Technical Investigation:

Climatic data and Biophysical Information:

Pretoria 22’44” South; 23’11”East

Pretoria has hot summers and moderately cold winters with moderate humidity levels. (Holm; p36) It is a summer rainfall area. The most suitable structures for such a climate feature high thermal mass, small openings and are often surrounded by a porch or “stoep.” (Konya; p22)

Rainfall charts of the Pretoria area collected over the last 60 years indicate an average annual rainfall of around 600mm with surges of just over 100mm per month in January and December and virtually no rain during winter months. (SAWeather.com) This means that there will be 140mm² of gutter for every 1m² of roof area to cater for the times of largest concentration of rainfall. (Wegelin; p43) Also, if rainwater is to be harvested for use throughout the year, approximately 40% of 600mm per square meter of roof should be catered for: 240mm per square meter of roof.

Pretoria Climatic Data: see adjacent chart

The optimum temperature for a building is around 22ºC. (Konya; p16) This is the outside temperature optimum for the body to regulate its own temperature. The temperatures in Pretoria average between 20º and 30º between winter and summer (SAWeather.com), so it is clear that, in this region, more needs to be done to ensure that

Temp	High	Ave Max	Ave Min	Low	Ave mm	Days>1m	24h Max
January	36	29	18	8	136	14	160
February	36	28	17	11	75	11	95
March	35	27	16	6	82	10	84
April	33	24	12	3	51	7	72
May	29	22	8	-1	13	3	40
June	25	19	5	-6	7	1	32
July	26	20	5	-4	3	1	18
Auguat	31	22	8	-1	6	2	15
September	34	26	12	2	22	3	43
October	36	27	14	4	71	9	108
November	36	27	16	7	98	12	67
December	35	28	17	7	110	15	50

Fig151: Climatic data of Tshwane

Fig152: Composite view standing at base of mountain across the river

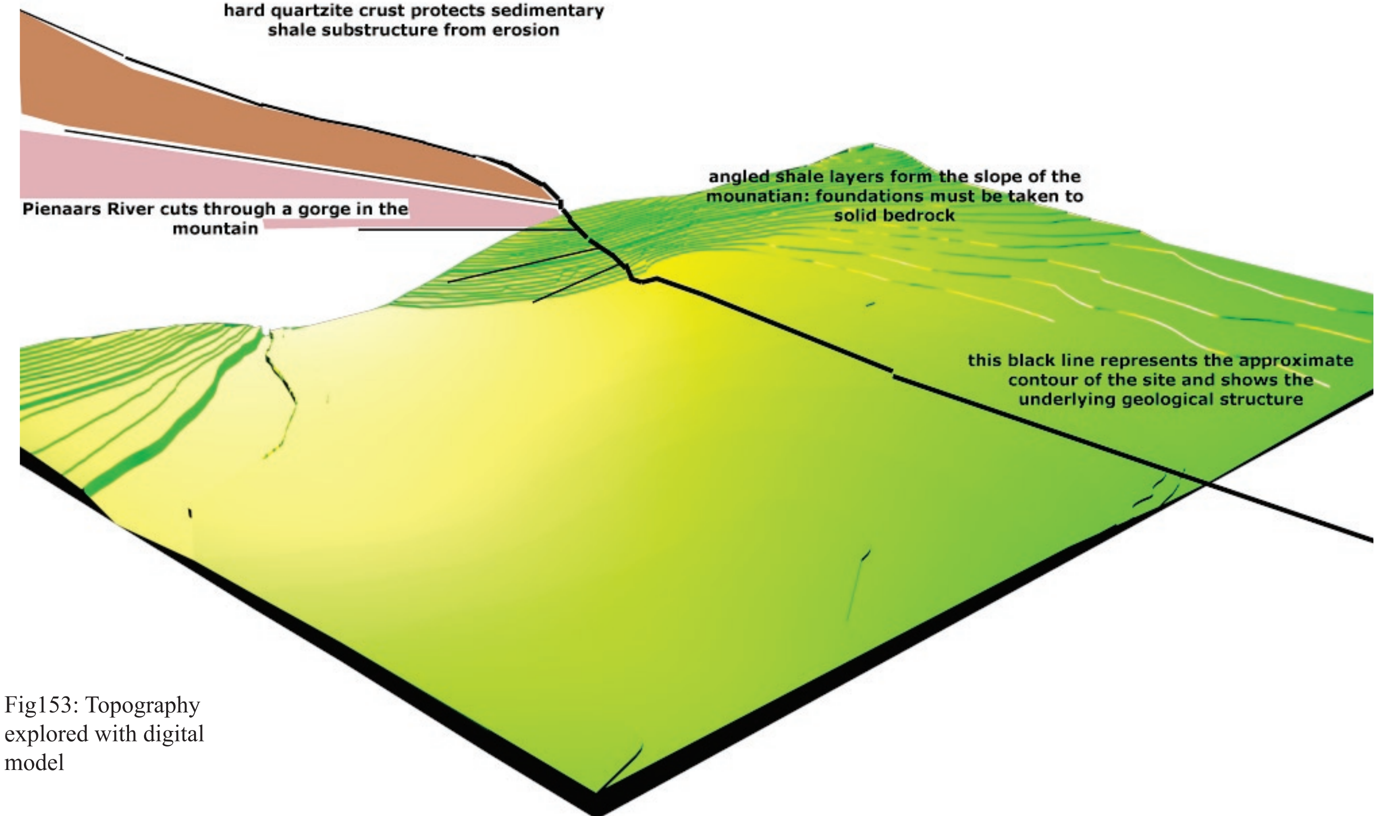
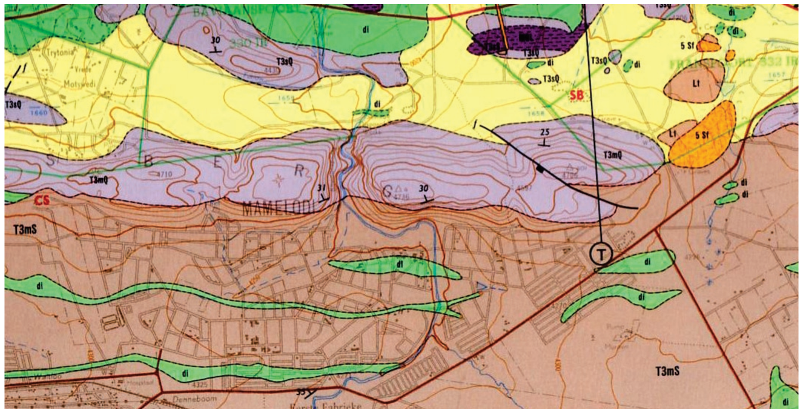


