

# 9. TECHNICAL INVESTIGATION

Key words: Rigid  
Dynamic  
Movement  
Open

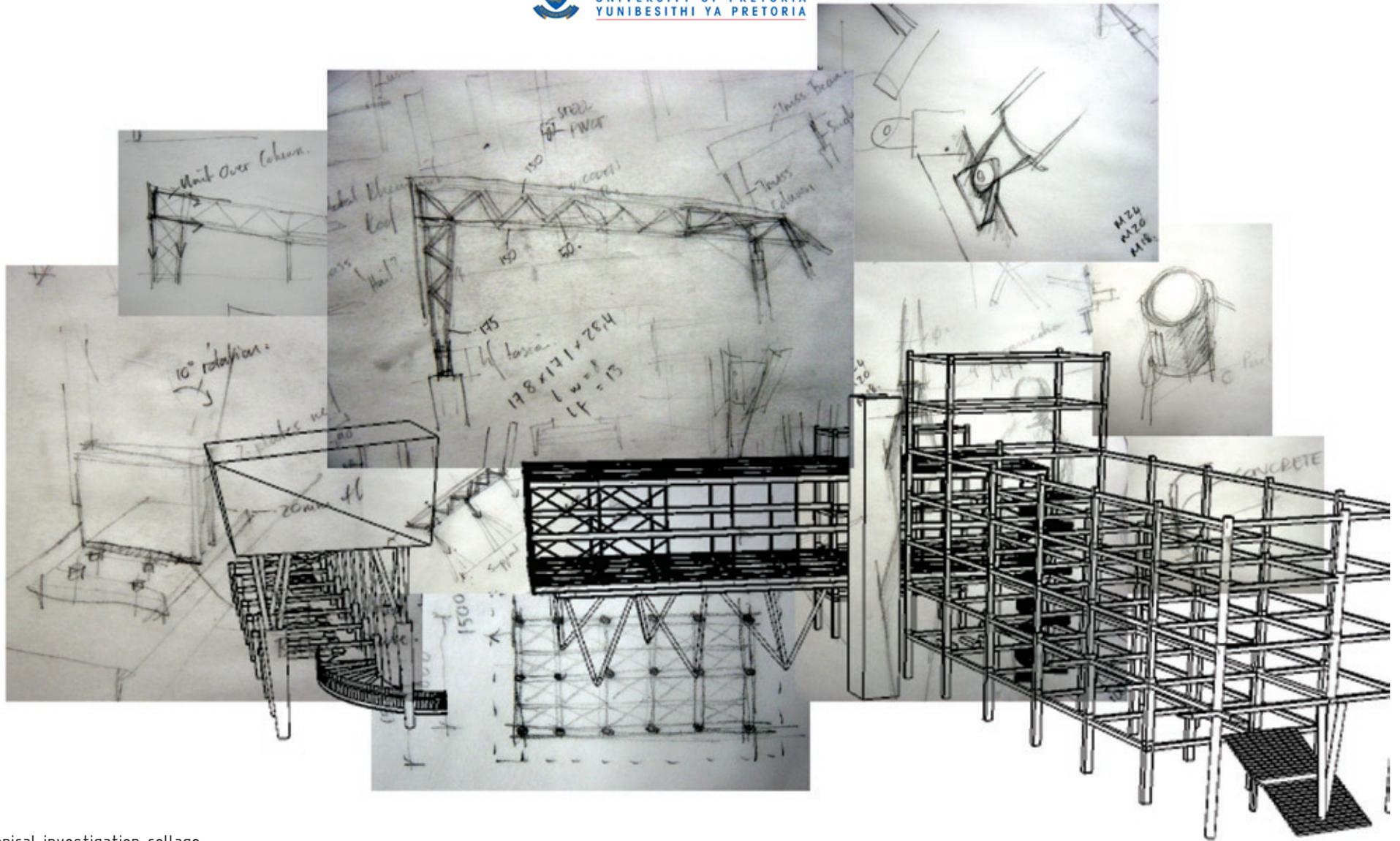


Fig 9.1: Technical investigation collage

## Basement

Following the design principle that the ground floor be demarcated for public and economic use, parking and services are allocated to the basement. The entrance and exit ramps servicing the basement are located in Paul Kruger Street.

The ramps have water drainage systems at street level and at basement level. The basement is a cavity construction and therefore sumps are used to drain floor water to the water filter storage tank in the north-east corner (the lowest point in the basement). Due to the proximity of the site to the Apies River flowing through the Zoological Gardens, the basement is waterproofed with a 0.45mm polyolefin damp proof membrane and a perforated footing pipe 150mm in diameter is laid alongside the retaining wall footing.

The basement is ventilated using a combination of passive and mechanical devices. Intake air occurs in the centre line of the basement by means of floor openings provided by planter boxes. The air is then mechanically swept and extracted around the perimeter by twelve 10,000l/s m<sup>2</sup> fans. The air outlets are punctuated through ground level to form large steel features in the market and urban square.

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The basement has a structural grid system of 8000mm in the east-west direction and 9000mm in the north-south direction. Cars park in the north-south direction. Columns are 700x300mm reinforced concrete with column heads designed by the engineer. The longer span is aligned in the north-south direction to maximize parking. The columns are recessed 500mm in the parking bay to ensure easy navigation into the parking bay by motorists.

Services such as the delivery area and the plant room are located in the basement in proximity to the security room for quality control purposes. The stairs and elevator are located adjacent to the security room for safety purposes.

