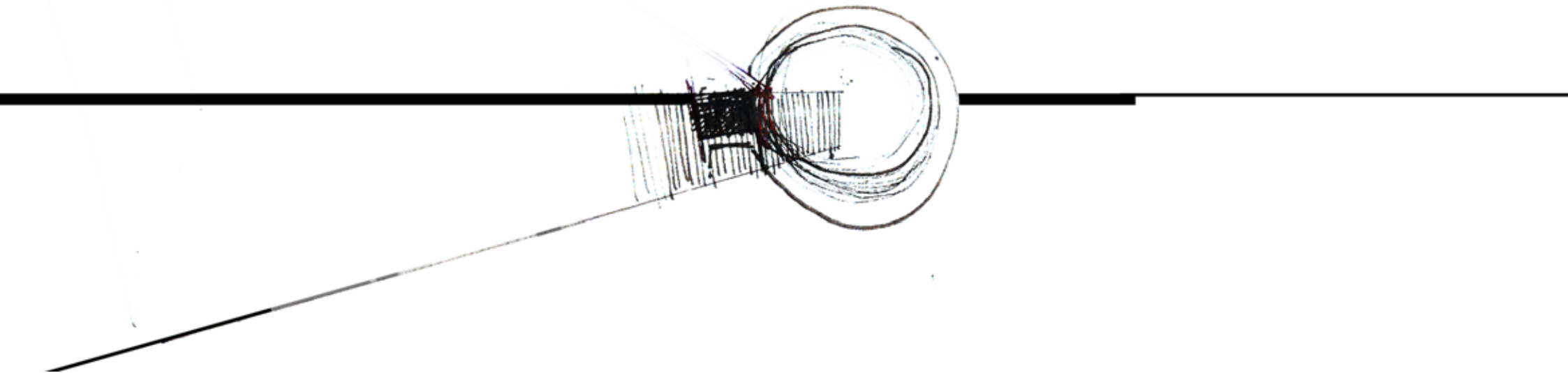


# TECHNICAL INVESTIGATION — 10



A sustainable approach requires a clear understanding of the whole - the goals for the project, the user and their needs and the context. The focus during the technical investigation phase of the study were the following:

- a) Passive design approaches and systems was investigated and developed to ensure that the transport interchange is energy efficient.**
- b) The embodied energy of the structure is minimised by optimising material use, using efficient structural systems and dematerialising building components through multi use and minimisation [GBSCA 2008:231].**
- c) Material use was ascertained through embodied energy calculations as well as the efficiency of structural systems.**
- d) Materials and structural systems was chosen to ensure more a robust, climate change sensitive structure.**
- e) The existing historical context informed the material use and structural system.**
- f) Future adaptability of the structural system.**

## 10.1 STRUCTURAL SYSTEMS

The BRT terminal building consists out of three structural systems/components, as indicated in Figure 9-01.

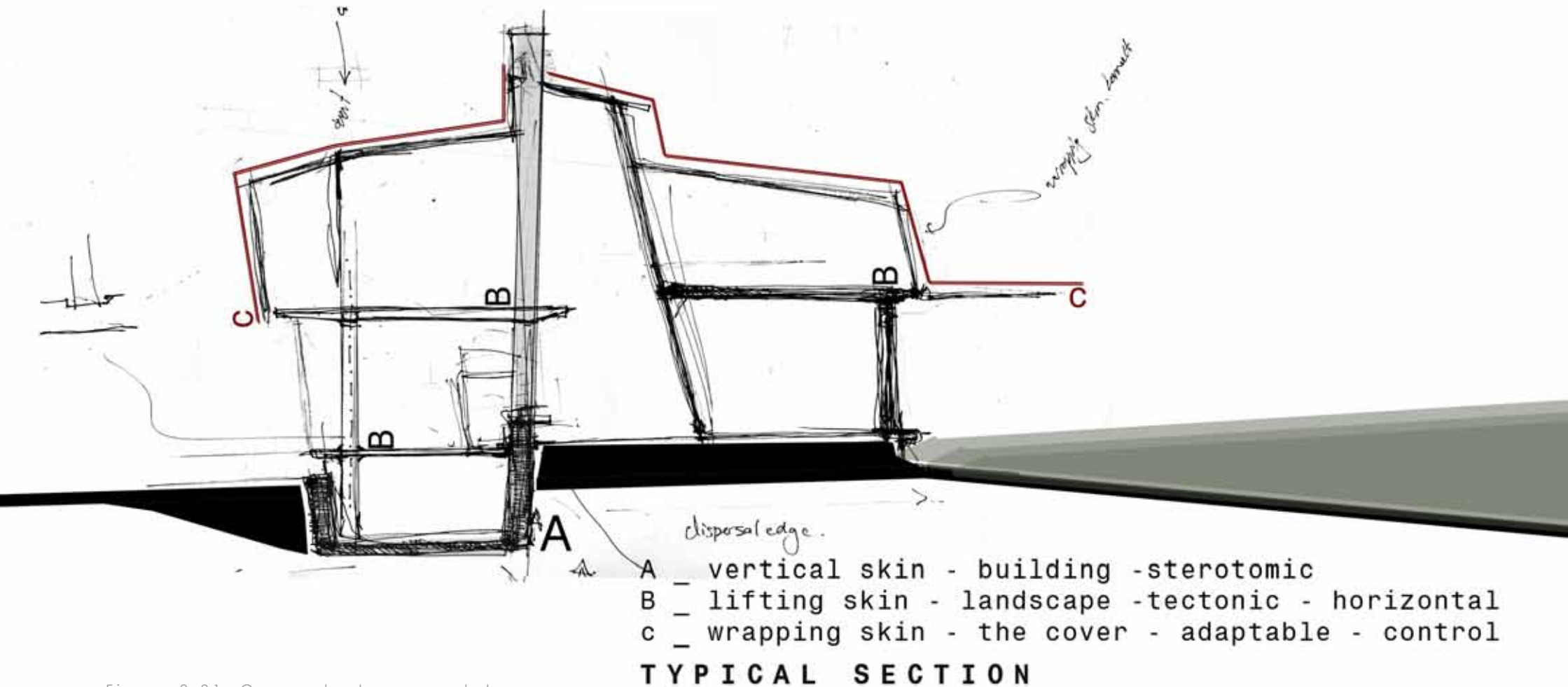


Figure 9-01: Conceptual approach to structural system [Source: Author]

### 10.1.1 System A [vertical stereotomic layers] “THE BUILDING”

**Two solid stereotomic structures mark the entrances into the terminal building.** These are positioned on important points identified during conceptual stage. The stereotomic structures refer to the solid facade of the Pretoria Main Station, and the layered and extended threshold into the station building. These structures respond in the same manner to the new movement layers/system superimposed on the Station Square and extend the threshold into the building.

**The core points are reinforced concrete framed structures with concrete block infill.**

The depth and thickness of the concrete block infill will be articulated by fixing the doors or windows to the inside face of the walls.

This will become a series of solid vertical skins that are referred to as “the BUILDING” of the structure. The horizontal articulation of the Pretoria Main Station porte cochere is extended into the new intervention. These horizontal lines is articulated on the east facing screens of the intervention.

The north facing office functions will be housed within these solid structures, by using the thermal mass and correct orientation a comfortable indoor environment will be achieved [Holm 1996:71; SANS 204-2:33].



Figure 9-02: Solid cores referring to the port cochere entrance of the station [Source: Author].

## 10.1.2 System B [horizontal tectonic layers] “THE LANDSCAPE”

The second structural system is seen as a series of adaptable, linking skins that connect Salvokop with the city and the BRT terminal building with the rest of the station functions. The proposed bridge extends from the edge of Salvokop and terminates on the edge of the Station Square – creating a new park over the railway lines. These linear structures will respond to the horizontal lines of the Pretoria Main Station's facade.

The structural system is a concrete column, beam and slab system – that articulates the horizontality of the structure. These structures fixed between the corepoints and existing station are an adaptable open “LANDSCAPE” of structural skins.

The structural system also refers to the open “hollow” foyer space of the Pretoria Main Station building. It creates open adaptable spaces along a central arcade, which accommodate movement through the building. The arcade allows the user to experience the changes of movement on the edges of the structure. The framed structure ensures adaptability as infill material can easily be fixed between these column structures.

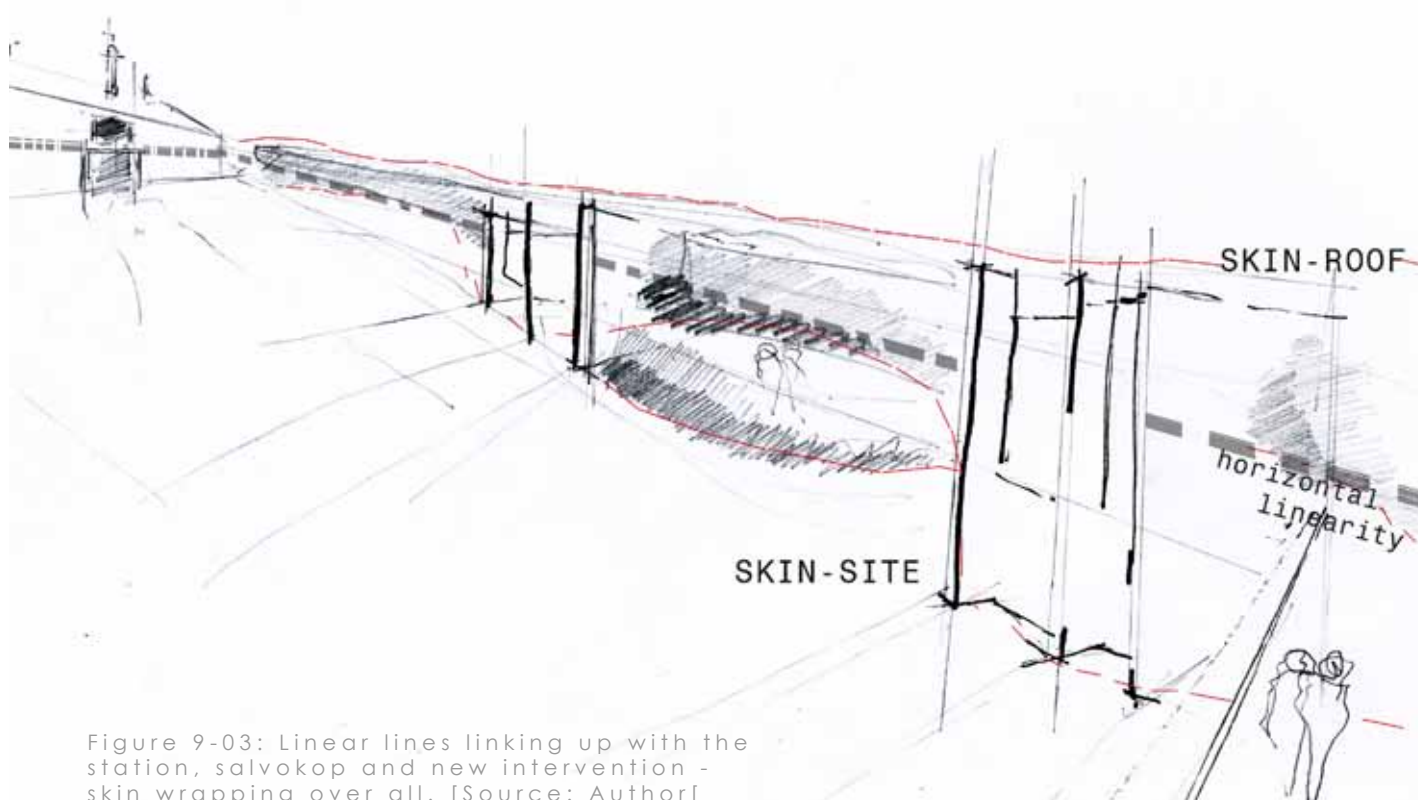


Figure 9-03: Linear lines linking up with the station, salvokop and new intervention - skin wrapping over all. [Source: Author]

### 10.1.3 System C [wrapping tectonic structure] “THE SKIN”

“THE SKIN”, is a light tectonic structure that wraps over the different spaces and binding the intervention together. This is articulated as a series of skins that adapt and change to provide the following services:

- a) Shade and shelter.
- b) Open and close to prevailing winds.
- c) Extract, contain and transmit heat.
- d) Generate energy and harness heat.
- e) Acts as a medium to integrate the landscape with the building.

The skin structure will be a composite system – steel, timber, composite timber and resin slats, glass and polycarbonate sheeting.

The skin will frame the Station Square to reinforce the building as an edge to the square.

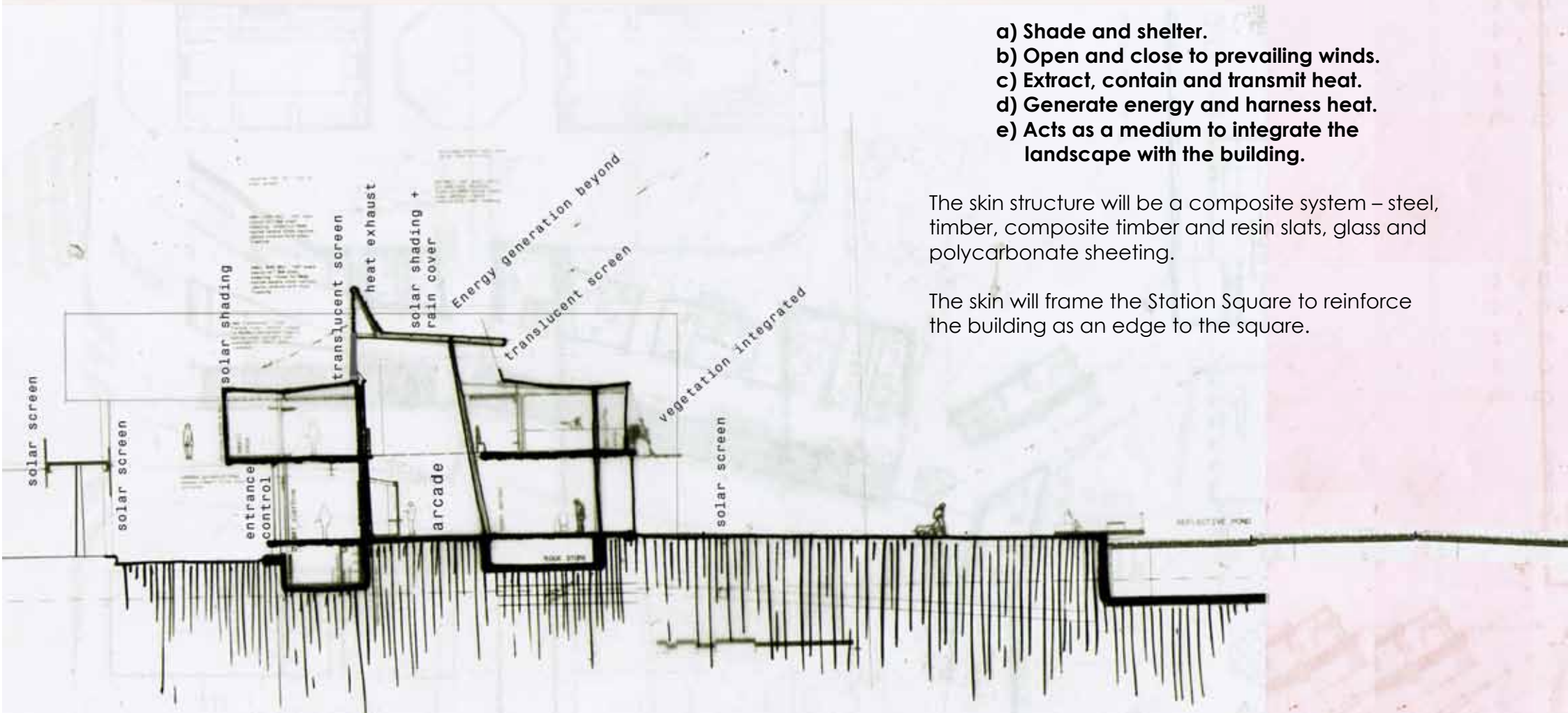


Figure 9-04: Image of section and skin wrapping [Source Author].

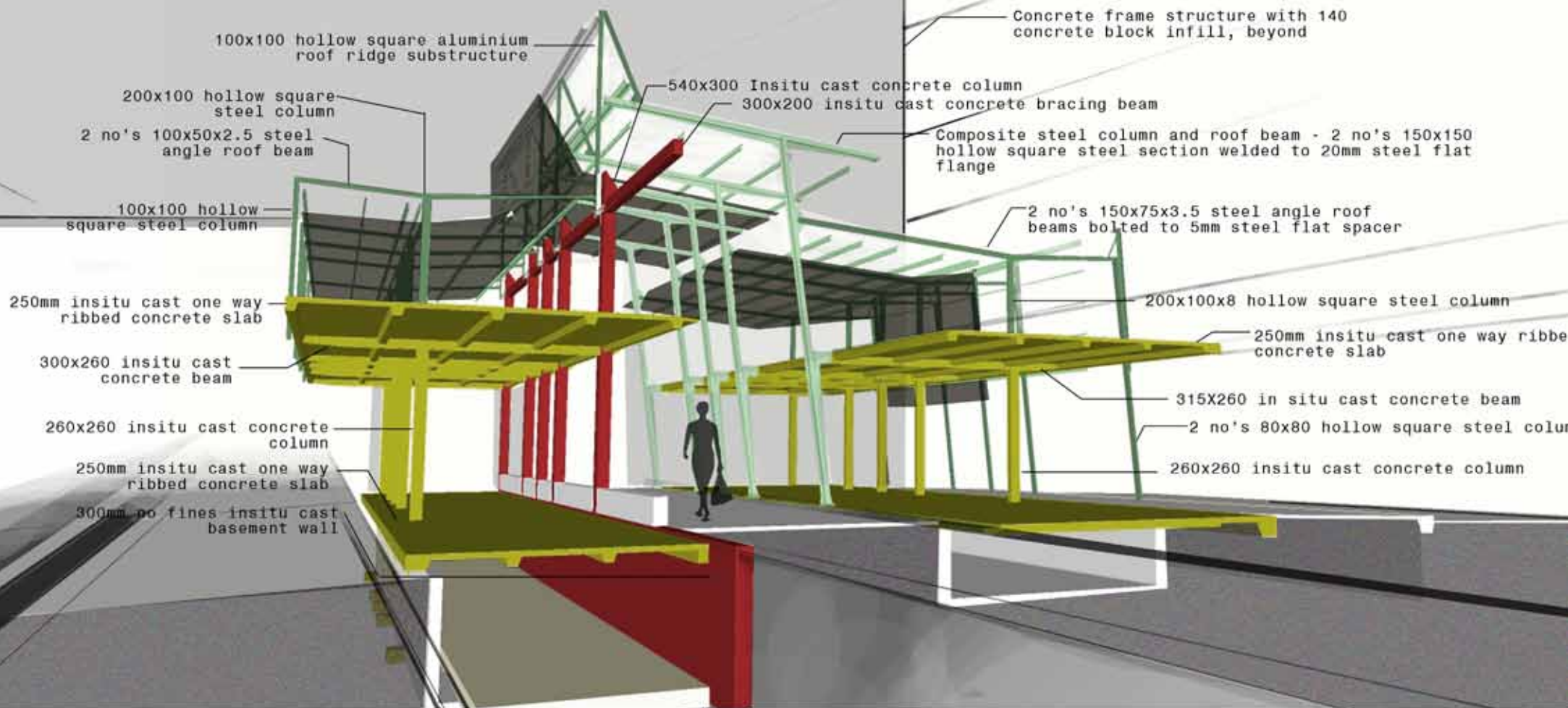
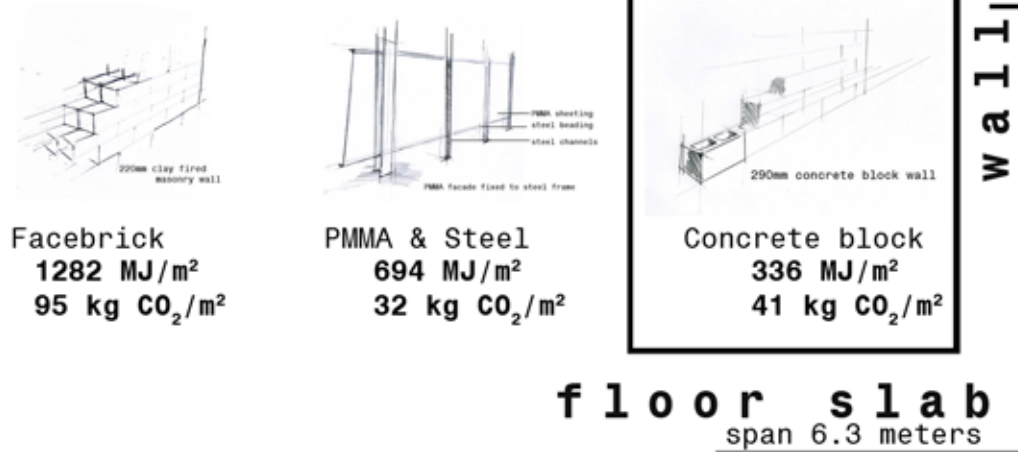


Figure 9-05: Structural components and system [Source Author].



