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This chapter illustrates the materials and systems used in the design.

TECHNICAL INVESTIGATION

1 INTRODUCTION

'Healthy environments', on a technical level, implies the use of materials which do not detract from human health (by for example releasing noxious gases) or from the health of the environment (sourced from unsustainable sources). The physical building should also not be inclined to sick building syndrome. This chapter discusses the construction of the design in different levels, relating to structure; skins; systems and materials used with the objective of creating a healthy environment. The Sustainability Building Assessment Tool (SBAT) rating system was implemented to quantify the sustainable potential of the building.

2 STRUCTURE

The main building structure consists of reinforced concrete made with Eco Cement and fly ash. Eco Cement contains magnesium oxide, which absorbs carbon dioxide from the atmosphere. Fly ash is a by-product of the combustion of coal, which is used in manufacturing electricity. Fly ash improves the strength of concrete, and decreases the amount of cement needed in the mix.

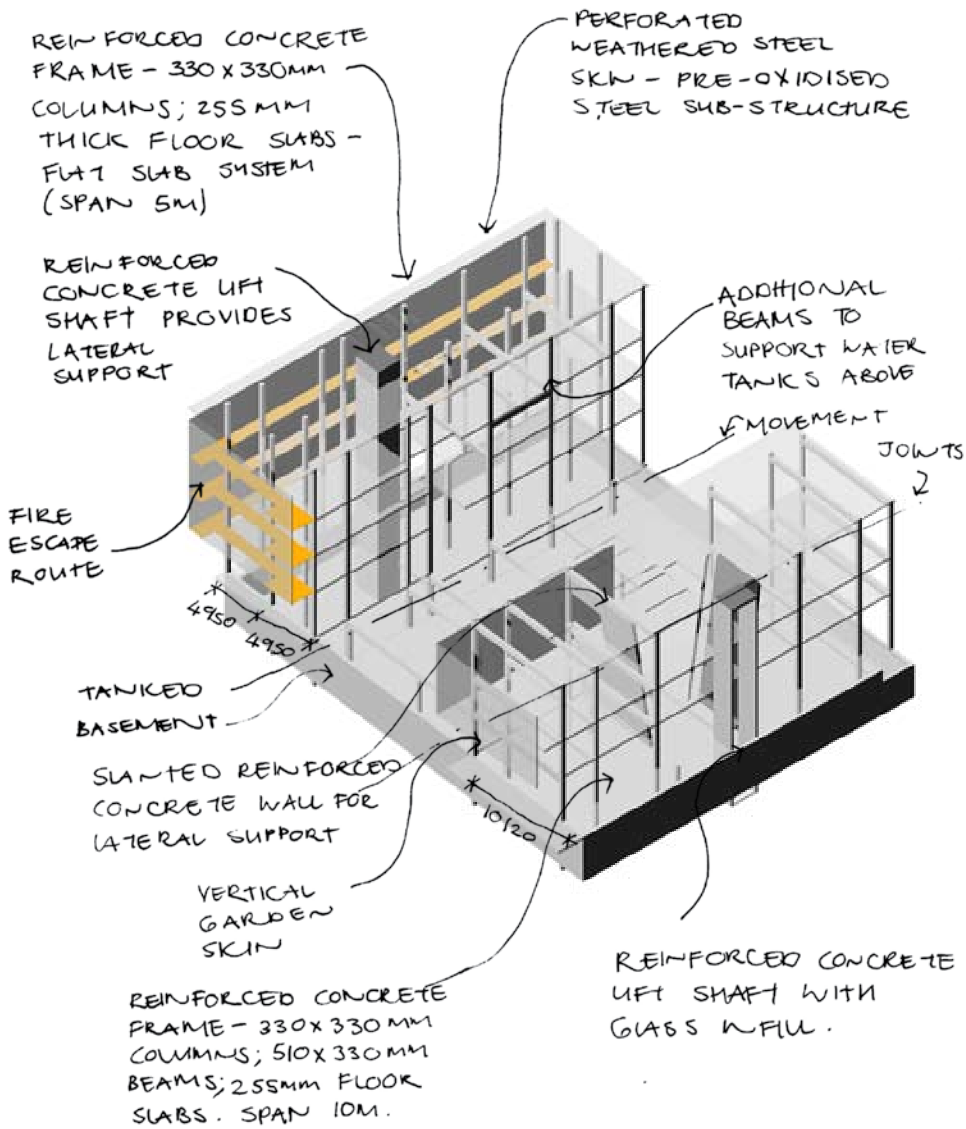

Fig 7.1 STRUCTURAL SYSTEM

3 SKINS

External skins wrap around the northern and western façades of both buildings. These skins protect the interior skins from excessive heat by acting as shading mechanisms, and also allows for ventilation to take place for the cooling of these façades. Interior skins provide thermal insulation to the interior of the building.

