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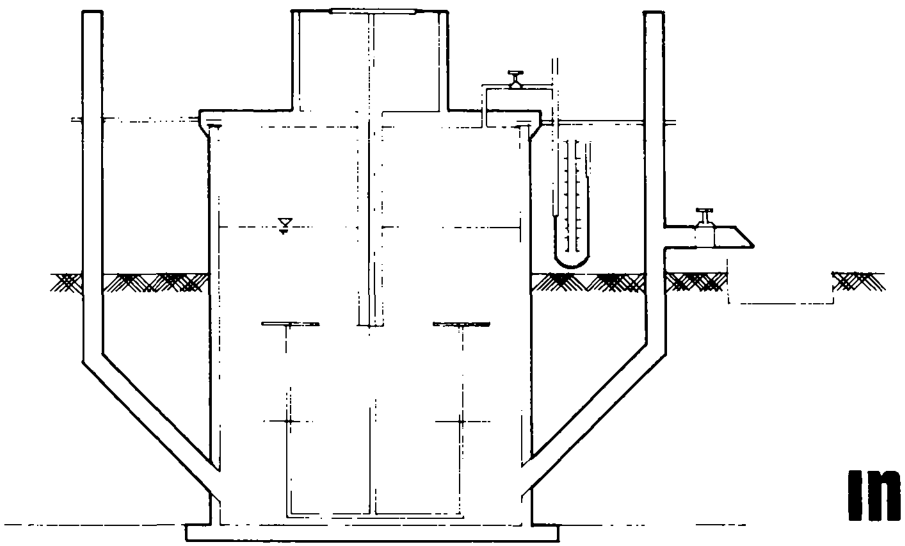
DO IT YOURSELF SERIES

Booklet Number 6

FERROCEMENT BIOGAS DIGESTER



INTERNATIONAL FERROCEMENT INFORMATION CENTER

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Contents

Foreword

Biogas production is a waste management technology that utilizes human, animal and agricultural wastes for methane generation. It has attracted considerable attention in view of its potential for waste recycling, pollution control and improvement of sanitary conditions, in addition to providing fuel energy and fertilizer. Widespread generation and use of biogas depend largely on the availability of inexpensive and appropriate plant designs which can be constructed with locally available materials and skills.

The International Ferrocement Information Center, as part of its efforts in accelerating the transfer of ferrocement technology to the rural areas of developing countries, has undertaken the publication of a series of "Do it yourself" booklets since 1979. This booklet, the sixth in the series, explains biogas production technology and the construction of the ferrocement biogas digester developed at the Asian Institute of Technology.

We hope that this effort will contribute to the improvement of the living conditions of many people in the developing countries.

The Director

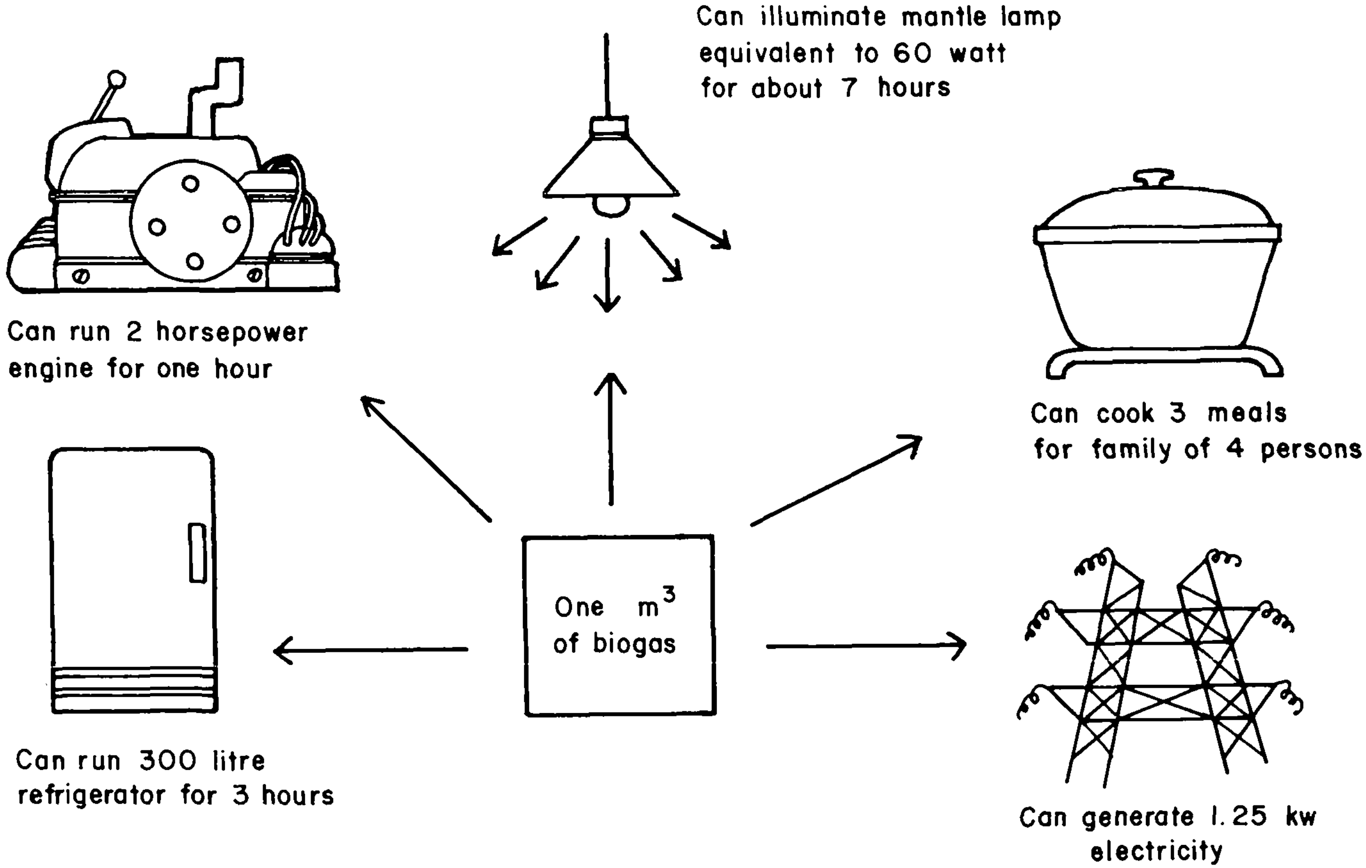


Fig. 1 Possible applications of biogas

Introduction to Biogas

Definition of Biogas

Biogas is a colorless, odorless and inflammable gas produced by the decomposition of organic matter by micro-organisms in the absence of oxygen. It is a mixture of methane gas, carbon dioxide and traces of other gases [1].

Uses of Biogas

Gas is primarily used for cooking and lighting. Lighting is justifiable only if electricity is not available as lighting consumes gas inefficiently and regular attention is required to keep lamps burning well. Gas could also be used for running engines, refrigerators and incubators [2]. The possible applications of biogas are illustrated in Fig. 1. Volumetric requirements for the various applications of methane are given in Table 1 [3]. The advantages and disadvantages of biogas are:

Advantages:

1. Improved sanitation resulting in better health.
2. Better fertilizer resulting in better crops.
3. Clean, fast cooking fuel.
4. Better lighting.
5. Less time consumed than collecting firewoods.

Table 1 Volumetric requirements for the various applications of methane+

Application	Rate of use	Amount (m^3)
Cooking	5 cm dia. burner/hour	0.3256
	10 cm dia. burner/hour	0.4672
	15 cm dia. burner/hour	0.6371
	per person/day	0.339 - 0.4247
	boiling 4.546 liters of water	0.283
Lighting	1 mantle lamps/hour	0.071 - 0.085
	2 mantle lamps/hour	0.140
	3 mantle lamps/hour	0.167
Refrigerator	Flame operated, 0.028 m^3 per hour per 0.028 m^3 of refrigerator space (1 cft/hour/1 cft refrigerator space)	0.034
Incubator	0.028 m^3 per 0.028 m^3 of incubator space (1 cft/hour/1 cft incubator space)	0.014 - 0.02
Gasoline Engine*		
CH4	per brake horse power/hour	0.312
Biogas	per brake horse power/hour	0.453
Equivalent to		
(a) Gasoline		
CH4	per 4.546 liters (gallon)	3.82 - 4.53
Biogas	per 4.546 liters (gallon)	5.09 - 7.07
(b) Diesel Oil		
CH4	per 4.546 liters (gallon)	4.25 - 5.32
Biogas	per 4.546 liters (gallon)	5.66 - 7.87

* at 25% efficiency

\+ Data from reference [3]

Disadvantages:

1. High initial capital outlay.
2. Requires enough livestock to give sufficient amount of wastes.
3. Requires water which sometimes is not readily available.

Production of Biogas

The production of biogas or fermentation is a function of bacteria and organic matter.

1. Bacteria are the single celled organism that feed on rich, organic matters in order to multiply.
2. Organic matter is the material from which all living organisms are made of. Organic matter used in the production of biogas may include: human and animal wastes, leaves, twigs, grasses, stalks from crops, algae and other agricultural waste.