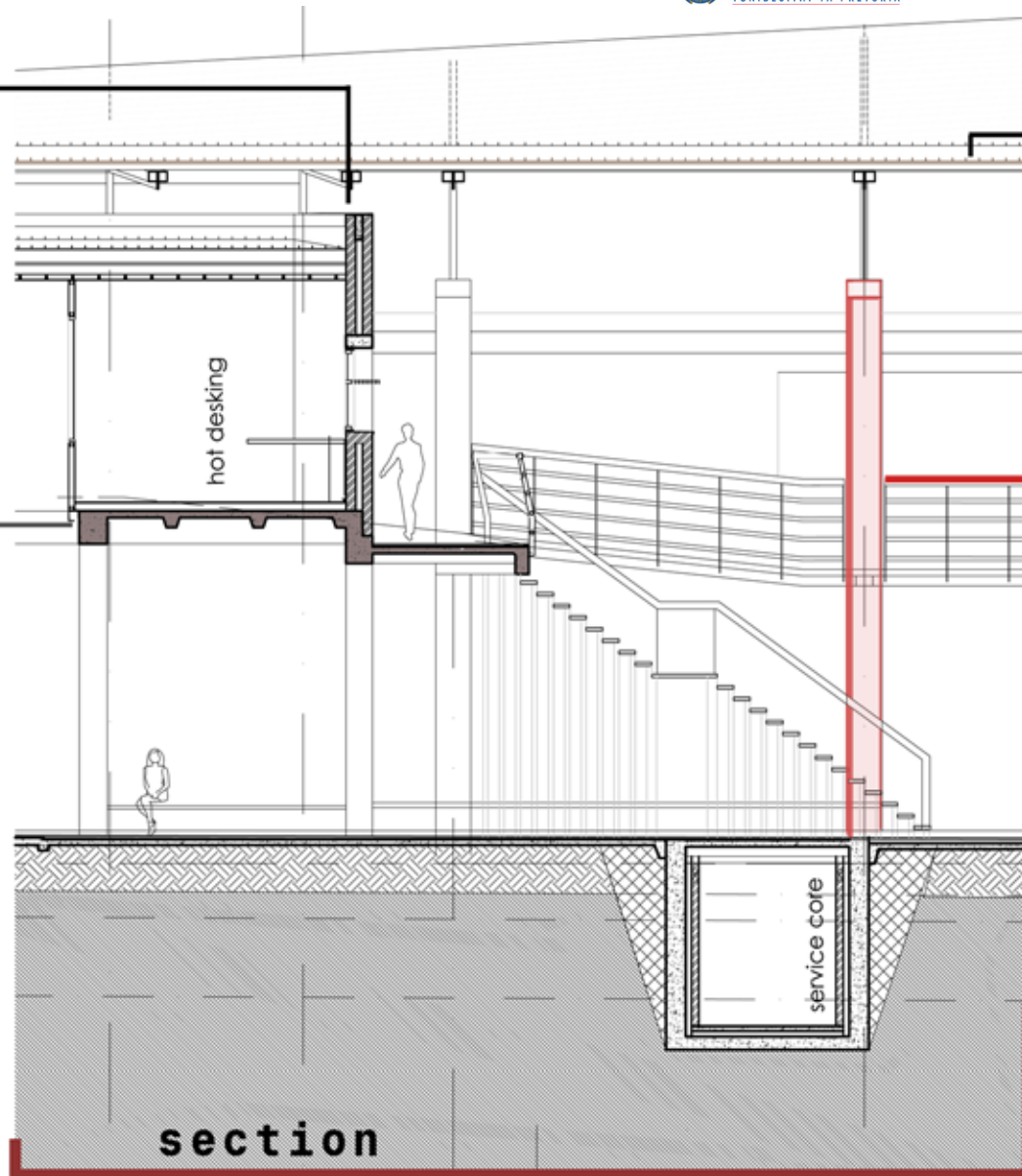


## 10.2 MATERIAL CHOICE AND FINISH

The material choice for the BRT terminal building was determined by:

- Embodied energy and carbon footprint.
- Robust nature and durability.
- Suitability to respond to the historic context.

Figure 9-06: Calculating the embodied energy and carbon footprint of different building components [Source: Author]



## roof

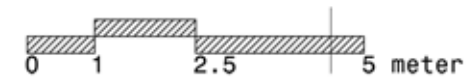
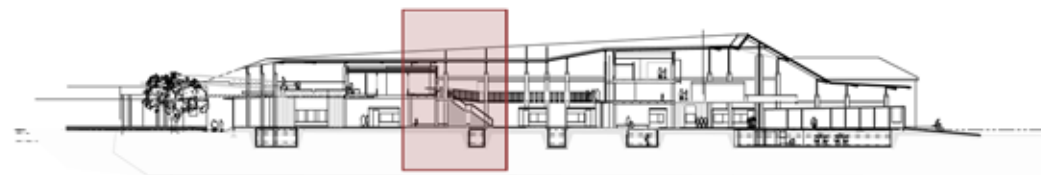
Steel sheeting  
264 MJ/m<sup>2</sup>  
19 kg CO<sub>2</sub>/m<sup>2</sup>  
PMMA sheeting  
455 MJ/m<sup>2</sup>  
14 kg CO<sub>2</sub>/m<sup>2</sup>

## column height 4 meters

Steel  
200 x 100  
471 MJ/m  
35 kg CO<sub>2</sub>/m

Masonry  
330mm x 330mm  
613 MJ/m  
45 kg CO<sub>2</sub>/m

Concrete  
270mm x 270mm  
392 MJ/m  
41 kg CO<sub>2</sub>/m



## 10.2.1 “Building” [A]

### In situ cast concrete frame structure

After analysing different column and floor systems it was concluded that in situ cast steel reinforced concrete column, beam and floor structure has the lowest embodied energy and carbon footprint. Refer to tables 13-04 to 13-09, pg 282-285.

**It was also concluded that one way ribbed concrete slab will be the most efficient system.** The floor span is 6,3 m with a 250mm deep concrete floor slab. The main concrete columns along the arcade are 540x300mm [1/18 slenderness ratio].

The in situ cast concrete columns and beams are sandblasted to ensure a rough texture – referring to the sand stone plinth of the station.

Thermal resistance of a concrete block wall with a cavity

$$R = 1/h_o + d_x/k_x + 1/h_c + d_y/k_y + 1/h_i$$

$$R = 1/28 + 0.14/1.5 + 1/5.3 + 0.14/1.5 + 1/20 = 0.46 \text{ m}^2\text{k/w}$$

$$U = 2.17 \text{ w/m}^2\text{k}$$

Thermal resistance of a concrete block wall without a cavity

$$R = 1/h_o + d_x/k_x + 1/h_c + d_y/k_y + 1/h_i$$

$$R = 1/28 + 0.28/1.5 + 1/20 = 0.27 \text{ m}^2\text{k/w}$$

$$U = 3.7 \text{ w/m}^2\text{k}$$

### Concrete block infill

**Concrete blocks are used, creating heavy vertical layers.** These are

cavity walls that are 390mm thick, using 140x190x190 blocks. This ensures that the wall has a high thermal mass, while the cavity will contribute significantly to the insulative value of the wall [Joubert 2010:37].

**After analysing different wall systems, it was concluded that concrete block walls will be the most energy efficient to use.** A 290 concrete block wall saves up to 75% carbon when compared to 220 facebrick wall. Refer to table 13-05, pg 283.

The concrete block wall will have raked joints to ensure that the masonry units are still visible after plastering and painting the walls. The texture and masonry units refers to the manner by which the station building is articulated.

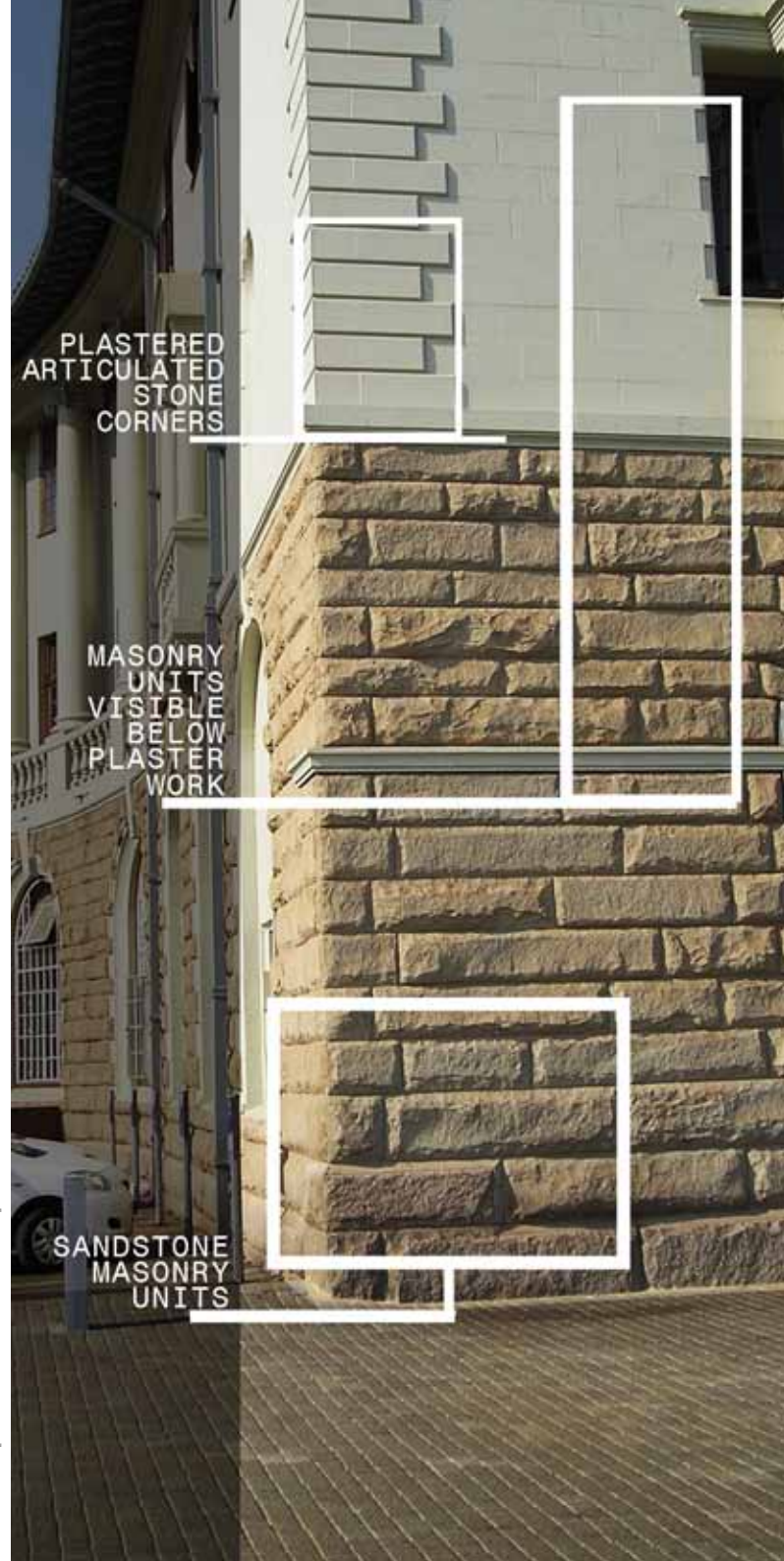


Figure 9-07: Materiality of the Pretoria Main Station wall [Source: Author].

## 10.2.2 “Landscape” [B]



Figure 9-08: Floor finish in Pretoria Main station [Source Author].



Figure 9-09: Natural colours of Salvokop [Source Author].

### In situ cast concrete frame structure

The structural system is off-shutter in situ cast concrete columns with 250mm deep one way ribbed floor slabs and with 315x260mm floor beams. The columns on this section will be 260x260mm [slenderness ratio 1/18].

### The floor beams are cantilevered on each side in an effort to use less material [Birsch 2002:252]

The concrete columns and beams is cast in smooth steel formwork panels, which are reusable.

### Floor finish.

The main concourse floor finish is ceramic tiles, referring to the tiled floor finish in the main station. **The floor finish extends into the new terminal building, linking the two structures and merging the boundaries.**

The floor finish of the bridging structure will be a 40 mm pigmented cement screed in shades of colours referring to the natural ground colour in Salvokop [Figure 9-09]. This will articulate the different movement routes [walking & cycling] as well as spaces on the bridge.

## 10.2.3 “Skin” [C]

The skin utilises different materials and finishes to respond specifically to its function, neighbouring buildings and the requirements of the internal environments.

### Structural steel

**Structural steel sections will be used as substructure for the wrapping “skin”.** Primary columns will be brought to site in sections and welded together and hand painted on site. Rafter beams and steel columns used higher up in the building will be galvanised and bolt fixed together on site. Highly exposed steel sections, the ridge ventilator, will be black anodised aluminium.

### Roof material

Steel roof sheeting was chosen for its efficiency in material use. Refer to Table 4-01, page 130. **Brown Built roof profile sheeting is used, can be fixed at a very low pitch [min 1:60] and allows for a very efficient use of rafters, fixed at 1500 mm centres apart [Brownbuilt 2010].** The 0.58mm ISQ 300 steel sheets have interlocking profiles that uses a clip-fixing system and can be pre-painted [Globalcoat™] [Brownbuilt 2010].

### Clear sheeting

**Clear polycarbonate sheeting is used to allow as much natural light in as possible into the main concourse.** 10mm Translucent fluted "Lexan Thermon clear" sheeting will be used, it has very high weather resistance while transmitting 82% of visible light [Complex plastics 2010].The sheeting will clampfixed to galvanised steel subframes.

### Solar screening

A solar screening device is used to create a defined edge on the western edge of the Station Square. **Composite recycled wood and resin slats are fixed to a handpainted steel substructure [Envirodeck].** The slats are composed of recycled 65% wood fibres and 35% high density polyethelyne [Envirodeck 2010:02]. It does not require extensive maintenance and will not fade in sunlight and is UV resistant [Enviro deck 2010:01&04].

Solid clip decking slats is cut to size and used as louvers. The colour will be "Kalahari Sandy Brown" [Envirodeck 2010] referring to the stone plinth of the Pretoria Main Station.



Figure 9-10: Brownbuilt roof sheeting fixed at a very high level. [Source: Author].



Figure 9-11: Collage of material finishes, colour and rhythm of the solar screen . [Source:www.dezeen.com; Author; www.archdaily.com]

## 10.3 SUSTAINABLE ACTIVE / PASSIVE SYSTEMS

### 10.3.1 Natural lighting

The central roof provides shading for the central arcade, large gaps between the roofs allow diffused sunlight into the central spaces of the structure. This ensures that less artificial lighting is used during the day.

The office functions make use of large south facing windows for good quality diffused daylight. Northern windows will be screened to provide glare protection from direct sunlight on the work levels.

The eastern and western edges of the building has glass envelopes - to ensure visibility and natural light into the building.

Trees are planted on the eastern and western edge of the building to block the direct sun from the retail and BRT stations. The landscape/ site will be adapted to act as an external covering skin to the intervention.

On the western edge the cycling bridge will provide solar screening for the BRT station platforms. The handrails are proposed to act as both barriers and solar screens.

