

CHAPTER 4

Construction Manual of Bio-gas Reactor

4.1 Planning

Criteria for Bio-gas Plant Construction

Family size

- 4.1.1 Farmer who wants to build a bio-gas plant must have animals to sustain the operation of the plant. The minimal number of animals required are :
- | | | |
|-------------------|----------|----|
| Cows or buffaloes | at least | 3 |
| Breeding pigs | at least | 10 |
- 4.1.2 Stationary enclosure which is not more than 20 meters from the bio-gas construction area.
- 4.1.3 Animal should remain enclosure all night or for a minimum of 12 hours.
- 4.1.4 There must be drainage alley connected directly to the bio-gas plant.
- 4.1.5 Access to ground water all year round and the water source should not be further than 20 meters from the bio-gas plant.
- 4.1.6 bio-gas usage should not be placed further than 100 meters from the plant.
- 4.1.7 Farmer and his family members must have interests in using gas, fermented manure and want to build a bio-gas plant to reduce the pollution in environment.
- 4.1.8 Required budget, materials and labour to build bio-gas plant.
- 4.1.9 Time and labour in maintenance bio-gas plant.

4.2 Design of Bio-gas Plant

The fixed dome bio-gas plant buried underground. There are 3 main connecting parts :

- 4.2.1 Mixing chamber:** where animal excrement is mixed with water before it is poured into digester chamber.
- 4.2.2 Digester chamber:** where excrement and water are fermented. Methane and other gases will be produced in the chamber and these gases will push manure and slurry at bottom of the floor into expansion chamber.
- 4.2.3 Expansion chamber:** collects excess manure and slurry. When gas is being used, manure and slurry will flow back into digester chamber to push gas up for usage. When the excess manure exceeds the volume of the chamber, the manure will be drained out.

This system is called dynamic system, when gas is produced inside the pit, the gas pressure will push manure and slurry at the bottom of the pit to flow up into expansion chamber. When this gas is used the slurry in the expansion chamber will flow back into the digester chamber to push the gas up for usage. This happens consistently. The plant will be operated efficiently for a long period of time if the gas pit does not cracked and the system

runs regularly. In each case the strength of the plant depends on fine construction, specification of materials according to the criteria suggested by the Bio-gas Programme, and strict adherence to the instruction manual on the maintenance of the bio-gas.

4.3 Location of the Bio-gas Plant

The plant should not be located further than 5 meters from the enclosure. The digester chamber must be in an open area and should not be near any water source or natural water as animal excrement may seep into underground water. The plant should also be situated on a slope and not on the low land to avoid the danger of floods. The excess manure from expansion chamber should flow into the farmer's field or the storage tank and not into natural water bodies such as rivers to avoid the risk of pollution. **(Figure 4.1)**

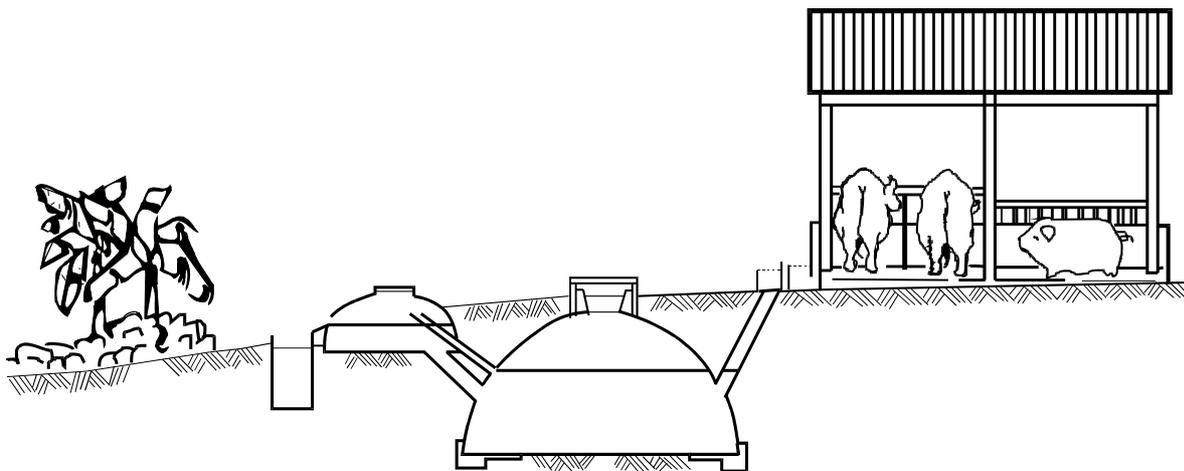


Figure 4.1 Location of the bio-gas plant

4.4 Sizes of Bio-gas that is Suitable for Farms

Consider the following number of livestock needed and the requirement of gas usage.

Livestock	4.6 m ³	8 m ³	12 m ³	16 m ³
Milking cows	2	3	5	7
Meat cows	3	6	12	18
Buffaloes	2	3	8	13
Pigs	10	15	25	38

How to calculate the size of bio-gas plant

Formula Fresh manure/day x amount of animal x 2(for cow/buffalo) or x 3 (for Pig)
x Retention time (60 days)

Example

- Question:** How big should a bio-gas plant be for a farm with 4 cows? (1 cow produces 8 kg of fresh excrement per day)

Answer

Formula animal excrement x number of animal x 2 x retention time

$$8 \quad \times \quad 4 \quad \times 2 \times \quad 60 \quad = 3,840 \text{ kg}$$

** Bio-gas plant should be built at the size of 4 M³*

- Question:** How big is the bio-gas plant for a farm with 45 Breeding pig over 60 kg ? (1 pig produces 2 kg of fresh excrement per day)

Answer

Formula animal excrement x amount of animal x 3 x retention time

$$2 \quad \times \quad 45 \quad \times 3 \times \quad 60 \quad = 16,200 \text{ kg}$$

**Bio-gas plant should be built at the size of 16 M³*

The bio-gas plant must have a concrete slab floor enclosure with a drainage alley with 1 % gradient. If the floor is not on slope, it must be elevated. If animal is being fed outside the enclosure (cows/buffaloes), it must be brought back to stay overnight in the enclosure.

4.5 Fresh Excrement of Animal per Day

1 meat or buffalo produces 8 kgs of fresh excrement per day

1 milk cow produces 15 Kgs of fresh excrement per day

1 pig (over > 60 Kgs) produces 2 kgs of fresh excrement per day

1 pig (< 60 Kgs)) produces 1.2 kgs of fresh excrement per day

200 chickens or 200 Birds, *Bio-gas plant should be built at the size of 1 M³*

4.6 Preparation for Construction

Implements in construction

measurement Tape	Pencil	Saw (wood and steel)
Rope or string	Hammer	Shovel
Axe	Square	Level measurement
Knife	Hoe	Rattan basket
Digger (Figure 2)	Spade	Wheel barrow
Plumb	Sponge	Concrete trowel
Radius stick(Figure 3)	Bucket	Soft broom
Steel trowel	Wooden trowel(Figure 4)	
Brush	Sand paper No 100	
Hard broom	Handles for digester chamber's lid(Figure 6)	
Hose for level control	Mould of digester chamber lid by Thai-German Program standard (Figure 5)	

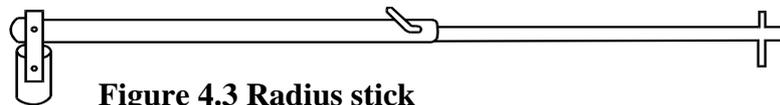


Figure 4.3 Radius stick

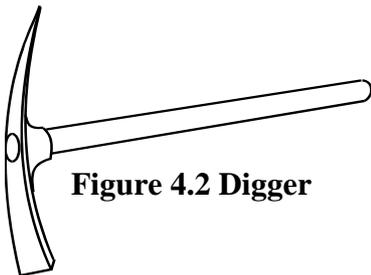


Figure 4.2 Digger

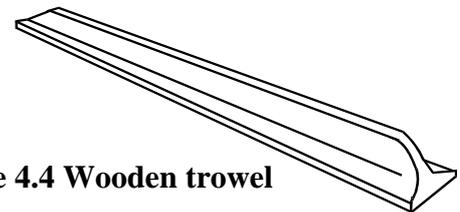


Figure 4.4 Wooden trowel

Figure 4.5 Mould of digester chamber lid

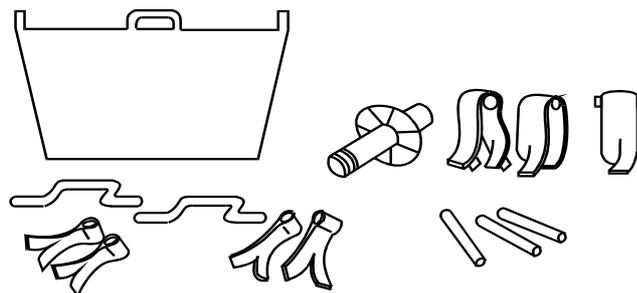


Figure 4.6 Handle for digester chamber's lid

4.7 The Principles of Layout

There are 2 ways of doing layout

4.7.1 Locate the lowest point of drainage alley and mark 30cm above this point. Mark a peg on the opposite side and balance the level between the peg and the mark over the alley with level adjusting hose. Tie temporary reference string between these 2 marks, mark out the center on the level line far from the enclosure at least

2.50 meters	➤	4.6 m ³	3.50 meters	➤	↔± m ³
2.70 meters	➤	8 m ³	4.00 meters	➤	↑± m ³
3.00 meters	➤	12 m ³	4.50 meters	➤	↔± m ³
3.30 meters	➤	16 m ³			

From the mark on the level line, set the center of digester chamber on the ground surface by using plumb. Draw the line to mark the size of digester chamber. Consider the suitable location by using radius (**Figure 4.7**)

1.55 meters	➤	4.6m ³	2.80 meters	➤	↔± m ³
2.01 meters	➤	8 m ³	2.25 meters	➤	↑± m ³
2.24 meters	➤	12 m ³	3.80 meters	➤	100 m ³
2.30 meters	➤	16 m ³			

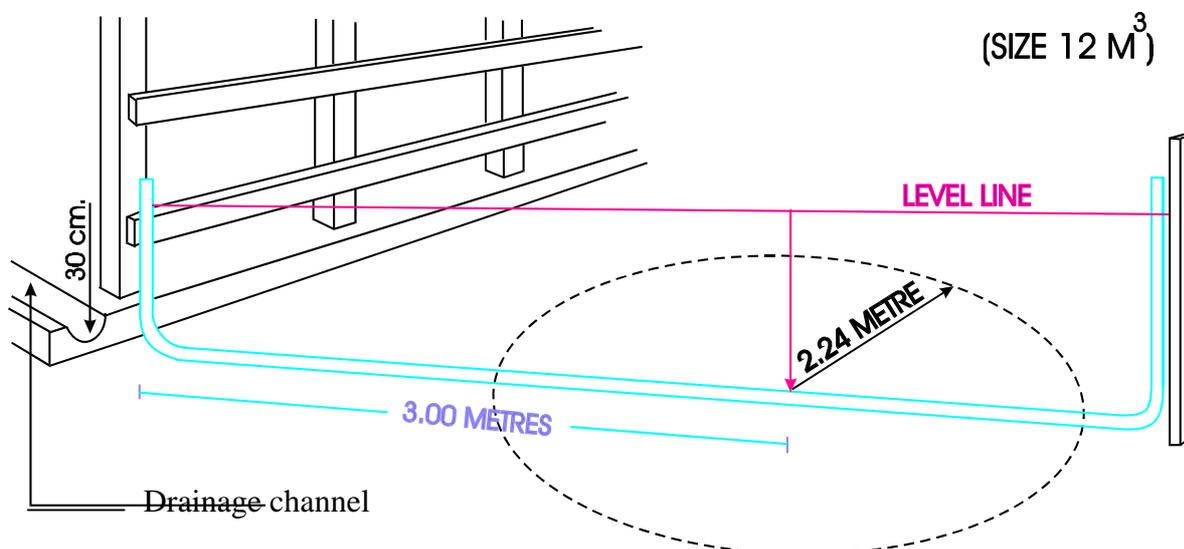


Figure 4.7 Principles of layout

4.7.2 To locate the storage tank, measure from the center of digester chamber

2.90 meters	➤	4.6m ³	5.70 meters	➤	30 m ³
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3.95 meters	➤ 8 m ³	7.04 meters	➤ 50 m ³
4.10 meters	➤ 12 m ³	8.03 meters	➤ 100 m ³
5.22 meters	➤ 16 m ³		

Find the lowest point to set the outlet point which is 60 cm lower than the level line and at least 15 cm over the ground to prevent the outside water to flow into the chamber. If the lowest point can not be located, check the drainage alley for the possibility of being elevated or excavated. When the outlet point is found, the temporary level line becomes level line. Cross another permanent level line to the first line at the center of the digester chamber to locate the center of digester chamber. Set the center of expansion chamber far from the center of digester chamber and mark with a peg.

2.50 meters	➤ 4.6m ³	4.40 meters	➤ 30 m ³
3.00 meters	➤ 8 m ³	5.36 meters	➤ 50 m ³
3.00 meters	➤ 12 m ³	6.16 meters	➤ 100 m ³
3.50 meters	➤ 16 m ³		

The location of expansion chamber should be on the opposite side of the mixing chamber or not over 45° as shown in picture (**Figure 4.8**)

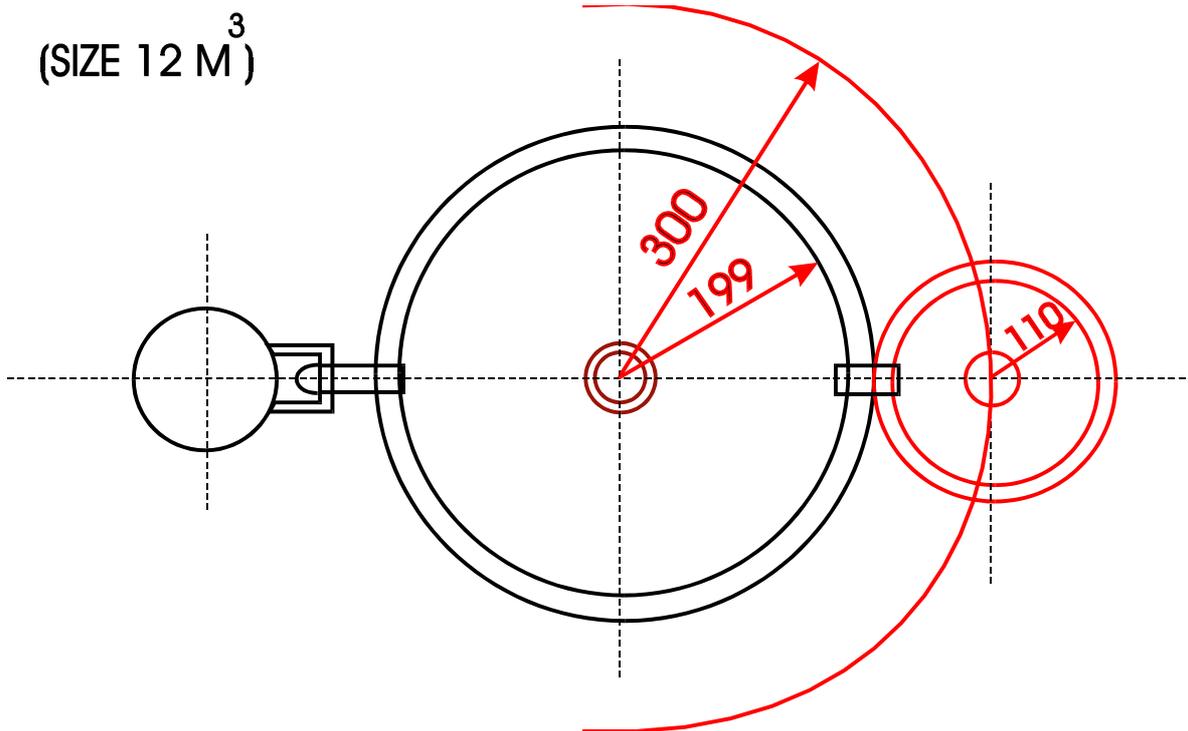


Figure 4.8 The location of expansion chamber

4.7.3 Think before excavating

Ensure that the diameter of the pit is excavated consistently with diameters begin equal at the top and the base, and at depth below level line as suggested below:

2.10 meters	➤ 4.6m ³	3.13 meters	➤ 30 m ³
2.39 meters	➤ 8 m ³	3.82 meters	➤ 50 m ³
2.42 meters	➤ 12 m ³	4.10 meters	➤ 100 m ³
2.67 meters	➤ 16 m ³		

Place excavated soil 50 cm away from the edge of the pit and do not put it on the ground where the expansion chamber, mixing chamber or outlet pipe will be constructed. It is a waste of time to have to remove this pile of soil later.(Figure 4.9)

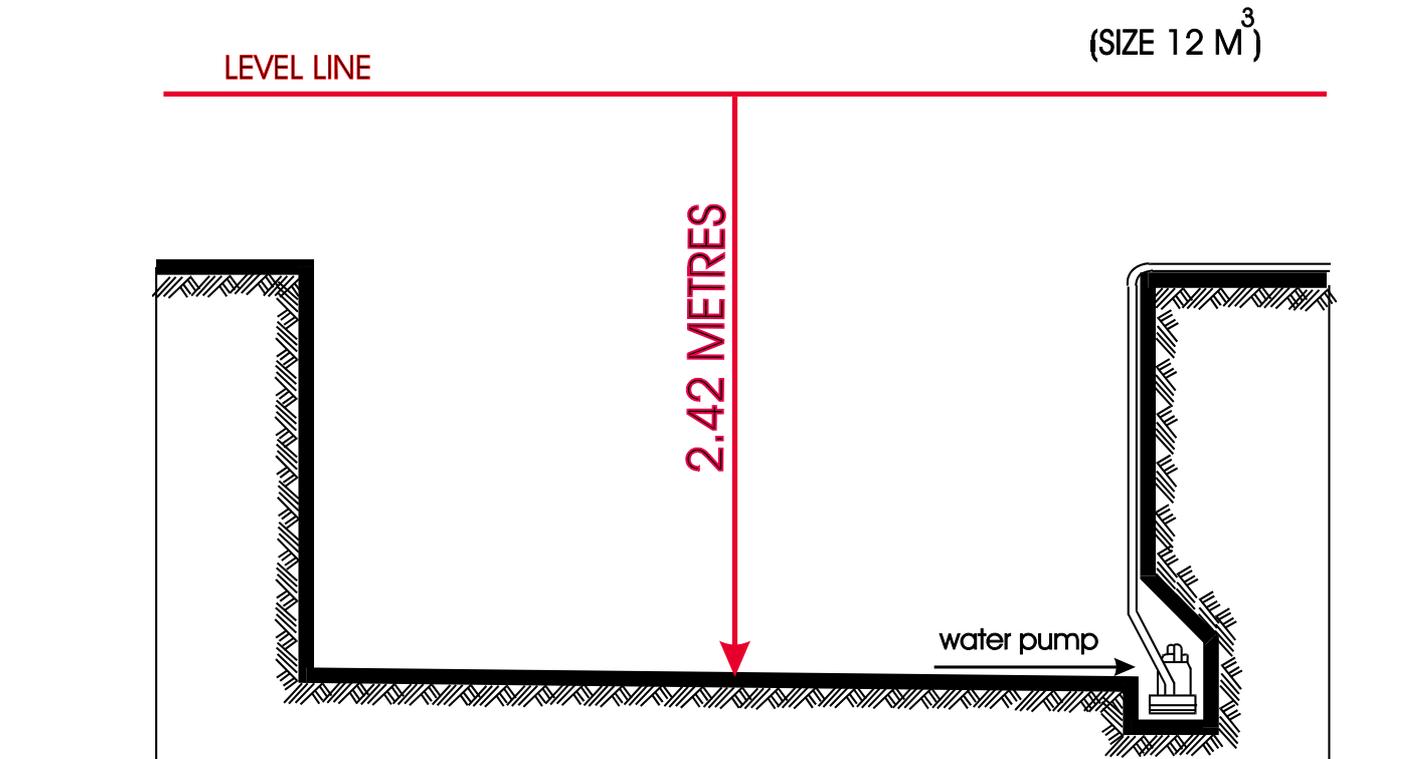


Figure 4.9 Excavating soil

Caution

Do not excavate deeper than suggested as the base of the chamber may not be strong enough. If there is any seepage, a small trap pit must be dug next to the outer edge of digester chamber base. The floor of the trap pit should be lower than the digester chamber so that ground water can flow into the trap pit.

