Government of Nepal

Alternative Energy Promotion Centre

National Rural & Renewal Energy Programme

(AEPC/NRREP)

Khumaltar, Lalitpur

MANUAL

MODEL BIOGAS PLANT

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Centre of Resilient Development (CoRD)

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Biogas Plant Model

INTRODUCTION

Government of Nepal under AEPC has been promoting domestic bio gas plant construction across the country since 1992. The sizes adopted for the construction of domestic biogas plants consist of GGC 2047 and Modified GGC 2047 for the sizes 2, 4, 6 and 8 m3 capacities. The experienced and qualified biogas companies are capable of constructing the smaller capacity biogas plants by following the available standard documents such as drawings, construction manual and specification approved by APEC.

More recently, the Government of Nepal has realized that bigger size biogas plants are required to meet increasing demand in the present context of energy crisis. Therefore, it has become necessary to introduce medium to large sizes biogas plants of sizes 12.5 to 35 m3.

For the standardization of medium to large size biogas plants, AEPC has prepared a prototype for sizes of 12.5, 15, 20, 25, 30 and 35 m3 biogas plants including all supporting documentation such as the construction manual and the design specification.

The sizes adopted for the construction of domestic biogas plants consist of GGC 2047 and Modified GGC 2047 for sizes 2, 4, 6, and 8 m3 capacities. All qualified biogas companies are able to construct them based upon the drawings and specification approved by AEPC. These household sized plants are mainly based on cattle manure as feedstock and are highly popular among the rural community of Nepal.

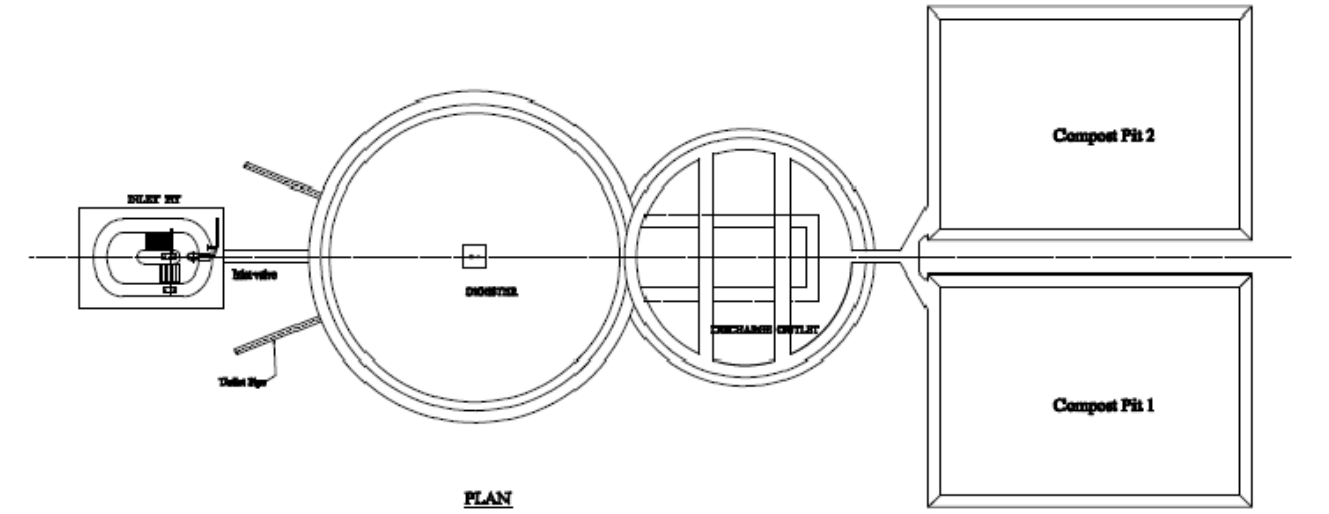
On the other hand, in view of prevailing energy crisis it is necessary to utilize various biodegradable wastes other than cattle or animal dung such as Municipal solid waste, waste generated from latrines and kitchen etc for mitigating pollution problem thereby improving health and sanitation of the inhabitants. In this context, it become necessary to introduce large sizes of biogas plants, say from 12.5 m3 up to 35 m3 or more. It is remarkable to note that with the initiation AEPC, BSP-Nepal and other organizations, reasonable number of large size biogas plants ranging from 15 m3 to 50 m3 have been installed at institutional and or community levels.

Considering that standardization of medium to large size biogas plants is still lacking, AEPC has initiated this project in view of standardizing biogas plants of various large sizes i.e. 12.5, 15, 20, 25, 30 and 35 m3. In this context to disseminate the design in the field this construction manual has been developed. It is understood that in the process of building local technical skills, AEPC is targeting a training programme for

the Consultants and consulting companies that can initiate the process and provide services for the installation of such technology in the country under SREP funded scheme.

The success or failure of any biogas plant mainly depends upon the quality of construction works. To come to a successfully constructed biogas plant, the mason should not only respect the dimensions as indicated on the drawing but also follow the correct construction method. Similarly supervisor should check the dimension and construction procedures plant construction time to time. In this manual a step by step fashion, the right construction method of the modified biogas design model has been given.

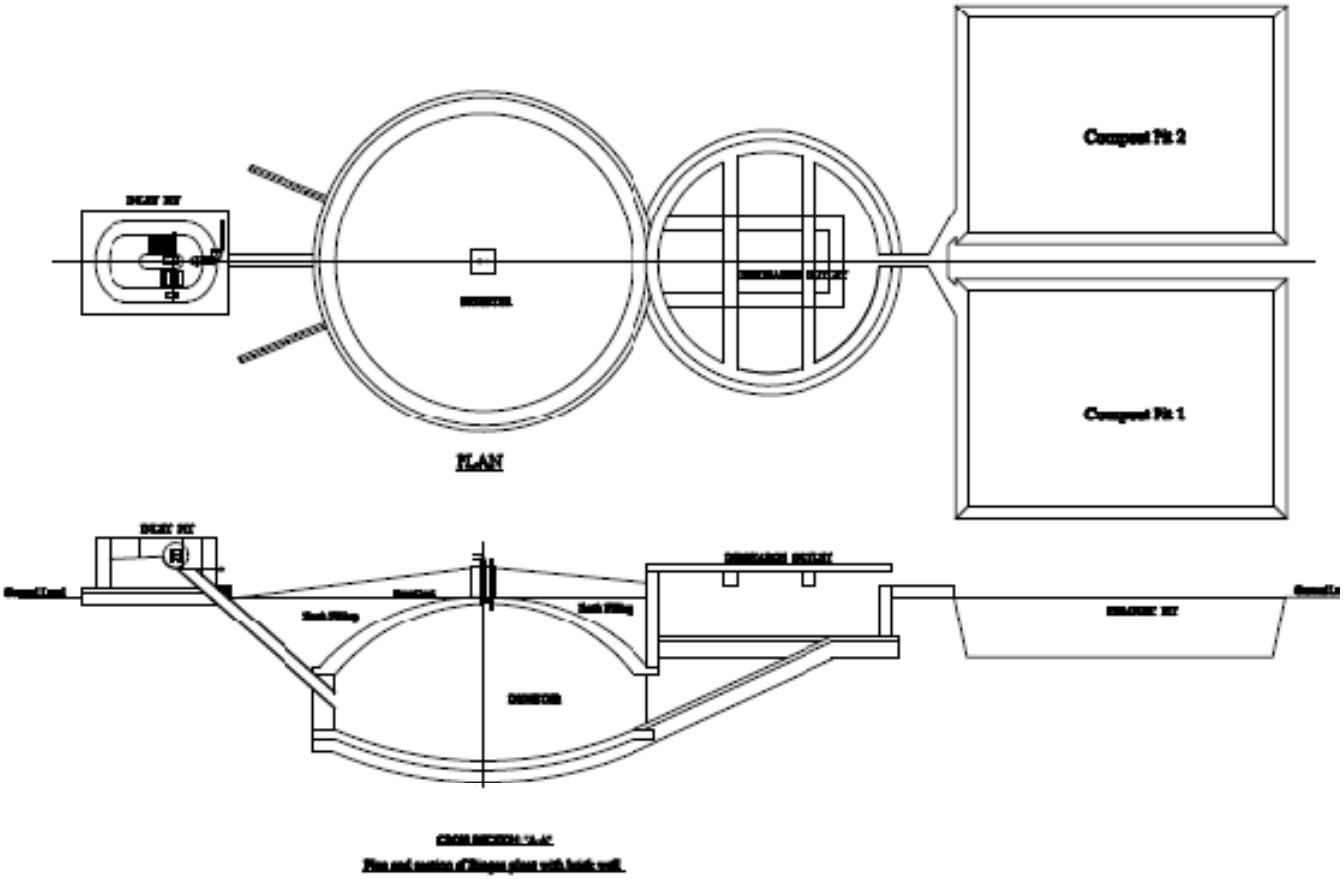
1. GENERAL BIOGAS PLANT (CONCRETE DIGESTER WALL)



