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LESSON
SERIES

March 2014

THE WRC POUR FLUSH TOILET

Lessons from Western Cape Trials





ACKNOWLEDGEMENTS

This lesson is compiled from **WRC Research Report No. K8/1018/3: Pour Flush Trials in the Western Cape**, by **Maluti GSM Consulting Engineers**.

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1 BACKGROUND

Two new innovations have emanated from WRC studies, which saw the development of:

- The pour flush pedestal which uses a minimum 1L to flush
- The low flush pedestal, based on the pour flush design which uses a 1.5L flush

About Pour Flush Technology

The pour flush design overcomes several of the challenges associated with current sanitation initiatives, namely:

- Dry sanitation / VIP Latrines – Maintenance of these latrines can be complex and unhygienic as the faecal waste must be stored directly below the toilet. The absence of a water seal also means that odours may be apparent unless the toilet is very well maintained. The presence of odours, plus the need for waste to be stored beneath the latrine normally prohibits a toilet being installed inside a house.
- Standard flush toilets – requires mains water and connection to a sewer or septic tank system. The large volume of water used to flush a conventional toilet may place a strain on limited resources and may be unaffordable for the household.



Pour Flush Pedestal



P-Trap Design

The pour flush bowl slopes steeply towards a small diameter outlet at 48 degrees to the horizontal. A minimum 25mm water seal is provided by the long radius P-trap fabricated from 63mm diameter fittings. The small volume of water within the P-trap and the gradual bend of the P-trap enables to the toilet to flush effectively on 1 to 2 litres of water.

The pour flush technology provides a viable alternative to the standard flush systems, which has the potential to be installed inside a dwelling and can be flushed using available greywater. It is considered to have the potential to make a significant contribution to the sanitation backlog in South Africa and further afield.

2 PILOTS AND APPLICATION TO DATE

The pilot studies of the Pour Flush toilet technology had the following objectives:

- To trial pour flush toilets in high density Urban / Peri Urban settlements of the Western Cape.
- To trial pour flush toilets as an alternative to conventional flush toilets at the Sustainability Institute.
- To evaluate the suitability of using pour flush technology in medium to high density settlements.
- To raise awareness and interest in pour flush technology as a viable sanitation option in the Western Cape.

A significant amount of effort was involved in liaising with the communities, partner organisations and municipal officials, to allow for the necessary process of explaining the technology and receiving community endorsement in a context where sanitation provision is a particularly sensitive issue.

i. The Sustainability Institute - Western Cape

The Sustainability Institute is an educational facility located near Stellenbosch. The Sustainability Institute offers post graduate studies in sustainable Development and provides a space for people to explore an approach to creating a more equitable society that lives in a way that sustains rather than destroys the eco-system within which all society is embedded. For this reason it was the perfect place to trial the pour flush technology in an environment where conventional full flush toilets are also available.

Pour flush toilets replaced existing toilets, giving the user free choice of which toilet to use. Water meters fitted with data loggers will enable monitoring of number of users and volume of water per flush. This will enable investigation into user preference and the volume of water that is actually used to flush waste. Cleaning staff will also be interviewed to evaluate the extent of soiling and blockage of the different toilet designs. Metering will commence before the toilets are installed to establish the baseline of cubicle preference and water consumption.

The male toilets have three cubicles, one pour flush toilet will be installed next to one remaining conventional toilet. The female toilets have seven cubicles, one pour flush toilet will be installed alongside the conventional toilets.

