STRUCTURAL DESIGN FOR REDUCING THE FUEL DEMAND

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ABSTRACT

One of the most influential problem visualized by our world is ozone depletion which is the direct effect of global warming. There are effective examinations being carried all over the country and also across the seas in order to reduce the hazardous effects of global warming. One such remedial measure used for reducing the global warming can be done by utilizing biogas as an alternative of our natural gas. It also comparatively reduces the emission of heat produced when being used. Biogas is estimated to have the potential to replace around 17% of the fuel. It is also a renewable fuel. The main objective of the biogas plant design is to bridge the gap between the people and the environment by reducing the air pollution and also to create an "ECOFRIENDLY" atmosphere by reducing the level of heat emission to the atmosphere by using biogas as fuel. My work is to prepare a detailed plan including all the structural elements required for the actual construction of the biogas plant along with a detailed estimate prepared as per the standard schedule of rates. This is likely to be more advantageous for our future generation.

Keyword: *- Bio Gas Plant, Fermentation , Digester Chamber, Hydraulic Chamber, Bending Moment And Shear Force*

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1. INTRODUCTION

1.1 General

A biogas plant is an anaerobic digester of organic matter for the purposes of treating waste and concurrently generating biogas fuel. The treated waste is a nutrient-rich, nitrogen-rich fertilizer while the biogas is mostly methane gas with inert gases including carbon dioxide and nitrogen. Biogas plants are a preferred alternative to burning dried animal dungs as a fuel and can be used for the treatment of human waste. Other feed stock which can be used includes the plant material, food waste and most type of animal dungs. Over a million biogas plants are been developed for the treatment of organic waste, alternative energy supply to direct burning in the home, and overall improvement of human health and environment.

The ministry of non-conventional energy sources has taken up programs such as NATIONAL PROGRAM ON BIOGAS DEVELOPMENT (NPBD) for setting up family type biogas plant, COMMUNITY, INSTITUTIONAL, NIGHT SOIL based biogas plants, RESEARCH AND DEVELOPMENT ON BIOGAS production and utilization technology.

1.2 Need for Study

The increasing demand for fuel at the present scenario will drastically reduce the fuel availability at the present generation. And the future generation will surely have to exist their life without the usage of fuel which is practically impossible. Also there is no chance for reducing the increasing fuel price as there is more and more demand day by day. So in order to replace this we go for the usage of biogas.

This can meet the major challenge met by the fuel industry by effectively replacing it and also by working efficiently, to recycle organic wastes for harnessing fuel, gas community and institutional levels for various usages including generation of locomotive power and electricity. To provide benefits of biogas technology to weaker sections of the society. So we need to study about the properties, production and appliances of biogas for using it efficiently. This can totally decrease the demand for fuel.

2. THEORETICAL STUDY OF BIOGAS

2.1GENERAL

Biogas technology is one of the most trusted and popular alternative energy sources used for cooking and lighting purposes in the present scenario for meeting the challenge of the fuel demand.

2.2 BIOGAS

Gas produced by anaerobic digestion or fermentation of organic matter under anaerobic conditions.

2.3 ORIGIN:

Biogas originates from bacteria in the process of bio-degradation of organic material under anaerobic (without air) conditions. The natural generation of biogas is an important part of the biochemical carbon cycle. Methanogens are the last link in a chain of microorganisms, which degrade organic material and return the decomposition products to the environment. In this process biogas is generated as a source of renewable energy.

2.4 CHEMICAL COMPOSITION OF BIOGAS:

Biogas = CH_4 + CO_2 + H_2S + N_2 + H_2 + etc.

Typical biogas composition:
Methane, CH_4 = 55-75 %
Carbon dioxide, CO_2 = 25-40%
Hydrogen sulphide, H_2S = 0-3%
Hydrogen, H_2 = 0-2%
Oxygen, O_2 = 0-2%

2.5 PRODUCTION OF BIOGAS OCCURS IN TWO STAGES

1. Bacteria break down complex organic materials.

2. Organic materials and CO_2 are either oxidized or reduced to CH_4 by methanogenic microorganism.

In this way methane is formed from fermentation of animal wastes or any cellulose organic materials, for fermentation several conditions such as air tightness, suitable temperature, necessary nutrients, water contents, maintaining a suitable PH balance should be met.