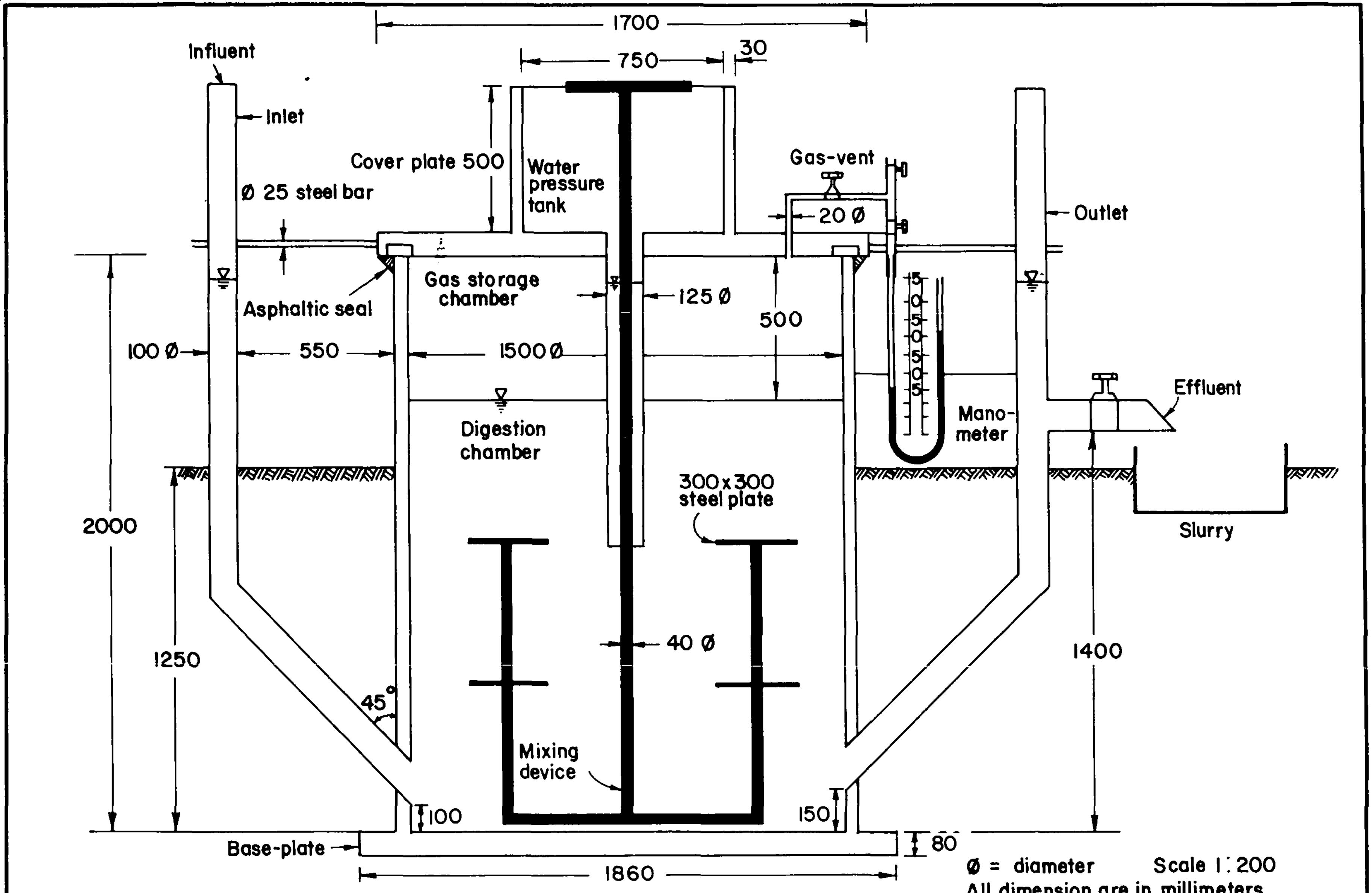


FIG. 2 AIT FERROCEMENT DIGESTER

Biogas Plant

Parts of a Biogas Plant

The biogas plant has two main parts (Fig. 2):

1. The digester/digester chamber where the biogas fermentation of the organic matter occurs.
2. Gas holder/gas storage chamber where the biogas is collected and stored. (Refer to Do it Yourself Booklet No. 3 - Ferrocement Biogas Holder).

The Digester

Digesters can be designed either batch or continuous operation. In batch digester system, the organic matter is only replaced when the biogas production has stopped. Regular supply of gas may be obtained by maintaining several digesters at different stages of digestion process. In continuous operation, fresh slurry is fed everyday to the digester. Continuous digester is more efficient and has higher gas production rate per unit digester volume than batch operation.

Fig. 3 Ferrocement biogas digesters at AIT.

Design Guidelines

Design Selection

Many gas plant designs can be found in various publications. Care should be taken in adapting these designs. When selecting a design the following factors need to be considered:

1. Availability of construction materials and skills.
2. Cost of materials.
3. Type of soil.
4. Raw materials available.
5. Knowledge and experience of the person utilizing the gas plant.

The digester discussed is the ferrocement digester developed at the Asian Institute of Technology. This digester has been successfully used for biogas and biomass production (Figs. 2-5).

Size Selection

The factors which influence the size selection are:

1. Amount of raw materials available (Table 2).
2. Quantity of gas required (Table 3).
3. Capital available.
4. Calculated retention time - retention time is the minimum time frame for optimum bacterial decomposition to take place to produce biogas and to destroy many toxic pathogens.

Fig. 4 Four 3.5 m^3 ferrocement digesters adjacent to four fish ponds (dimensions – 10 m wide, 20 m long and 1 m deep). The slurry from the digesters was collected and stored in a 1 m^3 storage tank to make a composite slurry sample prior to feeding.

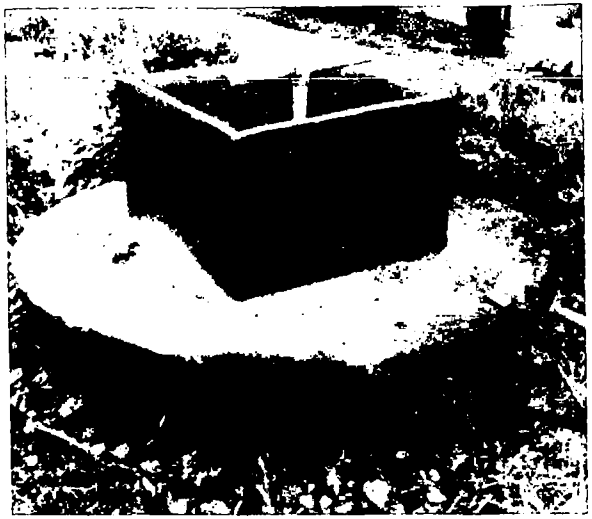


Fig. 5 Close up of the ferrocement biogas digester.

Table 2 Average Daily Gas Production Based on Head Count*

Source of Waste	Waste Production kg/d	Gas Production m^3/d
1 buffalo or European cow	15	0.50 - 0.74
1 Zebu cow	10	0.25 - 0.40
1 calf	5	0.15 - 0.25
1 pig	2.5	0.05 - 0.10
10 chicken		0.02 - 0.04
1 latrine use	1	0.02 - 0.03
1 sheep/goat		0.02 - 0.04

* Data from reference [4]

Site Selection

1. Locate near the source of raw material.
2. Locate near the place where the gas will be used - not more than 50 m away from point of gas consumption.
3. Site must be open and exposed to sunlight to hasten fermentation.
4. Locate far from drinking water source but close to water supply.
5. Site must have enough space for slurry storage. The slurry has to be exposed to air, stored or dried.
6. Site should have suitable foundations.
7. Site should not be easily submerged by water. Water table location will determine whether digester could be constructed underground or above ground.

Table 3 Average Gas Production Based on Waste Amount

Source of Waste	Gas Production	
	m^3/1,000 kg animal*	m^3/1,000 kg waste**
Dairy Cattle	2.53	-
Beef Cattle	2.47	-
Cattle (Cows & Buffaloes)	-	22 - 40
Pig	2.69	40 - 60
Poultry	6.92	65.5 - 115
Pretreated Crop Waste	-	40 - 40
Water Hyacinth	-	40 - 50

* of live weight [5]

** Apparently of fresh weight [2]

Materials Specifications

Cement: Use ordinary Portland Cement Type I and II for tropical countries, Type III for cold climates.

Sand:

1. Use well graded sand. Sand too fine or too coarse are not suitable.
2. Separate sand from stone using 6.4 mm (¼ inch) mesh screen.
3. No organic or chemical impurities. If quality is in doubt, wash with clean water.
4. Desirable sand grading if seives are available.

Sieve	Percent passing
3/4 in (9.50 mm)	100
No. 4 (4.75 mm)	95 to 100
No. 8 (2.36 mm)	80 to 100
No. 14 (1.18 mm)	50 to 85
No. 30 (600 µm)	25 to 60
No.100 (150 µm)	2 to 10

Water:

1. Water fit to drink is suitable.
2. Salty water should never be used.

Wire mesh:

1. Must be easily handle and flexible enough to be bent around corners.
2. Galvanized wire preferred as it is less likely to rust or corrode.
3. Use 0.5 mm to 1.00 mm diameter with 10 mm to 25 mm mesh opening.

4. Free from grease, oil, rust or anything that might reduce bond.

Skeletal steel:

1. Free from grease, oil detergents, organic matter, cracks or blow holes.
2. Bars are acceptable if no cracks appear after the following field test: "Bend bar into U shape and then straighten it out. Bend it again into U shape and straighten out".

