Cross Ventilation

Yeang (1998) states that in order to ensure adequate cross ventilation the width of a building should not exceed 15m and obstructions should be avoided. In order to facilitate cross ventilation the building footprint is 10m with a maximum depth of 12.8m where the footprint is extended. Where obstructions are necessary, these obstructions either allow air movement through openable windows or are not floor to ceiling height thereby allowing the building to ventilate freely.

Adaptability

As part of the passive design strategy, the need for adaptable systems was noted. Different groups of people and programs have different climatic needs that the building needs to respond to. Additionally, systems incorporated within the design must be able to cool during summer and heat the building during winter.

A displacement ventilation system where treated air is provided through a raised floor has been used for circulation of treated air in the northern and eastern wings of the building where occupants spend large amounts of time. This system allows air to be stratified within the internal space where treated air is lower – closer to where building occupants function - and warmer air higher within the interior space (Green Building Council of South Africa, 2011). Twist outlet floor diffusers allows for climatic control within small groups of occupants, thereby allowing the building occupants to have control over the amount of treated air they wish to receive.

In the southern wing of the building which is occupied sporadically and mostly at night, treated air is distributed though ducts in the ceiling.

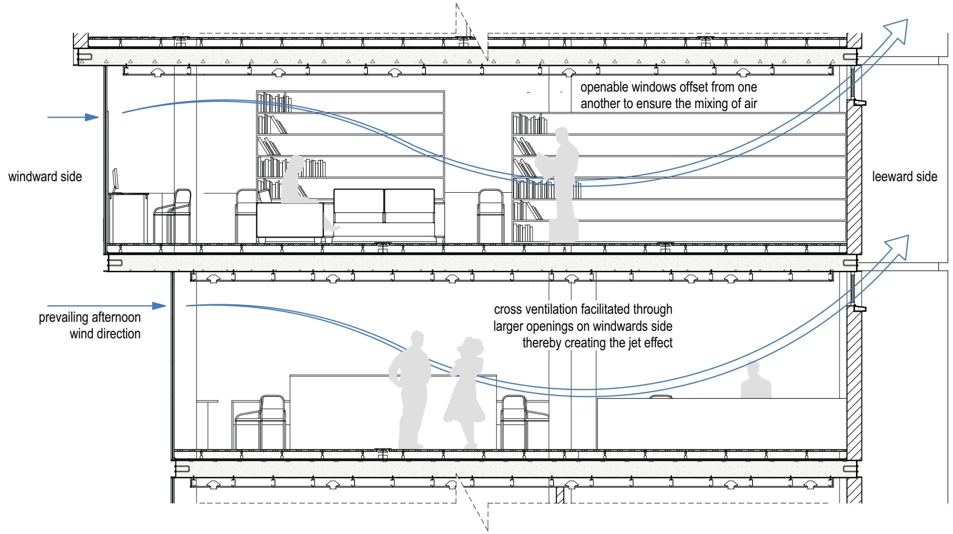


Fig. 7.19: Cross ventilation

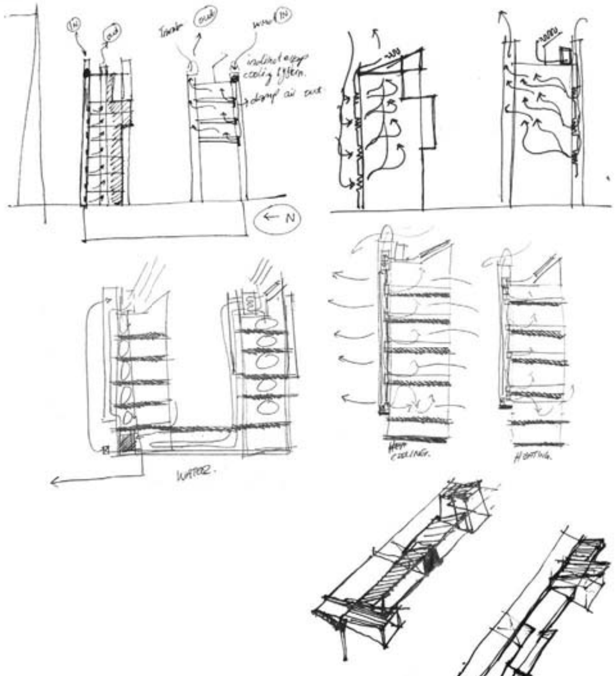


Fig. 7.20: Development of environmental system

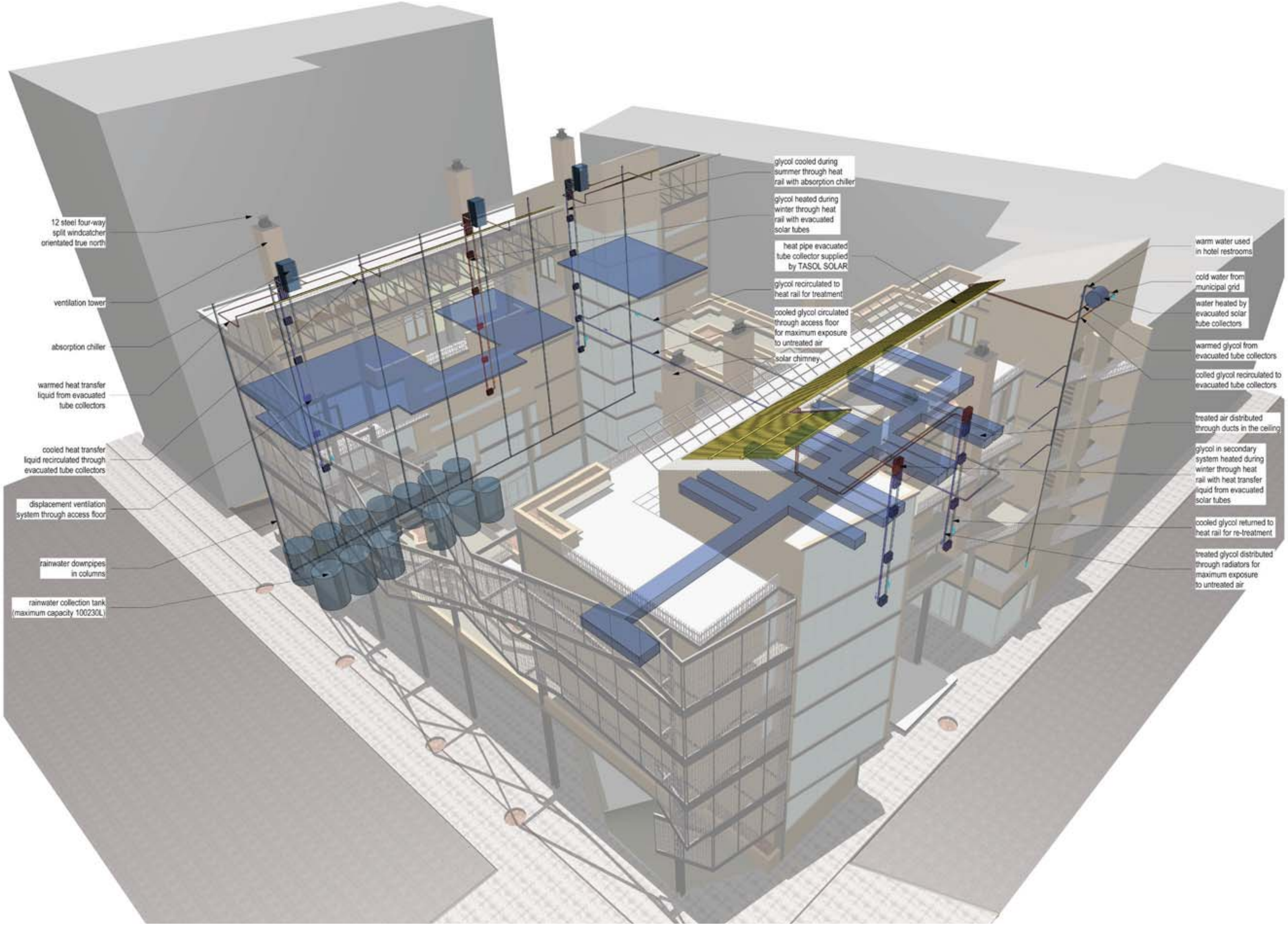


Fig. 7.21: Sustainability diagram

Summer Systems

During summer months a series of heat pipe evacuated-tube solar collectors are used to heat glycol up to 150˚C (Apricus, 2011). The evacuated tube collectors forms a closed system where individual tubes can be replaced without draining the entire system of its heat transferring liquid should one be damaged (GreenTerraFirma, 2007).

