REVIEW OF LOW COST SANITATION TECHNOLOGIES IN INDIA

Revised Assignment Report
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A. K. Roy

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IN INDIA

I N D E X

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Terms of Reference

a) Comparative study and documentation of available low cost pour flush latrine developed and in use. This will include design, designs of material and cost of construction and suitability of each design under different field and socio-economic conditions.

b) Explore possibilities of change in design/material of construction that will reduce the cost substantially without adversely effecting the efficiency and acceptance of the system.

c) Identify areas which need further research and development effort.

d) Prepare a report which will include but not limited to the following: details of various pour flush latrines available including design, material of construction and cost of construction at current prices; advantages and disadvantages of each design; recommendations for changes in design/material of construction with estimated savings.

Activities undertaken

Since the assignement was limited to a desk study, the tasks assigned to the Consultant had to depend on:

i) review of available documents;

ii) long distance discussions on telephone with various authorities, both government and non-government;

iii) discussion with the experts of Ministries of Urban and Rural Development and others; and

iv) postal correspondence.

Introduction

The absence of latrines and lack of proper excreta disposal system in India have their roots in the past Indian culture and tradition which emphasized that the place of defecation should not be adjunct to a home as it defiles its sanctity. Thus, history, culture and tradition had combined to ignore latrines in the design and architecture of Indian homes. Defecating away from home in the fields by returning human excreta into the soil or near a flowing river, so that the filth could remain away from home, was the guiding principle and this became a matter of habit and was thought to be most convenient. It is very much the same in the rural areas of the country to-day. It is interesting to note that ancient Indian manuscripts of 320 B.C. mention that defecation and urination were prohibited by law, if committed on roads, near reservoirs, temples, government offices etc. led to heavy penalties if violated. The privies came into existence with the advent of the Muslim era due to the "purdah" observed by the muslim women.

Proper collection and safe disposal of human excreta is

one of the basic needs for promotion of health, hygiene and environment. Considering the vastness of India, with its different culture, customs and attitudes, together with variations in climate and hydrogeological conditions, design of latrines which would suit both the urban and the rural population raises several complex problems. Considerable research efforts have been put in to find a suitable solution. The problem has engaged the attention of Public Health Departments ever since they were established. Investigations carried out however reveal that very little progress was made prior to mid fifties except for the introduction of septic tanks and sewerage more than a century ago. High cost, however, restricted their adoption. No systematic and scientific studies had been carried out to find out the drawbacks in the latrines in use and what improvements were needed to make them hygienic and safe for disposal of excreta.

With the introduction of Community Development and the National Water Supply and Sanitation Programmes as part of Five Year Plan (1950) activities for improving the sanitation facilities both in the urban and rural areas were undertaken. An urgent need was felt for a suitable type of latrine that could be widely adopted both in the rural and urban areas, and which would be affordable, acceptable and easily available.

Different Types of Latrines Used in India & Their Acceptability

The constructional features of some of the important type of latrines developed and used in the country in the past are mentioned below:

i) **Bucket/dry latrine**

In the urban areas "bucket latrines" continued to be the most common type of dry privies both in the households and also in many community toilets. The waste is removed periodically by scavengers which might be even after few days interval, to a trenching ground for composting. The scavengers may be employed by the local authorities or the work is carried out privately on payment. Dry commodes were also provided in earlier days in well-to-do homes who could afford a scavenger for the family for removal of the waste quickly. The bucket latrines have buckets or any other receptacle for retention of faeces (and some times urine and anal cleansing materials) which is periodically removed for disposal. The container is placed either on the floor in between the foot rests or in a small vault under the floor of the latrine cubicle. In the latter case the servicing of the latrine can be done from outside, through an opening, without entering the latrine cubicle. The initial cost of bucket latrine is low but servicing cost by scavengers is high. Moreover it is malodorous, creates fly nuisance and foul smell. Collection is physically, socially and culturally unacceptable and is a source of health hazard. Nearly 25% of the urban population is served at presently by

the bucket or dry privies. The present policy of the governments is to stop further construction of these privies and convert the existing ones into low cost pour flush toilets with leaching pits or connect them to sewers, wherever feasible.

ii) **Septic Tank Latrine**

It is not a low cost sanitation system but has been classified as medium cost. It has found acceptance to a very limited extent in the well-to-do homes both in the urban and rural areas. Septic tank is an underground water-tight settling chamber. The excreta with flushing water is discharged through a pipe from a latrine inside a house or from another building. The waste is partially treated in the tank and the effluent from the tank infiltrates into the ground through drain or soakage pit. Periodic desludging is required. The cleaning and disposal, if not handled properly, expose the persons handling the sludge to health hazards.

iii) **Aqua Privy**

The aqua privy is a simplified septic tank and has been used in different regions in the country and particularly in way-side stations in railways. The privy consists of a tank filled with water into which dips a chute or drop-pipe hanging from the latrine floor. The faeces and urine fall through the drop-pipe into the tank where they undergo

anaerobic digestion as in a septic tank. The digested sludge accumulates in the tank and has to be removed periodically. Water is added to compensate for evaporation and leakage losses to keep the waterseal intact. Excreta sticks to the pipe resulting in foul smell, mosquito and fly nuisance. The excreta floats and is visible from the pipe and splashing of water occurs. Hence this type of latrine is not socially acceptable and has been discarded in this country.

iv) **Bore hole latrine**

The latrine consists of a hole 300mm to 400 mm diameter dug in fairly soft soil by a special auger to a depth of about 6m or 1m below the ground water table. A concrete squatting plate with a central opening and foot-rest is placed over the hole and a suitable enclosure built around it for privacy. Once the hole is filled up, another bore has to be dug and the superstructure has to be shifted. The sides of the pit get fouled resulting in fly nuisance and foul smell.

v) **Hagevu flush latrine**

The Hagevu latrine is a modified pit latrine. A pit about half a meter in diameter is first dug to a depth of about one metre. After this depth, the diameter of the pit is gradually increased to about 1 metre at a depth of about 2.5 to 3 metres and nearly 1.5 m at a depth of 5 to 6 metres. If the nature of soil does not permit digging in a

slanting direction, the pit may be about 1 metre square or round throughout the whole depth. A latrine seat is placed over the pit and suitable superstructure is built. A pan and trap can also be provided from an offset enclosure. This was introduced in Mysore villages. This type of latrine is not popular.

vi) **Gopuri latrine**

This latrine was developed and used in Maharashtra State. The latrine is similar to a pit latrine.but the pit is constructed above the ground to facilitate removal of the excreta and for covering the excreta with ash, earth, paddy husk etc. from the rear of the pits. Each latrine is provided with 2 pits which are used alternately. The squatting plate with whole is mounted on the pit in use while the other pit not in use is covered with a galvanised iron sheet mounted on a frame. A vent pipe is also provided for exit of foul gases. The manure obtained after composting the excreta is used for agriculture. This type of latrine has not found acceptance by the people.

vii) **Khatghar type latrine**

This type was used in some parts of Maharashtra State. The latrine consists of masonry tank for 10 to 12 users and an auxillary tank to increase the detention period of the effluent. The seat consists of a cement pan to which is attached an automatically operated G.I. flap. With the

weight of the excreta and ablution water, the flap empties the contents into the tank and reverts itself to the original position automatically. The effluent from the auxillary pit is diverted into the adjoining refuse pits to accelerate the decomposition of the refuse. This type of latrine is not popular.

viii)**Dug well latrine**

This latrine was first introduced in West Bengal. A circular pit is dug to a depth of 3 to 4 metres. In the case of sandy soil, the depth is reduced. The pit is lined with pottery rings 225 to 300 mm depth. Brick or concrete ring with an earth mound is provided on top of the pit so that the squatting plate placed on top of it is at least 225 mm above the ground level to prevent rain water getting into the pit directly. This type of latrines are still in use, but are not popular.

ix) **Barapalli type latrine**

In an effort to improve environmental sanitation in villages, a pit latrine with water seal squatting plate over the pit was developed at the Barapalli village, Orissa State. A suitable mould was developed to cast the squatting plate and water seal. The dimensions of the latrine pit are 1 m diameter and 1 to 1.5 m. deep. This type of latrine is not popular.

x) **Community Toilets and Group Latrines**

These may be classified as low cost system. Community toilets require very careful operation and maintenance. The "pay and use" type of community toilets have set an example that they can be maintained properly. But "Group Latrines" which are to be maintained by a group of families using the latrine with self help or by employing a part time scavenger, have not been very successful because of the internal differences among the families using the latrine.

Development of Pour Flush Excreta Disposal System in India

Single pit pour flush latrines

Before mid-forties conventional water flush toilets were considered where sewerage system existed or septic tanks could be provided. These were in fact mostly found in the urban areas.

With the assistance of the All India Institute of Hygiene and Public Health (AIIH&PH), Calcutta, special efforts were made in undivided Bengal (Bangladesh & West Bengal) during 1940-54 to improve the bore hole latrines in rural areas. The Institute developed a bowl type water seal fixed to the squatting plate in one piece while casting.

However because of the limited life of the bore hole in that area, it was modified into a dug well by the Institute during the latter part of forties. This was the first introduction of a pour flush latrine. It had a single

leaching pit and was flushed with the water used for anal cleansing. The design was meant for the rural areas.

In Kerala, a squatting plate cast with a bowl is placed over the pit which is about 2.5 m deep and 0.75 m dia or 0.75 m x 0.75 m square. Over it, a superstructure is put up. This type of latrine is known as ESP water closet. When the first pit is filled up, either the pit is cleaned after removing the squatting plate or another pit is constructed and squatting plate is placed over it and superstructure is removed to the second pit. These latrines are no more popular and the Government is also not encouraging them.

In Gujarat, PF latrine was being provided earlier with a single off-set pit which was very deep (7 to 10 m deep). Now the practice of providing a single pit has almost been abandoned and latrines with two pits are being provided.

Research on pour flush latrines for rural areas was emphasized with the commencement of the Five Year Plan in 1951. The Planning Research cum Action Institute (PRAI), Lucknow undertook research on rural latrines with the assistance of WHO. Another important development was the establishment of Research-cum-Action (RCA) project in 1956 by the Union Ministry of Health with the assistance of the Ford Foundation. RCA project was conducted in the three centres at Poonamallee (Tamil Nadu), Singur (West Bengal) and Najafgarh (Delhi).

Double pit system

The Planning Research cum Action Institute, Lucknow was the first to develop the two pit off-set type pour flush latrine at the end of fifties. This was a break-through in the design of the pour flush latrine which till now was of single pit with the squatting plate over it. The PRAI type latrines could be flushed with 1.5 to 2 litres of water. PRAI suggested only a single pit to be constructed at the beginning and when it got filled up, the second pit was to be put up. The curved connecting pipe which was in use with the first pit, was directed towards the second one. The R.C.C. cover of the first pit was to be transferred to the second and the first was covered with earth. After maturing, the pit contents were to be used as a manure for agriculture. The capacity of the pit was of nearly 5 years. Most of the beneficiaries did not dig the second pit when it was full because of various reasons, and resorted to open defecation.

Advantages of double pits visavis single pit

The adoption of single pit is still being advocated by few as it is slightly economical (costs about 33% less) or where space is a constraint. However, experience during sixties and in the earlier period was that hundreds and thousands of adopters of single pit latrines never constructed the second one later and took to open defecation. The entire amount spent on the construction

proved to be infructuous. This was particularly significant considering the efforts put in by the Governments for implementing the programme and that the major portion of the cost was provided as subsidy by them. Investigation and analysis revealed the following short comings in the single pit system which were responsible for its non acceptance and promotion and they clearly revealed the need for constructing the second pit at the very beginning.

i) Emptying of pit was the major problem. The top surface had raw human excreta which had to be handled by scavengers who were not available in the villages. In the urban areas, inspite of availability of scavengers they were not readily willing for doing this type of job. The charges demanded were very high. Moreover emptying the contents manually was a health hazard. Emptying was possible, if the desludging could be done by sludge pumps. Both in the rural areas and urban areas, proper machine management by the local authorities considering their operation and maintenance was not possible. Even in the cities emptying of sludge from private household septic tanks by the local authorities, which is their obligatory task, can not be performed timely.

ii) The greatest draw back in a single pit system is that the usual labour available will not do the job of removing the pit cover or emptying the pit as it would need handling of fresh human excreta. Scavengers will

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ii) The greatest draw back in a single pit system is that the usual labour available will not do the job of removing the pit cover or emptying the pit as it would need handling of fresh human excreta. Scavengers will

have to be employed for the operation. Thus this will perpetuate the employment of scavengers which is against the very decision of the Governments and for which the Governments of India has introduced the programme of eradication of scavenging by adopting low cost sanitation.

iii) A site at a safe distance for emptying and drying the sludge was necessary as the top layer of the pit content is fresh human excreta.

iv) The desludging operation had to be done almost immediately after the pit had been filled up to enable its reuse. It was not possible to do so. In the rural areas the easy alternative was to take recourse to open air defecation while in the urban areas one had to depend on the use of toilets of neighbours or use a public toilet which obviously was not convenient considering the time taken in constructing a new pit or emptying an old one.

v) It was suggested by the planners that alternatively, a second pit could be constructed later, before the first pit is full. Advance indication of the filled up position of the pit could not be ascertained and the timely availability and mobilisation of masons/contractors to build the second pit was not practicable.

vi) The subsidy for the second pit was not given by the Government as it was not provided in the design and the entire cost of the second pit had to be borne by the beneficiaries. Thus the incentive to build the second pit was not there.

vii) Normally the single pit is deeper. Thus the initial cost of this pit is higher. Desludging is more difficult and costlier. There are more chances of pollution specially where the water table is high.

viii) The cost of desludging should also be taken into account to arrive at the real/actual cost.

Thus the economy effected in constructing only a single pit at the beginning was not popular and did not contribute to the expansion of the programme as envisaged. The double pit system, with both the pits lined and constructed at the very beginning was introduced. It was found to be more acceptable and permanent in nature and was therefore adopted. However latrine programme did not spread in the villages for lack of health education, promotional and motivational activities and above all it could not be afforded by the villages nor was it their felt need.

Introduction of LCS in Urban Areas of India

Attempts were made to introduce pour flush latrines (LCS) with twin leaching pits in urban areas from late sixties and early seventies as a local programme. A few

small towns which were more rural in character adopted the two pit system in the states of Tamil Nadu and Gujarat. The programme was taken up with the assistance of the Poonamallee Institute, Madras, and the Safai Vidhalya, Ahmedabad in the two states respectively. In Bihar state, this system with some changes was taken up very successfully in many towns and even in cities since early seventies by Sulabh Shauchalaya Sansthan now called Sulabh International, a non-governmental social organisation. By mid seventies even the state's capital city, Patna, was provided with thousands of these latrines which were named by the organisation as Sulabh Shauchalayas. The achievement of this organisation impressed the World Health Organisation, SEA Region which went into the details. The WHO organised a National Seminar (1978) at Patna on the conversion of bucket latrines into low cost pour flush toilets. Eminent public health engineers, public health scientists, sociologists, administrators, planners and decision makers both from the Central and State Governments attended the seminar. After deliberations and seeing the work done at Patna, the participants advised the Government of India for the adoption of pour flush two pit system in urban areas in specific hydrogeological and site conditions. This was the first positive step taken for adoption of LCS in the urban areas. However by then no systematic technical or scientific studies had been carried out by any of these organisations.

The indepth study on all aspects of pour flush latrine was first taken up by TAG (India) in June 1979. It carried out the evaluation of the existing pourflush systems in different states. Assistance of various experts as consultants and organisations like AIIH&PH, CBRI, NEERI, Poonamallee Health Institute, Gandhi Gram Institute and the National Swedish Institute for Building Research etc. were taken for investigations. An Expert Group constituted by TAG in 1981 established the design criteria of pour flush latrines in urban areas and a design, construction and maintenance manual of low cost PF latrine was prepared in 1984. Another Expert Group established the design criteria for rural pour flush latrines in 1985. Based on the feasibility reports of TAG, the Government of India and all the state governments decided in a conference in January 1983 that low cost pour flush latrines should be given the highest priority in all towns having population upto 100,000 and the pour flush system with twin pits should be adopted wherever possible. The designs and specifications proposed by TAG were accepted and adopted by GOI and all the State Governments with minor modifications by a few of them.

However because of the rising cost it has become necessary to review the design and specifications so that the cost could be reduced to the affordable limits of the beneficiaries as well as of the Governments, both in the urban and the rural areas.

Designs adopted in the various states by the

governments and different NGOs have been collected. These have stood the test of time and are being accepted and adopted also by the weaker section of the population, with some subsidy from the governments.

Latrine Designs Being Followed in States

1. West Bengal

Design I

The platform size is 900 mm x 750 mm with brick work in cement mortar 1:6. It is a latrine with a single pit, 1050 mm deep and 900 mm dia lined with empty bitumen drum. The latrine pan and trap are of earthen glazed ware. The pit cover is of 50 mm thick RCC. The cost of this type of latrine is about Rs. 860 at local rates. This type of latrine is not common these days. ↳ what year ?

Design II

The size of platform is 900 mm x 750 mm with brick work in cement mortar 1:6. The two pits are 1200 mm deep and 1000 mm dia and are lined with 75 mm thick brick wsork in cement mortar 1:6. The latrine pan and trap are of glazed burnt clay. The pit cover is of 75 mm thick RCC. The cost of this type of latrine is about Rs. 1250 (local rates)

Design III

The All India Institute of Hygiene and Public Health,

Calcutta have constructed PF latrines with 1050 mm x 950 mm platform and a single pit 3000 to 4500 mm deep and 900 mm dia. The pit is lined with burnt clay rings. The squatting pan is of mosaic and trap of cement concrete. The covering of pit slab is of 50 mm thick RCC. The cost of this type of latrine is about Rs. 890 at local rates. This design was adopted by the Institute for a demonstration units.

Design IV

The design adopted by Ramkrishna Mission constructing latrines in West Bengal is 2 pit (1000 mm deep and 900 mm dia lined with flat bricks i.e. 75 mm thick) PF latrine with mosaic pan and CC trap. The pit cover is 53 mm RCC slab. The local cost of latrine could not be aascertained but is expected to be about Rs. 1070 at Delhi rates.

Design V

The Women's Coordinating Council, Calcutta is constructing latrines in rural areas in West Bengal. The platform size is 900 mm x 900 mm. The two pits are 1025 mm deep and 975 mm dia each with 75 mm thick brick lining in cement mortar 1:6. If the beneficiary does not accept flat brick (75 mm thick) lining, 115 mm thick lining is provided. The pit cover is of 50 mm thick RCC. The cost of latrine with twin pits with flat brick lining is about Rs. 1100 at Delhi rates.

2. **Jammu & Kashmir**

The platform size is 900 mm x 787.5 mm. Two pits each 1680 mm deep and 1100 mm dia are provided with 115 mm thick brick lining. Mosaic squatting pan with CC trap are used. The pit cover is 75 mm thick RCC. The cost of this type of privy is about Rs. 2200 at Delhi rates. However the Government is now adopting the design suggested by TAG in the Feasibility Report of J&K.

3. **Tamil Nadu**

The platform size is 900 mm x 750 mm. Squatting pan and trap are of ceramic. The two pits are 1000 mm deep and 900 mm dia lined with 75 mm thick brick work. The pit cover is 50 mm thick RCC slab. The local bricks fired with wood, thatch etc. are used. The cost of this type of latrine is about Rs. 1435 at Delhi rates.

4. **Orissa**

The platform size is 1100 mm x 850 mm. The two leach pits are 1350 mm deep and 900 mm dia with 125 mm thick brick lining in cement mortar 1:8. The alternate layers are without mortar. The pit is or RCC cover 65 mm thick. The squatting pan is of mosaic and trap of cement concrete. The cost of this type of PF latrine is about Rs. 1900 at Delhi rates.

5. Meghalaya

In Meghalaya, PF latrine with single pit (2000 mm deep and 1200 mm dia lined with bamboo lining) are constructed. The life of bamboo lining is reported to be 7 to 8 years. The platform size is 1000 mm x 900 mm in stone masonry. The pits are covered with timber logs (ballies) and over it clay plaster is done. The cost of this type of latrine is reported to be about Rs. 870 at local rates.

6. Sikkim

The platform size is 1300 mm x 1200 mm. The foundation is of hand packed stone. The pits are 1300 mm deep and 1000 mm dia with lining in hand packed stone in 400 mm thickness. The top 300 mm height is in cement concrete 1:4:8. The pit cover is 75 mm thick RCC. The squatting pan is of fibre glass and trap of HDPE. The cost of latrine could not be ascertained.