Fig153: Topography explored with digital model

Fig154: Geological map of the region courtest of the Council for Geoscience



buildings stay cool during summer months. Roofs or ceilings must be insulated properly against direct solar gain and proper ventilation through structure is essential. Materials with high thermal mass draw heat out of the air through convection. Sun movement patterns show that the maximum solar altitude varies between 88º in mid-summer and 46º in mid-winter. A design angle of 64º is usually used, where the shadow line from the roof falls at the lowest point of openings from this projected angle. Since this building's North façade has no glazed openings, this design principle has merely been referred to since it must be clear that the desired effect is deep solar penetration into the shelter in winter but deep summer shadow. Shade is ensured through the use of 700mm roof overhang and the height of the roof permits sun just under 6m into the building at midday in winter. Deciduous trees which surround the reception building and are common throughout the park, also contribute to a seasonal temperature control inside the building between summer and winter, providing summer shade and allowing winter sun.

Predominant wind direction:

Summer: east-north-east to east-south-east with 41% days breezy

Winter: south-west with occasional north-east with 60% days breezy

From personal experience over 25 years in Pretoria it is clear that lush and deep summer shade is desirable. Winter can be dealt with by allowing direct sun and providing fire.

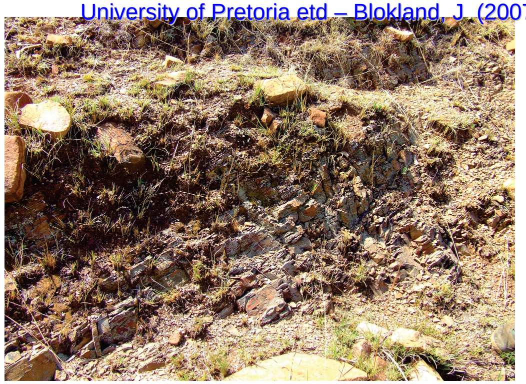
Amphitheatre

Amphitheatre:

Geology and topography of the area:

The Magaliesberg Mountain Range consists of a pediment, a layer of quartzite which effectively acts as a cover over layers of alternating shale and quartzitic sandstone. (Council for Geoscience (CFG); 1990) There may be hard igneous intrusions of diabase (hardened magma from deep in the earth) found throughout the range and a bed of loose angular rocks suspended in a soil matrix is present at lower parts of the slope, the tallus.

“The most common methodology for investigating slope stability is a combination of aerial photographic analysis backed up by field checks.” (Hechner. S.R. p149) Although this technique does not guarantee reliable results or comprehensive data, it has had to be used in this case as a full geotechnical report simply is not feasible for this project. Shale, the main geological feature of the slope where the amphitheatre is proposed, is a stable sedimentary rock which can be used as a construction material and can easily and support concrete foundations. The physical characteristics of shale can be defined as having “close parallel discontinuities formed in mudstones during diagenesis and resulting in fissility”. (Hechner. S.R. p148) Footings and structure on the slope will thus have to respond according to exact conditions at the position of construction as proper grounding can only happen properly directly on the bedrock. Herbert Baker insisted that all the foundations for the Union Buildings be taken all the way down to



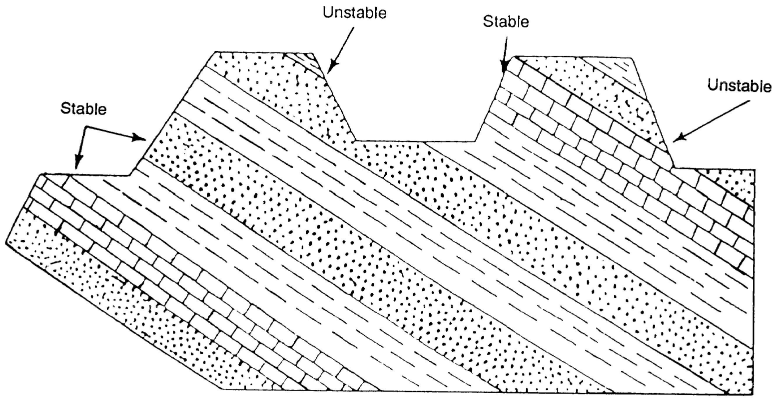


Figure 10-1. Slope of bedding planes.