When the required final depth is obtained, set the center at the base of digester chamber by crossing the level line and use a plumb to locate the center of the digester chamber. Draw 2 circles with the following radius

<i>Inner radius</i>	1.15 meters	and	<i>outer radius</i>	1.45 meters	➤	4.6 m ³
	1.46 meters			1.76 meters	➤	8 m ³
	1.70 meters			1.99 meters	➤	12 m ³
	1.94 meters			2.24 meters	➤	16 m ³
	2.43 meters			2.73 meters	➤	30 m ³
	2.90 meters			3.20 meters	➤	50 m ³
	3.50 meters			3.85 meters	➤	100 m ³

Excavate soil in the outer circle to a depth of 25cm deep and draw another circle of radius

0.85 meters	➤	4.6 m ³	1.98 meters	➤	30 m ³
1.01 meters	➤	8 m ³	2.55 meters	➤	50 m ³
1.25 meters	➤	12 m ³	3.05 meters	➤	100 m ³
1.50 meters	➤	16 m ³			

Excavate soil in the inner circle to a depth of 5 cm deep (Figure 4.10)

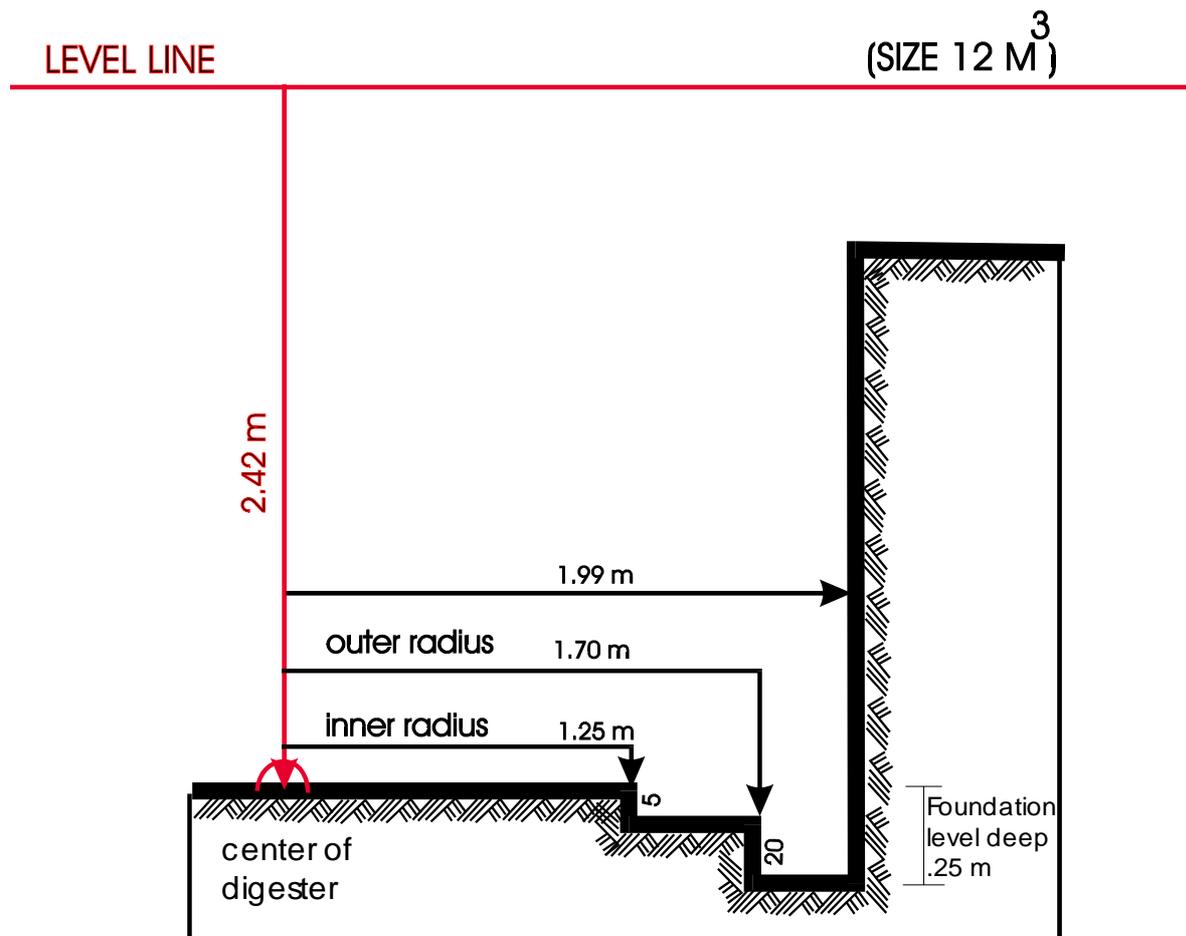


Figure 4.10 Excavate soil in the inner & outer radius

CHAPTER 5

Steps of Bio-gas Reactor Construction

5.1 Step 1

5.1.1 The strength of the chamber depends on beams

After the excavation is completed, the ground soil must be well pressed. Piles are required at the foundation in places where the ground is soft or filled with water or liquid. The crack will appear if the chamber is sinking. Set the level of beams using level line and marked with peg. (Figure 5.1)

2.00meters	➤	4.6 m ³	3.13 meters	➤	30 m ³
2.34 meters	➤	8 m ³	3.57 meters	➤	30 m ³
2.37 meters	➤	12 m ³	4.04 meters	➤	30 m ³
2.62 meters	➤	16 m ³			

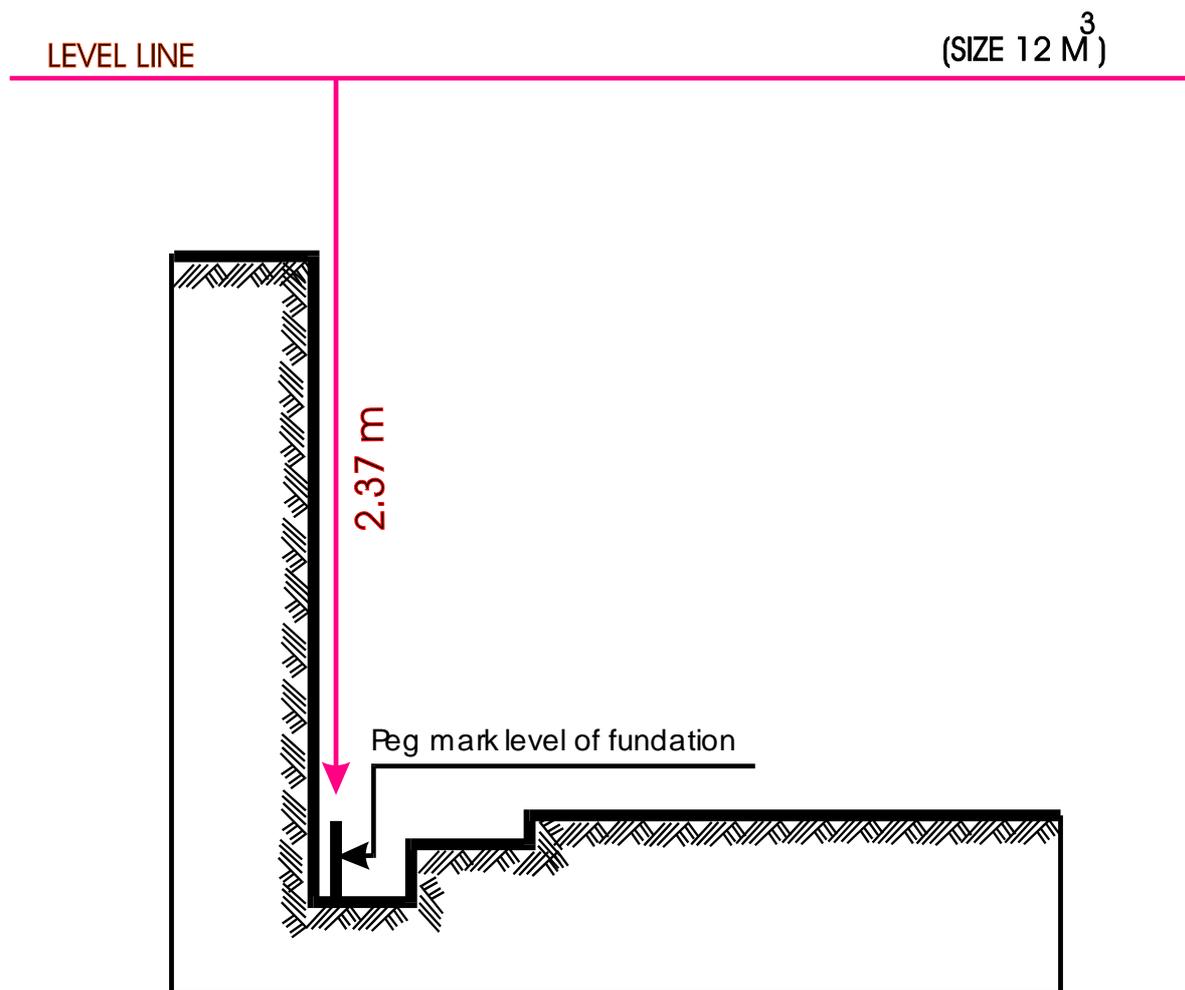


Figure 5.1 strength of the chamber depends on beams

Fill the foundation edge up to the same level as the ground with a mixture of cement 1 bucket : coarse sand 2 buckets : gravel 4 buckets (1 : 2 : 4 / volume). The mixture can be poured directly on the hard ground but fill the floor with coarse sand or gravel first if the ground is soft. While the cement is setting, cast the first layer of brickwork to allow the sufficient time for the bricks to attach to the cement base. The radius of brickwork is

1.30 meters	➤	4.6 m ³	2.55 meters	➤	30 m ³
1.57 meters	➤	8 m ³	3.00 meters	➤	50 m ³
1.80 meters	➤	12 m ³	3.58 meters	➤	100 m ³
2.05 meters	➤	16 m ³			

Ram half of the brick into the cement base and scrape the surface of the outer beam.
(Figure 5.2)

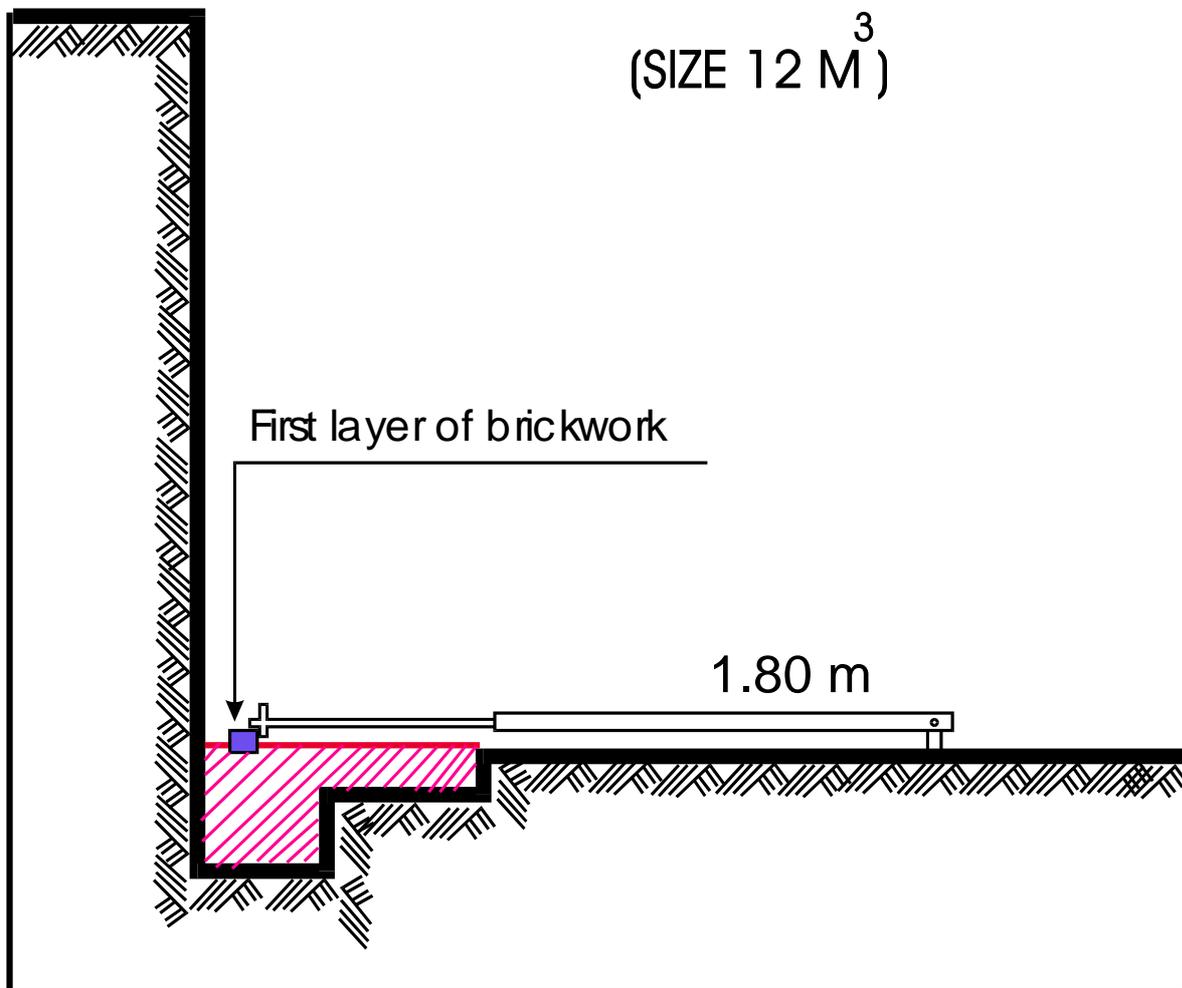


Figure 5.2 First layer of brick work

5.1.2 How to Line the Walls

When the first layer of brickwork was attached to the base, soak the bricks prepared for the next layer in water in order to wash out dust and to help the brick to settle better with cement. Concrete mixture is cement 1 bucket : lime 1/3 bucket : coarse sand 2.5 buckets (1 : 1/3 : 2.5 per volume). Set line for each brick using radius stick

1.30 meters	➤	4.6m ³	2.55 meters	➤	30 m ³
1.57 meters	➤	8 m ³	3.00 meters	➤	50 m ³
1.80 meters	➤	12 m ³	3.58 meters	➤	100 m ³
2.05 meters	➤	16 m ³			

Radius stick must be used with each layer of brick to keep the radius constant.(Figure 5.3) Joints should be offset and finish consecutively one layer after the other until 4 layers has been completed. Stop working and wait for the cement to dry after casting the third layer of brickwork - 10cm above the ground, place the outlet pipe then continue casting.

