Analysis and Design of Monolithic Domes for Low Cost Housing

[1]Kalaiselvi M, [2] Selvakumar T, [3] Padmasri .G
[1]Lecturer, Department of Civil Engineering, Central Polytechnic College, Chennai, Tamilnadu, India
[2]Lecturer, Department of Civil Engineering, Government Polytechnic College, Cheyyar, Tamilnadu, India
[3]U.G .Student Meenakshi Sundararajan Engineering College, Chennai, Tamilnadu, India

Abstract- This project includes analysis and design of Monolithic Concrete Dome for low cost housing and comparing its cost and energy efficiency with a conventional building. The project emphasizes the need for low cost housing in India and providing the best solution in the form of monolithic concrete domes that not only render cost efficiency but also have proved to be disaster resistant over the years. Monolithic Concrete Dome structures are comparatively more stable than normal conventional buildings.

Keywords - Analysis and design, Monolithic Concrete Dome, Energy efficiency, Low cost housing.

I. INTRODUCTION

In the twenty-first century the population of the world is increasing at very fast rate. So it is essential to design urban life spaces in accordance's to the needs of modern time. The primary objective of this project is to first prepare a plan for the MCD and then study the need for low cost housing in India where a large percentage of population is still lingering under poverty. Furthermore, the analysis and design of the proposed plan is to be carried out. Keeping the necessity of the project in mind, the cost estimation of the structure and its comparison with a similar sized conventional building is carried out.

- To prepare a plan for low cost monolithic concrete dome.
- To study the need for low cost housing in India.
- To carry out Analysis and Design of a proposed plan.
- To provide safe and cost efficient shelter for people with median household income.
- Monolithic concrete domes can serve as the safest structures in areas prone to Tornadoes and Earthquakes.
- In wake of Energy crisis, Domes serve to be energy efficient with lower running costs as they have lowest possible surface area for energy to escape.
- To achieve more Sustainability.

This project is a virtual project meaning that no actual or practical tests are supposed to be done for completion of this project. The project is initiated with the collection of information from existing journals, papers called literature review. After collecting the relevant information the projected is started. A computational approach to realize this goal was developed and is listed in the following steps:

1. Understanding the need for low cost housing in India.
2. Selecting the site that is most prone to earthquakes.
3. Planning the dome structure keeping in view the necessity of the project.
4. Analyzing and designing the dome to check its structural stability based on the given loading conditions.
5. Comparing the dome structure with a similar size conventional building by means of cost estimation.

II. METHODOLOGY

Ring Beam Footing:

Continuous reinforcing bars are embedded in the ring beam foundation. These rebar dowels securely connect the dome to its footing. The ring beam creates a solid base to construct the dome on. Rebar is bent over so that the Air form can be slid over the rebar and attached to the footing.

Figure.1- construction of foundation

Monolithic air form and its errection.

Monolithic construction process demands an Air form. The Monolithic Air form is a balloon like, inflatable structure that determines the shape and size of a dome. It's made of PVC-coated nylon or polyester fabric.. The Air form is a highly engineered fabric structure that should be handled with great care.

a) Laying it out

The Air form should be laid out over the foundation. The Airform will be attached on one side, then it‘s opposite. Then the quarter points, and their opposites and continued evenly all the way around. The Airlock is then attached to the appropriate opening. Once the Airform is in place, bolted down, and inspected, it can be inflated.

b) Attaching the Airform

Airforms can be attached a number of ways. The most common is a thin metal strap that is screwed on the outside with concrete screw anchors as shown below

c) Attaching Inflator Fans

After the Airform is attached, inflator fans are attached to the domes via air tubes that are welded in place.

d) Attaching Airlock

Once the air is turned on, the air lock is attached. The air lock serves as the entry point to the dome during the construction process. The airlock has two doors, so that while entering the dome, pressure will not be lost.

Attaching airlock

Dome inflation

Dual fans are used and often dual power sources, to decrease the chance of power loss. Keeping the air pressure in a dome is the most important factor during dome construction. Inflator fans are started and the Airform is inflated. Air pressure must be regulated. As the building inflates, the easiest way to adjust the pressure is by opening the airlock doors. When the Airform first becomes tight, the inside air pressure should be held at a minimum. Airform should then be checked for weak spots, holes, etc.

