LIGHTWEIGHT MOVEABLE SUPERSTRUCTURES FOR VIP TOILETS

Report to the
WATER RESEARCH COMMISSION

by

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WRC Report No. 1781/1/10
ISBN 978-1-4312-0005-4
Set No. 978-1-4312-0095-5

March 2011

This report forms part of a series of three reports. The other reports in the series are: Lightweight Toilet Superstructures: Manufacturing Guide (WRC Report No. TT 483/10), and Lightweight Toilet Superstructures: Installation & Assembly Guide (WRC Report No. TT 484/10).

EXECUTIVE SUMMARY

BACKGROUND

In South Africa there are still many households without access to basic infrastructure such as water and sanitation and in many areas, especially rural areas, onsite dry sanitation systems in the form of VIPs or Urine diversion toilets will continue to be an appropriate technology choice. Thus in meeting the backlogs, many toilets will have to be constructed. However, the current shortage of standard building materials of good quality combined with the critical skills shortages in these remote areas hamper efforts to provide this basic infrastructure. Many South African households will be provided with a VIP or its derivatives. Many of these systems will require rehabilitation or replacement when the pit reaches it capacity or design life. However, current standard construction techniques and materials make the superstructure very heavy to move to a new site or even to allow access for desludging. Superstructures are also difficult to dismantle and reuse the material to build a new structure. In many cases it is not possible for the average household to relocate the superstructure resulting in overflow of raw sewerage.

Current standard construction techniques and materials make the superstructure very heavy to move to a new site or even to allow access for desludging. Superstructures are also difficult to dismantle limiting the reuse of the material to build a new structure. In many cases it is not possible for the average household to relocate the superstructure resulting in overflow of raw sewerage. Modern technology and materials can be used to develop a building system that can be used by communities to build their own infrastructure.

OBJECTIVES AND AIMS

The aim of this project was to develop an affordable moveable superstructure for a VIP toilet that can be used in rural communities

RESULTS

A literature review was conducted to set up a list of the superstructures currently used with the current cost attached to each system. The perceived advantages and disadvantages of each system were taken into account in setting up requirements for a new VIP superstructure. Alternatives were manufactured, tested and priced to determine the most suitable moveable lightweight VIP superstructure.

In South Africa there are various systems available for the construction of the superstructure of toilets. These systems can be divided into two main groups namely the lightweight systems that can be moved (as a whole or dismantled) when the pit of a VIP is full and systems that cannot be moved as such but the material may be re-useable in the construction of a new superstructure.

Agrément tests are conducted on a full scale structure to ensure that the structure can withstand the forces that it will be subjected to during a typical lifespan without undue distortion or distress. These forces include wind loads, impact loads from people or sharp-edged objects colliding with walls, door slamming or localized loads caused by various fittings.

In South Africa structures should normally comply with the requirements set in the National Building Regulations. Some of the National codes of Practice are based on deemed to be fit rules and these rules are often based on experience. The National Homebuilders Registration Council has their own set of deemed to be fit rules and regulations and these or often not as onerous as that of the National Standards. If an alternative building material or system is used that does not fall within the areas covered by the National Building Standards, the material or system can be tested and certified as fit for purpose by the Agrément Board of South Africa.

During this project, a moveable lightweight superstructure system made from high strength fibre reinforced concrete was developed. This system consists of a base slab, wall panels, a roof and a door and the system can be provided to communities in package form or it can be manufactured by the communities themselves in controlled environments. A system that consists of bricks or blocks that cannot compete with a pre-cast system as far as cost or quality is concerned. The various systems available do not differ much in cost and other factors will determine which of the systems would be most suitable in a given community. A choice will have to be made to optimize community involvement while providing every household with an acceptable sanitation solution as soon as possible.

RECOMMENDATIONS FOR FUTURE RESEARCH

The major problem with the provision of VIP superstructures is that there is no standard requirement and each supplier determines what the quality of the product is that they wish to deliver. It is recommended that a National Standard should be developed with minimum requirements that all VIP superstructures should adhere to. These requirements can include aspects such as minimum dimensions, load capacities, requirements for doors and fittings.

Having minimum functional requirements for suppliers will prevent clients from opting for inferior products that may seem to be cheaper.

ACKNOWLEDGEMENTS

The authors would like to thank the Reference Group of WRC Project K5/1781/3 for the assistance and the constructive discussions during the duration of the project:

Mr JN Bhagwan

Mr B Mokgonyana

Mr DA Still

Mr JL Harrison

Mr RD Holden

Mr I Pearson

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1 INTRODUCTION AND OBJECTIVES

Before the first democratic elections in South Africa, there was no national entity that was responsible for water supply and sanitation in the country. The responsibility was fragmented and allocated to the local government in the previous four independent states, six self-governing territories and the dominant Republic of South Africa territory. This resulted in differing levels of service. The first democratic election in 1994 saw the National Department of Water and Forestry (DWAF) taking responsibility for addressing the sanitation service delivery backlog in the country. A budget of several million rand was allocated annually to addressing this need and the responsibility of ensuring that this money was appropriately spent rested heavily on this Department.

In South Africa there are still many households without access to basic infrastructure such as water and sanitation and the aim was to rectify this situation by 2010. In many areas, especially rural areas, onsite dry sanitation systems in the form of VIPs or Urine diversion toilets will continue to be an appropriate technology choice. Thus in meeting the backlogs many toilets will have to be constructed, however currently the shortage of standard building materials of good quality combined with the critical skills shortages in these remote areas will hamper efforts to provide this basic infrastructure. Modern technology and materials can be used to develop a building system that can be used by communities to build their own infrastructure.

At the start of this project a literature review was conducted to establish the current state of knowledge. Local and international experience were reported and used as input in developing lightweight moveable superstructures for VIP toilets. Conclusions are based not only on the literature review or personal experience but the input of significant role players involved in the supply of VIP superstructures.

2 ON SITE SANITATION OPTIONS

The White Paper on Basic Household Sanitation includes the following definition for sanitation: "*Sanitation refers to the principles and practices relating to the collection, removal or disposal of human excreta, household waste water and refuse as they impact upon people and the environment. Good sanitation includes appropriate health and hygiene awareness and behaviour, and acceptable, affordable and sustainable sanitation services.*"(DWAF, 2001).

There are numerous different on-site sanitation systems on the market that claim to offer various advantages. In Table 1 four different groups of sanitation systems that are widely used in developing countries are given. These are:

- **Dry on-site systems:** No water is needed for operation and digestion or collection of waste is dealt with on the premises of the user or owner.
- **Wet on site-systems:** Water is needed for proper operation and digestion of waste is dealt with on the premises of the user or owner.
- **Cartage systems:** Water is needed for proper operation and waste is collected to be transported to a central treatment facility.
- **Sewerage systems:** Water is needed to keep a network of connected facilities operating. The network leads to a central treatment facility.

Table 1: Sanitation systems used in developing countries (Van Oel, 2002)

Dry on-site facilities	**Wet on-site facilities**
► Simple Pit Latrine / unimproved pit toilet ► Ventilated improved pit latrine (VIP) ► Ventilated Improved Double Pit (VIDP) ► Chemical toilet ► Urine diversion toilet (UD)	► Pour-Flush Latrine ► Aqua-privy ► Septic Tank ► Biogas Digester ► Excreta-Fed Fish Pond
Cartage (off-site treatment)	**Sewerage (off-site treatment)**
► Latrine with Vault (bucket toilet) ► Conservancy tank (Pour-Flush and removal by tanker)	► Conventional Sewerage ► Simplified Sewerage / Shallow sewerage ► Settled sewerage / small-bore sewerage ► Covered storm water drains

Although bad construction methods, misuse and lack of money for proper operation can be causes of health-related problems with any system, the White Paper on Basic Household Sanitation (DWAF, 2001) identified four sanitation systems that are not recommended for future use within the borders of South Africa:

- **Simple pit latrines / Unimproved pit toilets:** These pits produce bad smells and are subject to fly nuisance and can easily become a source of disease.
- **Chemical toilets:** They are deemed to be too expensive and temporary.
- **Bucket toilet:** Bucket toilets (cartage) are unhygienic and environmentally undesirable. The intention is to phase out all bucket toilets as soon as possible.

- **Communal toilets:** Whatever the technique is, it should not be shared by more than one household. Communal toilets are considered unhygienic.

In South Africa the over-all recommended method for sanitation is the Ventilated Improved Pit latrine (VIP). Households should get the opportunity to choose for other facilities. These secondly recommended facilities are:

- **Dry-on-site (see Figure 1):** *Urine Diversion toilet:* This is the best dry on-site alternative in areas where a VIP is not possible. In areas close to where groundwater is collected this system can also be a safer solution than the VIP.
- **Wet-on-site (see Figure 2):** *Pour-flush toilet:* In areas that are not densely populated and where the people have money for flushing water and toilet paper. *The aqua privy and soak-away:* In more densely populated areas and where people have money for flushing water and toilet paper.

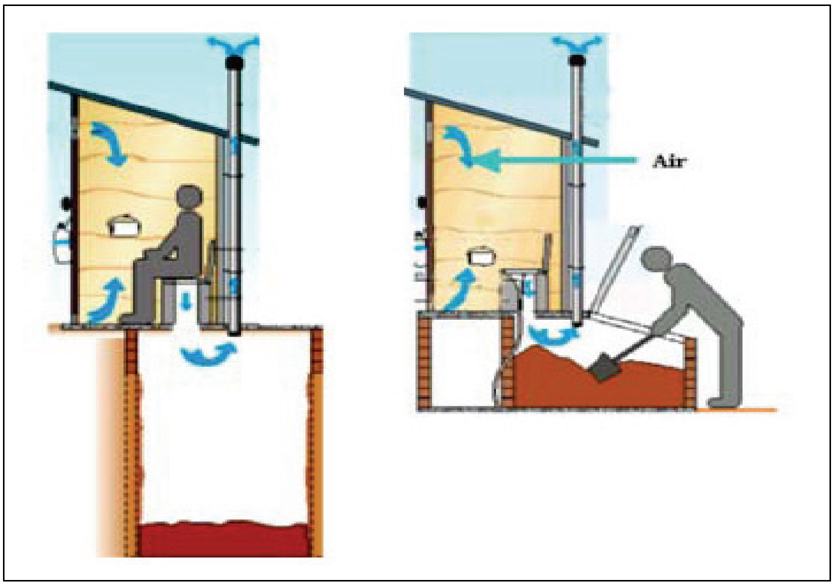


Figure 1: Adequate dry on-site systems. Left: VIP, Right: Urine diversion (DWAF, 2001)

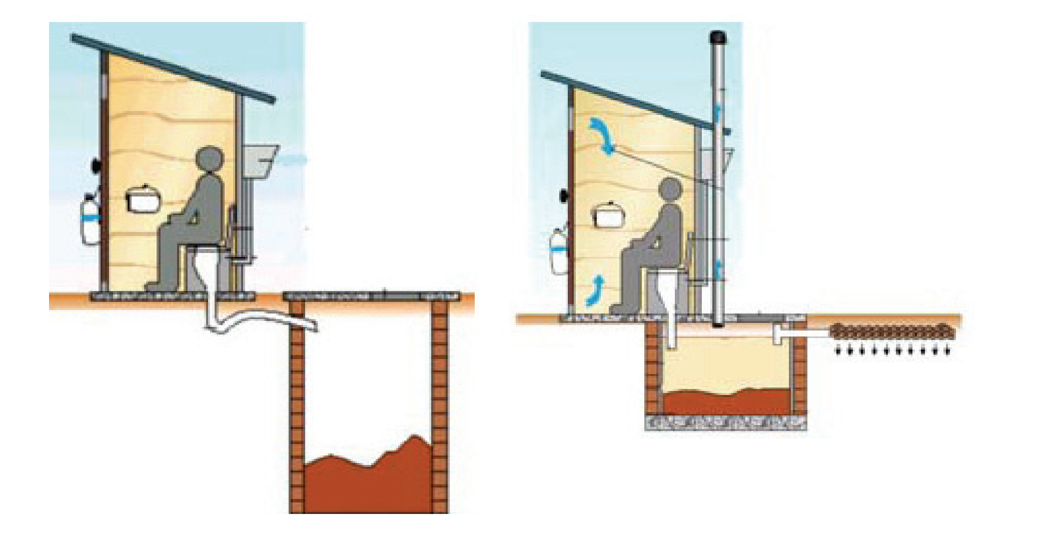


Figure 2: Adequate wet on-site systems. Left: Pour-flush toilet, Right: Aqua-privy and soak-away (DWAF, 2001)

2.1 Ventilated Pit Latrines (VIP)

The VIP consists of a pit dug into the ground onto which a superstructure is constructed to ensure the privacy of the user. It is important that the ventilation pipe be installed as this ensures the ventilation of the pit. VIP's can be installed under the following conditions:

- Free draining soils.
- Deep water tables, preferably deeper than 5 m.
- Rain water needs to be diverted away from the toilet.
- In sandy or collapsing soils, the pit must be lined. This lining should allow for the free draining of the pit to avoid the build-up of liquid in the pit.

The advantages of the VIP are as follows:

- Easy construction.
- The cost of the toilet is in the superstructure.
- It can be installed relatively quickly.

The disadvantages of the system are as follows:

- It cannot be installed in areas where the soil is not free draining, i.e. clayey areas or in rock.
- It will cause pollution as the process is not contained.

- Once the pit has been filled, the contents must be pumped out, or the toilet needs to be moved to a new location. In squatter areas, the latter may be a problem as the plots are generally very small and space is limited. The pumping of the contents will only be possible if the occupants of the system have not dumped foreign material into the pit. It also requires specialized equipment and should therefore be done by the local authority.
- The system does not allow for the disposal of the grey water.

2.2 Single Vault Urine Diversion Toilet

The single vault urine diversion ventilated pit latrine consists of a constructed vault for the faeces and a special pedestal, which has been designed to divert the urine from this vault. A urinal is also provided for use by males. Generally a soakaway is constructed for the disposal of the urine, but this practice could cause nitrogen pollution of the ground water. A small bore sewer system could be investigated for the collection and treatment of the urine as this would prevent the pollution of the ground water. This may also be required in areas where the soil is not free draining, thus causing ponding of the urine.

Some engineers have proposed the provision of a tank for the collection of the urine. This tank is then emptied on a regular basis and the urine can be used in agriculture (Austin, 2006). There are some reservations about the storage of the urine on-site as this may cause smells, and the underground tank would increase the cost and complexity of the system. The urine diversion single vault ventilated pit latrine can be installed in any location. The maintenance of the toilets is relative simple. The following actions are required:

- The dried faeces in the pit need to be scraped to the maintenance access on removal.
- The dried faeces of the previous month can be removed for burial in flower beds as humus.

The advantages of the single vault urine diversion toilet are seen as follows:

- Simple construction.
- It can be used in all soil and founding conditions.
- Easy maintenance.
- Durable structure that does not require to be moved.

- Pollution significantly reduced, and if the urine treatment system is provided, then the pollution caused by the system is minimized.
- Sustainable solution to sanitation.

The disadvantages of the system are seen as follows:

- The construction costs are relative high.
- The monthly maintenance has to be performed to ensure satisfactory performance of the system.

2.3 Double vault urine diversion toilet

The double vault urine diversion toilet consists of a constructed vault with two chambers for the faeces and a special pedestal, which has been designed to divert the urine from this vault. A urinal is also provided for use by males. The handling and treatment of the urine is similar to the single vault urine diversion pit latrine as described above.

The main difference between the single and the double vault urine diversion toilet is the double vault. In the double vault the one vault is used for a period until it is full, thereafter the pedestal is moved to the second vault. The vault that was used first is sealed and the faeces are composted until the second vault is filled. The composted material of the first vault is then removed by opening the maintenance access. This material should be stable and could be used as humus in the garden. The pedestal is moved back to the emptied vault, and the second vault is sealed for composting. The system is thus sustainable; the maintenance is easy and can be done by the home owner. While the system is in use, the only maintenance that is required is that the owner may have to scrape the dried faeces from underneath the pedestal to the sides of the pit to ensure even filling of the pit. The advantages of the double vault urine diversion ventilated pit latrines are similar to the advantages of the single vault toilet. In brief they are seen as follows:

- Simple construction.
- The system can be used in all soil and founding conditions.
- Easy maintenance.
- Durable structure that does not require to be moved.
- Pollution is significantly reduced, and if the urine treatment system is provided, then the pollution caused by the system is minimized.
- Sustainable solution to sanitation.

The disadvantages of the system are seen as follows:

- The construction costs are relative high.
- Regular maintenance has to be performed to ensure satisfactory performance of the system.

3 REGIONAL EXPERIENCE OF SUPERSTRUCTURES

In the literature reviewed many publications were based on research conducted on the toilet sub-structures and the different sanitation systems that can be used in rural communities. Although very little information has been published on the superstructure and the community needs for superstructure, any sanitation system will only work if a durable superstructure is provided for each toilet.

Van Oel (2002) conducted research on the improvement of sanitation in Mohlaletse village in Limpopo Province where most households make use of pit latrines, either poorly ventilated or not ventilated at all. A lot of the pit latrines, with an iron top structure, are affected by rust. Through the holes caused by the rust you can see and smell the human excreta and in the past small children have even fallen into these holes.

In Lesotho, the domestic VIP concept was adopted from the work carried out in Botswana and Zimbabwe, where the model originally used for school latrines was based on VIPs designed in Kumasi, Ghana (Blackett, 1994). The detailed designs had to be modified for the particular conditions in Lesotho. For example, consumer preferences dictated that squatting slabs in VIPs were totally unacceptable and a seat had to be incorporated into the design. Further, due to the influences of the South African way of life, everyone wanted to use a pedestal and seat, like those in a flush toilet. Likewise, a substantial superstructure with a door giving complete privacy is expected. The idea of sharing a latrine between households is not socially acceptable except in an emergency situation.

The technology of a particular latrine is just one aspect of design. If it is intended that the latrine be widely accepted and desired by people, then it must be liked. This means it should be attractive, odourless, comfortable, easy to use, simple to clean, suitable for children as well as adults and not offensive to any cultural or social norms.

The first VIP latrines built in Zimbabwe in the mid-1970s were rectangular with wooden doors, but wood was expensive, and the doors were often left open, with the result that the latrine interior was not kept dark and fly nuisance increased. Consequently, the superstructure was modified into a spiral shape, which provided privacy and shade without the need for a door. The superstructures of these early VIP latrines were constructed in either ferrocement or wooden poles plastered with mud. However, with suitable wooden poles becoming scarce, and the ferrocement model proving expensive to construct in the rural areas, brick VIP latrines soon became the favoured option. Cheaper materials did exist, but most low-cost latrines had short lives and required frequent maintenance. In contrast, brick VIP latrines were long lasting and required little maintenance. Bricks were readily available in most of the country, and this design had the additional advantage that it did not require a ventilation pipe, as ventilation could be provided by a brick chimney built into the superstructure.

The spiral Zimbabwe design, without a door, was not preferred in Lesotho, in part because people in Lesotho are often frightened that snakes or other small animals might lurk in the latrine. Likewise, the people wanted a seat, but one that was easy to clean and that an animal would not be able to hide behind. Hence, an acceptable bench seat was developed. Cheap plastic seat covers designed for flush toilets are readily available. By fixing a seat cover to the concrete seat slab over the seat hole, the comfort and acceptability of the latrine was further enhanced. This also had the additional advantage of ensuring that the pit was kept dark, while not stopping airflow through the latrine. From meetings, discussions, surveys and consumer feedback, it was clear that the preferred construction material for most people in the urban areas of Lesotho was concrete blocks. Most middle and lower income people aspired to have a concrete block house with a latrine constructed of the same materials.

The Ventilated Double Pit Latrine (VIDP) with alternating pit system seemed a perfect, permanent sanitation solution for small urban plots. It meant that mechanical pit emptying equipment would not need to be considered. The VIDP was heavily encouraged in the early 1980s and was standard on some site-and-service housing schemes. However, from the beginning most Basotho said they would never empty the pits manually, irrespective of what the contents looked and smelled like. It was assumed that with time this attitude could be changed, especially when people saw how innocuous the pit contents became. After a while, however, it became clear that the attitude was not going to change. Finding good equipment is only the beginning of the pit-emptying problem. The logistics of working in small towns, where numbers do not require an emptying vehicle on a full-time basis, still have to be worked out. People are naturally reluctant to pay for their pit to be emptied before it is full, but once it is full they want prompt service. So, at any one time there are likely to be a few people in each town demanding that their pits be emptied. Sending the vehicles back and forth between towns is very expensive, especially if there are only a few pits to service in each town. Additionally, the supervisory and maintenance problems increase when vehicles are scattered over a wide area. In Lesotho a long-term plan for pit-emptying around the country is badly needed. Related to pit emptying is the unresolved problem concerning the disposal of sludge (Blackett, 1994).