A ventilated gap separates the two skins in both buildings to minimize heat gain from the external skins, and to cool the buildings.

1 EXTERNAL SKINS

The northern building skin consists of perforated weathered steel, while the southern building skin consists of prefabricated vertical garden panels.

PERFORATED WEATHERED STEEL SKIN WITH OPERABLE PANELS

This flexible operable panel system allows the users a degree of control over their environment, as they can choose the degree of openness or enclosure. Sheet metal radiates heat quickly, which frequent perforations counter by allowing ventilation to take place. These perforations also filter light into the building, and cast shadows on the interior which mimic patterns of light through the leaves of a tree. A ventilated air gap separates the skin from the interior skin, and this allows space for a secondary fire escape route. This skin also visually distances the interior environment of the building from the chaos of the city street.

PROPERTIES OF WEATHERED STEEL

Weathered steel is an alloy of steel and copper, and weathers from a smooth steel to a coarse rusted texture over time. Oxidation causes a layer of rust to form on the surface of the plate. Once equilibrium is reached, this oxidation process stops, and the rust layer protects the material from further degradation. Run-off from this material stains surrounding areas, and thus a gutter is provided to catch run-off from this skin and to direct it into the storm water system. The dark colour and rough texture of this material results in less glare to surrounding buildings.

Weathered steel sheets come in standard sizes of 1.225m x 2.5m x 1.6mm. Each such plate will provide nine façade panels. The perforations will be laser-cut into these panels, and then fixed to the sub- structure.

SUB-STRUCTURE

Weathered steel may have an effect on the premature weathering of other metals. This can be prevented by either separating weathered steel from other metals, or by employing pre-oxidised steel sub-structure and welding connections.

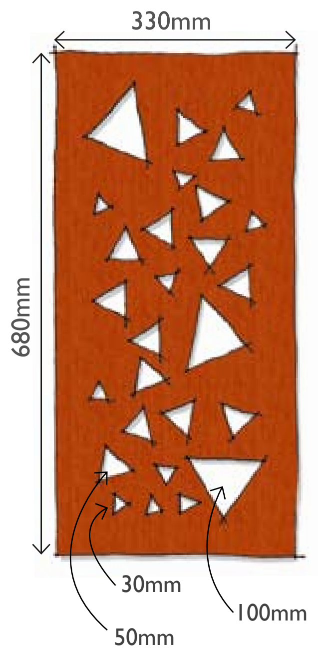

Fig 7.2 PANEL 1:10

VERTICAL GARDEN SKIN

The G-Sky prefabricated vertical garden system is employed as exterior skin on the southern building. *Clematis brachiata* (traveller's joy), an indigenous deciduous creeper, protects the interior skin from excessive sunlight in summer while allowing sunlight to penetrate into the building in winter. This creeper flower in summer, and the flowers may be used in traditional medicines to treat colds and headaches. This skin provides a soft edge to the southern edge of the square, and also perceptually distances the southern building from the activity in the square.

The vertical garden system will be irrigated with a drip irrigation system, which will source water from a rainwater tank on the top floor of the building. The sub-structure of the system is from stainless steel (see figure 7.3). The G-Sky system consists of panels which can be maintained and replaced easily.