7. Kerala

The size of platform is 1200 mm x 900 mm. The foundation is in random rubble stone masonry in mud mortar. However, in most of the areas of Kerala, bricks are used for masonry work. The two leach pits are 1800 mm deep and 900 mm dia each and lined in 200 mm thick brick work in cement mortar 1:6. The squatting pan is of fibre glass and trap of HDPE. The pit cover is of 75 mm thick RCC. The cost of latrine could not be ascertained.

However, in the World Bank assisted Kerala Water Supply and Sanitation Project, the PF latrines in urban as well as rural areas are being constructed as per designs suggested by TAG (India) in the Feasibility Reports of Kerala.

8. **Gujarat**

The platform size is 1000 mm x 800 mm. The toilet is constructed with two pits, 1000 mm deep and 1000 mm dia each lined with 75 mm thick brick work. The squatting pan and trap are of ceramic. RCC pit cover is 50 mm thick. The cost of this toilet is about Rs. 1340 (Delhi rates).

9. **Uttar Pradesh**

The design followed in rural areas in U.P. by Panchayati Raj Department is with two leach pits, 1200 mm deep and 900 mm dia each having 115 mm thick brick lining. The platform size is 1000 mm x 800 mm. The pit cover is of 75 mm thick RCC. Cement mosaic squatting pan and cc trap are used. The cost of latrine of this design is nearly Rs. 1830 (Delhi rates).

However in urban areas, the design suggested by TAG (India) in the Feasibility Report of U.P. is followed.

10. **Sulabh International**

The PF latrine constructed by Sulabh International is with two separate circular pits but in case space is a constraint, combined rectangular pit divided into two

chambers by a partition wall is provided. The platform is 1000 mm x 800 mm. The pits are 1225 mm deep and 900 mm dia. lined with 115 mm thick brick lining. The squatting pan is of fibre glass and trap of HDPE. The RCC slab for pit cover is 75 mm thick. The cost of toilet of this design is about Rs. 1840 (Delhi rates).

11. **Madras**

Voluntary Institute for Clean Environment (VOICE), Madras, a voluntary non-governmental organisation is constrructing PF latrines in Madras with 1219 mm dia circular platform in brick soling finished with cement mortar. The pits are 990 mm deep and combined square pits each 915 mm x 915 mm lined with ferro-cement. The pit cover is of RCC. The squating pan is of fibre glass and trap of HDPE. The cost of this type of latrine is about Rs. 1100 at local rates. This design has been adopted recently and therefore needs to be tried for some time before wide acceptance.

12. **Central Building Research Institute, Roorkee**

The design developed by CBRI for rural areas is with 1030 mm x 800 mm platform and two leach pits 1200 mm deep and 1070 mm dia each lined in 115 mm thick brick work in cement mortar 1:6. The squatting pan is of mosaic and CC trap. The pit cover is of RCC 75 mm thick in the centre sloping to 50 mm on sides. The estimated cost of this

latrine is about Rs. 1980 at local rates.

A brief summary of investigations carried out together with analysis and drawings are attached in annex 1.

Measures to Reduce the Cost of PF Latrine

Latrine Size

The size of latrine platform varies widely from state to state ranging from 750 mm x 900 mm to 1200 mm x 1300 mm. Anthropometric studies were conducted by the Central Building Research Institute, Roorkee by actual measurement of space required for comfortable use in all postures and movements to find out the optimum size of latrine platform. The studies revealed that 750 mm x 900 mm is the optimum size from the point of view of cost. In the feasibility reports prepared by TAG (India), 750 mm x 900 mm latrine size was recommended for urban areas and 800 mm x 1000 mm for rural areas. Since a vast number of latrines with 750 mm x 900 mm size have been constructed in a number of towns and these have been well received by the people, the same size may be adopted for rural areas also.

Materials

Bricks

In India bricks are manufactured at brick kilns with chimney using coal as fuel. Bricks are also manufactured at many places in the country in rural

areas by using wood, thatch, husk etc. as fuel for local use. The quality and strength of chimney fired kiln bricks is better than those manufactured for village use and costs about 35% higher than the latter. The locally manufactured bricks are good enough to be used for construction of latrine superstructure and pit lining. In Uttar Pradesh, Panchayati Raj Department which is the nodal agency for rural sanitation advocates the use of locally made bricks for latrine construction.

In chimney brick kilns, bricks in different grades are produced. Second class bricks which are about 12% cheaper than 1st class ones can be used for the construction of PF latrines.

Mortar

No doubt cement is the most efficient masonry mortar for construction of latrine superstructure and leaching pit lining, but it is a scarce and costly material. In many parts of the country, other alternative materials which are available locally and cost less can be used. It is suggested that the following type of mortars should be used depending upon their availability and cost:

(i) Cement mortar 1:6

(ii) Lime with surkhi (brick powder)/cinder/fly ash in 1:3 proportion (one lime : 3 surkhi/ cinder/fly ash)

(iii) *Rice - husk cement sand mortar (1:3)

(iv) *Mud mortar from clayey soil for construction of latrine cubicle foundation and plinth. However, the plinth should be plastered or pointed outside with cement or lime.

Pan and Trap

Squatting pans and traps of different materials are manufactured in India. At present GRP (fibre glass) pans are being used extensively all over the country. However, in Gujarat ceramic ones are being used since these are manufactured in Gujarat. In U.P., Panchayati Raj Department is using cement mosaic pans with cement traps in rural areas, so is All India Institute of Hygiene and Public Health, Calcutta in Singur villages. In the past mosaic or cement concrete (inner surface finished with red oxide) pans/traps were in use mostly in rural areas all over the country for the last several decades. With the introduction of GRP pans, which were developed in 1982 by TAG (India), use of mosaic ones has been reduced to some areas only.

*Central Building Research Institute, Roorkee.

The evaluation study carried out by the All India Institute of Hygiene & Public Health, Calcutta and Safai Vidhyalaya, Ahmedabad (now known as Environmental Sanitation Institute) on the performance of pans and traps of different materials has revealed that the mosaic pans work satisfactorily, though people's preference is more for ceramic, GRP or PVC pans because these are aesthetically better. The National Environmental Engineering and Research Institute (NEERI), Nagpur and the Central Building Research Institute, Roorkee also reported that the mosaic pans and cement traps are technically acceptable.

The cement mosaic squatting pans and cement concrete traps can be made locally by trained masons. These are much cheaper than the ceramic, PVC or GRP pans/traps. Their cost is Rs. 55 in comparison to Rs. 110 to 125 for GRP pans and HDPE trap, and ceramic and PVC ones are still more costly. It is suggested that in order to economise the cost, the mosaic pans and cement traps should be used.

Pipe

Stoneware, PVC or AC pipes or covered brick drain are used for connecting the toilet pan with leaching pits. Earlier cement concrete pipes manufactured locally in two halves and joined with cement mortar were being used by Planning Research Cum Action Institute,

Lucknow, U.P., Public Health Institute, Poonamallee, AIIH&PH, Calcutta and many others. The experience of these institutes indicates that though the inner surface of locally made CC pipe is not as smooth as that of PVC/AC/stoneware pipes, yet the performance of the former type is good - it does not require additional water for flushing and human excreta also does not stick to the surface.

It is, therefore, suggested that locally made CC pipes should be used to cut down the cost of latrine. An advantage of using mosaic pans, concrete pipes and traps particularly in rural areas would be to create rural employment for which the government is very keen.

Foundation and Plinth

There is a tendency of the implementing agencies to keep the foundation of the latrine superstructure deep and wide as of other building structure. But since the latrine superstucture is very light, load coming over the foundatiion is not heavy. Hence the depth* and width of the foundation can be kept as 225 mm in normal conditions (where the soil is not loose or filled up). For foundation, dry brick ballast (75 mm thick and 225 mm wide) should be laid and compacted well. After compaction, a thin layer of soil should be spread over the ballast and compaction be done again with watering.

*Central Building Research Institute, Roorkee.

Over the ballast brick masonry be done in mud mortar upto plinth level (a layer of brick in 225 mm width and over it brick work in 115 mm width i.e. half brick width). The plinth height may be kept as 225 mm, if the site is not subjected to water logging.

Connection to Leach Pit

Where pipes are used for connecting the latrine pan to pits, a chamber is provided to facilitate cleaning of pipes, if choked and for diverting the flow to another pit when the pit in use is full, by blocking the mouth of one pipe in the chamber. With the drain, no chamber is provided.

In some states like Tamil Nadu, stoneware pipes with chamber are used for connecting the toilet pan with pits. Stoneware pipes are costlier than AC/PVC pipes. The cost analysis indicate that it is economical to construct a Y shape covered drain immediately after the trap and there after using a locally made C.C. pipe (see drawing no.1). In case locally made C.C. pipes are not to be used, AC non-pressure pipe could be used. Y drain will serve the purpose of a chamber as cleaning or diversion of flow can be done by removing the cover of the drain.

Flooring

Generally flooring is done in 25 mm thick cement

concrete 1:2:4 with stone grit over 75 mm thick cement concrete 1:4:8 and surface rendered smooth with neat cement. In order to reduce the cost, flooring could be done either (i) 25 mm thick c.c. 1:2:4 with brick ballast over 75 mm dry brick ballast well compacted*; or (ii) 25 mm thick cement plaster 1:4 over flat bricks# with joints filled with sand. However, the earth base should be well compacted and top surface be made smooth with neat cement.

Footrests

The purpose of footrests is to guide the user to sit in the right position and to provide comfort in the squatting position. General practice is to use ceramic, fibre glass or mosaic footrests. For effecting economy, bricks (corners rounded) can be used as footrests. The bricks can be fixed in position keeping the top level 20 mm above the proposed floor level, while laying the ballast for flooring. The top and exposed sides should be plastered with cement mortar 1:4 and finished smooth with neat cement at the time of laying the top floor concrete or doing plaster for flooring.

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* This type of flooring is being provided by U.P. Housing & Development Board in low income housinng.

\# Type of flooring provided in Tamil Nadu in low income houses.

Leaching Pits

The feasibility reports prepared by TAG (India) suggested that the pits in urban areas should be designed for 3 years desluding interval and for rural areas 2 years interval. Studies conducted have shown that if the pit contents are left for one year, all viruses, bacteria and protozoa will be dead, as will most helminths with the exception of Ascaris lumbricoides, although only a few Ascaris ova will be viable after this time*. The chances of viable Ascaris eggs being present are greater if the pit is wet and partly below the water table. However, risk involved in reusing the humus of the pit that has remained buried for at least 12 months is small and the pit contents can safely be handled and used on agriculture fields after this time. Hence minimum acceptable design interval between successive manual desludgings could be one year#. However to provide flexibility in removing the pit contents, it is advisable to keep this interval as 2 years. To economise the cost, the pits in urban areas too can be designed for 2 year desluding interval.

Large number of rural latrines with pits having 2 years

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* Sanitation and Disease - Health Aspects of Excreta and Waste-Water Management by Richard G. Feachem, David J. Bradley, Hemda Garelick, D. Duncan Mara.

\# TAG Technical Note No. 15 - The Design of Pour Flush Latrines by D. Cuncan Mara.

capacity constructed about 5 years back have been reported to be working very satisfactorily and users are satisfied.

Optimisation of the size of leach pit

The pit cover and lining of leach pit are the main constituents in the cost of a pourflush latrine. The cost of these constituents was analysed and an equation* has been developed to find the minima. The equation is:

$$\text{Total cost } C = \pi DHC_1 + \frac{\pi D^2}{4} C_2$$

Where D = Diameter of pit

H = Effective depth of pit

C_1 = Cost/sqm of pit lining

C_2 = Cost of cover/sqm of thickness

After deciding the type of lining and pit cover and determining their costs, most economical size of pit can be worked out from the above equation.

Pit Lining

Pit lining is necessary to avoid collapsing of pit. Lining could be done with honey comb brick work, stones, laterite rock cut into bricks, or ferro cement. Burnt clay or cement concrete rings with holes could also be used. Lining could be done with treated

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* Central Building Research Institute, Roorkee.

bamboos, wooden planks or logs or tar drums too. The material selected for lining will depend upon the relative cost and availability.

Tar drum lining

The study carried out by the Indian Council of Medical Research (ICMR) has shown that the life of tar drum lining is very limited.

Observations were made by the ICMR on the performance and suitability of pit lining of different materials in use for 1 to 3 years. The results* obtained are summarised in annex- 2.

Bamboo lining

Where bamboos are grown and available at low cost, bamboo lining can be done (see drawing no.2). Such type of lining is done in Meghalaya and it has been observed that this type of lining lasts 7 to 8 years. The pits are made deep - designed for 7-8 years use and when the pit is filled up, it is abandoned and another pit is constructed.

Log or stone lining

In hills where bricks are not available and have to be transported from long distances, lining with stones or

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* Indian Council of Medical Research Special Report no. 40-A Decade of Research in Environmental Sanitation (1951-60) by T.R. Bhaskaran,AIIH&PH Calcutta - New Delhi 1962

wooden logs or planks, coated with moth resistant paint may work out economical. The life of wooden logs/planks is not correctly known, nevertheless it may last for 8 to 10 years.

In stone lining, one layer at the bottom and the portion above the invert level of incoming pipe or drain should be in random rubble (RR) stone masonry in cement mortar 1:6 or lime mortar 1:3. In between two layers of masonry, dry stone pitching with a layer in cement mortar 1:6 in the middle be done. This type of lining was done in Almore (U.P.) in a number of pits about 7 years back and the pits are standing and working satisfactorily.

Laterite blocks

In South, laterite rocks are found at a number of places. The buildings are constructed with blocks (regular shape like bricks) cut from laterite rock. In case use of bricks or other appropriate material is found expensive, laterite rocks shaped to the required size bricks can be used and laid in cement mortar 1:6 for pit lining. The portion between pit bottom and invert level of incoming drain or pipe will have holes. However in pits dug in laterite formation, lining is not necessary.

Ferro-cement

Prefabricated ferro-cement rings for circular pits and sheets for rectangular pits can be used for pit lining. Central Building Research Institute, Roorkee constructed circular leach pits with ferro-cement lining but it worked out costlier than brick lining. Since the thickness of ferro-cement lining is not much, there is an apprehension that the reinforcement (chicken mesh) provided in the ferro-cement may be effected in the long run by the gases produced in the pit. However, the CBRI has observed that there was no adverse effect after using the pit with ferro-cement lining for 5 years.

Cement concrete rings

Lining can also be done with 40 mm thick and 300 to 400 mm high 1:2:4 cement concrete rings with ends reinforced by one 6 mm dia m.s. bar at each end. The rings will have holes for percolation of liquid and dispersal of gases in the soil. The ends are reinforced* so that the rings may not get damaged during transportation and handling. While lining, the rings are placed one over the other. At top one layer of brick work 115 mm in width is done in cement mortar 1:6 for the support of slab.

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* Central Building Research Institute, Roorkee.

Where bricks are costly or not available gravel, cinder and soil cement are also suitable for making rings. Suitable reinforcement is necessary to avoid breakage during transportation. The casting of the rings may not be possible at site. Therefore cement briquettes* which may not require highly skilled labour may be a better solution for remote areas. The briquettes 75mm wide and 75mm thickness can be made in 3 to 4 pieces. Local sand can be used in casting the briquettes in cement mortar 1:6.

C.C. ring lining is economical where the stone grit and coarse sand are available locally at low rates. The construction with rings is easy where the sub-soil water level is high (above the bottom of the pit). Cement concrete ring lining is being done in Kerala especially in coastal areas for ease of construction, due to high ground water level.

However, if rings of more than 1000 mm dia are needed, their handling becomes a problem due to heavy weight, the height of the ring should be reduced.

Burnt clay rings

In some parts of India like West Bengal, Assam and Orissa, burnt clay rings are manufactured by local

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* Indian Council of Medical Research Special Report no. 40-A Decade of Research in Environmental Sanitation (1951-60) by T.R. Bhaskaran, AIIH&PH Calcutta - New Delhi 1962.

craftsmen (potters) and these are being used for lining of dug wells. All India Institute of Hygiene and Public Health, Calcutta and Ramkrishna Mission Lokasiksha Parishad have constructed leach pits with clay ring lining in West Bengal. In some of the pits, rings with holes were used, while in some, open jointed rings (leaving gap betwen two rings) without holes were used. These pits are in use for about 10-12 years and these are reported to be functioning well. The rings have withstood the strain of desluding of pits. The National Environmental Institute, Nagpur has also suggested the use of burnt clay rings with holes for pit lining.

The rings are manufactured upto 1000 mm dia. Thickness of shell is 15 mm to 25 mm. Each ring costs Rs. 15 to 2o depending upon the size, thickness and height.

Clay rings should be used for lining only when the pits are located within the premises where the top of pit is likely to be subjected to light load. The rings used for lining should have uniform deep cherry red or copper colour and should be properly burnt and have holes.

For lining, rings with holes should be put one over the other and jointed with cement mortar 1:6. The Regional Research Laboratory, Council of Scientific & Industrial Research, Jorhat, Assam has reported that if rings are placed over each other without mortar, the rings are

likely to crack under load. Rings should be raised upto the bottom of the incoming pipe and drain. Above this, 115 mm thick solid brick work in cement mortar 1:6 should be provided upto the level where the cover is to be placed.

Potters are available almost all over the country to manufacture earthenware. They can easily be trained to manufacture clay rings locally. However, clay used for the manufacture of rings in West Bengal, Assam etc. should be analysed to find out its properties and quality to find out areas where similar clay suitable for the manufacture of rings is available or alternatively if the local soil can be used to make rings of required quality if necessary with some admixture to provide suitable composition of the ingradients.

Brick lining

Bricks are available in almost all areas in the country. Hence pit lining is mostly being done in brick work all over the country. TAG (India) suggested* flat brick (75 mm thick) lining in cement mortar 1:6. For rural areas, as an alternative#, lining in 115 thick

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* TAG Technical Note No.10 - Manual on the Design, Construction and Maintenance of Low Cost Pourflush Waterseal Latrines in India

\# Report of the Committee on Design Criteria for Pour-flush Waterseal Latrines in Rural Communities in India - The Technology Advisory Group - India March 1985.

dry jointed brick work with 2-3 rings in cement mortar 1:6 in between (each ring consisting of one layer of brick work) was also suggested.

The Central Building Research Institute, Roorkee has also suggeted that pits can be lined with flat bricks (75 mm thick) in cement mortar 1:8 instead of 115 thick in 1:6 cement mortar being adopted at present. Dr O.P. Jain, renowned structural engineer and the then Head of Civil Engineering Department, Roorkee University confirmed that flat brick lining in 1:6 mortar with honey comb is structurally safe provided 2 to 3 rings of one brick layer each (depending upon the size of pit) in solid brick work are provided in between.

However in practice lining is not being done in flat bricks; almost all implementing agencies are adopting 115 mm thickness. Nevertheless the pits lined with flat bricks constructed about 4 years back in Uttar Pradesh and West Bengal have been found working satisfactorily. The Women's Coordinating Council, Calcutta a voluntary social organisation is doing low cost sanitation in rural areas in West Bengal. They also construct pits with 75 mm thick brick lining but the option to choose 75 mm or 115 mm thick lining is left to the beneficiary. However, their experience is that most of the people go in for 115 mm thick lining.

A few cases of collapsing of pits with flat brick lining were reported in Maharashtra. Perhaps reasons for their failure were faulty workmanship and earth filling before allowing the cement mortar in brick work to set.

Since 75 mm thick brick lining is structurally safe and most economical (if bricks are used), it will be appropriate to carry out evaluation to study the performance of pits in use with flat brick lining and to know the reaction and misgivings of the people about it and also to find out the causes of failure at some places. There is also a need to put up demonstration units in various states to educate and convince the implementing agencies and the people that it is safe, since 75 mm lining will cost Rs. 350. against Rs. 510 for 115 mm lining in second class bricks.

Since at present neither implementing agencies adopt flat brick or dry jointed 115 mm thick brick lining nor beneficiaries accept, the design has been provided with 115 mm thick brick lining.

- A ring of solid brick layer 225 mm wide as foundation below the bottom of pit and over it brick work with holes in alternate layers. Though Dr. O.P. Jain, from structural point of view suggested only 2 to 3 rings of solid brick work in between yet since in practice

it is difficult to follow this, holes are suggested in alternate layers only. By this, the cost is increased slightly but it provides ease in construction.

