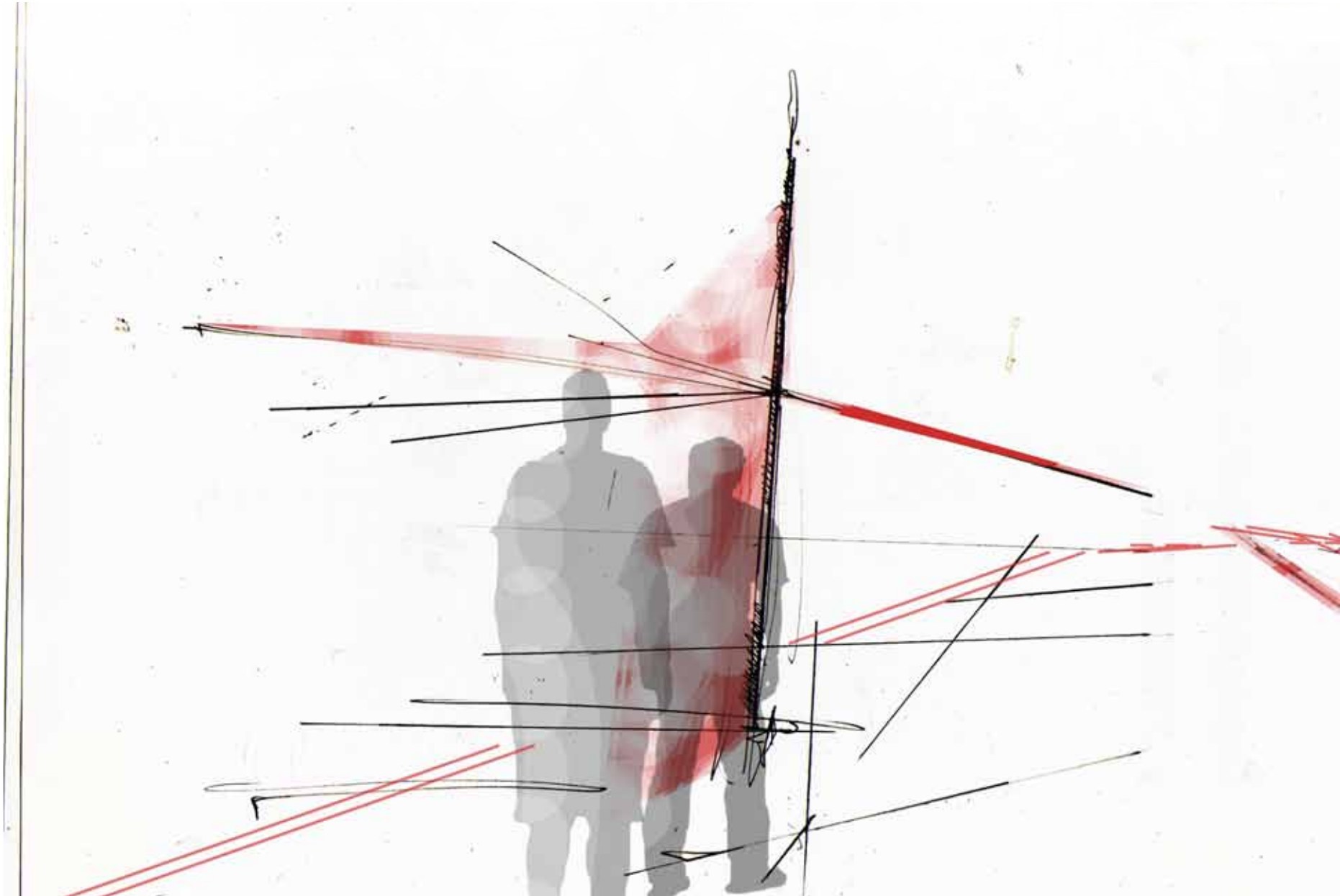
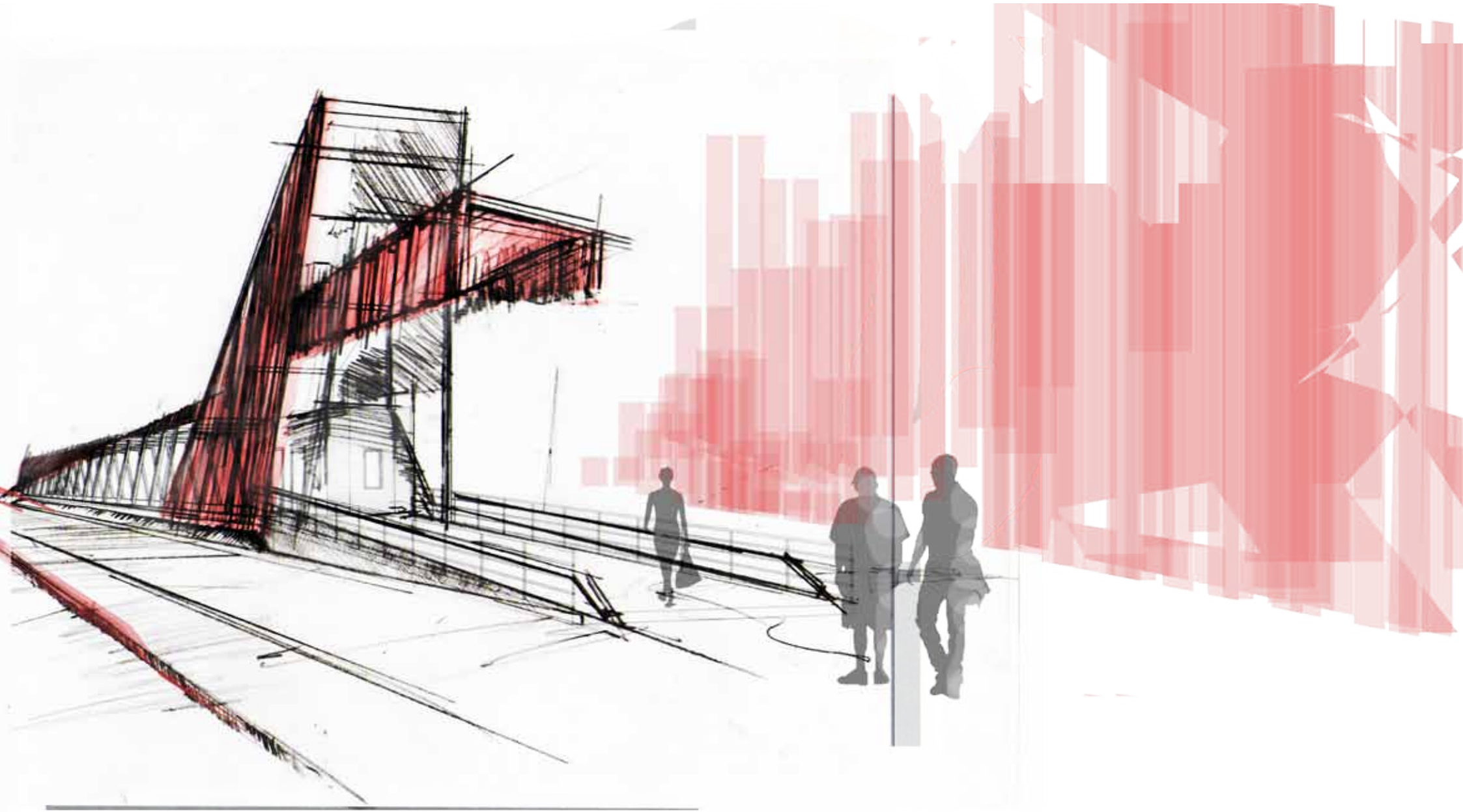