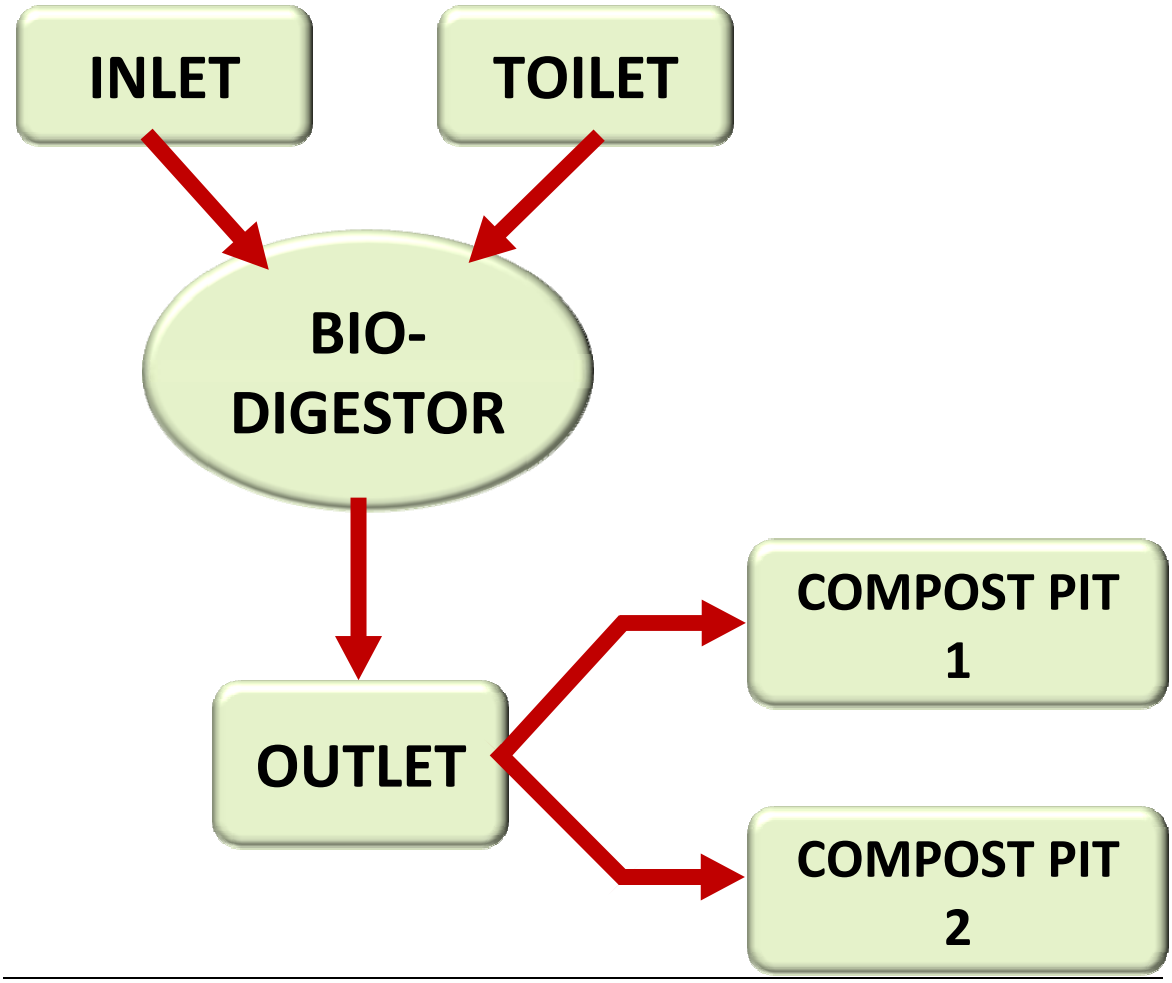
CROSS SECTION: "A-A"

Plan and section of Biogas plant with concrete wall

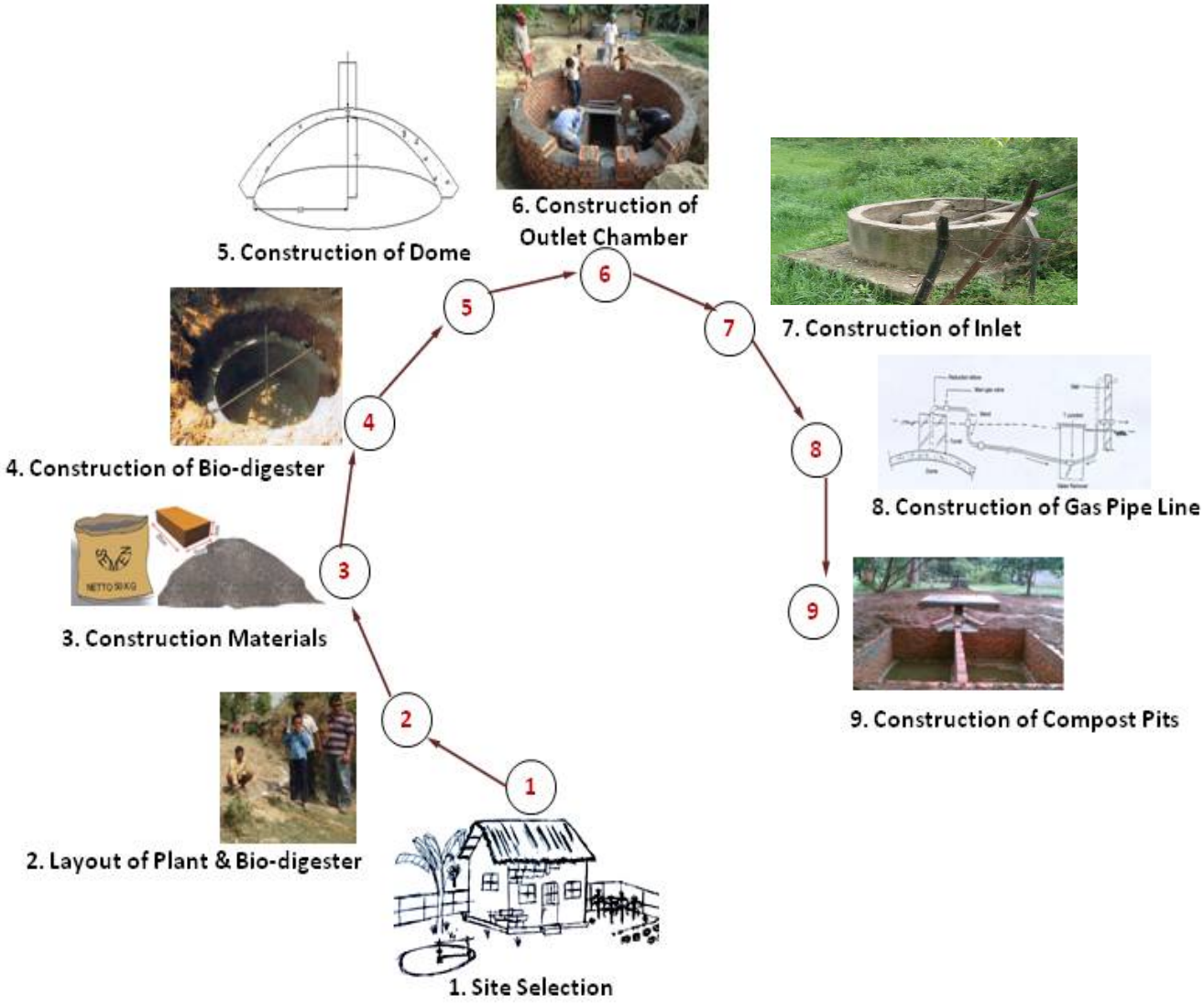
GENERAL BIOGAS PLANT (BRICK MASONRY DIGESTER WALL)



