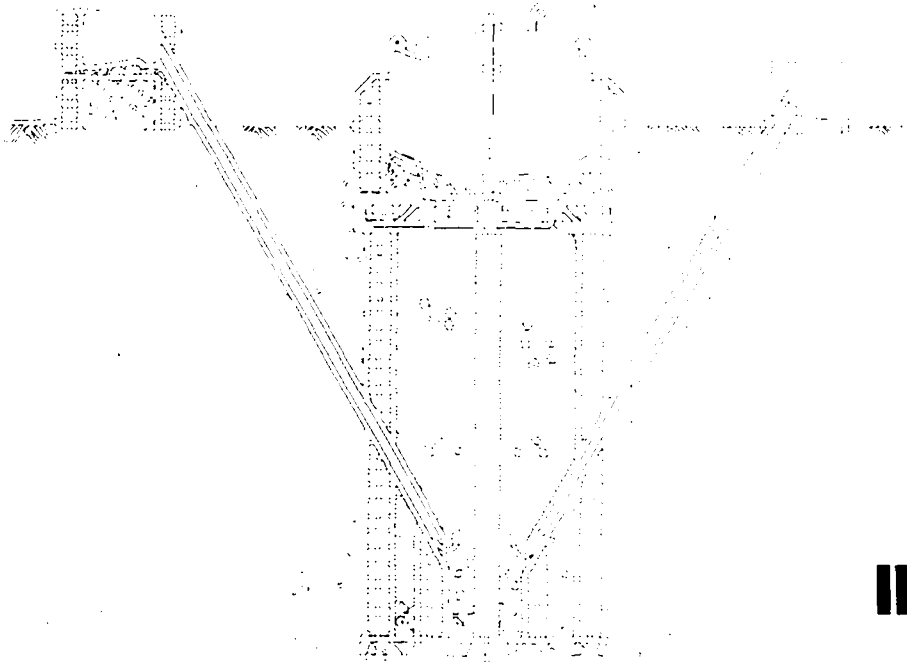
DO IT YOURSELF SERIES

Booklet Number 3

FERROCEMENT BIOGAS HOLDER



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DO IT YOURSELF SERIES

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FERROCEMENT BIOGAS HOLDER

P. C. Sharma and V. S. Gopalaratnam

IFIC

INTERNATIONAL FERROCEMENT INFORMATION CENTER

Ferrocement Biogas Holder

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Foreword

In May 1979 the International Ferrocement Information Center (IFIC) started the publication of a series of " Do it yourself" Booklets as part of its efforts in accelerating the transfer of ferrocement technology to the rural areas of developing countries.

After the publication of Booklet No. 1 on " Ferrocement Grain Storage Bin" , and Booklet No. 2 on " Ferrocement Water Tank" , the IFIC is making available Booklet No. 3 on " Ferrocement Biogas Holder"

Biogas is already widely used, for instance in India and China where it is estimated that over 7 million plants are being operated. The energy crisis is proving to be an incentive in the development of biogas utilization. It is, therefore, timely to promote the use of ferrocement, a very versatile and cheap construction material, for building biogas holders.

We hope that the present booklet will facilitate the construction of simple, inexpensive biogas holders in many villages of developing countries.

As a result of the feedbacks that we received on Booklet No. 1, we have modified the format of the present booklet which will now comprise of two parts :

Part I : Instruction manual
Part II : Get down to do it

Further suggestions for improving the subsequent booklets on this series will be most welcome.

The Director

Instruction Manual Part I

An Introduction to Biogas Plant 1

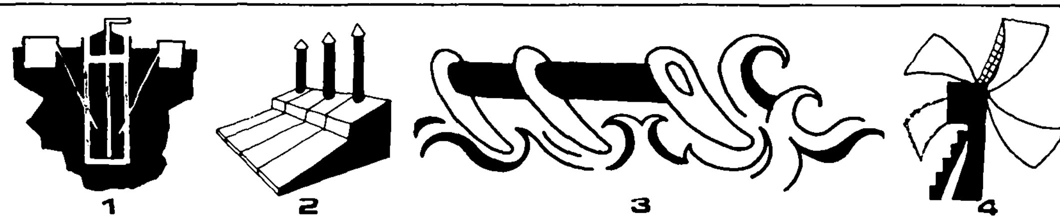
The need for alternate sources of energy

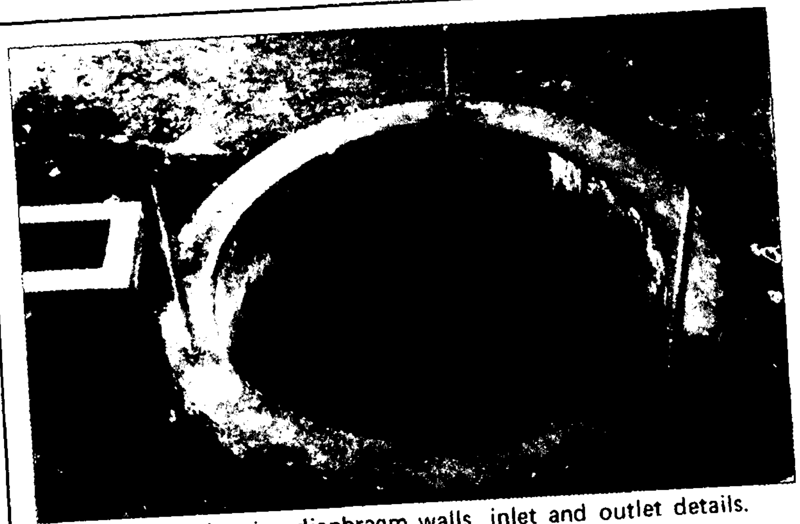
In a world of dwindling conventional energy resources, a rising population and rapid technological advancements, it is inevitable in the near future that the present energy conversion systems should undergo drastic changes. Keeping in view the ever depleting natural resources for conventional sources of energy, researchers the world over are focusing their attention on varied forms of renewable energy sources. Amongst the most promising are biowastes, solar radiation, tidal waves, geothermal gases and the wind. With the present level of understanding on the subject of energy from renewable sources, production of biogas has been identified as a technology most ideally suited for the developing countries. Besides being the most economical when compared to other renewable energy sources, the technology has the added advantage of being appropriate, efficient and least hazardous. A set of tables presented in Appendix I highlights the advantages of utilizing biowastes as an alternate source of energy.

Biogas plant

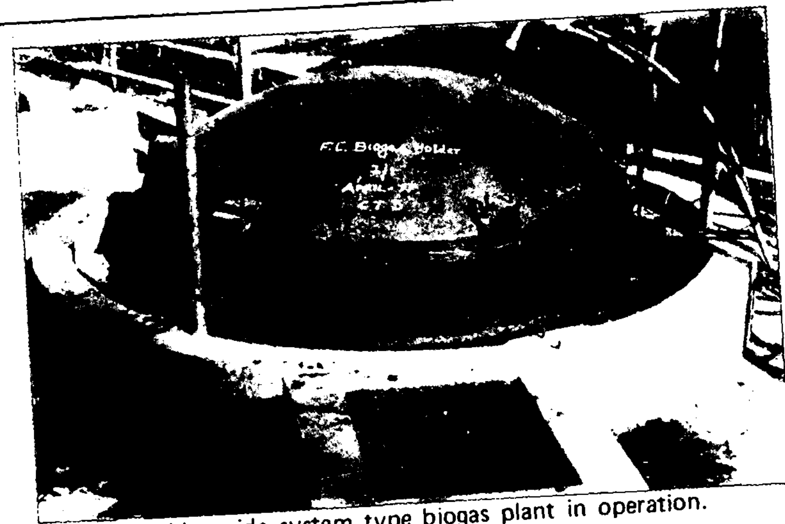
The process equipment used to generate methane-rich gaseous fuel by recycling biological wastes is termed as a biogas plant. Such plants have been in operation in many parts of Asia for over a decade. In the due course of evolution these plants have undergone numerous design modifications. The typical biogas plant of the conventional design consists of a digester and gas holder. The digester is a well (preferably dug below ground level to facilitate easy operation) in which the slurry containing fermentable material (human, animal and agricultural wastes) mixed with the required quantity of water is fed through an inlet pipe every day. The slurry undergoes anerobic decomposition, releasing gas containing 50–60% methane besides carbon dioxide, hydrogen sulphide and traces of moisture. The digested slurry flows through an outlet pipe into an outlet tank. The gas generated by fermentation is collected in the gas holder which floats on the slurry like a stopper. The self weight of the gas holder exerts a pressure of 8–25 cm of water column (depending upon the weight of the holder).

1. *A biogas plant*
2. Solar rice dryer
3. Wave energy generator
4. Wind mill





Digester showing diaphragm walls, inlet and outlet details.



A side guide system type biogas plant in operation.

Details of the side guide system.

A central guide system type biogas plant in operation.

Ferrocement Biogas Holder 2

Why a gas holder in ferrocement ?

For the conventional biogas plants, gas holders are fabricated in steel. In such plants the gas holder accounts for about 40–50%of the total cost. Besides higher initial cost, these gas holders are highly susceptible to corrosion and rusting as a result of which maintenance costs are also high. They also have a very limited life.

Based on experiments at Structural Engineering Research Centre (SERC), Roorkee, India, it has been observed that ferrocement gas holders besides being far superior in functional aspects, cost only half as much as steel gas holders. Among the advantages of using ferrocement for construction of biogas holders are :

- The technology involved is labour intensive and calls for only moderate skills and is, therefore, ideally suited for application in the rural areas of developing countries.
- The material has low thermal conductivity and as a result, the rate of gas production is fairly uniform in all seasons.
- It has a high resistance to corrosion and, therefore, needs minimum of maintenance.
- Ferrocement has good resistance to impact and hence can withstand the rigours of transportation and handling.
- As a consequence of the ease of construction, any accidental damage caused can be equally easily repaired.
- Constituent materials that are required for ferrocement construction are readily available in most developing countries.

What is ferrocement ?

The American Concrete Institute has suggested the most acceptable definition of ferrocement :

> " Ferrocement is a type of thin wall reinforced concrete construction where usually a hydraulic cement is reinforced with layers of continuous and relatively small diameter mesh. Mesh may be made of metallic materials or other suitable materials"

Although this definition is broad in scope, the most common form of ferrocement is made from steel, wire mesh, cement, sand and water. Dispersion of steel in the form of wire meshes makes it distinctly different from conventional reinforced concrete. This also results in superior strength and crack arresting properties. Even in extremely stressed cases crack widths are smaller for ferrocement elements as when compared to conventional reinforced concrete. This makes it ideally suited for use in structures that retain liquids (tanks, channels and boats) or gases (gas holders).

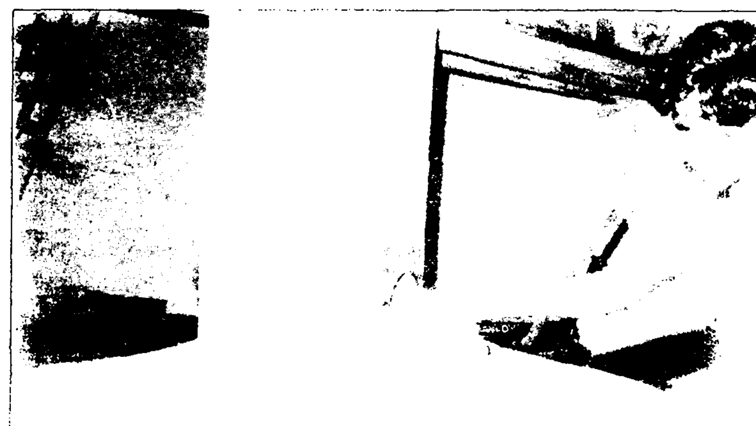
What is the extent of developmental work carried out on the use of ferrocement for construction of biogas holders ?

India has been the first and only country using ferrocement for construction of biogas holders. Extensive developmental work has been carried out at the SERC. These studies have included research on suitable production techniques and performance evaluation of ferrocement gas holders. Various types, shapes, methods of construction, types of coatings and procedures for testing these biogas holders have been evolved. Optimization studies using different design parameters have also been carried out. Long term performance tests (durations lasting over 3 years) have proved beyond doubt that ferrocement gas holders can outlive gas holders made from other conventional materials of construction (like steel).

