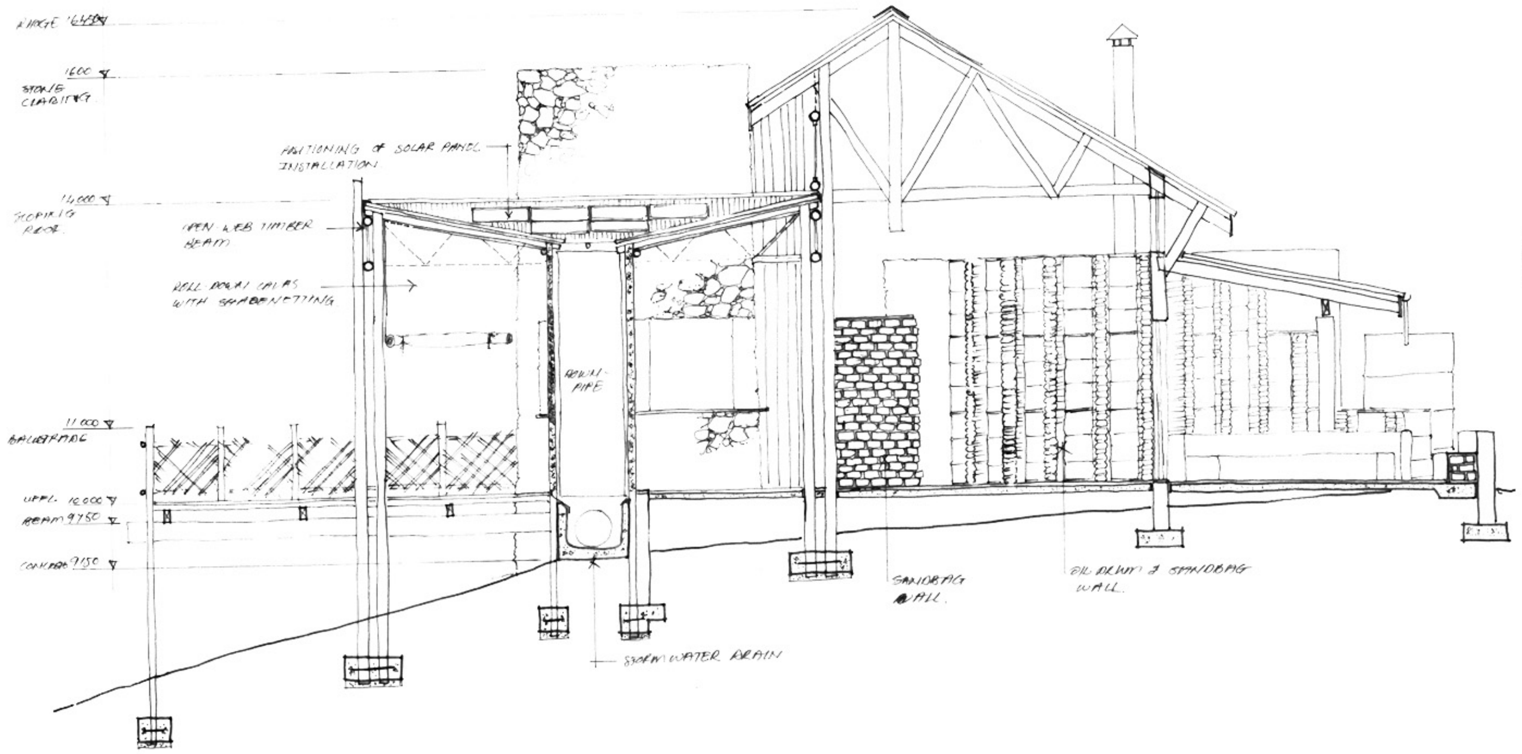
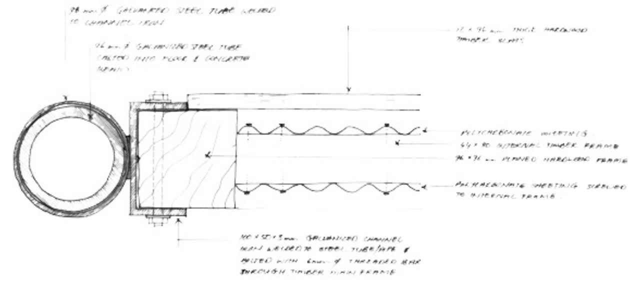
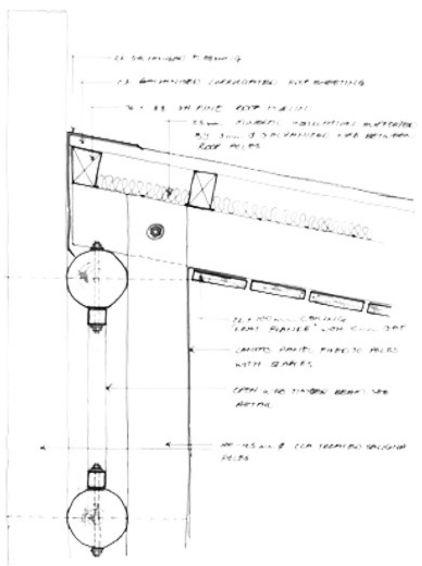
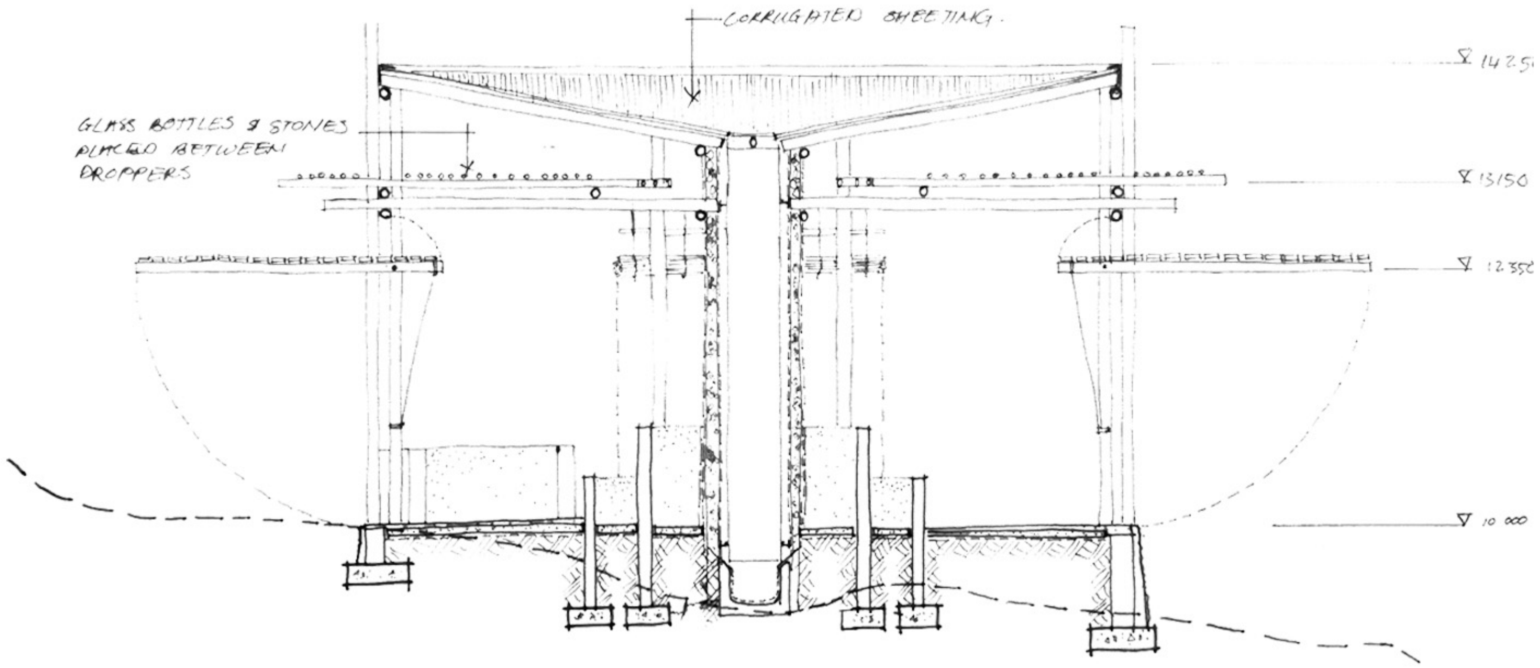

SANDBAG WALL
STORM WATER DRAIN






CORRUGATED SHEETING
GLASS BOTTLES & STONES PLACED BETWEEN DROPPERS

WALL CONSTRUCTION

7.1 Wall Construction

7.1.1 Compacted earth blocks

Benefits of using earth as building material includes:
- Local skills and knowledge of traditional building methods are used
- Thick earth walls in buildings are "energy efficient"
- Earth blocks are cheaper than conventional bricks or concrete
- Using local soil eliminates transport cost of conventional building materials.

Simple tests can be done to establish if the local soils are suitable to make earth blocks and which binder must be added when stabilized earth blocks are made. These tests determine the composition, plasticity and shrinkage characteristics of the soil. Soil composition is done by sedimentation.

Proportions of gravel, sand and clay needed to manufacture:

Stabilized earth blocks		**Unstabilized earth blocks**	
Clay	: 5% = 20%	Clay : Silt	: 50% = 60%
Silt	: 10% = 25%	Sand / Gravel	: 40% = 50%
Sand	: 25% = 50%		
Gravel	: 25% = 40%		

(Bolton, M. et al. 2001)