2.6 MECHANISM OF FERMENTATION

A. Group of Biogas microbes

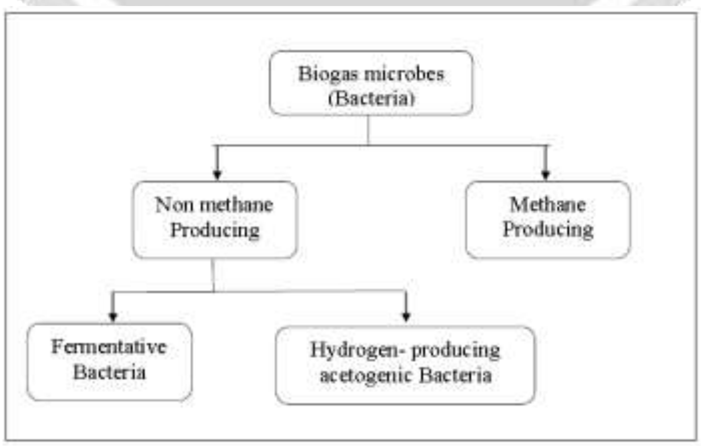

Fig -1: Group of biogas microbes

B. Group of microbes involved in 3 stages of biogas fermentation

1st Stage: Fermentative bacteria

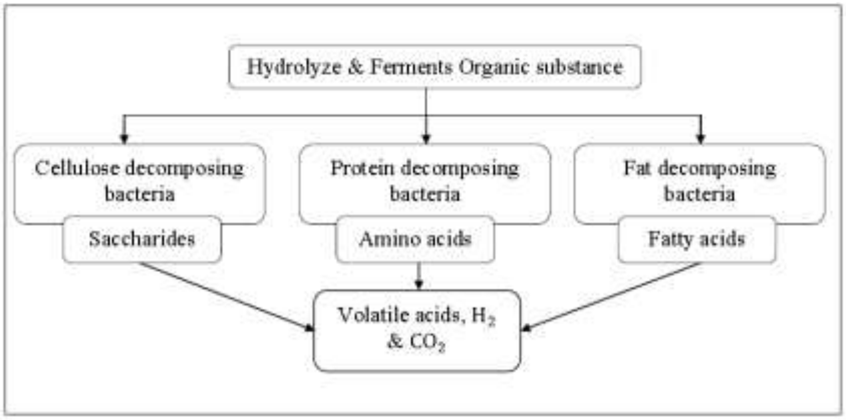

Fig -2: Fermentative bacteria

2nd Stage: Hydrogen producing acetogenic bacteria

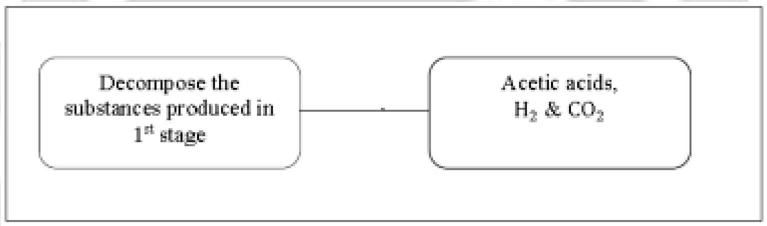

Fig -3 : Hydrogen producing acetogenic bacteria

3rd Stage: Methane producing bacteria

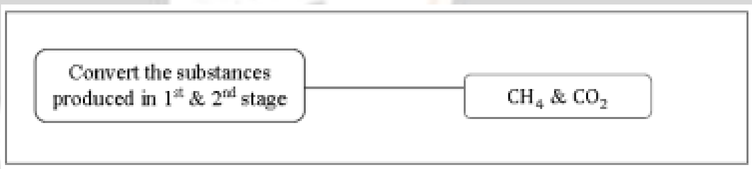

Fig -4 : Methane producing bacteria

3. THEORETICAL STUDY OF BIOGAS PLANT

3.1 GENERAL

A biogas plant supplies energy and fertilizer. It improves hygiene and protects the environment. A biogas plant lightens the burden on the state budget. A biogas plant is a modern energy source. It improves life in the country there by reducing the fuel demand.

It can satisfy these expectations only if it is well designed.

3.2 BIOGAS PLANT

A biogas plant is an anaerobic digester of organic material for the purpose of treating waste and concurrently generating biogas fuel.

3.3 CLASSIFICATION OF BIOGAS PLANT

1. Based on the fermentation process

    a. Continuous
    b. Semi-continuous
    c. Batch type

2. Based on the operation of digester
    a. Fixed dome type
    b. Floating drum type
3. Based on the shape of the digester
    a. Horizontal type
    b. Vertical type
    c. Based on the loading rate
    d. Based on the HRT
    e. Based on construction material
    f. Based on the feed material

3.4 SELECTION OF BIOGAS PLANT

Successful construction of the biogas plant requires a proper design and adherence to follow correct construction methods. The success or failure of biogas plant primarily depend on the quality of construction work. The fixed dome biogas plant has become prolific across Asia.

The advantages of fixed dome plant includes the following:

- Simplicity of design
- Few moving parts
- Low cost to construction
- Low maintenance

Hence the FIXED DOME PLANT TYPE is selected for the design.

3.5 RESOURCE USED

If human excreta is combined with decomposable waste such as animal waste and kitchen waste, and water it will give off gas as it decomposes. Given the right temperature and mix of the waste, much of the gas will be methane, which is flammable. The mix of gas produced is called biogas. Biogas plants have been incorporated in to domestic latrines in a number of countries with mixed success. The plants are used widely in china where the gas produced is used for cooking and lighting.

Biogas plants store the wastes for about 30 days. This removes some of the pathogenic organisms but by no means all. It is better to store the excreta for a period prior to or after putting them in the biogas tank.

Biogas plants can be expensive to build and difficult to operate. Poor maintenance leads to loss of gas production and blockage of the digester tank with solids. They are only appropriate in communities with a commitment to recycling organic wastes and where there are few alternative power sources.