2. FLOW DIAGRAM OF BIOGAS PLANT



CONSTRUCTION PROCEDURE OF BIOGAS PLANT



Construction Procedure of Biogas Plant

1. SITE SELECTION

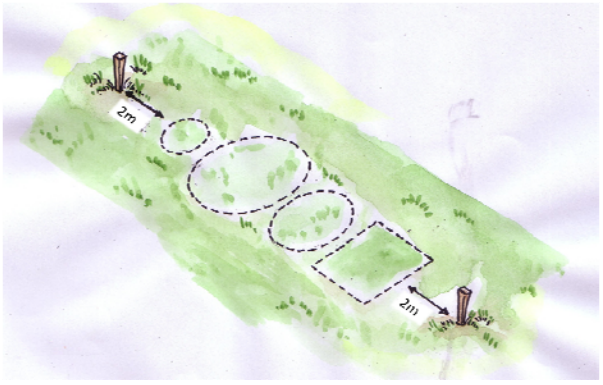
- The following procedures should be followed while site selection for a bio-gas plant is made:
- The area available should be adequate to accommodate all the units of the plant.
- Care should be taken that the site receives full sunlight without any obstruction from other surrounding structures or vegetation.
- Do not select low lying areas for the plant as water logging will create problems.
- Check the water table in the existing wells close to the plant location before site selection. If the water table is above the bottom level of the digester, an alternative appropriate site should be selected.
- The plant should be located at least 20 m away from the water sources such as wells, springs, tube wells etc .to avoid possible contamination of water sources.
- The site selected should be away from trees or tree stumps to mitigate the root hazard in the pre/post construction phase.
- To make plant operation easy and to avoid wastage of raw materials specially the waste substrate, the plant must be as close as possible to the waste source (cattle-shed, poultry waste collection chamber, kitchen waste, night soil pipe).
- The nearest water source should not be at a distance of more than 20 minutes walk. Otherwise more time in fetching water from the source to the plant will bring unnecessary burden to the owner during the operation of the plant.
- If longer gas-pipe is used the cost will be increased as the pipe is expensive. Furthermore, longer pipe increases the risk of gas leakage due to more joints in it. The main valve has

to be opened and closed before and after use. Therefore, the plant should be as close as possible to the point of use

- so that the above problems are eliminated.
- The edge of the foundation of the plant should be at least two meters away from the house or any other building to avoid risk of damages.

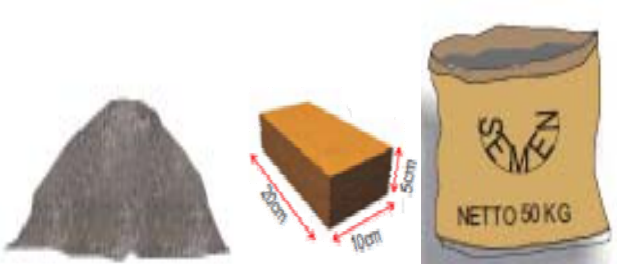
2. LAY OUT OF PLANT AND DIGESTER

- Calculate the tentative length and breadth of the plant required as per the available drawing.
- Level the ground before a plant lay out could be started.
- Mark with white powder on the center line for inlet, digester, outlet and compost pits on the ground so that all are accommodated in the same plane.
- Fix 2 wooden pegs 2 m away from the end points of the plant as reference points during the construction.



- Fix a small wooden peg in the ground which will act as the center for the digester.
- One end of a cord is attached to this peg with the length equal to the internal radius of the digester including plaster thickness, wall thickness and the footing offset.
- The other end of the cord is held tight without disturbing the position of the wooden peg and moved along a circular path. This circular mark made on the ground is covered with white powder (lime).

3. CONSTRUCTION MATERIALS



If the construction materials to be used in the plant construction such as cement, sand, aggregate etc. are not of good quality, the quality of plant will be poor even if design and workmanship involved are excellent. In order to select these materials of best quality, their brief description regarding the specifications has been given hereunder.

a) Cement

- The cement brand selected must have Nepal Standard (NS).
- The cement shall be 43 grade Ordinary Portland Cement (OPC).
- The cement bags shall be properly sealed and bear the Nepal Standard (NS) on the cover.
- It shall be stored in a dry place, in regular piles not exceeding ten bags high and in such a manner that it will be efficiently protected from moisture and contamination.
- Set cement should immediately be removed from the work and replaced.

b) Sand

- Fine aggregates or sand shall be clean and free from coagulated lumps.
- The quantity of impurities especially the mud in the sand can be determined by a simple test using a bottle. This is called the “bottle test”. This procedure is as follows:

  - A small quantity of the sample sand is put in the bottle. After this, water is poured in and the bottle is vigorously stirred.
  - The bottle is then left stationary to allow the sand to settle down. The particles of sand are heavier than that of mud so it settles down quickly.
  - After 20 - 25 minutes, the layer of mud verses sand inside the bottle is measured. If the sand contains 3% or more impurities, it must be washed with clean water.
- Coarse and granular sand can be used for concreting work but fine sand will be better for plastering work.

c) Gravel

- Aggregate shall be stone crushed. They shall be hard, strong and clean.
- It should be free from other materials such as, plastics, papers, brickbats, plants etc.
- If it is dirty, it should be washed with clean water.

d) Water

- Water is mainly used for preparing the mortar for masonry work, concreting work and plastering. It is also used to soak bricks/stones before using them.
- Besides these, water is also used for washing sand and aggregates.
- Water used for all the works should be clean.
- Never use dirty water for any works.
- pH value of water should not exceed 7.

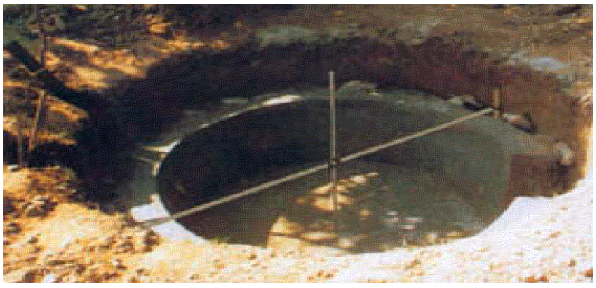
e) Bricks

- Bricks used for masonry works should be kiln burnt.
- Locally available bricks should be in regular shape. However, the sizes available are varying from hilly to plain areas.
- To check the quality of bricks, two bricks are randomly selected from the delivered quantity. If the bricks are well burnt, they produce a distinct sound when hit to each other.

f) Stones

- The stones must be clean, strong and of good quality. Stones should be washed if they are dirty.

4. CONSTRUCTION OF BIO-DIGESTER



a) Excavation of Pit

Following steps are followed once a suitable site is identified and selected.

- After the layout is complete excavation for the digester is started.
- During the excavation, the pit wall should be as vertical as possible.