Cement Service Bureau, Madras, Department of Fisheries, Tamil Nadu and, Khadi and Village Industries Commission, Bombay are the other organizations that have produced and successfully used biogas holders made of ferrocement in India.

Additionally, SERC, Roorkee, has also developed a semi-mechanised process for producing thin wall closed cylindrical ferrocement units. This technology has also been adopted for fabrication of ferrocement biogas holders. Appendix II gives a brief description of the process equipment. Note however that for the design discussed in this booklet this process is not readily adaptable.

A side guide system plant in operation. Photograph shows details of gas outlet connection.



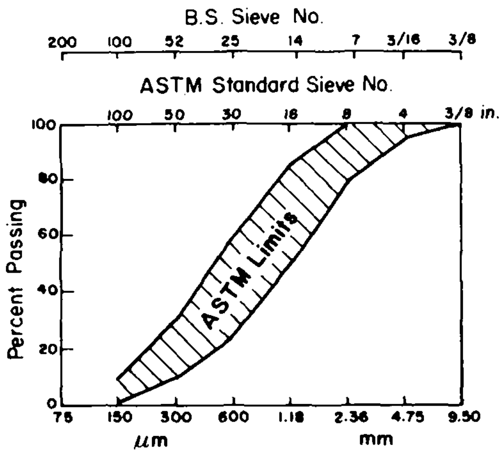
Finishing touches being applied to a central guide system type gas holder.

Material Specifications 3

What are the specifications of the materials to be used ?

Cement : Cement acts as a hydraulic binder binding particles of sand, steel and wiremesh into one compact and strong mass. It is hence essential that only fresh cement of uniform consistency and free from lumps or other foreign matter should be used. Ordinary Portland Cement conforming to ASTM C– 150 (or equivalent) is to be used. Type I and Type II are normally recommended in tropical countries with no special environmental constraints. Type III is to be used for construction in cold climates, while Type V is to be used where resistance to sulphate attack is desired. For the construction of biogas holders, Type I is recommended.

Sand · Although sand is the cheapest of the materials that constitute ferrocement, great care is to be taken in its selection and grading because it accounts for about 60%of the total volume of ferrocement. Sand should comply with ASTM Standard C–33 (or equivalent) for fine aggregates. It should be clean, hard, strong, free of organic impurities (ASTM C–40 or equivalent) and deleterious substances. It should be inert with respect to other materials used and of suitable type with regard to strength, density, shrinkage and durability of the mortar made with it. Desirable sand grading is given below.



Sieve	Per cent passing
3/8 in. (9.50 mm)	100
No. 4 (4.75 mm)	95 to 100
No. 8 (2.36 mm)	80 to 100
No. 16 (1.18 mm)	50 to 85
No. 30 (600 μm)	25 to 60
No. 50 (300 μm)	10 to 30
No. 100 (150 μm)	2 to 10

Water : Water used for mixing and curing is to be fresh and free from organic impurities and harmful chemical substances which lead to a deterioration in the properties of mortar. Use of sea water is to be avoided. Potable water is fit for use as mixing water as well as for curing ferrocement structures.

Wire mesh : Several types of wire meshes are available: hexagonal wire mesh, welded or woven square mesh, expanded metal mesh and Watson mesh. It has been observed that galvanized square (woven) mesh performs the best. The mesh should be clean and free from all loose mill scale, dust, rust and coatings, such as paint, oil or anything that might reduce bond. The woven square mesh shall conform to ASTM Standard A – 185 (or equivalent) with a wire diameter of around 1.3 mm (18 gage) and spacing of around 12 mm (½ in.).

Skeletal steel : Steel bars are used for making a frame of the structure over which the mesh is placed. To keep the thickness of ferrocement elements down, 5 – 6 mm mild steel bars and 3 – 4 mm galvanised iron wires are recommended. The surface of these bars and wires should be free from grease oil, rust, detergents and other organic matters. A simple field test could be conducted thus; bend the bar into a U shape and then straighten it out. Bend it again into a U and on straightening, if no cracks appear at the bend then the bar is acceptable. They should conform to ASTM A – 615 and ASTM A – 616 (or equivalent).

Welded wire fabric : *The welded wire fabric which is to be used in combination with wire mesh shall comply with* ASTM Standards A – 496 and A – 497 (or equivalent). The wire recommended for biogas holders should be around 2.8 mm in diameter (12 gage), with a spacing of 75 to 100 mm. The surface of the fabric shall be free from all loose dust and coatings that might reduce bond.

Mild steel angle : Mild steel angle (20 x 20 x 3 mm) is required for the bottom ring and, top and bottom bracings of the biogas holder. Aside for lending rigidity to the biogas holder the bottom ring provides for protection against chipping off of mortar around the bottom edge. Standard mild steel angles used in conventional construction is recommended for use in the construction of a biogas holder.

Water proofing chemicals : It has been observed that addition of water proofing compounds in mortar for biogas holders, improves its properties. Special considerations shall be given to the use of additives in cement mortar for special purposes and shall comply with approved standards if any, or should be based on actual performance tests.

Binding (tying) wire : For tying the mesh layers onto the skeletal steel and the welded wire fabric, use of annealed (soft) galvanized wires of 24 or 26 gage is recommended. However, cut pieces of wires from meshes could also be used for tying.

Coatings : Coatings to be used for ferrocement should have good adhesion to substrate mortar, good abrasive resisting properties, should be durable up to specified temperature and pressure, should be chemically inert and should be impervious to water and gas. Asphalt based *coatings, epoxy paints, polyurethane coatings and chlorinated rubber paints are amongst the types of coatings that have been tested for use on* ferrocement biogas holders. Asphalt based coatings perform well but they tend to become tacky during summer. Epoxy paints are expensive and not so readily available in most areas. It has been observed that chlorinated rubber paints and polyurethane coatings perform satisfactorily besides being reasonably cheap, and use of these is recommended, on the internal as well as the external surfaces.

Material Estimations 4

Notations

The list of notations used in this chapter is given below :

A = Total area of wire mesh required (m^2)
A_{co} = Total area to be coated (m^2)
A_d = Surface area of the dome roof (m^2)
A_f = Total area of welded wire fabric required (m^2)
A_w = Surface area of wall (m^2)
d = Diameter of the gas holder (m)
G_t = Total length of galvanized iron wire required for the gas holder (m)
h = Height of the wall of the gas holder (m)
L = Total length of mild steel angles required (m)
L_a = Length of mild steel angle required for bottom ring (m)
L_b = Length of mild steel angle required for bracings (m)
L_{gp} = Length of the galvanized iron guide pipe required (m)
L_s = Total length of 6 mm diameter mild steel bars for the reinforcement cage (m)
L_5 = Total length of 8 – 10 mm diameter mild steel bars for the scum breaking arrangement (m)
n = Number of layers of mesh (usually 2)
r = Central rise of the dome (m)
t_d = Thickness of the dome roof (m)
t_w = thickness of the wall (m)
V_{co} = Volume of coating required (lit.)
V_m = Volume of mortar (m^3)
V_s = Volume of sand (m^3)
W_c = Weight of cement (kg)
W_s = Weight of sand (kg)
W_w = Weight of water (kg)

Wire mesh

The total area of mesh required for the biogas holder is to be calculated thus :

$$A = 1.1\ (A_w + A_d)\ n \qquad \text{. . . . . . . (1)}$$

where, A_w = 3.14dh, and

$$A_d = \frac{3.14}{4} d^2 \times 1.2$$ (1.2 is the factor used to get the curved surface area of the roof from plan area of the roof)

n = number of layers of wiremesh, generally 2.

Mild steel angles

The length of mild steel angle (20 x 20 x 3 mm) required for the bottom ring of skeletal steel frame is calculated thus :

$$L_a = 3.14\ d$$

The length of mild steel angle (20 x 20 x 3 mm) for bracings at the bottom and top of the wall can be calculated from :

$$L_b = \begin{cases} 4d & \text{(side guide system)} \\ 3d & \text{(central guide system)} \end{cases}$$

Hence, total length of mild steel angle required is

$$L = 1.1\ (L_a + L_b) \qquad \ldots\ldots\ (2)$$

Welded wire fabric

Assuming that the width of the welded wire fabric equals the height of the wall, the total area of welded wire fabric required could be estimated thus :

$$A_f = (3.14d + 0.1)\ h \qquad \ldots\ldots\ (3)$$

Note that the term 0.1 is added for a 10 cm horizontal overlap that is to be provided. Also, if the width of the welded wire fabric is smaller or greater, than the wall height, the formula for A_f will have to be accordingly adjusted to provide for vertical overlaps or cut out waste.

Mild steel bar

Mild steel bars of 6 mm diameter are used for the basic steel skeleton of the biogas holder. Mild steel bars are used for the top ring (at the wall roof joint), vertical reinforcement, radial arcs of the dome roof and extra reinforcement at all other places where auxiliary fittings are incorporated, like sockets, guide pipe (central guide system), connection between bracing angles and wall rings. Additionally, 8 mm or 10 mm vertical bars are provided between bracings for scum breaking (refer to scum breaking details in Part II of this booklet).

The total length of 6 mm diameter mild steel bars required is given by

$$L_s = 1.1\ (L_1 + L_2 + L_3 + L_4) \qquad \ldots\ldots\ (4)$$

where,

L_1 = length of bar required for top ring = 3.14d

L_2 = length of bars required for vertical reinforcement = 4h

L_3 = length of bars required for radial arcs = (1.2d) 2

L_4 = length of bars required for anchoring = 2 m (approx.)

The total length of 8 – 10 mm bars required for the vertical scum breaking arrangement is given by

$$L_5 = \begin{cases} 4h \text{ (side guide system)} \\ 3h \text{ (central guide system)} \end{cases} \qquad \ldots\ldots\ldots (5)$$

Galvanized iron wires

Galvanized iron wires of 3 mm diameter are used for radial arcs as well as intermediate rings for the dome roof. These help in providing *additional reinforcement besides a more accurate profile for laying the mesh layers onto the skeletal steel cage.*

About 8-12 galvanized iron wire radial arcs are recommended depending upon the size of the biogas holder (refer Appendix III). Galvanized iron wire rings are also to be provided as specified in Appendix III. For example, for a 1.0 m^3 capacity gas holder, 8 radial arcs and 5 rings are to be provided for the dome roof, in addition to the four 6 mm diameter mild steel bar radial arcs. Appendix IV gives details of how G_t is to be computed.

$$G_t = 1.1\,(G_{ra} + G_r) \qquad \ldots\ldots\ldots (6)$$

where, G_{ra} = length of galvanized iron wire required for the radial arcs = $8\left(\frac{d}{2}\right)1.2$ or $12\left(\frac{d}{2}\right)1.2$ depending respectively on whether 8 or 12 additional arcs are used and,

G_r = length of galvanized iron wire required for all the rings = sum of the circumferences of the individual rings.

Auxiliary fittings

Among the auxiliary fittings are two sockets for 12 mm galvanized iron pipe and/or 20 mm galvanized iron pipe depending upon the gas outlet pipe size. These sockets should also have matching plugs which are to be fixed to them during plastering.

Guide system

Materials for bracings and scum breaking bars which are a part of the guide system have been estimated earlier in sections on mild steel angles and mild steel bars respectively. Other than these, the only material required is a 50 mm diameter galvanized iron guide pipe (only for the central guide system. The side guide system does not require the pipe), the length of which is estimated thus

$$L_{gp} = (h + r + t_d + 0.05) \qquad \ldots\ldots\ldots (7)$$

The term 0.05 is provided for an additional 5 cm projection over the center of the dome roof.

For a side guide system an arrangement comprising 6 wheels, which facilitate vertical movement of the gas holder, is to be provided (details of this arrangement are included in Part II of the book).

Mortar

The total quantity of mortar required for the gas holder construction, based on the previously defined parameters is estimated thus :

$V_m = V_s = 1.1(A_w t_w + A_d t_d)$

$W_s = 2{,}000\ V_s$ (2,000 kg/m^3 = specific weight of sand) .... (8)

$W_c = W_s/2$ (cement : sand = 1.2) .... (9)

$W_w = 0.4\ W_c$ (water cement ratio = 0.4) .... (10)

Admixtures like wetting agents or other waterproofing compounds are to be added in amounts as per the manufacturer's specifications.