3.6 DETERMINING PLANT SIZE

The biogas plant size is dependent on the average daily feed stock and expected hydraulic retention time of the material in the biogas system. Generally, 150 kilograms of feedstock complimented with 150 liters of water per day with a hydraulic retention time of 40 days.

The required quantity of feedstock and water is mixed in the inlet tank and the slurry is discharged to the digester vessel for digestion. The gas produced through methanogenesis is discharged to the collected in the dome. The digested slurry flows to the outlet tank through the manhole. The slurry then flows through the overflow opening in the outlet tank to the compost pit. The gas is supplied form the dome to the point of application through a pipeline.

When a biogas plant is underfed the gas production will be low; in this case, the pressure of the gas might not be sufficient to fully displace the slurry in the outlet chamber. It is important to design the plant keeping hydrostatic pressure higher at the inlet tank than the outlet tank. The hydrostatic pressure from slurry in the inlet and outlet tanks will pressurize the biogas accumulated in the dome. If too much material is fed into the digester and the volume of gas is consumed, the slurry may enter the gas pipe and to the appliances.

4. VOLUME CALCULATION FOR BIOGAS PLANT

4.1 Digester Chamber

Total no. of students in our college = 1750

No. of students in hostel:

Boys hostel = 150

Girls hostel = 100

Future extension = 100

Total = 350
Discharge per day for human = 0.5 kg
There for the total amount of discharge from 350 students = 350 x 0.5 = 175 kg
The total solid value of fresh discharge (% by wt.) = 20
Therefore, 175 x 0.20 = 35 kg.
Total solid wastage = 8 % (favorable)
8 kg solid = 100 kg INFLUENT
1 kg solid = 100/8
35 kg solid = 100/8 x 35 = 437.5 kg.
Water to be added with fresh discharge to make the ts value 8 % = 0.75 (human)
= 437.5 – (350 x 0.75) =437.5 kg – 262.5 kg =175 kg.
Working volume of digester = Vgs + vf
Vgs + vf = Q x HRT
= 437.5 x 30 (hydraulic retention time = 30 days for human wastage) = 13125 kg = 13.125 m3
From geometrical assumptions:
Vgs + vf = 0.80 v
V = 13.12/0.8
V =16.40 m3.
D =1.3078V1/3 =1.3078(16.40)1/3 =3.30 m.
V3 = π/4 (D2H)
H = 1.32 m.
From assumptions,
F1 = D/5 = 0.66 m
F2 = D/8 = 0.4125 m
R1 = 0.725 D = 2.3925 m
R2 = 1.0625 D = 3.506 m
V1 = 0.0827 D3 = 2.97 m3
VC = 0.05V = 0.82 m3
V2 = 0.05011 D3 = 1.801 m3

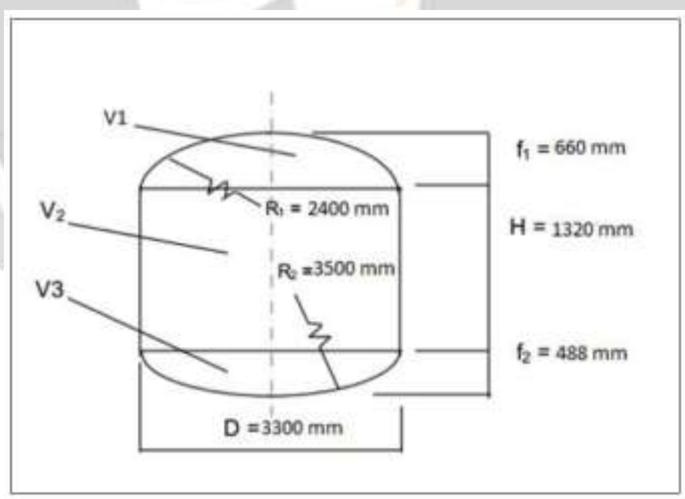

Fig -5: Volume of digester chamber

4.2 Hydraulic Chamber
VC = 0.05V = 0.05 x 16.406 = 0.8203 m3
Vgs = 0.50 x (Vgs + Vf + Vs) x K
= 0.50 (V – VC) x K = 3.1172 m3
Vc + Vgs = 3.9375 m3
Again, V1 = {[Vc + Vgs] – [π/4(D2H)]}

H1 = 0.113m

We have fixed

h = 1000 mm water volume.