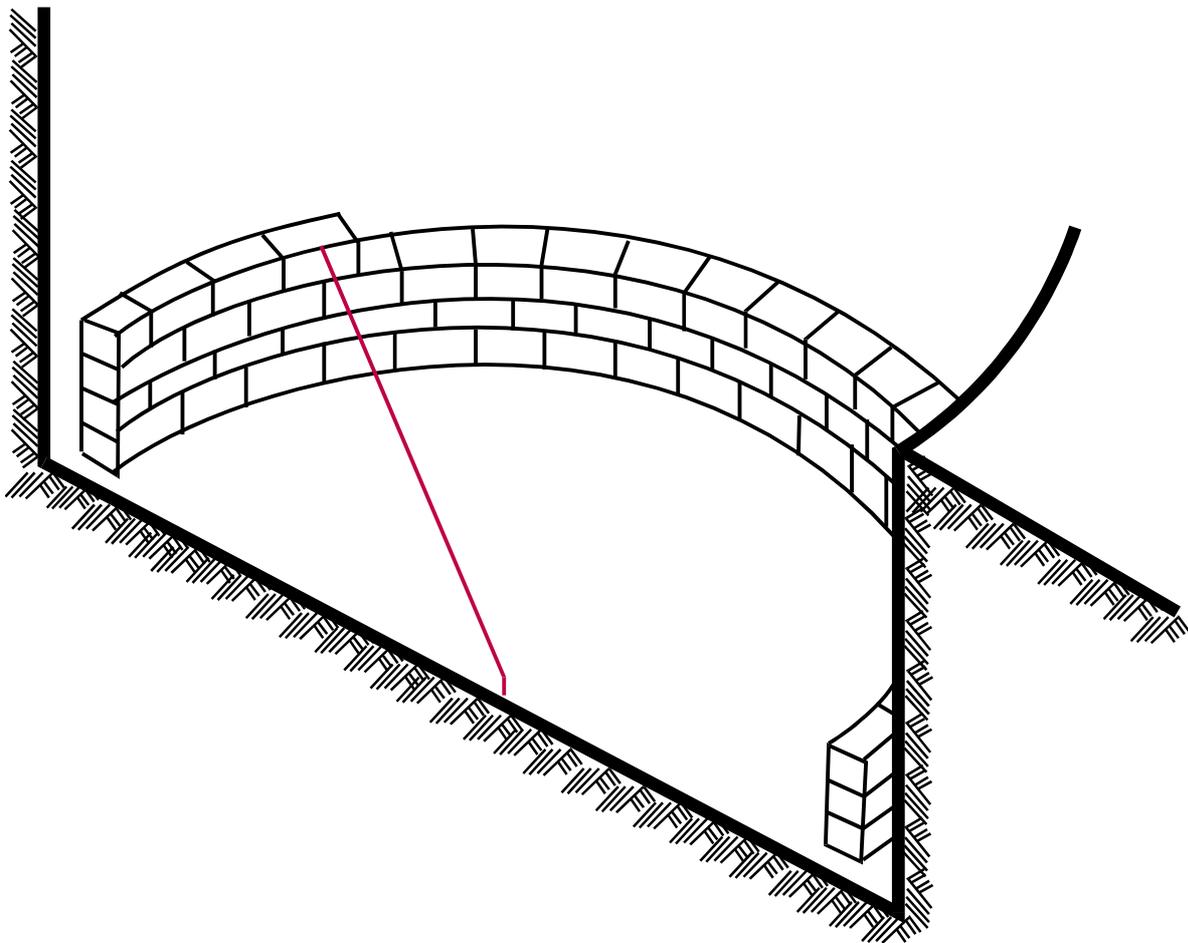


Figure 5.3 layer of brick to keep the radius stick constant

Seal the outside of the wall 3 layer high with cement mortar. Cement mixture is cement 1 bucket : coarse sand : 2 buckets : gravel 4 buckets (1 : 2 : 4 per volume). (Figure 5.4)
 When the layer is 1.60 meters measured from level line, leave a hole to place outlet pipe and inlet pipe (measure from the level line to the end of pipes). Continue casting until the level of brick work is

1.50 meters	➤	4.6 m ³	1.44 meters	➤	30 m ³
1.44 meters	➤	8 m ³	1.78 meters	➤	30 m ³
1.29 meters	➤	12 m ³	2.04 meters	➤	30 m ³
1.38 meters	➤	16 m ³			

Stop casting and leave it to dry. Apply the outside wall with plaster 1 cm thick using the same mixture as for building wall.

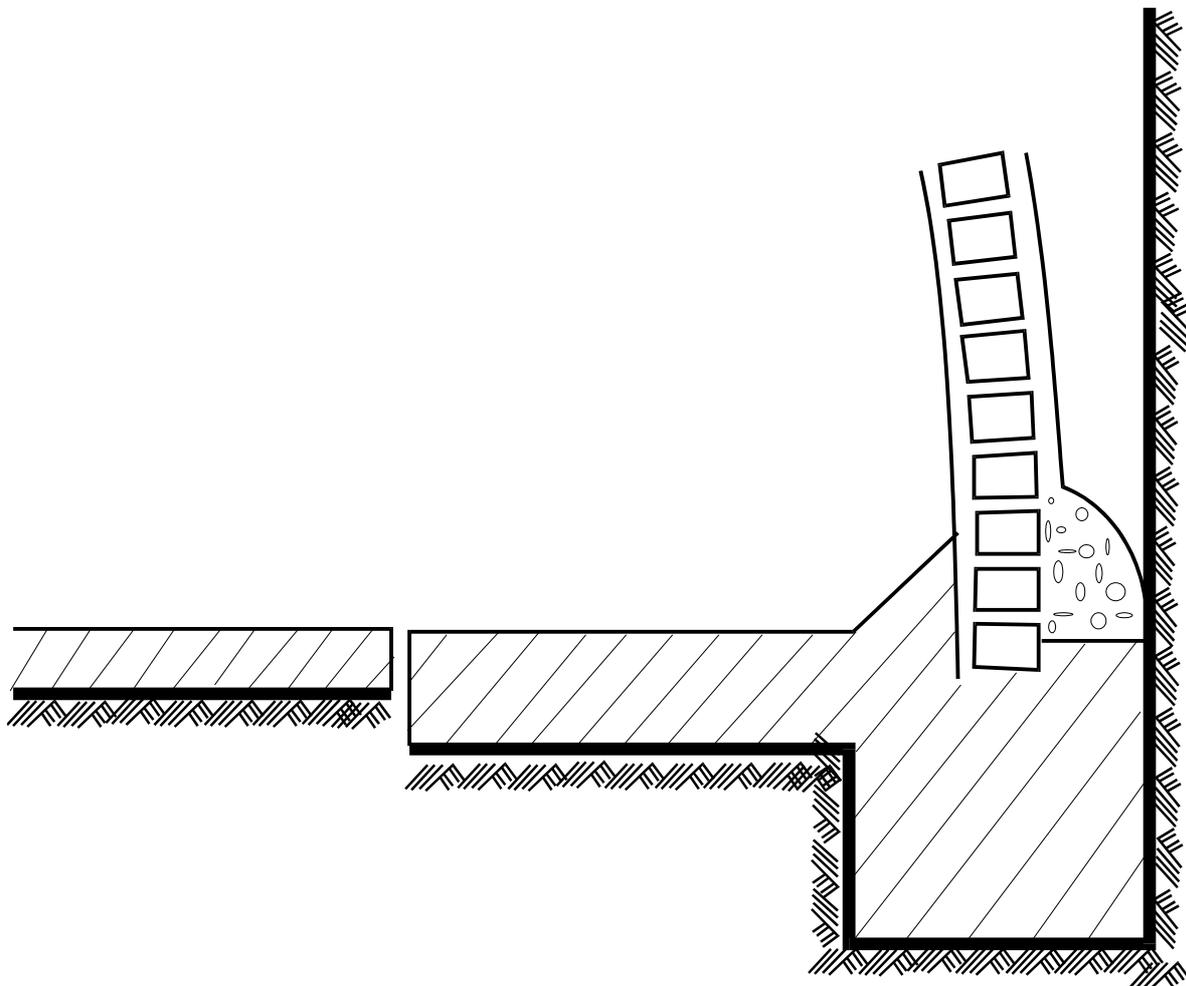


Figure 5.4 Seal the outside of the wall 3 layer high

5.1.3 Lower Outlet Pip and Storage Tank

This is for bio-gas plant that is filled with pig excrement. The residue of pig excrement is harder and sinks faster causing blockage. This 8 or 10 inch PVC diameter outlet pipe is rested at the bottom of the digester chamber wall. The bottom edge of the pipe is connected to the brickwork when it was constructed 10 cm or 3 layers above the floor ground (Figure 5.5). Before placing the pipe, use saw to scrape the outside of the pipe to let the cement settle better and to prevent seeping of water. At the upper end of the pipe build a square pit near the expansion chamber. The bottom floor of the storage tank is at the same level as the expansion chamber. The size of the storage tank is 25 cm (width) x 30 cm (length) x 60 cm (Height). There is an alley connected to outlet pipe of the expansion chamber or to storage tank to collect manure (Figure 5.6).

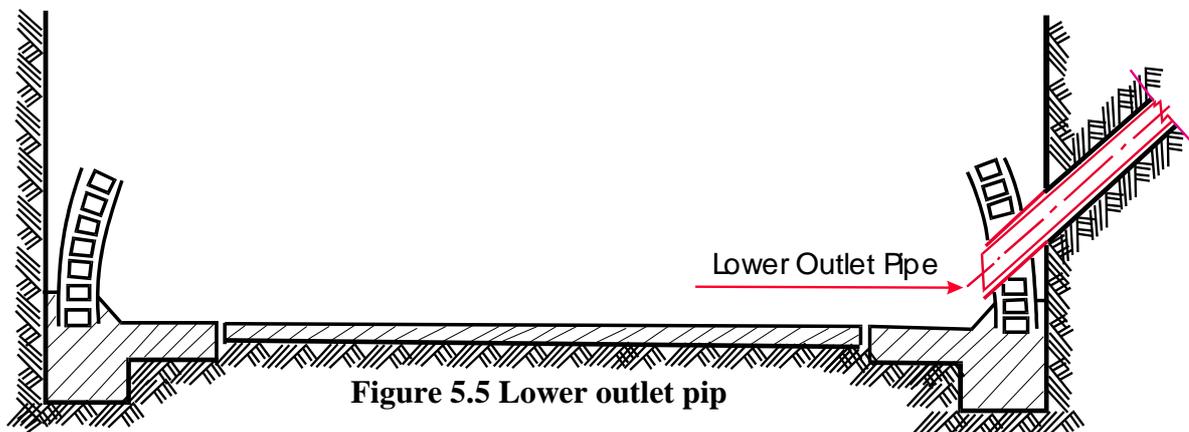
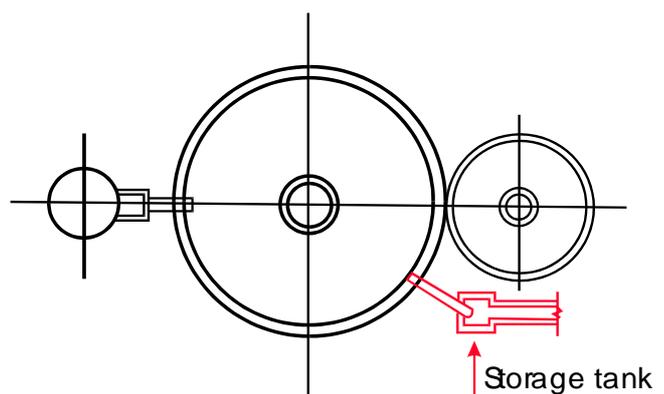


Figure 14 Lower Outlet Pip



5.1.4 Inlet Pipe

The end of Inlet pipe is rests 1.60 meters from the level line. PVC pipe (or concrete pipe diameter 8 –10 inch) is required. Scrape the outside of PVC mixing pipe by saw to let the cement settle well and prevent seepage of water. Locate where the pipe should be placed and ram the pipe well into cement and keep the pipe in position with pegs.(Figure 5.7)

1.60 meters	➤	4.6,8,12,16 m ³
1.74 meters	➤	30 m ³
2.08 meters	➤	50 m ³
2.14 meters	➤	100 m ³

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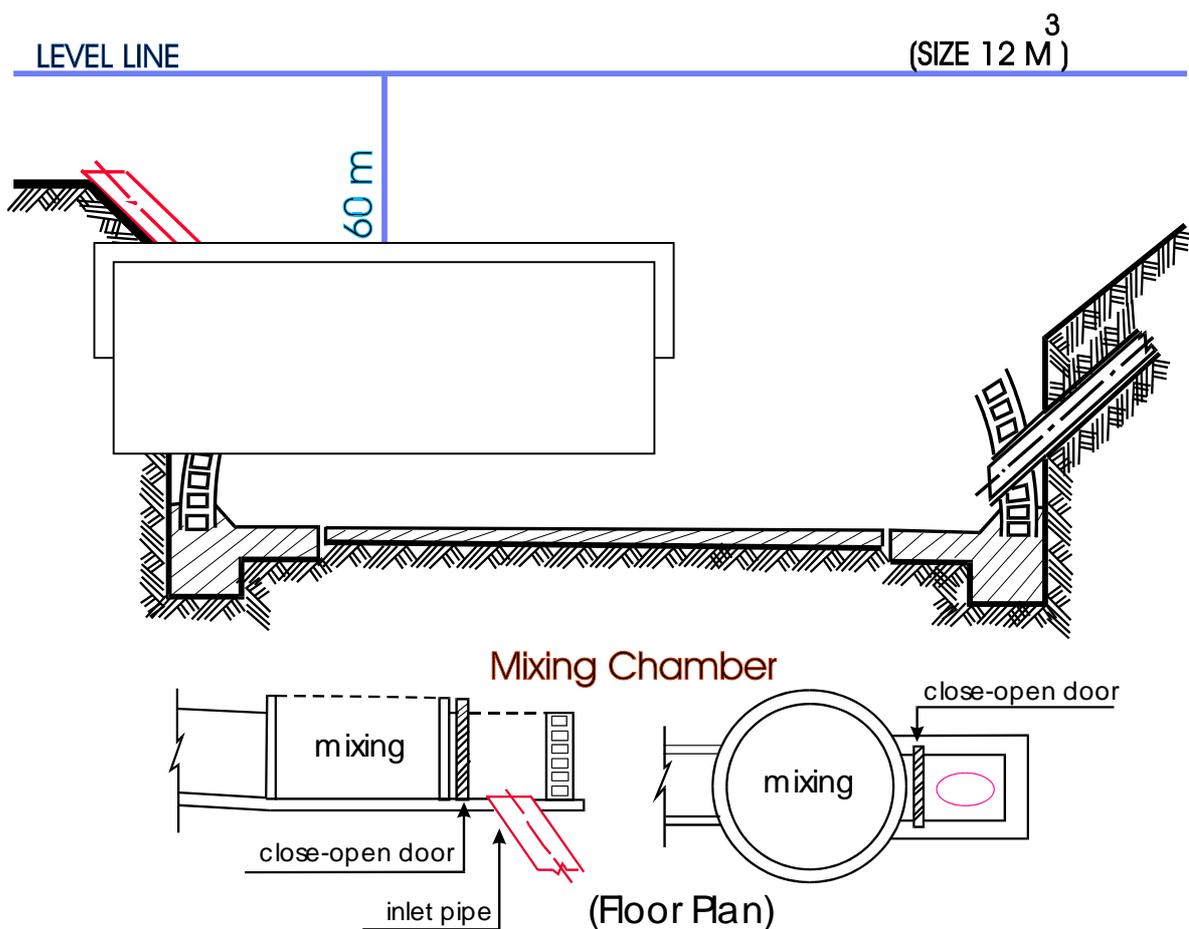


Figure 5.7 Inlet pipe

5.1.5 Outlet Pipe and Gas Control Pipe

Outlet pipe drains slurry and manure that had been broken down and stores them in expansion chamber. At the same time it controls gas pressure inside the chamber by releasing out exceeding gas or when gas is not being used. This prevents the wall of the chamber from exposing to high pressure. Increasing the life span of the gas chamber. The outlet pipe is made of concrete with diameter 10-12 inch. The bottom of the pipe is placed at the same level of weak ring, measured from reference line to the top edge of the pipe

1.35 meters	➤	4.6 m ³	1.44 meters	➤	30 m ³
1.44 meters	➤	8 m ³	1.78 meters	➤	50 m ³
1.29 meters	➤	12 m ³	2.04 meters	➤	100 m ³
1.38 meters	➤	16 m ³			

The inside of the top of the pipe must be lined straight to a string that is tied to the level line at 90° to the center of the expansion chamber. Pour cement under the pipe for supporting and the pipes are kept in position by pegs. Continue the rest of the brickwork and face the concrete outside wall (Figure 5.8).

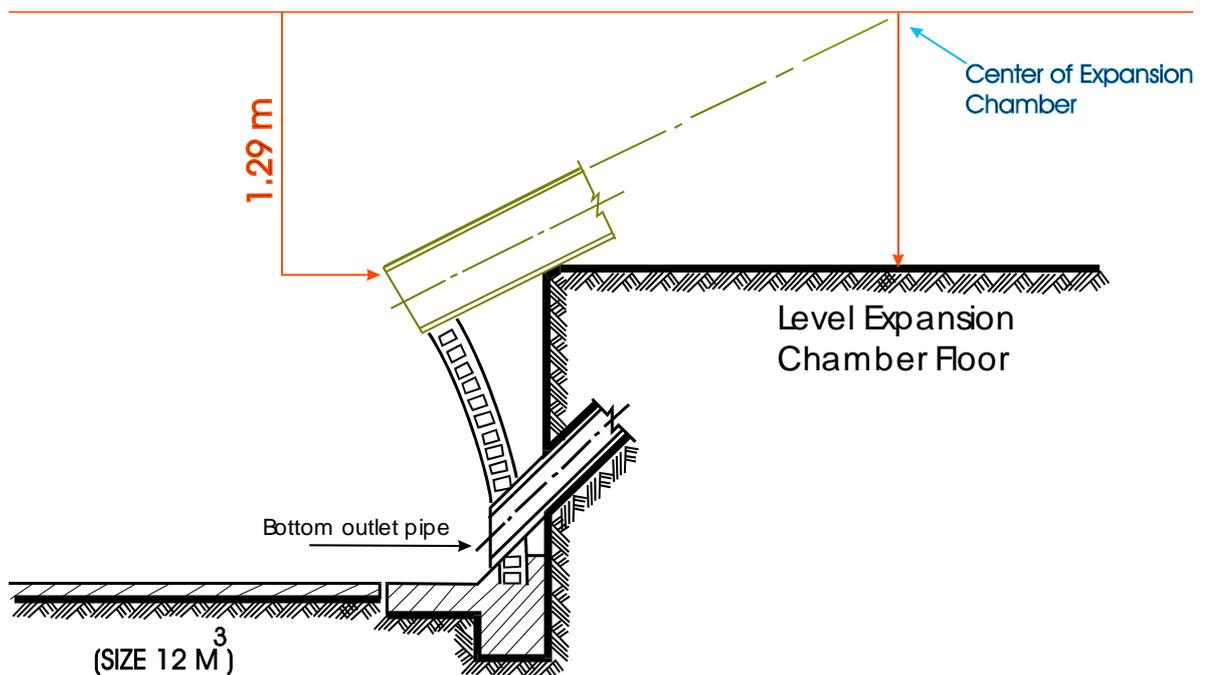


Figure 5.8 Outlet pipe & Gas control

5.1.6 Plaster the bottom to avoid leaking

When the wall is built at the height to start the weak ring, measure from the level line

1.35 meters	➤	4.6 m ³	1.44 meters	➤	30 m ³
1.44 meters	➤	8 m ³	1.78 meters	➤	50 m ³
1.29 meters	➤	12 m ³	2.04 meters	➤	100 m ³
1.38 meters	➤	16 m ³			

Clean the inside of the digester chamber and cover with lean mortar the mixture of cement 1 bucket : lime 1/3 bucket : fine sand 2.5 bucket (1 : 1/3 : 2.5 per Volume). Plaster the inside of the wall to 1 cm thick then plaster another layer at 1 cm thick. When cement is setting, use sponge to smooth the wall and to prevent leakage. When the plaster is finished, apply cement to cover the digester chamber floor 5 cm using the mixture cement 1 bucket : coarse sand 2 buckets : gravel 4 buckets (1 : 2 : 4 per Volume), do not cover the center. Leave to dry.