Tie wire:

Use annealed (soft) galvanized wires of 24 or 26 gage. Cut pieces of wires from the meshes could also be used for tying.

PVC pipes:

1. Use good quality pipes with minimum diameter of 100 mm for inlet, outlet pipes and drainage pipes.
2. Use 20 mm diameter for gas vent; 125 mm diameter for inlet of mixing device.
3. Free from crack, junctions, holes and broken edges.

Steel accessories:

1. Use good quality steel pipe for mixing device.
2. Check weld connection of steel disks.
3. Use 4 of 5 mm thick steel plates (300 mm x 300 mm)
4. Use 25 mm diameter steel bars as stay for the inlet and outlet pipes.
5. Free from grease, oil, detergents, organic matter, cracks or blow holes.

Construction Procedure

I. Materials and Tools

Prepare all materials (Table 4) and tools (Fig. 6) needed for the construction of digester including the following accessories.

1. 100 mm diameter PVC pipe for inlet and outlet pipes.
2. 125 mm pipe guide and socket for the mixing devices.
3. 20 mm diameter PVC pipe for gas-vent.
4. 25 mm diameter stay bars.
5. 40 mm diameter steel pipe for mixing device.
6. Four 5 mm thick steel plates (300 mm x 300 mm)
7. Three air flow control valve.
8. One effluent gate valve.
9. Glass rod: two 1 m long and one 0.30 m long.
10. Plastic tube to fit into glass rod: two 0.5 m long.
11. Plywood of 1 m width and 1.5 m length.
12. One ordinary water bottle.

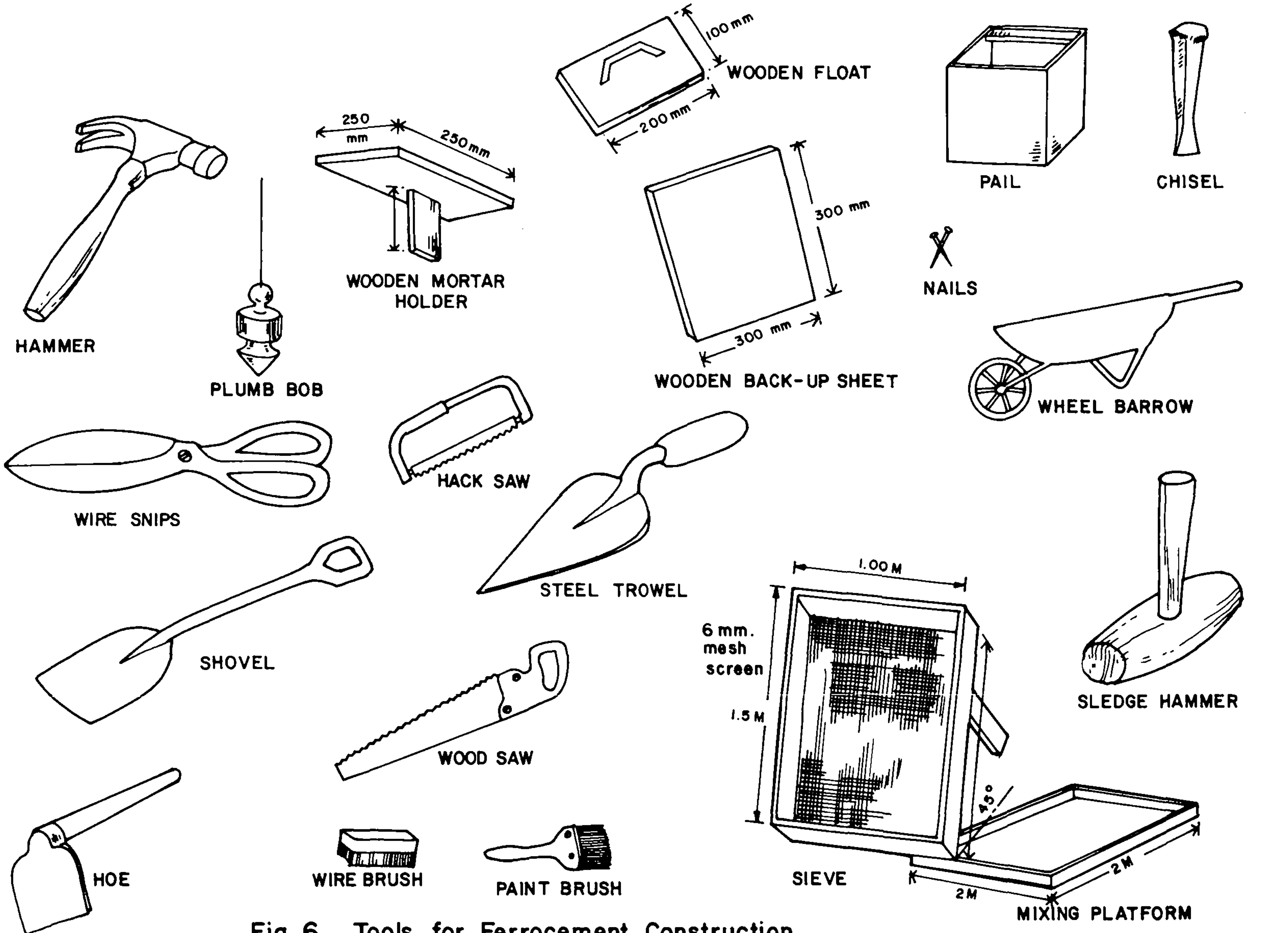


Fig. 6 Tools for Ferrocement Construction

Table 4 Cost Estimation of the Ferrocement Digester (3.5 m^3)

Item	Quantity reqd.	Unit Cost ฿	Cost ฿
a. Ferrocement Wall & Pressure Tank			
Portland Cement	380.0 kg	1.70	646.00
Sand	0.4 m^3	200.00	80.00
Wiremesh	22.5 m^2	20.00	450.00
Steel Bars	61.5 kg	9.00	553.00
Sub-Total			1729.00
b. R.C. Base and Lid			
Mortar	0.4 m^3	1600.00	640.00
Steel Bars	130.0 kg	9.00	1170.00
Sub-Total			1810.00
c. Labor			
Skilled	20.0	25.0	500.00
Unskilled	80.0	15.0	1200.00
Sub-Total			1700.00
d. Misc.			
Coating			250.00
Accessary Piping			500.00
Sub-Total			750.00
TOTAL			5989.00

* 1US$ = ฿28.00, Cost figures in March 1985 for Thailand

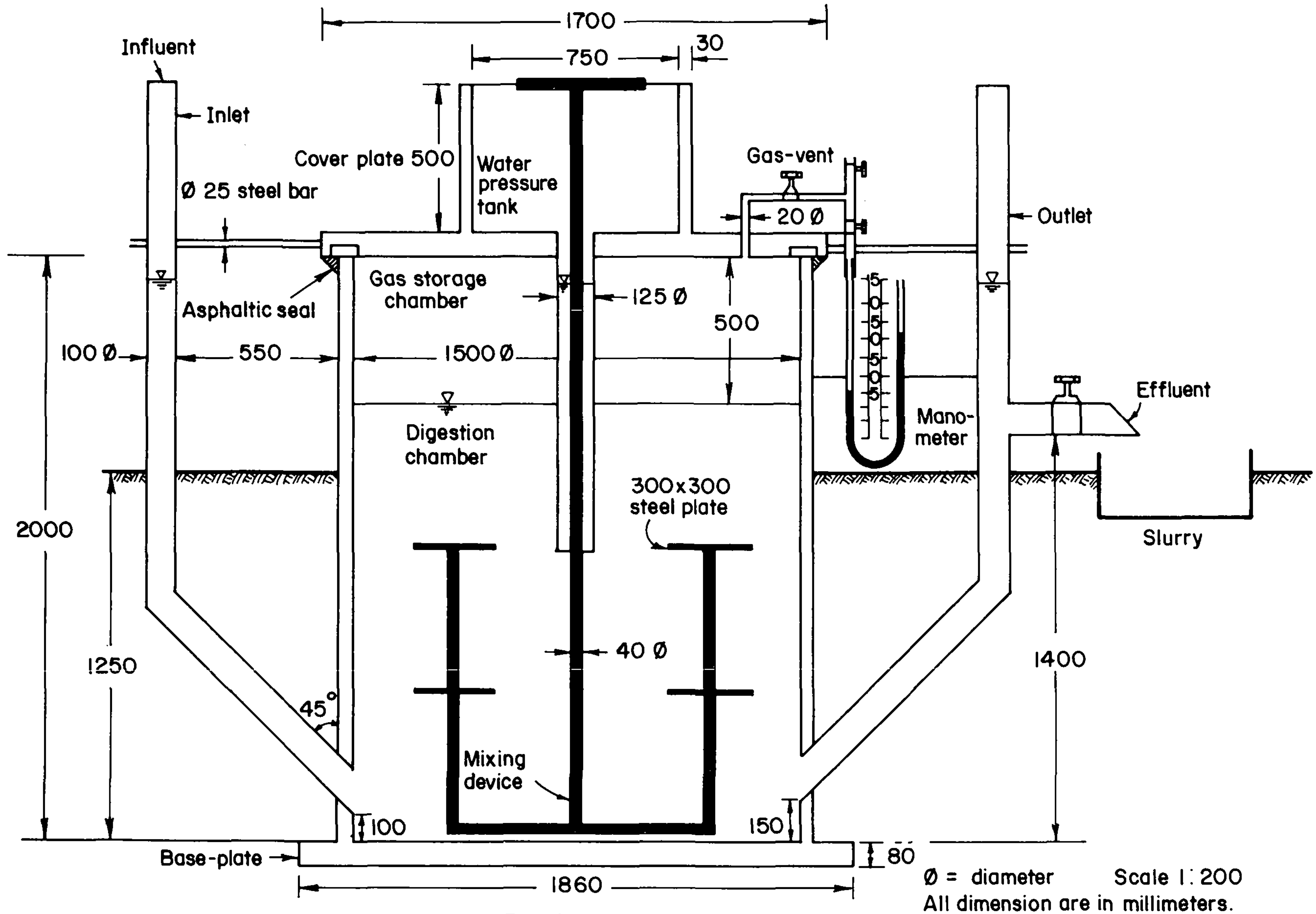


FIG. 7 AIT FERROCEMENT DIGESTER

Fabricate all accessories as shown in Fig. 7.