Although the intention was to install Pour Flush toilets to replace existing toilets at the Sustainability Institute, the small size of the cubicles and the need to fit with existing drainage meant that it was not possible to install the pour flush toilets. However, a monitoring programme was undertaken to evaluate the impact of water consumption on toilet selection. This was achieved as follows:

- i. Install meters to measure the volume per flush of each toilet and user preference for a particular cubicle

- ii. Place signage on each of the cubicle doors to alert the user to the volume of water used by the different toilets and then monitor whether there is a shift in preference based on the volume of water used.
- iii. Install the pour flush toilets and repeat ii)

The above process was necessary in order to analyse the impact of known water consumption on usage patterns and to hypothesise the demand for a low volume toilet design. We intend to install a more compact toilet once this has been developed through the WRC Micro-Flush project



Meter Installation

ii. Klipheuwel Informal Settlement, City of Cape Town

Klipheuwel is a township situated on the R304 about 30 km west of the town of Stellenbosch. It is relatively new and well-spaced out township. There are several roads in and out of the township and a number of the residents have space for gardens around their properties. At least 6 people are managing subsistence gardens within the confines of Klipheuwel itself.

Approximately 80% of the community is served with AfriSan dry composting toilets, serving individual households. The toilets are installed inside precast concrete structures outside people houses. The maintenance contract between AfriSan and the City of Cape Town has ended, with maintenance now being undertaken by the City. Waste is collected in plastic bags which must be emptied every two weeks, indications are that the waste does not dry in accordance with its design principles.

It is understood that the City is seeking alternative solutions for this community and has given permission for AgriProtein to conduct some research using the Black Soldier Fly (BSF) larvae for the

treatment of faecal waste from Klipheuwel. The pour flush technology would enable effective collection of faecal waste without excess water, such that it can be effectively treated using the BSF larvae.

The original plan for this site was to retrofit the existing precast concrete toilets. However, the small size of these structures (internal width of 830mm and depth of 870mm) meant it would have been difficult to install the pour flush toilet complete with hand wash basin and grey water bucket. It was therefore decided, with encouragement from the community, to construct toilets to provide new sanitation facilities for un-serviced households.

Five pour flush toilets replaced the existing AfriSan toilets and discharge to soakage pits. The solids are retained in a container for periodic emptying by AgriProtein.

The sewage will initially be discharged into a septic tank which would later be modified to enable effective harvesting of solids. A suitable position for the boidigestor was agreed with the community near the bottom of the site, from where 5 households were identified who could be serviced from the septic tank. The topography at Klipheuwel is quite flat such that the drainage needed to be carefully routed to ensure that a minimum gradient of 1 in 50 could be maintained for all sewer pipework.



Aerial photo of Klipheuwel



Existing EcoSan Toilets

Inspection chambers were purposely avoided to improve affordability, and avoid unauthorised discharge of waste into the sewer, (research at other high density sites has indicated that a common cause of sewer blockage is the discharge of food scraps and waste into the sewer via inspection chambers). Furthermore, inspection chambers are hydraulically inefficient in surcharge conditions due to the turbulence experienced on exit and entry of the sewer pipe. Rodding eyes are provided at all bends to enable clearing of blockage should this be required.

All pipework, the septic tank and floor slabs were completed by our builders (Terrence and James). It was decided to construct the superstructure from timber and zinc to be a familiar form of construction that could be undertaken by locals. The materials and artisans were sourced from the community to promote future replicability. The demonstration structure was constructed with the local artisans who were then provided with tools and basic support to complete the task. Unfortunately (as may have been expected) the quality of materials and workmanship was not to the standard that one would hope, but this has not distracted from the appreciation and success of the project.



Map of Pilot Site at Klipheuwel (left) and Typical Pipework (right)

Individual toilets were provided in the yard of individual houses; those benefitting from Municipal toilets are serviced in a similar way. Each of the recipients were asked where they would like their toilet to be installed with consideration of connection into the sewer.

Approximately 56m of drainage piping was laid with rodding eyes at the top of each section that leads to the septic tank. The drainage pipes feed in to a 2200 litre septic tank, the supernatant discharges to a French Drain to a similar specification as was used at Klein Begin.



(Demonstration Toilet)



Magrieta with her new toilet (left) and Finishing touches (right)

We anticipate that the septic tank will have capacity to serve up to 100 households due to the low volumes associated with the pour flush toilet, it is hoped that the network can be extended to serve additional houses. There are also plans to modify the inlet of the septic tank to assist the harvesting of faecal waste for Biocycle's BSF project, we would also like to extend the french drain to irrigate a tree plantation and thereby minimise infiltration of supernatant.