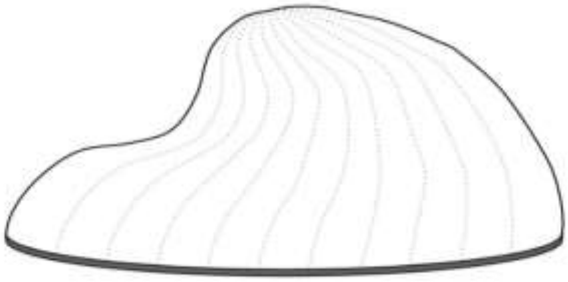

Figure. 2- Attachment of airform

Polyurethane foam application

The airform surface must be dry before applying polyurethane Foam. Any moisture on the surface before spraying will cause blistering. Also the foam will not adhere to a wet surface. Give the Airform time to dry. Heat can be applied to the inside to eliminate moisture if needed. The following are the steps involved in Foam Application.

Step 1: Prime

Treating the Airform with Monoform Primeris an absolute must. Monoform creates a better bond between the Airform and the foam; it acts as glue for the foam. It can be applied with an airless paint gun over the entire interior Airform surface.

Step 2: Choosing a Foam and Application

Foam comes in several set times and is available for cold or warm weather. The speed of foam used depends on the season and climate. Accurate ratio foam will raise perpendicular to the surface being sprayed against. If the foam slides, it is not setting fast enough. Use the fastest setting foam available for the season and climate. The foam machine needs to be adjusted to spray one part Chemical And one part Chemical B (1:1 ratio).

Step 3: Test Thickness

Spray another 1/2- to 3/4-inch layer of foam, making the total thickness, at this point, an inch and a quarter. Test the thickness of the foam by gently probing with an ice pick. Too much probing may make holes in the foamwhich can cause blistering. A lot of probing also increases the risk for puncturing the Airform.

Figure .3- Application of polyurethane foam

Types of rebars used in the construction of monolithic domes

a) Hoop Rebar

Rebar that actually does the most good to hold the dome up is hoop rebar that goes around the dome. Hoop rebar performs somewhat like the hoops on a barrel. Hence, they should be located as far toward the outside as is practical. As pressure is applied to the Monolithic Dome, the dome will try to dimple immediately under the pressure.

b) Vertical Rebar

The vertical layer of rebar is laid against the hoops. For Monolithic Domes requiring thicker shells, rebar should still be placed to the outside.

Rebar Hanger Placement and Final Foam Application

Attach one rebar hanger at the top centre of the dome. To secure the centre top hanger, a thin layer of foam is sprayed over the hanger. If rebar hangers are not covered with enough foam, they will not be secure enough to hold the rebar. The top centre hanger is now used as a marking guide.

After the rebar hangers are placed, secure the hangers by completing the foam spraying job with1/2 to 3/4 inch of foam at a perpendicular angle to prevent excess foam build-up on the hangers. When foaming is complete, begin tying the rebar.

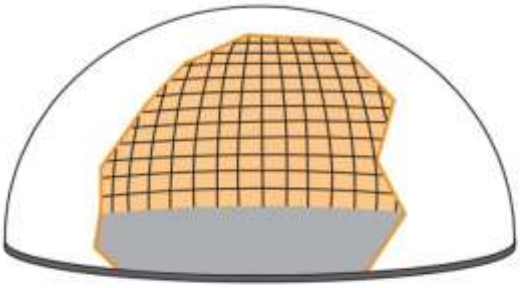

Figure.4 - Reinforcement using Rebar

Shotcrete

Shotcrete is a mixed mortar of cement, sand, 3/8 minus aggregate, and water projected at high velocity onto a surface. The force of the jet impacting on the surface compacts the material. A relatively dry mixture is used so that the material supports itself minimizing sagging or sloughing, even when used for vertical and overhead applications. The cement, sand, aggregate, and water are mixed by suitable means, and then pumped through a hose by a specially designed mortar pump. **Basic Steps for Applying Shotcrete to a Monolithic Dome**

Layer One

The shotcrete is started at the bottom of the dome. First, a thick, tapered layer of shotcrete should be applied around the entire circumference of the dome, at the base, up to about one foot high. This ensures the concrete on the footing is good‖ concrete and not rebound shotcrete. A 1/2" to1" layer is then sprayed on the surface from ground level up to about 6‘high. From 6‘high on up to the top third of the dome, a 1/2" layer is applied. The top third of the dome is covered with1/4" to 1/2" of shotcrete.