- Lining over the invert level of incoming pipe or drain upto the bottom of pit cover in solid brick work i.e. without any openings.
- All brick work in cement mortar 1:6 or any other suitable mortar of equivalent strength.
- IInd class chimney fired bricks or bricks made locally in rural areas be used.

Lining in mud mortar is not being suggested because there is a risk of mud being washed off resulting in pit collapse.

Pit cover

At present RCC slabs are being used all over the country for covering the pits even though the pits may be located at a place where they may not be subjected to heavy loading. In most of the cases the pits are constructed within the premises where the loading is not expected to be heavy. Hence in order to achieve cost reduction, following alternatives keeping in view the site conditions can be adopted:

i) **Burnt clay vat**

Vats of burnt clay (shape - half hollow sphere) are manufactured by local potters and these are used for feeding the cattles. Inverted vat can be used for covering the pit in rural areas where only light load is likely to come over the pits. The vat should have a minimum of 200 mm earth cover over it. However this should be tried in some demonstration units for field testing.

ii) **Cement concrete dome**

25 mm thick 1:2:4 cement concrete dome with 50 mm x 50 mm ring beam reinforced by a 6 mm dia m.s bar can safely be used for covering the pits. However where the load over the cover is expected to be 200 kg/sqm, the ring beam should be reinforced by a 10 mm dia m.s bar and 24 gauge chicken wire mesh or 12 mm mesh be provided in 150 mm width at the end of dome* (see drawing no.3).

Concrete domes were in use in late fifties and early sixties to cover the pits in rural areas.

iii) **Flag Stone**

In many parts of India like Rajasthan, parts of U.P., Madhya Pradesh, stone slabs are available

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* Suggested by the Central Building Research Institute, Roorkee.

and used for roofing etc. These slabs can conveniently be used as pit covers. Thickness of stone slab will depend upon the loading, span and quality of stone.

iv) **Bamboos or wooden logs**

In Meghalaya, pits are covered by bamboos tied to each other and covered with thatch or palm leaves and earth over it. The life of this type of covering is reported to be 7 to 8 years. In areas where bamboos are grown and available at low cost, bamboo mat cover can be provided.

In hills where transport of cement and steel is very cumbersome and costly, 125 mm dia wooden logs tied to each other covered with leaves and earth over it can be used economically.

v) **R.C.C. slab**

RCC slabs are manufactured with stone grit, which is procured and carted from long distances in most of the places; consequently it is a costly material. The brick ballast is availabel locally at almsot all the places. The ballast from over burnt bricks can be used in place of stone grit. In West Bengal, this practice is in vogue for laying RCC roofs except the top one. The CBRI, Roorkee has also suggested the use of brick ballast from overburnt bricks which has adequate crushing strength.

Superstructure

The function of the toilet superstructure is to provide privacy and to protect the user and the toilet from the weather. The superstructure should be economical and affordable and be consistent with the main building structure. In rural areas, most of the houses are of mud with thatch or tile roof. It has been observed that if the latrine superstructure is made of bricks with RCC roof and the dwelling house is of mud, the tendency of the household is to use it as a storage space. The latrine superstructure should be built by using the local materials and by and large conform to the standard and specifications of the dwelling house.

In the rural areas, the superstructure may be one of the following types:

i) Mud walls with thatch or tile roof. The mud walls may be plastered with ordinary mud mortar containing mud and "bhusa" (clipped and crushed rice/wheat straw) and adding to it bitumen cut back prepared from hot bitumen and Kerosene oil. This type of plaster* needs minor maintenance once in a few years. However, a skirting in cement mortar 1:4 may be provided to a 150 mm height above the latrine floor on the inner side of walls

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* Source: Central Building Research Institute,Roorkee.

to protect the mud walls from erosion in washing of floor.

ii) Walls of date palm/coconut tree leaves or bamboo matting with bamboo frame and thatch roof with mud or cement mortar 1:6 plaster inside and outside. In eastern region and coastal areas of the country, the dwelling houses are generally constructed of these specifications. As stated in (i) above, skirting be provided in the latrine cubicle if mud plastering is done.

iii) Thatch or 'arhar'* stick walls with bamboo frame and thatch roof.

iv) In hills: Walls of slates or small stones in mud mortar with roof of slates. Outside may be pointed in cement mortar 1:6 and a skirting as mentioned in (i) above be provided inside.

In the above cases, instead of a door shutter, a curtain of jute or gunny bag can be used. However if a wooden door is to be provided, locally available timber should be used.

In urban areas, the dwelling in slums and of economical weaker sections are generally of the same type as in rural areas. Hence, the latrine superstructure in such areas can be one of the four types described above.

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* A species of lentil grown in India.

A low cost design of a pucca superstructure could be as follows (see drawing no.1).

Walls: The cost of brick wall with different specifications has been worked out, which is as follows:

		Per sqm
i)	75 mm thick wall in cement mortar 1:6 with cement plaster 1:6 on one side	Rs. 81
ii)	115 mm thick wall in cement mortar 1:6 with joints flushed at the time of construction (without plaster or pointing)	Rs. 82
iii)	115 mm thick wall in mud mortar with cement plaster 1:6 or cement pointing on both sides	Rs. 99

The cost of alternatives (i) and (ii) is almost the same. TAG (India) had suggested 75 mm thick walls for superstructure but no where it was adopted as people think it is too weak. Hence 115 mm thick brick wall in cement mortar 1:6 be adopted.

600mm wide door opening is provided upto the roof level to avoid provision of lintel. Height to be 1850mm in the front sloping 1700mm in the rear.

Ventilation:

450mm x 225mm opening with brick jali (small openings) in the rear wall.

Roof

Roof can be of R.C.C. or asbestos sheet. Precast 50mm thick R.C.C. slab 1:2:4 with brick ballast and 6mm dia bar reinforcement could be used. The sheets can be supported on two 60mm x 50mm thick wooden battens fixed on the wall - one at the front and the other at the rear. The sheet will be anchored to the battens by J bolts. The cost of R.C.C. roof would be Rs. 150, while that of A C sheet will be Rs. 135.

Door

Door is one of the costliest items of the superstructure since timber is very costly. To economise the cost, the door need not be of full height of opening. A 1200mm high door to be fixed about 50mm above the latrine floor level should serve the purpose of privacy. The door could be 24 gauge m.s. sheet fixed on a wooden frame or split bamboos nailed close to each other on a bamboo or wooden frame. The cost of M.S. sheet door would be Rs. 300 and that of bamboos Rs.170.

Plastering

The exposed outside surface of masonry upto plinth

level should be plastered with cement mortar 1:6 to protect the mud joints.

RESEARCH NEEDS AND DEVELOPMENT EFFORTS

Research is needed in several areas to further develop the low cost technology to ascertain their impact and to find out the least cost techniques. Various designs with different materials are in use. But whether the least cost design has been adopted is not known. Demonstration units need to be put up and suitability of designs, materials and cost effectiveness have to be field tested. This is to be studied for some period to establish the least cost design. Some of the subjects for research and demonstration are described below:

(i) **Pit Lining**

(a) Lining in flat bricks: As mentioned on page 39, evaluation and study be carried out.

(b) Clay rings: Study is needed to determine their strength and effect of desludging pits for long term use not only in the rural areas but in urban towns in suitable conditions. The optimum size and thickness of rings, and size and number of holes in each ring are also to be determined. An in depth study of existing latrines with clay ring lining and also open dug wells using clay rings need to be carried out to determine the

suitability of clay rings.

(c) Stabilised Soil Bricks*: Sun-dried bricks used for house construction in rural areas are weak in strength and are susceptible to erosion by water. Different stabilising materials viz. cement, bitumen, industrial waste like suger press mud etc. added with soil improve the quality of bricks in varying degrees. Cement soil bricks are of higher strength. Bitumen stabilised bricks donot improve strength but are good in water resistance. Study is needed to find out the efficacy and cost effectiveness of different type of stabilised bricks for leach pit lining. These will be useful for areas where bricks and stone are not available readily.

(d) Cement Concrete Rings: Cement concrete rings are used widely in Tamil Nadu for dug well lining. In some parts of Kerala, these are used for leach pit lining also. The use of cement concrete rings will be economical in places (i) where cost of bricks or stone is high; (ii) where coarse sand and stone grit are available locally at low cost; and (iii) where water table is very high rendering the brick work cumbersome and costly. Study is needed to determine the cost effectiveness, proportion of

*Source: Central Building Research Institute, Roorkee. ICMR Special Report no. 40 (1962)

cement, sand and stone grit, thickness and height of rings to achieve desired strength. Rings are difficult to carry to remote places. Cement concrete briquettes could be used in their place. Study on the use of briquettes as in the case of rings stated above may also be carried out.

(e) Ferro Cement: At places where availability of bricks is difficult and costly, the use of ferro cement lining may be economical. But since ferro cement lining is thin, it is to be determined whether the reinforcement provided in the ferro cement will get corroded in the long run due to the effect of gases produced in the pit.

(f) Bamboos: In some regions in India, bamboos are grown in abundance. These can be used for pit lining economically in those areas. Study is needed to find out (i) if the bamboos could last longer by any treatment (ii) whether it is economically viable to use them or substituted by any other material.

(g) Wooden Logs: In hilly areas of India, use of bricks is very costly since these have to be procured from far away places. Though stones are available locally in hills but carriage from querries and higher thickness of lining make the use of stone costly at most of the places. Timber

is generally available, hence wooden logs can be used. But study is needed to find out the life of such lining.

(ii) **Separation of Pits from Drinking Water Sources**

The Manual On Design, Construction, Operation and Maintenance of Pour-flush Waterseal Latrines published by the World Bank (TAG Technical Note No. 10) specifies the minimum distance of leach pits from dug wells and hand pumps as 3 to 10 metres in different type of soils. In congested areas in towns maintaining the specified distance is not possible at many places. Studies are needed to find out if the distances specified in the TAG Manual can be reduced without jeopardising the safety aspects for prevention of pollution of drinking water sources or ground water in different ground water levels and geohydrological conditions. Similar studies as to the safe depth and distance of a hand pump tube well in specified soil conditions from a latrine pit are needed.

(iii) **Waste Water Disposal in Rural Areas**

Waste water due to bathing and from kitchen stagnates on the village paths causing aesthetic and environmental problems. it is a source for spreading of filaria in the villages. A low cost system for the safe disposal of waste water is

needed.

Recommended Design and Cost

The design should be such that it maximises the use of local materials without sacrificing the structural safety and performance and widely acceptable, easy and simple in construction. Based on these principles, it should be a minimum cost solution. In is no good that in order to keep the cost barest minimum, if the design suggested is not accepted by the masses or adopted by the implementing agencies.

The design recommended is as follows (drawing no.1)

Platform

Size	:	750 mm x 900 mm (internal)
Foundation	:	225 mm deep and 225 mm wide
Plinth	:	225 mm high
Mortar	:	Mud
Flooring	:	25 mm cement concrete 1:2:4 (in brick ballast) over 75 mm dry brick ballast well compacted Or 12 mm cement plaster 1:4 over flat bricks with joints filled with sand over well compacted surface.
Pan	:	Cement mosaic (polished)

Trap	:	Cement concrete (inner surface smooth)
Footrests	:	Brick plastered smooth
Connection to pit		
Pipe	:	75 mm dia locally made C C pipe or non-pressure A C pipe
Diversion arrangement:		Y covered channel
Leach pits		
No. of pits	:	2
Deslugding interval	:	2 years
Lining	:	115 mm thick IInd class brick work in cement mortar 1:6. In rural areas local bricks to be used.
Pit cover	:	75 mm thick RCC 1:2:4 flat slab with brick ballast or 25mm thick dome shaped RCC 1:2:4 with ring beam in rural areas, and in urban areas wherever feasible

The cost of PF toilet upto substructure level based on the design suggested above (drawing no.1) comes to Rs. 1188 (Delhi rate) with RCC flat pit cover in urban areas, and Rs. 974 (Delhi rate) with RCC domical pit cover in rural areas. In case pit lining is done in flat bricks or burnt clay rings, the above cost would be reduced further by about Rs. 140 and Rs. 120 respectively. The item-wise savings on account of suggested modifications in the design generally in vogue are indicated below.

COMPARATIVE COST OF DESIGN IN PRACTICE AND AS PROPOSED

(upto superstructure level)

Generally in practice	Proposed	Cost (in practice) Rs.	Cost (proposed) Rs.	Saving (Rs.) Urban	Saving (Rs.) Rural
1. Latrine platform 1000mm x 800 mm.Foundation 300 mm deep and 225 wide - one layer of brick over 75 mm c.c. 1:4:8 and over it 115 mm thick brick work upto 300 mm high plinth. All brick work in cement mortar 1:6 with 1st class bricks	1. Latrine platform 900 mm x 750 mm. Foundation 225 mm deep and 225 wide - one layer of brick over 75 mm dry brick ballast well consolidated with earth and over it 115 mm thick brick work upto 225 mm high plinth. All brick work in mud mortar with IInd class bricks (in rural areas locally made bricks to be used)	376	145 Urban 135 Rural	231	241
2. Flooring - 25 mm C.C. 1:2:4 with stone grit over 75 mm c.c. 1:4:8 and top surface rendered smooth with neat cement	2. Flooring - 25 mm c.c. 1:2:4 with brick ballast over 75 mm dry brick ballast well compacted and top surface rendered smooth with neat cement	73	37	36	36
3. Fixing of fibre glass squatting pand and HDPE 20 mm water-seal trap and ceramic rectangular footrests	3. Fixing of cement squatting pan and c.c. trap of 20 mm waterseal and footrests of bricks plastered smooth with cement mortar 1:4	170	90	80	80
4. Connection to leach pit - brick masonry inspection chamber (225mm x 225mm inner size) with drain and benching; and 75mm dia PVC pipe	4. Y covered brick drain and 75mm dia. non-pressure A C pipe	100	75	25	25
Or	Or				
U shape covered brick drain	Y covered brick drain and 75mm dia c c pipe	125	65		

5. Two leach pits	5. Two leach pits				
In urban areas: 3 years desludging interval lined with 115mm thick brick work in cement mortar 1:6 with 1st class bricks; alternate layers between the bottom of pit and invert level of pipe or drain to have holes; free board i.e. above the invert level of pipe or drain 300 mm high solid brick work	In urban areas same as in practice but capacity for 2 years desludging interval and free board 225mm; and brick work in 11nd class bricks	681	545	136	-
In rural areas;same as above but capacity based on 2 year desludging interval	In rural areas:same as in practice but free board 225 mm and brick work in locally manufactured bricks fired with wood, thatch etc.	586	495	-	91
6. Plaster:lining top to be plastered in cement mortar 1:6 to make the top surface level for resting the pit cover well in position	6. Top not to be plastered but while laying brick courses, to be checked with spirit level that top layer is perfectly horizontal	9	2	7	7
7. Pit cover: 75 mm thick RCC 1:2:4 flat slab with stone grit	7. Pit cover: 75 mm thick RCC 1:2:4 flat slab with brick ballast	316	304	12	12
	Or				
	25 mm thick RCC 1:2:4 (with stone grit) dome with 50 mm x 50 mm ring beam in rural areas	-	155	-	-
	Total Urban	1750	1188		
	Rural	1655	974		

Suggested Superstructure

At present latrine superstructure is built by the beneficiary himself according to his means and choice. In urban areas, emphasis of State and Central Governments is on the conversion of bucket/dry latrines to PF toilets so construction of a new superstructure is not generally required. It has been experienced that where latrine cubicle is needed, especially in rural areas, in many cases it is not provided and the latrine is not used making the expenditure incurred infructuous.

In order that the toilet is immediately used after construction, the Working Group set up by GOI for framing an approach paper for sanitation in rural areas has recommended that superstructure upto 1200 mm height (without roof and door) should also be provided along with the latrine by the implementing agency. This recommendation has been accepted by the Steering Committee and forwarded to the Planning Commission, GOI for incorporation in the Eighth Five Year Plan. Details of suggested superstructure (drawing no.1):

Thickness of wall	:	115 mm
Masonry	:	Brick work in cement mortar 1:6 in urban areas (as the walls are 115 mm thick) but in rural areas and urban slums the walls should be consistent with dwelling house structure

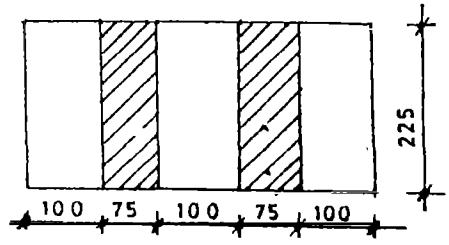
Height	:	1850 mm in the front sloping to 1700 mm at the rear
Door opening	:	600 mm upto roof level
Ventilation	:	450 mm x 225 mm in brick jali
Door shutter	:	1200 mm high shutter with country wood frame and m.s. sheet 24 gauge in urban areas; and 1200 mm high shutter of split bamboos with two country wood braces in rural The shutter to be fixed on two m.s. pitel hinges properly secured in wall in cement concrete 1:3:6.
Roof	:	A C sheet fixed on country wood battens or of other materials consistent with dwelling house structure.

Second class chimeny fired kiln bricks or locally manufactured bricks fired with wood, thatch, husk etc. should be used for pit lining and superstructure.

The cost of superstructure as suggested above would be about Rs. 940. In rural areas, the cost of superstructure as recommended by Steering Committee to Planning Commission

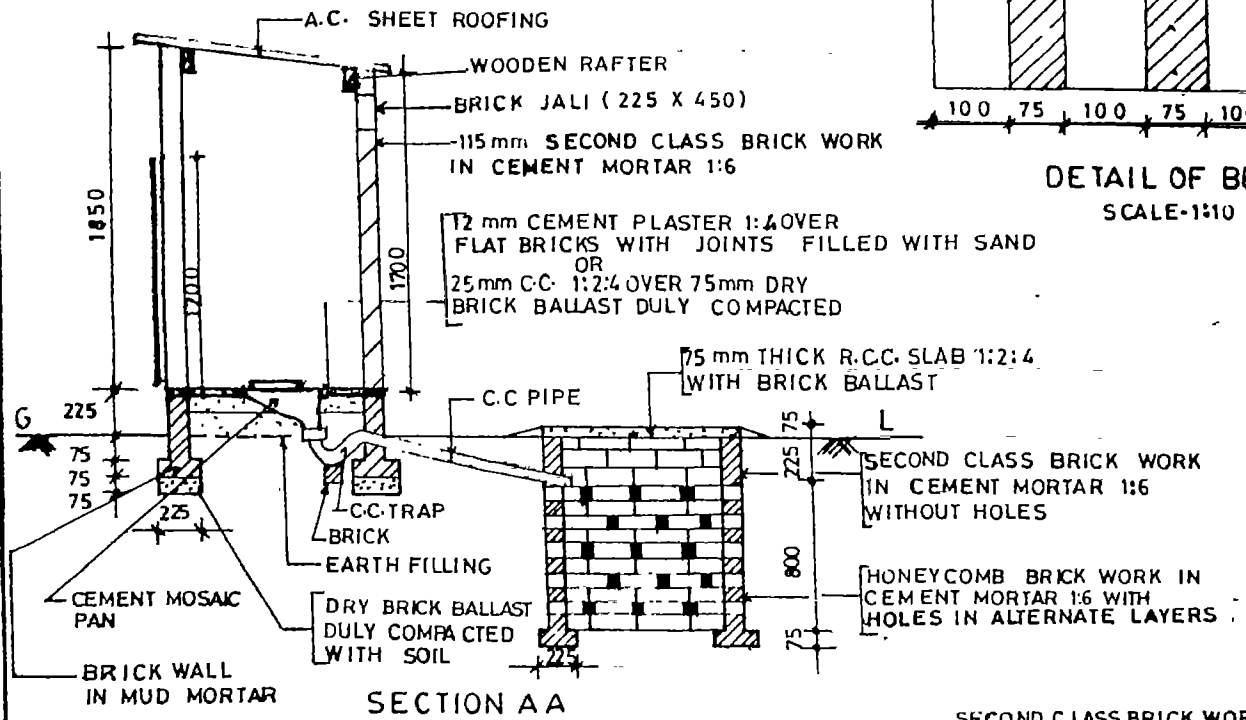
(1200 mm high walls without roof and door) would be Rs. 315. The beneficiary will provide a certain himself on the door opening for privacy.

