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The Sustainable Building Assessment Tool (SBAT) has been designed to assess the sustainability of buildings. This is done by assessing the performance of a building in relation to a number of economic, social and environmental criteria. The tool has been designed to be appropriate for use in developing countries and therefore includes aspects such as the impact of the building on the local economy, not normally included in other assessment systems.

The tool can be used in design stages of a new building, or for the refurbishment of an existing building. It is designed to encourage the development of more sustainable buildings by enabling different options to be evaluated rapidly and compared. The tool also enables a building to be rated in terms of its sustainability. This enables buildings to be compared to each other and to benchmarks. The tool has been developed by the Sustainable Buildings Group of the Division of Building and Construction Technology, CSIR, Pretoria, South Africa.

The tool is designed to be very easy to use and generates graphical reports which enable performance to be easily read. The tool is also not building type-specific and can be used on a variety of buildings such as offices, factories, schools, clinics and housing (Gibberd; 2002; CSIR).

Social

1. Occupant comfort priority: 5

- **Lighting –** the emphasis of the design is to let in as much natural day lighting as possible (see *Fenestration and Signs*).
- **Ventilation –** the emphasis of the design is to enhance natural ventilation and to promote cross – ventilation. This will all be managed manually by the occupants through openable windows. The stack effect will be used to enhance air movement through the building by passive cooling in summer and heat gain in winter. This will also be managed manually (see *Environmental Qualities*).
- **Noise** – this appears not to be a problem. Acoustic engineering will be addressed in the auditorium e.g. acoustic panels (see *Materials)*.
- **Views** – Occupants should be 6 m or less away from a window with views outside. Where this is not possible, indirect natural lighting and framed views are desirable (see *Access and Legibility*).
- **Green Outside**- Easy access to outside spaces ensured by visually- and physically permeable facades as well as planting inside the building (see *Landscaping)*.

sustainability building assessment tool

01

2. Inclusive environments priority: 5

- **Public transport** – the development is at the furthest point 300 m away from a taxi terminal, 500m away from the Pretoria Station and 150 m away from a bus stop (see *Urban Design*).
- **Routes**- all the routes in and around the building have smooth and even surfaces and are handicap- friendly (see *Access and Legibility*).
- **Entrance**- the entrance to the building is open and legible. This enhances the gateway and landmark qualities of the building (see *Identity*).
- **Circulation** – all the spaces and staircases are connected and linked by ramps. This becomes a functional as well as a visual element (see *Foundations, Structure and Circulation*).
- **Furniture and fittings**- (see *Spatial Planning).*
- **Toilets and kitchens** – all of these spaces are disabled- friendly and easily accessible (see *Spatial Planning*).

3. Access to facilities priority: 3

- **Childcare**- available on site (see *Robustness and Flexibility*).
- **Banking** – close by ± 1-2 km.
- **Retail** – available on site. Forms part of greater inner city central business district (see *Urban Design)*.
- **Communication**- extensive internet and digital library. Electronic communication is promoted.
- **Residential** – available on site. Overnight facilities, apartments and high density residential area on the northern part of the site (see *Urban Design)*.

4. Participation & control priority: 5

- **Environmental control** – windows openable to outside as well as to the chimney stack, to ensure cross ventilation and air movement, all manually operated (see *Environmental Qualities*).
- **User adaptation** – the interior and exterior spaces create an opportunity for personalisation and re-arrangement because of its openness and flexibility e.g. moveable walls and stairs. Thermal comfort can also be controlled by occupants (see *Robustness and Flexibility*).
- **Social spaces** – personnel rooms are available for occupants. Seating is created along all the main pedestrian routes. All communal spaces are large enough for social gatherings, and the multi- purpose hall could be opened up to include the adjacent outside spaces (see *Robustness and Flexibility*).
- **Amenities** – there is easy access to all amenities including the cafeteria/ hall, kitchen spaces, class rooms and ablution facilities placed along circulation routes.
- **Community involvement** – this building has a social function and serves the greater community. The functions include study rooms, information classes, a digital library etc. all to uplift and educate the community.

5. Education, health and safety priority: 4

- **Education** – this is the single most important function of the building. The library, evening classes and the study carrels all contribute to that.
- **Safety & Security** – all the routes are well lit and passive surveillance is promoted through a mixed use development e.g. the evening classes and the overnight facilities. The Building Management Systems will include security systems.
- **Health** – recreation spaces are created in and around the building including a sports field on the northern part of the site. The indoor air quality is controlled by passive means.

Economic

6. Local economy priority: 3

- **Local contractors** – within 10 km
- **Local material supply** – within 50 km
- **Local components** – within 50 km
- **SMME's** – the security, cafeteria, maintenance etc. will be outsourced to different companies. The retail component on the northern side of the site will be practised by the local community. The management of the resource centre will be done by University of Pretoria, Unisa, Pretoria Technickon and smaller colleges.
- **Repairs and maintenance** – within 60 km.

7. Efficiency of use priority: 5

- **Usable space**- not more than 30% un-usable e.g. services and circulation. (see *Spatial Planning*)
- **Occupancy**- for 18 to 24 hrs a day.
- **Management of space**- hot desking in the office space, management by different universities, technikon and colleges.
- **Use of technology**- digital library and internet communication.
- **Disruption and Downtime**- all the passive systems will have as back up the conventional mechanical and electrical systems.

8. Adaptability and flexibility priority: 5

- **Vertical dimension** – 4m in the resource centre because of its civic function and flexibility, 3m in the rest of the development for maximum adaptability (see *Robustness and Flexibility*).
- **Internal partitions**- any division of spaces by moveable, adaptable walls or heavy stage curtains.
- **Services** – all services in a central, concrete service spine incl. mechanical-, electrical services and passive systems. Ventilation in the building will be supplied by cross ventilation and the stack effect. Solar panels will generate electricity which will be put back into the conventional grid system (see *Environmental Qualities).*

- **Structure**- mainly a steel structure. A lightweight steel structure will be used for moveable elements and roofs as well as for visual diversity (see *Foundations, Structure and Circulation).*

- **Circulation and service spaces** – These spaces will be provided in the service spine to promote flexibility and robustness (see *Robustness and Flexibility).*

9. Ongoing costs priority: 4

- **Maintenance**- easy, manageable low maintenance materials like stock brick, concrete and steel. Maintenance of the building will be outsourced to a SMME.

- **Cleaning** – floors will be solid with hard finish – no thick carpets (except in the Auditorium)

- All windows are reachable and cleanable.

- This function will be outsourced to a SMME.

- **Security** – passive surveillance is enhanced by mixed use and 18 hour activity. This function will be outsourced to a SMME.

- **Cost monitoring and shared costs** – this will all be managed by the different educational institutions and bureaus of the DEAT and DE.

10. Capital costs priority: 3

- **Consultant fees**

- **Build ability**- the building will be built economically, with a simple form, replication of elements and conventional materials.

- **Construction**- the shell will be built first and the finishes later. Phasing for the whole development could be proposed.

- **Shared costs** – size- and the quantity as well as costs will be reduced.

- **Use existing** – the historical clubhouse, hall and existing Berea Park High School and all its current functions will be kept (see *Briefing document & Context Study- Historical Context*).

- **Plate efficiency** – (see *Spatial Planning).*

- **Capital:** ongoing cost: building size (*will be addressed later in financial report*).

Environment

11. Water priority: 5

- **Grey water** will be re used . All the stored water will be pumped by energy from solar panels. A network of pipes will be installed though the building to create a circular grey water system. The sewerage will form part of the municipal system (see *Environmental qualities).*

- **Rainwater** – will be harvested, stored and used for grey water circulation and irrigation (see *Environmental Qualities*).

- **Water use** – all water efficient devices and the use thereof minimised by harvesting.

- **Grey water** – for washing, flushing toilet and irrigation and used in a closed system. This water after use will be sent through a gravel bed to filter and clean.

- **Run off**- most surfaces on the site will be pervious and absorbent surfaces. Gardens will be used on the roof and in the building. Hard surfaces will be used to define spaces.

- **Planting**- all planting will be indigenous and serve an educational purpose demonstrating ecosystems. Rainwater will be used for irrigation (see *Landscaping).*

12. Energy priority: 3

- **Location** – 50m from closest transport node.

- **Ventilation system** – will be based on a passive cross ventilation- and stack effect system (see *Environmental Qualities*).

- **Heating & cooling system**- heat gain through direct northern sunlight and a closable chimney stack (see *Environmental Qualities)*.

- **Appliances & fittings** – low energy appliances and fluorescent artificial lighting.

- **Renewable energy**- solar energy for electricity generation as part of the electrical grid system. Energy usage will be lowered by placing generated electricity back in grid by means of a meter system (see *Environmental Qualities*).

13. Recycling and Reuse priority: 3

- **Toxic waste**- if it is produced there will be safe disposal and placed at an allocated area.

- **Inorganic waste**- place for sorting, storage, pick up and recyclable waste (see *Environmental Qualities*).

- **Organic waste** – a suggestion is that all this waste will be sorted and picked up by a pig farmer in exchange for compost.

- **Sewerage**- will connect with the municipal connection and could then be recycled on a larger scale.

- **Construction waste**- no wastage of material and demolishing of existing structures. Modular and conventional material is used.

14. Site priority: 4

- **Brownfield site**- The site is a sports field, disturbed with traces of previous buildings.
- **Neighbouring buildings** – all buildings have access to sunlight. All the historical buildings are kept with the placement of the new buildings respectful to the existing (see *Urban Design*).
- **Vegetation**- roof gardens will be placed on the roof of the southern wing of the Resource Centre building, with planting all through the building (see *Landscaping).*
- **Habitat**- All the planting along the river is preserved. Ecosystems will be explained and has an educational function. Natural, local flora is vegetated.
- **Landscape** inputs are not artificial and disruption due to construction kept to a minimum.

15. Materials and components priority :4

- **Embodied energy** – Low embodied energy material like timber, concrete, brick and steel is used. Steel has a long life cycle and is structurally strong (see *Materials).*
- **Material/ Component sources-** All material could be recycled. Modular structural systems designed and – material used.
- **Manufacturing processes**- no pollution during manufacturing.
- **Recycled/ reused materials and components** – as far as possible recycled structural steel from demolished buildings will be used.
- **Construction processes-** no excavation, or damage to vegetation.
- **Components & modular coordination** – a structural grid will be used and modular bricks and windows will be used.

