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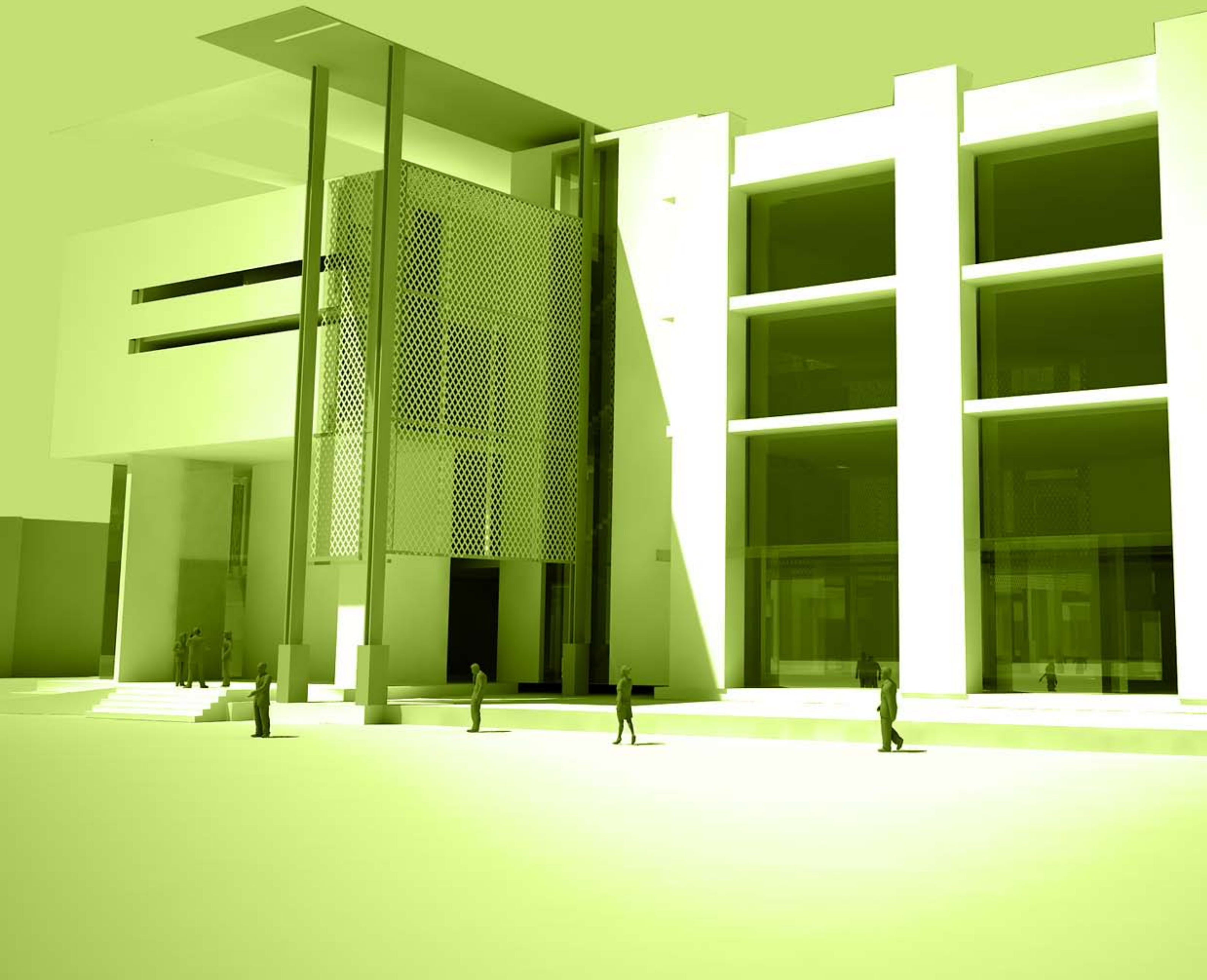

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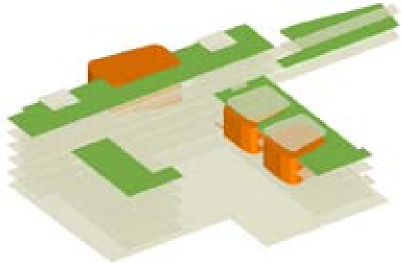
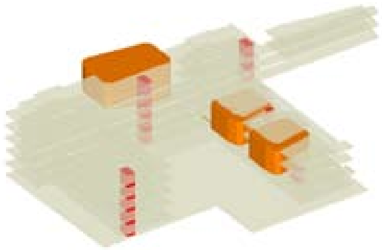
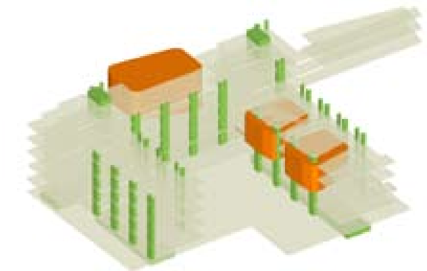
_green roof



_recycling



_ventilation



_water harvesting

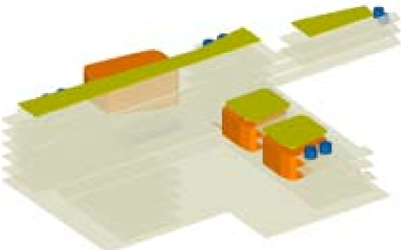


fig. 170 [a] sustainable features of the facility

The environmental benefits from building green are beyond dispute. It delivers a suite of compelling economic and social benefits that conventional buildings do not. The main objective of this study is to produce a building with a carbon minus footprint, using less energy than it consumes. This will ensure buildings in future can function on their own grid structure without any energy input other than natural resources, ensuring a more viable life span for the building. The study will investigate the possibility of this objective.

Sustainable features of the facility includes:

-Rooftop garden [fifth elevation]
-Solar water heating
-Grey water recycling and rainwater collection
-Low flush toilets
-Recycling facilities
-High recycled content of structural concrete
-Sewage plant in basement
-Natural stack ventilation
-Night cooling
-Absorption chillers
-Fully operable shading on the facade
-[West facade of louvres powered by photovoltaic cells] that track the sun [Northern facade fixed shading system]
-Wavy concrete ceilings [increasing surface area for enhanced airflow]
-Use of thermal mass to heat and cool structure
-Specification of low Volatile Organic Compound emission products and materials

"Pretoria regionalism...reflects a particular response to nature and landscape through the economical use of naturally available and industrially produced materials with an empirical response to climate..."
[Fisher, R.C. 1998: p. 123]

Inspired by Brazil Builds, many civic and institutional buildings built after the 1940's display elements such as Brise Soleil, roof gardens and fluid concrete form work. **[Fisher, R.C. 1998: p.197-229]**

_building aims

-sustainable site development
-water efficiency
-energy efficiency
-indoor environmental quality
-reduced consumption of building materials

_structure

A concrete structure was selected as the load-bearing component. This material has a high recycled content and is organized in a structural grid of 8,5 x 7,8m, to allow for the flexible use of space for its proposed and possible future uses. The building's structure originates from the basement. The facility needs to provide parking, since the public transport is not sufficient for all the building users, therefor a single level basement parking is proposed, replacing the parking of the previous site in use. Additional parking is provided by proposed parking areas, within the group framework, placed outside campus. This allows free pedestrian movement towards the site and at street level. The basement is an open drain system, offering the opportunity to catch the rainwater, stored in a water storage tank within the basement. Mechanical sumps are placed at regular intervals, regulating the surface drainage. The water storage tank has an overflow to connect to the storm water channel. The basement is raised 1000mm above the ground level to allow natural ventilation and minimising the need for mechanical systems. Additional extractor fans are installed to remove excess polluted air.
The reinforced two-way floor slabs have a 340mm thickness with reinforced columns of 300x700mm, recommended by engineer [Carl von Geyso]

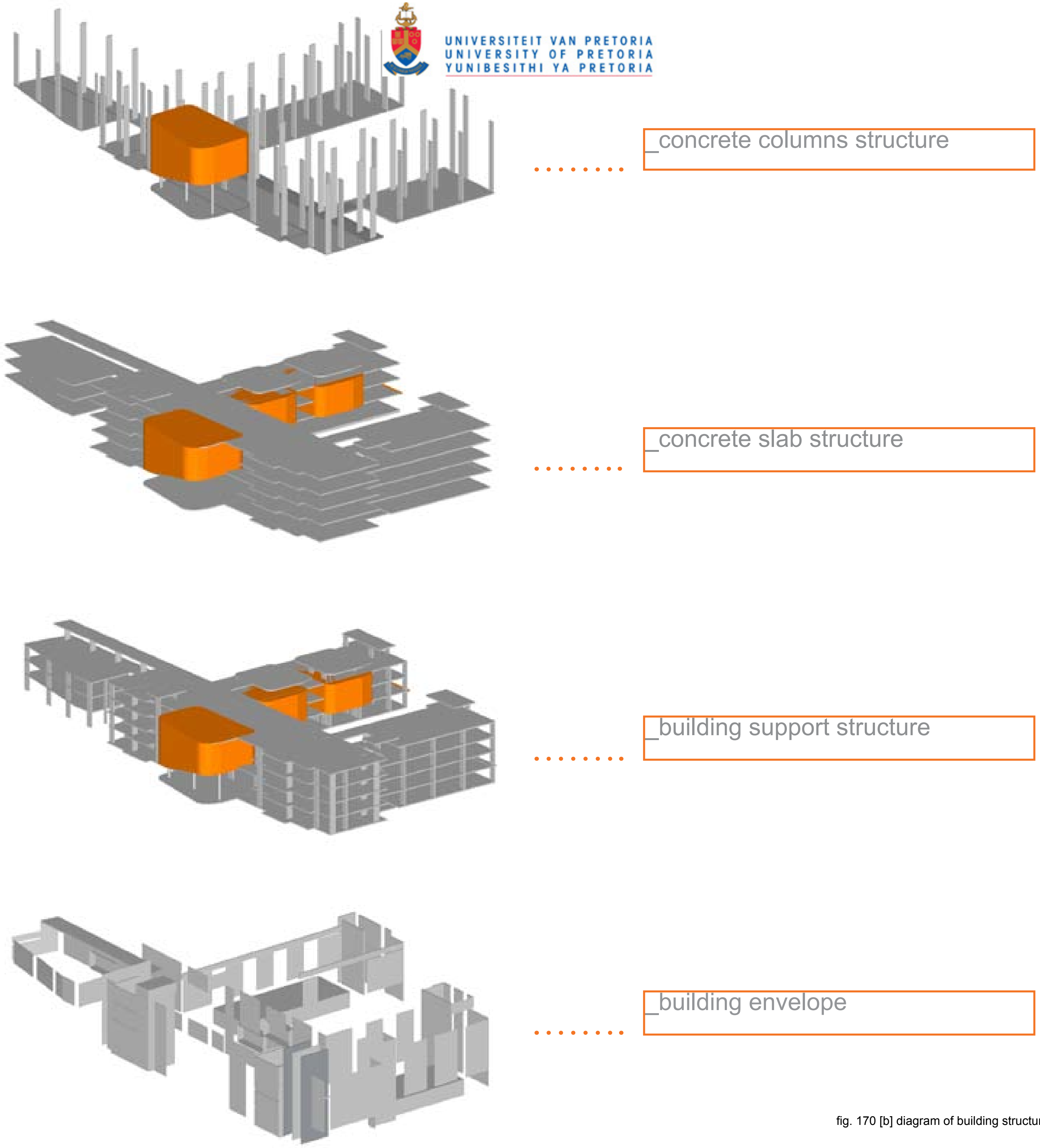


fig. 170 [b] diagram of building structure


fig. 171

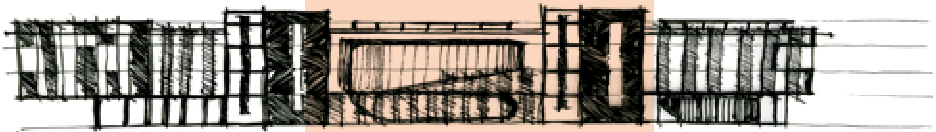


fig. 172

fig. 173

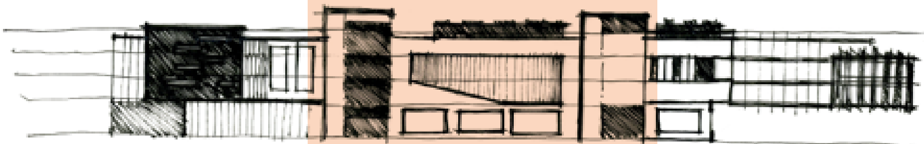


fig. 174

The concrete roof ensures sufficient insulation capacity;
offers the opportunity as an extra live-out space;
functions as a green roof;
filtering captured rainwater;
has a thermal heating and cooling capability to maintain a temperate internal environment;
allows for future development;
and respects the local Pretoria regionalism.

_the skin

For the building to act as a biologic entity, the building needs to be wrapped in a few layers of 'skin'. The skin consists of three main elements, the floor, wall and ceiling. Each has a finish, a structure and a material composition, influencing the energy flow within the structure. Therefor, the envelope of the building plays a vital role in the success of the building's micro-climate. The building envelope can be applied in different ways, depending on the specific requirements of the different building facades. Factors determining an effective system includes:
_the orientation;
_the function it hosts;
_occupant comfort;
_use of a natural or mechanical system;
_need for natural ventilation

There exists a fine balance between the tightness and breathe-ability of a building. Applying a balance between both these principles will create a stable, comfortable micro-climate.
Applying a few layers, consisting of a comfortable, self-cleaning layer placed next to the skin;
an air-confining composite;
and a moisture-, wind-, or solar protective or -responsive layer;
creates an effective, flexible symbiotic facade system.

