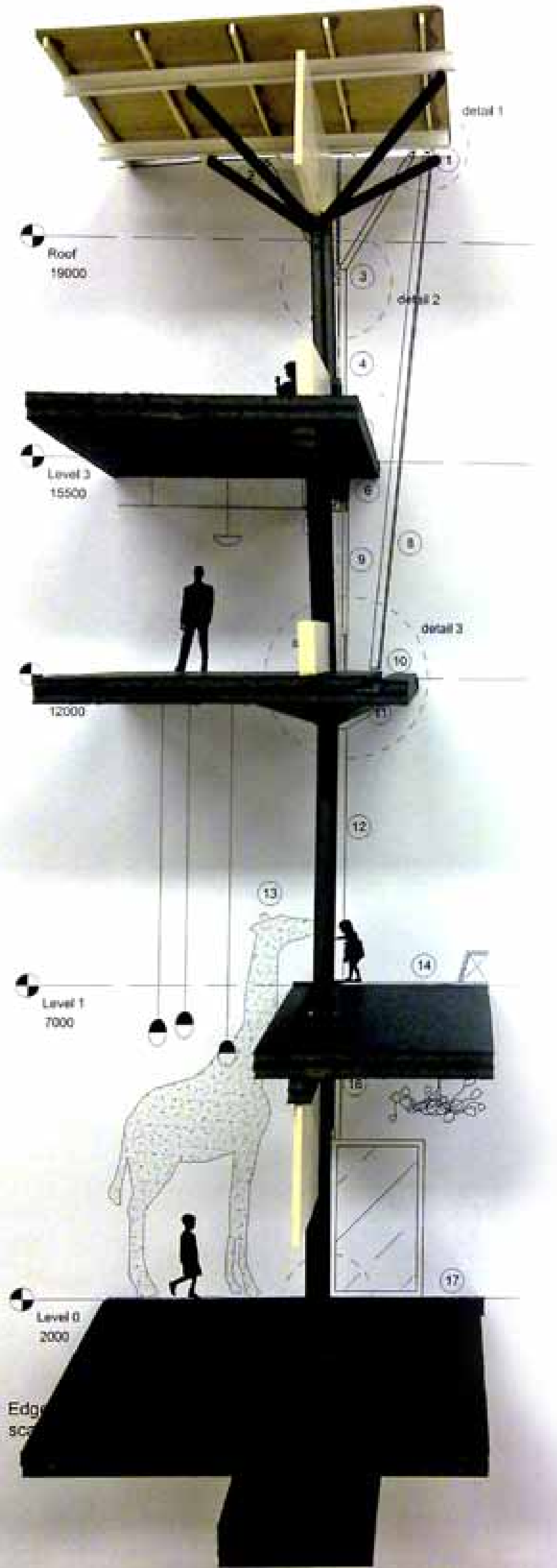


figure 117. photo of technical model

"Architecture is the art of organizing space. It is through construction that it expresses itself."

(Perret, 1952)

chapter 7 technological investigation

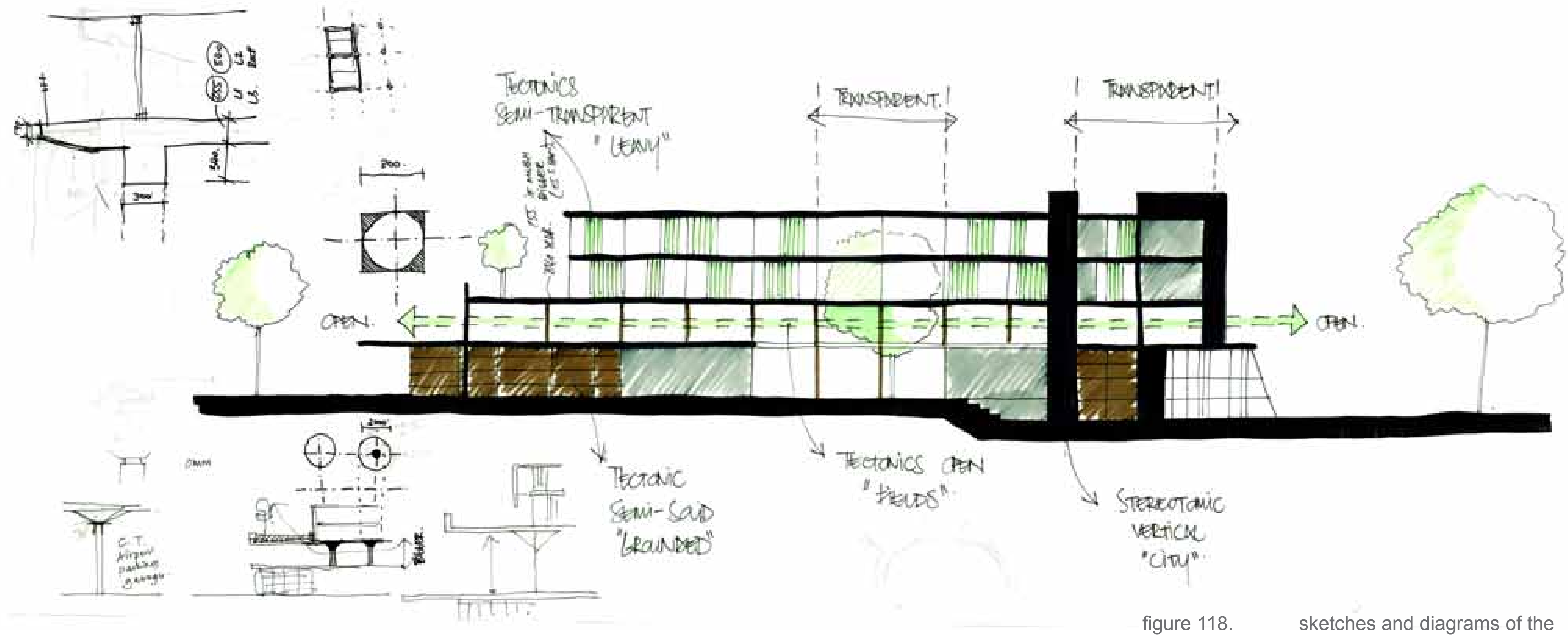


figure 118. sketches and diagrams of the beginnings of a techtonic language

7. TECHNOLOGICAL INVESTIGATION

7.1 TECHNOLOGICAL CONCEPT

The technological concept is based on the play between the vertical and horizontal elements that make up the structure. Vertical elements are accentuated by the open horisontal components. This draws back to the design concept of nature and the city.

The stereotomic elements relate to the city context, with hard vertical structures penetrating the building. It grounds the floating upper levels and the materiality relates back to the Museum and elements found in structures in the Zoo.

The tectonics in the development are based on more natural elements. The ground level speaks to the earth and is grounded by gabion walls seperating the public sidewalks and the semi-private Zoo functions. The open first level relates to an open natural environment, framing views of the Zoo as users pass through the level.

The two upper levels represent a lighter and semi-transparent tectonic, symbolising the tops of tree-like structures, letting light through while still creating a private realm for the office space.

7.2 *STEREOTOMIC & TECTONIC*

According to Gottfried Semper, the building crafts are divided into two distinct categories. Firstly, the “stereotomic” represents the repetitious piling up of massive elements to compose a volume, and secondly; the “tectonics” which are the lightweight components composed to define a spatial matrix.

(Frampton, K. 1996. P. 5)

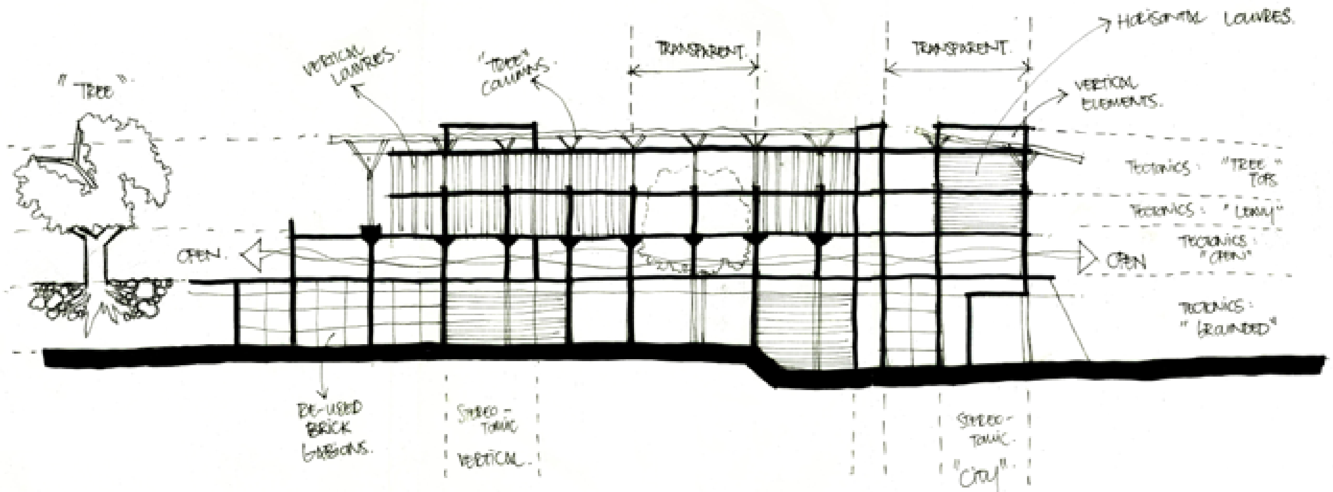


figure 119. sketch showing stereotomic and tectonic concept

The Stereotomic elements consists of a concrete column and beam structure, developed on a structural grid to simplify the construction process.

The columns range from 300x300mm concrete columns on the ground level to 300mm dia. round columns with mushroom caps on the first level. On the second and third level the columns change to round steel pipes that are cut and joined to form a tree-like structural element that will carry the roof structure.

The effect of the column designs is that the stereotomic mass becomes lighter higher up in the building. Concrete columns are cast in timber shutters, to leave a natural cast print on the concrete. Concrete floors are cast on structural beams to transfer the loads down to the columns.

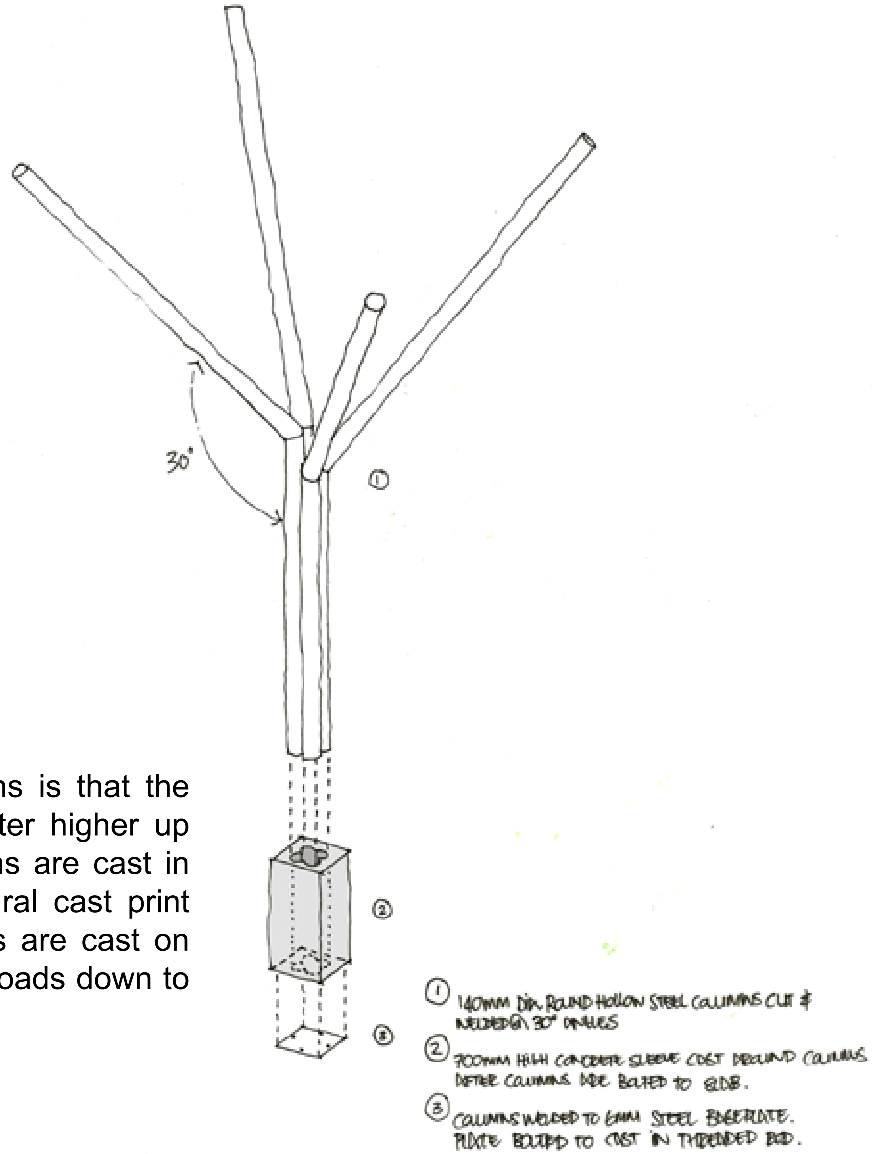


figure 120. detail of column assembly

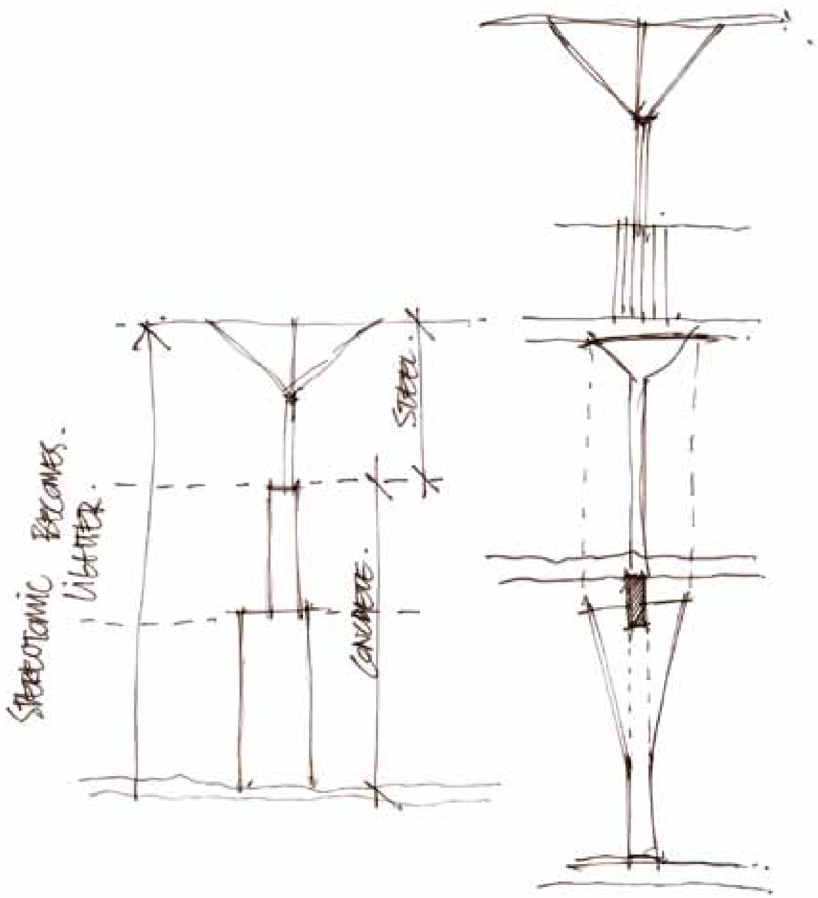
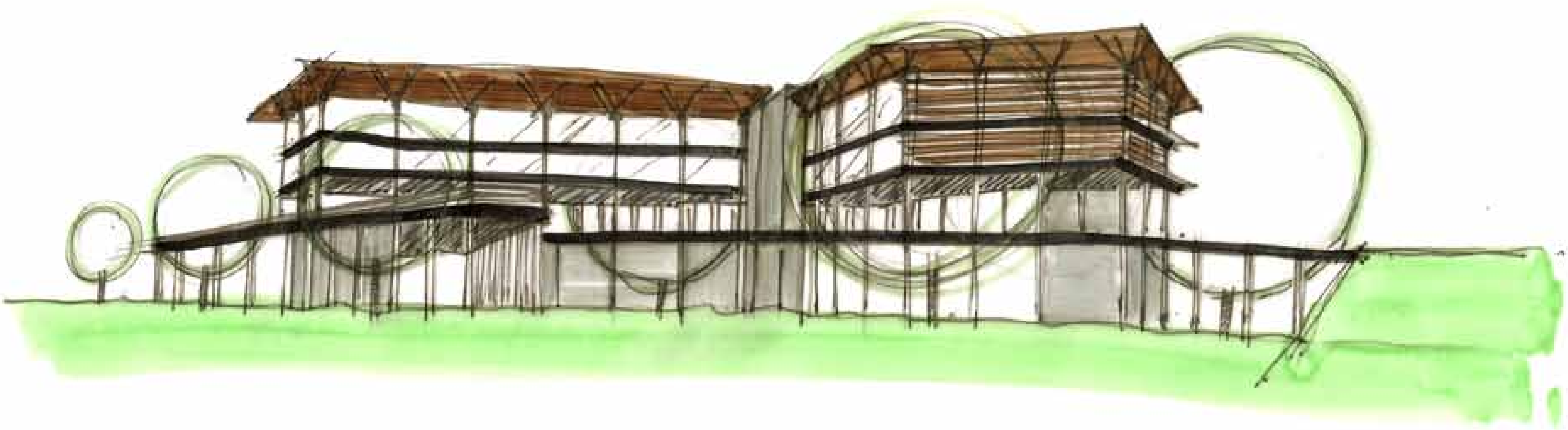


figure 121. diagram showing stereotomic investigation

figure 122. 3d showing stereotomic arrangement

figure 123. sketch showing tectonic investigation



The Tectonic is treated with various elements, depending on where in the proposal it is situated. Restaurants, offices and zoo facilities on the ground floor are fitted with timber louvered partitions that can be closed for privacy, or opened up to the public. While open, these partitions also function as shading devices.