DRAWING NO-1

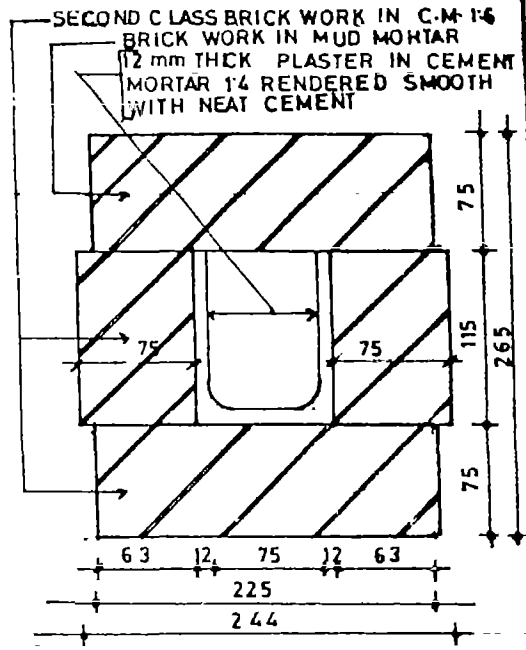


DETAIL OF BRICK JALI

SCALE-1:10

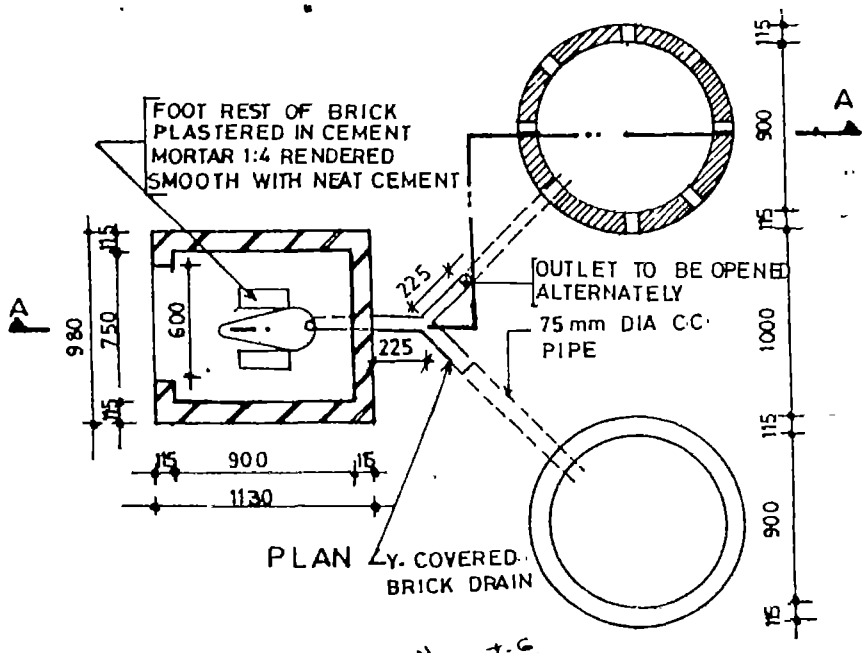


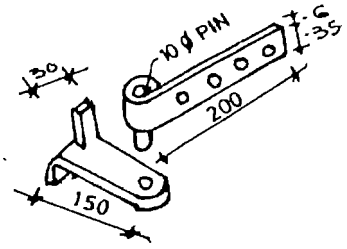
SECTION A A



DETAIL OF BRICK DRAIN

SCALE 1:50

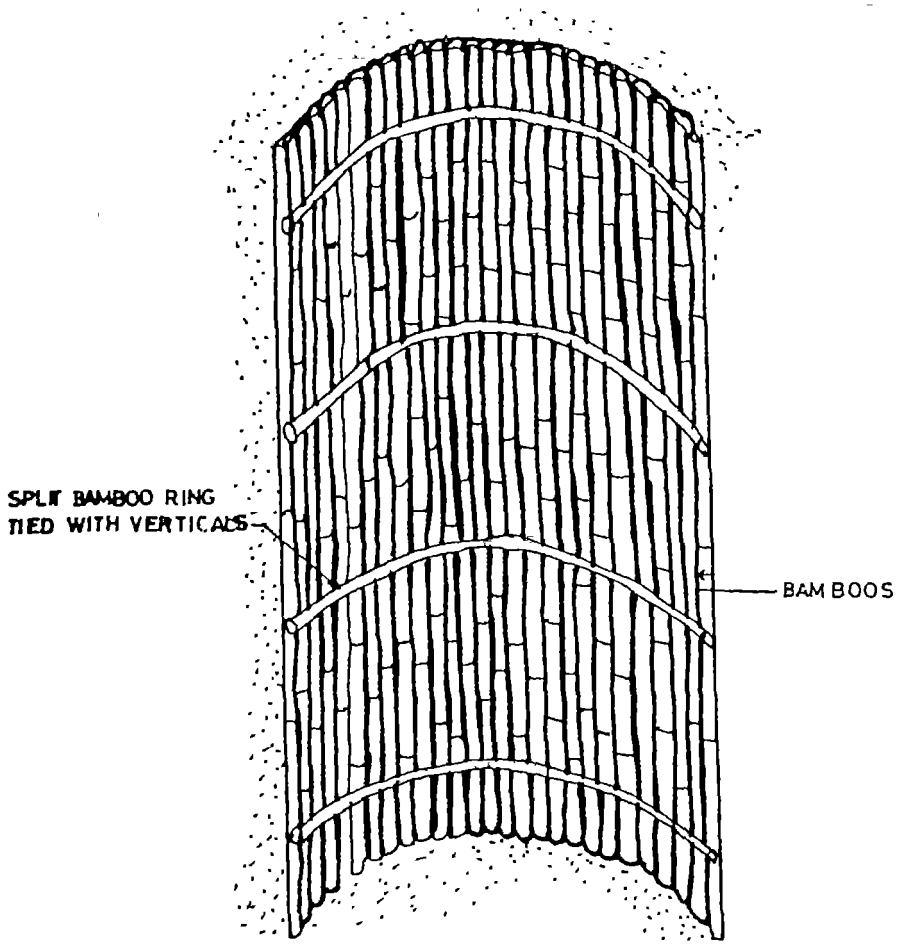




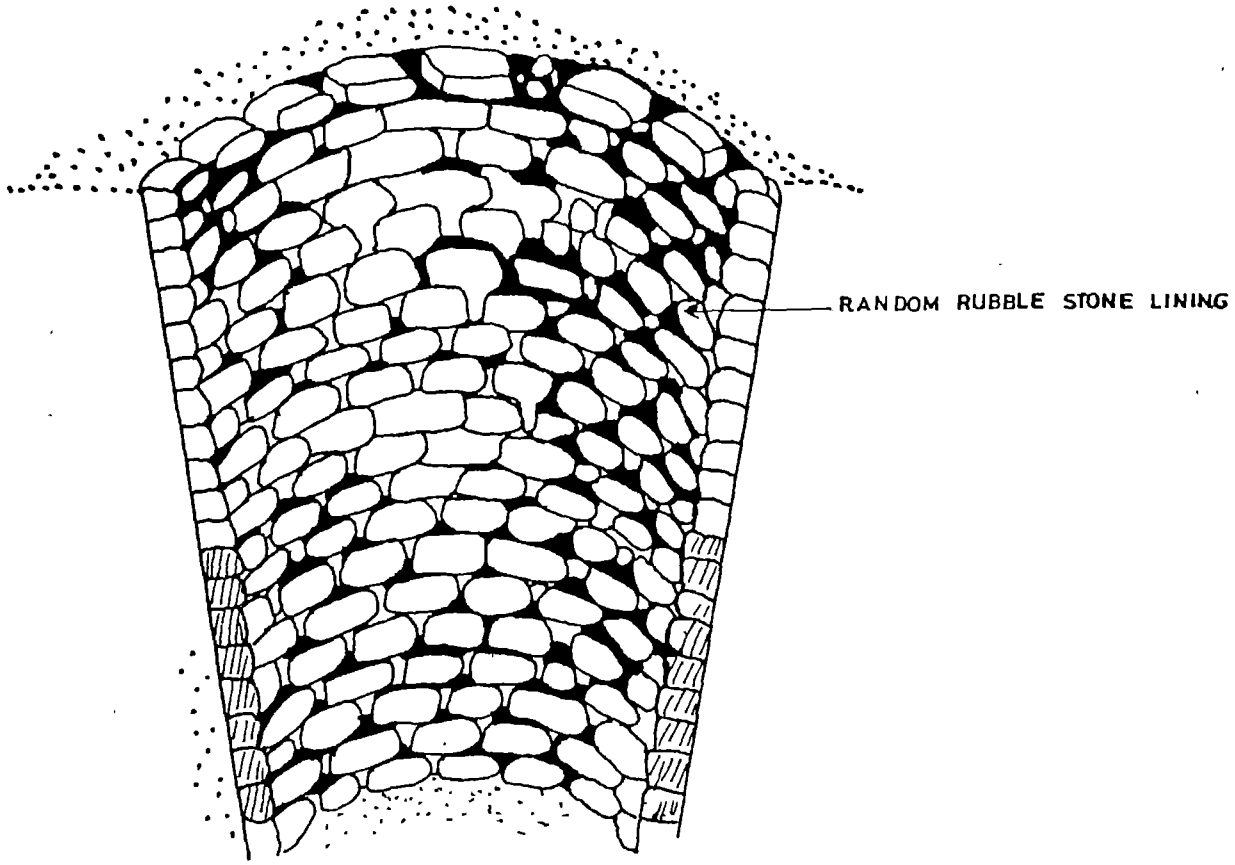
DETAIL OF PINTEL HINGE

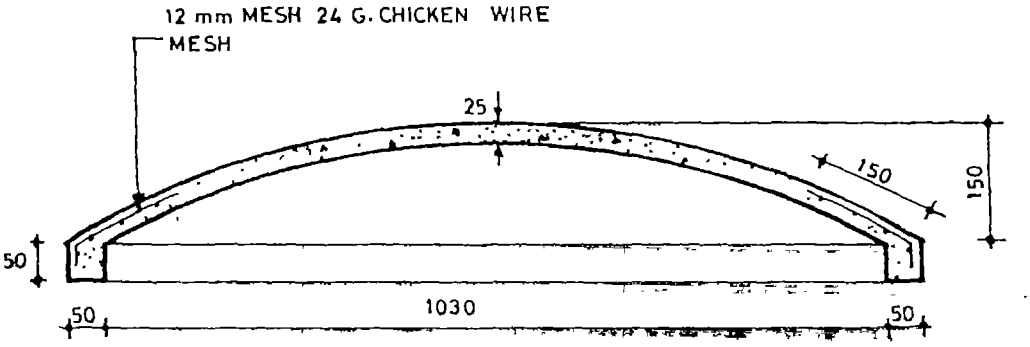
SUGGESTED DESIGN OF POUR FLUSH WATER SEAL LATRINE WITH TWO LEACH PITS.

DRAWING NO-2

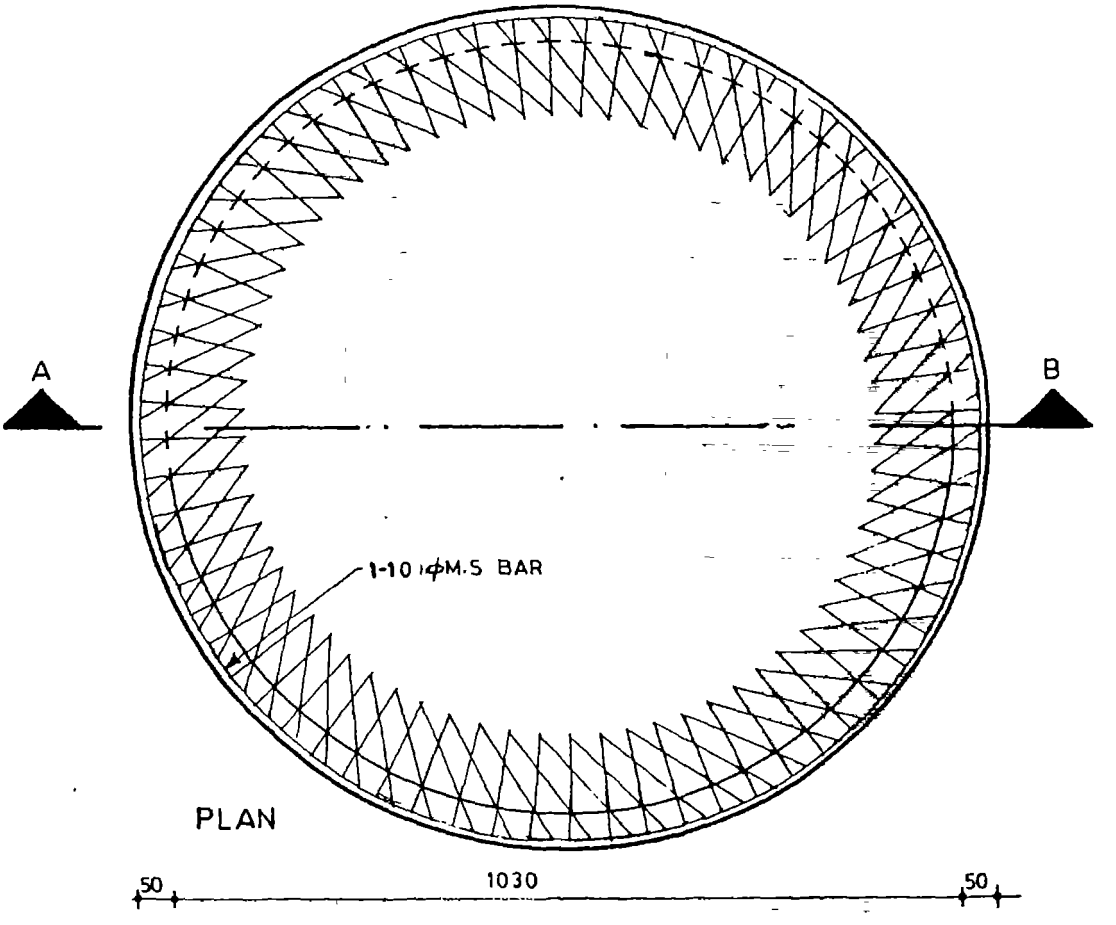


BAMBOO LINING





SECTION AT A-B



DOME SHAPED COVER FOR LEACHING PIT

DETAILS OF LATRINE DESIGN BEING FOLLOWED IN DIFFERENT STATES IN INDIA

Platform size mm	Foundation and plinth	Flooring	Size of pit mm	Pit lining	Pan and trap	Pit cover	Pit connection	Superstructure	Cost Rs.	
									Substructure	Superstructure
2	3	4	5	6	7	8	9	10	11	12
900x750	Foundation - 300mm deep and 250 mm wide Plinth-300 mm Foundation-250mm thick brick work in c.m. 1:6	25mm stone floor with stone chips	1050 deep & 900 dia	Bitumen drum	Earthen glazed ware	50mm thick R.C.C. 1:2:4 slab	S.W.pipe & junction chamber	Wall-125 mm thick brick work in c.m.1:6 Roof-Asbestos sheet local. Door-G.I. sheet door	860 at local rates	1050 at local rates
900x750	Foundation - 300mm deep and 230 mm wide. Plinth - 150 mm Foundation - 75mm thick c.c. 1:3:6 and over it brick work in c.m. 1:6	25 mm c.c. 1:2:4 over 75 mm thick c.c. 1:6:12	1200 deep & 1000 dia	75mm thick brick work in c.m. 1:6	Glazed burnt clay	75mm thick RCC 1:2:4 slab	Brick drain	Wall-75 mm thick brick work in C.M. 1:4 Plaster-12 mm thick cement plaster 1:4 Roof- R.C.C. 50mm thick Door-Wooden battened door	1250 at local rates	1050 at local rates

1	2	3	4	5	6	7	8	9	10	11	12
VOICE, Madras	1219 dia	Foundation- 150mm deep Plinth- 300mm Foundation- brick soling finished with cement mortar	25mm thick c.c. 1:2:4 including neat cement punning	990 deep and 915x 915 rectan-gular plt- 2 nos combi-ned	Ferro cement	Fibre glass	RCC slab 1:2:4	Pipe with chamber	Conical super-structure in ferro cement reinforced shelter and FRP door	1100 at local rates	710 at local rates
CBRI Roo. kee	1030x800	Foundation- 300mm deep and 230 mm wide Plinth - 230 mm Foundation- 75mm thick c.c. 1:8:16 over it brick work in c.m. 1:6 (230 mm and 115mm wide footing)	25mm c.c. floor 1:2:4 over 75mm thick c.c. 1:8:16 or flat bricks	1200 deep and 1070 dia.	Brick work 115mm thick in cement mortar 1:6	Mosaic pan and cement trap	75mm to 50mm sloping 1:2:4 slab	Junction chamber with cement pipe or brick channel	Wall- 115mm thick brick work in c.m. 1:6 20mm DPC with c.c. 1:2:4 plaster-12mm in c. m. 1:6 inside Roof-2 prefab brick panels with one 6mm dia bar in each panel Both ways in deck concrete	1980 at local rates	1260 at local rates

1	2	3	4	5	6	7	8	9	10	11	12
12. Gujarat	1000x800	Foundation- 225 mm deep and 225 mm wide Plinth- 225mm Foundation-225mm thick brick ballast mixed with sand & over it 112mm brick work in c.m. 1:6	25mm thick c.c. 1:2:4 over 75 mm thick brick ballast	1000 deep and 1000 dia	75mm thick honey comb brick work in c.m. 1:6	Ceramic pan and trap	50mm thick RCC 1:2:4 slab	Brick drain	Wall- 110 mm thick brick in c.m. 1:6 with 12mm cement plaster 1:4 inside upto 600 mm height . Roof- 50mm thick RCC 1:2:4 slab Door-wooden battened	1340 (Delhi rates)	1270 (Delhi rates)
13. Panchayati Raj Deptt., U.P.	1000x800	Foundation- 225 mm deep and 350 mm wide Plinth- 300 mm Foundation-350mm thick dry brick ballast in mud & over it 230mm thick brick work in c.m. 1:6	25mm c.c. 1:2:4 over 75mm thick lime concrete	1200 deep and 900 dia	115 mm thick honey comb brick work in 1:6	Cement mosaic	75mm RCC 1:2:4 slab	Chamber and cement pipe	Wall- 115mm brick work in 1:6 Roof - Thatch/ tile Door-Wooden battened	1830 (Delhi rates)	990 (Delhi rates)
14. Sulabh International	1000x800	Foundation- 300mm deep and 225 mm wide Plinth- 300mm Foundation-75mm thick cement concrete 1:4:8 & over it brick work in c.m. 1:6 (225 mm & 115 mm footings)	25mm thick c.c. 1:2:4 over 75mm thick c.c. 1:5:10	1225 deep and 900 dia	115 mm thick honey comb brick work in c.m. 1:6	Fibre glass pan and HDPE trap	75mm thick RCC slab 1:2:4	Brick drain	-	1840 (Delhi rates)	-