11 BRT PROTOTYPE DESIGN



The BRT prototype developed out of the theoretical research and the conceptual development of the BRT terminal building.
The prototype is designed more specifically for the first stage of the BRT system in Tshwane
– the Line 1 connecting the northern suburbs with the city centre.

The architectural language developed out of the conceptual investigation for the BRT terminal building as well as the need to respond to its immediate context and the city. It was decided to develop a lower scale structure that blends into the urban context – while the entrance is articulated with a steep sloping roof. The use of diagonal lines refer to the experience of speed and movement. **The high entrance becomes a recognisable node within the urban context**

The design of the prototypical station will continue into the next semester and culminate in a finalised design.

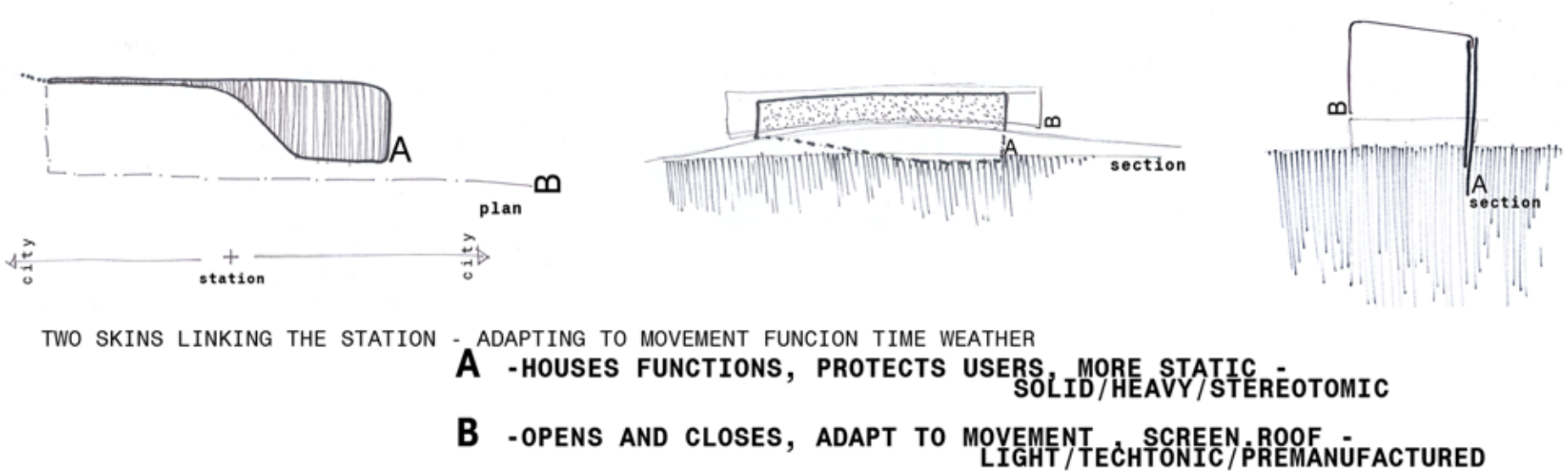
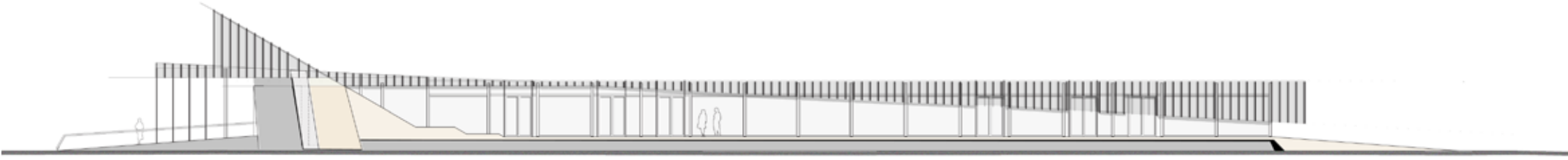
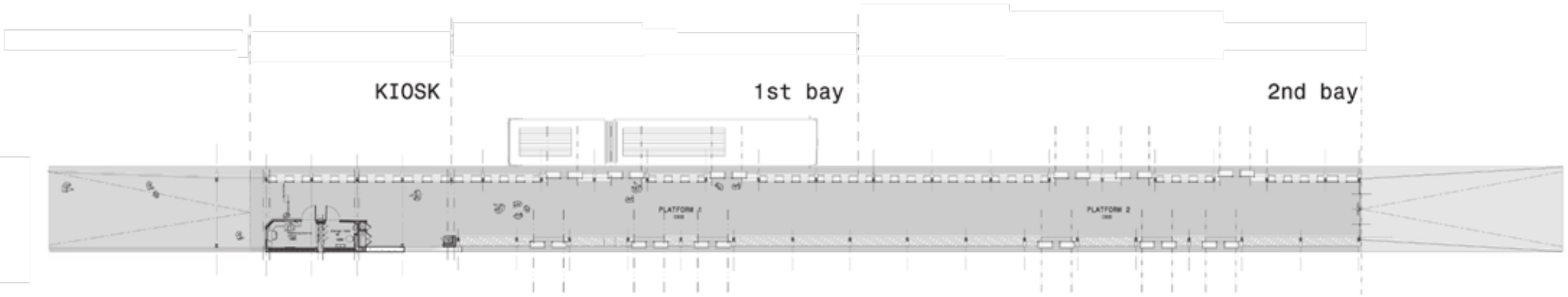