The western facade of the main wing conveys an environmental message as a dynamic facade system following the sun. The hydraulically controlled recycled timber shutters automatically open and close depending on the sun's position. The northern facade of the two sub-wings is a fixed system, regulating specific viewpoints and light reflections specific to interior use. The east and south facades is defined by fresh-air shafts integrated from the roof down. The eastern shaft is further defined by a central circulation spine, connecting the pedestrian on ground floor with pedestrian flow on the first level. This allow the user to reach its destination without any vehicular interference and at the same time offers the opportunity to share in the entertainment value of the proposed facility.

fig. 175 [a] Transparent facade

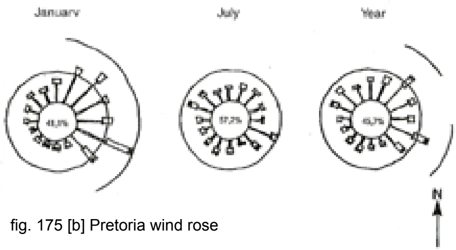


fig. 175 [b] Pretoria wind rose

_ventilation

At present, there is an increasing demand for cooling and climatisation in many parts of the world The distinct distribution of the cooling demand over the day, with a peak at noon and early afternoon, there is also a peak in electric power consumption which already leads to shortages in the electric power supply grids. The most effective method to lessen the energy demand of the building, is to eliminate the need for mechanical cooling through climate-adapted design. To be able to identify an appropriate cooling strategy for a specific building, an understanding of three things is required:

_climate;
_building type;
_pattern of operation.

_climate

The city of Tshwane is situated within a climate zone with distinct rainy and dry seasons, a large daily temperature variation and strong solar radiation. Humidity levels are moderate.

-location: 25,8' to 30,7' East and 22,0' to 25,9' South.

-temperature: the maximum diurnal variation occurs in the winter [July - 15K below the comfort zone], while the average monthly diurnal variation is 13K. Summer season the temperature extend approximately 3K above the comfort zone.

-humidity: the humidity levels are moderate and are not considered problematic. The average monthly relative humidity level is 59%.

-wind: summer winds are predominantly east-north-easterly to east-south-easterly. Winter winds are predominantly south-westerly with a fair amount originating from the north east. [D.Holm - Manual of energy conscious design]

The buildings' main ventilation system is composed of an integral two part hybrid system. The passive system, which is mechanically aided by a series of small industrial fans, air intake is located at the rooftop - to ensure the air is not influenced by radiated heat from hard surfaces surrounding the building and less polluted, clean, fresh air intake is obtained. The air is transported down by a vertical duct system, cooling the air temperature further, placed in regular intervals according to the structural grid. In the basement the air is further cooled by a geothermal pipe system made up of horizontal placed closed loop polyethylene pipes, requiring the minimum excavation of 1.5m - 2.5m. These pipes use the earth as a heat sink to provide cooling by removing heat from the air circulating through the building. The system consists of three subsystems including: a geothermal heat pump [moving the heat between the building and the circulating air]; an earth loop piping system [for transferring heat between the air and the earth]; and a distribution system [for delivering cooling air to the building]. The building footprint consists of a West-facing main wing and two North-facing sub-wings. Vertical stacking chimneys placed on the North and West facade, creates a stack effect and expel 50% of the fresh air supplied by the distribution system. The concrete floor slabs are night ventilated to cool the structure in advance. This enables the concrete slabs to radiate cool air during the early morning hours and to function as a heat sink as the interior spaces heats up during the day. As soon as the thermal mass reached its maximum heat absorbing capacity, the active system kicks in, usually during the late afternoon.

The active system, is a solar thermal cooling system with absorption chillers. The system has a lower environmental impact

fig. 176 ventilation concept sketches

compared to other refrigeration devices, produced via a heat source instead of electric power. The system consists of a Direct-fired chiller [using a refrigerant - lithium bromide] or an Indirect-fired system [using a hot water source e.g solar water heater]. The latter was chosen for the proposed project. Flat plate collectors would generate the heat for driving the absorption chiller, to cut electrical peak loads during the summer and to reduce fossil fuel consumption. The operation of the Absorption Chiller, is characterised by the temperature levels of three external media [heating - 90'C hot water input; chilled - 15'C chilled water output; and re-cooling - 32'C cooling water input]. The system is based on attracting and releasing water within the loop, undergoing a two-stage process of dilution and concentration. The water flows through a four stage process of evaporation - condensation - evaporation - absorption. To move heat is an integral part of the process.

_ventilation strategy

- 100% fresh air supplying duct system;
- vertical stacking chimneys with wind turbines to expel circulated air;
- a geothermal pipe system, generating cool fresh air, circulated through the building via a distribution system;
- solar assisted air conditioning [absorption chillers];
- HVAC back-up system;
- night cooling [during summer];
- additional solar water heating [during winter].

_cooling strategy

2am-6am: 100% fresh air is supplied from rooftop via the distribution system, circulating through raised floors

to cool the concrete structure.
6am-2pm: Passive mode - Occupants arrive and air handling unit supply 100% fresh air. The air is circulated through the geothermal pipes and pumped into the raised floors by low energy fans. The cool air rises through the space, heats up and exhaust via the exhaust plenums and wind turbines on the western and northern facades respectively.
3pm: Active mode - On days with extreme conditions, the absorption chiller units is used to maintain a cool and comfortable micro-climate This method is typically employed in temperate climates, similar to Pretoria. [During malfunctioning of the systems in place, the HVAC system is activated].

_heating strategy

2am-6am: Hot water circulates through water pipes cast in the concrete floor slabs. The water is heated by solar water heaters fixed on the roof, it is stored in a central storage tank. Further head gain include the active northern and western facade, which consists of a triple glazed system to insulate the building. Functioning as a solar trap during the winter months.
6am: Occupants arrive and fresh air is supplied via the supplying duct system. The air is then transferred to the geothermal pipes and pumped through the raised floors on each floor level, heated by the floor slabs via latent heat and the solar water pipes. The warm air rises, heats up and exhaust through the exhaust plenums and wind turbines on the western and northern facades respectively. [During extreme cold conditions the HVAC system is activated].

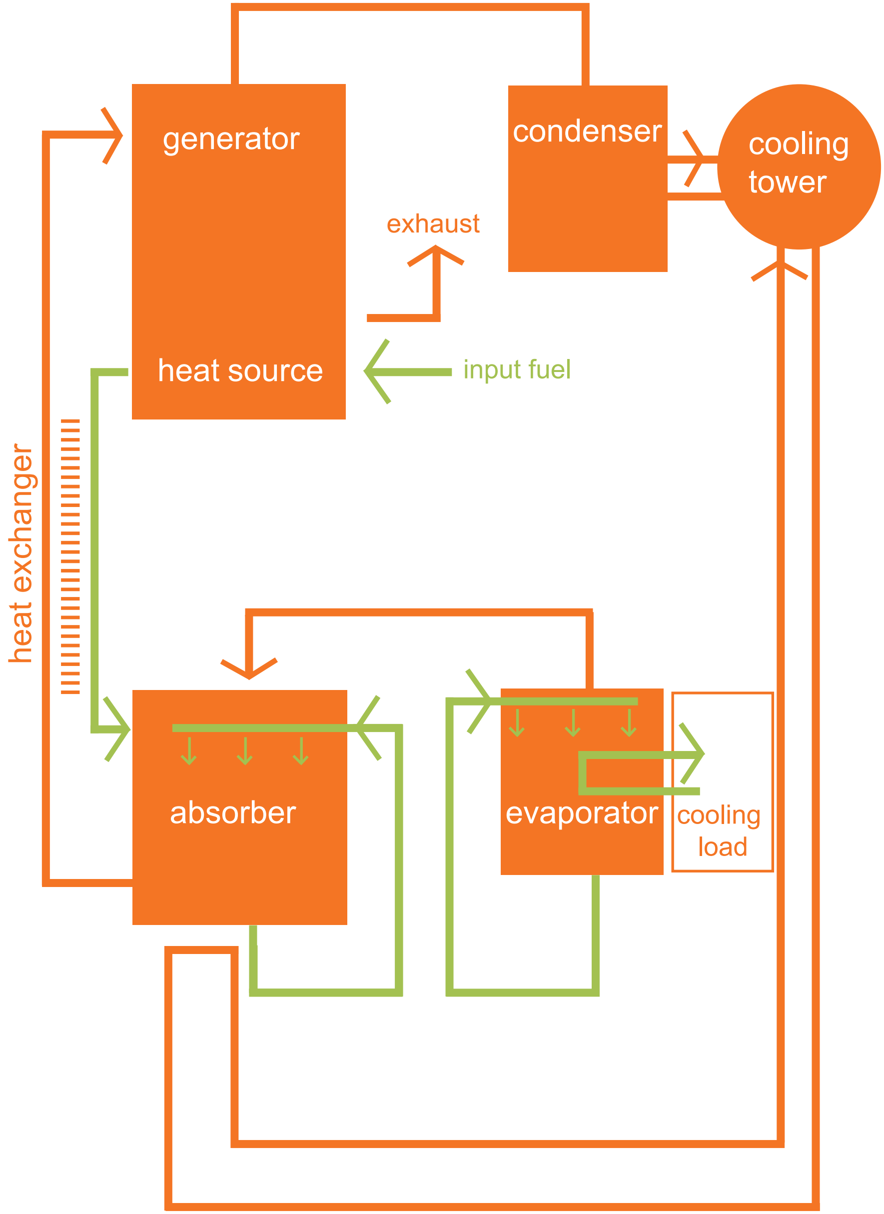


fig. 177 schematic diagram of the absorption refrigeration cycle

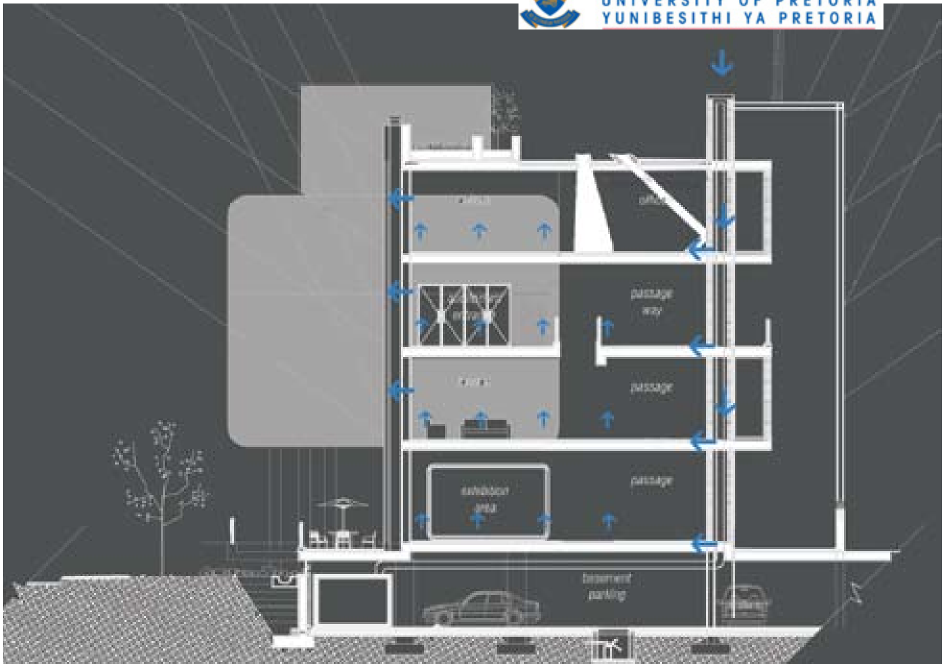


fig. 178 [a] night cooling

fig. 178 [b] passive mode, ventilation cooling

2 am - 6 am

NIGHT COOLING

100% fresh air circulates through the building, cooling the concrete structure.

