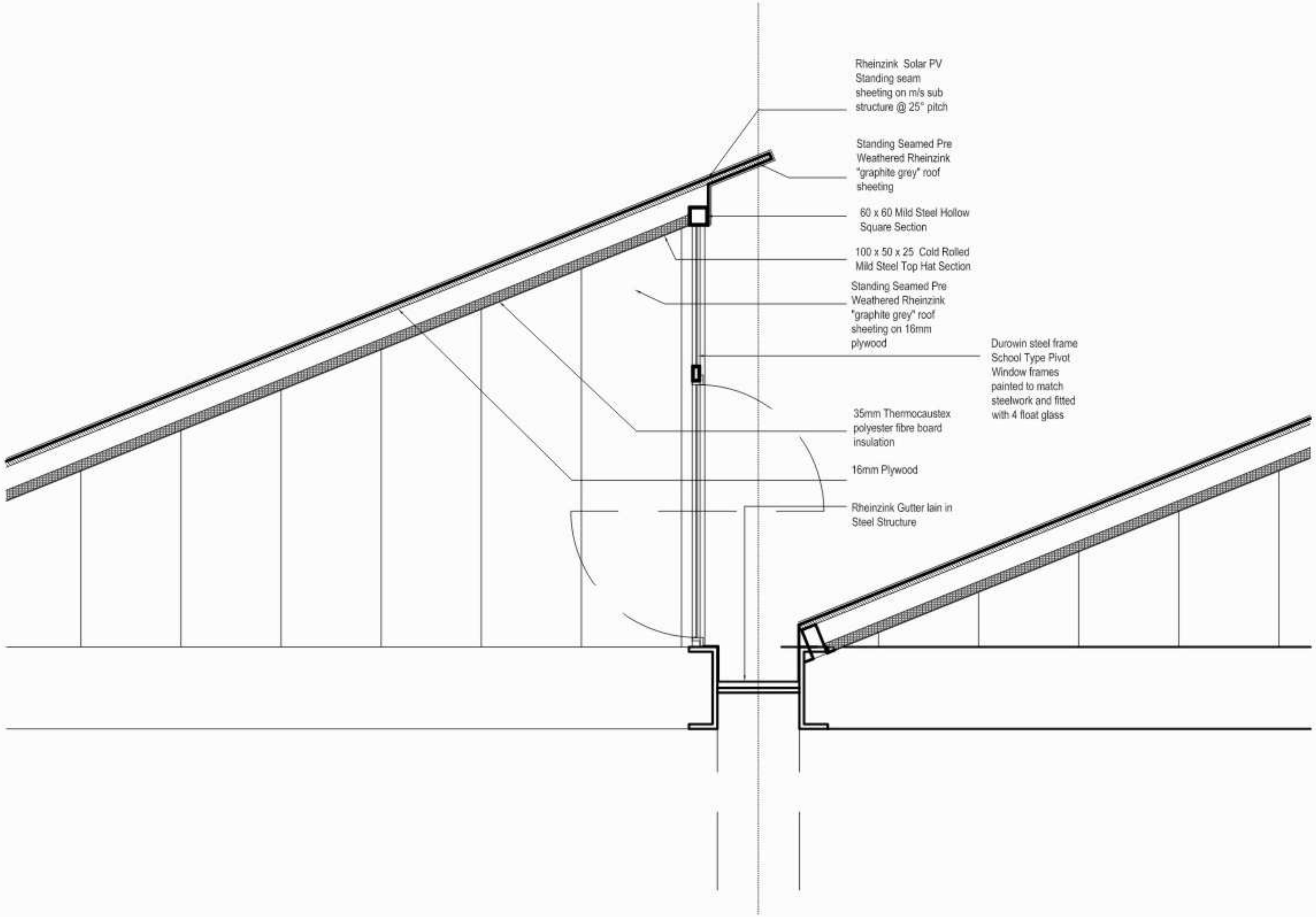
Wall System Detail

Scale 1:50



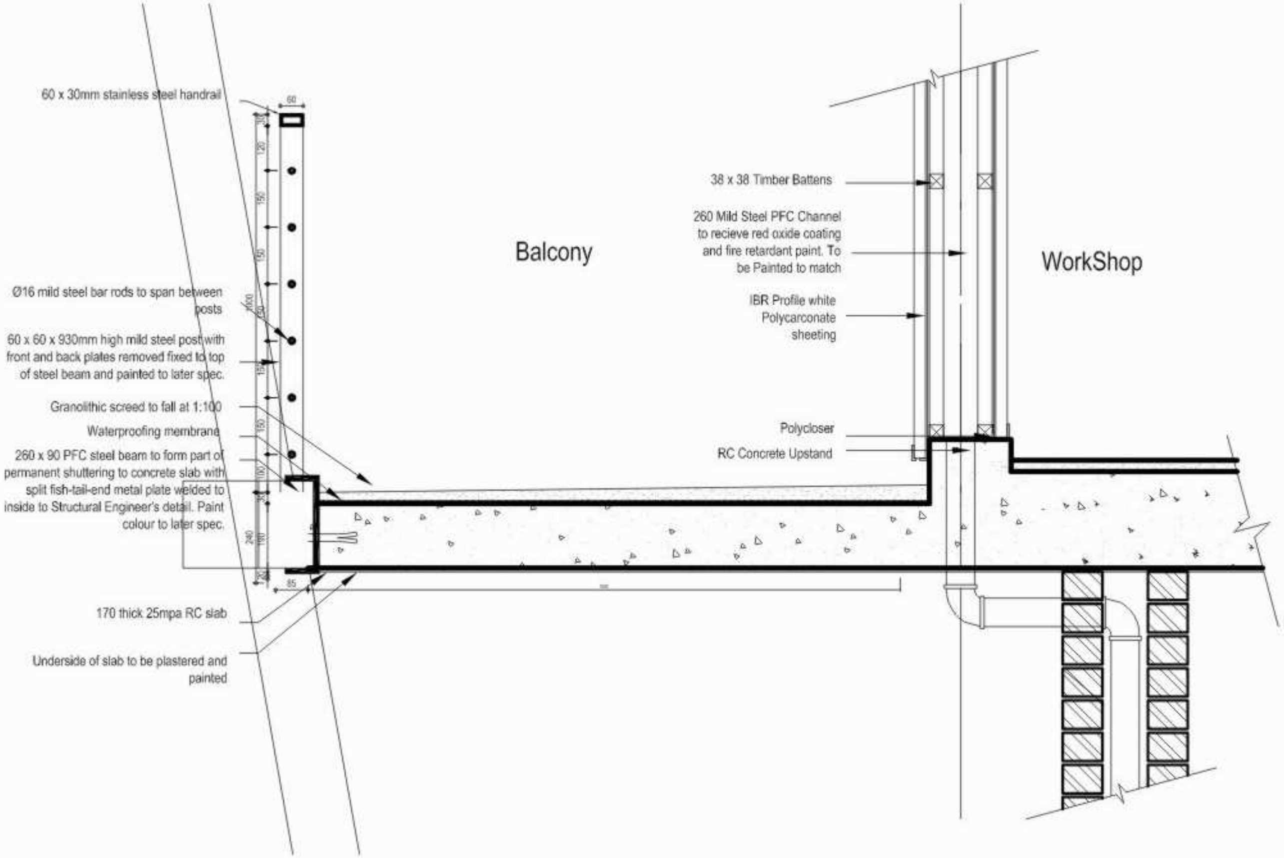
Roofing System Detail

Scale 1:20



Balcony Detail

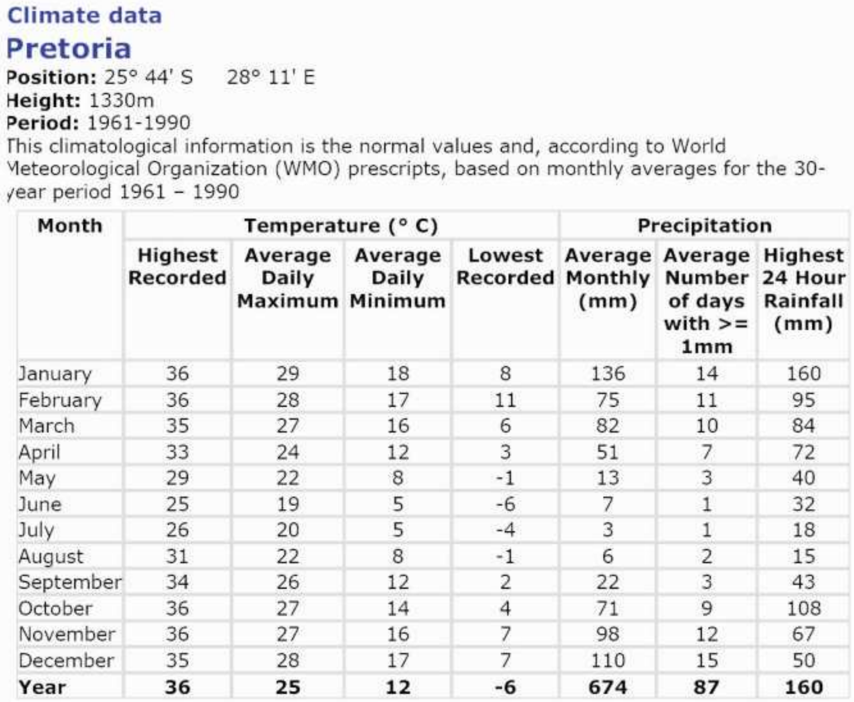
Scale 1:20



Sizing Rainwater Downpipes

Using the above criteria and assuming the highest 30year data on record, namely 160mm over a 24 hour period and using that as an hourly rate, the following discharge is needed