In research areas in India the performance of the double pit pour-flush latrines is generally quite good. Technical problems are to a large extent related to indiscriminate use of a standardized design, without paying attention to soil conditions, groundwater table and the availability of water. Where superstructures are provided with the latrine, the latrine is often used for other purposes and where they are not provided, people are reluctant to construct them. Although an approach where the community and the beneficiaries are involved in planning and implementation and awareness and motivation campaigns are carried out is seldom used, it leads to much better results (IRC International Water and Sanitation Centre, 1997).

According to the IRC International Water and Sanitation Centre (1997) local authorities are rarely involved in planning and implementation of the sanitation schemes, although they have the responsibility to motivate the beneficiaries, to provide services for operation and maintenance and to collect loan repayments. As a result, technical knowledge on the systems is insufficient and interest in providing services for operation and maintenance is lacking. There is no budget or strategy for services for operation and maintenance. At national and state level the authorities who carry out planning and design and supervise implementation, are never responsible for operation and maintenance and they are often not sufficiently aware of the operation and maintenance requirements. This is reflected in the selection of contractors and the determination of unit cost at state level and the lack of capacity building at local level.

In the Mvula Trust's Northern Cape programme a surprising number of people have decided that the inconvenience of occasionally handling the faeces far outweighs the cost of moving a toilet therefore they have chosen a system where they have to handle the dry excreta. The programmes have also encouraged significant community innovation. These ideas when disseminated to other communities further encourage innovation and building of self-esteem which is essential to escape from the poverty trap. The decision by a household on whether to install wet or dry sanitation depends on a number of factors. According to Holden (2001) these are:

a. The capital cost of the system. This is influenced by whether or not the householder and locally available skills can be involved in the construction of the system, geology, geohydrology, climate; settlement density (for communal systems) and availability of water. Household and local skills can be utilized if local construction techniques and locally available materials are used. This also ensures the technology is replicable when the sanitation programme is complete. The introduction of fencing or roofing wire as reinforcement, cement pedestals created using a fibre-glass mould, the development of the Archloo and the use of local building materials such as mud block have ensured that the capital cost is affordable to households while ensuring that the maximum amount of money is retained within the community. Climate can also influence choice of systems, particularly desiccating systems as hot, humid or cold wet conditions can influence the drying out of the faecal pile.

b. Whether the household is prepared to be physically involved in the maintenance of the system. The first decision is around whether or not a household is prepared to handle dry faeces. If they are, urine diversion or double pit VIP, which are permanent structures, are options if not a single pit VIP which will require to be moved when full is the option (If desludging is not viable). Table 2 indicates the effort required for each system. What is not reflected is the sense of pride in a permanent structure. People are more likely to invest more money in a permanent structure than one, which they know, will be broken down after a period of time. What is also interesting is that women are more likely to accept a system where faeces need to be handled then men.

c. If the system involves outside maintenance whether the household can and is prepared to pay for this. Sucking of a septic tank or pit, treatment at a central works, maintenance of a reticulation all involves paying someone. If the household and/or the municipality through the equitable share and cross subsidies is not able to afford it then the system is not viable.

Table 2: Maintenance requirement over a period of 15 years (Holden, 2001)

System	Life Span	Maintenance Requirement				
		Description	Frequency	Hours	Total Hours	Additional Costs
Urine Diversion/ DVIP	Permanent	Empty pit and compost	3 months	0.25	15	None
Single VIP	15 years	Build new toilet	15 years	60	60	New materials

d. Whether there is the institutional capacity to support the chosen system. Where a system is chosen which requires institutional support the question arises as to whether or not there are enough consumers paying to enable a municipality to establish it. Although the individual might feel they have sufficient funds if overall there is insufficient funding then there will not be the capacity to support the chosen system.

e. If water is required whether or not there is a sufficient supply. Some systems require water to operate. Before choosing any system it must be determined in the source is sufficient to support such a system. If not it will be the responsibility of the household to pay for this additional costs as first priority is basic services.

f. The risk of failure and the environmental impact. Before choosing a system a household and municipality must look at what happens if the system fails and will they have the necessary resources to rectify this failure. A great deal of concern is expressed over the pollution of groundwater from pit latrines. If, however, a correct assessment is carried out and pit type latrines are not constructed where they are not suitable then the risk of pollution is slight and the municipality's responsibilities minimal.

The Catholic Relieve Service (CRS) had an emergency relief program in Ethiopia where they concluded that the quality of toilet construction varied across project areas, depending in large part upon how much families could afford in superstructures. The toilets in the Eastern Ethiopia project were dug into sandy soil, which tended to collapse in over time and the superstructures were cones of loosely fitted sticks with complete transparency and no roofs. While the slabs were substantial, the rest of the toilet construction in Eastern Ethiopian and Southern Nations, Nationalities and Peoples' Region (SNNPR) projects looked somewhat insubstantial and appeared "temporary." The VIP latrines observed in Tigray were very well built and would be long lasting but are not replicable. The simpler pit toilets promoted by this project may be more replicable but may be spoiled by rain going in the pits, or in the case of Eastern Ethiopia, may collapse due to the sandy soils. More effort was put into building sustainable water supply systems built of quality materials than what was put into sanitation. This is because extremely poor households were expected to build toilets alone. The quality of maintenance of all latrines inspected during the evaluation was very good indeed. All were clean, none smelled and few had flies. The project sanitarian in SNNPR knew the value of adding ash to toilets to prevent smell and fly breeding, and households were advised to do this. However the open tops of toilet superstructures and the inward slant of the slabs resulted in rain coming into the pits causing increased smell and fly breeding.

In August 1994 the Mvula Trust initiated a programme of 12 sanitation projects to pilot its work with rural sanitation. These pilot projects demonstrated that VIP type latrines can be built to an attractive standard on community based sanitation projects far more cost effectively than many had thought possible, thanks largely to the mobilization of the owner contribution and a funding policy which encourages thrift. The cost (as published in 1997) for the different systems used can be seen in Table 3.

Superstructures tended to be built predominantly from concrete blocks, although there were exceptions where corrugated iron, locally made clay fired bricks, asbestos sheets or ferrocement was used. Concrete blocks can be used to promote the status of sanitation, but are costly. There is still a challenge to successfully research and promote alternatives. Still & Holden (1997) concluded that the use of soil-cement bricks produced using simple high pressure moulding systems should be investigated.

According to information published by the Mvula Trust rural people generally relocate or rebuilt their toilets on new pits when existing pits become full. This was quite easy with light corrugated iron super structures. However, since 2003, all new VIPs funded by the Department of Water Affairs and Forestry have been made from concrete blocks, concrete panels or are Archloos. Mvula began WRC-funded research in 2004 to develop modified designs for Archloos and other concrete based toilets for easy relocation to new pits. The slab and foundations are modified so that a tractor, bullock team or winch can be hooked up to the toilet to slide it to a new pit. The results from this project are seen as very important and it will be included in this literature review when the final project report is obtained.

Table 3: Summary of Mvula pilot project details (Still & Holden, 1997)

Project	Preferred Option	Cash Cost per Toilet						Additional Owner Contributions
		Mat-erial	Lab-our	Trans port	Total	Dep-osit	Cost to Project	
Dukuduku	Block with door	R633	R100	R70	R803	R0	R803	Dig pit, make 120 blocks, assist builder, provide door, frame, hinges, lock
Ga-Mashishi	Block with door	R537	R180	R40	R757	R50	R707	Dig pit, collect rock and sand to line pit
Ga-Rasai	Corrugated iron with door	R577	R200	R30	R807	R77	R730	Dig pit
Inadi	Phungalutho[1] with precast pit cover and roof	R610	R200	R120	R930	R0	R930	Level site, dig pit & foundation
Mafefe	Block with door	R760	R400	R236	R1396	R0	R1396	Only pits dug, but these were all demonstration latrines at institutional sites
Mbazwana	Phungalutho with lined pit, moulded roof	R500	R500	R100	R1100	R300	R800	Level site, dig pit, fetch water
Mtumbane	Phungalutho with corrugated fibre cement sheets.	R700	R300	R0	R1000	R30	R970	Dig pit, assist builder, transport all materials from store to site
Newline	Block with door.	R590	R180	R25	R795	R120	R675	Make blocks
Nkomazi	Both ferrocement spiral and block with walkaround	R455 R550	R300 R300	R25 R25	R780 R875	R74 R174	R706 R701	Dig pit, make blocks , assist builder.
Themba-lethu	Dependant on soil depth, single pit or double pit clay brick with door.	R693 R496	R90 R65	R25 R25	R808 R586	R0 R0	R808 R586	Dig pit, assist builder, collect sand and water, provide door, frame, hinges and bolts.

Although good quality plastic pedestals for use in VIP toilets are manufactured in urban areas, the Mvula Trust is promoting the use of cast concrete pedestals, molded in communities, using special fiberglass moulds. When these pedestals are sanded down and painted they look as good as ceramic flush toilet pedestals. By manufacturing the pedestals in the rural communities jobs are created.

In terms of preventing the spread of disease, washing hands is at least as important as the toilet itself. Mvula has experimented with plastic wine taps and five litre buckets (approximately R30), and in conjunction with the CSIR a self closing tap and mounting bracket which is designed to be used on a two litre drink bottle (approximately R15).

When VIP pits are full the conventional solution has been to empty them with a vacuum tanker. These are expensive, and often cannot reach rural households owing to bad roads and restricted access to households. In 2004 the Mvula Trust started research funded by various municipalities and the Water Research Commission, to pilot small scale pit emptying. A portable suction pump is used to transfer the contents to a new pit dug close by, and then the new pit is closed. It is envisaged that SMMEs could own and operate these suction pumps. If this project is successful it could significantly reduce the need for relocation of pit latrines.

4 COMMUNITY INVOLVEMENT

The sanitation policy of the South African government stresses that sanitation is not simply a matter of providing toilets, but rather an integrated approach which encompasses institutional and organizational frameworks as well as financial, technical, environmental, social and educational considerations (DWAF 1996). It is recognized that the country cannot afford to provide waterborne sanitation for all its citizens – nor, for that matter, should it necessarily aspire to do so. It is also acknowledged that, at all levels, the sanitation problem is related to socio-cultural, educational and institutional issues, with the lack of appropriate facilities and inadequate guidelines being a contributory factor.

Austin conducted research in a rural community at Emzamweni High School, which is a rural educational institution in South Africa that serves a number of low-income communities. Sanitation was a badly neglected aspect, with the facilities consisting of old, unimproved pit latrines, which were in a filthy and unhygienic condition due to a lack of proper care and maintenance. The Municipality decided to construct a new toilet block, using the opportunity to demonstrate ecological sanitation technology. The challenge was to introduce ecosan at an institutional facility, rather than in a home. The concept was therefore thoroughly workshopped with the principal and teachers, who would be ultimately responsible for transferring the required knowledge of operation and maintenance procedures to the pupils, in order to ensure proper use of the toilets. Information booklets and posters were also prepared and given to the school for use as teaching aids. Despite the careful preparation and intensive training, however, the teachers were not committed to ensuring that the pupils used the facilities properly, and the project was therefore a failure. Nevertheless, some valuable lessons were learned for future implementation of urine diversion sanitation projects at South African schools. The problem of ownership will always occur when something is given for nothing. Austin concluded that every school, no matter how poor, should contribute **something** towards new sanitation facilities in order to obtain some sort of commitment to proper care.

Experience gained from the national sanitation programme has shown that, in general, the biggest problem faced by households in improving their environmental sanitation is not an unwillingness to change or a lack of recognition of the problem, but:

- A lack of knowledge, i.e. not knowing how to build a VIP or urine diversion toilet;
- Lack of finance;
- Lack of access to water (both in quantity and quality).
- Lack of belief in themselves. People that do not believe that they can do anything to improve the situation themselves.

The health and hygiene component of the sanitation programmes has to focus on helping people directly address these issues rather than lecturing them without providing solutions.

The Low-cost Urban Sanitation Program started in Lesotho in 1980 as a pilot component of a much larger urban development project. By 1994 it had developed into a national program. The keys to the success of the low-cost sanitation program in general and particularly in the urban areas of Lesotho have been:

(1) an affordable and acceptable latrine design;
(2) minimal direct grants or subsidies to holders;
(3) all latrine construction done by the private sector;
(4) a comprehensive program of VIP latrine promotion, health and hygiene education;
(5) integration of the project into existing government structures and
(6) strong coordination in policy and planning between different departments promoting improved sanitation.

The projects adopted a participatory approach in which community members through their elected representatives were directly involved in the conceptualization, planning, design and implementation of the project. Participation in decision making enables the community members to understand the underlying principles for implementing the project, which is to educate and inform communities about the benefits of living in safer environments as well as good health practices and improved hygiene.

Sound professional practice in this context is about facilitating and supporting the process as much as possible and nurturing the process of planning and ensuring successful implementation of the project. Meetings with members of the community, officials and councillors are essential in order to achieve buy in.

The delivery of sanitation services involves two components, training of community members in health and hygiene best practices and the construction of the VIP latrines. In order to achieve the objectives identified, active participation in consultation increases communication between all role players and ‘ownership’ of both the health and hygiene programme and VIP latrines is realized. Community members are the most important role players in ensuring proper service delivery. Communities know their needs, resources, and capabilities, it is the community that will win or lose the most in any attempt to introduce basic sanitation.

However, effective participation requires commitment, honesty, clear boundaries, and is a two way communication process. Further, there is a need to undertake a comprehensive educational process whereby all the beneficiaries are exposed to health and hygiene best practices. Each beneficiary has to be trained on the operation and maintenance aspects of the VIP latrine system.

When the trainees get the chance to choose for an alternative they can be regarded as 'able to make an informed choice', but can also help the head of their household to make this choice. There are a number of aspects households should be made aware of before an informed choice can be made. These are:

- Costs of construction (if households have to pay themselves or partly contribute)
- Costs of maintenance and operation
- Essential acts to keep the system operational and hygienic
- Responsibilities at failure

During the training programme these aspects can be taught to the trainees.

Sanitation is the weakest part of the water and sanitation sector. The approach taken in Ethiopia by CRS to find simpler and more replicable solutions was commended by their project evaluators. It was recommended that the project consider adding more toilet designs as choices for households and communities, and each future project should aim for 100% toilet coverage within a short span of time involving a few weeks or months. It is not adequate to do demonstration toilets in communities and then leave. Projects need to stick with communities until they achieve full sanitation coverage. This may be achieved through community organization/mobilization and community management principles applied to the development of their water schemes. Toilets demonstrated should be fully replicable by all families regardless of income. This may mean promoting toilet designs that are even simpler than most projects now advocate or maybe even entirely different.

A type of latrine can be constructed with a variety of superstructures, seats, etc. It is preferable that a household chooses and pays for its own superstructure. The simplest form of appliance is a plain seat or pedestal, or a squatting plate (CSIR, 1991).

The materials used for latrine promotion, health and user education must be carefully researched and produced. They must consider the needs of semiliterate or illiterate people, address all income groups, and be carefully targeted and economically produced. Ideas taken from other projects are useful, but must be carefully adapted to ensure they suit the particular socio-cultural context at hand.

Cultural attitudes are unlikely to be the same in any two countries. In many countries, they will also differ from region to region. Sanitation work often touches on local traditions, beliefs, habits and customs. It is essential for the implementing agency to have a clear understanding of these factors. Such information must be researched thoroughly and treated with sensitivity. In some cases this knowledge can also be used to assist in the aims of promoting better sanitation.

5 STRUCTURAL REQUIREMENTS FOR VIP SUPERSTRUCTURES

Typical requirements are:

- Soft body impact resistance is measured by dropping a 30 kg sand bag twice from a height of 900 mm and twice from a height of 1 400 mm. No significant damage should be visible after the first two blows and the second two blows should not cause the structure to collapse.

- Hard body impact resistance is measured by dropping a 1.8 kg steel impact tool twice from a height of 375 mm. No significant damage should be visible after the test.

- The structure is tested to resist an outward wind pressure of 0.67 kN/m^2 on the walls and an uplift pressure of 0.67 kN/m^2 on the roof. The roof should be tied down and the connections to the walls should also be able to withstand the uplift forces.

- The structure should not be damaged by door slamming and to test the door slamming resistance a force of 150 N is applied to a 25 kg door that is open to 60^{o} and the door is slammed 10 times. No signs of damage should be visible after testing.

6 SUPERSTRUCTURES AVAILABLE

These systems are discussed below and where possible prices, as indicated in Appendix A were obtained in November 2009.

6.1 Moveable superstructures

Pre-cast concrete U-sections

The new pre-cast concrete toilets that were used in the R32,5 million Ugu District Municipality Rural Household Sanitation Project – Programmes 4, 5 and 6 that was implemented between March 2004 and March 2006 won the SAICE National Award for Community-based Projects in 2006 (SAICE, 2007). The purpose of this project, in keeping with the National Sanitation Policy, was to provide a socially acceptable basic level of sanitation to rural communities within the Ugu District Municipality which was economically feasible, sustainable, environmentally friendly and which assists in improving the current and long-term health status of the community with the provision of Ventilated Improved Pit (VIP) toilets, linked to health and hygiene education programmes for the beneficiaries.

In addition, implementation solutions targeting maximum utilisation of local labour and materials were aimed at creating employment opportunities and providing skills development during construction. Long-term sustainability was promoted by ensuring the training and use of local labour in the construction of the VIP toilets so that skills would be retained within the community for the construction of new toilets and for the removal and re-erection of toilets when pits filled up. Toilet superstructures have been designed to be removed and reinstalled in segments, over new pits, when the need arises. The new structure, as indicated in Figure 3, utilised pre-cast concrete culvert like ‘c-sections’ for the walls that are durable, maintenance free and sturdy, but at the same time modular.

Figure 3: Pre-cast C-sections (SAICE, 2007).

This allowed for transportation of components over difficult terrain, utilising of local people during construction, removal and re-assembly of the superstructure over a new pit when the pits are full. Pre-cast concrete slabs and wall sections were stored at central depots, and then transported through often steep and difficult terrain to individual household sites using local labour. The area over the pit was levelled and the cover slab positioned to receive the superstructure comprising four culvert-like precast concrete ‘c-sections’. The galvanised steel roof sheet, PVC vent pipe with flyscreen fitted to the cover slab and a wooden door and frame completed the toilet, which was then handed over to the beneficiary. The cost of the superstructure and cover slab (prior to installation) was R2 275 in 2007.

Cemforce Easy Loo VIP system

The CEMFORCE EasyLoo VIP Toilet as can be seen in Figure 4 is constructed by installing a toilet superstructure with a floor slab over an unlined, partly or completely lined pit. The toilet complies with SANS 10365-1:2004 specifications and bears an Agrément South Africa certificate of approval (Cert. No.: 299-2003). The internal measurements of the superstructure are 1 100 mm deep x 840 mm wide x 2 000 mm high. The door, made from 1 mm thick galvanized steel and measuring 815 mm x 1 800 mm high, opens outwards on a steel pivotal hinge and has a spring-loaded lockable latch. The walls and roof of the toilet are manufactured under controlled factory conditions as 40 mm thick lightweight cement panels and assembled with 8 mm bolts on site.

Figure 4: Cemforce Easy Loo VIP (http://www.cemforce.com)

The panel construction resembles a sandwich of two 6 mm glass reinforced cement (GRC) skins and a 28 mm polystyrene and cement core. When the pit is full, the toilet can be moved to a new pit with a simple tool they developed. This can be done at household level without having to take the toilet apart or the use of expensive machinery. The dimension of the floor slab are 1 500 mm x 2 000 mm x 75 mm thick and it is manufactured under controlled factory conditions from polystyrene cement (density 1000 kg/m^3), reinforced with #156 steel reinforcing mesh and a hard wearing single 6mm GRC skin applied on top.

The plastic pedestal (Atlas Plastics Type VIP 300, colour: granite) with white plastic toilet seat and cover (DPE FR01 ELF 82) is a standard fitting to the toilet. The vent pipe is 110 mm in diameter and 2 700 mm long (extending more than 500 mm above toilet structure) in black plastic with patented vent hood. All holder bats and bolts to tie the pipe to the roof slab are supplied with the toilet kit and the cost was R3 000 (delivered to site) in 2009.