Figure 11-01: Conceptual approach to the design of the BRT station [Source: Author]



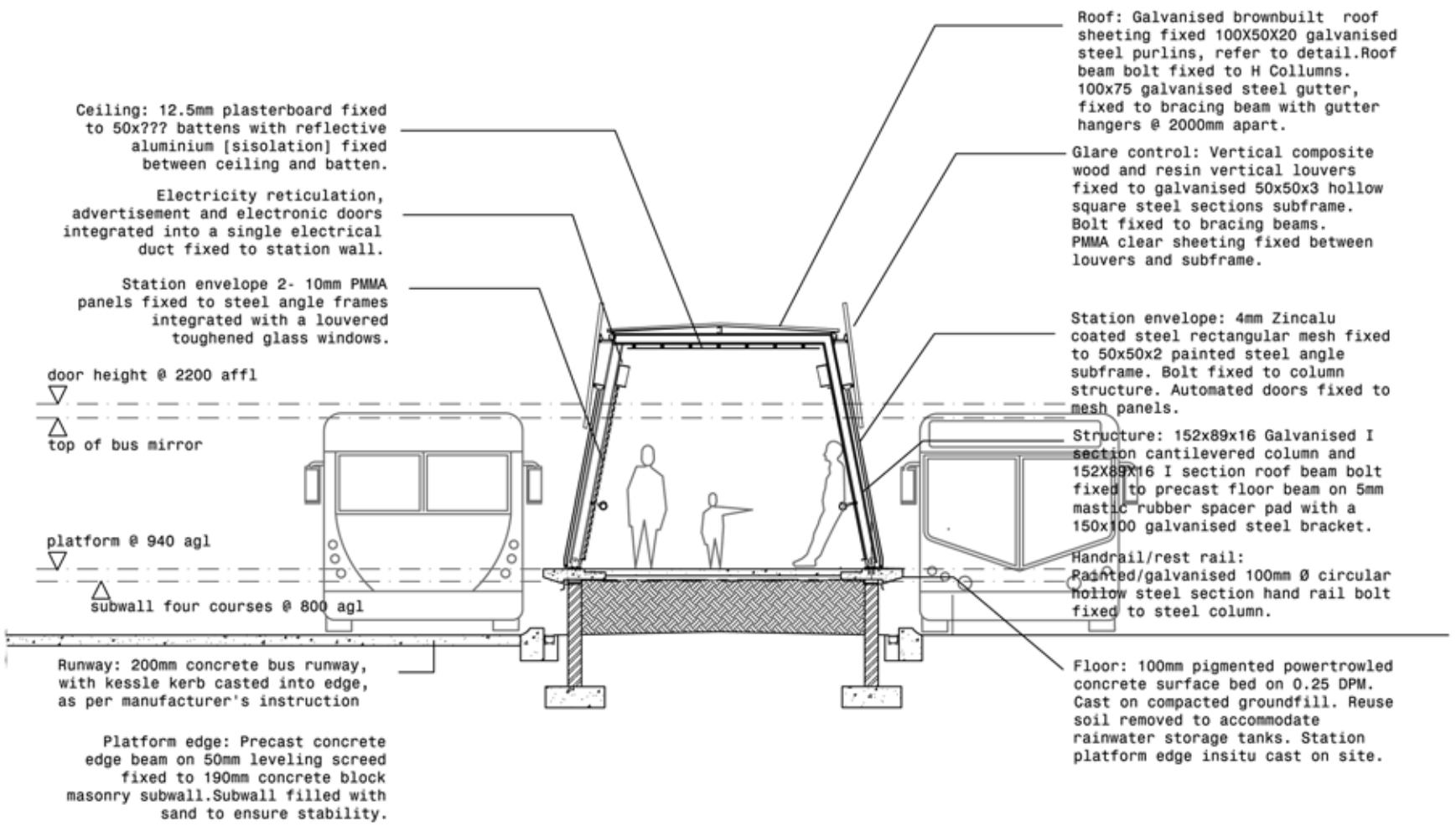
ELEVATION 1

Figure 11-02: Elevation [A] of the BRT station [Source: Author]