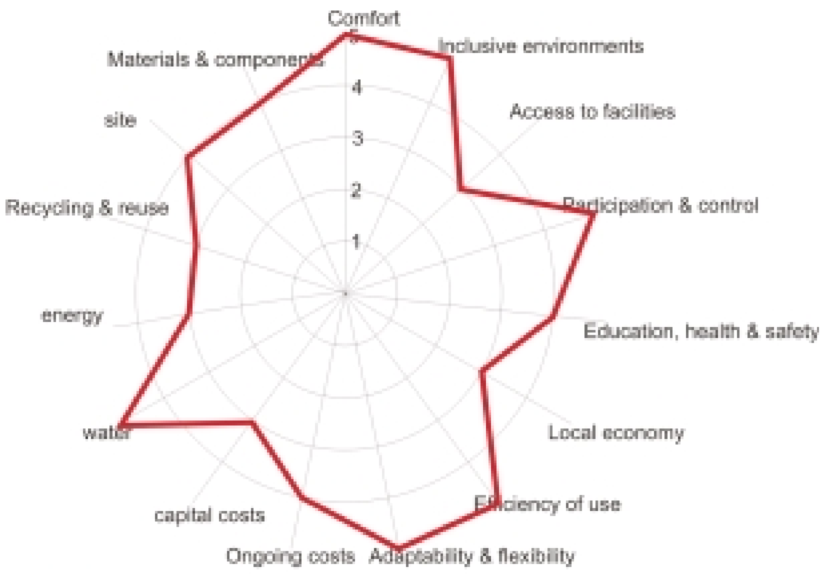


Figure 1.1: **SBAT** targetsetting

02 objectives & guidelines

To read the achievement of these objectives see the *Design essay* and *Technical report*
- To establish a visual identity for the building: enhancing its landmark- and gateway qualities and making it recognisable and identifiable through circulation systems and routes **(Figure 2.1)**

- To integrate public and private spaces through a multi functional development **(Figure 2.2)**

– To fragment the building to achieve desirable outdoor spaces and diversity in use and passive surveillance.

- To emphasise the buildings social uplifting role.

- To address the buildings political role through for example questioning the physical fabric of a wall and the way it is managed.

- To adopt the concept of the virtual office where information processing takes place by telephone, fax and data processing systems.

- To design a sustainable building with less energy use.

- To use natural systems to regulate climate, to use solar energy in generating electricity and to harvest rainwater for grey water and irrigation use **(Figure 2.3)**.
- To design an economic building regarding energy, function and space.
- The adopt the design guidelines as in *Responsive Environments*:

Permeability:
-To give choices and alternative ways through an environment and to lead people in a certain direction e.g. ramps and circulation through the building.

Variety:
- To give the user a choice of experiences and to maximise variety. The building volumes and scale are very important e.g. the different functions have a different volume and scale **(Figure 2.4)**.

Legibility:
- To ease the understanding of the layout of the building. Differing qualities and spatial enclosures are used for different routes, junctions and different volumes. For example the transparency of the facades and horizontal- and vertical textures will make the function of the building more legible **(Figure 2.5)**.

Robustness:
- To design a multi-purpose building. This could be achieved with careful consideration of lighting, volume, scale etc. It is achieved in the building through moveable walls and curtains. The possibility of adding mezzanine floors in the double volumes of the resource centre is addressed.

(up to this point – Bentley et al; 1998; p.10)

Visual appropriateness:
- To address the detail appearance and interpretation of the building. The building is interpreted as having meanings and makes people aware of the choices offered (see *Identity).*

Richness:
- To increase the choice of sense experiences with the choice of materials and construction techniques.

Personalisation:
- To accommodate for public participation in the design of the building and to leave room for individual input by the occupant. This should not erode the public role of the building.

(Up to this point – Bentley et al; 1998; p.11).

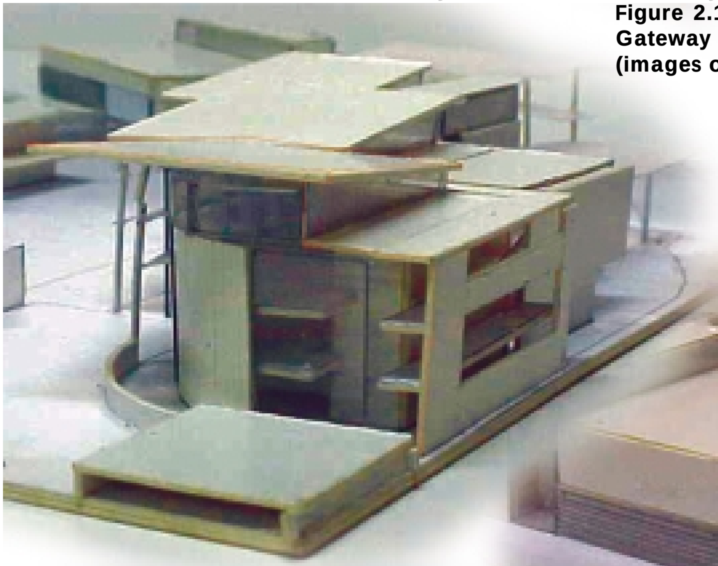


Figure 2.1:
Gateway and landmark quality
(images of the concept model)

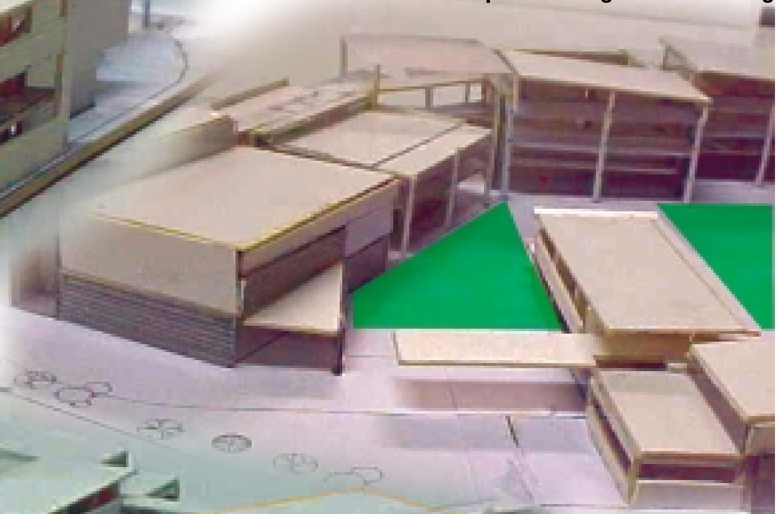


Figure 2.2:
Public and private - fragmented building

Figure 2.4:
Variety in different volumes

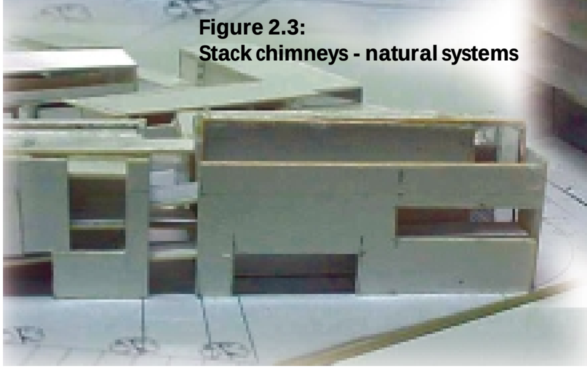
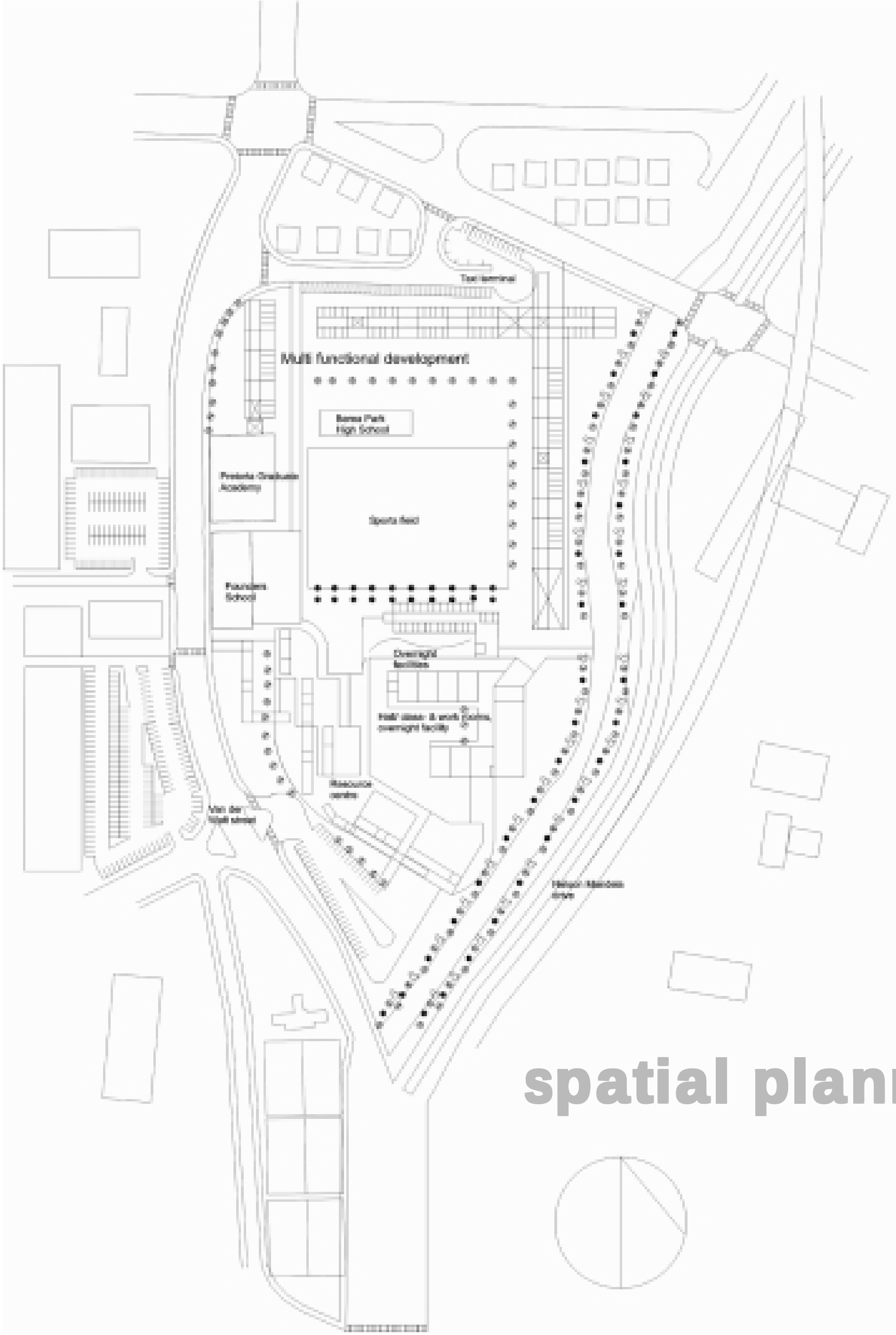


Figure 2.3:
Stack chimneys - natural systems

Figure 2.5:
Legibility - transparency of facades



spatial planning 03

Figure 3.1:
Spatial site planning
(not to scale)

All the following targets were met in the design. Elementary mathematics were used to keep communication easy. Some calculations could be taken further by an engineer.