Solid partitions are created with gabion boxes filled with brick, re-used from the demolished buildings.

On the open first floor, partitions become more transparent, with glass and mesh bounding the spaces. However, on this level the tectonics are kept to a minimum to offer visitors the maximum view over the natural elements of the Zoo.

The two upper levels are designated for office space and are enclosed by glazing. Vertical and horisontal louvre shading devices cover the facades and create a more private space. Areas on these floors are kept open and uncovered in order to create transparent sections in the building so that visitors in the square can still enjoy the views to the Zoo. Planted verandas also lend some privacy to the open space on the upper levels, while connecting the building with the natural surroundings.

The lightweight steel roof falls that to the North in order to create larger overhangs over office spaces.

figure 124. sketch showing hierarchy between stereotomic and tectonics

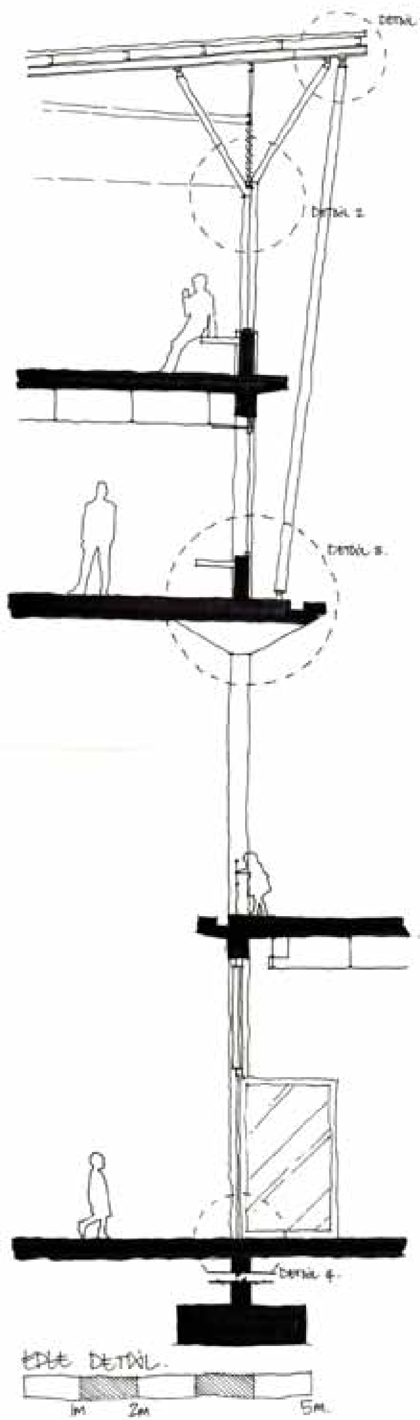


figure 126. interior rendering of double volume space in offices

7.2 SECTIONS

The following sub-chapter documents sections through the proposal. The aim of this is to examine the stereotomic together with the tectonic elements. This provides a spatial representation of what the proposal might look like. The sections also include a materiality and a programmatic investigation.

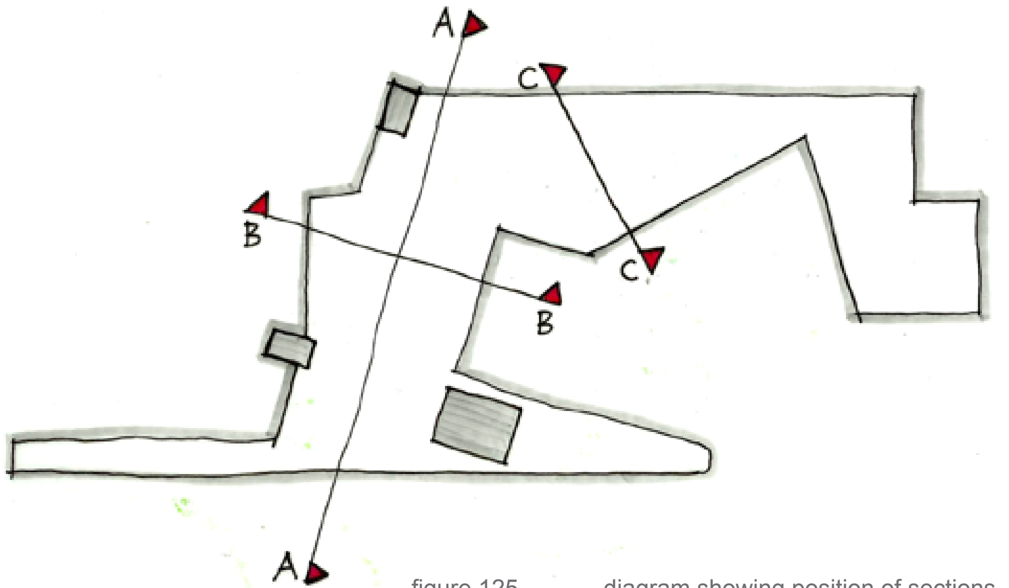
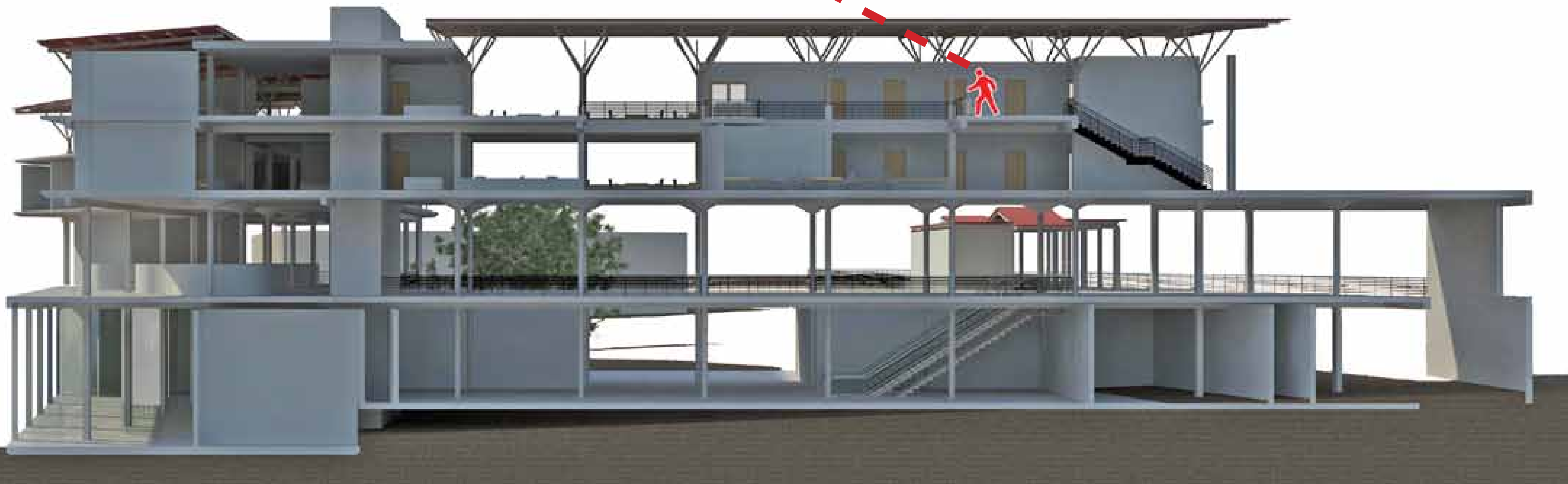


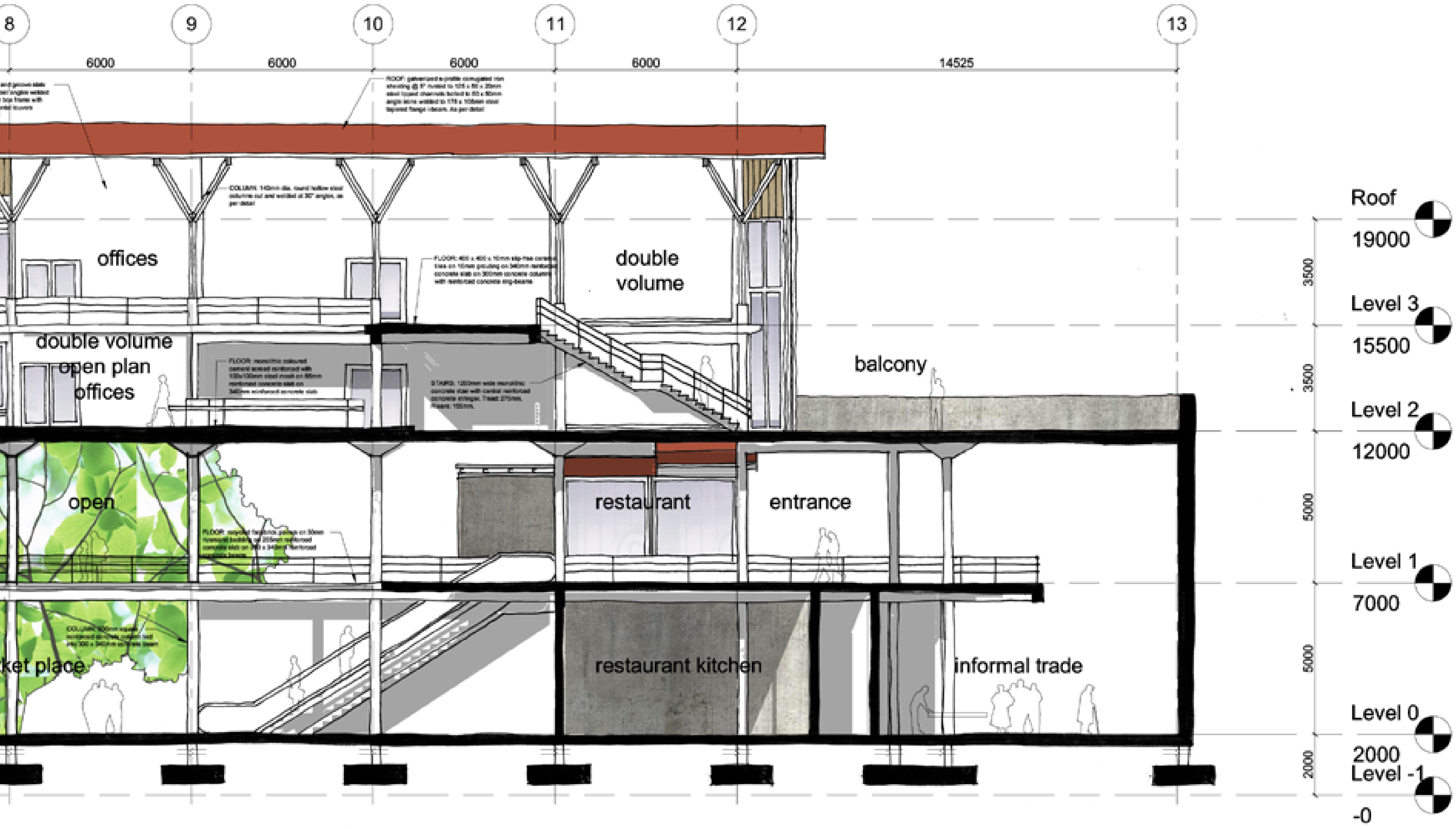
figure 125. diagram showing position of sections

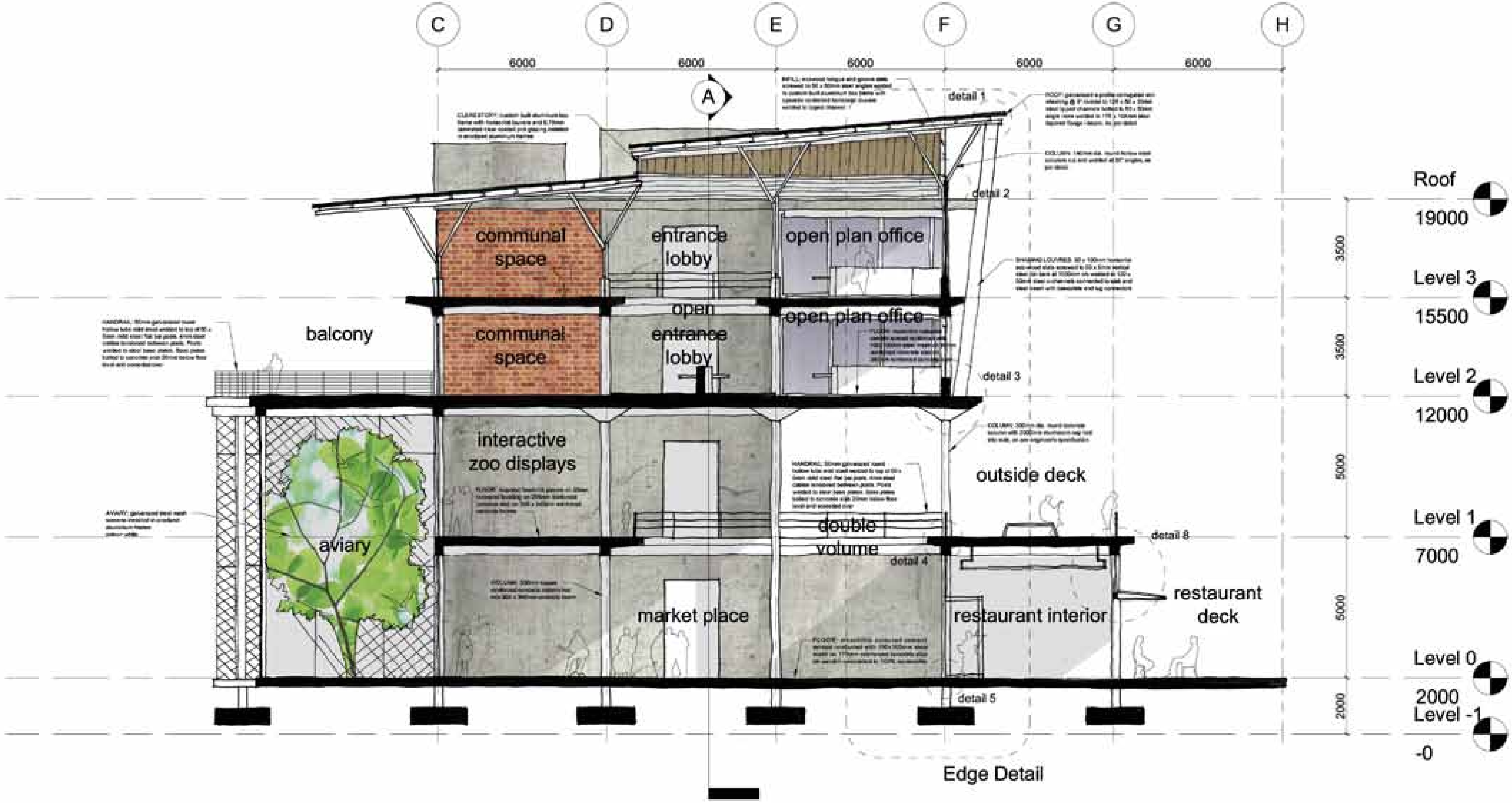
figure 127. 3d section through West wing