Fig155: Exposed shale substrata against the slope

Fig156: Angular quartze rocks in a loose soil matrix provides an abundance of building material where excavation must take place

Fig157: Slope stability as it related to sedimenary geological structure

Fig158: Very steep slopes are often stabilised with a combination of textiles and planting

Fig159: Naturally occurring plants are most suitable for this purpose

Amphitheatre

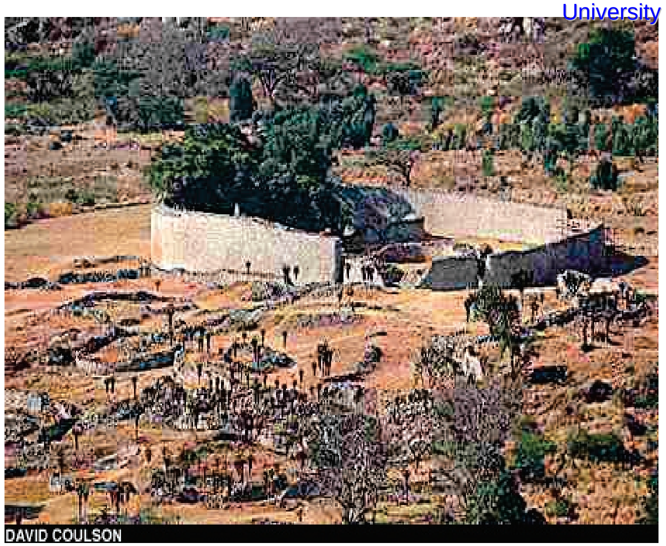


Fig160: Great Zimbabwe is a great example of the tradition of stone construction in Africa

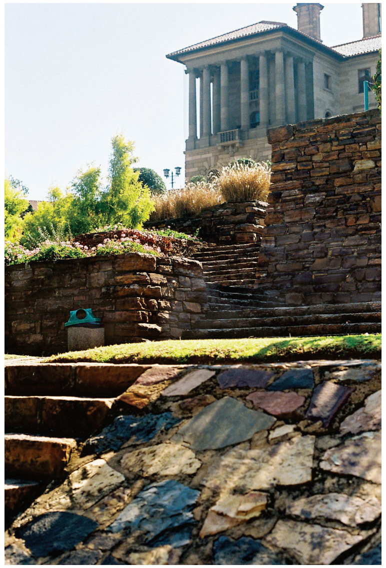


Fig161: The southern slopes Meintjieskop where the Union Buildings are sited are stabilised with local shale

Fig162: Gabion walls are used to prevent erosion in rivers

the bedrock. (The Union Buildings; 2006) This also the recommendation for the amphitheatre and all stabilising retainer walls on the mountain slope. Foundations will mostly be piles, but some key walls will be continuous as illustrated in the final drawings.

Slope stability is critical for a safe and durable structure. For the sake of ease of construction and the fact that suitable material is abundant on site, retainer walls not taller than 2.5m will be built of locally sourced quartzite. Reinforced concrete with gravel drains and weep holes which are then clad in stone will be used for any walls taller than 2.5m.

The angle that the underlying geological formations follow is conducive to a naturally stable slope as illustrated in figure 157. In harsh conditions, various options are available for slope stabilization including geotextile reinforcing, rock reinforcement and steel mesh (as is the case along Chapman's Peak Road in Cape Town). The two decisive factors in slope stability are slope gradient and ground water. The main objective in slope stabilization in to ensure that failure of land mass does not occur which could threaten the safety of people. A terrace system will be employed for the access ramp area. In the seating area, a concrete surface will ensure minimal hydraulic permeation into the soil. Water will be carried away over the surface.

The horizontal finished surface of the amphitheatre will be concrete cast in situ with surface drainage

Amphitheatre

to the two outer edges of the seating bowl. Vertical surfaces can be left bare or built up as exposed shale.

The angle of the slope and the required position for the stage will play a large role in determining the shape and position of the amphitheatre seating. See figures 176 and 177.

Stone wall construction:

A slenderness ratio of 1:12 is generally used for stone construction if the rock type is stable enough. (Smit; 3-5) The rock naturally found in Moretele Park is quartzitic sandstone or metamorphic quartz. The highest height for a wall in the project is around 6m. Walls less than 2.5m tall will be built of stone. Taller walls will be built of concrete left with an off-shutter finish.