FSR = -commercial – 7698 m²
- offices -3168 m²
- residential – 2104 m²
- overnight facilities- 2400 m²
- resource centre- 8829 m²
- hall & classrooms – 2251 m²
- 26450 m²
- site- 48282 m²

= 26450 m²
48282 m²
= 0,55

Coverage = 15931 m²
48282 m²
= 32 %

Parking = 1,5 bays/ 100 m² building
= 400 bays maximum - * the reason is that the site is surrounded by a major public transport node

Height = 3 storeys maximum
* The reason for this is that the site is in a residential area, and part of the green open space system.

Building lines = 12m on river side because of the flood line.

SLOAP (space left over after planning) = 0

Plate ratio = Floorarea (excluding roofed courtyard) : elevation
= 9177 m²: 2667,3 m²
= 30% or 0,3 (not more than 0,4) for appropriate ventilation and lighting.

Volume : Envelope
= 36705,6 m³ : 4986,6
= 0,13

Daylighting : Floorarea (Excluding roofed courtyard)
= 9177 m²: 2819,3 m²
= 30% - minimum 10% is needed according to the NBR.

Ventilation : Floorarea (excluding roofed courtyard)
Average of 60% opening sections of windows
= 2255 m²: 9177 m²
= 25% - minimum 5% is needed according to the NBR.

% of site that is landscaping (ideally 90%)
= 11 563,3 m² / 25132,5 m²
= 46 % planted.

BULK – 26450 m²

PARKING – 400 BAYS FOR WHOLE DEVELOPMENT - 5000 m²

RETAIL – 7698 m² 29%

RESIDENTIAL – 4504 m² 17%

COMMERCIAL/OFFICE – 3168 m² 12%

RESOURCE CENTRE- 11080 m² 42% (OFFICE + RESOURCE CENTRE = 42% + 12% = 54%)
(Fig. 4.1)

Economy:

Total area (Including roofed courtyards) : Area services, structure, circulation
= 9177 m² : 2749,4 m²
= 70% lettable

For passive climate regulation certain guidelines can be implemented:
-A mono-pitch roof to stimulate natural air flow through the building.
-A ventilated roof structure to let warm air escape.
-Large overhangs on the northern and eastern side, with shading devices on the east.
-A solid western façade
-The sun should be kept out in summer and let in during winter on the northern facade.
-The integration of nature, public and private spaces is desirable on the eastern and southern side
-The different courtyards should have identity and comfortable microclimate.
-Deciduous trees could be planted on the northern façade to let sunlight in during winter.
-Evergreen trees could be planted on the western façade to keep the sun out throughout the year.
-A designed passive climate system is desirable to minimise the use of non-renewable energy.
(Figure 4.1)

Addressing the climate of Pretoria, the building will be built out of masses, with minimal light through small windows and light coloured surface that reflect the sun (Daniels; 1998; p.50).

For heat gain and to use that as an energy source, surfaces can be painted black to absorb sunlight (Daniels; 1998; p.58).The solar radiation in the Pretoria area is > 2200 kWhr/ m², which is excellent for solar production (Daniels; 1998; p.59).

Figure 4.1:
Environmental control

4.1 Electricity generating

The use of grid electricity is reduced. The electricity generated through photovoltaic solar panels will be placed back in the grid to minimise units used **(Figure 4.2)**.

The annual net energy use for buildings:
General electricity use:

Space heating	73 MJ/m²/yr
Water heating	6 MJ/m²/yr
Cooling	48 MJ/m²/yr
Ventilation	16 MJ/m²/yr
Int. Lighting energy	40 MJ/m²/yr
Ext. Lighting energy	4 MJ/m²/yr
Pumps & Fans	6 MJ/m²/yr
Elev/ Esc.	1 MJ/m²/yr
Receptacles/ event equipment	12 MJ/m²/yr
Other	1 MJ/m²/yr

Electricity used in Resource centre according to benchmarks:
200 kwhr/ m²/ yr (benchmark for building with low energy benchmarks)
= <u>720 MJ/ m²/ yr</u> (building should have enough: heat gain, low energy lighting, no A/C etc.)

Best practice is 97 MJ/m²/yr
Normal practice- office over 3000 m² = 397 kwh/m²/year
1 kilo watt hour = 3,6 MJ

Energy consumed in Resource Centre:
= 200 kwhr/ m²/ yr x (9177 + 4586 m²)
= <u>275 2600</u> kwhr/ yr

<u>Only 10% of solar energy generated is usable</u>

environmental qualities, energy production and passive climate 04

Winter:

Solar energy = Surface area of panels x 5 kwhr/ m²/ day
= 1140 m² x 5 kwhr/ m²
= 5700 kwhr
= 570 kwhr is usable (10%)
= 570 kwhr/ day x 365 days
= 208050 kwhr/ year

Summer:

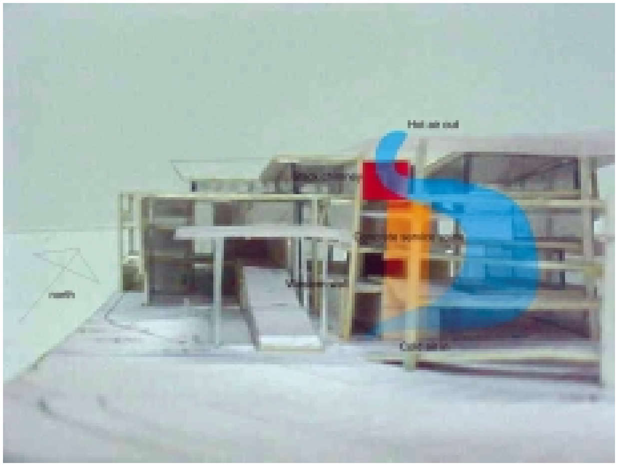
Solar energy = Surface area of panels x 7 kwhr/ m²
= 1140 m² x 7 kwhr/ m²/day
= 7980 kwhr
= 798 kwhr/ day x 365 days
= 291270 kwhr/ year

Percentage generated:

$\frac{208050 \text{ kwhr/ yr}}{275\,2600 \text{ kwhr/ yr}}$ $\frac{291270 \text{ kwhr/ yr}}{275\,2600 \text{ kwhr/ yr}}$

= 7,5% (winter) to 10,5% (summer) of annual electricity replaced in grid annually

Figure 4.3:
Ventilation system



Economy:

The price of the solar panels is R 3000/ m²
= 4500 m² x R3000
= R 3420000

30c / kwhr for energy use
= 0,30 x 275 2600 kwhr/ year
= R 825780
= 11% of R 825780
= R82578 less will be paid yearly for electricity

(www.greenbuilding.ca)

Figure 4.2:
Renewable solar energy

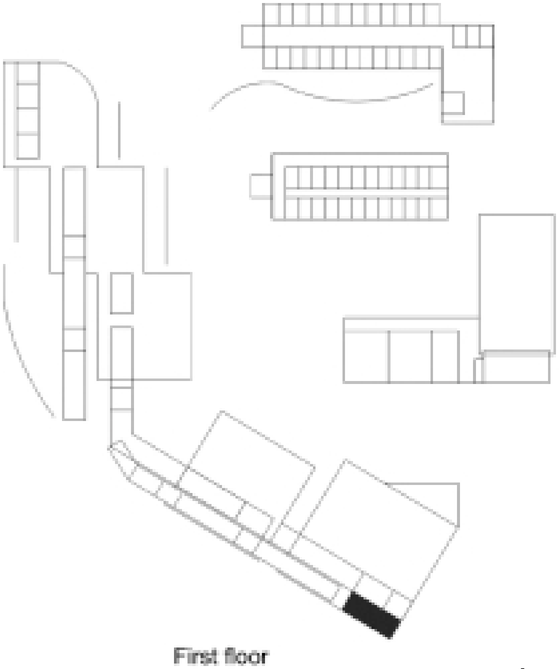


Figure 4.4:
First floor plan showing rock store area

4.2 Ventilation

The aim is to ensure that the need for mechanical ventilation is minimised and the passive climate of the building is appropriate and managed manually by the occupants **(Figure 4.3)**.

Any openings must at the minimum be 5% of the floor area. Awning windows on the first and second floor ensure that opposite pressure zones are created.

To achieve appropriate ventilation in the summer, the sun should rather be kept out. Another important aspect is the colour of surfaces, appropriate isolation, the distribution of openings along the façade, and the ability to close the chimney stack during winter time.