Coating

The total area to be coated is to be estimated as :

$A_{co} = 1.1(A_w + A_d)2$; (internal as well as external surface)

To calculate the quantity of chlorinated rubber paint or polyurethane coating (as earlier recommended), manufacturer's specification of its covering area is required.

$V_{co} = A_{co}$ / (covering area) .... (11)

While reinforcement and dimensional details are presented in Appendix III for gas holders of various capacities, Appendix IV illustrates estimation of materials required for the construction of a gas holder of 1 m^3 capacity (Plant capacity of 2.5 m^3).

Biogas Holder Construction 5

Introduction

This chapter describes the various stages in the construction of a ferrocement biogas holder. The major steps involved in the construction are:

- Drawing profiles on the floor
- Preparing the skeleton cage
- Tying wire meshes
- Plastering
- Curing
- Inspection and testing
- Painting and errection

These stages are sequentially described in the following sections of the chapter.

At the onset one has to decide on the type and size of the biogas holder. Two types of guide systems for the vertical movement of the gas holder, when the biogas plant is in operation, are available. The central guide system facilitates an easy and efficient rotational method of scum breaking. The side guide system on the other hand though is relatively inefficient for scum breaking, offers numerous merits like ease of construction, ease of maintenance and quick repairs (unlike the central guide system). Details of these guide systems are presented in Part II of the booklet.

Since the biogas holder has to fit into the digester of a biogas plant, its dimensions are of prime importance. The clearance between the gas holder which acts as a stopper and the digester should be just adequate. If the clearance is more than necessary, a lot of gas would be wasted while at the same time, inadequate clearance hinders the operational efficiency of the plant as well as posing erectional difficulties. It has been observed that for digesters of diameter less than 2 m, a 9 – 10 cm annular clearance between the digester and the gas holder is ideal for efficient operation, while for digesters of over 2 m diameter, a 12 cm clearance should be provided.

Drawing profiles on the floor

Gas holder profiles (plan as well as cross sectional elevation) are to be marked on the floor. This ensures accurate cutting and bending *of steel reinforcements* besides helping in maintaining precise dimensional control.

Preparing the skeletal steel cage

The skeletal steel cage for wall consists of a ring of mild steel angle at the base of the gas holder which is connected to a ring of 6 *mm diameter bar at the wall–roof joint* by 4 equally spaced vertical bars of 6 mm diameter. Welded wire fabric earlier specified is cut in the required width (equal to the wall height) and welded onto this frame along the circumference. All joints are welded in such a manner that weld deposits are present in the curved plane along the wall. This is necessary to reduce the effective wall thickness of the biogas holder. Slag from all weld spots should be chipped off.

The skeletal steel cage for the roof consists of 4, 6 mm diameter bars originating from the 6 mm ring at the wall–roof joint and connecting each other orthogonally at the apex of the dome. These are all profiled into appropriate arcs, so that the roof is shaped like a low–rise dome. Two threaded sockets are welded at appropriate places for gas outlet and manometer connections. These sockets are plugged prior to plastering operations, to prevent mortar from clogging them.

Additionally, 3 mm diameter galvanized iron wires can be used in the form of radial arcs and rings to provide a proper profile for the roof mesh as well as provide increased roof strength. All dimensional details connected with the skeletal steel cage are presented in Appendix III and illustrated in Part II of this booklet.

Tying wire meshes

Use of two layers of 18 gage galvanized square (woven) mesh of 12 mm wire spacing is recommended. One layer is to be tied on the inside of the skeletal steel frame and another on the outside using earlier specified tying wires. To ensure proper profile and compactness of reinforcements these mesh layers should be tied at 20 cm spacing along both the vertical and *circumferential directions* streching the meshes taut. Care should be taken to provide a 10 cm overlaps of meshes where these have to be joined. In the case of wall–roof joint mesh layers should have laps of 10 cm each on the wall portion as well as the roof dome. The two layers of mesh placed should be staggered in such a way that the effective opening size is reduced to half of the individual mesh opening. This misalignment provides for a more uniform distribution of reinforcement as well as a superior bond for plastering the mortar.

Plastering

Before plastering can be undertaken, required quantities of mixed mortar should be prepared. The recommended mix proportions by weight are:

Cement: sand: water = 1:2:0.4

Water proofing or other similar admixtures are to be thoroughly dry–mixed with cement and sand before water is added to the mix. Sand should be properly sieved and void of all impurities as earlier specified and in Chapter 3. Mix the mortar in batches in such a manner. that each batch of mixed mortar is plastered within an hour after mixing. This batching will reduce wastage of mortar caused as a result of partial setting. Note, however, *that the consistency of the mortar mixes* should be the same for all the batches.

Prior to plastering it should be ensured that the reinforcement cage is completed, including all accessory attachments such as gas outlet socket, manometer socket and the central guide pipe. Bulge or slackness in wire mesh should be removed by readjusting the mesh, by beating to the proper profile and tying the meshes at more places to retain the designed shape.

The reinforcement cage is to be brushed using a steel fiber brush to remove all loose scales on the cage, and mounted on three supports. These supports will enable persons to enter the inside of the reinforcement cage to carry out plastering operations.

Plaster should be applied by a person (hereafter referred to, as mason) from the inside, pushing mortar onto the layers of meshes, with the assistance of another person (hereafter referred to, as helper) who is to hold a sheet of plywood or galvanized iron on the corresponding area, outside. Mortar application can be accomplished by either using the trowel or the hand. The helper is to shift the backing sheet of plywood or galvanized iron to the adjoining area when plastering is completed on the earlier region. 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. It is recommended that the roof be plastered prior to plastering the wall portion. Extra care is to be taken while plastering around the gas outlet and manometer sockets. When the first application of mortar on both the roof and the wall have been completed, a coir brush is used to scrape off excessive mortar build-up, as well as making the layer rough so as to improve adhesion of the finishing layer.

The gas holder is to be left to dry for 24 hours before application of the finishing layer. Mortar used for finishing is proportioned in the same manner as earlier and applied over the earlier roughened inside and outside surface of the gas holder. Final wall thickness of around 15 mm including a 3 mm cover on both the inside and outside is suggested. For the dome roof a thickness of 20 mm with the same 3 mm cover on both the top and the bottom surfaces, is suggested.

Curing

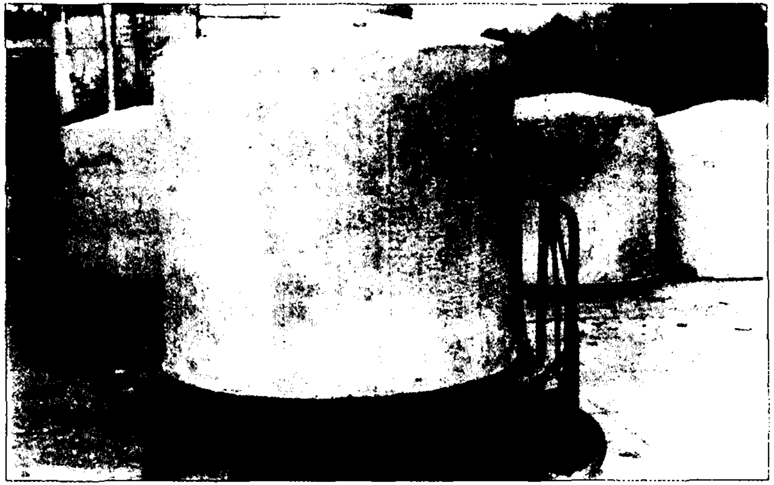
For any ferrocement structure, this is one of the most important stages, and more so for a biogas holder. This is the stage when the mortar mix attains its strength. In the first two weeks the mortar attains nearly most of its designed strength, although a curing period of 21 days is suggested. Curing can start 24 hours after application of the finishing layer. In case dry patches are observed during this 24 hour period, a fine spray of water over these patches is recommended to keep them moist. The most common curing procedure is to cover the gas holder with jute bags which are kept moist for the entire curing period with regular spraying of water.

Inspection and testing

After proper curing, the gas holder is to be tested in either a test pit or the digester itself. Details of this stage are presented in the next chapter.

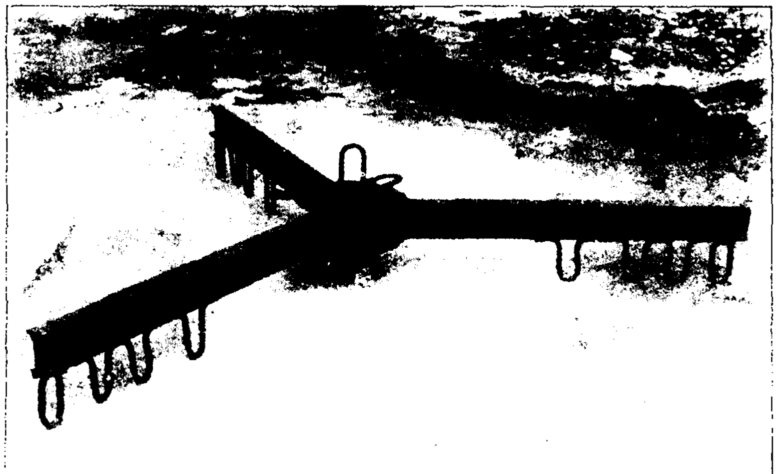
Painting and erection

Once the gas holder has been successfully tested, it should be allowed to dry completely before painting can begin. Details of this stage are also presented in the next chapter.



Correct method of shifting biogas holders.

Incorrect practice of rolling a gas holder during shifting.



A steel girder specially designed to lift biogas holders of different sizes.

Photograph shows the girder (shown alongside) being used to lift a gas holder from the digester

Post - Construction Operations 6

Among the post-construction operations to be carried out are:

Testing
Repairing (if necessary)
Drying and Painting
Installation

Testing

After curing operations have been completed, ferrocement biogas holders have to be tested for possible leaks that have escaped the attention during ordinary visual inspection. Gas outlet and manometer pipes are temporarily sealed with threaded plugs and commonly used plumbing sealant (fibrous white lead paste). The gas holder is lowered into an empty test-pit or a digester. Water is filled in the pit until the gas holder lifts to a height of 30 cm from the bottom of the pit. At this point, the gas holder contains air which is under pressure due to the self-weight of the gasholder. Soap solution is poured on the gas holder surface and points of leakage, which are located by escaping air bubbles, are marked. After testing the entire surface of the gas holder, leakage points are to be repaired following the directions suggested in the next section. In case no defects are observed, the gas holder should be left as such for a day after recording the level at which it is floating. If on the subsequent day there is an appreciable drop in this level, it indicates that there still exists points from which leakage occurs. A more careful search for such defects is suggested using the earlier method. On the contrary if there is no drop in the level of the gas holder on the subsequent day, it indicates that the gas holder is air tight.

Repairing

Ferrocement biogas holders do not require regular maintenance like steel gas holders. In case poorly constructed or poorly cured patches are identified while testing, or the holder has been accidentally damaged while installation, it can be repaired without much difficulty. While smaller surface cracks or identations can be rectified while painting, larger or deeper cracks and other localized damages are to be corrected following the procedure suggested below:

1. Mortar in and around the damaged area is chipped off using a fine round head chisel and a small hammer exposing all

reinforcement. Mortar in the adjoining area is chipped upto levels where the inside and outside wire mesh layers are exposed. Reinforcement in the affected area is straightened and profiled if necessary. In some cases, it may be necessary to add additional reinforcement.

2. The adjoining area of chipped mortar is coated with a rich cement slurry using a cement brush.
3. The damaged area is now ready for replastering following the procedure described earlier in plastering.
4. The replastered area is to be cured for 3 - 4 days before the holder is once again tested. After all leakages have been sealed, the biogas holder is to be dried before painting can be undertaken.

Drying and Painting

After successful testing, the biogas holder is to be dried (avoid direct sunlight). Interior and exterior sufaces are brushed to ensure that loose particles and dust are removed. Two coats of paint are to be applied to both the interior and the exterior of the biogas holder. The first coat of paint with vertical strokes is applied followed by a second coat with horizontal strokes. It is necessary to allow for a 2 - 4 hour drying period between the two coats, or as specified by the paint manufacturer. Care should be taken to adequately fill all hairline surface cracks, pinholes and other minor defects with primer and paint.