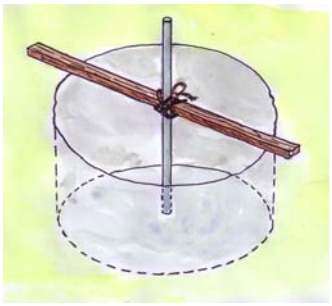
- The excavated soil is placed at least 1 m away from the pit so that the soil does not fall in the pit during the excavation and to avoid possible collapse of the pit wall due to its self weight.
- If loose soil is confronted during the excavation, earth protection works will be required to hold it.
- When underground water is encountered, another pit close to it is prepared so that the water flows down in this pit, from where the collected water can be drained out.
- The excavation is done up to the depth of C. (refer to the prototype drawing)
- For the excavation of the digester bottom, first of all locate the inner wall position by deducting the offset width p and wall thickness t1. (refer to the prototype drawing)
- Measure a1 from the inner wall towards the center of the digester and mark a point. Excavate up to a depth of a2 including the thickness of RCC and Stone soling. (refer to the prototype drawing)

- Measure b1 from the inner wall towards the center of the digester and mark a point. Excavate up to a depth of b2 including the thickness of RCC and Stone soling. (refer to the prototype drawing)
- Measure c1 from the inner wall towards the center of the digester and mark a point. Excavate up to a depth of c2 including the thickness of RCC and Stone soling. (refer to the prototype drawing)
- Measure d1 from the inner wall towards the center of the digester and mark a point. Excavate up to a depth of d2 including the thickness of RCC and Stone soling. (refer to the prototype drawing)
- Repeat the same steps from the other side of the digester.
- After the completion of excavation the digester bottom will be as shown in the prototype drawing.

Note: If ground water of large stone/boulders is encountered in the pit during the excavation, the technical person at the site will give the final advice for further course of action.

b) Construction of Round Wall

- The curved bottom surface of the digester is gently patted and properly leveled.
- Fix a straight iron rod or GI pipe in a vertical position at the center of the digester. Choose the length that is enough to cover the top of the digester dome.
- The diameter of the iron rod or the GI pipe selected should be enough to keep the rod straight when fixed on the ground.
- A horizontal pole or a pipe has to be placed across the pit edges so that the vertical rod or pipe can be secured with it



- The verticality of the rod or pipe when secured with the horizontal pipe is checked using a plumb bob.
- Any deviation found will be corrected to make the rod or pipe vertical.

- Stone soling of thickness t3 (refer to the prototype drawing) is made above this leveled surface. The stone boulders should be placed as closely as possible.

- Select the proper size of the rebar as required. (refer to the bar bending schedule)
- Clean, straighten, cut and bend the rebar as per the requirement. (refer to the bar bending schedule)
- Reinforcement steel bars are placed on the stone surface and bind them with steel binding wires. (refer to the bar bending schedule)
- Mix cement, sand and aggregate in the ratio of cement 1: sand 1.5: aggregate 3 (1:1.5:3) on a clean dry surface.
- Add water gradually in it to make a uniform concrete mix.
- The quantity of water for mixing will be equal to 50% of the dry cement quantity used for the mix.
- Pour the concrete gently on the stone surface with a thickness of t3. (refer to the prototype drawing).
- The vertical rod or pipe is immediately pulled vertically after the concreting works so that the bottom end of the rod or pipe touches the finished concrete surface avoiding the fixing of rod or pipe in the concrete.
- Check once again the verticality of the pipe.
- Cover the concrete surface with plastic sheet for the night to avoid any damage by the rain.
- Remove the plastic sheet on the following day and cover with used jute bags.
- Sprinkle water 4-5 times a day for 3 days on the jute bags to keep it wet.
- The concrete is allowed to set for 3 days before any work on it could be started.

Note:

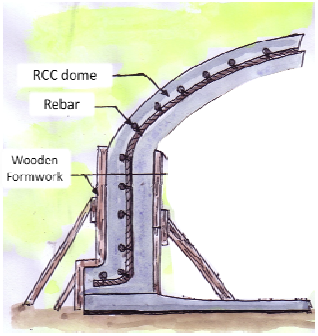
For the RCC round wall, the vertical rebar should be attached with the rebar of the digester floor before the casting of the floor.

1. OPTION A: BRICK WALL

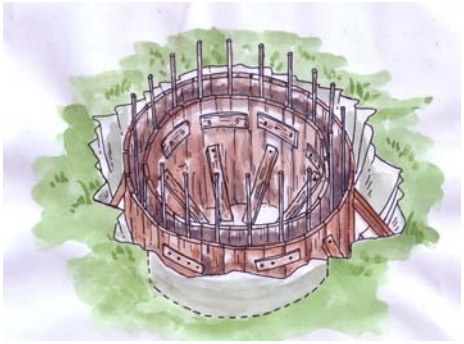
- Immerse bricks in a clean water tank for at least 6 hours for proper soaking.
- Mix cement and sand in the ratio of cement 1: sand 4 (1:4) on a clean dry surface.
- Add water gradually to it to prepare a uniform cement mortar.
- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.
- The brick laying is started from the edge (internal radius) towards the offset as per the designed wall thickness.
- 10 mm cement mortar shall be laid on each layer of brick wall.
- The brick joint gap for cement mortar should be in the range of 10-15 mm.
- The brick joints of first layer and the second layer should never fall in a vertical line.
- The newly constructed brick wall height should not go beyond 1m at a time.
- The verticality of the wall should be checked with a plumb bob for each layer of the brick wall during the laying of bricks.
- The waste slurry inlet pipe of 6” diameter and the toilet waste pipe of 6” diameter must be placed in position when the round-wall is 35 cm high.

2. OPTION B: RCC WALL

- Select the proper size of the rebar as required. (refer to the bar bending schedule)
- Clean, straighten, cut and bend the rebar as per the requirement. (refer to the bar bending schedule)
- Bind the vertical rebar with the floor rebar placed above the stone surface.
- Horizontal rebar are joined with the vertical rebar by using steel binding wires. (refer to the prototype drawing)



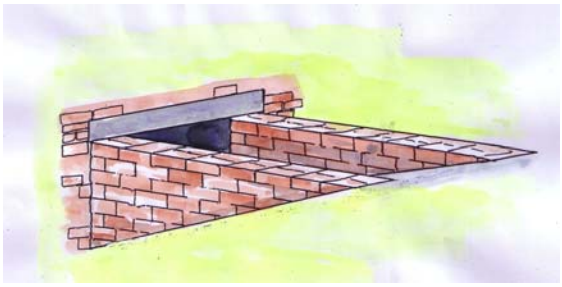
- Concrete the digester floor first.
- Select suitable size of the timber for form work.
- Erect these timber members on both sides of the rebar providing space as required.
- Adequate bracing is provided to the timber members on both sides to keep the frame vertical.



- Mix cement, sand and aggregate in the ratio of cement 1: sand 1.5: aggregate 3 (1:1.5:3) on a clean dry surface.
- Add water gradually to it to make a uniform concrete mix.
- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.
- Pour the mix in to the frame and tamping with a metal rod is applied for proper compaction by avoiding any formation of voids in the concrete.
- Complete the concreting up to the required height in one day.
- Remove the frame after 3 days.
- Cover the top of the wall by used jute bags.
- Soak the jute bags with water at least 4-5 times a day for 7 days. Sprinkle water on the walls as many times as the jute bags are soaked.

- The inclination of the waste slurry pipe will be 60 degrees.
- The waste slurry pipe will be at the center line of the inlet chamber as shown in the drawing.
- The toilet waste pipe can be on either side of the waste slurry pipe. (refer to the prototype drawing) Please see above
- The 2 toilet waste pipes are positioned in a way that their inclination does not exceed 45 degrees.

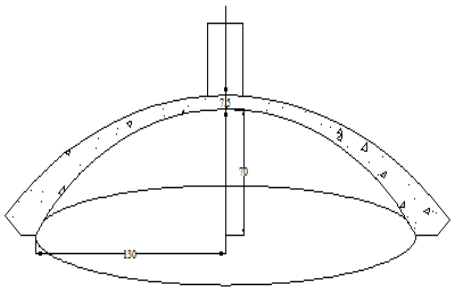
- The inlet chamber and the toilet pipes shall be laid close to digester chamber so that the inlet pipes have adequate slope to avoid any blockages in the pipes.
- Exactly on the opposite of the waste inlet pipe, an opening of width (refer to the prototype drawing) ____ cm is left in the round wall which acts as a manhole.