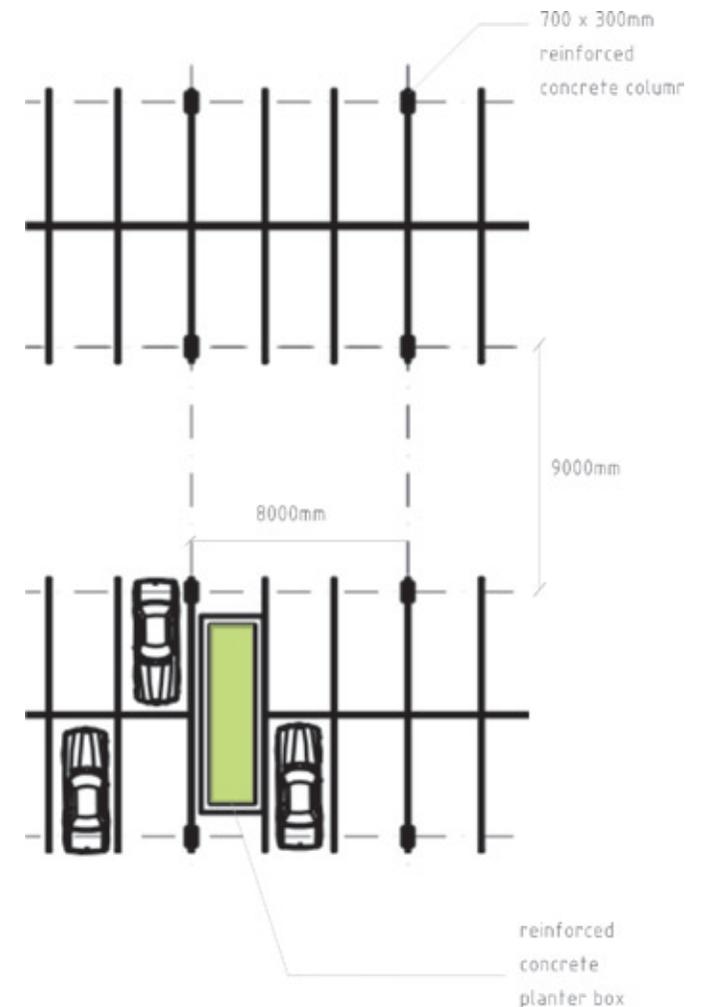


Fig 9.2: Basement parking

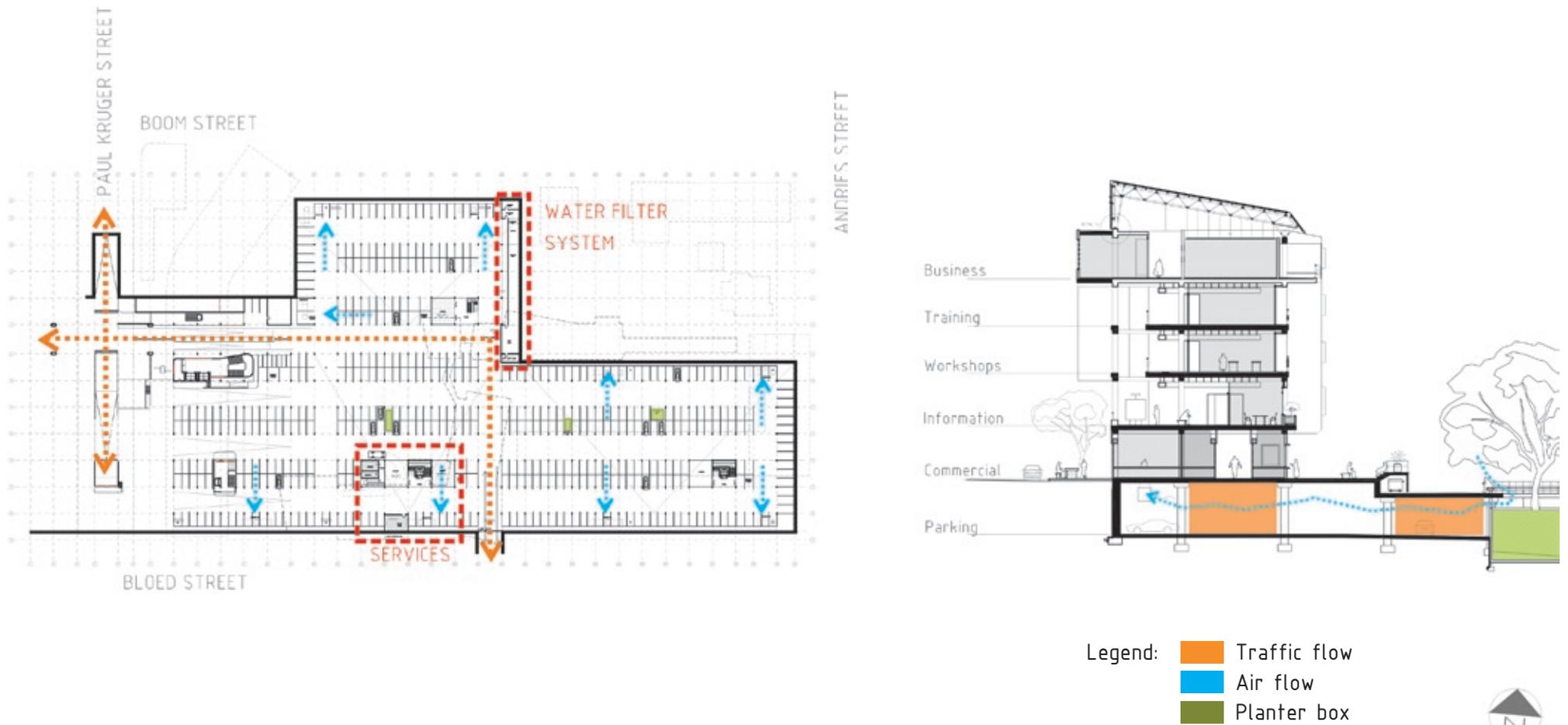


Fig 9.3: Basement plan and section



## Rigid Box

Following the grid system through to the ground floor, it is clear that the construction of the building requires large spans. The grid system of the building is 8000mm in the east-west direction. In the north-south direction it is 6000mm from the street build to line to the first grid line, and 9000mm from the first grid line to the second grid line.

A reinforced concrete slab and two-way beam system is used for the construction of the rigid component adjacent to Bloed Street. Concrete is used to create a heavy permanent structure that indicates its permanence in the urban context. The dimensions of the columns, slab and beams are calculated relative to the required span distance, as in Table 9.1, 9.2 and 9.3 (Orten 1990:30-54).

The horizontal slab element is expressed over the vertical column element. This is done to emphasize the horizontal linearity of the structure. The vertical element is expressed by certain 'free' columns and by the spiral staircase in order to juxtapose the horizontal linearity.

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Table 9.1: Column calculations

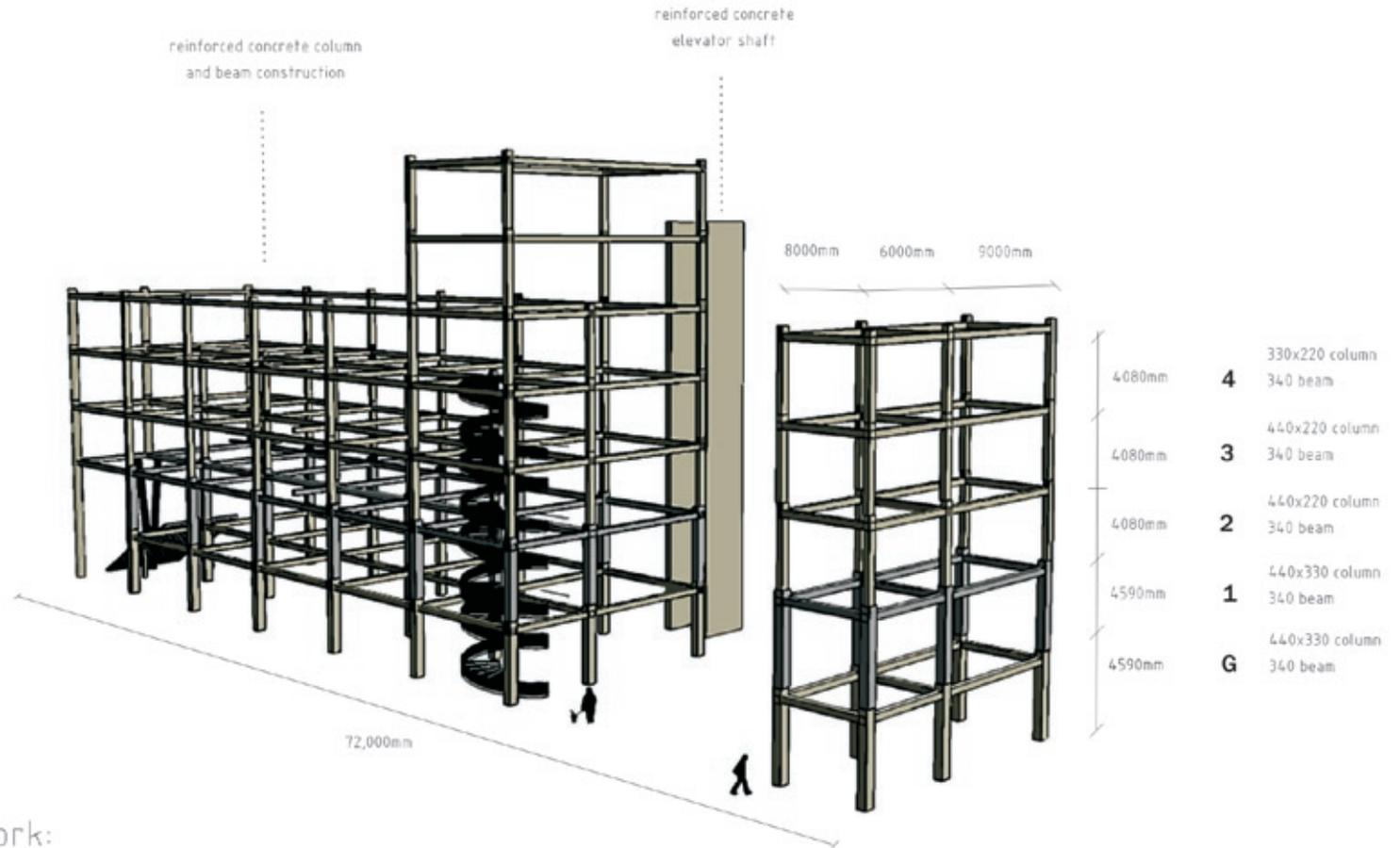
FLOOR	L/dmax	L/dmin	L/d (use)	SPAN (L) (mm)	DEPTH (d) (mm)	USE (mm)
<b>Basement</b>						
Wall	25	18	20	4590	226	330
Column	15	6	9	4590	510	700
Ground	15	6	12	4590	383	440
First	15	6	12	4590	383	440
Second	15	6	15	4080	272	330
Third	15	6	15	4080	272	330
Fourth	15	6	15	4080	272	330

Table 9.2: Slab calculations

SPAN (L) (mm)	L/dmax	L/dmin	L/d	DEPTH (d) (mm)	USE (mm)
9000	35	28	30	297	340
6000	35	28	33	184	340
8000	35	28	33	245	340

Table 9.3: Beam calculations

SPAN (L) (mm)	L/dmax	L/dmin	L/d	DEPTH (d) (mm)	USE (mm)
9000	35	28	30	297	330
6000	35	28	33	184	330
8000	35	28	33	245	330



### Concrete work:

Use min 30MPa concrete. All columns and beams to have softboard lining in formwork to achieve attractive finish and eliminate blow-holes and imperfections. Min 30mm concrete cover over steel reinforcement in concrete columns and beams.