H = h3 + F1 + HI

h3 = 0.227m

F1 + H1 = Vgs

Again,

Vgs = VH

VH = 3.1172 = $\pi/4$ (DH) 2 x h3

DH = (3.1172 x 4)/ (π x h3) = 4.18 m

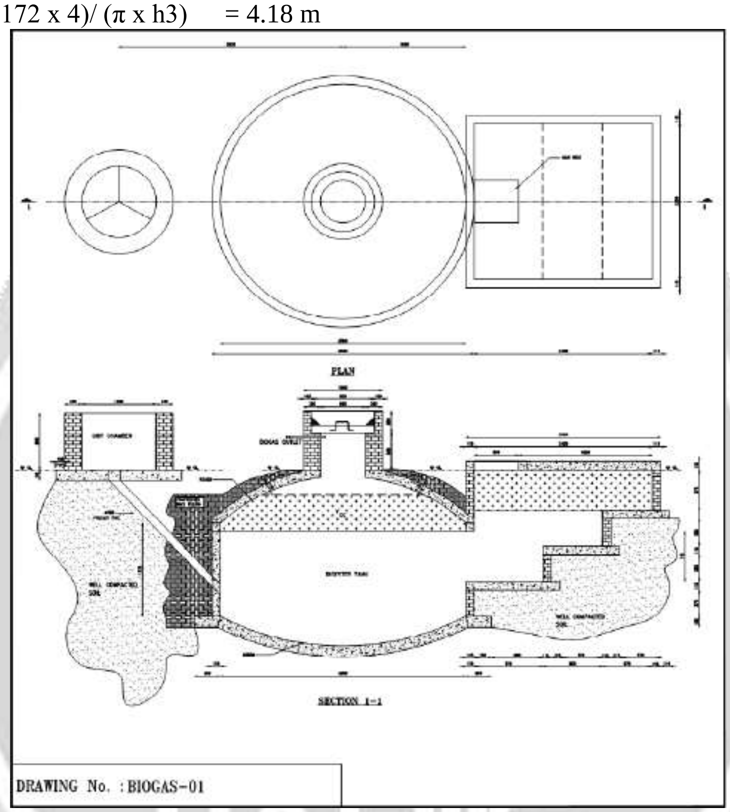

Fig -6: Plan & Elevation

5. PLANNING SPECIFICATIONS

The plant is of 3.5m height. The digester chamber is of height 1.320m and radius of 3.30m, the bottom dome radius is of 3.5m and the top dome radius is of 2.4m. The inlet chamber is of volume 1m3. And the outlet chamber is of dimensions 2.4m x 2.2m.

5.1 Design Specifications

The design specifications used for analysis of the structure model in STAAD are as follows,

Digester Dimensions

Diameter = 3.30m

Height = 1.320m

Dome dimensions

Top dome radius = 2.4m

Bottom dome radius = 3.5m

The design parameters used in STAAD for analysis are,

1.Compressive strength of concrete

i.FC = 20000 kN/m2

2.Yield strength of reinforcement

i.FY = 415000 kN/m2
3.Plate thickness
i.Top dome = 0.11m
ii.Wall = 0.11m
iii.Bottom dome = 0.15m

5.2 Load Calculation

Total height of plant	= 2.75m	
Gas pressure on wall inside the tank	= 2.75 x 16 (Unit wt. of biogas = 16)	= 0.442 kN/m2
Gas pressure on bottom dome	= 0.442 kN/m2	
Gas pressure on bottom dome	= -0.442 kN/m2	

Earth pressure	= 18 x 0.33 x 0.746	= 4.445 kN/m2

By dividing the top dome in to equal no. of plates:

Plate dimensions	= 0.29 x 0.29 m
Plate 1 @ 0.29m	= 0.7425 kN/m2
Plate 2 @ 0.58m	= 10485 kN/m2
Plate 3 @ 0.87m	= 2.20 kN/ m2
Plate 4 @ 1.16m	= 2.97 kN/m2
Plate 5 @ 1.45m	= 3.68 kN/m2
Unit wt. of soil	= 18 kN/m2
Angle of repose	= 30
Earth pressure	= 5.94 kN/ m3
Earth pressure along the Total height	= 16.335 kN/m2
Earth pressure x height of (top dome +digester)	= 12.771 kN/m2
For a Total height of 1.35, Earth pressure	= 12.771 kN/m2

By dividing the walls in to equal .no of plates
Plate dimensions as = 0.22 x 0.22 m

For plate 1 @ 0.22m	= 2.0812 kN/m2
For plate 2 @ 0.44m	= 4.1624 kN/m2
For plate 3 @ 0.66m	= 3.2436 kN/m2
For plate 4 @ 0.88m	= 8.234 kN/m2
For plate 5 @ 1.1m	= 10.406 kN/m2
For plate 6 @ 1.32m	= 12.771 kN/m2
Angle of repose	=30
K	= 0.33
Total height =	2.75m
Earth pressure	= 16.5 kN/m2

Dividing the dome in to equal no. of plates

Plate dimensions	= 0.10 x 0.10 m
For plate 1 @ 2.25m	= 13.5 kN/m2
For plate 2 @ 2.35m	= 14.1 kN/m2
For plate 3 @ 2.45m	= 14.7 kN/m2
For plate 4 @ 2.55m	= 15.3 kN/m2
For plate 6 @ 2.65m	= 15.9 kN/m2