1. Mixing device by welding.
2. Inlet and outlet pipes by welding.
3. Gas-vent by welding.
4. Guide pipe socket for mixing device. Grooved one of the ends of the socket to facilitate attachment of the guide pipe. Weld a 20 mm lid to the socket.
5. Guide pipe for mixing device. Grooved one end of the 10.6 m long pipe.

II. Site Preparation

1. Select site on soils with adequate bearing capacity considering all factors.
2. Excavate a hole of about 1.5 m deep and 3.3 m in diameter.
3. Lay sand about 250 mm thick for a diameter of 2.0 m and compact firmly.

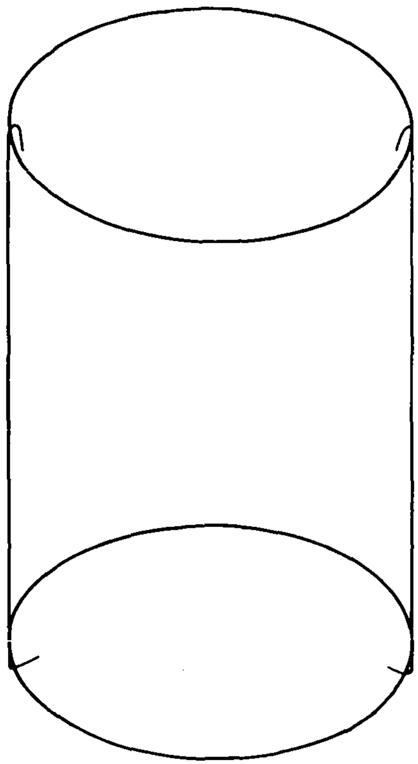


Fig. 8

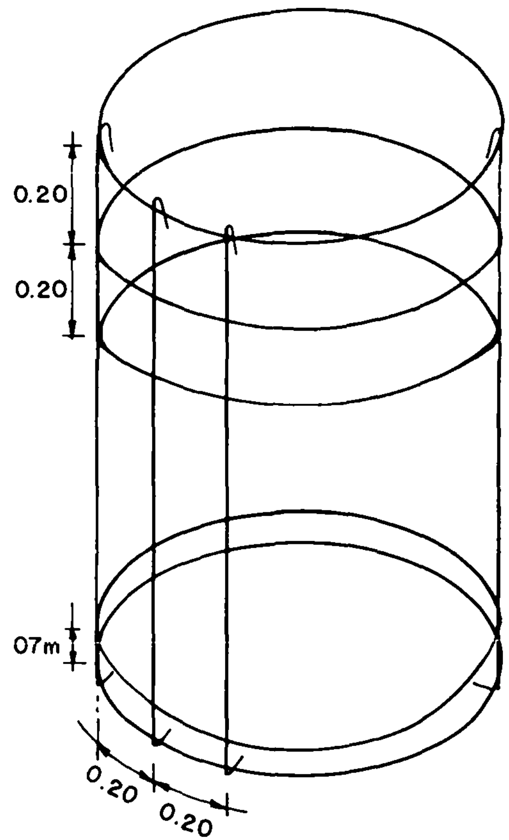


Fig. 9

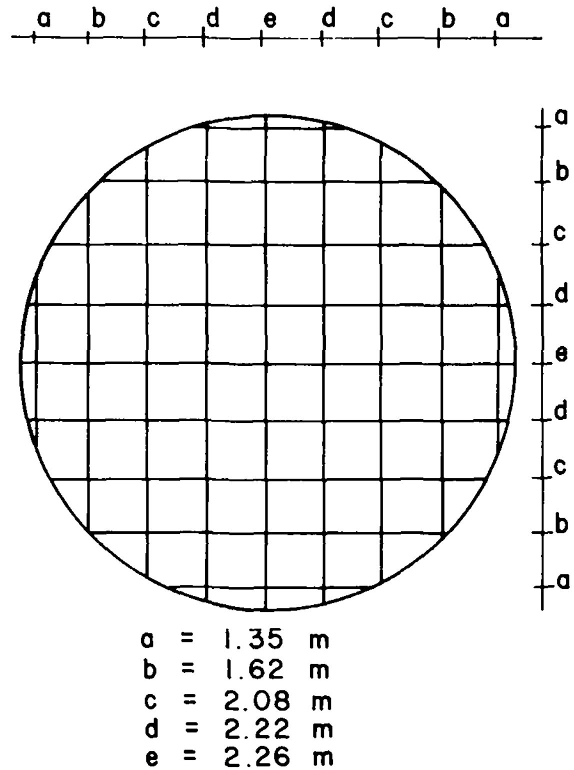


Fig.10 Base reinforcement plan

III Fabrication of the Reinforcement Cage

A. Reinforcement Cage for the Digester Cylinder

1. Cut the 9 mm diameter steel bars into specified length:

   Vertical bars : 27 at 2.40 m
   Circumferential bars : 12 at 5.60 m

   Base reinforcement is a square grid so the length varies as follows: "a" 8 bars at 1.35 m; "b" 8 bars at 1.62 m; "c" 8 bars at 2.08 m; "d" 8 bars at 2.22 m and "e" 4 bars at 2.26 m.

2. Bend bars to proper profiles: bend both ends of vertical bars and base reinforcement by 0.20 m as shown in Fig. 8. Provide overlap for circumferential bars of 0.20 m.

3. Tie two vertical bars to circumferential bars at the base level and another at the roof-wall joint level (Fig. 8).

4. Subsequently the 25 vertical bars are tied at the base and roof-level circumferential bars at 0.20 m interval (Fig. 9).

5. Tie the ten remaining circumferential bars along the height of the wall from the top at 0.20 m interval (Fig. 9).

6. Base reinforcement: Bend bars to proper profiles. Fabricate the first layer of reinforcing steel, 9 mm in diameter, at 0.20 m interval in any two orthogonal directions and tie at intersecting points (Fig. 10). Repeat to fabricate the second layer.