Installation

Care should be taken while installing a ferrocement biogas holder. For a central guide system type biogas plant, it is necessary to lift the gas holder over the guide pipe that projects from the diaphragm wall of the digester, and gradually lower it until the holder rests on the ledge of the digester. For a side guide system type biogas plant while it might not be necessary to lift the biogas holder as high as that in a central guide system type plant, it still has to be carefully placed over the ledge of the digester. Also care has to be taken to adjust the side guide wheels that are to be fixed on the digester outer walls at six locations equally spaced along the circumference. Specially designed lifting and handling inserts illustrated in Part II of the booklet are recommended for installation purposes. Small jib cranes or tripods with pulley-winch mechanisms could prove to be a big help, specially for large scale production.

Once the gasholder has been set in place, plugs from the gas outlet and manometer pipes can be unscrewed and these fitted to the distribution lines and manometer respectively. Although a manometer (a simple gadget used to measure the pressure of the gas) is not necessary, it would assist in controlling the feed quantities and intervals for uniform production of gas at a constant pressure.

Additional Reading 7

1. CROOK, M., "A Chinese Biogas Manual", Translated from Chinese by the author and edited by Ariane van Buren, Intermediate Technology Publications Limited, London, U.K., May 1979, 160 pp.
2. CEMENT SERVICE BUREAU, "Ferrocement Cowdung Gas Plant", Pamphlet No. 9 of the Cement Service Bureau, Madras, India.
3. ESCAP, "Biogas Technology & Utilization Fuel, Feed and Fertilizer for Rural Areas", Newsletter on Biogas, Economic and Social Commission for Asia and the Pacific, Bangkok, August 1976.
4. KANAKSABAPATHY, T., "Gobar Gas Holder Built of Ferrocement", Indian Concrete Journal, Vol. 49, No. 12, 1975, pp. 355-359 and pp. 376.
5. NARAYANASWAMY, V.P., RAMAN, N.V., JAYARAMAN, H.B. and SHARMA, P.C., "Optimum design of Biogas Plants", National Seminar on Technology for Agricultural Development, Chandigarh, India, 1977, pp. 54-62.
6. RAMAN, N.V., NARAYANASWAMY, V.P., SHARMA, P.C. and JAYARAMAN, H.B., "Ferrocement Gas Holder for Biogas Plants", Published in the proceedings of the International Conference on the Materials of Construction for Developing Countries, Asian Institute of Technology, Bangkok, Thailand, August 22-24, 1978, pp. 749-764. (Also reprinted in the Journal of Ferrocement, Vol. 9, No. 2, April 1979, pp. 93-102).
7. SATHIANATHAN, M.A., "Bio-gas – Achievements and Challenges", Published by Association of Voluntry Agencies for Rural Development, New Delhi, India, June 1975. 192 pp.
8. SURYAKUMAR, G.V., SHARMA, P.C., GOPALAKRISHNAN, S. and RAMAN, N.V., "Casting Technology for Ferrocement Cylindrical Units", all India Seminar on Development in Construction Technology, The Institution of Engineers (India), Bombay, December 1975, 12 pp.

This booklet does not venture into details of the digester or operational aspects of a biogas plant. Reference 1 and 7 should provide an exhaustive idea on these aspects. The design of digesters in Chapter XI of Reference 7 is recommended for use with ferrocement biogas holder.

Appendices 8

APPENDIX I : Advantages of Utilizing Biowastes as an Alternate Source of Energy.

APPENDIX II : Semi–Mechanized Process for Casting Cylindrical Units.

APPENDIX III : Dimensional and Other Construction Details of Biogas Holders of Various Capacities.

APPENDIX IV : Sample Calculations for Estimating Materials Required in the Construction of a 1.00 m^3 Capacity Central Guide Type Biogas Holder.

APPENDIX I
Advantages of Utilizing Biowastes as an Alternative Source of Energy *

Table 1. The fuel value of biogas that could be produced by effective utilization of all animal and human wastes, in a country like India.

Item	Amount
A. Estimated dung produced	1595.0 million tonnes
B. Biogas from A	587.0 million m^3
C. Estimated population of India	650 million
D. Biogas from C	19.1 million m^3
E. Total biogas available (B + D)	606.1 million m^3
F. Coal equivalent	1128.3 million tonnes
G. Petrol equivalent	362.4 million liters

Table 2. Comparative yearly benefits from various methods of utilizing cow-dung (KVIC estimate assuming use of 45 kgs of fresh dung each day)

Method of Utilization	Fuel obtained	Effective heat value	Manure	Net value in Rupees
1. Composted in manure pit	Nil	Nil	7 cart loads	105
2. Converted to cakes	3.65 tonnes	1.55 million K.cal.	Nil	197
3. Digested in a biogas plant	620 m^3	1.87 million K.cal.	10 cart loads	303

Table 3. Comparative gas production from different kinds of wastes (50.8 kg - 1 cwt of fresh waste).

Type of Waste	Gas produced (m^3)
Cow dung	1.33 – 2.18
Pig manure	2.18 – 3.54
Green Vegetables and crop wastes	1.33 – 2.63
Potato haulms	1.33 – 2.18
Straw	1.33 – 2.18

* Data for Tables 1 – 6 extracted from reference 7 listed in chapter 7.

Table 4. Gas production per unit dry weight.

Type of waste	Gas produced (m^3/Kg)
Cow dung	0.19 – 0.29
Pig manure	3.74 – 4.99
Chicken Wastes	0.37 – 0.82
Conventional Sewage	0.37 – 0.56
Straw	0.37 – 0.39
Green Vegetables and crop wastes	0.37 – 0.39

Table 5. 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	0.71 – 0.85
	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 hour 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

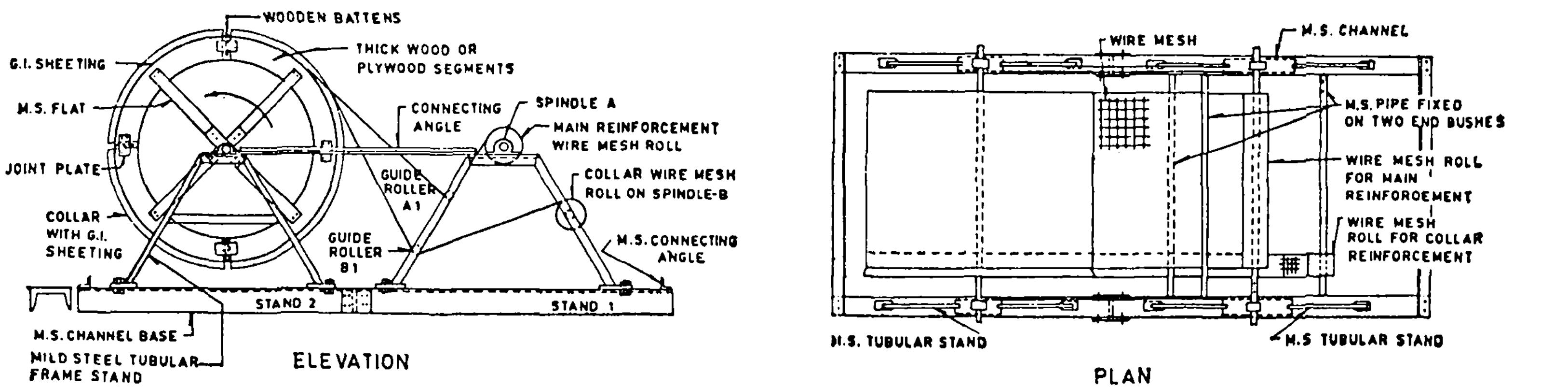
Table 6. Fuel value of biogas and other major fuels (all per kg of fuel).

Fuel	B. T. U.
Soft Coke	5000 – 5454
Coal	6177
Charcoal	5680 – 6364
Fire Wood	3182 – 3864
Kerosene	8844
Furnace Oil	8844
High Speed Diesel	8836
Solvent Oil	8864
Biogas	5909 – 6818
Methane	9782

APPENDIX II

Semi-Mechanized Process for Casting Cylindrical Units

The process of casting and equipment described below has been developed by the Structural Engineering Research Center (SERC), Roorkee. The process includes a continous winding of wiremesh from a wiremesh roll onto a cylindrical mould and simultaneous application of the cement mortar on the wiremesh as and when it is wound on the mould. This ensures a high degree of compaction of mortar and enables a good control over thickness. The process is labour intensive and does not use expensive machinery. A diagrammatic representation of the casting equipment developed at the Centre is illustrated in the figure below.



Process equipment for casting of cylindrical elements (covered by a SERC patent).

The process of casting a cylindrical unit consists of the following steps :

The wiremesh roll for the cylindrical unit is mounted on spindle 'A' and the wiremesh roll for the collar portion of the units is mounted on spindle 'B'. The mould for casting the cylindrical unit is mounted on stand 2. The wiremesh is initially tied to the cylindrical mould. The cylindrical mould is rotated in the forward direction as shown by the arrow in the figure so that the mesh gets wound on the mould. When sufficient portion of the mesh is wound on the mould, the rotation of the mould is arrested and a 1: 2 cement mortar mix (with waterproofing compound if necessary) is applied over this portion. The mould is rotated further and the process repeated until the required number of layers of wiremesh are wound on the mould and the required effective thickness is obtained. The last layer of wiremesh is given an extra lap length and the wiremesh is cut from the roll and tied to the inner layers of wiremesh already in position. The surface is finished with cement mortar maintaining proper cover to reinforcement. After 24 hours, the mould along with casting is removed from the process equipment and the unit is then demoulded. The unit is given a finishing coat of cement mortar on the inside surface and is cured for 14 days with water before it is used for assembling the biogas holder. A 10 cm strip of wiremesh is left unplastered at the collar-less periphery of the cylindrical unit. This is lapped with projecting meshes from the roof unit (which is cast seperately on masonry moulds) and plastered to obtain an impermeable roof-wall joint.

APPENDIX III

Dimensional and Other Construction Details of Biogas Holders of Various Capacities
(Based on 40% plant capacity)

Serial Number	Capacity (m^3)		Internal Diameter (m)	Cross-Section Area (m^2)	Gas Holder Wall Height (m)	Wall		Roof		
	Plant	Gas Holder				Thickness (cm)	Reinforce-ment(Type)	Thickness (cm)	Rise (cm)	Reinforce-ment(Type)
1	1.50	0.60	0.90	0.64	1.00	1.5 – 2.0	W	2.0	10.0	Y
2	2.00	0.80	1.20	1.13	0.80	1.5 – 2.0	W	2.0	10.0	Y
3	2.50	1.00	1.20	1.13	1.00	1.5 – 2.0	W	2.0	10.0	Y
4	3.00	1.20	1.40	1.54	0.90	2.0 – 2.5	X	2.0	15.0	Z
5	4.00	1.60	1.45	1.65	1.10	2.0 – 2.5	X	2.0	15.0	Z
6	5.00	2.00	1.50	1.77	1.30	2.0 – 2.5	X	2.0	15.0	Z

1. Reinforcement Type W = 20 x 20 x 3 mm mild steel angle ring A at the bottom. 6 mm diameter mild steel ring at the roof-wall joint. Four 6 mm diameter mild steel vertical reinforcing bars connecting these two rings, equally spaced along the circumference. This cage is to be wrapped by 12 gauge 100 x 100 mm welded wire fabric and two layers of 18 gauge 12 x 12 mm square mesh, one on each side of the skeletal steel cage.
2. Reinforcement Type X = 20 x 20 x 3 mm mild steel angle ring A at the bottom. 6 mm diameter mild steel ring at the roof-wall joint. Six 6 mm diameter mild steel vertical reinforcing bars connecting these two rings, equally spaced along the circumference. This cage is to be wrapped by 12 gauge 75 x 75 mm welded wire fabric and two layers of 18 gauge 12 x 12 mm square mesh, one on each side of the skeletal steel cage.
3. Reinforcement Type Y = Four 6 mm diameter radial arcs equally spaced, originating at ring R and ending at the apex of the roof dome, eight 3 mm diameter galvanized iron wire radial arcs equally spaced to supplement the 6 mm reinforcement. Five 3 mm diameter galvanized iron wire rings, equally spaced along these radial arcs. Two layers of 18 gauge 12 x 12 mm square mesh, one on each side of the skeletal steel cage.
4. Reinforcement Type Z = Six 6 mm diameter radial arcs equally spaced, originating at ring R and ending at the apex of the roof dome. Twelve 3 mm diameter galvanized iron wire radial arcs equally spaced to supplement the 6 mm reinforcement. Eight 3 mm diameter galvanized iron wire rings, equally spaced along these radial arcs. Two layers of 18 gauge 12 x 12 mm square mesh, one on each side of the skeletal steel cage.
5. Mortar composition by weight = cement : sand : water : : 1.0 : 2.0 : 0.4