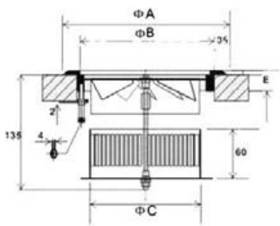
The system is mounted at 25˚ in order to allow optimal functionality within the climate of Pretoria where an angle of 25-30˚ is required to make adequate use of solar collectors. A passive tracking effect is achieved through the rounded surface of the tube, allowing it to function throughout the day (Apricus, 2011).

The warmed glycol is then used to transfer heat to a secondary closed system containing a solution of lithium bromide and water in a solar powered absorption chiller through a heat rail. The lithium bromide is liberated from the solution through the application of heat after which it produces a refrigerating effect (Yazaki energy systems, 2010). The refrigerating effect is then used to cool glycol in a third closed system encased within the ventilation ducts on the northern side of the northern wing.

Wind enters the building from the roof through a series of four way split ventilators. Air is then cooled through indirect evaporative cooling by moving over copper extruded low fin tubes in the tertiary closed system from where it enters the building and is dispersed throughout the interior space with the use of twist outlet floor diffusers. The air is then heated by office equipment and building occupants that causes it to rise due to the venturi effect from where it escapes through the atrium and is evacuated from the building through ventilation grills on the roof.

The southern wing, being inhabited for fewer hours of the day does not make use of an absorption chiller. Indirect evaporative cooling caused by air moving over the closed glycol system encased in the southern ventilation intake ducts lowers the internal temperature slightly after which it is distributed through ducts in the ceiling and is evacuated from the space though ventilation grills.

From the ventilation grills, heated air then enters a series of solar chimneys that are isolated from the habitable space and uses solar radiation through tinted glass to further heat the air thereby causing it to rise and exit the building above the roof. As the temperature in the solar chimney increase throughout the day, air is exhausted faster causing fresh air intake through the ventilation ducts to increase to accommodate the pressure difference (Rabah & Mito, 2003). Functioning of the system therefore increase throughout the day as external ambient temperatures increase.