BSF Larvae



Typical View of Klipheuwel Settlement

iii. Klein Begin Community, Grabouw, Theewaterskloof.

The community of Klein Begin own the land on which they reside. As private land owners, the municipality does not provide free basic water services to this community. They have good access to water via a borehole and rudimentary reticulation to yard taps. The existing communal toilet blocks discharge to a septic tank and are in a poor state of repair.

The Lighthouse Foundation has established a crèche in the community and is involved in several upliftment initiatives within the community. They have been donated a biodigester to which we will connect two toilets to serve the crèche. 3-4 additional toilets will be installed inside people's homes and connected to soakage pits or the biodigester.



Map of Klein Begin



Existing Toilet



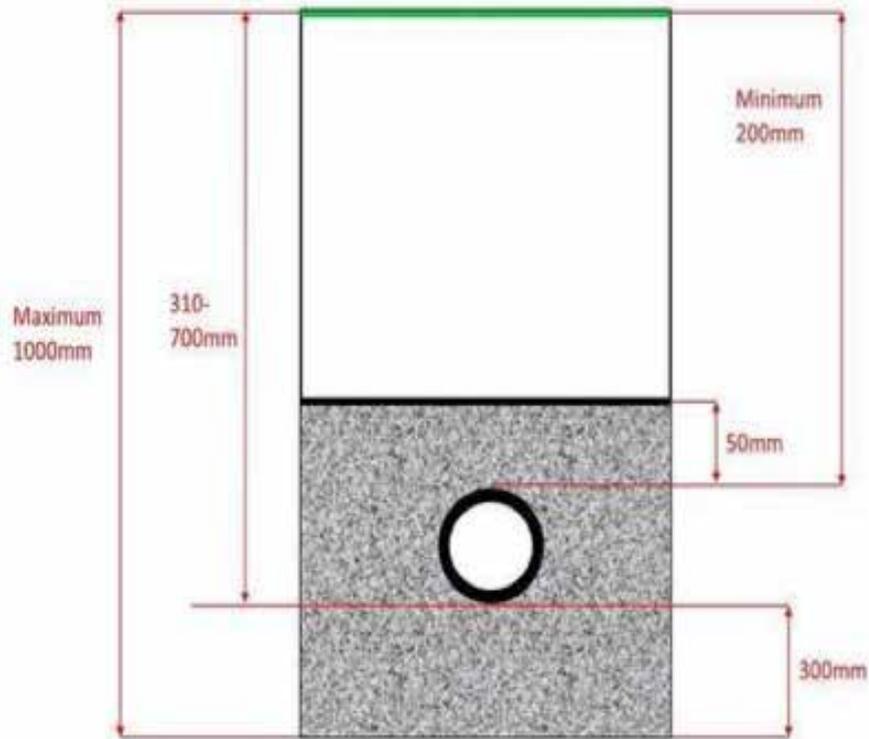
Typical View of Klein Begin Timber Building

A total of four toilets were installed at Klein Begin as indicated in the figure below:



Location of Klein Begin pour Flush Toilets

A biodigester was installed by Sustainable Engineering Solutions as part of a separate project, but the project team did however construct the soakaway to enable effective infiltration of the supernatant. The design of the French drain followed guidance from the UK's BRE365 soakaway specification which is more stringent about maintaining a good aerated zone than South African specifications. This aerated zone enables growth of aerobic bacteria which are effective at breaking down pathogens. The French drain must be laid flat along the contour with the invert of the pipe no deeper than 700mm below ground. The conveyance pipe should only be slotted on the underside and should be encased in a good layer of stone. A Geotextile was used to avoid migration of fines into the French drain.



Typical French Drain Dimensions

Three additional toilets were installed inside the existing communal facility, replacing broken infrastructure. Initial work was undertaken to install one further toilet but the septic tank into which it will discharge is full. We are awaiting the community to arrange for the septic tank to be emptied before this 5th toilet is installed.