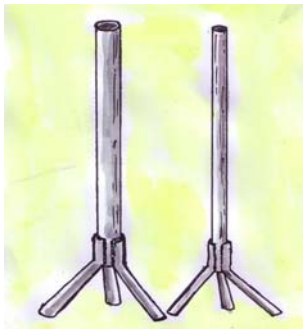
- The concrete slab for the outlet opening should be casted on the ground close to the dome construction.
- Select the proper size of the rebar as required. (refer to the bar bending schedule)
- Clean, straighten, cut and bend the rebar as per the requirement. (refer to the bar bending schedule)
- Prepare a wooden frame as per the size of the beam.
- Spread a plastic sheet on a flat surface.
- Mix cement, sand and aggregate in the ratio of cement 1: sand 1.5: aggregate 3 (1:1.5:3) on a clean dry surface.
- Add water gradually to it to make a uniform concrete mix.
- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.
- Pour the mix into the frame and allow it to set for 3 days.
- Carry the slab to place on the brick opening or concrete opening.
- When the round-wall has reached the correct height C (refer to the prototype drawing), the inside wall is plastered with cement mortar.
- The brick wall should be sprinkled with water before plastering.
- The RCC wall requires light chipping before plastering.
- Mix cement and sand in the ratio of cement 1: sand 4 (1:4) on a clean dry surface.
- Add water slowly in it to make a uniform cement mortar.
- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.
- 12.5 mm thickness plaster is applied on the inner wall of the digester.

- The plastered walls should be sprinkled with water 4-5 times a day for curing after 24 hours of plastering.

5. CONSTRUCTION OF DOME

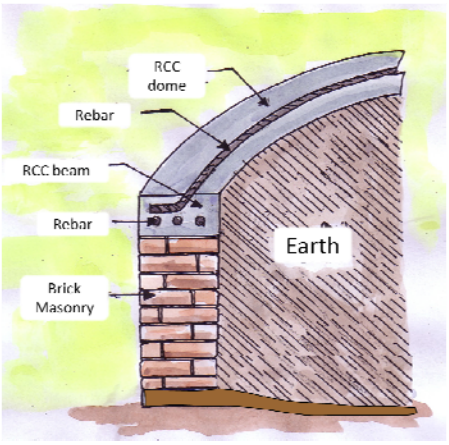


- Backfill the outer walls of the digester with proper compaction.
- Proper compaction of soil will eliminate the possibility of cracks in the round wall when soil is placed in the pit for mould preparation.
- Take care that only loose soil and no other materials is used for the backfilling of the outer walls of the digester.
- Mark A as the dome height on the vertical rod or the GI pipe fixed earlier. (refer to the prototype drawing)
- Fill the pit with a layer of soil 30 cm at a time and compact it properly up to the required height. (refer to the prototype drawing)
- The compaction adopted will make the mould safe and avoid the possibility of subsidence.
- Take 37.5 mm and 12.5 mm two GI pipes of length 77 cm.
- Weld 3 small length of steel rods at the bottom of each pipe. (refer to the drawing below)



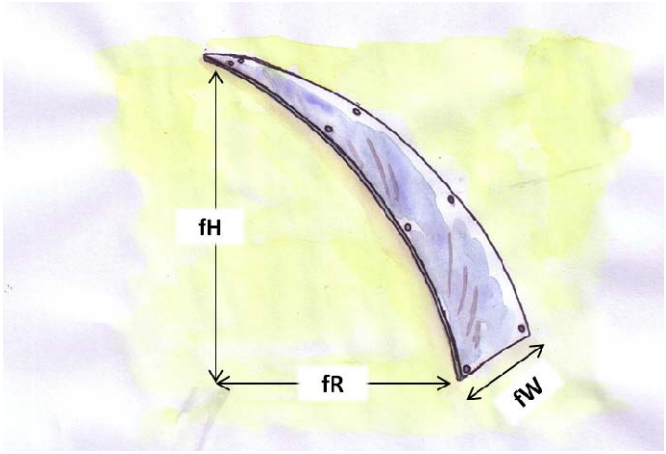
- The vertical rod is gradually pulled as the mould preparation progresses.
- Once the mould is prepared, the top surface is patted gently to make the surface smooth.

- Remove the vertical rod completely and insert 2 small sections of HDPE pipes of 50 mm diameter in the hole so that the top of the HDPE pipes are on the dome surface.
- To check the roundness, the metallic dome template is place on the mould top. Make sure that template inner surface touches the earth when placed on the mould top.
- The template can be checked by making sure the top is horizontal and the side exactly vertical.
- The part of the template that touches the round wall must be in the same position all over the round wall.
- When the earth mould has the exact shape of the template, a thin plastic sheet is spread over the mould top.
- Plastic sheet once removed after the concreting works will provide smooth surface creating difficulties in cement plastering of the dome inner wall.
- Sand can be spread over the plastic sheet to make the dome inner surface rough for efficient cement plastering.
- The plastic sheet will prevent earth soaking water from the fresh concrete.
- Reinforce Cement Concrete (RCC) Work is done. (refer to Annex)
- Place the rebar on the brick wall for the round beam. (refer to bar bending schedule)



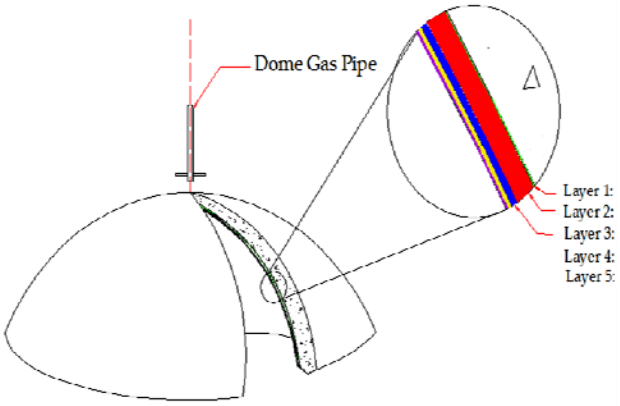
- Similarly, place the rebar on the plastic sheet placed on the mould top. (refer to the bar bending schedule)
- First, complete the concreting of the ring beam.
- The thickness of the ring will be 10 cm and the width equal to the breadth of brick wall. (refer to the prototype drawing)
- The casting has to be done as quickly as possible and without interruptions as this will affect the quality of the cast. No concrete older than 30 minutes should be used.

- The concerting for the dome will start from the bottom and progress in a circular direction towards the top.
- Under no circumstance should the concreting of dome be done part wise from bottom to top.
- Take a sharp pointed metallic rod to measure the concrete thickness.
- Insert the rod in the 2 points, one at the top and the other at the bottom of the dome and pull it out.
- Measure the wet length of the rod with a measuring tape and confirm with the required thickness. (refer to the prototype drawing)
- The concerting of dome can be done by using metallic dome having 18 pieces connected with each other by locking arrangements. No earth mould is required in this process.



- *For fH , fR , fW , refer dimension table.*
- Cover the dome top with a plastic sheet for a night immediately after the concreting works is over to protect the surface damage by possible rain.
- Cover the dome surface with used jute bags as it is not possible to retain water on the dome surface for curing.
- Sprinkle water 4 to 5 times or even more depending upon the weather condition from the day after the casting onwards to keep the jute bags wet for curing the concrete. This process is carried for at least 7 days depending upon the climate of the plant location.
- After 3 weeks of dome casting, the earth used for mould preparation is gradually removed from the pit through the outlet of the digester provided in the ring wall.
- When all earth and the plastic sheet are removed from the dome, the dome inner wall is thoroughly brushed and cleaned with water.