Resource Centre:

13,5m x 24m x 4
= 1296 m² per stepped plan

= 260 persons x 7,8l/s
= 2028 l/s
= 2,03 m³/s
= 7308 m³/h (2,03 x 3600)
= 7308 / 1296
= 5,64 air changes/ hour
- ideal 3-4 air changes/hour

Offices:

15m x 25m x 3m
= 1125 m²

1125/ 4,7 x 6 l/s
= 1436 l/s
= 1,44 m³/s
= 4,6 air changes/ hour
- 6l/s per occupant or per 4,7 m² and ideally 4-6 air changes/ hour

Auditorium:

20m x 30m x 4m
= 2400 m²

2400 persons x 1,7 l/s
= 4,08 m³/s
= 6,12 air changes / hour
- 6 -10 air changes/ hour

5% of the building floor area should be open-able windows to ensure desirable ventilation
(Adler et al; 1998; p.384 & 387)

Economy:

Air conditioning use is approximately 48 MJ/m²/ year (Benchmark: www. greenbuilding.ca)
1 kWhr = 3,6 MJ
= 13,3 kWhr/ m²/ year x (9177 + 4586 m²)
= 183 506,67 kWhr/ yr used on AC
= R 55052 saved annually on AC

4.3 Air

The ventilation in the building will be managed passively by the stack effect with more than one stack strategically and locally placed. These stacks will be a metal surface with a south facing window. The spine will cool-off during the night and hot air during the day will pass through the spine and cool-off. The air will enter the spine at a lower point and will move through the occupied spaces. The hot, used, stale air will be released higher up through the outlet in the spine, through the stack chimney.

Windows will be placed on the spine on the northern side, high up to let air escape there.

The advantages of a system like this are cost effectiveness by combining the dual roles of weather proof skin and energy collector into one building integrated component. The reduction of the effective U-value of the building envelope by adding the cover layer and recycling the fabric heat losses that otherwise would have been lost to the external environment (Ho et al; 1997; p.293). This air heating solar collector comprise of a 2m long section of profiled cladding with a depth of 0,03m, finished with a black coating resistant to 120 ºC. A backing of 0,1m thick fibre glass insulation is used (Ho et al; 1997; p.296).

In the auditorium a rock bed will be placed to cool off the theatre space. A two meter space is needed for the air to move before reaching the wet rock storage bed. This will be placed on the southern side of the auditorium as part of the service spine **(Figure 4.4)**.

1 m³/ 10 m² of floor area rock is needed to cool of the space.

Important principles for the winter time are that the Northern façade will have some dark areas, with 20% of the floor area in direct sunlight. The southern façade must have porous isolation on the outside of the building e.g. mix of concrete slurry and polystyrene pieces. The eastern façade must ideally be open to outside spaces and to the river. The sun shading devices will be of canvas and mainly placed on the eastern façade, and will be manually adjustable.

Ventilation is based on the fact that the sun should rather be kept out than let in. The painted colours are important to absorb or reflect sunlight. There should be enough isolation for the winter time and all openings in the facades should be evenly distributed and spaced along the façade. Openings should be low on the one façade and high on the opposite façade to encourage cross ventilation. The occupants should be able to close the stack off completely during the winter time to keep warm air in the building.

The orientation of the building will determine the façade treatment. The southern façade will have optimal light penetration, northern façade will have smaller glass and external shading, the western façade will have passive solar heat gain and the eastern façade will have moveable shading devices (Daniels; 1998; p.115).

4.4 Rainwater

Water cooling is a good system to use and will bring down the microclimate in an urban area down with 2-3K. It could be achieved by a water surface in front of a window e.g. a temperature of 32º C, a relative humidity of 40 %, a wind speed of 3 m/s, the water source 5m away and 10m in length will cool the building by 2K (Daniels; 1998; p.64). The Apies River will cool down the development by 3K.

The rainwater harvested by the roofs will be channelled to a collection tank on the ground floor and filtered there. The water will then be pumped through the building by electricity generated by a solar panel. This pumped water will be used for grey water e.g. hand wash, bath, etc. After it is used it will be sent through a gravel bed to filter it clean. It is then placed in the system again. The pumps and tanks will be placed in the service spine **(Figure 4.5)**.

4.5 Water harvesting

To put grey water back in circulation it could be sent through a reed bed on the roof garden for re use. On the ground level there will be tanks and the water will be pumped by the energy of a solar panel.

Example: (water harvested)

$2088m^2 \times 0.7m/year$

$= 1461,6\ m^3/year$ $* 1000\ L = 1m^3$

$= 1461\ 600\ l/year\ /\ 365\ days$

$= 4004\ l/day$

= 4004/ water use in building

= x % of daily water consumption harvested

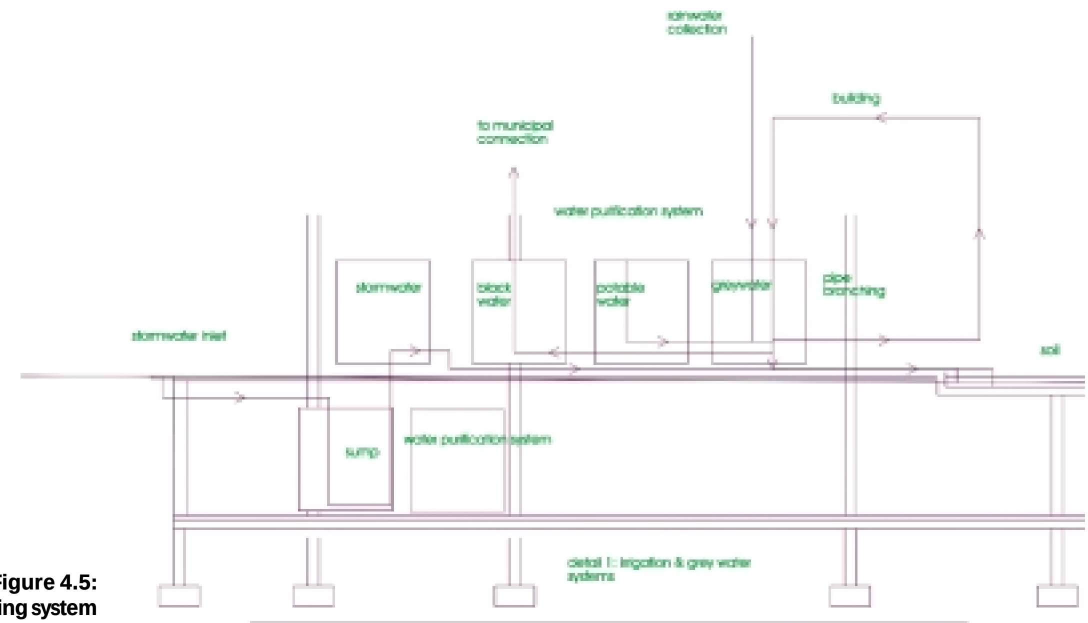


Figure 4.5:
Rainwater harvesting system

General water consumption:
Office = 23 l/person/day
Retail = 11 l/person/day
Residential = 130 l/person/ day

Water consumed Resource Centre:
= 23 l x 900 people
= <u>20700 l/day</u>

Overnight Facilities:
= 130 l x 100
= <u>13000 l/day</u>

Landscaping = (2 x s x a x v x 25)/ 1000 m³
S = species
= 1,0- cool season grass, 0,5- ground cover, 0,7- warm season grass, 0,2- shrubs & trees
A = area in m²
V = evapo- transpiration
= <u>19,5</u> or 13,0 or 14,3

= (2 x 0,5 x (9230.8/2) x 19,5 x 25)/ 1000 m³
= 2250 m³ per year water consumed
= 6,2 m³ per day
= <u>6164 l/day consumed</u>

Water harvested:
= 4483, 175 m² x 0,7m/year
= 3138,2 m³/ year
= <u>8597,9 l/day</u> / 39864 l/day
= <u>21,6 % of daily consumption replaced by rainwater harvesting</u>

Economy:
Water costs approximately R0, 003 / L.
3138233,5 L harvested yearly
Yearly approximately R 10 000 will be saved by rainwater harvesting.
(www.greenbuilding.ca)

4.6 Water holding structures

The rainwater harvested is an estimated 8597, 9 L/day and it will be stored in standard reinforced fibreglass water tanks. The total daily consumption of water is 39 864 L/day for the whole development. If a benchmark of 60% (23 918, 4 L/day) is used for grey water and irrigation usage, the water harvested is 35% of daily use. The calculations are theoretical.

The amount of water tanks used for rainwater harvesting is 4 x 4500 L tanks on the roof and on the ground floor there will be an allocated area for the distribution tanks. These 4 ground floor tanks will provide for storm water, black water, potable water and grey water. Water to be pumped by energy from solar panel.

4.7 Systems

The systems in the building include the following:
- Ventilation & passive climate through cross ventilation, the stack effect and cooling by the Apies River.
- Lighting is by means of natural lighting
- Security access through passive surveillance and personnel at every exit/ entrance
- Circulation – ramps used by handicapped will also double as fire escapes
Fire escape staircases at each end of the building
- Wet services- rain water irrigation/ Grey water/ Drinking
- cooling on eastern façade
- grey water circulation system
- sun panel as energy generator for water pump

See *Traffic & Fire*

4.8 Waste management

This includes the allocation of an area for waste management where all wastes are sorted and recycled **(Figure 4.6)**.
Organic waste for example food could be exchanged for compost with a farmer, but due to the size of the site compost could be produced on site.
The size of the waste management centre:
0, 4 m² of 100 m² (Gibberd; 2002; Short Course)
= 9177 m² / 100 m²
= 91, 77 x 0,4
= <u>37 m² needed</u>

4.9 Services

The building has a service spine with clip-on facilities. All the dry and wet services, as well as the passive climate system, will be accommodated in this concrete spine. This will ensure flexibility and functionality. The passive climate systems will also be accommodated in this spine.

Electricity, water, heating and cooling all indicated on the plans and sketches **(Figure 4.7)**.