SECTION A-A
scale 1:200

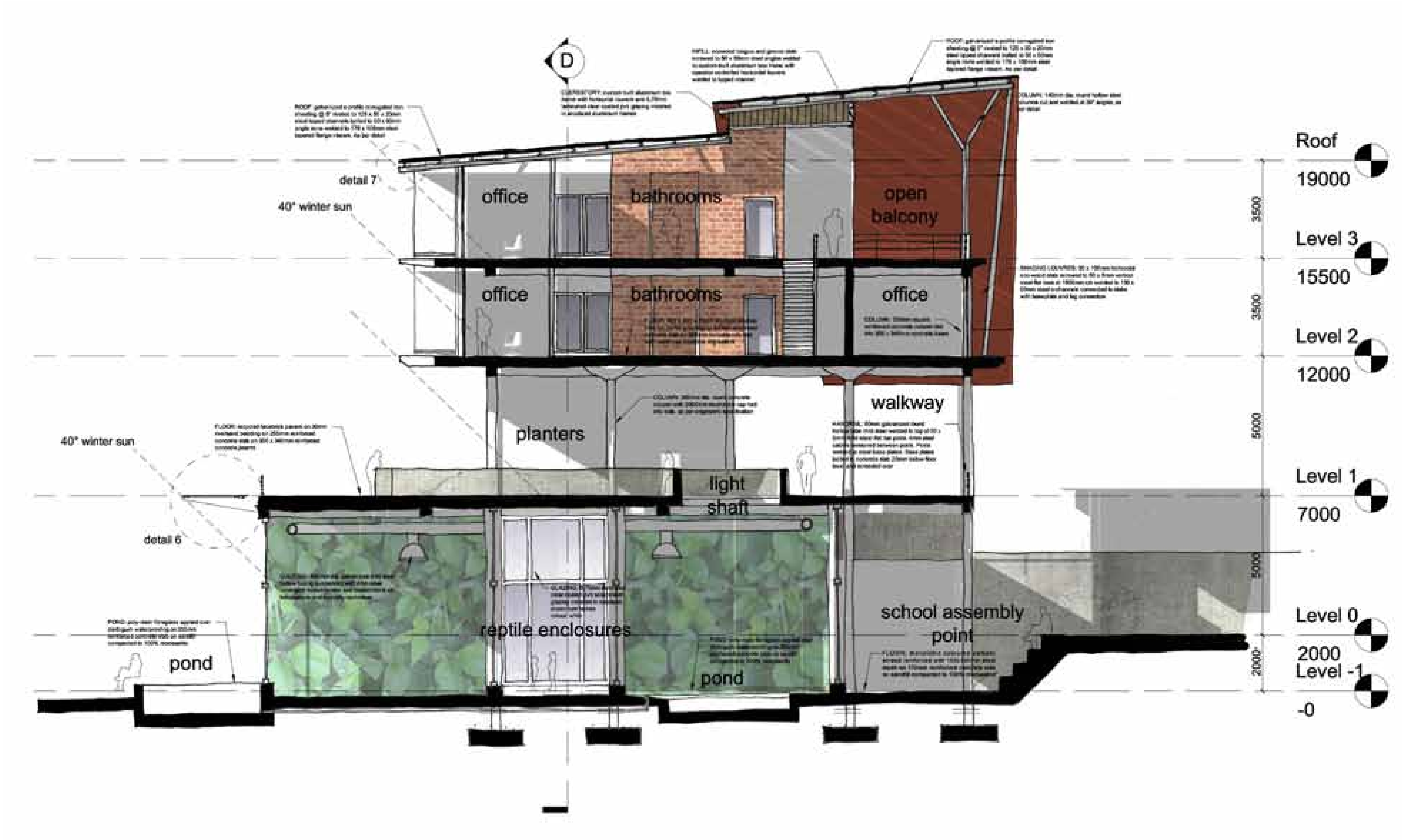
figure 128. section a-a





SECTION B-B
scale 1:200

figure 129. section b-b



SECTION C-C

scale 1:200

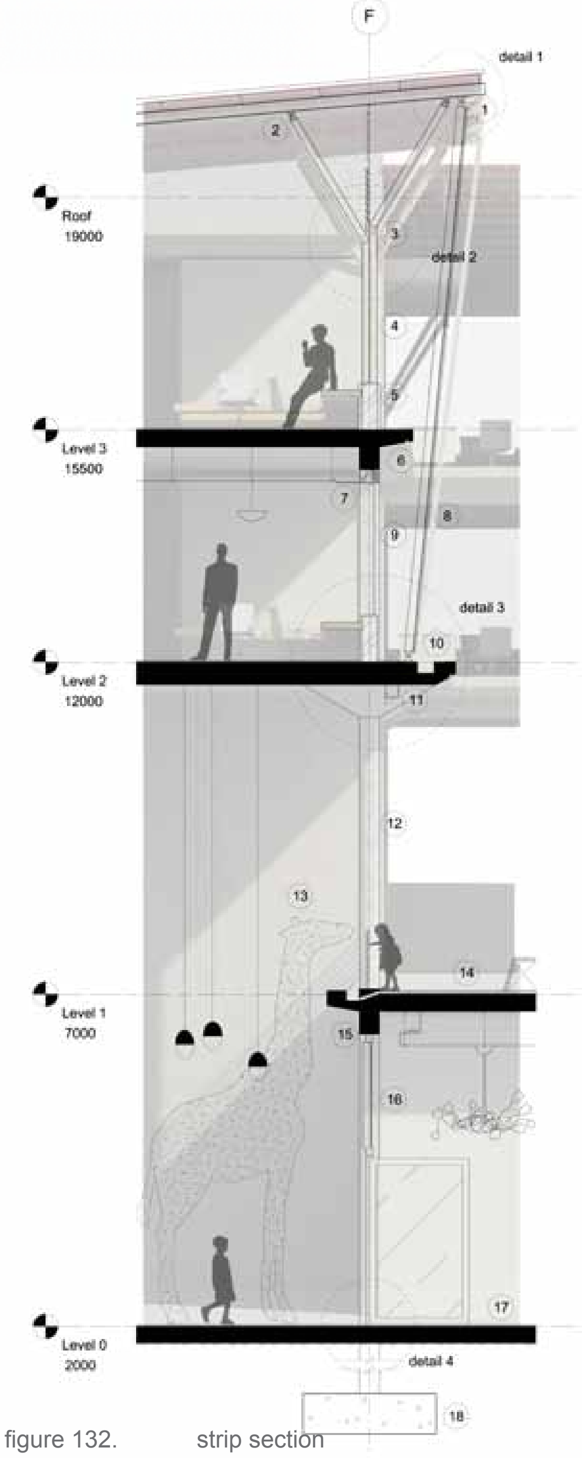
figure 130. section c-c

SECTION D-D

scale 1:200

figure 131. section d-d


C
offices
reception
office
offices
reception
office
meeting point &
view deck
shaft
resfreshment
shop
reptile and bathroom
service shaft
reptile enclosures
bathroom
corridor
information
office
Roof
19000
Level 3
15500
Level 2
12000
Level 1
7000
Level 0
2000
Level -1
-0
3500
3500
5000
5000
2000



1. galvanized s-profile corrugated iron sheeting riveted to130 x 50mm steel c-channels welded to 178 x 108mm steel tapered flange i-beam
2. 150mm dia. baseplate welded to steel columns and under side of i-beams lugs welded to baseplate with holes for bolt and nut connection
3. 140mm dia. round hollow steel columns cast into concrete footing columns cut and welded at 30° angles (see detail 5)
4. 6,76mm laminated clear coated pvb glazing installed in anodized aluminium frames colour: white
5. 230mm brick wall built to 700mm a.f.f.l. plastered and painted colour: light brown
6. 25mm screed on 255mm concrete slab soil to be treated with insecticide screed on exterior to fall to edge
7. 200mm high steel box with aluminium louvres and turning closers bolted to under side of concrete beam
8. 50mm steel flat bars at 1500mm c/c welded to 130mm steel c-channels connected to slab and i-beam with baseplate and lug connectors 30 x 100mm horisontal eco-wood slats screwed to channels
9. 6,76mm laminated clear coated pvb glazing installed in anodized aluminium frames colour: white
10. 25mm screed on 340mm concrete slab soil to be treated with insecticide screed on exterior to fall to gutter
11. retractable rain shields bolted to under side of slab
12. 300mm dia. round concrete column with 2000mm dia. concrete cap
13. silhouette of zoo animals sandblasted on concrete wall to expose aggregate
14. recycled facebrick pavers on 30mm riversand bedding on 255mm reinforced concrete slab concrete to fall to gutter 50mm dia. pvc sleaved weep holes at 1800 c/c
15. 340 x 300mm concrete beam
16. 300 x 300mm concrete column
17. 25mm screed on 170mm surface bed on well compacted layers of fillings of maximum 150mm soil to be treated with insecticide 0,25mm polyethylene damp proofing membrane with 150mm sealed joints
18. 600 x 2000mm concrete pad foundation to engineer's specifications

figure 132. strip section

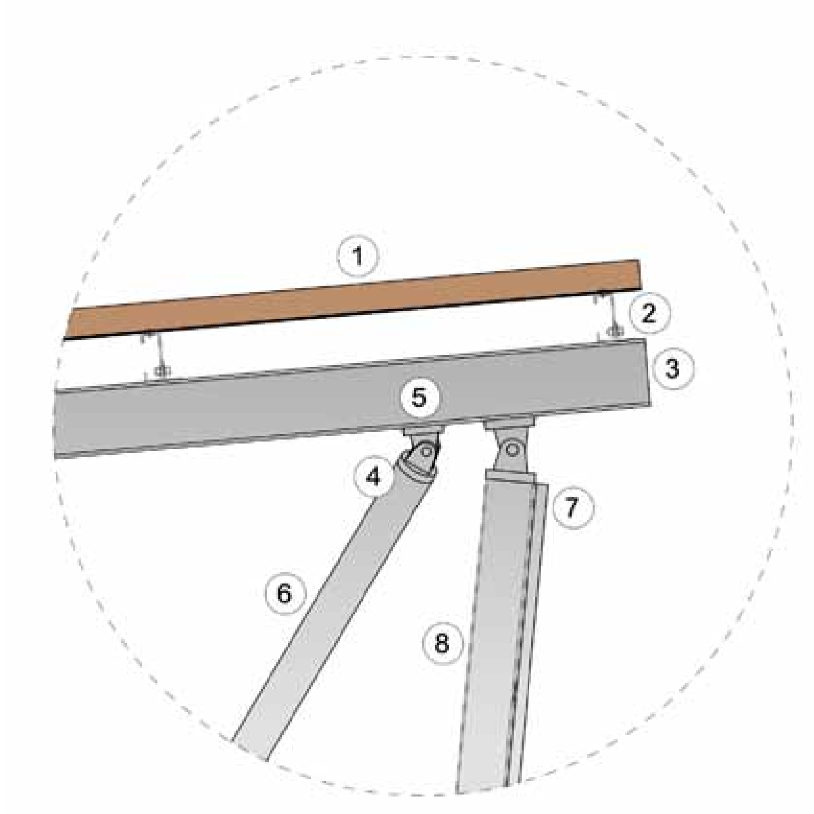


figure 133. detail 1. roof and column connection

7.3 DETAILS

The following details show technical resolution in stereotomic and tectonic scenarios found within the proposal. All details were designed keeping the technological concept in mind, and serve to add complexity and refinement to the design itself.

1 galvanized s-profile corrugated iron sheeting riveted to steel c-channels at 5°

2 125 x 50 x 20mm steel lipped channels bolted to 50 x 50mm angle irons
angles welded to steel i-beam

3 178 x 108mm steel tapered flange i-beam

4 25mm 150mm dia. baseplate welded to steel columns and under side of i-beams

5 25mm lugs welded to baseplate with 10mm holes for bolt and nut connection

6 140mm dia. round hollow steel columns cast into concrete footing
columns cut and welded at 30° angles
(see detail 5)

7 30 x 100mm horisontal eco-wood slats screwed to 50 x 5mm steel flat bars at 1500mm c/c

8 flat bars welded to 130 x 50mm steel c-channels connected to slab and i-beam with baseplate and lug connectors

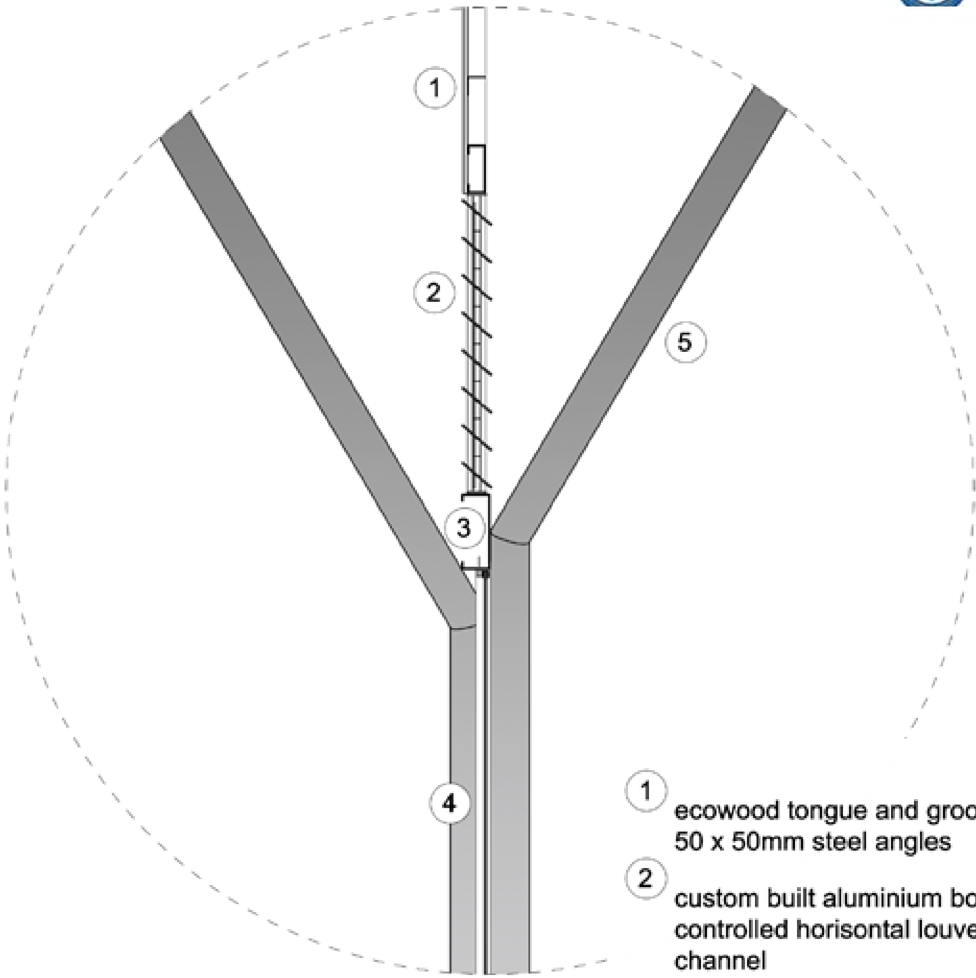


figure 134. detail 2. tectonics around columns

1 ecowood tongue and groove slats screwed to 50 x 50mm steel angles

2 custom built aluminium box frame with operator controlled horisontal louvers welded to lipped channel

3 200 x75 x20mm steel lipped channel welded to inside of steel columns

4 6,76mm laminated clear coated pvb glazing installed in anodized aluminium frames
colour: white

5 140mm dia. round hollow steel columns cast into concrete footing
columns cut and welded at 30° angles
(see detail 5)

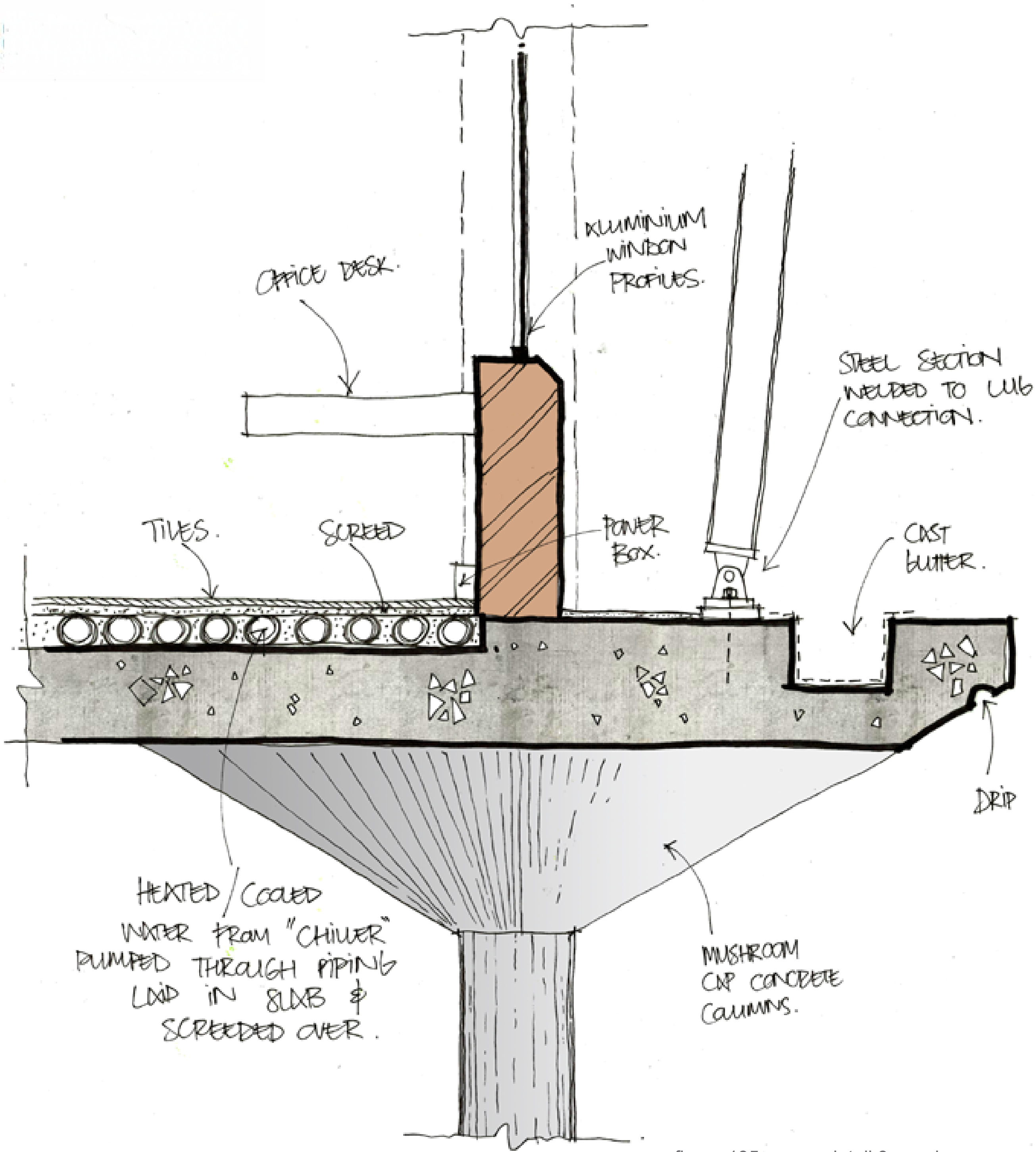
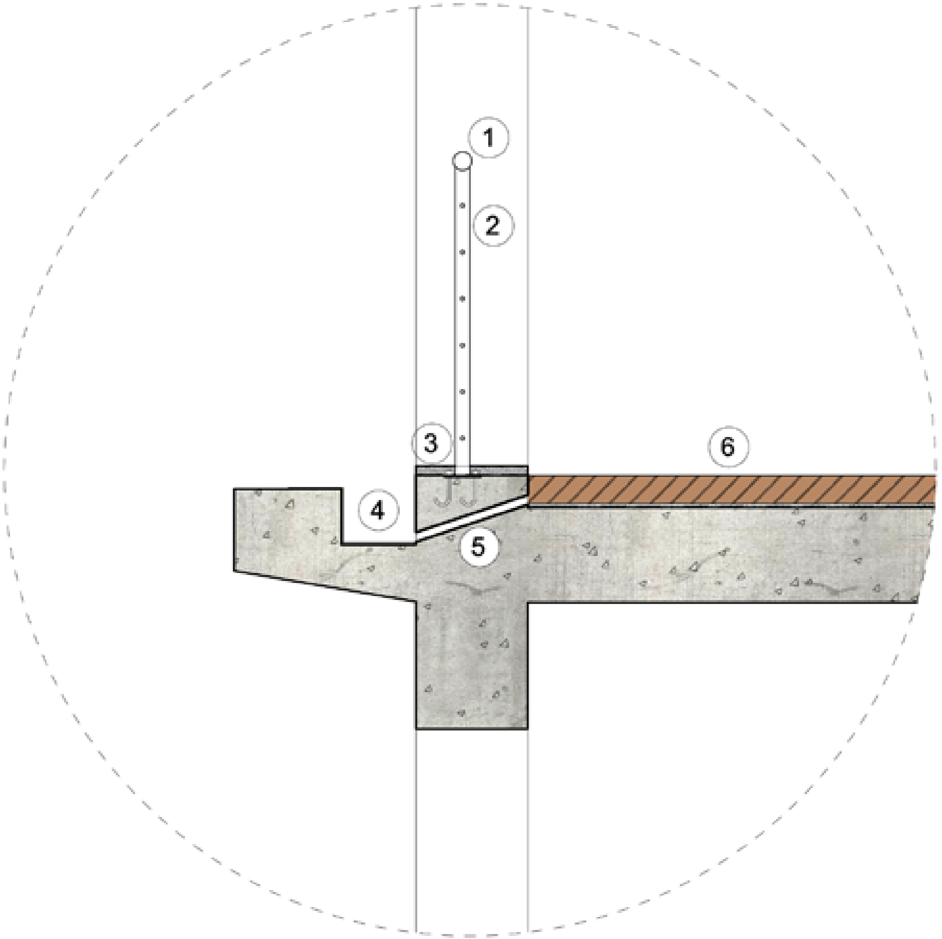


figure 135. detail 3. mushroom cap and slab detail



1 50 x 2mm galvanized round hollow tube mildsteel handrail welded to flat bars

2 50 x 5mm galvanized mild steel flat bar balusters welded to base plate. 4mm steel cables threaded through and tensioned between balusters