Size	ΦA	ΦB	ΦC	ΦE
150	190	140	124	14
200	240	190	160	19

Fig. 7.22: Twist outlet floor diffuser

Fig. 7.23: Posi lock access floor

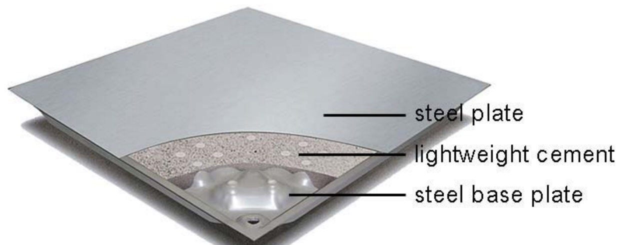


Fig. 7.24: Posi lock access floor composition

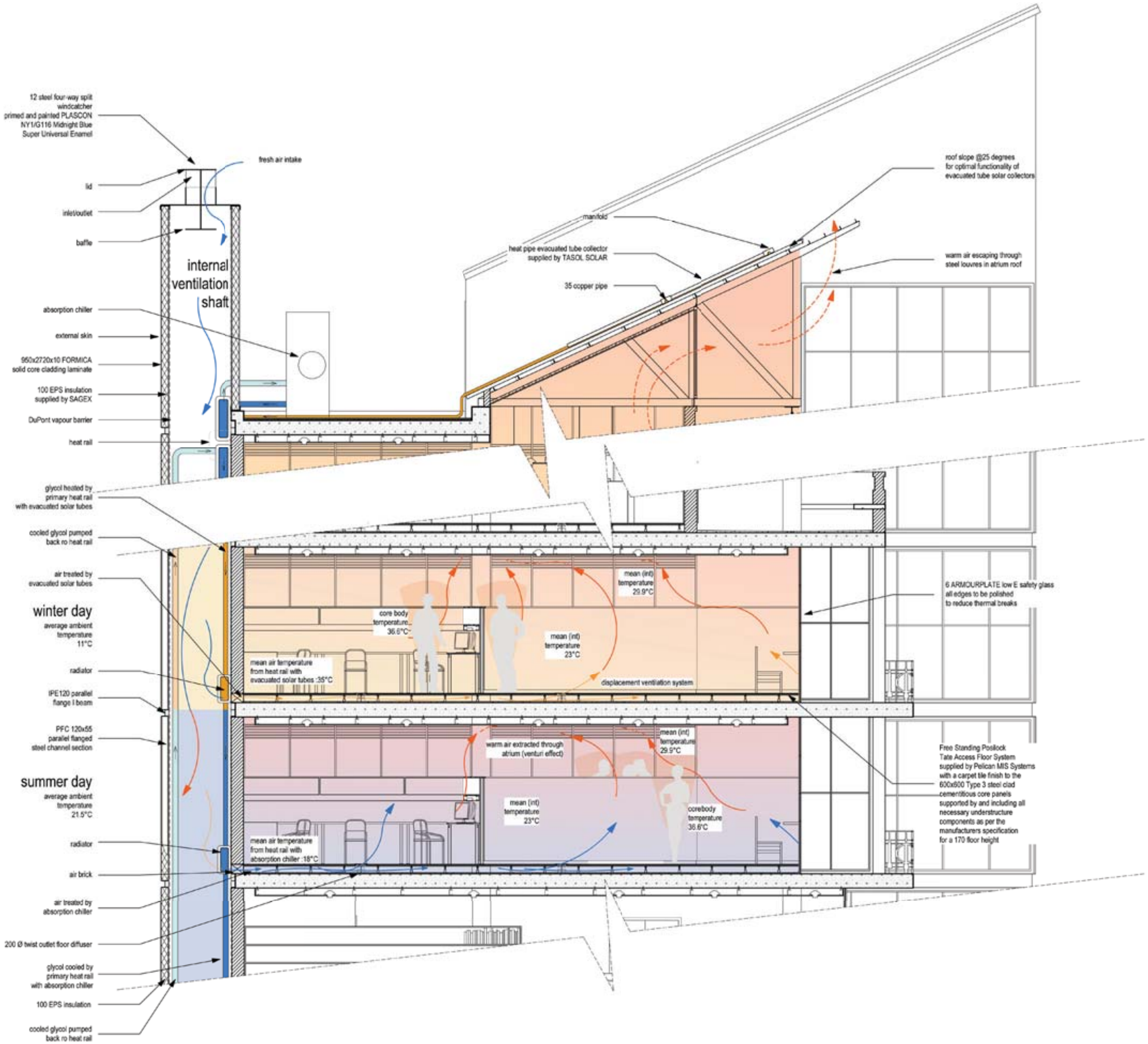


Fig. 7.25: Detail section indicating functioning of systems

Winter Systems

During winter months the absorption chiller is bypassed. Warmed heat transferring liquid from the evacuated tube collectors are used to heat the tertiary closed system encased in the ducts directly after which cold air is heated by moving over the radiators and distributed to internal spaces in a similar fashion as in summer months and evacuated from the building.

Additionally trombe walls are incorporated at the back of the solar chimneys. These walls will be heated throughout the day and radiated into the building at a suitable time due to the flywheel effect.

Ventilation Ducts

Ventilation ducts and solar chimneys are attached to the exterior of the building thereby reducing the amount of floor space lost to vertical ducts needed for distribution of treated air within the building and incorporating green design into the building aesthetic.

Steel construction has been used for external duct supports to keep the structure as light as possible and allow suspension from the side of the building. This allows the ducts not to extend to ground floor to still allow the passage of cars to the basement and preventing ducts from diminishing the connection between the new square and Station Square.

The primary duct structure consists of IPE120 parallel flange I beam bottom and top rails with PFC 120x55 parallel flanged steel channel section studs bolted to the top and bottom rail. The structure is cladded with exterior grade Formica SolidCore and filled with 100 expanded polystyrene insulation to prevent loss of heat and cold from treated air. A DuPont vapour barrier is inserted between the cladding and insulation to prevent vapour from moving into the building should condensation occur.

Ventilation ducts are connected to the structure by cutting back flanges of the top and bottom rail and fixing the webb to gusset plates welded to the steel channel incorporated with the floor slab. With the I - beam being smaller than the channel it is connected to, the gusset plate closes the duct where connected to the channel and serves to prevent treated air from escaping before entering the building.

The ducts are topped with four way split ventilators. The ventilators are orientated 45 degrees to the prevailing wind direction as this orientation creates the highest pressure difference between windward and leeward sides and results in the highest duct speeds (Gage & Graham 2000:234-244). On wind still days, air supply is provided by low energy fans which turn off when adequate pressure difference has been created between intakes and exhaust points for the system to function without mechanical aid.

Natural Light

In order to decrease the experience of crowding and promote occupant comfort, high levels of natural light is allowed to penetrate the building.

Natural light is maximised through floor to ceiling windows, curtain walls and celestory windows and controlled through the use of horisontal solar screens along the northern facade.