Figure 4.7:
Steel service spine

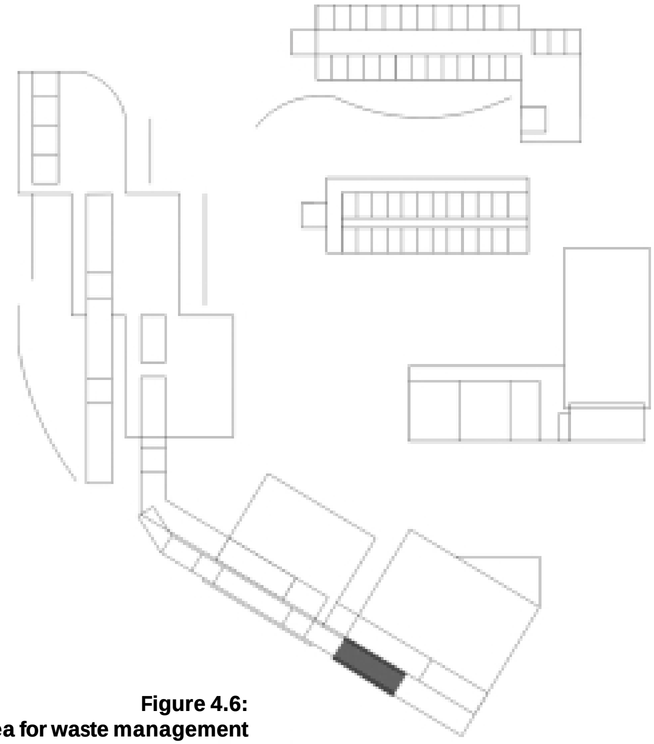


Figure 4.6:
Ground floor with allocated area for waste management

5.1 Foundations

Reaction: After soil testing in andesite on a large site, ordinary footings or slightly deeper strip foundations can be used (Purnell, 1984: 35). Deep piling can be used in these problematic soils to reach inactive material with a suitable bearing capacity (Minimum 1,5 MPA). Stiffened raft foundation is recommended.

This foundation compromises a grid of reinforced concrete beams cast integrally with the floor slab (Purnell, 1984: 36).

Subsurface pipes and drains, by means of flexible joints, need to be installed to prevent subsurface drainage. Drainage should divert rainwater away from the foundations. Trees with excessive dessicating influence should be kept away from these structures.

In excavations vertical pre cast concrete piles can be used tied back with anchors and horizontal concrete plastering. Some sort of shoring technique should be used on all excavation faces (Purnell, 1984: 36)

The syenite weathers in the same way as andesite. With deep excavation in these soils, strong inflows of water must be anticipated. Attention must be given to construction joints (Purnell, 1984: 37).

5.2 Structure

The structure of the building will be steel column and beam with a concrete slab. Steel will be used for beams and to carry some of the lightweight roof structures. Steel will be used because it appears lighter, creates visual variety and has higher structural strength.

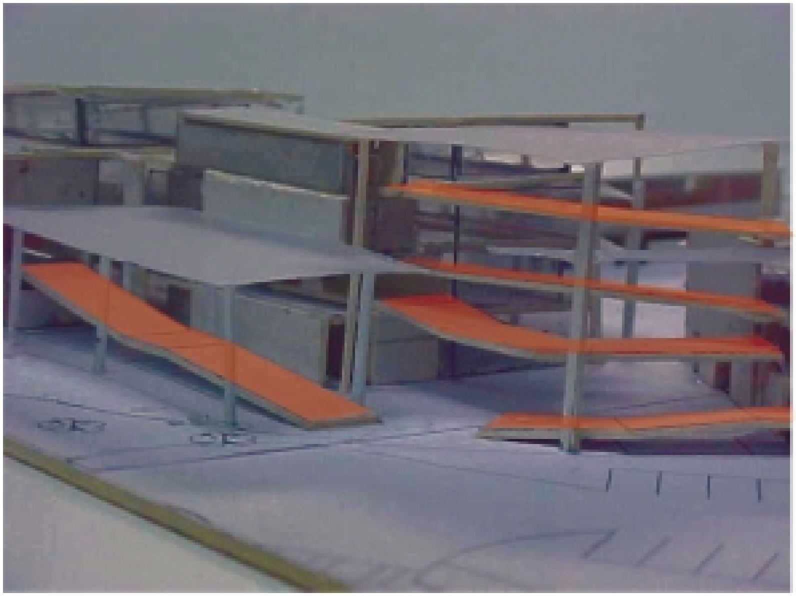
Steel will be used in all the different types of buildings for the staircases and wherever a lightweight structure is needed.

Concrete as a structural system has low embodied energy because it is produced on site. This method is labour intensive and attribute to skills transfer and job creation. This structural system will be used in all the buildings because the wet works will be already in place on the site, and therefore more economic.

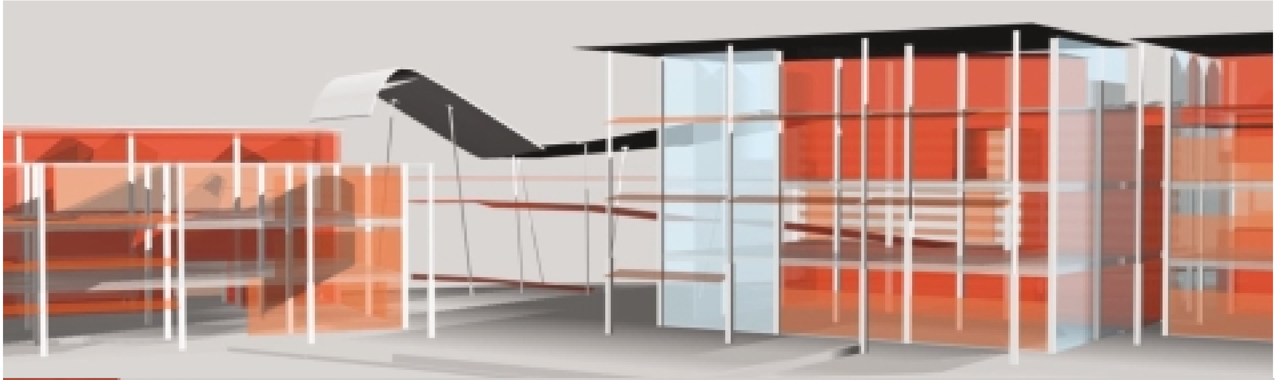
5.3 Circulation

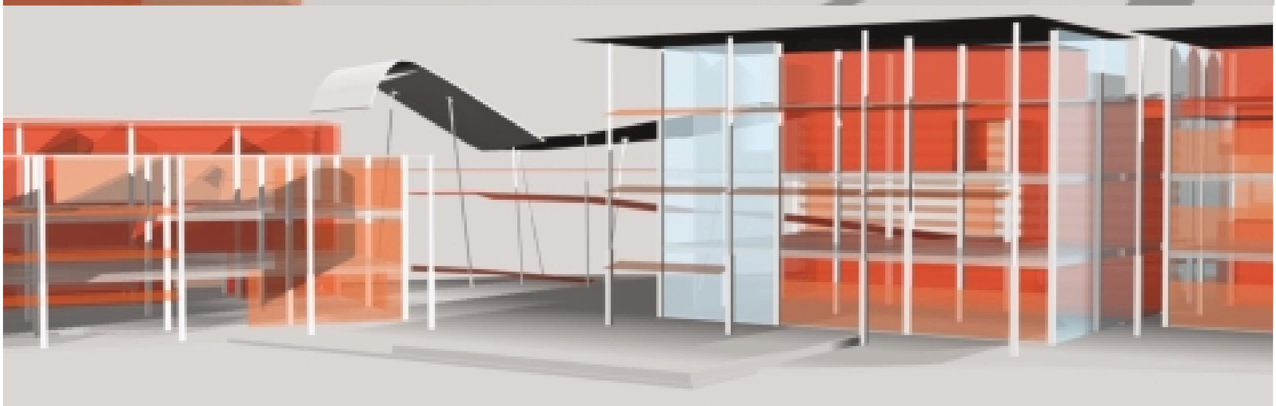
The main circulation will be with concrete and steel ramps connecting all the different spaces in the building. At each end of the concrete service spine there will be a concrete and steel staircase that will be used mainly as fire escapes. The circulation "corridors" are limited to the western side of the Resource centre building adjacent to the service spine. This makes circulation easier because it is legible and accessible to any user. The ramps will also be used as fire escapes. The classrooms/hall and overnight facilities circulation will be through corridors in the buildings and fire escapes will be provided according to the National Building Regulations. All external circulation will be on paved walkways **(Figure 5.1)**.

Figure 5.1: Circulation ramps



05 foundations, structure and circulation





Embodied energy of construction materials:

- Sheet steel – 34 GJ/Tonne
- Softwood – 3,4 GJ/Tonne
- Brick – 2,5 GJ/Tonne   0,4 kwhr/ kg
- Concrete – 1,7 GJ/Tonne 0,2 kwhr/ kg
- Plasterboard – 4,4 GJ/Tonne
- Concrete tiles – 12 GJ/Tonne
- Vinyl – 70 GJ/Tonne
- Plastic – 150 GJ/Tonne

Water consumed in the manufacturing processes of materials:

- 1 ton bricks – 2200 l
- 1 ton steel – 165 000 l
- 1 ton plastic – 1,32 million l

The materials used in the design will be stock brick, concrete with reclaimed aggregate, steel, glass, timber and canvas. The majority of the materials have a low embodied energy and can be made on site. The only material with a high embodied energy is steel, but it has a long life span, low maintenance and good structural quality. All the material can be recycled.