Fig 9.4: Perspective of Rigid Box structure

Floors are covered with a 50mm screed consisting of one part cement and two parts sand. The floors are then finished with 2mm Cemcrete® Floorcrete in conjunction with Flexbond as per manufacturer's specifications. Interior and exterior walls are plastered with 3mm Skimplaster® and covered with two coats of Glutone® paint as per specified colour.

Exterior materials are robust and hard, consisting mainly of steel, aluminium and concrete. Interior materials are softer and consist of inlaid red clay tiles and hardwood doors and frames. The materials play on each other to form a contrast that represents the difference between the hard city and the soft human.

Electrical services are located in 600 x 300mm steel mesh rectangular shafts. The steel mesh is framed with 25x25x3,0 steel cold formed equal angles at the corners. The frame are suspended from the concrete roof with 12 diameter solid steel rods. The steel rods are connected to the shaft frame with steel cleats and M8 bolts.

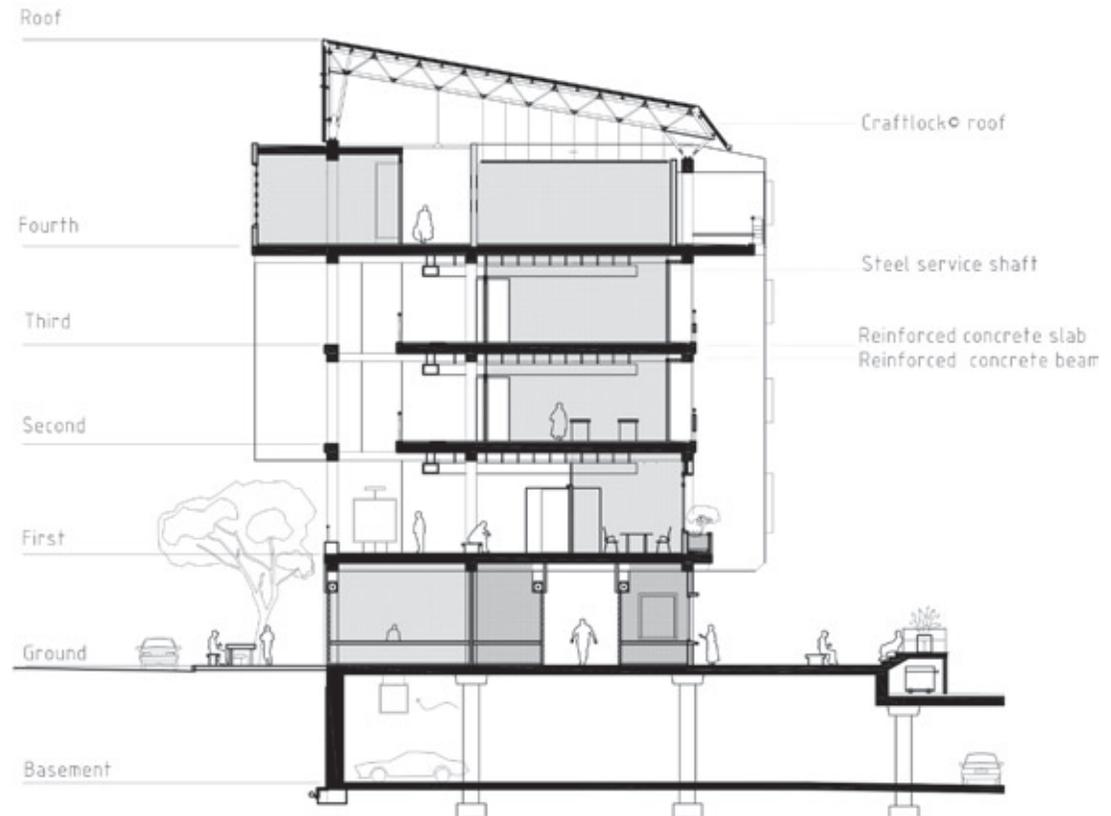


Fig 9.5: Section through rigid box

## TECHNICAL INVESTIGATION

The encompassing Craftlock® roof is supported by a bolt-connected steel truss system. The dimensions of the truss system are summarized in Table 9.4 (Orten 1990: 30-54).

The top and bottom rafters of the truss system have to be separated by a distance of 980mm. The truss rafters are 127x146x22kg/m steel T-sections cut from I-section while the bracing is 50x50x5 equal angle steel profile. Purlins are 250x50x20x3 cold formed steel lipped channels connected to the rafter by 125x75x8 steel angle cleats. High tensile bolts of grade 6.8 and 8.8 are used to ensure the stability of the structure.

The value of the roof is that all components are able to be removed and re-used if necessary. If the building is to expand in a vertical direction, it is important that the roof be able to be disassembled and reassembled with the minimum effort and use of new materials.

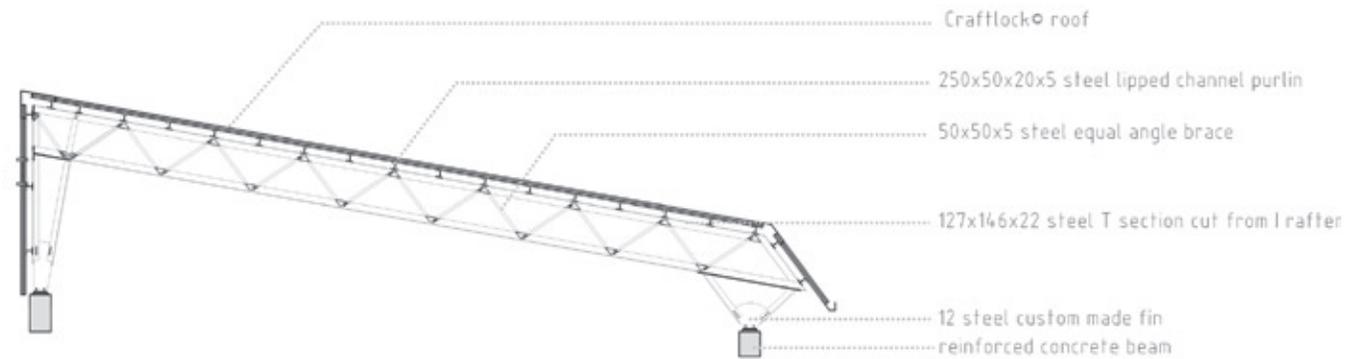


Fig 9.6: Roof truss structure

Table 9.4: Steel truss calculations

Element	SPAN (L) (mm)	L/dmax	L/dmin	L/d	DEPTH (d) (mm)	USE	PROFILE
Vertical	3500	25	20	22	162	127x146x22	T from I
Truss total	15000	18	10	15	978	980mm	
Truss element	3000	25	20	22	138	102x133x15	T from I
Bracing	1000	25	20	22	46	50x50x5	Equal angle
Purlins	8000	35	25	32	250	250x50x20x3	Lipped channel

## Factory

The factory is a dynamic box rotated 10° east from the north south axis of the grid. It is a steel framed rectangular box supported by circular steel columns. All steel is to be painted with two coats of zinc phosphate primer and two coats intumescent paint in order to comply with SABS 1319 before entering the site. The dimensions of the steel components are summarized in Table 9.5 (Orten 1990: 30-54).