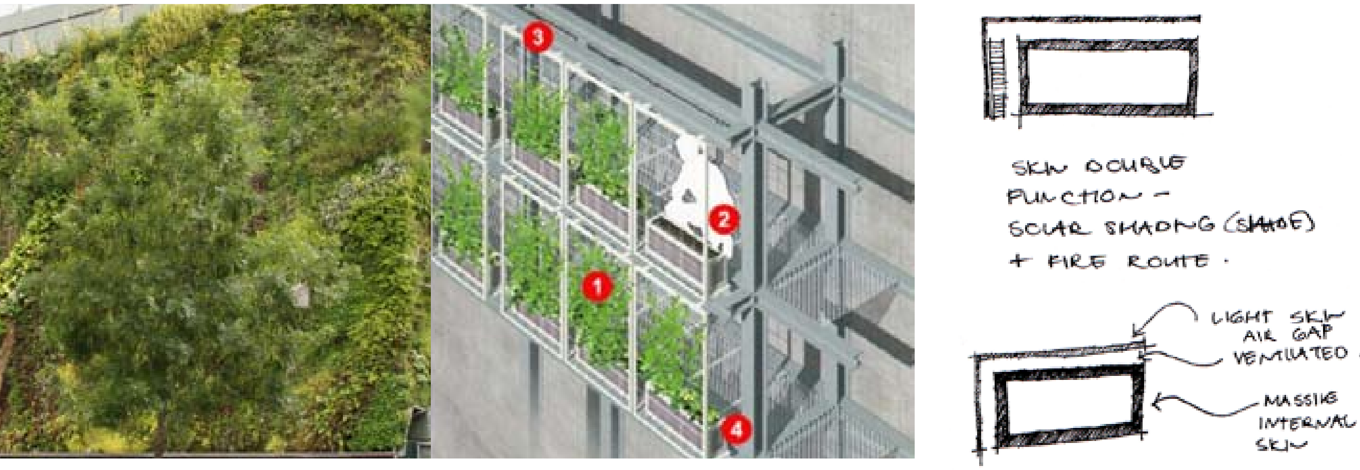

Fig 7.3 G-SKY VERTICAL GARDEN SYSTEM (left); FUNCTIONING OF SKINS

2 INTERNAL SKINS

The internal skins of both buildings will consist of a combination of masonry cavity walls and low emissivity glass curtain walls.

MASONRY SKIN

Masonry cavity walls reduce the ingress of moisture into a building, thus reducing the chances of fungal growth. Cavity walls also have lower U-values than double skin walls (220mm). An un-plastered 220mm brick skin has a U-value of 3.25 W/m^2k, while a cavity wall, consisting of two 110mm brick walls separated by a 50mm cavity, has a U-value of 2 W/m^2k (see Appendix B). A lower U-value means better resistance to heat transfer, thus a cavity wall is well suited to function as an internal skin.

GLASS SKIN

A low emissivity Smartglass will be used to minimize heat radiation and glare in the building, and for thermal insulation. The Intruderprufe Low E in the ColourVue E range admits 82% of daylight, while having a 0.74 shading coefficient. It has a U value of 3.4, and eliminates 99% of UV rays (see Appendix B).

The core of the building will have a low-emissivity glass facade, while the rest of the building will have a combination of the cavity masonry wall skin and low-emissivity glass windows.

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WATER MANAGEMENT

RAINWATER HARVESTING

Water from both roofs will be harvested to supplement the use of municipal water on the site.

Pretoria receives 674mm of rain in a year (Schulze. 1980: 23). This means that 230k*l* of water can be harvested from each roof each year (see Appendix B), which translates into a possible 600*l* per day.

Rainwater from the roof of the northern building will be harvested into a 500*l* tank on the top floor. Additional rainwater will be diverted via the wet service cores to seven 1000*l* rainwater storage tanks in the basement. After filtering, this water will contribute to the flushing of water closets in the building; 500*l* can flush 83 water closets.

The southern building will also house a 500*l* rainwater storage tank on the top floor. This will be utilised for the irrigation of the vertical garden and the planted roof, as well as for supplementing the flushing of water closets in the building.

When these rainwater tanks become empty, water from the basement rainwater storage tank can be pumped up to fill them. Water from this basement tank will also be used for the irrigation of the garden. Run-off from hard surfaces will be filtered and stored in this storage tank.

