TECHNICAL INVESTIGATION

The technical investigation towards the building aims to analyse efficient methods of minimising the use of material with high-embodied energy. The use of these materials reduces consumption of non-renewable energy and reduces the building construction costs by applying low cost material with long life durability. This is combined with the use of climatic elements such as sun and wind. Solar panels, roof insulation, bio fuel and wind turbines are the systems used for energy production and climate control. To achieve sustainable results the investigation will be based on an analysis of the climate of the proposed site in order to apply adequate design methods and materials.

CLIMATE

The climate of Pretoria is generally warm in summer with a maximum average temperature of 27C° and a 15C° minimum. The weather in winter is more or less warm during the day due to solar radiation that equalises the cold temperature, and is very cold over night. The maximum average temperature is 21C° and 7C° minimum. The average rainfall over the year is 56mm where January and December has the highest rainfall, with 136mm and 110mm respectively. Wind blows predominately from North-east in summer and South-west in winter. Humidity levels are not considered problematic in the region, with the average in summer at 55% and 50% in winter.
(D, Holm, 1996:69)

EXPLORATION OF DESIGN METHODS

Water harvesting and passive use of solar energy are the technical methods chosen to explore and evaluate whether they are sustainable for the design concept. These methods aim to create a comfortable living space while increasing energy efficiency and reducing consumption costs.

Water Harvesting

Water harvesting is a process of collecting and storing rainwater that has run off from the roof, roads and other surfaces, and storing it in tanks for future use. Water harvested from the abovementioned surfaces is not suitable for human consumption without treatment. In urban areas rainwater is used for flushing toilets and watering the garden. Due to insufficient rainfall in the region and the high density of the project, this method was omitted.

Passive Solar Energy

Passive solar energy is the use of natural environmental resources such as sun and wind temperature to generate energy. The design of passive solar energy in the building aims to achieve a comfort zone indoors by using the resources mentioned above together with building materials.

A comfort zone is a space in which a human body can easily adjust to the environment with the available energy.

EXAMPLES OF THE METHODS USED IN THE BUILDING

Bedzed

Bedzed is one of the largest housing associations in London.

It was designed by Arup and architect Bill Dunster and built in 2002.The buildings are key to generating social advancement and prosperity in the area, and are also a great example of the use of passive energy.

The buildings were designed to use low-cost renewable energy. Therefore, the design was generated to control the indoor climate during different seasons, so that mechanical systems could be omitted.

The creation of a greenhouse was one of the methods used to control solar heat indoors.

It extends from the ground to the second floor. Thick walls were provided to control heat escaping if the external conditions changed.

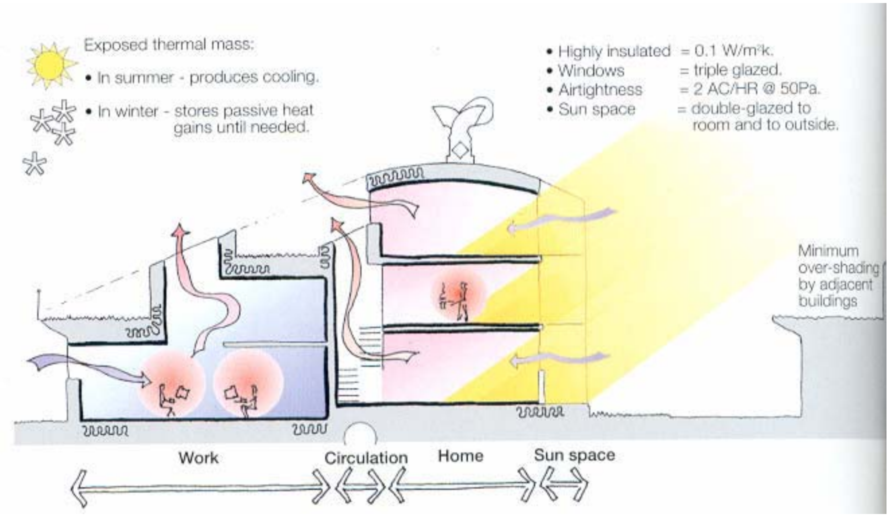


Figure 6.3.1.1 Building physics
(Brown, 1/2003, 12)

The building has both homes and workspaces. They have different orientations according to use. The office machine room in the workspaces building is oriented North to avoid solar heat gain during the summer, while maximising natural daylight and reducing the need for daytime artificial lighting.