PLAN

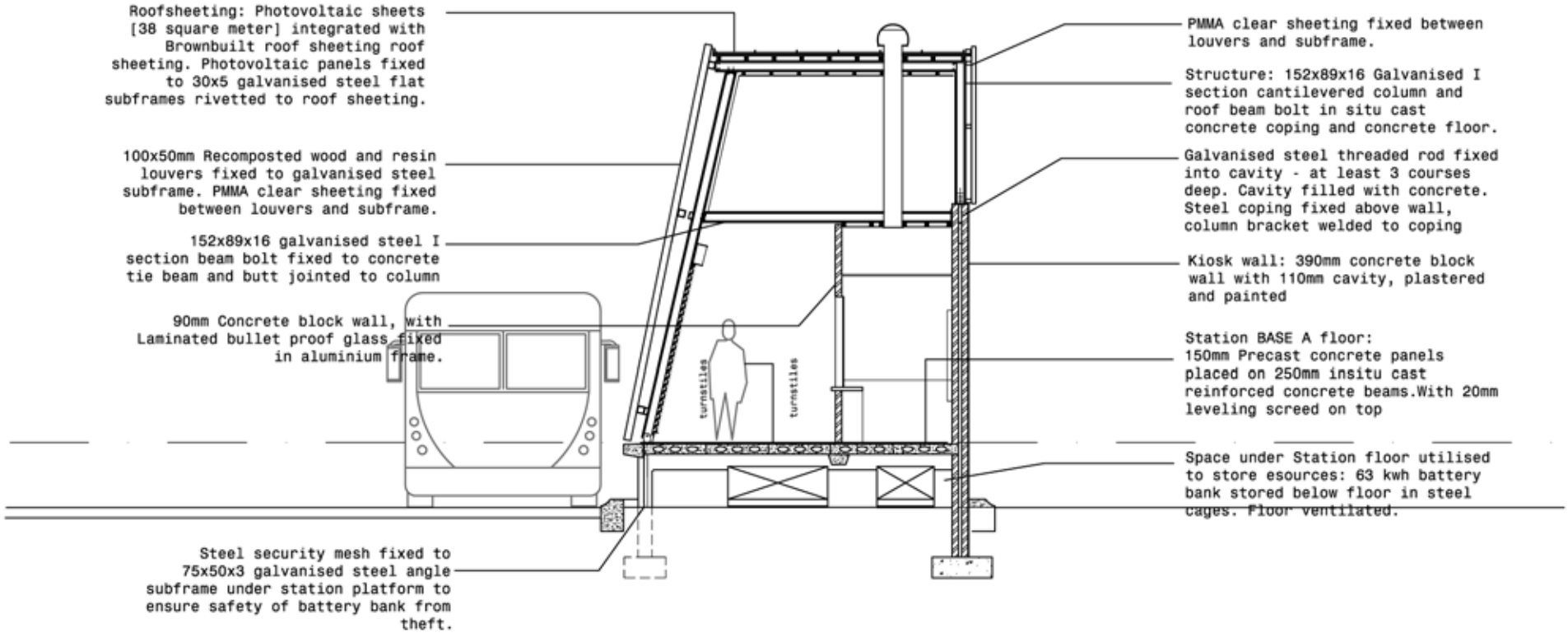
Figure 11-03: Plan of the BRT station [Source: Author]



SECTION AA

- typical section through station

Figure 11-04: Typical section AA of the BRT station [Source: Author]



SECTION BB
- typical section through kiosk

Figure 11-05: Typical section BB of the BRT station [Source: Author]

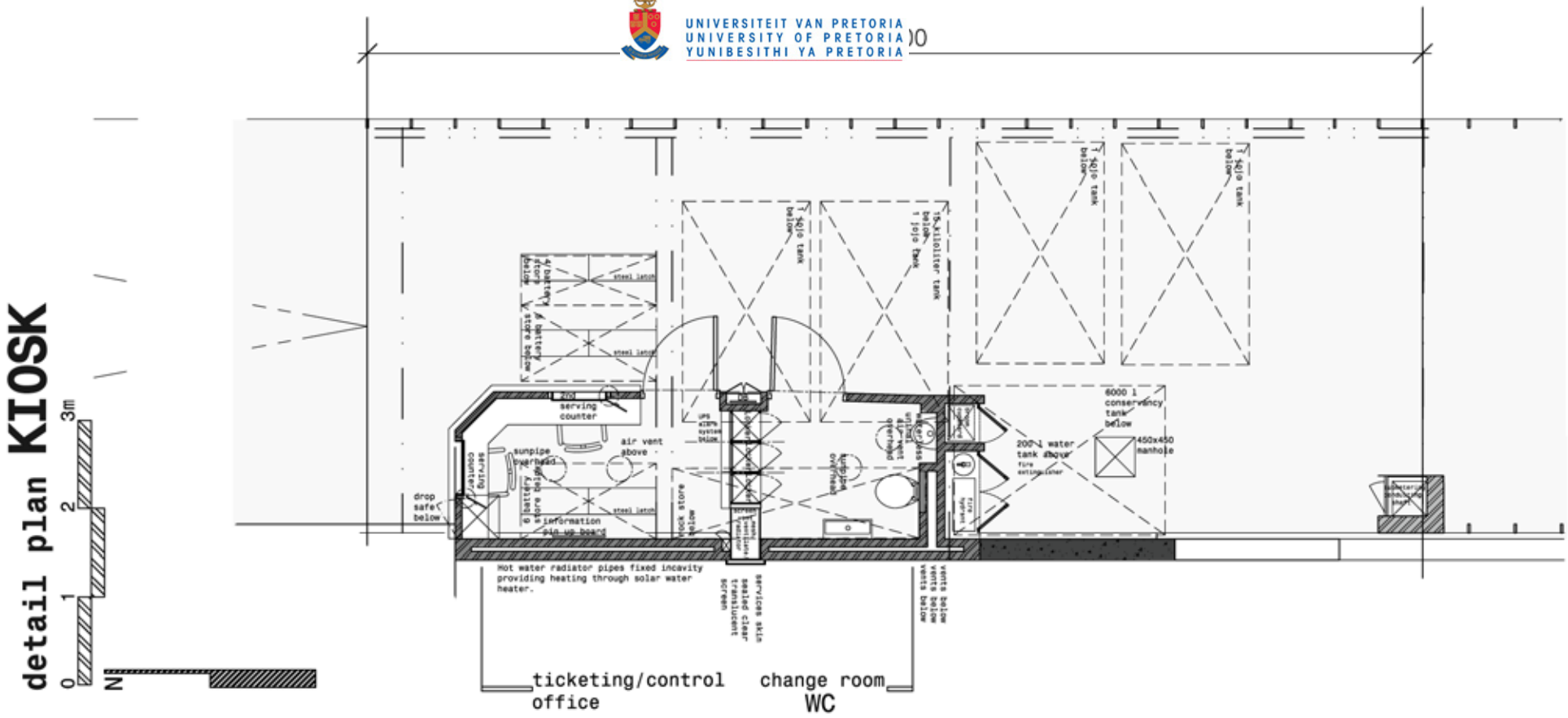
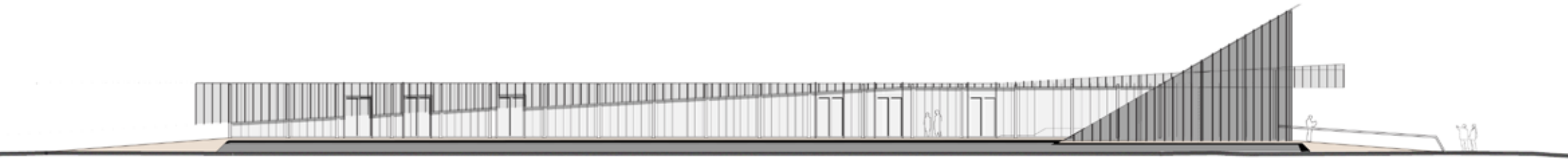
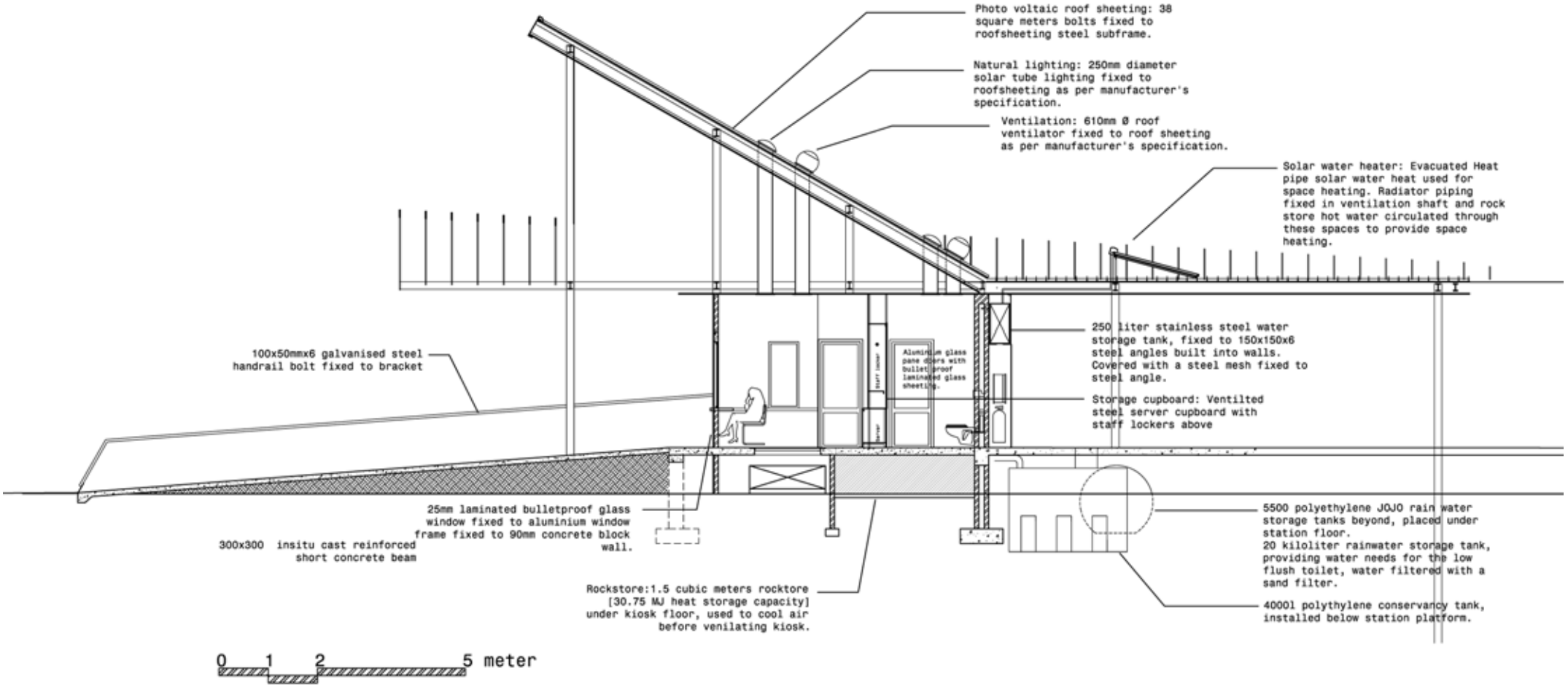