7. STAAD MODEL

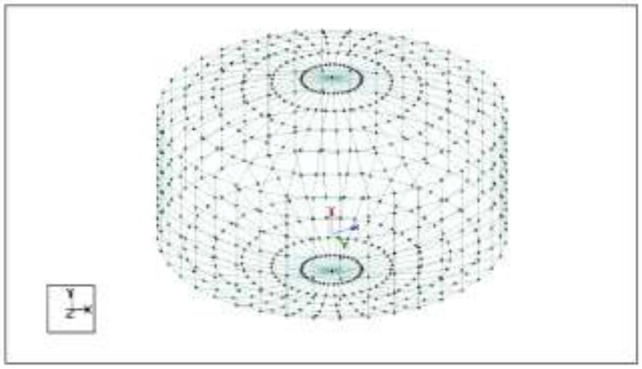

Figure 9.1 : Geometic view

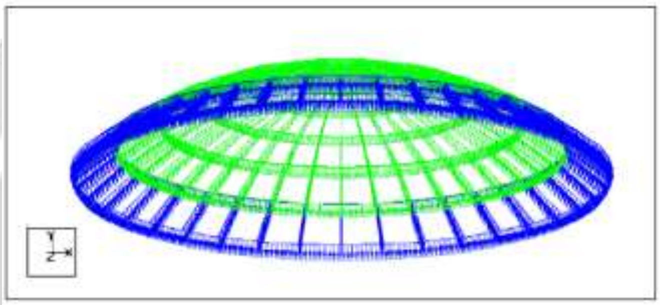

Figure 9.8 : Load due to soil pressure on top dome

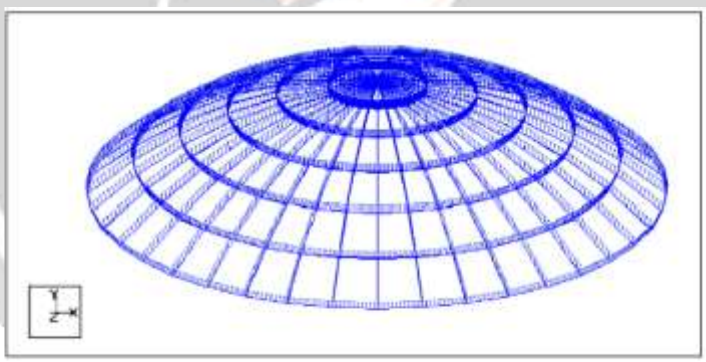

Figure 9.9 : Load due to soil & gas pressure on top dome

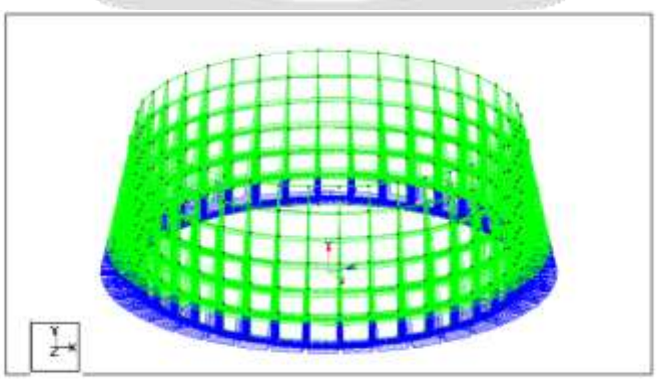

Figure 9.10 : Load due to soil pressure on the circular wall

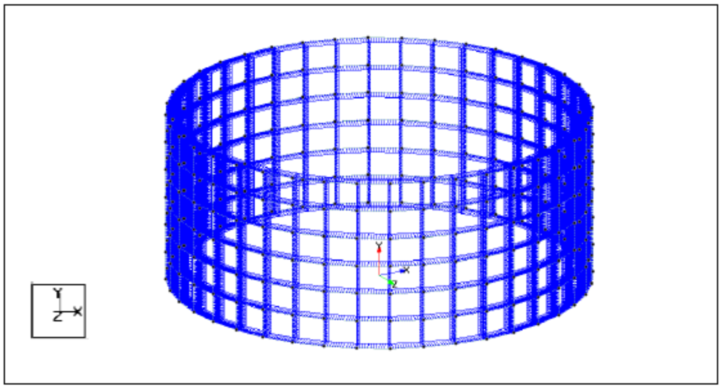

Figure 9.11 Load due to soil & gas pressure on circular wall

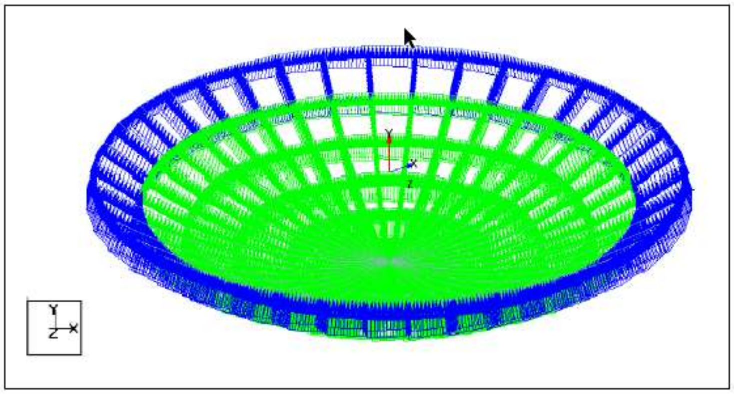

Figure 9.12 : Load due to soil pressure on bottom dome

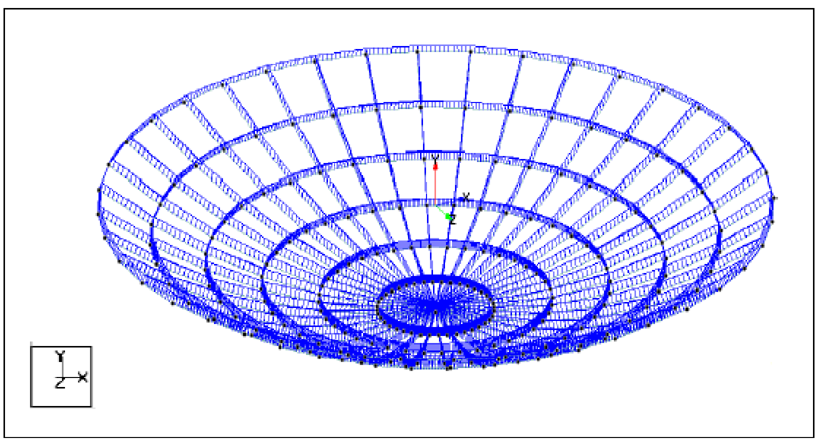

Figure 9.13 : Load due to soil & gas pressue on the bottom dome

8. RESULTS OF BENDING MOMENT AND SHEAR FORCE

8.1Top Dome: Pressure Due To Dry Soil Outside The Tank

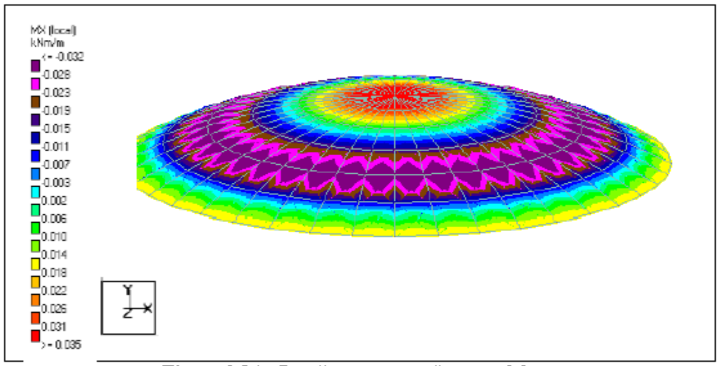

Figure 9.14 : Bending moment diagram-M**X**

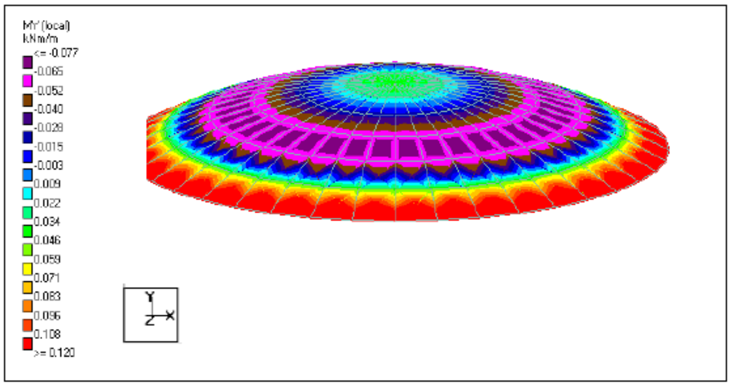

Figure 9.15 : Bending moment diagram-M**Y**