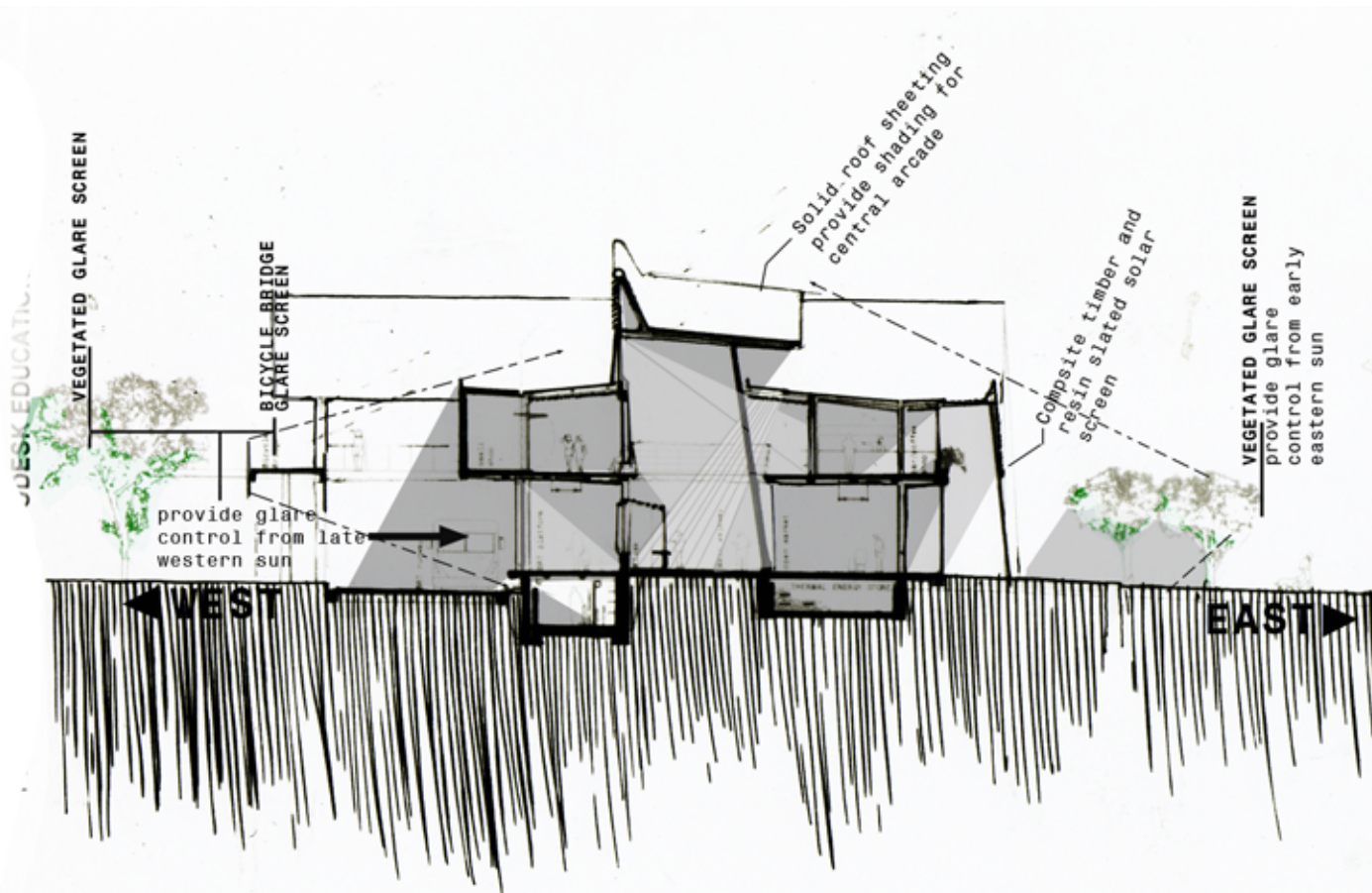
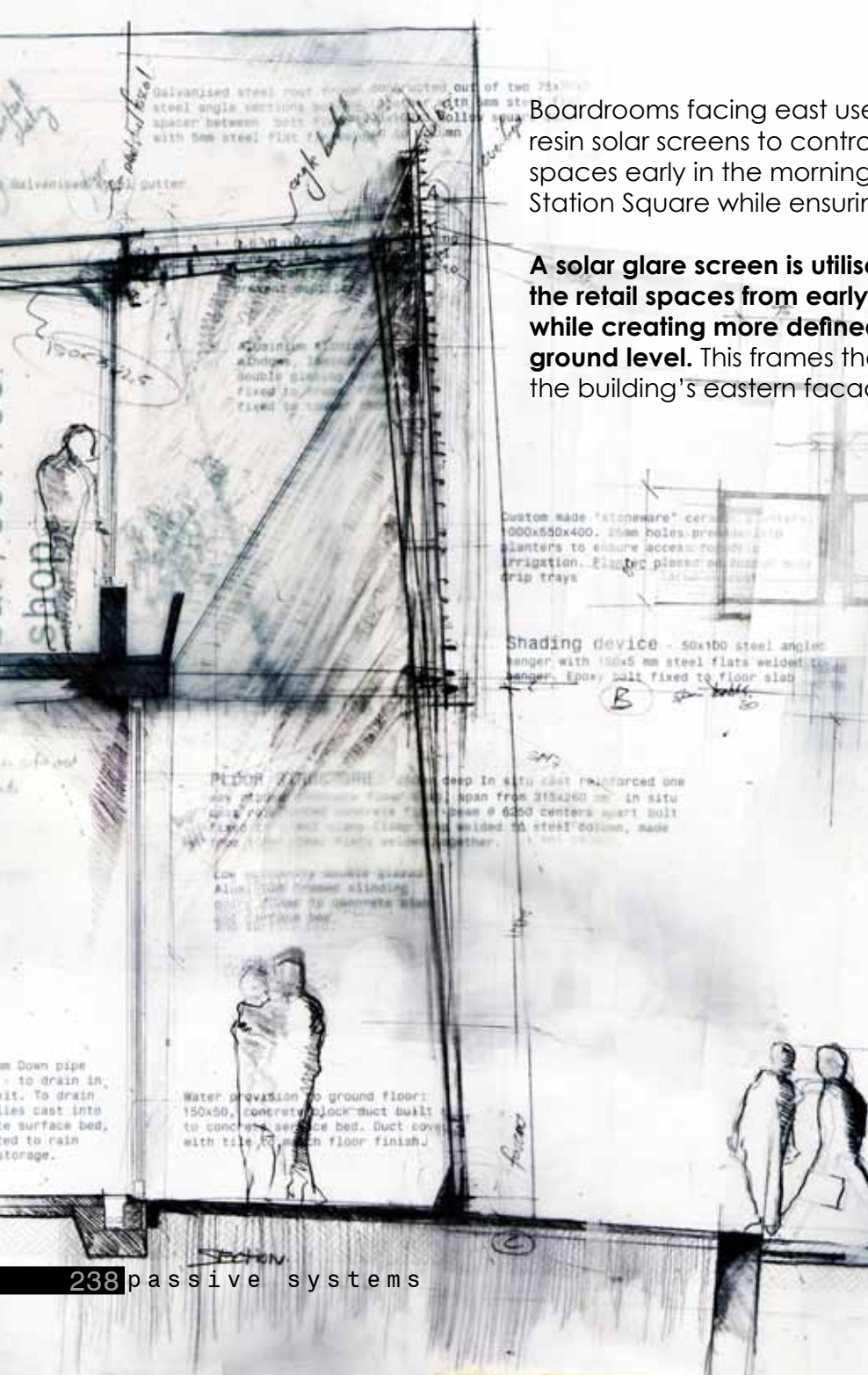


Figure 9-12: Solar screening system of building [Source: Author]



Boardrooms facing east uses of composite wood and resin solar screens to control the sunlight entering the spaces early in the morning. This allows a visual link to the Station Square while ensuring a comfortable interior.

**A solar glare screen is utilised to act a glare control for the retail spaces from early summer morning sunlight, while creating more defined spaces for the users on ground level.** This frames the Station Square and unify the building's eastern facade.

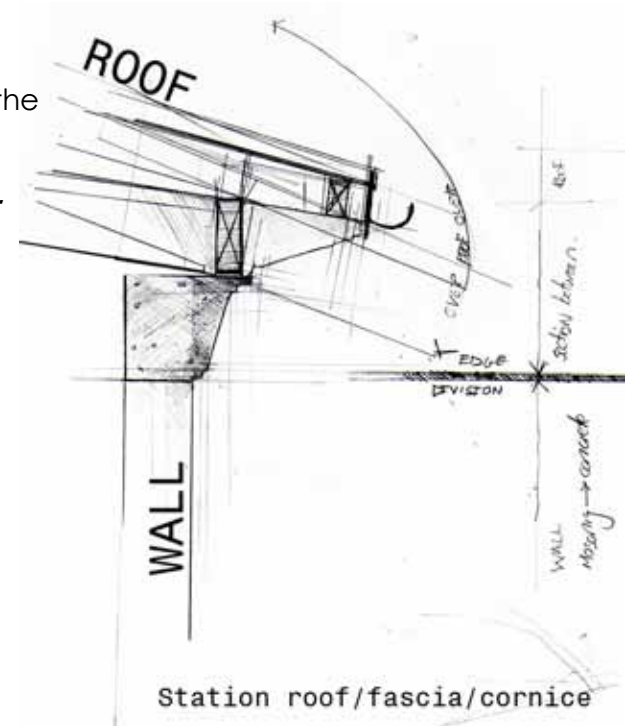


Figure 9-14: Detail development: Referring to the station roof [Source: Author]

Figure 9-13: Section developing [Source: Author]

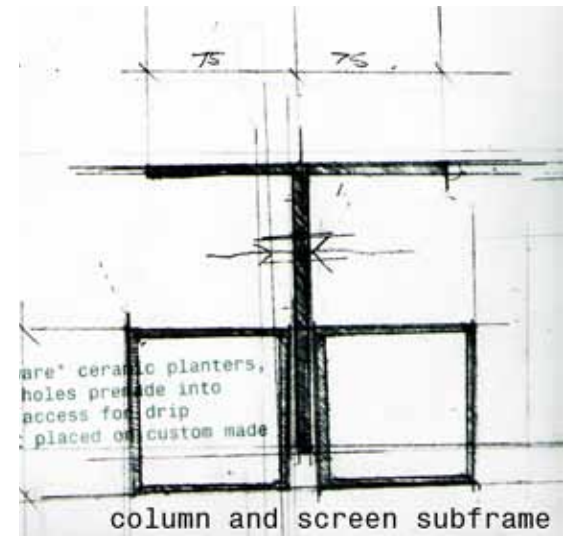


Figure 9-15: Steel Column of solar screen [Source: Author]

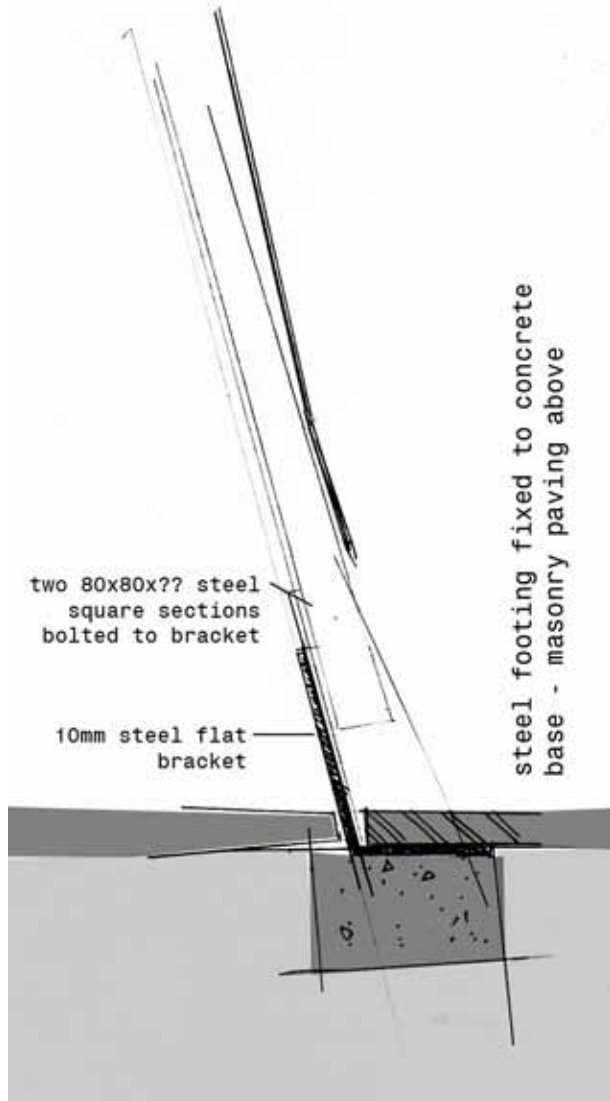


Figure 9-16: Column footing  
[Source: Author]

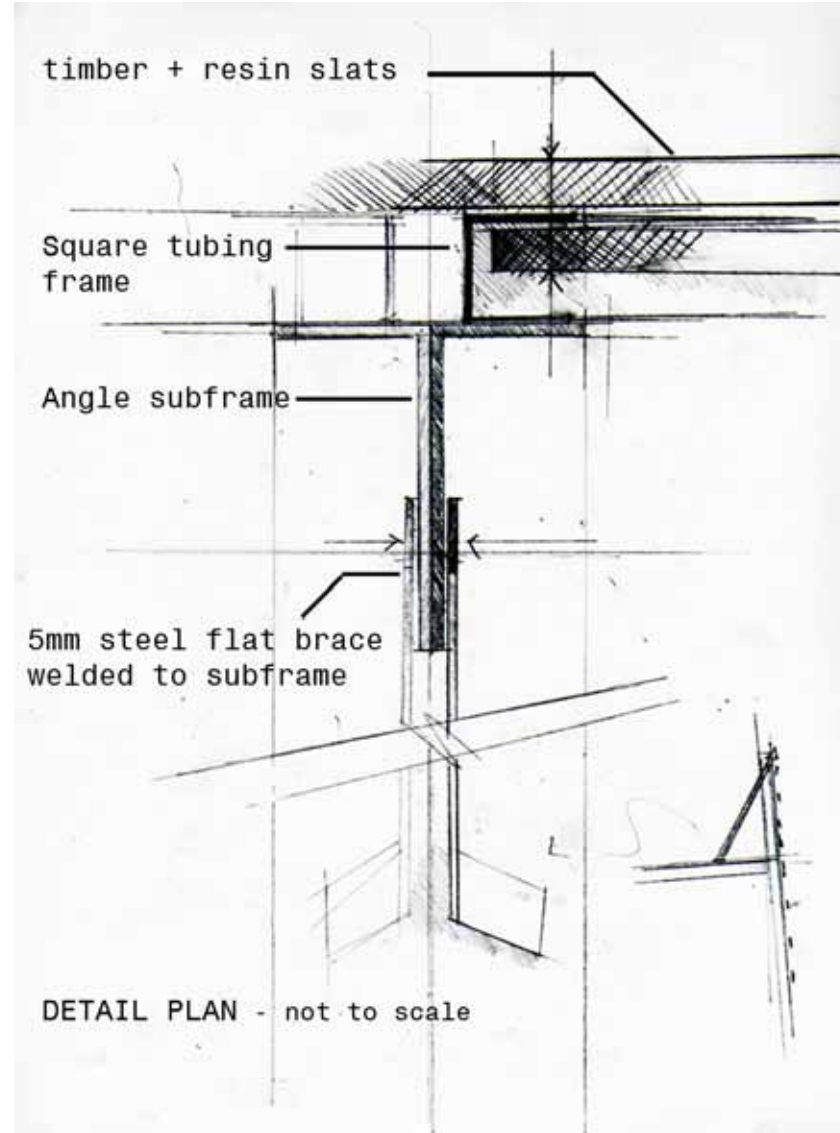


Figure 9-17: Steel Bracing connection  
[Source: Author]



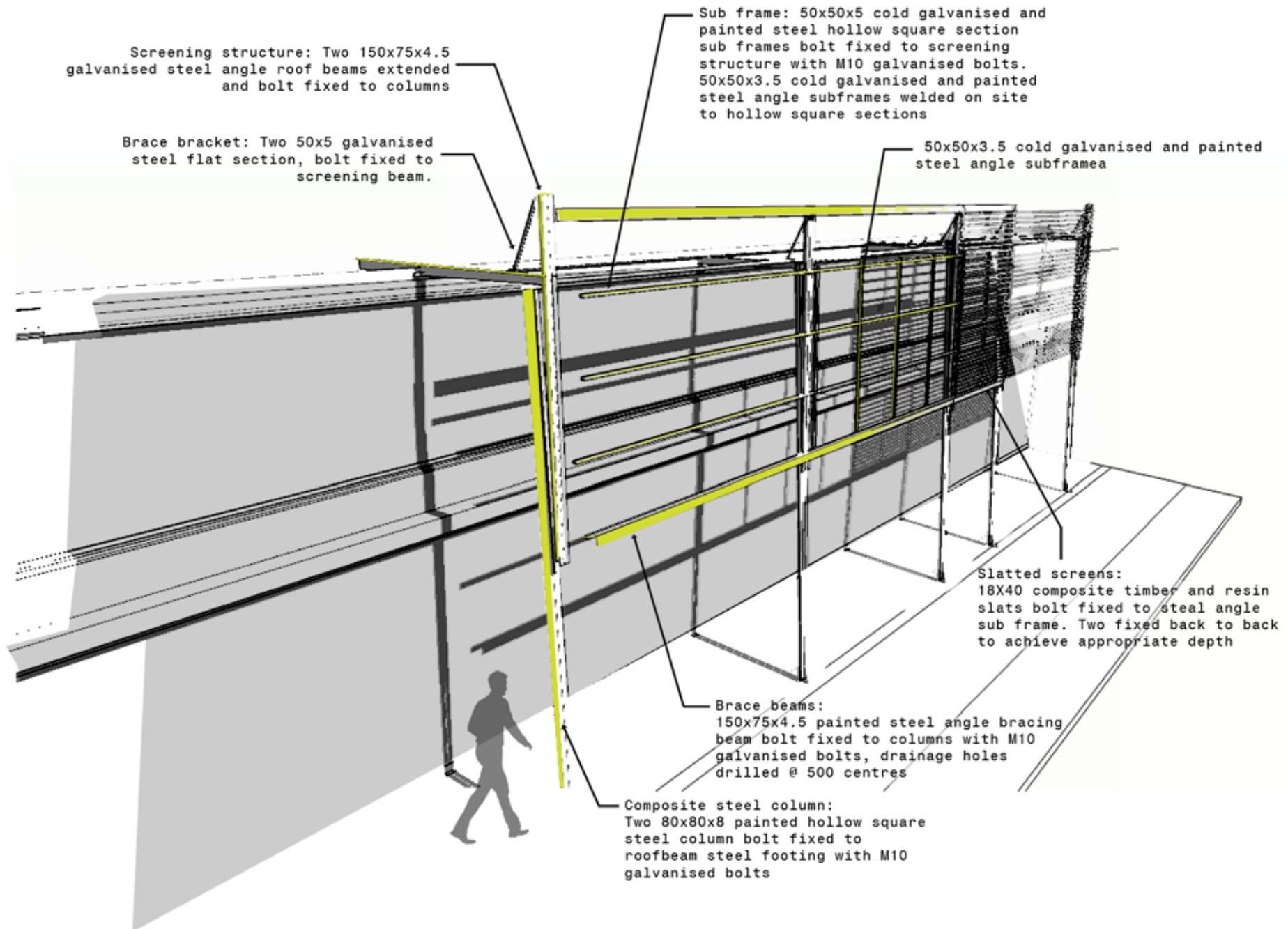


Figure 9-18: Perspective of screen detail components [Source: Author]

### 10.3.2 Ventilation and heating/cooling

The heating and cooling as well as ventilation strategy for the building is developed out of an ecosystemic approach, integrating a series of different systems. As indicated in Figure 9-19 the whole building is divided into four zones:

- a) Mechanically ventilated western zone – [BRT platforms and Small stores]
- b) Cross ventilated, surface heated and cooled eastern zone - [Retail shops]
- c) Cross ventilated office zones [BRT control offices and Offices]
- d) Naturally ventilated main concourse and bridge

The strategy aims to shade the whole building to prevent heat build up, using the main concourse as an exhaust for the different zones.