Gabions are free draining walls composed of loosely packed aggregate caged in steel “baskets” which can be used for anything from structural walls to retainer walls and embankment reinforcement. Gabions also allow plant growth. In landscape application, gabion construction will be employed, in some scenarios, for its low visual impact, ease of construction and its ability to support plants. Welded galvanised steel mesh gabion baskets are recommended with indigenous fill.







Fig163 - Fig 169: The process of building dry packed stone retainer walls requires specialised skills

Fig170: Freedom Park features stone cladding which appears dry packed, but is fixed with steel ties to masonary structures

Fig171: At Red Rock Ridge, natural topography has been used to house an amphi-theatre

Fig172: The finished seating area has little impact on the natural surroundings

Fig173: Ancient ruins on the English west coast demonstrate a variety of possible spaces on a slope

Fig174; 175: Advances in digital sound technology make it possible to simulate the effect of theatre sound almost anywhere

Acoustics:

Since this is an open-air theatre, acoustics can only be regulated up to a point. Invasive noise from traffic or machinery being operated in the township can not be avoided, but noise sources are all situated far from the seating area. Large performances will rely on the use of sound equipment brought along when stages are erected as is currently the case. The simplicity of the amphitheatre ensures that many usually detrimental factors such as creaky seats or noisy doors are eliminated. Audience approach is limited to the sides of the seating bowl and separated from seated patrons by the stairs. Sound level requirements are usually around 40dB (average: various genres of performance each consider different levels to be optimum), marginally less than the average conversation level voice from a few meters. (Burris-Meyer and Cole; p42)

Vertical surfaces on seating should be left exposed to encourage some reverberation within the seating bowl, but this will be largely negated by people when seated who will themselves absorb a large portion of the sound. Since the theatre space is open air, there is very little that can be done structurally to enhance the acoustic properties of the space. Reverberation and sound control will have to be done electronically. A sound control platform will be provided at the top of the seating bowl from which the technical aspects of performance can be controlled.

Amphitheatre

Line of sight:

View of the stage is fundamental to a staging any variety of performance. Elevation of the seating is determined by the potential lines of vision as. "Occupants of all seats are visually related to the performance when their seats are oriented toward the stage." (Burris-Meyer and Cole; p33) This necessitates the curving of the arrangement of the seating on plan. Were seating to be individually furnished, their distribution horizontally would be staggered, since "no patron should sit directly in front of another one unless more than one row distant." (Burris-Meyer and Cole; p33) In this amphitheatre, seating organisation will be left up to the patron. Vertical elevation of seating is determined by "providing every second row full sight elevation (12cm)", a mathematical projection of which, combined with the distance between rows, provides the parabolic shape that informs the placement of seating. (Neufert; p479) The front row is positioned 10m from the front of the stage and from here, the seating arrangement is projected up the slope.

Horizontal seating position is determined by the projection of an arc from the centre stage outward, maximising the required view. This is done to visually connect the audience to the stage, and also to create a sense of "better mutual perception." (Neufert; p479)

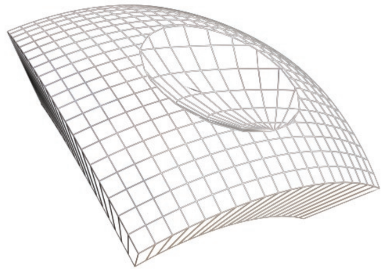


Fig176: The shape of the amphitheatre is concetually an indentation in the earth, a scoop out of the mountainside

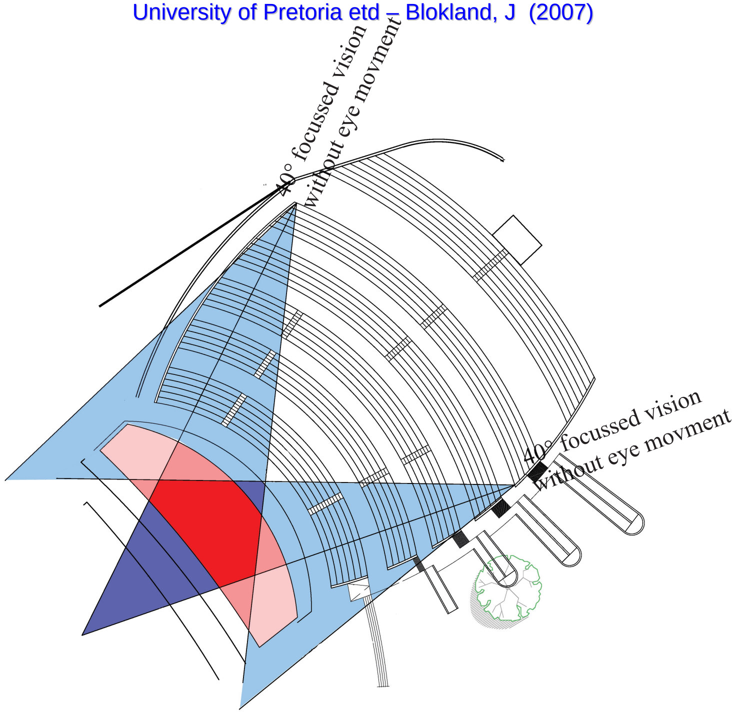


Fig177: Plan view of seating arrangement; curve of seating projected from focal point