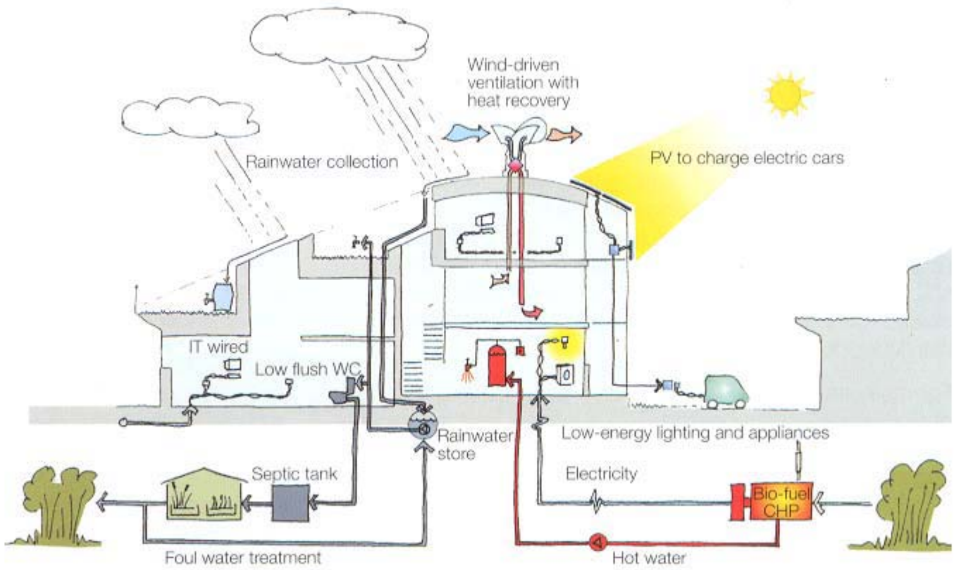


Figure 6.3.1.2 Mechanical and electrical system (Brown, 1/2003, 12)

Homes, on the other hand, have less occupancy density and less internal heat gain, so by facing South, they gain supplementary solar heat.

The wind cowl ventilation system pumps fresh air to remove condensation moisture from the kitchens and bathrooms as well as toilet smells and kitchen fumes.

Conventionally, much high-grade fan and pump electricity is consumed to deliver low-grade energy to achieve a comfortable room temperature control and ventilation. This tends to be significant because these systems run for extended operating periods. As building envelopes become more airtight to reduce uncontrolled heat-loss, provision of controlled minimum ventilation becomes particularly important.

The photovoltaic panels were provided on the Southern façades of the building, to supply power to electrical vehicles. Rainwater is collected to reduce the cost of treated potable water. It is collected from roof surfaces and stored in underground tanks for irrigation and toilet flushing.

Photovoltaic system

The use of solar energy through a photovoltaic system is a real alternative to the conventional electricity production in low-cost housing. The highly developed artificial climatising technology of the '50s allowed architects to design building envelopes without particular concern for their orientation. In the '80s, building regulations were imposed to save energy, which has resulted in new buildings with two and three-layer outer skin constructions, which were expensive and more characteristic than stylistic features.

Today photovoltaic panels not only function to collect and store solar energy, but are also integrated into building design elements.

Façade and roof areas are integrated actively into energy and thermal systems with the idea of making self-sufficient buildings.

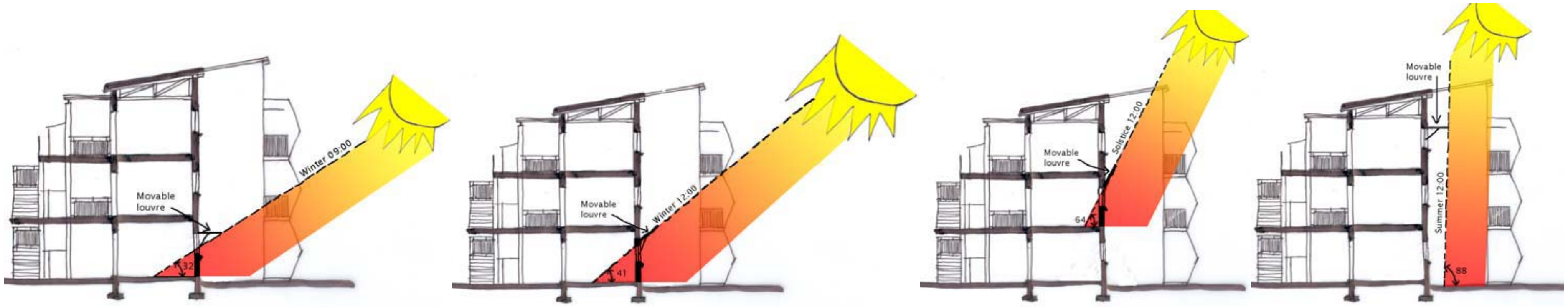
Figure 6.3.2.1 Photovoltaic panels on to of the roof tiles (Toggweieler, 1993, 51)

Figure 6.3.2.2 Photovoltaic panels as a building element (Toggweieler, 1993, 65-60)

BUILDING RESPONSE

The building was designed to respond to local climate factors using passive solar energy methods and materials with low energy consumption. The proposed site has major impact on climate. The low density of trees, open land and sun heat are generators of uncomfortable temperatures. The highest point sun angle in summer, solstice, and winter are 88C°, 64C° and 41C° respectively. (Holm, 1996:72)

Therefore, the buildings were placed at a minimum distance of 12,5m in relation to building height and roof orientation, to control sun penetration into the building from 9 o'clock. The building controls indoors temperature by radiation, conduction and convention.