Exposed materials with high thermal mass are integrated with this strategy to passively cool or heat to the indoor environment [refer to precedent 4, pg 150].

The temperature within these zones will not differ greatly, yet provide a comfortable indoor environment where the transition between the spaces are comfortable as well.

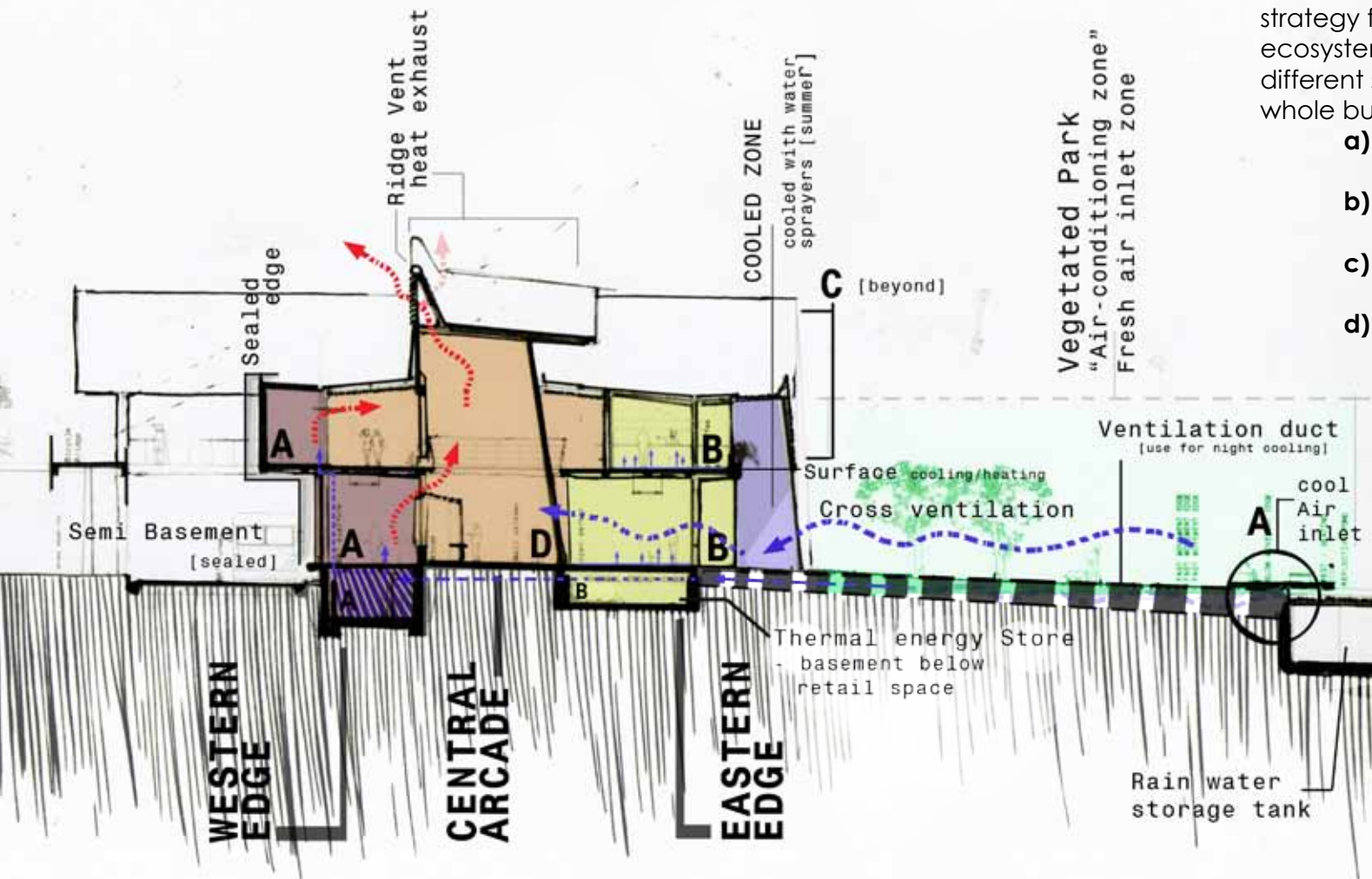


Figure 9-19: Ventilation systems and zoning within the building [Source: Author]

## ZONE A

Zone A is situated on the western edge of the building and houses the BRT platforms and small shops above. There will be high amounts of commuters moving through the platforms daily [at peak hour > 2000 people per hour] [Advanced Logistics Group 2008:115]. It is clear from Graph 13-02 [pg 302] and climate change predictions [Engelbrecht 2010] that cooling will be the main focus within this zone. The maximum cooling load is 69 kW which is in February.

**The zone is mechanically ventilated to prevent air from the BRT runway filtering into the station. Air is collected from above the reflective ponds in the Station Square and cooled through evaporative cooling using a concrete ventilation duct with water sprayers.** This will ensure that clean air is drawn through the system.

Inside the duct a series of water sprayers will be installed, to cool the air as it is drawn through the duct [Holm 1996:12]. To prevent legionella disease the water flow is controlled to ensure all moisture evaporates before touching the surface of the ventilation duct. The air duct will also be accessible to ensure that it is cleaned regularly.

An air handler unit is installed in the sealed semi-basement. The semi-basement is used as a duct to reticulated the air and introduce it into the station through ventilation panels cast into the floor.

**The principle of displacement ventilation is used in the system.** By introducing pressurised cold air at a low level into a space and allowing hot air to exit through the displacement by air pressure differences, 50% energy can be saved as less cold air is needed to ensure a comfortable indoor environment [Carew 2009:06].

## ZONE B

Zone B houses the eastern retail edge, **these spaces are designed to ensure good cross ventilation**, the minimum floor to ceiling height was calculated using the following principle:

$$\begin{aligned} \text{Room Width} < 5 \text{ Height} \\ & \text{[through ventilation]} \\ \text{Room width} < 2 \text{ Height} \\ & \text{[one sided ventilation]} \\ & \text{[Halliday 2008:258]}. \end{aligned}$$

Planting within the Station Square, and integrated into the building will cool the micro climate ensuring that the air is cooled and cleaned before entering the building [refer to section 2.5.1]. The building is orientated in such a manner to allow prevailing wind from the Station Square into the interior spaces.

During the extremely hot periods the air will be pre-cooled in the "cooled zone", refer to Figure 9-19, with through an evaporative cooling method using mist sprayers.

As the building is 940mm above ground level to ensure easy access for disabled commuters onto the platforms, the opportunity to use the infill space as a thermal energy store was utilised.

**The indoor environments in zone B are surface cooled and heated by incorporating high mass floors with water radiator pipes [in a closed circuit] and a 105 m<sup>3</sup> thermal energy store.**

The thermal energy store below zone B will be filled with water [Specific Heat coefficient of 4180 J/kgK] [Dincer 2001:378; Joubert 2010:5]. Integrating this system with water as a phase change material and a solar water heater a 6 months cycle system is developed [Dincer 2001:380]. The system effectively displaces thermal energy by removing heat from the structure in the summer and transferring it back into the building in the winter [Hollmuller *et al* 2006:01].

Water will be circulated in a closed loop with series 20mm copper pipes.

To additionally cool or heat the thermal store water will be circulated through a flat bed solar water heater collector. This will be used during the day to add heat into the system [Dincer 2001:380] and at night to remove heat from the system through radiation.

## Zone C.

**Zone C is naturally ventilated and makes use of the thermal mass of the building material to ensure a comfortable indoor environment is created.**

The floor to ceiling height is 2.6 meters to ensure that the width of the office building is never more than 5 times the floor to ceiling height [Halliday 2008:258].

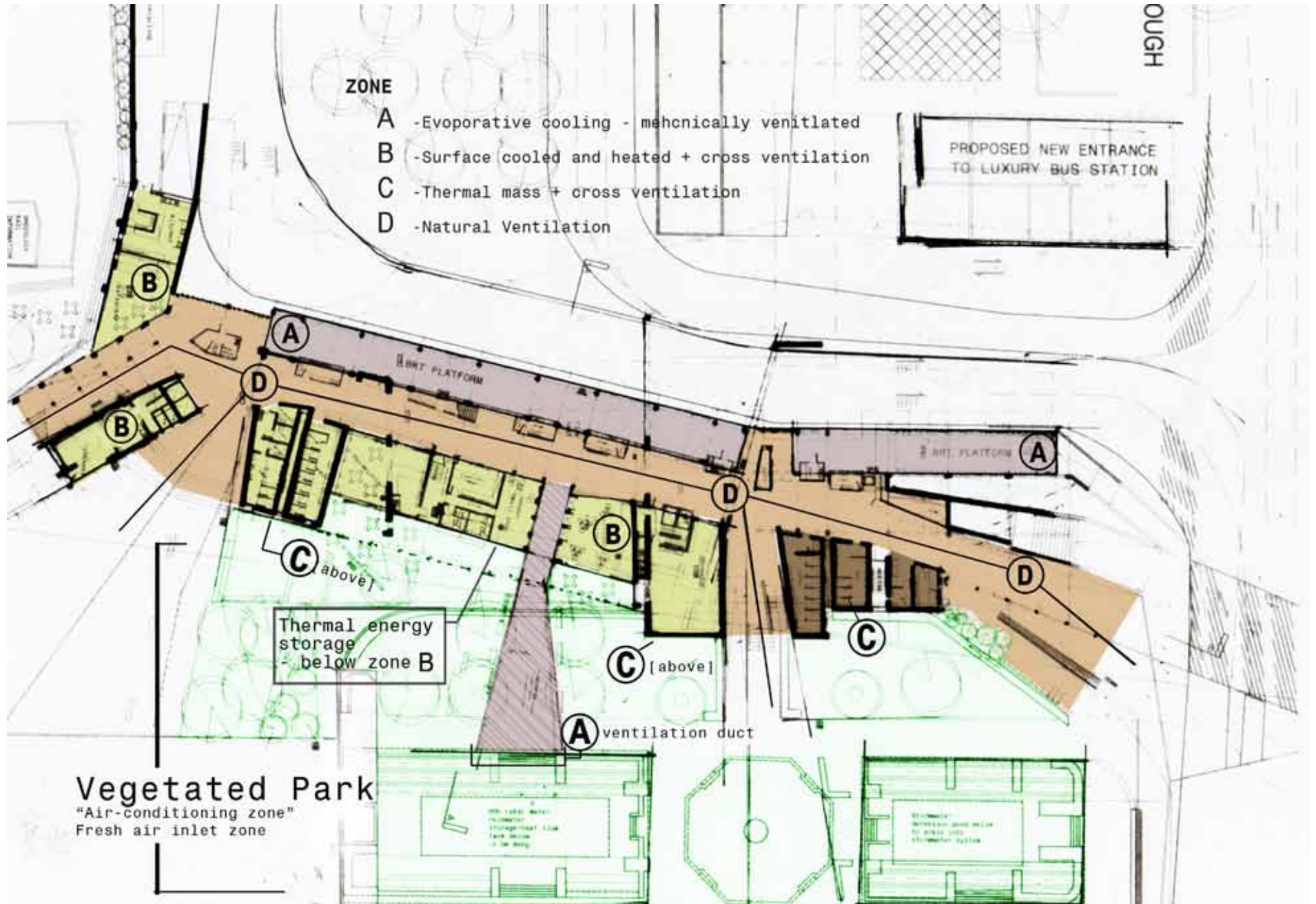


Figure 9-20: Zoning of indoor spaces [Source: Author]

## ZONE D - Main Concourse

The main concourse and bridge are defined as naturally ventilated low pressure zones. By utilising the stack effect this zone will act as an exhaust to draw air through zones A, B and C.

The stack effect forces air into the building at a low level, while driving warm air out at the top and is effective for up to five times the distance from the inlet to the exhaust [Halliday 2008:270]. This is achieved by the density difference between the warmer air inside the building and the cooler air outside [Halliday 2008:258].

A ridge ventilator is fixed to the top of the roof and to act as a chimney to remove excess heat from the building. A high air temperatures will be achieved by the following;

- Heat generated from the commuters walking through the space.
- The ridge vent will be black anodised aluminium that will heat up quickly during the day. As solar gain can be used to enhance the stack effect, this can be particularly effective in Pretoria with its clear skies [Halliday 2008:258].
- The prevailing wind on the site comes from the south easterly direction and will create a negative pressure on the

leeward side of the roof, this will improve the stack effect and pull air from the main concourse [Holm & Viljoen 1996:16; DETR 1998:9].

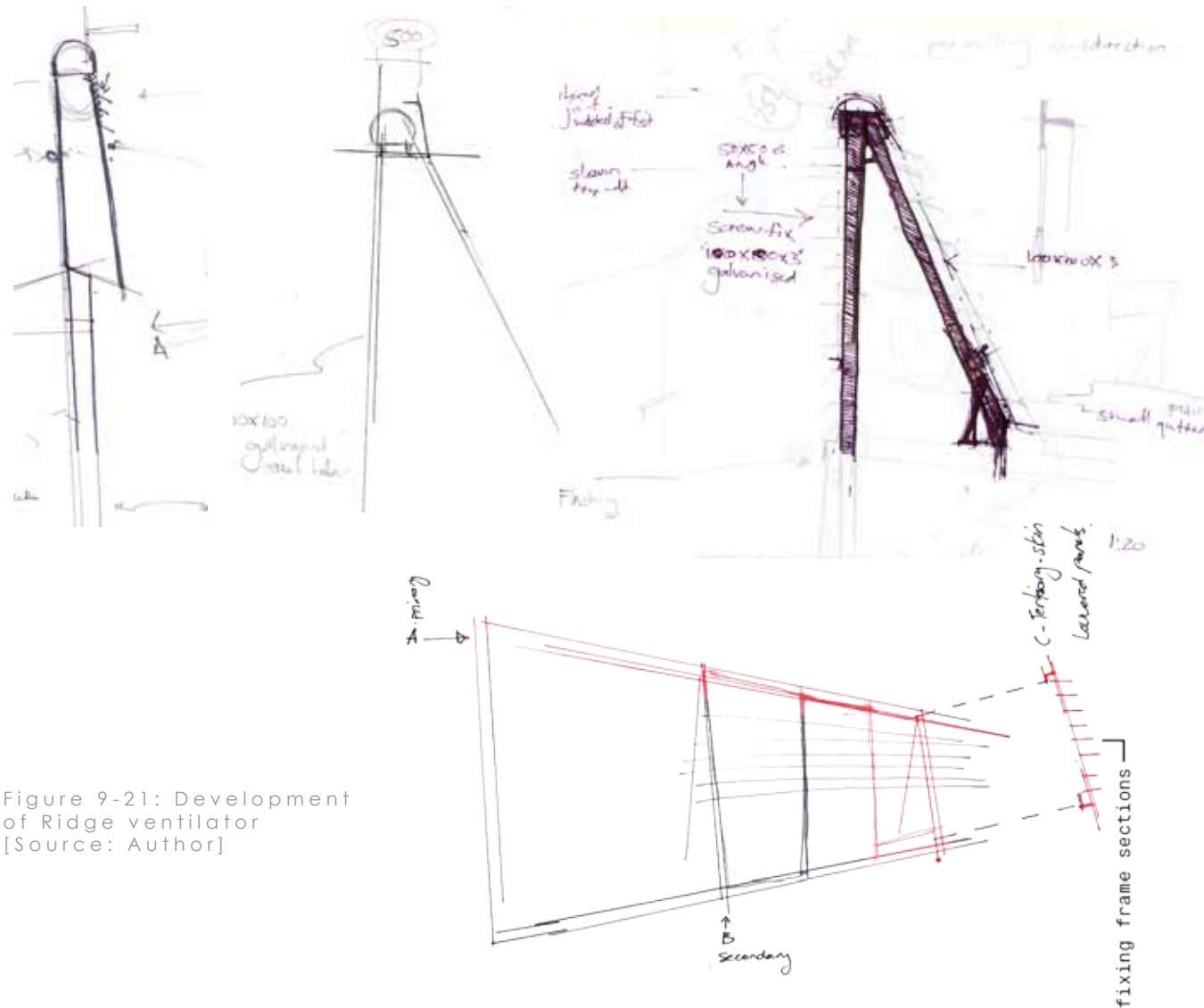
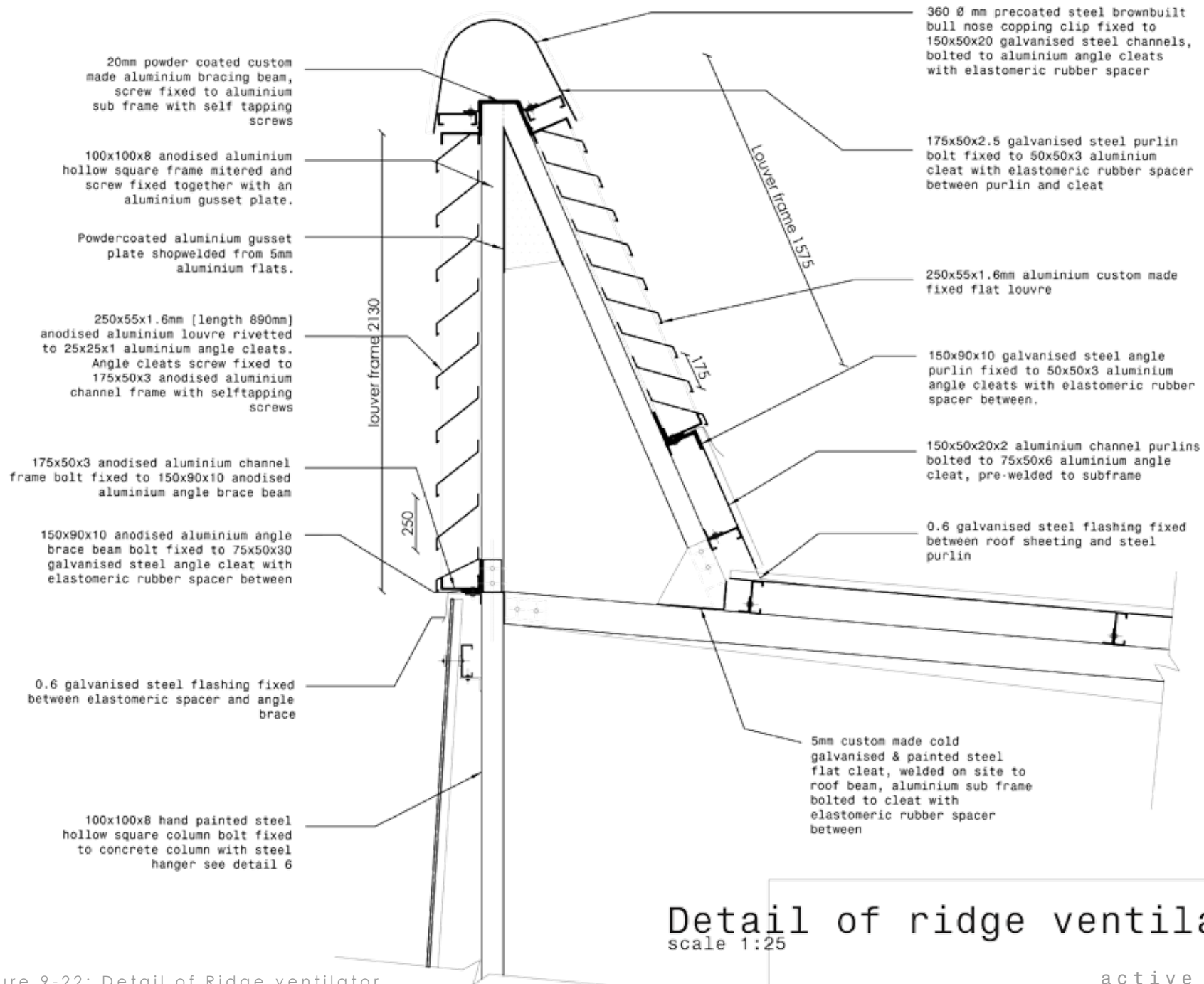