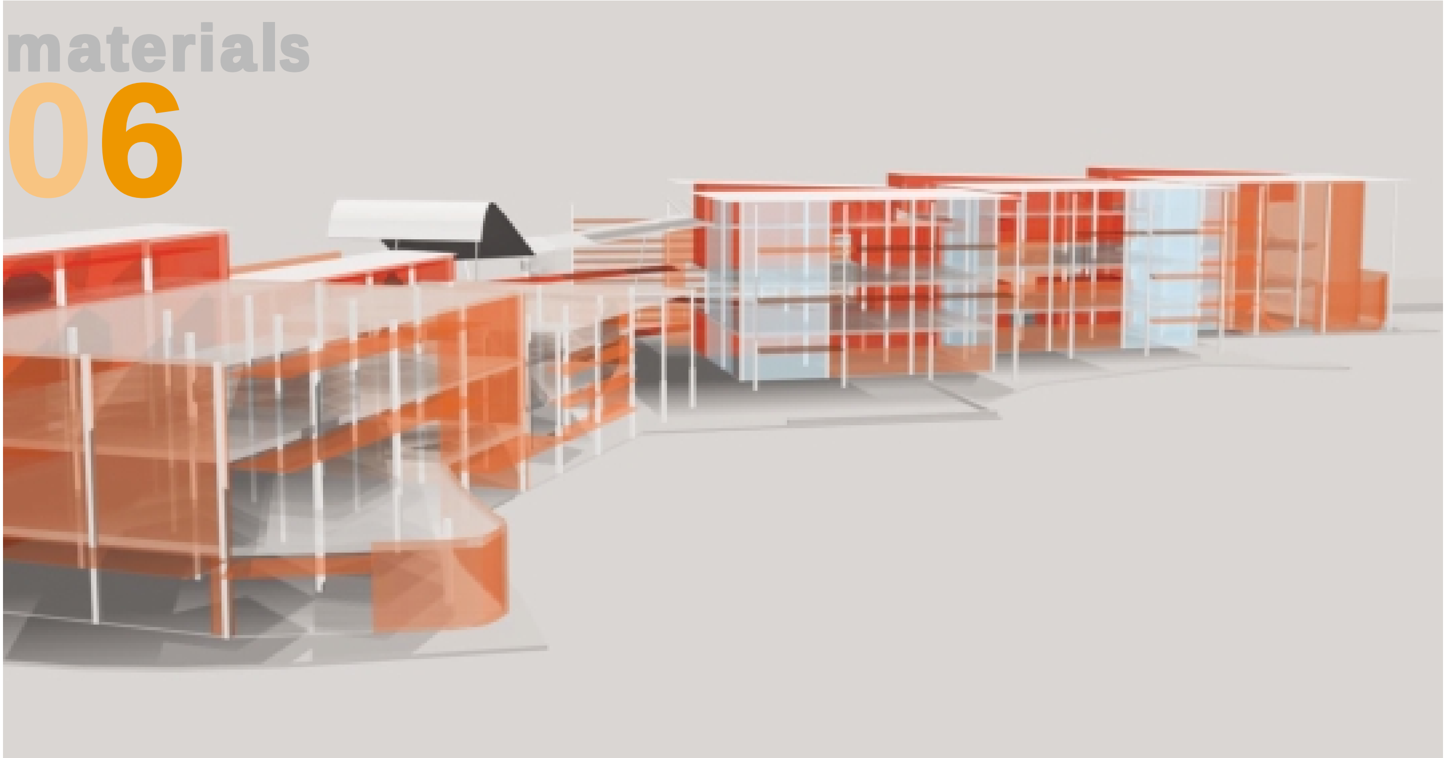
Certain materials used for specific elements:

Foundations: concrete with reclaimed aggregate. This will limit the need for new gravel required (Anink et al; 1996; p.40)

Floor construction: Concrete on permanent formwork.

Walls: Brick will be used for external non loadbearing walls because its production requires little energy and the process is pollution free. Concrete walls should preferably be cellular concrete blocks because of less material use, but concrete with reclaimed aggregate is also an option (Anink et al; 1996; p.44). Moveable walls will be of frames and panels, because it is light weight and use less material. The cavity will be insulated for sound with mineral wool (Anink et al; 1996; p.45).
Roofs: The roofs on the Resource Centre will be a steel construction with corrugated sheeting. The steel can be recycled if treated against corrosion. On the classrooms and overnight facilities a pine timber roof structure will be used. The insulation will be mineral wool and sisalation.

Economy:



The Resource Centre will cost approximately R 4500/ m² = R 41 296 500

The classrooms/hall and overnight facilities will cost approximately R 3500/ m² = R 16 051 000

A sophisticated building with durable finishes and sustainable passive climate systems will be designed.

6.1 Interior design: materials & finishes

The interior finishes will include:
Floors- Linoleum floor finish kept to a minimum, noise absorbing floor finish e.g. carpets, painted- and polished concrete floors.

Walls- In situ concrete walls- off-shutter concrete, stock brick – plastered and un-plastered, painted colours strategically placed.

Ceiling- Soffit of concrete slab painted white for light reflection or permanent formwork (Anink et al; 1996; p.24).

Frames- Steel/ Timber frames strategically placed.

Colour – The use of colour achieve a balanced relationship between stimulation and reassurance, order and variety, relatedness and contrast. Colour integrates order and explains (Daniels; 1998; p.104).

6.2. Acoustics

In the auditorium there will be a need for acoustic material used in the interior.
Isolation in the interior will be achieved by cavity walls plastered with bints. A cavity wall with glass wool isolation will be better.
Double glazing will be used, with an absorbent material on the inside for example timber shutters.

Finishes include:
Floor: 6mm carpet on a 10mm under felt – factor = 0,73
Seating: upholstered – factor = 0,5
Curtain: factor = 0,6
Shutters: 6mm plywood – factor = 0,4 for an 60m open air space and low 125 Hz. Good isolation, not good absorber.
(Van Zyl; 2001; p.7-11 – 7-14)

07 fenestration & signs

The emphasis is on a transparent, legible window. The fenestration of the building is so placed as to maximise interior occupant comfort regarding passive climate and lighting. The eastern façade has the most glazing with canvas sun shading, opening up to the river, the northern façade's glazing ensures winter heat gain, the southern façade glazing will provide lighting especially for working, studying. Indirect lighting will be achieved by the strategic placement of the windows **(Figure 7.1)**.

Signs will be discussed in the theory part of this thesis, *Visual Culture & Architecture*. In the design, place for signage should be provided and will be something dynamic and mobile e.g. projected imagery on the roofs and walls.

This kind of signage will be educational and the openness of the building compliments the legibility and the visual appropriateness of the building.

7.1 Day lighting

Natural lighting and illiuminance is desirable in the building to minimise the use of electricity and artificial lighting.

General information for calculations:

- The day light illuminance outside for design purposes is 15 000 lux.
- The depth of the room must be < 2 x the height of the building e.g. 4-6m deep
- The general reflectance of a white ceiling is 70%, a pastel wall is 50% and a dark floor is 15%
- The general illuminance in a building:
  - Lecture rooms – 70 – 150 lux
  - Offices/ Library – 200 lux
  - Bedrooms- 50 lux
  - Kitchen – 100 lux

The two main formulas for calculation of the internal illuminance:
(van Rensburg; 2001)

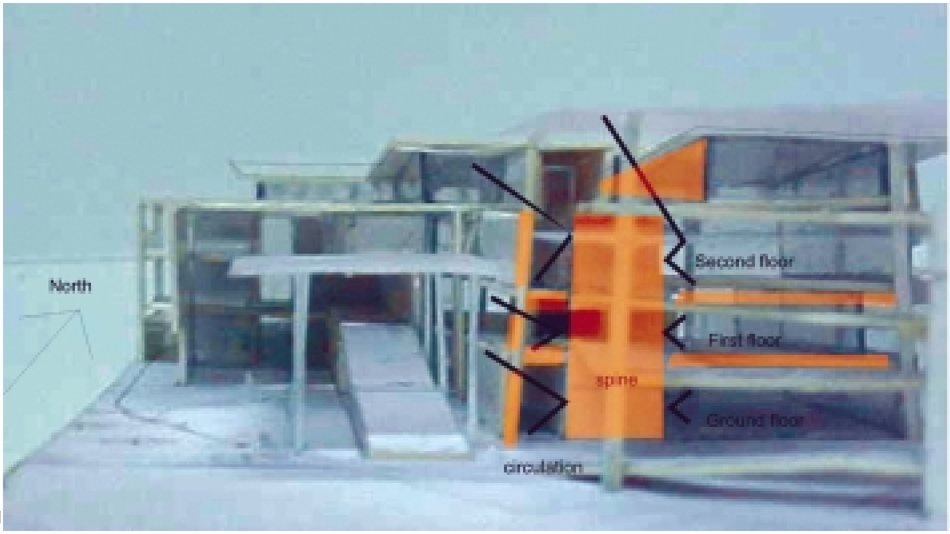


Figure 7.1: Indirect natural lighting

RDF = DDF x EOBF / GF x DTF

all values found in tables in notes

I int = RDF x I eks / 100

Resource centre:
RDF = 1,75 x 0,9 / 1,1 x 1,7
= 0,84

I int = 0,84 x 15 000 lux / 100
= 126 lux ideal 70 – 150 lux

On internal side of room- light in by saw tooth roof with no angle:
RDF = 4,5 x 0,5 / 1,1 x 1,7
= 1,2

I int = 1,2 x 15000 lux / 100
= 180 lux – extreme

thus Resource centre at 126 – 180 lux

Classrooms:

RDF = 1,9 X 0,9 / 1,1 X 1,7
= 0.9

I int = 0,9 x 15000 lux / 100
= 137 lux

Outside offices:
RDF = 2,75 x 0,9 / 1,1 x 1,7
= 1,32

I int = 1,32 x 15000 lux / 100
= 198 lux

Overnight facilities:
RDF = 1,3 x 0,9 / 1,1 x 1,7
= 0,62

I int = 0,6 x 15000 lux / 100
= 94 lux

10 % of floor area should be windows according to the NBR – this will ensure appropriate lighting.

Economy:

Energy used for artificial lighting according to the GB tool (www.greenbuilding.ca) is 44 MJ/m²/yr.
= 12,2 kWhr/ m²/yr x (9177 + 4586 m²)
= 167906, 6 kWhr/ yr used for interior and exterior lighting
= 44% of daily lighting is natural
= 73 879, 784 kWhr/yr saved
= R 22164 saved (R 0,30/ kWhr)

8.1 Vegetation

The Ecological dimension is defined as:

The human fascination with natural growth is the change independently of human design and therefore the impossibility of total manipulation.

The ideal is a planted roof structure. If 50- to 100m width is planted, the temperature of the structure would be 3,5 K lower because of a free flow of cold streams through the structure (Daniels; 1998; p.69). On planted roofs and facades, the variation in temperature is minimised from 100 K to only 30K.