Layer Two

Second layer is usually applied on the second day. Up to a 1" layer is applied from ground level to approximately 8‘. From 8‘to the top, a 1/2" layer is then applied.

Layer Three

The third layer is an exact duplicate of the second layer, except that dome will support more weight and the layers can go on thicker and higher. The concrete around the base of the dome will be strong enough to support additional concrete if it is needed for extra thickness.

Layer Four

Layer four is a repeat of the third. The base should be worked for smoothness. Particular attention should be given to the depth gauges.

Final Layer

The final layer should be relatively thin (about 1/4" to 1/2") to permit a smooth finish. Before spraying this last layer, depth is checked. If adequate thickness is not reached by this time, it is necessary to spray additional layers as needed. The finishing layer of concrete should be sprayed from the top down. It seems easier to make a nice finish if the final concrete layer starts at the top.

Figure.5 - Spraying of Shotcrete

This project is a structural design project and during the course of the project we will gain useful knowledge in:

- Design of Structural elements
- Design of dome structure as per hoop and meridian stresses.
- Design of ring beam for foundation.

Software / Equipment used

Various software which will be used in this project are

- Auto CAD
- STAAD.Pro
- STAAD foundation

III. RESULTS

Planning

Planning of the monolithic concrete dome plays a very important role in designing the structure. The plan of the dome, elevation was drawn in Auto cad.

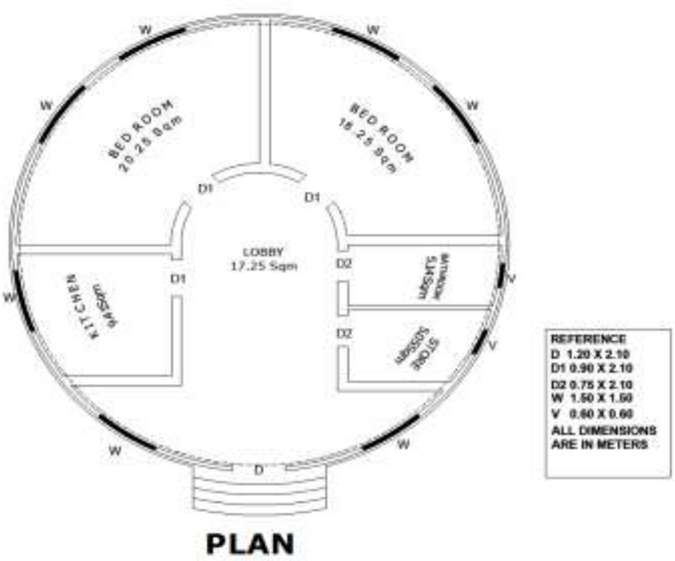

Figure. 6 – Plan of the monolithic concrete dome

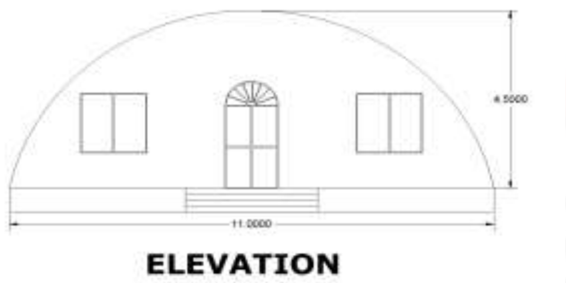

Figure. 7 - Elevation of the monolithic concrete dome

Analysis

The analysis was done using Staad.Pro software. The loads given for the analysis

Self weight of dome = thickness × wt. of concrete
= 0.1 m × 25 kN/m^3
= 2.5 kN/m^2

i) Live load due to wind, snow = 1.5 kN/m^2
Total wt. (w) = 4 kN/m^2
ii) Dead load =1.5 × 4 = 6 kN/m^2
iii) Seismic load = medium soil
iv) Wind load = 250 km/hr (based on the Extreme Weather Events over India in the last 100 years)