Figure 9-21: Development of Ridge ventilator [Source: Author]



Detail of ridge ventilator  
scale 1:25

Figure 9-22: Detail of Ridge ventilator  
[Source: Author]

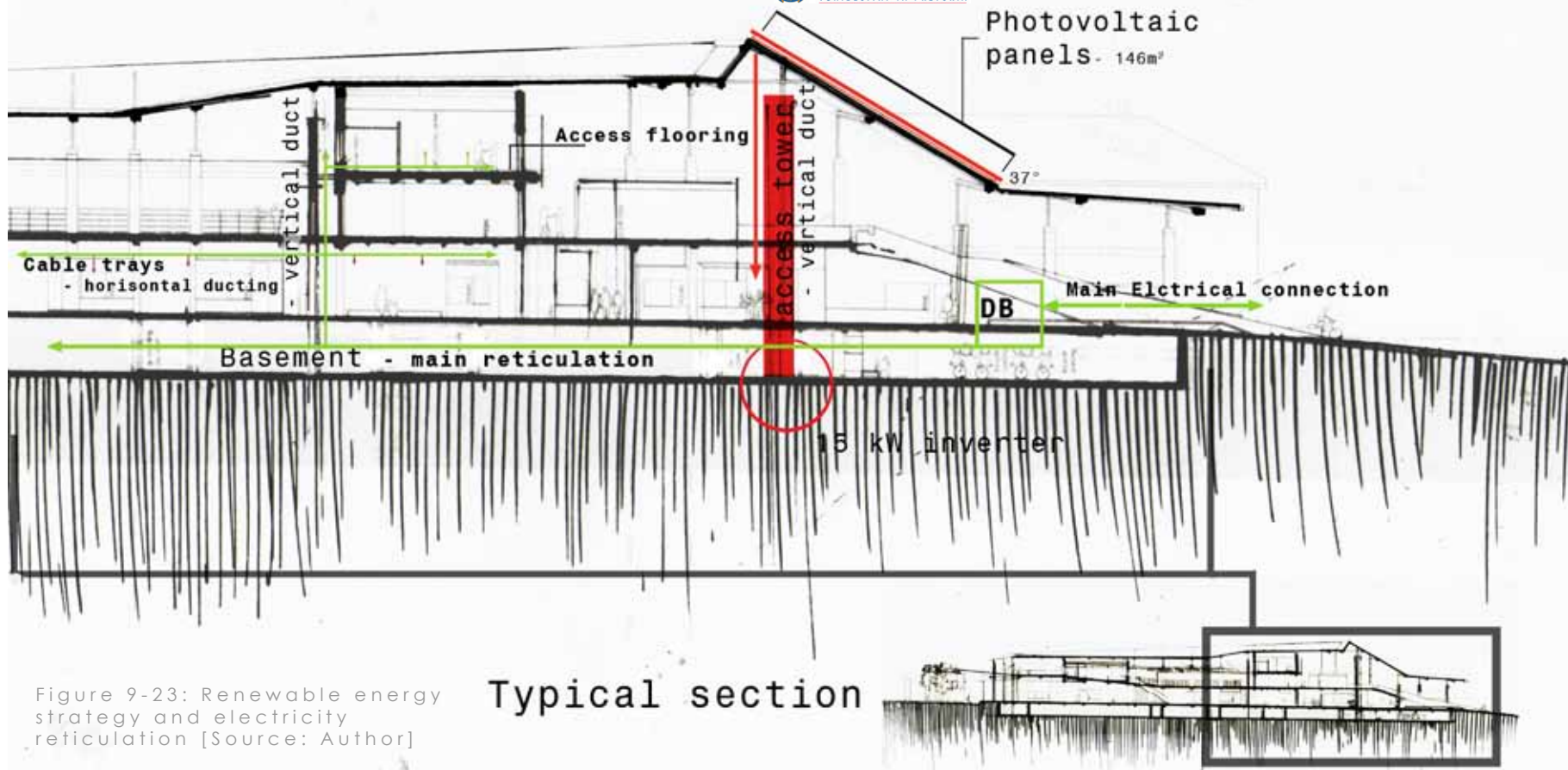


Figure 9-23: Renewable energy strategy and electricity reticulation [Source: Author]

### Typical section

#### 10.3.3. Generating electricity.

Due to the inefficiency of existing renewable energy systems only a portions of the energy consumption will be generated on site [Holm 2010]. The artificial lighting energy consumption as calculated according to the SANS 204-08 minimum illuminance/lighting levels. The total energy required per day is 81 kWh , refer to table 13-17, pg 290.

The photovoltaic panels will be directly connected to the grid to ensure 90% efficiency [storing the energy in batteries normally have 75% efficiency] [Moraal 2010].

Photovoltaic panels can on average generate 0.62 kWh/m<sup>2</sup> per day in Pretoria [Holm 2010], to ensure 81 kWh energy is generated per day a photovoltaic system of 146 m<sup>2</sup> will be needed, refer to Table 13-19, pg 291.

A 15 kW grid tied inverter [Five 3 kW inverters that services portions of the whole system] will be used to convert the photovoltaic energy from DC to AC [Wiredirect 2010; Planmypower 2010].

Additional energy will be purchased through a tradable renewable energy certification process, to ensure that renewable energy initiatives is supported and develop in South Africa.

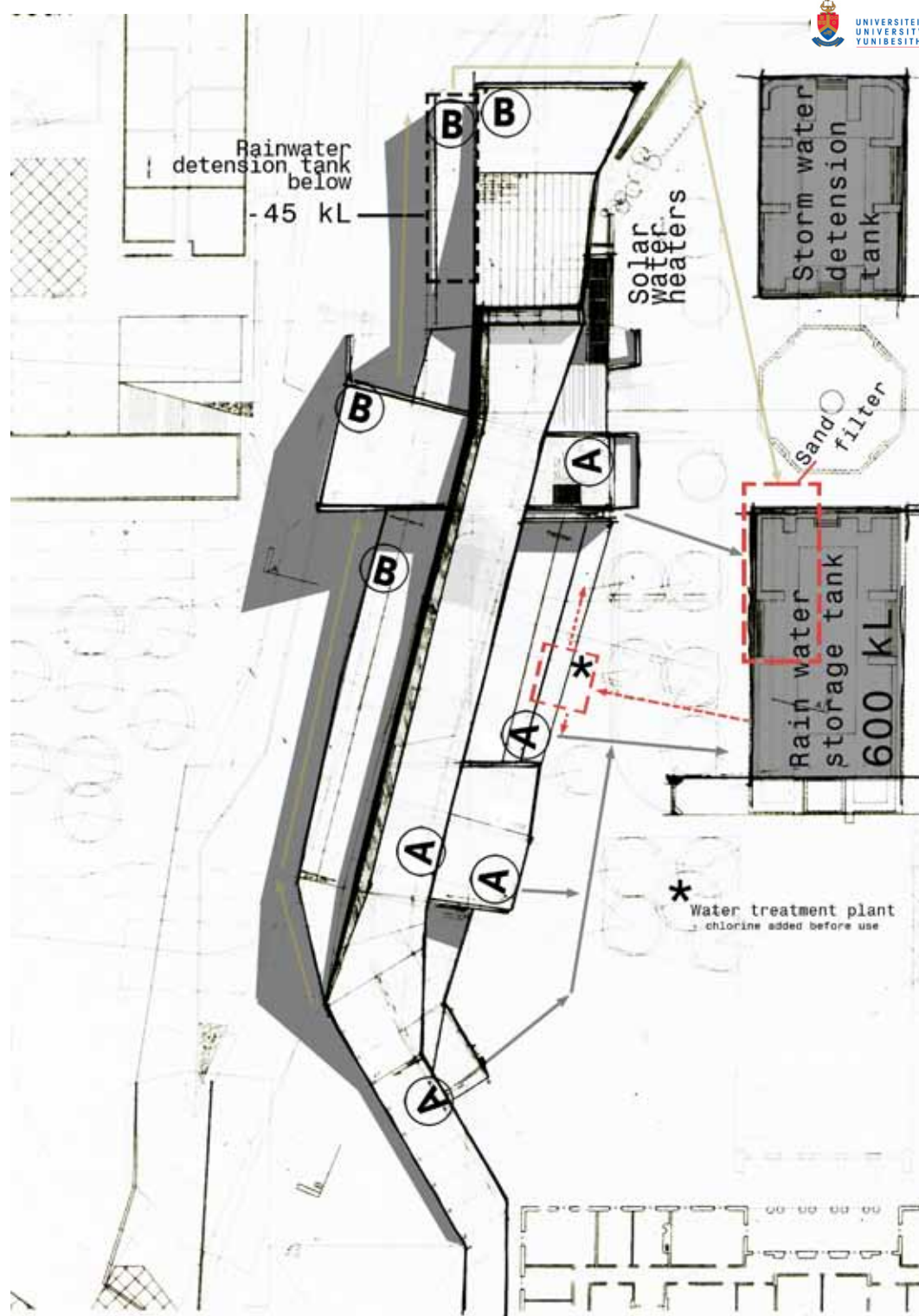


Figure 9-24: Rain water harvesting strategy [Source: Author]

### 10.3.4. Solar water heater for showers.

Solar water heaters in combination with electrical geysers are used to heat the water for the cyclists' shower facilities. Eight glass heat evacuating solar water collectors are proposed to be installed above the ablution core and service a 1400 liter tank [Apricus 2010]. Water consumption of the shower facilities are controlled by only allowing a five minute shower with controlled water valves and limiting the flow rate [10 liters per minute] [Gibbert 2009:131]. Refer to Table 13-20, pg 292 for water calculations.

### 10.3.5. Harvesting rain water

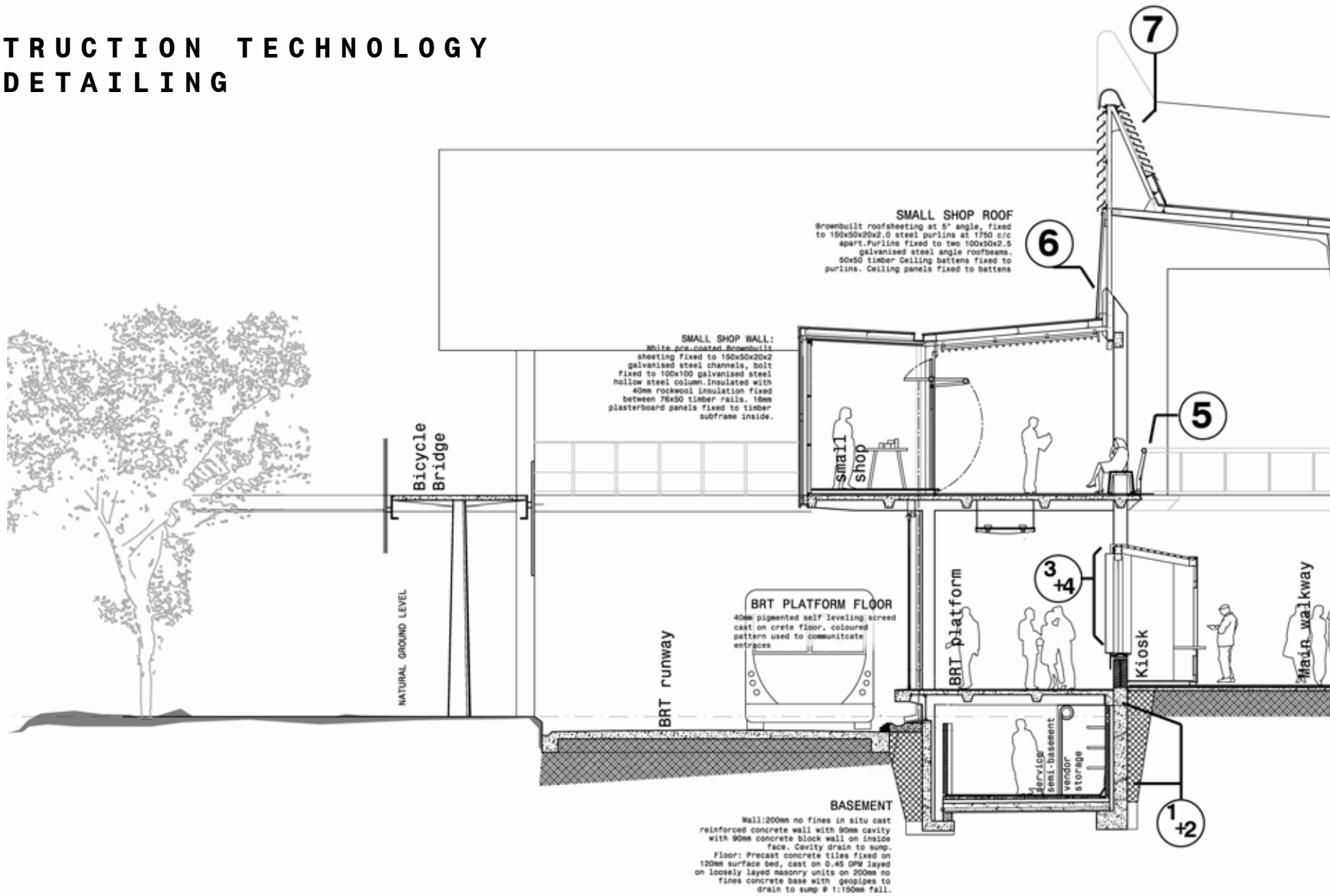
**Rainwater is collected from the roofs to service the public toilets.**

The total roof area is 2050m<sup>2</sup>, yet only 90% of the total rain water can be harvested [Gibbert 2009:125]. A storage tank of 600 kL will store the rainwater and ensure that the public toilets can be serviced for 11 months of the year, refer to Table 13-21, pg 292. A Rainwater storage tank is positioned below the reflective pond in the Station Square, with a 24m<sup>3</sup> sand filter that pre filters the water before storing it – this ensure that the water is not contaminated [GIBBERT 2009:133] [Refer to Table 13-22, pg 292].

An 18 kL holding tank will pre-store the water to guarantee that it passes through the filter at a slow rate [1liter/1 m<sup>2</sup>/min] ensuring that it is adequately cleaned before storing it [Van Lengen 2008:619].