- Check carefully for any pores on the concrete surface.
- Any pore on the surface will help to release the gas from the pore.
- If the gas comes in contact with the steel rebar can cause rusting and weaken its strength.
- The clear cover for rebar shall be at least 60mm from bottom layer of upper dome so as to avoid chemical reaction with rebar.
- Cover blocks of size 60mmX60mm X 60mm of PCC 1:1.5:3 are prepared and are bind with the dome rebar at multiple places to maintain uniform cover of 60 mm before the concreting.
- Apply carefully the following cement works on the inner surface to make the dome gas-tight.
- Layer 1: Cement - water flush.
- Layer 2: 10 mm thick plaster in the ratio of 1 cement: 2 sand (1:2).
- Layer 3: 5 mm thick punning in the ration of 1 cement: 1 sand (1:1).
- Layer 4: Cement/acrylic emulsion paint coating, 1.5 part paint - 20 part cement.
- Layer 5: Cement/acrylic emulsion paint coating, 1 part paint - 2 part cement.

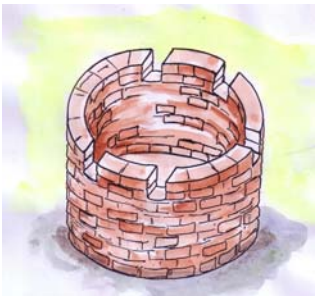


- A plaster coat must be at least one day old before the next layer can be put on.
- Execute the plaster work with the greatest care and without interruptions. The well functioning of the plant is very much depending on the gas tightness of dome.
- Prepare for the turret construction.
- Clean the top surface of the dome with metal brush and spray water on it so that all the dirt is removed.
- Brick work is started. (refer to Annex)
- Backfilling is done around the dome with the excavated soil. Compaction at regular depth is provided. The height of the backfilling will be as shown in the drawing.
- Proper and adequate measures have to be adopted for the workers while working inside the digester as proper ventilation is not available.

6. CONSTRUCTION OF OUTLET CHAMBER

- Ensure that the outlet tank is constructed on a slightly higher elevation than the surroundings so that there are no chances of rain water entering the outlet chamber during the rainy season.
- Take a cord of length equal to the radius of the outlet chamber plus the wall thickness and the plaster.
- Mark and fix with a wooden peg on the center line of the outlet chamber at a distance equal to the cord length by holding one end of the cord.
- Attach one end of this cord on the peg and holding tight the other end move in a circular path. Mark the circular path with a white powder.
- Excavate up to a depth of g1from the ground level. (refer to the prototype drawing)
- Place the excavated earth safe from the pit edge so that the pit wall does not collapse with its self weight.
- Measure e1 from the outer wall of the discharge outlet towards the center of the outlet chamber and mark a point. Excavate up to a depth of e2 including the thickness of PCC and Stone soling. (refer to the prototype drawing)
- Measure L from the outer wall of the discharge outlet towards the center of the outlet chamber and mark a point. No excavation is required indicating the point where the outlet discharge ramp ends. (refer to the prototype drawing)
- The outlet ramp is gently patted and leveled properly.
- Stone soling of thickness s2 is laid on the ramp of the outlet chamber. Place the boulders as close as possible.
- Mix cement, sand and aggregate in the ratio of Cement 1: sand 2: aggregate 4 on a clean dry surface.

- Add water gradually to it to make a uniform concrete mix.
- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.
- Pour the concrete mix of 27.5 cm thickness above the stone soling.
- Brick work on the 2 ends of the outlet ramp is started (refer to Annex).
- Backfill and compact the space behind the ramp wall properly.
- Stone soling of thickness t2 is done in the remaining part of discharge chamber. Place the stones as close as possible. (refer to the prototype drawing)
- Plain Cement Concrete (PCC) work is started.
- Pour the concrete mix on the stone soling and make a PCC of thickness 27.5 cm. (refer to the prototype drawing)
- This PCC will cover the top surface of the 2 brick walls.
- Sprinkle water 4 to 5 times a day for 7 days on the finished PCC surface the following day for the curing.
- Brick work is started. (refer to Annex)
- The height of the round brick wall will be ___ m. (refer to the prototype drawing)
- Provide opening on the top of the brick wall for the waste discharge to the compost pit.
- The size of the opening will be ___ mm x ___ mm.



- Provide opening on the 2 sides of the ring wall for casting the beam.
- The size of opening will be ___ mm x ___ mm.
- Select the proper size of the timber and prepare 2 form works for the casting of 2 beams.
- The length of the form work will be equivalent to the internal diameter of the discharge chamber.
- Fix the form work with adequate props from below to support the weight of the frame and the self weight of the rebar and the concrete.
- The opening of the form shall be equal to the width and height of the beam.
- The props can be locally available bamboos.

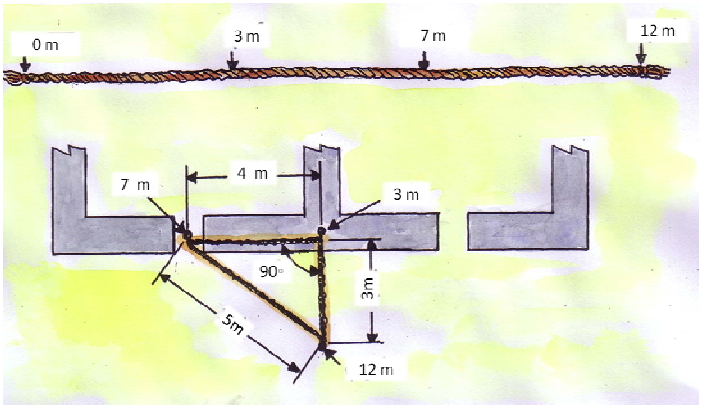
- Reinforce Cement Concrete (RCC) work is started. (refer to Annex)
- Place these rebar in the frame and bind them with steel binding wires. (refer to the prototype drawing)
- Pour the mix in the frame from one end of the form work.
- Take a 2 feet metal rod and tamp the concrete in the frame for a proper compaction and eliminate the possibility of void formation in the concrete.
- Cover the beam with used jute bags and sprinkle it with water from the next day.
- Sprinkle water 4 to 5 times a day for 7 days for curing.
- Before the cement plaster work is started, sprinkle clean water on all the brick surfaces.
- Cement plaster work is started. (refer to Annex)
- The form work for the casting of the beams is removed after 3 weeks.
- Clean the beam surface and apply light chipping on it for plaster work.
- Cement plaster work is started. (refer to Annex)
- Sprinkle water for 4-5 times a day for 7 days on all the plaster surfaces for curing.
- Prepare a flat and clean surface for the casting of chamber covers close to the chamber so that it can be carried to the chamber location without difficulty.
- Spread a thin sheet of plastic over this surface to cover the entire cover area of the slabs.
- Make 9 pieces for the cover slabs. (refer to the drawing below)

- Select the proper size of the rebar as required. (refer to the bar bending schedule)
- Reinforce Cement Concrete (RCC) is started. (refer to Annex)
- Place these rebar in the frames and bind them with the binding wires. (refer to the bar bending schedule)
- Pour the mix properly in the frames separately and pat the concrete surface gently so that the compaction avoids any formation of voids in the concrete.
- The thickness of the concrete slab will be ___ cm. (refer to the prototype drawing)

- Cover the frames with a plastic sheet for the night and avoid any damage by the rains.
- Sprinkle water on the slab surfaces with water 4 to 5 times a day for 7 days for curing.
- Dislodge the frames from the casted slabs.
- Lift the cover slabs to remove the plastic sheets.
- Check both the surfaces of the slabs. Any exposure of rebar is exposed to corrosion by the fumes produced in the chamber. In that case, proper cement plaster should be applied on both sides of the slabs.