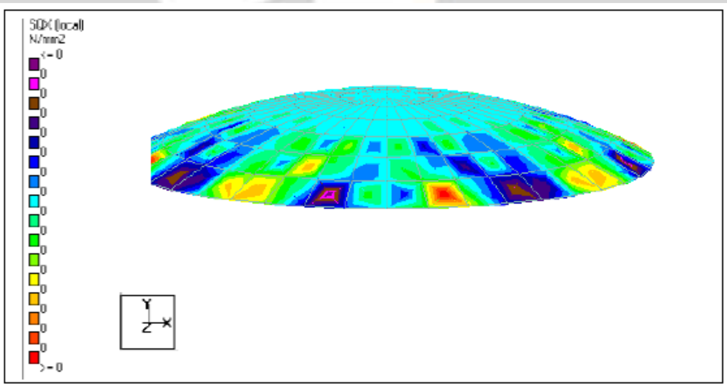

Figure 9.16 : Shear force diagram-F**X**

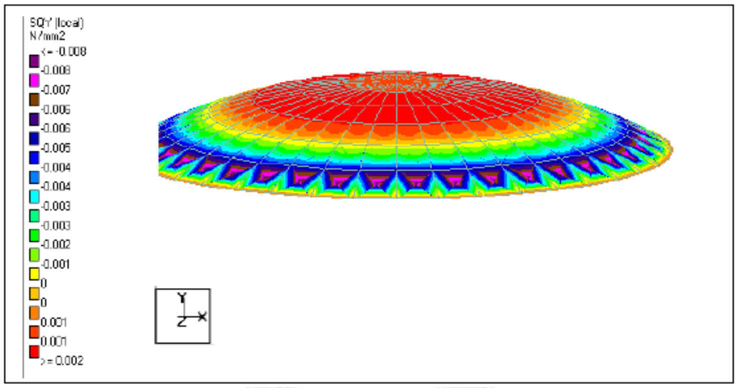

Figure 9.17 Shear force diagram-F**Y**

8.2 Circular Wall: Pressure Due To Soil Outside The Tank

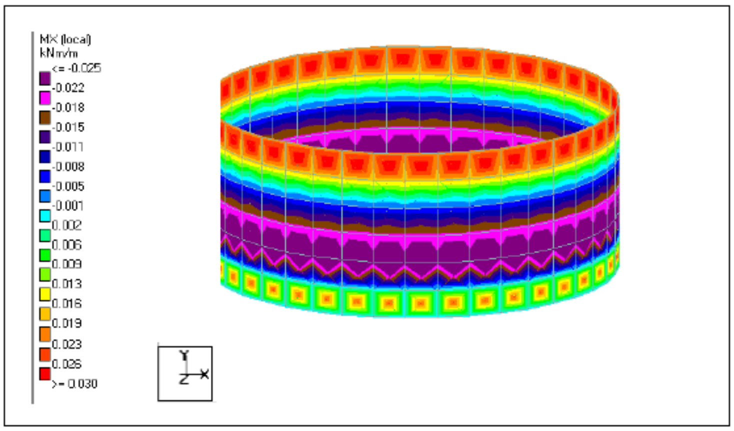

Figure 9.18 : Bending moment diagram-M**X**

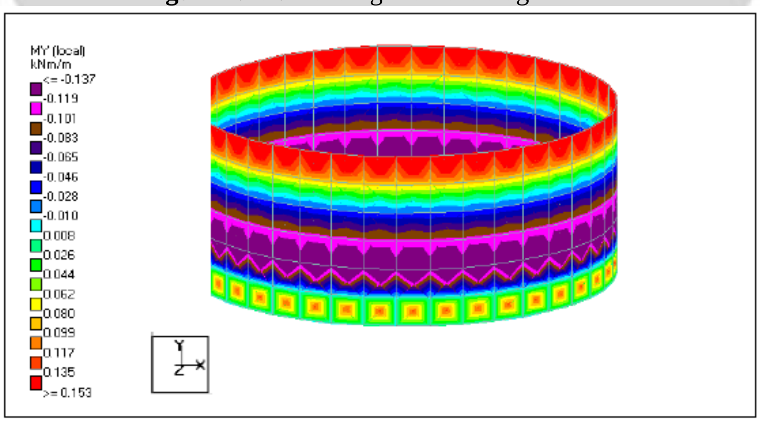

Figure 9.19 : Bending moment diagram-M**Y**

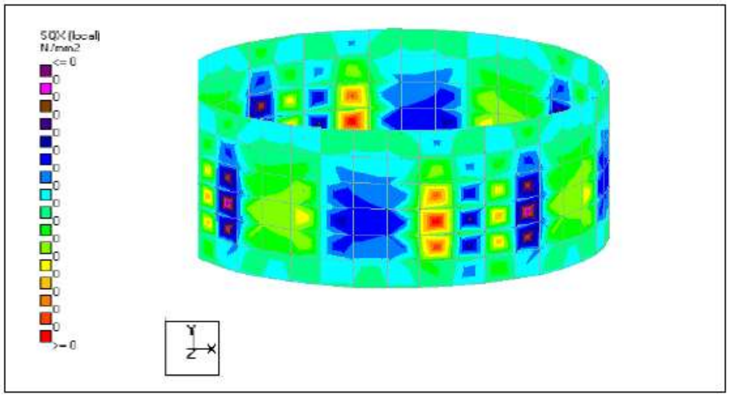

Figure 9.20 : Shear force diagram-F**X**

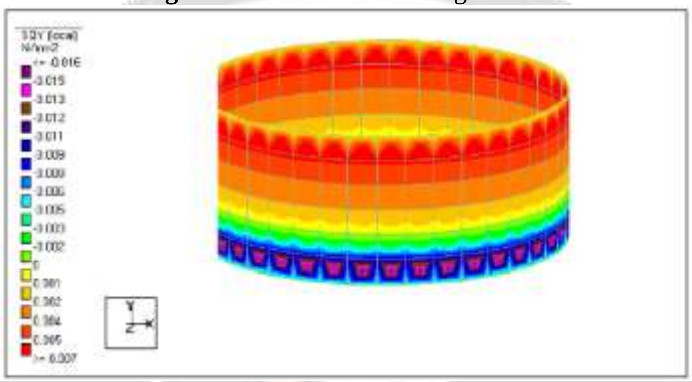

Figure 9.21: Shear force diagram-F**Y**

8.3 Bottom Dome: Pressure Due To Soil Outside The Tank

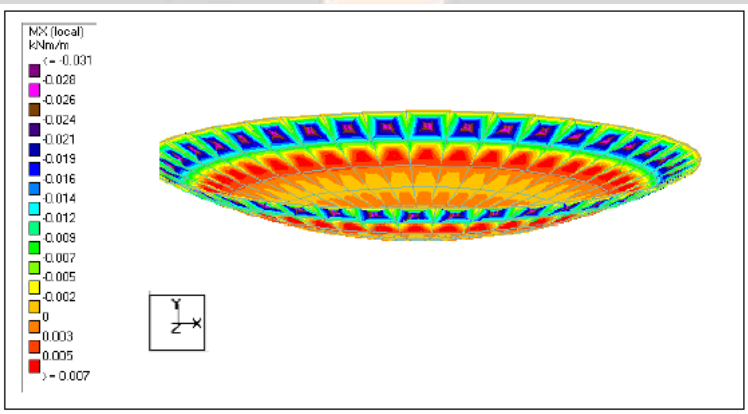

Figure 9.22 : Bending moment diagram-M**X**

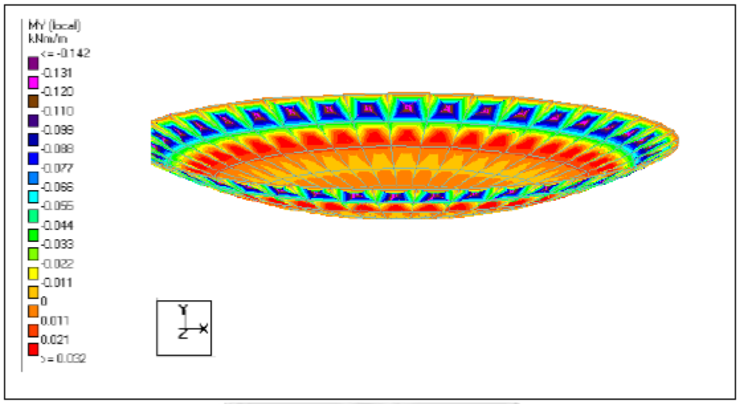

Figure 9.23 : Bending moment diagram-M**Y**

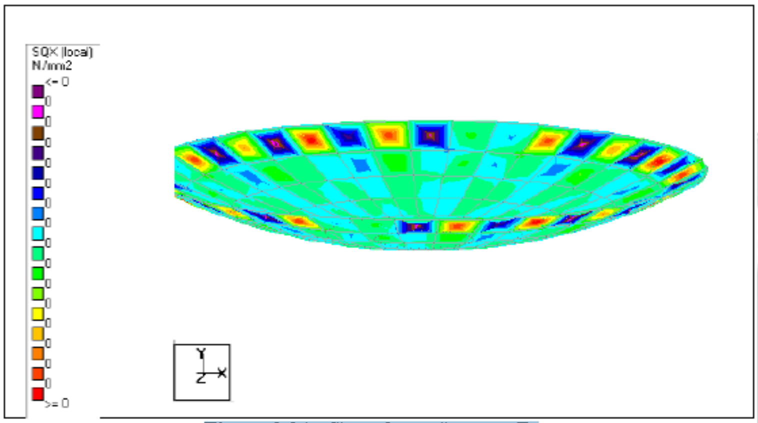

Figure 9.24 : Shear force diagram-F**X**

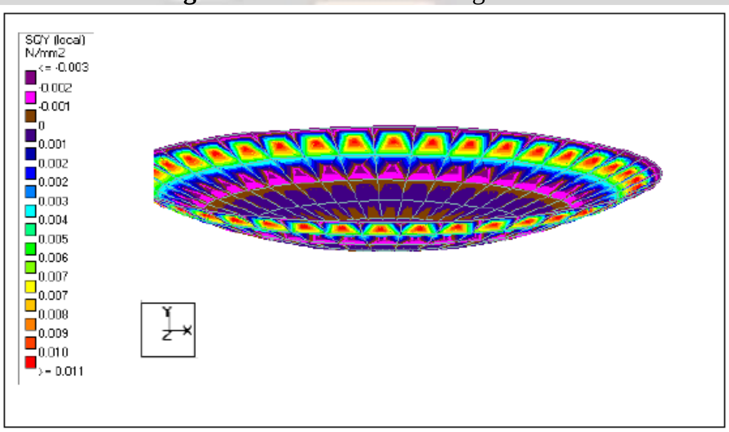

Figure 9.25 : Shear force diagram-F**Y**

9.RESULTS & DISCUSSION