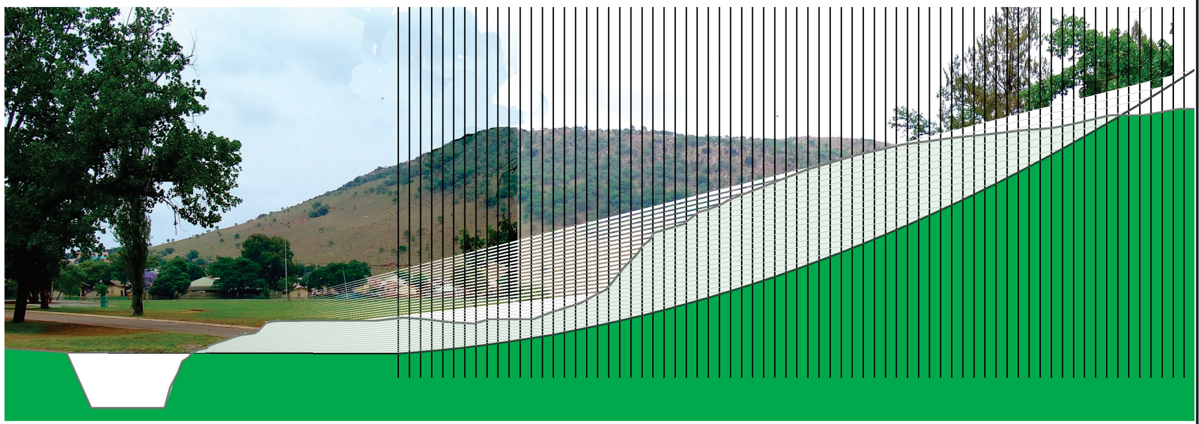
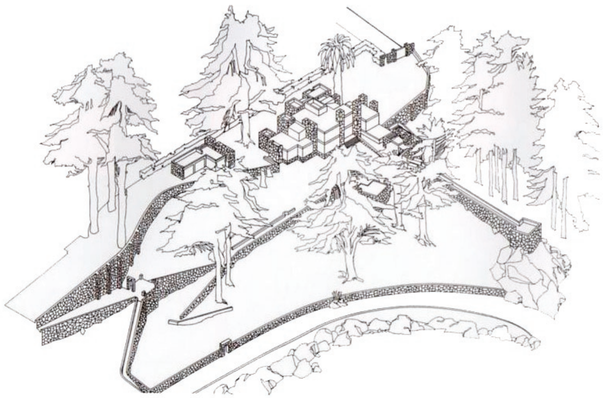


Fig178: The parabolic line that is used to organise the seating area is calculated by projecting full sight elevation (12cm) to every second row to ensure that all spectators have an unobstructed view of the stage.

Amphitheatre



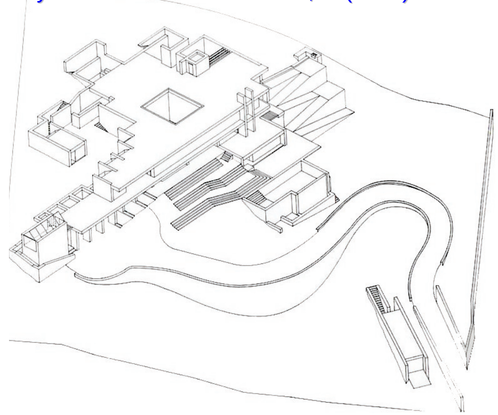


Fig179: Matte House in Zapallar, Chile, built of locally sourced stone, blends into its surroundings

Fig180: Elisa House in Chile shows a smooth transition into a sloping landscape

Fig181: 50 year floodline

Fig182: Access is imperative for an inclusive public space

Other commonly considered factors such as ceiling shape, side wall design and proportions of the theatre are obviously not applicable in this instance.

Access:

All areas of the park are to be accessible by all. The provision of ramps allows for this. Stairs furthermore permit movement around some landscaped areas and provide alternative options for easy movement. Legs are the ultimate all terrain vehicle.

Footbridges allow movement across the Pienaars River, but must be designed by an engineer and must take the 50 year flood line of the river into account (as shown in the adjacent diagram). The conceptual design of the main bridge, in this case, forms a continuation of the main footpath and spans flat across the river. It spans between 7 and 8 meters and is proposed as a concrete structure.

Ramps can have a maximum inclination of 1: 12 or 5 degrees to the horizontal (**as per SABS and NBR requirements**) and decrease in width the further up the slope they are found, so as to accommodate reducing numbers of users.