The steel columns are made off site. They consist of 324x8 hollow circular profiles, of various lengths but with an average length of 5500mm. Welded to the ends of the columns are 10° tapered hollow steel cones with a length of 600mm. All columns are numbered during the manufacturing phase to ensure the correct placement upon construction.

The columns are welded to 12 thick steel endplates and bolted with grade 8.8 bolts to the factory truss support at the top and the fin support at the bottom. The top connections of the columns follow the structural grid of the factory, while the bottom connections follow the structural grid of the basement. The difference causes the columns to take a dynamic stance between the horizontal and vertical vectors.

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Table 9.5: Factory calculations

COMPONENT	L/dmax	L/dmin	L/d	SPAN (L) (mm)	DEPTH (d) (mm)	USE (mm)	PROFILE
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### Support Column

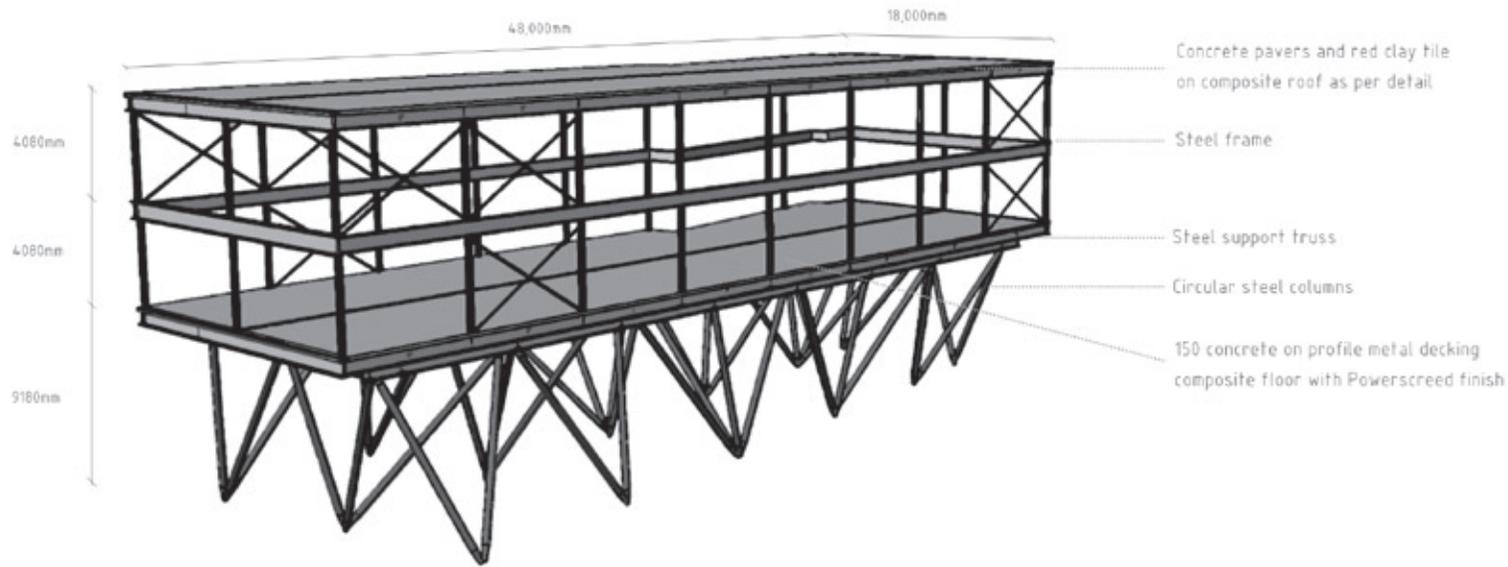
Vertical	35	20	20	5500	275	300	Circular
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### Factory Box

Vertical	25	20	23	4080	175	203x203x60	H-section
V Brace	35	25	30	1500	50	80x80x8	Equal angle
NS Beam	25	20	20	6000	300	305x305x137	H-section
EW Beam	25	20	25	3000	120	152x152x30	H-section
H Brace	35	25	30	3000	100	101x20x23	T cut from H
Floor				3000		385x41x0.6	Metal sheet

### Truss support

Truss total	12000	18	10	10	1200	1200	
NS Beam	25	20	20	6000	300	305x305x137	H-section
EW Beam	25	20	25	3000	120	203x203x60	H-section
H Brace	35	25	30	3000	100	101x20x23	T cut from H



### Steelworks:

All steel is to be painted with two coats zinc phosphate primer to comply with SABS 1319 before entering the site.

Structural steel is to be further painted with two coats intumescent paint to have fire resistance of minimum two hours.

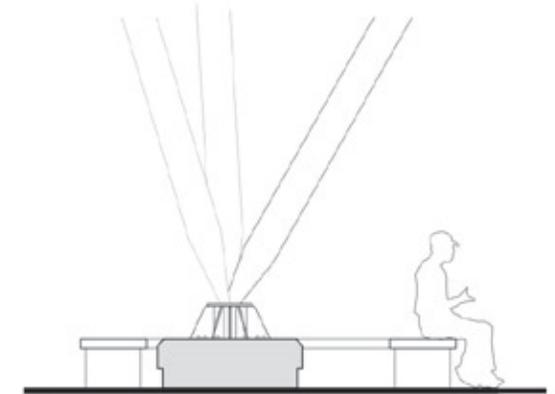
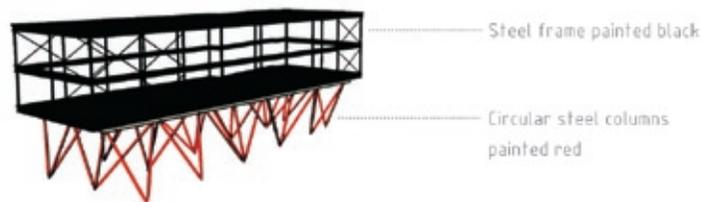


Fig 9.7: Perspective of factory frame with column foot detail



The truss support system conveys the dead and live loads from the factory to the vertical support columns. The truss has a vertical depth of 1200mm. The bottom rafter of the truss connects to the column support, while the top rafter of the truss forms the factory floor. The depth of the truss creates the illusion that the factory is floating above the support columns and therefore free from the urban context.

The bottom rafters of the truss in the north south direction are 305x305x137 steel H-sections. The east-west rafters are 203x203x60kg/m steel H-sections. Steel fins are placed at the connection points to prevent shear failure of the web. The east-west rafter is welded to a 125x75x8 steel angle cleat and bolted with high tensile bolts of grade 8.8 to the north south rafter. The top and bottom rafters are braced with 101x20x23 T-sections cut from H-sections. The brace beams are bolted to 10mm thick steel gussets, which are welded to the rafters. The gussets are custom made to have an elegant appearance and to follow the line of the brace beams.

The factory box has a structural grid of 6000mm in the north-south direction and 3000mm in the east-west direction. The north-south rafters are 305x305x137 steel H-sections and the east-west rafters are 152x152x30 steel H-sections. The east-west rafters are welded to 125x75x8 steel angle cleats and bolted with high tensile bolts of grade 8.8 to the north south rafters.

Additional support is provided in the north-south direction using 101x20x23 T-sections cut from H-sections. This allows the composite deck floor to become part of the bracing system, stabilizing the floor structure.

The composite floor consists of 150mm concrete cover over 385x41x0.6 ribbed metal floor sheet welded with shear metal studs to the east west rafter. A 50mm screed is used to cover the composite floor and finished with 15mm Powerscreed© to ensure that the factory has a durable, long-lasting low maintenance surface. The vibration of the floor due to the machinery is compensated for by using 25mm thick neoprene rubber between the steel and the concrete.

The east and south façades of the factory consist of aluminium framed sliding glass rectangular windows. The horizontal dimension of the windows is longer than the vertical dimension in order to emphasize the horizontal linearity of the structure. The use of sliding windows allows communication between the outside and the inside.