6 am - 3 pm

OCCUPANTS ARRIVE

air-handling unit on roof turns on and supply filtered 100% fresh air

air circulates down the eastern and southern shaft to the geo-thermal pipe system

the air is cooled and pumped by high speed fans into raised floors on each floor level

the cooled air enters the space, heats up and exhaust through the exhaust shafts

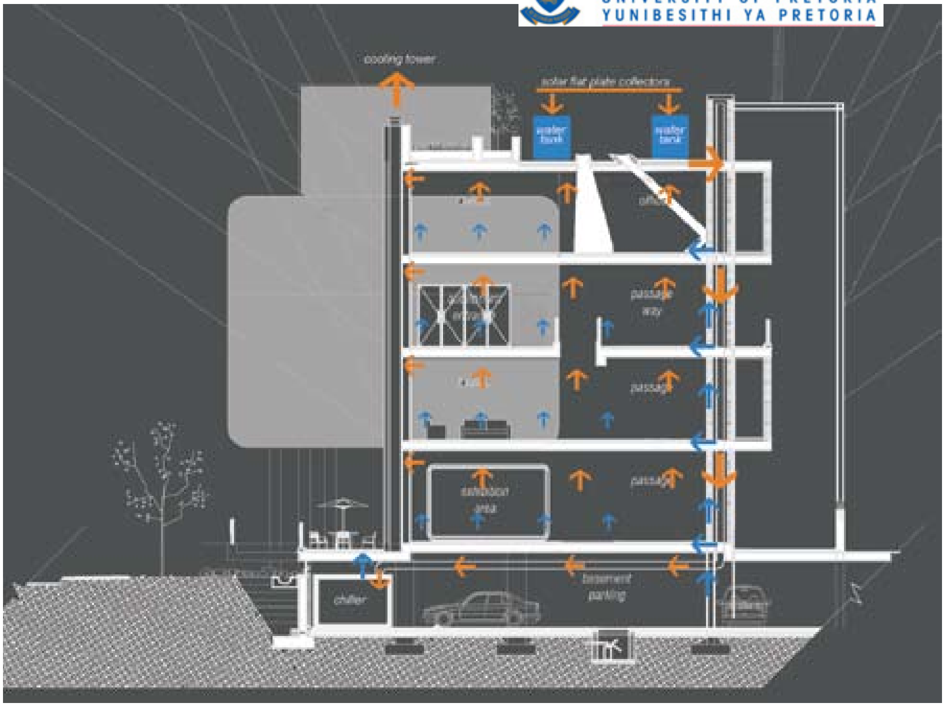


fig. 179 [a] active mode, absorption chillers

FUNCTION	AIR EXCHANGE RATE REQUIRED
Theatre	3.5 per person
Cafeteria	5.0 per person
Kitchen	17.5 per person
Retail	7.5 per person
Auditorium	5.0 per person
Offices	5.0 per person
Exhibition space	3.5 per person
Ablution	20 per person

fig. 179 [b] table of required ventilation rates

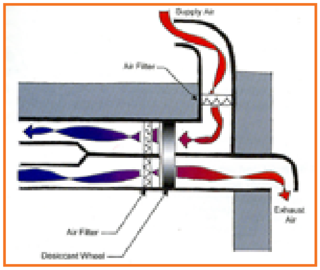


fig. 179 [c] heat exchanger

3 pm -

EXTREME CONDITIONS

during extreme hot conditions the building switch from passive to active mode

flat plate collectors placed on the concrete roof act as heat source for the absorption chiller

hot water from central storage tank is circulated to the absorption chiller unit situated in the basement

the water flows through a 4 stage process of evaporation - condensation - evaporation - absorption

the chilled air is then circulated through the suspended floors and cools the interior space

IN CASE OF A MAL-FUNCTIONING OF ANY SYSTEM IN PLACE

an HVAC system can be activated

fig. 180 [a] heating strategy

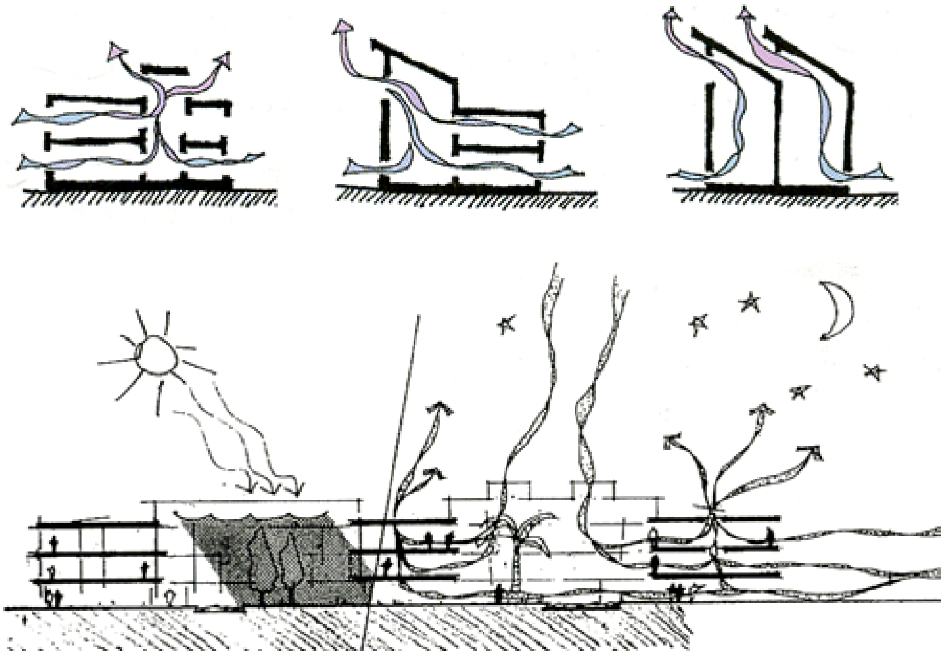


fig. 180 [b] schematic diagram of thermal heat gain

2 am - 6 am

THERMAL HEAT GAIN

the concrete structure has the capacity to function as a heat sink, radiating heat during the night, ensuring the space heats up before occupants arrive

6 am - 3 pm

OCCUPANTS ARRIVE

water heated by the solar water heaters is transferred to the water pipes cast in the concrete slabs

this will heat the concrete structure even further

100% fresh air is pumped through the floors, ensuring the air heats up before it enters the space

the warm air rises and exhaust through the exhaust plenums on the northern or western facade

shafts exhaust through the rooftop mounted wind turbines

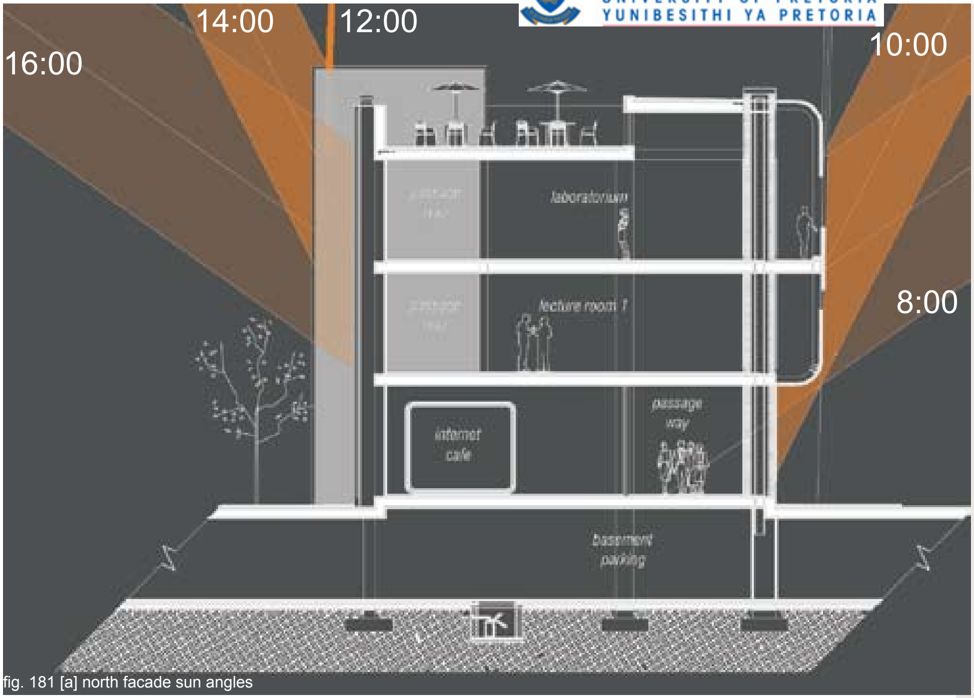


fig. 181 [a] north facade sun angles

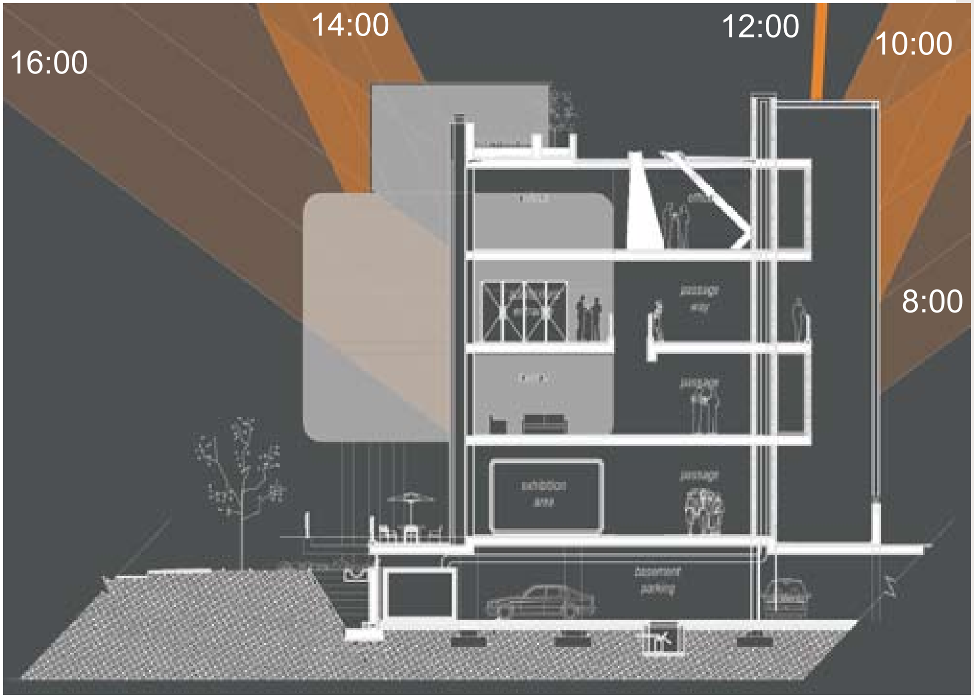


fig. 181 [b] west facade sun angles

_task lighting

Daylighting is the key to good energy performance and occupant satisfaction. Its the most sustainable source of light and should be used optimally. To allow occupants to regulate their light levels at their workstations is of extreme importance. Extra mechanisms can be added, blinds, adjustable louvers, screens, to adapt to the light intensity levels at a specific time of day. Top lighting, used in the central circulation spine, allows even levels of diffuse light to be distributed. It connects the user with life outside the building. Glare and unwanted optical illusion can be avoided by using lights placed in positions for adequate light levels.

_north facade [21 December; summer]

_west facade [21 December;summer]

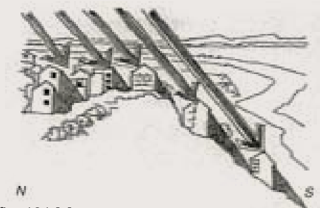


fig. 181 [c]

The artificial lighting system has high-frequency control equipment [reduce danger of nausea, headaches associated with fluorescent lighting], which can permit dimming, to be used on fluorescent luminaries for lower energy consumption. Automatic sensors can be added to control these lights for further energy savings. Theses sensors monitor movement and daylight, switch on-and-of accordingly.