Drainage:

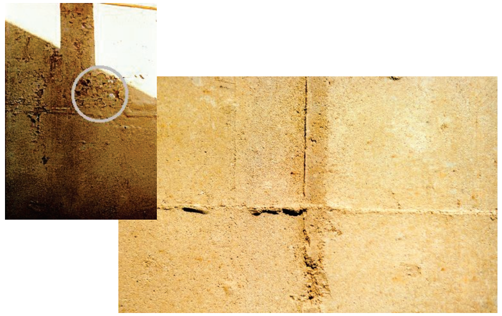
Although there is a natural system of surface drainage already existing, the built structure of the amphitheatre requires special consideration for its own drainage especially where retainer walls are needed as part of the landscaping. All retainer walls are to be provided with gravel drains and water outlets to the outside. Surface flow will be directed to channels which drain into the Pienaars River at designated points. The amphitheatre related functions are to be drained as shown in the final drawings.

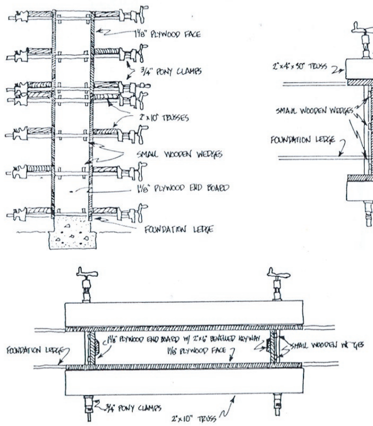
Reception Building:

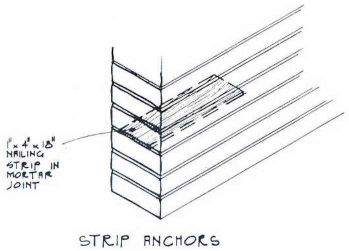
Rammed Earth:

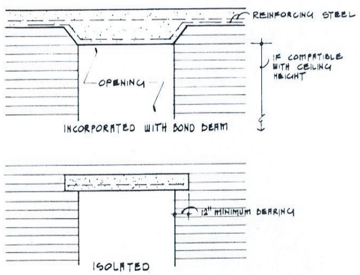
Africa, particularly the north, has a rich rammed earth tradition and many local peoples such as the SeSotho tribe and the Ndebeles from the northern parts of South Africa employed this technique for wall construction centuries before the arrival of any colonists. Rammed earth is renowned for its properties of thermal inertia, its resilience to weathering and its aesthetic qualities which vary depending on the technique used in construction. “Nearly every industrialised country has tried to update this building method” (Doat et al; p41) The aesthetic finish in this project will be similar to a section through sedimentary geology.

A soil with 15 - 18% clay content is the most suitable material for use in rammed earth structures. This soil is mixed to a content of approximately 6% cement which stabilises the mixture (McHenry; p98). Soil tests are performed to determine whether the mix is consistent and suitably moist.









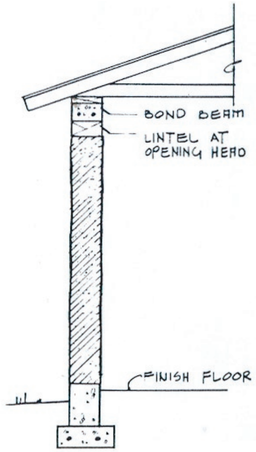


FIGURE 6.20. Typical wall section.

Fig183: Adobe construction has been used in Central and South America for hundreds of years. iIt remains popular

Fig184: Rammed earth is at risk of erosion if not treated where exposed.

Fig185: Rammed earth wall joint

Fig186: Modern rammed earth structures are elegant and durable

Fig187: A typical shuttering system used for rammed earth construction

Fig188: Wall ties used to attach frames are built into the wall during construction

Fig189: All openings are supported with a lintol, generally of wood or precast concrete

Fig190: A typical section through a rammed earth wall

Fig191a: Earthworks

Fig191b: Foundations

Fig191c: Formwork

Fig191d: Compaction

Fig191e: Wall going up

Fig191f: Bond beam

Ideal soil composition is:

- 0 - 15% gravel
- 40 – 50% sand
- 20 – 35% silt
- 15 – 25% clay

All organic matter should be removed from the soil as well as any stones “larger than a walnut.” Rammed earth walls are generally built with a slenderness ration of around 1:10 implying that a wall 500mm thick can be built up to about 7m. No walls should ever be less than 400mm wide, for practical purposes during compaction.

Walls are built in place inside form work. Compaction of the soil mix is done by hand. Foundations are of cast concrete, wall footings are to be built from local rock to a level of at least 300mm above the natural ground line, providing a weather proof base for the rammed earth walls to stand on.

All wall openings must be supported by a pre-stressed concrete lintol and built into the wall to a depth of at least 300mm.

Details of a typical wall section, basic formwork, lintols, bond beams and openings are illustrated in figures 186 - 189.

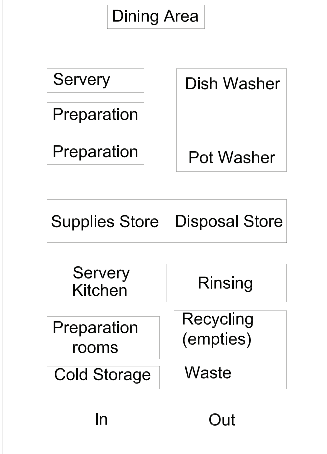
Because of the stresses placed on formwork during compaction, formwork should be of 4-5cm thick planks or reinforced if no suck planks are available.