The factory can communicate with the street and with the market. The north façade opens up to an open foyer with aluminium framed glass pivot doors. The west façade is screened by using craft lock cladding. Steel stairs run along the western façade of the factory leading from the second floor level to the roof garden. Rectangular woven wire mesh screens the stairs from the harsh west sun and wraps around the bottom of the factory truss support to prevent birds from nesting in the steel truss system.



Fig 9.9: Plan of steel floor frame



Fig 9.10: Plan of steel truss frame

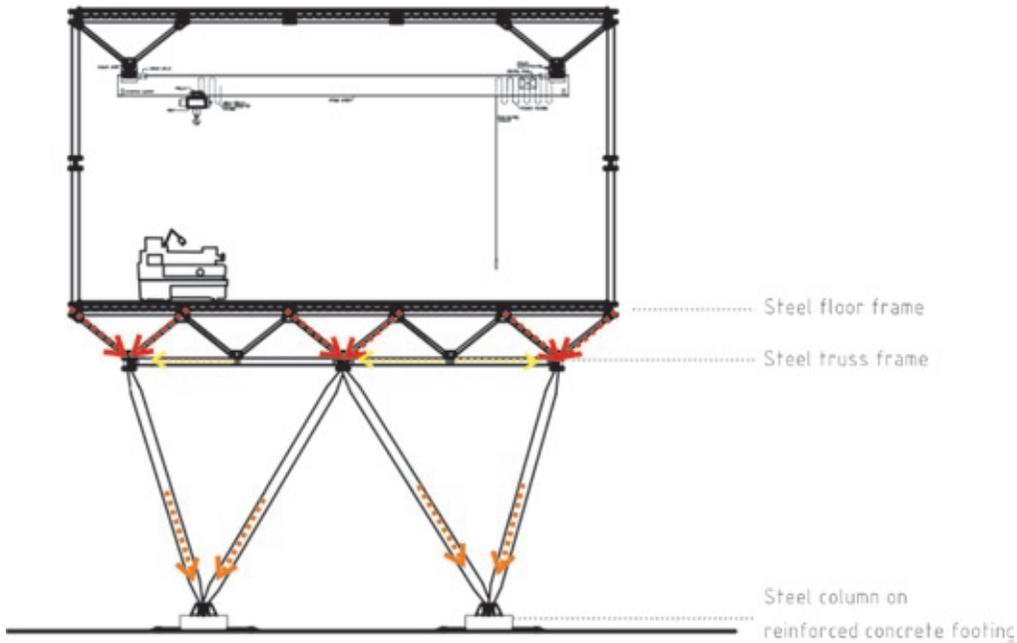


Fig 9.8: Section through factory structure



## White bridge box

A steel plated metal box painted white forms a bridge between the rigid box and the factory. The metal box is supported by 152x152x30 steel H-section rafters and spans from the rigid concrete structure to the north-south rafter of the factory.

The steel box is vertically supported using 100x100x5 steel hollow square sections at 3000mm centre. On the second floor, the metal box is the entrance to the factory from the rigid concrete structure. On the third floor, it functions as a boardroom overlooking the factory, and connected to the factory management office with a steel bridge spanning over the factory floor.

The boardroom is sound insulated using 50mm fiberglass between the metal sheet and the hardwood interior panels. On the fourth floor, it functions as a bridge between the roof garden and the rigid concrete structure.

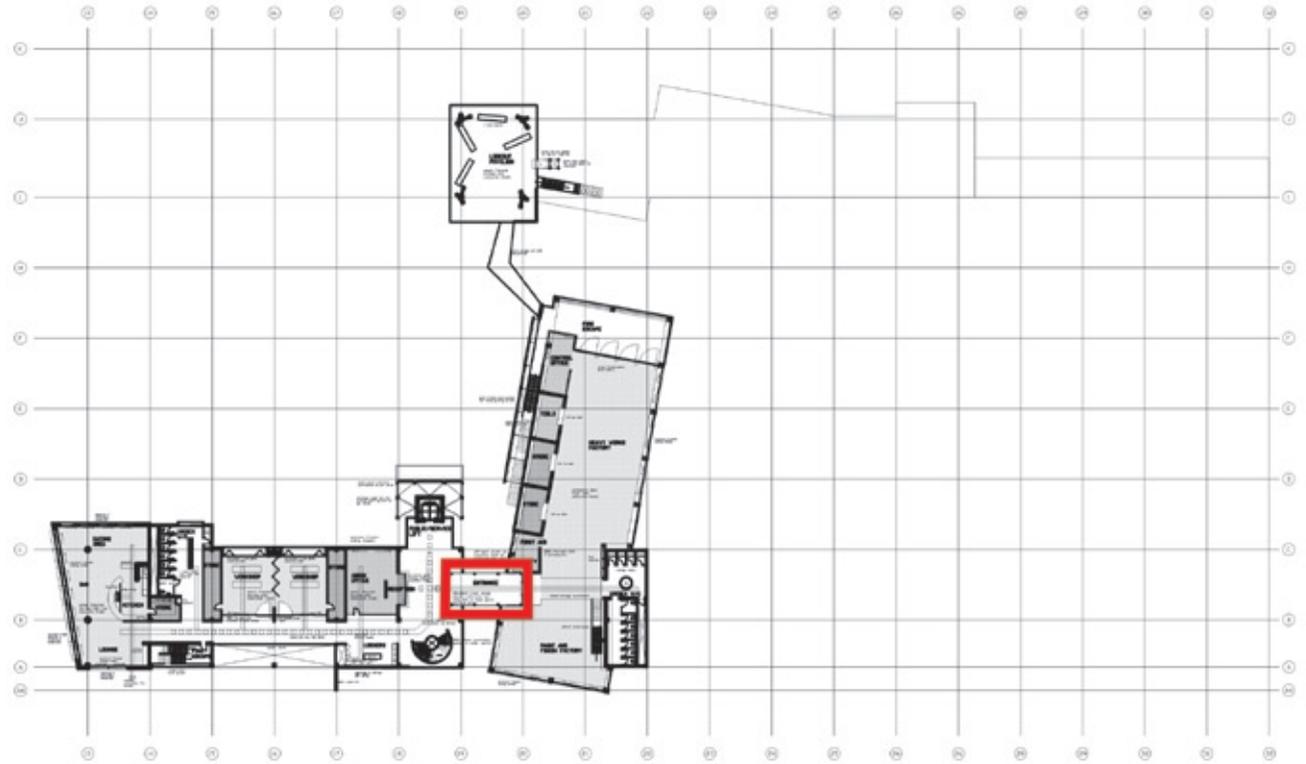


Fig 9.11: Bridge box on second floor plan

## TECHNICAL INVESTIGATION

## The Open Pavilion

The open pavilion is a culmination of the contrast between hard and soft, permanent and ephemeral. The pavilion is anchored to the ground level with robust off-shutter reinforced concrete columns following the grid pattern of the basement.

The roof is clad with acrylic Plexiglas Satinice® panels of various colours. The panels allow between 50 and 75% light transmission depending on the colour used. The velvet texture combined with the different colours gives the pavilion a colourful yet soft atmosphere.

Above the public shower facility, the roof is clad with Solardome® water heating panels. Water comes from the central reservoir to the Solardome® panels with a 150mm diameter uPVC pipe. The water is heated in the Solardome® panels and then stored in the geysers in the service shafts.