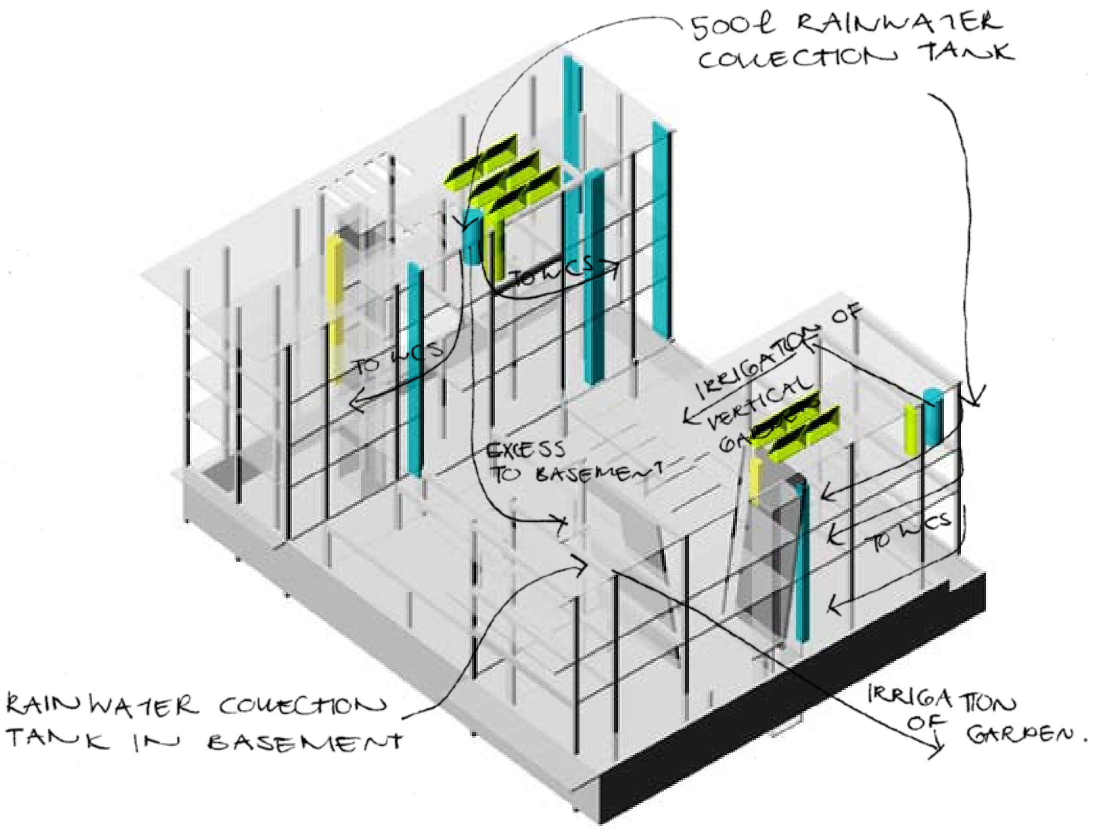


Fig 7.4 WATER SYSTEM

SOLAR WATER HEATING

Evacuated tube indirect solar water heating systems will be employed in both buildings. In the northern building, these will heat water for the showers in the change rooms on the first floor. In winter, this hot water will also be pumped through the building for radiant heating (see Heating + Cooling). In the southern building, the solar water heating system will be used for radiant heating in winter.

Evacuated tube solar collectors will be located on both roofs (see fig. 7.5). In this system, solar collectors are separated from geysers, which will be located on the third floor both buildings. Anti-freeze fluid is reticulated through the collector tubes, and this is used to warm water in the geyser. For the northern building, four collectors will be needed to heat two 400*l* geysers, while the southern building will need two collectors to heat one 400*l* geyser (see Appendix B).

Solar collectors will be angled at latitude (25.7 degrees) plus 5 degrees for better winter orientation, thus 30 degrees facing north.