Rocla one-piece or panel toilet

Rocla has for years produced a one-piece pre-cast concrete toilet as can be seen in Figure 5. This toilet is delivered to site in one piece and it is known to last well but criticism against these toilets has been that the units are very heavy and cannot be moved without lifting equipment.

Figure 5: Rocla one-piece and panel toilets (http://www.rocla.co.za)

Rocla has in the recent past been manufacturing a new light weight concrete sanitation unit which consists of a panel toilet with internal dimensions of 900 mm wide, 1100 mm deep and 2000 mm high that can be assembled within 15 minutes on site.

The panels are bolted together and the toilet can be relocated by the household. The toilet is located on a circular base that acts as slab over the pit. The pit can be accessed through an opening in the slab as indicated in Figure 5. Rocla has been partnering with municipalities and communities to set up small factories to produce the panels with labour intensive construction methods. One manufacturing setup can manufacture large numbers of units in one month. These units are offered for R3 500 per superstructure (delivered to site in 2009).

Amalooloo

The superstructure of the Amalooloo, as can be seen in Figure 6, consists of eight concrete panels manufactured with 40 MPa concrete and reinforced with 4 mm deformed wire. The structure is available in kit form and it is designed to be assembled with minimal training by non-skilled persons from local communities. The complete structure can be dismantled and re-erected elsewhere. The Superstructure can be upgraded to a waterborne system without structural changes. The manufacturers state that the structure is not only able to withstand wind forces as laid down by SABS 0160 – 1989 but also the vertical movement of heaving sub-soils without cracking. The superstructure was sold for R2 400 per unit in 2009.

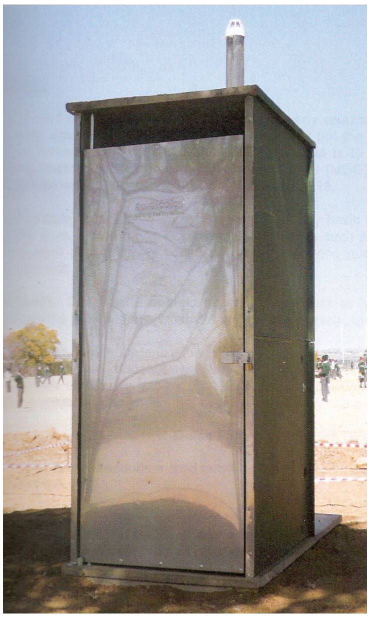


Figure 6: Amalooloo toilet (http://www.amalooloo.com).

The Amalooloo toilet comes with a specially manufactured door as well as a patented plastic pedestal and special child seat as well as a basin that can be used for washing hands inside the unit. The water from the basin drains into a cistern that can be used to operate the toilet as semi flushing. The extra water that enters the pit can be accommodated with the special pit liner that can form part of this system.

Camdeloo

The Camdeloo VIP consists of pre-cast concrete panels as can be seen in Figure 7. The concrete floor slab is cast in situ while the superstructure is pre-cast and bolted together on site. This system is labour intensive and local manufacturing ensures that the money spent on providing sanitation remains in the community.

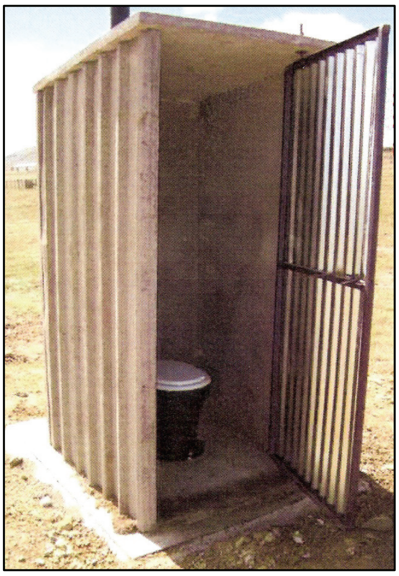


Figure 7: Camdeloo superstructure (Camdekon Engineers, 2009)

Eldoloo

The Eldoloo superstructure that can be seen in Figure 8 consists of eight 50 MPa pre-cast concrete panels reinforced with 5.6 mm wire mesh. The wall panels are design by a structural engineer and all panels are tested for impact loading. The base panel is load tested to carry a load of 1.5 kN/m^2. The galvanized door of this superstructure is spring loaded to ensure that the door is always closed thus preventing wind damage. The Eldoloo superstructure cost R2 600 delivered to site in 2009.

Figure 8: Eldoloo superstructure (Eldocrete, 2009)

HS Mark 7 Composting sanitation system

This fibreglass system is supplied in component form for site assembly and installation as indicated in Figure 9. The estimated cost of the kit (excluding the pit liner and composting unit) was in the region of R2 200 in 2007.

Figure 9: HS Mark 7 Fibreglass Composting Sanitation System
Pioneer Plastics portable toilet hut (Hungerford Schroeder, 2007)

Pioneer Plastics uses a rotational moulding machine to manufacture portable plastic toilet huts. The outside and inside of such a hut can be seen in the photo in Figure 10. The cost of such a hut was quoted as R3 933 in 2007.

Figure 10: Pioneer portable plastic toilet hut (http://www.pioneerplastics.co.za)

JoJo tanks toilet hut with pedestal

JoJo tanks is the largest manufacturer of water tanks in South Africa and although they started manufacturing fiberglass water tanks in the 1970s, they decided to increase the robustness of their products by changing to polyethylene in the 1980s. They manufacture toilet huts as can be seen in Figure 11. In 2007 the quoted cost of such a hut was R2 273.

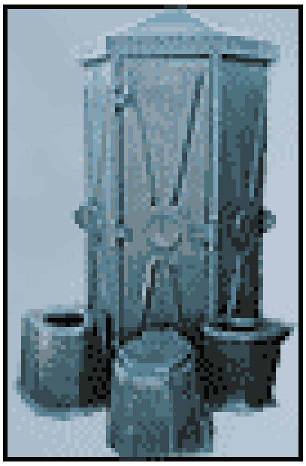


Figure 11: JoJo toilet hut with pedestal (http://www.jojotanks.co.za)

6.2 Non moveable superstructures

Compressed stabilized earth blocks

In places where the soil is not very stable it is necessary to line the pit of a VIP toilet to prevent it from collapsing. Mvula uses wedge-shaped blocks, arranged in a circle, to line pits. These form a strong arch, and neither mortar nor "brick force" is required to hold them together. Mvula has also designed a simple portable mould so people within communities can make the blocks on site thereby supporting local economic development.

The Hydraform building system, as shown in Figure 12, uses interlocking blocks with minimal mortar due to interlocking shear keys and minimal plaster due to its face brick finish. This interlocking masonry system enables speedier construction of high quality, aesthetic and affordable building. The standard Hydraform block measures between 220 and 240 mm long, 220mm wide and 115 mm deep, has beveled or chamfered edges and weighs between 9 and 12 kg. Specialized equipment can be used by rural communities to manufacture their own building blocks and 7 or 8 people can manufacture up to 200 blocks per hour. Hydraform blocks (220 x 120 x 115) are sold for R3.60 per block (excluding VAT). The cost of a dry-stacked superstructure built with these blocks was calculated at R2 252.12 in 2007.

Figure 12: Hydraform interlocking blocks made from compressed stabilized earth (http://www.hydraform.com)

Archloo

The Archloo structures (see Figure 13) are built entirely without reinforcing. Hessian is present in the catenary purely as an in-situ formwork. Wall thicknesses can be as low as 25mm. The Archloo superstructure is produced by draping (stapling) course hessian between two catenary forms. This hessian is then painted with thin slurry, and then a thin layer of plaster is added. Up to 3 layers of plaster are added, allowing drying time

(4-7hrs) between layers. The cost of the structure varies massively with the area, cost of sand, cost of cement, etc. but the quoted material cost for Pretoria was R2 232 in 2007.

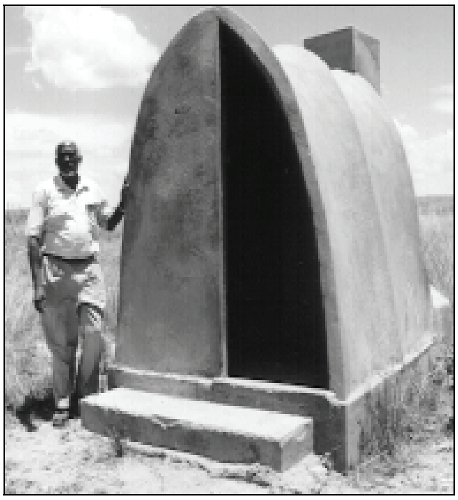


Figure 13: Example of Archloo superstructure (http://www.gde.co.za)

Conventional brick and mortar structures

Various authorities use different brick VIP superstructures. Typical layouts for a VIP can be seen in Appendix B with details provided by the CSIR (Bester & Austin, 1996). The cost of various layouts as well as options for making cement blocks and purchasing bricks were compared in Appendix A. As labour cost was not taken into account in any of the calculated costs, the options with large community involvement (such as making blocks and casting slabs) seems to be the cheapest, but the actual cost of community involvement will have to be added to the material cost.

Comparison of systems

A list of different systems available with the material cost of each can be seen in Appendix A. It is difficult to compare the cost of the systems as the cost of the pre-manufactured systems includes the cost of labour while the labour component required to construct the block and brick structures is not included in the material cost. It is clear that there is very little difference in cost between the systems and it is factors other than cost that will determine which superstructure is most suitable in a specific environment. The least expensive superstructure would have been one made of natural materials such as reeds or timber but that is not deemed to be durable. Corrugated iron superstructures get too hot and are no longer seen as an acceptable alternative. There is a perception that the plastic and fiberglass superstructures are less durable and are likely to be blown over in a storm. The systems with the largest community involvement are the systems where the bricks and slabs are manufactured by the community, but these systems are also prone to failure as a result of lack of quality control. The systems that seem to work the best are the pre-manufactured systems that are just assembled on site. The only way of improving the systems already in existence would be to reduce the volume of material used per toilet superstructure.

7 PRELIMINARY INVESTIGATIONS BY THE UNIVERSITY OF PRETORIA

At first the development of a moveable superstructure for a VIP toilet sounds like a technical challenge, but the literature reviewed indicate that the technical challenge is not the main problem with the provision of VIP superstructures. There are systems available that should meet the need of the societies, but there seems to be other stumbling blocks that limit the success of these systems. These stumbling blocks could be any combination of the following:

- Inferior quality of systems available;
- Community perception that systems are inferior;
- Lack of community buy in (unwillingness to accept that waterbourne sewer system is not an option or unwillingness to handle human waste);
- Lack of community participation;
- Lack of health training;
- Lack of training on how to use and maintain VIP toilets;
- Lack of training on how to build VIP toilets;
- Lack of centralized roll out policy.

The literature reviewed clearly indicates that it would be impossible to develop a system without active participation from the communities that will be the end users of the product. Community health training is an essential prerequisite for successful implementation of a sanitation system. The more successful systems seem to involve the local builders in the manufacture and construction of the toilets.

7.1 Technical requirements for options initially investigated

Based on the literature reviewed it was decided that the system that is developed must meet the following criteria:

- The superstructure should be useable for different types of sanitation systems.

- The slab should be manufactured to allow access to the pit other than through the pedestal.
- The superstructure has to be moveable.
- The superstructure must be adjustable to allow changes in layout.
- The local community must benefit financially from the construction process.
- The superstructure has to be durable and aesthetically acceptable.
- The risk of failure of critical components has to be limited.

It was decided to investigate two types of systems, with the first being a system that can be dismantled while the second uses blocks that can be re-used if the structure is moved. The volume of material used will be reduced by using very high strength concrete for the panels and entraining large volumes of air (more than 50% of the volume) into the blocks.

7.2 High strength concrete

A fourth year Civil Engineering student at the University of Pretoria has completed his final year research project on developing an alternative VIP toilet system and more detail can be found in his report (Bateman, 2007). He chose to use high strength concrete panels that vary in thickness between 16mm and 20 mm. These panels have been tested and they meet the structural requirements for Agrement certification. The VIP superstructure that he built in the Civil Engineering laboratories of the University of Pretoria can be seen in Figure 14. The panels can be manufactured in a factory and transported to site where local labour can be used to construct the units. Alternatively it is an option to provide rural communities with bags of blended material that can be mixed with a small mixer and cast into moulds without vibration. By training rural builders and setting them up with basic equipment and moulds, it should be possible for rural communities to make their own pre-cast panels.

These builders could operate in a type of franchise system where they do not have to pay for the materials and equipment up front. They could also get start-up funding by extension of the pilot project that will form part of this project. The pre-blending of materials (sand, cement, etc.) will limit the risks taken by the rural builders.

Figure 14: Casting of high strength panels

Local people can also be trained to conduct quality control testing such as a “sandbag test” which would immediately indicate whether the product has been manufactured to specification. The sandbag test is indicated in Figure 15, where a 30 kg bag is dropped from a height of 900 mm resulting in no visible damage and a height of 1 400 mm without destructing the panel. These panels can be assembled on site and moved with three people.

Figure 15: Sand bag test

Limit state design principles, as indicated in Figure 16 were used to design the reinforced concrete panels. It is assumed that the stresses caused by the bending of the panels under load conditions will be resisted by the interaction between the steel and the concrete. The concrete forms a compression block while the steel yields in tension. The probability of failure is limited by the use of partial safety factor and a material safety factor (γ_m) of 1.5 and 1.15 is used for the concrete and the steel respectively. A load safety factor of 1.2 is used for own weight while 1.6 is used for imposed load. The panels were designed to withstand their own weight during movement and wind loads once constructed. The floor panels were designed to withstand a load of 500 kg.

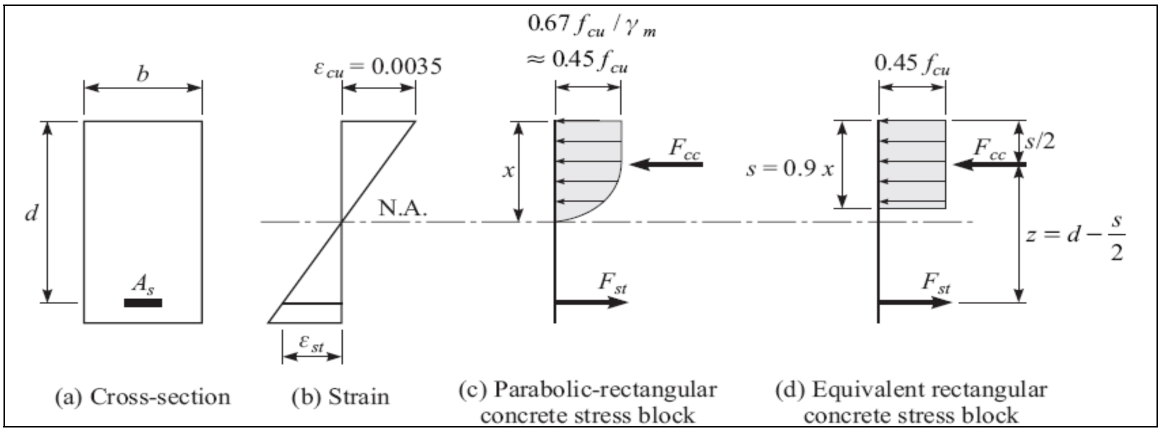


Figure 16: Reinforced concrete design principles

To minimize material cost for the wall and roof panels, it was decided to use a standard 50 x 50 x 3 mm mesh. To minimize the volume of concrete required a characteristic concrete strength (f_{cu}) of 80 MPa was used. The panel thickness can be adjusted for lower or higher strength concrete. With the chosen material composition the roof slab needs to have a thickness of 16 mm, the walls 20 mm and the floor slab at least 25 mm.

The floor slab was cast as a single unit with six handles to move the panel and a 200 mm deep down-stand to ensure that groundwater would not seep in under the slab thus causing collapse of the pit. The mould before casting but with the steel reinforcing in place can be seen in Figure 17. The base weighed 160 kg, which means that 6 people were required to move the slab. It is also impossible to get access to the pit from outside the superstructure while the latest research indicates that proper access to pits is essential (Bhagwan et al., 2008). It was therefore decided to investigate a modular system that can be adjusted to suit individual requirements for emptying of the pit as well as variations in superstructure layout.

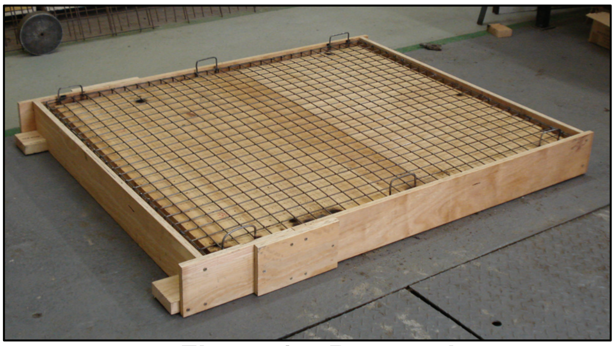


Figure 17: Base slab

The first version of a slab system that allowed for access to the pit can be seen in Figure 18. The system consisted of high strength beams that can be pre-cast in a factory and infill panels that can be cast on site. The superstructure bolts to the beams, thus reducing the risk of collapse of the slab.

Figure 18: Slab system

For the first version of the superstructure, each panel was cast into an angle iron frame that acted as a permanent shutter. The panels could be connected on site by tack welding the panels as indicated in Figure 19. The structure would have to be painted to prevent the steel from rusting. Problems were experienced with connecting the roof to the walls and the risk of rusting was deemed to be too high. It was thus decided to use galvanized steel bolts for connections. By casting long nuts and small ducts into panels the panels can be bolted together on site. An example of a cast in long nut in the end of a beam can be seen in Figure 20.

Figure 19: Steel angle iron connections

Figure 20: Galvanized long nut connection

The cost of the superstructure was calculated in 2007 as can be seen in Table 4. This cost will still increase when the cost of precision moulds is included. It is clear that the cost of the steel door is excessive and other alternatives for doors had to be investigated. It may be necessary for communities to make their own doors.

Table 4: High strength concrete cost in 2007

High strength concrete panels		
Component	**Mass (kg)**	**Cost (R)**
Side Panel	80.00	R 219
Side Panel	80.00	R 219
Rear Panel	80.00	R 70
Roof	25.00	R 26
Steel Door	17.00	R 455
Accessories:		
Vent pipe, flyscreen		
and Pedestal		R 250
Bolts		R 50
Base	160.00	R 269
	442.00	**R 1,558**

7.3 Lightweight building blocks

The literature indicates that there could be a possibility that rural communities would prefer to have VIP superstructures made from bricks. To ensure ease of construction and quality control, lightweight concrete blocks can be manufactured using equipment and material supplied by large enterprises to small businesses working in a franchise type of setup. The volume of materials (sand and cement) required can be limited by entraining large volumes of air into the blocks, resulting in large lightweight blocks. The equipment required is available on a trailer as indicated in Figure 21 and the business can move around by putting the cement on a small truck while pulling all the equipment. The equipment is specially developed to manufacture 180 l of foamed concrete from a bag of cement, two bags of ash and a twenty litre pail of water. It is also possible to pre-mix and bag materials to ensure quality.

Figure 21: Equipment required for making foamed concrete blocks

The blocks can be stacked dry as indicated in Figure 22. The blocks in this photo are 200 mm high, 200 mm thick and 400 mm long and they can easily be handled by female builders without the skills normally required to build a masonry wall. The size of the blocks can be adjusted to suit. To ensure that the walls are not blown over in storms, the blocks can have holes in the core, through which a steel bar can be placed to tie the roof to the floor slab.

Figure 22: Dry stacking of lightweight blocks

After the blocks are placed, polypropylene net, or carpet backing can be placed over the surface. The net can be kept in position with a staple gun and a small compressor can be used to spray a cement paste layer onto the surface as indicated in Figure 23. If this system is used for a moveable superstructure, the net can be pulled off the surface, the bricks can be re-used and a new layer of net and sprayed concrete can be applied within a day. A local contractor can be trained to do this.

Figure 23: Spraying of surface

The cost of the superstructure manufactured using the foamed concrete block system as described can be seen in Table 5.

Table 5: Foamed concrete superstructure cost in 2007

Foamed concrete blocks				
Ground Slab	Item	1	R 269.00	R 269.00
Foamed concrete blocks (440x110x200)	No	85	R 8.00	R 680.00
Polypropylene netting	m2	23	R 5.00	R 115.00
Plastermix	l	115	R 0.89	R 102.35
6mm Reinforcing (5.8m lengths)	No	2	R 10.16	R 20.32
Corrugated iron sheet (1800x600mm)	No	2	R 78.00	R 156.00
75mm high precast lintel	No	1	R 24.00	R 24.00
1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
Steel Door	No	1	R 455.00	R 455.00
2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
Micselleneous Items	Item	1	R 50.00	R 50.00
				R 2,020.67

7.4 Preliminary conclusions

During the development process it was decided that the only way to improve the systems currently in use would be to enable communities to take ownership of the system by manufacturing and building as much of the system as possible. The building industry has been experiencing significant problems because of the low quality of building materials used and the lack of training of builders to make informed decisions when choosing materials.