Winter at 09:00h 32 C° | Winter at12:00h 41C° | Solstice at 12:00h 64C° | Summer at 12:00 88C°

Figure 6.4.1 Sun angle

MATERIAL APPLIED IN THE DESIGN PROPOSED

The skin of the building separates the indoor and outdoor environment by using materials with different physical properties and layout orientation to achieve sustainability.

Mass

Thermal mass is a property of building material that provides storage heat. Masonry wall is one of the elements that used in the design concept to reduce temperature swing by controlling heat flow from outside to inside and vice versa, keeping indoor temperatures adequate for humankind.

Conduction

Glazing in doors and windows is the conduction element that allows heat transmission. The use of glazing reduces solar radiation through reflection in summer and absorbs solar radiation in winter for effective performance of the comfort zone.

Areas of the building facing North where windows are placed, act as a greenhouse effect which collects and traps solar radiation to heat the building during the winter season.

The greenhouse effect consists of a passive solar heating system.

A passive solar heating system is a method that collects, stores, and redistributes solar energy without the use of fans, pumps or complex controllers.

Windows facing north capture heat from the sun more than any other orientation during the winter season.

During the day, radiation from the sun transmits short wave solar energy and passes easily right through the glazing. Furniture, floors, walls and other objects absorb it. Indoor elements warm up, increasing their emission of radiation in the long wave and store it for nighttime use. To prevent overheating in the summer, the indoor space must be vented through the openings.