	Design Area	Rainfall Intensity mm/h	Reqd Gutter discharge area (mm²)	(cm²)	Actual supplied (cm²)
Roof Area 1	47sqm	160	7400	74	**90**
Roof Area 2	68sqm	160	11000	110	**156**



Climate data

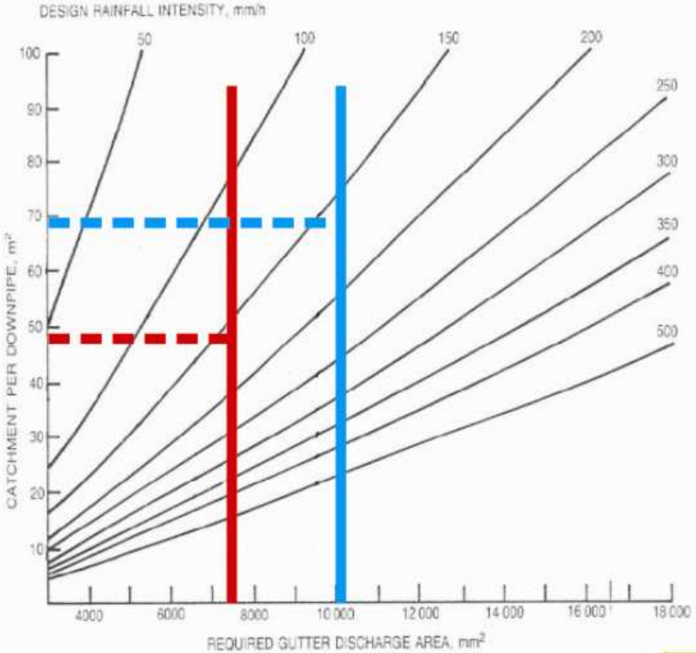
Pretoria

Position: 25° 44' S 28° 11' E
Height: 1330m
Period: 1961-1990

This climatological information is the normal values and, according to World Meteorological Organization (WMO) prescripts, based on monthly averages for the 30-year period 1961 – 1990

Month	Temperature (° C)				Precipitation		
	Highest Recorded	Average Daily Maximum	Average Daily Minimum	Lowest Recorded	Average Monthly (mm)	Average Number of days with >= 1mm	Highest 24 Hour Rainfall (mm)
January	36	29	18	8	136	14	160
February	36	28	17	11	75	11	95
March	35	27	16	6	82	10	84
April	33	24	12	3	51	7	72
May	29	22	8	-1	13	3	40
June	25	19	5	-6	7	1	32
July	26	20	5	-4	3	1	18
August	31	22	8	-1	6	2	15
September	34	26	12	2	22	3	43
October	36	27	14	4	71	9	108
November	36	27	16	7	98	12	67
December	35	28	17	7	110	15	50
Year	**36**	**25**	**12**	**-6**	**674**	**87**	**160**

http://www.weathersa.co.za/Climat/Climstats/PretoriaStats.jsp

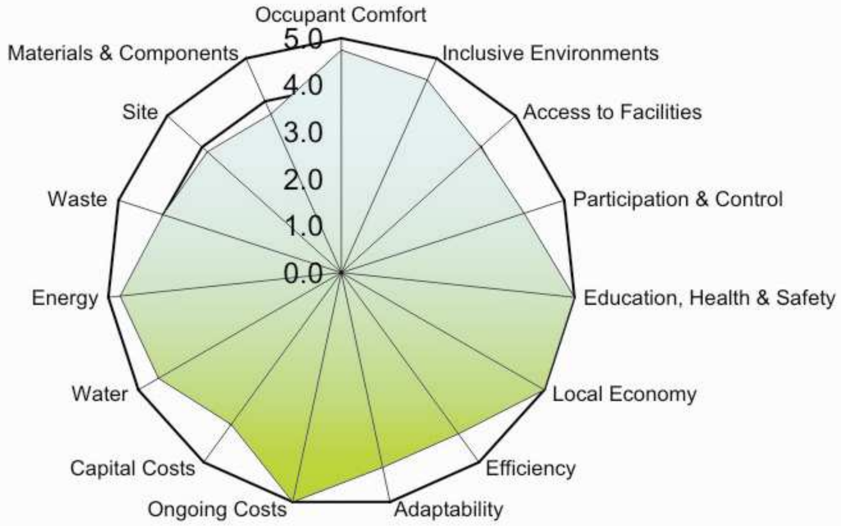


Sizing Downpipes (Krige 2007)

Sustainable Building Assessm

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

PROJECT		ASSESSMENT	
Project title:	Green Building Workshop	Date:	10-Sep-07
Location:	Marabastad, Pretoria	Undertaken by:	Mark Falconer
Building type (specify):	Commercial		
Internal area (m2):	6250		
Number of users:			
Building life cycle stage (specify):	Design		



Social	4.5	Economic	4.5	Environmental	4.2
		Overall	4.4		

Produced by SBAT Tool created by Jeremy Gibberd (Gibberd, 2003)