Community involvement in manufacturing and building VIP superstructures can only be successful is a proper quality control system is in place. It is suggested that a franchising system is used, where the materials needed is pre-blended and sold to the communities in bags that eliminate the need of precision batching to ensure quality.

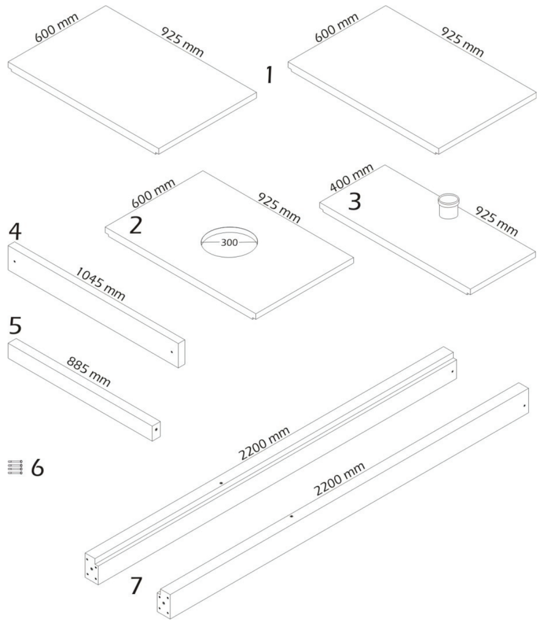
Initial indications were that both the high strength concrete panels and the foamed concrete blocks would be feasible systems and both alternatives were developed further. Information obtained from the literature review as well as discussions with stakeholders influenced the systems investigated in the final phase of this project.

8 SYSTEMS DEVELOPED AT THE UNIVERSITY OF PRETORIA

8.1 Base system

With the development of a base system it was decided that the system must be flexible to ensure that the base can be used with different superstructure layouts. It must be possible to empty the pit without accessing the superstructure and the local community must be able to cast and construct the slabs without extensive training or equipment. The components for the recommended base system can be seen in Figure 24.

Local collapse of the pit has caused some slabs to fall into the pit and therefore it was decided to use an edge-beam system (base support beams) that would make it impossible for a small section of the slab to fall into the pit. Edge-beams, with the capacity to span more than 2m, on both sides of the pit will ensure safety. These beams need to be light and strong and as the safety of the whole system depends on the edge-beams, it is recommended that these beams are manufactured in a pre-cast factory where pre-stressed concrete is manufactured. These edge beams are 80 mm wide and 125 mm deep and they contain four pre-stressed wires each.



Components

1) 2 x Base Panels (no holes or pipe inserts)
2) 1 x Base Panel with 300mm hole
3) 1 x Base Panel with PVC Waste attachment
4) 1 x Front Cross Beam
5) 1 x Back Cross Beam
6) 4 x Stainless Steel Bolts
7) 2 x Base Support Beams

Figure 24: Base system

The rest of the base system can be cast by communities in small factories in the communities. A system of precision steel moulds can be used to ensure that the components fit together tightly. The components fit together as indicated in the diagram in Figure 25 and a completed base system can be seen in the photo in Figure 26. The base components can be carried by hand and assembled in minutes.

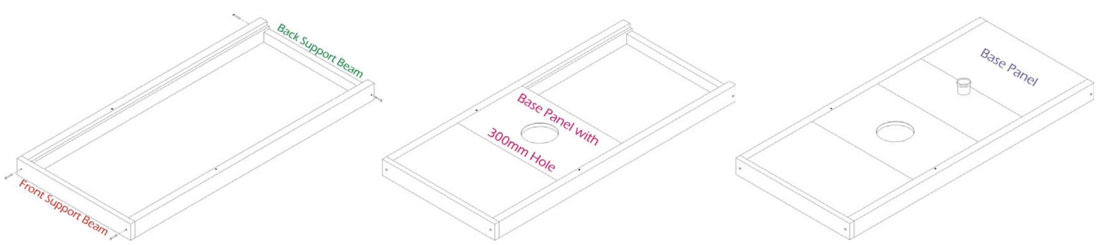


Figure 25: Assembling base system

Figure 26: Base system

8.2 High strength wall panels

Based on the preliminary work conducted by the final year research project student (Mr Bateman) in 2007, a panel system as indicated in Figure 27 was developed. Although the 16 mm thick panels developed in 2007 were strong enough to withstand all forces, the visual impact of the very thin structure was such that it felt unsafe. It was therefore decided to thicken the edges of all panels. All panels are manufactured in precision moulds and the connections are formed through casting nuts into panels at exact locations. The panels can be bolted to the base and each other as indicated in Figure 28. Assembling this system takes minutes.

The ease of the assembly process can clearly be seen in the photos in Figure 29. The structure can be taken apart to move, but it is also light enough to move as a whole with a jack trolley as indicated in the photo on the right.

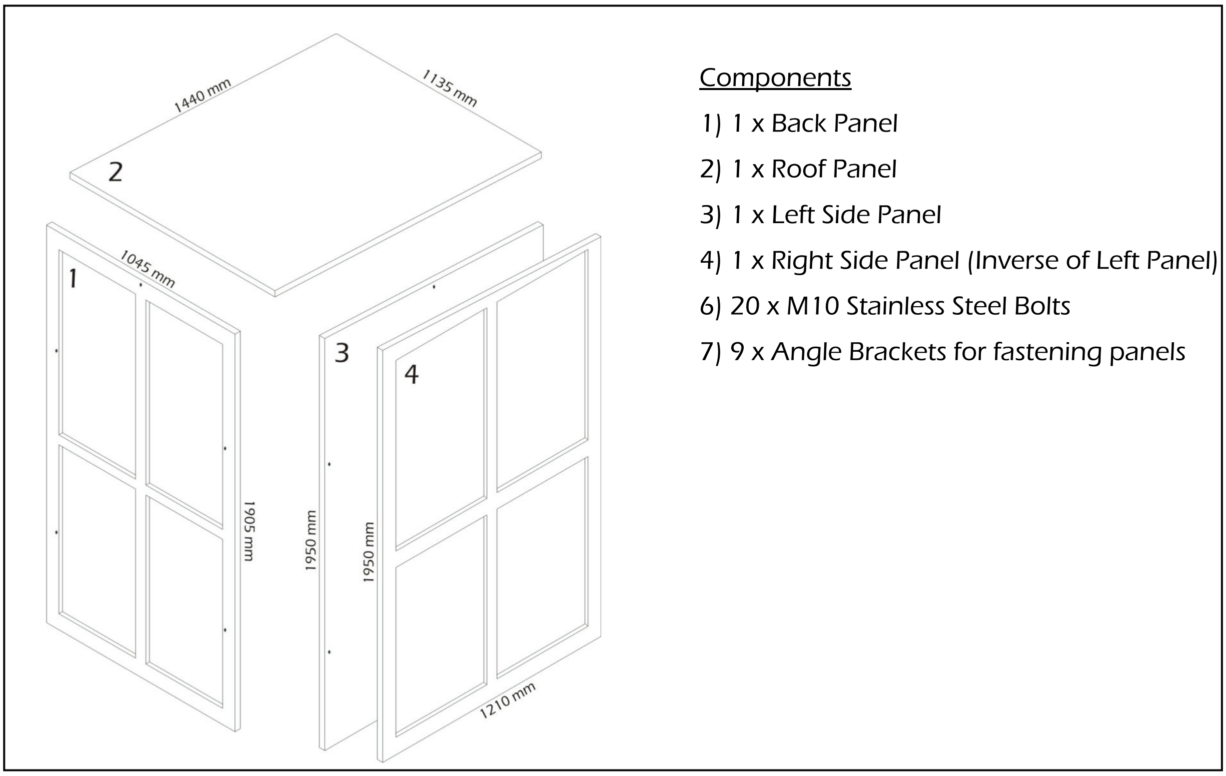


Figure 27: Wall panel components

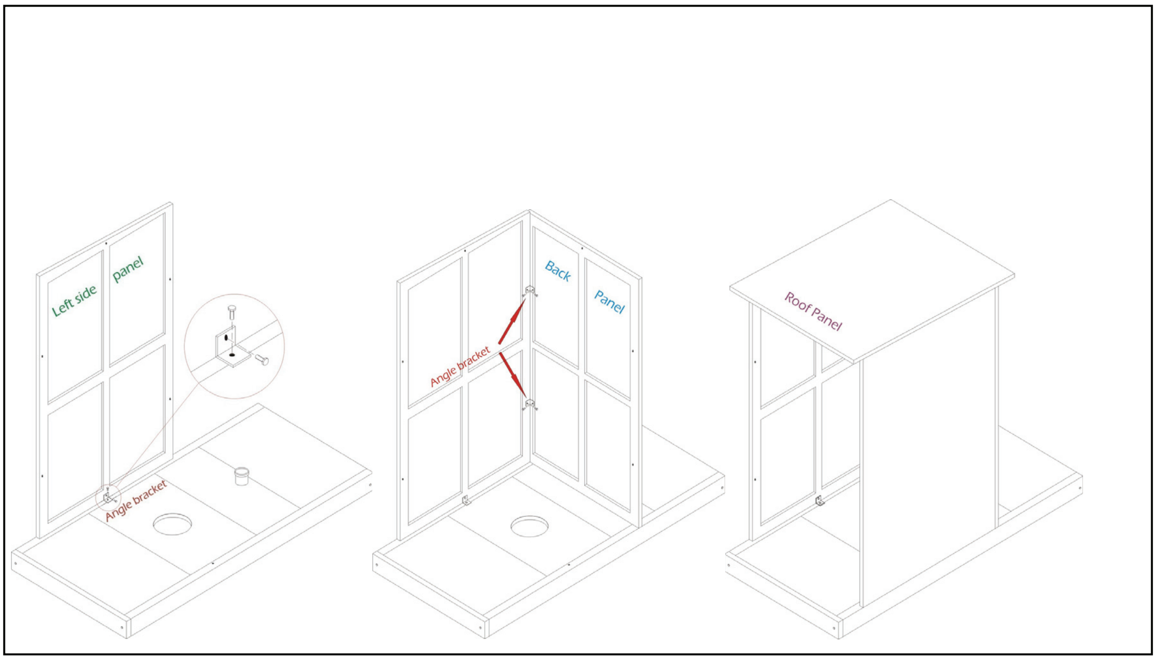


Figure 28: Wall panel assembly

Figure 29: Photos of panel assembly

8.3 Foamed concrete block walls

The second system under consideration involved the use of lightweight blocks made of foamed concrete. The blocks are cast in gang-moulds that interlock (see Figure 30) and can easily be assembled by unskilled labour.

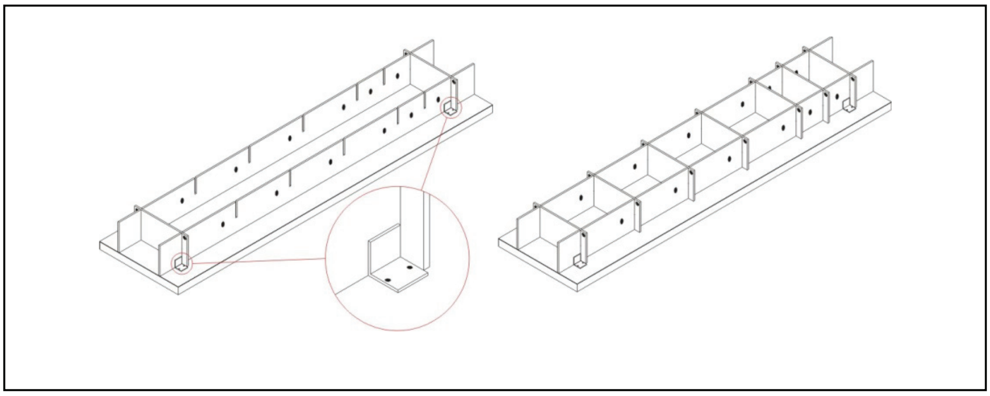


Figure 30: Gang-moulds for foamed concrete blocks

These blocks are manufactured by mixing a mixture containing air entrainer in a high speed shear mixer as indicated in Figure 31. The mixture materials are again pre-blended and supplied in bags. The community can make their own blocks by just adding a pail of water to the bag of blended materials in the mixer.

<u>Required Tools</u>

- Lightweight Concrete Mixer
- Steel Trowel & Plastic Trowel
- Scraper
- Pliers
- Wheel Barrow
- Measuring Scale
- Set-square
- 1l Bucket

Figure 31: Casting foamed concrete blocks

The fact that these blocks are precision cast means that they can be dry-stacked as indicated in Figure 32. After stacking blocks the structure can be wrapped in polypropylene netting (similar to carpet backing). The structure can then be plastered using a pigmented cement plaster. The finishing can be sprayed on. To ensure stability and keep the roof in place, threaded rods are used on the corners of the structure and horizontal spreader beams of high strength concrete are used at the level of the door hinges.

Figure 32: Stacking and wrapping of block structure

9 STRENGTH TESTING

9.1 Background

There are no standard requirements for a VIP superstructure and very few systems that are currently in use meet the building requirements or have an Agrement certificate. To ensure that any superstructure that is manufactured is strong enough some criteria should be met.

It was decided that the Agrement minimum strength criteria would be suitable measures to evaluate the superstructure. As the superstructure is relatively light, the wind loading on the roof and the walls as well as impact of heavy objects could be causes for failure.

It was more difficult to decide what a fair strength requirement for the base system would be. If the superstructure is used for the intended use, a design pointload of

0.9 kN or a uniformly distributed load of 0.5 kN/m^2 would be used. In the design process these loads would be multiplied by a load safety factor of 1.6. A material safety factor of 1.5 would be used in design, resulting in a combined safety factor of just more than 2. The strength of the panel as determined through physical testing thus have to be more than twice the strength required from calculations to ensure that the risk of failure is limited.

As only a limited number of samples were tested there is a chance that the results are not representative of the average. The sample tested could be at the top end of the strength distribution, which means that an additional safety factor would be required and this factor is dependent on the repeatability of the manufacturing process used in the factory where the products are made. To take this additional risk into account, the actual measured failure load that elements can resist should be between 3 and 5 times the load that could be experienced during use.

9.2 Concrete strength

The concrete used for the high strength fibre reinforced concrete superstructure had a characteristic strength of 80 MPa, which means that 95% of the concrete cubes crushed after 28 days of curing in water baths have to be stronger than 80 MPa. The typical strength development of the concrete can be seen in the graph in Figure 33.

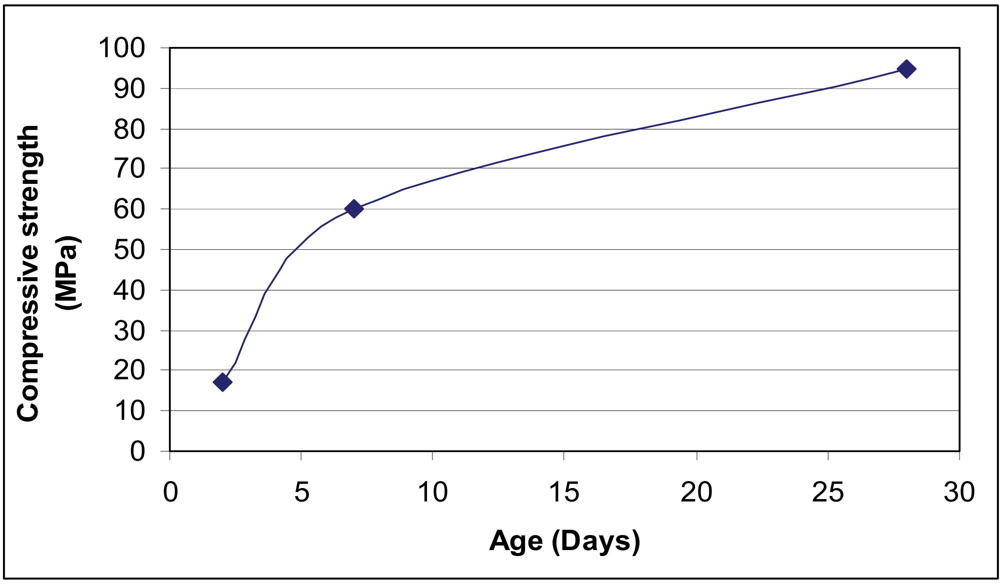


Figure 33: Concrete strength development

9.3 Base system

All base panels are made of 80 MPa concrete and contain 80 kg/m^3 high strength, hooked ended, hard drawn wire fibres. The panels are reinforced with a steel mesh that can be cut to fit the moulds (50 mm x 50 mm x 1.6 mm mesh). It was impossible to design the panels with the holes in them and therefore it was decided to conduct trial and error testing until the beam system around the openings meets the strength requirement.

The plain floor panels were tested first and a point load was applied to the centre of the panel while the panel was supported on the ends as can be seen in Figure 34. This load represents a person standing on the floor panel and the load deflection behaviour of the panel can be seen in the graph in Figure 35.

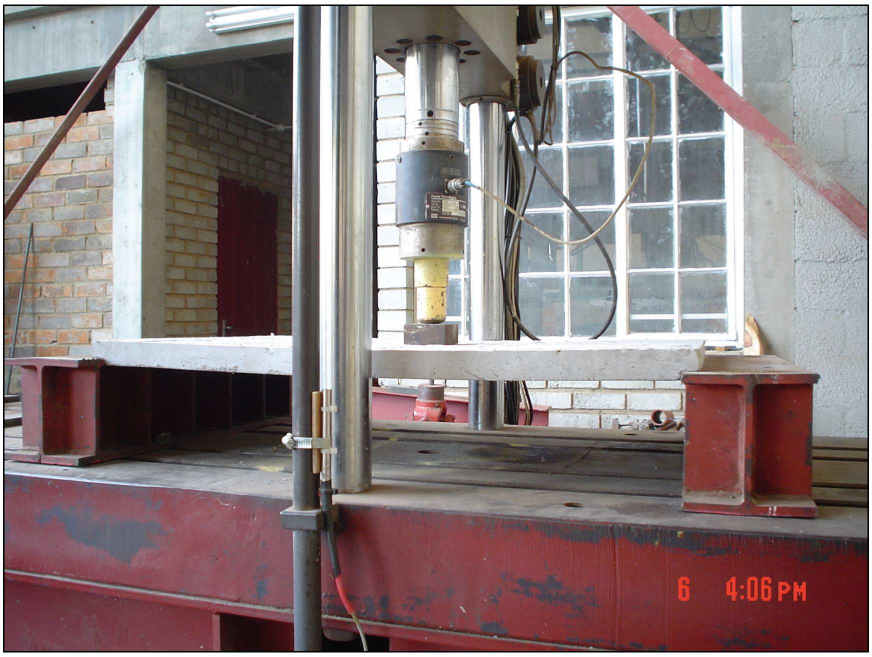


Figure 34: Testing floor panel

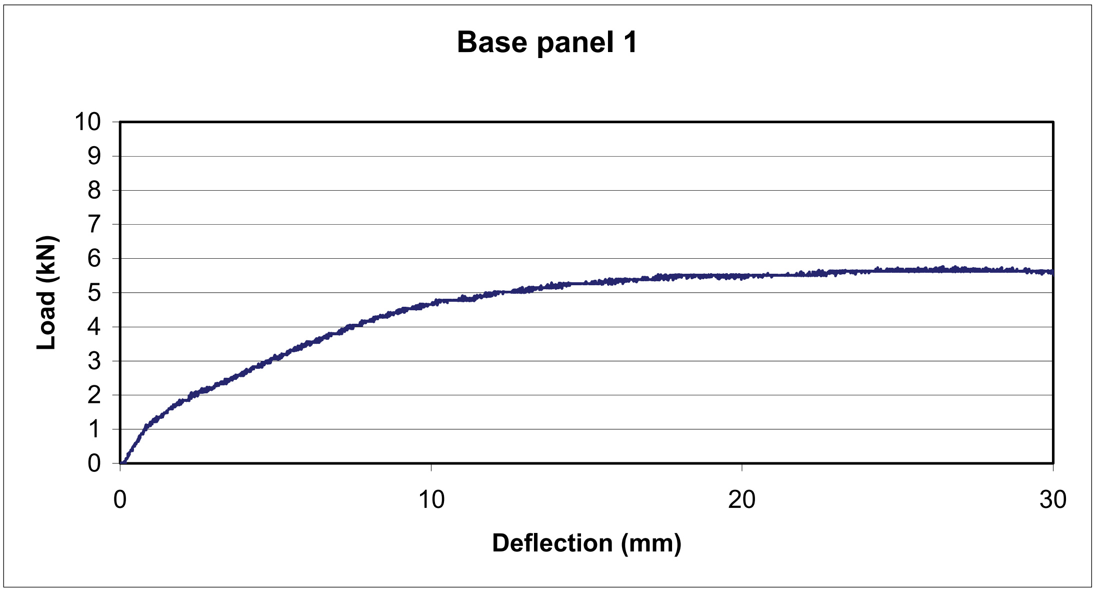


Figure 35: Load deflection behaviour of floor panel

From the graph in Figure 35 it can clearly be seen that the steel in the panel only starts flowing after the point load exceeded 5 kN and therefore the panel is deemed to be strong enough to resist any reasonable load that it should experience in use.