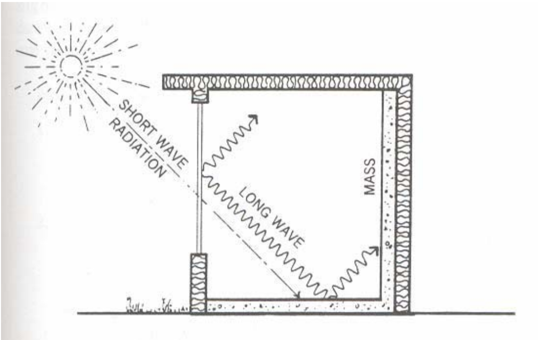


Figure 6.5.2.1

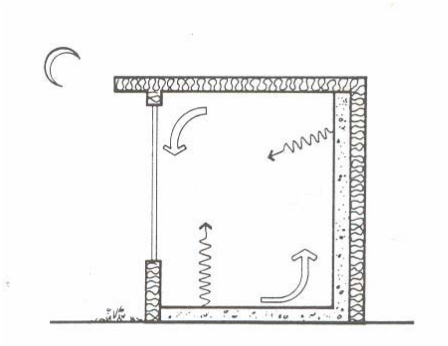


Figure 6.5.2.2

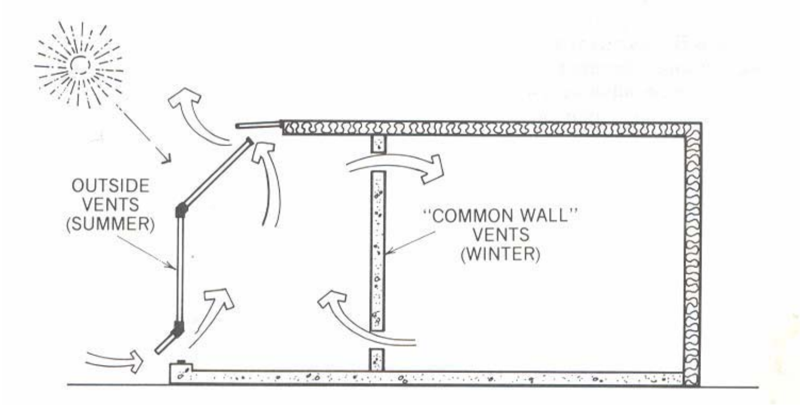


Figure 6.5.2.3

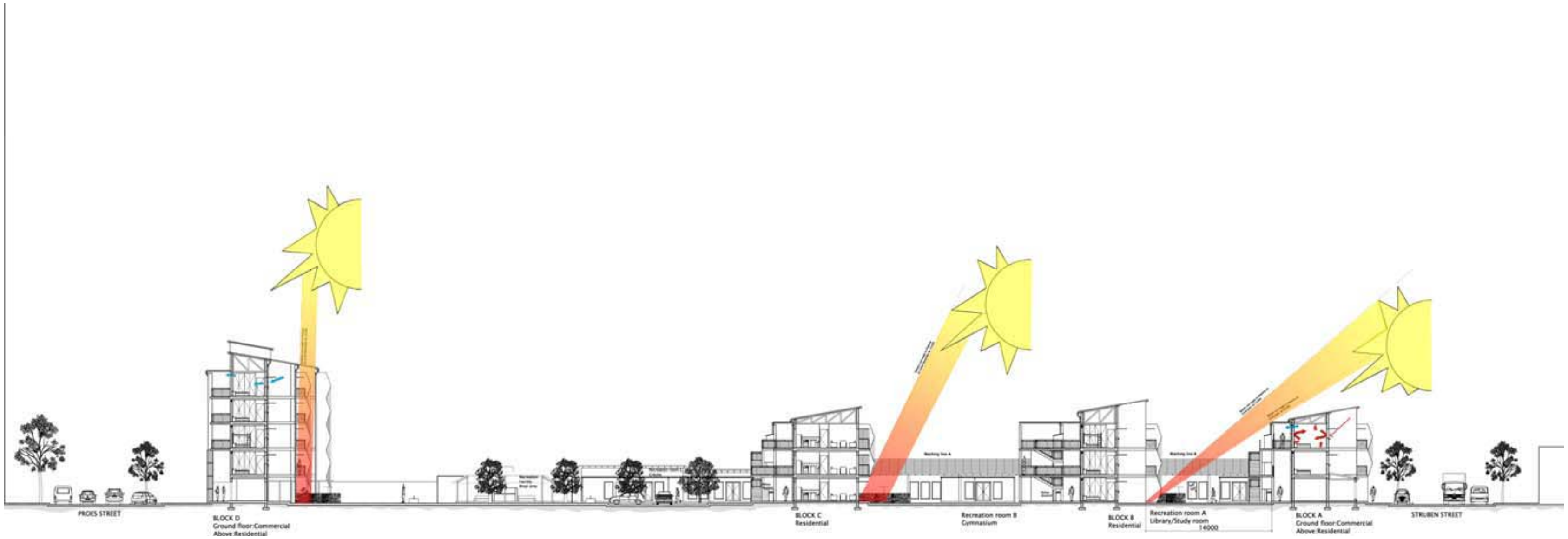


Figure 6.5.2.4 Building responding to climate factors

Radiation

The building gains solar heat through openings, windows and doors.

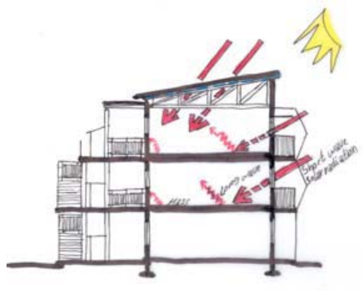


Figure 6.5.3.1

Conduction

The internal spaces absorb heat through openings and store heat in furniture, walls and floors for later use.

Figure 6.5.4.1

Convection

The use of openings allows air-flow to moderate temperature indoors. Windows, doors and airbricks are place on opposite sides, orientated North-south for effective cross ventilation.

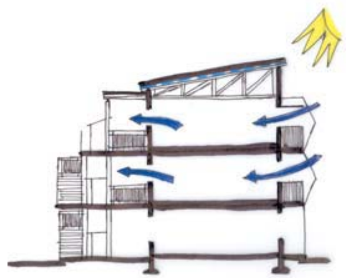


Figure 6.5.5.1

Solar Control Device

External movable wood louvers are control devices designed for sun angle orientation specifically in rooms where people spend most of their time. Louvers are made out of wood with steel arms as a control device. The steel arm regulates the louver to control sun angle radiation. Balconies oriented North-west have vertical cladding made out of wood with gaps of 50mm between them. The shade creates comfort zones for people standing in it by reducing Western sun radiation.

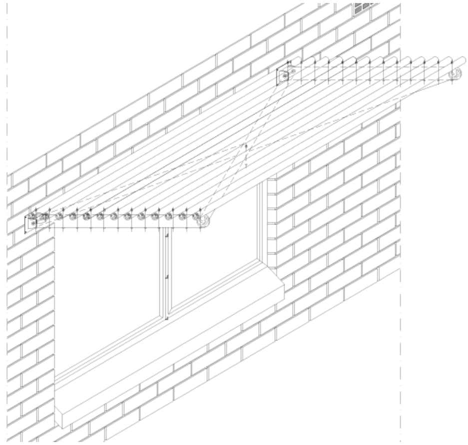


Figure 6.5.6.1 Movable louver

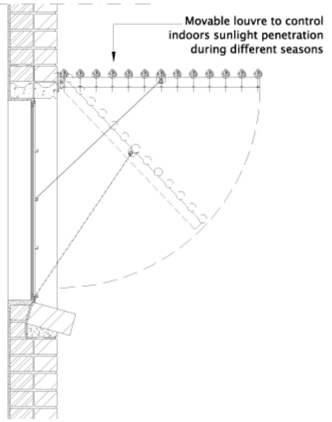


Figure 6.5.6.2 Section illustrating louvre controlling sun angle radiation

Solar energy systems

Conventional water heating systems consume most of the energy compared to other appliances in a house. For low electricity consumption, a solar water heater is the appropriate system for hot water provision. Photovoltaic panels are method integrated into the building design to capture solar radiation for electricity production. The production of electricity from this system will provide energy for electrical fencing, street- lights and for heating water. The panels are placed on the Northern façade of each building for maximum sun radiation capture. Panels also are placed on poles for street-lights and electrical fences. The use of natural resources will increase the capital cost of the project, but in the long run the costs of energy consumption will be lower.