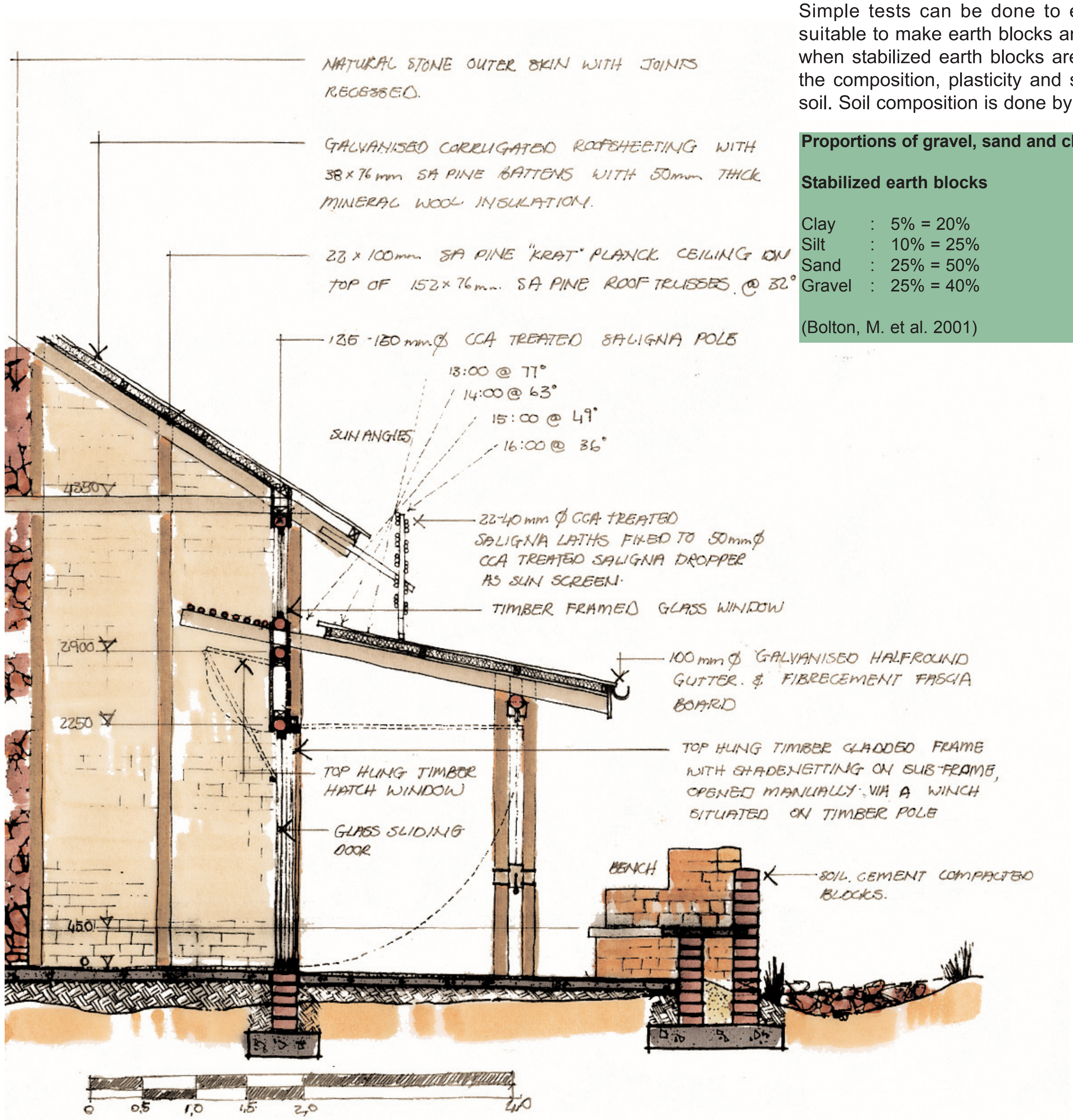


Fig. 7.1.1.1 Sitting bench infront of restaurant

Usage of the shrinkage test will give an indication to the amount of cement and lime that needs to be added to make stabilized earth blocks.

Gap	**Cement : Soil**	**Lime : Soil**
< 15mm	1 cement : 18 soil	not suitable
15mm < 30mm	1 cement : 16 soil	not suitable
30mm < 45mm	1 cement : 14 soil1	lime : 14 soil
45mm < 60mm	1 cement : 10 soil1	lime : 10 soil

(Bolton, M. et al. 2001)

Construction methods for earth blocks are the same as for conventional bricks. The same guidelines must be followed in terms of quality, workmanship and control.

Stabilized earth blocks are used for the foundation walls and one layer around all openings. Normal stretcher bond is sufficient for block laying. Positioning of waterproofing in the structure is similar to conventional structures where it is located under surface beds, and DPC is in the walls and under window cills. Ring beams are necessary to anchor roof trusses and it adds to the stability of the whole structure. These earth blocks however have some structural restrictions which include:
- height of eaves wall max. 2.5m
- length of gable wall max. 6.5m
- width of door or window opening max. 1.5m

These earth blocks will only be used for low non-load bearing walls. Only stabilized earth blocks will be used because no plaster finish will be applied (Fig. 7.1.1.1). These stabilized blocks' weathering resistance will be improved by painting it with a clear waterproofing paint.

Another type of earth block (Hydraform blocks) will be used as structural material. A more consistent and better quality block is produced through the use of manually operated machinery. These blocks are produced by mixing local soil and 5% (4Mpa) or 10% (7Mpa) cement and compressing the mixture in a block-making machine. Blocks are air-dried and their strengths are affected by cement content, quality, and curing time. The blocks are not burnt and therefore environmentally friendly. They are interlocking and dry stacked, minimizing the need for mortar. A typical wall construction is the same as the normal earth blocks, but where stabilized blocks would be used, hydraform blocks must be bedded in mortar and the same applies to the ring beam (Fig. 7.1.1.1).

The reason for using the normal earth blocks is that the machinery needed to make the hydraform blocks is expensive. Renting these machines is more economical, thus the shorter the period it is on site the more economical it would be.

WALL CONSTRUCTION

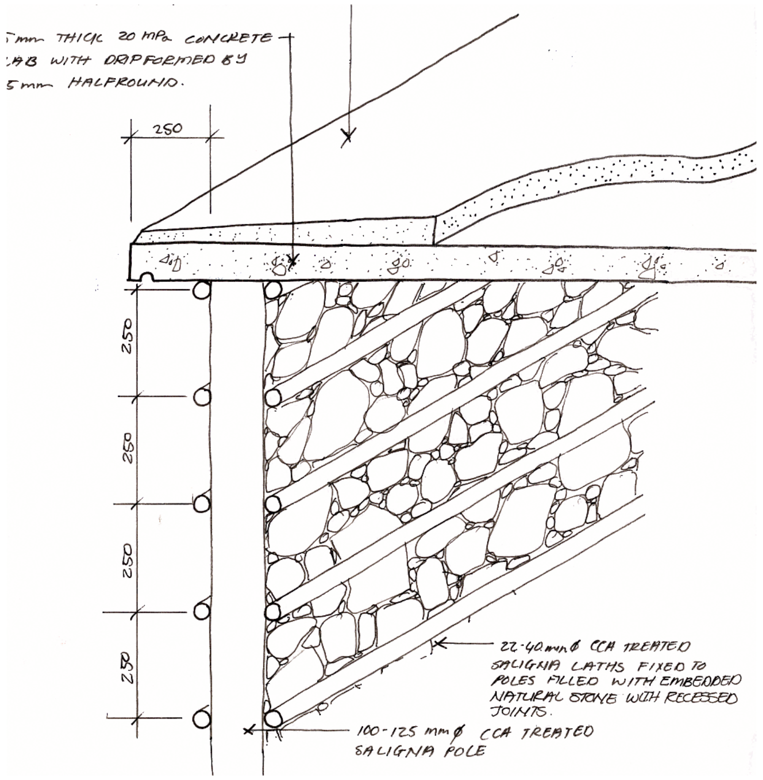


Fig. 7.1.2.1   Isometric of Timber and Stone wall

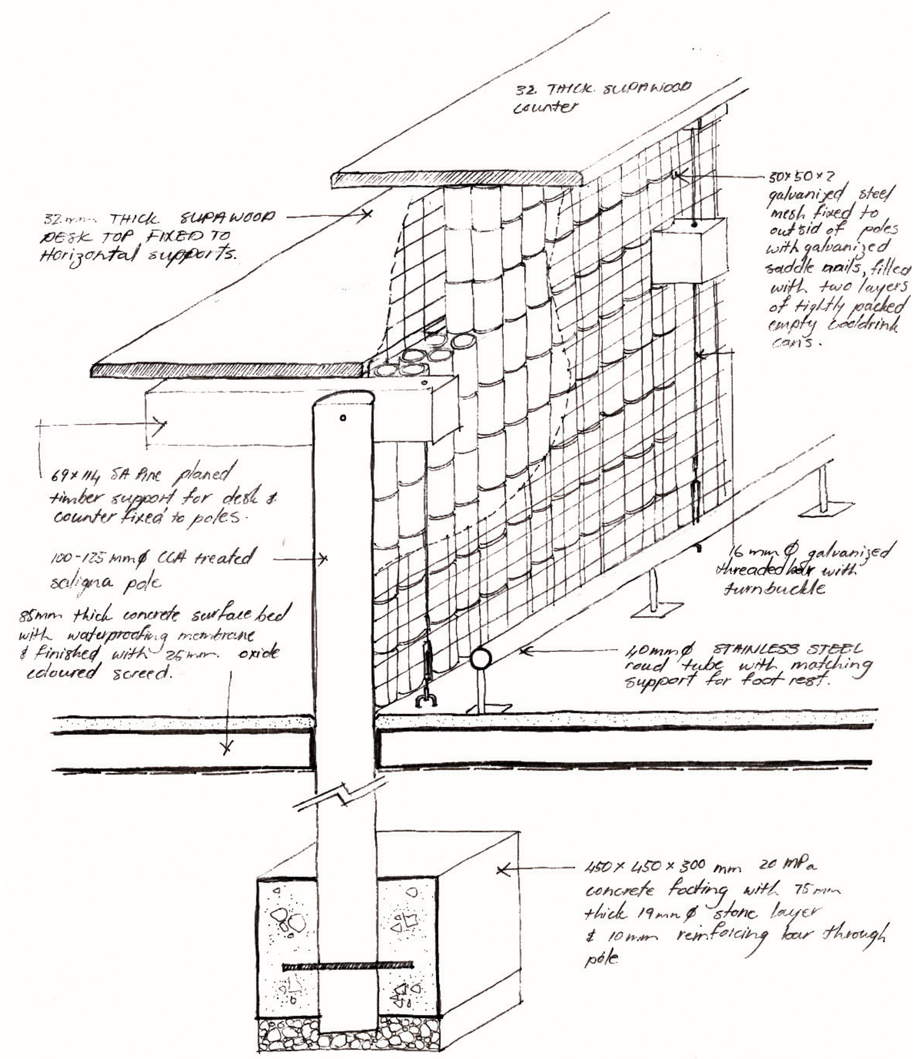


Fig. 7.1.2.2   Isometric of Reception desk

7.1.2   Natural stone and timber

The textures obtained from these materials emphasize the areas where they are applied. The thermal properties of natural stone are a decisive characteristic to its application. Natural stone has similar thermal performance to those of brick and concrete and sometimes even better.

Stonewalls built solid with mortar are used as heat barriers in summer months and a heat store in winter months. This is the reasoning behind the thicker walls. These walls also absorb the heat from the internal spaces, which is generated by humans and appliances to keep the inside temperature cooler during summer months.

The dry stacking of stone is used where permanent ventilation is needed. To give more stability to these walls, timber laths are fixed perpendicular, in relation to the height of the wall, to the timber roof support structure (Fig. 7.1.2.1).

7.1.3   Recycled materials

The function of most internal, non-load bearing walls in buildings are either for privacy, defining spaces or keeping climate out. These elements can be substituted with a material other than conventional brick, as in common practice. The use of alternative materials presented the opportunity to make use of materials, which are available in the area. Contributing to the philosophy of saving nature, recyclable materials such as tin cans (Fig. 7.1.2.2), glass bottles and steel oil drums are sourced from the local communities. Simple construction methods are used to stabilize these surfaces. The resulting textures contribute to the articulation of spaces and elements.

The sandbags that are combined with the steel oil drums were chosen because of their ability to take-on the shape of the drum. This configuration (Fig. 7.1.2.3) created a fairly solid surface that was needed to separate the kitchen from the public space of the restaurant.