7. CONSTRUCTION OF INLET PIT

- The inlet pit is constructed to mix waste and water.
- The layout of this unit is governed by the slope of the inlet pipe joined to the digester.
- The inclination of the dung waste slurry pipe is 60 degrees.
- This pipe will emerge out of the ground on center line of the plant.
- The inlet pipe level should be 15 cm above the discharge outlet level.
- Level the ground and complete the layout.
- Take a cord of length 12 m and put an ink mark at 3 and 7 m.
- First person will hold both the ends of the cord and the second person will hold the 3 m mark.
- The second person will place the 3 m mark on the 1m point on the



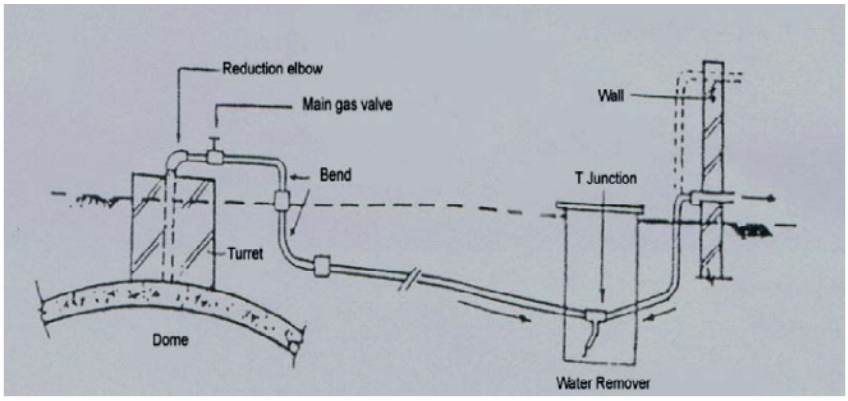
center line of the pit and the third person while holding the 7 m mark will pull the string from the first person and place it on the ground in such a way that the sides of the triangle formed are 3, 4 and 5 m.

- Mark the new location where the 7 m mark touches the ground.
- Similar procedure is followed in the opposite side of the pit.
- This procedure will help to keep the walls at 90 degrees to the center line.
- Follow the same procedures at the 3 corners..
- Excavate up to a depth of 10 cm from the ground level.
- Stone is laid on the excavated surface for a thickness of ___ cm.
- Place the stone boulders as closely as possible.
- Plain Cement Concrete (PCC) work is started. (refer to Annex).
- Pour the concrete on the stone soling for a thickness of __ cm. (refer to the prototype drawing)
- Brick work is started. (refer to Annex)
- Fix the mixture accessories in the inlet chamber. (refer to the prototype drawing)
- Cement plaster work is started. (refer to Annex)

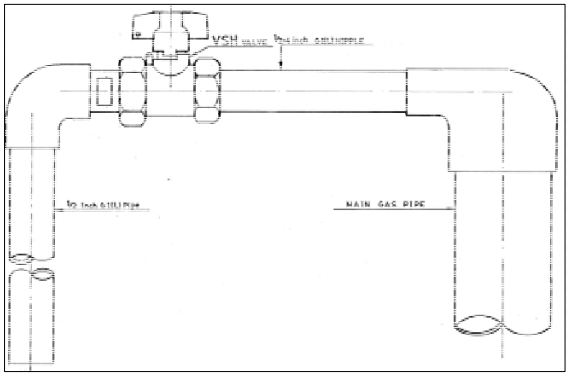
Note:

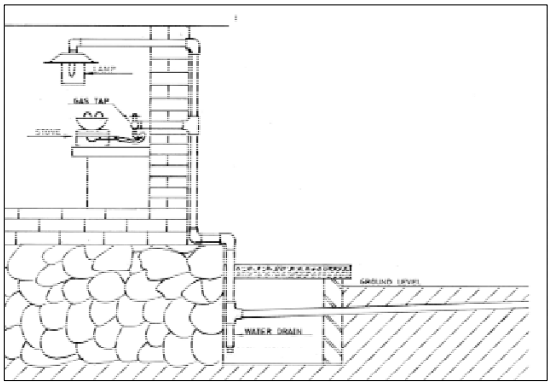
In case of toilet attachment to the plant it is better to construct without siphon or trap as the pan with siphon needs more water which may result excess water inside the digester. It is also not possible to de-block the pipe when the toilet has a trap. The toilet should not be farther than 45 degree from the center line. Additionally, the toilet pan level should be at least 15 cm above the outlet overflow level.

8. CONSTRUCTION OF GAS PIPE LINE



The gas pipe conveying the gas from the plant to users point is vulnerable for damages by people, domestic animals and rodents. Therefore, only heavy quality galvanized iron pipe should be used which must be, where possible, buried 30 cm below ground level. Fittings in the pipeline must be sealed with zinc putty and Teflon tape. Any other sealing agent, like grease, paint only, soap etc. must not be allowed. To reduce the risk of leakage, the use of fittings, especially unions, should be kept to a necessary minimum. No fittings should be placed between the main gas valve and the dome gas pipe.

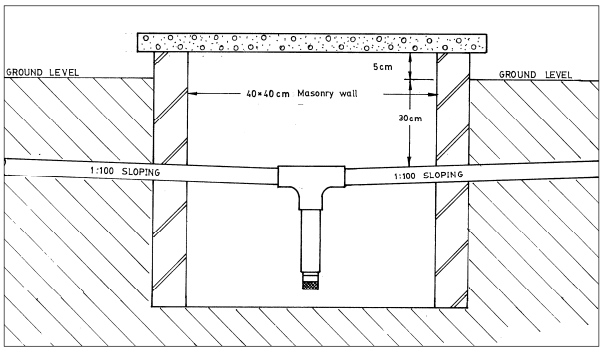




The biogas coming from the digester is saturated with water vapor. This water vapor will condense at the walls of the pipeline. If this condensed water is not removed regularly, it will ultimately clog the pipeline. Hence, a water drain has to be placed in the pipeline. The position of the water drain should be inclined below the lowest point of the pipeline so that water will flow by gravity to the trap. Water can be removed by opening the drain. As this has to be done periodically the drain must be well accessible and protected in a well-maintained drain pit.

For connecting burners with gas pipeline, use of transparent polyethylene hose must be avoided. Only neoprene rubber hose of the best quality should be used.

As soon as there is gas production, all joints and taps must be checked for leakage by applying a thick soap solution. If there is leakage the foam will either move or break.



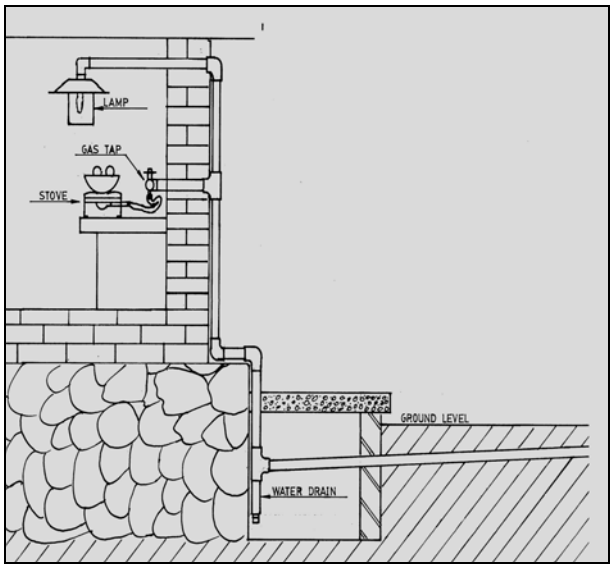
CONSTRUCTION OF WATER DRAIN PIT

- Identify a proper location for the water drain device.
- Level the ground and complete the layout.
- Take a cord of length 12 m and put an ink mark at 3 and 7 m.
- First person will hold both the ends of the cord and the second person will hold the 3 m mark.
- The second person will place the 3 m mark on a point on the ground and the third person while holding the 7 m mark will pull the string from the first person and place it on the ground in such a way that the sides of the triangle formed are 3, 4 and 5 m.
- Mark the new location where the 7 m mark touches the ground.
- Mark 60 cm on the 7 m length from the point 3 m.
- Similar procedure is followed at the 3 sides of the pit.
- It will then provide a square of 60 cm x 60 cm
- To check the square of the pit measure the 2 diagonals with a measuring tape.
- If the diagonals found are not equal repeat the lay out.
- This procedure will put the walls at 90 degrees.
- Mark the square with white powder.
- Excavate the pit such that the depth does not exceed 40 cm from the existing ground level.
- No soiling with any material is required.
- Brick work is started. (refer to Annex).
- Once the brick wall reaches a desired height, lay the gas pipes opposite to each other with a slope of 1:100 from the 2 sides of the pit.
- Join the 2 ends of these pipes with a tee with one end facing towards the pit bottom.
- The tee should lie in the center of the pit.