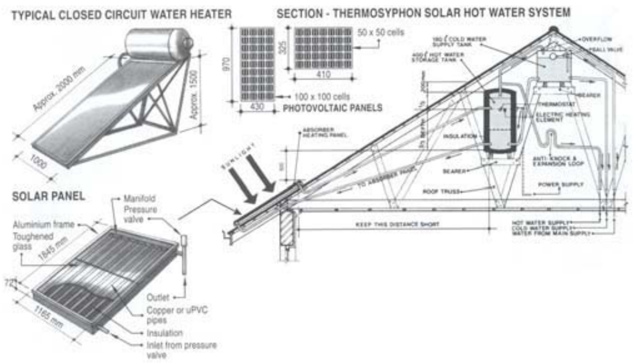


Figure 6.5.7.1 Types of solar water heaters (Grobbelaar, 1992:70)

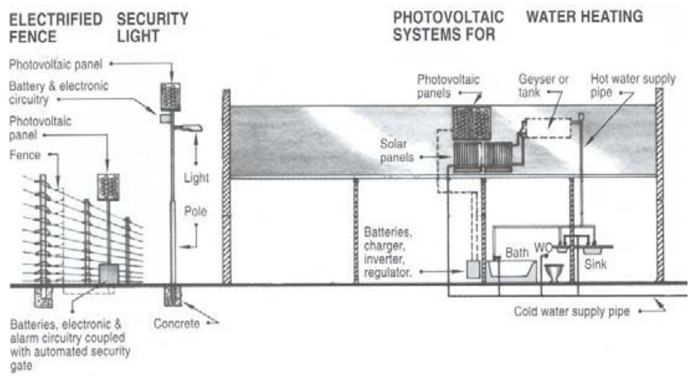


Figure 6.5.7.2 Appliance of photovoltaic in security system (Grobbelaar, 1992:70)

SUBSTRUCTURE

Foundation

The foundation has the function to sustain and transmit to the ground on which the combination dead loads imposed rest, in order to avoid any movement that can affect the stability of the building.
(Chudley, Greeno, 1998:163)

According to engineers, 700x230mm double wall strip foundations and 850x230mm movement joint foundations are the suitable substructures for the proposed project. Double wall strip foundation is ideal particularly for this type of building where 255mm and 170mm reinforced concrete slabs with 460x230mm and 2300x230mm reinforced concrete columns are applied. The buildings are split into blocks which means it does not line up in the same grid for the design purpose. Therefore, movement joint foundation was introduced

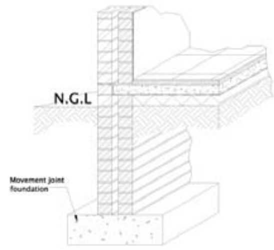


Figure 6.6.1.1 Movement joint foundation

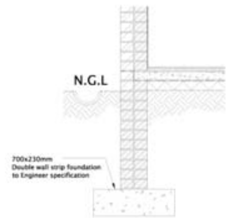


Figure 6.6.1.2 Double wall strip foundation

SUPERSTRUCTURE

Slab

Ground floor slabs aim to provide a level surface with sufficient capacity to sustain imposed loads from building elements. For climate purposes it traps penetration of water and water vapour into the building and reduces heat loss
(Chudley,Greeno 1998:475)

The slab used in the building is composed of fill compact in maximum 150 layers to 90% mod, plastic membrane, 85mm concrete surface bed, 25mm screed and 300x300mm ceramic tiles. Reinforced concrete slabs used on floors above are not economically sustainable for spans over 5m. To reduce the cost of construction 230x170mm reinforced concrete beams were incorporated into the structure design to span in two directions between the columns. The use of beams could compromise the height of the floors. However the beams were placed underneath walls and columns so as to not disturb the height of floors.

Columns

460x230mm and 230x230mm reinforced concrete columns are the vertical load-bearing members of the structure that transmits the slab's and beam's load to the foundation. The rectangular 460x230mm columns are used in the building of 5 storey due to the load quantity that the foundation caries. Square 230x230mm columns used in the building of 3 storey and some parts of 5 storey building where the foundation caries a low load.

Walls

230mm external walls and 115mm internal walls are used in the building. Stock bricks are used in plastered sections while face bricks are used on external walls for aesthetic and maintenance purposes. Nahoon Travertine face bricks are used for external walls.

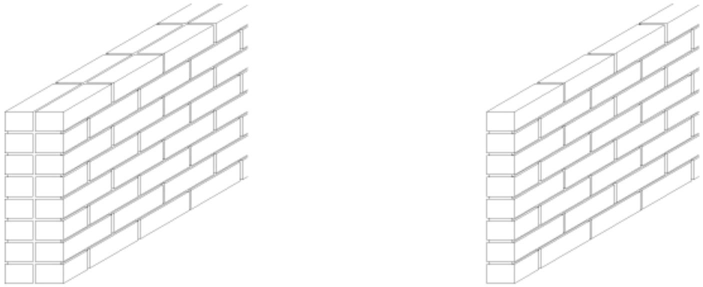


Figure 6.7.3.1 230mm external and 115mm internal walls

Figure 6.7.3.2 Nahoon Travertine FBA (Grobbelaar, 1992:13)

Curtain walls

Steel windows are cheaper in initial cost and have long life durability with low cost maintenance. 4mm clear float glass and 4mm obscured glass are used on domestic levels. 6mm safety glass with aluminum frames are placed on commercial levels due to large areas used.