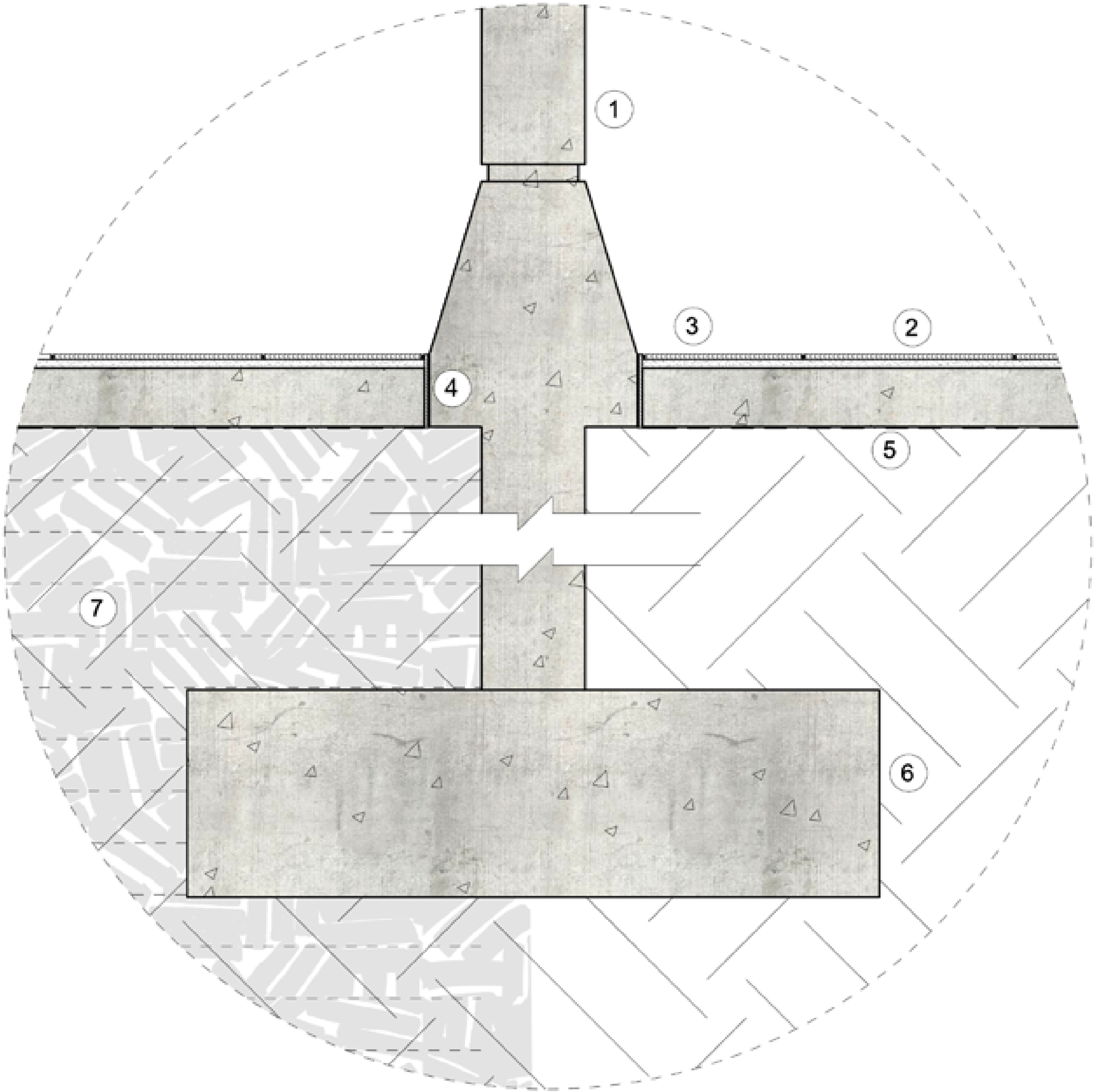
3 10mm steel base plate bolted to threaded rod cast into reinforced concrete

4 derbigum waterproofing over 150 x 200mm concrete water channel

5 20mm uPVC drainage pipe cast into concrete @ 2000mm spacing

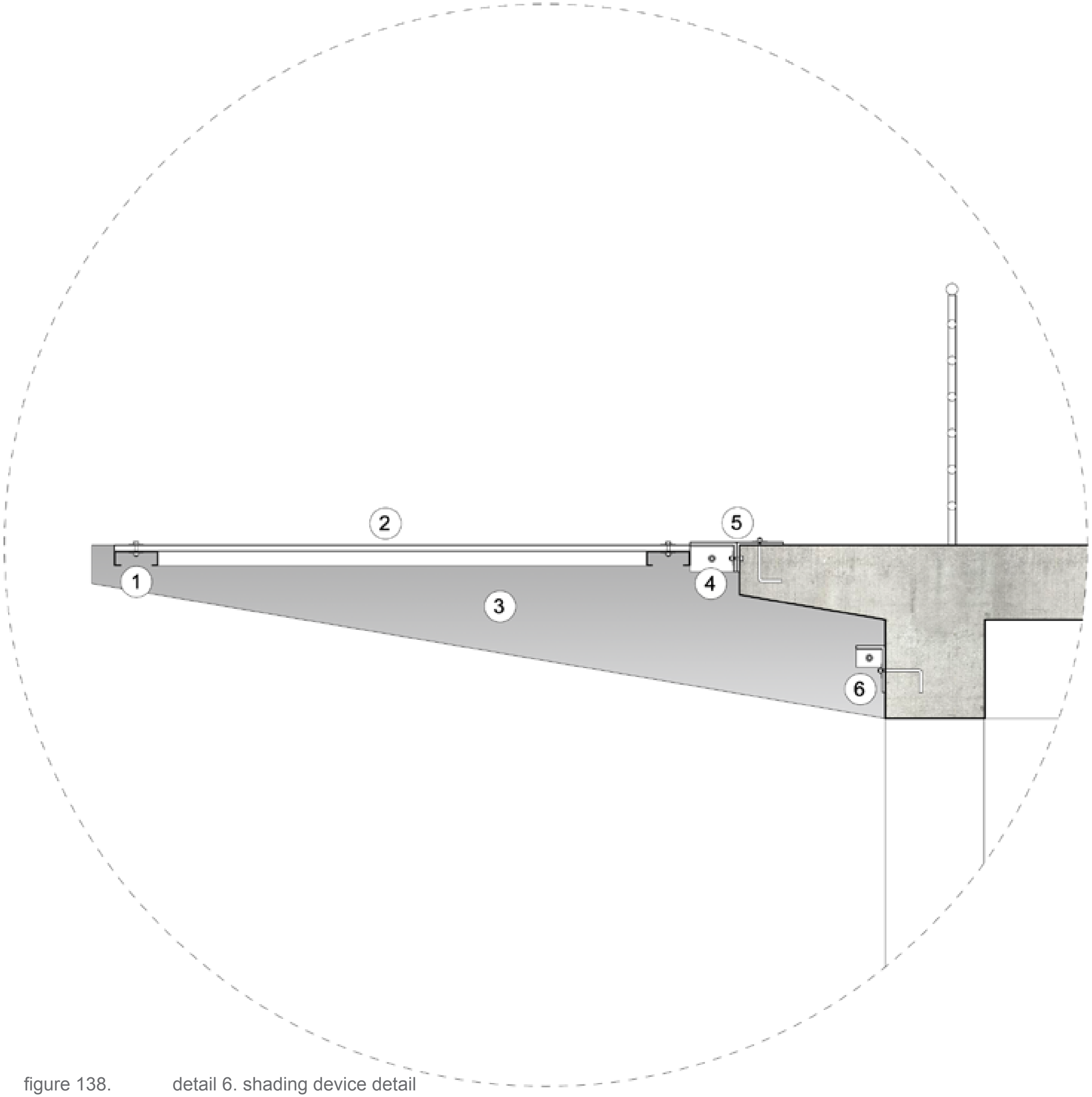
6 recycled facebrick pavers on 30mm riversand bedding on derbigum waterproofing on 255mm reinforced concrete slab

figure 136. detail 4. slab and gutter detail



1. 300 x 300mm cast-in-situ concrete column with 600mm round base and 20mm deep shadow line
2. 600 x 600 x 10mm slip-free ceramic tiles on 10mm grouting
3. 25mm screed on 170mm surface bed on well compacted layers of fillings of maximum 150mm soil to be treated with insecticide
4. 10mm soft board infill between column and slab
5. 0,25mm polyethylene damp proofing membrane with 150mm sealed joints
6. 600 x 2000mm concrete pad foundation to engineer's specifications
7. compacted soil fillings in layers of 150mm maximum

figure 137. detail 5. floor and foundation detail



1 150 x 50 x 20mm steel c-channel welded to mild steel profile cut plate

2 50 x 20mm eco wood slats bolted to c-channels

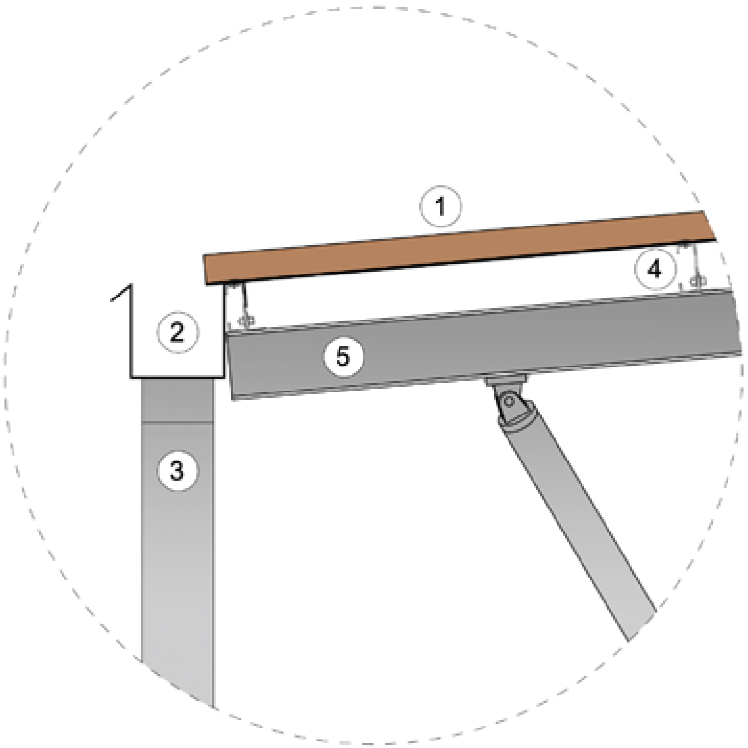
3 4mm galvanized mild steel plate water jet cut to profile and bolted to mild steel angles @ 3000mm spacing

4 90 x 90 x 6mm mild steel angles bolted to profile cut plate and welded to 90 x 150 x 10mm mild steel angles

5 90 x 150 x 10mm mild steel angles bolted together and to threaded rod cast in reinforced concrete slab

6 60 x 60 x 4mm mild steel angle bolted to profile cut plate and welded to 90 x 150 x 10mm mild steel angle. angle bolted to threaded rod cast in reinforced concrete beam

figure 138. detail 6. shading device detail



1. galvanized s-profile corrugated iron sheeting riveted to steel c-channels at 5°
2. 250 x 250mm galvanized mild steel box gutter bent over and riveted to steel lipped channels (140mm²/m² of roof area)
3. 190 x 190mm galvanized mild steel down pipe connected to box gutter (100mm²/m² of roof area)
4. 125 x 50 x 20mm steel lipped channels bolted to 50 x 50mm angle irons angles welded to steel i-beam
5. 178 x 108mm steel tapered flange i-beam

figure 139. detail 7. roof and gutter detail

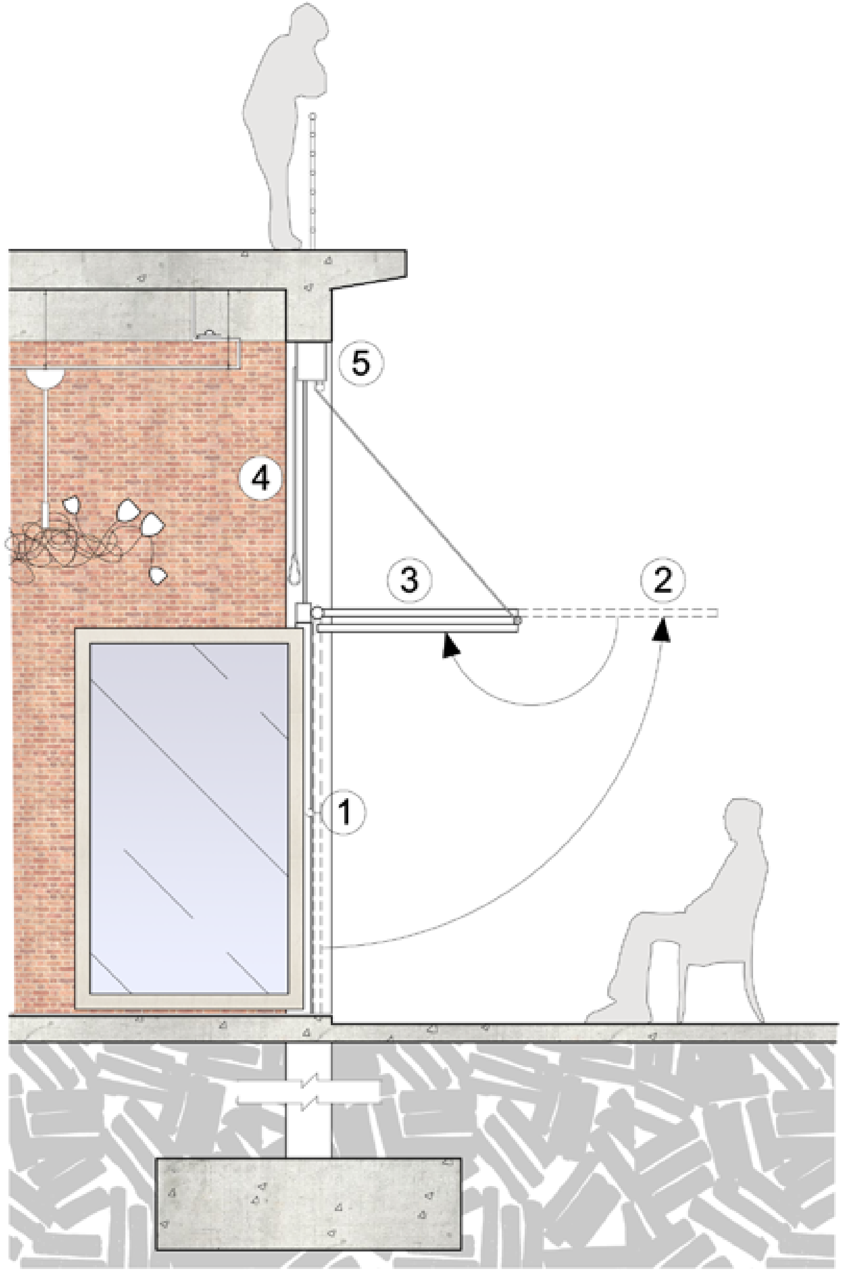


figure 140. detail 8. foldable shading detail

1 50 x 20mm ecowood slats screwed to a folding aluminium frame hinged from bolt cast into concrete columns

2 louvre panels tilted to a horisontal position via chain link

3 bottom louvre panel folds back in and clips into position under top panel

4 panels are drawn upwards via a chain link

5 chain link operates over a series of pullies and locks chain in position when panels are drawn to a horisontal position