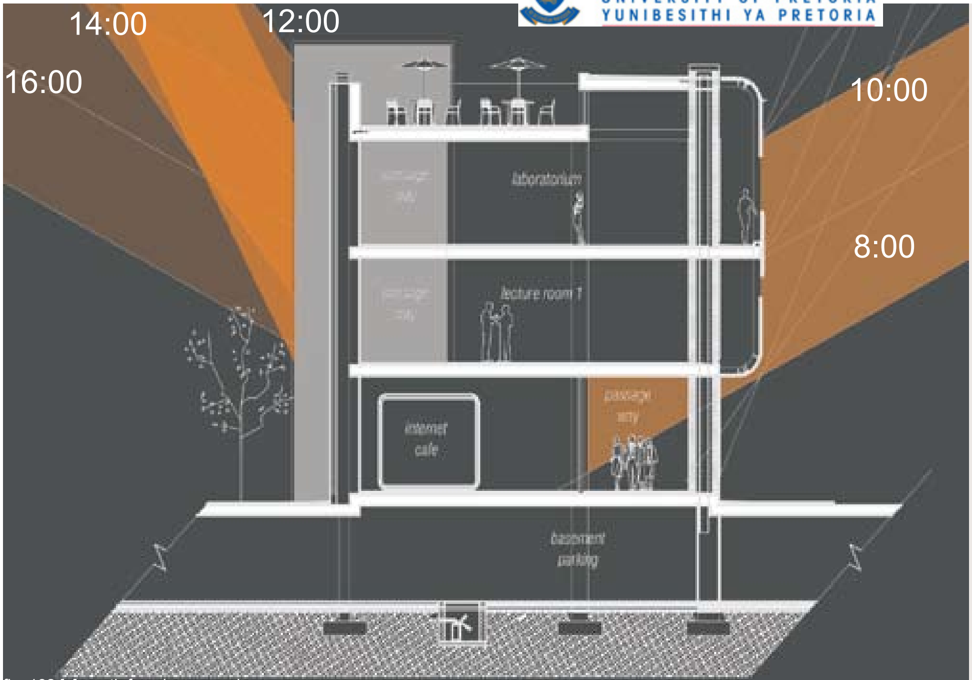


fig. 182 [a] north facade sun angles

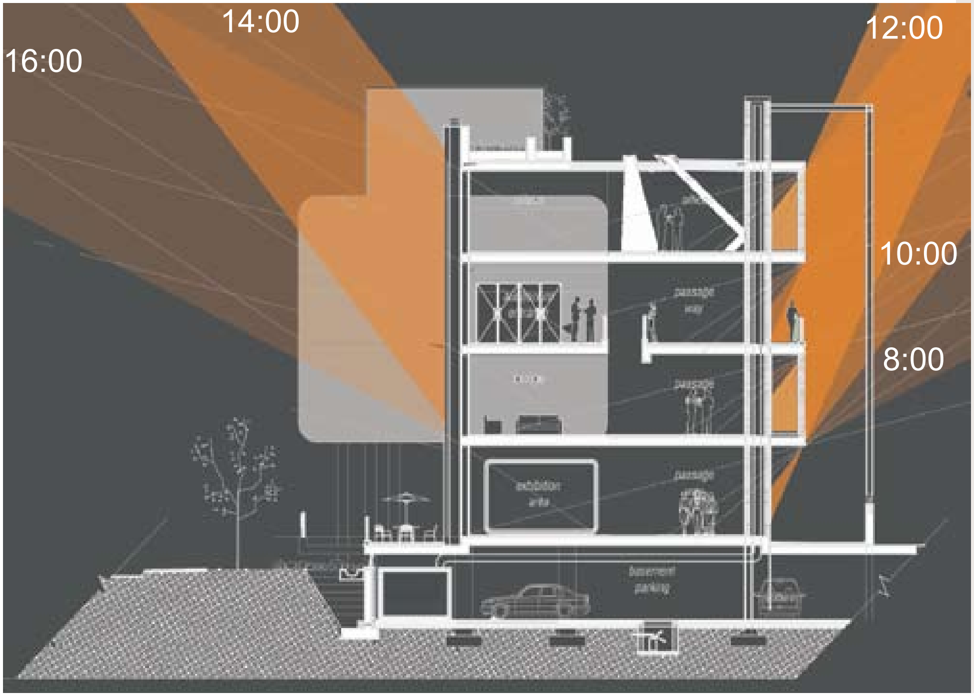
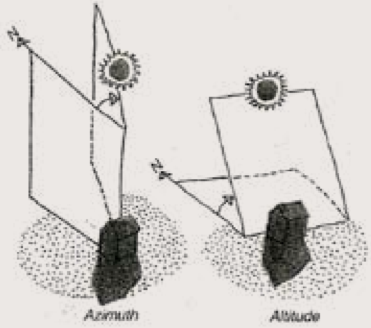
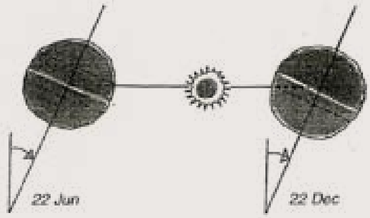


fig. 182 [b] west facade sun angles



_north facade [21 March/21 September; spring/autumn]

_west facade [21 March/21 September; spring/autumn]



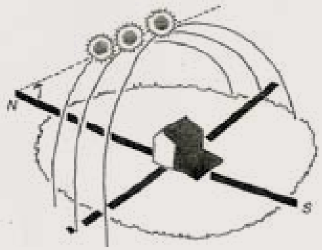


fig. 182 [c]

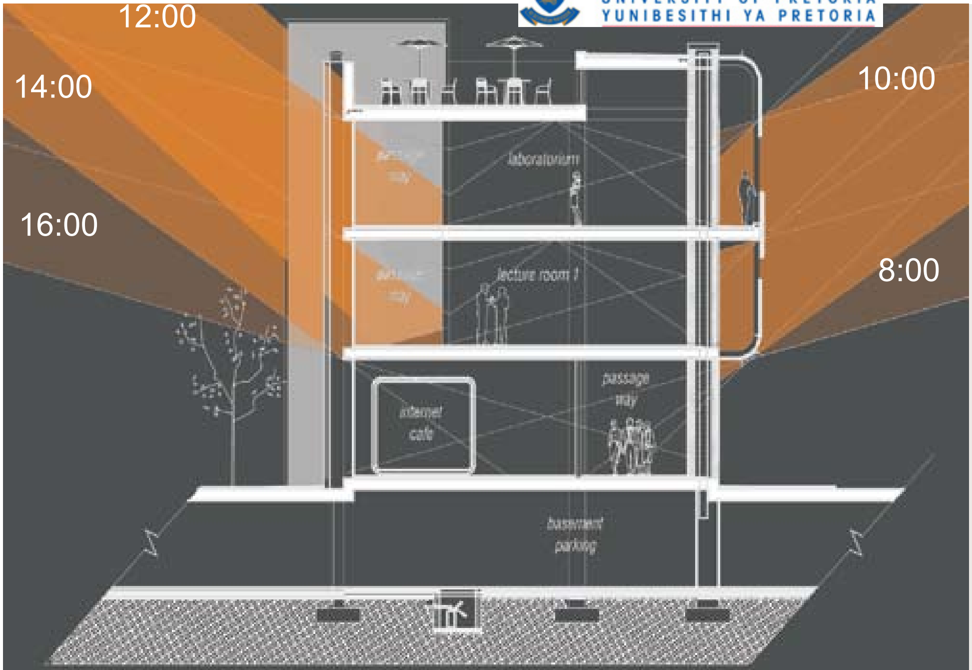
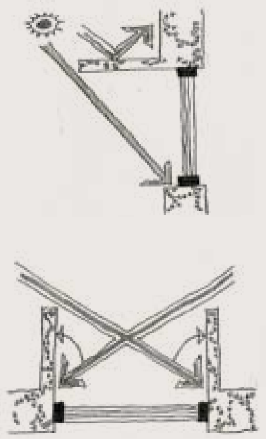
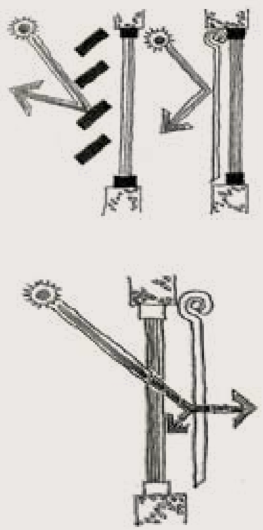


fig. 183 [a] north facade sun angles



_north facade [21 June; winter]

_west facade [21 June; winter]



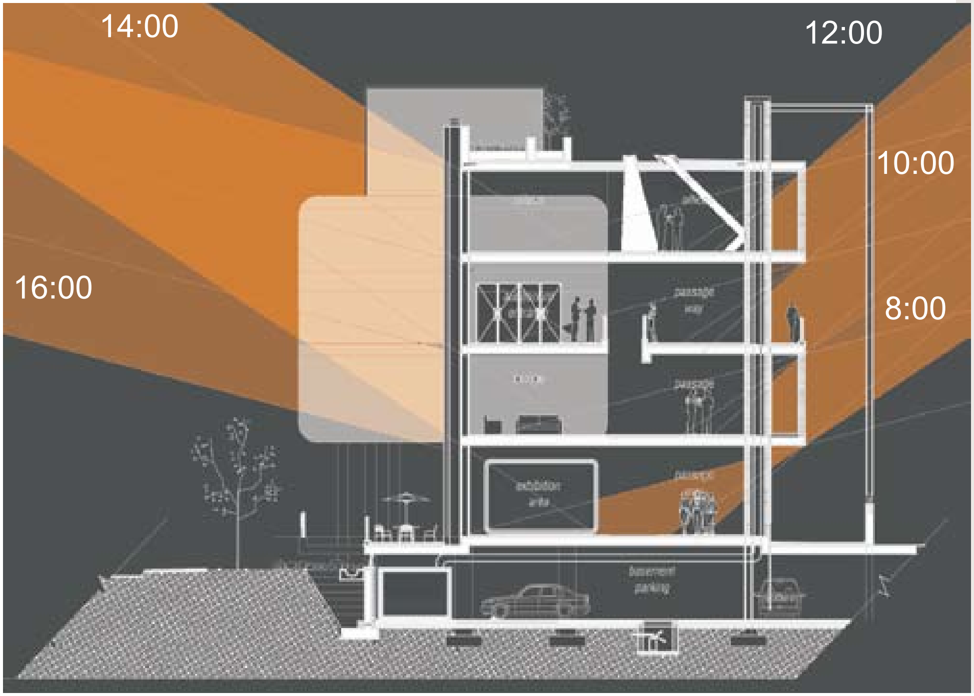


fig. 183 [b] west facade sun angles

fig. 183 [c] solar shading devices

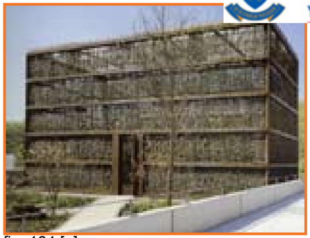
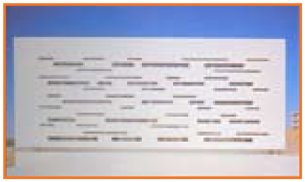


fig. 184 [a]


fig. 184 [b]



_north facade

The slab overhangs are adequate to prevent too much direct sunlight from entering the space in the summer months. The central walkway is placed on the northern facade, ensuring heat gain do not enter the occupant space. Light that does enter during winter, is absorbed by the clay tiles and released at night to heat the rooms. The stacking chimneys, creates a rhythm of thermal mass, released into the rooms at night. A planted screen covers the open windows between the stacking chimneys. These screens consists of a steel structure, covered by a steel mesh cladding screen for creepers to grow. This planted screen regulate the temperature of the building, functioning as a sun barrier during the summer, and allows sun to penetrate during winter months.

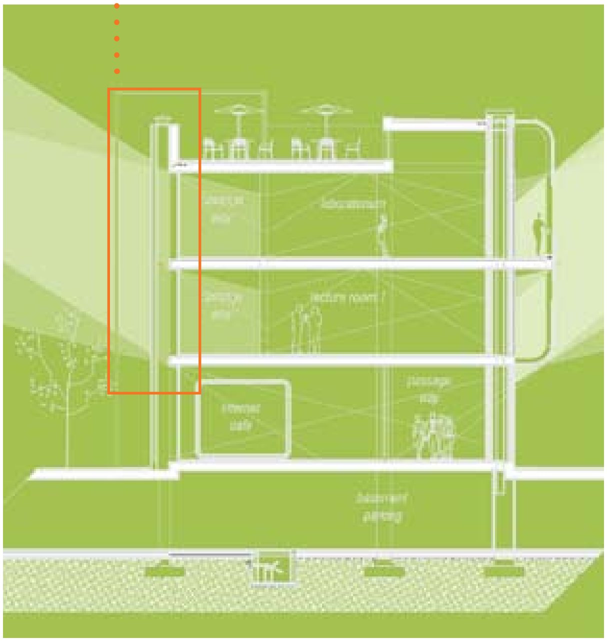


fig. 185

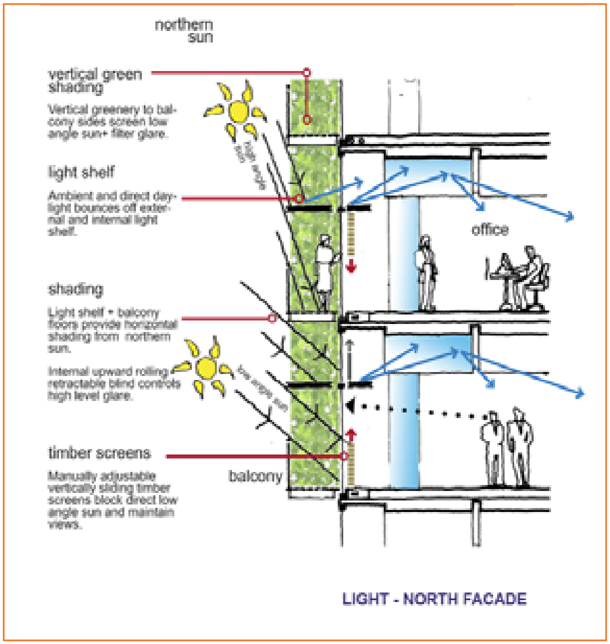


fig. 186

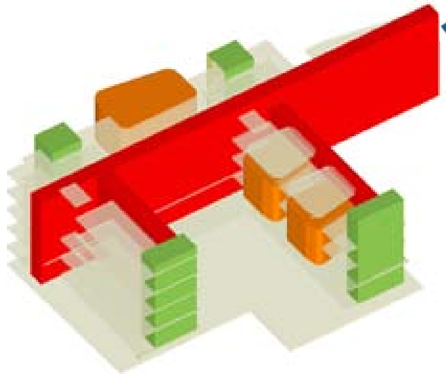
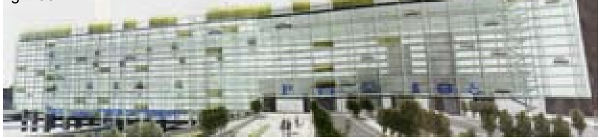


fig. 187 [a]

fig. 188

fig. 189

fig. 190



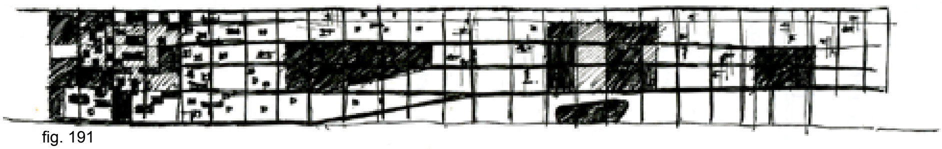


fig. 191

_east facade

_concept
The concept of this facade was to act as a transparent or translucent facade, showing the movement within the building and to enable the users of the building, to connect with nature, through view points [connecting the building with its existing context], pause areas or specific placed balconies. The facade becomes a linear pedestrian spine. As the back-bone of the building, it links the vertical and the horizontal circulation cores on all the floor levels.