Doors

All doors are also steel frame on residential levels and aluminum frame on commercial levels. The flat units are compiled with external 2 paneled timber doors and internal flush doors. On the commercial level, the external doors are 6mm safety glass. The internal doors are also flush doors.

Air-brick

Most of the houses in South Africa do not have air-bricks or other systems that allow cross ventilation in the building. Small-scale houses without cross ventilation systems, especially in winter, with doors and windows closed become critical for air flow and an uncomfortable space to live in. Air-brick is one of the methods that can be used in this season to reduce this effect. The building provides air-brick in each compartment of the flat units due to the size of the units and high-density occupancy that absorbs heat.

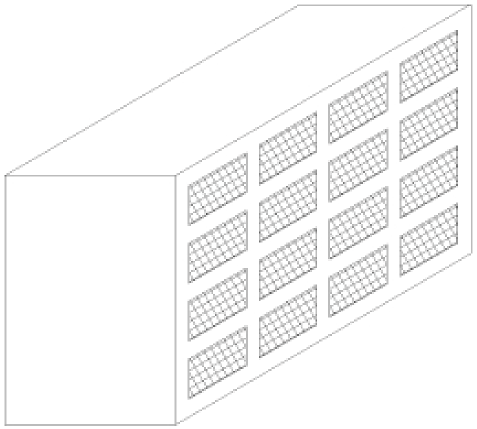
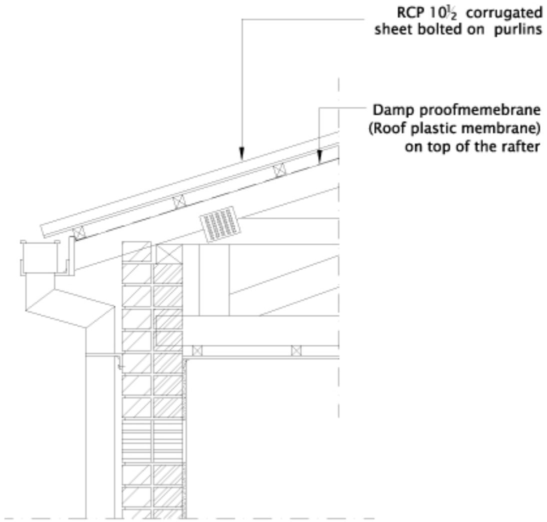


Figure 6.7.6.1 .Air brick

Roof

Materials of roof trusses and sheeting also have impact on heat gain. Wood is used for roof trusses due to low heat absorption. RCP 10½ roof sheeting is the most available, durable and affordable on the local market. It is lighter to carry and easy to assemble. The higher heat conduction is the negative point of the product, but with use of an insulation device in the roof it will perform well. As discussed in the chapter above, the size of the units in relation to air-flow indoors, the introduction of an insulation device in the roof will control heat flow. 54mm bubble fibre insulation is placed between trusses and roof sheeting. Bubble fibre traps heat indoors reducing heat loss from the roof. In the summer it will offer resistance against heat gain.



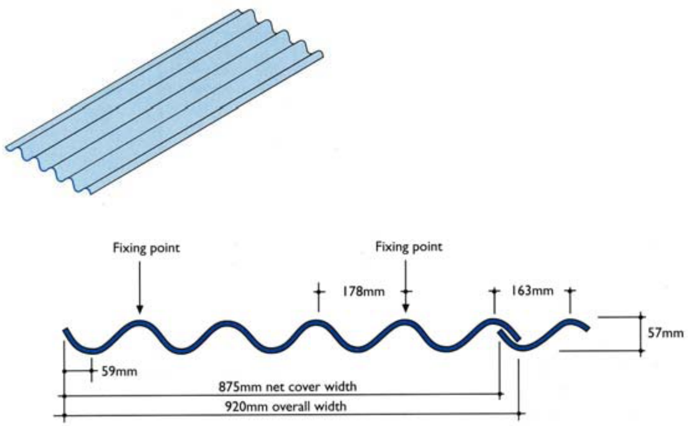


Figure 6.7.7.1 Roof section

Figure 6.7.7.2 RCP 10½ roof sheeting (www.everite.co.za)

Storm water

Metal gutters and 110mm diameter steel down pipes are the storm water channels that will collect rainwater from the roof and direct it to storm water drains through runoffs. Stormwater drains compiled within National Building Regulations (SABS 0400) where drain points do not exceed 40m.