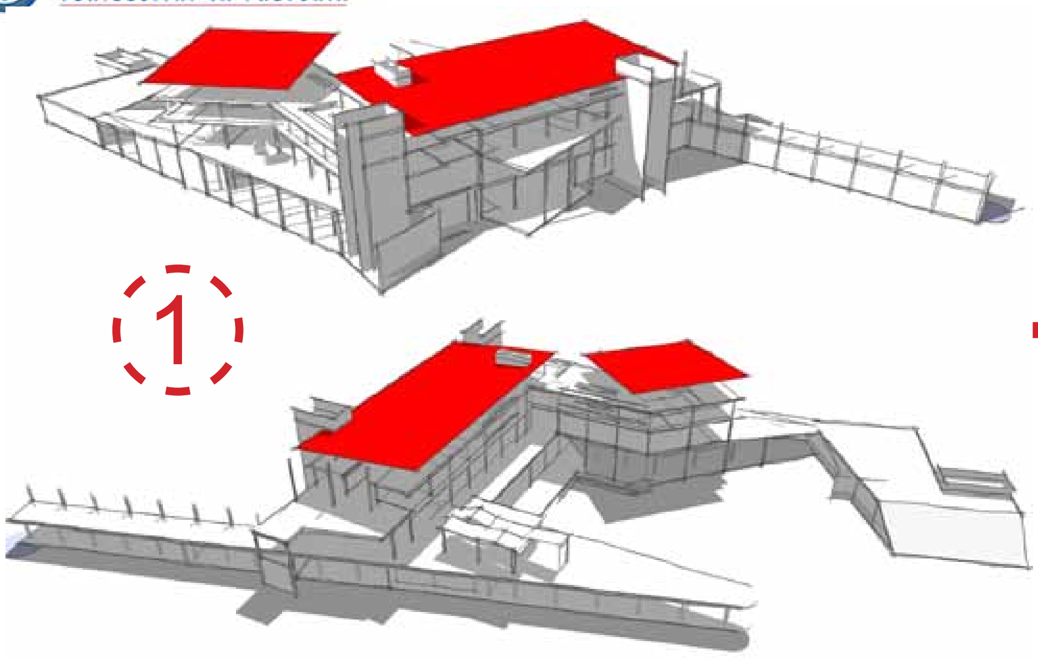


figure 141. roof development 1. single sheets

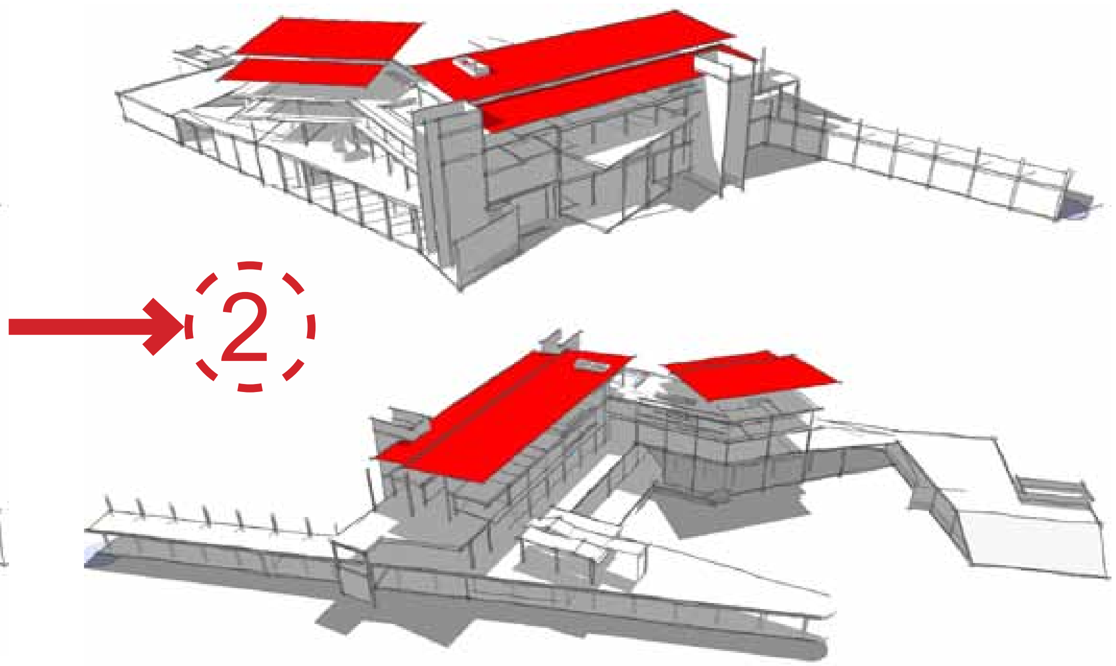


figure 142. roof development 2. roof split for clerestories

7.4 ROOF

PHASE 1

The roofing initially started off as two large monopitch roofs covering the two wings of the office levels. The uncovered section between the roofs would become an open deck and service area.

The problem existed that the roofs felt dissociated and the monopitch became too monotonous.

PHASE 2

In phase 2 the two roofs were split down their lengths to effectively create four roofs. The two facing the public square were raised in order to create a space for clerestory windows and louvres under the roof.

However, the roofs are still not connected and does not unify the two wings.

PHASE 3

The two roofs are joined by an additional monopitch roof over the North-West corner. A concrete slab is added above the circulation core for servicing the lift and hosting water tanks.

The roofs and the building itself still do not communicate as one project.

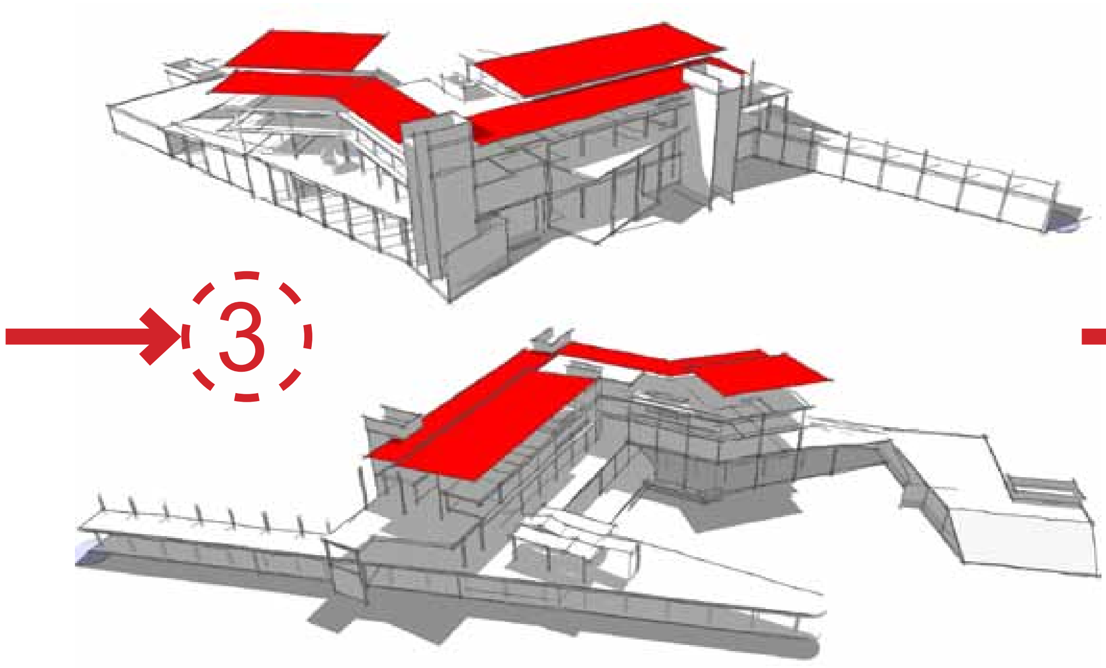


figure 143. roof development 3. two roofs connected over circulation core

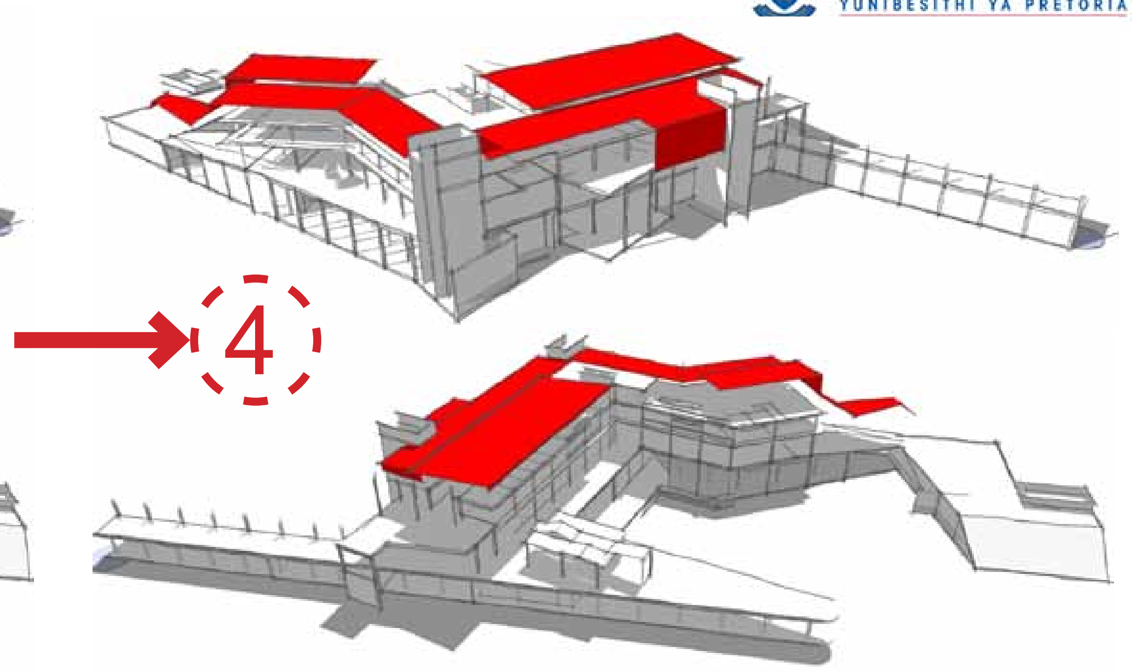


figure 144. roof development 4. roof wraps around building and extends above entrance

PHASE 4

In the final phase of the roof development the Western roof folded over the building to create shading from the afternoon sun. The Northern roof extended to create a bigger overhang. In order to accentuate the entrance of the Zoo, a portion of the roof above it is extended and folds down over the pedestrian ramp. This extension is held up by two larger tree-like columns that define the entrance portal.

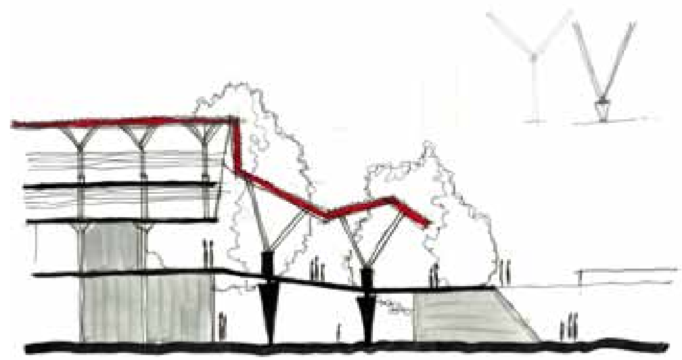


figure 145. diagrammatic elevation of roof above entrance

figure 147. example of re-used brick gabion wall

figure 146. re-used brick gabion perimiter wall

7.5 MATERIALS

Materials play a pivotal role in creating the feel of a space, but also in how that space relates to its immediate surroundings. It defines how people will interact with a building.

By specifying locally available and renewable materials, the proposal aims to create a sustainable environment that is also easily maintained and adds quality to the finished product.

7.5.1 RE-USED FACEBRICK

With the demolition of the current Zoo facilities, which are all built with facebrick, a lot of half crushed brick will be readily available on site. The brick will be sorted on site and re-used in various applications.

Gabion walls, 500mm in thickness, and reinforced with steel are built on site and filled with the facebrick. These walls form porous barriers along the informal trade and inside the open market.

In order to accentuate the outdoor feel of the open first level, the concrete floor slab will be finished with a layer of river sand and brick pavers. These pavers will also be re-used facebrick that will be cut on site to specific sizes in order to create paving patters and ensure a level surface.

figure 149. example of timber screen wall

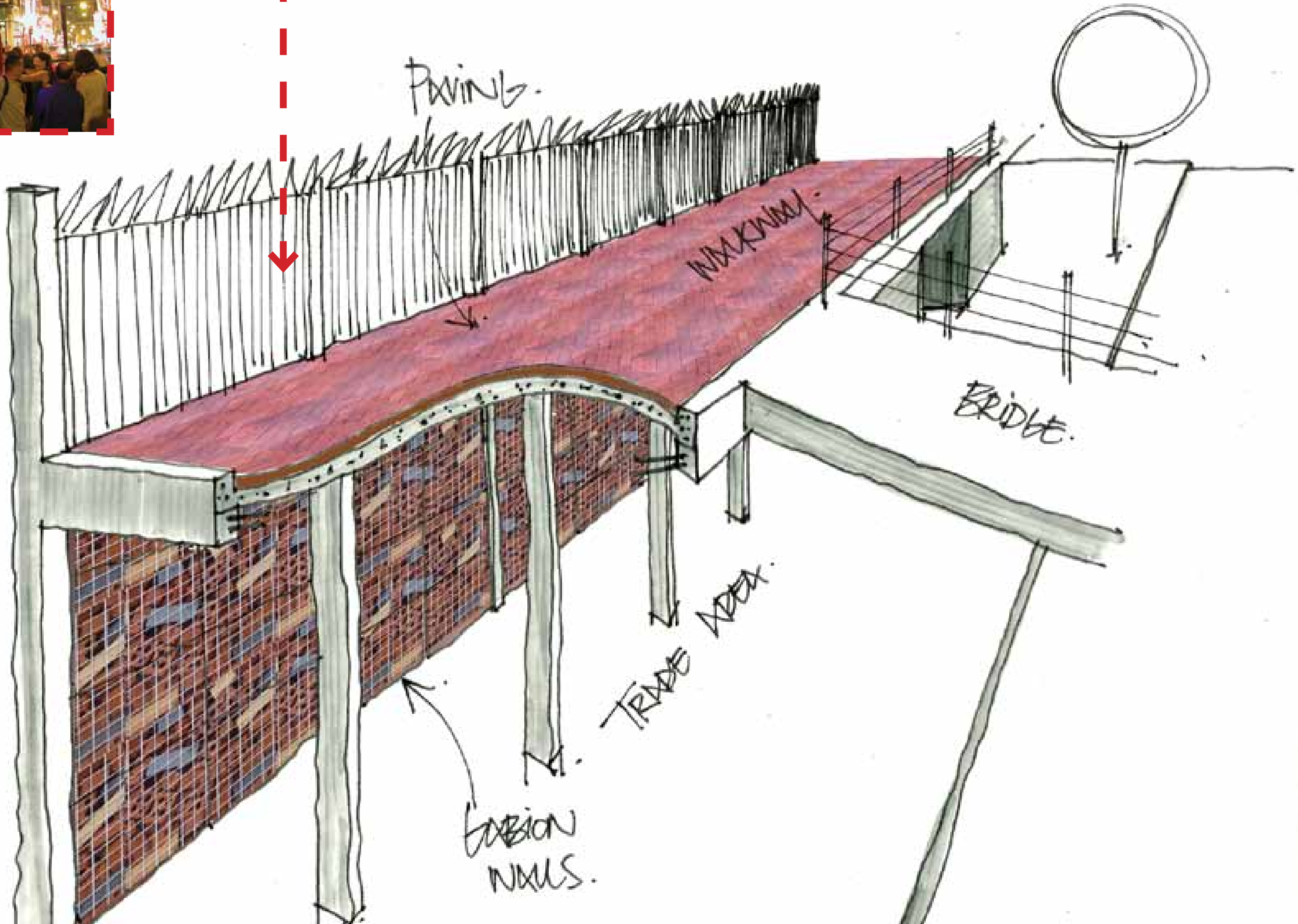


figure 148. sketch showing application of re-used facebrick

figure 150. typical ECOWOOD extrusion commonly used for decking

"the use of wood in polymers is nothing new and has been used for many years as a cheap filler. It was only during the past ten years that the use of wood as the primary ingredient in extrusion compounds started taking the stage."

(www.ecowood.co.za)

7.5.2 ECOWOOD (tm)

Extruded wood is fast becoming a sustainable substitute for both traditional polymers and natural wood. The benefits include savings in labour and machine costs, and more importantly the re-use of available materials.

Ecowood can be formed through extrusion, injection-moulding or compression moulding and is available in a variety of colours. The compounds contain between 50% and 75% natural fibre, with H.D.P.E. as the polymer base.

Extruded Ecowood slats will be fixed to steel frames and applied to facades to serve as louvre shading devices. The benefit of Ecowood in this application is that is requires very little maintenance.

Specially formed Ecowood strips will also be used around the public square, where the partitions on the restaurant facades will fold up to form pergolas over the seating areas.

Ecowood decking will be specified outside restaurants as this is an effective decking material in high traffic areas. The finish can easily be repaired if it scratches, and the product is fully recyclable after use.