Table 1 – Beam force details

BEAM FORCE DETAILS					
Axial force (Fx)(kN)	Shear force (Fy)(kN)	Shear force (Fz)(kN)	Bending moment(kNm) (Mx)	(My)	(Mz)
0.169	1.303	0.004	0.005	0.001	0.141
-1.595	-1.303	-0.004	-0.005	-0.001	-0.087

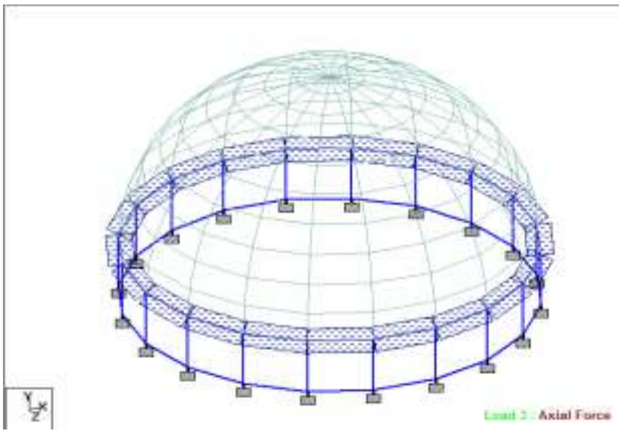

Figure. 8 – Axial Force (Fx)

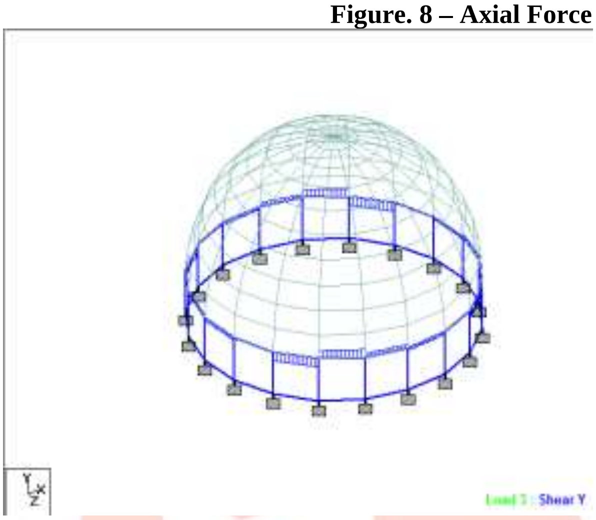

Figure. 9 – Shear Force (Fy)

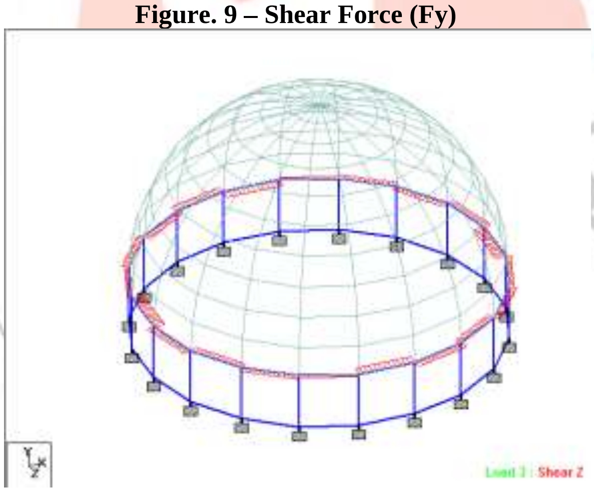

Figure. 10 – Shear Force (Fz)