The exterior cladding of the east facade, lets natural light through but limit early-morning sun radiation within the building. An I-beam steel frame con-struction covers the facade, cladded with an imprinted perforated steel screen, resembling the earth's life giving forms, water [blue], earth [brown], and nature [green]. This labyrinth of colours mimic an animal skin pattern, resembling the biomimicry principle, giving the building a dynamic edge.

The east facade of the two sub-wings host the vertical fire stairs and gives a solid edge to the building

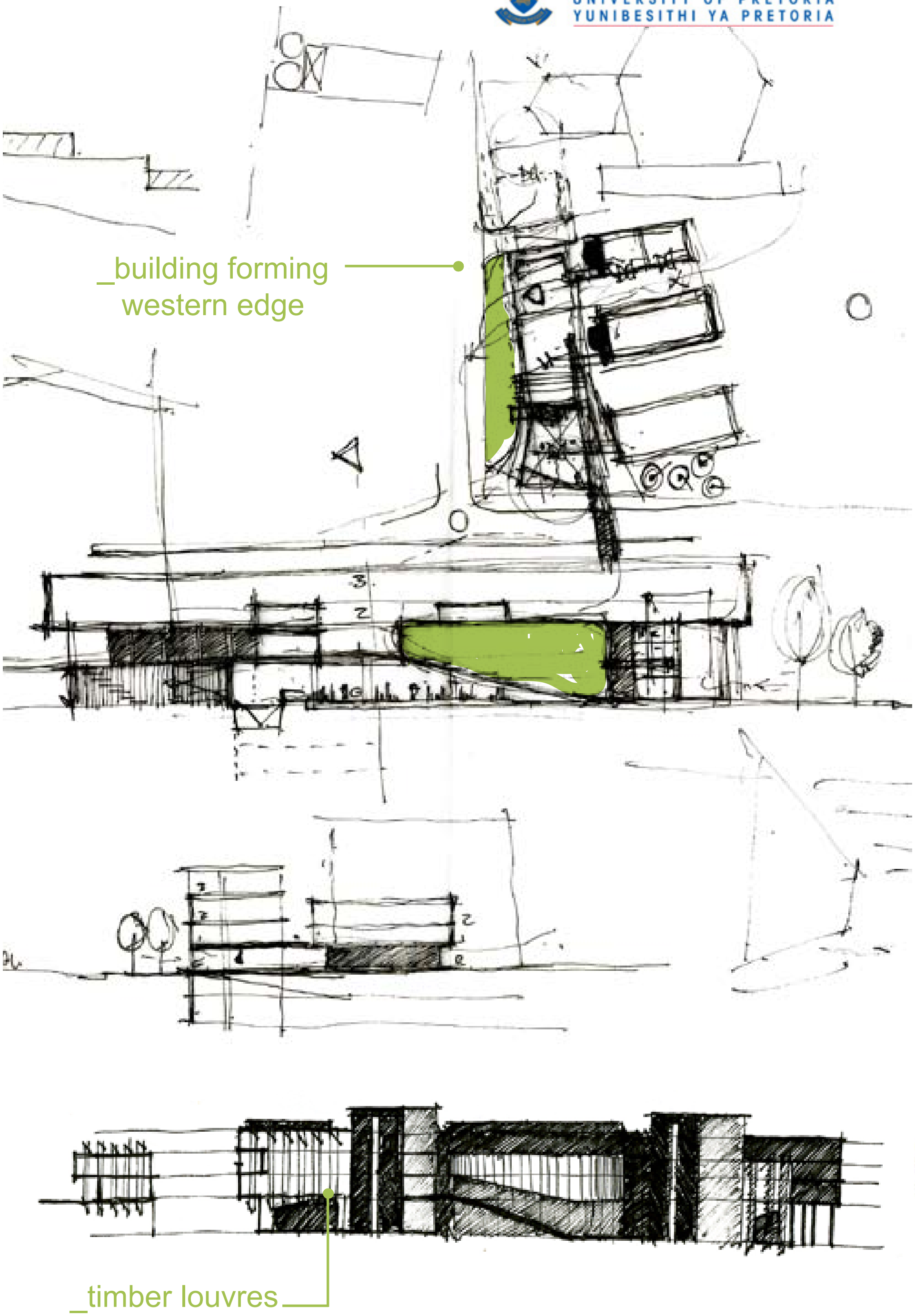
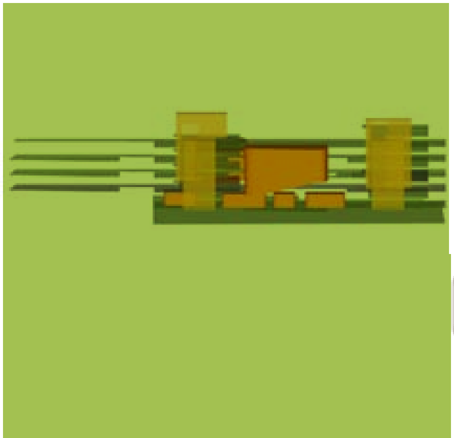


fig. 192 concept development of west facade

_west facade

The facade forms the edge alongside the ring road, creating a semi-public courtyard. It hosts the service cores and vertical circulation zones as well as the main auditorium, linking all the building functions to the heart of the building. The facade treatment differ, stacking chimneys at regular intervals, with wind turbines illustrate the ventilation system in place. These structures create a rhythm alongside the facade. Further facade treatment includes vertical louvres following the sun pattern, driven by solar power and made of a relatively new material on the market bamboo. The bamboo louvres are connected to a steel frame sub-structure, which is connected to horizontal placed I-beam structure, connected to the stacking chimneys by a fixing plate. These louvres allow the control of the micro-climate of the building and prevent latent heat gain during summer months. The facade becomes one of the buildings' dynamic features. Alternatives to bamboo louvres were investigated, depending on the clients' preference and its cost effectiveness.

_planted screen
_perforated steel
_solar panels
_recycled wood



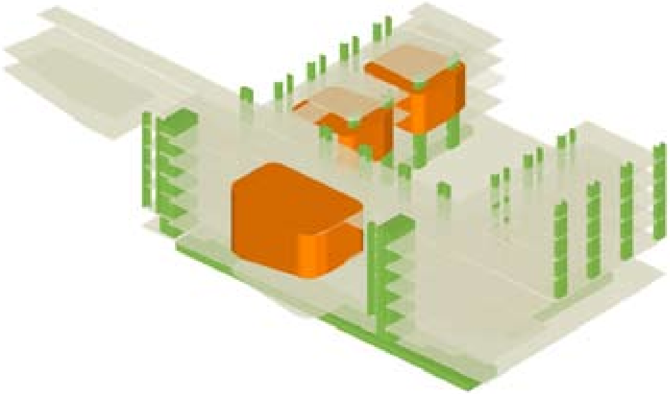
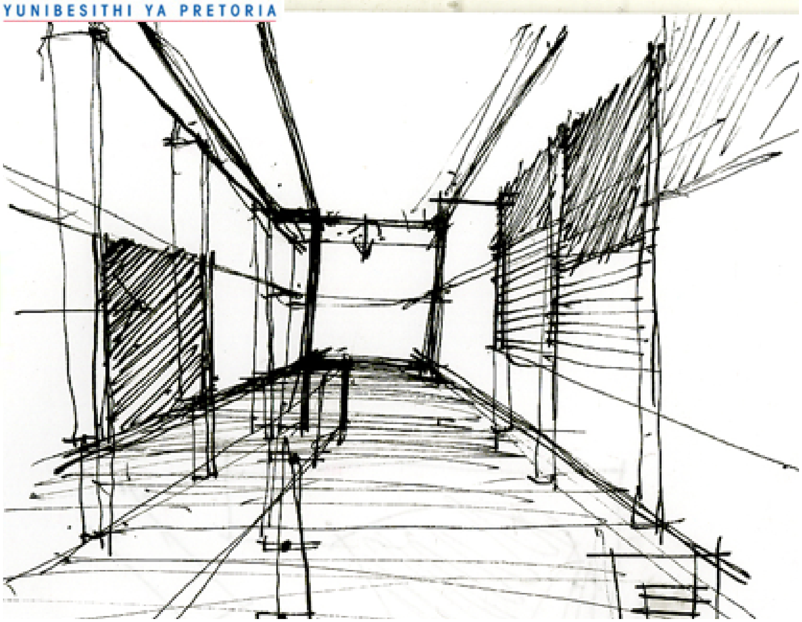


fig. 193 [a]



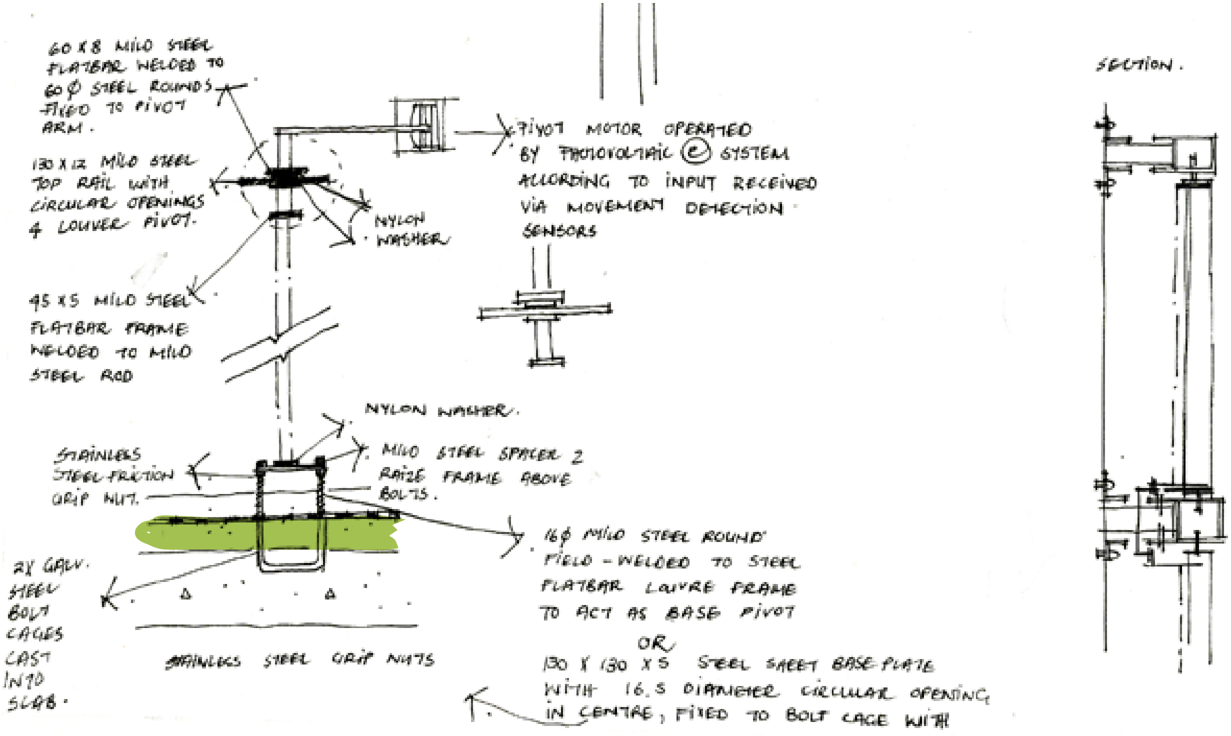


fig. 193 [b] concept construction details of west facade louvre system

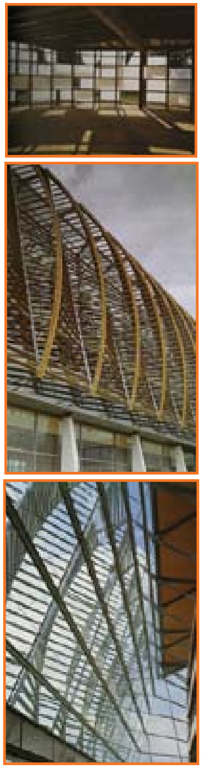


fig. 194 [a]

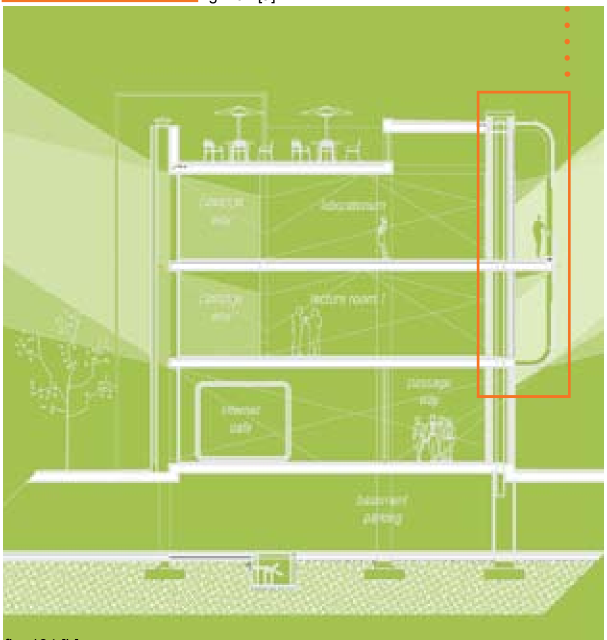


fig. 194 [b]

_south facade

The northern sub-wing, hosting the two lecture rooms, is screened on the southern facade, with balconies living out onto the courtyard. A small amount of southern light will penetrate directly into the lecture rooms, workshop and laboratory.
The southern sub-wing, offers views to the street and its famous fever trees. With the library and an office level at the top, the green corridor offers a tranquil feel, ideal for these functions. This facade has clerestory windows to allow light to enter the facilities.