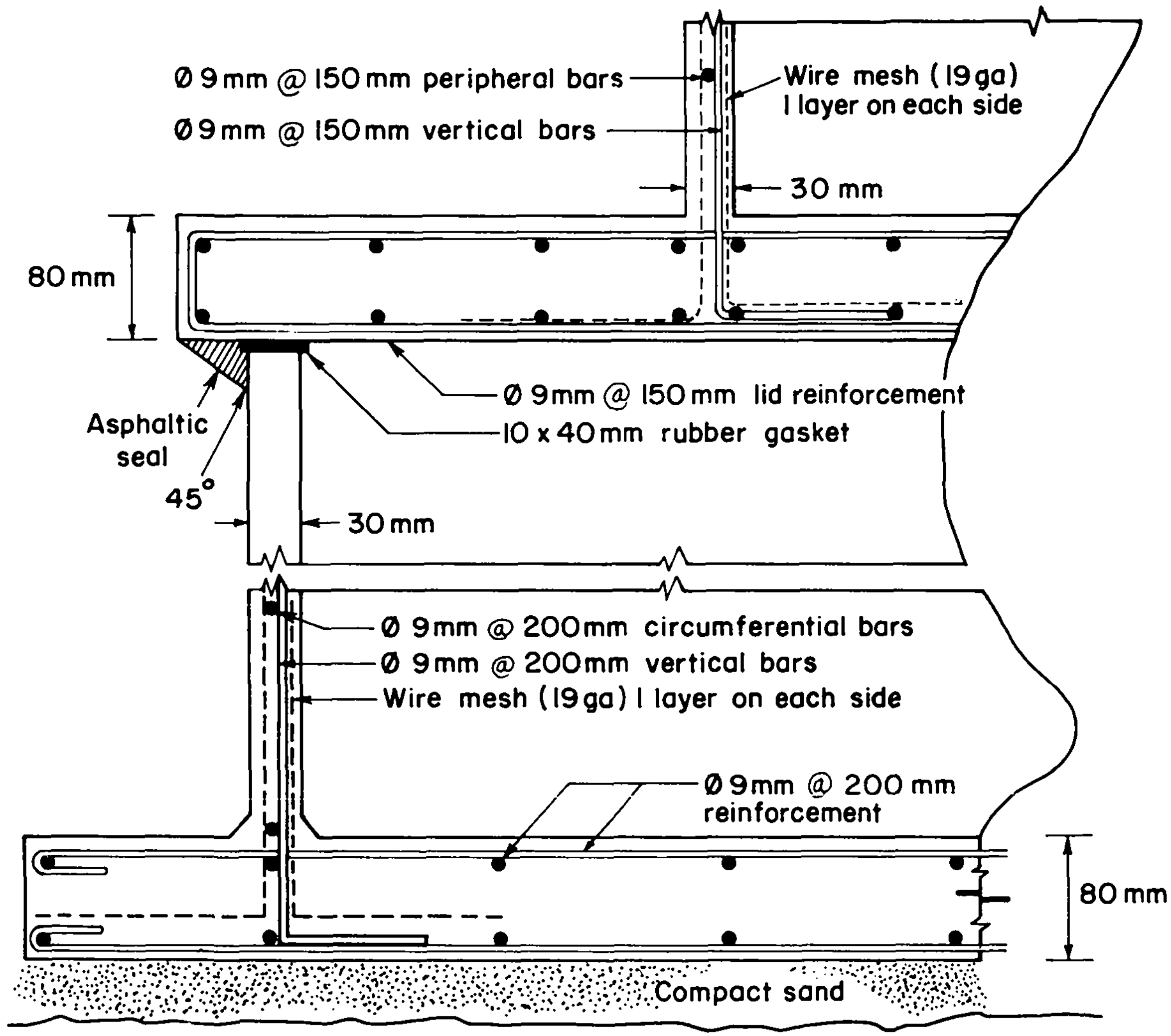


Fig. 11 Structural details of the ferrocement biogas digester

7. Tie the first layer of the base reinforcement to the vertical bars at 60 mm distance from the bottom. Tie the second layer at the bottom of the vertical bars (Fig. 11).

8. Use two layers of wire mesh, wrap one layer on each side of the skeletal steel frame. To ensure proper profile and compactness of reinforcements, these mesh layers should be tied at 0.20 m interval along the vertical and circumferential directions stretching the meshes taut. Care should be taken to provide at least 10.0 mm overlap of meshes at the joints. The two layers should be staggered in such a way that the effective opening size is reduced to half of the individual mesh opening (Fig. 12). The misalignment provides for a more uniform distribution of reinforcement as well as a superior bond for the mortar while plastering.

9. Extend the wire mesh into the base and bend 0.20 m to provide continuity.

B. Reinforcement Cage for the Water Pressure Tank and Lid (fabricate this cage during curing of the digester wall).

1. Cut the 9 mm diameter bars into specified length:

Vertical bars :	12 at 0.90 m
Peripheral bars :	5 at 3.20 m
Lid reinforcement:	"a" 8 bars at 1.20 m
	"b" 8 bars at 1.60 m
	"c" 8 bars at 1.80 m
	"d" 8 bars at 2.00 m
	"e" 8 bars at 2.07 m
	"f" 8 bars at 1.00 m.

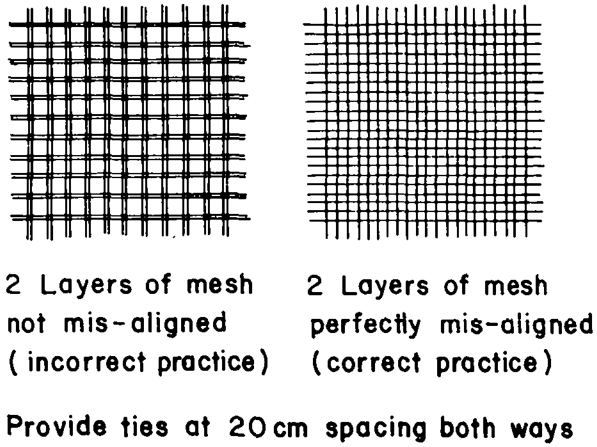


Fig.12 Laying of meshes

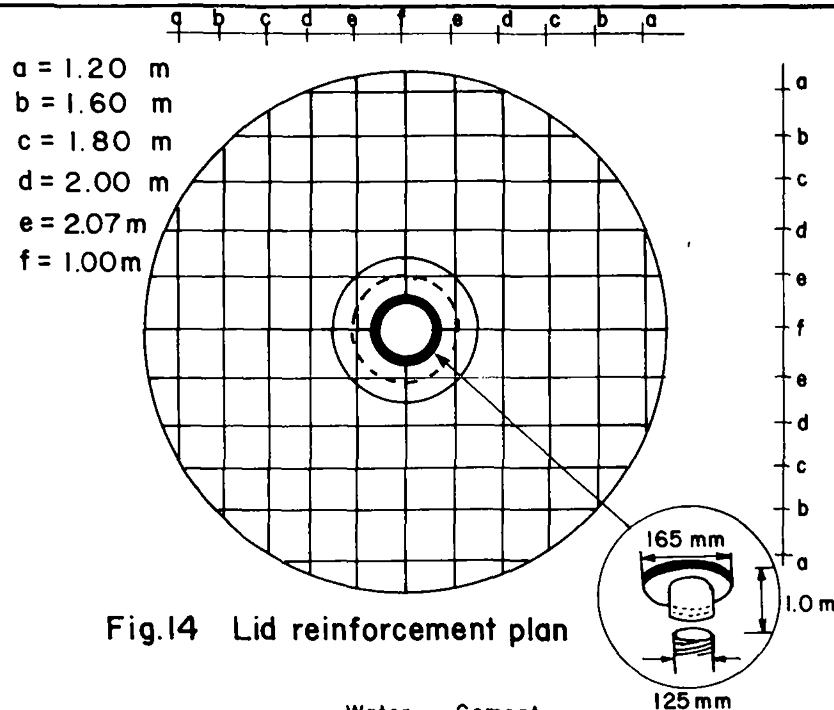


Fig.14 Lid reinforcement plan

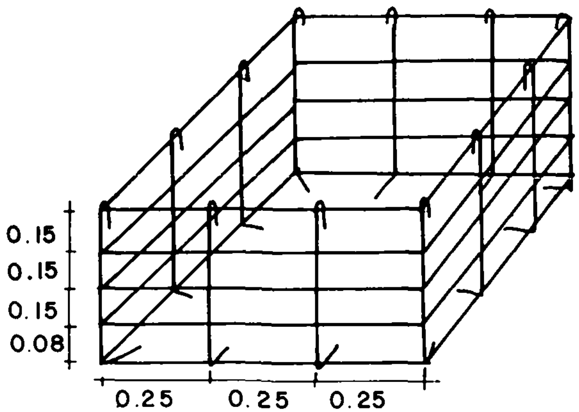


Fig.13 Reinforcement of water pressure tank

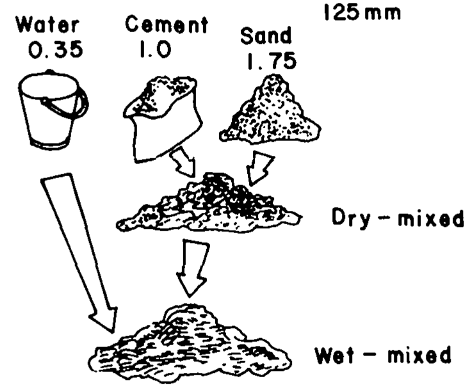


Fig.15 Mortar mix

2. Bend bars to proper profiles : Bend both ends of vertical and peripheral reinforcement as shown in Fig. 13. Bend the peripheral bars into a square of 0.75 m sides with 0.20 m overlap.

3. Tie vertical bars at the corners of the peripheral bars, one at the top and another at the base. Subsequently, tie vertical bars at 0.25 m intervals (Fig. 13).

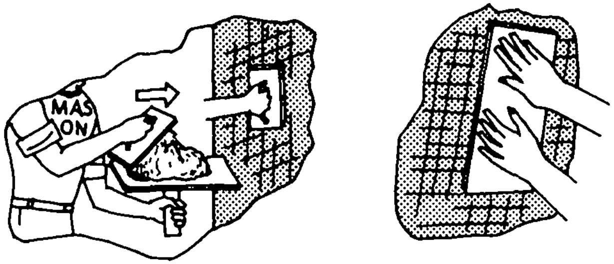
4. Tie the three remaining peripheral bars along the height from the top at 0.15 m interval (Fig. 13).

5. Lid reinforcement : Bend bars to proper profiles. Fabricate the first layers of reinforcing steel, 9 mm in diameter at 0.15 m intervals in any orthogonal directions and tie at intersecting points (Fig. 14). Repeat to fabricate the second layer.

6. Tie the first layer of the base reinforcement to the vertical bars at 60 mm distance from the bottom. Tie the second layer at the bottom of the vertical bars (Fig. 11). Position the inlet pipe socket (Fig. 14) and weld the ends of reinforcement "f" to the pipe.

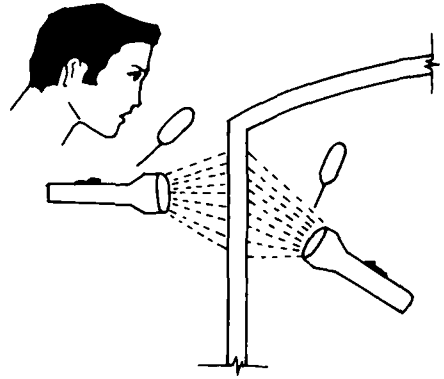
7. Use 19 gage wire mesh : one layer on each side of the skeletal steel frame. To ensure proper profile and compactness of reinforcements, these mesh layers should be tied at 0.20 m interval along the vertical and circumferential directions stretching the meshes taut. Care should be taken to provide at least 10.0 mm overlap of meshes at the joints. The two layers should be staggered in such a way that the effective opening size is reduced to half of the individual mesh opening (Fig. 12). The misalignement provides for a more uniform distribution of reinforcement as well as a superior bond for the mortar while plastering.