Sourcing the product is also efficient as the plant is situated in Limpopo, and transporting the product to site will not be a problem.

figure 151. surface texture of ECOWOOD

figure 152. 3d showing ecowood louvres on facade

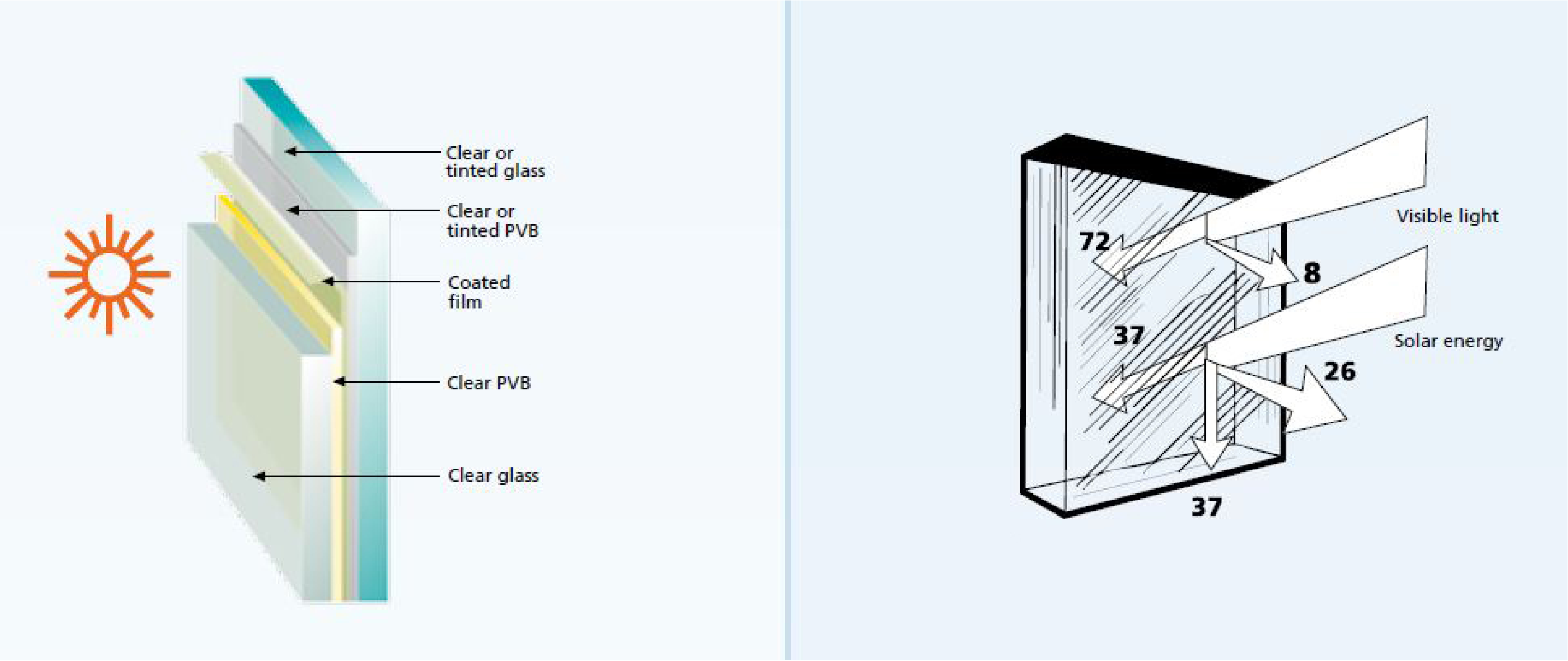


figure 153. COOLVUE composition and transmittance information

7.5.3 COOLVUE (tm)

"CoolVue glass meets the growing demand for natural day lighting and building transparency, without the heat gain associated with ordinary clear glass. CoolVue can transmit more than 70% of visible light while blocking more than 50% of solar heat." (Smartglass catalogue)

The product is a laminated clear coated safety glass that is manufactured by laminating a wavelength-selective heat rejecting coating between two layers of PVB and glass. It also reduces noise transmissions, increases safety and filters up to 99.5% of short wave UV radiation.

CoolVue will be specified for the glazing around the two upper floors housing offices. The product transmits visible light, therefore solar louvres will be added to the facades to minimize glare inside the offices.

The 6,76mm thick glazing panel are standard made in 2440x2000mm panels, and care is given to design the building facades to accommodate these sizes so that unnecessary cutting is not needed.

The glazing panels are installed in white powder coated aluminium profiles, and the profiles are fixed to the building structure.

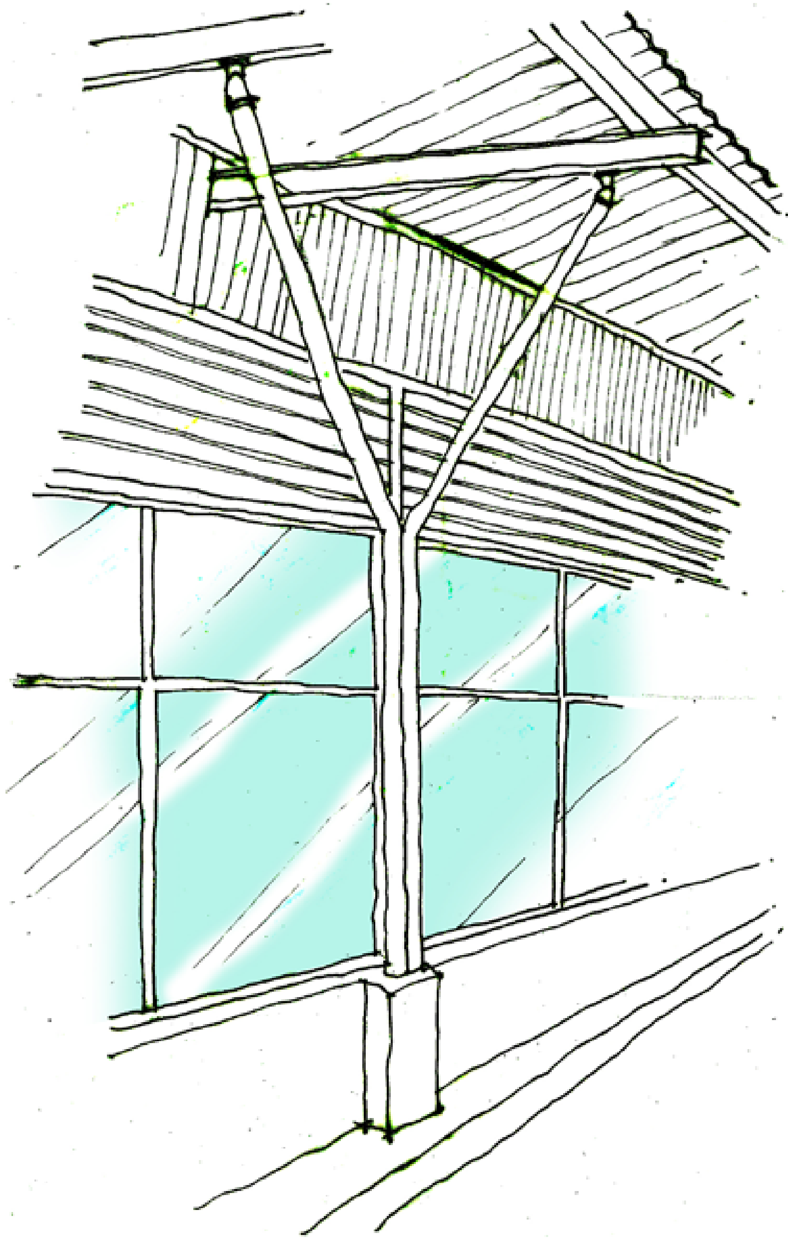


figure 154. sketch showing application of COOLVUE glazing

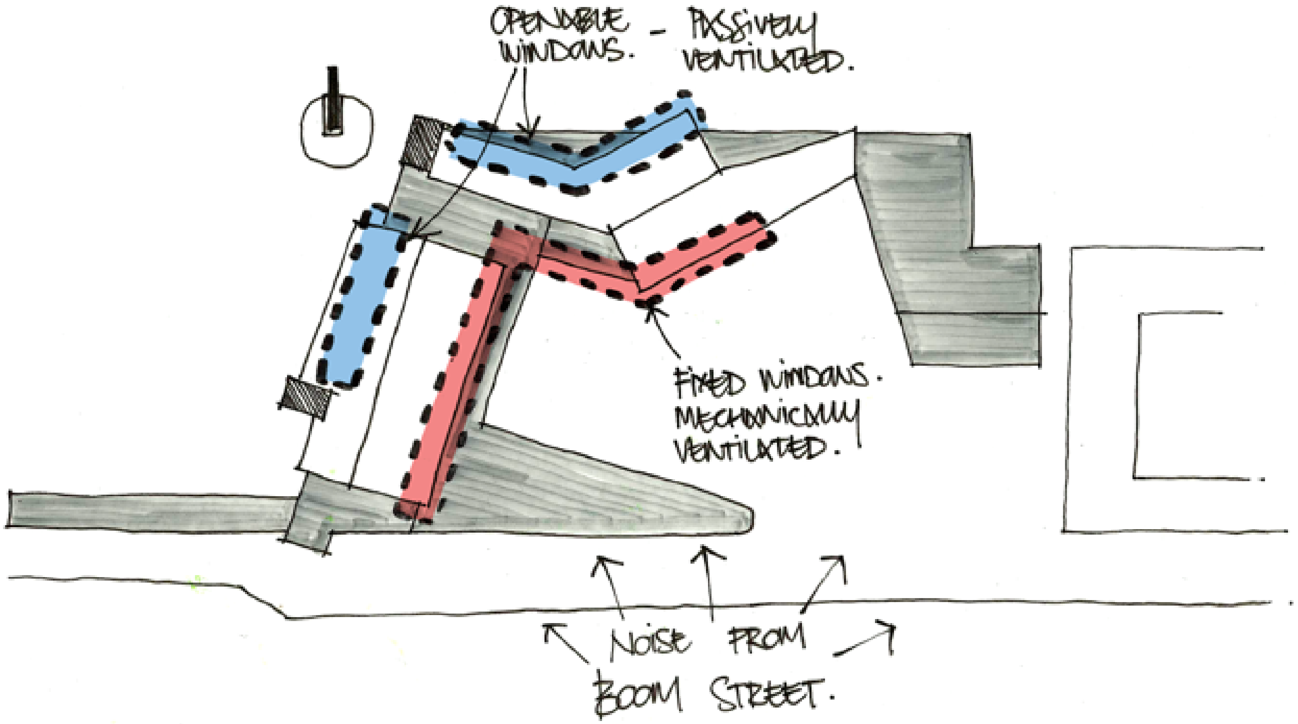


figure 155. diagram showing location of fixed and operable windows

7.6 SUSTAINABLE SYSTEMS

7.6.1 PASSIVE VENTILATION

Due to their open edges, the public ground level and open first level is passively ventilated. The ground level is open to the Public square on the East and the West is bordered by the mesh covered aviary. This, coupled with gabion walls, allows air to move freely through the open market space and restaurant seating areas.

The first level, where visitors enter the building is open to all sides to enhance views of the Zoo. This promotes air flow throughout the development and cools the micro-climate down as air passes through the natural environment of the Zoo.

The office floors are fitted with operable louvres in the facade that allows fresh air to pass through the offices, to the central open core. Louvres can be controlled to the users requirements. Air is moved mechanically (see 7.6.2) through the South and East facing offices. The central cores ventilate through louvres above the clerestory windows in the roof.

The Information centre is also passively ventilated as its North, East and Western facades opens up to allow sunlight and moving air in.

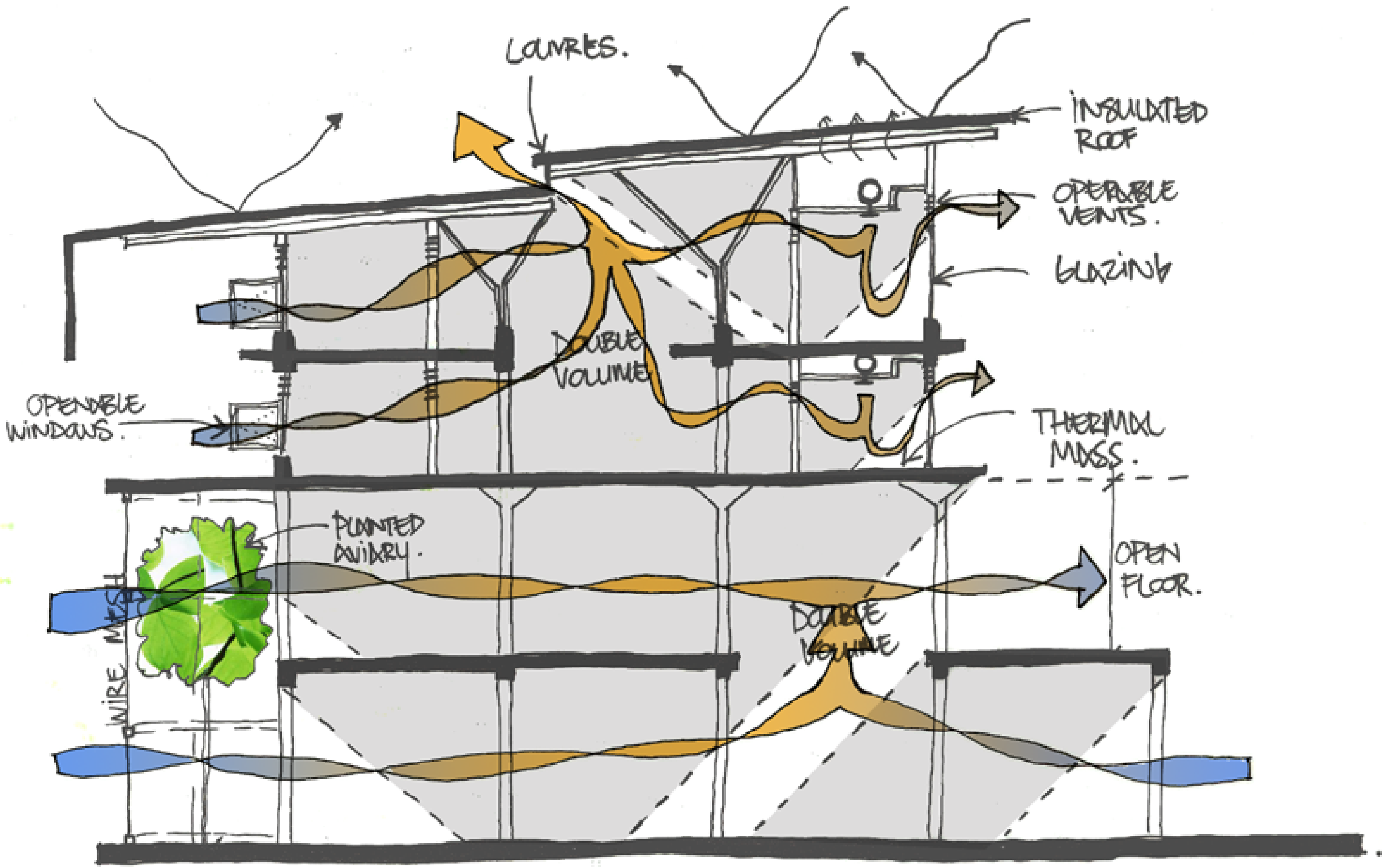


figure 156. diagrammatic section showing natural ventilation through building

7.6.2 MECHANICAL VENTILATION

The new Reptile enclosures require mechanical ventilation for cooling and heating air , as well as regulating humidity inside the enclosures. Ventilation is controlled from a mechanical room located on the North-West corner of the building.

The addition of the mechanical room provides resources to ventilate and extract the restaurant kitchens, which are located around and to the South of the ventilation room.

Mechanical ventilation will also be supplied to the office levels, but will not be conditioned. Instead, the building relies on ambient temperatures being controlled by pumping heated or cooled water through the concrete slab. (see 7.7.3)

The North and West facing offices are fitted with operable windows, which can be opened to let fresh air into the building. The South and East facing offices will be provided with mechanical ventilation, as opening widows on Boom street's side of the proposal may increase noise in the offices.