5.2 Step 2

5.2.1 Why does the soil have to be pressed firmly?

When the concrete face inside the wall is done, fill the outside dome 30 cm high with soil. Press firmly and fill more soil, press firmly again. It is not recommended to fill soil up to the top and press only once because the bottom soil would not be pressed well enough, and the dome will crack. The outside back filling helps to support the high pressure of gas inside the dome. The back filling should be higher than the layers of brickwork and press the soil to the level of the radius stick (Figure 5.9).

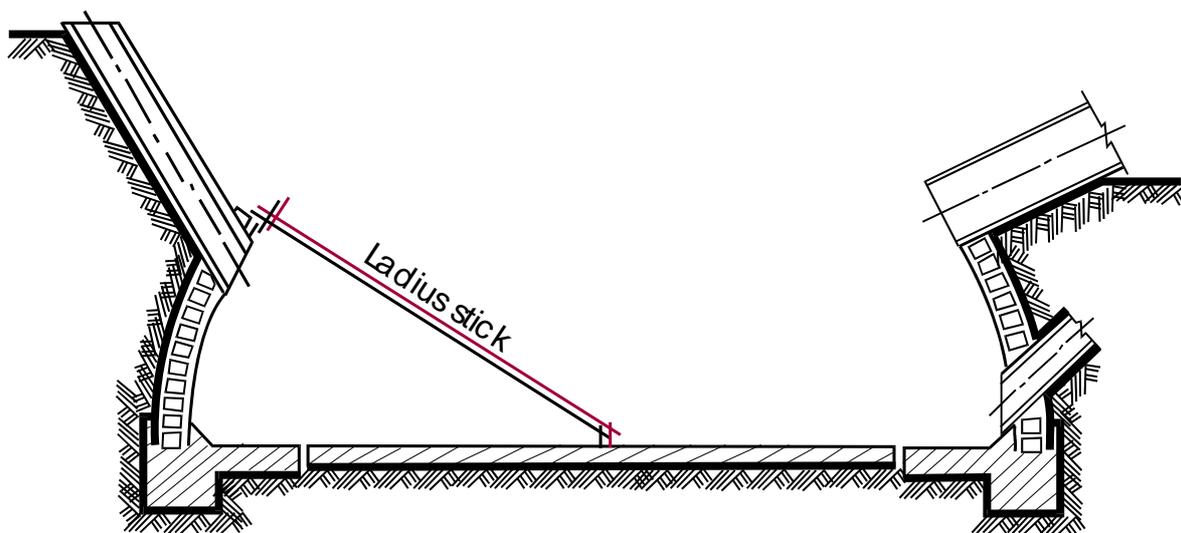


Figure 5.9 Outside back filling

Notice Face concrete inside the wall before back filling to avoid the problem of having water outside dome.

5.2.2 What is a Weak Ring?

A **weak ring** is constructed to separate the bottom wall and the upper part of dome. When the ground is sinking or the wall is cracked, the weak ring will prevent the vertical crack spreading up to the top of the dome. The weak ring is a soft mixture and flexible.

Mark a circle from the existing wall use radius

1.42 meters	➤ 4.6 m ³	2.67 meters	➤ 30 m ³
1.69 meters	➤ 8 m ³	3.12 meters	➤ 50 m ³
1.92 meters	➤ 12 m ³	3.70 meters	➤ 100 m ³
2.17 meters	➤ 16 m ³		

The weak ring is built by placing bricks to form a wall outside the radius. The distance between the wall and weak ring is 1 brick wide. The mixture of cement 1 bucket : lime 3 buckets : fine sand 15 buckets (1 : 3 : 15 per Volume) is required to form a circle over the top of the wall until the thickness is the same as the thickness of the formed brick. Use hard broom to scrape the cement while it is setting then start the next layer of cement until 3 layers are finished. With the same method applied in one day, the thickness of the cement will be approximately 10 cm. Smooth the last layer and leave it to be hardened for 24-48 hours (Figure 5.10).

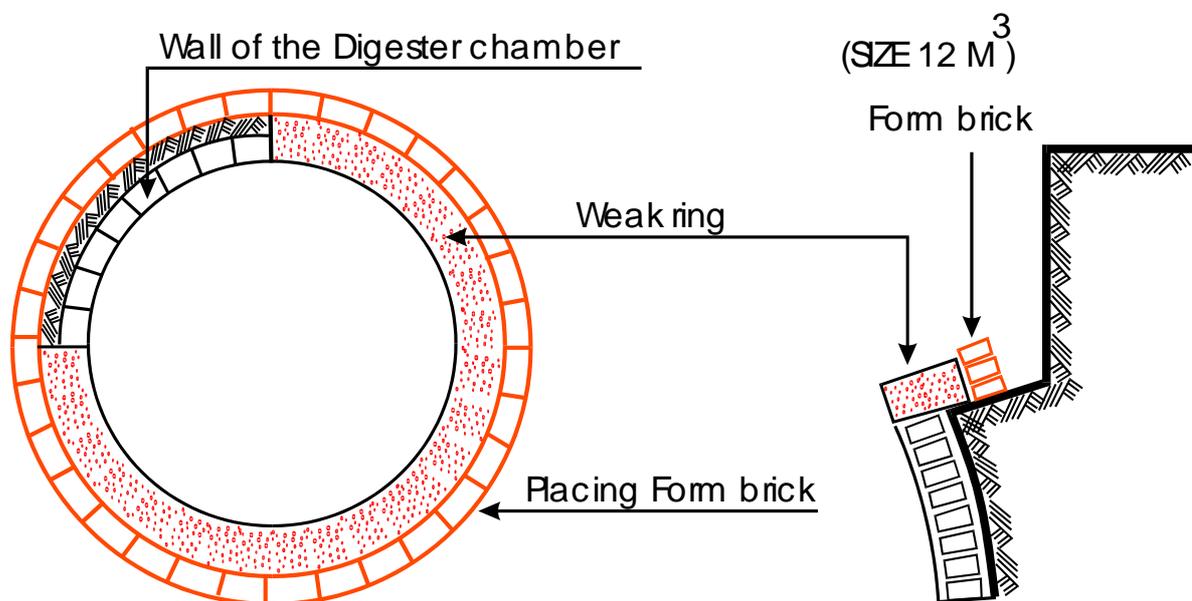


Figure 5.10 The weakring

Notice Do not use lime replacement

5.2.3 What is the Purpose of Expansion Chamber and How it is Built?

The expansion chamber controls the volume of gas in digester chamber and is involved in pushing gas up for usage when the valve is opened., it also drains out manure that has been digester.

To build an expansion chamber, fill the soil up and firmly press. Draw a circle to mark the size of the expansion chamber use radius

1.10 meters	➤	4.6 m ³	1.50 meters	➤	30 m ³
1.25 meters	➤	8 m ³	1.88 meters	➤	50 m ³
1.30 meters	➤	12 m ³	2.07 meters	➤	100 m ³
1.50 meters	➤	16 m ³			

Mark out where the drainage alley will be excavated then dig a hole to build an expansion chamber according to the drawing. The depth of the chamber is measured from the level line approximately

1.10 meters	➤	4.6 m ³	1.04 meters	➤	30 m ³
1.16 meters	➤	8 m ³	1.05 meters	➤	50 m ³
1.05 meters	➤	12 m ³	1.22 meters	➤	100 m ³
1.10 meters	➤	16 m ³			

Use plumb to find the center of expansion chamber floor and mark it. Mix the mixture of cement 1 bucket : coarse sand 2 buckets : gravel 4 buckets (1 : 2 : 4 per volume).and apply to built a 5 cm thick floor. The floor is at the same level of the upper edge of the outlet pipe. While the cement is setting, cast the first layer of brickwork use radius to control the line of brickwork (Figure 5.11).

0.90 meters	➤	4.6 m ³	1.30 meters	➤	30 m ³
0.95 meters	➤	8 m ³	1.68 meters	➤	50 m ³
1.10 meters	➤	12 m ³	1.87 meters	➤	100 m ³
1.30 meters	➤	16 m ³			

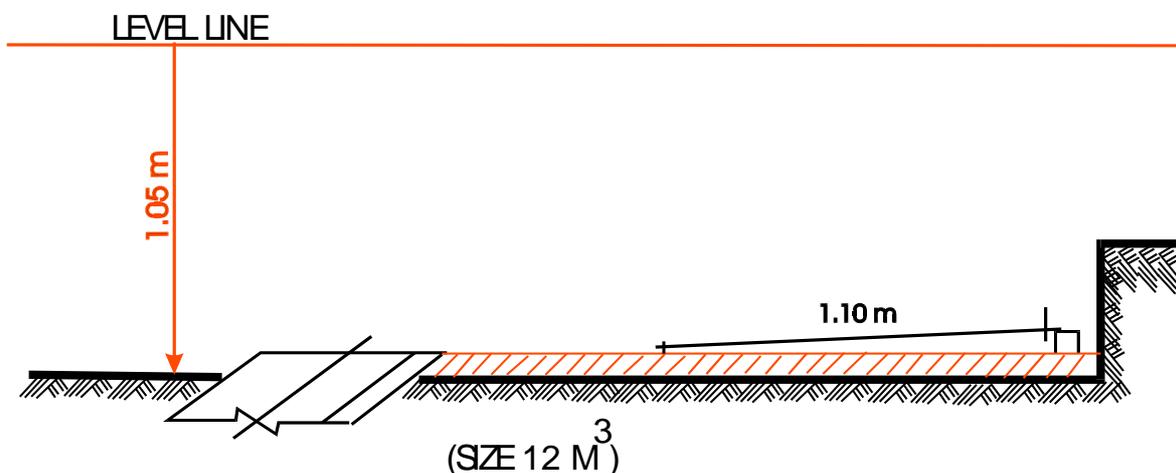


Figure 5.11 Expansion chamber floor

When the first layer is finished, leave it to dry. Soak the bricks prepared for other layers in water to let the cement set better. The mixture of cement 1 buckets : lime 1/3 bucket : coarse sand 2.5 buckets (1 : 1/3 : 2.5 per Volume) is applied to cast a brick wall and use radius stick to maintain the consistency (Figure 5.12).

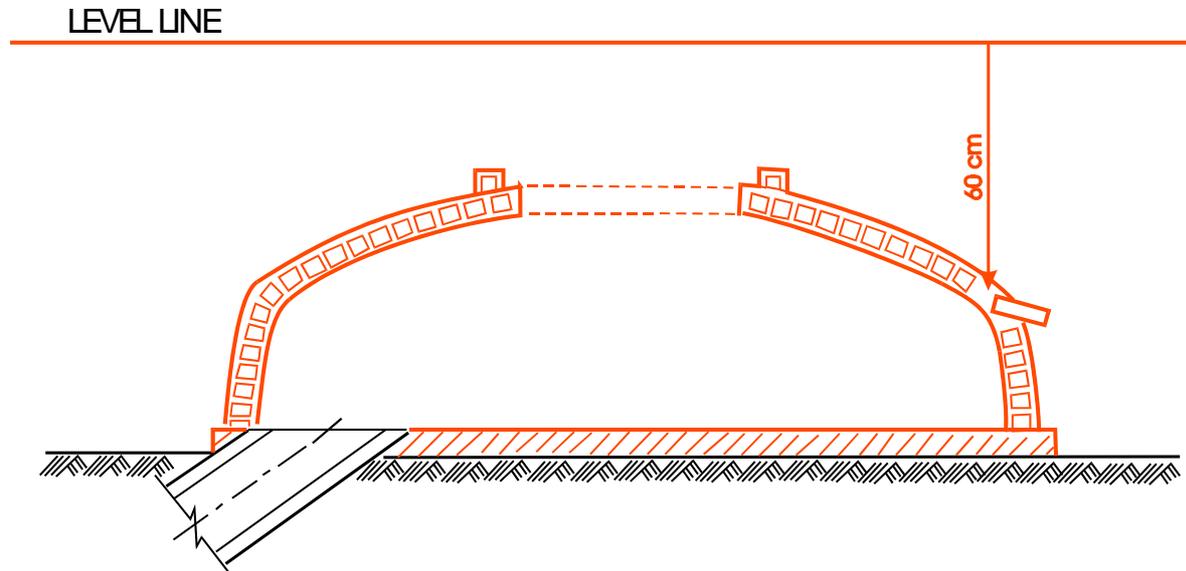


Figure 5.12 Cast a brick expansion chamber wall

When the wall is approximately 60 cm high from the level line, place header bricks where the expansion outlet starts in order to support another layer of bricks. (This outlet width is twice a size of 2 bricks and as high as 3 layers of bricks.) Leave it to be hardened. Mix the mixture of cement 1 bucket : lime 1/3 bucket : fine sand 2.5 buckets (1 : 1/3 : 2.5 per Volume), face the concrete both sides of the wall 1 cm thick and smooth them. When it is dry, continue casting the wall and leave 80cm wide at the top as the outlet. Face the concrete both sides of the wall. Build an outlet channel on the vertical until reaches 90cm from level line. Leave it to be hardened. Face the concrete both sides 1cm thick and smooth the edge (Figure 5.13).

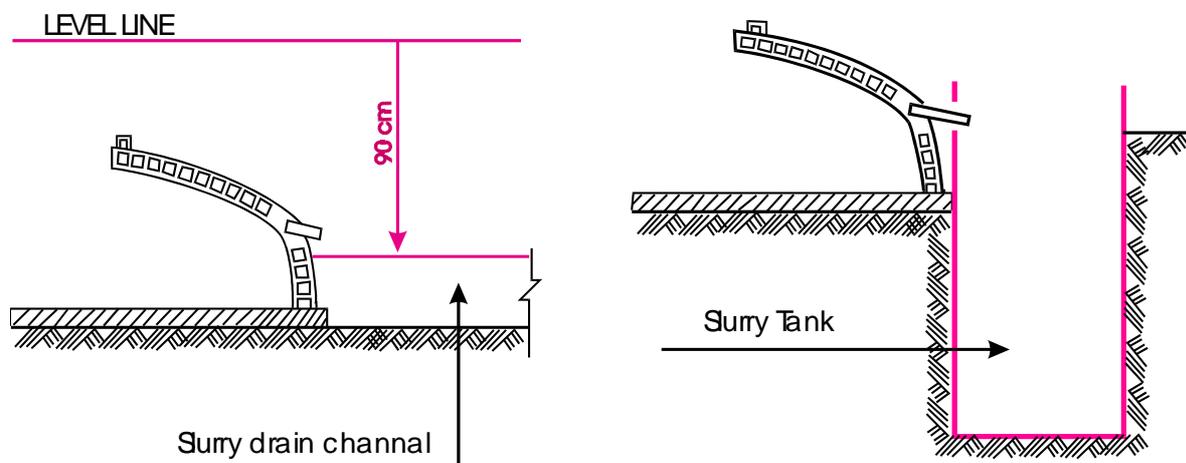


Figure 5.13 Slurry drainage channel & Slurry tank

5.3 Step 3

5.3.1 What is a Dome?

The dome collects gas and is located at the top of the digester chamber, separated from the lower wall by weak ring. Build the fixed dome by casting one layer of vertical bricks on top of the weak ring. On each layer, the lower part of brick sticks out 3-5 cm towards the inside of the dome. Build the next layer using the following radius.

1.30 meters	➤	4.6 m ³	2.55 meters	➤	30 m ³
1.57 meters	➤	8 m ³	3.00 meters	➤	50 m ³
1.80 meters	➤	12 m ³	3.58 meters	➤	100 m ³
2.05 meters	➤	16 m ³			

Cast 5 layers and stop (to build strong ring). When finished continue building until the top of fixed dome is 42 cm wide. Leave it to harden. Pour cement to cover of the digester chamber that had been left earlier (Figure 5.14).