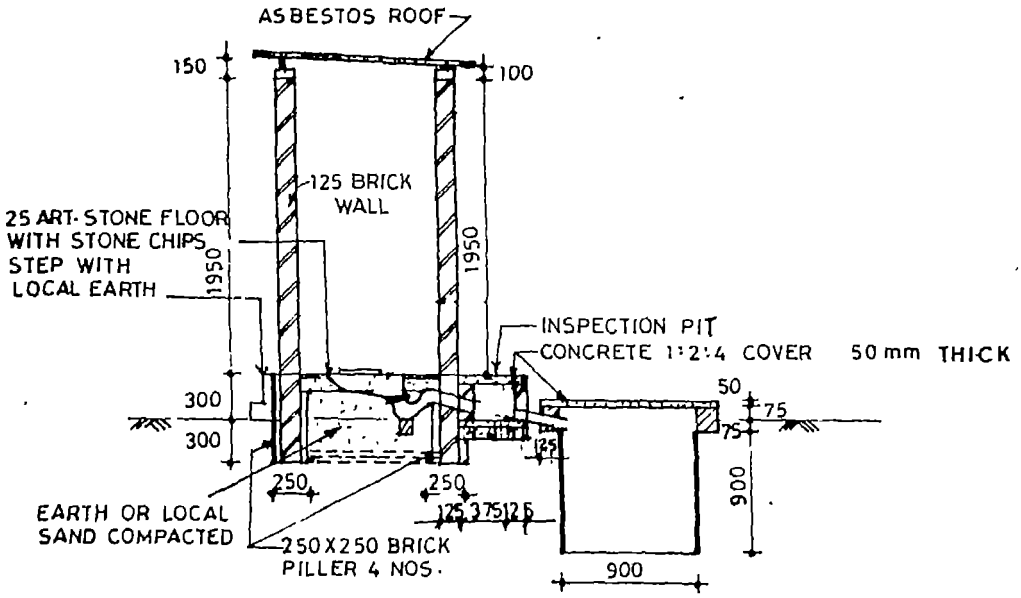
Annex-1

1	2	3	4	5	6	7	8	9	10	11	12
Megha-laya	1000x900	Foundation- 550mm deep and 300 mm wide Plinth- 300 mm Foundation- 300mm thick stone soling and over it 250 mm thick stone masonry in c.m. 1:6	20mm thick c.c.topping 1:1:2 over 65mm c.c. 1:4:8	2000 deep and 1200 dia	Pit lining with bam-boos	Fibre glass	Timber ballies and over it clay plaster	Brick drain	Wall- balli posts and bamboos matting with mud plaster inside & outside Roof-thatch Door-bamboo matting	870 at local rates	430 at local rates
Sikkim	1300x1200	Foundation- 150mm deep & 400mm wide Plinth- 300mm Foundation- 400mm thick hand packed stone & over it c.c. 1:4:8	Hand packed stone filling & over it 76mm c.c. floor 1:3:6	1300 deep and 1000 dia	Hand packed stone wall 400mm thick and over it for 300mm height c.c. 1:4:8	Fibre glass	75mm thick RCC 1:2:4 slab	S.W.pipe and junction chamber	Wall-thatch bamboos mat wall with mud plaster Roof- 24 gauge G.I. sheet	-	1300 (Delhi rates)
Kerala	1200x900	Foundation- 300mm deep and 400 mm wide Plinth- 300 mm Foundation- R.R. stone masonry in mud mortar	75mm thick c.c. 1:4:8 & over it plaster in c.m. 1:4	1800 deep and 900 dia	200mm thick honey comb brick work in c.m. 1:6	Fibre glass	75mm thick RCC 1:2:4 slab	S.W.pipe and junction chamber	Wall- 100mm thick brick work in c.m. 1:6 Roof- A.C. sheet Door- Wooden battened door with A.C. plain sheet	-	1300 (Delhi rates)

1	2	3	4	5	6	7	8	9	10	11	12
6. Jammu & Kashmir	900x787.5	Foundation- 450mm deep & 225 mm wide Foundation-dry brick ballast & over it c.c. 1:4:8 and 112.5 mm thick brick work in c.m. 1:6	25mm cement concrete 1:2:4 over 75mm dry brick ballast	1680 deep & 1100 dia	112mm thick brick work in c.m. 1:6	Mosaic pan and cement trap	75mm thick RCC slab	Covered brick drain	Wall - 112 mm thick brick in c.m. 1:6 Roof - G.I. sheet Door-wooden battened	2200 (Delhi rates)	1600 (Delhi rates)
7. Tamil Nadu	900x750	Foundation- 300mm deep & 230 mm wide Plinth - 150mm Foundation- Cement concrete 1:4:8 & over it 115 mm thick brick work in c.m. 1:6	25mm thick brick work in c.m. 1:6	1000 deep & 900 dia	75mm thick brick work in c.m. 1:6	Ceramic pan and trap	50mm thick RCC slab	S.W.pipe and junction chamber	Wall- 115 mm thick brick work in c.m. 1:6 Roof- RCC 1:2:4 slab	1435 (Delhi rates)	875 (Delhi rates)
8. Orissa	1100x850	Foundation- 375 mm deep and 350 mm wide Plinth- 600 mm Foundation-75mm dry brick ballast over it 125mm thick brick work in c.m. 1:8	25mm thick c.c.1:2:4 over 75 mm thick dry brick ballast	1350 deep & 900 dia	125mm thick brick work in c.m. 1:8 (alternate layers without mortar)	Cement mosaic pan and cement trap	65mm thick RCC 1:2:4 slab	Brick drain	-	1900 (Delhi rates)	-

Annex-1

1	2	3	4	5	6	7	8	9	10	11	12
3. West Bengal All India Institute of Hygiene & Public Health, Calcutta at Singur	1050x900	Foundation-300mm deep & 375 mm wide Plinth-450mm Foundation concrete-75mm thick c.c. 1:3:6 & over it 250 mm thick brick work in cement mortar 1:6	12mm cement plaster 1:4 over 50 mm c.c. 1:4:8	3000 to 4500 deep & 900 dia	Burnt clay rings	Mosaic pan & cement concrete trap	50mm thick RCC slab	Burnt clay pipe with brick masonry chamber	Wall-half brick thickness in c.m. 1:6 Roof- tiled roof	890 (at local rates)	870 (at local rates)
4. West Bengal Ramkrishna Mission Loksiksha Parishad Narendra-Pur	1050x800	Foundation-225mm deep and 225 mm wide Plinth - 225 mm Foundation- 225mm thick brick work in c.m. 1:6 & over it brick work 115 mm thick in c.m. 1:6	25mm c.c. 1:2:4 over 75 mm dry brick ballast	1000 deep & 900 dia	75mm thick honey comb brick work in 1:6	Cement mosaic	53mm thick R.C.C. slab 1:2:4	Brick drain	Wall - Bamboo jali Roof- 50mm RCC slab or tiles	1070	-
5. West Bengal Women's Coordinating Council Calcutta	900x900	Foundation- 225mm deep & 225 mm wide Plinth- 225 mm Foundation -dry brick ballast & over it brick work in c.m. 1:6 (225 mm and 125 mm wide footing)	25mm c.c. flooring in 1:2:4 over 75mm thick dry brick ballast mixed with sand	1025 deep and 975 dia	75mm thick honey comb brick work in c.m. 1:6	Fibre glass	50mm thick RCC in 1:2:4	Brick drain	Wall- 125mm thick brick work in c.m. 1:6 Plaster - 12mm thick inside upto 300 mm height in c.m. 1:4 Roof- 50mm thick R.C.C. 1:2:4 slab Door- wooden battened door	1100 (Delhi rates)	1200 (Delhi rates)



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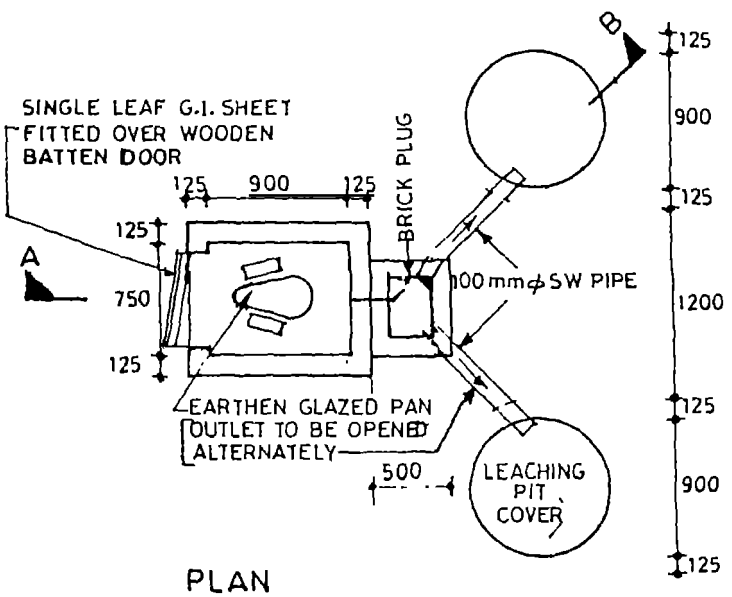
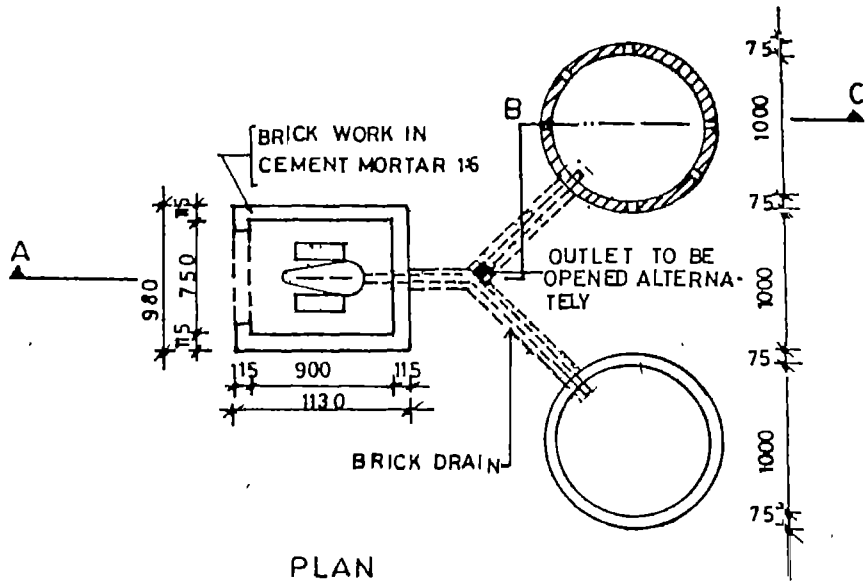


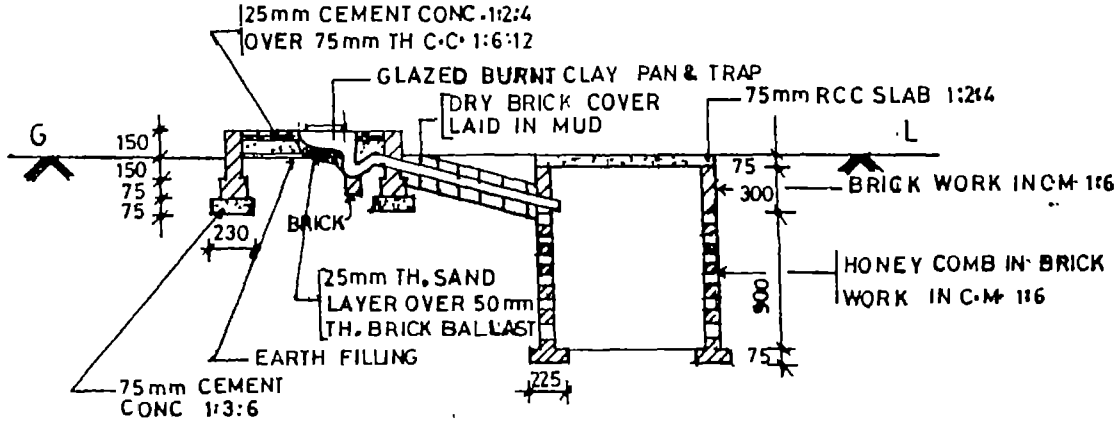
PLAN

NOTE
ALL DIMENSIONS ARE IN mm
SCALE- 1:5

WEST BENGAL
DESIGN-I
(RURAL)



PLAN

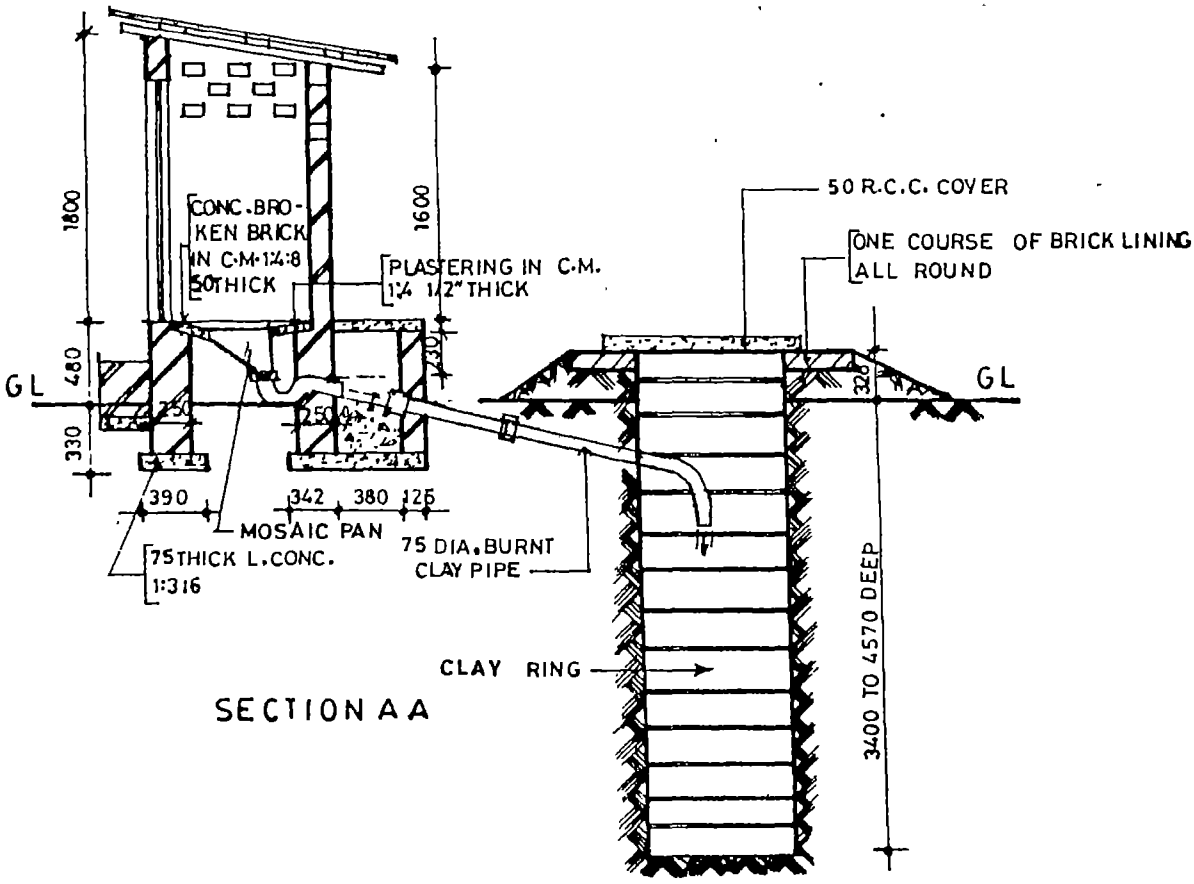


SECTION A B C

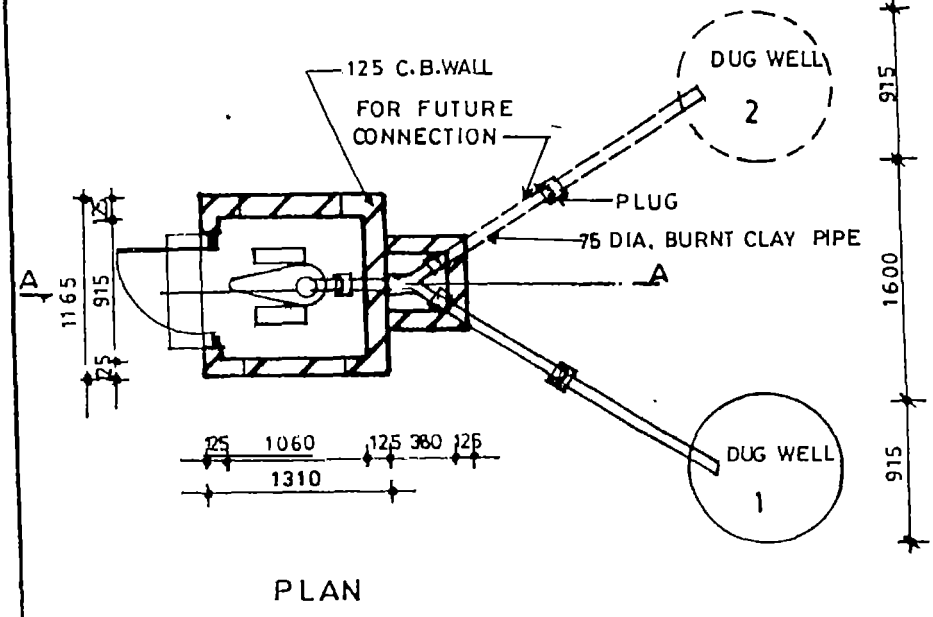
NOTE
ALL DIMENSIONS ARE IN mm
SCALE - 1:5

WEST BENGAL
DESIGN-II
(RURAL)

ANNEX-I



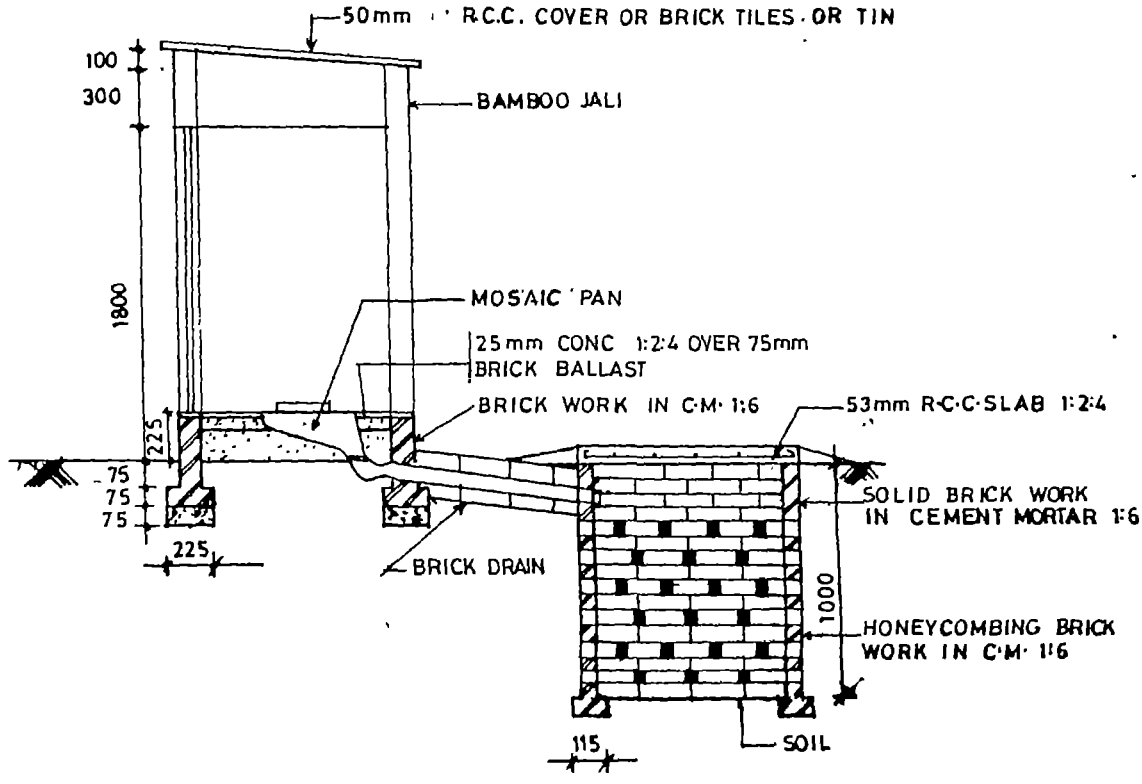
SECTION A A



PLAN

NOTE
ALL DIMENSIONS ARE IN mm

ALL INDIA INSTITUTE OF HYGIENE & PUBLIC HEALTH
CALCUTTA
RURAL (SINGUR)