08landscaping

Northern slopes

Ochua Pulchra (lekkerbeuk),
**Burkea Africana* (wilde sering) – wilde sering (Breitenbach et al; 2001; p.72)
Strychos Purgens (Botterklapper),
Bequertiodenron (Stamvrug),
#*Ficus pretoriae* (Wildevy) (Venter et al; 1996; p.71)
-or *Ficus thonningii* (Gewone wurgvy)
-**evergreen**, max 15m, nat. no. 48
- suitable in a large garden/park
- **has an aggressive root system (not near buildings)**
-help to control erosion
-humus rich, deep loamy soil
-whole year flowering, fruiting with October the peak **(Figure 8.1)**.
#*Rhus* (Karee) (Venter et al; 1996; p.102)
-**evergreen**, max 9m, nat. no. 386
-flowering- June to September
-fruiting- September to January
- **non-aggressive root system**, in any soil **(Figure 8.2)**.
#*Acacia Caffra* (wag 'n bietjie) (Venter et al; 1996; p.67)
- **deciduous**, max 17m, no. 162
- flowering- September to November, fruiting- January to May
- grass grows beneath
- **aggressive root system**
- growth rate 700 – 900 m/year (Fast)

Figure 8.1:
Ficus pretoriae

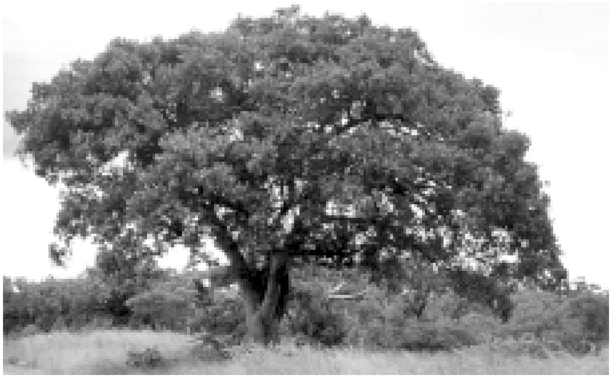


Figure 82:
Rhus

Figure 8.5:
Cassinopsis ilicifolia

Figure 8.4:
Halleria Lucida

Figure 8.3:
Celtis Africana

Southern slopes

**Protea Caffra* (Suikerbos) (Breitenbach et al; 2001; p.41)
#Acacia Caffra

Riverbanks

#Celtis Africana (Witstinkhout) (Venter et al; 1996; p.257)
- **deciduous**, max 40m, no.39
- flowering- August to October, Fruiting- October to February
- good shade in summer, sun in winter
- ideal container plant – **non-aggressive roots (Figure 8.3)**.

#Kiggelaria africana (Wilde perske) (Venter et al; 1996; p.270)
- **evergreen to semi-deciduous**, max 20m
- **non aggressive roots**
- ideal in bird garden

#Halleria Lucida (Notsung) (Venter et al; 1996; p.237)
- **evergreen tree**, max 10 – 30m, no.670
- flowering- April to December, fruiting- June to February
- bird garden, shrubbery
- **non aggressive root system (Figure 8.4)**.

** Leucosidea sericea* – oudehout (Breitenbach et al; 2001; p. 59)

#Buddleja salvifolia (Saliehout) (Venter et al; 1996; p.197)
- **evergreen to semi deciduous**, max 8m, no. 637
- flowering – August to October, fruiting – October to December
- birds, insects
- stabilizing embankments, hedges, container plant
- **aggressive root system**

#Cassinopsis ilicifolia (Lemoentjiedoring) (Venter et al; 1996; p.131)
- **evergreen**, max 5m, no. 420
- flowering- September to November, fruiting- February to May
- singly planted, could be cut into tree
- birds
- **non- aggressive root system**
- container plant **(Figure 8.5)**.

amenities 09

The building has a community function; placing a learner's centre in the Pretoria CBD. There is a lack of public amenities in the inner city and to make it accessible to everyone it needs to have an 18 hour activity to enhance security and to make the development viable.

These amenities include:
- Concrete roofs to accommodate views to Union Buildings and Unisa and to create green spaces.
-Public spaces that is open, visual and used for interaction.
-Semi-private spaces that could be used for educational functions and community gatherings.
-Informal/ formal trading on the northern part of the site to accommodate the pedestrian and commuter.
-A sport field for soccer games and the sport activities of the schools and college on the site. This will have a community function to give green spaces in the inner city.
-An urban park with a mix of activity and function.
-Education facility to teach and inform people living and working in the inner city. This also involves the mentioned educational institutions in the community and to inform possible future students.
-These functions fit in with the policy of the European Union who provides the funding for this project.

The deliveries will happen at the BMS allocated area and distributed through the building. The entrances will be enhanced visually by means of architectural elements and needs to be easily accessible **(Figure 10.1)**.

The idea with the transportation in- and around the site is to minimise the use of the individual car, and to increase the use of public transport (Daniels; 1998; p.111).

10 entrances & deliveries

10.1 Traffic

The existing entrance to the site on van der Walt Street is used for access. All the pedestrian crossings at the traffic lights are emphasised and van der Walt Street has added pedestrian crossings to link the visitor parking across the road. The on site parking on the southern side of the site is kept to a minimum to limit the use of the individual car. The northern part of the site has no structured parking but the play ground could be used as parking certain times of the day.

The parking for the development is limited to 400 because of the public transport node close- and on the site including the train station, taxi terminal and bus stops.

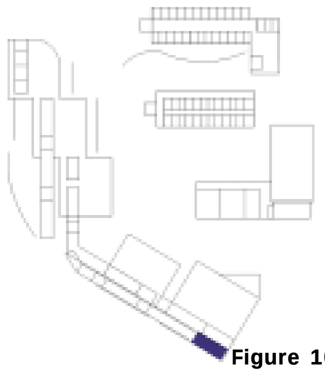


Figure 10.1: Allocated area for Building Management Systems

11 fire design & building management systems

Fire:

2 Escape routes if >45m to nearest escape route
Room >50 persons
120 minute lagtime- floor, ceiling, walls
Door 800mm wide
Route width- 120 people 1,1m
- 190 people 1,8m
Well ventilated
Fire hydrant for every 500 sqm.
Extinguisher 1/ 200sqm - 9 litre type
Adequate balustrades should be provided.
(SABS; 1990; p. 181- 198)

BMS:

This area will include the waste management, security systems, water circulation systems, rock store and climate control systems. In the spine all water tanks and pipes will be allocated. The air pipes will be located in the spine and under the circulation ramps. Security personnel as well as deliveries will be located there.

To read how the following objectives were achieved see the *Design essay .*
The important objectives:
-accessible routes with a variety of choice and use
-permeability
-hierarchy of public/ private spaces: the size thereof determines importance of building
-sensory and functional diversity
-legibility: identifiable according to principles
-articulation of ground surface: spatiality & visual zones
-Landmark, gateway building: beacon of reference, generator **(Figure 12.1)**
-Wall, floor, roof: hierarchy, symmetry, rhythm and layering
-Materials and symbolism.

Legibility

The modern city has confusing important activity systems with bureaucracy being more important (Bentley et al;p.42). There is a lack of orientating elements that give the user something to remember.

Nodes, edges, paths, districts and landmarks on a smaller scale are implemented in the design of the buildings **(Figure 12.2)**.

Paths – This will follow the most important features in a building e.g. a specific wall

Nodes- This will be certain junctions and important open spaces in and around the building **(Figure 12.3)**.

Landmark- There will be beacons visible from the southern entrance into the city as well as from strategic points on the site e.g. the chimney stacks for ventilation becoming visual elements.

Edges – This for example the Apies river and any route that is not used as a path. This will be perceived as an edge, permeable or impermeable.

Districts- the building should have some identity in the context and environment. Some clues of the context should be evident.

12 access & legibility

Paths and nodes should be reinforced to make the building legible. Views should be enhanced e.g. the south western view to the classrooms and hall through the entrance to the Resource centre. Splayed corners, setbacks and higher ratios of enclosing walls will lead the viewer to the next path.

13 robustness & flexibility

The idea is that **all** spaces, inside and outside, could be used for any desired activity. That is why the ceiling heights vary from 3 – 4m, a structural grid of 8-10m is used, any occupant is 7,5m maximum away from natural lighting and natural ventilation and the passive climate can be manually controlled by the occupants **(Figure 13.1)**.

Moveable walls and -curtains will ensure flexibility in larger spaces. In the classrooms/ hall, walls will slide out to create a bigger interior space and more intimate outdoor spaces at the same time **(Figure 13.2)**.

Where double volumes are created, it could easily be filled in with a lightweight floor if another level is required. Certain staircases will be moveable, e.g. at the book stacks, to ensure flexibility and mobility. The "in-between" spaces could be seen as "non-programmatic": this is any communal space that could be used for any function. This gives the occupier a choice to utilise the space to fulfil their needs and wants **(Figure 13.3)**.