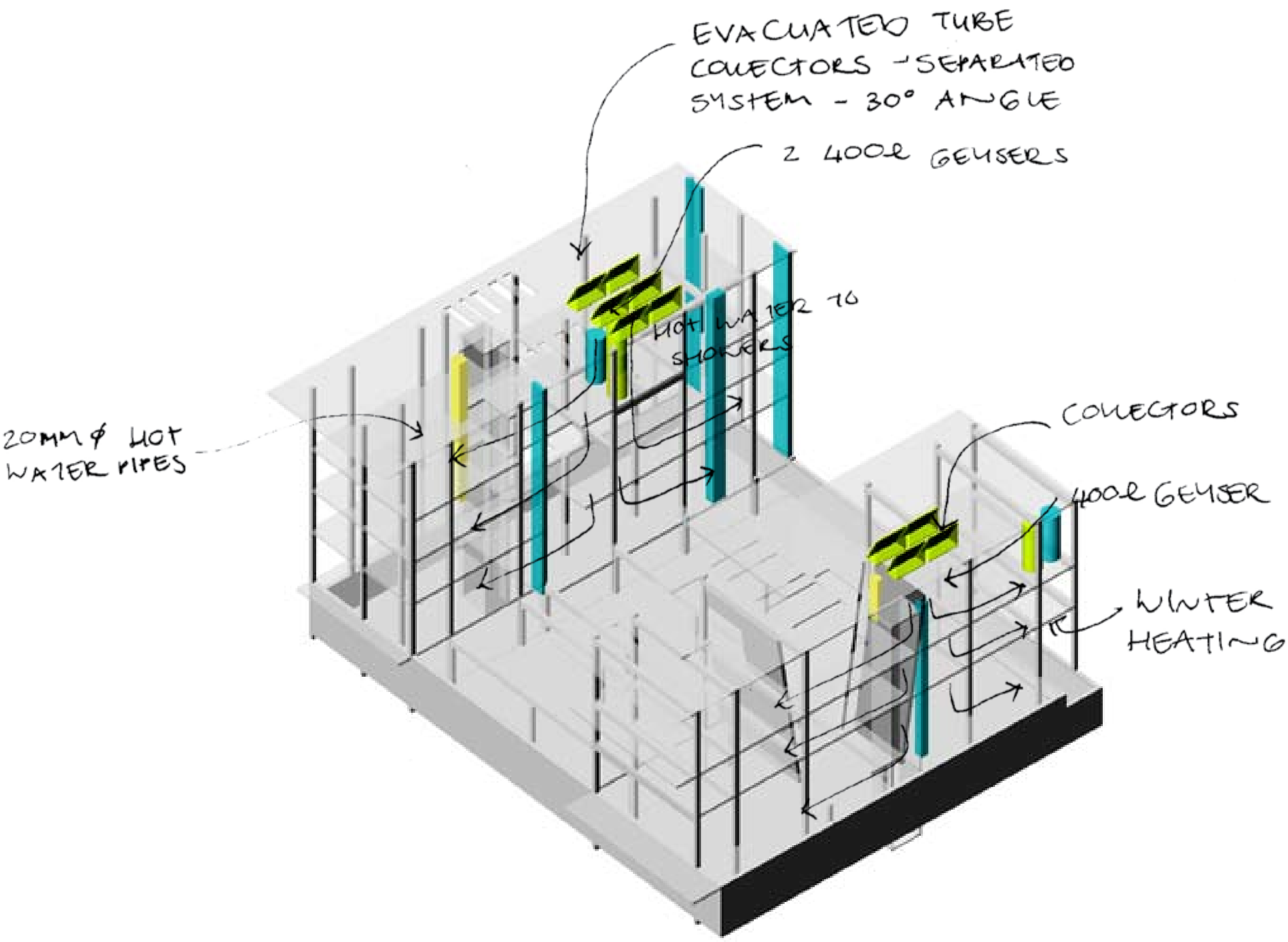


Fig 7.5 SOLAR WATER HEATING SYSTEM

NATURAL VENTILATION

Both buildings and the basement will be naturally ventilated. To achieve thermal comfort with natural ventilation in summer, the following need to be implemented (Clements-Croome, 1997: 116):

_ insulate the envelope insulation of the envelope
_ effective and adjustable shading
_ high levels of thermal mass
_ operable windows
_ tall floor to ceiling heights, to allow warm air to collect above head height.

As naturally ventilated environments react to outside temperatures, internal temperatures may be higher than comfort levels allow in very hot conditions. This is acceptable for 10% of the time (Clements-Croome, 1997: 110).

Areas of 'closer comfort' and 'looser comfort' (Clements-Croome, 1997: 153) were identified (see fig. 6.6). In areas of 'closer comfort' the user will be able to regulate shading and ventilation, while in areas of 'looser comfort', the building management will be in charge of shading and ventilation (and thus it will be slower to respond to a change in weather).

'Closer comfort' is needed in areas which will be used 90% of the operational time of the building, such as offices and the gym. 'Looser comfort' can be provided in circulation areas and the core, which will only be used intermittently.

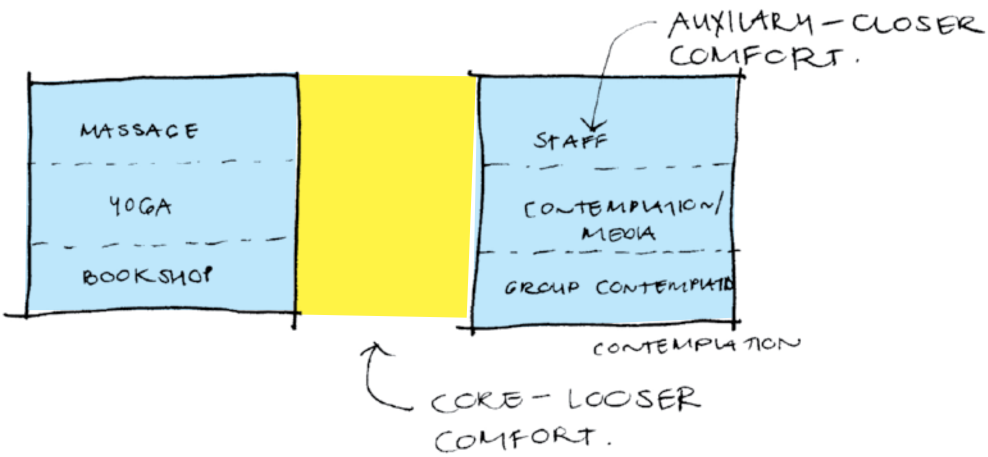


Fig 7.6 CLOSER + LOOSER COMFORT

NIGHT-TIME COOLING

Night-time cooling, working in conjunction with natural ventilation, will cool the building at night. Windows will be left open at night to admit the cool night air, which will cool the exposed thermal mass of the building. During the day, warm air will be vented to the atmosphere. According to Smith (2007: 40), the system works best when internal solar gains are kept to a minimum, and also in thin buildings, with less than 15 metres between façades. The proposed buildings are both shaded on the north and west façades, and are both 10 metres deep. Night cooling of high thermal mass structures can reduce the peak temperature by 2-3°C (Smith, 2007: 40).

WINTER HEATING STATEGY

During winter, hot water from the solar water heaters will be reticulated through 20mm pipes in the cavity of the southern wall of both buildings. The brick walls will absorb heat from these pipes and radiate it into the interior of the building.

The southern building will also make use of passive solar gain during winter, as the deciduous creepers on the vertical garden will lose their leaves and allow sunlight to penetrate into the building.