Figure 11-06: Detail plan of Kiosk [Source: Author]



ELEVATION 2

Figure 11-07: Elevation [B] of the BRT station [Source: Author]



SECTION CC
- section through station entrance

Figure 11-08: Detail section CC of entrance [Source: Author]

11.2 STRUCTURE AND SYSTEMS

The structural systems and service systems used in the BRT station were developed along with the terminal building and are elaborated on in the chapter 10. The following aspects regarding the prototype will be discussed:

a) Structural system and material use
b) Energy used and harvesting
c) Ventilation system
d) Water harvesting.

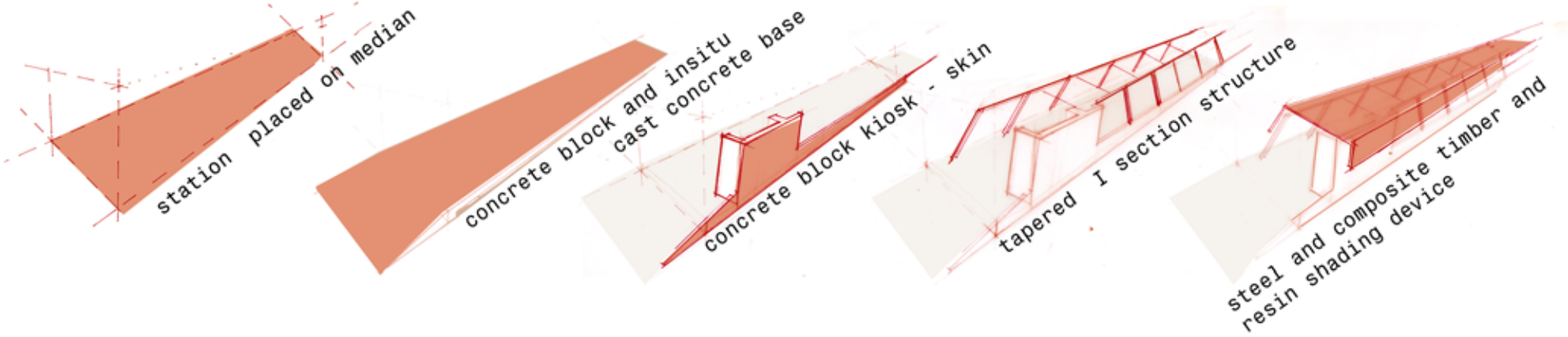


Figure 11-09: Structural components of the BRT station [Source: Author]

11.2.1 Structural system and material choice.

The structural system and material choice for the BRT station focuses on minimizing the embodied energy and carbon footprint of the station. The materials were also chosen according to the framework established [refer to section 4.4] and focused on materials that are robust enough to withstand the high usage of the station.