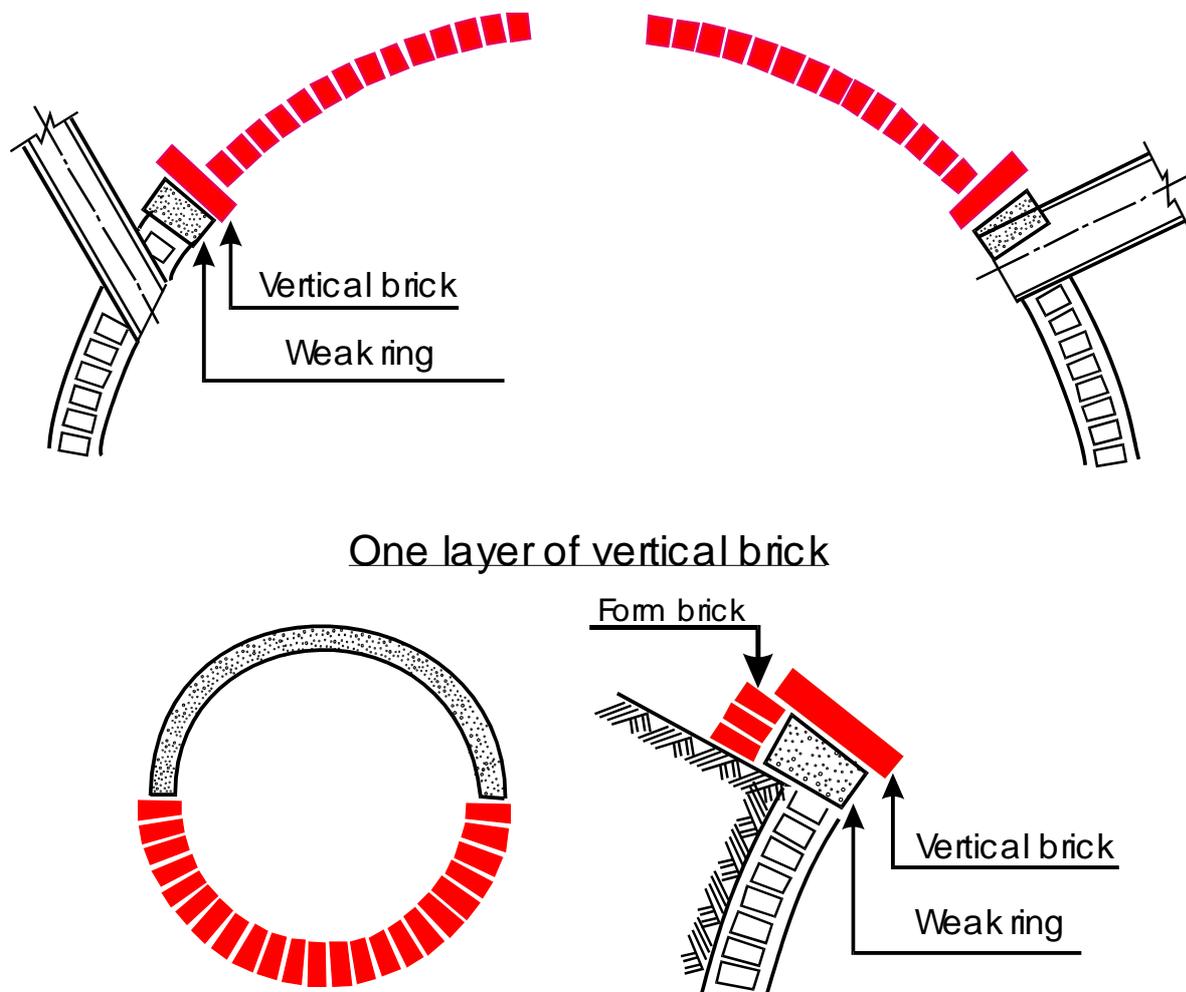


Figure 5.14 The Digester chamber dome

5.3.2 Non Crack Dome

Clear the loose cement and clean inside of the fixed dome. Spread lime water over the dome.

First concrete face Apply a mixture of cement 1 bucket : lime 1/3 bucket : coarse sand 2.5 buckets (1 : 1/3 : 2.5 per Volume) to the inside dome to a thickness of 1 cm. Use hard broom to scrape the plaster and leave it for one day.

Second concrete face Apply a mixture of cement 1 bucket : lime 1/4 bucket : coarse sand 2.5 buckets (1 : 1/4 : 2.5 per Volume) to the wall to a thickness of 1 cm thick after lime water is spread. Scrape the wall and leave it to be dry for 1 day.

Third concrete face Mix waterproofer with the same mixture of cement mortar. Plaster the dome 1 cm thick including the outlet (manhole). Polish well. Cover the neck of the chamber with sacks for retention (Figure 5.15).

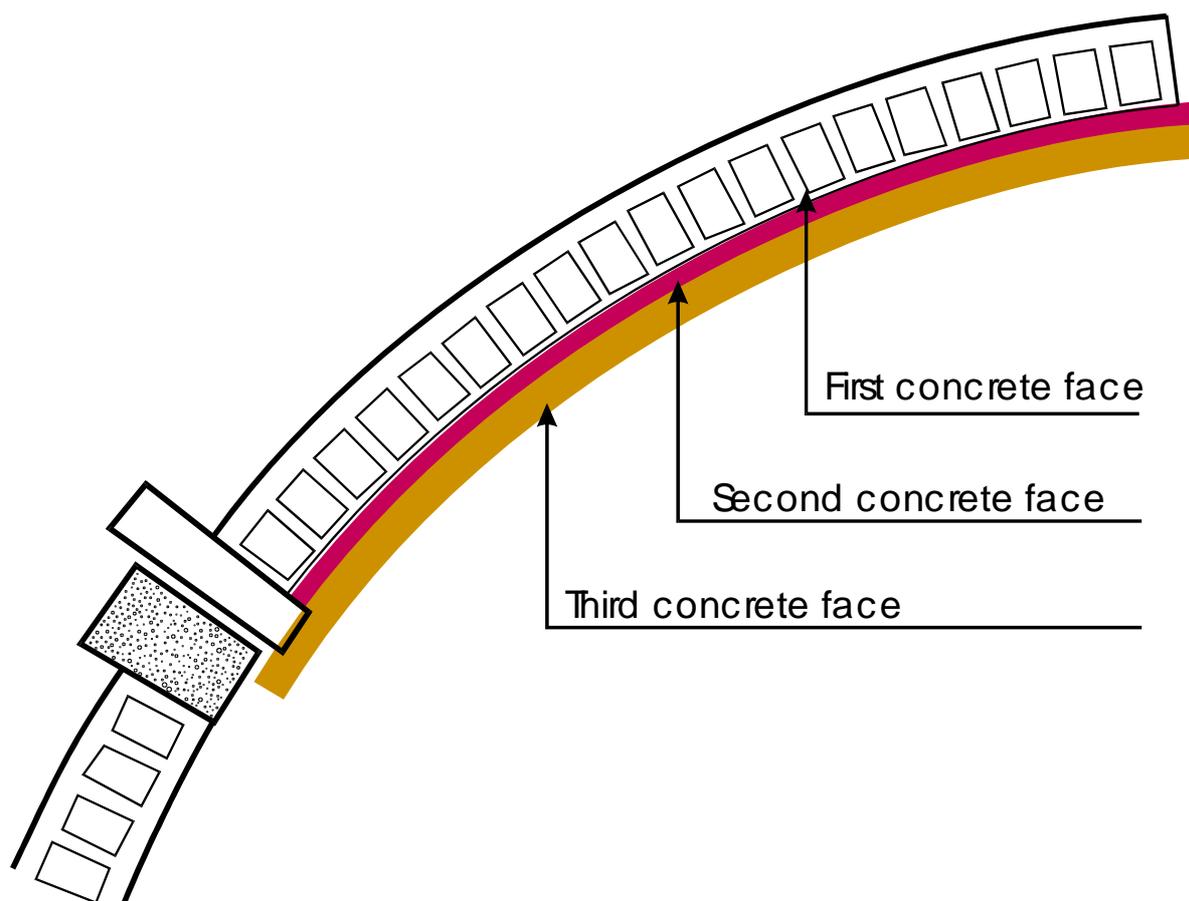


Figure 5.15 The dome concrete face

Notice Fixed dome is where gas is collected. Workers must follow the instruction strictly. Do not rush to face the concrete in one day, it cannot prevent the crack.

5.3.3 Strong Ring is the Beam of Fixed Dome

The upper part of fixed dome is also very important. The strength of fixed dome is required by the mixture of cement 1 bucket : coarse sand 2 buckets : gravel 4 buckets (1 : 2 : 4 per Volume). Before the cement is poured, remove the brick of the weak ring. Chip the soil under weak ring until reaches the first brick and strike the loosen cement out. Clean the outside wall, spread weak ring and 3 layers above with lime water. Pour cement to cover the vertical bricks in a shape of turtle back. Leave it to dry for one night (Figure 5.16).

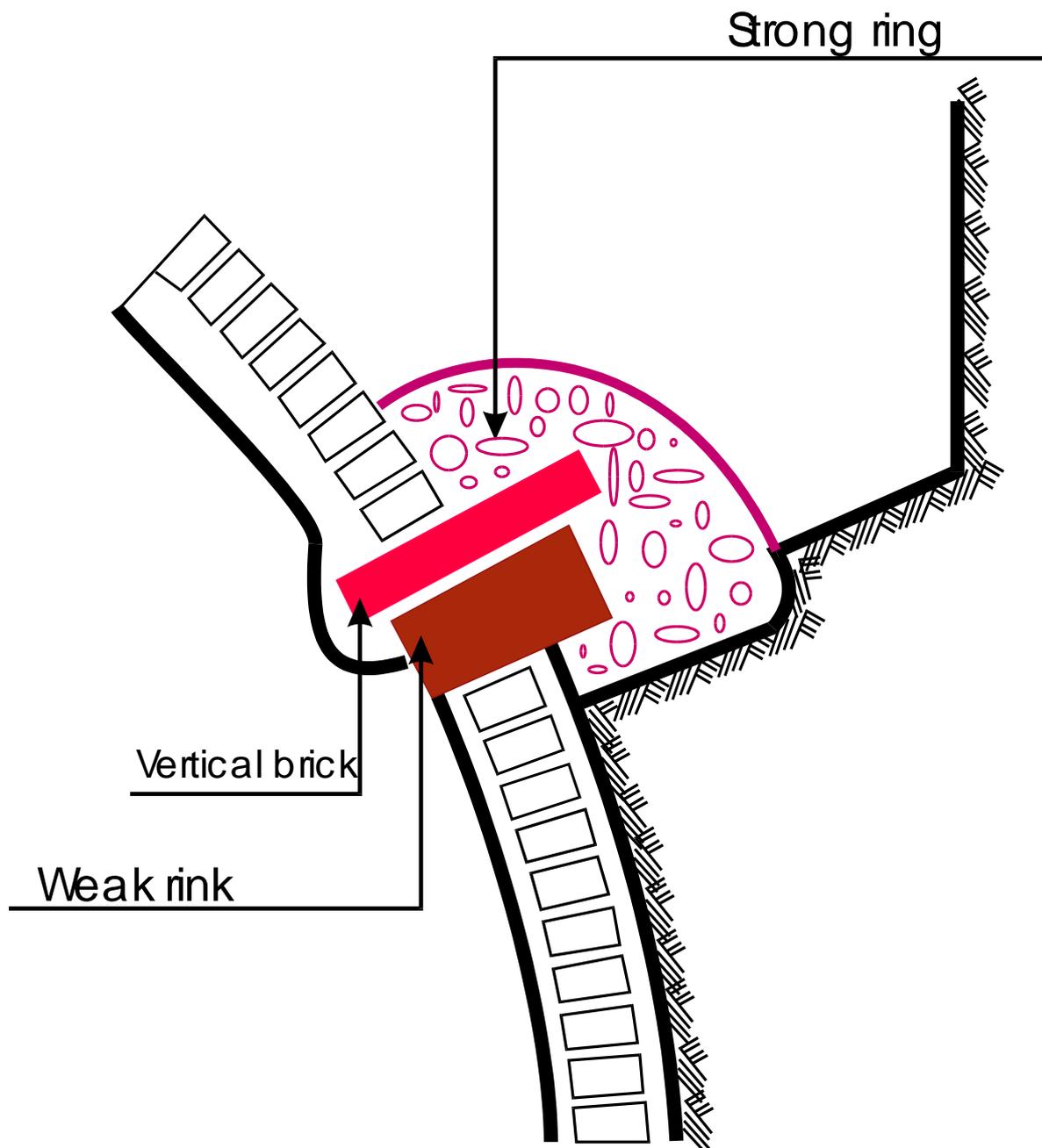


Figure 5.16 The strong ring

5.3.4 Why is the Neck of the Chamber Required?

The neck of the chamber is built to support the lid. Place a 70-80 cm diameter concrete ring on top of the open chamber. Adjust this 42cm hole until it is in the middle of the ring. Use water adjusting level to balance the vertical level. Use nail to mark the circle and remove the ring. Build up an edge with cement mortar and replace the ring exactly at the marked spot. Place steel mould to shape the inner wall. Put bricks inside the mould for ballast to stop the mould from moving. Coat oil to the outer mould to facilitate the removal of the mould (Figure 5.17). Clean the floor and spread the floor and the neck of the chamber with lime water. Use the mixture of cement 3 buckets : coarse sand 6 buckets : gravel 9 buckets (3 : 6 : 9 per Volume) to fill the gap until the height is 10 cm below the edge of the mould. Poke well to get rid of air bubbles. Place a wedge plugged with banana stem, (Figure 5.19) 4 cm measured from the top edge of the mould to the back of the wedge (Figure 5.18). Mark the position of wedges on the cement edged when the mould is removed, it will be easy to find the position later. There are 3 pieces of the wedges rested in triangle position with the end of each wedge 48 cm apart from each other (Figure 5.20). The gas pipe lies directly opposite one of the wedges. . Pour the rest of the cement to fill up to the top of the neck without poking because it may cause the wedges to move. Smooth the surface and leave it to dry for one day.

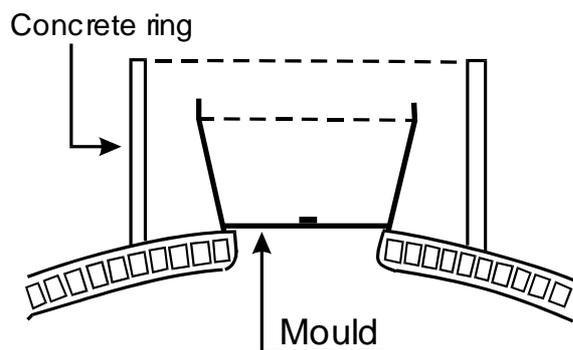


Figure 5.17 The neck

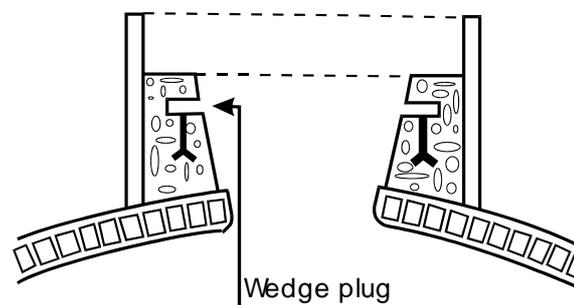


Figure 5.18 Position of the wedge plug

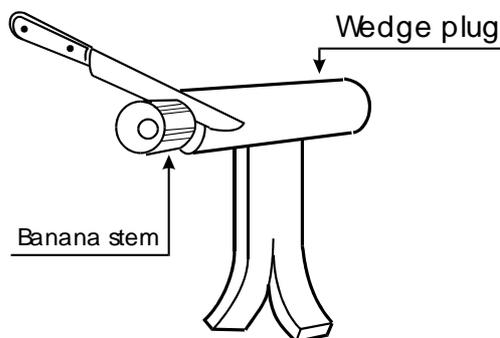


Figure 5.19 wedge plugged with banana stem

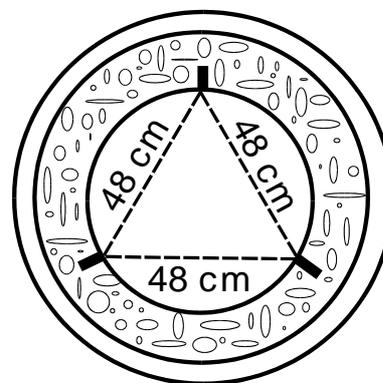


Figure 5.20 Triangle position

5.3.5 How to Mould the Lid?

Before moulding the lid, the steel mould and gas pipe must be cleaned with wire brush. Coat the inside with oil and set the gas pipe together with 90° (1.5 inch) joint. Pour the mixture of cement 2 bucket : coarse sand 4 bucket (1 : 2 per Volume) into the mould until a depth of 15 cm is reached. Use a hammer strike the outside mould to get rid of air bubbles. Secure 2 handles by tying to a bamboo stick laid across top of the mould. Smooth the surface and leave it to harden. Use a sack to cover the mould to avoid any cracks. After 1-2 days remove the mould and leave the lid in water until it is being used (Figure 5.21).