Constructing French Drain



Creche Toilet



Toilet 3 Installation existing dilapidated structure, (note septic tank was located directly below toilet so toilet had to be set forward to accommodate long P-trap)



Toilets 3 and 4 complete

iv. Enkanini Informal Settlement, Stellenbosch

Enkanini is a rapidly expanding informal settlement on the outskirts of Stellenbosch. In recent years the municipality has maintained a boundary fence which has resulted in increased densification of the community. The municipality provides communal toilet blocks at various positions in the site which are connected to a municipal sewer, this sewer frequently surcharges due to blockage and stormwater ingress.

The Sustainability Institute has an established relationship with the people of Enkanini and has conducted several research projects in this community, including the well-publicised i-shack project. Initial plans for the Enkanini pilot were to connect five toilets to a condominal sewer, discharging to a conservancy tank at the Sustainability Institutes 'resource centre'. The density of this community is too high, and the dwellings too small to enable the installation of private toilets or the construction of soakage pits. Five toilets sites have been identified where there is sufficient space and suitable topography to enable the construction of the condominal sewer. The toilets will be shared between 3 to 5 households who will take responsibility for their maintenance.

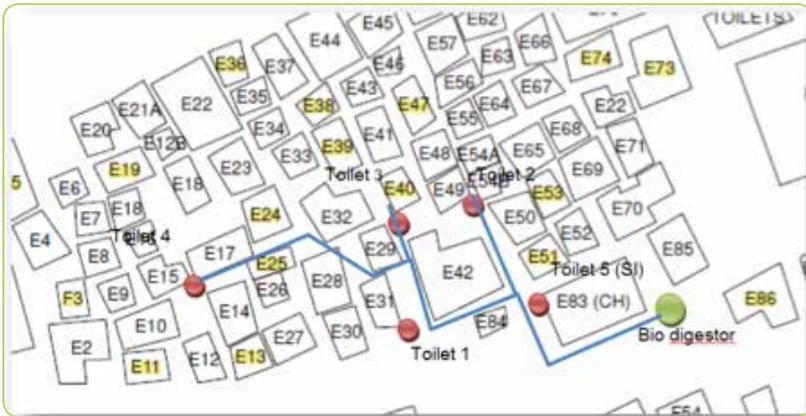
The conservancy tank was originally deemed necessary to avoid the need for connecting to a municipal sewer. However subsequent permission was given by the municipality to discharge into the sewer on a trial basis, this enabled the installation of a biodigester with the supernatant discharging to the municipal sewer approximately 30m from the site.



Typical space constraints and access between shacks



The toilets are connected via a network of approximately 50m of condominal sewer, discharging into a biodigester at the Sustainability Institutes 'resource centre'. As discussed in the Klipheuwel pilot, the sewer design has purposefully avoided inspection chambers to avoid unwanted disposal of waste into the sewer which could cause blockage. The outlet of the Biodigester is fitted with an irrigation meter to measure flow, and this discharges via a 30m pipeline to the municipal sewer. The biodigester is the prefabricated Agama Biogs pro which can handle 1080 litres of effluent per day.



Map of Section E, Enkanini



Yondela, a co-researcher, discussing possible toilet positions with future users.

In consultation with the community it was agreed to construct the toilets from precast concrete panels. A modular concrete system was required to enable the toilets to be carried through tight spaces. The panels were laid on two courses of sandbags filled with a dry sand cement mix.

A good foundation is essential at Enkanini where surface erosion is a high risk due to the steep topography and low permeability soil. Because the toilets have outward opening doors, they are just large enough to install a handwash basin and bucket inside.



1



2



3



4

1. Placing the roof slab
2. Biodigester Installation
3. Toilet 1 Complete
4. Handwash Basin

3 LESSONS AND EXPERIENCES

The feedback during the installation process has been extremely positive with all sites being receptive to the technology and observations to date confirm that the pour flush design is working well without blockage.