The station base is a100 mm power trowled concrete surface bed cast on soil infill and 190mm concrete block subwalls. The station edge is an insitu cast reinforced concrete edge. This approach will contain 46% less embodied energy than casting the whole station base in concrete, refer to Table 13-12, pg 287. Local labour will be used for the construction that will contribute to social and economical sustainability.

The ticket office will be constructed from concrete blocks. A plastered 240mm cavity walls has the lowest embodied energy, refer to Table 13-05, pg 283, as well as a high thermal mass.

The roof and envelope structure is a dry construction process. The galvanized steel structure is constructed out of 152x89x16kg/m I-beam column and beam structures.

By tapering the structure 17% steel will be saved – lowering the embodied energy of the structure [refer to Tables 13-16, pg 289].

Only one side of the station is enclosed with PMMA sheeting protecting for the commuters from driving rain and wind. This materialhas a high embodied energy but will be strong enough to withstand vandalism.

11.2.2 Heating and ventilation system

The station waiting area will be naturally ventilated. As the commuters will only wait 5 minutes on average for the next bus it will not be energy efficient to cool/heat the waiting areas.

The ticket office will need to be heated during the winter, refer to Graph 13-03, pg 296. **Heat evacuated tubes [Apricus 2010] are fixed to the roof from which very hot water is circulated through the rock store and concrete wall to provide space heating.** The water circulates in 20mm copper pipes.

610mm Ø roof ventilators is fixed in the roof of the office to draw air through the 1.5 m^3 rockstore into the office [Turbovent 2010]. One ventilator has a exchange rate of 6150 m3 /hr will mean that the office will have an air change rate of 0.5 per hour [Turbovent 2010].

11.2.3 Energy use and harvesting

The daily energy consumption of the station has been calculated as 22kWh per day, refer to Tables 13-24+25 , pg 293-4. **A photovoltaic system, 35m^2, is integrated with the roof sheeting [at 37° north facing] to provide renewable carbon free energy.**

The energy will be stored in a 63.9 kWh battery bank, this will be store in the base of the station under the floor, refer to Table 13-26, pg 294.

250mm Ø solar tubes are installed in the roofs of the ticket office and change room [solartube 2010]. A single solar tube provides adequate day lighting for 22 m^2 and will ensure that less artificial lighting is used during the day within the office [Solartube 2010].

11.2.4 Rain water harvesting

Water will be collected from the station roof, for the toilet. Four 5500l water storage tanks [JOJO tanks 2010] is positioned under the station floor to store 20 kiloliters, refer to Table 13-28, pg 295. This will provide enough water for the toilet, while a waterless urinal will be installed to minimise water consumption.

11.2.5 Carbon footprint & Environmental Rating

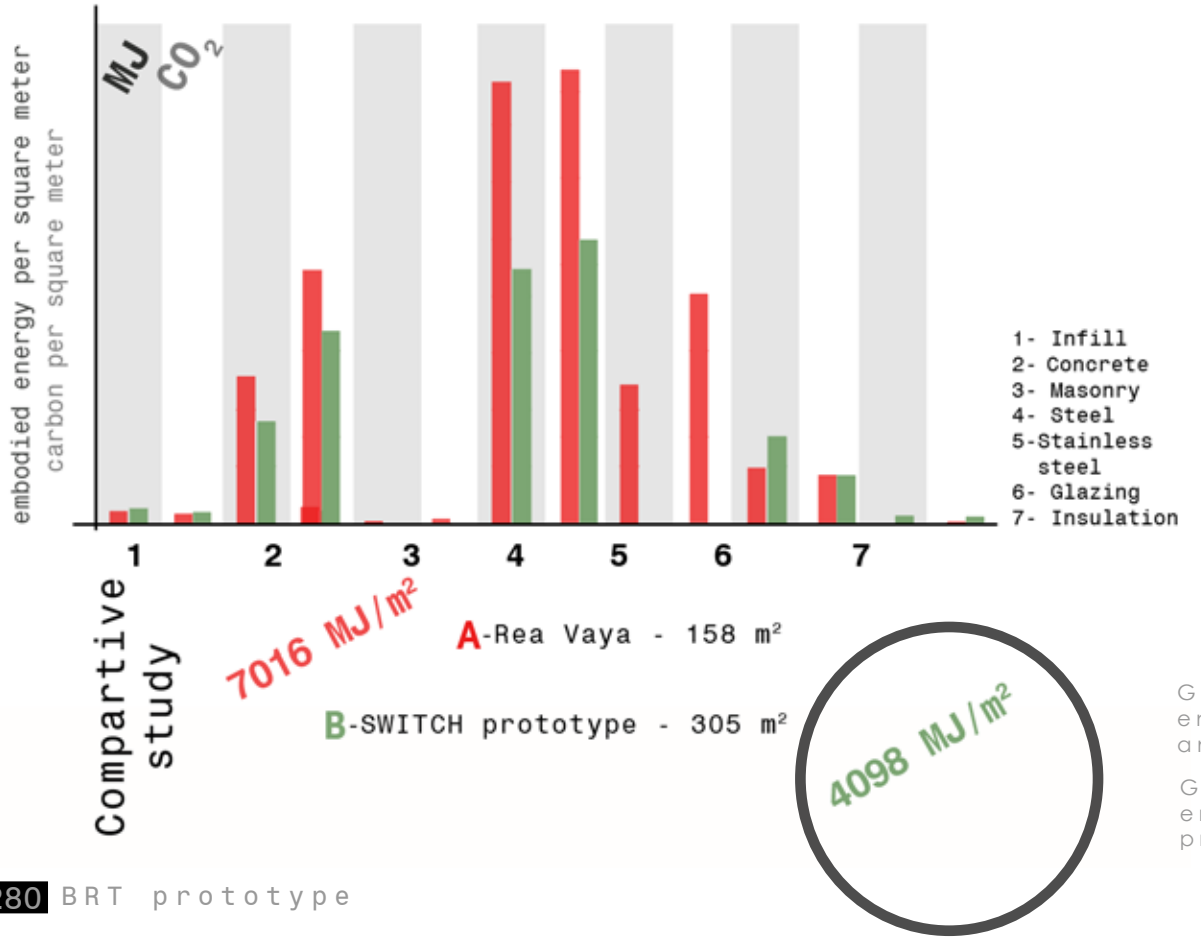
The carbon footprint and embodied energy of the prototypical station structure has been calculated and compared to a Rea Vaya BRT station in Johannesburg.