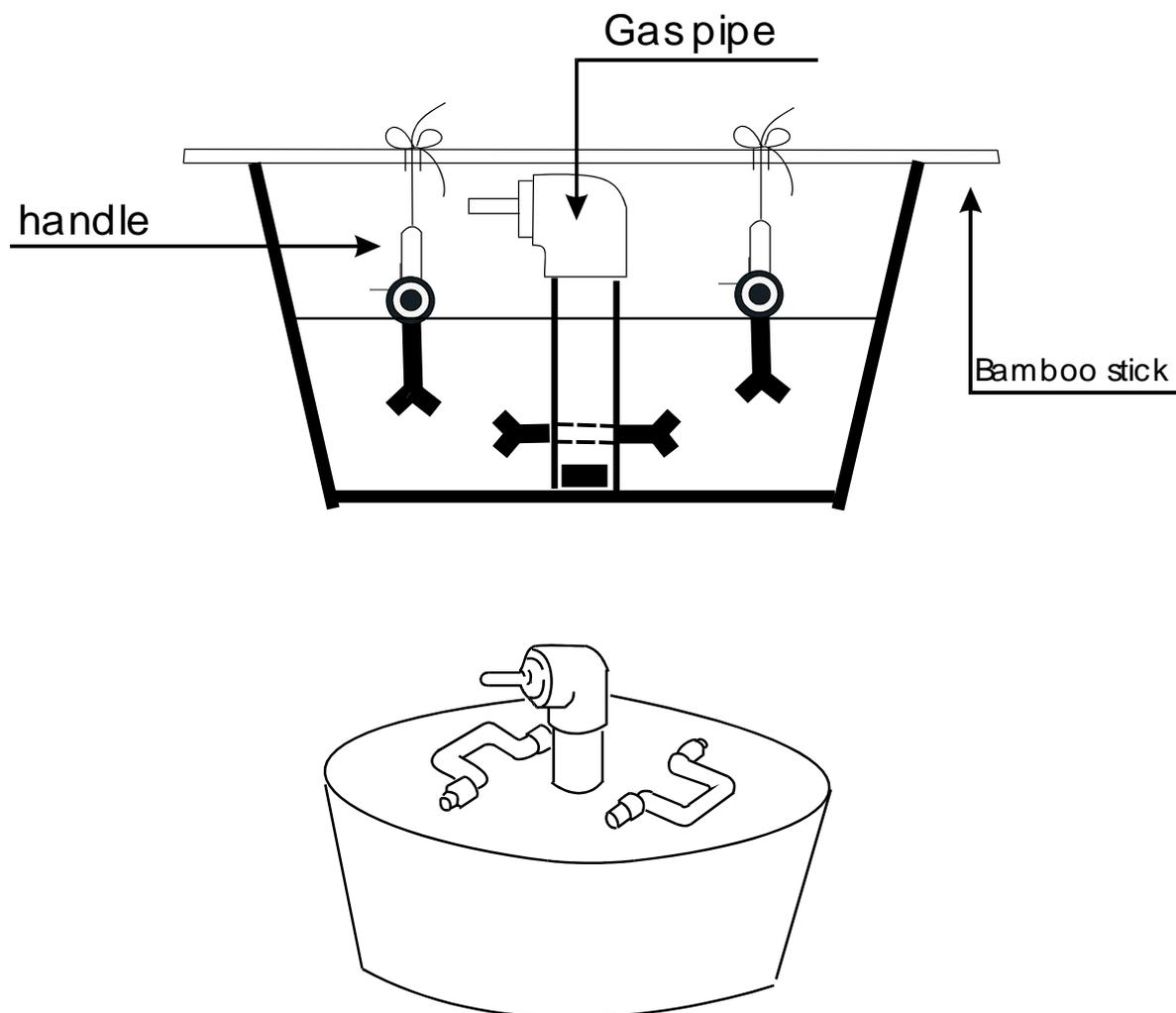


Figure 5.21 The lid

5.3.6 The Outside Dome Plaster

Clean the outer wall including the strong ring and spread with lime water. The mixture of cement 1 bucket : lime 1/3 bucket : coarse sand 2.5 buckets : (1 : 1/3 : 2.5 per Volume) is required to plaster the outer wall until the thickness of 3 cm is reached. Polish and leave it to be hardened (Figure 5.22). When the cement is completely dry, cover it with sacks and apply water 3 times a day to maintain the retention. After that fill the back with soil. The expansion chamber and the digester chamber must be covered well under the soil and only the necks are left free to avoid any cracks and to let the weight of soil support against the dome. Vegetables or grass can be planted on the top to prevent eroding or provide a good sight.

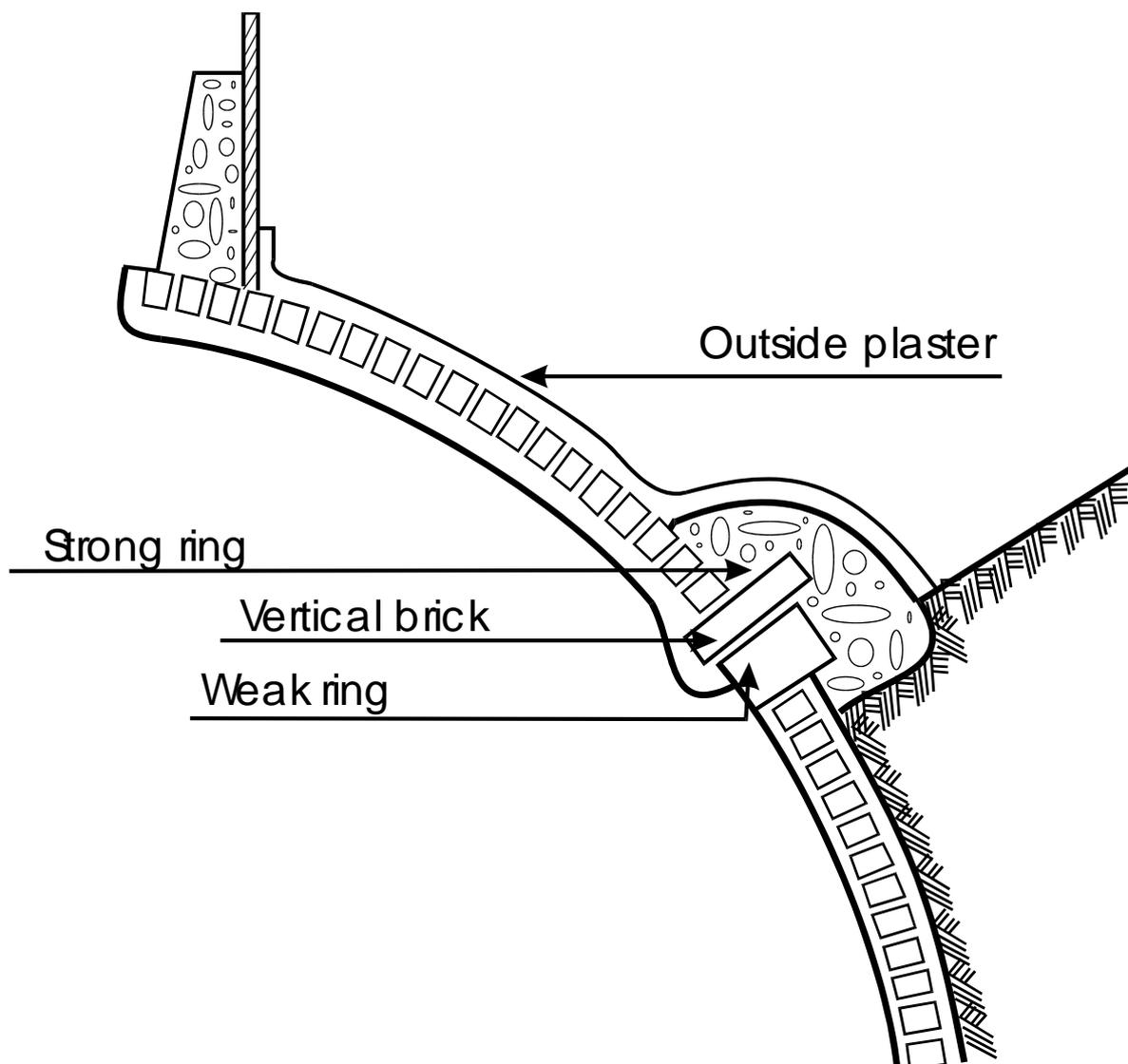


Figure 5.22 The outer plaster cement

5.4 Step 4

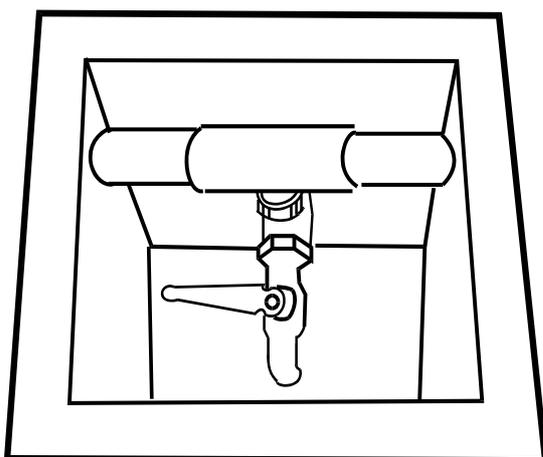
5.4.1 Gas Pipe Installation

It is one of the most important Steps of the construction. If the pipes are badly connected or if there is any leakage, the volume of gas will decrease. Some farmers will blame it on the construction of the chambers

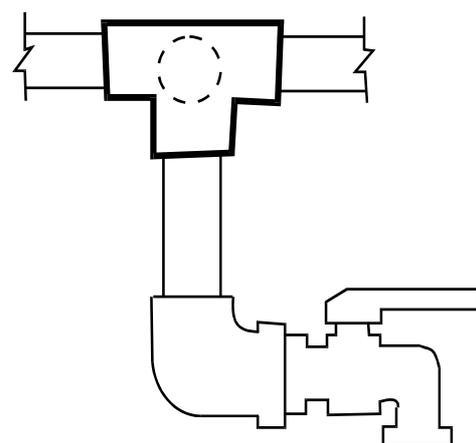
5.4.2 The Piping System

1. **Excavating the channel.** Set the level of the channel slight slope from the valve at the outlet to the lowest point at least 20 cm deep and 20 cm wide. From the lowest point dig a trap water pit sizes 30 cm x 50 cm x 50 cm. Form a brick wall, fill the floor with cement and face the concrete to the inner wall with cement added waterproofer.
2. **Gas pipe.** If the piping distance is within 20 meters use 6/8 inch PVC pipe. The 1 inch pipe is suitable for the distance further than 20 meters.
3. **Checking the pipe.** The pipe is checked by closing one end with a palm and letting a person blow through the other end of the pipe. Blow for 1 minute, if the pressure is still stable, it indicates the sufficiency. If the pressure is reducing, the pipe is leaking, change new pipe.
4. **Clean the pipe and joint.** Use sand paper No.100 to scrape the end of pipe and inside the joint then clean well.
5. **Gluing.** Apply glue onto the parts that will be connected both the end of the pipe and inside the joint. Put them together and press with palms for 30 seconds then release.
6. **Water trap.** Apply T-joint 15-20 cm downward into water trap pit and install the valve at the end of the joint (Figure 5.23).
7. **Piping system.** Line the pipe to an area where the gas will be used. Install a gas valve and steel plate collar over the PVC pipe to connect to gas equipment. The pipe must be well covered underground to avoid cracks caused by animal or vehicles.

Figure 5.23 Water trap



Water Trap Pond



Water Trap

Notice To connect to screw pipe use tape to wind threads before connection. Do not wind too tight, the pipe may break. The locations where valve should be in stalled are the outlet of digester chamber, the place where gas the equipment will be installed and manometer.

5.4.3 Closing the Lid

Use well kneaded clay (without any stones) to plaster around the edge of the manhole or the outlet to a thickness of 1cm. Plaster the lid 0.5 thick. Remove the banana stems used to clog the wedge. Put the lid to cover the edge of the outlet slowly and check the level. Press hard using body weight. Insert pegs to secure under the wedges and fill with water until they are covered. Before closing the lid, plan where the gas pipe is to be connected (Figure 5.24).

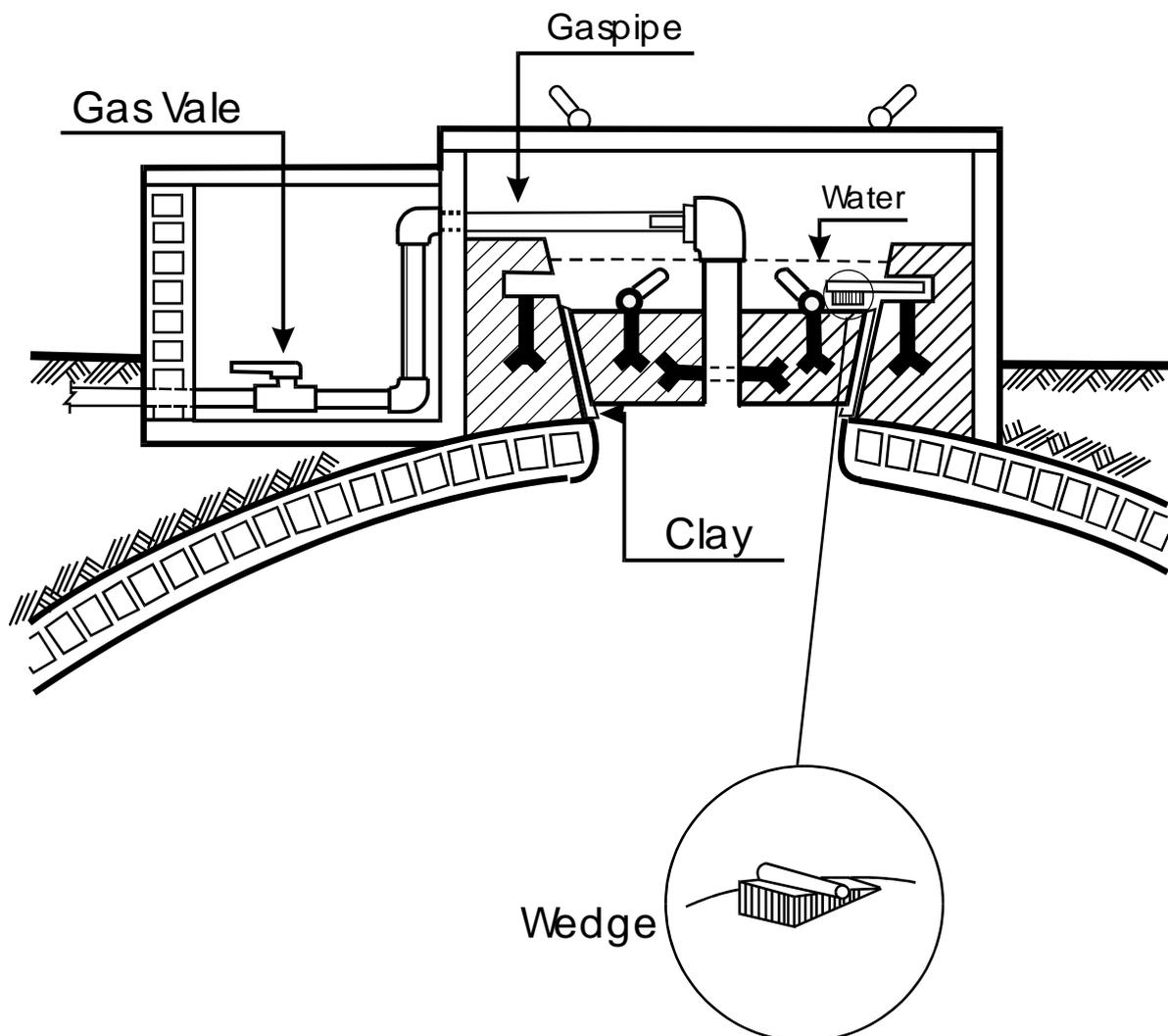


Figure 5.24 Closing the lid

5.4.4 Why the Chamber has to be Tested?

The most important process of constructing the bio-gas plant is to test the gas chamber and gas pipe. If there is any crack, gas can not be stored. Before filling animal excrement, the leakage must be tested.

Testing unit

Mano-meter is connected to the gas pipe at the outlet of the digester chamber. Fill water into either the inlet pipe or expansion chamber until the mono meter can be read 80 cm. (40 x 2) and leave it for 12 hours.

If the pressure reduces by less than 10 cm (5 x 2), the gas chamber is in good condition. If the pressure reduces more than 10 cm, check the possible sites where water is seeping, for example at the bottom of digester chamber, the bottom of the expansion chamber or leakage of air through fixed dome. Repair cracks and leaks and test again until air is not leaking (Figure 5.25).

Testing gas pipe. Close valves of the digester chamber and the water trap. Open kitchen valve and blow into gas pipe until the pressure is at 80 cm. Close valve in the kitchen leave it for 1 hour. If the pressure reduces, there is leakage. Check every joints and T joints by using soap water. The bubbles will indicate the leakage. Change a new joint. When the gas chamber is tested and there is no leakage, fill the animal excrement without release water in the chamber.

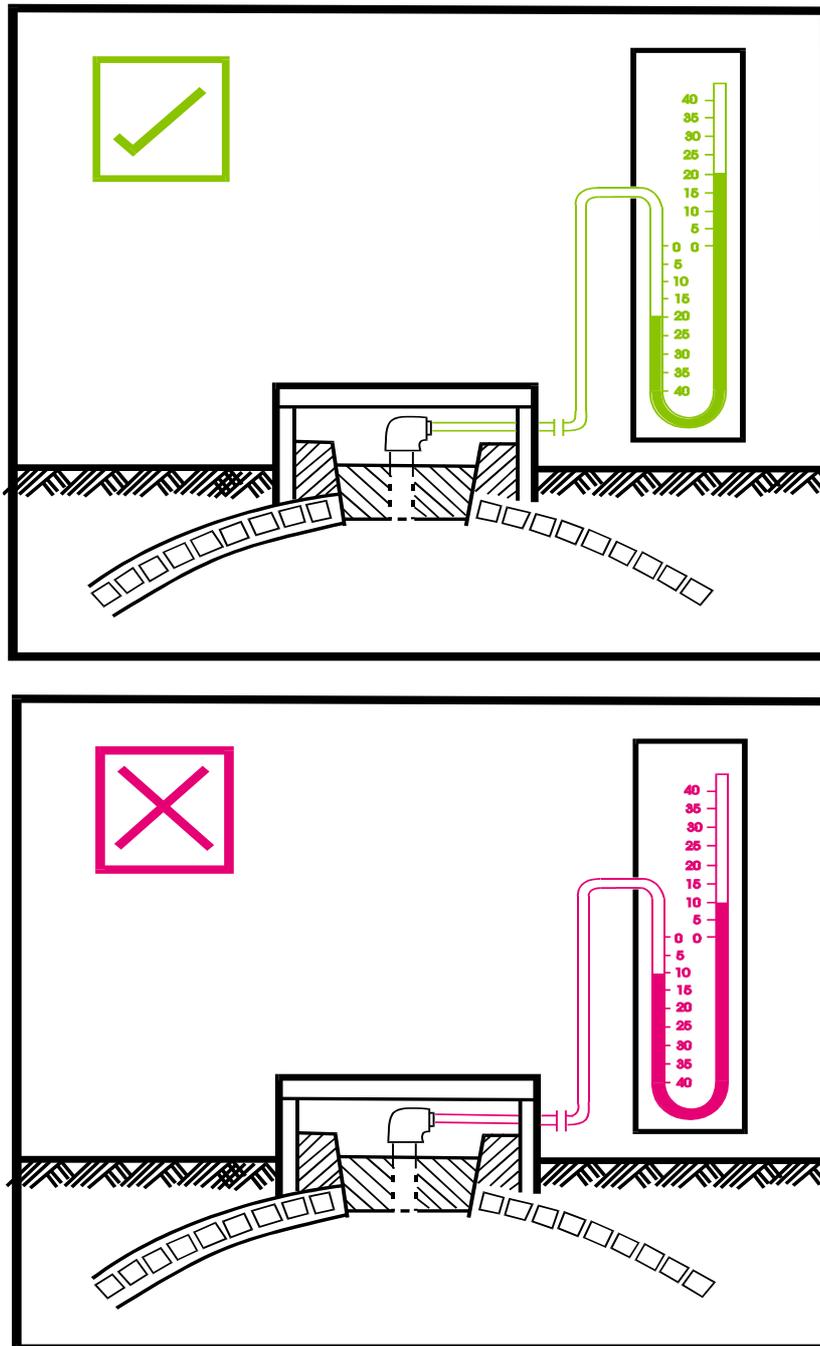


Figure 5.25 Manometer Testing

Notice If the gas pipe is already connected to the digester chamber, the chamber and pipe can be tested together by installing the mono meter. Close kitchen's valve and water trap valve then open valve at the digester chamber. Testing according to the above suggestion.