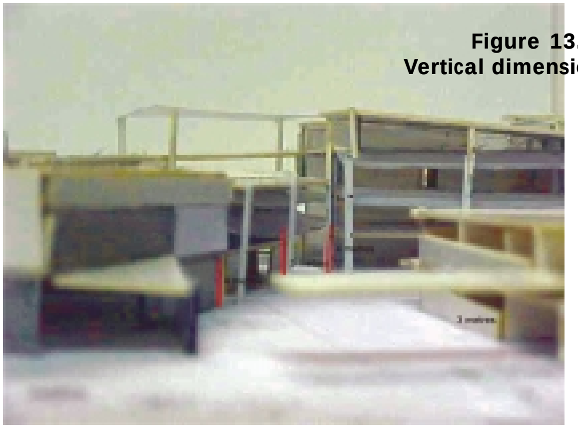


Figure 13.1: Vertical dimension

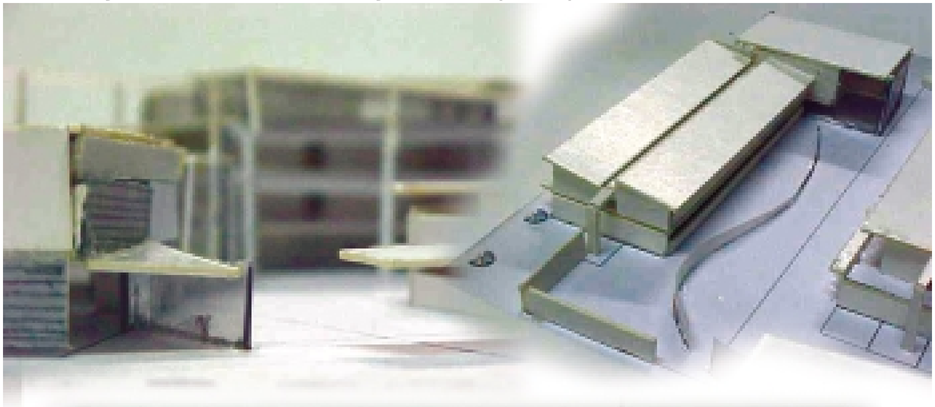


Figure 12.1:
Views

Figure 12.3:
Nodes

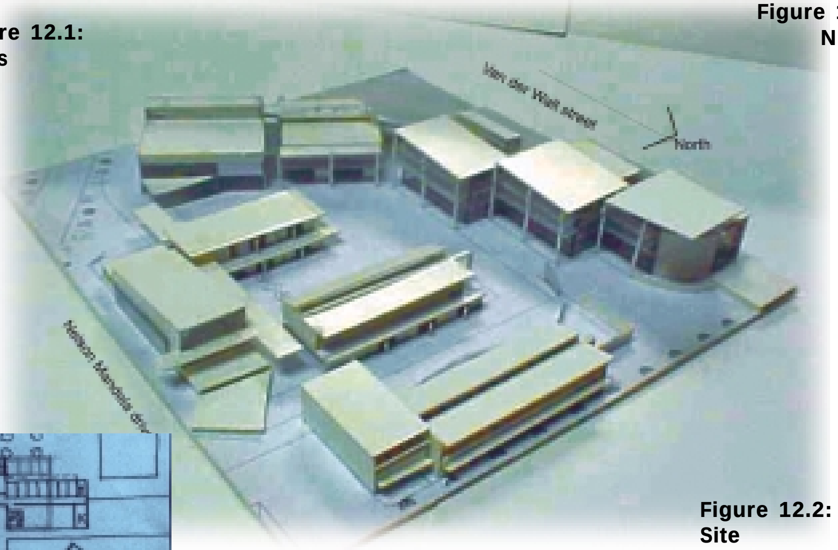
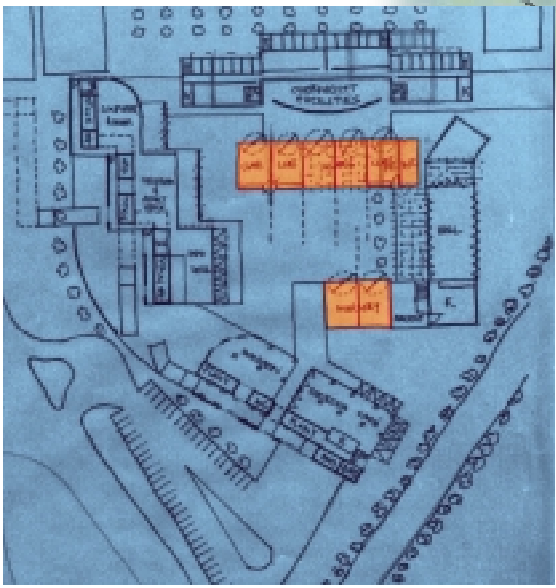


Figure 12.2:
Site

Figure 13.2:
Adaptability



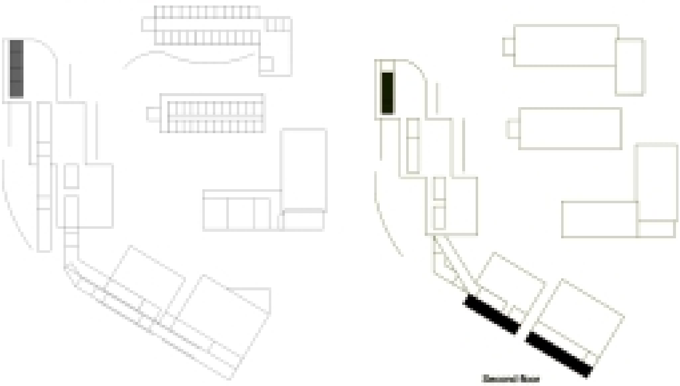


Figure 13.3:
Social spaces

MODULAYERMODULAYERMODULAYER

To react to the regionalism of the third vernacular:
-brick
-corrugated sheeting
-bag-wash wall finish
-pre-cast concrete/
-decorative use of brick
-sun panels
are used in the design of the building
(See *Briefing Document and Context Study*).

This vernacular takes into account:
-function
-climate
-historical context
-availability of materials

To establish an identity the *visual appropriateness* should be addressed.

Visual appropriateness supports robustness and a wide variety of different backgrounds of the viewer are used to determine appropriateness. The outside defines the public realm and the area it is located in will determine the form. The use of legibility is to read the pattern of uses and to establish a democratic environment. A variety is achieved if an image of every area is appropriate as a setting. To achieve large scale robustness the building should look like several things at once and small scale robustness needs to accommodate all the different backgrounds of the users (Bentley et al; ;p.76).

People have learned meanings determined by the group. Different experiences and objectives differ and variety and robustness are cues for the experience. The landmark quality of the building is something contextual with noticeable vertical- and horizontal rhythms, skylines, wall detail (material colouring, patterning), windows, doors and ground level detail. The elements and relationships determine this visual quality (Bentley et al; p.89) **(Figure 14.1)**.

14 identity

14.1 Walls, floors and roofs

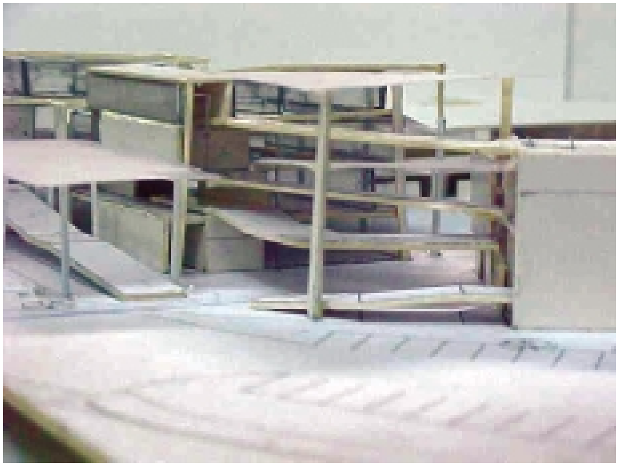
The architecture of the building is successful in its simplicity. The loose pavilion buildings are placed on the site to create a hierarchy of outdoor spaces and to be respectful to the historical buildings. There are emphasised relationships and articulation between the different pavilions.

The western façade to van der Walt Street and the parking forms a hard edge with punctured openings to create vistas and views through the building. The eastern façade forms a colonnade and opens up to the green open spaces and the river. This glass façade will have canvas sun shading.

The circulation ramps cut through the floors and walls of the building creating an awareness of the different elements of architecture. The viewer is then challenged to question the materiality and politics of architecture. The roofs are placed as expressive elements that let in light and enhance natural ventilation. The entrance roofs are lightweight concrete and function as space defining elements.

Hierarchy and function of spaces are legible to the user and serve an orientating functions.

Figure 14.1: Entrances



14.2 Electric Ladyland, Bellevue road, Kloof, Durban -OMM Design Workshop

Electric Ladyland is used as a precedent to establish an identity for the Resource Centre.

In this building the aesthetic is in its simplicity, the resolution of tectonics and the assembly of elements. There are striking juxtapositions of materials, like concrete, glass and steel, and a restriction in the use thereof, the imaginative details and spatial formal purity (Unknown; 2002; p.35). The site is set as a stage and the result is an innovative, robust and versatile building. The only form giving and articulation is at the linkage between the different pavilions. There is a dynamic relationship between the buildings with a definite presence to the historical Cape Dutch house as a landmark and pivot point. The influence of this building is evident in the design of the Learner's Resource Centre at Berea Park. In this design, emphasis is placed on the loose pavilion buildings, with articulation strategically placed on façade and plan, with respect to the existing Clubhouse and Hall.

The double storey rectangular blocks are at acute angles to the Cape Dutch house and each other. High volumes ensure adaptability and response to changing working teams **(Figure 14.2)**. The fully opening doors and windows ensure functional flexibility in access, with mobile stairs, adjustable levels in the interior (Unknown; 2001; p.32).

The triangular courtyard and intimate semi enclosed spaces at loosely linked junctions create mediating zones between outside, public areas and office areas. The courtyard edge has an external circulation route with circular columns, next to glass curtain walls, shaded by a projecting roof slab and hanging sails **(Figure 14.3)**. The fine tuned composition, gripping vistas and characteristics differentiate between the structures (Unknown; 2001; p.10).

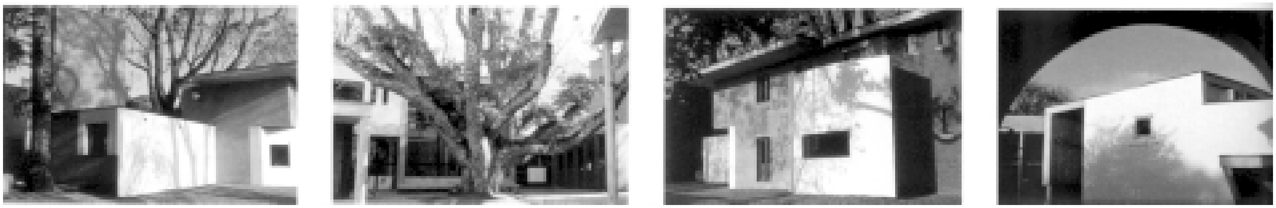
The building has proportioned detailed facades with a hard edge of punctured openings to the traffic and parking **(Figure 14.4)**. These edges are off shutter concrete. A spatial dynamic is created by flat surfaces, porches and recesses (Lipman; 2003; p.42).

This building is a noteworthy example of simple, functional yet aesthetic South African Architecture.

Figure 14.2: High volumes

Figure 14.3: Circulation route

Figure 14.4: Punctured openings



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