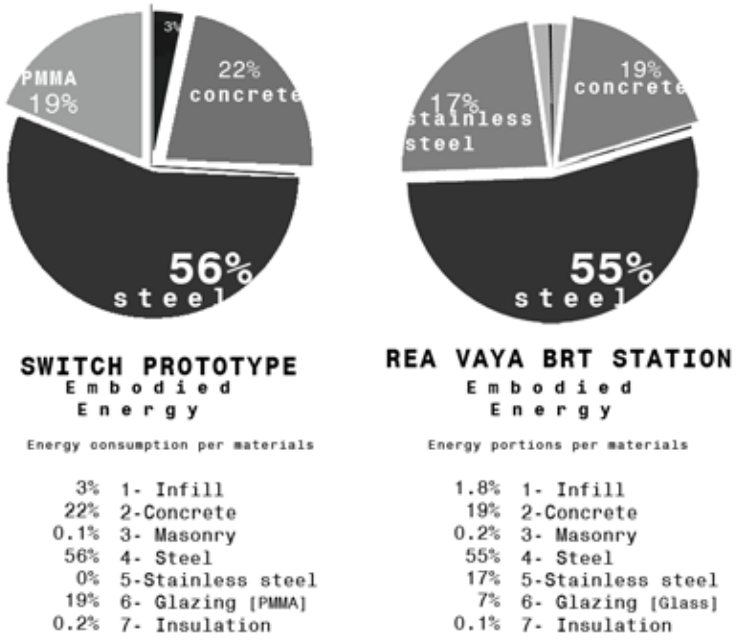
Figures used in the calculations were taken from the material analysis in section 4.4, pg 124.

The "Switch" prototype has a 42 % lower embodied energy and carbon footprint per square meter than the Rea Vaya BRT station.

The total embodied energy of the Switch prototype is 1 249 956 MJ [Table 11-01] while the Rea Vaya station has a total of 1 108 540 MJ [Table 4-02].

This can be attributed to the size difference of the two stations [158 m² - Rea Vaya; 305 m² - Switch], as the Switch prototypical station needs to be bigger to accommodate the high number of commuters from the northern suburbs in Tshwane that will be using the system.





Graph 11-01: Comparative study of the embodied energy and carbon footprint of the Switch prototype and Rea Vaya Station [Source Author]

Graph 11-02: Comparative study of the embodied energy of material use compared to the whole[Switch prototype and Rea Vaya Station] [Source Author]

EMBODIED ENERGY _ SWITCH PROTOTYPE

Material	Component	Size m3	kg/m³	Weight kg	MJ/kg	kg CO_2/kg	Embodied energy MJ	Carbon Footrpint KG
Infill aggregate	Infill base 780mm deep	202.7	2000	405 400	0.1	0.005	40540	2027
Concrete	Ramp	5.4	2400	12 960	2.42	0.256	31363.2	3317.76
	Ramp surface bed	10.8	1900	20 520	1.39	0.209	28522.8	4288.68
	low column [kiosk]	0.15	2400	360	2.42	0.256	871.2	92.16
	floor beam [kiosk]	0.828	2400	1 987	2.42	0.256	4809.024	508.7232
	Precast floor[kiosk]	8.55	2400	20 520	3.7	0.39	75924	8002.8
	skuins muur [east elevation]	3.9	2400	9 360	2.42	0.256	22651.2	2396.16
	Floor 100mm [power trowled]	27.7	1900	52 630	1.39	0.209	73155.7	10999.67
Concrete block	Low wall - retain	16	1900	30 400	0.81	0.098	24624	2979.2
Concrete block	Kiosk wall	8.17	1900	15 523	0.81	0.098	12573.63	1521.254
concrete floor	Ramp Paving	0	1900	0	1.39	0.209	0	0
Masonry	Ramp Paving	0	1900	0	0.81	0.098	0	0
Alumium	Doors frame							
Steel	Steel "vastrap"@ bus entrance	0	8000	0	29.44	2.22	0	0
	I-beam Collums	0.44	8000	3 520	29.44	2.22	103628.8	7814.4
	Roof beam	0	8000	0	29.44	2.22	0	0
	Purlins @ 700 centres	0	8000	0	29.44	2.22	0	0
	Bracing member C channels	0.15	8000	1 200	29.44	2.22	35328	2664
	Footings	0.0007	8000	6	29.44	2.22	164.864	12.432
	I-beam Collums [Kiosk]	0.15	8000	1 200	29.44	2.22	35328	2664
	Bracing member [kiosk]	0.026	8000	208	29.44	2.22	6123.52	461.76
	Footings	0.0001	8000	1	29.44	2.22	23.552	1.776
	Corrugate roof	0.0.09	8000	8 000	39	2.82	312000	22560
	Corrugate roof [kiosk]	0.22	8000	1 760	39	2.82	68640	4963.2
	Corrugated Ceiling	0	8000	0	31.5	0.256	0	0
	Steel facia board	0.0012	8000	10	29.44	2.22	282.624	21.312
	Steel door frames	0	8000	0	29.44	2.22	0	0
	Steel gate	0	8000	0	29.44	2.22	0	0
	Steel handrail	0.2	8000	1 600	29.44	2.22	47104	3552
	Steel handrail [ramp]	0.053	8000	424	29.44	2.22	12482.56	941.28
	Window structural frame	0.248	8000	1 984	29.44	2.22	58408.96	4404.48
	Louver frame	0.0078	8000	62	29.44	2.22	1837.056	138.528
	Window bead	0	8000	0	29.44	2.22	0	0
Stainless Steel	Handrail	0	7500	0	56.41	6.15	0	0
	Seat -rest	0	7500	0	56.41	6.15	0	0
	Stainless steel office	0	7500	0	56.41	6.15	0	0
	Bus entrance handrail	0	7500	0	56.41	6.15	0	0
Glass	Glass elevation	0	2400	0	35	2	0	0
MESH*	elevation [west] [136m²]	136	5.92	805	56.41	2.53	45416.8192	2036.9536
PMMA	elevation [east]	1.6	940	1 504	80.5	2.53	121072	3805.12
PMMA	elevation [rain cover]	0.6	940	564	80.5	2.53	45402	1426.92
	Glass door BRT door	0.09	2400	216	35	2	7560	432
	Glass panel @ kiosk [bullet proof]	0.1	2400	240	35	2	8400	480
	Emergency exit	0.037	2400	89	35	2	3108	177.6
	Plastic louvers #	0.11	940	103	19	1	1964.6	103.4
	Ceiling	3.4	900	3 060	6.75	0.38	20655	1162.8
Insulation	Ceiling	0	11	0	28	1.35	0	0
						TOTAL	1249965.109	95957.3688
						Area	305	305
						per meter	4 098.25	314.61