In Figure 36 the panel with the opening for the vent can be seen after failure. These panels needed a thicker edge beam to ensure that it does not fail prematurely as a result of the opening in midspan. The actual load deflection behaviour of this panel can be seen in Figure 37. This panel can carry a much higher load than the plain base panel, but it is the panel that would have to support the wall panel and any additional load incurred from material stored on the roof of the structure.

Figure 36: Panel with opening after testing

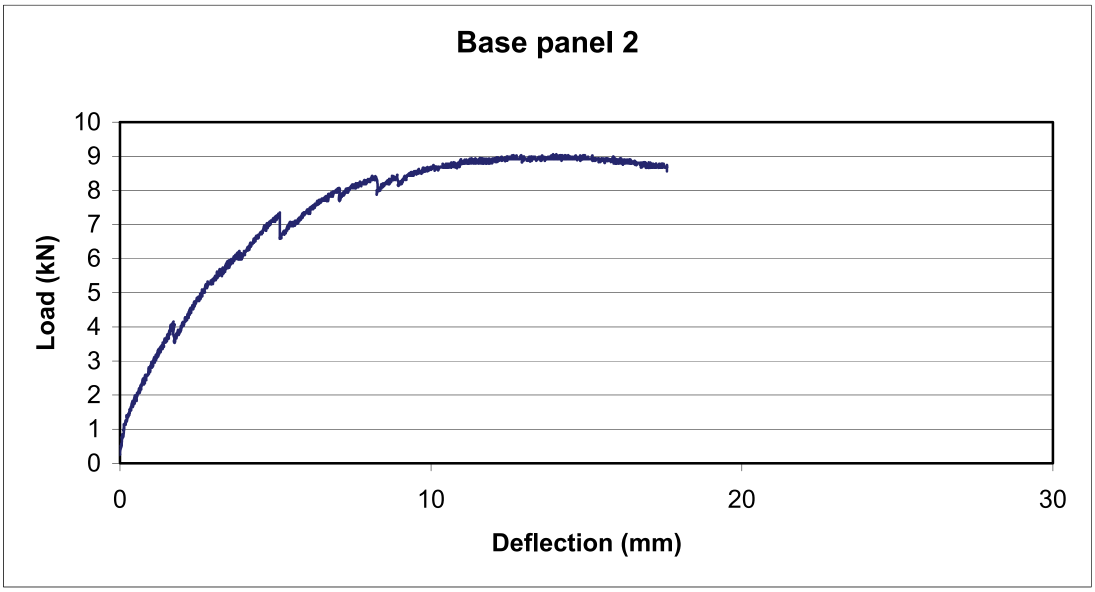


Figure 37: Load deflection behaviour of base panel with opening

It is important to note that the failure is ductile and the panel is still in one piece. This type of failure will ensure that the users of the superstructure have sufficient warning of impending failure to prevent loss of life in case of severe abuse of the structure.

Theoretically the edge beams of the floor slab system should be supported by soil over the full length of the beam and only the floor panels should span over the pit. If however the pit collapses the beams must be able to carry the load of a person on the floor slab to ensure that the person using the VIP toilet does not fall into the pit. The edge beams were tested by supporting only the ends and applying a load to the centre of the beam as indicated in Figure 38. The load deflection behaviour of the side beams can be seen in Figure 39. Two beams were tested and it can clearly be seen that limited deflection takes place for loads of up to 5 kN.

Figure 38: Testing of edge beams

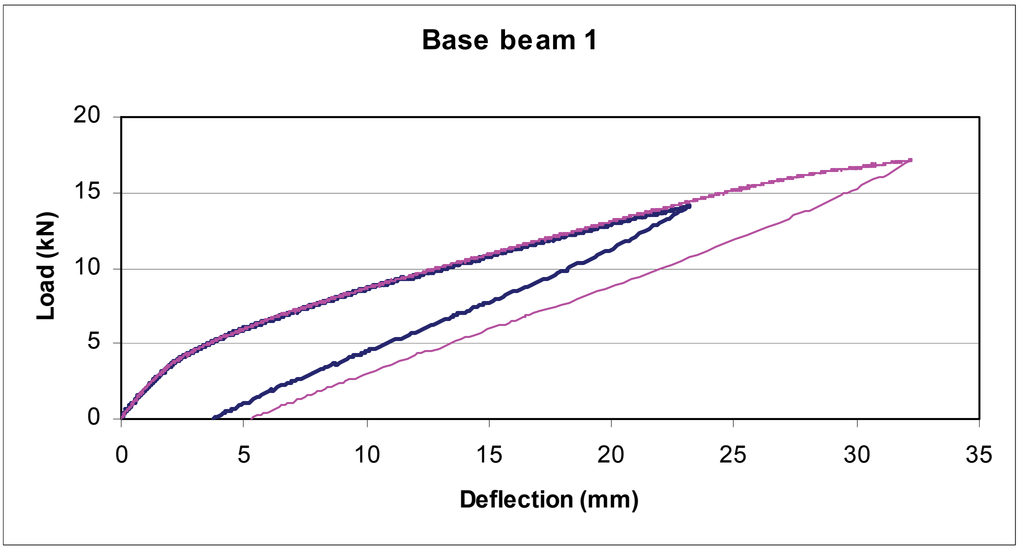


Figure 39: Load deflection behaviour of edge beams

9.4 High strength panels

All panels required for the superstructure were made of 80 MPa concrete and contained 80 kg/m^3 high strength, hooked ended, hard drawn wire fibres. The panels are reinforced with a steel mesh that can be cut to fit the moulds (50 mm x 50 mm x 1.6 mm mesh). A 5.6 mm diameter high yield steel bar is required as reinforcing in each of the thickened sections of the wall and roof panels and these bars can be bent and cut in the factory.

The wall and roof panels were tested by loading them at third points with line loads as indicated in Figure 40. Each type of panel was loaded from both the inside and the outside (from the side with the thickened sections and the smooth side).

The load deflection behaviour of the back panel can be seen in Figure 41. The blue line in the graph was plotted for a panel tested with the smooth side to the top, while the pink line was plotted for a panel tested with the thickened beams to the top. It can be seen that for the panel tested with the smooth side to the top a load of 1.5 kN can be resisted without the concrete cracking and the maximum load supported is in the region of 2.8 kN. A load of 1.5 kN results in a bending moment of 0.45 kNm and uniformly distributed wind load of 1.11 kN/m^2. This is significantly more than the design wind load of 0.3 kN/m^2.

Figure 40: Test setup for wall panels

The panel that was tested with the smooth side to the bottom had a lower stiffness and deflected more at equivalent loads. The second panel does however show linear elastic behaviour up to a load of 2 kN.

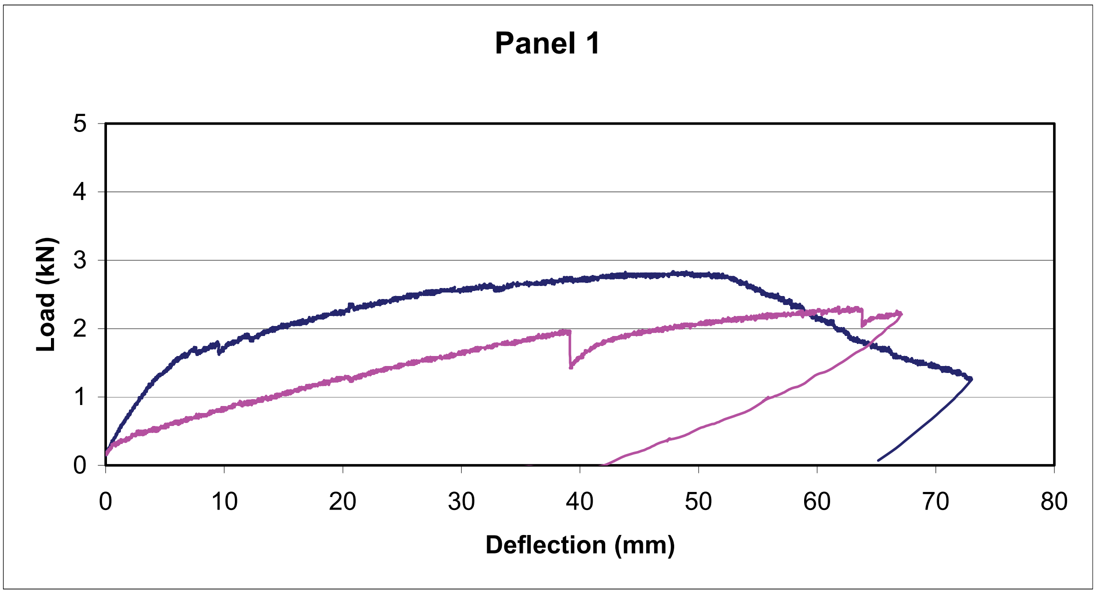


Figure 41: Load deflection behaviour of back wall panel

The roof structure was tested for uplift as well as extra loading and a container with 450 litres of water was placed on the roof, as shown in Figure 42, while the movement of all panels was recorded. Insignificant movement took place during the loading and no creep was observed during the five days that the structure was loaded.

The superstructure was also subjected to the soft body impact test as well as the hard body impact test as prescribed by Agrement SA and the structure seems to meet the requirements of both these tests.

Figure 42: Load on roof of VIP superstructure

9.5 Block walls

The foamed concrete strength decreases with density. The shear mixing process produces foamed concrete with a dry density between 1 000 and 1 200 kg/m^3 and this density results in a minimum compressive strength in the region of 10 MPa. Normal bricks have a compressive strength between 3 and 10 MPa and 110 mm thick brick walls have been successfully used for VIP superstructures. The structure will not blow over as threaded rods are used in the corners and tied to the base and the roof. The spreader beams ensure that the whole structure acts as a unit.

10 FINANCIAL VIABILITY OF DIFFERENT OPTIONS

Hardware store prices were used to cost the materials. A ten year lifetime was considered and the following three alternatives were considered:

- A large factory is set up to manufacture 20 toilets a day. The system consists of the floor slab system as well as the thin wall panels. All components are manufactured by experienced pre-cast manufacturers. These manufactures might be able to reduce the material costs as bulk prices should be lower than the values used in the calculations.
- A small factory where a person in the community works with three friends to manufacture one toilet a day. The system consists of the floor slab system as well as the thin wall panels. The edge-beams have to be purchased in as the expertise will not be available to cast these beams, but all other components are cast by the team.
- The floor slab is purchased in and a small factory is set up to manufacture foamed concrete blocks.

The minimum amount that can be charged for each of the systems was calculated assuming a minimum acceptable rate of return of 15%. The assumptions made as well as the calculations can be seen in Table 6, 7 and 8 respectively. The cost of steel moulds and materials for one toilet was used as calculated in Appendix C to F. The three alternatives resulted in the following minimum costs per unit:

- R2486.05
- R3187.55
- R3824.95

These values indicate that it would be financially feasible to manufacture the panel system in a pre-cast factory. The cost of this system compares well with those currently available, but the cost also proves that the current systems are mostly fairly priced.

If the aim is to create employment, it would cost an extra R700 per toilet to empower the community to manufacture their own units. The block system does not seem to be viable and the construction time also indicates that it is not a suitable system for the VIP superstructures. The final version of the high strength fibre reinforced concrete VIP superstructure system that was developed during this project can be seen in Figure 43.

11 TECHNOLOGY TRANSFER

It was decided not to patent the VIP superstructure but to share the knowledge with the industry. Technology transfer took place through demonstrations and workshops.

Figure 43: High strength fibre reinforced concrete VIP superstructure

Five half day demonstrations took place at district municipalities on the following dates at venues as indicated:

1) Polokwane, Limpopo: Presentation at Provincial Sanitation Task Team (PSTT) meeting held on 7th October 2009 at the Department of Water Affairs, Limpopo Regional office- 511.
2) East London: 2 November 2009

3) Port Alfred: 3 November 2009
4) Durban: 5 November 2009
5) Harrismith: 6 November 2009

Table 6: VIP superstructure costing – 2009

Large factory(Determination of the minimum sale price to achieve 15% MARR)

Labour costs

Labour cost per day (R130 per labourer, 20 labourers)	R 2,600.00	
Labour cost per year	R 520,000.00	Working year is 200 days, 8 hours per day

Equipment costs

Cost of moulds (2x material cost) (20 moulds @ R40 588.80 per mould)	R 811,776.10	Moulds must be replaced after 2000 repetitions(Every 10 years)
Cost of 380L electric mixer with 5 year life span	R 28,500.00	
Cost of rotary hammer drill, assuming 10 year life span	R 2,560.00	
Cost of concrete cutter, assuming 10 year life span	R 14,190.00	
2450*1200 vibrating table, assuming 10 year life span	R 23,940.00	
Cost of wheel barrow (20 @ R615 each) assume 10 year life span	R 12,300.00	
Total equipment cost	R 893,266.10	

Material costs

Cost of material used in single VIP toilet	R 2,016.33
Material cost per year (Make 20 toilets per day)	R 8,065,325.77

Rent(Conservative value for industrial rental rate)

Using factory with 1000m^2 of space at R60 per m^2 per month

Rent per month	R 60,000.00
Rent per year	R 720,000.00

Minimum sale price to achieve 15% MARR found to be approximately R2486.05

Loan of R1 200 000 taken to cover initial equipment cost

Year	Capital	Equipment	Equipment	Labour	Material	Rent	Sales	Total depreciation	Loan repayment	Cashflow bewfore ta	Taxable cashflow	Tax	Cashflow after tax	Constant purchasing power
0	R 1,200,000.00	R 893,266.10	R 893,266.10							-R 1,200,000.00	-R 1,200,000.00		-R 1,200,000.00	-R 1,200,000.00
1			R 0.00	R 598,000.00	R 9,033,164.87	R 828,000.00	R 11,137,504.00	R 89,326.61	R -267,017.57	R 411,321.56	R 321,994.95	R 90,158.59	R 321,162.98	R 286,752.66
2			R 0.00	R 687,700.00	R 10,117,144.65	R 952,200.00	R 12,474,004.48	R 89,326.61	R -267,017.57	R 449,942.26	R 360,615.65	R 100,972.38	R 348,969.88	R 278,196.65
3			R 0.00	R 790,855.00	R 11,331,202.01	R 1,095,030.00	R 13,970,885.02	R 89,326.61	R -267,017.57	R 486,780.44	R 397,453.83	R 111,287.07	R 375,493.37	R 267,268.76
4			R 0.00	R 909,483.25	R 12,690,946.25	R 1,259,284.50	R 15,647,391.22	R 89,326.61	R -267,017.57	R 520,659.65	R 431,333.04	R 120,773.25	R 399,886.40	R 254,135.04
5		R 28,500.00	R 50,226.74	R 1,045,905.74	R 14,213,859.80	R 1,448,177.18	R 17,525,078.17	R 89,326.61	R -267,017.57	R 499,891.14	R 410,564.53	R 114,958.07	R 384,933.07	R 218,421.36
6			R 0.00	R 1,202,791.60	R 15,919,522.98	R 1,665,403.75	R 19,628,087.55	R 89,326.61	R -267,017.57	R 573,351.65	R 484,025.04	R 135,527.01	R 437,824.64	R 221,815.59
7			R 0.00	R 1,383,210.34	R 17,829,865.74	R 1,915,214.31	R 21,983,458.05	R 89,326.61	R -267,017.57	R 588,150.09	R 498,823.48	R 139,670.58	R 448,479.52	R 202,869.36
8			R 0.00	R 1,590,691.89	R 19,969,449.62	R 2,202,496.46	R 24,621,473.02	R 89,326.61	R -267,017.57	R 591,817.48	R 502,490.87	R 140,697.44	R 451,120.03	R 182,199.82
9			R 0.00	R 1,829,295.67	R 22,365,783.58	R 2,532,870.93	R 27,576,049.78	R 89,326.61	R -267,017.57	R 581,082.03	R 491,755.42	R 137,691.52	R 443,390.51	R 159,891.06
10			R 0.00	R 2,103,690.02	R 25,049,677.61	R 2,912,801.57	R 30,885,175.75	R 89,326.61	R -267,017.57	R 551,988.98	R 462,662.37	R 129,545.46	R 422,443.52	R 136,015.51

15.00% IRR

*Inflation on rental rates taken as 15% (Rounded down from Statistics South Africas 15.2% for the fourth quarter of 2008)

*Inflation on labour rates taken as 15% (Rounded down from Statistics South Africas 15.1% for the period Sept. 2007 to Sept. 2008)

*Inflation on equipment and material rates taken as 12% (Rounded up from Statistics South Africas CPI of 11.7% for the period Jan 2008 to Nov. 2008)

*Assuming sales value increases at CPI rate for inflation, 12%

*Depreciation on all equipment calculated using the straight line method with zero salvage value

*Tax rates acquired from SARS and apply for small businesses, rates are as shown in tabel below

01/04/2008 – 31/03/2009	0%	1 – 46 000
	10%	46 001 – 300 000
	28%	300 001 and above

*The rate of repayment of loan was estimated using a rate equal to prime (15%) plus 3 and a loan repayment period of 10 years

Table 7: VIP superstructure costing – 2009

Small factory(Determination of the minimum sale price to achieve 15% MARR)

Labour costs

Labour cost per day (R75 per labourer, 4 labourers)	R 300.00
Labour cost per year	R 60,000.00

Equipment costs

Cost of moulds (2x material cost)	R 22,024.21
Cost of 380L electric mixer with 5 year life span	R 28,500.00
Cost of rotary hammer drill, assuming 10 year life span	R 2,560.00
Cost of concrete cutter, assuming 10 year life span	R 14,190.00
2450*1200 vibrating table, assuming 10 year life span	R 23,940.00
Cost of wheel barrow, assuming 10 year life span	R 615.00
Total equipment cost	R 91,829.21

Material costs

Cost of material used in single VIP toilet excluding beams	R 1,727.31
Cost to purchase beams used in a single VIP toilet(R75/m)	R 474.38
Material cost per year (Make 1 toilet per day)	R 440,336.98

Rent(Conservative value for industrial rental rate)

Using factory with 100m^2 of space at R60 per m^2 per month

Rent per month	R 6,000.00
Rent per year	R 72,000.00

Minimum sale price to achieve 15% MARR found to be approximately R3 187.55

Loan of R120 000 taken to cover initial equipment cost

Year	Capital	Equipment	Labour	Material	Rent	Sales	Cashflow before tax	Tax	Cashflow after tax	Constant purchasing power
0	R 120,000.00	R 91,829.21					-R 120,000.00		-R 120,000.00	-R 120,000.00
1		R 0.00	R 69,000.00	R 493,177.42	R 82,800.00	R 714,011.20	R 34,749.40	R 0.00	R 34,749.40	R 31,026.25
2		R 0.00	R 79,350.00	R 552,358.71	R 95,220.00	R 799,692.54	R 38,479.45	R 0.00	R 38,479.45	R 30,675.58
3		R 0.00	R 91,252.50	R 618,641.75	R 109,503.00	R 895,655.65	R 41,974.01	R 0.00	R 41,974.01	R 29,876.27
4		R 0.00	R 104,940.38	R 692,878.76	R 125,928.45	R 1,003,134.33	R 45,102.35	R 0.00	R 45,102.35	R 28,663.36
5		R 50,226.74	R 120,681.43	R 776,024.22	R 144,817.72	R 1,123,510.45	-R 2,524.04	R 0.00	-R 2,524.04	-R 1,432.21
6		R 0.00	R 138,783.65	R 869,147.12	R 166,540.38	R 1,258,331.70	R 49,576.17	R 0.00	R 49,576.17	R 25,116.83
7		R 0.00	R 159,601.19	R 973,444.78	R 191,521.43	R 1,409,331.50	R 50,479.72	R 0.00	R 50,479.72	R 22,834.46
8		R 0.00	R 183,541.37	R 1,090,258.15	R 220,249.65	R 1,578,451.28	R 50,117.73	R 0.00	R 50,117.73	R 20,241.71
9		R 0.00	R 211,072.58	R 1,221,089.13	R 253,287.09	R 1,767,865.44	R 48,132.25	R 0.00	R 48,132.25	R 17,356.97
10		R 0.00	R 242,733.46	R 1,367,619.82	R 291,280.16	R 1,980,009.29	R 44,091.46	R 0.00	R 44,091.46	R 14,196.27