8. Extend the wire mesh into the lid and bend 0.20 m to provide continuity (Fig. 11).



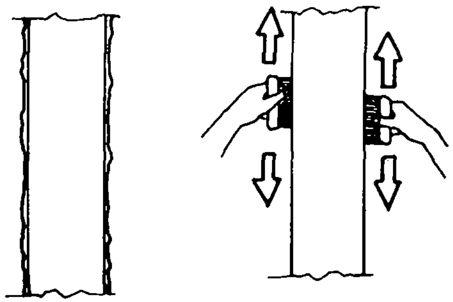
Mason impregnates mortar from the inside of the tank while the helper holds a back-up sheet on the outside

Fig. 16 Plastering



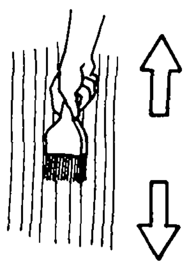
Use of magnifying lens and torch to locate hairline cracks. Alternatively the tank could be filled with water and tested for leakage

Fig. 18 Inspection



Scraping out excessive mortar build-up. This also improves adhesion of finishing coat.

Fig. 17 Improvement of adhesion



First apply vertical strokes

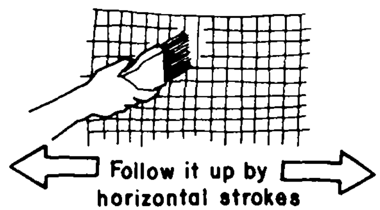


Fig. 19 Painting

IV Plastering

Casting of Base

1. Place the digester cage into the excavated hole.

2. Use mix proportion of 1:1.75:0.35 cement-sand-water by weight. Mix dry ingredients first (Fig. 15), blend thoroughly and break up all lumps.

3. Make a hole in the center of the mixture and add water gradually, then stir to a uniform consistency.

   IMPORTANT: **Mix thoroughly to uniform consistency.**

4. Pour mortar to cast the base. Cure for a day before plastering the wall.

5. Attach the inlet and outlet sockets (Fig. 20).

6. Mix mortar by batches repeating steps 2 to 3. Each batch must be plastered within an hour after mixing. This batching will reduce wastage of mortar due to partial setting. Care must be taken to maintain consistency of the mortar mixes for all batches.

7. The plaster is applied by the mason by hand or trowel from inside pushing mortar onto the layers of meshes, with the helper holding a sheet of plywood on the corresponding area outside (Fig. 16). The mason should ensure that mortar is well compacted and a 3 mm cover for the reinforcements is provided on finishing both the inside as well as the outside surfaces.

8. Extra care should be taken while plastering around the rim of the digester, the inlet and outlet sockets.

9. After 24 hours, excess mortar must be brush off before application of the finishing layer. Final wall thickness of about 30 mm including a minimum cover of 3 mm on both side is suggested. (Fig. 17).

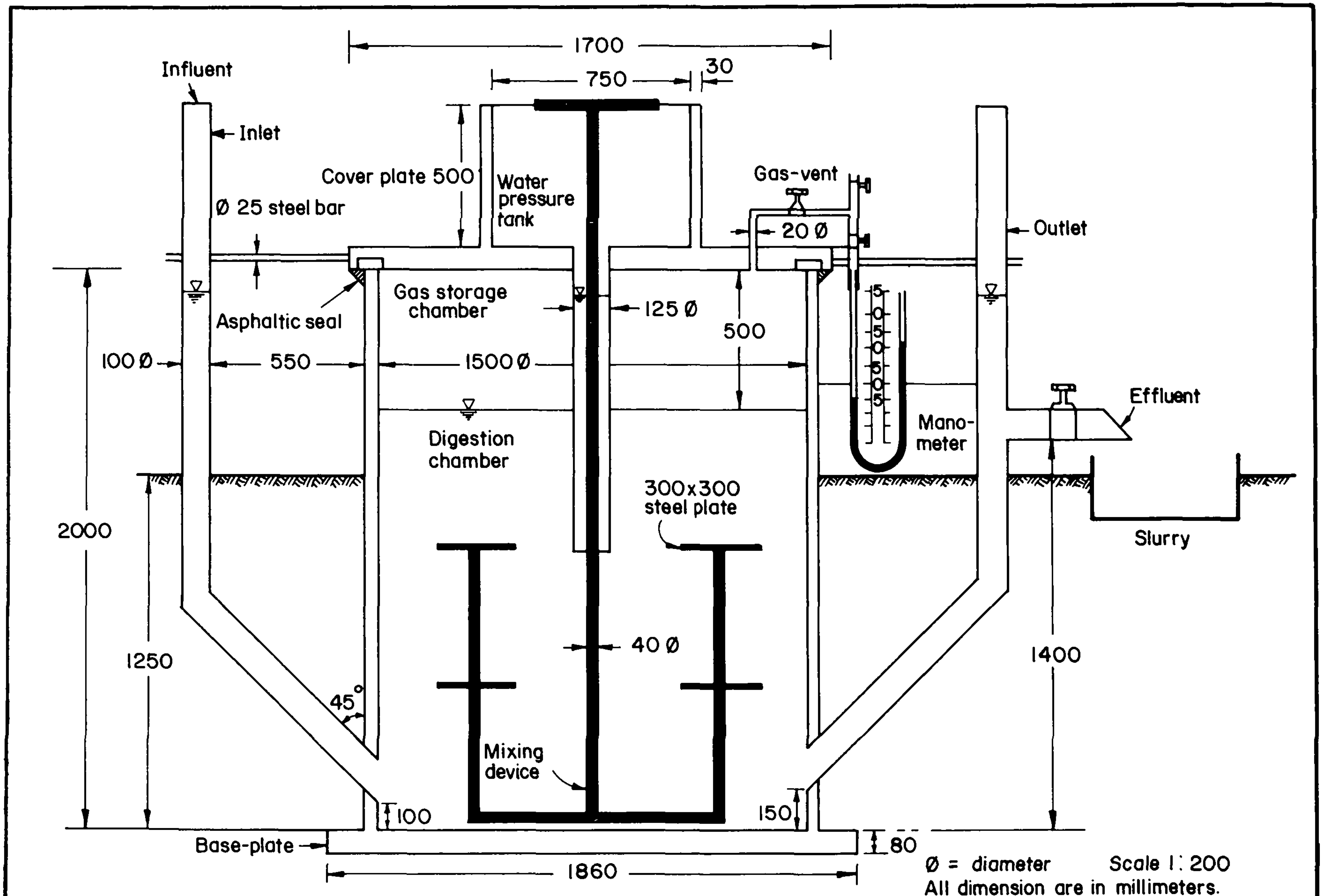


FIG. 20 AIT FERROCEMENT DIGESTER

10. Curing can start 24 hours after application of the finishing layer. Wet jute or hessian bags are used to cover the digester. They are kept moist at all times for a total of 28 days. Shrinkage cracks could appear on the surface of the structure if curing is improperly done (Fig. 18).

11. Plaster the water pressure tank and cast the lid in the same procedure. To allow movement of this component, spread polyethylene sheet under the cage before plastering. Prior to plastering check that all accessory attachments such as sockets of the gas vent and the guide pipe socket for mixing device are in-place (Fig. 20).

V Mounting the Lid and Water Pressure Tank (Fig. 20)

1. After seven days of curing, place a ring of rubber gasket (10 mm x 40 mm) on the rim of the digester chamber to ensure air tightness.