Solar screens are fixed to gusset plates that are factory welded to the steel channel fixed to the floor slab.

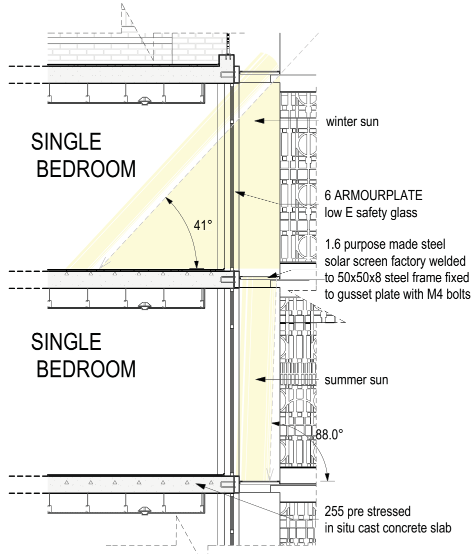


Fig. 7.26: Strip section illustrating day lighting on northern facade

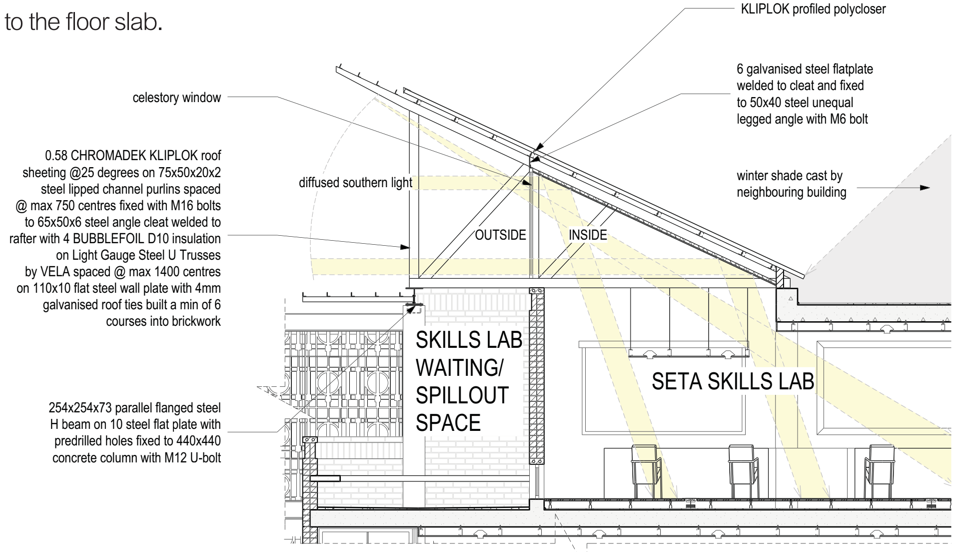


Fig. 7.27: Detail: roof construction and southern light through celestory window

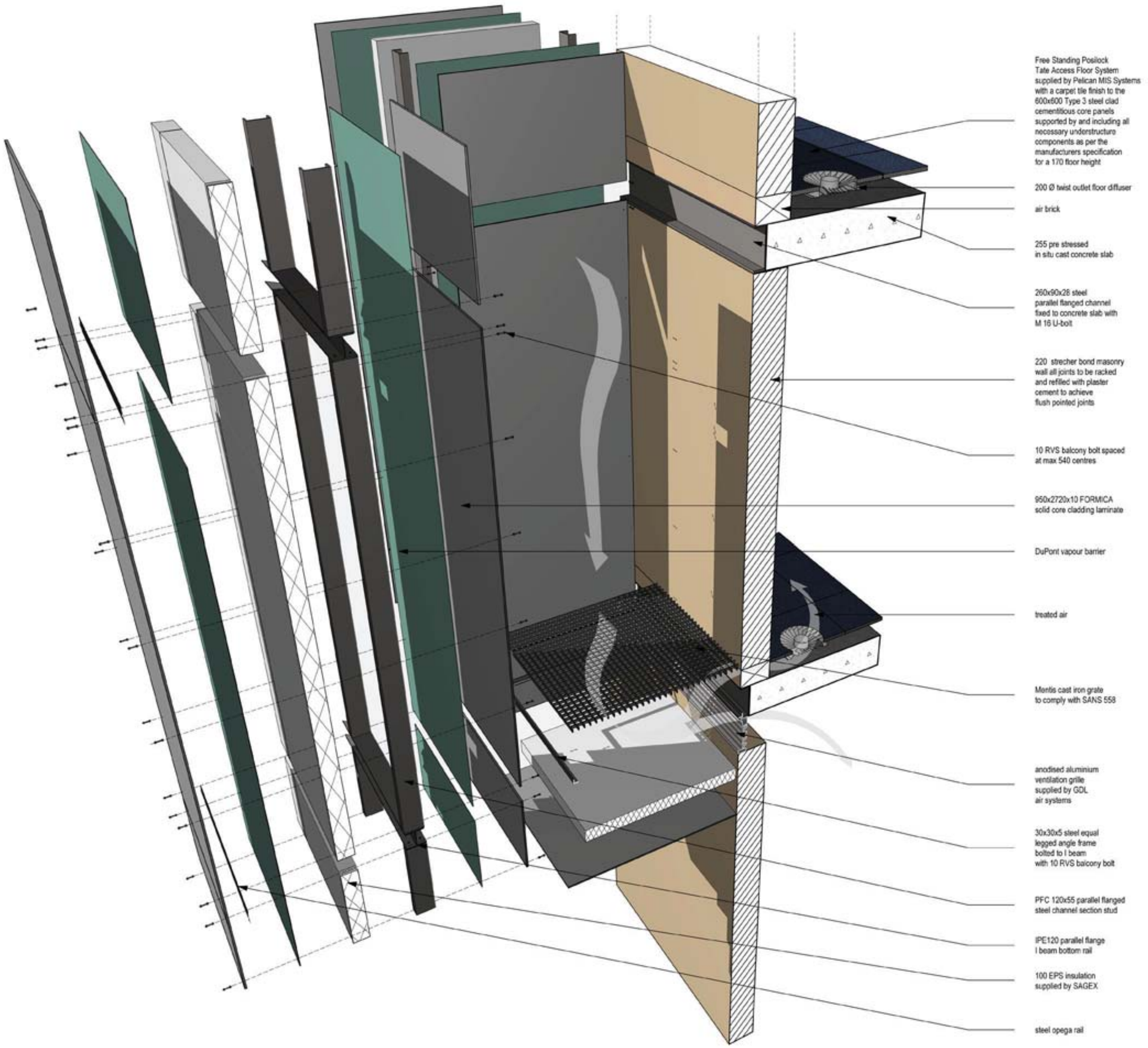


Fig.7.28: Exploded axonometric of ventilation tower

Water

Water is collected from the catchment area on the roof of the building as well as from the public square. The water is then filtered and stored in the basement from where it re circulated within the building.

Collected rainwater is distributed to restrooms, where it is used to re fill depleted water cisterns for the flushing of water closets and urinals. Rainwater used, reduces municipal water supply by 100230L per month for seven months of the year after which it is used to supplement the water provided by the municipality.

	Runoff	v.	130kL	Overflow
December	179841.6	79611.6	79611.6	0
January	212630.4	192012	130000	62012
February	130161.6	221943.6	130000	91943.6
March	113270.4	234984	130000	104984
April	25833.6	160587.6	130000	30587.6
May	32788.8	93146.4	93146.4	0
June	22852.8	15769.2	15769.2	0
July	7948.8	-76512	-76512	0
August	8942.4	-91287.6	-91287.6	0
September	13910.4	-86319.6	-86319.6	0
October	38750.4	-61479.6	-61479.6	0
November	88430.4	-11799.6	-11799.6	0

Fig.7.29: Rain water calculations

Material selection

Material selection has been influenced by the context as well as material attributes and environmental considerations such as the flywheel effect. The flywheel effect indicates the ability of high mass materials to radiate heat into a space at a later time when it is better suited (Bothma, 2004: 74).

Material choice has therefore been made in order to promote identity within the area, further *entopia* and respond to environmental considerations.

Building Envelope

Contextual and environmental considerations led to the choice of 220 masonry walls for all northern facades as well as southern facades as determined by tectonic response to hierarchy.

Masonry construction is used throughout the precinct and is suitable to Pretoria's climate. 220 Masonry walls will retain heat during the day and radiate stored heat roughly 5.5 hours later due to the time lag of the flywheel effect, thereby increasing internal temperatures slightly during cooler evenings and preventing overheating of internal space during the day. Use of 110 brick or untreated glass for the building envelope would result in a time lag of 2.3 and 0.0 hours respectively leading to stored heat being radiated during the warmest part of the day when it is most undesirable.