The following points are the keys highlights, conclusions, and recommendations of the pour flush trials to date:

- Successful installation of the pour flush toilets at 3 different sites
- In the case of Enkanini, there is a willingness to contribute to the maintenance of the facility.
- Communal pour flush toilets at Klein Begin working and being kept clean, despite failure of previous flush toilets due to lack of household servicing.
- 2 litres is commonly used to flush and clean the toilet.
- Stellenbosch Municipality is considering incorporating Pour Flush into their standard specifications for informal settlements.
- The pour flush design works well with a simplified sewerage network.
- The low volume flush of the pour flush toilet is complimentary to anaerobic treatment systems where hydraulic retention time is a key factor
- Multi-stakeholder collaboration is important (Municipalities, Communities, Sustainability Institute, Students, Biocycle, Lighthouse Foundation, Sustainable Engineering. Solutions)
- The cost of a Pour Flush installation may be less than the typical costs of a VIP latrine and significantly less than full waterborne sewerage.

Recommendations

For all retrofit applications it would be useful to raise the outlet of the pour flush toilet to match the international sanitary ware standard, where the centre of the 110mm outlet is 190mm above floor level (approx. 170mm for the 65mm pour flush outlet). This could be achieved by raising the floor of the toilet and creating a new step or raising the pan of the pour flush toilet.

The design of the P-Trap should be reviewed and optimised with the following considerations:

- Potential blockage risk from cans and drinks bottles due to the deep narrow outlet.
- Total length of P-Trap could be reduced by increasing the pipe diameter slightly and reducing the radius of the bend.

The South African Bureau of Standards (SABS) should be engaged to modify current standards and building regulations to accommodate the pour flush pedestal design.

Appendix 1: Toilet Design Guide

PAVEPRINT CC
CK 1991/025325/23
VAT REG NO: 4670132646
TRADING AS:-



MANUFACTURERS AND CONTRACTORS SINCE 1973

SILICA ROAD
ATHLONE INDUSTRIA II
TEL: 021 691 0027 / 8 / 9
WEB SITE: www.concretex.co.za

P O BOX 24177
LANSLOWNE 7779
FAX: 021 691 0072
EMAIL: concretex@mweb.co.za

PRECAST CONCRETE REINFORCED VENTILATED IMPROVED PIT LATRINE. 1

SPECIFICATION

GENERAL DESCRIPTION:

- The system comprises of a pitliner below the ground made up of concrete panels bolted together.
- A concrete slab is placed on top of the liner walls forming the floor base for the top of the toilet structure.
- This top structure also consists of concrete panels bolted together with a concrete roof, steel door, pedestal and a vent pipe.

1. PIT LINER

- 1.1. Excavate ground +/- 1 100mm in depth by +/- 1 300mm in width and +/- 1700mm in length.
- 1.2. Use the steel template supplied, set level and place 4 x concrete pads to receive the pitline panels.
- 1.3. Position panels on base pads and bolt together using the 1 200mm and 1 600mm panels.
- 1.4 Reinforcement: Panels are reinforced using prestressed steel of the crimped variety and to be free of rust, loose scale, flux, grease or oil substances and shall in general comply with BS5896.
The required concrete compressive strength in all prefabricated prestressed elements shall be a minimum of 25mpa at 28 days determined in accordance with SABS method 863.

Members: M. P. Ryan, J. J. Ryan & L. Z. Magxabela

2. FLOOR SLAB:

The dimensions of the floor slab must be 1 300mm x 2 000mm x 75mm thick. These panels are reinforced as per 1,4.to withstand a live load of 300 kg plus the weight of the concrete top structure applied on an area 1.0m² in the centre of the slab.

3. TOP STRUCTURE:

- 3.1. Concrete panels 60mm thick x 500mm wide x 2 000mm in length are erected on top of the floor slab in a vertical position and are bolted together to form a cubicle measuring 1 000 x 1 000 x 2000mm
- 3.2. Roof slab for top structure: Lightweight concrete panel 1 100 x 1 100 x 60mm is placed on top of the structure wall panels.
- 3.3. Reinforcement as per 1.4 and steel mesh ref. 100
- 3.4. Door: Galvanised steel door suitably braced and measuring 815mm x 1 800mm high opening outwards on a steel pivotal hinge.