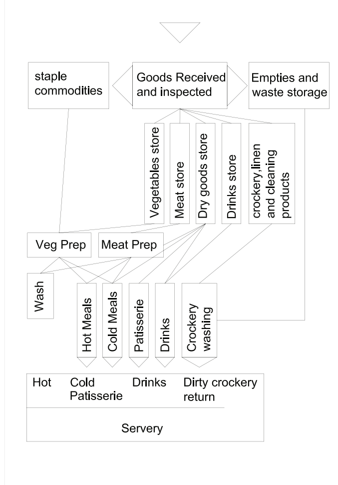
Kitchen:

Kitchen function diagrams have been used to determine the functional arrangement of this kitchen based on the various requirements in a typical commercial kitchen. These have been adapted to the needs of a kitchen which will function primarily as a cafeteria, but have the capacity to adapt efficiently when catering for formal functions. The size of the whole kitchen is sized so as to cater for a multiple course meal for an average of 200 people at events in the “shelter”. However, school outings see the park hosting around 500 children at a time and the festivals larger numbers still, when the kitchen will operate as a cafeteria. The kitchen must therefore be able to produce meals of a ranging type and variety.

The electrical requirements of a kitchen of this size necessitate the installation of 3-phase power for some industrial equipment like stove plates, ovens, power hose cleaners, dish washers and plate warming ovens (salamanders).

The area designated as the waiter station on the final plans is to have a dual function: it will be used as a condimant and cutlery shelf for the cafeteria and also as the servery for waiters at catered functions. Waiter stations will be provided at either end of the passage and the passage is designed around a one way movement system for waiters, where clientelle will more through a controlled queing aisle when using the cafeteria.