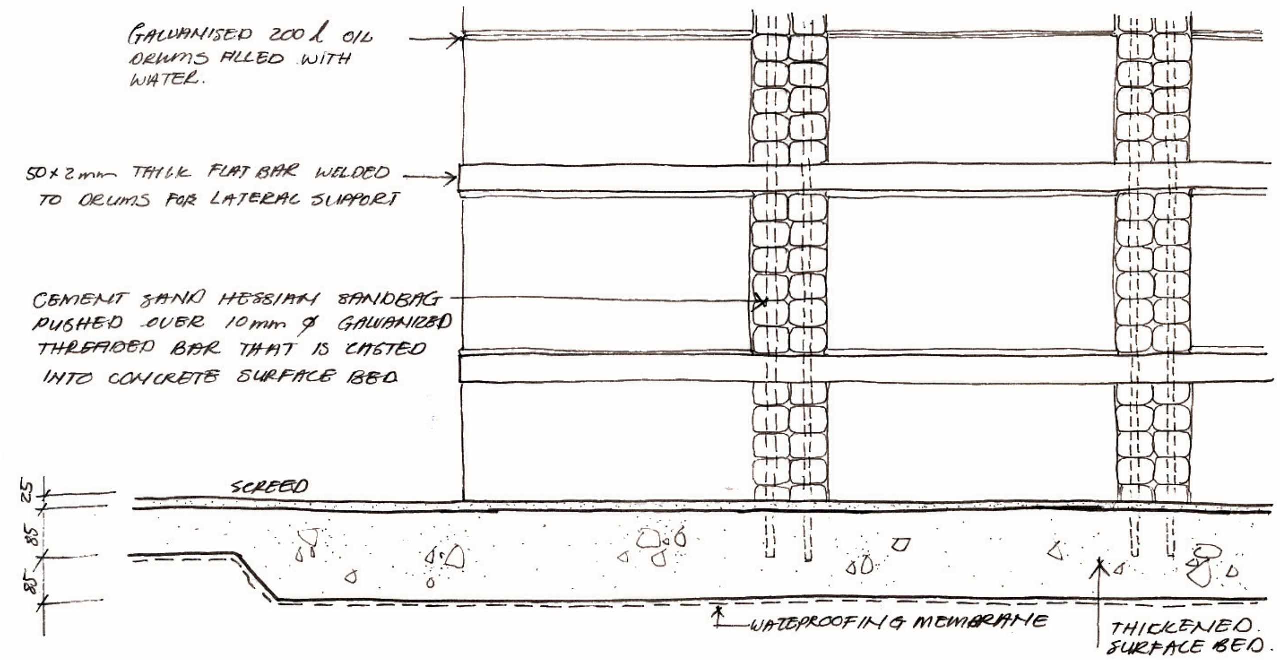
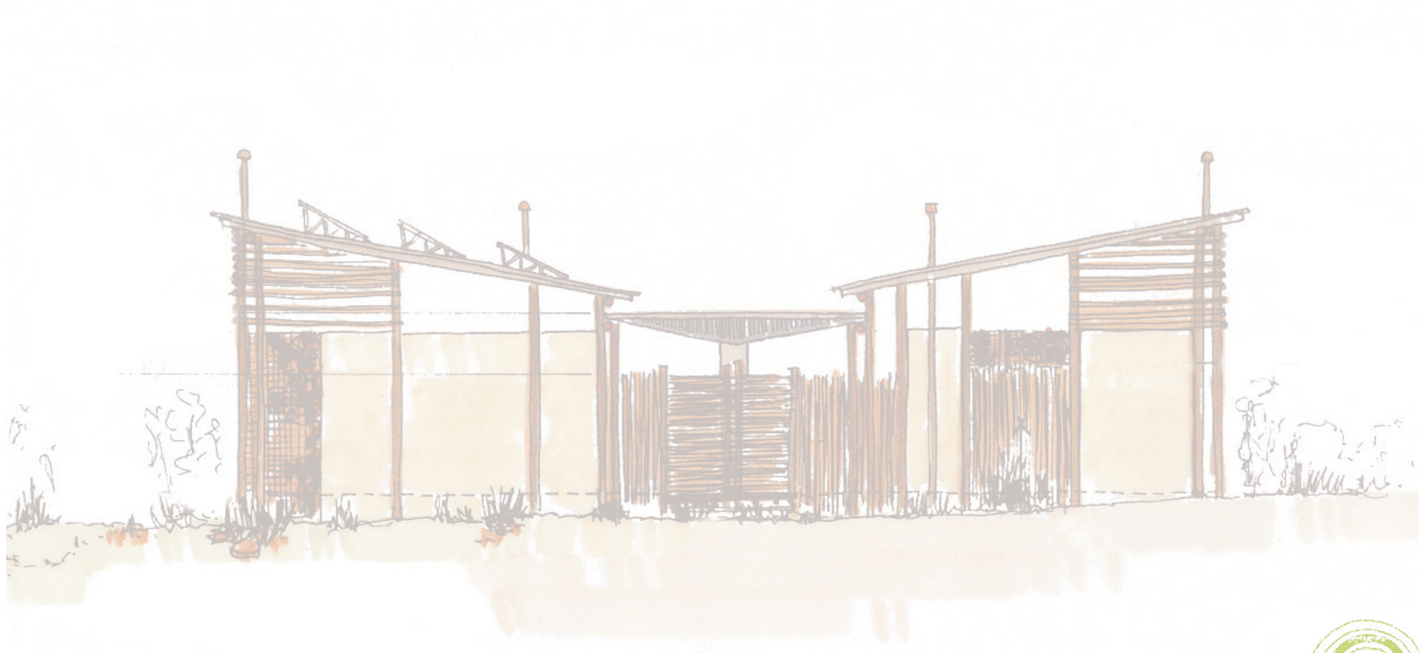


Fig. 7.1.2.3   Sandbag and oil drum wall in Restaurant



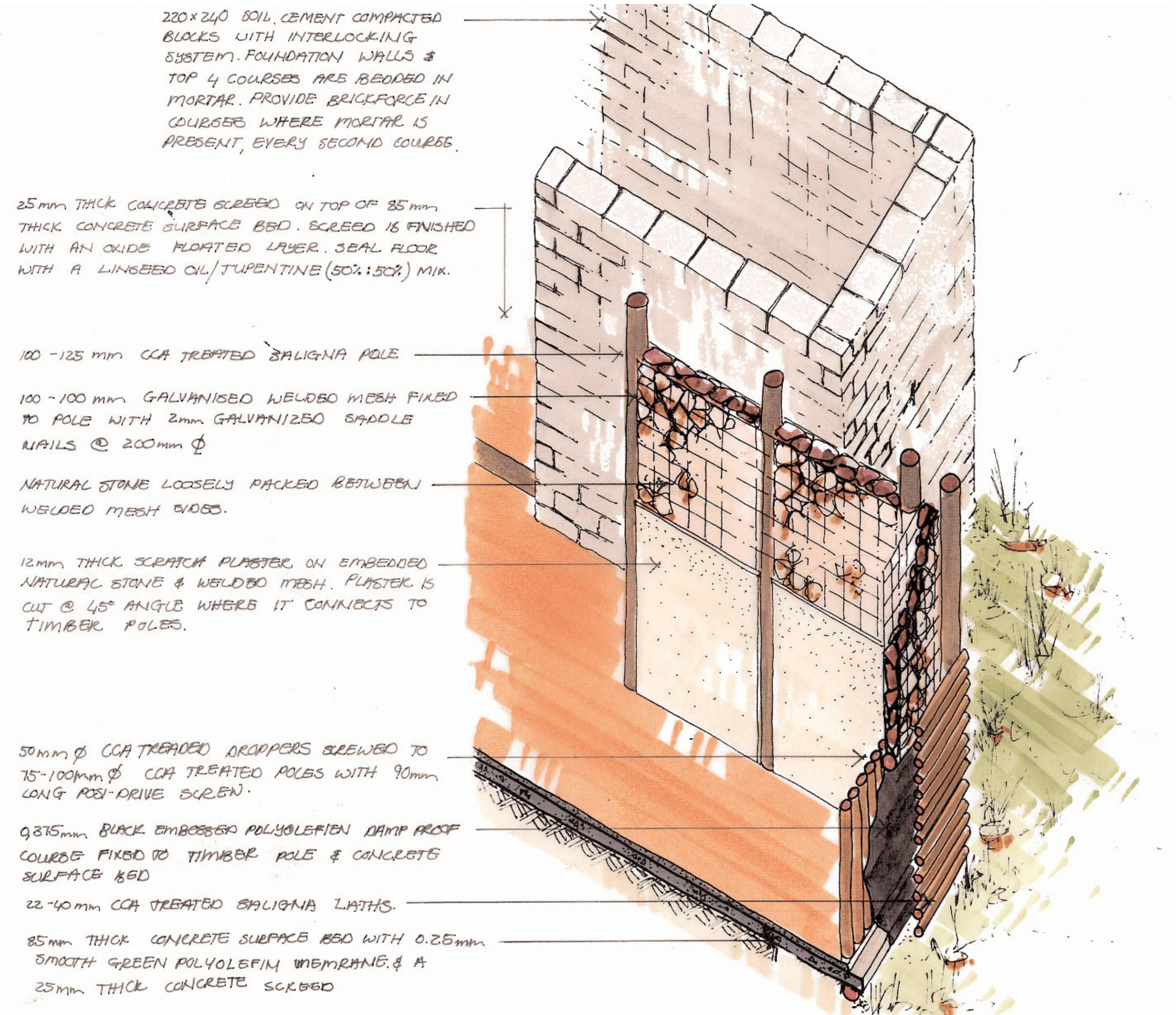


Fig. 7.1.4.1 Isometric of public ablution wall construction

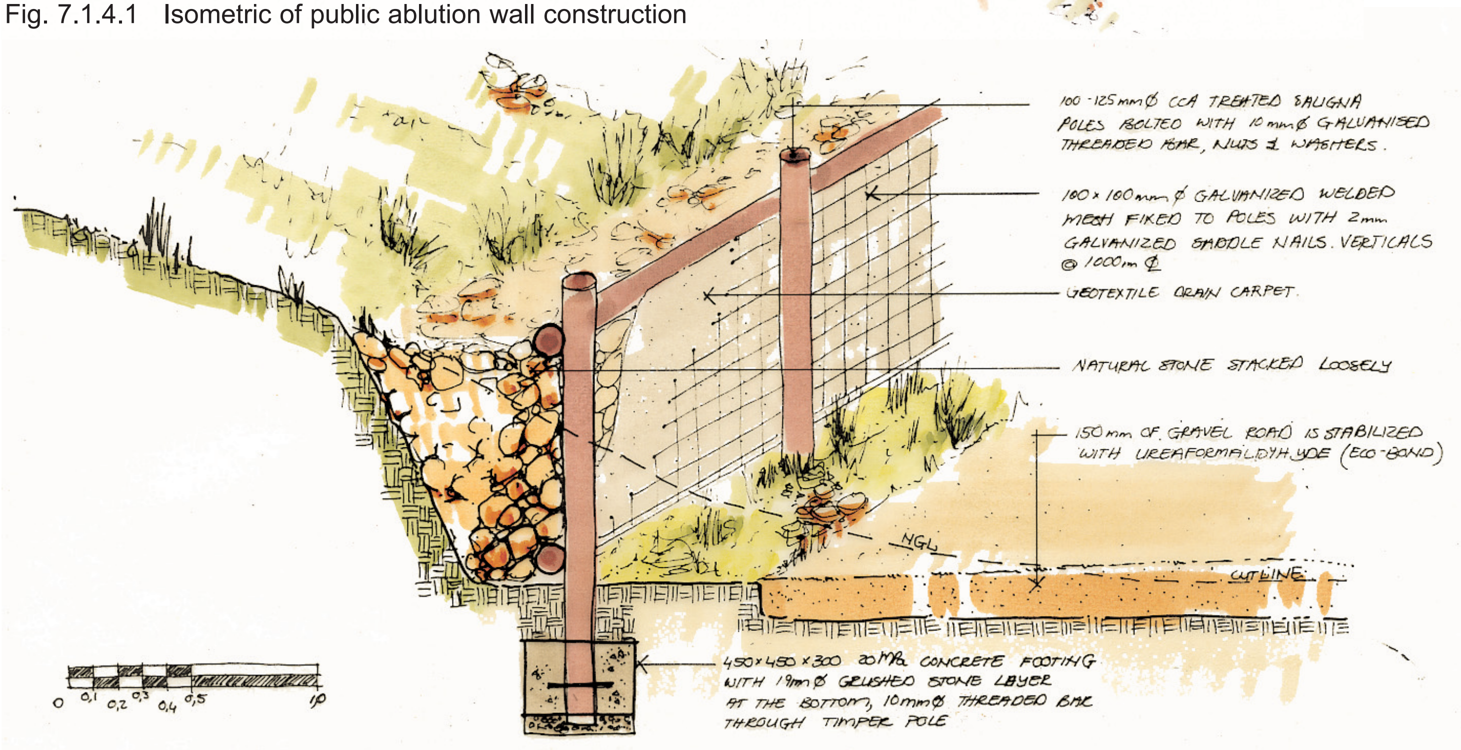


Fig. 7.1.5.1 Retaining wall construction at waste recyling storage

WALL CONSTRUCTION

7.1.4 Rubble Walls

The unwanted birdcage, swinery and masonry rubble that are around the existing farmhouse is a resource that can be used as construction material. In order to use this rubble economically, it is used as non-load bearing material. This indicated that roof structures had to have a separate support system.