4. PLASTIC PEDESTAL:

The plastic pedestal (Atlas Plastics type VIP200) with plastic toilet seat and cover is fitted into an opening in the floor slab which leads into the pitliner.

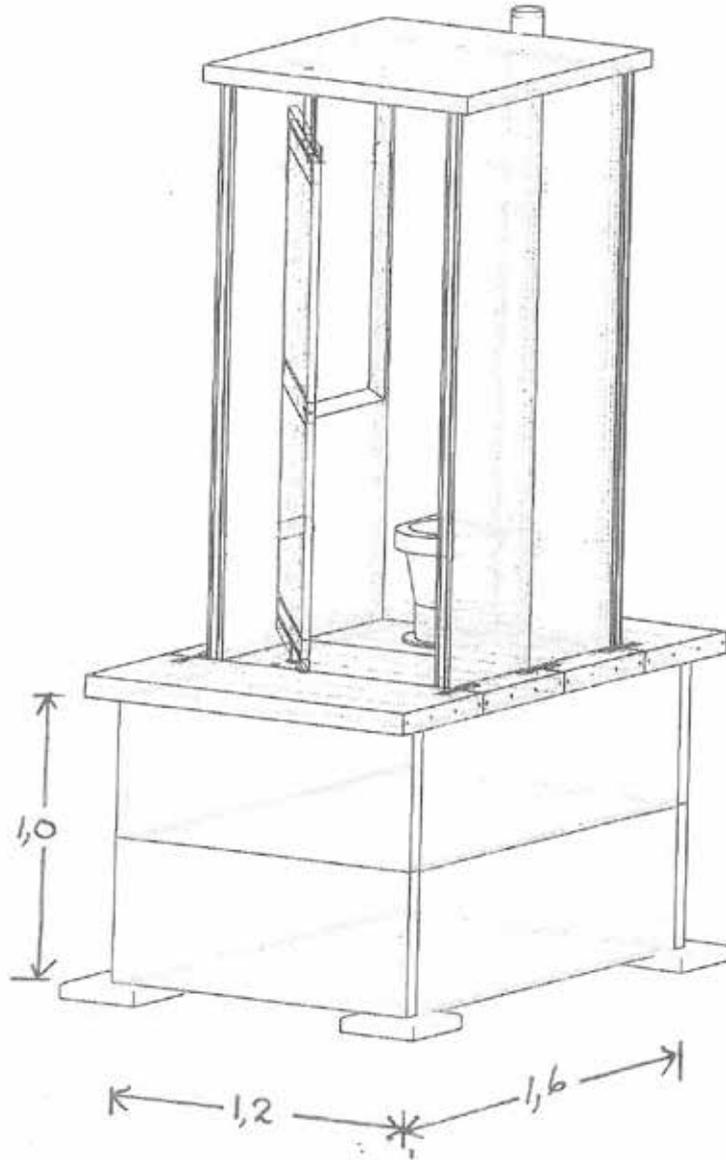
THE VENT PIPE:

The vent pipe is 110mm in diameter x 2 400mm in length in black plastic (UV resistant) with vent cowl and fly screen.