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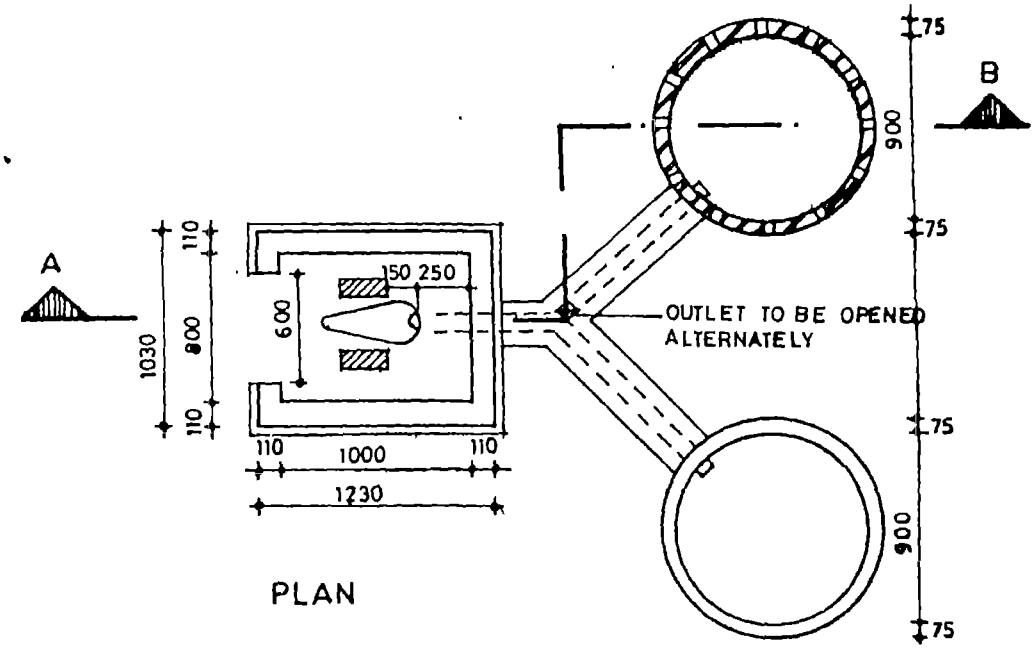
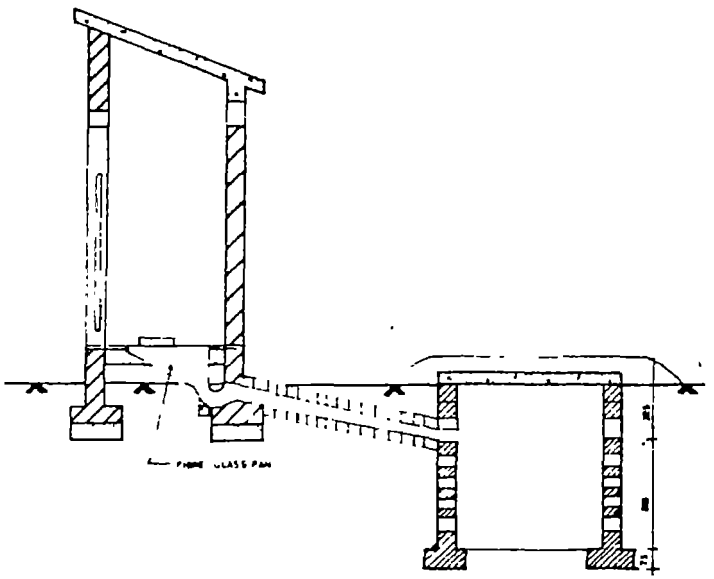


PLAN

RAM KRISHNA MISSION LOKASHIKSA PARISAD NARENDRAPUR WEST BENGAL (RURAL)

ANNEX



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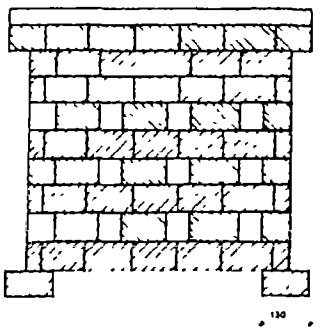
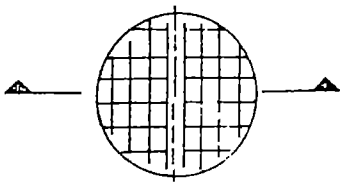
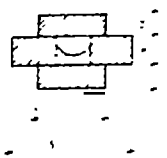


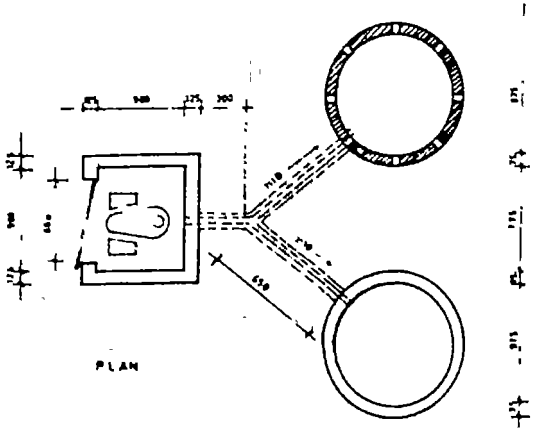
SECTION OF PIT



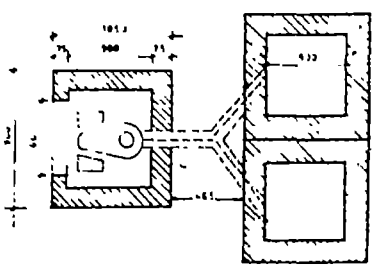
COVER P



BRICK DRAIN

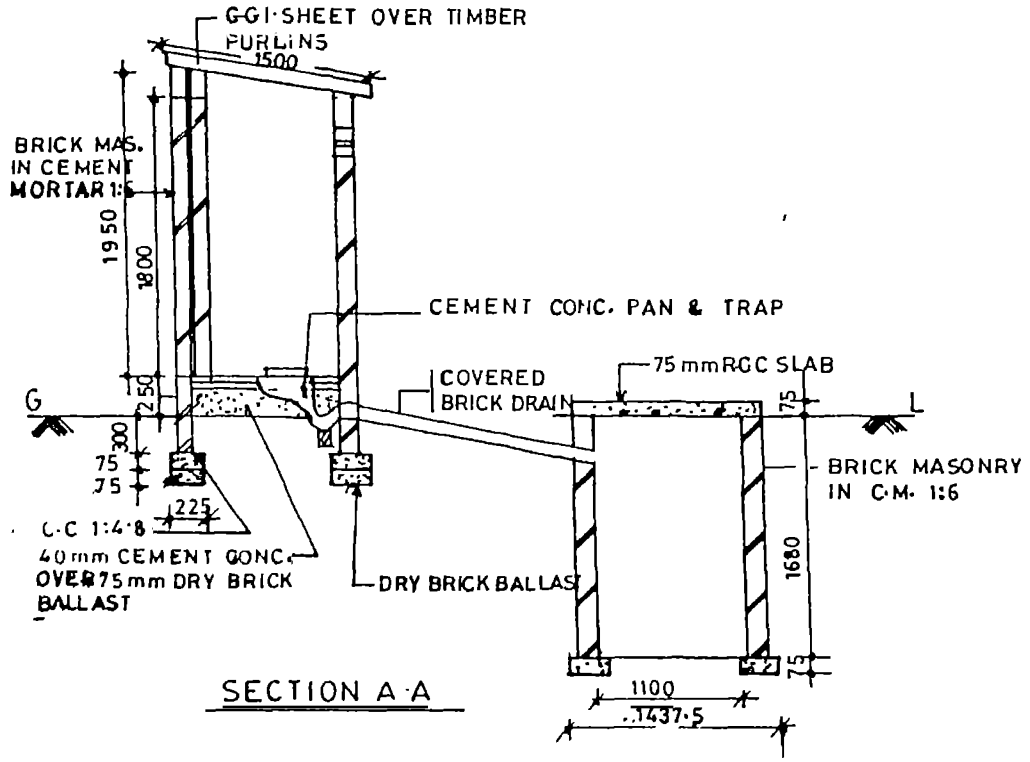


PLAN



ALTERNATIVE PLAN

WOMEN'S CO-ORDINATING COUNCIL CALCUTTA



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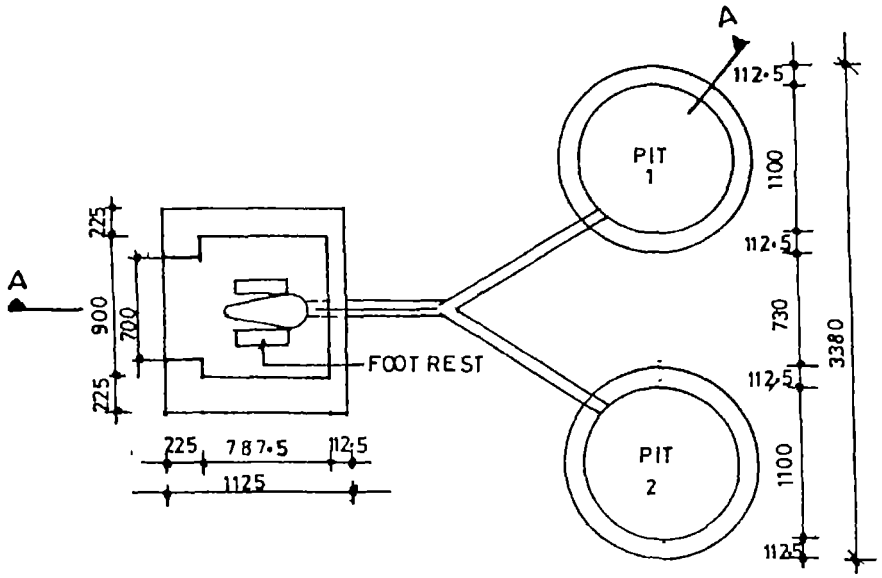


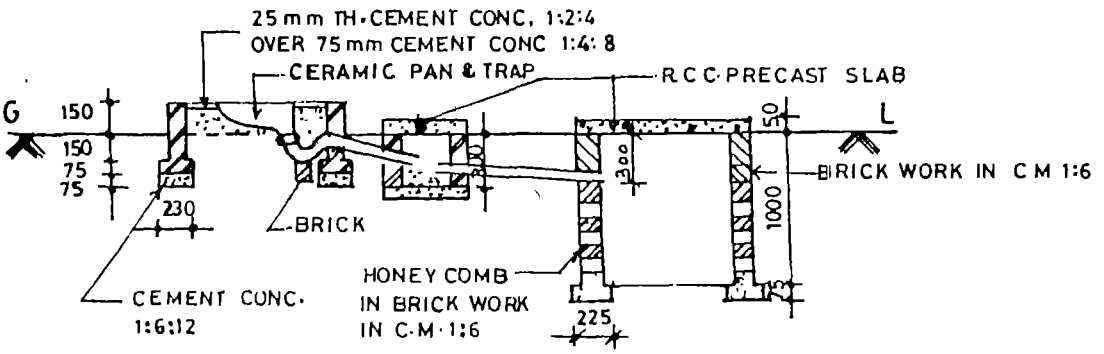
PLAN

NOTE

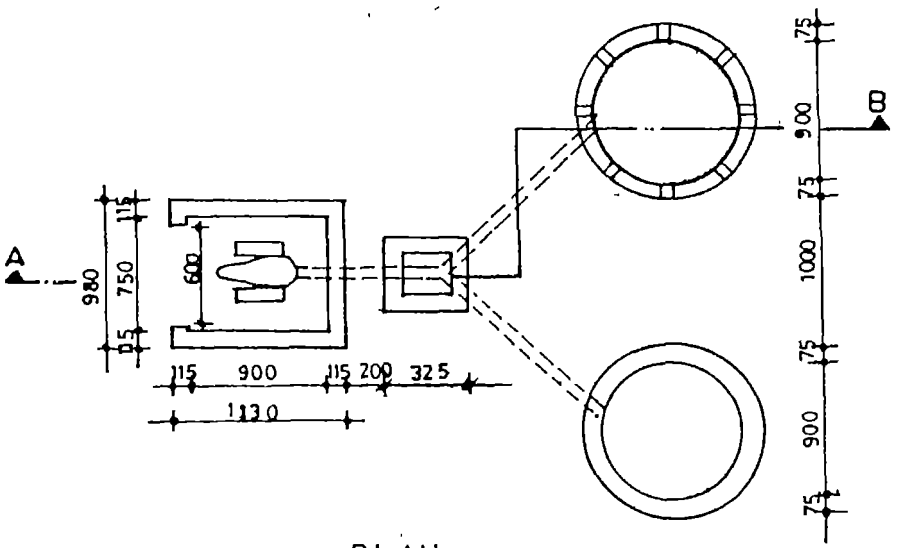
ALL DIMENSIONS ARE IN mm

SCALE - 1:5

J. & K.



SECTION A-B



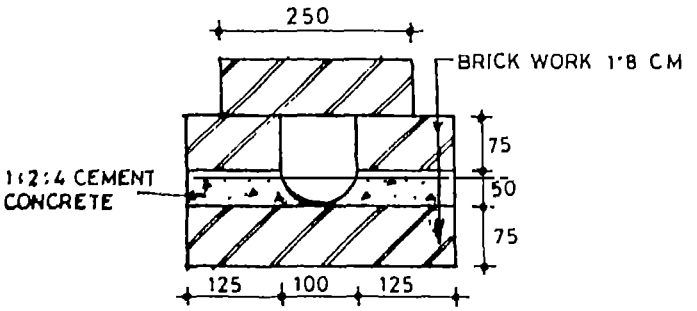
PLAN

NOTE

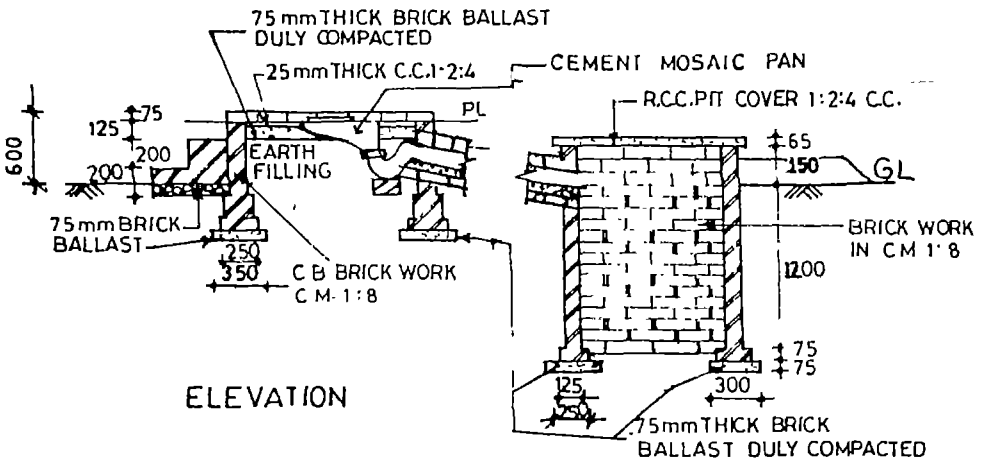
ALL DIMENSIONS ARE IN mm

SCALE – 1:5

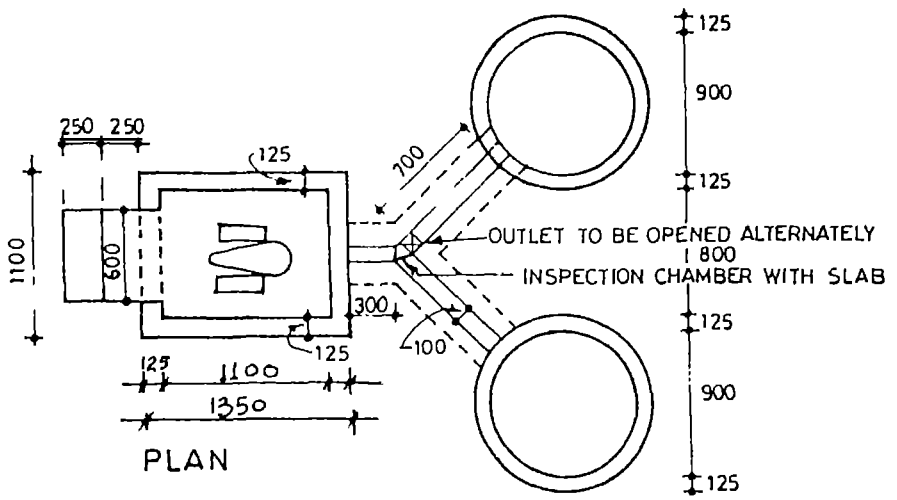
TAMIL NADU



CROSS SECTION OF DRAIN



ELEVATION



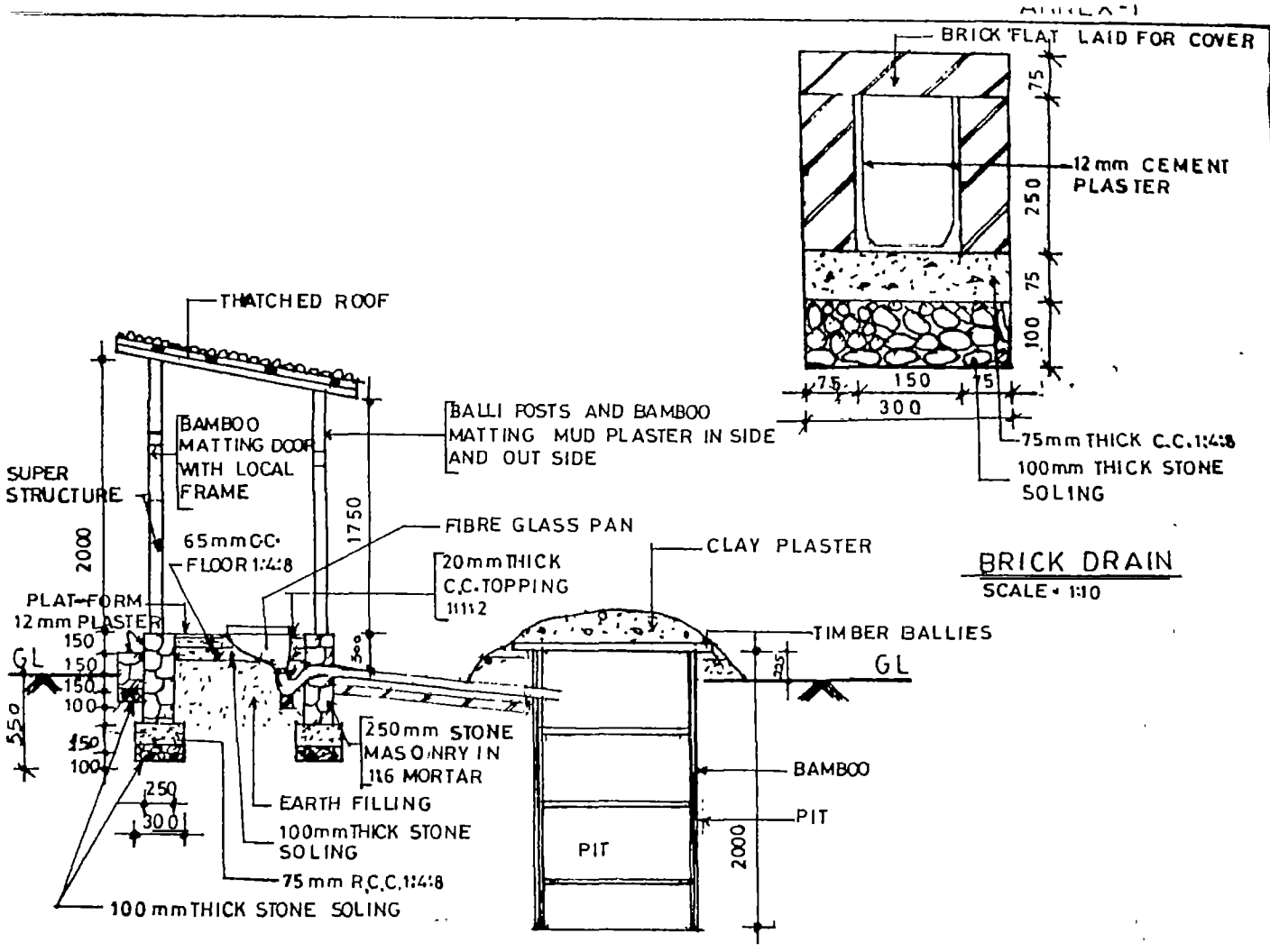
PLAN

NOTE

ALL DIMENSIONS ARE IN mm

SCALE - 1:5

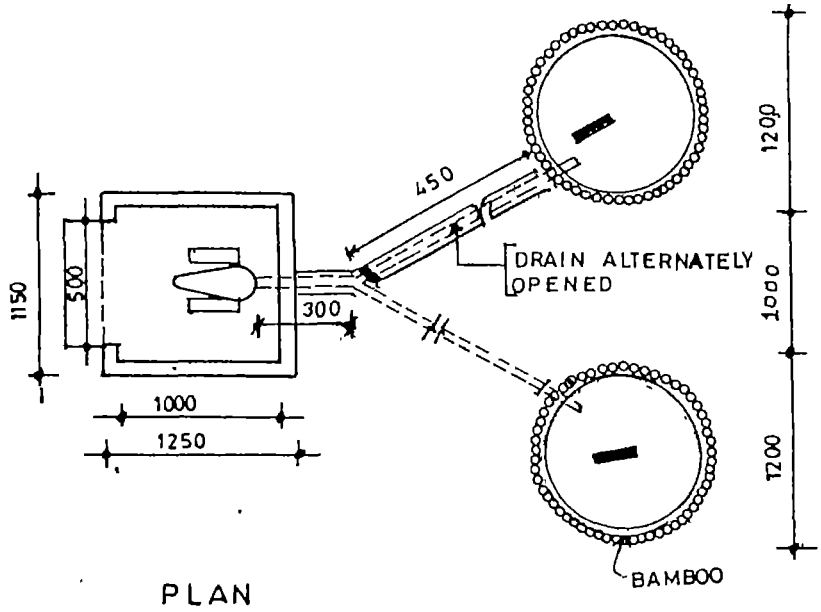
ORISSA
(RURAL)