This rubble is used as infill between vertical roof supports. The cavity formed is then filled with this rubble. Aesthetically the finished surfaced is not complimenting the proposed framework (Fig. 7.1.4.1). The surface is finished with a 12mm thick scratch plaster.

7.1.5 Retaining Walls

Cutting of the landscape, especially for the roads, leaves bare unstable soil surfaces open to weathering. A material was needed which will fade away into the natural landscape after a year or two. The best solution was a combination of timber, welded mesh and geo-textile. The timber poles provided the lateral strength to avoid diagonal sliding of topsoil. The geo-textile matt will allow water drainage and assist in the re-establishment of vegetation. The distance for the geo-textile to span between the vertical supports is too far therefore welded mesh is used to provide the extra lateral support (Fig. 7.1.5.1).

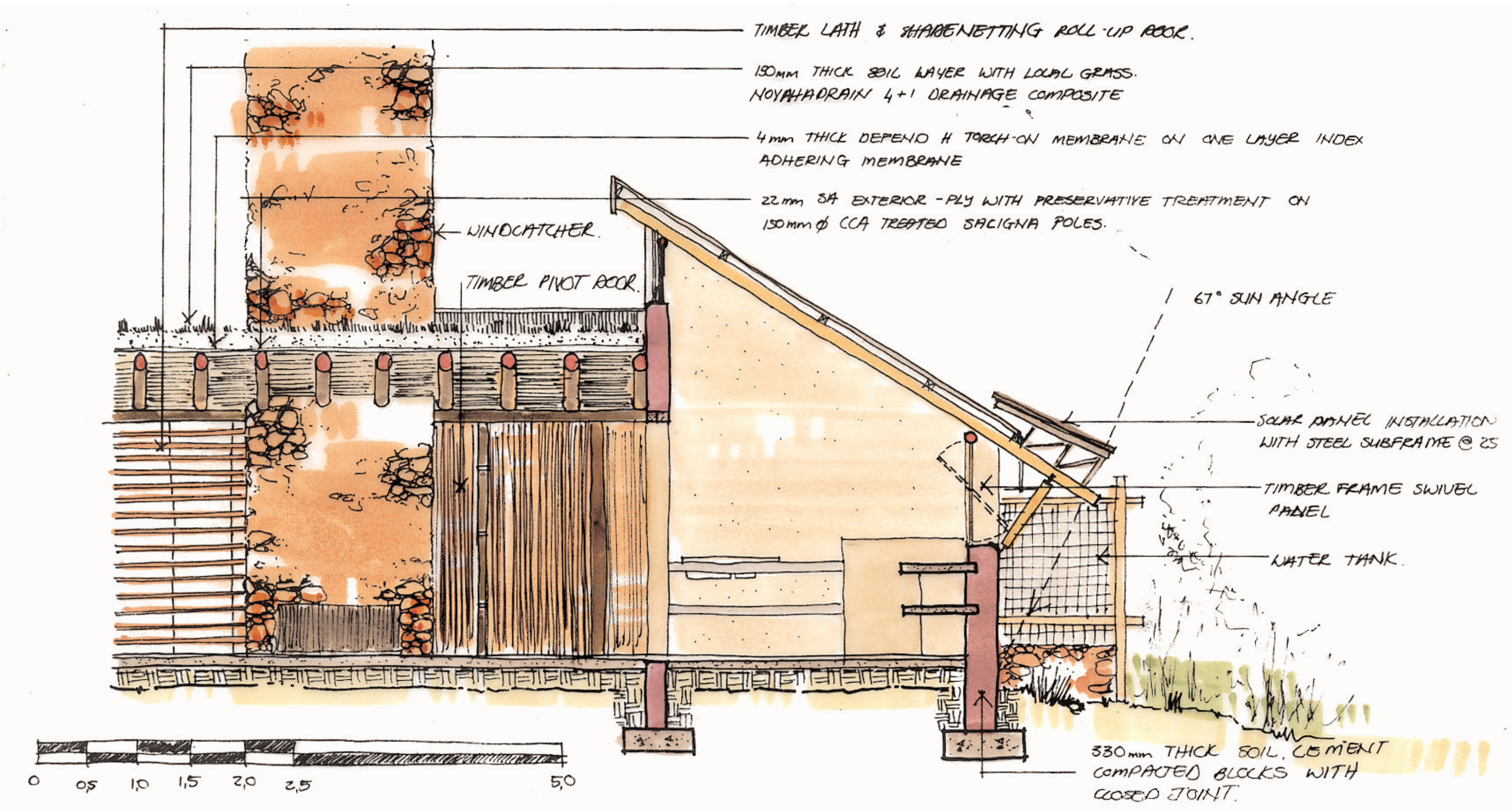


Fig. 7.2.1.1 Section of Tourist unit external wall

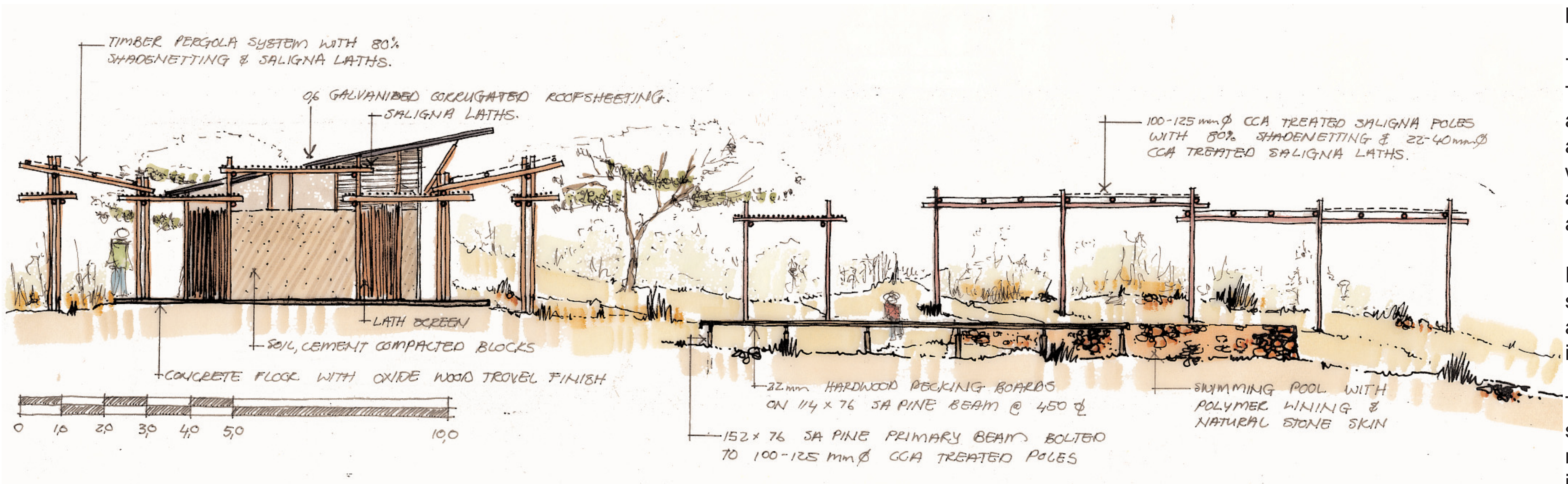


Fig. 7.2.2.1 Pergola structure at public swimming pool

SHADING

7.2 Shading

7.2.1 Roof Construction

The roof materials where made up of conventional SA pine roof trusses and galvanised corrugated roof sheeting. These elements not only keep the wind and rain at bay and provide privacy, but shelter humans from the scorching sun. The larger roof overhangs shade most of the thermal mass from direct sunlight (Fig. 7.2.1.1), in turn contributing to the cooler temperatures created inside the buildings.

Using a larger size beam, which would have normally been sufficient for the span of the roof truss, creates the roof overhang. The 152x76mm SA Pine beams with the lightweight corrugated roofsheeting are able to cantilever with extra diagonal supports. The roof edges needed to stay clean and simple.

Recycled pallet planks are used as ceiling boards that are fixed to the top of the roof trusses. Mineral wool insulation (50mm thick) is placed on top of the planks before the roof battens are nailed down. This configuration creates an air packet between the roof sheeting and the insulation. By providing vents at the gable walls the air can circulate, removing any hot air from the roof space.

Using thatch simultaneously provides all the natural thermal characteristics criteria. The CCA (Chrome Copper Arsenic) treated Saligna poles used can also achieve the cantilever length needed for the 100% shading of walls during summer months.

7.2.2 Pergolas

Saligna poles and laths are used to make up pergola structures. These structures create a variety of shading devices (Fig. 7.2.2.1). Through the placement of the laths the percentage of shading is manipulated. A closely laid blanket of laths can give up to 90% shading. Opening the gaps between laths creates a filtered light with 70% lower shading. In order to create a 100% shading a retractable roof is added to the structure.

This roof is comprised of a canvas panel, whose sides are fastened to a roller that runs in a channel. It is manually operated by pulling a piece of ropein the front of the canvas panel.

7.2.3 Composite Screens

The timber slats are fixed on to a frame which pivots vertically around its centre point. The opening between the slats is determined according to the suns' angles. No direct sunlight penetration will be allowed in summer months. The lower sun angle in winter allows a percentage of the sunlight through between 09:00am and 15:00pm.

In order to allow a higher percentage of sunlight through, the screens can simply be pushed away. The screens run on a roller and track system. A large sliding window keeps out wind and rain if the wooden screens are moved aside.

The third part of these screens comprise of shadenetting. This shadenetting is used at night in the summer months to allow nighttime ventilation of buildings but stops any bugs trying to get in .