APPENDIX IV

Sample Calculations for Estimating Materials Required in the Construction of a 1.0m^3 Capacity Central Guide Type Biogas Holder

Based on the biogas holder capacity (40%of the Plant capacity), the following specifications can be readily obtained from Appendix III:

Plant Capacity	=	2.5 m^3
Biogas holder capacity	=	1.0 m^3
Internal diameter = d	=	1.2 m
Gas holder wall height = h	=	1.0 m
Wall thickness = t_w	=	1.5 – 2.0 cm
Roof thickness = t_d	=	2.0 cm
Rise = r	=	10.0 cm
Number of layers of mesh = n	=	2

Wire mesh

The total area of mesh (18 ga, ½" x ½") required for a ferrocement biogas holder is given by equation 1 (Chapter 4):

$$A_w = 3.14\,dh = 3.768\ m^2$$

$$A_d = (3.14/4)d^2 \times 1.2 = 1.356\ m^2$$

Therefore, $$A = 1.1\,(A_w + A_d)n = 11.273\ m^2 = 12\ m^2 \text{ (approx.)}$$

Mild steel angles

The length of mild steel angles required for the bottom ring of the skeletal steel frame, and top and bottom bracings are given by (assume a central guide system type gas holder).

$$L_a = 3.14\,d = 3.768\ m$$

$$L_b = 3d = 3.6\ m$$

Hence, total length of mild steel angles required (20 x 20 x 3 mm) is given by

$$L = 1.1\,(L_a + L_b) = 8.105\ m = 9.00\ m \text{ (approx.)}$$

Welded wire fabric

Assume that width of the welded wire fabric available is 1 m. Hence area of the welded wire fabric required (12 ga. 100 x 100 mm) is

$$A_f = (3.14\,d + 0.1)h = 3.868\ m^2 = 4.0\ m^2 \text{ (approx.)}$$

Mild steel bars

Total length of 6 mm diameter mild steel bars required can be computed thus :

$$L_1 = 3.14\,d = 3.768\ m$$

$$L_2 = 4h = 4.000\ m$$

$$L_3 = (1.2d)2 = 2.880\ m$$

$$L_4 \text{ (approx.)} = 2.000\ m$$

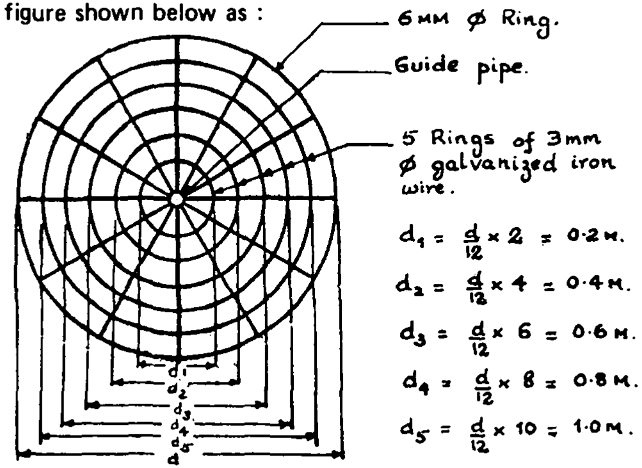
Therefore $$L_s = 1.1\,(L_1 + L_2 + L_3 + L_4) = 13.913\ m = 14.0\ m \text{ (approx.)}$$

Provide 8 mm diameter mild steel bars for the vertical scum breaking arrangement. Total length of 8 mm diameter mild steel bars required hence equals :

$$L_5 = 3h = 3.0\ m$$

Galvanized iron wires

From the footnote in Appendix III, it can be observed that 5 rings are (3mm diameter galvanized iron wire) provided for the roof (equally spaced). The diameter of each of these rings can be computed from the figure shown below as :



Total circumference of the 5 galvanized iron wire rings is therefore equal to :

$$G_r = 3.14\ (d_1 + d_2 + d_3 + d_4 + d_5) \quad = \quad 9.42 \text{ m}$$

The footnote in Appendix III also suggests the use of 8 galvanized iron wire radial arcs. Hence,

$$G_{ra} \quad = \quad 8\ (\frac{d}{2})\ 1.2 \quad = \quad 5.76 \text{ m}$$

The total length of 3 mm diameter galvanized iron wire required for the roof is hence given by equation (6) in Chapter 4 as,

$$G_t \quad = \quad 1.1\ (G_{ra} + G_r) = \quad 16.70 \text{ m} \quad = \quad 17.0\text{m} \quad \text{(approx.)}$$

Auxiliary fittings

Provide for 2 openings in the roof dome using 12 mm diameter galvanized iron pipe — one for the gas outlet and another for the manometer. Secure these openings with plugs while plastering.

Guide system

Since the present estimating is being carried out for a central guide system type of biogas holder, it will be necessary to provide a central guide pipe (50 mm diameter galvanized iron pipe) of length,

$$L_{gp} \quad = \quad (h + r + t_d + 0.05) \quad = \quad 1.17 \text{ m} \quad = \quad 1.5 \text{ m (approx.)}$$

(note that t_d has to be converted into meters)

Mortar

The total quantities of the constituents of the mortar can be estimated using previously defined parameters (refer to the notations listed in Chapter 4)

$$V_m \quad = \quad V_s \quad = \quad 1.1(A_w t_w + A_d t_d) \quad = \quad 0.12 \text{ m}^3$$

(note that t_w and t_d have to be converted into meters)

$$W_s \quad = \quad 2000\ V_s \quad = \quad 240.00 \text{ kgs.} \quad = \quad 250 \text{ kgs.(approx.)}$$

$$W_c \quad = \quad W_s/2 \quad = \quad 125 \text{ kgs.}$$

$$W_w \quad = \quad 0.4 W_c \quad = \quad 50 \text{ kgs.}$$

For computing admixture quantities (if it is desired) refer to manufacturer's specifications.

Coating

The total area to be coated is estimated as

$$A_{co} \quad = \quad 1.1\ (A_w + A_d)2 \quad = \quad 11.27 \text{ m}^2 \quad = \quad 15 \text{ m}^2 \text{ (approx.)}$$

To calculate the quantity of chlorinated rubber paint or polyurethene coating (as earlier recommended), manufacturer's specification of its covering area is required

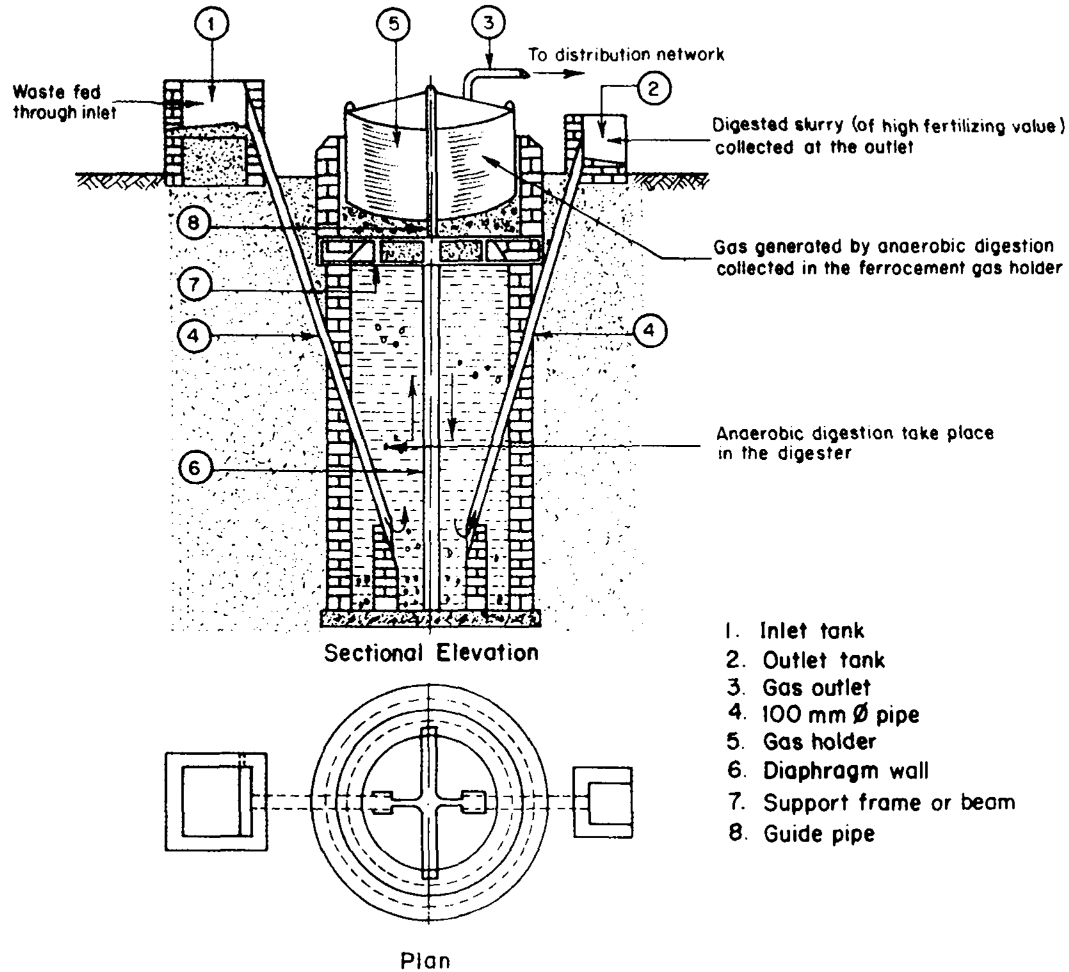
$$V_{co} \quad = \quad A_{co}/(\text{covering area})$$

Materials required for the construction of a 1.0 m^3 capacity central guide type biogas holder✦

Material	Quantity
Wire mesh (18 ga., ½" x ½")	12.0 m^2
Mild steel angles (20 x 20 x 3 mm)	9.0 m
Welded wire fabric (12 ga., 100 x 100 mm)	4.0 m^2
Mild steel bars	
6 mm diameter	14.0 m
8 mm diameter	3.0 m
Galvanized iron wire (3mm diameter)	17.0 m
Auxiliary fittings	as necessary
Guide pipe (50 mm diameter)	1.5 m
Sand	250.0 kgs.
Cement	125.0 kgs.
Water	50.0 kgs.
Coating and Admixtures	as necessary