_conclusion

The building is well insulated, with triple glazing windows, to ensure the micro-climate is stable, and the ventilation systems is functioning at optimum level. The main auditorium on the Western facade is well insulated, to prevent latent heat entering the building during evening functions. The building is still able to breathe through the passive stack ventilation, producing 100% fresh filtered air to the building. This would prevent sick building syndrome to occur and ensure a healthy micro-climate for the occupant. A closed-loop system, managed mechanically by the building itself, was opted for, since all of the building facilities are not occupied 24/7. This allows the building to save energy. The third floor office level, has specific placed windows for occupants to regulate according to their specific requirements.

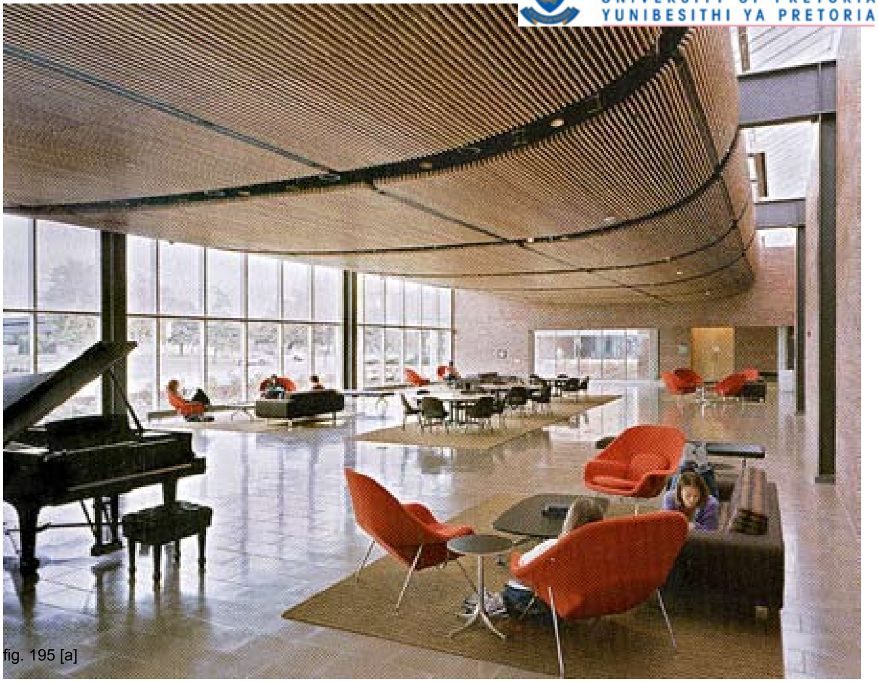


fig. 195 [a]

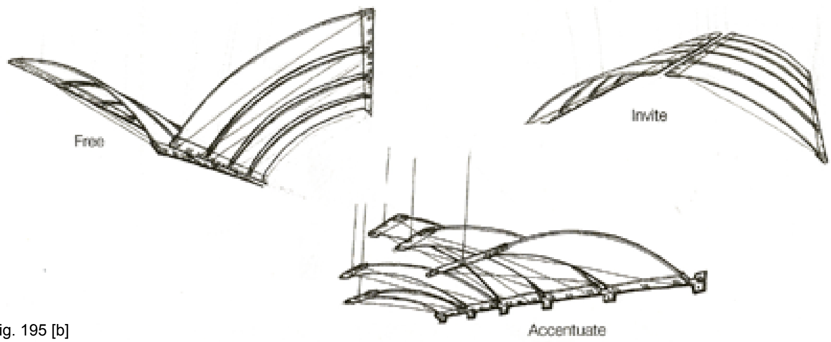


fig. 195 [b]

fig. 195 [c]

_acoustics

The noise levels on campus is relatively low, compared to noise levels in the CBD. The auditorium and lecture rooms, needing a sound-proof environment, is well insulated for this specific purpose.

_auditorium

A 220mm concrete wall, with 80mm mineral wool fibre under open spaces timber battens. The ceilings consists of specific placed acoustic panels, with soft seating and a carpet floor finish for further sound absorption.

_lecture rooms

A 220mm concrete wall, with 80mm mineral wool fibre under open spaces timber battens. Ceilings will assist in sound absorption.

Recommended sound levels:

Room	DB
Reception	45-55
Lecture rooms	30-35
Exhibition space	40-45
Kitchen	45-50
Restaurant	40-50
Auditorium	30-35
Office	35-40
Library	35-40

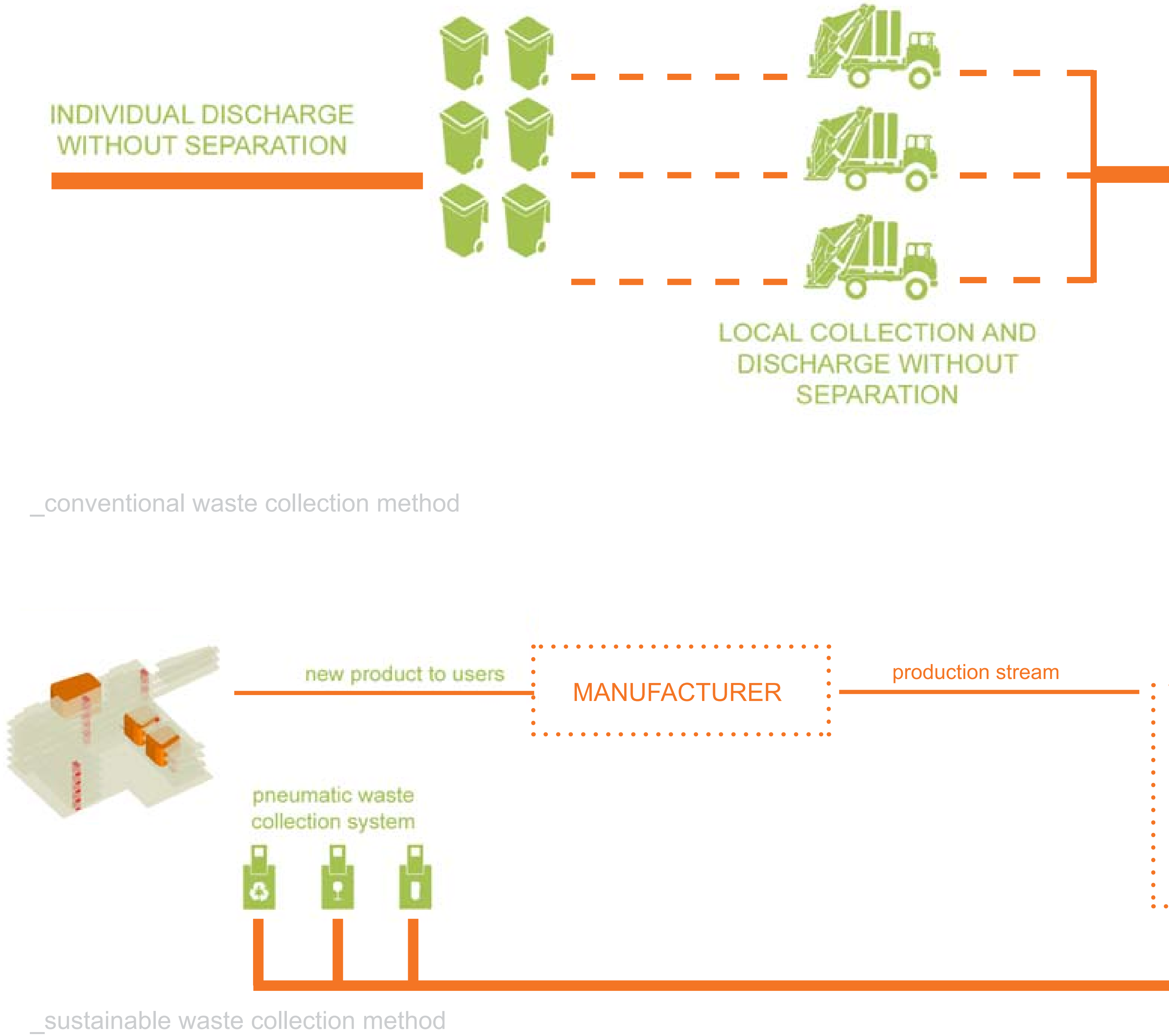
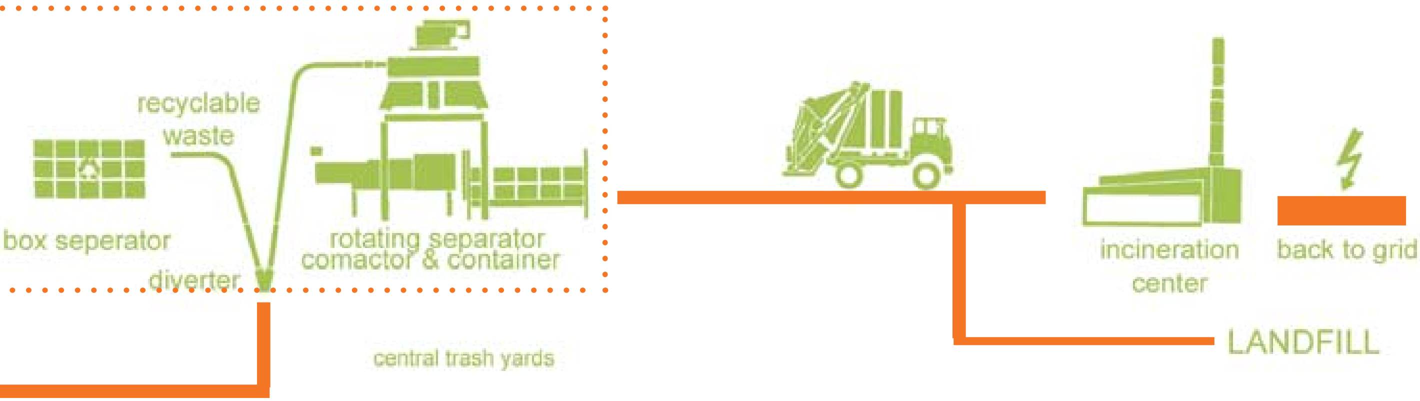
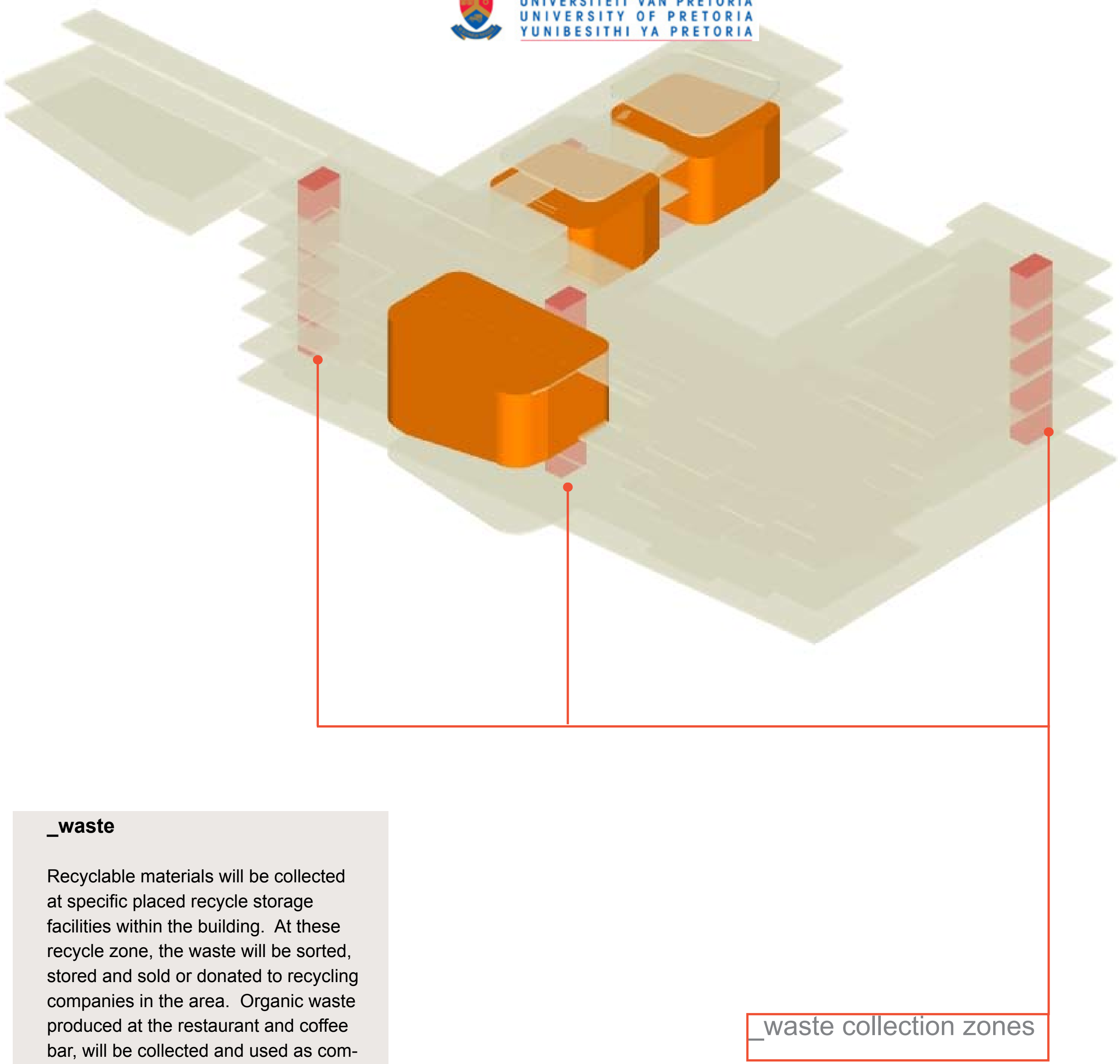