15.00% IRR

*Inflation on rental rates taken as 15% (Rounded down from Statistics South Africas 15.2% for the fourth quarter of 2008)

*Inflation on labour rates taken as 15% (Rounded down from Statistics South Africas 15.1% for the period Sept. 2007 to Sept. 2008)

*Inflation on equipment and material rates taken as 12% (Rounded up from Statistics South Africas CPI of 11.7% for the period Jan 2008 to Nov. 2008)

*Assuming sales value increases at CPI rate for inflation, 12%

*Depreciation on all equipment calculated using the straight line method with zero salvage value

*Tax rates acquired from SARS and apply for small businesses, rates are as shown in tabel below

01/04/2008 – 31/03/2009	0%	1 – 46 000
	10%	46 001 – 300 000
	28%	300 001 and above

*The rate of repayment of loan was estimated using a rate equal to prime (15%) plus 3 and a loan repayment period of 10 years

Table 8: VIP superstructure costing – 2009

Small block factory(Determination of the minimum sale price to achieve 15% MARR)

Labour costs

Labour cost per day (R75 per labourer, 4 labourers)	R 300.00	
Labour cost per year	R 60,000.00	Working year is 200 days, 8 hours per day

Equipment costs

Cost of moulds	R 13,242.00	Moulds must be replaced after 2000 repetitions (Every 10 years)
Cost of variable speed ribbon mixer with 5 year life span	R 70,000.00	
Cost of rotary hammer drill, assuming 10 year life span	R 2,560.00	
Cost of wheel barrow, assuming 10 year life span	R 615.00	
Total equipment cost	R 86,417.00	

Material costs

Cost of material used in single VIP toilet excluding base	R 1,954.04
Cost to purchase bases	R 827.65
Material cost per year (Make 1 toilet per day)	R 556,338.14

Rent(Conservative value for industrial rental rate)

Using factory with 100m^2 of space at R60 per m^2 per month

Rent per month	R 6,000.00
Rent per year	R 72,000.00

Minimum sale price to achieve 15% MARR found to be approximately R3 824.95

Loan of R120 000 taken to cover initial equipment cost

Year	Capital	Equipment	Equipment	Labour	Material	Rent	Sales	Cashflow before tax	Tax	Cashflow after tax	Constant purchasing power
0	R 120,000.00	R 86,417.00	R 86,417.00					-R 120,000.00		-R 120,000.00	-R 120,000.00
1			R 0.00	R 69,000.00	R 623,098.72	R 82,800.00	R 856,788.80		R 0.00	R 0.00	R 0.00
2			R 0.00	R 79,350.00	R 697,870.57	R 95,220.00	R 959,603.46	R 52,878.50	R 0.00	R 52,878.50	R 42,154.42
3			R 0.00	R 91,252.50	R 781,615.03	R 109,503.00	R 1,074,755.87	R 58,100.95	R 0.00	R 58,100.95	R 41,355.11
4			R 0.00	R 104,940.38	R 875,408.84	R 125,928.45	R 1,203,726.58	R 63,164.53	R 0.00	R 63,164.53	R 40,142.20
5		R 70,000.00	R 123,363.92	R 120,681.43	R 980,457.90	R 144,817.72	R 1,348,173.76	-R 55,431.59	R 0.00	-R 55,431.59	-R 31,453.37
6			R 0.00	R 138,783.65	R 1,098,112.85	R 166,540.38	R 1,509,954.62	R 72,233.36	R 0.00	R 72,233.36	R 36,595.67
7			R 0.00	R 159,601.19	R 1,229,886.39	R 191,521.43	R 1,691,149.17	R 75,855.77	R 0.00	R 75,855.77	R 34,313.30
8			R 0.00	R 183,541.37	R 1,377,472.75	R 220,249.65	R 1,894,087.07	R 78,538.91	R 0.00	R 78,538.91	R 31,720.55
9			R 0.00	R 211,072.58	R 1,542,769.49	R 253,287.09	R 2,121,377.52	R 79,963.98	R 0.00	R 79,963.98	R 28,835.81
10			R 0.00	R 242,733.46	R 1,727,901.82	R 291,280.16	R 2,375,942.82	R 79,742.99	R 0.00	R 79,742.99	R 25,675.11

15.00%	IRR

*Inflation on rental rates taken as 15% (Rounded down from Statistics South Africas 15.2% for the fourth quarter of 2008)

*Inflation on labour rates taken as 15% (Rounded down from Statistics South Africas 15.1% for the period Sept. 2007 to Sept. 2008)

*Inflation on equipment and material rates taken as 12% (Rounded up from Statistics South Africas CPI of 11.7% for the period Jan 2008 to Nov. 2008)

*Assuming sales value increases at CPI rate for inflation, 12%

*Depreciation on all equipment calculated using the straight line method with zero salvage value

*Tax rates acquired from SARS and apply for small businesses, rates are as shown in tabel below

01/04/2008 – 31/03/2009	0%	1 – 46 000
	10%	46 001 – 300 000
	28%	300 001 and above

*The rate of repayment of loan was estimated using a rate equal to prime (15%) plus 3 and a loan repayment period of 10 years

A workshop was held at the University of Pretoria on Wednesday 20 January 2010. Instead of a second workshop, significant current players were met or interviewed individually. These interviews included meetings with representatives from the following companies:

Amalooloo (Lukas Fourie)
Eldocrete (Werner Viljoen)
Rocla (Andre Labuschagne)
Mvula Trust (Johnson Klu)

There are a number of well priced, high quality moveable concrete superstructures on the market but all role players are disadvantaged by suppliers that deliver inferior products at lower prices. The decision making process for awarding sanitation projects is also not transparent. All role players agree that it is essential to have a National Standard for VIP structures where the minimum functional requirements are listed. This will enable manufacturers to supply the most affordable yet acceptable superstructure.

The research team also took part in a VIP exhibition in Barkley East on 21 September 2009. In place of the second workshop two VIP superstructures have also been manufactured that will be erected at the CSIR sanitation exhibition area (March 2010) as well as at the WISA conference in Durban (April 2010).

12 CONCLUSIONS AND RECOMMENDATIONS

There are few shortcuts in a pilot sanitation scheme. Planners must carefully conduct economic and social research, build demonstration units, and monitor and evaluate the reactions of the potential users, before a truly appropriate system can be found. The various systems available do not differ much in cost and other factors will determine which of the systems would be most suitable in a given community. A choice will have to be made to optimize community involvement while providing every household with an acceptable sanitation solution as soon as possible.

During this project a moveable lightweight superstructure system made from high strength fibre reinforced concrete was developed. This system consists of a base slab, wall panels, a roof and a door and the system can be provided to communities in package form or it can be manufactured by the communities themselves in controlled environments. A system that consists of bricks or blocks that cannot compete with a pre-cast system as far as cost or quality is concerned.

The major problem with the provision of VIP superstructures is that there is no standard requirement and each supplier determines what the quality of the product is that they wish to deliver. It is recommended that a National Standard should be developed with minimum requirements that all VIP superstructures should adhere to. These requirements can include aspects such as minimum dimensions, load capacities, requirements for doors and fittings. Having minimum functional requirements for suppliers will prevent clients from opting for inferior products that may seem to be cheaper.

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APPENDIX:

APPENDIX A

(2007 Rates)

A: **RECTANGULAR VIP SUPERSTRUCTURE**

Note: Quantites used in the calculations below were obtained from:
Bester, J W and Austin, LM. Building VIP's: Guidelines for the Design and Constuction of Domestic Ventilated Improved Pit Toilets. 1996. CSIR.

Superstructure No	Description	Unit	Quantity	Rate	Costs
A1	***220x110x75 Brick Walls with Ferrocement Roof (buy bricks)***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Bricks (buy)	No	432	R 0.85	R 367.20
	Cement	Bags	2	R 53.00	R 106.00
	Sand	m3	0.279	R 175.00	R 48.83
	3 folds of chicken wire	m2	4.800	R 25.00	R 120.00
	Hessian	m2	2.170	R 47.00	R 101.99
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,663.43
A2	***220x110x75 Brick Walls with Ferrocement Roof (make bricks)***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Cement	Bags	4	R 53.00	R 212.00
	Sand	m3	0.549	R 175.00	R 96.08
	3 folds of chicken wire	m2	4.800	R 25.00	R 120.00
	Hessian	m2	2.170	R 47.00	R 101.99
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,449.48
A3	***220x110x75 Brick Walls with Corrugated Iron Roof (buy bricks)***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Bricks (buy)	No	432	R 0.85	R 367.20
	Cement	Bags	2	R 53.00	R 106.00
	Sand	m3	0.216	R 175.00	R 37.80
	Corrugated iron sheet (1800x600mm)	No	2	R 78.00	R 156.00
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,586.42
A4	***220x110x75 Brick Walls with Corrugated Iron Roof (make bricks)***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Cement	Bags	3	R 53.00	R 159.00
	Sand	m3	0.486	R 175.00	R 85.05
	Corrugated iron sheet (1800x600mm)	No	2	R 78.00	R 156.00
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,319.47

A5	***300x150x150 Block Walls with Ferrocement Roof (make blocks)***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Cement	Bags	3	R 53.00	R 159.00
	Sand	m3	0.424	R 175.00	R 74.20
	3 folds of chicken wire	m2	4.800	R 25.00	R 120.00
	Hessian	m2	4.800	R 47.00	R 225.60
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,448.22
A6	***300x150x150 Block Walls with Corrugated Iron Roof (make blocks)***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Cement	Bags	2	R 53.00	R 106.00
	Sand	m3	0.361	R 175.00	R 63.18
	Corrugated iron sheet (1800x600mm)	No	2	R 78.00	R 156.00
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,244.59
A7	***440x200x160 Block Walls with Ferrocement Roof (make blocks)***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Cement	Bags	3	R 53.00	R 159.00
	Sand	m3	0.392	R 175.00	R 68.60
	3 folds of chicken wire	m2	4.800	R 25.00	R 120.00
	Hessian	m2	4.800	R 47.00	R 225.60
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,492.62
A8	***440x200x160 Block Walls with Corrugated Iron Roof (make blocks)***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Cement	Bags	2	R 53.00	R 106.00
	Sand	m3	0.329	R 175.00	R 57.58
	Corrugated iron sheet (1800x600mm)	No	2	R 78.00	R 156.00
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,238.99
A9	***1200x2000x40mm Ferrocement Panels with Ferrocement Roof***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Cement	Bags	4	R 53.00	R 212.00
	Sand	m3	0.380	R 175.00	R 66.47
	3 folds of chicken wire	m2	22.350	R 25.00	R 558.75
	Hessian	m2	8.940	R 47.00	R 420.18
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,935.40

A10	***1200x2000x40mm Ferrocement Panels with Corrugated Iron Roof***				
	Ground Slab	Item	1	R 241.42	R 241.42
	Cement	Bags	3	R 53.00	R 159.00
	Sand	m3	0.317	R 175.00	R 55.44
	Corrugated iron sheet (1800x600mm)	No	2	R 78.00	R 156.00
	75mm high precast lintel	No	1	R 24.00	R 24.00
	1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
	Steel Door	No	1	R 455.00	R 455.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,289.86

B: SQUARE SPIRAL VIP SUPERSTRUCTURE

Note: Quantites used in the calculations below were obtained from:
Bester, J W and Austin, LM. Building VIP's: Guidelines for the Design and Constuction of Domestic Ventilated Improved Pit Toilets. 1996. CSIR.

Superstructure No	Description	Unit	Quantity	Rate	Costs
B1	***220x110x75 Brick Walls and Ventpipe with Ferrocement roof (buy bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Bricks (buy)	No	968	R 0.85	R 822.80
	Cement	Bags	4	R 53.00	R 212.00
	Sand	m3	0.652	R 175.00	R 114.10
	3 folds of chicken wire	m2	13.200	R 25.00	R 330.00
	Hessian	m2	3.885	R 47.00	R 182.60
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,897.41
B2	***220x110x75 Brick Walls, PVC Ventpipe with Ferrocement roof (buy bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Bricks (buy)	No	830	R 0.85	R 705.50
	Cement	Bags	4	R 53.00	R 212.00
	Sand	m3	0.583	R 175.00	R 102.03
	3 folds of chicken wire	m2	13.200	R 25.00	R 330.00
	Hessian	m2	3.885	R 47.00	R 182.60
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	N/A	R 100.00
					R 1,921.03
B3	***220x110x75 Brick Walls and Ventpipe with Ferrocement roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	8	R 53.00	R 424.00
	Sand	m3	1.257	R 175.00	R 219.98
	3 folds of chicken wire	m2	13.200	R 25.00	R 330.00
	Hessian	m2	3.885	R 47.00	R 182.60
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,392.48
B4	***220x110x75 Brick Walls, PVC Ventpipe with Ferrocement roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	7	R 53.00	R 371.00
	Sand	m3	1.102	R 175.00	R 192.85
	3 folds of chicken wire	m2	13.200	R 25.00	R 330.00
	Hessian	m2	3.885	R 47.00	R 182.60
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,415.36
B5	***220x110x75 Brick Walls and Ventpipe with Corrugated Iron roof (buy bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Bricks (buy)	No	968	R 0.85	R 822.80
	Cement	Bags	3	R 53.00	R 159.00
	Sand	m3	0.484	R 175.00	R 84.70
	Corrugated iron sheet (2200x600mm)	No	4	R 96.00	R 384.00
	2100x76x38mm pine wall plates	No	3	R 23.00	R 69.00
	Micselleneous Items	Item	1	N/A	R 100.00
					R 1,805.41

Superstructure No	Description	Unit	Quantity	Rate	Costs
B6	***220x110x75 Brick Walls, PVC Ventpipe with Corrugated Iron roof (buy bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Bricks (buy)	No	830	R 0.85	R 705.50
	Cement	Bags	3	R 53.00	R 159.00
	Sand	m3	0.484	R 175.00	R 84.70
	Corrugated iron sheet (2200x600mm)	No	4	R 96.00	R 384.00
	2100x76x38mm pine wall plates	No	3	R 23.00	R 69.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,741.11
B7	***220x110x75 Brick Walls and Ventpipe with Corrugated Iron roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	6	R 53.00	R 318.00
	Sand	m3	1.089	R 175.00	R 190.58
	Corrugated iron sheet (2200x600mm)	No	4	R 96.00	R 384.00
	2100x76x38mm pine wall plates	No	3	R 23.00	R 69.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,197.49

Superstructure No	Description	Unit	Quantity	Rate	Costs
B8	***220x110x75 Brick Walls, PVC Ventpipe with Corrugated Iron roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	5	R 53.00	R 265.00
	Sand	m3	0.934	R 175.00	R 163.45
	Corrugated iron sheet (2200x600mm)	No	4	R 96.00	R 384.00
	2100x76x38mm pine wall plates	No	3	R 23.00	R 69.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,220.36

B9	***300x150x150 Block Walls and Ventpipe with Ferrocement roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	6	R 53.00	R 318.00
	Sand	m3	0.987	R 175.00	R 172.73
	3 folds of chicken wire	m2	13.200	R 25.00	R 330.00
	Hessian	m2	3.885	R 47.00	R 182.60
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,239.23
B10	***300x150x150 Block Walls, PVC Ventpipe with Ferrocement roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	5	R 53.00	R 265.00
	Sand	m3	0.862	R 175.00	R 150.77
	3 folds of chicken wire	m2	13.200	R 25.00	R 330.00
	Hessian	m2	3.885	R 47.00	R 182.60
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,267.28
B11	***300x150x150 Block Walls and Ventpipe with Corrugated Iron roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	5	R 53.00	R 265.00
	Sand	m3	0.819	R 175.00	R 143.33
	Corrugated iron sheet (2200x600mm)	No	4	R 96.00	R 384.00
	2100x76x38mm pine wall plates	No	3	R 23.00	R 69.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,097.24
B12	***300x150x150 Block Walls, PVC Ventpipe with Corrugated Iron roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	4	R 53.00	R 212.00
	Sand	m3	0.694	R 175.00	R 121.37
	Corrugated iron sheet (2200x600mm)	m2	4.000	R 96.00	R 384.00
	2100x76x38mm pine wall plates	No	3	R 23.00	R 69.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,125.28
B13	***400x200x160 Block Walls and Ventpipe with Ferrocement roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	6	R 53.00	R 318.00
	Sand	m3	0.908	R 175.00	R 158.97
	3 folds of chicken wire	m2	13.200	R 25.00	R 330.00
	Hessian	m2	3.885	R 47.00	R 182.60
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,225.48
B14	***400x200x160 Block Walls, PVC Ventpipe with Ferrocement roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	5	R 53.00	R 265.00
	Sand	m3	0.790	R 175.00	R 138.21
	3 folds of chicken wire	m2	13.200	R 25.00	R 330.00
	Hessian	m2	3.885	R 47.00	R 182.60
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,254.71

B15	***400x200x160 Block Walls and Ventpipe with Corrugated Iron roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	4	R 53.00	R 212.00
	Sand	m3	0.740	R 175.00	R 129.57
	Corrugated iron sheet (2200x600mm)	No	4	R 96.00	R 384.00
	2100x76x38mm pine wall plates	No	3	R 23.00	R 69.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,030.48
B16	***400x200x160 Block Walls, PVC Ventpipe with Corrugated Iron roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	4	R 53.00	R 212.00
	Sand	m3	0.622	R 175.00	R 108.81
	Corrugated iron sheet (2200x600mm)	No	4	R 96.00	R 384.00
	2100x76x38mm pine wall plates	No	3	R 23.00	R 69.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,112.72

NOTE:

1 Add **R604.00** to each superstructure if a steel door is installed. (R455.00 for steel door plus frame and hinges and R149 for 1 litre Maxicare Rust-free paint)

2 Subtract **R304.00** from each superstructure if the Ferrocement roof does not extend over spiral opening.

3 Subtract **R215.00** from each superstructure if the Corrugated Iron roof does not extend over spiral opening. (use 2 1800x600mm sheets)

C: CIRCULAR SPIRAL VIP

Superstructure No	Description	Unit	Quantity	Rate	Costs
C1	***220x110x75 Brick Wall, PVC Ventpipe with Ferrocement Roof (buy bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Bricks (buy)	No	660	R 0.85	R 561.00
	Cement	Bags	3	R 53.00	R 159.00
	Sand	m3	0.455	R 175.00	R 79.63
	3 folds of chicken wire	m2	12.600	R 25.00	R 315.00
	Hessian	m2	4.200	R 47.00	R 197.40
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,650.94
C2	***220x110x75 Brick Wall, PVC Ventpipe with Ferrocement Roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	5	R 53.00	R 265.00
	Sand	m3	0.868	R 175.00	R 151.90
	3 folds of chicken wire	m2	12.600	R 25.00	R 315.00
	Hessian	m2	4.200	R 47.00	R 197.40
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,268.21
C3	***220x110x75 Brick Wall, PVC Ventpipe with Thatch Roof (buy bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Bricks (buy)	No	660	R 0.85	R 561.00
	Cement	Bags	2	R 53.00	R 106.00
	Sand	m3	0.330	R 175.00	R 57.75
	1300mm wooden rafters (50mm ϕ)	No	6	R 17.00	R 102.00
	1150mm purlins (32mm ϕ)	No	6	R 17.00	R 102.00
	920mm purlins (32mm ϕ)	No	6	R 8.50	R 51.00
	690mm purlins (32mm ϕ)	No	6	R 8.50	R 51.00
	460mm purlins (32mm ϕ)	No	6	R 6.00	R 36.00
	230mm purlins (32mm ϕ)	No	6	R 6.00	R 36.00
	Grass (assume 10% of superstructure cost)	Item	1	R 145.00	R 145.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,586.66
C4	***220x110x75 Brick Wall, PVC Ventpipe with Thatch Roof (make bricks)***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	4	R 53.00	R 212.00
	Sand	m3	0.743	R 175.00	R 130.03
	1300mm wooden rafters (50mm ϕ)	No	6	R 17.00	R 102.00
	1150mm purlins (32mm ϕ)	No	6	R 17.00	R 102.00
	920mm purlins (32mm ϕ)	No	6	R 8.50	R 51.00
	690mm purlins (32mm ϕ)	No	6	R 8.50	R 51.00
	460mm purlins (32mm ϕ)	No	6	R 6.00	R 36.00
	230mm purlins (32mm ϕ)	No	6	R 6.00	R 36.00
	Grass (assume 10% of superstructure cost)	Item	1	R 110.00	R 110.00
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 1,168.94

C5	***Ferrocement Wall, PVC Ventpipe with Ferrocement Roof***				
	Ground Slab	Item	1	R 185.91	R 185.91
	Cement	Bags	5	R 53.00	R 265.00
	Sand	m3	0.560	R 175.00	R 98.00
	3 folds of chicken wire	m2	48.600	R 25.00	R 1,215.00
	Hessian	m2	16.200	R 47.00	R 761.40
	2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
	Micselleneous Items	Item	1	R 50.00	R 50.00
					R 2,678.31

D: ARCHLOO VIP SUPERSTRUCTURE

Description	Unit	Quantity	Rate	Costs
Ground Slab	Item	1	R 241.42	R 241.42
Cement	Bags	9	R 53.00	R 477.00
Sand	m3	0.94	R 175.00	R 164.50
Hessian	m2	15.56	R 47.00	R 731.32
3 Folds Chicken Wire	m2	0.39	R 25.00	R 9.75
2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
Micselleneous Items	Item	1	R 50.00	R 50.00
Steel Door	No	1	R 455.00	R 455.00
				R 2,231.99

E3 Hydraform blocks

Ground Slab	Item	1	R 269.00	R 269.00
Hydraform blocks (220x120x115)	No	280	R 4.10	R 1,149.12
Corrugated iron sheet (1800x600mm)	No	2	R 78.00	R 156.00
75mm high precast lintel	No	1	R 24.00	R 24.00
1200x76x38mm pine wall plates	No	2	R 23.00	R 46.00
Steel Door	No	1	R 455.00	R 455.00
2500mm PVC Ventpipe (110mm ϕ)	No	1	R 103.00	R 103.00
Micselleneous Items	Item	1	R 50.00	R 50.00
				R 2,252.12

VIP SUPERSTRUCTURE PRICELIST

[All Prices Include VAT]

A: **Rectangular VIP Superstructure**

NOTE: For detailed cost consult the Bill of Quantities.