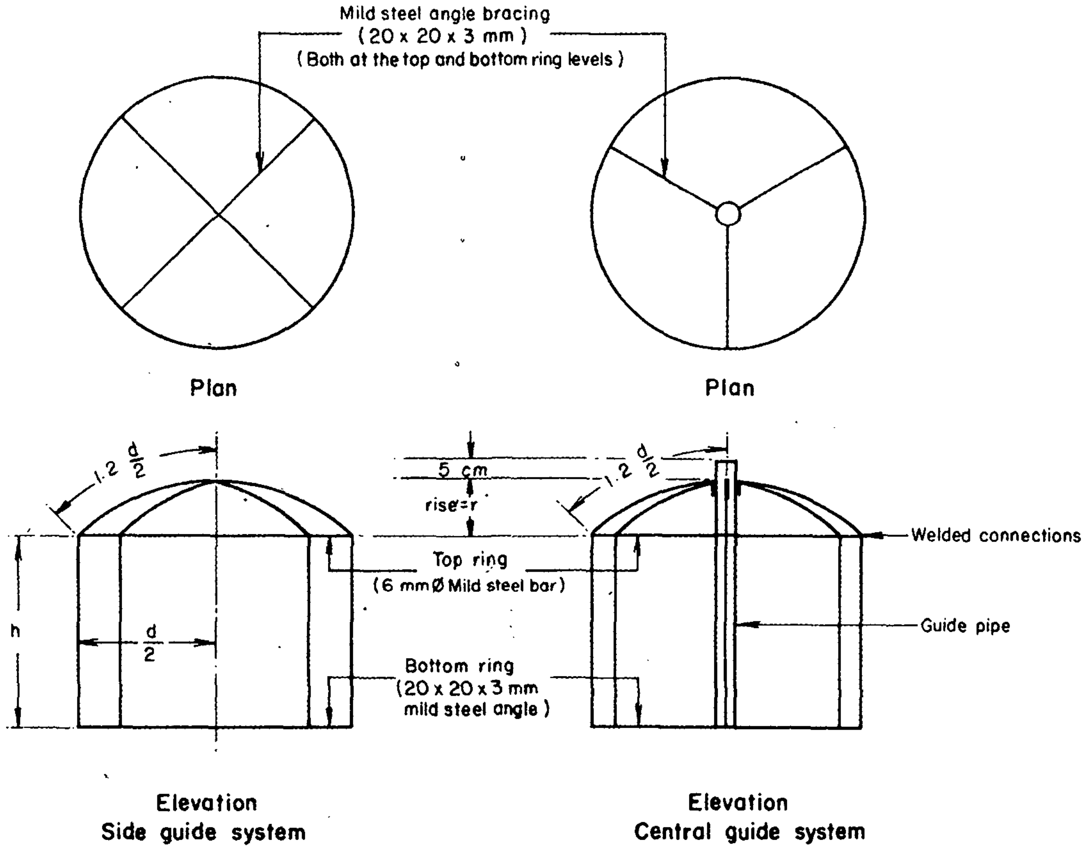
✦For a plant capacity of 2.5 m^3 per day

Get Down to Do it — Part II

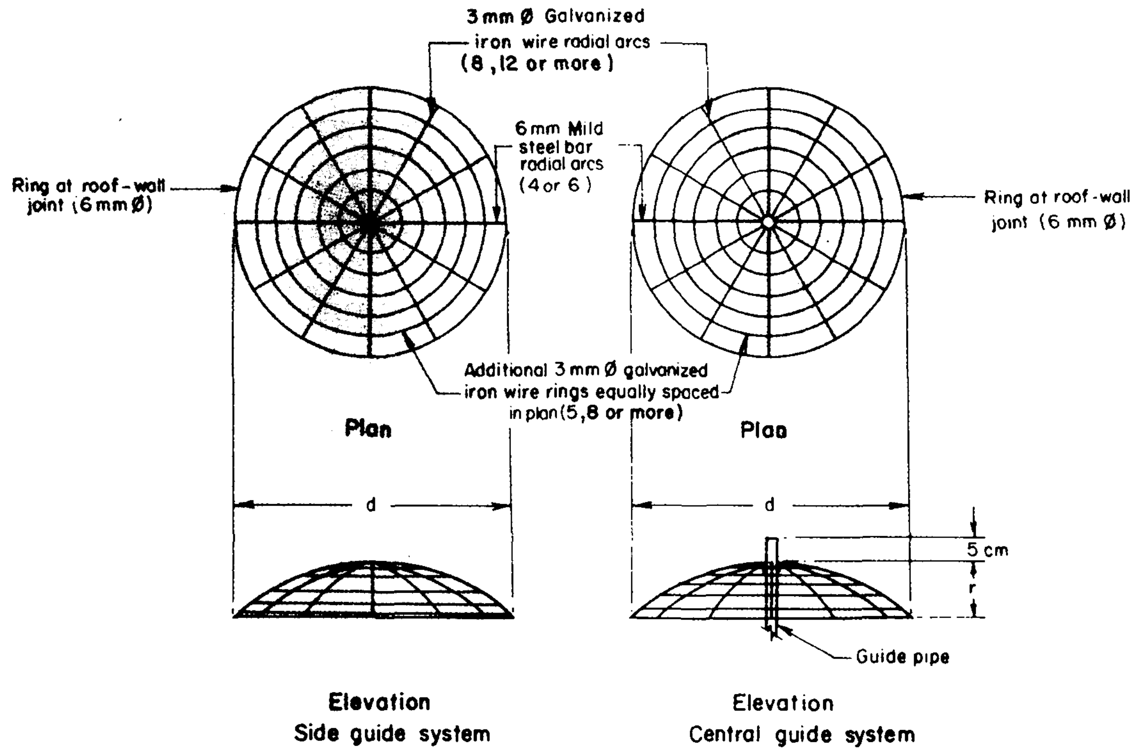


A TYPICAL BIOGAS PLANT OF THE KVIC DESIGN

(This design is recommended for use with a ferrocement gas holder)

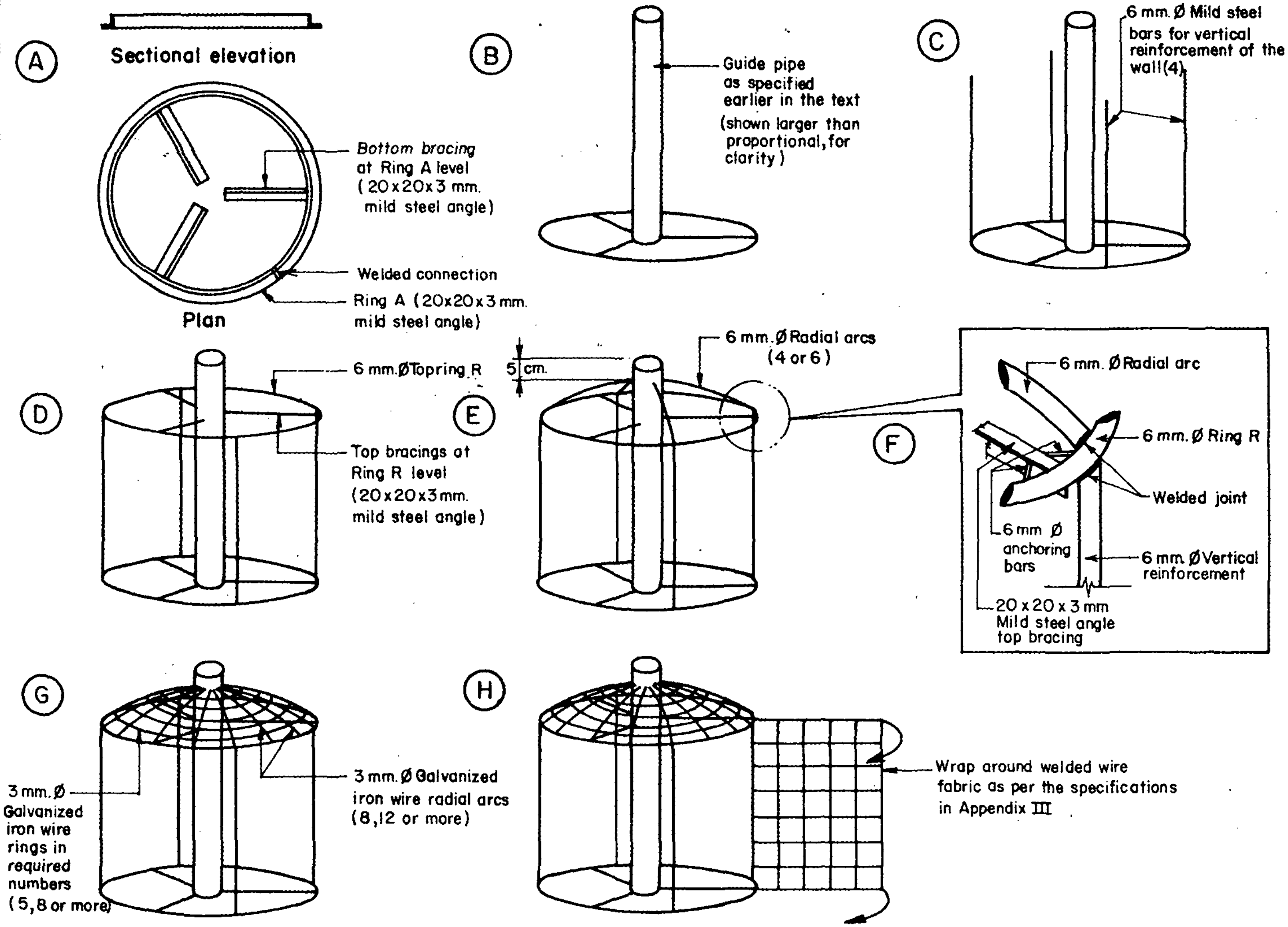


PROFILES OF SKELETAL STEEL CAGE TO BE DRAWN (I)

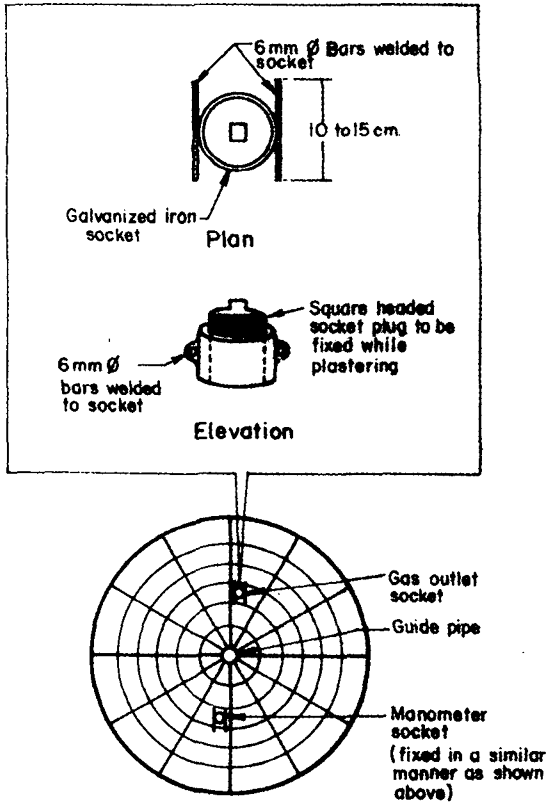


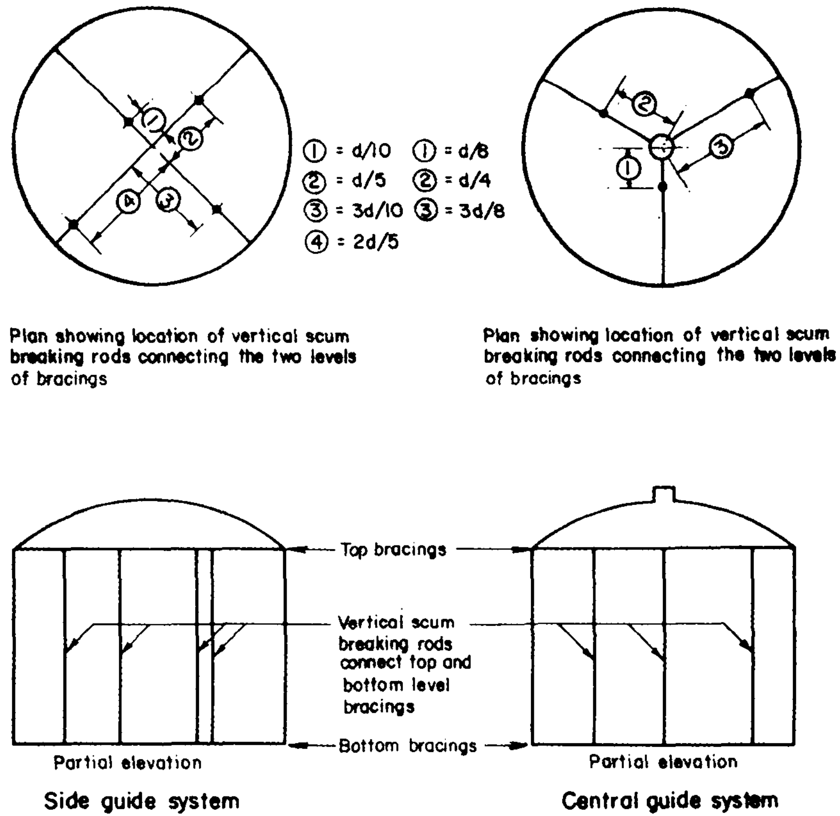
PROFILES OF DOME ROOF TO BE DRAWN (II)