Chapter 6

Additional Information in Reactor Construction

6.1 Where to Fill in Animal Excrement?

The drainage alley must be built connected to the enclosure. The floor should be slightly arched polished. The excrement will flow easily and no residue will be left. Connect the alley to the inlet of the mixing chamber. There is a gate built at the mixing chamber for mixing the excrement and let it flow into the chamber (Figure 6.1).

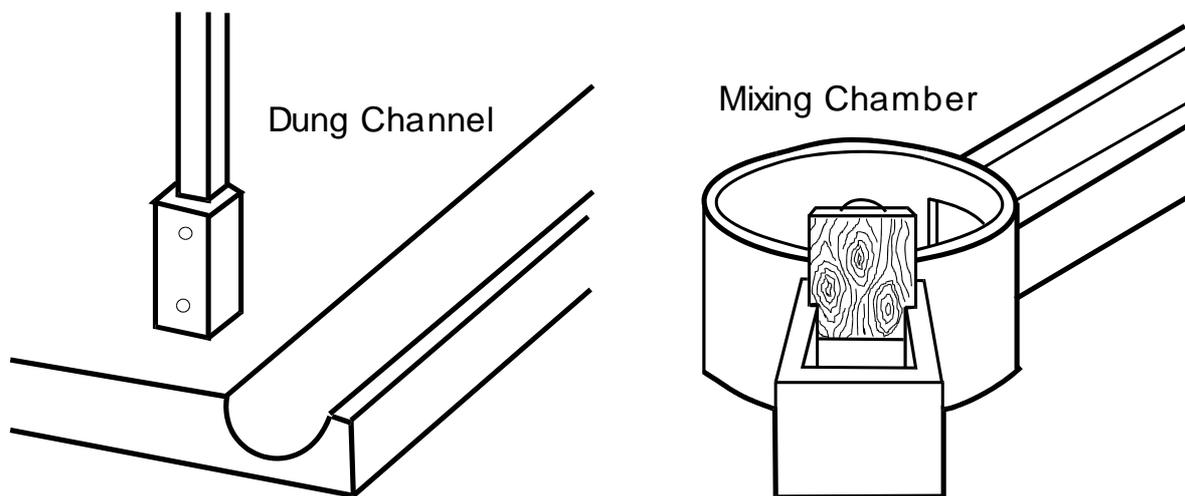


Figure 6.1 Dung channel & mixing chamber

6.2 Lids

Lids are required to prevent animal and rain water to fall in and also to keep it tidy. The lids are for

- ✱ Digester chamber
- ✱ Pit where the valve is installed for the digester chamber.
- ✱ Expansion chamber
- ✱ Water trap pit
- ✱ Storage tank

6.3 Storage Tank

Storage tank collects overflow manure from the expansion chamber. Manure in the storage tank can be used as fertilizer to improve soil by pouring over agricultural fields, fruit plantations grass. It prevents the manure from overflowing to the outside ground (Figure 6.2).

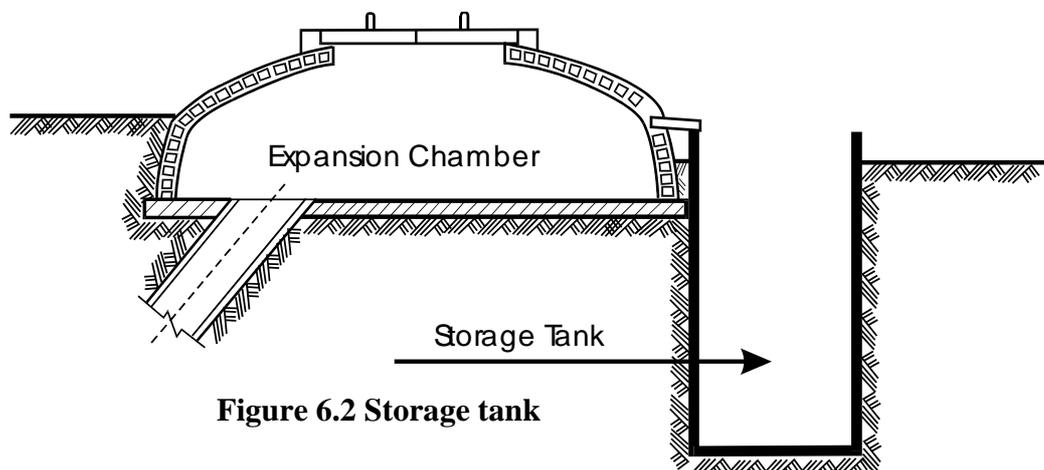


Figure 6.2 Storage tank

6.4 Addition of the First Animal Excrement

After the chamber is tested, animal excrement can be filled into the mixing chamber without releasing water. When the excrement is added, use the water from the expansion chamber to mix and stir until it become liquid slurry. Release the testing pressure by opening valve at the water trap. Let the air vent out until it is empty then close the valve. The manure will flow into the digester chamber. It is not recommended to fill up the top at one time so as to avoid the slow production of gas or decomposing. It should be added portion by portion until full. The first adding takes about 7 days as follows :

6.4.1 The first filling (first 7 days), use cow or buffalo excrement

	4.6 m ³	8 m ³	12 m ³	16 m ³	100 m ³ pig
Cow or buffalo excrement	330 liters	600 liters	800 liters	1200 liters	4,000 liters
Water	330 liters	600 liters	800 liters	1200 liters	8,000 liters

Notice If cow or buffalo excrement is not available, pig excrement is accepted by using half of the suggested quantity. After 2 weeks, add normally according to the manual.

6.4.2 Next filling, after the first 7 days, add excrement daily

	4.6 m ³	8 m ³	12 m ³	16 m ³	100m ³
Cow or buffalo excrement	38 liters	70 liters	100 liters	140 liters	833 liters
Water	38 liters	70 liters	100 liters	140 liters	833 liters
Pig excrement	25 liters	50 liters	70 liters	90 liters	660 liters
Water	50 liters	100 liters	140 liters	180 liters	1,320 liters

Gas will be produced within 2-3 days.

Notice Do not fill more than suggested because gas will cease. If filling too little, gas will be slowly produced.

6.6 Equipment Used in Construction

Description	4.6m ³	8 m ³	12 m ³	16 m ³
Grounded rocks or gravel ½ inch	2 m ³	2 m ³	3 m ³	4 m ³
Coarse sand	2 m ³	3 m ³	3 m ³	4 m ³
Fine sand	1 m ³	2 m ³	3 m ³	4 m ³
Brick size 7x17 cm tin 4.5 cm.	2,500 pcs	3,000 pcs.	4,200 pcs.	5,000pcs
Cement	22 bags	25 bags	35 bags	40 bags
Waterproofer	1 tin	1 tin	1 tin	1 tin
Lime	6 bags	8 bags	10 bags	15 bags
Lime replace	1 tin	1 tin	1 tin	1 tin
Concrete pipe diameter 10-12 inch	1 piece	1 piece	1 piece	1 piece
Concrete ring diameter 70 cm	2 pieces	2 pieces	2 pieces	2 pieces
Concrete ring diameter 80 cm (Storage tank)	2 pieces	3 pieces	3 pieces	3 pieces
PVC pipe diameter 6”(inlet and lower outlet)	1piece	1 piece	1 piece	1 piece
Handle set		1 set	1 set	1 set
Mono-meter		1 set	1 set	1 set

Equipment Used in Construction (continued)

Description	30m ³	50m ³	100m ³
Grounded rocks or gravel ½ inch	6 m ³	3m ³	10 m ³
Coarse sand	6 m ³	12 m ³	15 m ³
Fine sand	6 m ³	6 m ³	10 m ³
Brick size 7x17 cm tin 4.5 cm.	6,500 pcs	13,000pcs	18,000pcs
Cement	70 bags	120 bags	170 bags
Waterproofer	1 tin	1 tin	2 tin
Lime	15 bags	20 bags	30 bags
Lime replace	2 tin	3 tin	4 tin
PVC pipe diameter 10-12 inch	2 piece	3 piece	3 piece
Concrete ring diameter 70 cm	2 piece	2 piece	2 piece
Concrete ring diameter 80 cm (Storage tank)	3 piece	3 piece	3 piece
Handle set	1 set	1 set	1 set
Mono-meter	1 set	1 set	1 set

6.7 Summary of Ratio of Cement Mixture for Construction

Step of construction	Cement bucket	Water proofer	Lime bucket	Sand bucket	Gravel bucket
Base of digester and expansion chamber	1	-	-	2	4
Chamber walls	1	-	1/3	2.5	-
Back filling	1	-	-	2	4
Outer wall mortar	1	-	1/3	2.5	-
Weak ring	1	-	3	1.5	-
Strong ring	1	-	-	2	4
Mortar for Digester chamber bottom wall	1	-	1/3	2.5	-
Mortar for inner wall of digester dome – first layer	1	-	1/3	2.5	-
Mortar for inner wall of digester dome – second layer	1	-	1/4	2.5	-
Mortar for inner wall of digester dome – third layer	1	with	1/4	2.5	-
Polish mortar	1	with	-	-	-
Digester chamber neck	1	-	-	2	4
Digester chamber lid	2	-	-	4	-
Mortar for water trap pit	1	With	1/3	2.5	-

Notice

- Follow the instruction of lime replace on the label strictly
- 1/3 means in one bucket, divide the material into 3 parts and use only one part
- 1/4 means in one bucket, divide the material into 4 parts and use only one part

Caution

Do not use lime replacement when constructing the weak ring

6.8 Materials Used to Connect Gas Pipe per one Chamber

Description	Quantity	Remarks
1. 90° Iron joint	1 pc.	Use with lid
2. Iron joint diameter 1.5 “ reduce to 6/8 “	1 pc.	Use with lid
3. Hose holder 6/8“	2 pcs.	Use with lid
4. Water valve 6/8”	1 pc.	Use with outlet
5. Water valve 4/8 “	1 pc.	Use before connecting with stove
6. Water tap 4/8”	1 pc.	Use with water trap
7. Hose joint (brass)4/8” reduce to 3/8”	2 pcs.	Use with stove
8. Joint 6/8”	1 pc.	Use with tap
9. Joint 6/8”	2 pcs.	Use at the neck of the chamber
10. Joint 4/8” inner screw	2 pcs.	Use with tap
11. Joint 4/8” outer screw	2 pcs.	
12. T joint 6/8” reduce to 4/8”	1 pc.	To the kitchen
13. T joint 4/8 inner screw	1 pc.	Use with manometer pipe
14. Thick hose diameter 1”	1 ft	Use with the neck of the chamber
15. Gas hose	1 meter	Use with gas stove
16. Straight joint 6/8 reduce to 4/8	1 pc.	Use in the kitchen
17. Tape	2 roll	
18. Hose clamp 1”	2 pcs.	
19. Hose clamp 4/8”	3 pcs.	
20. PVC pip 4/8”	1 pc.	
21. PVC pipe 6/8”	Real quantity used	
22. Straight joint 6/8” and 4/8”	Real quantity used	
23. 90° joint 6/8” and 4/8”	Real quantity used	
24. Glue used with PVC pipe and clamp	Real quantity used	
25. Stove or equipment used with gas	Real quantity used	
26. Mono-meter	1 set	

Notice Use the same brand of PVC pipes, joints and glue.

6.9 Sand Bed Filter

Excavated soil 4 x 2.40 m x 95 cm deep from reference line to build a sand bed filter of sizes 8-16 m³. Pour cement to form a 6 cm high beam. Lay a course of bricks divided into 3 beds of size 1.20 x 2.20 m. On the length sides of each wall lay one brick horizontal to form an edge to wipe the manure. On the back of each brick is 70 cm lower than the reference line. Lay another course of bricks. Build a drainage alley connected between the sand bed filter and the outlet of the expansion chamber. This alley is parallel to the filter. The width of the alley is 20 cm and 2 cm deep from the outlet of the expansion chamber.

Make a small hole in the middle of each bed at the end of the sand bed filter. Insert a 2 inches PVC joint to let the filtered slurry flow out. Build an alley to connect to the end of the sand bed filter to let filtered water to drain out or to flow into the storage tank. When finished, face the concrete both inside and outside. Pour cement to cover each floor of the beds with 3 cm slope from the side into the middle and from the start of the sand bed filter to the end (Figure 6.3, 6.4).

Sand bed filter consists

First layer 10 cm thick of gravel or grounded rocks size ½ inch

Second layer Nylon mesh

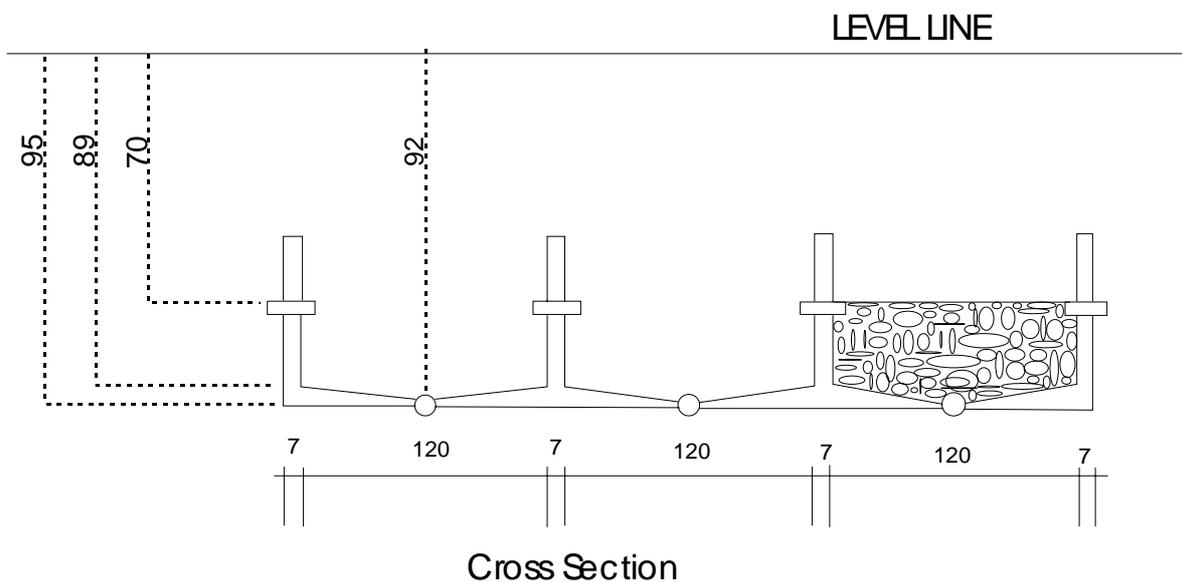


Figure 6.3 Sand bed filter

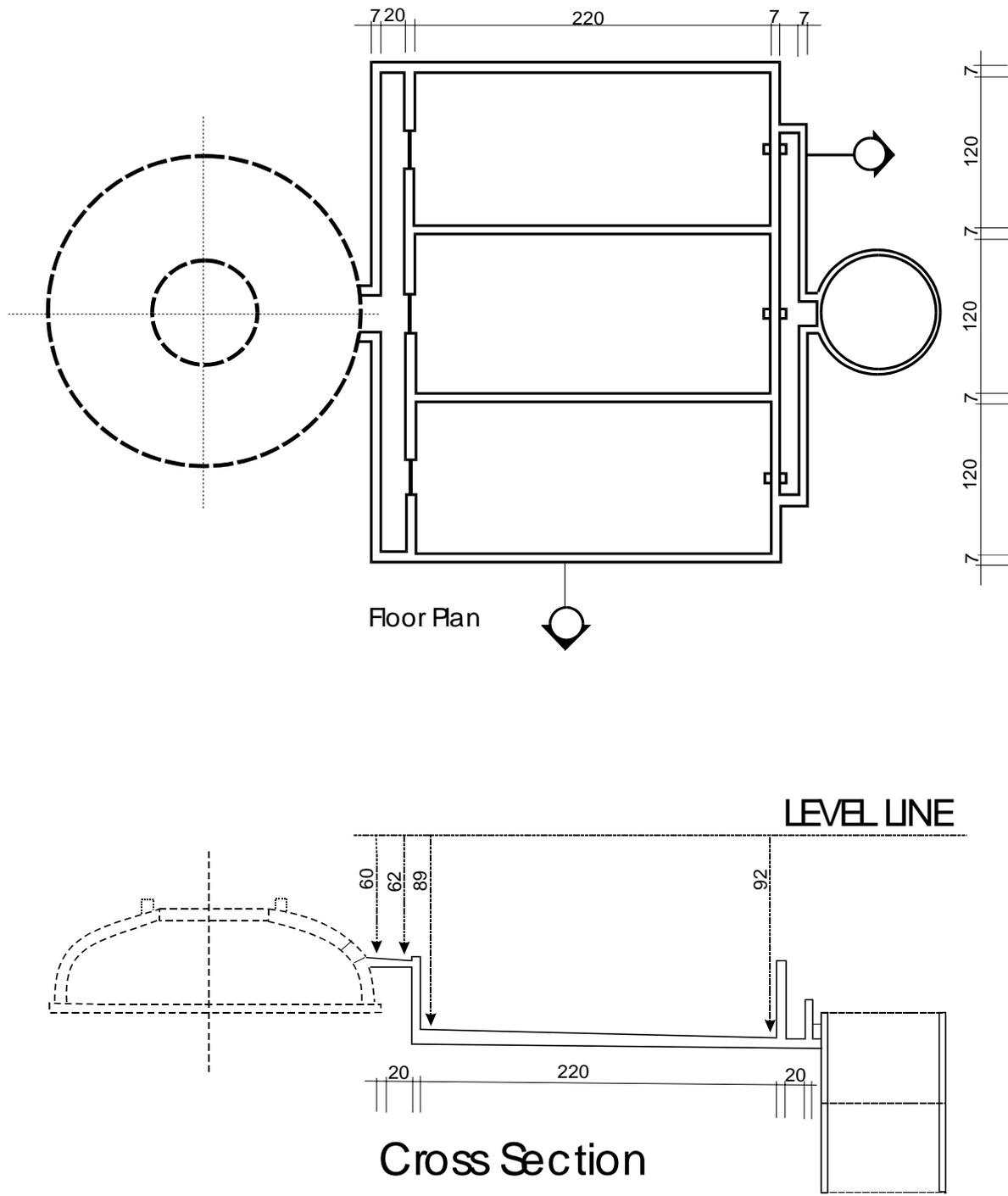
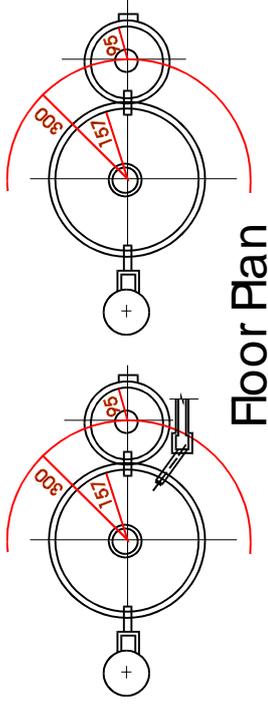