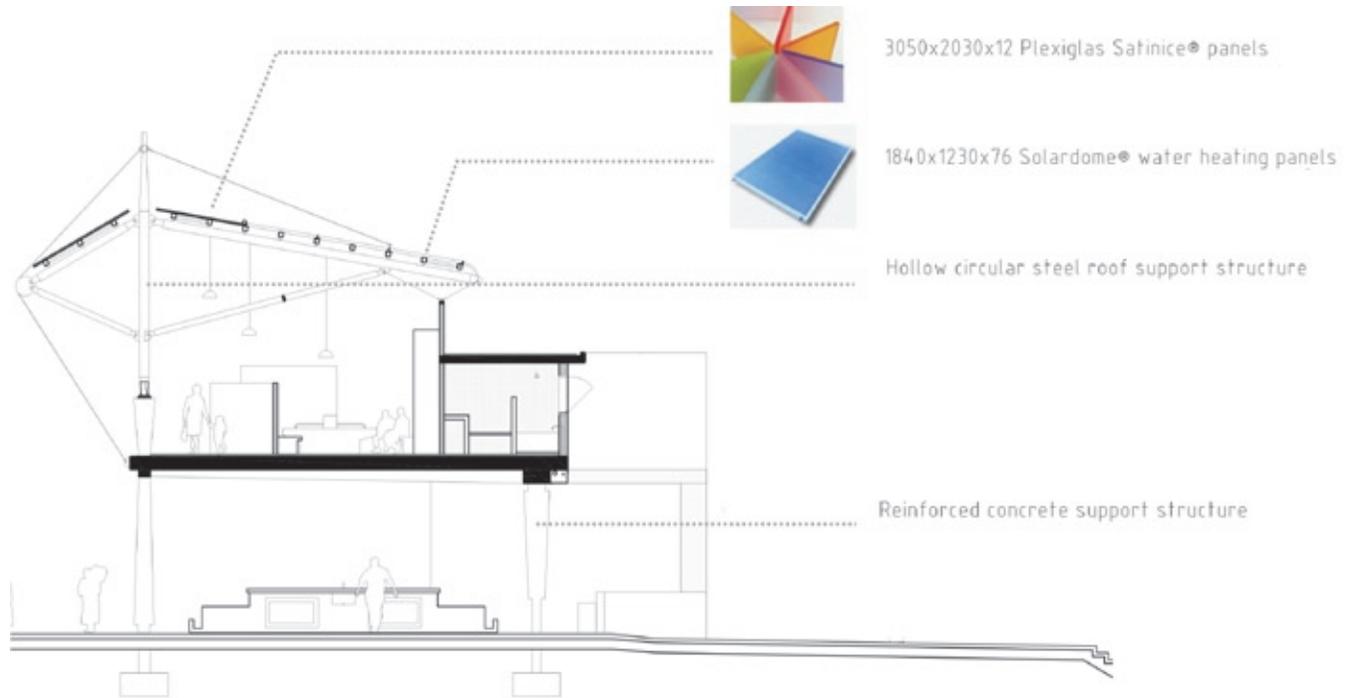


Fig 9.12: Section through open pavilion



The roof structure is supported by 276x6 hollow circular steel columns welded to 12 endplates and bolted to the concrete columns. Perpendicular rafters of 219x4,5 hollow circular steel profiles are pin-connected to the column with 10 custom made steel fins and high tensile bolts. The brace beams are 178x4,5 hollow circular steel profiles and rotated 45 degrees from the column. The brace beams are pin-connect to the rafters with 10 custom made steel fins and high tensile bolts.

The steel columns extend beyond the roof line in order to connect with the 6 wire tensile cable. The tensile cable is taken around a custom made steel disc with a groove and connected to the concrete floor slab in order to ensure structural stability of the roof.

The circular steel profile roof structure of the open pavilion communicates with the circular steel columns of the factory frame. The columns of the roof structure is painted red to enhance the perceived strength of the structure. The remaining elements (rafters, bracing and purlins) are painted black.

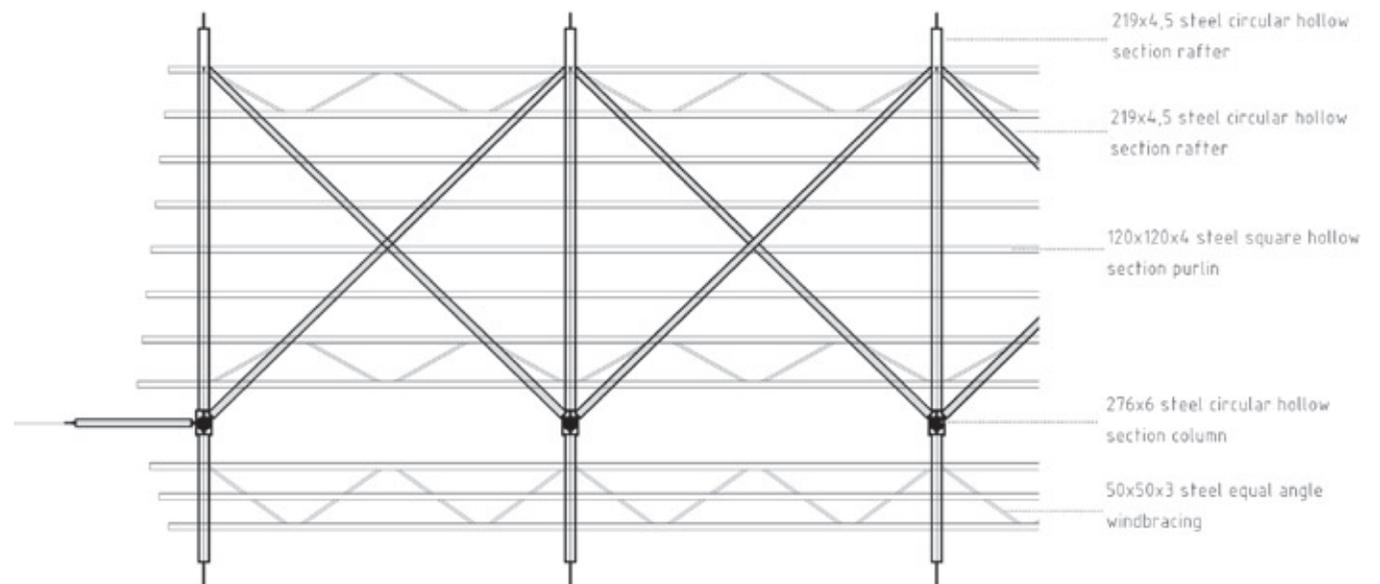


Fig 9.13: Plan of roof structure

## TECHNICAL INVESTIGATION

## Site water use

The 30-year average rainfall in the Pretoria CBD region is 674mm according to the South African Weather Agency (South African Weather Service 2007). The effective ground floor area of the market and urban square is 15,840m<sup>2</sup>. Thus, on average, 10,690m<sup>3</sup> rainwater is lost into the municipal storm water drains from the site every year.

The hard concrete and tile surface of the market and urban square allows the rainwater to be channelled to cast iron storm water drains. The 150mm diameter uPVC drain pipes are connected to the 180m<sup>3</sup> water storage tank in the basement. From the basement tank, the water is naturally filtered through sand, gravel and rock layers and mechanically pumped into the water reservoir in the centre of the site. The water reservoir stores 720m<sup>3</sup> water.

The reinforced concrete water reservoir has the capacity to store the water demand of the open pavilion for 6 months, as calculated in Table 9.6 and 9.7. The remainder of the water supply from the reservoir is used to clean the market and urban square and to irrigate the flora.