fig 196 [a] schematic diagram illustrating waste collection methods


local waste collection center
LANDFILL

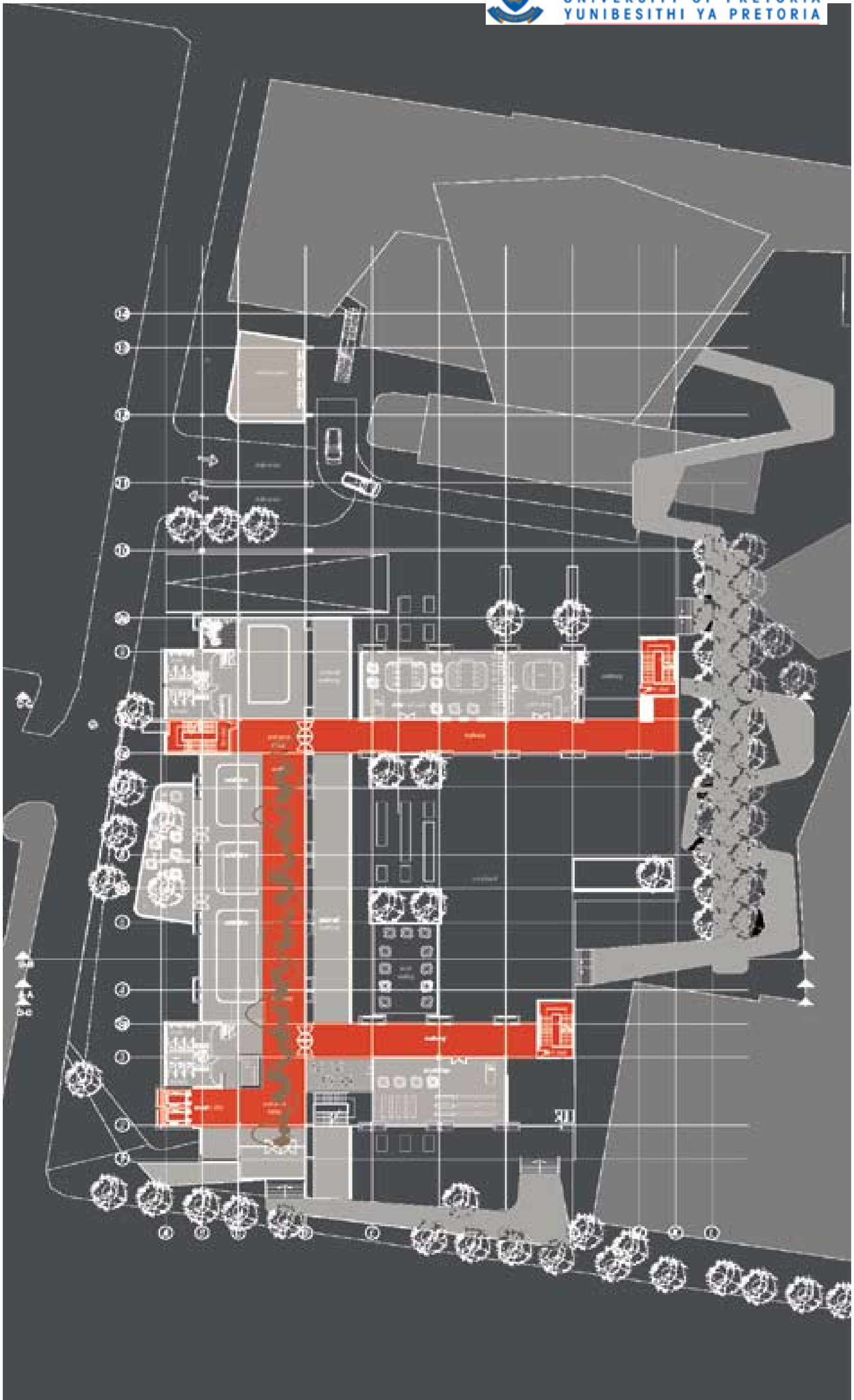

recyclable waste
box seperator
diverter
rotating separator comactor & container
central trash yards
incineration center
back to grid
LANDFILL



_waste

Recyclable materials will be collected at specific placed recycle storage facilities within the building. At these recycle zone, the waste will be sorted, stored and sold or donated to recycling companies in the area. Organic waste produced at the restaurant and coffee bar, will be collected and used as compost for landscaping and student experiments, planted in the roof garden.

fig. 196 [b] model view of facility's waste collection

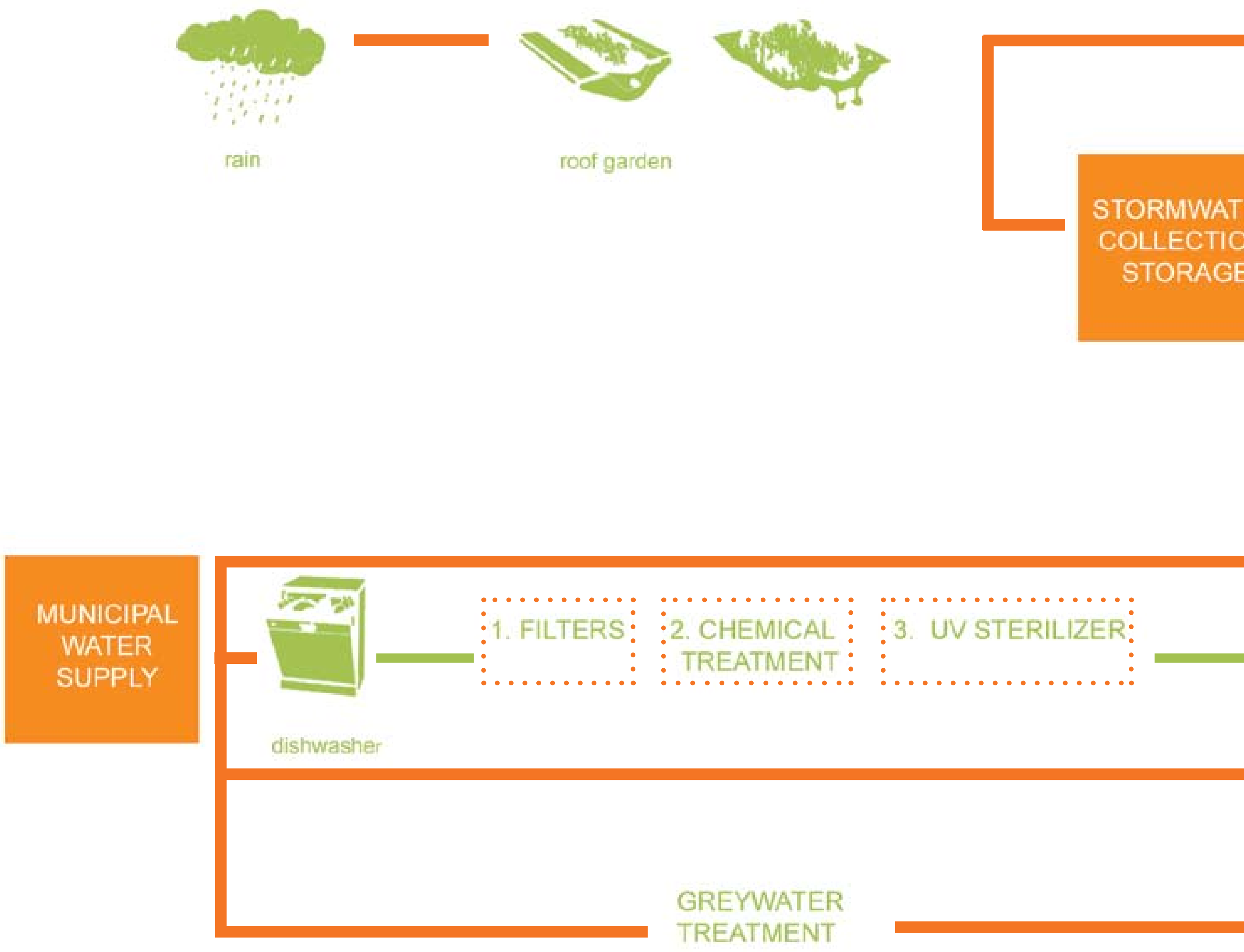


_fire

The escape routes are in accordance with part T of the National Building Regulations, specifying that an escape route may not exceed 45m. A fire detection and sprinkler system, with smoke detectors within the rooms will be installed according to suppliers' specifications. Fire Hose reels are supplied at 30m intervals. These are place in appropriate positions to prevent obstruction from circulation spaces. The fire hose reels and extinguishers are marked clearly with appropriate signage. Emergency exits will be allocated on either side of the building. Lift shafts as well as lift doors will be fire resistant, to prevent fire entering the building from the basement or spreading to other floors.

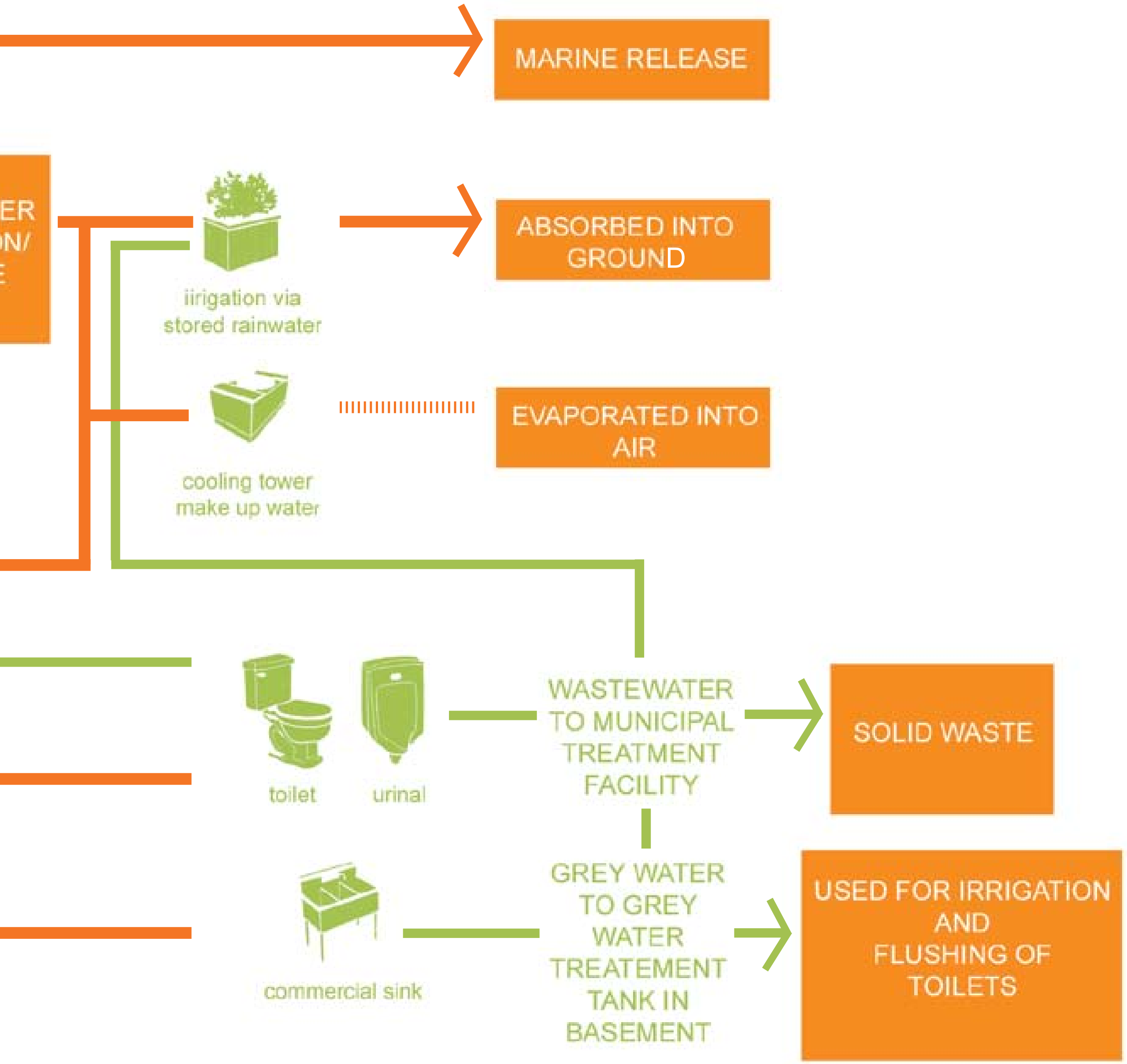
_security

The building will have controlled access at certain points, the library, auditorium, lecture rooms, workshop, laboratory, fire stairs [access from outside], and the office floor level. These specific control points are needed, since most of the building, [ground floor level and first floor level], is used by all campus students.