used particle board figure - doubled the figure to use 35 MJ/kg
* used stainless steel embodied energy - will have to be analysed
calculated according to weigth per square meter - as per manufacturer's specification.

Table 11-01: Embodied energy and carbon footprint analysis of Switch prototypical BRT station [Source: Author]

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Rating of Switch BRT prototype

An Environmental rating assessment has been done for the Switch prototype. The Green Star Office Rating Tool was used and adapted to rate applicable aspects of the design.

Aspects assessed by the tool that were deemed not applicable were removed from the assessment process in an effort to give a fair rating.

Summary of Sustainability rating of Prototype*

* Green Star SA - Office Design V1 adapted and used.

		SCORE AVAILABLE	TOTAL ACHIEVED	%	WEIGHTING	WEIGHTED SCORE
Management						
	None of the credits were applicable to the design process.					
Indoor Environment Quality						
IEQ-1	Ventilation Rates	3	3			
IEQ-2	Air Change Effectiveness	2	2			
IEQ-3	Carbon Dioxide Monitoring & Control	1	0			
IEQ-4	Daylight	3	3			
IEQ-5	Daylight Glare Control	1	1			
IEQ-7	Electric Lighting Levels	1	1			
IEQ-8	External Views	2	2			
IEQ-9	Thermal Comfort	2	0			
IEQ-10	Individual Comfort Control	2	2			
IEQ-11	Hazardous Materials	1	0			
IEQ-12	Internal Noise Levels	2	0			
IEQ-13	Volatile Organic Compounds	2	0			
IEQ-14	Formaldehyde Minimisation	1	0			
IEQ-15	Mould Prevention	1	1			
IEQ-16	Tenant Exhaust Riser	1	0			
IEQ-17	Environmental Tobacco Smoke Avoidance	1	1			
	TOTAL	**26**	**16**	**61.53846**	**0.15**	**9.230769231**
Energy						
ENE-1	Greenhouse Gas Emissions	20	20			
ENE-2	Energy Sub-metering	2	2			
ENE-3	Lighting Power Density	4	3			
ENE-4	Lighting Zoning	2	0			
ENE-5	Peak Energy Demand Reduction	2	2			
	TOTAL	**30**	**27**	**90**	**0.25**	**22.5**
Transport						
TRA-3	Cycle Facilities	3	0			
TRA-4	Commuting Mass Transport	5	3			
TRA-5	Local Connectivity	2	2			
	TOTAL	**10**	**5**	**50**	**0.09**	**4.5**

		SCORE AVAILABLE		TOTAL ACHIEVED	%	WEIGHTING	WEIGHTED SCORE
Water							
WAT-1	Occupant Amenity Water	5		5			
WAT-2	Water Meters	2		0			
WAT-4	Heat Rejection Water	4		4			
WAT-5	Fire System Water Consumption	1		0			
	TOTAL	**12**		**9**	**75**	**0.14**	**10.5**
Materials							
MAT-1	Recycling Waste Storage	2		0			
MAT-3	Reused Materials	1		0			
MAT-4	Concrete	3		1			
MAT-7	PVC Mininisation	1		0			
MAT-9	Design for disassembly	1		1			
Mat-10	Dematerialisation	1		1			
Mat- 11	Local Sourcing	2		1			
	TOTAL	**11**		**4**	**36.36364**	**0.13**	**4.727272727**
Land Use & Ecology							
ECO_2	Reuse of Land	2		2			
ECO-4	Change in ecological value	4		0			
	TOTAL	**6**		**2**	**33.33333**	**0.07**	**2.333333333**
Emmissions							
EMI-1	Refrigerant/Gaseous ODP	1		1			
EMI-2	Refrigerant GWP	2		2			
EMI-4	Insulant ODP	1		0			
EMI-5	Watercourse Pollution	3		0			
EMI-6	Discharge to Sewer	5		0			
EMI-7	Light Pollution	1		1			
EMI-8	Legionella	1		1			
	TOTAL	**14**		**5**	**35.71429**	**0.08**	**2.857142857**
	TOTAL SCORE						56.64851815
	WEIGHTED SCORE	exluding Management credits					**62%**
	RATING	**FIVE STAR RATING**					

Table 11-02: Environmental assessment summary [Source: Author - based on the Green Star SA - Office V1 rating tool]

This assessment does give one a fair idea of the performance of the Switch prototypical station, though one must keep in mind that this tool focusses on office buildings and does not necessarily assess the appropriate design aspects.

The BRT prototype performs very well in terms of energy consumption, indoor environment, water conservation and public transport accessibility.

The design process focussed on the minimisation of material use - which has led to a low carbon footprint and embodied energy [refer to Graph 11-01]. This is not necessarily reflected in the rating assessment, which shows that a sustainable intervention has many more aspects to focus on.

Yet the fact that the BRT prototype scores a five star rating shows that the Green Star SA rating tools do focus to mitigating climate change as well.