Glass curtain walls are constructed from Armourclad low-e safety glass. Low emissivity glass provides enhanced insulation to the glass facade in a single glazing application which prevents treated air within the building to escape though the envelope while still allowing high levels of light transmission and visual connectivity to the public square (Smartglass, 2011).

Glass curtain walls are placed on the southern facade of the building where heat gain due to the greenhouse effect will be less severe. Glass envelopes on the western side of the building, where the sun is more severe, is protected by the screen shading the western side of the building.
Both materials contributing to the main building envelope is manufactured locally thereby reducing energy consumption by lowering embodied energy attributed to transportation.

Formica SolidCore

Formica SolidCore has been specified for the cladding of the ventilation ducts. This material is a rigid, self supporting, lightweight laminated sheet with an acrylic overlay for UV protection (PG Bison, 2009). The

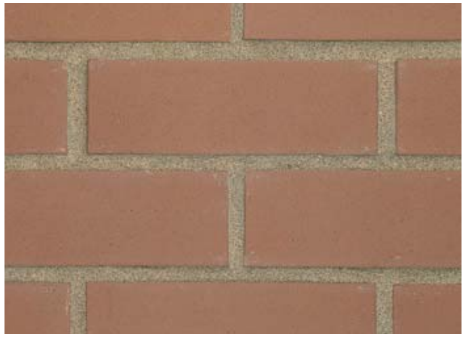


Fig. 7.30: Corobrik Roan Satin brick

Fig. 7.31: Low e safety glass

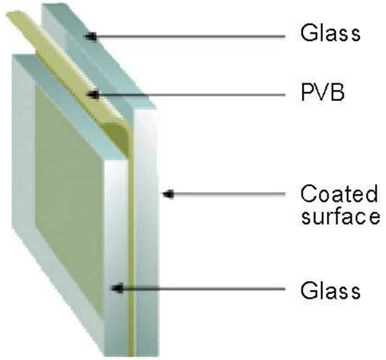


Fig. 7.32: Low e safety glass composition

Fig. 7.33: Formica SolidCore

material has been selected to contrast with other materials within the context, thereby accentuating green interventions within the building and is suitable for its application due to its lightweight nature, self supporting rigidity and in built UV protection.

Maximum panel sizes are 2050x1300 and have been considered during detailing of the ducts. Cladding sheets are factory cut and fit within panel sizes available leading to less material used and reduced wastage on site. Additionally the material is manufactured locally thereby reducing embodied energy and transportation cost.

Steel

Steel has been used for the construction of the screen, pergolas and shading devices to fit contextually and promote identity formation within the liminal space.

Other metals such as Aluminium have been considered but it has been found that steel is more advantageous for the application. Embodied energy density by mass for aluminium is 227 MJ/Kg in comparison with galvanised steel which is 34.8 MJ/Kg (Victoria University of Wellington, 2011).

Although aluminium is lighter and lower in maintenance, cost and embodied energy associated with aluminium renders it unsuitable when considering the amount of material needed.

Light Gauge Steel Trusses

Light gauge steel U-trusses supplied by Vela have been used in preference to timber trusses. Light steel trusses offer numerous benefits and fits contextually where exposed due to the preference of steel within the liminal space.

These trusses are fully recyclable, non combustible and galvanised in order to protect the material from the climate (Specifile, 2011). Steel trusses are fabricated according to profiles needed and reduces the amount of wasted material.

Timber is a natural resource with a low embodied energy of 2.0 MJ/Kg (Victoria University of Wellington, 2011) but is rarely recycled and needs to be transported fully assembled to site (Specifile, 2011). Light steel trusses can be assembled on site and is 30% lighter than timber thereby reducing transport costs by 60% and allows on site training opportunities.