GREEN ROOF

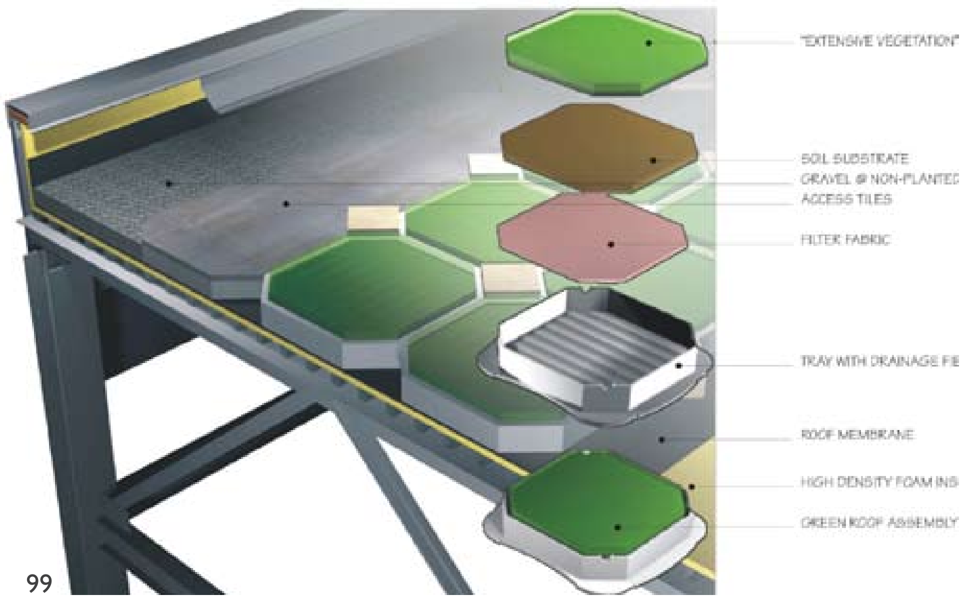
Planted roofs will be applied to both buildings. A modular, pre-grown extensive system will be employed which is easier to maintain; applies a lighter load; and allows for easier roof maintenance access than traditional (intensive) systems.

Water wise indigenous ground covers with shallow root systems, for example *Duchesnea indica* (wild strawberry); *Asparagus asparagoides* (cape smilax); *Lamium maculatum* (lamium); *Plectranthus madagascariensis* (madagascar spurflower) and *Plectranthus verticillatus* (money plant), to landscape architect's specification, will be planted. Drip irrigation will be used, and water will be pumped up from the rainwater tanks on the top floors of both buildings.

BENEFITS OF GREEN ROOFS

Green roofs (*www.greenroofs.org*):
_ reduce the urban heat-island effect
_ improve thermal insulation of roofs
_ increase biodiversity in the city
_ aid storm water retention
_ protect roof surfaces

Fig 7.7 EXTENSIVE GREEN ROOF SYSTEM



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The northern building has two escape routes – one via the central core and another via the building skin, with stairs on the western façade. The southern building only needs one escape route (SABS0400 TT16.2), as it is 3 storeys high and its top floor has an occupation of less than 25 people. One fire hose reel and one portable fire extinguisher will be provided on each floor (SABS 0400 TT35.2 + TT 37.4).