Table 9.6: Water storage

Activity	Consumption dm <sup>3</sup> (liter)	Description	Number (units)	Usage p/day	Demand (day) m <sup>3</sup>	Demand (6 month) m <sup>3</sup>
Shower	36	4minutes/person	11	6	2.38	434
Basin	3	handwash	18	4	0.22	39
Cook basin	5	dish wash	8	4	0.16	29
Toilet	9	per flush	9	8	0.65	118
<b>Total</b>					<b>3.40</b>	<b>621</b>

Table 9.7: Water demand

Acticity	Supply m <sup>3</sup>	Demand m <sup>3</sup>	% of Supply
Reservoir	720		
Basement	180		
<b>Total</b>	<b>900</b>		
Shower use		434	48
Basin		39	4
Cook basin		29	3
Toilet		118	13
<b>Total</b>			<b>69</b>



Average annual rainfall : 6  
Site area : 15,840m<sup>2</sup>  
Water volume : 7,485m<sup>3</sup>

Site drain : cast iron grid  
150 diameter uPVC pipe  
to south edge (lowest on site)

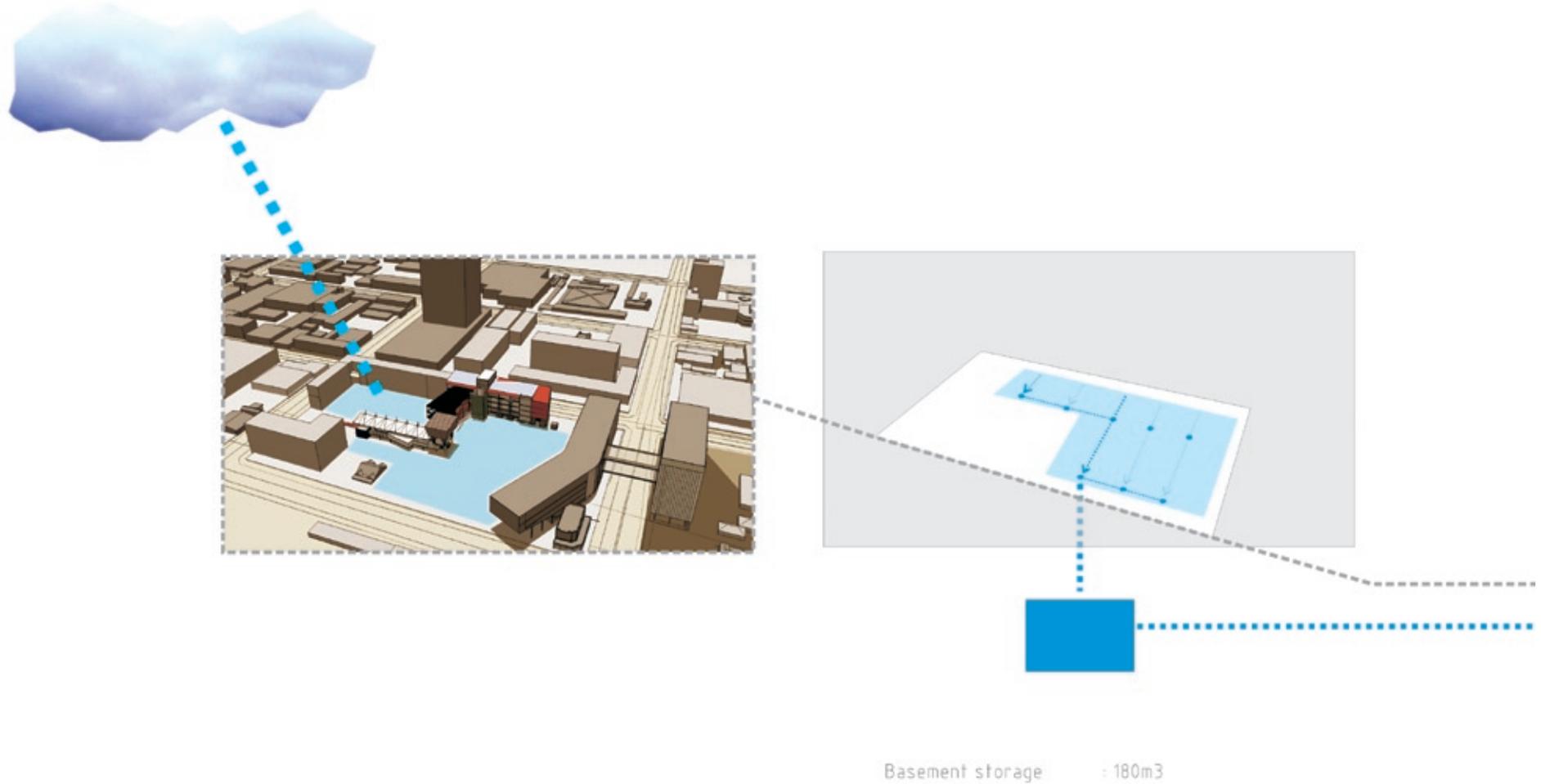


Fig 9.14: Diagram of site water use

TECHNICAL INVESTIGATION

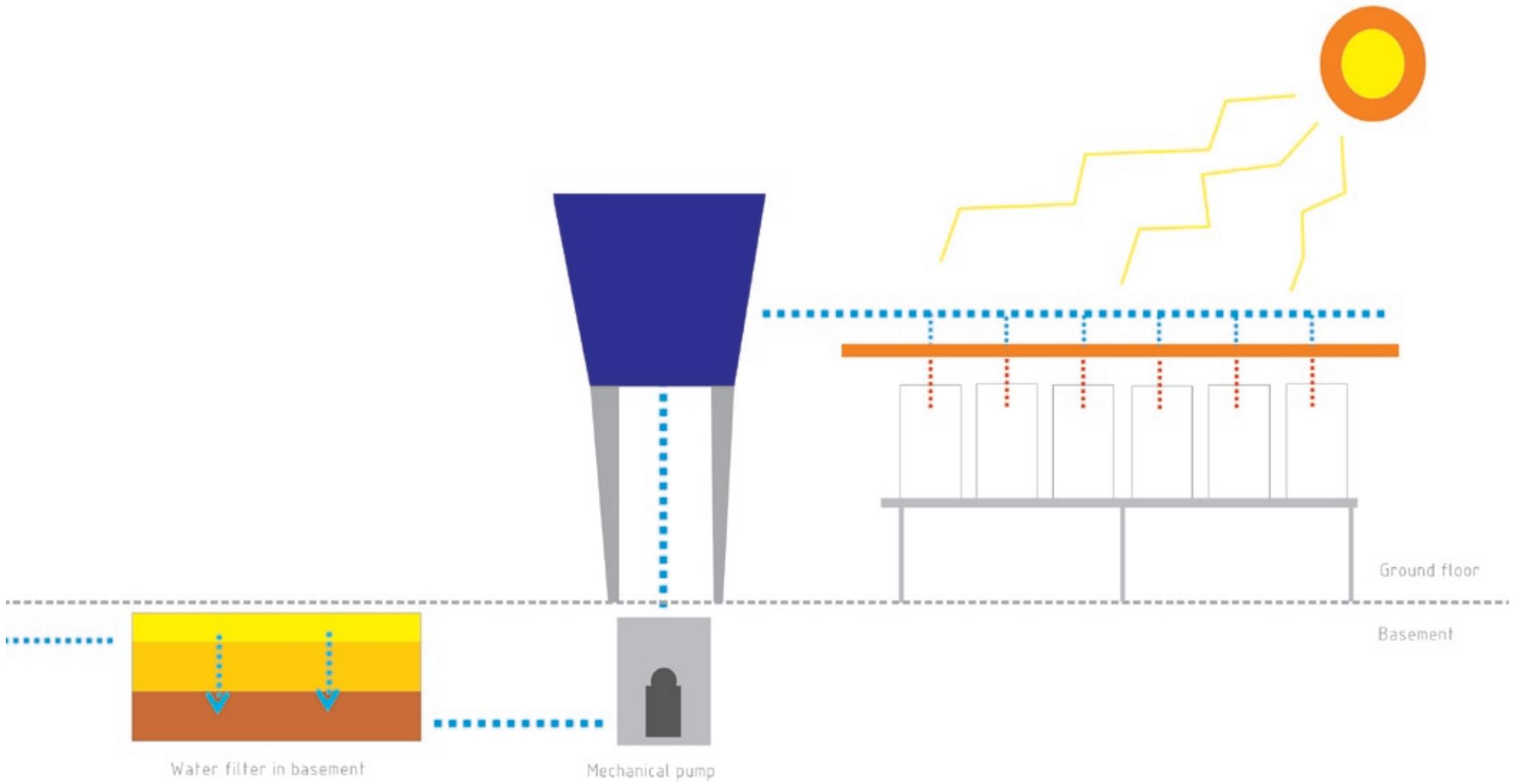


Site reservoir : 720m<sup>3</sup>

reinforced concrete

shower : 450m<sup>3</sup> demand

Solardome® water heater



## Solar Design

The water tower acts as a solar clock in the market area. The shadow line extends deep into the market during the late afternoons.