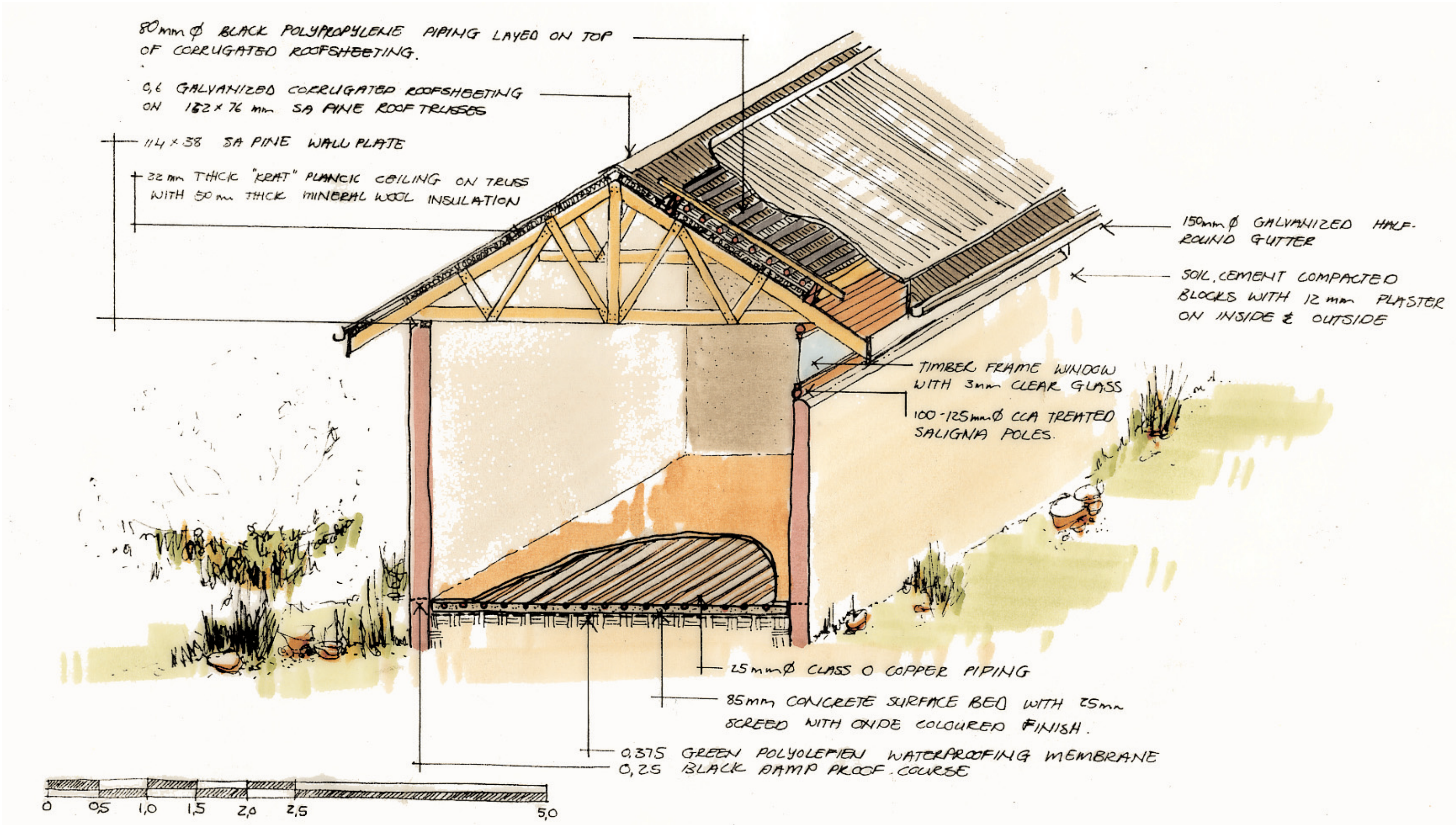


Fig. 7.3.1.1 Isometric of underfloor heating in Tourist units

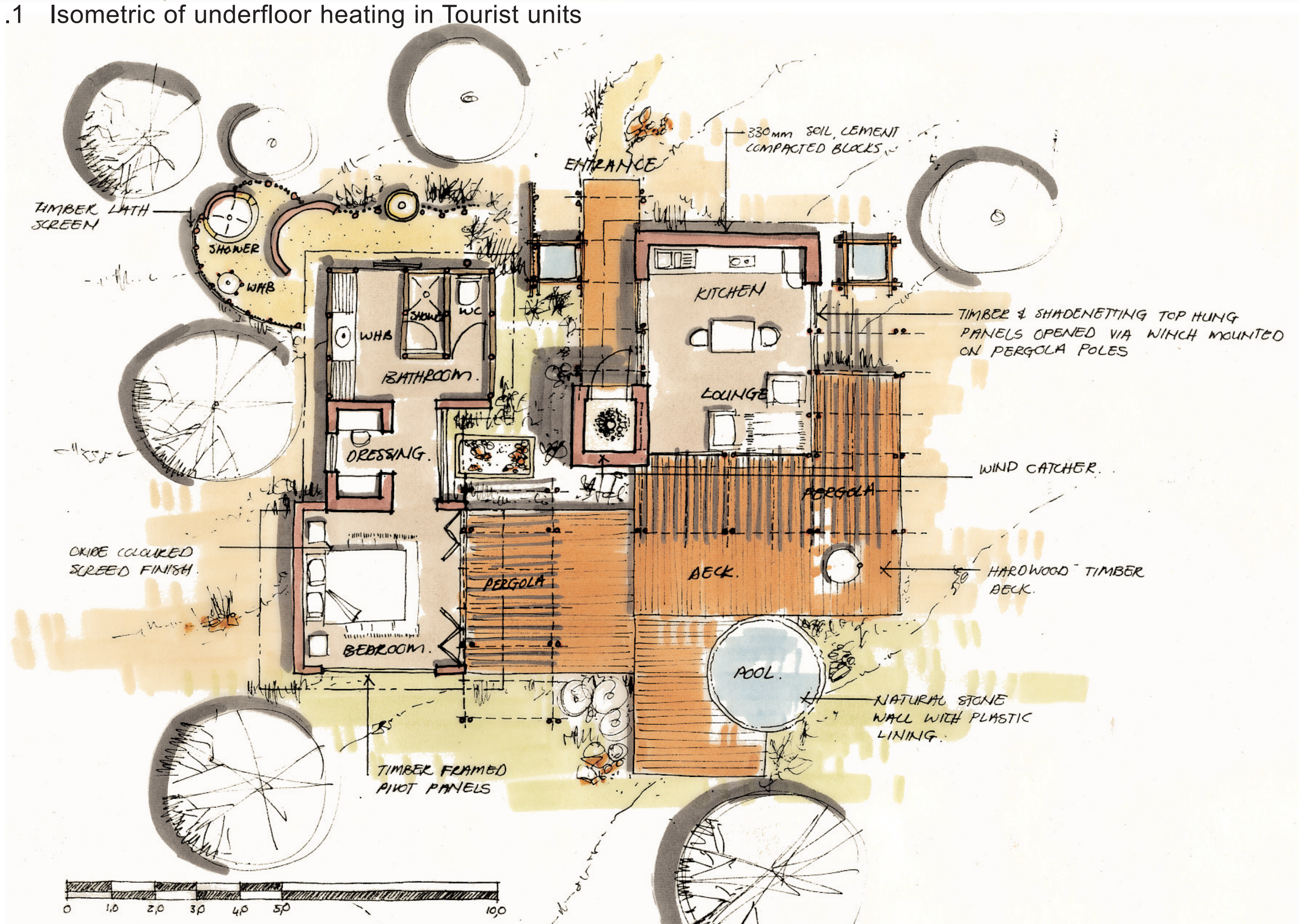


Fig. 7.3.2.1 Plan: tourist unit

SPACE HEATING

7.3 Space heating

7.3.1 Under floor heating (Fig. 7.3.1.1)

A network of copper pipes is cast into the concrete surface bed in the bedrooms of the accommodation units. The network is equipped with an inlet and outlet valve. The outlet valve connects to the main used water drains, which is subsequently transported by gravitation to the irrigation reservoirs. The inlet valve is connected to the solar water store that is situated in the roof structure.

The solar water store consists of black polypropylene piping, which stores water during daytime. This piping is not in direct sunlight but positioned directly underneath the corrugated roof sheeting because of aesthetics. The air around these pipes is heated through heat transmitted by the corrugated roof sheeting. The thickness of the side wall of the polypropylene pipe and the surrounding hot air will create a measure of insulation after sunset so that the hot water does not loose too much of its heat before being used. The heat is stored in the water until it is needed during cold winter nights when by manually opening the inlet valve to the under floor copper piping, the concrete floor, in turn will radiate the heat into the occupied space.

During the hot summer months, this system will not be operational as no heating of internal spaces is required.

7.3.2 Thermal mass (Fig. 7.3.2.1)

Two bodies in space exchange radiant energy, the warmer body to the cooler body. This basic fact of physics plays a big roll in our comfort in that we are always exchanging heat with our surroundings by radiation (and conduction and convention). In winter we are often warmer than most surfaces around us so part of our heat loss, and comfort and discomfort, is always by radiation.

Comfort is a product of air temperature, air movement, humidity and the mean radiant temperature. Thermal mass walls and floors are warmed by the sun and typically provide warmer surfaces around us than light frame construction with drywall. These warm surfaces provide us with radiant heat and can be comfortable at lower air temperatures.

Thermal mass is needed to store heat for winter days and nights. High thermal construction such as brick, concrete blocks filled with concrete, water in containers, phase change materials and concrete are just some of the materials that can be used for this purpose. Given the specific context, compacted earth blocks and natural stone does allow the same characteristics of other materials to perform and in some cases even better that the more expensive artificial "environmentally friendly" products.