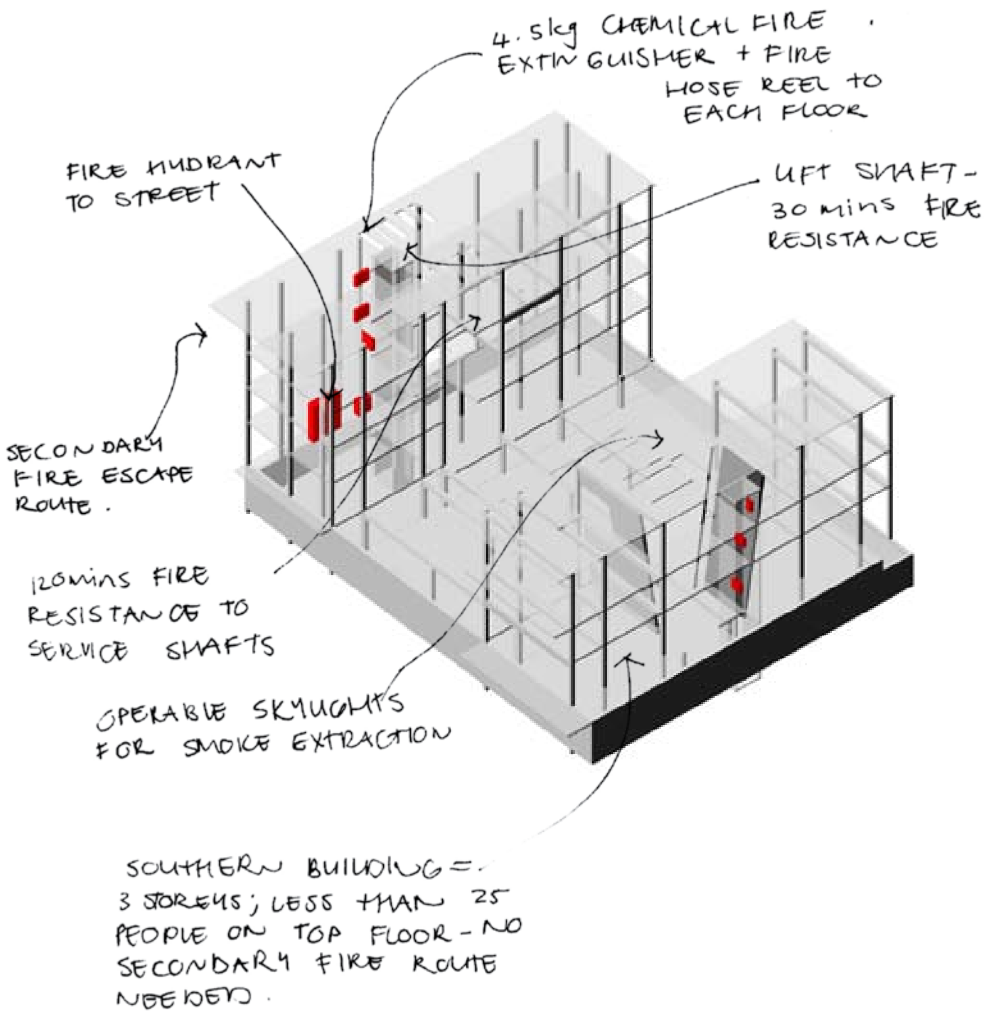

Fig 7.8 FIRE SYSTEM

5 MATERIALS

Materials were sourced for their sustainability; their non-intrusion on human health; for their tactile quality and for their contribution to the austere character of the design.

On an urban scale, this project suggests the use of Titanium dioxide-embedded concrete pavers on new sidewalks and as a second paving material for the square, as this absorbs noxious nitrogen dioxide (NO_2) from vehicle emission and converts it into harmless NO_3 (*www.treehugger.com*).

MATERIAL PALLETE

REINFORCED CONCRETE — STRUCTURE; STAIRS

BENEFITS

_ Fly-ash reinforced concrete with crushed concrete aggregate
_ Use EcoCement in mix - absorbs CO_2 from the atmosphere
_ Massive - retains heat or coolness - flywheel effect

IMPLICATIONS

_ Mouldable; shuttering - chamfered edges; drip joints; waterproofing
_ Shuttering leaves texture on soffit surface

WEATHERED STEEL — NORTHERN BUILDING SKIN

BENEFITS

_ Forms protective layer
_ Minimises glare to surrounding buildings
_ Low maintenance

IMPLICATIONS

_ Manage run-off to minimise staining (gutter skin system)
_ Adjacent materials of pre-oxidised steel + welded connections

VERTICAL GARDEN — SOUTHERN BUILDING SKIN

BENEFITS

_ Carbon sink + renews itself
_ Releases oxygen to building
_ Deciduous creepers filter sunlight in summer + let it through in winter

IMPLICATIONS

_ Drip irrigation needed
_ Divided into panels for easy maintenance - GSky system

FACE BRICK (Mahoni Satin FBA) — INTERNAL SKINS

BENEFITS

_ Local material
_ Good thermal insulation
_ Low maintenance

IMPLICATIONS

_ Standard brick modules (85 x 110mm)

Fig 7.9 MATERIAL - CONCRETE; WEATHERED STEEL; VERTICAL GARDEN; FACE BRICK (top to bottom)

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GRANITE COBBLESTONES — SQUARE

BENEFITS
_ Natural material
_ Local material

IMPLICATIONS
_ Drainage to inlets
_ On concrete screed laid to fall towards inlets

RHINOLITE GYPSUM PLASTER — CONTEMPLATION SPACE

BENEFITS
_ Smooth finish; paint with EnviroLite paints

IMPLICATIONS
_ Apply oil based paint bonding liquid before painting

PIGMENTED PLASTER — CHANGE ROOMS

BENEFITS
_ Rough finish

IMPLICATIONS
_ Seal with acrylic matt sealant

EUCALYPTUS MICROCORYS TIMBER — LIGHT STRUCTURES

BENEFITS
_ Renewable material
_ Hard wood

IMPLICATIONS
_ External use - treat with a pressure impregnated preservative
_ Use standard sizes and lengths

GREEN ROOF — CONCRETE ROOFS

BENEFITS
_ Prevents roof from becoming heat island
_ Insulates building
_ Encourages biodiversity