- Continue with the brick work until it is 10 cm above the existing ground level.
- Cement plaster work is started. (refer to Annex)
- Prepare a flat and clean surface for the casting of water drain pit covers.
- Spread a thin sheet of plastic over this surface.
- Make one piece for the cover slab.
- Plain Cement Concrete (PCC) is started. (refer to Annex)
- Pour the mix properly in the frames separately and pat the concrete surface gently so that the compaction avoids any formation of voids in the concrete.
- The thickness of the concrete slab will be 10 cm.
- Cover the frames with a plastic sheet for the night and avoid any damage by the rains.
- Sprinkle water on the slab surfaces with water 4 to 5 times a day for 7 days for curing.
- Dislodge the frames from the casted slabs.
- Lift the cover slabs to remove the plastic sheets.
- Carry the slab and cover the pit.

POINTS TO CONSIDER

- It should be easy to replace the water drain device as a when required, therefore the size of the water drain pit should be suitable for a 12” pipe wrench to work with.



Cross section of water drain pit

- To avoid storm water from entering the pit and filling it with eroded soil the top edge of the water drain pit should approximately 5 to 8 cm above the ground.

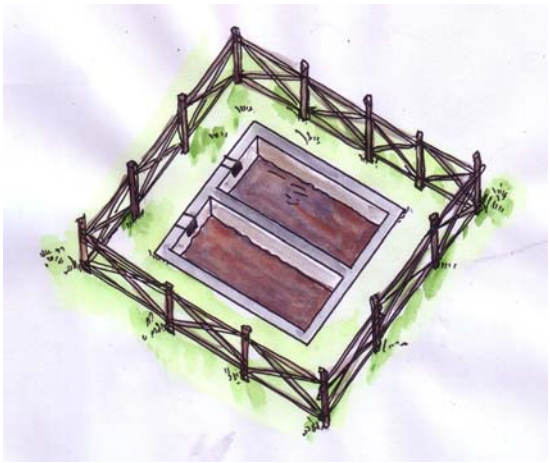
- The thickness of the water drain pit should be made thin so that it could be lifted easily to operate the water drain.
- The bottom of the pit should not be plastered because the water released from the water drain device needs to be absorbed by the ground. But the sides of the drain pit can be plastered.
- Water drain pit can be either constructed near the house or at the center of the pipeline. It should not be constructed near the turret.
- Depending on the terrain and distance, some time more than one water drain devices needs to be installed in the pipeline.

9. CONSTRUCTION OF COMPOST PITS

- The pits are located close to the outlet overflow so that the waste slurry runs freely into the pits.
- The distance between the outlet chamber and the pit is maintained at 1m apart.
- The size of the compost pits shall have a capacity equal to the plant volume.
- Prepare for the layout of the compost pits
- Refer the previous marked reference points. Mark on the center line of the pits at a distance of 1 m.
- Take a cord of length 12 m and put an ink mark at 3 and 7 m.
- First person will hold both the ends of the cord and the second person will hold the 3 m mark.
- The second person will place the 3 m mark on the 1m point on the center line of the pits and the third person while holding the 7 m mark will pull the string from the first person

and place it on the ground in such a way that the sides of the triangle formed are 3, 4 and 5 m.

- Mark the new location where the 7 m mark touches the ground.
- Similar procedure is followed in the opposite side of the pit.
- This procedure will help to keep the walls at 90 degrees to the center line.
- Follow the same procedures at the 3 corners of each pit.
- The length and the breadth of the pit walls are marked as per the dimensions. (refer to the prototype drawing).
- White powder is used for the lay out.
- Excavate the pit up to a depth of ____ m. (refer to the prototype drawing)
- Immerse bricks in a clean water tank for at least 6 hours for proper soaking.
- Brick work is started. (refer to Annex)
- The discharge outlet channel is bifurcated in 2 which are joined to 2 separate pits. (refer to the prototype drawing)
- The inclination of the 2 bifurcated channels shall be 90 degrees. (refer to the prototype drawing)
- Cement plaster work is started. (refer to Annex)
- Provide fencing across the pits to protect children from injury.



- Local available materials can be used for the fencing.

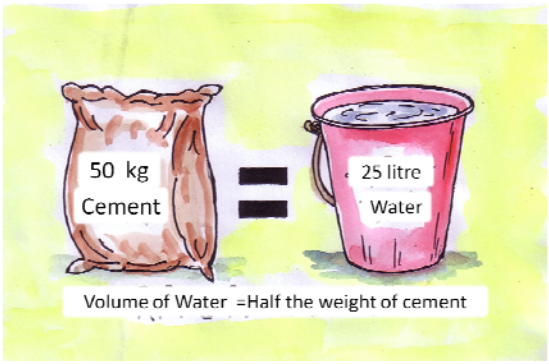
Note:

- Length and width mentioned in the above table can be changed according to the space available without changing the volume of the pits.
- If possible length, width should be doubled.
- Depth of the pit should not exceed 1 meter (100 cm) due to safety reason.

ANNEX

1. REINFORCE CEMENT CONCRETE (RCC) WORK

- Select the proper size of the rebar as required.
- Clean, straighten, cut and bend the rebar as per the requirement.
- Mix cement, sand and aggregate in the ratio of cement 1: sand 1.5: aggregate 3 (1:1.5:3) on a clean dry surface.
- Add water gradually in it to make a uniform concrete mix.
- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.



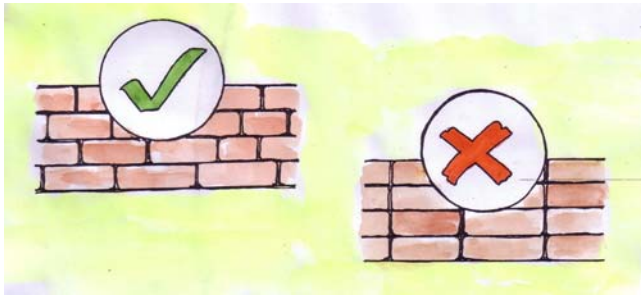
2. PLAIN CEMENT CONCRETE (PCC) WORK

- Mix cement, sand and aggregate in the ratio of cement 1: sand 2: aggregate 4 (1:2:4) on a clean dry surface.
- Add water gradually in it to make a uniform concrete mix.
- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.

3. BRICK WORK

- Immerse bricks in a clean water tank for at least 6 hours for proper soaking.
- Mix cement and sand in the ratio of cement 1: sand 4 (1:4) on a clean dry surface.
- Add water gradually to it to make a uniform cement mortar.

- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.
- 10 mm cement mortar shall be laid on each layer of brick wall.
- The brick joint gap for cement mortar should be in the range of 10-15 mm.
- The brick joints of first layer and the second layer should never fall in a vertical line.
- The verticality of the wall should be checked with a plumb bob for each layer of the brick wall during the laying of bricks.
- The wall height shall be above the ground level so that no rain water enters the pits.



4. CEMENT PLASTER WORK

- Mix cement and sand in the ration of cement 1: sand 4 (1:4) on a clean dry surface.
- Add water gradually in it to prepare a uniform cement mortar.
- The quantity of water for mixing will be equal to 50% of the cement quantity used for the mix.
- Sprinkle water on all the walls.
- 12.5 mm thick plaster is applied on all the walls.
- Sprinkle water 4-5 times a day for 7 days on these plastered walls for curing.