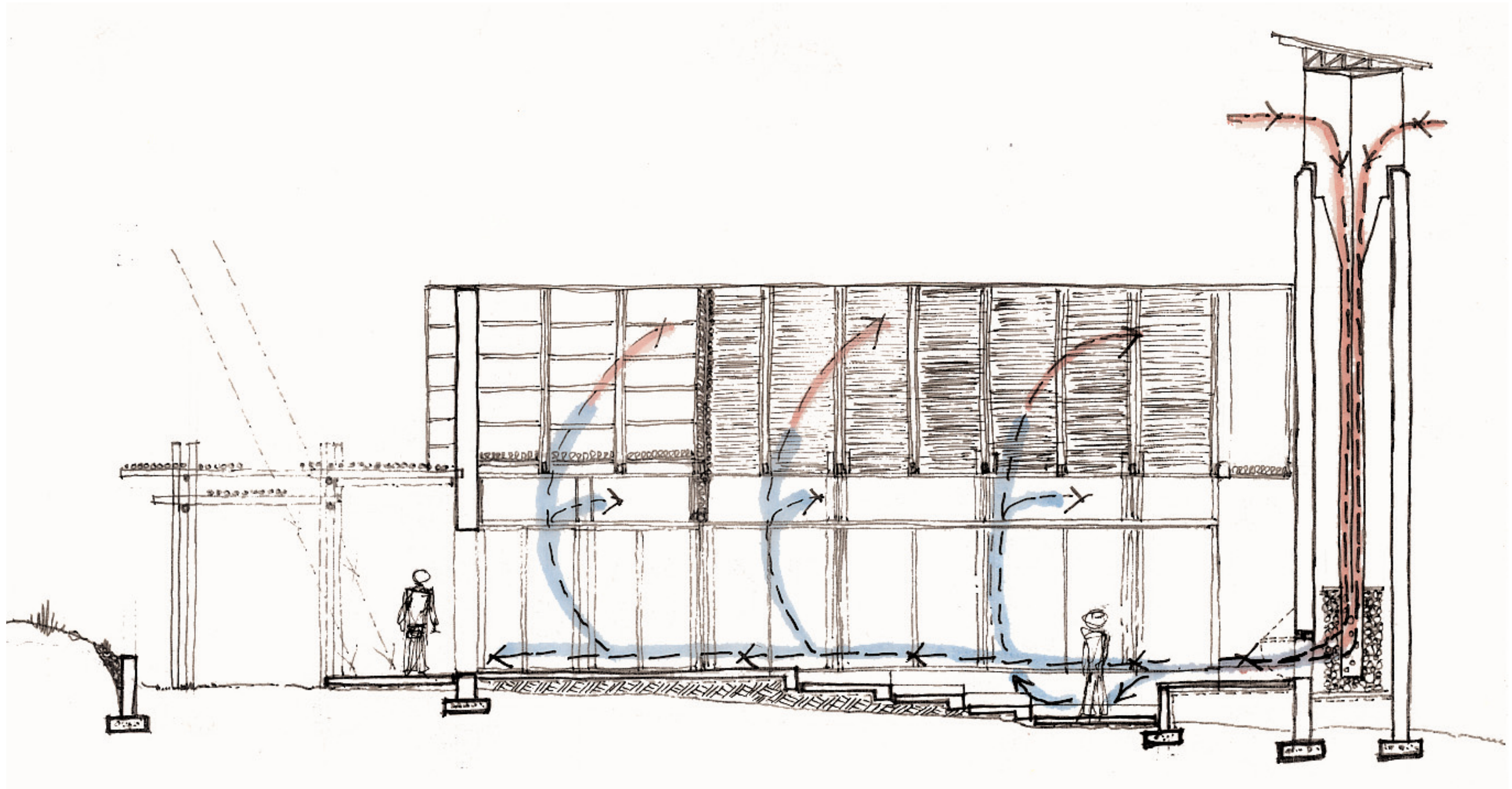


Fig. 7.4.1.1 Ventilation of Conference hall

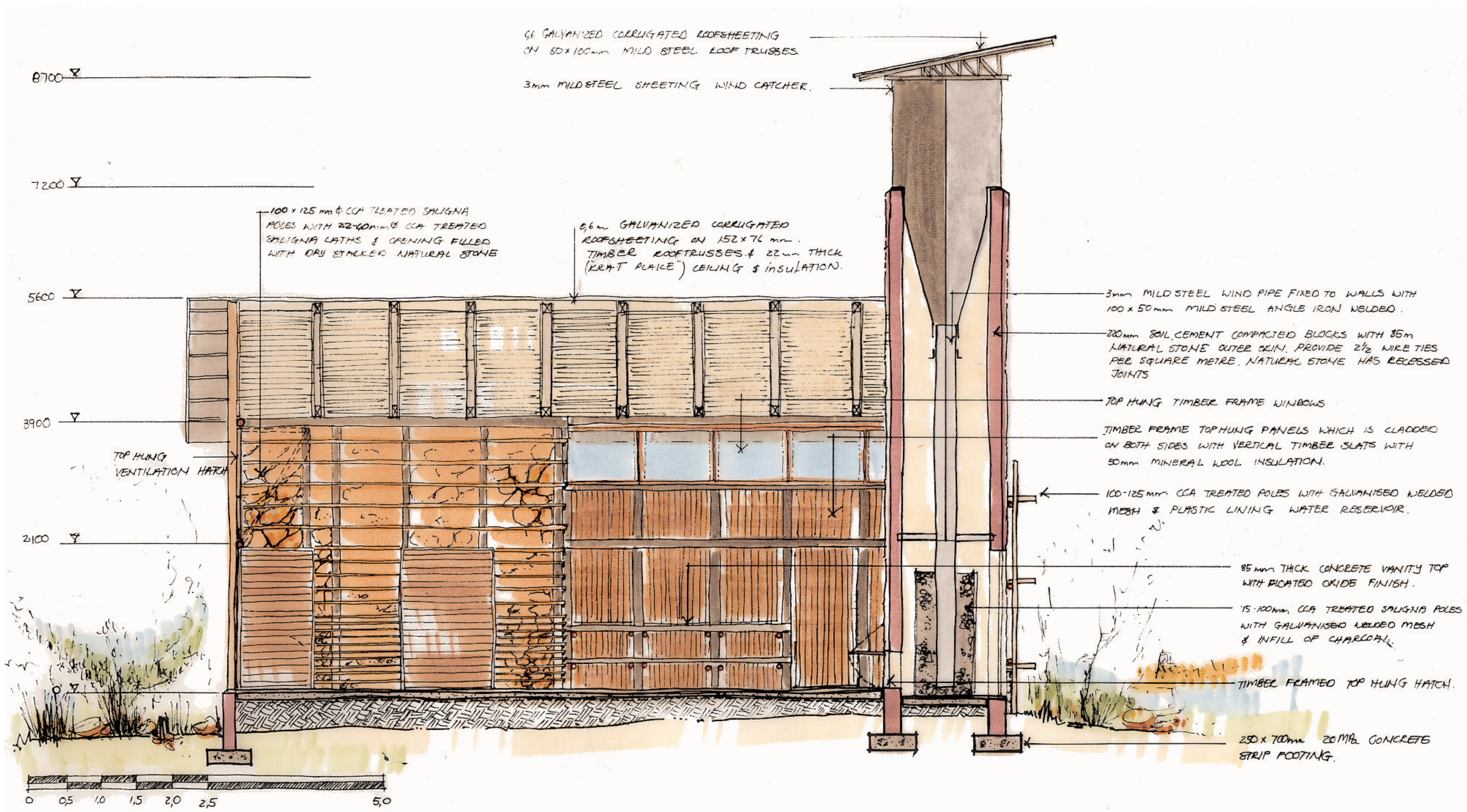


Fig. 7.4.2.1 Section through Skills training facility

NATURAL COOLING

7.4 Natural Cooling

7.4.1 Natural ventilation

Ventilation is the replacement of stale air by fresh or outside air. A distinction is made between the requirements for comfort and health. The health requirements must be satisfied in all weather conditions. The requirements for comfort are usually under specific weather conditions only. Two forces operating separately or together achieve natural ventilation of buildings. Thermal or temperature forces and aero motive or wind forces.

Thermal forces are created when the air near the bottom of a stack is heated. Convection currents are set up and the hot air rises up the stack, this air is then replaced by cooler air from the adjoining space. Whenever a difference in temperature occurs, thus a difference in density exists between the air inside and the air outside the building, the exchange of outdoor and indoor air takes place. This exchange can only take place when ventilation openings are provided, which must be of different levels.

The positioning of ventilation openings and the pressure distribution patterns of the wind determine ventilation of buildings by wind forces. Windward walls are subjected to a positive pressure and leeward walls are subjected to a negative pressure or suction. The main roof pitch used in the project is 32°. Therefore the windward slope is under a positive pressure and the leeward slope is under suction (Fig 7.4.1.1).

7.4.2 Wind catcher and Evaporative cooling

Water on a wet surface will evaporate if it is exposed to the air. This air must have a dew point lower than the surface temperature. The rate at which the evaporation will take place depends on the humidity of the surrounding air, the air speed and the surface temperature. Thus the higher the air speed and the lower the humidity in the surrounding air, the higher the evaporation rate.

The system developed was derived from the "malgaf" or wind catcher, which was invented for hot arid zones, and the traditional outside farm fridge. The applied system is a combination of the above-mentioned operations.

Because of the swirling wind in the valley, the wind inlet openings were divided into four. The average wind speed is too low to effectively evaporate the water and create the right pressure in the bottom of the tower. In order to increase the wind speed an inversed venturi stack effect was applied (Fig. 7.4.2.1). The air volume that comes through the opening is compressed by reducing the down pipe cross sectional area in relation to the inlet opening. This compression of air results in a higher air speed through the down pipe. The bottom of the tower is filled with charcoal. This is wet manually by pouring water into a steel container that is perforated at the bottom. This will allow constant moisture content on the charcoal. The down pipe is also perforated on the section, which sits inside the charcoal. The air in the down pipe is then pushed through the charcoal causing the water evaporate and thus lowering the air temperature.

Removable insulated panels on the outer side of the tower are opened to let the colder air into the living spaces. In order for the whole system to start, a small low voltage fan is placed inside the outer wall. This fan will assist in the start up of the system. Once the air is moving a draft is formed and can only be stopped when the panels are shut.

INFRASTRUCTURE

7.5 Infrastructure

7.5.1 Rainwater harvesting (Fig. 7.5.1.1 & 7.5.1.2)

Some of the advantages of rainwater collection are that it is renewable, available at the point of consumption, generally of very good quality and it may be used as drinking water without any treatment. The main application of the rainwater collection in the project is for the irrigation of cultivated land. Seventy percent of the rainwater will be temporarily stored in storage tanks at the point of harvesting. This water can be used for the evaporative cooling system and also any general use such as watering of vegetation and cleaning purposes around the buildings. The other 30% will directly flow to the big water reservoirs at the agricultural plant.

Amount of water obtained from rainwater harvesting:

The total area of catchment surface x Annual rainfall
2 573 square metre x 550mm per annum

= 1 415 150 litres/year

Total litres per year are multiplied by 80% because of losses due to evaporation and run off that does not flow into the gutters.

TOTAL: 1 132 m^3/year

Amount of water needed for irrigation of cultivated land:

Area of cultivated land = 10 hectares + 12 tunnels
Plants per hectare = 33 000 plants
Plants per tunnel = 1 500 plants
Water needed per plant = 0.85l / plant / day for open land
= 1.5l / plant / day for tunnels
(This figure incorporates annual rainfall)

Water needed for ten hectares: = 30 000pl x 10 hectares
= 300 000 plants
= 300 000pl x 0.85l/pl
= 255 000 l/day
= 61 200 000 l/year

Water needed for 12 tunnels = 2500 pl x 12 tunnels
= 30 000 plants
= 30 000 plants x 1.5 l/pl
= 45 000 l/day
= 10 800 000 l/year

Occupation rate of cultivated land and tunnels is 65% (240 days / year)

Total amount of water needed per year
= 61 2000 000l + 10 800 000l
= 72 000 000 l
= 72 000 m^3/year