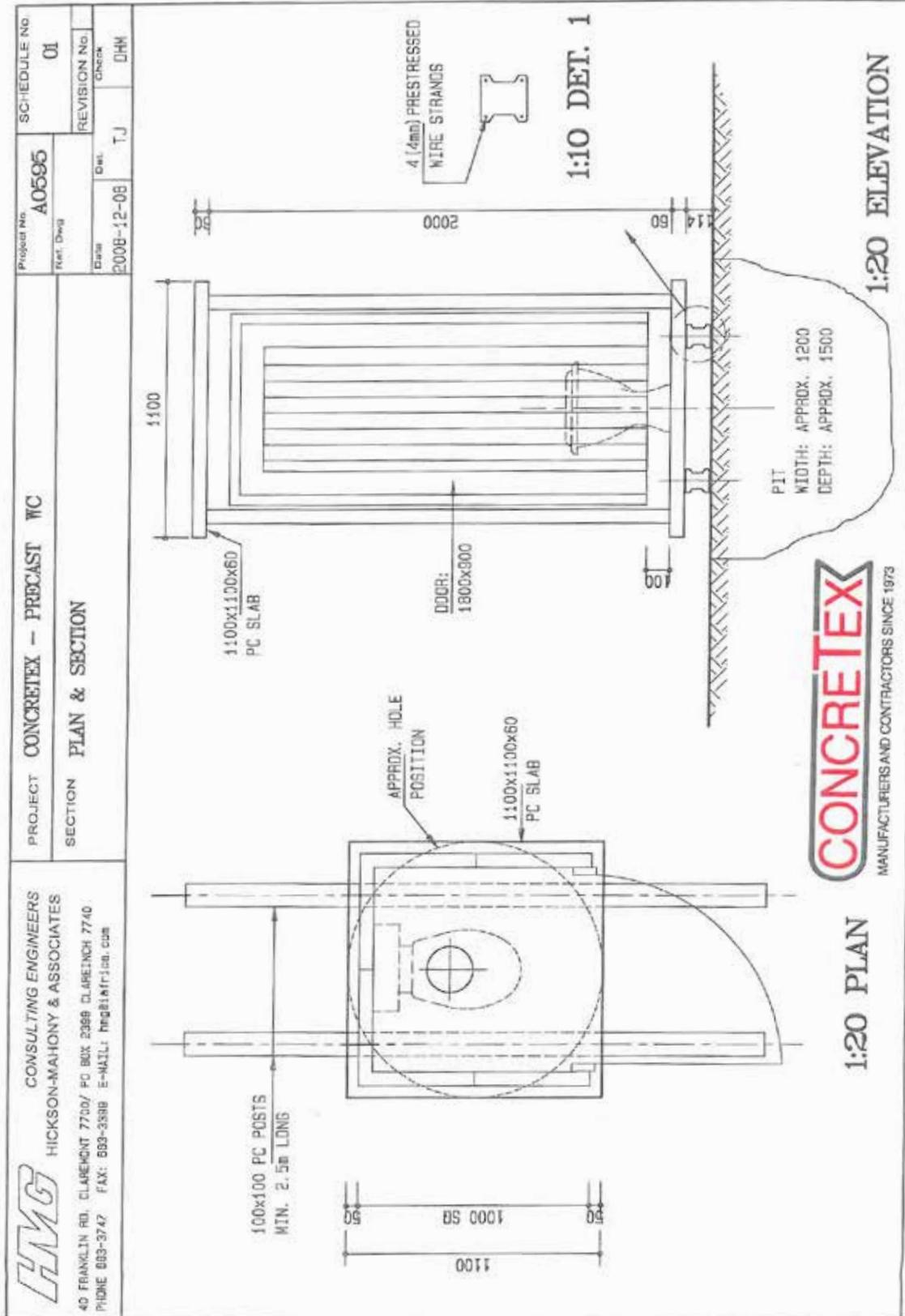
Holder bats x 2 to be fixed to the rear wall of the top structure to hold the vent pipe in position.