Figure 6.7.8.1 Stormwater drain

Figure 6.7.8.2 Stormwater layout

FIRE STABILITY OF STRUCTURAL ELEMENTS

All the columns comply with fire stability regulations of structural elements for multi-storey buildings.
The class of occupancy of the building is E3 and G1where the stability rating is 120 and 60 minutes.

Provision of Escape Routes

The escape routes of the building comply with the SABS. Corridors are provided on each floor on the South side with travel distance less than 45m, 2m in width, to the nearest 1.1m wide stairways. The steel stairways covered with chain link fencing is provided on the Western side of the South building
The 230mm and 115mm brick walls comply with fire rating resistance of 120 minutes.

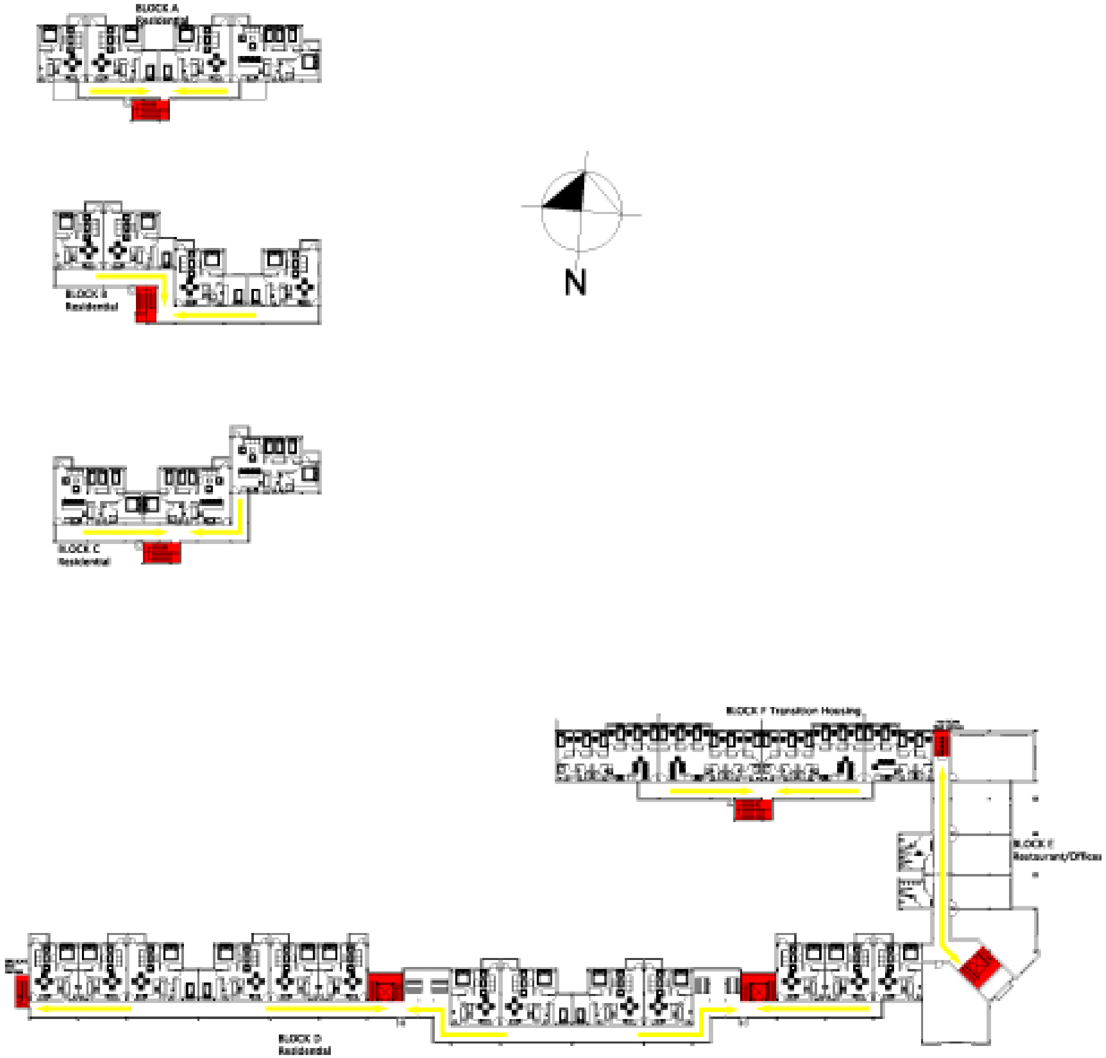


Figure 6.8.1.1 Fire escape route layout

Markings and Signposting

The building is clearly marked and signposted indicating the direction of exits and fire fighting equipment in case of any emergency. Signs used comply with the standard symbolic system, which is coloured. Sign symbols are provided adjacent to the exit, fixed the on wall just above door height.

The fire hose reel sign symbol is provided on the wall adjacent to the fire hose reel.