# 10.4 CONSTRUCTION TECHNOLOGY AND DETAILING



SECTION AA- construction technology



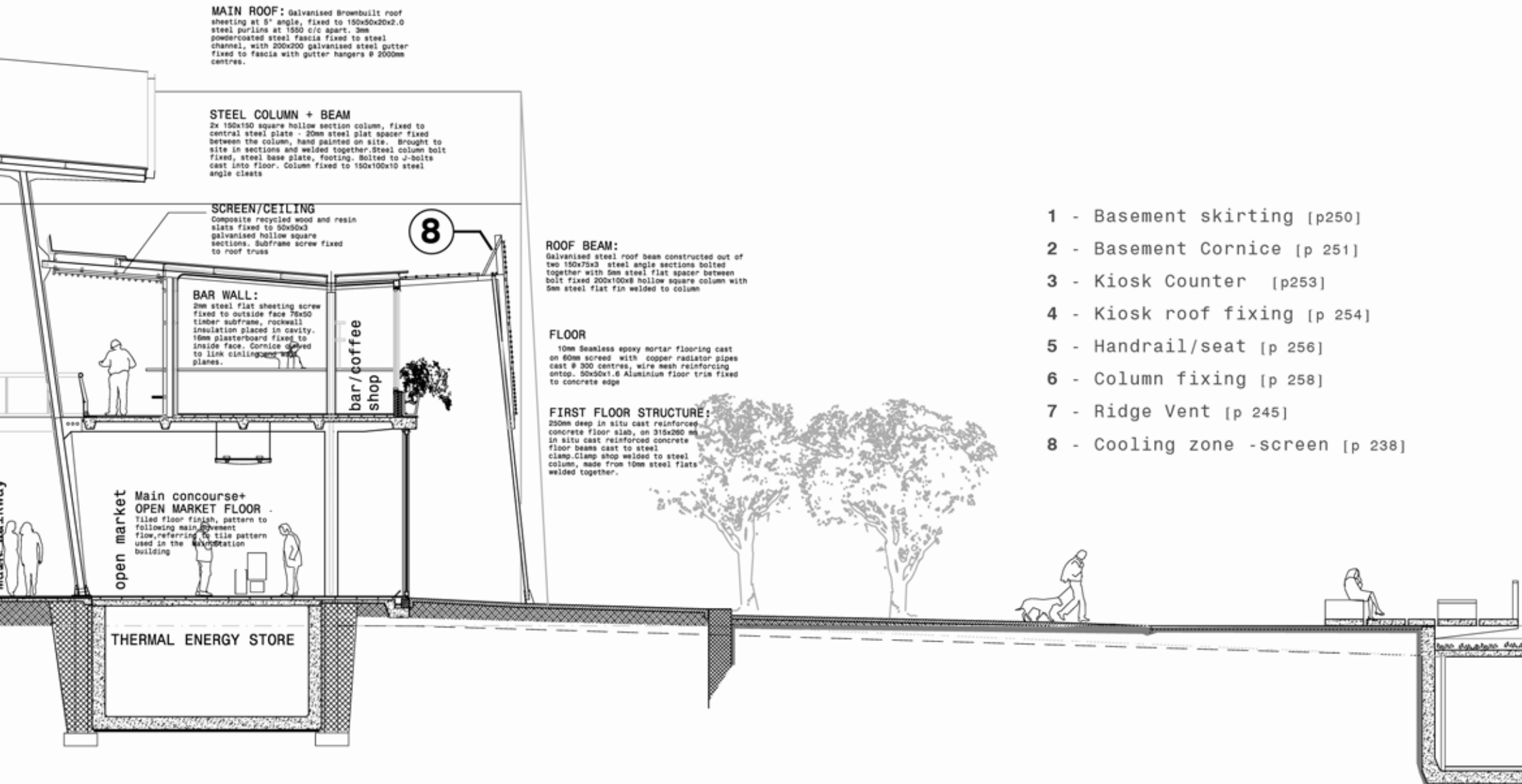
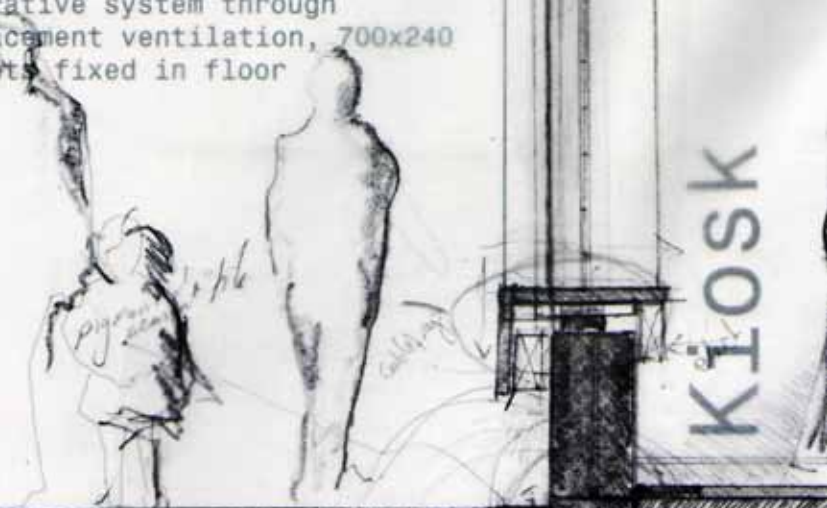


Figure 9-25: Detail section through structure [Source: Author]



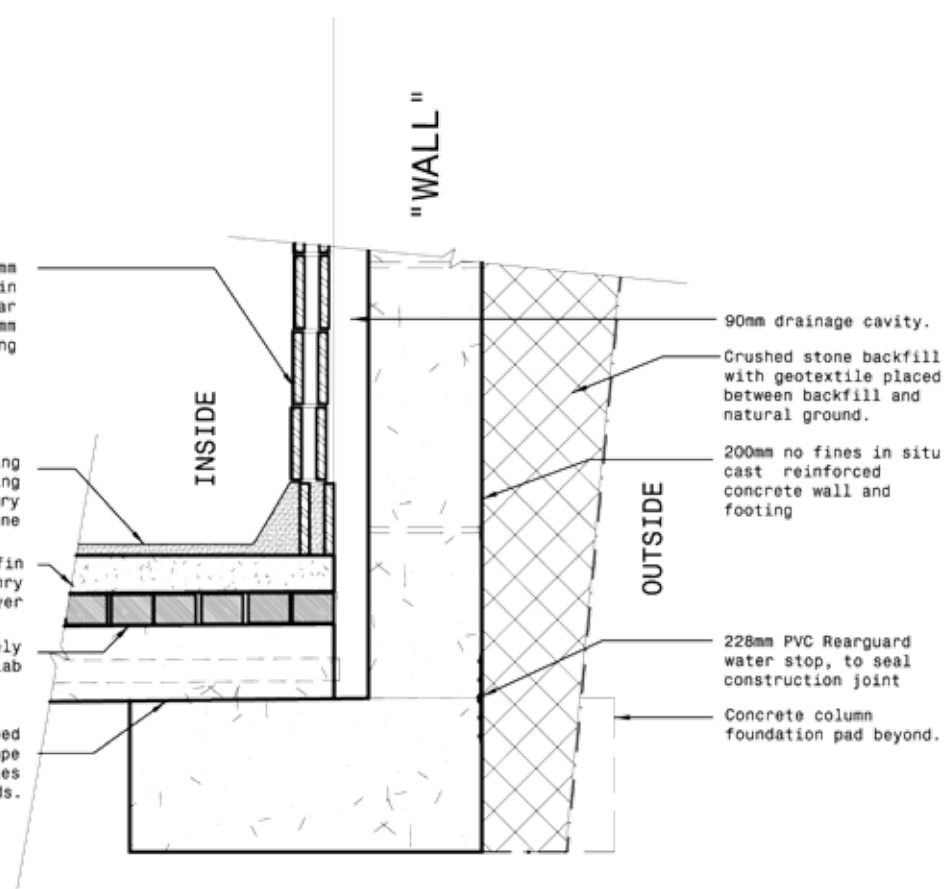
Plastered and painted 90mm concrete block wall, built in stretcher bond with deep mortar joints. Corbeled to allow 20mm overhang for flush floor skirting

40mm pigmented selfleveling cement screed. Floor skirting taken up to corbelled masonry line

120mm surface bed on 0.45 polyolefin DPM, placed on top of masonry drainage layer

Clay fired masonry units loosely packed on concrete slab

200mm no fines concrete slab, sloped towards drainage gutter, min slope 1:150. Geopipes cast into slab, holes facing downwards.



90mm drainage cavity.

Crushed stone backfill with geotextile placed between backfill and natural ground.

200mm no fines in situ cast reinforced concrete wall and footing

228mm PVC Rearguard water stop, to seal construction joint

Concrete column foundation pad beyond.

**DETAIL: BASEMENT FLOOR SKIRTING**  
scale 1:20

Figure 9-26: Development of detail [Source: Author]

Figure 9-27: Detail of basement skirting [Source: Author]

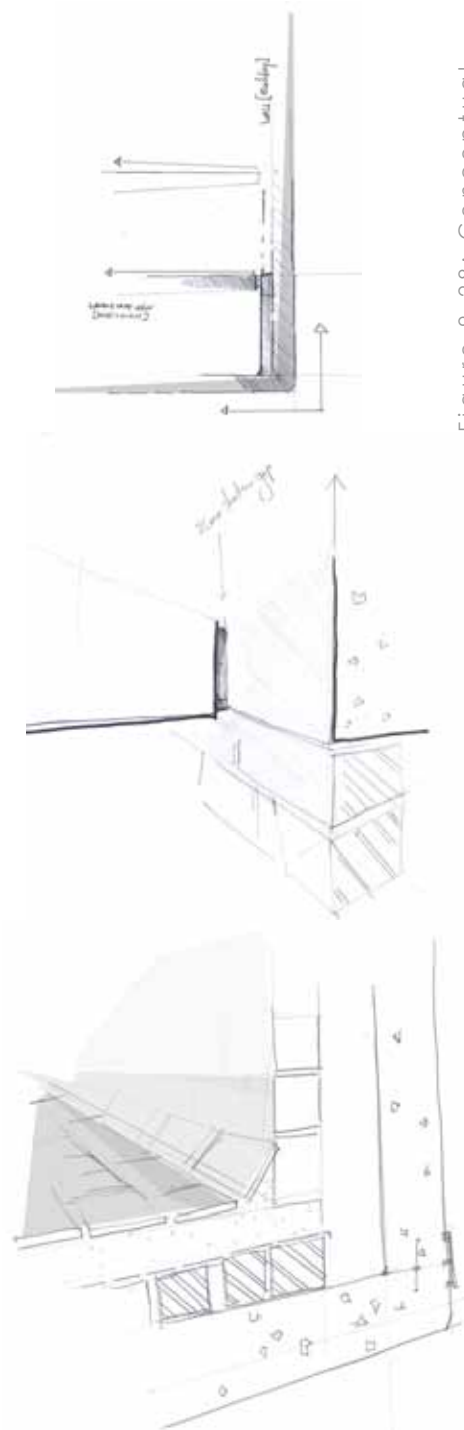


Figure 9-28: Conceptual approach to basement [Source: Author]

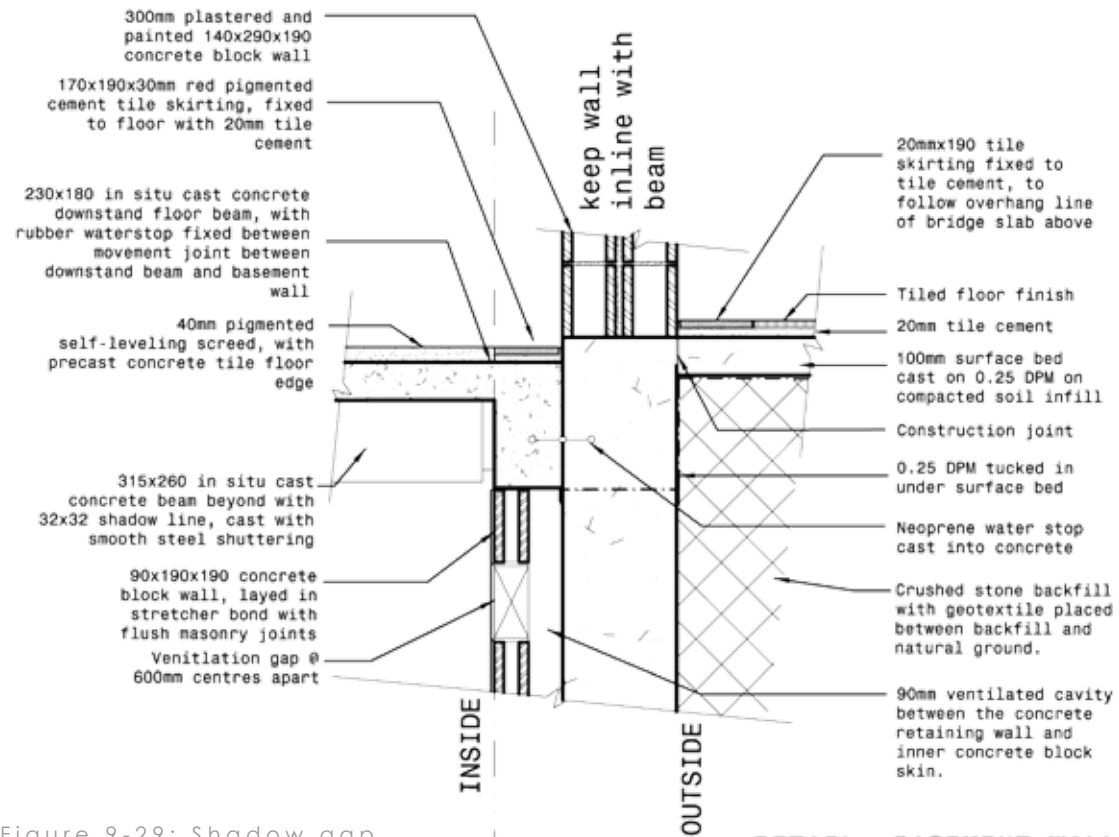


Figure 9-29: Shadow gap detail of basement wall [Source: Author]

Figure 9-30: Skirting in basement [Source: Author]

Figure 9-31: Detail of basement ceiling shadow gap [Source: Author]

**DETAIL: BASEMENT WALL AND ROOF**  
 scale 1:20

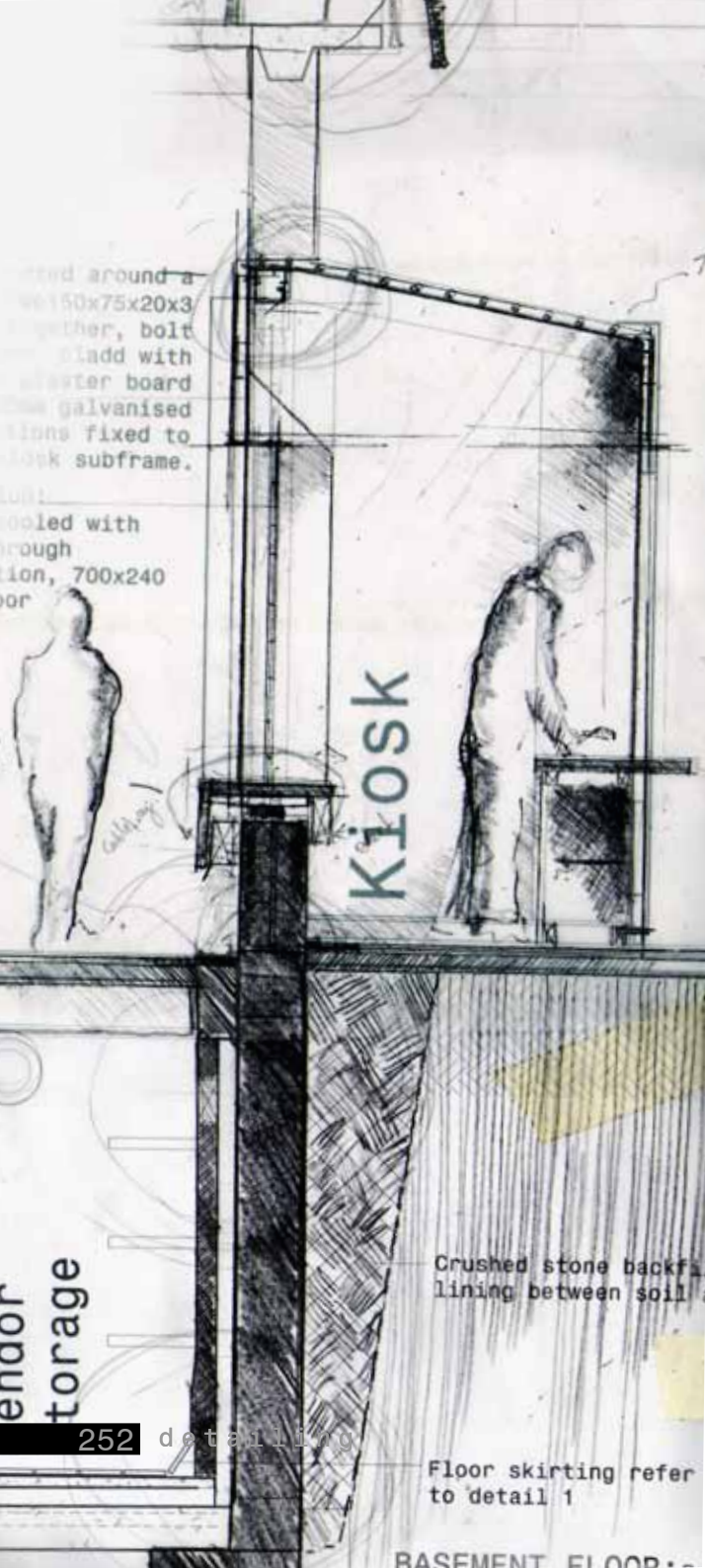


Figure 9-32: Development of Kiosk detail [Source: Author]

Figure 9-33: Conceptual approach to kiosk detail [Source: Author]

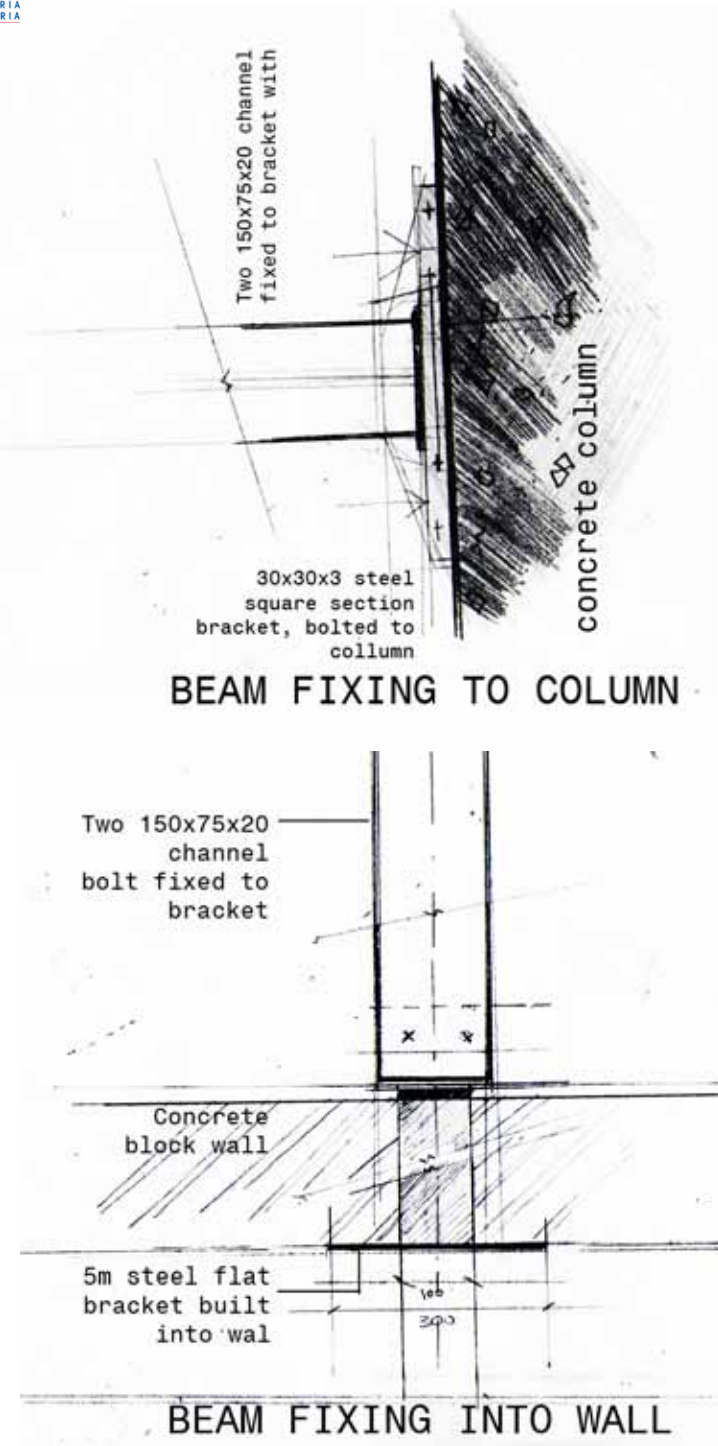
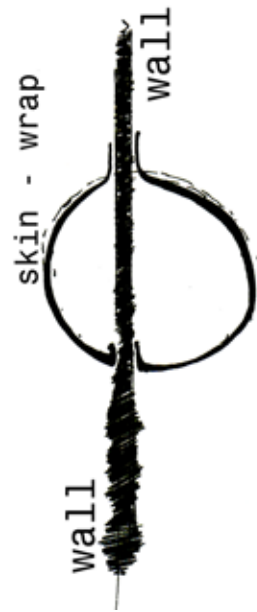