- The study on the design of circular biogas plant was made using conventional method and finite element theory method.
- The conventional method of design of biogas plant are done based on the is code provision IS 3370 and IS 456.
- Finite element method of analysis of biogas plant are done using stadd PRO the design of these plant is done based on the results of the analysis.

- The economical design of biogas plant of different cross section are identified by both conventional method and finite element method.
- Reinforcement details are prepared based on the design.
- The total estimated cost for the usage of LPG during the college running duration for one year exceeds to a great extent when comparing with the installation cost of the biogas plant.
- The approximate fuel cost (LPG) for our college is about Rs.12, 000 per month. And for 10 months is Rs.1, 20,000 whereas the estimated cost for initial construction of biogas plant is Rs.1, 02,000. So this design of biogas plant is very economical.

10. CONCLUSION

The title “Structural Design for Reducing the Fuel Demand” may be a simple one to hear but a lot of hard-work is required in order to design a biogas plant structure under safety conditions.

On taking this project I have learnt various basic requirements, design procedure and importance of a biogas plant.

I have also learnt to use the software’s such as STAAD.Pro and Auto-CAD for the required purposes. It is an important learning requirement since these software’s are mandatory in the civil engineering field of study.

11. FUTURE SCOPE

Since biogas plant is a more advantageous structure for generating the fuel it has a very great scope for the future in reducing the fuel demand and thereby reducing the most influential problem visualized by our world such as global warming. This also adds to the improvement of creating an ecofriendly atmosphere to the present and future scenario.

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