Figure 6.8.2.1 Signposting

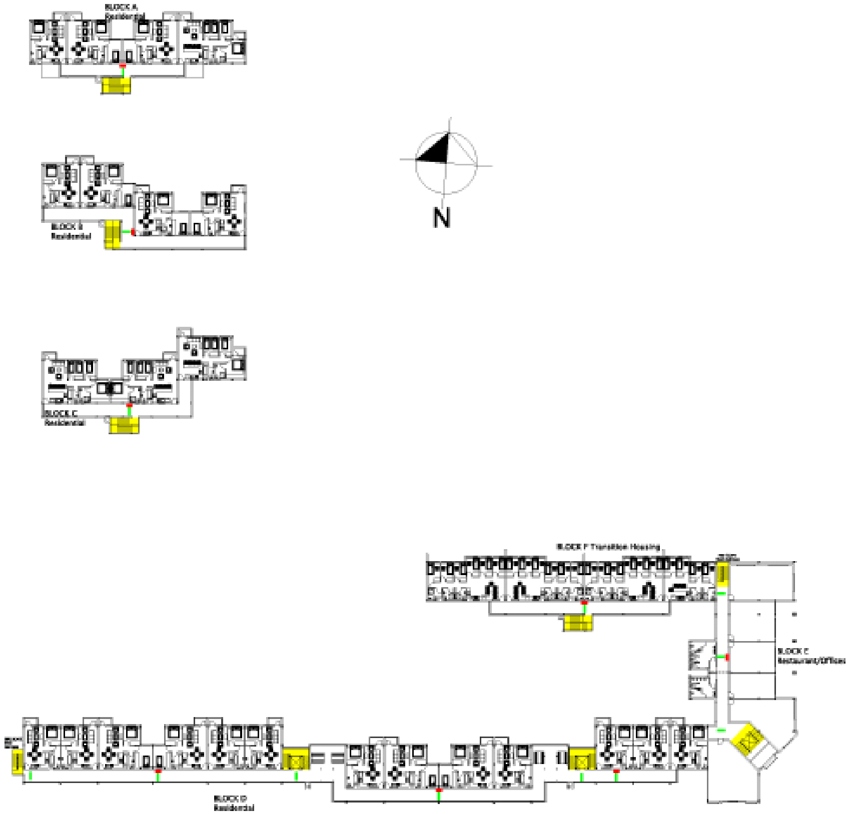


Figure 6.8.2.2 Location of signposting

Provision of Fire Fighting Equipment

The fire fighting equipment in the building is installed so as to be ready at all times for their purpose. The position of the equipment is clearly visible and indicated by symbolic signs which comply with the requirements contained in SABS 1186.Each floor is provided with fire hose reels and fire extinguishers placed next to each stairway.

Figure 6.8.3.1 Fire fighting equipment

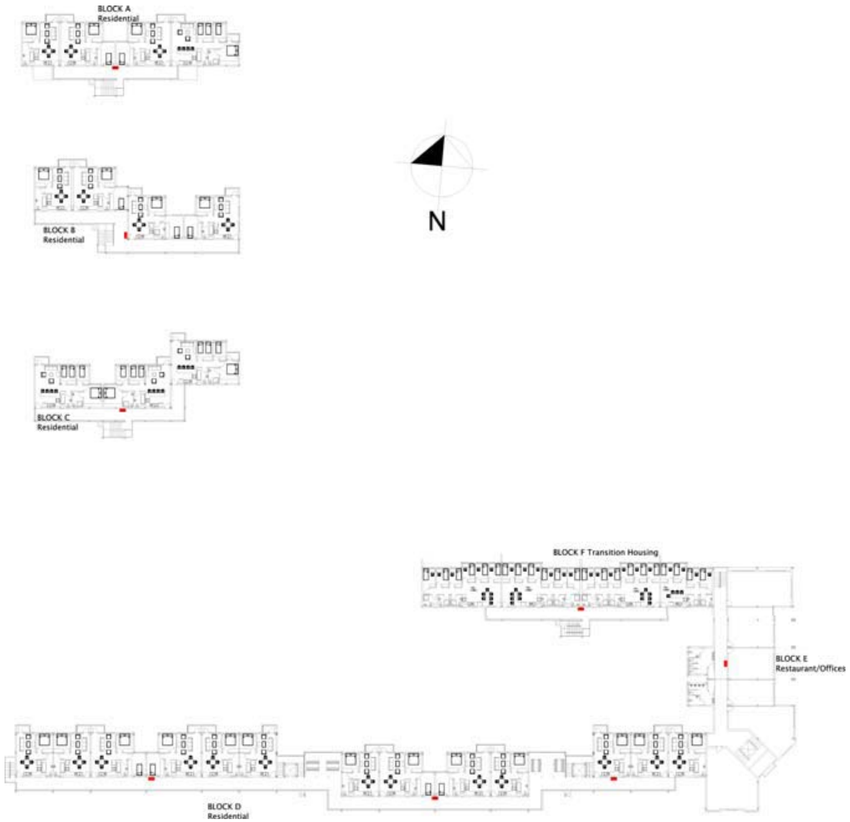


Figure 6.8.3.2 Position of fire fighting equipment