BRICK DRAIN

SCALE - 1:10

CROSS SECTION



PLAN

NOTE

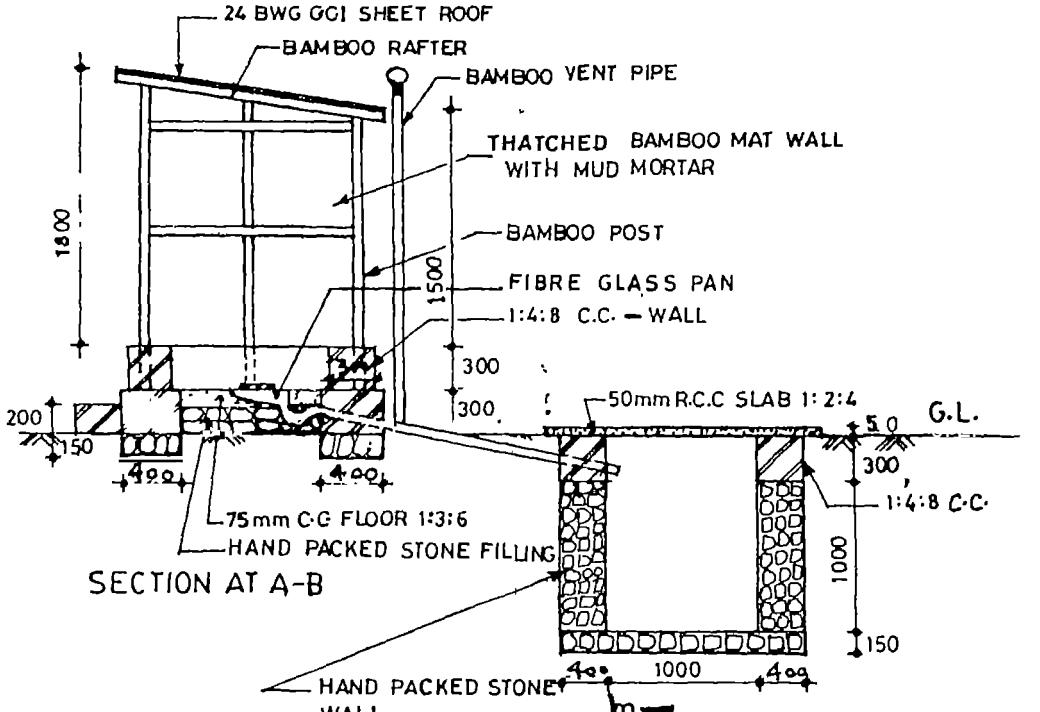
ALL DIMENSIONS ARE IN mm

SCALE - 1:5

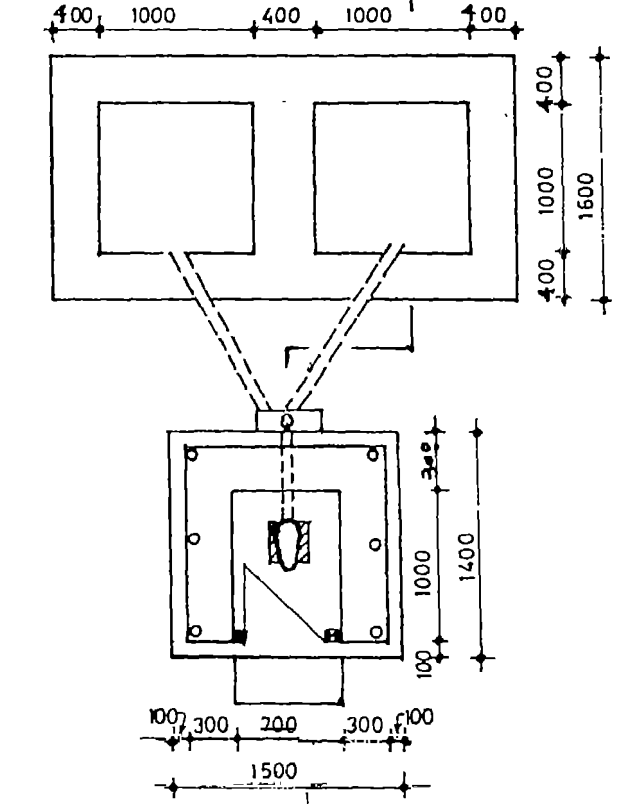
MEGHALAYA

(RURAL)

ANNEX-1

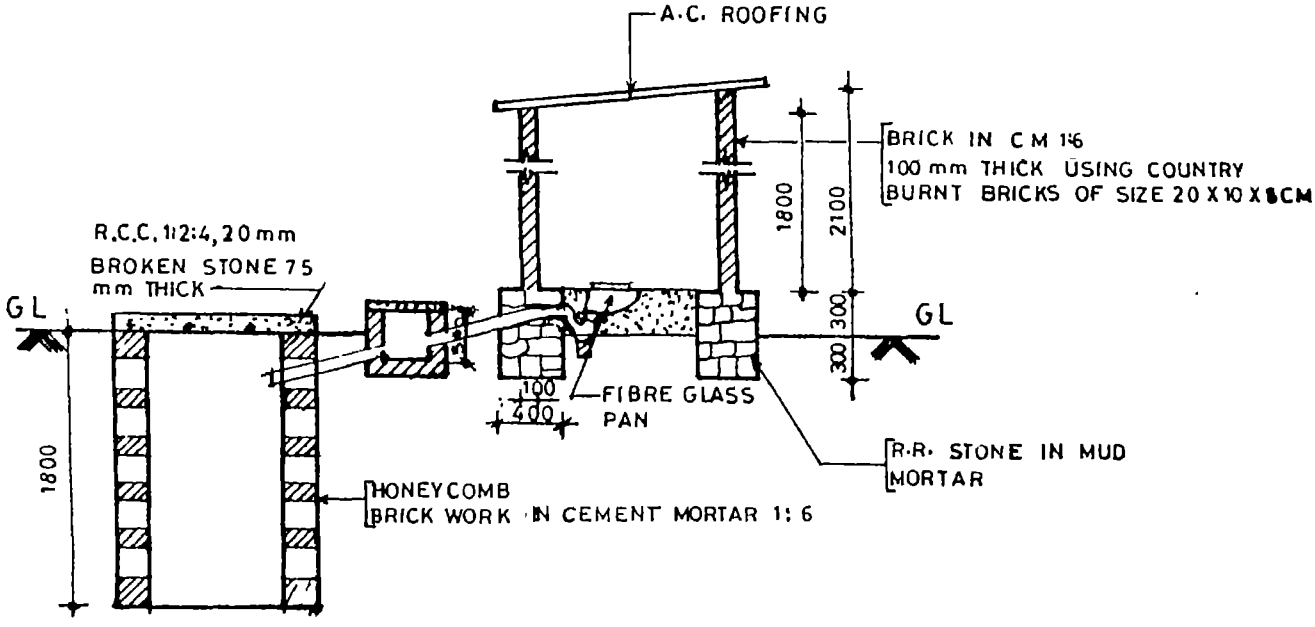


SECTION AT A-B



PLAN

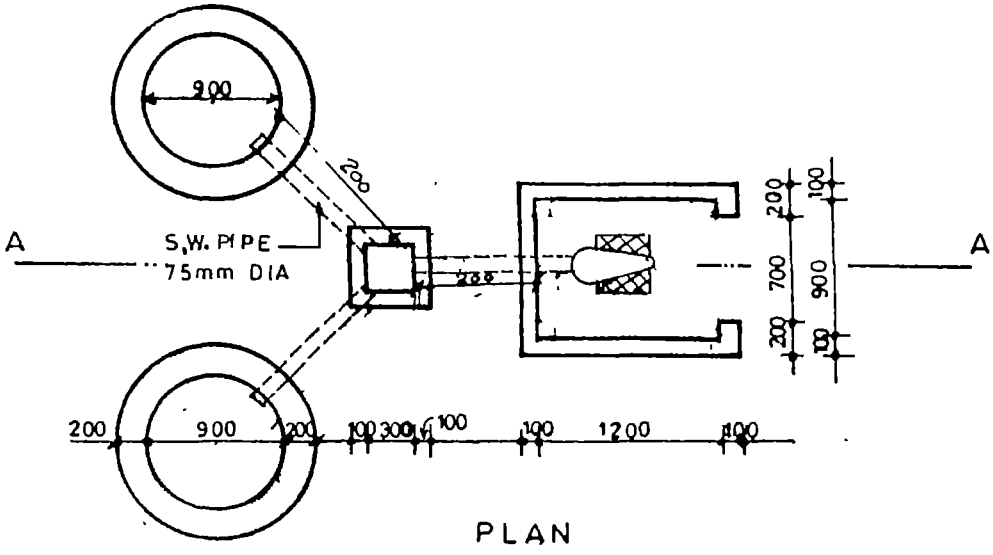
SIKKIM
RURAL DEVELOPMENT DEPARTMENT



SECTION-AA

DOOR - 70 X 180 CM BATTENED DOOR
USING AC PLAIN SHEET

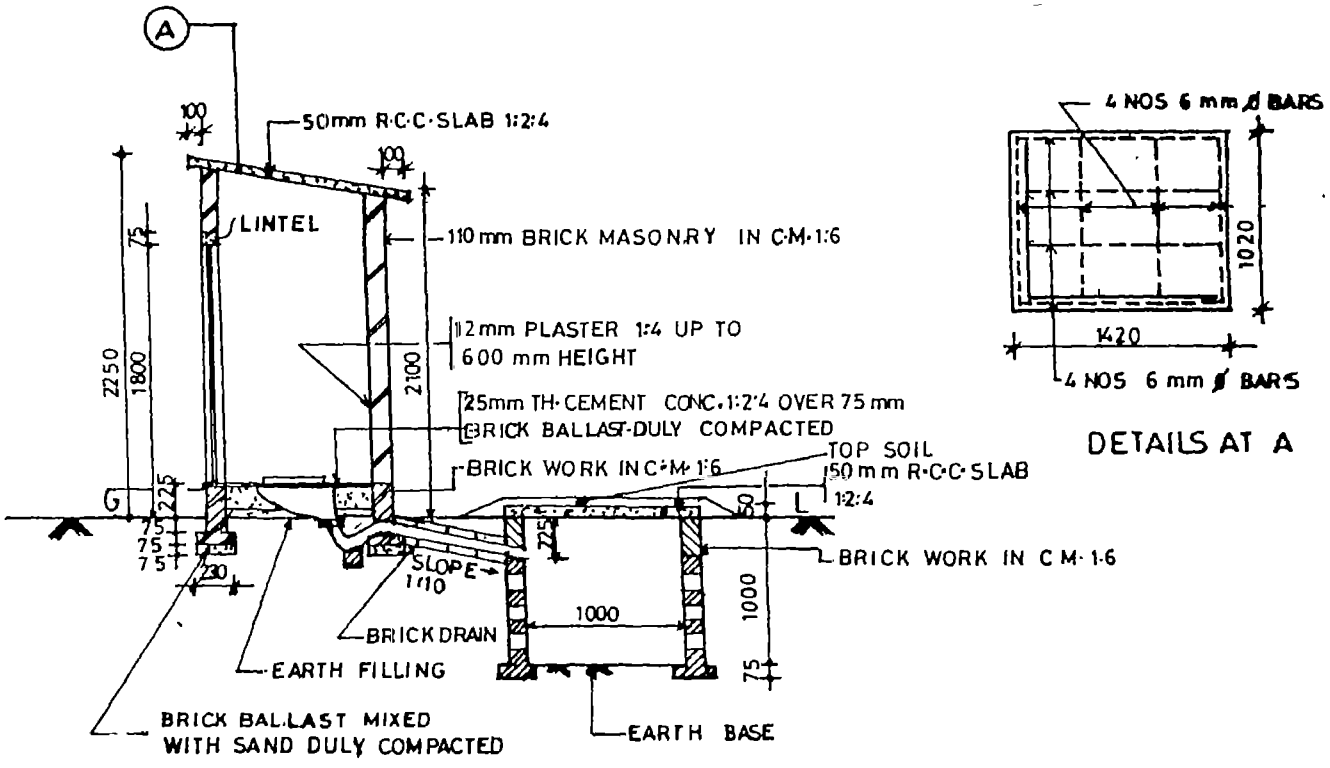
PAN – 450 mm INDIAN CLOSET



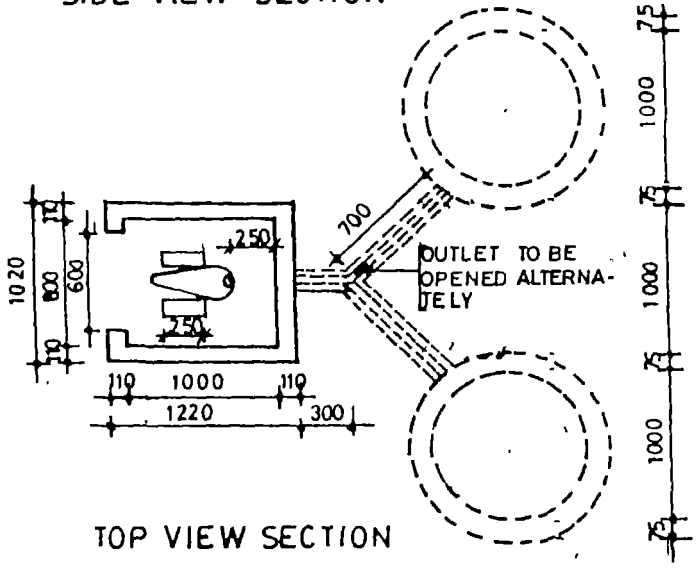
PLAN

NOTE
ALL DIMENSIONS ARE IN mm
SCALE - 1:5

KERALA
(RURAL)



SIDE VIEW SECTION

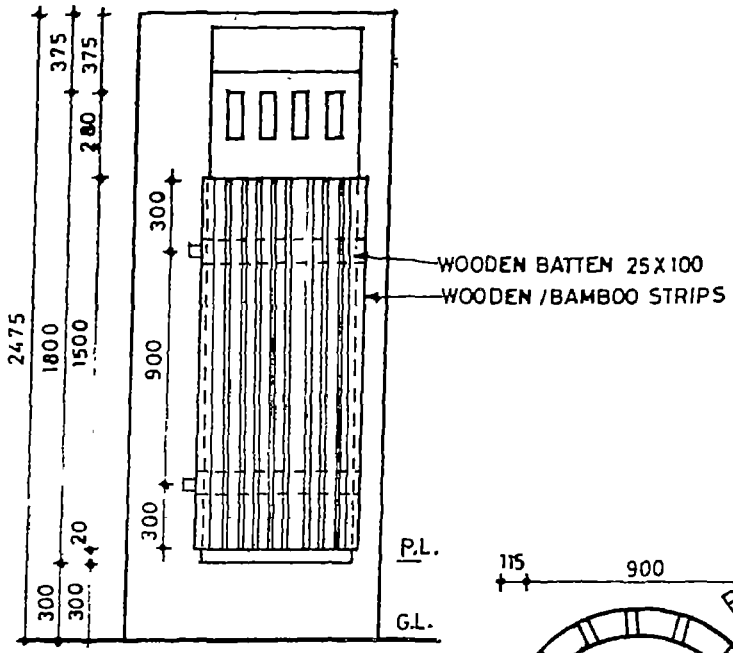


TOP VIEW SECTION

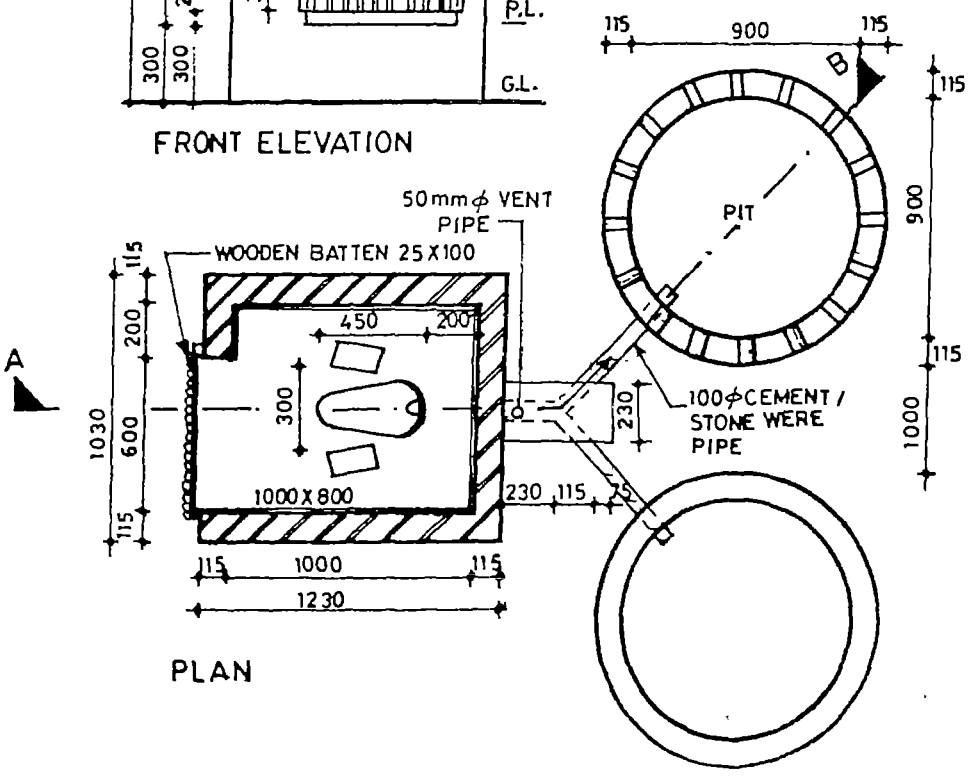
ALL DIMENSIONS ARE IN mm

GUJRAT WATER SUPPLY AND SEVERAGE BOARD
(URBAN)