Figure 6.4 Sand bed filter

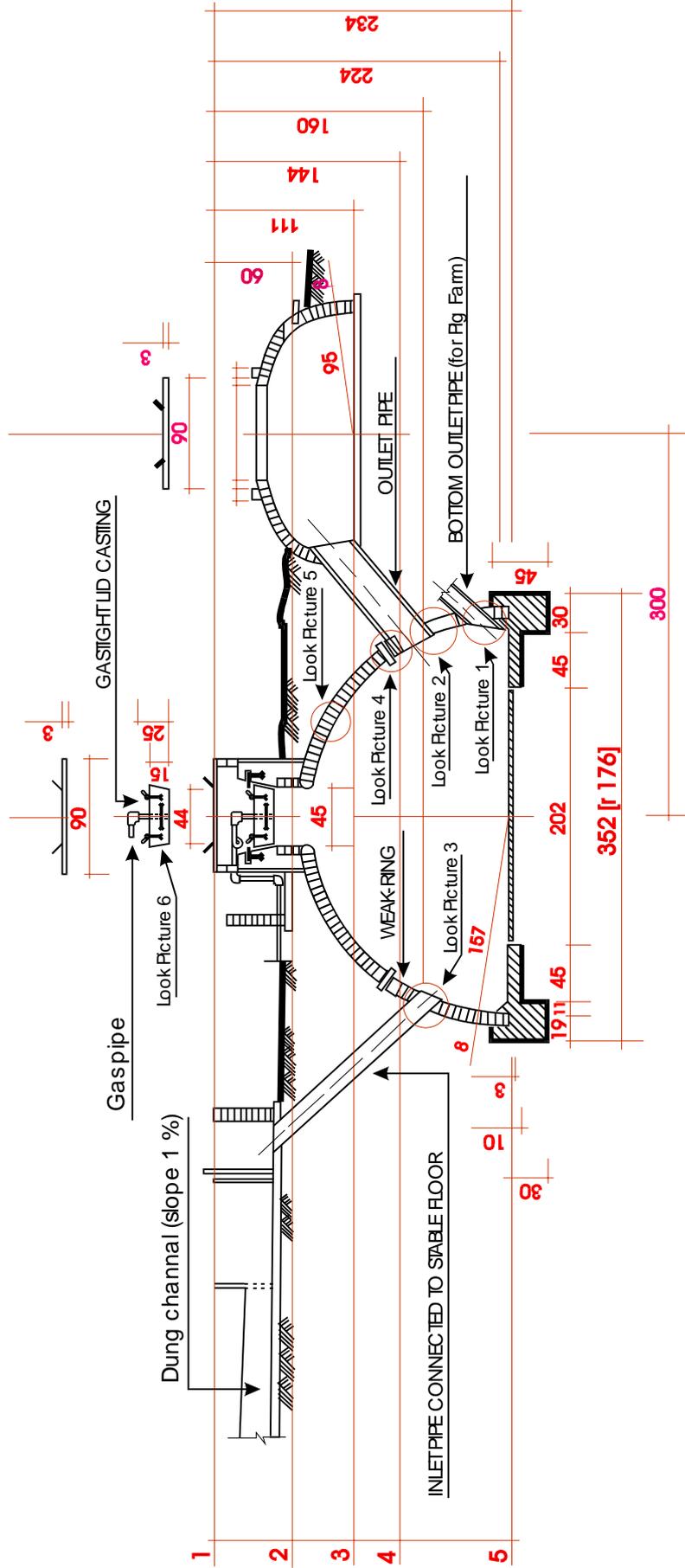
REMARK

- ① HORIZONTAL REFERENCE LINE 0 CM.
- ② HIGHEST SLURRY LEVEL 60 CM.
- ③ BOTTOM OF EXPANSION CHAMBER 111 CM.
- ④ LOWEST SLURRY LEVEL, WEAK RING 144 CM.
- ⑤ BOTTOM LINE 234 CM.

Size 8 m³

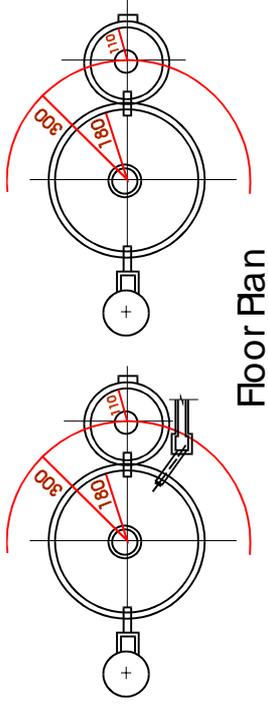


Floor Plan

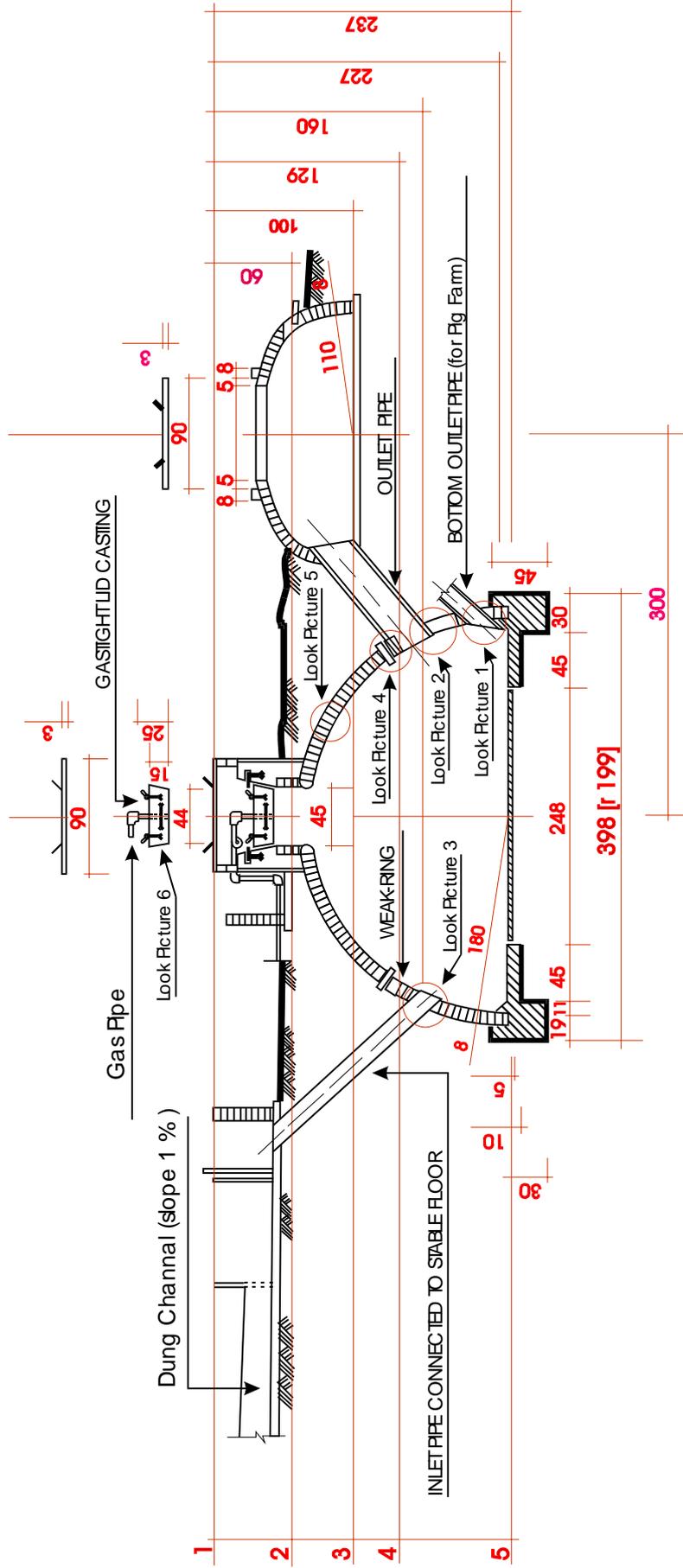


REMARK

- ① HORIZONTAL REFERENCE LINE 0 CM.
 - ② HIGHEST SLURRY LEVEL 60 CM.
 - ③ BOTTOM OF EXPANSION CHAMBER 111 CM.
 - ④ LOWEST SLURRY LEVEL, WEAK RING 144 CM.
 - ⑤ BOTTOM LINE 234 CM.
- ALL DIMENSION IS CENTIMETER

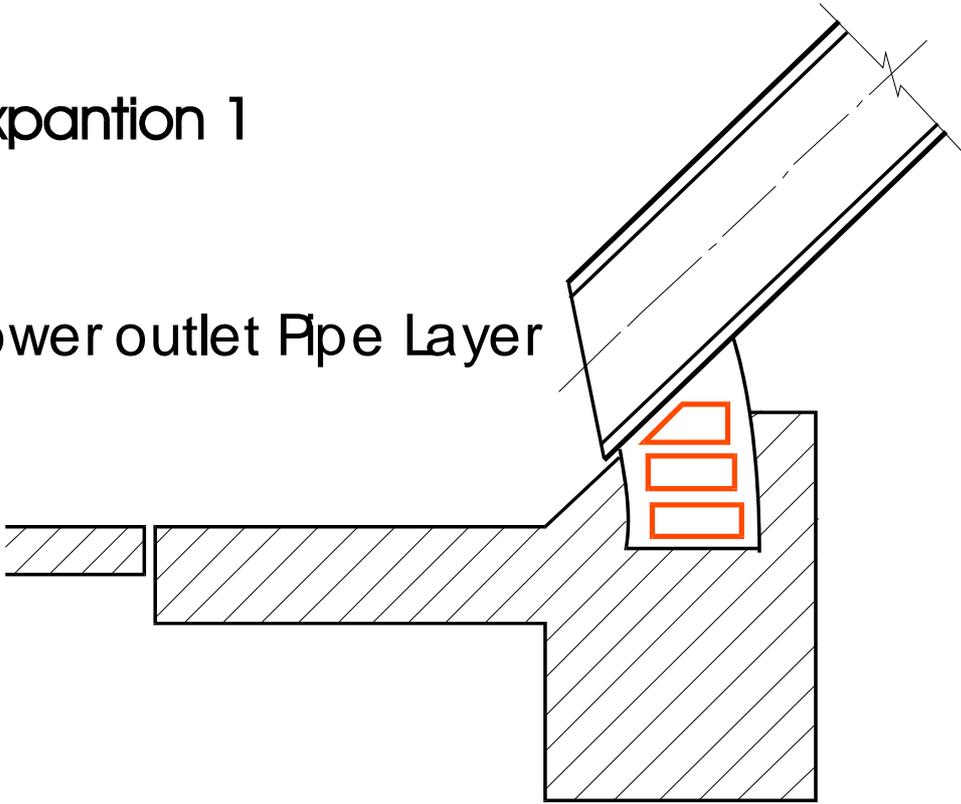


Floor Plan



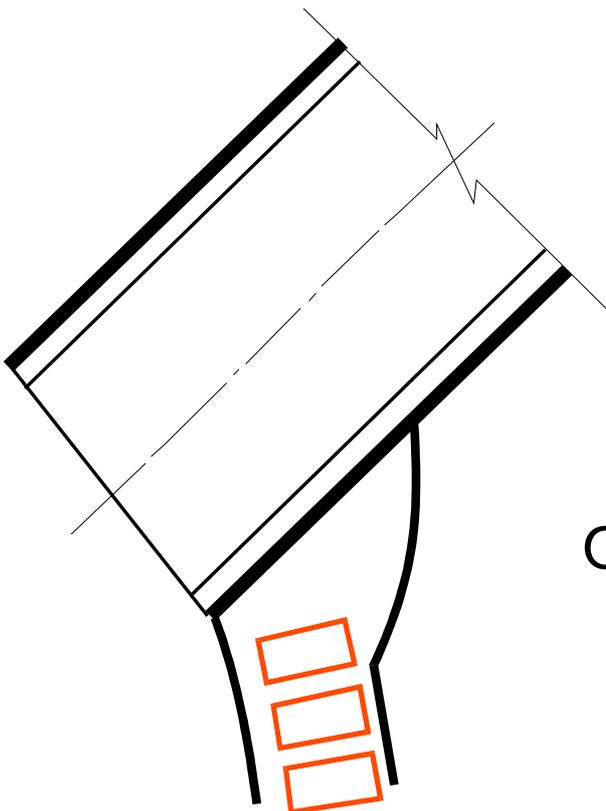
Expantion 1

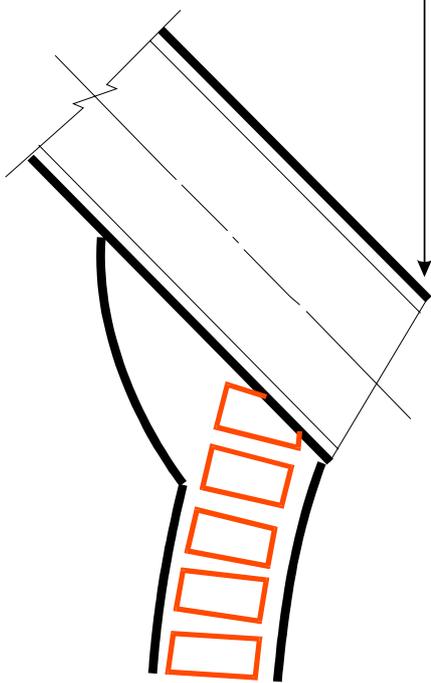
Lower outlet Pipe Layer



Expantion 2

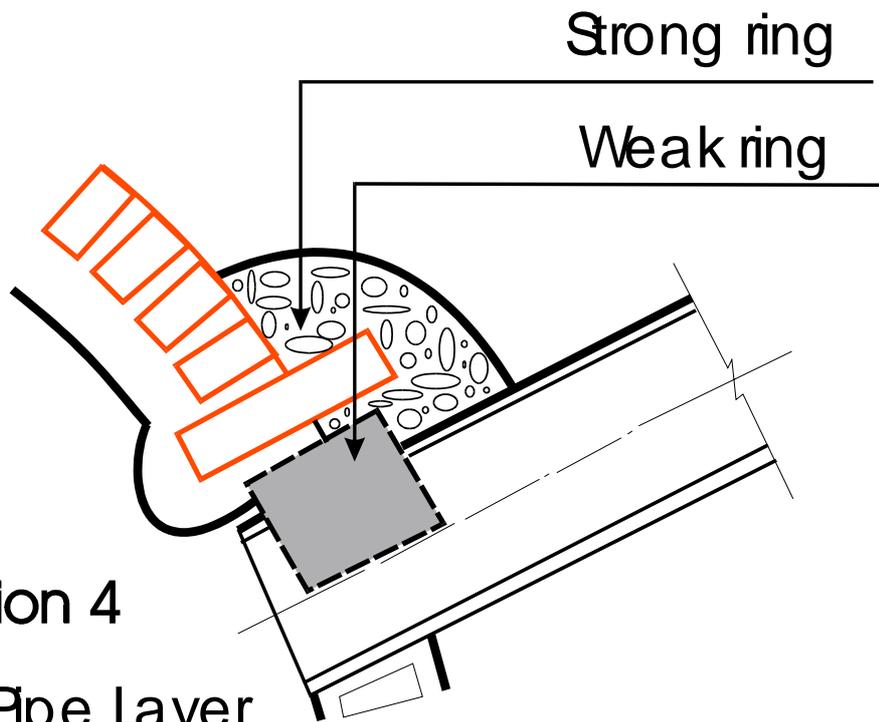
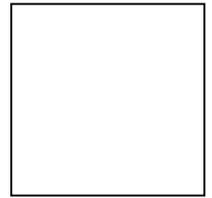
Outlet Pipe Layer





Expansion 3

Inlet Pipe Layer



Strong ring

Weak ring

Expansion 4

Outlet Pipe Layer

Weak ring

Strong ring

Expansion 5 Inside Plastering