(Figures in brackets indicate numbers of such reinforcement necessary for gas holders of various capacities – also refer Appendix III)



STAGES IN PREPARING REINFORCING CAGE FOR A CENTRAL GUIDE BIOGAS HOLDER.
(A side guide biogas holder cage can be similarly fabricated with minor modifications stated earlier)

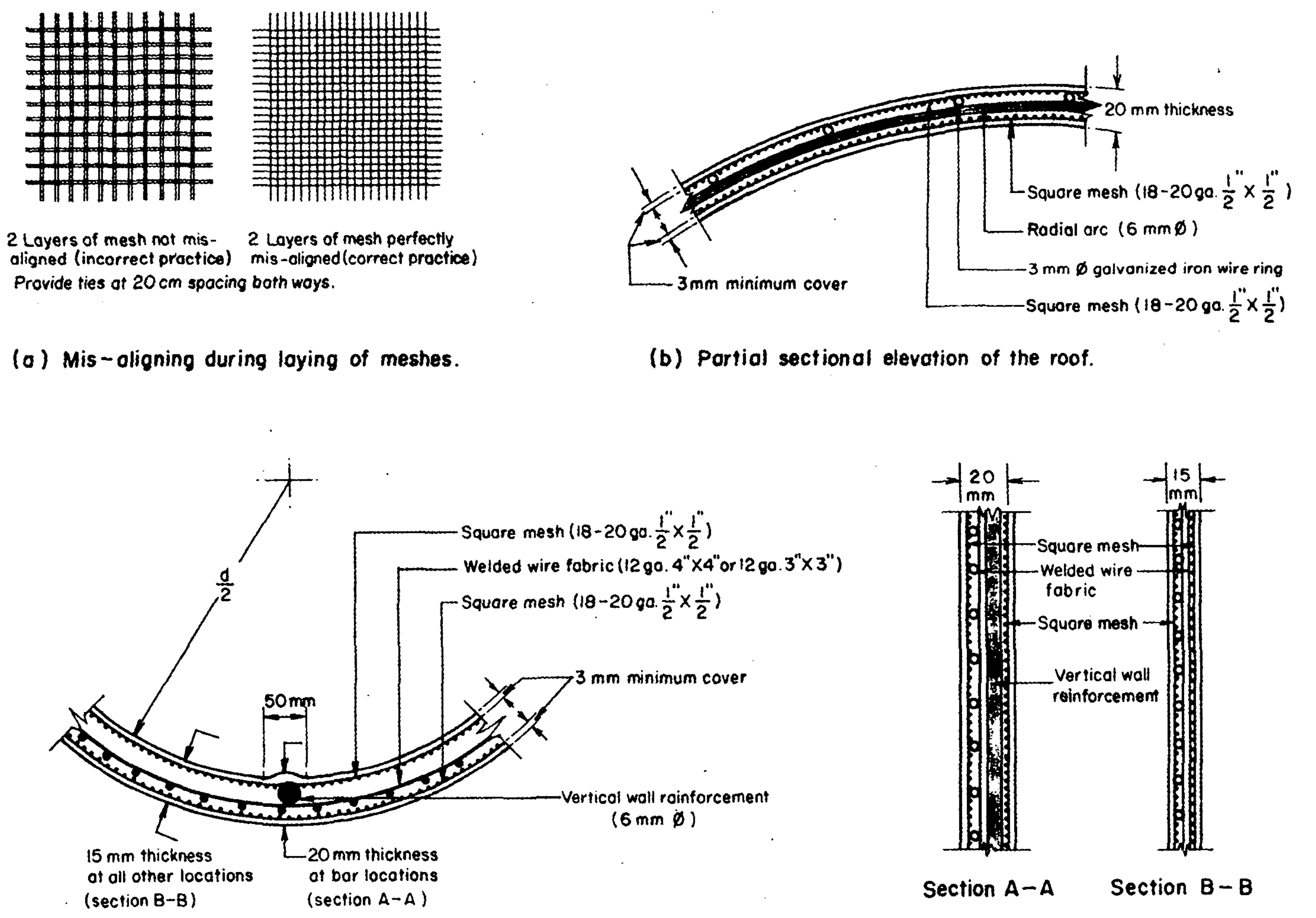




(A) Plan of the roof dome of a central guide biogas holder showing details of socket fittings (note: for a side guide biogas holder gas outlet can be located at the apex of the roof dome).

(B) Drawings show details of the scum breaking arrangement to be provided for the biogas holders of both the central and side guide types.

AUXILIARY FITTINGS

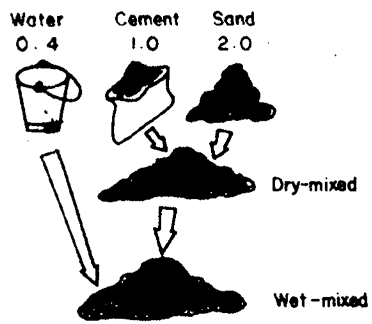


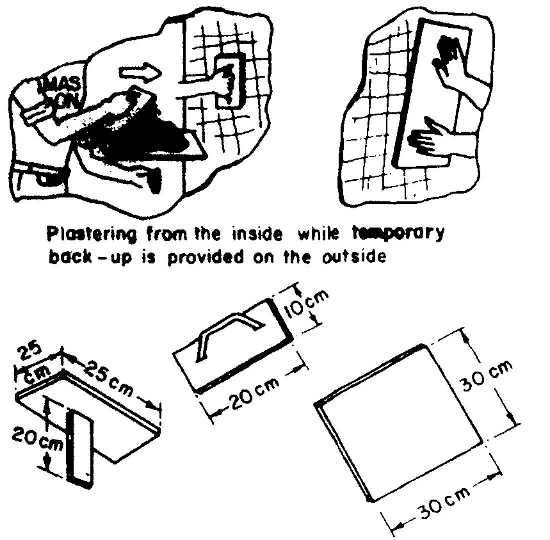
(a) Mis-aligning during laying of meshes.

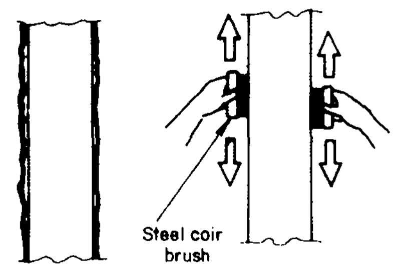
(b) Partial sectional elevation of the roof.

(c) Partial sections of the wall showing reinforcement details.

MESH LAYUP DETAILS





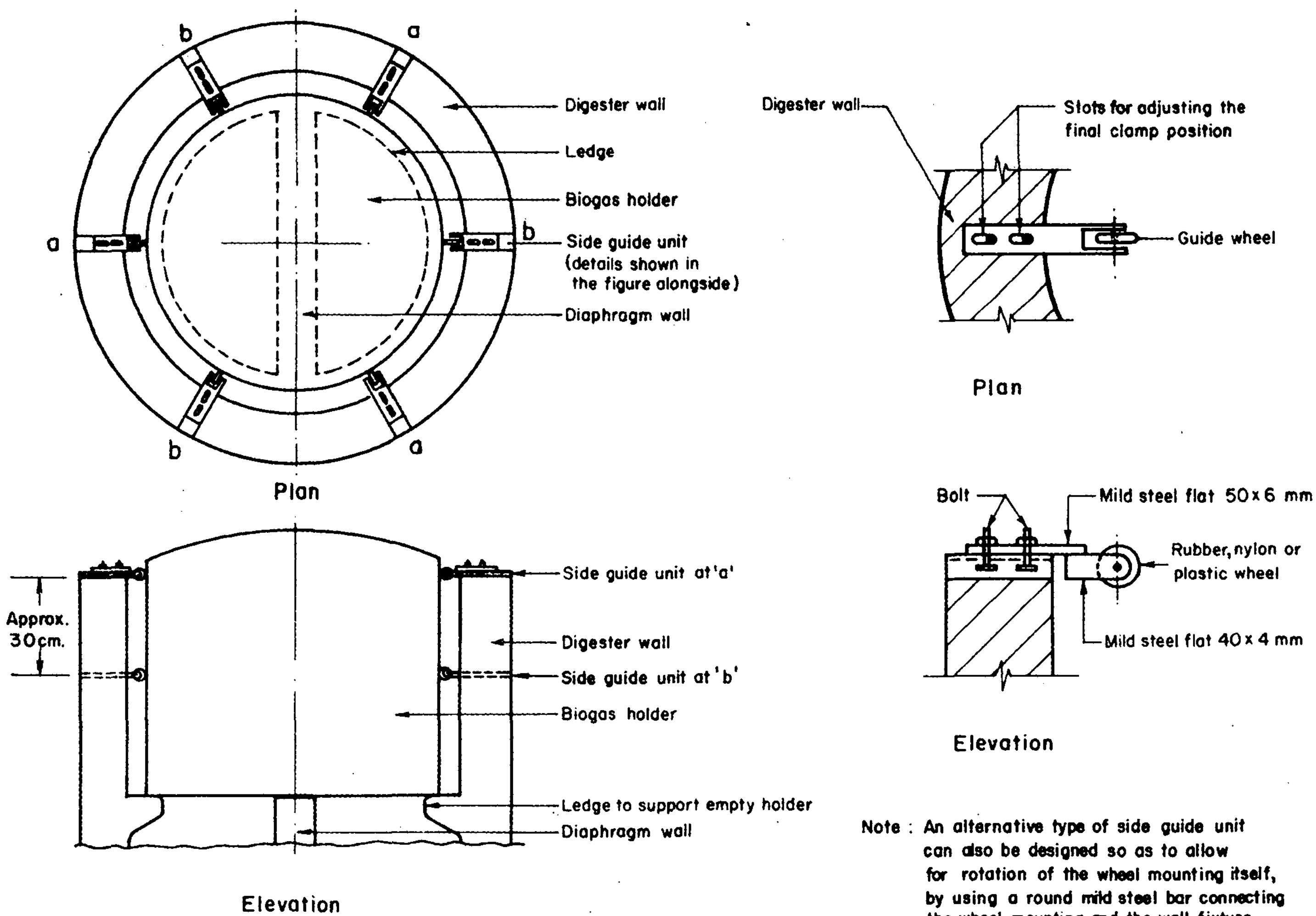


(a) Mix proportions by weight for mortar mix that is to be used for plastering. Although the the constituents can be mixed manually, use of a pan type mixer is recommended.

(b) Plastering technique and simple equipments that make plastering an easy task. Mason impregnates mortar from the inside of the biogas holder cage while the helper holds a back-up sheet on the outside.

(c) Scraping out excessive mortar build-up. This also improves adhesion of the finishing coat.

MORTAR MIXING AND PLASTERING.

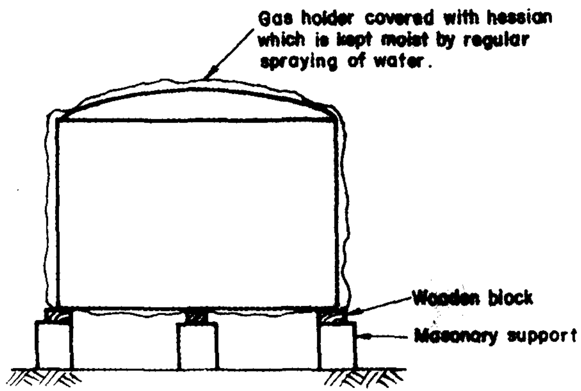


(a) Location of side guide units

Note : An alternative type of side guide unit can also be designed so as to allow for rotation of the wheel mounting itself, by using a round mild steel bar connecting the wheel mounting and the wall fixture. The mild steel bar can then be rotated about its axis.

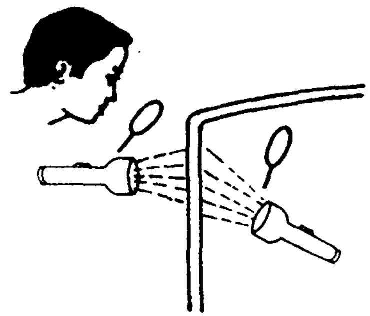
(b) Details of the side guide unit

DETAILS OF THE SIDE GUIDE SYSTEM



Curing should be carried out in a temporary shed so as to avoid direct exposure to the sun.