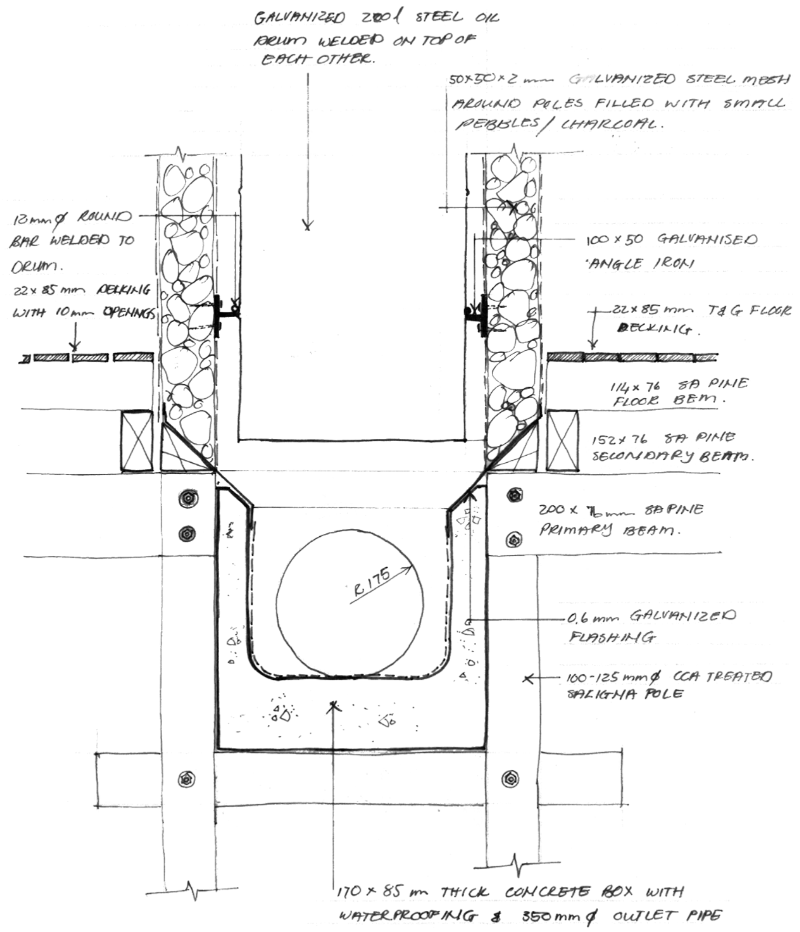


Fig. 7.5.1.1 Rainwater harvesting at Restaurant

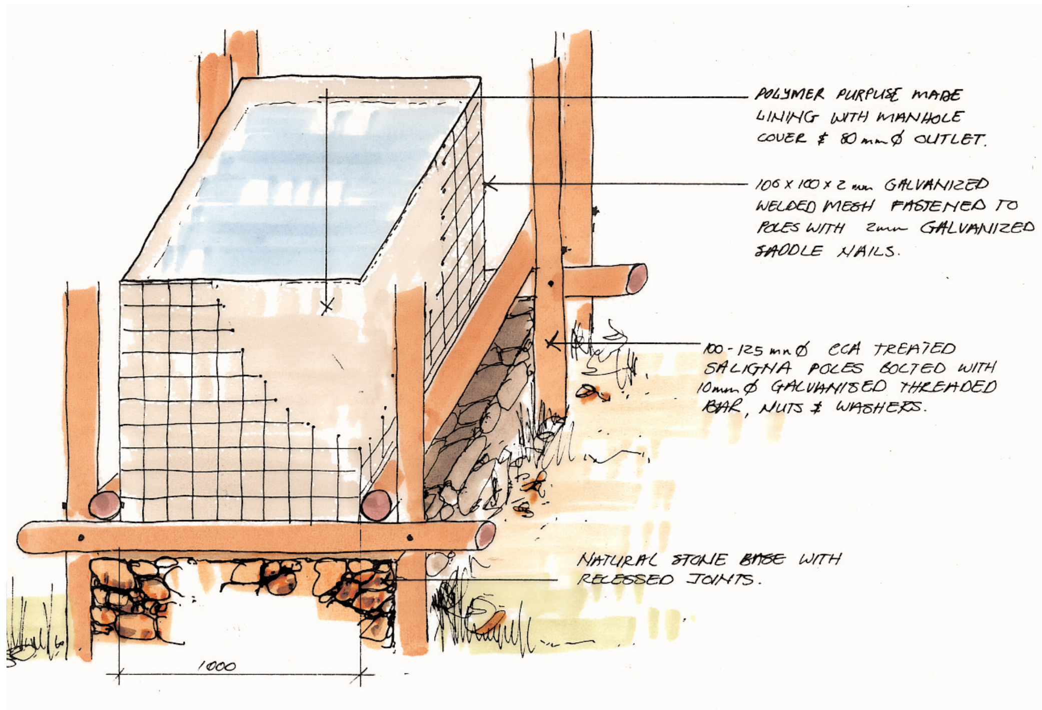
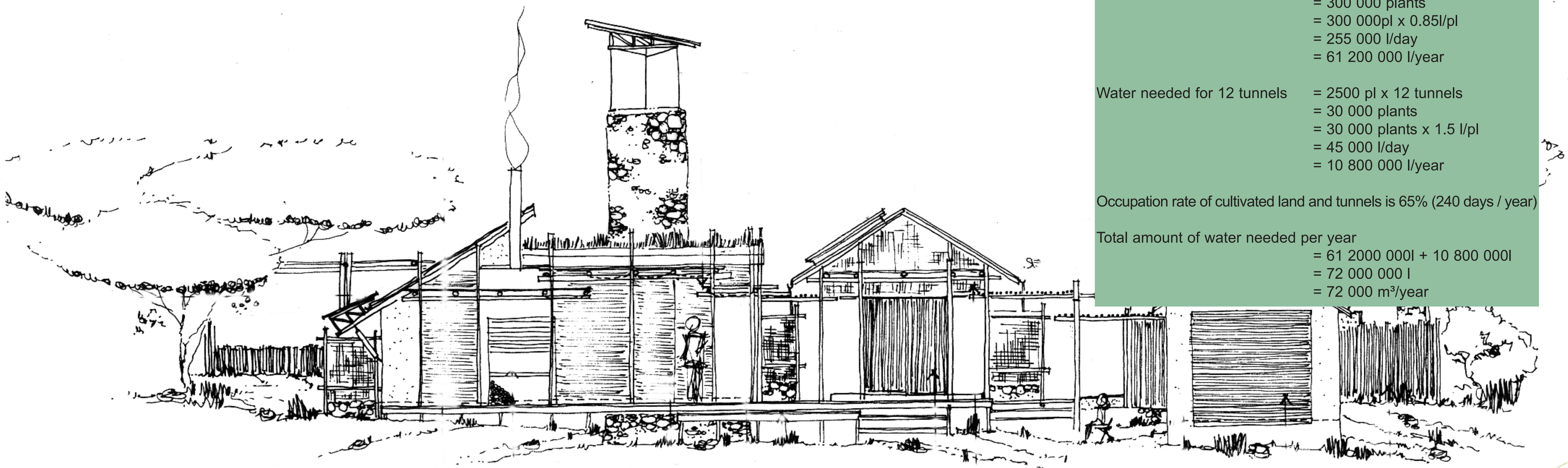


Fig. 7.5.1.2 Rainwater storage tanks



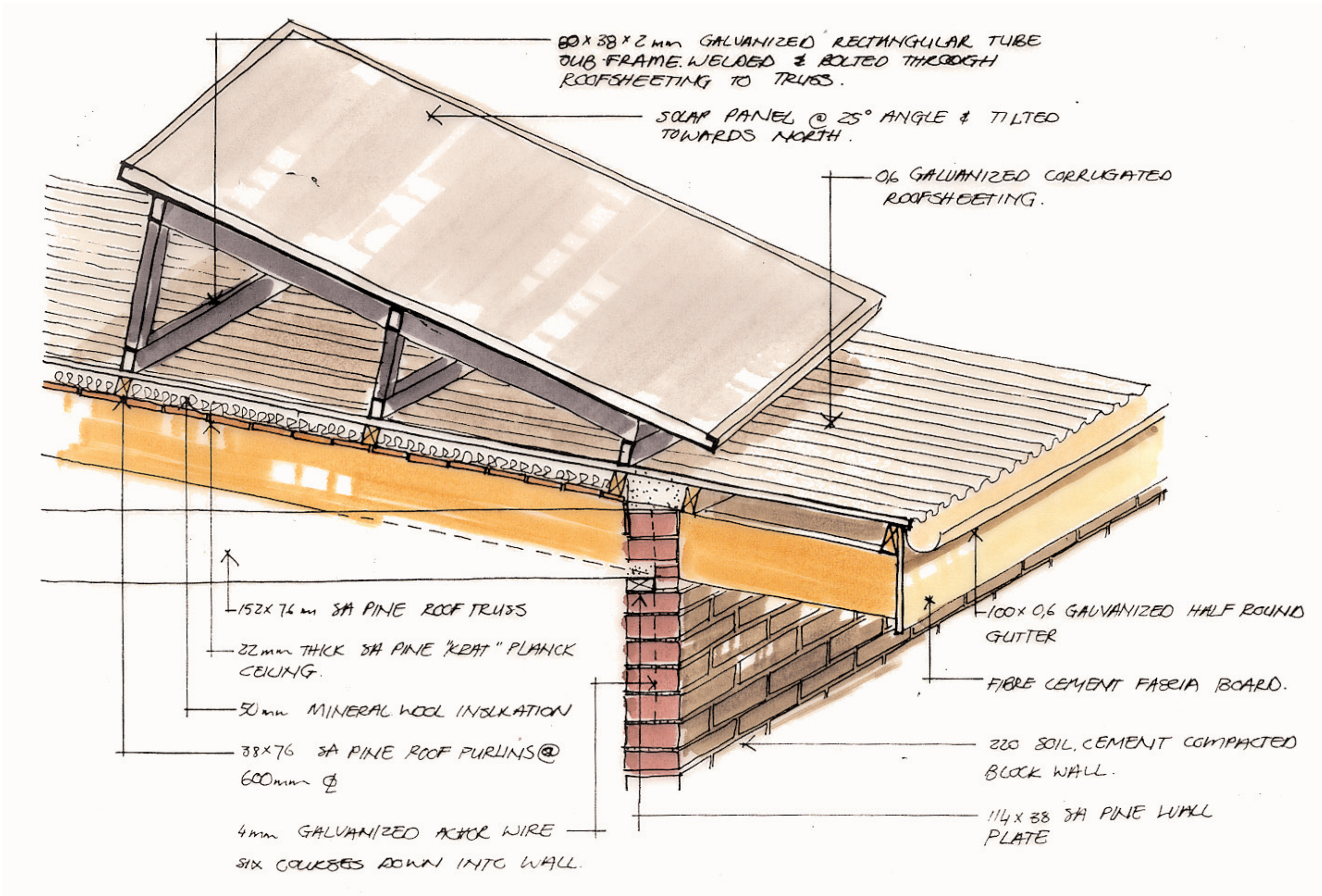


Fig. 7.5.2.1 Solar installation at Agriculture plant

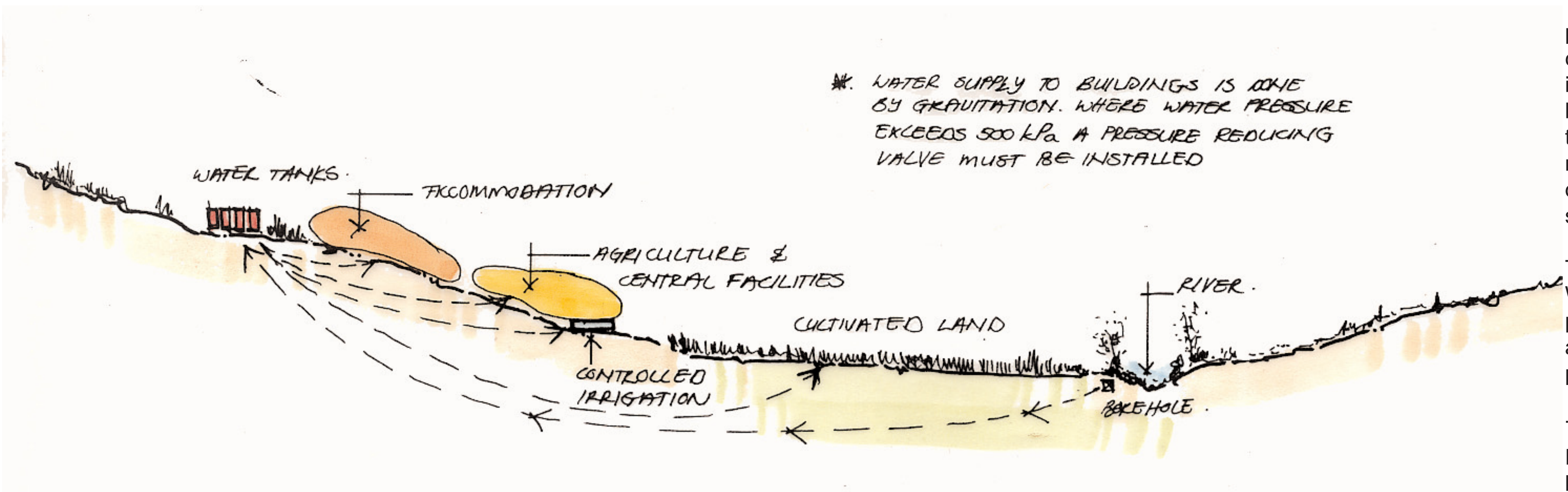


Fig. 7.5.4.1 Water reticulation

7.5.2 Energy

Four types of energy are used in the project: Eskom, solar power, liquid petroleum gas and bio-fuels.