Fig. 7.34: Light gauge steel trusses

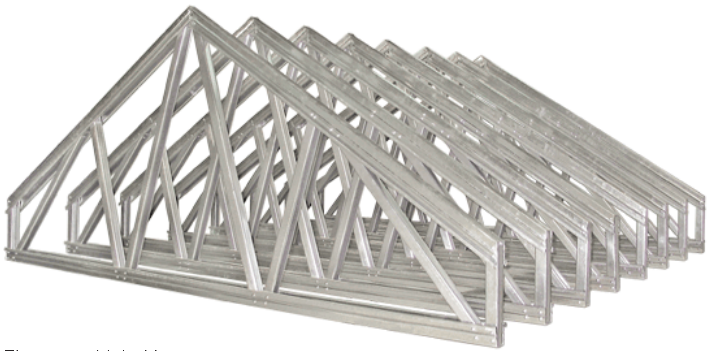


Fig. 7.35: Vela U-truss

Building Element	Width or description	Time lag of heat flow (h)
Brick wall	101.6mm 203.2mm 304.8mm	2.3 5.5 8.0
Concrete	50.8mm 101.6mm 152.4mm 203.2mm 254mm 304.8mm	1.0 2.6 3.8 5.1 6.4 7.6
Glass	window block	0.0 2.0
Stone	203.2mm 304.8mm	5.4 8.0
Frame	wood, plaster - no insulation wood, plaster & insulation	0.8 3.0
Roofs	light construction medium construction heavy contruction	0.7-1.3 1.4-2.4 2.5-5.0

Fig. 7.36: Material time lag due to the flywheel effect

Services

Services are distributed vertically within the building through service shafts. The shafts contain wet services as well as electrical cables and information lines.

Electrical and information cables are encased within separate 150 diameter fibre cement sleeves to protect them from wet services should problems occur and to prevent disruption to information services due to the proximity of the electrical cables.

Pipes for the removal of black and grey water are included within the service shafts except for the northern wing where pipes are allowed to run down the external envelope of the building. These pipes are hidden from public view by placing them behind a screen.

Services are distributed horizontally within the internal space through access floors and ceilings. Services distributed through access floor include electrical cables and information lines with electrical cables for lights being distributed through the ceiling as well as electrical supply and information lines where access floors are not provided.

Fig. 7.37: Service distribution: fourth floor

Fig. 7.38: Service distribution

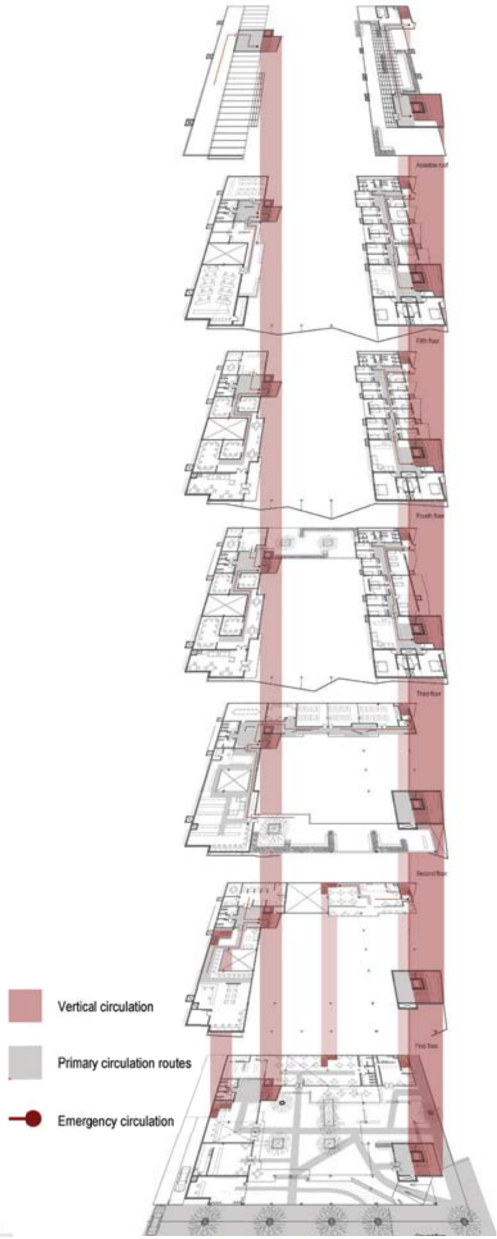


Fig. 7.39: Circulation

Fig. 7.40: Fire plan: fourth floor

Fire

In Accordance with Part TT 16.4 of SABS 0400 no fire escape is more than 45m away from the edges of the building. Three staircases run the full height of the structure and serve as fire escapes.

The escape route from classrooms housed within the eastern wing of the building allow for two options of escape with the south eastern fire escape end northern main staircase serving as exit points.

Fixed hose reels are provided for every 500 m² and portable fire extinguishers for every 200 m² as required by section TT of the building regulations.

In case of fire, smoke is evacuated from internal spaces through ventilation grills located within the atrium for the northern block and extract air grilles located within the ceiling of the southern wing from where it is evacuated through the celestory windows and solar chimneys respectively.