	Description	Price
A1	220x110x75 Brick Walls with Ferrocement Roof (buy bricks)	R 1,663.43
A2	220x110x75 Brick Walls with Ferrocement Roof (make bricks)	R 1,449.48
A3	220x110x75 Brick Walls with Corrugated Iron Roof (buy bricks)	R 1,586.42
A4	220x110x75 Brick Walls with Corrugated Iron Roof (make bricks)	R 1,319.47
A5	300x150x150 Block Walls with Ferrocement Roof (make blocks)	R 1,448.22
A6	300x150x150 Block Walls with Corrugated Iron Roof (make blocks)	R 1,244.59
A7	440x200x160 Block Walls with Ferrocement Roof (make blocks)	R 1,492.62
A8	440x200x160 Block Walls with Corrugated Iron Roof (make blocks)	R 1,238.99
A9	1200x2000x40mm Ferrocement Panels with Ferrocement Roof	R 1,935.40
A10	1200x2000x40mm Ferrocement Panels with Corrugated Iron Roof	R 1,289.86

B: **Square Spiral VIP Superstructure**

NOTE: For detailed cost consult the Bill of Quantities.

	Description	Price
B1	220x110x75 Brick Walls and Ventpipe with Ferrocement roof (buy bricks)	R 1,897.41
B2	220x110x75 Brick Walls, PVC Ventpipe with Ferrocement roof (buy bricks)	R 1,921.03
B3	220x110x75 Brick Walls and Ventpipe with Ferrocement roof (make bricks)	R 1,392.48
B4	220x110x75 Brick Walls, PVC Ventpipe with Ferrocement roof (make bricks)	R 1,415.36
B5	220x110x75 Brick Walls and Ventpipe with Corrugated Iron roof (buy bricks)	R 1,805.41
B6	220x110x75 Brick Walls, PVC Ventpipe with Corrugated Iron roof (buy bricks)	R 1,741.11
B7	220x110x75 Brick Walls and Ventpipe with Corrugated Iron roof (make bricks)	R 1,197.49
B8	220x110x75 Brick Walls, PVC Ventpipe with Corrugated Iron roof (make bricks)	R 1,220.36
B9	300x150x150 Block Walls and Ventpipe with Ferrocement roof (make bricks)	R 1,239.23
B10	300x150x150 Block Walls, PVC Ventpipe with Ferrocement roof (make bricks)	R 1,267.28
B11	300x150x150 Block Walls and Ventpipe with Corrugated Iron roof (make bricks)	R 1,097.24
B12	300x150x150 Block Walls, PVC Ventpipe with Corrugated Iron roof (make bricks)	R 1,125.28
B13	400x200x160 Block Walls and Ventpipe with Ferrocement roof (make bricks)	R 1,225.48
B14	400x200x160 Block Walls, PVC Ventpipe with Ferrocement roof (make bricks)	R 1,254.71
B15	400x200x160 Block Walls and Ventpipe with Corrugated Iron roof (make bricks)	R 1,030.48
B16	400x200x160 Block Walls, PVC Ventpipe with Corrugated Iron roof (make bricks)	R 1,112.72

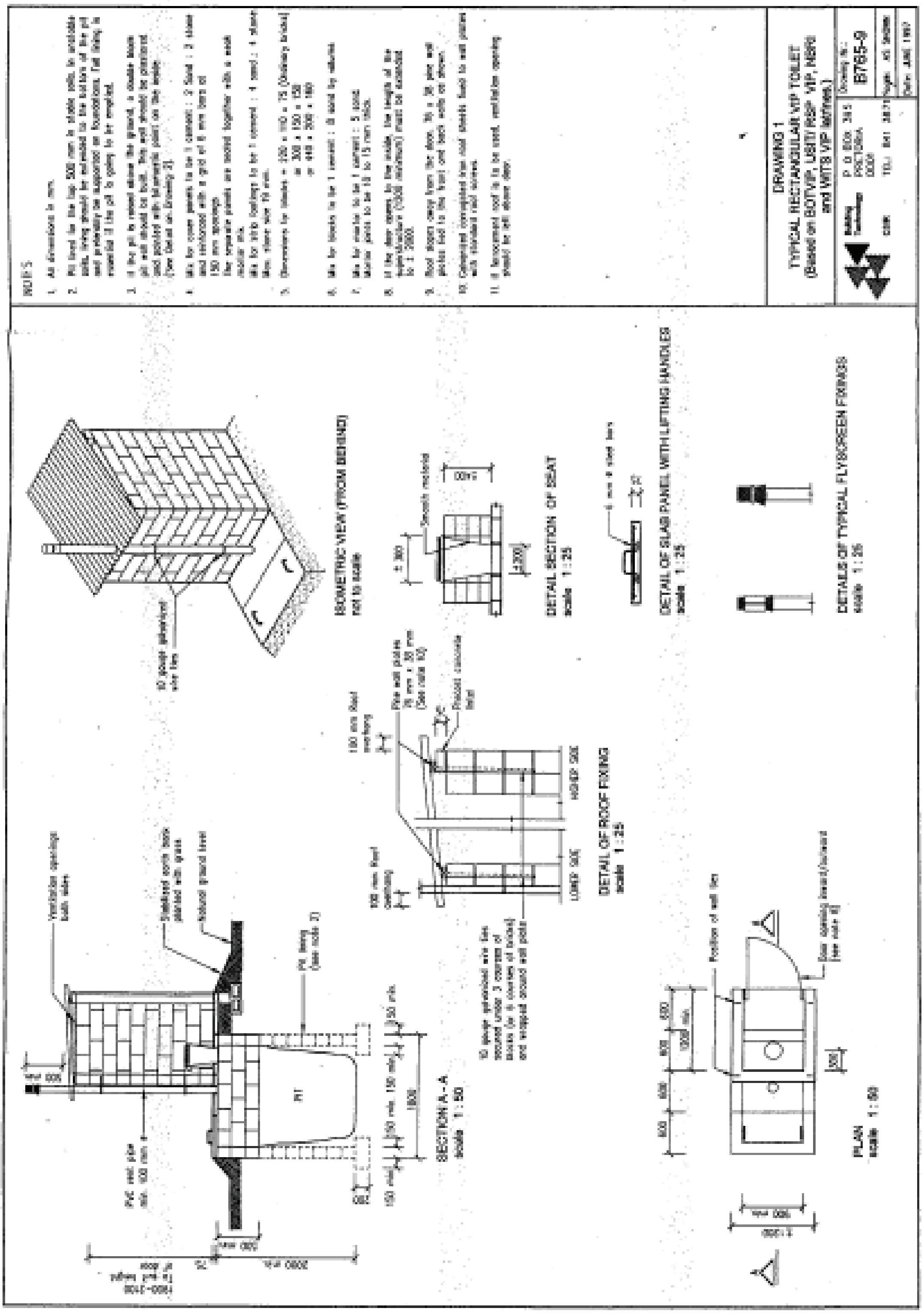
C:	**Circular Spiral VIP Superstructure**	
NOTE:	For detailed cost consult the Bill of Quantities.	
	Description	**Price**
C1	220x110x75 Brick Wall, PVC Ventpipe with Ferrocement Roof (buy bricks)	R 1,650.94
C2	220x110x75 Brick Wall, PVC Ventpipe with Ferrocement Roof (make bricks)	R 1,268.21
C3	220x110x75 Brick Wall, PVC Ventpipe with Thatch Roof (buy bricks)	R 1,586.66
C4	220x110x75 Brick Wall, PVC Ventpipe with Thatch Roof (make bricks)	R 1,168.94
C5	Ferrocement Wall, PVC Ventpipe with Ferrocement Roof	R 2,678.31

D:	**Archloo VIP Superstructure**	
NOTE:	For detailed cost consult the Bill of Quantities.	
	Description	**Price**
D1	Archloo design	R 2,231.99

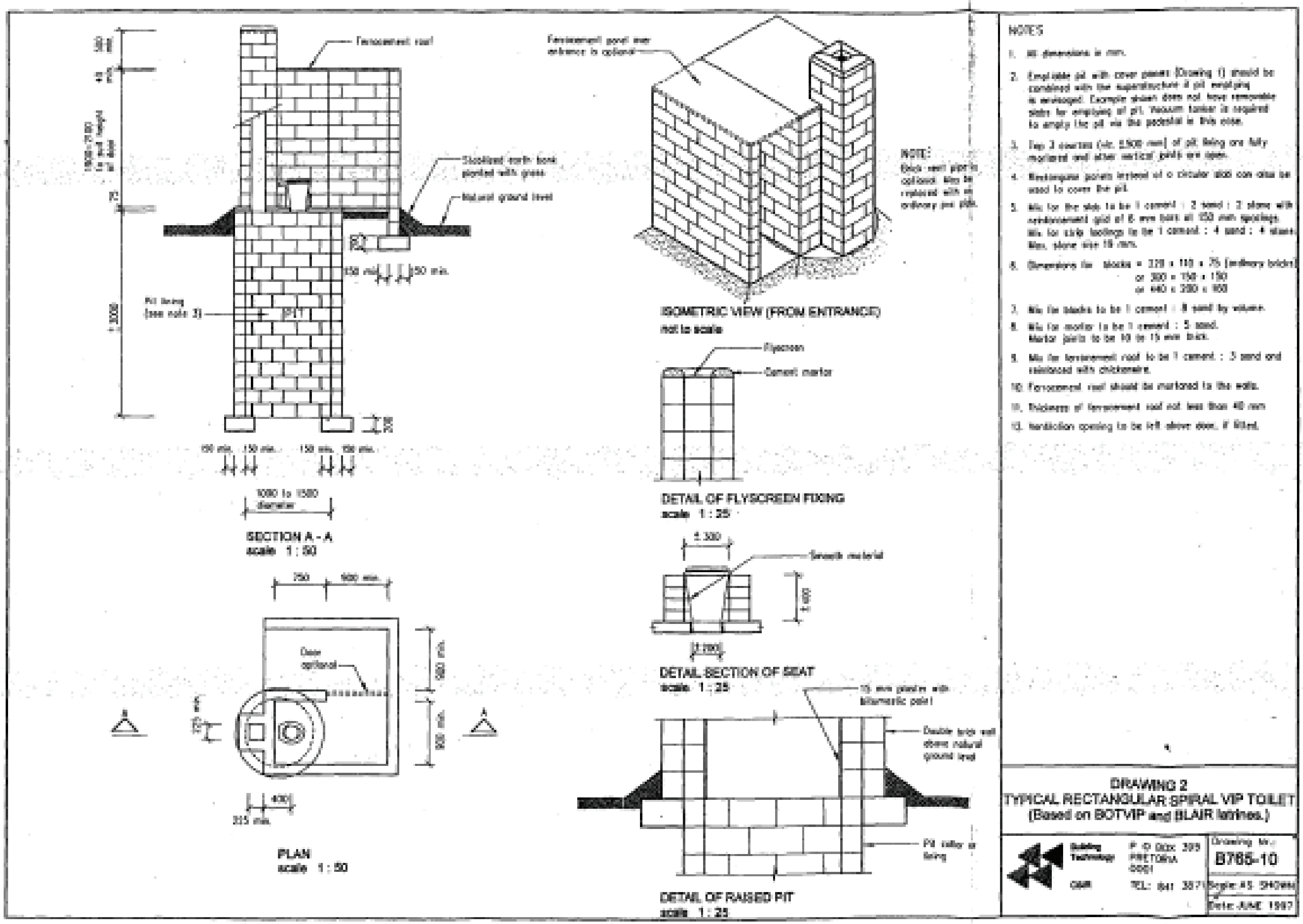
E:	**Other Rectangular VIP Superstructures**	
NOTE:	Cost of superstructure E1 was provided by the eThekwini Municipality. Cost of superstructure E2 was provided by the manufacturer.	
	Description	**Price**
E1	Pre-cast U-shaped sections with Ferrocement Roof	R 2,275.00
E2	Cemforce Easyloo	R 2,337.00
E3	Hydraform blocks with Corrugated Iron roof	R 2,252.12

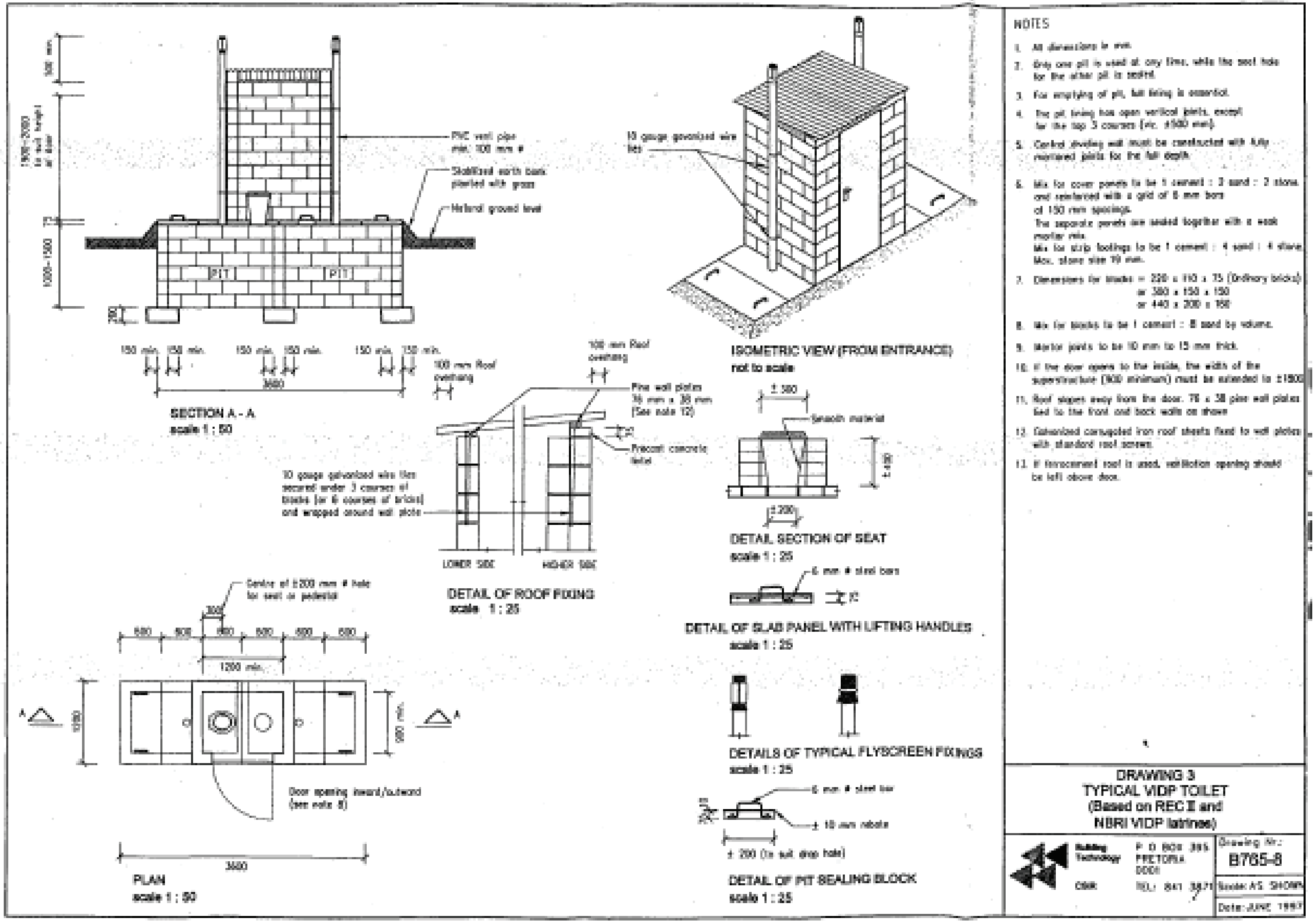
F:	**Pre-manufactured Design (Plastic/Fibre Glass)**	
NOTE:	Cost of superstructure was provided by the manufacturers.	
	Description	**Price**
F1	Jo-Jo Plastic VIP superstructure	R 2,273.16
F2	EcoSan Plastic VIP superstructure	R 2,333.58
F3	Pioneer Plastics VIP superstructure	R 3,933.00

APPENDIX B



DRAWING 1
TYPICAL RECTANGULAR VIP TOILET
(Based on BOTVIP, UBT/RSP VIP, NBRI and WITS VIP latrines)
B765-9
ISOMETRIC VIEW (FROM BEHIND)
not to scale
DETAIL SECTION OF SEAT
scale 1 : 25
DETAIL OF SLAB PANEL WITH LIFTING HANDLES
scale 1 : 25
DETAILS OF TYPICAL FLYSCREEN FIXINGS
scale 1 : 25
DETAIL OF ROOF FIXING
scale 1 : 25
SECTION A - A
scale 1 : 50
PLAN
scale 1 : 50
NOTES


Ferrocement roof
Ferrocement panel over entrance is optional
Stabilised earth bank planted with grass
Natural ground level
Pit lining (see note 3)
PIT
NOTE:
Brick vent pipe is optional. May be replaced with an ordinary vent pipe.
ISOMETRIC VIEW (FROM ENTRANCE)
not to scale
Flyscreen
Cement mortar
DETAIL OF FLYSCREEN FIXING
scale 1 : 25
Smooth material
DETAIL SECTION OF SEAT
scale 1 : 25
1000 to 1500 diameter
SECTION A - A
scale 1 : 50
Door optional
PLAN
scale 1 : 50
15 mm plaster with bitumastic paint
Double brick wall above natural ground level
Pit collar or lining
DETAIL OF RAISED PIT
scale 1 : 25
NOTES
1. All dimensions in mm.
2. Emptiable pit with cover panels (Drawing 1) should be combined with the superstructure if pit emptying is envisaged. Example shown does not have removable slabs for emptying of pit. Vacuum tanker is required to empty the pit via the pedestal in this case.
3. Top 3 courses (ca. 2,500 mm) of pit lining are fully mortared and other vertical joints are open.
4. Rectangular panels instead of a circular slab can also be used to cover the pit.
5. Mix for the slab to be 1 cement : 2 sand : 2 stone with reinforcement grid of 6 mm bars at 150 mm spacings. Mix for strip footings to be 1 cement : 4 sand : 4 stone. Max. stone size 19 mm.
6. Dimensions for blocks = 220 x 110 x 75 (ordinary bricks) or 300 x 150 x 150 or 440 x 200 x 100
7. Mix for blocks to be 1 cement : 8 sand by volume.
8. Mix for mortar to be 1 cement : 5 sand. Mortar joints to be 10 to 15 mm thick.
9. Mix for ferrocement roof to be 1 cement : 3 sand and reinforced with chickenwire.
10. Ferrocement roof should be mortared to the walls.
11. Thickness of ferrocement roof not less than 40 mm
12. Ventilation opening to be left above door, if fitted.
DRAWING 2
TYPICAL RECTANGULAR SPIRAL VIP TOILET
(Based on BOTVIP and BLAIR latrines.)
Building Technology
CSIR
P O BOX 395
PRETORIA
0001
Drawing No.:
B765-10
Date: JUNE 1997