IMPLICATIONS
_ Extensive system - lighter load; easier maintenance
_ Irrigation needed; maintenance access

Fig 7.10 MATERIAL - GRANITE COBBLES; GYPSUM PLASTER; PIGMENTED PLASTER; TIMBER; GREEN ROOF (top to bottom)

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EPOXY COATED SCREED — SEMI-PRIVATE SPACES

BENEFITS
_ Massive - flywheel effect
_ Smooth finish

IMPLICATIONS
_ Control joints at 3x3m intervals + around columns

BAMBOO FLOORING — PRIVATE SPACES

BENEFITS
_ Renewable material
_ Tactile quality

IMPLICATIONS
_ Laid on 60mm non-absorbent foam pad with latex glue
_ 20mm expansion joint at wall junctions

FROSTED GLASS — SEMI-PRIVATE SPACES

BENEFITS
_ Light transmission without compromising privacy
_ Glass is fully recyclable

IMPLICATIONS
_ Safety glass minimum 6mm thick
_ Lightweight aluminium frame; glass fins for lateral stability

BAMBOO WALL CLADDING — PRIVATE SPACES

BENEFITS
_ Renewable material
_ Natural material

IMPLICATIONS
_ Laminated veneer on composite board base
_ Panels fixed to masonry wall with countersunk stainless steel self-tapping screws + wall plugs

Fig 7.11 MATERIAL - EPOXY COATED SCREED; BAMBOO FLOORING; FROSTED GLASS; BAMBOO WALL FINISH (top to bottom)

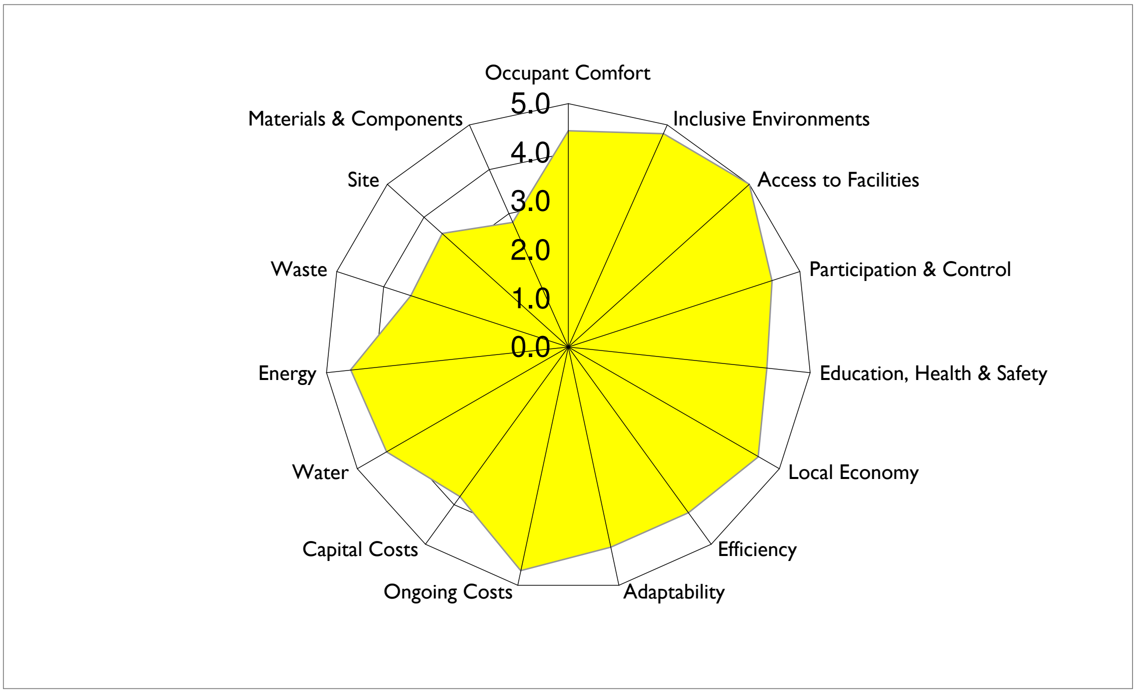
6 SBAT RATING

The Sustainability Building Assessment Tool (SBAT) was implemented to rate the sustainability of the design; the construction process and the management of the building.

Many of the criteria in the SBAT was not relevant to a thesis project, so certain assumptions were made, for example regarding the management of the building.

Points were awarded for each division, and three marks were awarded out of 5. The project rated 4.6 for social performance; 4.3 for economic performance and 3.7 for environmental performance. The overall rating was 4.2, which rates as 'excellent'.

The graph below illustrates the performance of this project:



Social	4.6	Economic	4.3	Environmental	3.7
Overall	4.2	Classification			

Fig 7.12 SUSTAINABLE BUILDING ASSESSMENT TOOL RESULTS