2. Attach the 125 mm diameter PVC pipe guide to the pipe guide socket.

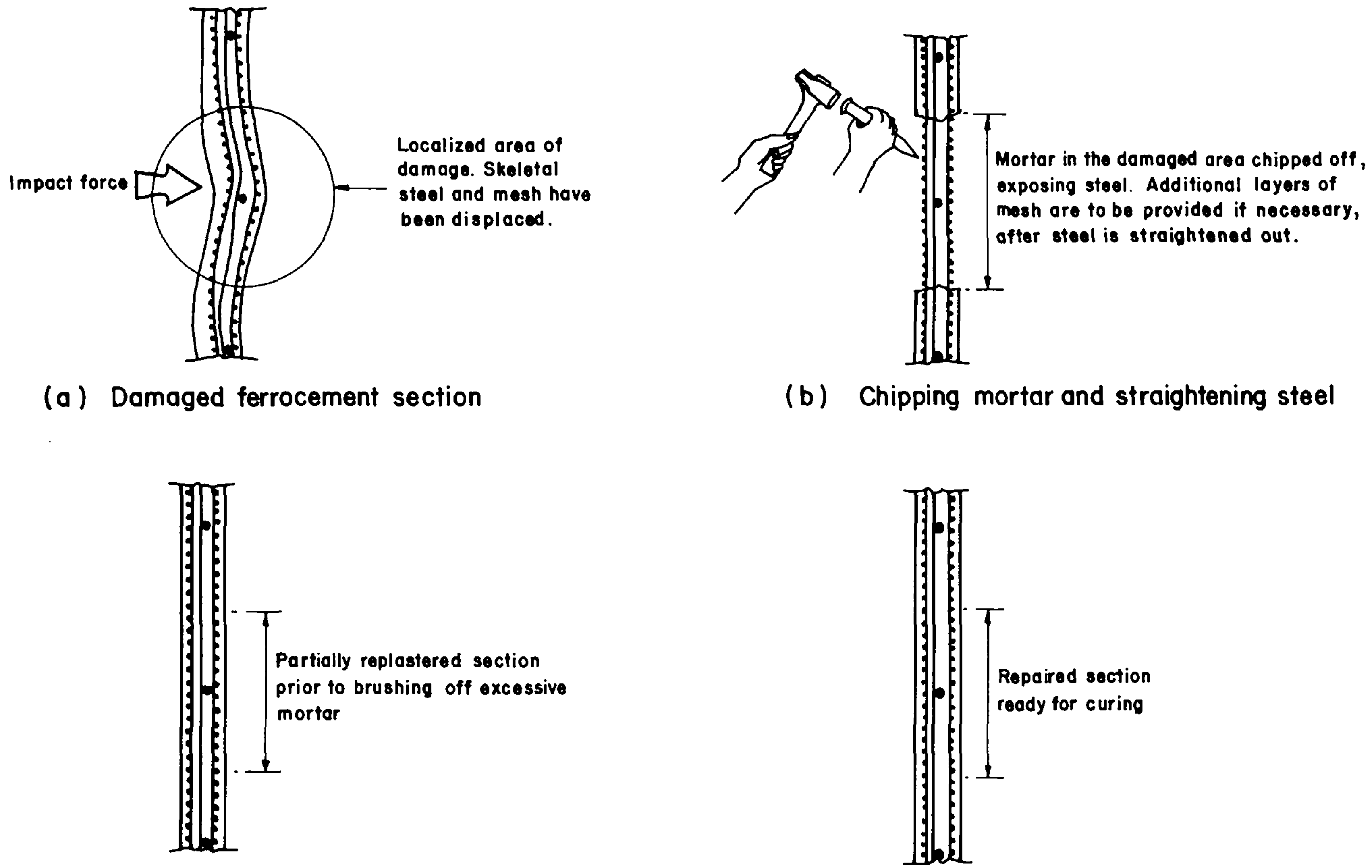
3. Lower the mixing device in place without handle.

4. Place the lid and water pressure tank component on the digester rim (Fig. 20). Seal with fresh cement paste or any other sealant.

5. Cover wall with hessian bags and cure for the required 28 days.

VI Testing

After proper curing, seal the outlet and inlet sockets with plugs. Test the digester by filling it with water and observe exterior surface for damp patches after retaining water for 24 hours. Mark location of cracks, pinholes and damp patches (Fig. 18).



(a) Damaged ferrocement section

(b) Chipping mortar and straightening steel

(c) Repair partially complete

(d) Completed section

Fig. 21 STAGES IN REPAIRING A DAMAGED SECTION

VII Repairing

Small damp patches could be repaired by applying two coats of interior and exterior paints. Apply first coat with vertical strokes followed by the second coat applied with horizontal strokes (Fig. 19).

Small hairline cracks and pinholes could be filled up using a rich cement-sand paste (1:1 by weight) after roughening the crack or pinhole location to ensure proper adhesion.

For larger cracks or localized damage, the following procedure of repair is suggested (Fig. 21):

1. Mortar in and around the area is chipped off exposing all reinforcement. Reinforcement in affected area is strengthened and additional layers of mesh are to be provided if necessary.
2. The edges of the chipped mortar is coated with rich cement slurry using a cement brush.
3. The damaged area is now plastered.
4. The replastered area is to be cured 3-4 days and retested before painting.

After successful testing, the tank is dried for 3-4 days (avoid direct sunlight).

VIII Accessory Attachment

Accessory attachments such as inlet pipes, outlet pipes and gas vent are to be completed (Fig. 20). Be sure alignment of the inlet pipes and outlet pipes are maintained during backfilling. Attach the manometer as shown in Figs. 20 and 22.

IX Painting

Exposed surface of the digester is brushed to ensure that loose particles or dust are removed. The first coat of black paint is applied with vertical strokes followed by the second coat applied with horizontal strokes (Fig. 19). Allow for a 2-4 hours drying period between the two coats or as specified by the paint manufacturer.

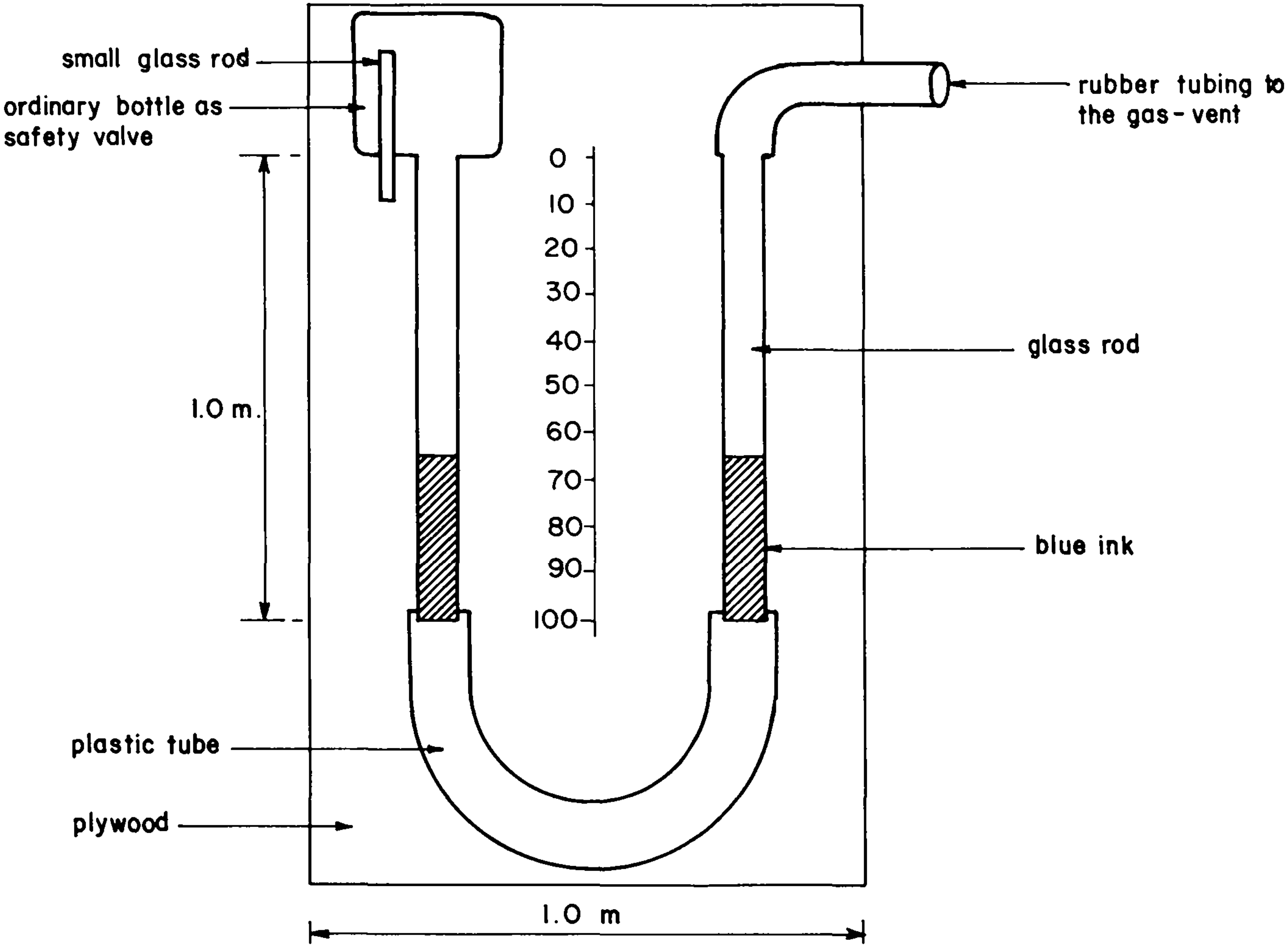


Fig. 22 Manometer

Operation and Maintenance

Starting the Plant

1. Mix the raw materials:

   a. Animal wastes and water can be mixed by using any mixing device until there are NO LUMPS. This is essential as gas production will be reduced if there are lumps. Right consistency of the mixture should be like a thick pea soup or thicker.

RECOMMENDED MIX FOR TROPICAL COUNTRIES: one part of animal waste to one part of water by weight.

   b. Nightsoil (NS), rice straw (RS) and water hyacinth (WH) can be used as raw materials. Rice straw and water hyacinth should be chopped to reduce size (Fig. 23). The proper proportion of the mixture depends on the nightsoil (human excreta) characteristics. The criteria is to produce carbon/nitrogen (C/N) ratio of 25:1.

RECOMMENDED MIX - NS:RS:WH

	dry weight basis	wet weight basis
minimum value	0.5:2.00:1.00	3.00:1.50: 1.30
maximum value	1.5:4.00:4.00	8.35:9.50:11.50

2. Load the digester with 3.0 m^3 of the raw material mixture.

3. Load with 200 liter of anaerobically digested sludge when digester is about ¼ full of raw material mixture to ensure mixing well with the slurry (Fig. 24).