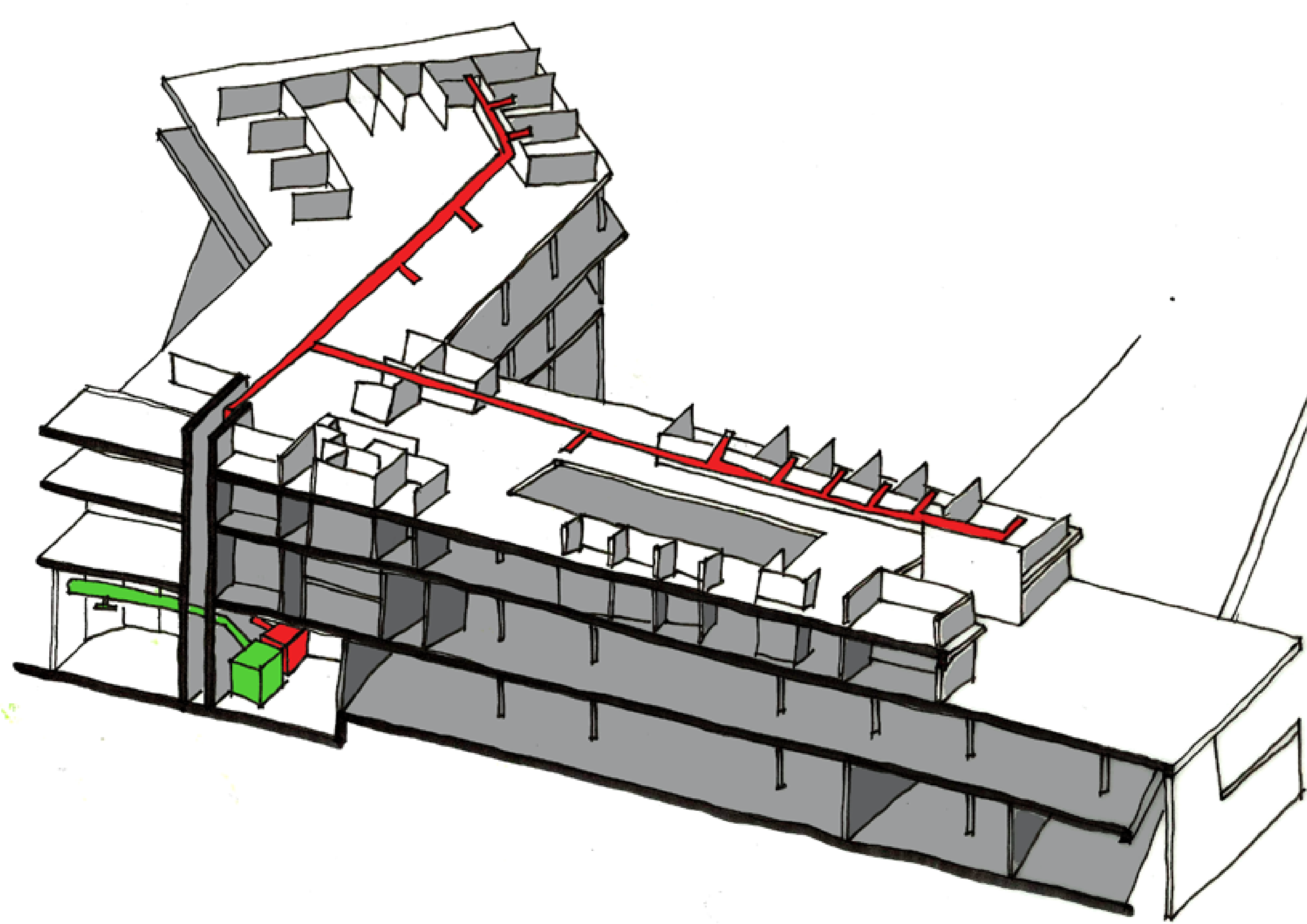


figure 157. diagrammatic section showing mechanical ventilation through building

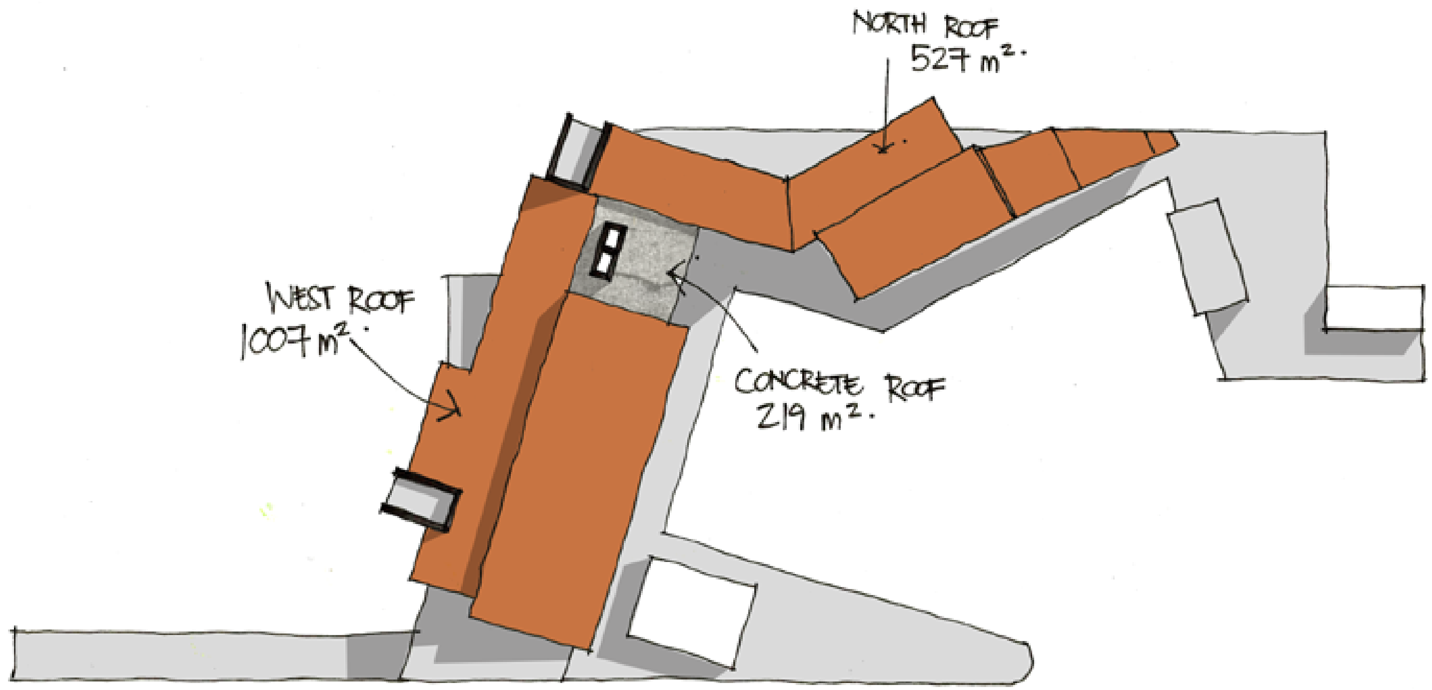


figure 158. diagram showing position and sizes of roofs used for water harvesting

7.6.3 WATER COLLECTION

Rainwater falling on the roofs covering the offices will be collected in steel gutters and directed down to collection tanks situated at various points around the proposal. The water collected in these tanks will be used in various services and activities.

Tank #1 is situated above the public ground floor bathroom and services the cisterns in this bathroom. Tank #2 is located in the mechanical ventilation room and supplies water to the reptile enclosures ponds. Overflow water from this tank will also be used in the ponds in front of the Aquarium. Tank #3 supplies water to the cisterns in the bathrooms on the office levels and located on a flat concrete slab above the bathrooms. The last tank is positioned in the back of house area and the water is used for hosing down the refuse area.

Water runoff from the restaurant decks and walkways all around the proposal will be collected, and directed to the chiller plant to the North-West of the proposal. (see 7.7.3)

The following calculations show that by harvesting the rainwater on site, the proposal can supply 80% of its annual water needs through harvested water. This amounts to a big save in water costs, and promotes the sustainability of the project.

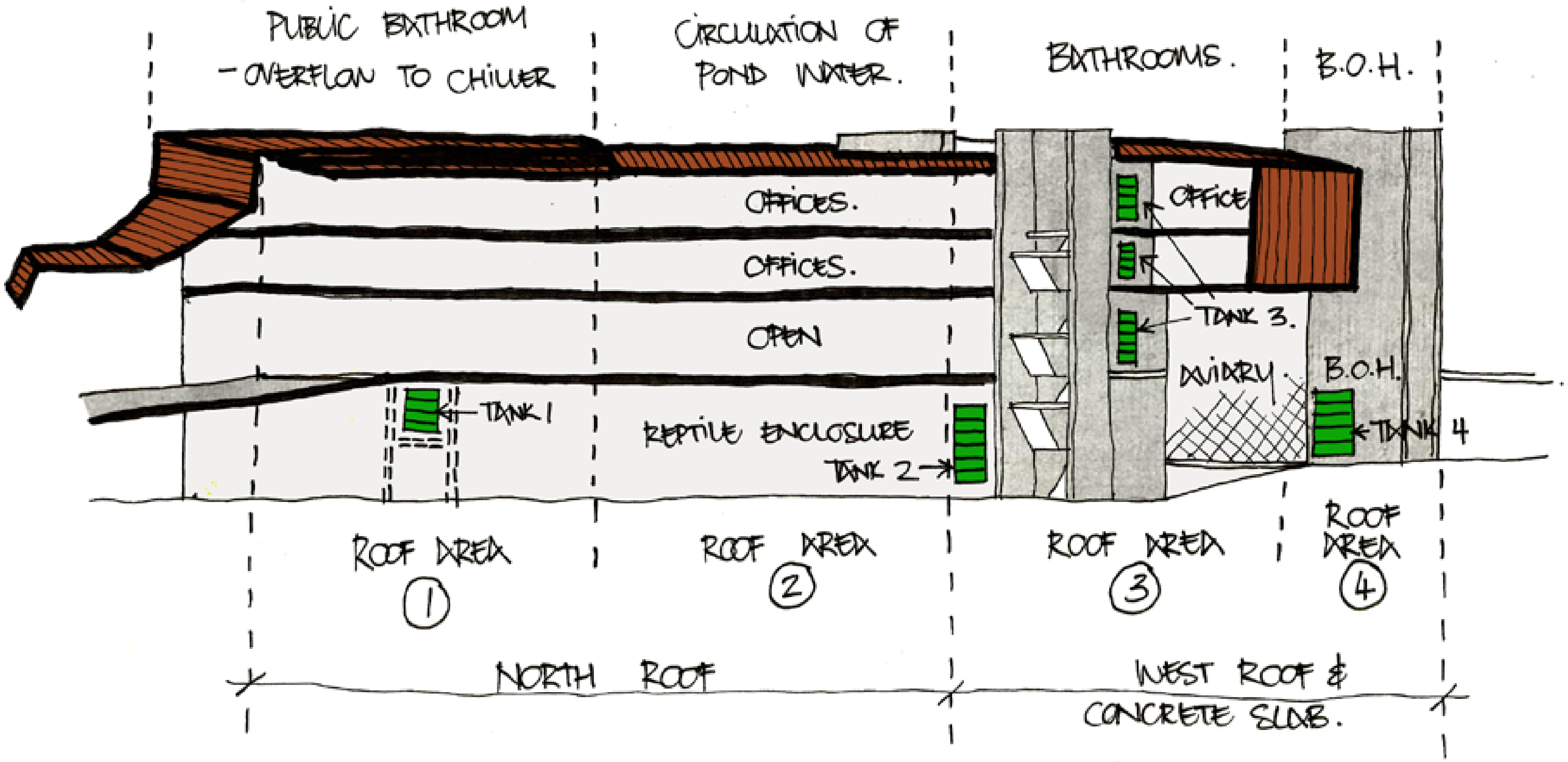


figure 159. diagram showing water tanks points and uses

Potential rainwater harvesting capacity			
area of roof(m²)	annual rainfall (mm²)	potential capacity (L)	total after 10% loss (L)
1,753	480	841,440	757,296

table 1. potential rainwater harvesting capacity

The calculations clearly show the advantages of harvesting rainwater on site. With the calculated roof area covering 480m², the projected total rainwater collected is 842,440 litres per year. After deducting a 10% evaporation factor, the total amounts to 757,296 litres.

According to Dr. Jeremy Gibberd (Green Building Handbook for South Africa), 40% of a buildings water supply must come from harvested water in order for it to be considered sustainable.

After calculating the proposal's annual water usage, and comparing it to the amount of water harvested during the year, it is clear that 80% of the buildings water can be supplied by rain water.

Overflow water can be re-directed to a number of uses, including irrigation, re-filling the ponds in the reptile enclosures and supplying water to the chiller plant.

Number of sanitary fittings		
level	toilets	basins
level 0	9	10
level 1	8	5
level 2	6	6
level 3	6	6
TOTAL	**29**	**27**

table 2. number of sanitary fittings in proposal

Water consumption				
device	#	consumption (L)	uses/day	total consumption (L)
toilets	29	7	8	1,624
basins	27	3	8	648
cleaning	4	20	3	240
				25,121/day
				77,872/month

table 3. total water consumption of proposal

Tank capacity required		
months with low rainfall	consumption/month (L)	required capacity (L)
4	77,872	311,488

table 4. water catchment tank capacities required in project

Water saved				
month	rainfall (mm²)	water harvested (L)	monthly consumption (L)	additional mains water required (L)
jan	82	129,560	78,000	-51,560
feb	60	94,800	78,000	-16,800
mar	52	82,160	78,000	-4,160
apr	33	52,140	78,000	25,860
may	11	17,380	78,000	60,620
june	5	7,900	78,000	70,100
july	3	4,740	78,000	73,260
aug	6	9,480	78,000	68,520
sep	17	26,860	78,000	51,140
oct	43	67,940	78,000	10,060
nov	85	134,300	78,000	-56,300
dec	81	127,980	78,000	-49,980
TOTAL	478	755,240	936,000	180,760

table 5. water saved on an annual basis

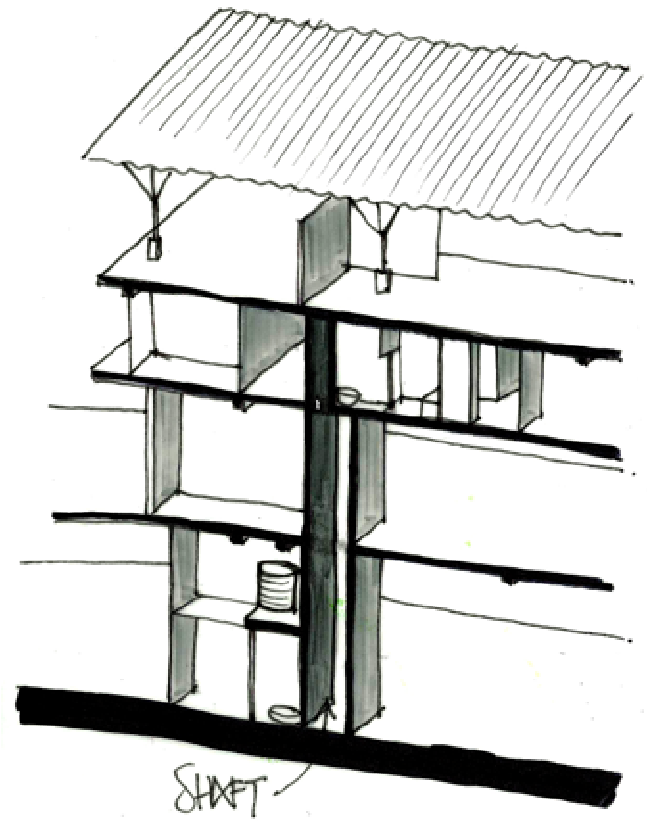


figure 160. diagrammatic section showing internal sanitary connections

7.6.4 SANITARY SERVICES

The proposal aims at grouping all sanitary services together in order to simplify installation and maintenance after completion.

Bathrooms and tea kitchens in the West wing are situated on top of each other, and join to the most Western wall. All piping is exposed on the exterior of the building, and are screened off by a cable system that attaches to the wall.

The cable system is then planted with creeper plants to completely screen off the services. These plants are watered by a drip system that receives its water supply from the same collection tank that services these bathrooms.

In the North wing, a central service shaft runs from the ground up to the top floor. This shaft houses the piping for bathroom and tea kitchens located around it. Due to the 7000mm slab to soffit height on the ground floor, another concrete slab is added 4000mm above the original floor level that hosts an additional water tank. This tank provides water for cisterns in the public bathroom on the ground floor.

All sanitary waste connects to the main line which is situated 5000m to the North of the proposal.