Figure 9-34: Steel beam fixing to column [Source: Author]

Figure 9-35: Steel column fixing to subwall [Source: Author]

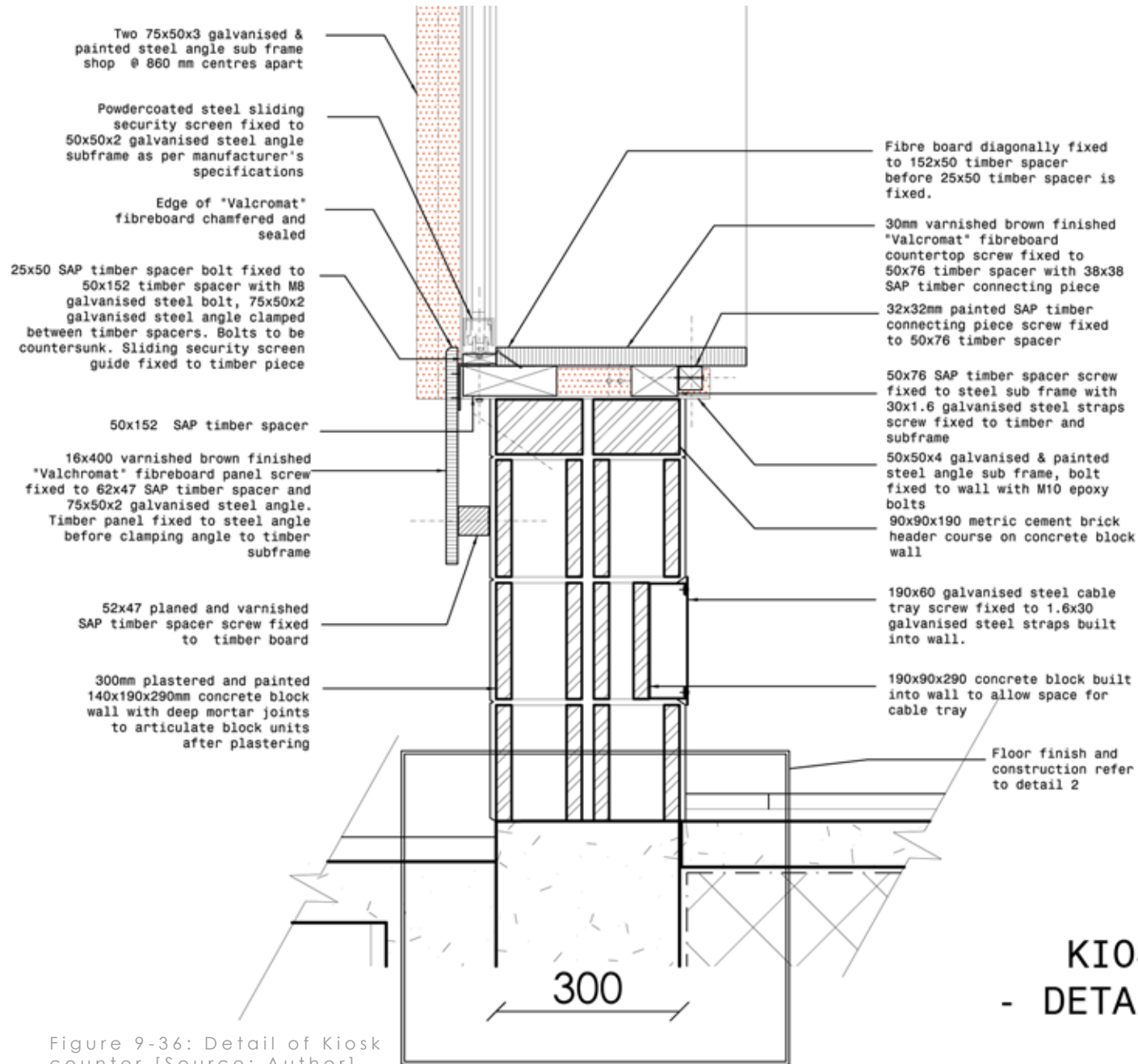


Figure 9-36: Detail of Kiosk counter [Source: Author]

**KIOSK COUNTER  
- DETAIL SECTION  
scale 1:10**

20mm Ø galvanised solid round slotted through 24mm Ø predrilled hole. Solid round end slotted into painted 50x50x2mm hollow square section welded on site to subframe

Two 75x50x3 galvanised & painted steel angle sub frame shop welded and bolt fixed to steel beam with 50x50x2.5 painted steel angle cleats @ 860 mm centres. Use M10 galvanised steel bolts 50x50x2.5 painted steel angle cleats

Two 150x75x20x3 galvanised & painted lipped channels shop welded together, bolt fixed to column

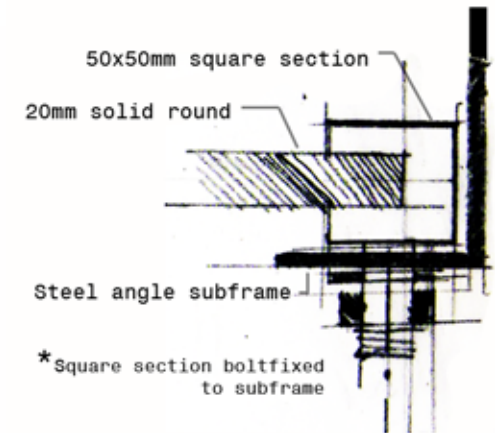
75x50x3 galvanised & painted steel channel bolt fixed to steel angle sub frame with M8 galvanised bolts

1mm painted steel flat sheeting riveted to 75x50x3 steel channel Painted steel angle hanger bolt fixed to sub frame with M8 galvanised bolts. Shop welded with 3mm steel flat sections, 30x30x3 and 50x100x3 steel angles

30mm varnished brown finished "Valcromat" fibreboard screw fixed to 30x30x2.5 steel hanger with self tapping timber screws

50x50x2 painted steel angle subframe welded to hanger on site.

Powdercoated steel sliding security screen fixed to 50x50x2 galvanised steel angle subframe

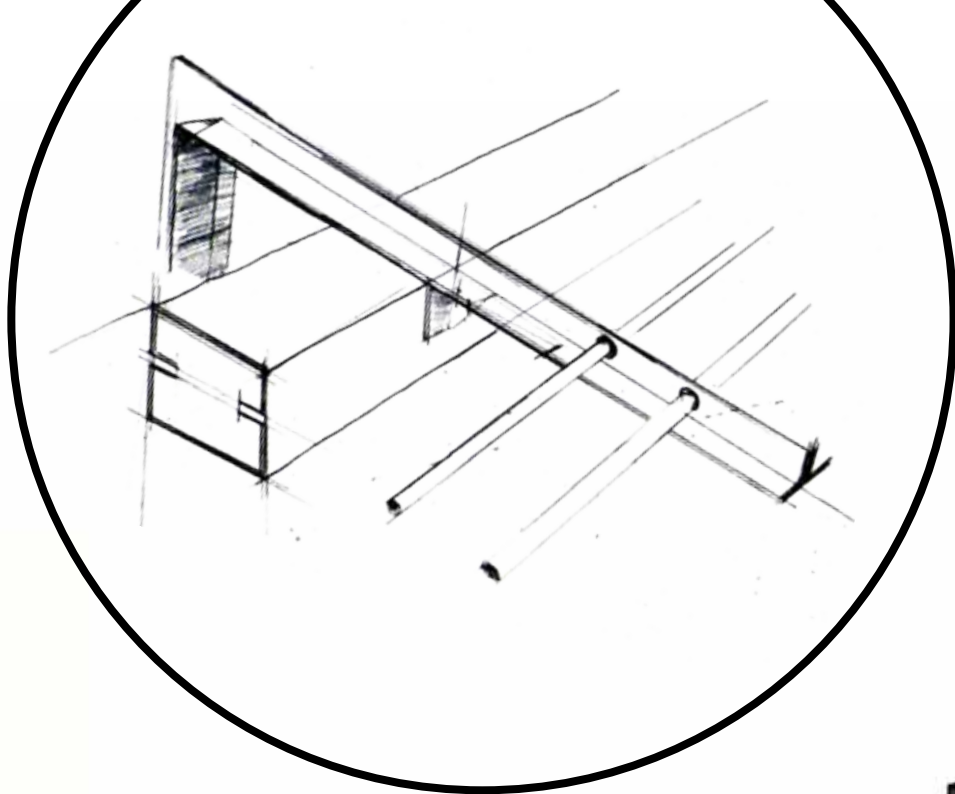


End fixing of solid round sections

Figure 9-38: End fixing of solid rounds [Source: Author]

Figure 9-37: Detail of Kiosk roof [Source: Author]

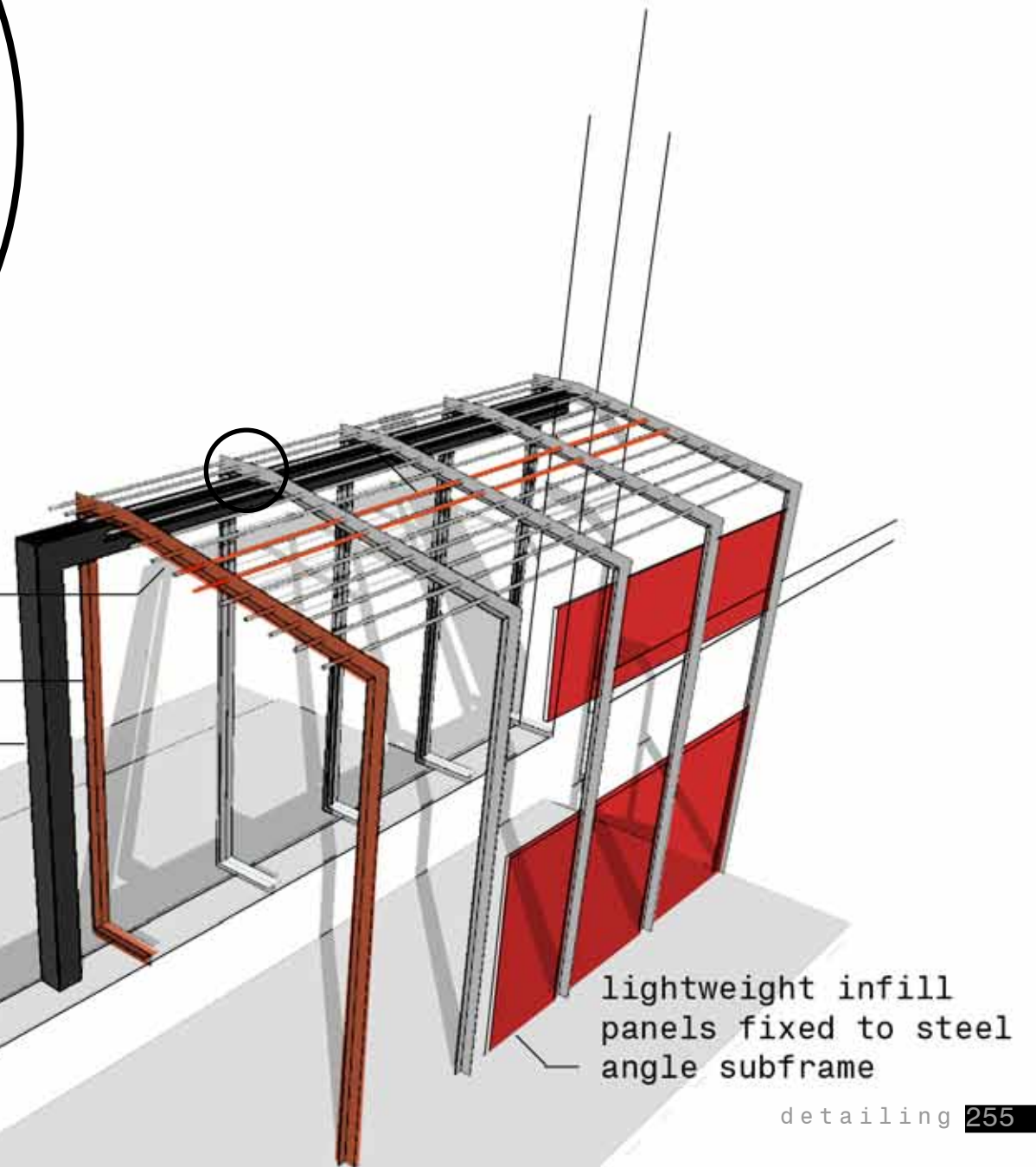
KIOSK SUBFRAME - DETAIL SECTION  
scale 1:10



Solid round bracing+buglar bars

Steel angle subframe

C-channel column/beam



lightweight infill panels fixed to steel angle subframe

Figure 9-39: Perspective of structural system of kiosk [Source: Author]



FIXED RAIL 1:2

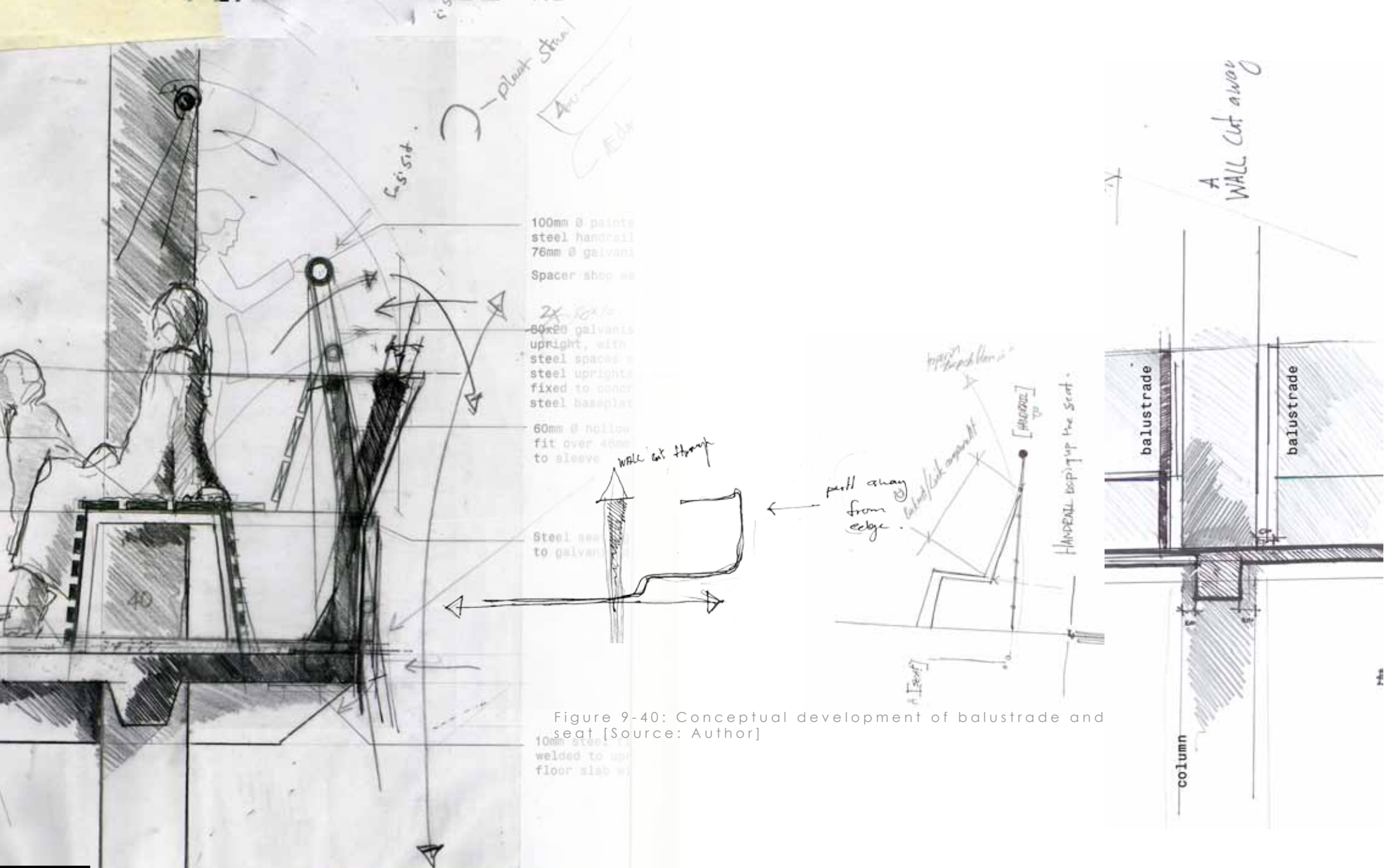
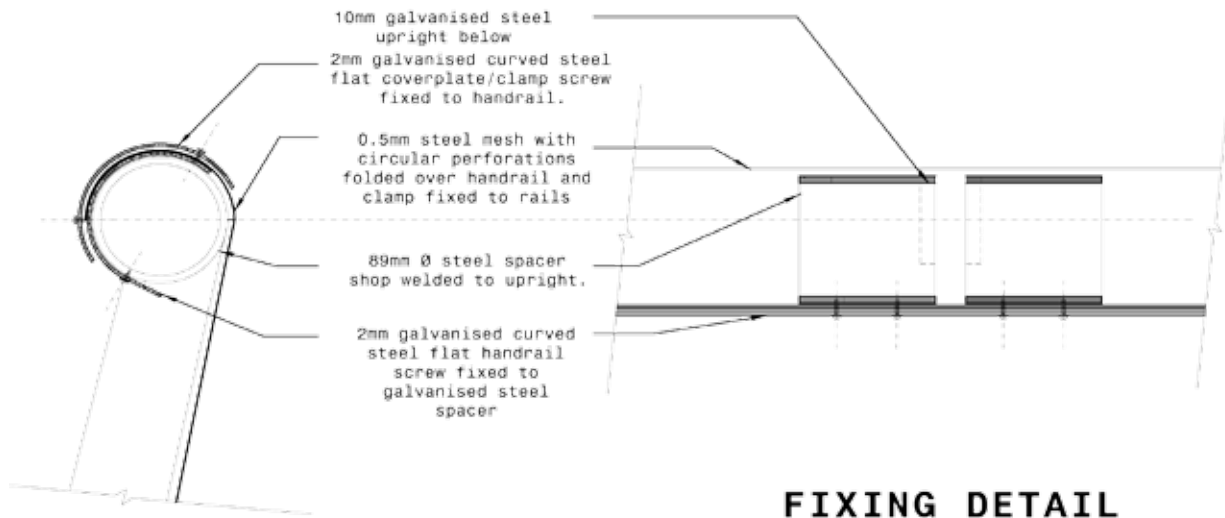
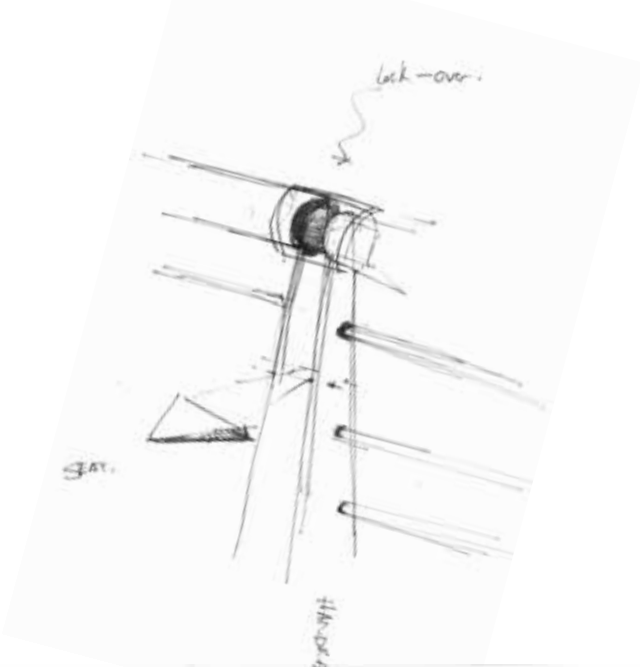