The solar penetration is controlled by the use of overhangs on the northern facade. This limits the solar penetration in the summer and allows maximum solar penetration in the winter.

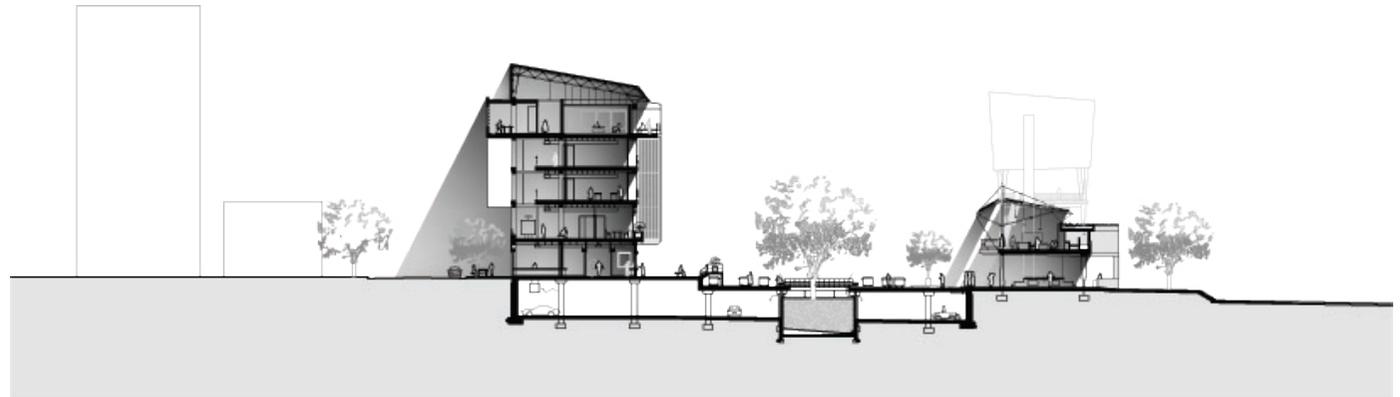


Fig 9.15: Solar penetration, 21 December at 10h00



Fig 9.16: 21 December, 10h00



Fig 9.17: 21 December, 14h00



Fig 9.18: 21 December, 16h00

## TECHNICAL INVESTIGATION



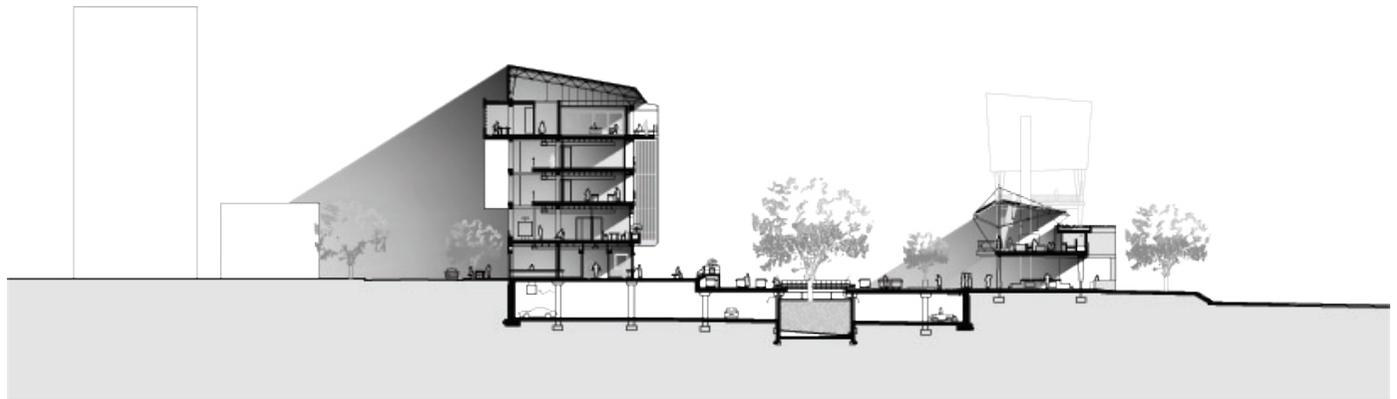


Fig 9.19: Solar penetration, 21 June at 10h00

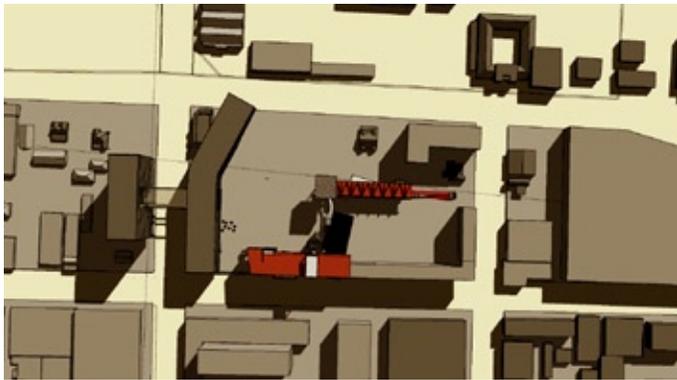


Fig 9.20: 21 June, 10h00

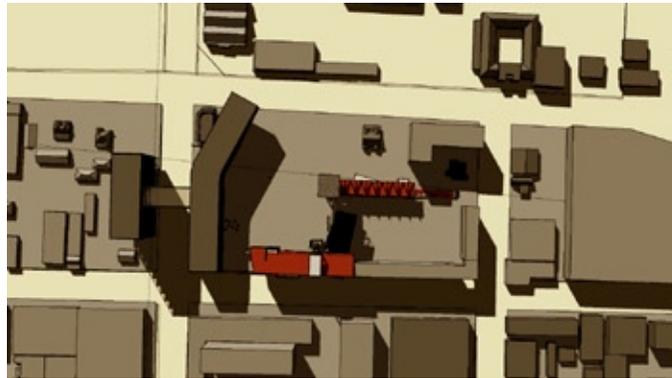


Fig 9.21: 21 June, 14h00



Fig 9.22: 21 June, 16h00



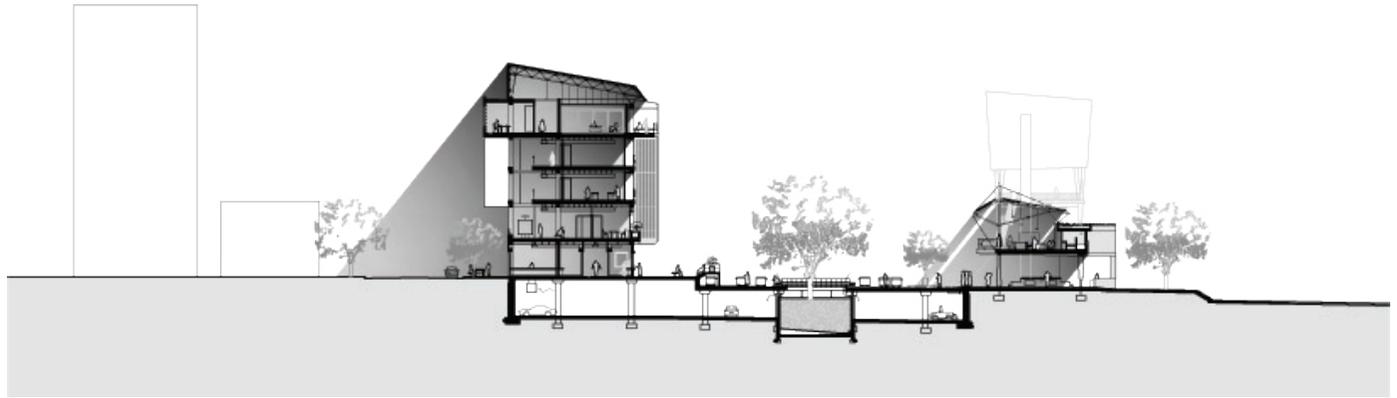


Fig 9.23: Solar penetration, 21 September at 10h00



Fig 9.24: 21 September, 10h00



Fig 9.25: 21 September, 14h00



Fig 9.26: 21 September, 16h00

## TECHNICAL INVESTIGATION