4. Allow 50 days to acclimatize the anaerobic bacteria, then followed by continuous feeding for 3 months.

5. Open gas valves and gas taps connected to the biogas digester so air can escape. After this, they should be kept close.

Fig. 23 Water hyacinth and rice straw should be cut to reduce size.

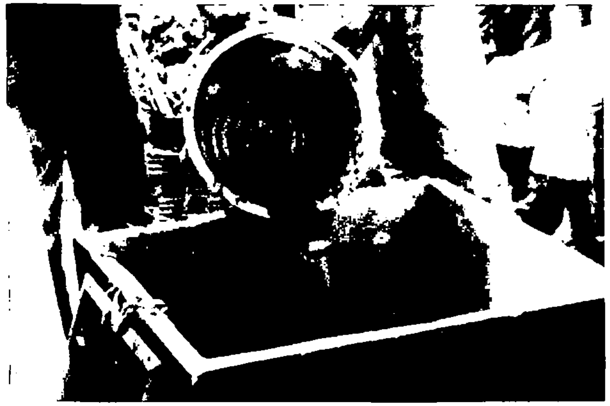


Fig. 24 Load 200 liter of anaerobically digested sludge when digester is about ¼ full of raw material.

Fig. 25 Mix the correct amount of animal waste with equal amount of water.

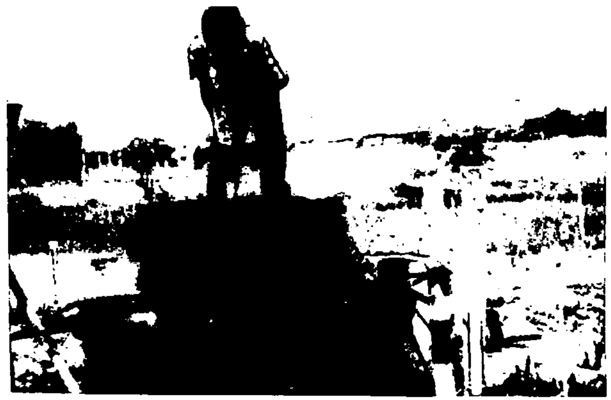


Fig. 26 Stir the contents of the digester as this increases gas production.

CAUTION

The first batch of gas produced must not be used. It may contain air and therefore can be explosive. Allow the gas to escape. Check that no smoking or naked lights nearby while gas is escaping.

The second batch of gas produced may or may not burn well. Open the main gas valve only after checking all gas taps for stoves and lamps are closed. To test, light a match and then turn on the gas. The gas should burn with a blue flame.

Daily Feeding

1. Mix the correct amount of animal wastes with the equal amount of water to obtain the correct slurry consistency (Fig. 25).

   Mixed slurry weight for production of one m^3 gas = 54.6 kg

   Weight of fresh animal wastes = 27.3 kg
   Weight of water = 27.3 kg

   Mix slurry for the daily feed in a mixing pit. Mark the depth on the mixing pit as guide for daily mixing. When slurry is well mixed, feed into the digester.

   Nightsoil, rice stalk and water hyacinth mixture can also be used.

   IMPORTANT : Stir the contents of the digester after daily feeding as this increases the gas production. Stirring breaks up the scum layer which tends to form on the surface (Fig. 26).

2. Operate at hydraulic detention time of 50-70 days.

3. The quantity of influent feed must be equal to the quantity of slurry withdrawn in order to maintain good operating conditions.

Maintenance

1. Twice a week, insert a cleaning rod in the inlet and outlet pipes to remove any blockage.

2. Check leakage points: at sockets, pipe junctions etc. once a month and seal these if required.

Problems and Remedies

Problem	Possible cause	Remedy
Difficulty in mixing the content of digester	. scum accumulation, at the upper part of the slurry, inside the digester	. Release pressure . Rigorous mixing of the slurry . Withdrawal of parts of the slurry . Feeding of the slurry and mixing of the slurry again
No gas, steady reading in manometer	. insufficient bacteria . lack of time . leak in gas holder or gas pipe . hard scum slurry blocks gas	. add more . have patience . check for leak, locate and repair . stir to break hardscum
No gas at stove plenty in drum	. gas pipe locked	. open escape lock
Gas would not burn	. wrong kind of gas being formed	. slurry too thick or too thin. Measure accurately . have patience
Flame soon dies	. water in line	. drain water out
Excessive gas build up and foaming	. high solid content . blockage of slurry outlet pipe	. add water to maintain ratio of 1:1.5 (waste to water) . clear away blockage of slurry outlet pipe

Biomass Production

The digester slurry can be used for fish culture [6, 7]. The organic loading should be properly controlled so that the pond water dissolved oxygen (DO) does not reach zero at dawn due to algal respiration during dark periods. Fish normally become suffocative if subjected to low DO for a certain period of time.

Utilizing Fermentation Slurry

Slurry contains a full range of minerals, including a lot of nitrogen which is mostly lost during aerobic composting. Nitrogen is a most important nutrient substance for plant growth.

In order to obtain the optimum fertilizing effect, the slurry should be plowed into the soil about 1 week before sowing takes place. Grain crops can be fertilized once or twice more before harvesting. Vegetable crops should not be fertilized again during the growth phase.

CAUTION : If nightsoil is used as raw material do not apply slurry directly to the field to avoid contamination. Use after storage.

The slurry must be stored until it is time to spread it. There are two ways of storing :

1. as liquid fertilizer, in covered pit.

2. as solid manure, in a compost pit. In this case, nitrogen is lost but other agricultural refuse can be included in the compost to increase the fertilizer volume.

GUIDELINES : One cubic meter of slurry can fertilize about 100m^2 of land per year. The increase in crop yield is in the region of 10-20% and can be increased by regular watering.

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Glossary of Terms

Anaerobic Digestion : The stabilization of organic material by bacteria in the absence of oxygen.

Bacteria : Primitive organisms, generally free of pigment, which reproduce by dividing in one, two or three planes. They occur as single cells, group, chains or filaments, and do not require light for their life processes. They may be grown by special culturing out of their native habitat. Bacteria is broken down into three sub-categories:

- Aerobic - bacteria which require free (elementary) oxygen for their growth.
- Anaerobic - bacteria which grow in the absence of free oxygen and derive oxygen from breaking down complex substances.
- Pathogenic - bacteria which can cause disease.

Biogas Plant : It is the device used to process organic wastes to produce biogas and sludge and/or simply to serve a useful purpose such as control of pollution.

Carbon : Nitrogen : (C/N Ratio) The ratio by weight of carbon to nitrogen in a sample. In general a ratio of around 20-30:1 is considered 'best' for anaerobic digestion.

Digester : A tank in which solids are stored for the purpose of permitting anaerobic decomposition.

Digestion : The process by which complete organic molecules are broken down into simpler molecules.

Fermentation : Anaerobic decomposition.

Sludge : The precipitate at the bottom of the digester, mostly of solid substances.

Slurry : The liquid manure that comes out of the gas plant. It is called sometimes effluent.

About IFIC

The International Ferrocement Information Center (IFIC) was founded in October 1976 at the Asian Institute of Technology under the joint sponsorship of the Institute's Division of Structural Engineering and Construction and the Library and Regional Documentation Center. IFIC was established as a result of the recommendations made in 1972 by the U.S. National Academy of Science's Advisory Committee on Technological Innovation (ACTI). IFIC receives financial support from the Government of Australia, Canadian International Development Agency (CIDA), Government of France, Government of New Zealand, and the International Development Research Center (IDRC) of Canada.

Basically, IFIC serves as a clearing house for information on ferrocement and related materials. In cooperation with national societies, universities, libraries, information centers, government agencies, research organizations, engineering and consulting firms all over the world, IFIC attempts to collect information on all forms of ferrocement applications either published or unpublished. This information is identified and sorted before it is repackaged and disseminated as widely as possible through IFIC's publications and IFIC's reference and reprographic services. All information collected by IFIC are entered into a computerized data base using ISIS system. These information are available on request. In addition, IFIC offers referral services.

A quarterly publication, the "Journal of Ferrocement", is the main disseminating tool of IFIC. IFIC has also published the monograph "Ferrocement", Do It Yourself Booklets, Slide Presentation Series, State-of-the-Art Reviews, bibliography and reports. FOCUS, the information brochure of IFIC, is published in 16 languages as part of IFIC's attempt to reach out to the rural areas of the developing countries. Currently, IFIC is compiling a directory of IFIC consultants and ferrocement experts.

To transfer ferrocement technology to the rural areas of developing countries, IFIC organizes training programs, seminars, study-tours, conferences and symposia. For these activities, IFIC acts as an initiator; identifying needs, finding funding and experts, and bringing people together. So far, IFIC has successfully undertaken training programs for Indonesia and Malaysia; a regional symposium and training course in India; a seminar to introduce ferrocement in Malaysia; another seminar to introduce ferrocement to Africans; study-tour in Thailand and Indonesia for African officials; the Second International Symposium on Ferrocement (14-16 January 1985) and a Short Course on Design and Construction of Ferrocement Structures (8-12 January 1985). IFIC has initiated the establishment of a national research and training center in Malaysia, the National Centre of Ferrocement at the University of Roorkee in India and a Ferrocement Information Network in Asia and Africa. Currently, IFIC is organizing the Ferrocement Corrosion : An International Correspondence Symposium.

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