Figure 9-40: Conceptual development of balustrade and seat [Source: Author]

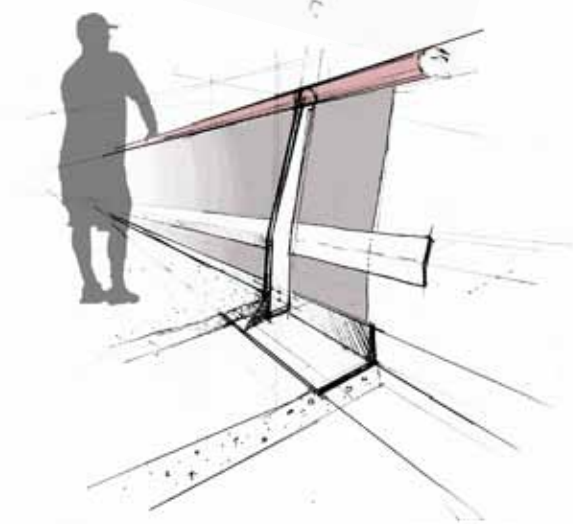


- 10mm galvanised steel upright below
- 2mm galvanised curved steel flat coverplate/clamp screw fixed to handrail.
- 0.5mm steel mesh with circular perforations folded over handrail and clamp fixed to rails
- 89mm Ø steel spacer shop welded to upright.
- 2mm galvanised curved steel flat handrail screw fixed to galvanised steel spacer

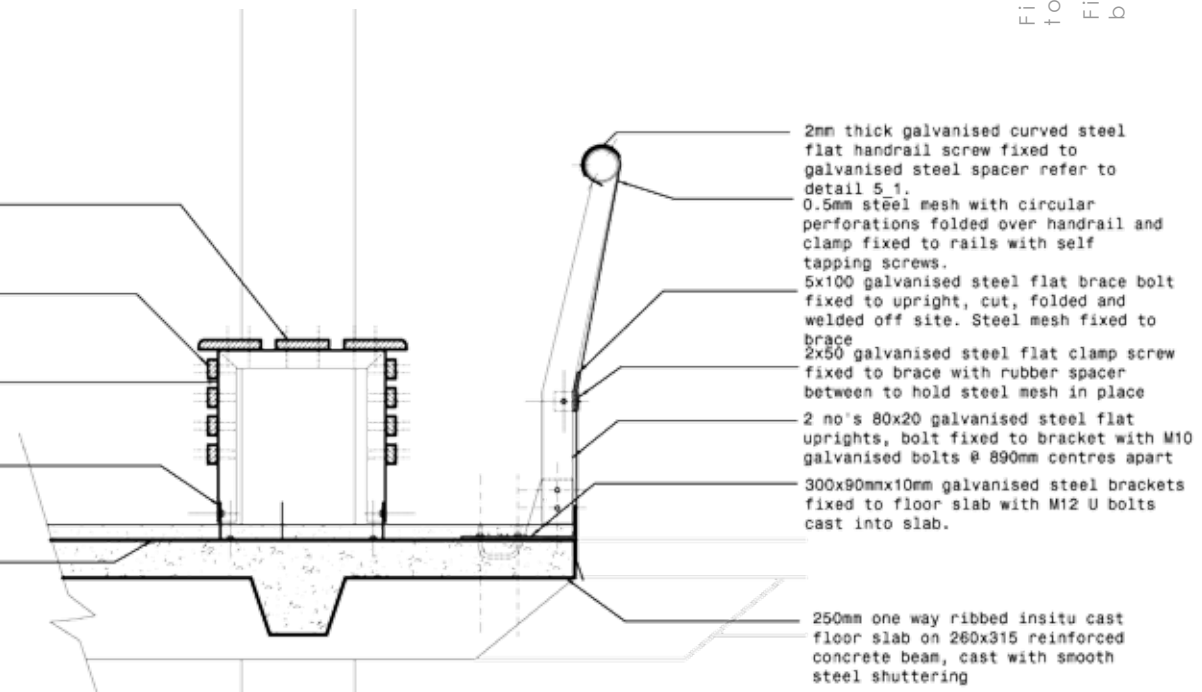
**FIXING DETAIL**  
scale 1:5

Figure 9-41: Detail fixing of handrail to balustrade [Source: Author]

Figure 9-42: Detail section of balustrade/ seat [Source: Author]



- 140x25 Pre-finished composite wood and resin slats screw fixed to steel angle sub frame from below
- 22x50 Pre-finished composite wood and resin slats screw fixed to steel angles.
- 2 no's 50x50x3 galvanised steel angle seating frames bolt fixed to 100x50x3 galvanised steel angle cleats with M10 galvanised bolts @ 445mm centres apart
- 100x50x3 galvanised steel angle cleats bolt fixed to concrete slab with M10 epoxy bolts
- 40mm pigmented screed cast on slab lightly reinforced with wire mesh fixed to slab.



- 2mm thick galvanised curved steel flat handrail screw fixed to galvanised steel spacer refer to detail 5.1.
- 0.5mm steel mesh with circular perforations folded over handrail and clamp fixed to rails with self tapping screws.
- 5x100 galvanised steel flat brace bolt fixed to upright, cut, folded and welded off site. Steel mesh fixed to brace
- 2x50 galvanised steel flat clamp screw fixed to brace with rubber spacer between to hold steel mesh in place
- 2 no's 80x20 galvanised steel flat uprights, bolt fixed to bracket with M10 galvanised bolts @ 890mm centres apart
- 300x90mmx10mm galvanised steel brackets fixed to floor slab with M12 U bolts cast into slab.
- 250mm one way ribbed insitu cast floor slab on 260x315 reinforced concrete beam, cast with smooth steel shuttering

**DETAIL HANDRAIL/SEAT**  
scale 1:20

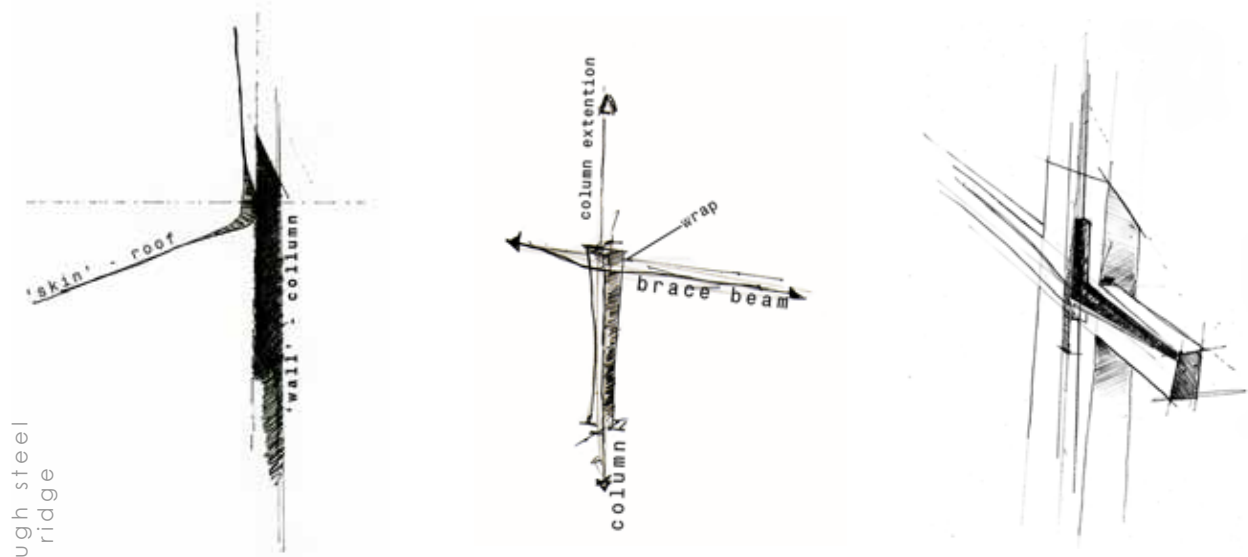
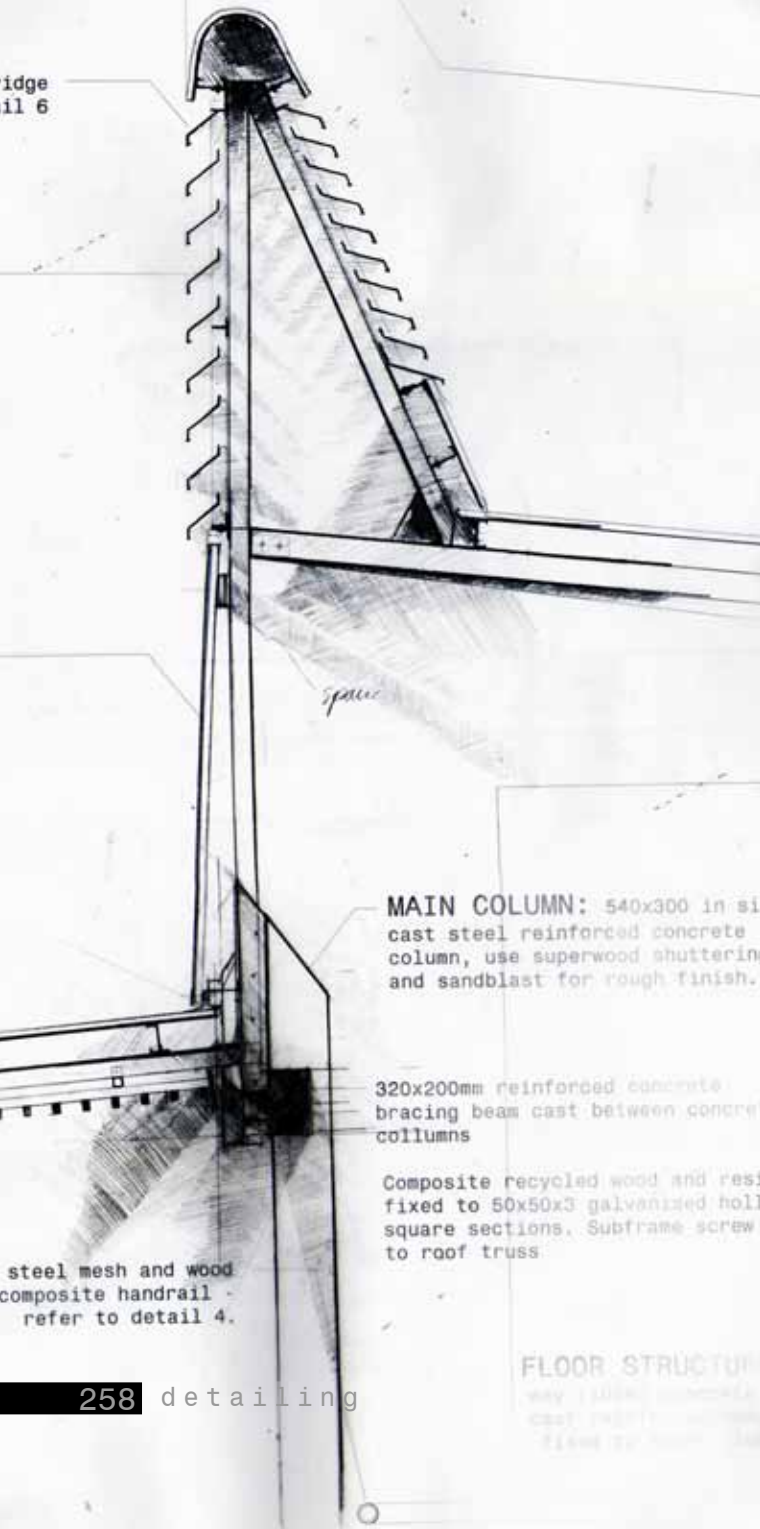


Figure 9-44: Conceptual development of steel column bracket [Source: Author]

Figure 9-43: Section through steel column bracket and roof ridge [Source: Author]

10mm Translucent "Lexan Therman clear" sheets clamped to 38x38x4 galvanised square hollow steel uprights with 3x40mm steel flat clamp, elastomeric rubber spacer in between.

3x40mm galvanised steel flat clamp

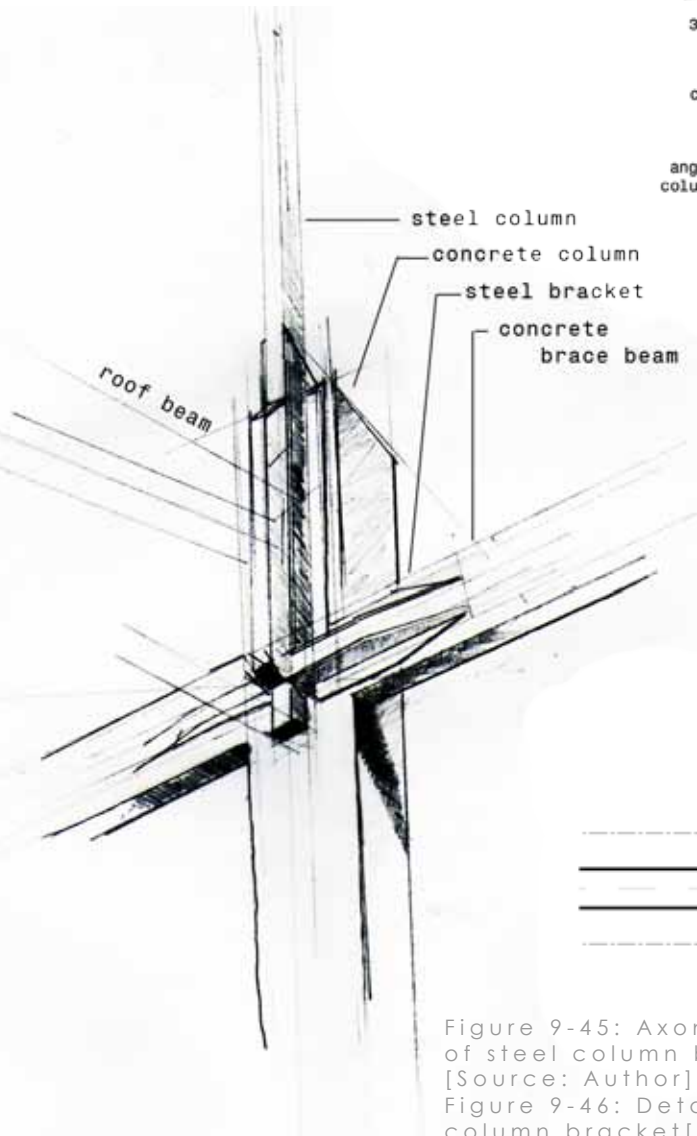
38x38x4 galvanised steel upright bolt fixed to galvanised steel channel with M8 galvanised bolts @ 1040 centres

125x65x3.5 galvanised steel channel bolt fixed to 50X50X4 galvanised steel angle cleat with M8 galvanised bolts

30x1.6 steel flashing fixed between steel upright and channel

Brownbuilt steel roofsheeting, clip-fixed to 150x50x2.5 galvanised steel fixing component

2 no's 100x50x2.5 galvanised steel angle roof beams, bolt fixed to steel column with M10 galvanised steel bolts



48x48 sanded and sealed SAP timber subframe screw fixed to 50x50x3 galvanised hollow square sections with selftapping screws. Steel hollow sections bolt fixed to roof beam with 50x50x2.5 galvanised steel angle cleats

22x50 Composite recycled wood and resin slats fixed to SAP timber subframe

100x100x8 galvanised & painted hollow square steel fixing component shop welded to galvanised & painted 100x100x8 steel column

100x100x8 galvanised & painted hollow square steel column with 100x100x8 galvanised & painted hollow square steel fixing piece shop welded to column, column bolt fixed to steel bracket with M10 galvanised bolts

100x100x8 galvanised and painted hollow square steel fixing piece shop welded to column

100x100x8 galvanised & painted hollow square steel column with 100x100x8 fixing piece shop welded to column, bolt fixed to steel bracket with M10 galvanised steel bolts

540x300 in situ cast steel reinforced concrete column, use recycled timber shuttering and sandblasted for rough finish

320x200mm reinforced concrete bracing beam cast in recycled timber shuttering and sandblasted for a rough finish

1250x1620 galvanised & painted steel bracket constructed out of 150x90x8 steel angles cut and welded off site. Bracket bolt fixed to bracing beam with M10 epoxy bolts

540x300 in situ cast steel reinforced concrete column, use superwood shuttering and sandblasted for rough finish.

100x50x2.5 galvanised steel channel roof beam, bolt fixed to steel fixing piece with M10 galvanised steel bolts.

320x200mm reinforced concrete bracing beam below

1250x1620 galvanised & painted steel bracket constructed out of 150x90x8 steel angles cut and welded off site. Bracket bolt fixed to bracing beam with M10 epoxy bolts

Figure 9-45: Axonometric view of steel column bracket [Source: Author]  
Figure 9-46: Detail section of column bracket [Source: Author]  
Figure 9-47: Detail plan of column bracket [Source: Author]

DETAIL SECTION  
1:20

DETAIL PLAN  
1:20