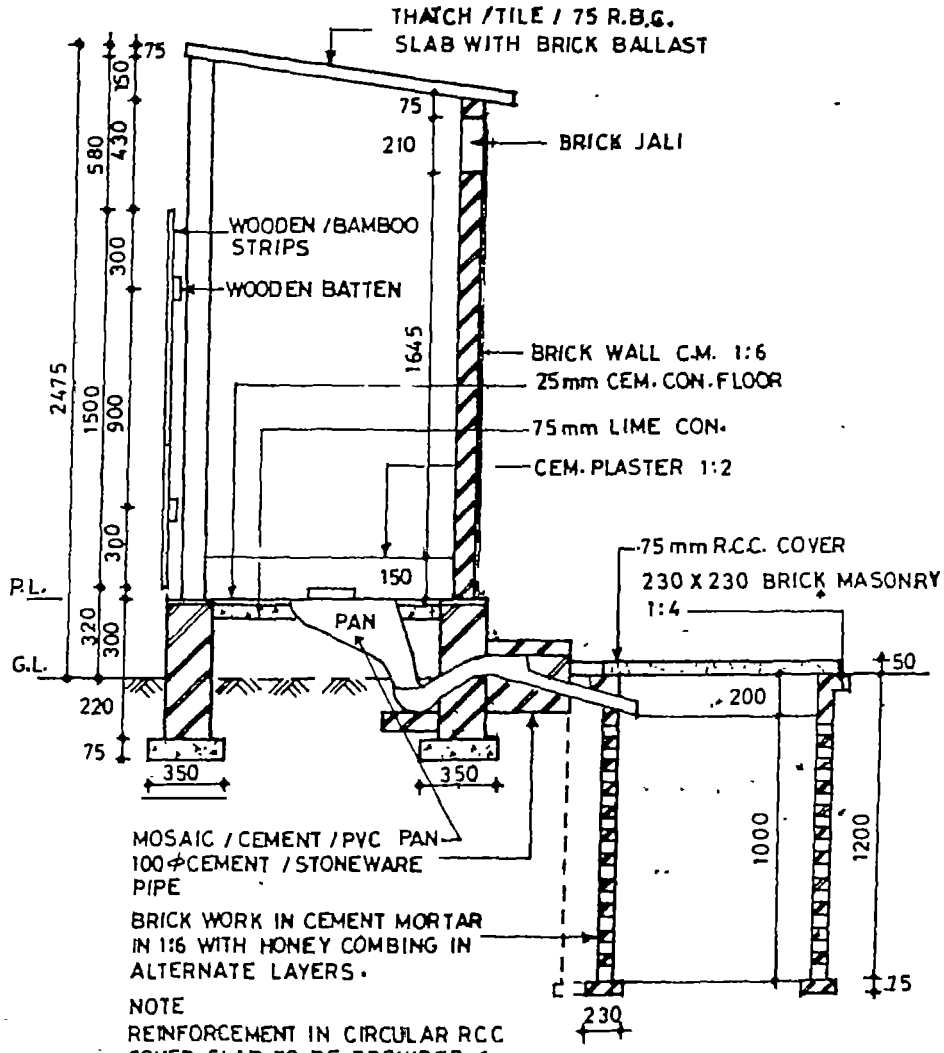
ANNEX-1



FRONT ELEVATION



PLAN

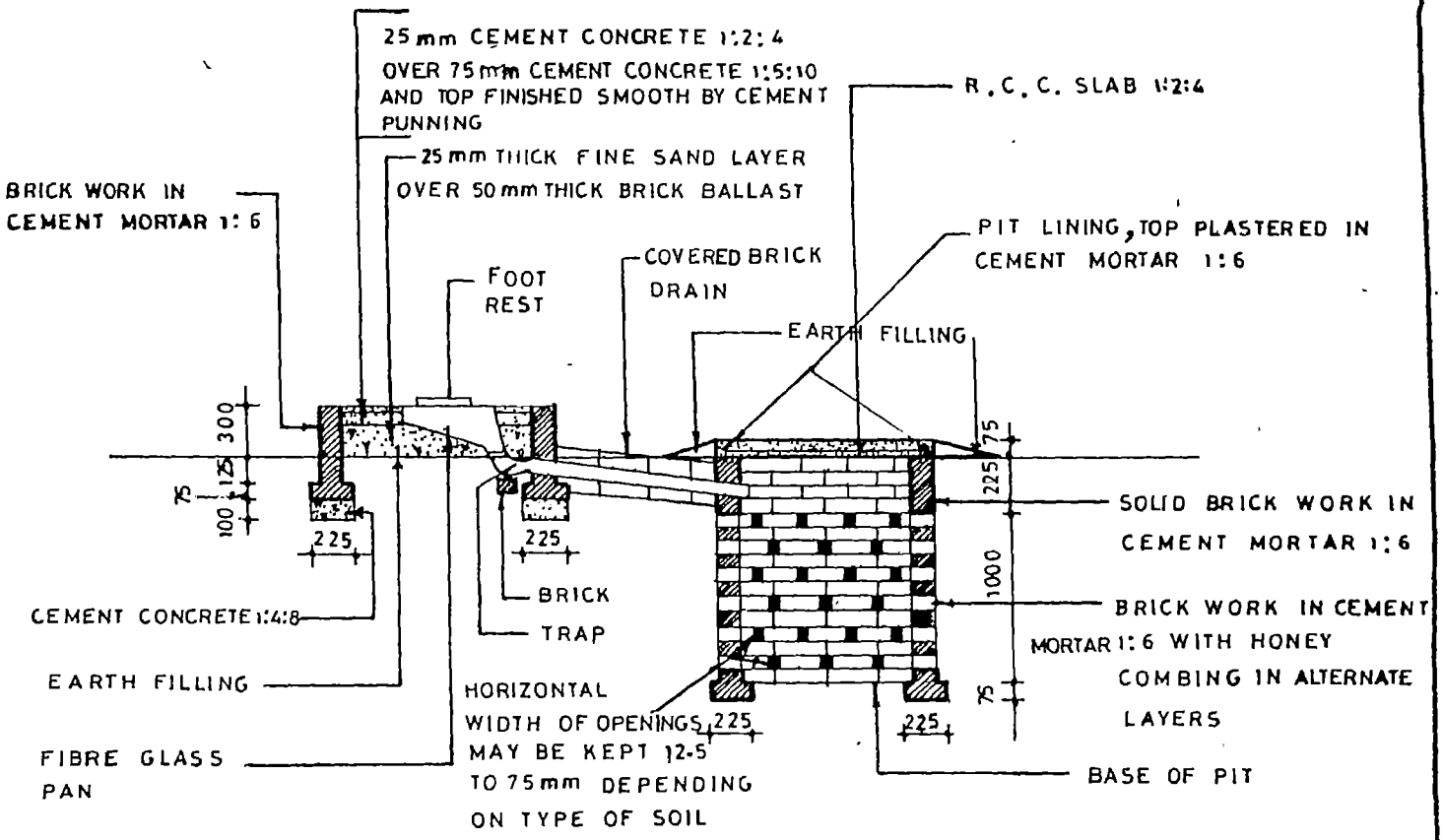


NOTE
REINFORCEMENT IN CIRCULAR RCC COVER SLAB TO BE PROVIDED 6 mmφ BARS @ 150 mm BOTH WAYS

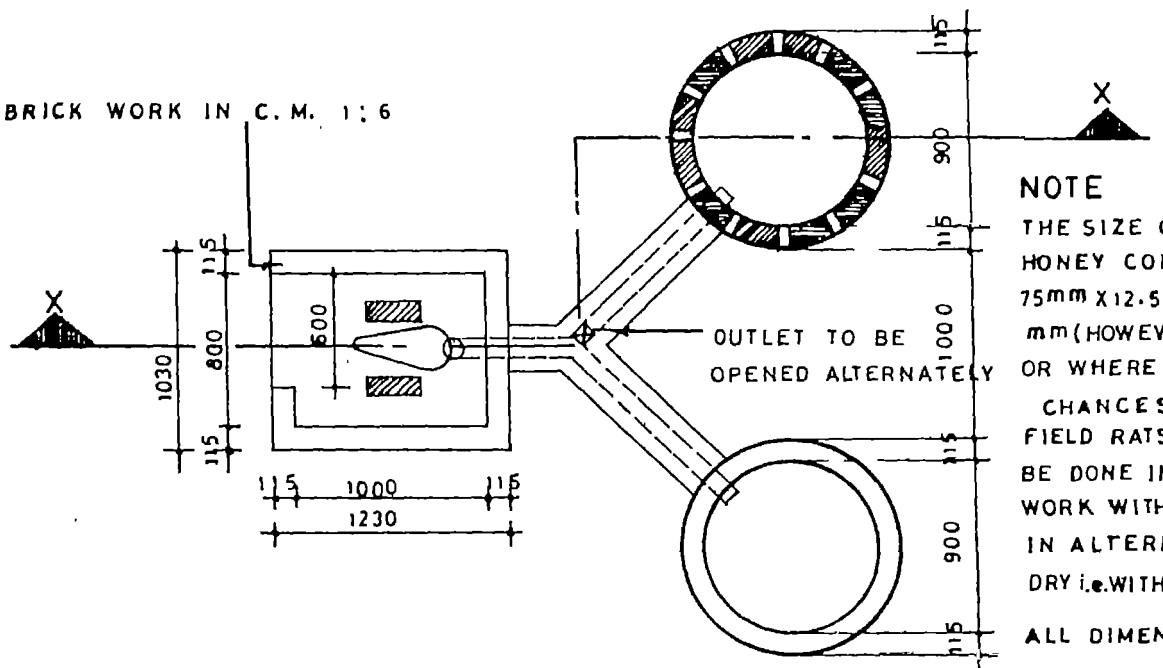
SECTION AT A-B

updesco - LUCKNOW (UP)

POUR FLUSH LATRINE IN RURAL AREAS



SECTION ON X—X



PLAN

NOTE

THE SIZE OF HOLES IN HONEY COMBING SHOULD BE 75 mm X 12.5 mm TO 75 mm X 115 mm (HOWEVER IN SANDY SOIL OR WHERE THERE ARE CHANCES OF DAMAGE BY FIELD RATS, LINING SHOULD BE DONE IN SOLID BRICK WORK WITH VERTICAL JOINTS IN ALTERNATE LAYERS DRY i.e. WITH NO MORTAR.)

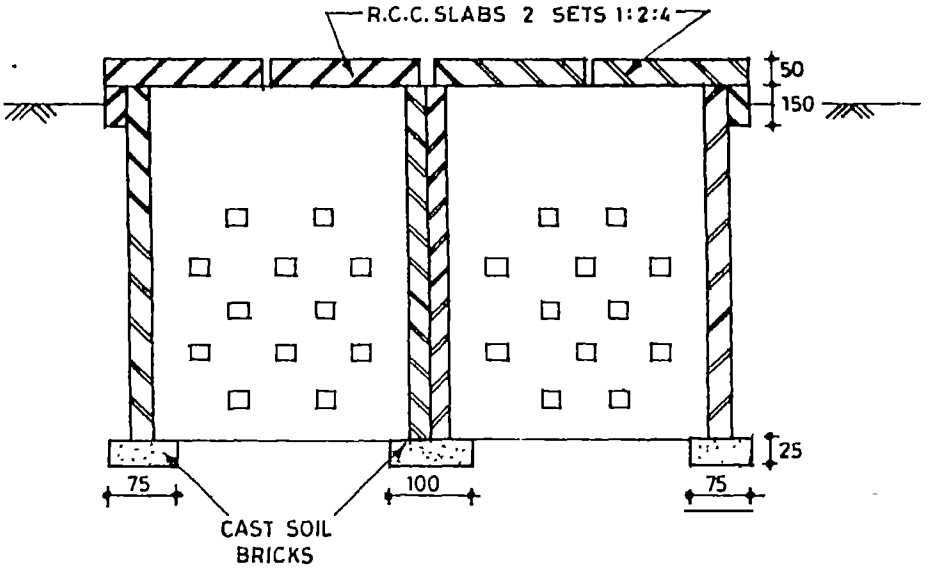
ALL DIMENSIONS ARE IN mm

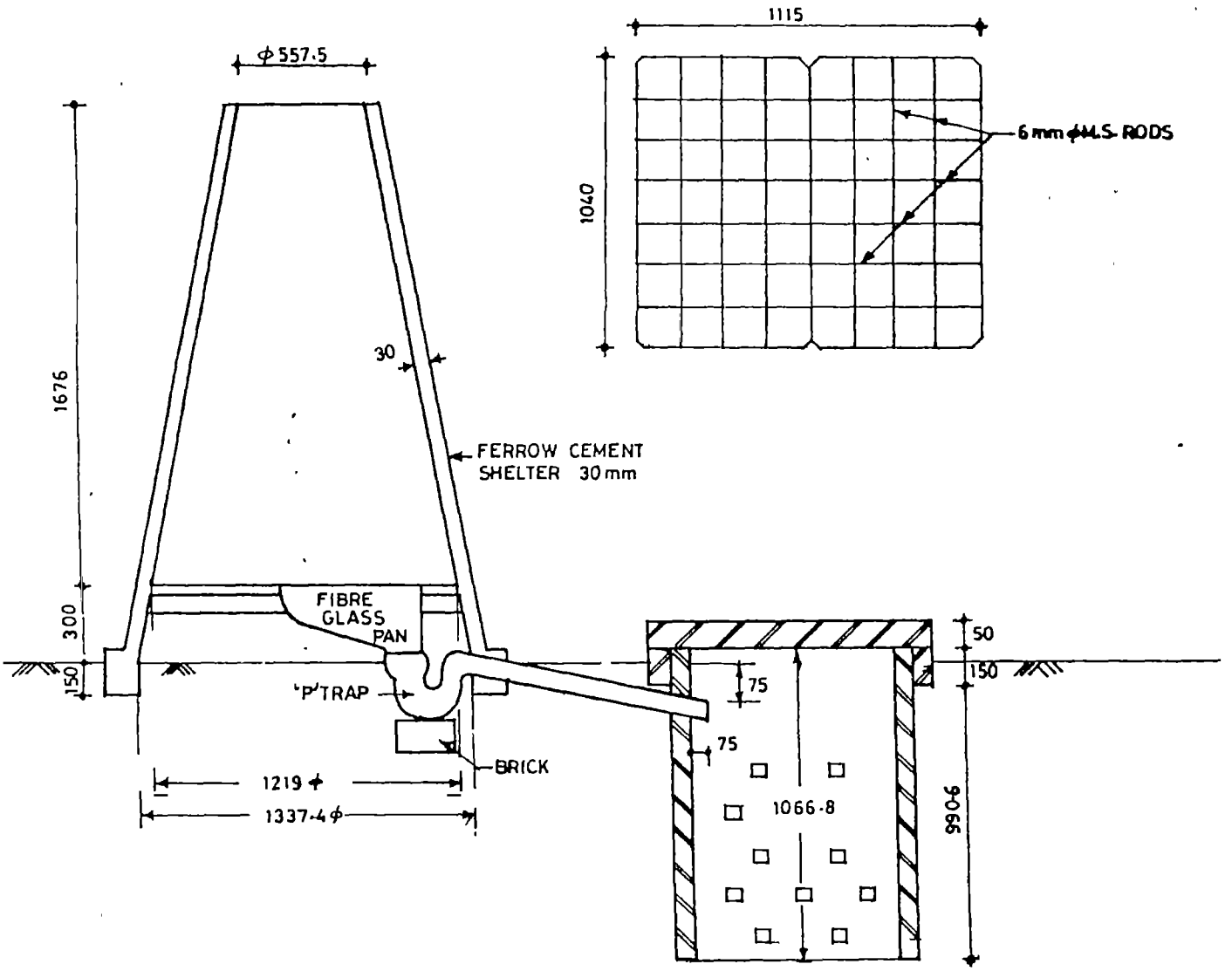
SULABH INTERNATIONAL DELHI

DESIGN OF SULABH SHAUCHALAYA FOR FIVE USERS

SCALE 1:40

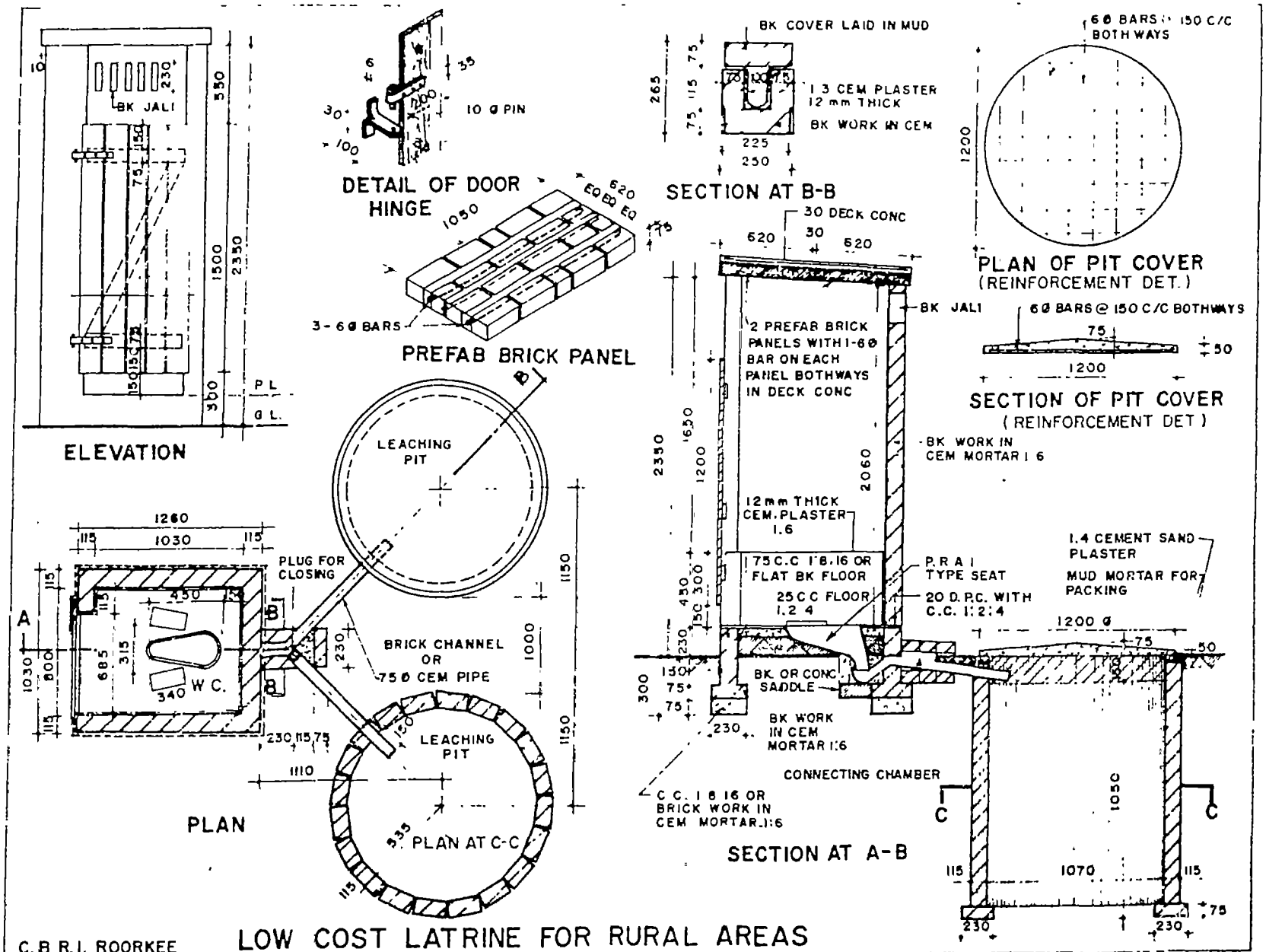
DRG. NO. GEN. 68T/85





POUR FLUSH LATRINE FOR VOLUNTARY INSTITUTE FOR CLEAN ENVIRONMENT (VOICE) MADRAS

ANNEX I



C.B.R.I., ROORKEE

LOW COST LATRINE FOR RURAL AREAS

RESULTS OF STUDY CARRIED OUT BY ICMR ON SUITABILITY OF PIT LINING WITH DIFFERENT MATERIALS

Type of lining	Cost of lining (Rs.)	Number of latrines under observation	Period of observation	Performance of the lining	Remarks
R.C.C. Rings					
Metal concrete 1:2:4 rings-Thickness 1.5" Internal diameter 2'6" Height 1'9"-5 ring used for each plt. The rings were provided with leaching holes 1/8" diameter	35	5	3 years (1957-1960)	Lining intact-no caving. Popular with the users.	+
Brick in clay					
4.5" thick, brick with clay lining-Bricks cut into curved shape to fit in the hole 2'6" diameter were used	25	5	3 years (1957-1960)	Lining intact-no caving. Construction somewhat difficult.	+
Empty tar drums					
Drums cut to size and tied together with G.I. wires to form 2'6" diameter barrel. Top drum was provided with perforations.	12	5	3 years (1957-1960)	Lining shows signs of deterioration. May not last for more than 3 to 4 years. Construction difficult	-
Bamboo matting					-
Single Bamboo sticks tied around bamboo post and reinforced by bamboo reapers	7	5	3 years (1957-1960)	All the pits collapsed before 3 years. Evidence of white ant damage.	-
Mango wood planks (untreated)					
Made of plank 8.5'-9' x5"x1"- The planks kept in position by 1/16"x 0.5" mild steel bars to form a 2'6" diameter cylindrical barrel.	44	5	3 years (1957-1960)	Planks decay white ant damage.	-

Cinder-concrete					
Rings made of cinder concrete without reinforcement 1:2:4 2'6" diameter. 1'9" height 1 3/4" thickness and provided with 1/8" holes.	25	40	1 year (1959-1960)	Lining intact-may be expected to last long -cinder not easily available-rings difficult to transport.	+
Treated mango wood planks (same as 5)					
Lining of 9 latrines treated with coal tar and 6 with cashew. oil.	42	15	2 years (1958-1960)	Lining intact at the end of 2 years. White ant damage in portion above water level.	-
Treated bamboo basket weave					
Bamboo basket 2'6" diameter 9' high and made stiff with coir at 12" intervals. 9 number coated with coal tar and 6 number with cashew oil.	21	15	2 years (1958-1960)	Nine latrines have already collapsed. White ant damage.	-
Gravel concrete rings					
Made of cement surki and sand machine made coir 3/16" is used as reinforcement 3" centre to centre.	21	15	1 year (1959-1960)	Lining intact no caving-very popular with the people.	+
Soil cement rings					
Soil cement (1:4) with 70% cement and 30% surki in place of full quantity of cement and 75% river sand and 25% local sand in place of the full quantity of fine aggregates.	21	15	1 year (1959-1960)	-do-	+

Remarks: + = Satisfactory
- = Not satisfactory