NOTES
1. All dimensions in mm.
2. Only one pit is used at any time, while the seat hole for the other pit is sealed.
3. For emptying of pit, full lining is essential.
4. The pit lining has open vertical joints, except for the top 3 courses (vic. ±500 mm).
5. Central dividing wall must be constructed with fully mortared joints for the full depth.
6. Mix for cover panels to be 1 cement : 3 sand : 2 stone and reinforced with a grid of 6 mm bars at 150 mm spacings. The separate panels are sealed together with a weak mortar mix. Mix for strip footings to be 1 cement : 4 sand : 4 stone Max. stone size 19 mm.
7. Dimensions for blocks = 220 x 110 x 75 (Ordinary bricks) or 380 x 150 x 150 or 440 x 200 x 150
8. Mix for blocks to be 1 cement : 8 sand by volume.
9. Mortar joints to be 10 mm to 15 mm thick.
10. If the door opens to the inside, the width of the superstructure (900 minimum) must be extended to ±1500
11. Roof slopes away from the door. 76 x 38 pine wall plates tied to the front and back walls as shown
12. Galvanized corrugated iron roof sheets fixed to wall plates with standard roof screws.
13. If fibrocement roof is used, ventilation opening should be left above door.
PVC vent pipe min. 100 mm ø
Stabilized earth bank planted with grass
Natural ground level
PIT
PIT
SECTION A - A
scale 1 : 50
10 gauge galvanized wire ties
ISOMETRIC VIEW (FROM ENTRANCE)
not to scale
100 mm Roof overhang
Pine wall plates 76 mm x 38 mm (See note 12)
Precast concrete lintel
10 gauge galvanized wire ties secured under 3 courses of blocks (or 6 courses of bricks) and wrapped around wall plate
LOWER SIDE
HIGHER SIDE
DETAIL OF ROOF FIXING
scale 1 : 25
Smooth material
DETAIL SECTION OF SEAT
scale 1 : 25
6 mm ø steel bars
DETAIL OF SLAB PANEL WITH LIFTING HANDLES
scale 1 : 25
DETAILS OF TYPICAL FLYSCREEN FIXINGS
scale 1 : 25
6 mm ø steel bar
± 10 mm rebate
± 200 (to suit drop hole)
DETAIL OF PIT SEALING BLOCK
scale 1 : 25
Centre of ±200 mm ø hole for seat or pedestal
1200 min.
900 min.
Door opening inward/outward (see note 8)
3600
PLAN
scale 1 : 50
DRAWING 3
TYPICAL VIDP TOILET
(Based on REC II and NBRI VIDP latrines)
Building Technology
CSIR
P O BOX 395 PRETORIA 0001
TEL: 841 3871
Drawing Nr.:
B765-8
Scale: AS SHOWN
Date: JUNE 1997

APPENDIX C

Materials needed for steel moulds

2009 Cost of steel used for moulds in Large factory (Standard sizes)

Description	Unit	Quantity	Rate	Costs
127*64 Channel	6m	2	R1,096.32	R2,192.64
200*75 Channel	6m	1	R2,825.58	R2,825.58
40*20 Flat bar	6m	1	R474.24	R474.24
10*10 Square bar	6m	1	R55.02	R55.02
200*25 Flat bar	6m	1	R3,559.08	R3,559.08
80*80*8 Angle	6m	1	R515.76	R515.76
40*40*4 Angle	6m	3	R175.74	R527.22
30*30*3 Angle	6m	5	R98.82	R494.10
25.4*25.4*3 Square tube	6m	10	R170.88	R1,708.80
2500*1200*5 Sheet	No	4	R1,504.26	R6,017.04
2450*1225*2 Sheet	No	3	R610.42	R1,831.26
M8*50 Hexagonal bolts and nuts, Grade 4.6	Per 100	2	R46.83	R93.66
				R20,294.40

Cost of unused material

Description	Unit	Quantity	Rate	Costs
200*75 Channel	m	0.355	R470.93	R167.18
127*64 Channel	m	3.2	R182.72	R584.70
40*20 Flat bar	m	1.6	R79.04	R126.46
10*10 Square bar	m	5.8	R9.17	R53.19
200*125*25 End plate	m	5.75	R593.18	R3,410.79
2500*1200*5 Sheet	m^2	0.37573	R501.42	R188.40
80*80*6 Angle	m	0.71	R85.96	R61.03
40*40*4 Angle	m	5.43	R29.29	R159.04
25.4*25.4*3 Square tube	m	1.21	R28.48	R34.46
2450*1225*2 Sheet	m^2	0.48447	R203.39	R98.54
30*30*3 Angle	m	5.76	R16.47	R94.87
				R4,978.66

Cost of steel used for moulds (Excl. unused material)

Description	Unit	Quantity	Rate	Costs
200*75 Channel	m	5.645	R470.93	R2,658.40
127*64 Channel	m	8.8	R182.72	R1,607.94
40*20 Flat bar	m	4.4	R79.04	R347.78
10*10 Square bar	m	0.2	R9.17	R1.83
200*125*25 End plate	m	0.25	R593.18	R148.30
2500*1200*5 Sheet	m^2	11.6243	R501.42	R5,828.64
80*80*6 Angle	m	5.29	R85.96	R454.73
40*40*4 Angle	m	12.57	R29.29	R368.18
25.4*25.4*3 Square tube	m	58.79	R28.48	R1,674.34
2450*1225*2 Sheet	m^2	8.51928	R203.39	R1,732.74
30*30*3 Angle	m	24.24	R16.47	R399.23
M8*50 Hexagonal bolts and nuts, Grade 4.6	Per 100	2	R46.83	R93.66
				R15,315.76

*All steel section prices acquired from Macsteel as of 12 Jan 2009, except 25.4 Square tube price from Balwins steel as of 01 Dec 2008
*Steel section prices are inclusive of VAT @ 14%
*Bolt prices acquired from Obex Fasteners as of Sept 2005
*Bolt prices adjusted using 14% VAT and an annual inflation rate of 12%
*127*64 Channel price used instead of specified 125*60 channel as this section was unavailable
*200*75 Channel price used instead of specified 200*60 channel as this section was unavailable
*40*20 Flat bar price used instead of specified 30*20 flat bar as this section was unavailable

Individual mould costs 2009

Cost of base support beam mould

Description	Unit	Quantity	Rate	Costs
200*75 Channel	m	4.6	R470.93	R2,166.28
127*64 Channel	m	8.8	R182.72	R1,607.94
40*20 Flat bar	m	4.4	R79.04	R347.78
10*10 Square bar	m	0.2	R9.17	R1.83
109*52*5 Flat bar	m^2	0.02267	R501.42	R11.37
200*125*25 End plate	m	0.25	R593.18	R148.30
				R4,283.49

Cost of back cross beam mould

Description	Unit	Quantity	Rate	Costs
200*75 Channel	m	1.045	R470.93	R492.12
80*80*6 Angle	m	2.17	R485.96	R186.53
				R678.66

Cost of front cross beam mould

Description	Unit	Quantity	Rate	Costs
40*40*4 Angle	m	2.49	R29.29	R72.93
25.4*25.4*3 Square tube	m	1.13	R28.48	R32.18
205*1200*5 Sheet	m^2	0.246	R501.42	R123.35
				R228.46

Cost of base panel mould with 300mm hole

Description	Unit	Quantity	Rate	Costs
25.4*25.4*3 Square tube	m	2.7	R28.48	R76.90
40*40*4 Angle	m	3.36	R29.29	R98.41
1225*2450*2 Sheet cut to 240*740&942*40	m^2	0.21528	R203.39	R43.79
680*1200*5 Sheet	m^2	0.816	R501.42	R409.16
				R628.25

Cost of base panel mould (Need 2 of them)

Description	Unit	Quantity	Rate	Costs
25.4*25.4*3 Square tube	m	2.7	R28.48	R76.90
40*40*4 Angle	m	3.36	R29.29	R98.41
1225*2450*2 Sheet cut to 2×240*740	m^2	0.3552	R203.39	R72.24
680*1200*5 Sheet	m^2	0.816	R501.42	R409.16
				R656.71

Cost of base panel mould with PVC insert

Description	Unit	Quantity	Rate	Costs
80*80*6 Angle	m	3.12	R85.96	R268.20
600*1200*5 Sheet	m^2	0.72	R501.42	R361.02
400*880*2 Sheet & 2×400*70*2 Sheet	m^2	0.408	R203.39	R82.98
25.4*25.4*3 Square tube	m	2.712	R28.48	R77.24
				R789.44

Cost of roof panel mould

Description	Unit	Quantity	Rate	Costs
3×150*1200*5 Sheet & 6×150*352*5 Sheet	m^2	0.8568	R501.42	R429.62
25.4*25.4*3 Square tube	m	2.898	R28.48	R82.54
30*30*3 Angle	m	5.28	R16.47	R86.96
4×480*705*2 Sheet	m^2	1.3536	R203.39	R275.31
				R874.42

Cost of left side panel mould (Equal to right panel mould cost)

Description	Unit	Quantity	Rate	Costs
7×150*410*5 Sheet	m^2	0.43305	R501.42	R217.14
6×150*2035*5 & 5×150*410*5 Sheet	m^2	2.139	R501.42	R1,072.54
25.4*25.4*3 Square tube	m	17.58	R28.48	R500.68
30*30*3 Angle	m	6.46	R16.47	R106.40
2×540*950*2 & 2×540*850*2 Sheets	m^2	1.944	R203.39	R395.39
				R2,292.14

Cost of back panel mould

Description	Unit	Quantity	Rate	Costs
1970*1110*5 Sheet	m^2	2.1867	R501.42	R1,096.46
2×540*950*2 & 2×540*850*2 Sheet	m^2	1.944	r203.39	R395.39
30*30*3 Angle	m	6.04	R16.47	R99.48
25.4*25.4*3 Square tube	m	8.79	R28.48	R250.34
				R1,841.66

Total cost for all moulds	R15,222.10

Cost of steel used for moulds in Small factory (Standard sizes)

Description	Unit	Quantity	Rate	Costs
80*80*8 Angle	6m	1	R515.76	R515.76
40*40*4 Angle	6m	2	R175.74	R351.48
30*30*3 Angle	6m	5	R98.82	R494.10
25.4*25.4*3 Square tube	6m	10	R170.88	R1,708.80
2500*1200*5 Sheet	No	4	R1,504.26	R6,017.04
2450*1225*2 Sheet	No	3	R610.42	R1,831.26
M8*50 Hexagonal bolts and nuts, Grade 4.6	Per 100	2	R46.83	R93.66
				R11,012.10

APPENDIX D

Materials needed for VIP base – 2009

Cost of individual components
Cost of base support beam

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.0063	Kg	19.77	R1.32	R26.10
Witbank CSF	0.0007	Kg	1.48	R2.15	R3.19
Lethabo pozzfill (fly ash)	0.0021	Kg	4.94	R0.14	R0.69
Water	0.0085	Kg	8.46	R0.00	R0.03
Dolomite	0.0264	Kg	71.18	R0.09	R6.41
Bekaert Dramix 30*0.5	0.0006	Kg	4.39	R22.80	R100.16
P100 Superplastisiser	0.0003	Kg	0.35	R30.51	R10.65
O100 Retarder	0.0001	Kg	0.12	R30.51	R3.56
Y5.6 reinforcing bar		6m	4.00	R20.00	R80.00
Totals	0.0449		114.70		R230.78

Cost of back cross beam

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.00044	Kg	1.37	R1.32	R1.81
Witbank CSF	0.00005	Kg	0.10	R2.15	R0.22
Lethabo pozzfill (fly ash)	0.00015	Kg	0.34	R0.14	R0.05
Water	0.00059	Kg	0.59	R0.00	R0.00
Dolomite	0.00183	Kg	4.93	R0.09	R0.44
Bekaert Dramix 30*0.5	0.00004	Kg	0.30	R22.80	R6.94
P100 Superplastisiser	0.00002	Kg	0.02	R30.51	R0.74
O100 Retarder	0.00001	Kg	0.01	R30.51	R0.25
Totals	0.00312		7.67		R10.45

Cost of front cross beam

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.00080	Kg	2.52	R1.32	R3.32
Witbank CSF	0.00009	Kg	0.19	R2.15	R0.41
Lethabo pozzfill (fly ash)	0.00027	Kg	0.63	R0.14	R0.09
Water	0.00108	Kg	1.08	R0.00	R0.00
Dolomite	0.00335	Kg	9.06	R0.09	R0.82
Bekaert Dramix 30*0.5	0.00007	Kg	0.56	R22.80	R12.75
P100 Superplastisiser	0.00004	Kg	0.04	R30.51	R1.36
O100 Retarder	0.00001	Kg	0.01	R30.51	R0.45
Totals	0.00572		7.68		R19.19

Cost of base panel (Need 2 of them)

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.00286	Kg	8.98	R1.32	R11.86
Witbank CSF	0.00031	Kg	0.67	R2.15	R1.45
Lethabo pozzfill (fly ash)	0.00098	Kg	2.25	R0.14	R0.31
Water	0.00359	Kg	3.59	R0.00	R0.01
Dolomite	0.01072	Kg	28.95	R0.09	R2.61
Silica sand	0.00141	Kg	3.39	R0.17	R0.58
Dramix Micro	0.00015	Kg	1.19	R30.78	R36.66
Polypropylene	0.00004	Kg	0.04	R42.18	R1.69
P100 Superplastisiser	0.00012	Kg	0.12	R30.51	R3.65
O100 Retarder	0.00006	Kg	0.06	R30.51	R1.82
Totals	0.02024		49.24		R60.64

Cost of base panel with 300mm hole

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.00284	Kg	8.93	R1.32	R11.79
Witbank CSF	0.00030	Kg	0.67	R2.15	R1.44
Lethabo pozzfill (fly ash)	0.00097	Kg	2.23	R0.14	R0.31
Water	0.00357	Kg	3.57	R0.00	R0.01
Dolomite	0.01066	Kg	28.78	R0.09	R2.59
Silica sand	0.00141	Kg	3.37	R0.17	R0.57
Dramix Micro	0.00015	Kg	1.18	R30.78	R36.46
Polypropylene	0.00004	Kg	0.04	R42.18	R1.68
P100 Superplastisiser	0.00011	Kg	0.12	R30.51	R3.63
O100 Retarder	0.00006	Kg	0.06	R30.51	R1.81
Totals	0.02013		48.97		R60.30

Cost of base panel with PVC insert

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.00294	Kg	9.23	R1.32	R12.19
Witbank CSF	0.00031	Kg	0.69	R2.15	R1.49
Lethabo pozzfill (fly ash)	0.00100	Kg	2.31	R0.14	R0.32
Water	0.00369	Kg	3.69	R0.00	R0.01
Dolomite	0.01102	Kg	29.75	R0.09	R2.68
Silica sand	0.00145	Kg	3.49	R0.17	R0.59
Dramix Micro	0.00016	Kg	1.22	R30.78	R37.68
Polypropylene	0.00005	Kg	0.04	R42.18	R1.73
P100 Superplastisiser	0.00012	Kg	0.12	R30.51	R3.76
O100 Retarder	0.00006	Kg	0.06	R30.51	R1.88
Totals	0.0208032		50.62		R62.33

Total cost	**R504.34**

APPENDIX E

Materials needed for VIP superstructure made of high strength panels – 2009

Cost of individual components

Cost of roof panel

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.00421	Kg	13.22	R1.32	R17.44
Witbank CSF	0.00045	Kg	0.99	R2.15	R2.13
Lethabo pozzfill (fly ash)	0.00144	Kg	3.30	R0.14	R0.46
Water	0.00529	Kg	5.29	R0.00	R0.02
Dolomite	0.01577	Kg	42.59	R0.09	R3.83
Silica sand	0.00208	Kg	4.99	R0.17	R0.85
Bekaert Dramix 30*0.5	0.00022	Kg	1.75	R22.80	R39.96
Weld mesh 50*50*1.6mm		m^2	1.44	R38.33	R55.20
5.6 Y steel	6.00000	m	7.00	R20.00	R23.33
Polypropylene	0.00006	Kg	0.06	R42.18	R2.48
P100 Superplastisiser	0.00017	Kg	0.18	R30.51	R5.38
O100 Retarder	0.00008	Kg	0.09	R30.51	R2.68
Long nuts 10 mm			4.00	R2.30	R9.20
Totals	0.0297792		80.89		R162.97

Cost of left panel which is the same as the cost for the right panel

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.00563	Kg	17.67	R1.32	R23.33
Witbank CSF	0.00060	Kg	1.33	R2.15	R2.85
Lethabo pozzfill (fly ash)	0.00192	Kg	4.42	R0.14	R0.62
Water	0.00707	Kg	7.07	R0.00	R0.02
Dolomite	0.02109	Kg	56.95	R0.09	R5.13
Silica sand	0.00278	Kg	6.68	R0.17	R1.14
Bekaert Dramix 30*0.5	0.00030	Kg	2.34	R22.80	R53.44
Weld mesh 50*50*1.6mm		m^2	2.40	R38.33	R91.99
5.6 Y steel	6.00000	m	9.60	R20.00	R32.00
Polypropylene	0.00009	Kg	0.08	R42.18	R3.32
P100 Superplastisiser	0.00023	Kg	0.24	R30.51	R7.19
O100 Retarder	0.00011	Kg	0.12	R30.51	R3.59
Long nuts 10 mm			6.00	R2.30	R13.80
Totals	0.03982		108.89		R238.41

Cost of back panel

Description	V (m^3)	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	0.00517	Kg	16.24	R1.32	R21.43
Witbank CSF	0.00055	Kg	1.22	R2.15	R2.62
Lethabo pozzfill (fly ash)	0.00177	Kg	4.06	R0.14	R0.57
Water	0.00650	Kg	6.50	R0.00	R0.02
Dolomite	0.01938	Kg	52.33	R0.09	R4.71
Silica sand	0.00256	Kg	6.13	R0.17	R1.04
Bekaert Dramix 30*0.5	0.00027	Kg	2.15	R22.80	R49.10
Weld mesh 50*50*1.6mm		m^2	1.80	R38.33	R68.99
5.6 Y steel	6.00000	m	9.00	R20.00	R30.00
Polypropylene	0.00008	Kg	0.07	R42.18	R3.05
P100 Superplastisiser	0.00021	Kg	0.22	R30.51	R6.61
O100 Retarder	0.00010	Kg	0.11	R30.51	R3.30
Long nuts 10 mm			6.00	R2.30	R13.80
Totals	0.0365899		99.83		R205.24
	0.28121009		731.93		

Total cost					**R845.03**

APPENDIX F

Materials needed for VIP superstructure made of foamed concrete blocks – 2009

Cost of single VIP structure

Description	Unit	Quantity	Rate	Costs
Holcim CEM 52.5R	Kg	187.57	R1.32	R247.59
Lethabo pozzfill (fly ash)	Kg	562.71	R0.14	R78.78
Water	Kg	309.49	R0.00	R1.08
Polypropylene	Kg	1.88	R42.18	R79.09
Superplastisizer	l	0.95	R14.00	R13.30
Foaming agent	l	1.88	R25.00	R47.00
Stabilizing beams	nr	3.00	R40.00	R120.00
Netting (16 m^2)	m^2	16.00	R17.00	R272.00
Paint (Stippelcrete)	m^2	16.00	R20.00	R320.00
Roof incl timber	m^2	1.44	R80.00	R115.20
Threaded rod	6m	4	R20.00	R80.00
Accessories:				
Vent pipe, flyscreen				
and Pedestal	Item	1	R280	R280
Steel door	Item	1	R300.00	R300.00
				R1,954.04