(a) Curing



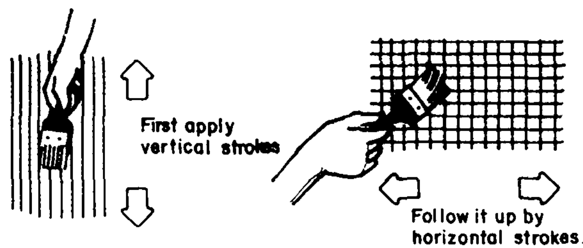
Use of magnifying lens and torch to locate hairline cracks. Alternatively, the inside of the gas holder could be smoked (by burning rags) to trace crack locations.

(b) Inspection

Primer solidification pan.

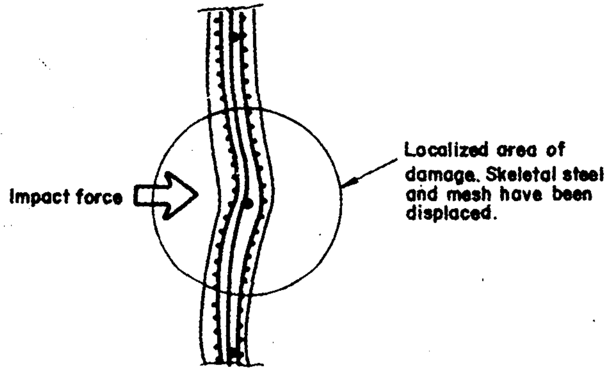
Primer should be rubbed into hairline cracks and pinholes prior to painting.

(c) Application of primer

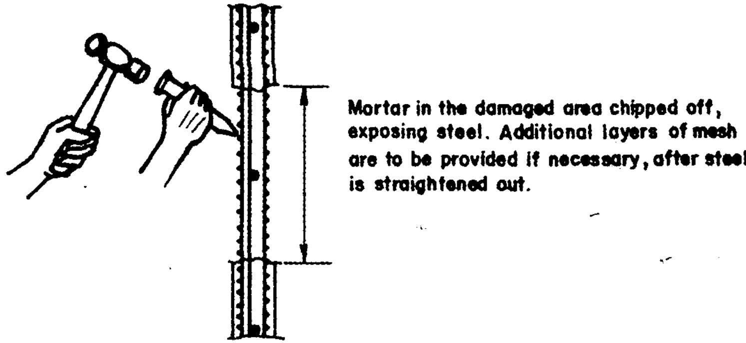


(d) Painting

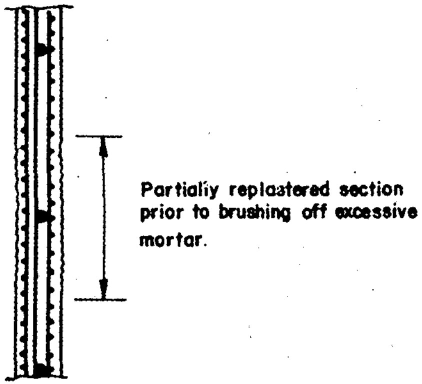
CURING, INSPECTION AND PAINTING



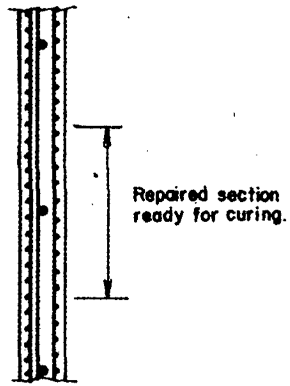
(a) Damaged ferrocement section



(b) Chipping mortar and straightening steel

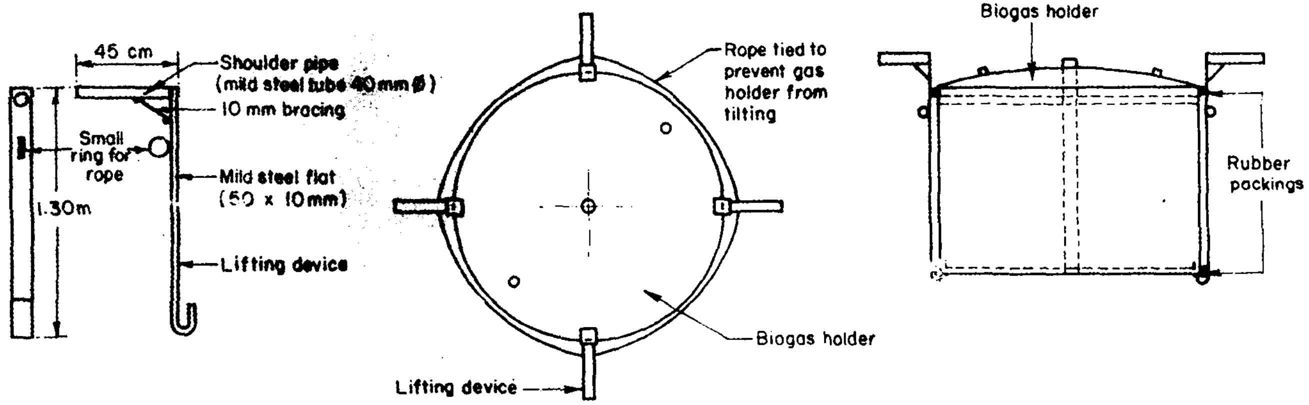


(c) Repair partially complete

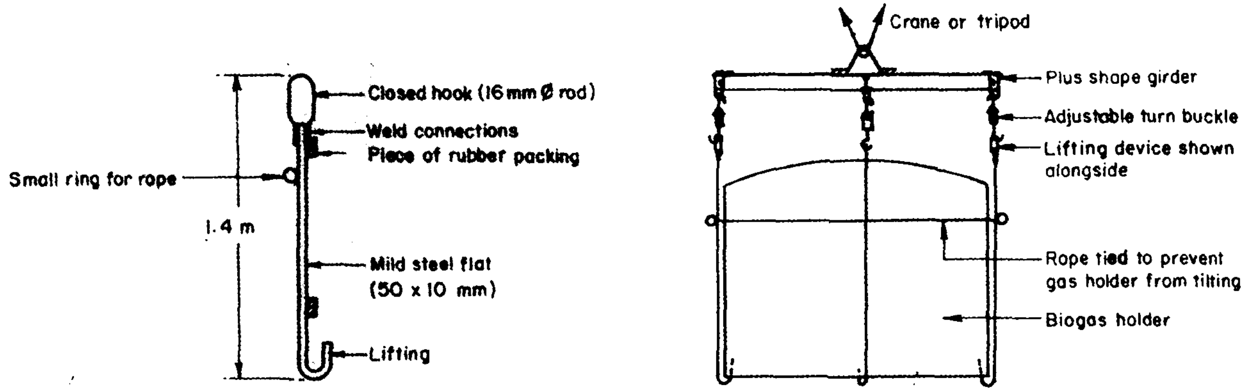


(d) Completed section

STAGES IN REPAIRING A DAMAGED SECTION

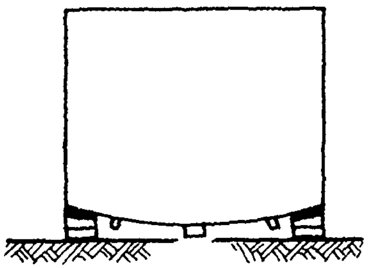


(a) Lifting device for manual shifting.

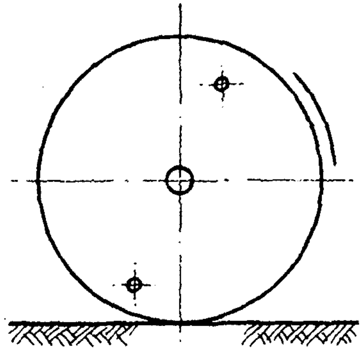


(b) Lifting device for use with cranes or tripods

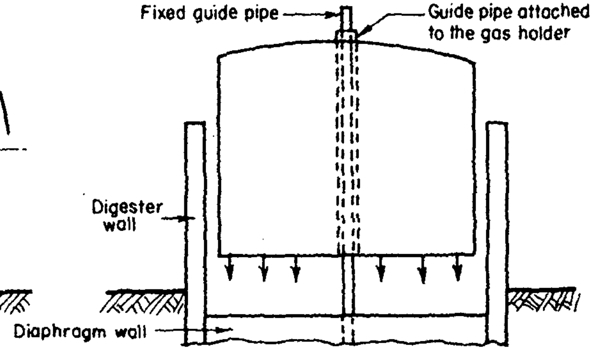
MECHANISM FOR HANDLING BIOGAS HOLDERS.



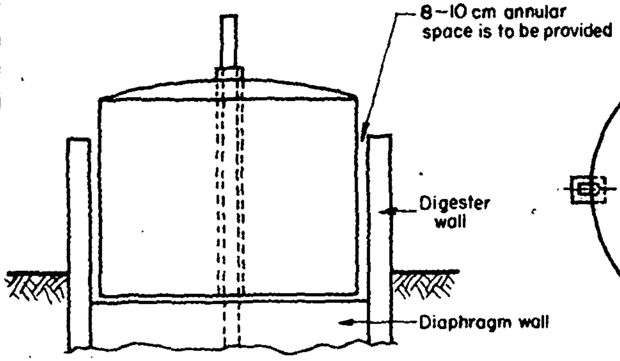
Do not leave a gas holder inverted during plastering curing, painting or when completed



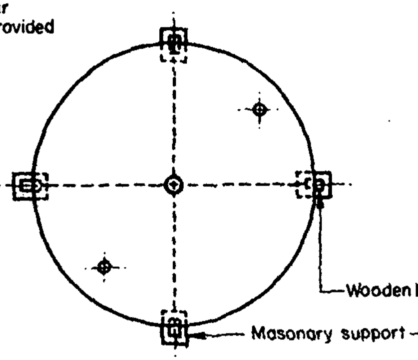
Do not roll a gas holder on its sides during shifting and handling

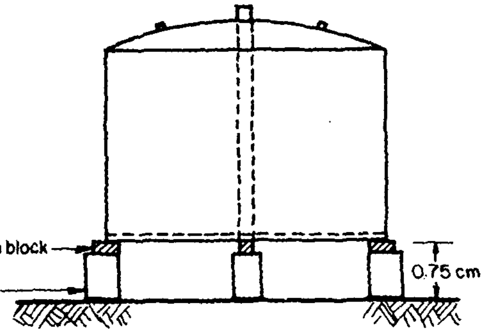


Do not drop gas holder into the digester. Place it gently on the diaphragm wall



Provide adequate annular space between gas holder and digester. Inadequate space results in inefficient operations, while more than adequate space results in loss of gas.





Provide four temporary masonary supports for the gas holder while it is being plastered, cured or painted. The height of the support should permit easy accessibility of the inside of the gas holder

SOME COMMON DO'S AND DONT'S

About IFIC

The **International Ferrocement Information Center (IFIC)** was founded in October 1976 at the Asian Institute of Technology (AIT) under the joint sponsorship of the Institute's Division of Structural Engineering and Construction and the Library and Regional Documentation Center. The IFIC was established as a result of the recommendations made in 1972 by the U.S, National Academy of Sciences's Advisory Committee on Technological Innovation (ACTI). IFIC receives financial support from the United States Agency for International Development (USAID), the 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 publication and on request through IFIC's reference and reprographic services.

IFIC publishes :

The quarterly "**Journal of Ferrocement**",

Monographs (such as "**Ferrocement**" – a comprehensive state-of-the-art review of properties and potential applications of ferrocement – published in August 1978).

Simple brochures on ferrocement in various languages.

Bibliography on ferrocement (Vol. 1 containing 736 items of references classified according to subject – published in November 1978).

Series of simple "Do it yourself" booklets on specific rural utility structures (like this publication, two booklets on **Ferrocement Grain Storage Bin** and **Ferrocement Water Tank** have already been published earlier, and there are a few others under draft).

IFIC also envisages to sponsor training sessions on ferrocement construction to be conducted at AIT for specialists from various developing countries (one such 4 month training for 9 Indonesian engineers financed by USAID was completed in October 1978). For more *information on IFIC write to: The Director, International Ferrocement Information Center, Asian Institute of Technology, P.O. Box 2754,* Bangkok, Thailand.