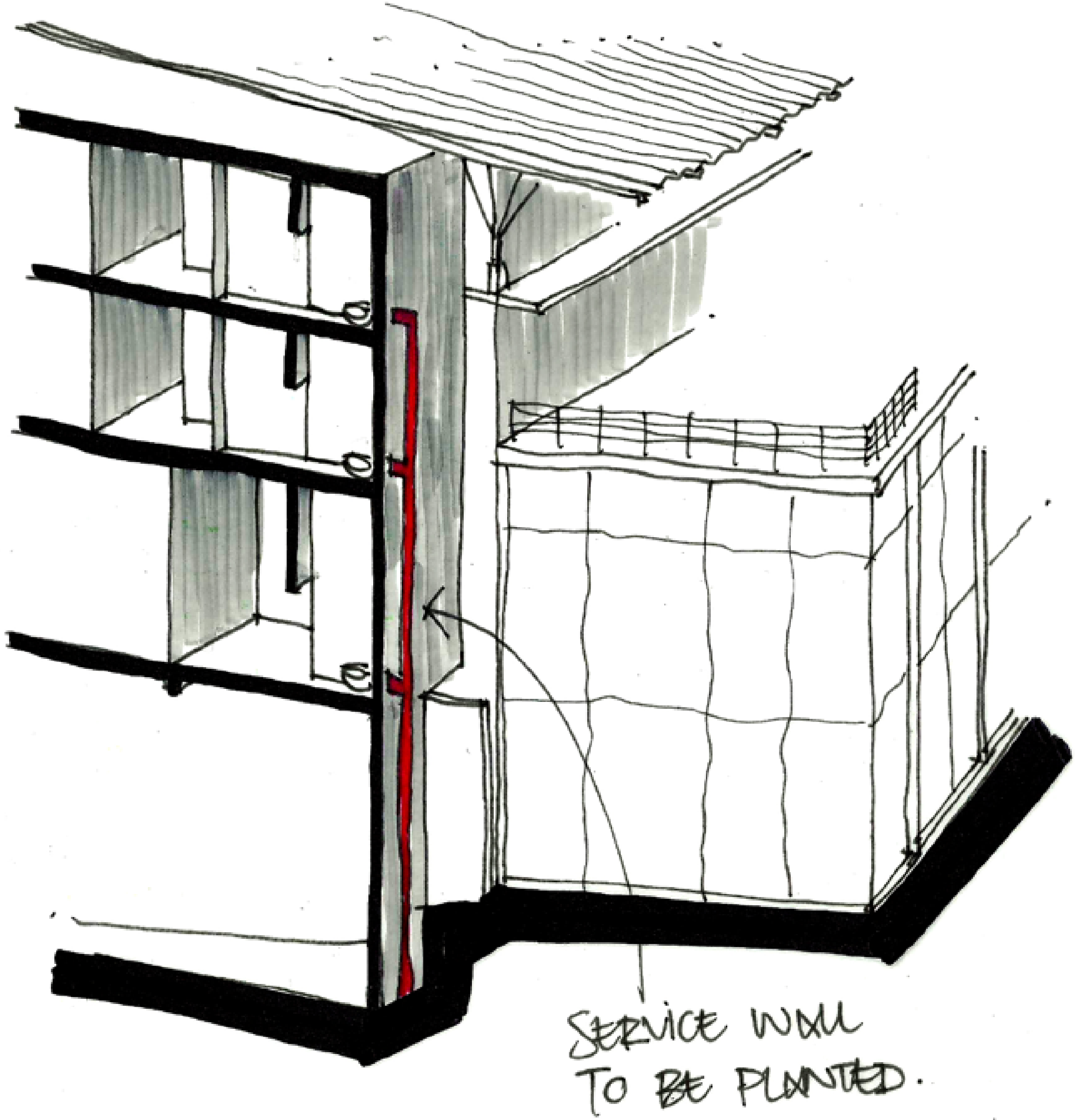


figure 161. diagrammatic section showing external sanitary connections

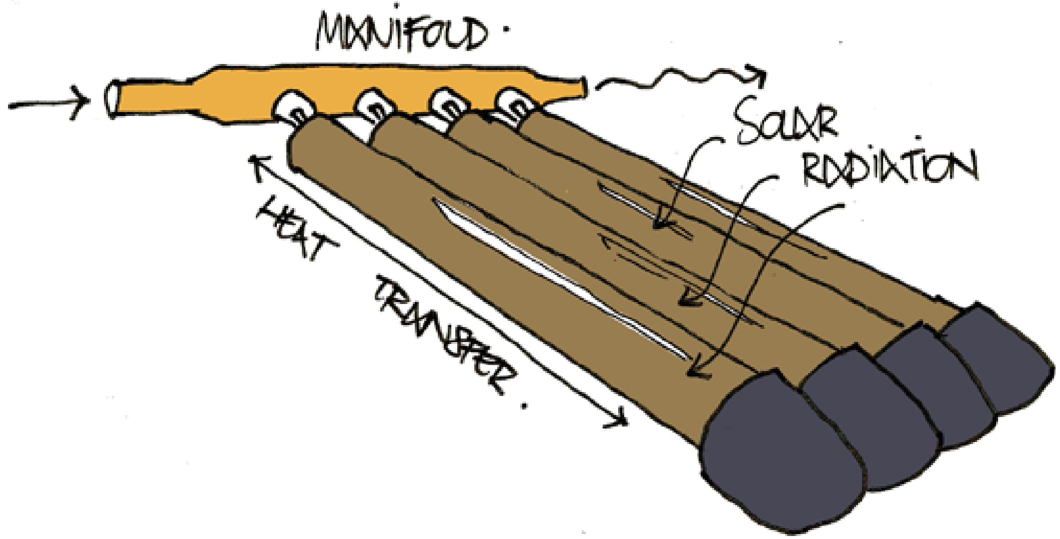


figure 162. 3d diagram of evacuated tube system

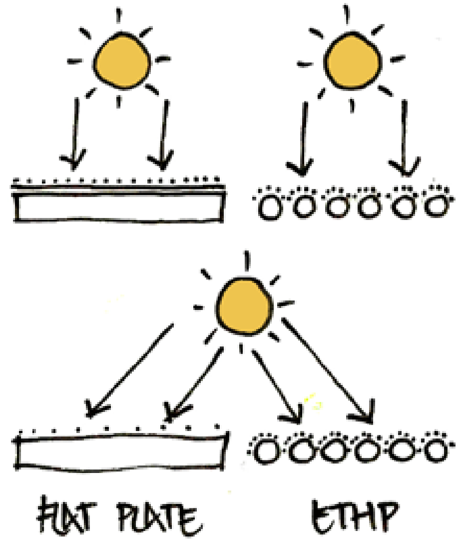


figure 163. direct vs. angled sunlight on ETHP

7.6.5 SOLAR HEATING

Heating in the proposal is based on an ETHP solar collector, that is pumped through a 20mm PVC pipe laid on top of the concrete slab before the screed is applied.

Evacuated glass tubes form the basis for an ETHP (evacuated tube heat pipe) solar collector. Each evacuated tube consists of two glass tubes, one within the other. The outer tube is made of transparent borosilicate glass, which is very strong. The inner tube is made of the same material, but is coated with a material which gives the tube excellent heat absorption qualities.The air between the tubes is withdrawn. This forms a vacuum which eliminates conductive and convective heat loss.

A copper heat pipe is installed inside the inner tube. As the tubes are heated by solar radiation, the heat is transmitted to the copper pipe. Heat is then transfered to the tip of the pipe which is connected to the collector's heat transfer manifold. Water is then heated by the tips as it is passed through the manifold.

An advantage of an ETHP system is that it is still effective on cloudy days. The tubes are able to absorb infrared rays that pass through clouds. The tubes are aligned in parallel, and the angle of mounting depends on the location's latitude.

The shape of the tubes provides superior absorption when it is compared to flat panel absorbers. The reason for this being that the round shape is able to receive direct sunlight, no matter what time of day it is.

The ETHP solar collector will be situated on the concrete slab above the circulation core. This results in the collectors receiving sun all

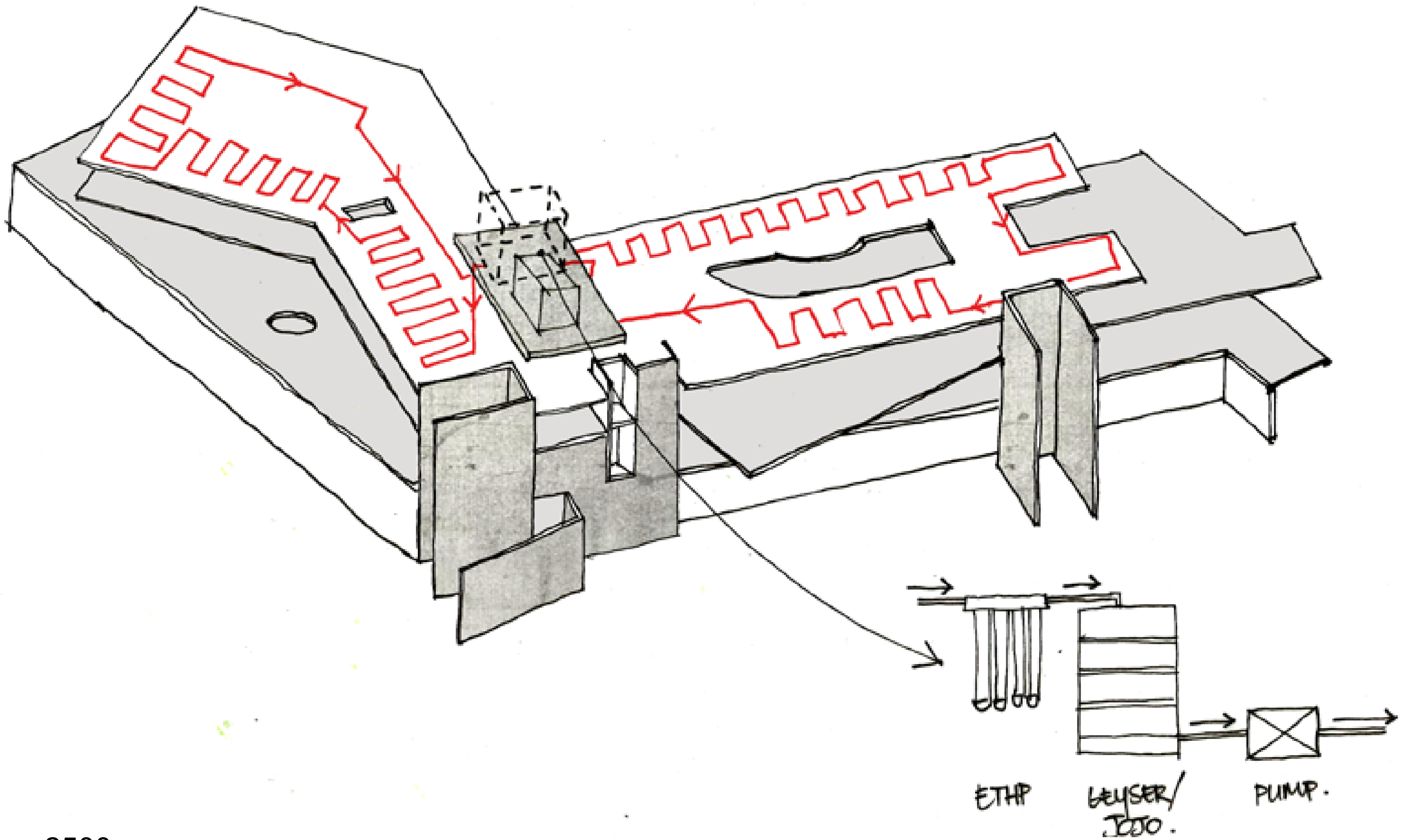


figure 164. 3d diagram of heating system in the proposal

day. The system will be connected to a 2500 litre collection tank, and a small pump, which will move the water through the system of PVC pipes hidden in the floor. This system will only be provided on the office levels, where user satisfaction is vital. The ambient temperature of the levels will be augmented as the water in the pipes heat up the stereotomic elements in the building.

figure 165. image of an air cooled chiller

7.6.6 MECHANICAL COOLING

Cooling the proposal consists of an air cooled chiller that is used to cool down water that is pumped through a 20mm PVC pipe laid on top of the concrete slab before the screed is applied.

Air cooled chillers offer good performance, considering they do not require large cooling towers or condensing pumps. This can save costs on installation and maintenance. Another cost saving factor is that air cooled chillers do not need large mechanical rooms. It is a free standing unit that can be erected anywhere and simply screened off.

Water is pumper through a radiator inside the chiller. At the same time cool air is ducted through the radiator to cool the water down. the cooled water is then pumped from the chiller through the PVC piping.

This cools down the mass of the building, bringing down the ambient temperatures. The water, which is pumped in a closed loop, is then returned to the chiller to be cooled down again.

The cooled water is pumped through the same set of pipes as used for the heating. In summer months, when chilling is required, the water flow is re-directed and bypasses the solar heater.

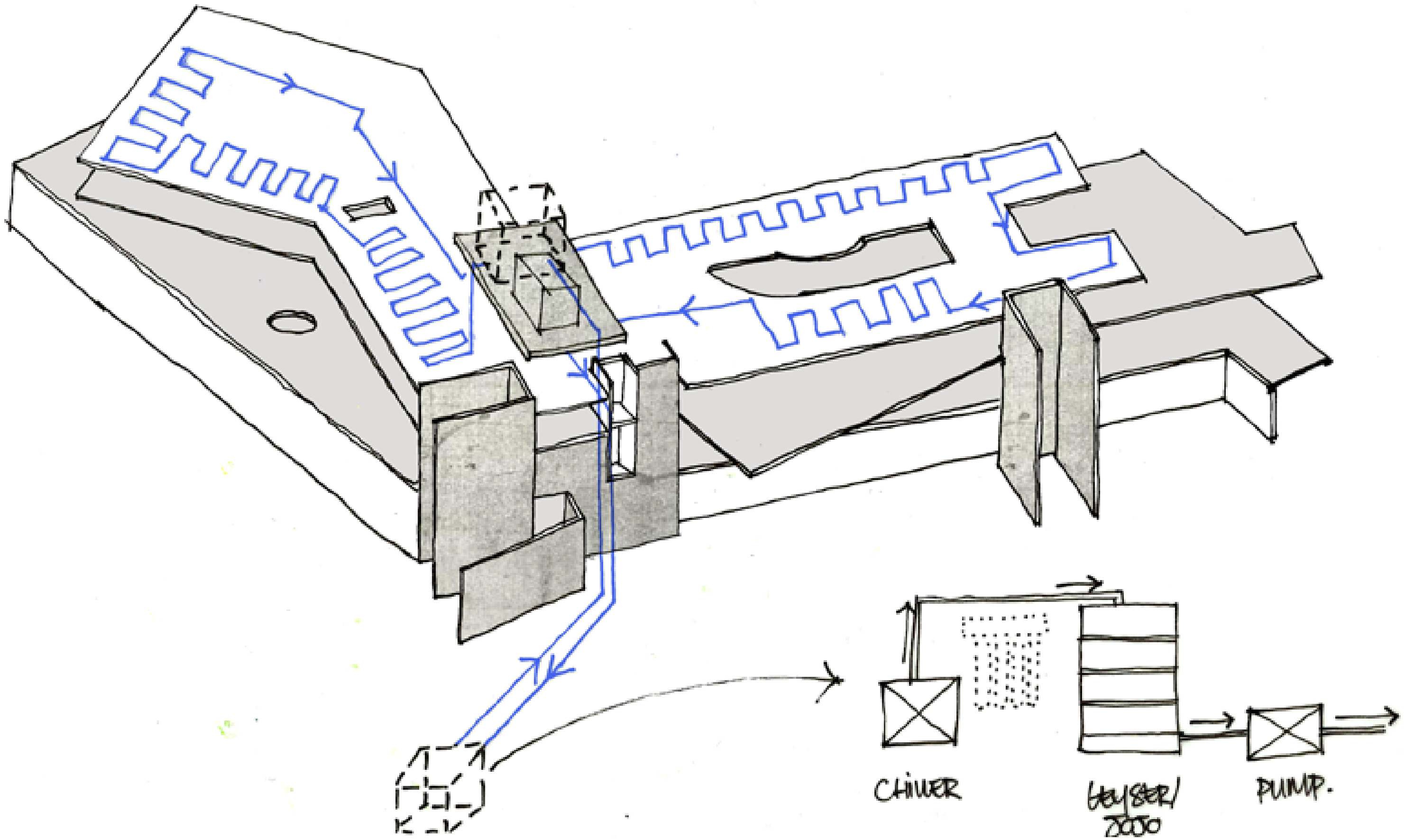


figure 166. 3d diagram of cooling system in the proposal

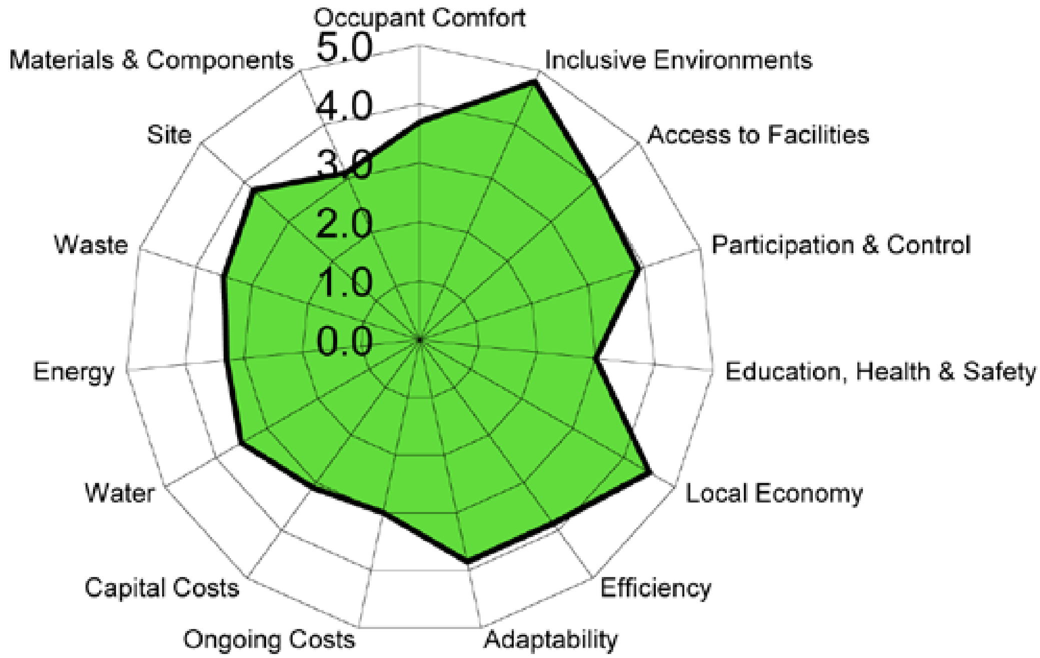


figure 167. sbat results chart

7.6.7 SBAT RESULTS

After completion of the SBAT analysis, it showed that the project scored as follows:

Social: 3.9/5

Economic: 3.7/5

Environmental: 3.4/5

with an average score of 3.5.

This is a good measure of where the project is currently in terms of social and environmental issues. It also provides a clear indication of areas that still need attention, that will be dealt with before the end of the programme.

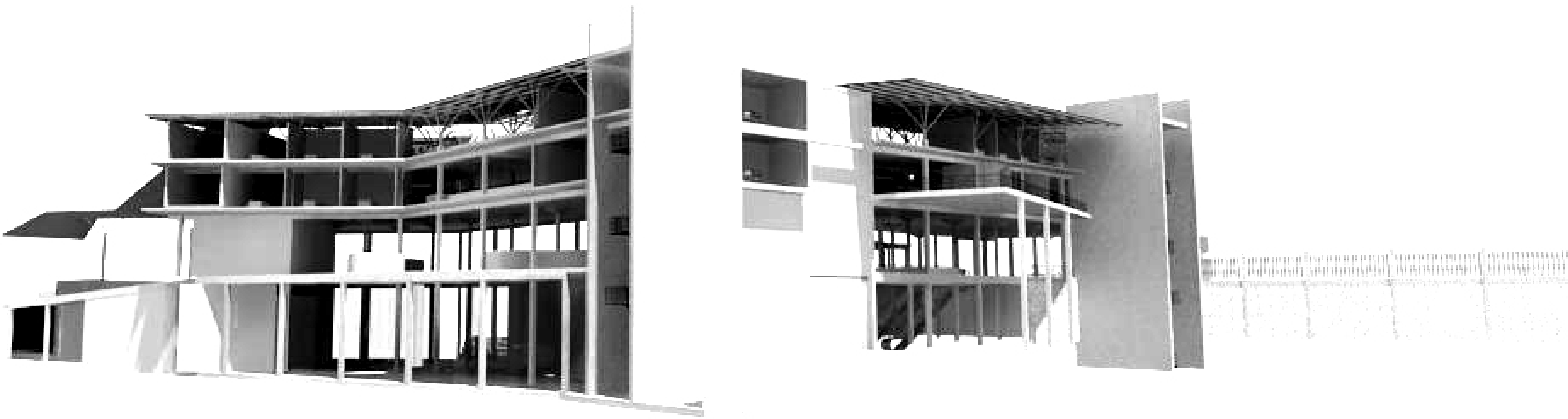


figure 168. 3d of proposal from north west corner