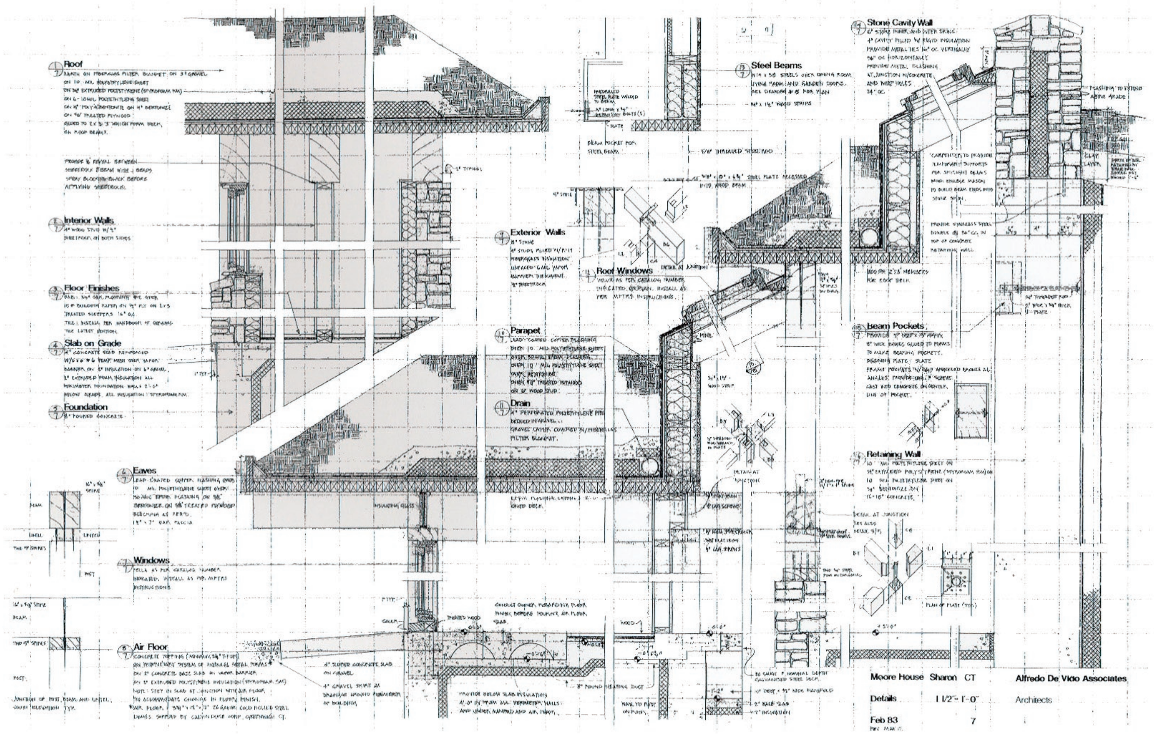


Fig191: Kitchen function diagramme after Neufert

Fig192: Kitchen organisation diagramme after Neufert

Fig193: Details of a planted roof at Moore House in Sharon, Connecticut

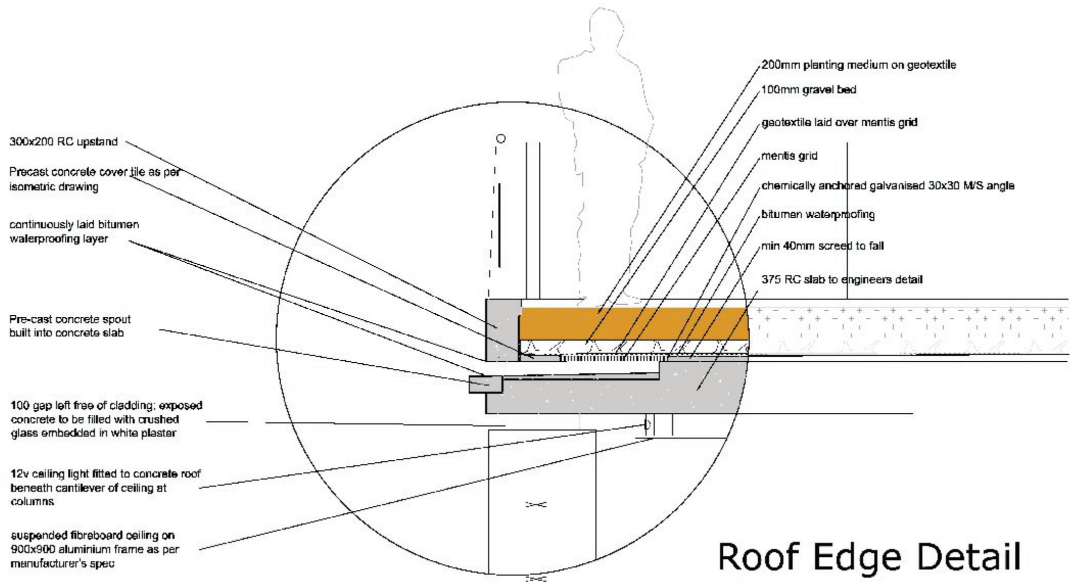


Fig194: Roof edge detail showing outlet spout and planting layers

Fig195 and Figure 196: Examples of solar lighting paving blocks

Planted roof:

Planted roofs have long been used in flat roof buildings. They provide an aesthetic quality not possible with steel sheeting or tiles and also serve to insulate roofs against excessive gain from solar radiation. Planted roofs can also be made accessible to building users.

Waterproofing is essential. A gravel bed below the soil layer facilitates drainage and must be separated from the soil by a geotextile. The proposed planting, kikuyu lawn grass, has water needs similar to the lawns found in the park and as such can be maintained by processes already in place. This composite structure is detailed in the final drawings and a precedent of application can be seen in figure 192, House Moore.

Calculations for drainage are based on the area of the roof. A minimum of 140mm² per m² of roof area is required for gutters which in turn are to be laid at a minimum pitch of 1:200 to the outlets. (Wegelin; p10.28) Outlets will have no downpipes, but spouts (large weep holes) will direct water into sunken collection basins lined with river stones in the concrete skirt surrounding the building.

Details of the drainage and water outlets are shown adjacent.

Lookout platform:

Lighting:

Solar powered lights set inside paving blocks permit lighting along pathways without the installation of cables or a power supply. This makes lighting pathways in remote or conserved areas feasible and simple. Examples are shows in Figures 195 and 196 Maintenance will simply mean replacement.

The mountain is notorious for being a haven for criminals and vagrants and ever encroaching informal settlers are beginning to threaten the future of the mountain as a nature reserve. Lighting against the slope will eliminate some potential danger by illuminating the area after dark. Furthermore, lights will be visible throughout the year from within Mamelodi and thus serve as a constant reminder of the heritage that its occupants share.

Lookout Points:

There is currently a project underway to establish hiking trails on the mountain. The lookout platform, the "Eye of Mogale" has been proposed at the base of the cliff high up the mountain, but this facility will only be accessible by foot. it is to be no more than a small (2m by 3m) platform where a robust naval-type telescope will be mounted to look over the township. The primary platform will be positioned at the top of the seating area of the amphitheatre.

Fig 201: Example of a public use telescope

Fig 202: Example of a public use telescope

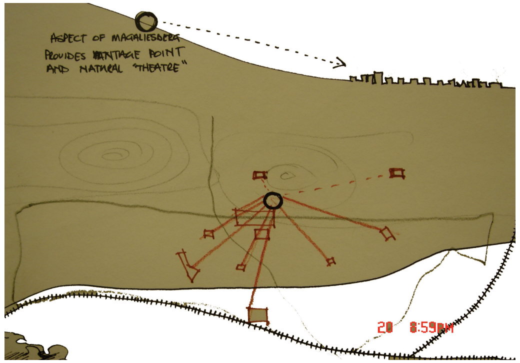


Fig197:

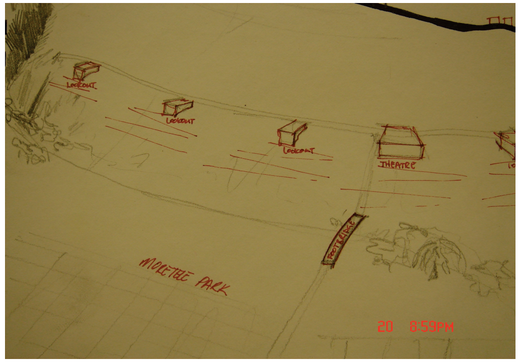


Fig198:

Fig199:

Lookout