General usage of lights and low power appliances makes use of solar power, which is obtained from photovoltaics (Fig. 7.5.2.1). The solar installation is split into different zones because a central solar plant would have caused cables to run extreme lengths (power loss directly equivalent to length of cable) to consumption point due to distances between facilities.

Eskom power is used for appliances which need a more constant power supply, such as cold rooms, packaging appliances and water pumps at the agricultural plant.

Liquid petroleum gas is used for all cooking appliances. A 5l instant electric geyser supplies hot water needed at sinks. These geysers are connected to the solar installations. Hot water that is needed for bathroom facilities is supplied via a "donkey" boiler. The organic waste from the agricultural plant is used as fuel for the 'donkey" boilers. This waste is left to dry and then compacted into fire briquettes. These briquettes are also used at the braai facilities. No natural wood will be used for any fires.

The solar installation is integrated with the Eskom electricity grid. Any extra power derived from the solar panels after the battery storage is at full capacity, will be put back into the Eskom electricity grid, thus saving more on Eskom electricity.

See Addendum A for calculations.

7.5.3 Roads (Fig. 7.1.5.1)

The width of the road is kept to the minimum required for the use of a tractor and trailer. Passing of vehicles is restricted to certain points allocated along the roads. At these points the roads are widened to enable the one vehicle to park temporarily and wait for the other vehicle to pass.

The road surface is treated with Eco-bond. Eco-bond is a product that stabilizes the top layer by binding the particles. It is compatible with abroad range of soils, only if the clay percentage is less than 20%.The soil is ripped first to the required depth before eco-bond is sprayed on. A rotovator is then used to mix the soil and Eco-bond. After levelling and shaping the roads a roller is used to compact the surface. This application dramatically increases the water resistance and strength of the soil.

The storm water run-off is directed into the natural vegetation. Where the slope causes a run-off along the shoulder of the road, placing of natural stone on the soil directing the water further away from the road surface. The stones are used as a preventative measure for soil erosion.

7.5.4 Water reticulation

Fig 7.5.4.1 is a schematical illustration of the water reticulation between the main facilities.

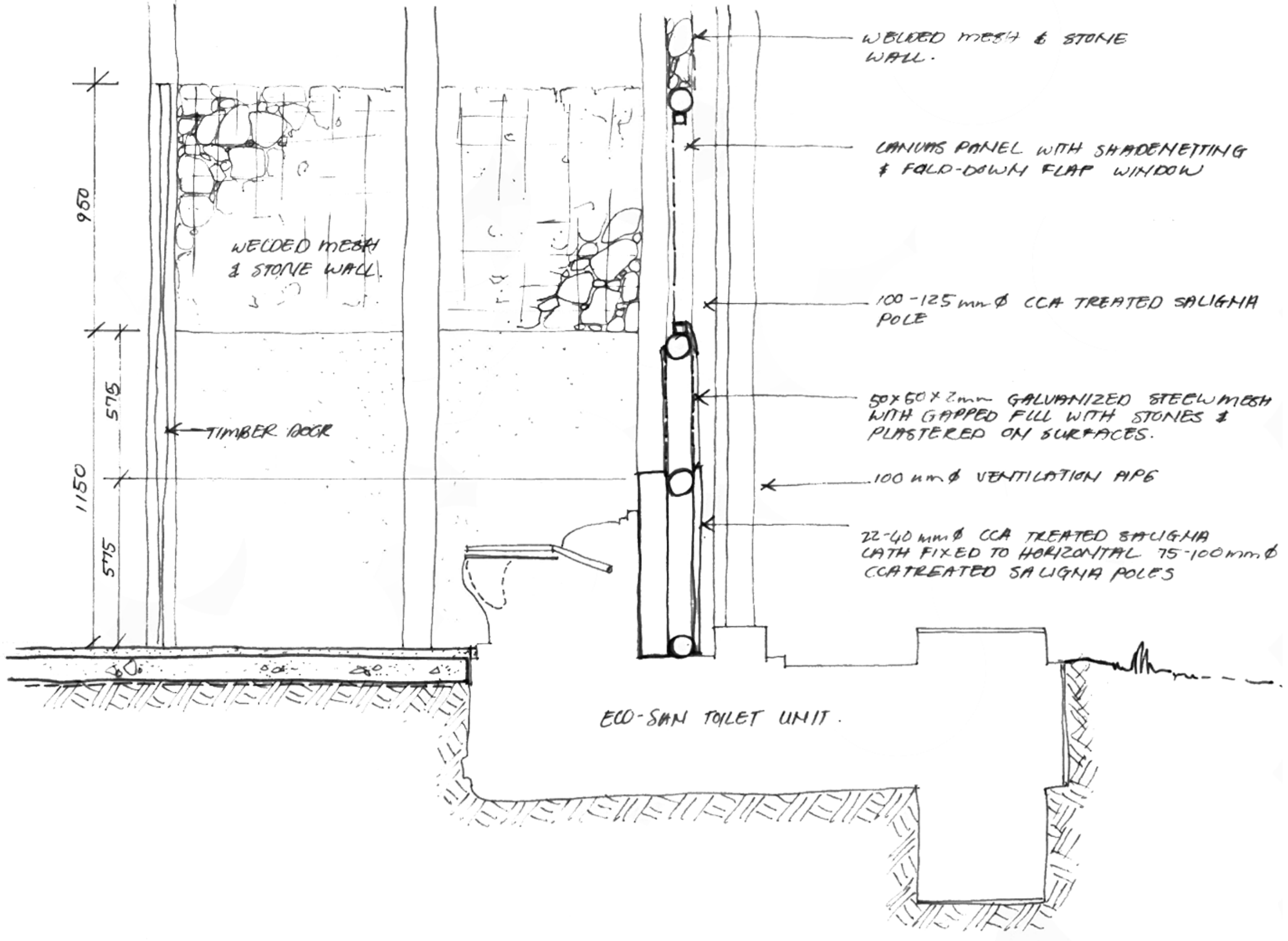


Fig. 7.6.2.1 Section through Eco-San waterless toilet

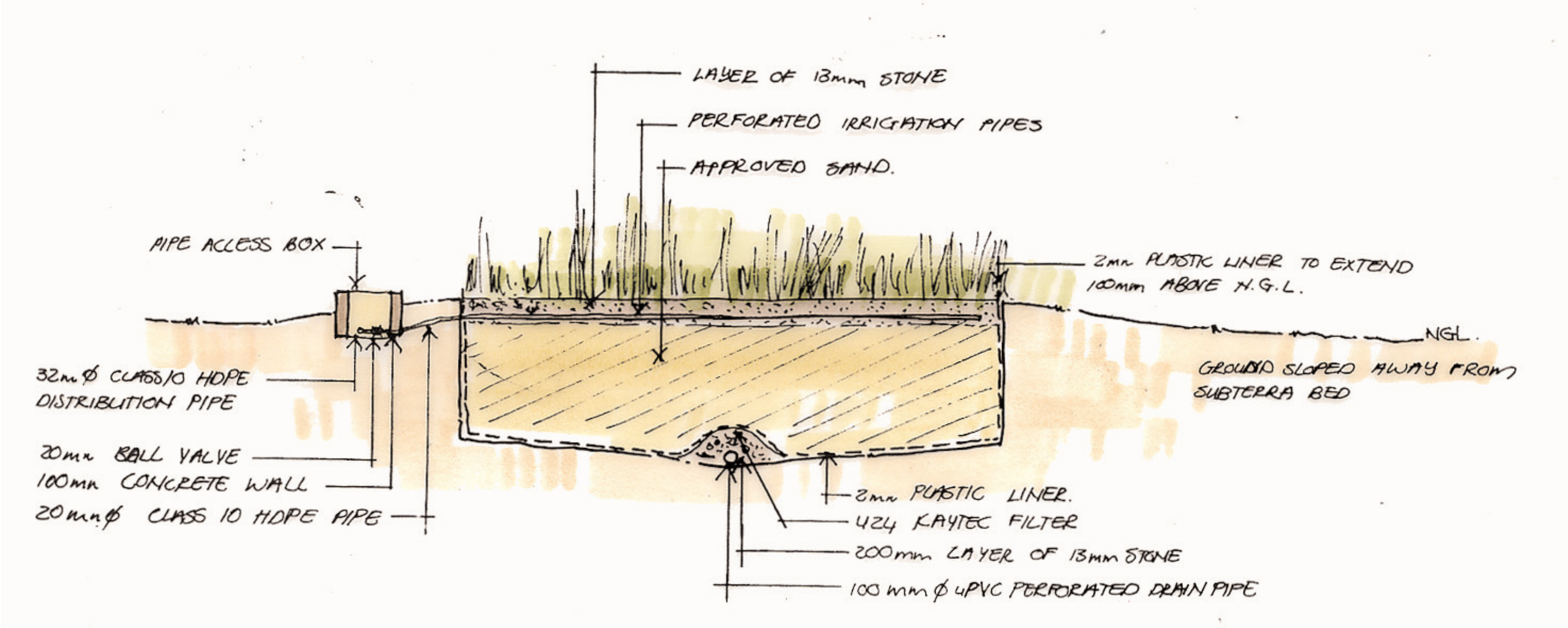


Fig. 7.6.3.1 Artificial wetland

7.6 Waste management

7.6.1 Organic and inorganic waste

A recycle area is located on the western side of the agricultural plant. All the organic waste from the agricultural plant is re-used as described in section 7.5.2. Garden refuge is converted into compost that is worked back into the land. All the inorganic waste (tin, glass, steel etc) and organic waste that is not re-used on the farm such as paper (contain possible chemicals) is sorted and removed by entrepreneurs from the local community to acceptable re-cycling facilities.

7.6.2 Eco-San toilets (Fig. 7.6.2.1)

The amount of water saved by using a dry sanitation system is astronomical. Approximately 550l of sewerage is generated per person per year. Taking the water out of the equation results in only 50l of excretion, an annual saving of 500l of water per person. A dry excreta is then the only end product that need to be disposed of or processed.

How it works: Human excreta falls down a vertical chute and into one end of a specially designed helical screw conveyor. Every time the toilet lid is lifted, a steel mechanism rotates the conveyor. With each rotation the product moves slowly. After 25 days in the helical screw conveyor the dry waste falls into a reusable bag. It takes 6 to 9 months for the bag to fill with dry / odourless waste.

The dry waste can now be processed into compost that is used on the agricultural land.

7.6.3 Subterra Artificial Wetlands (Fig. 7.6.3.1)

In natural wetlands, water seeps into the soil, flows along roots and is filtered by various sand and gravel layers and micro-organisms. Artificial reed bed purification systems use a combination of mechanical and biological resources to process wastewater.

Compared to conventional sanitation and washing facilities, a reduced amount of wastewater is generated in the development. This reduction is due to the use of waterless toilets and urinals. The only water that needs to be purified is grey water. The pre-purification of the grey water takes place in the multi-chambered pit. The subsequent transport of wastewater to the reed bed is brought about by a pressure pipe system that guarantees an even distribution of effluent over the filtration bed. The bed consists of different layers of sand and gravel and is planted with reeds. The root system of the plants ensures a constant aeration of the soil. The purified water is now collected in pipes, from where it flows to a control tank, where it can be tested and subsequently used for irrigation of cultivated lands. See Addendum B for an in depth process description