_water harvesting

fig. 198 schematic diagram illustrating the water harvesting method


ER
ON/
E
MARINE RELEASE
iirigation via stored rainwater
ABSORBED INTO GROUND
cooling tower make up water
EVAPORATED INTO AIR
toilet
urinal
WASTEWATER TO MUNICIPAL TREATMENT FACILITY
SOLID WASTE
commercial sink
GREY WATER TO GREY WATER TREATEMENT TANK IN BASEMENT
USED FOR IRRIGATION AND FLUSHING OF TOILETS

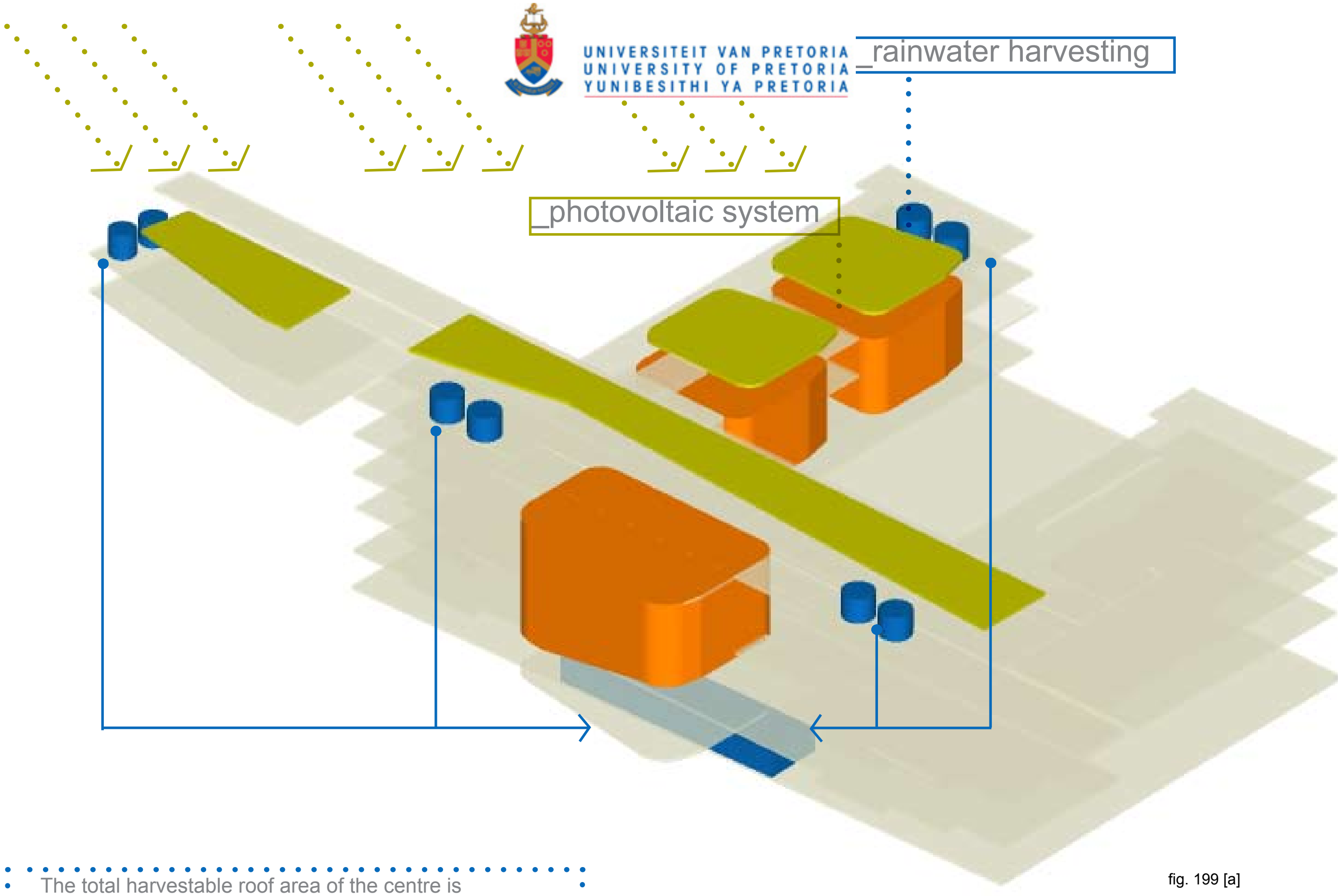


fig. 199 [a]

The total harvestable roof area of the centre is 1244m2. The possible annual savings by using the grey water for flushing of WC's and for irrigation is:

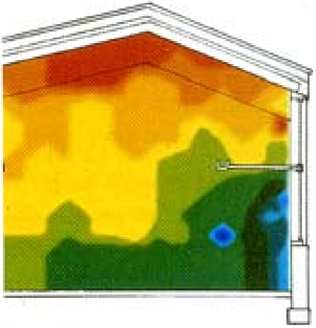
_potential annual rainwater harvesting volume:
Total roof area = 1244m2
Approximate annual rainfall = 745.25mm
= 1244 x 0.74525
= 927.091m3
= 927 274 l

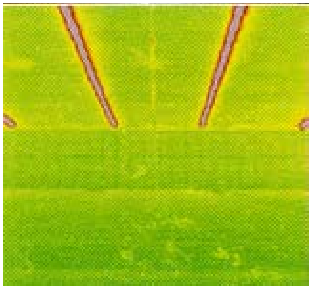
_highest monthly rainfall [November] harvesting for sizing of water storage:
Total roof area = 1244m2
Approximate annual rainfall = 168.8mm
= 1244 x 0.1688
= 209.9872m3
= 209 9872 l

_harvested rainwater volume = 923.3 m3
_current cost per 1 m3 = R10
_possible annual savings = R9 233

	Aggregate rainfall in mm/ month for the Pretoria area:	Total water harvesting area = 1244m2 Total amount of water harvested [kl]
January	101.3	126
February	108.8	134
March	63.8	79
April	37.5	47
May	48.4	60
June	3.8	4.7
July	2.3	2.8
August	2.3	2.8
September	11.3	14
October	82.5	103
November	168.8	210
December	112.5	140
	745.27 mm	923.3 kl

fig. 199 [b] table of water storage requirements





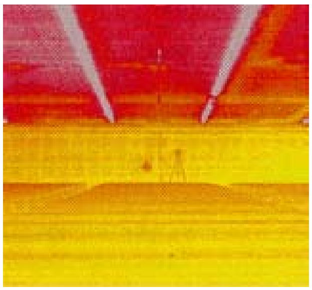
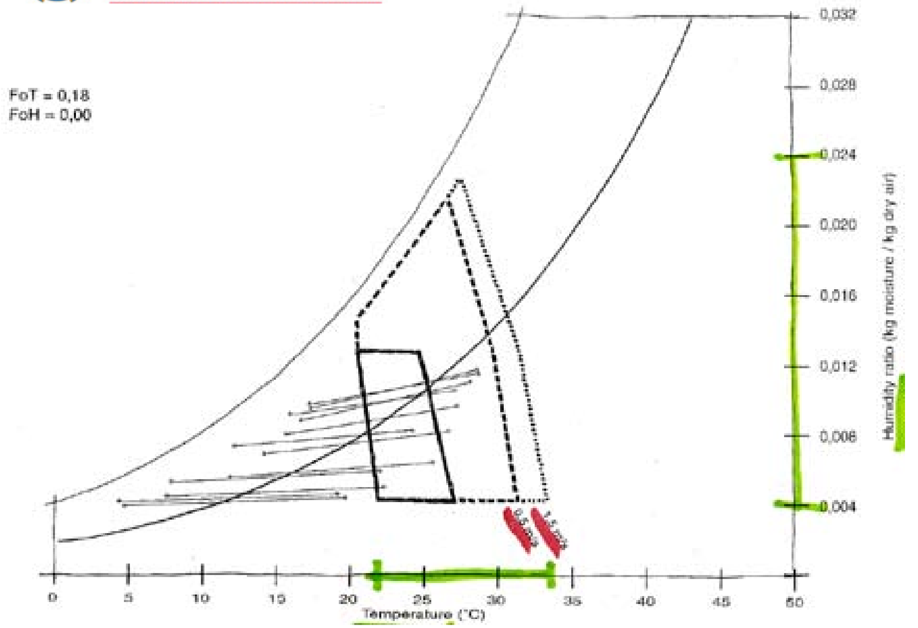


fig. 200 [a]



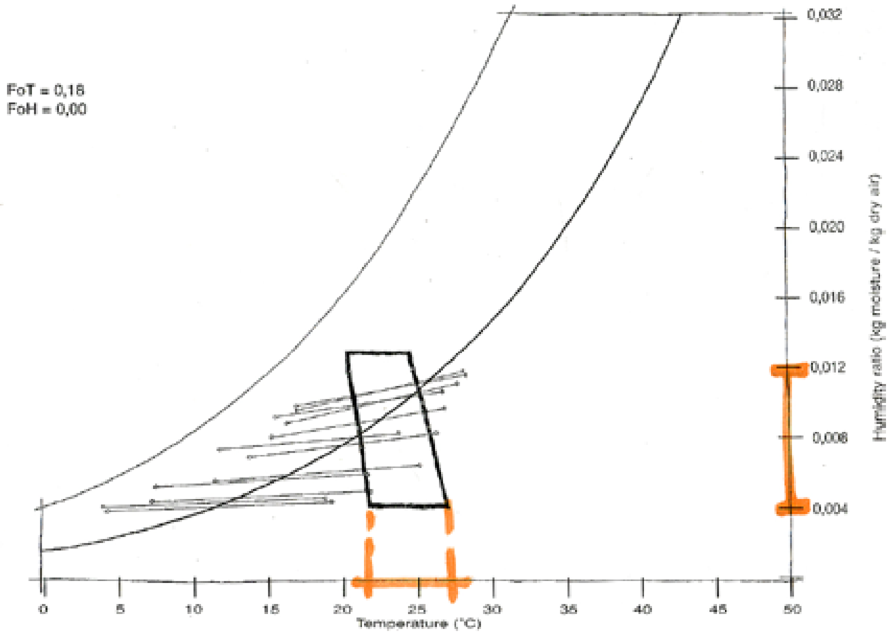


fig. 200 [b]

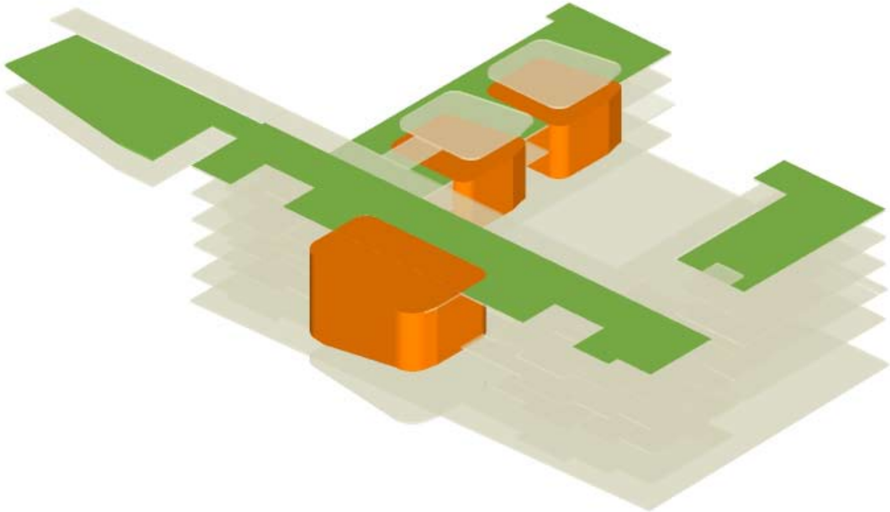


fig. 200 [c]

The roof [1244 m2], will be used as a roof garden and further utilized for rainwater harvesting. To reduce water consumption, rainwater from the roof as well as greywater from basins and air-conditioning cooler units is camputered and stored in a concrete tank, sealed with epoxy, placed in the basement. Low flushing toilets, waterless urinals and taps with sensors to limit water consumption.

The roof garden will function as the fifth elevation of the building. It has a high insulation value, filtrate rainwater for water storage, allow recreational activities to take place, can be utilized for experimental purposes and host solar panels for solar water heating.

Photovoltaic panels [1.7 x 2.3m] will be used to heat water for the absorption chillers. The water will be stored in central placed hot water storage tanks and from there distributed to the restaurant kitechen, to the absorption chiller plant within the basement and during winter months to the water pipes within the concrete floor slabs.

The panels will also be used as an electricity source to rotate the western facades' vertical louvre system.

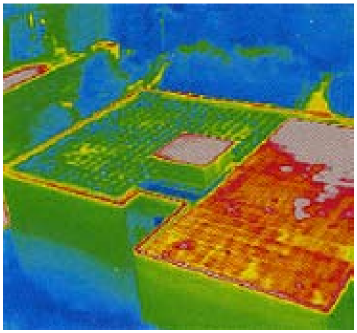


fig. 200 [d]