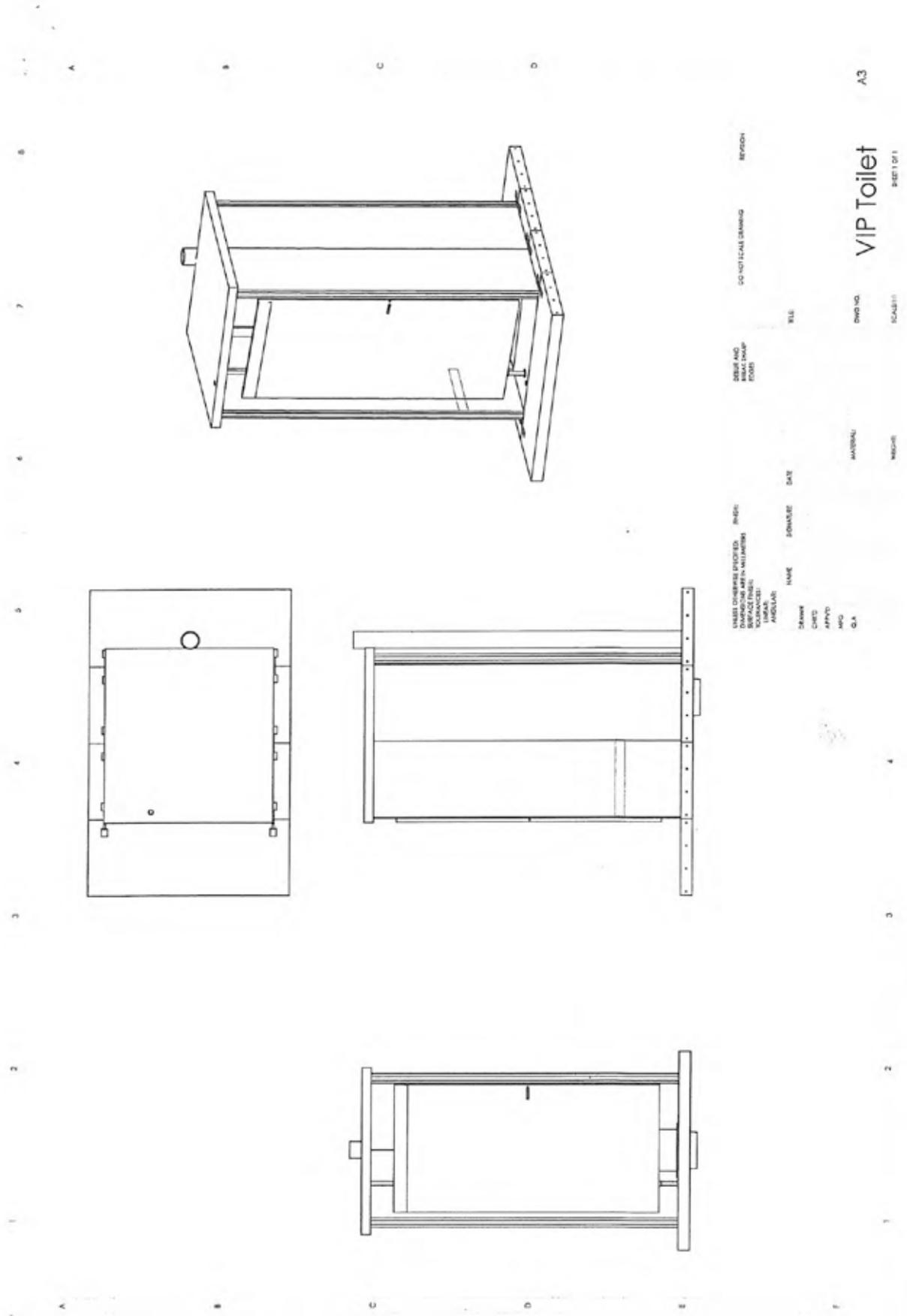
The pipe is inserted into a hole in the floor slab to ventilate the pit.

DRAWING NO 2



CONCRETEX
MANUFACTURERS AND CONTRACTORS SINCE 1973





NAME: [REDACTED] SHEET: [REDACTED]
 DRAWING NUMBER: [REDACTED]
 DATE: [REDACTED]
 DRAWN BY: [REDACTED]
 CHECKED BY: [REDACTED]
 APPROVED BY: [REDACTED]
 TITLE: [REDACTED]

DWG NO. [REDACTED] SHEET OF 1
 SCALE: [REDACTED]

PROJECT: [REDACTED]



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