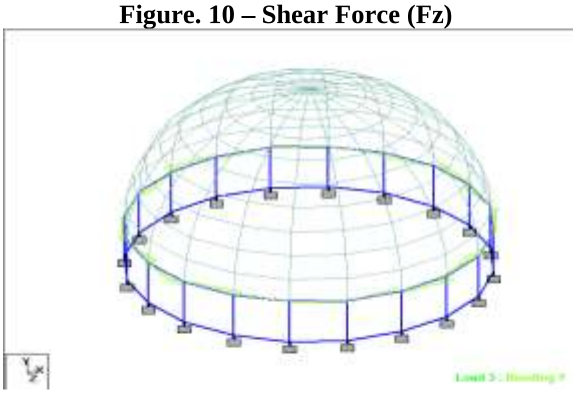

Figure. 11 – Bending Moment (My)

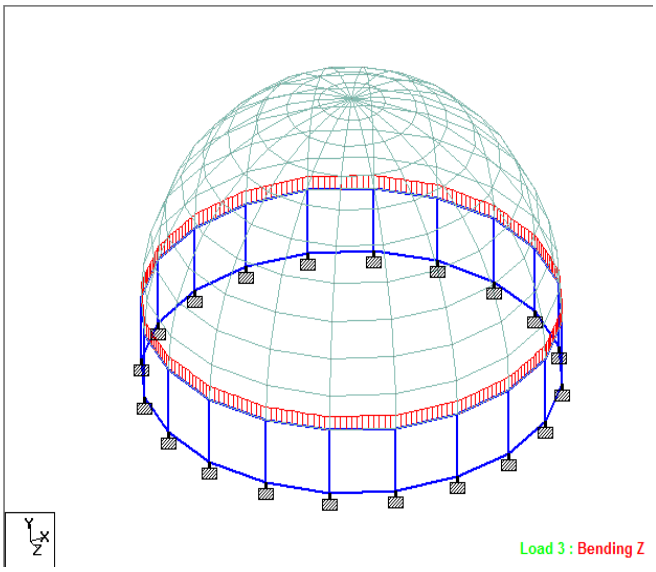

Figure. 12 – Bending Moment (Mz)

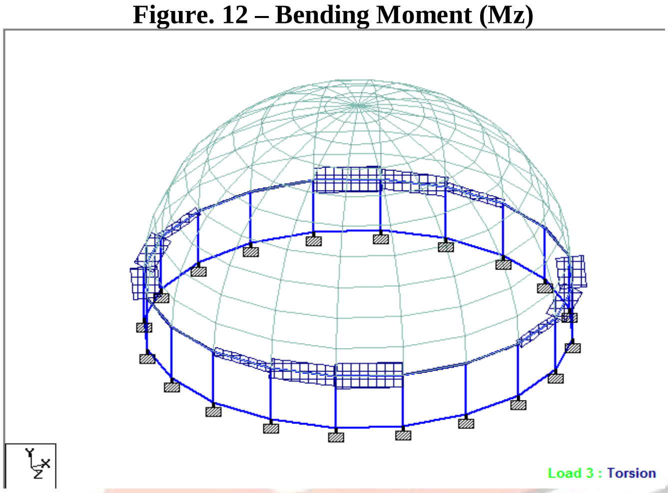

Figure. 13 – Torsional force

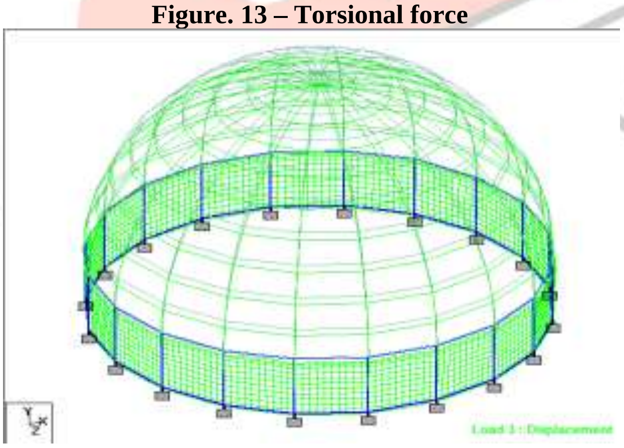

Figure. 14– Displacement due to Loads

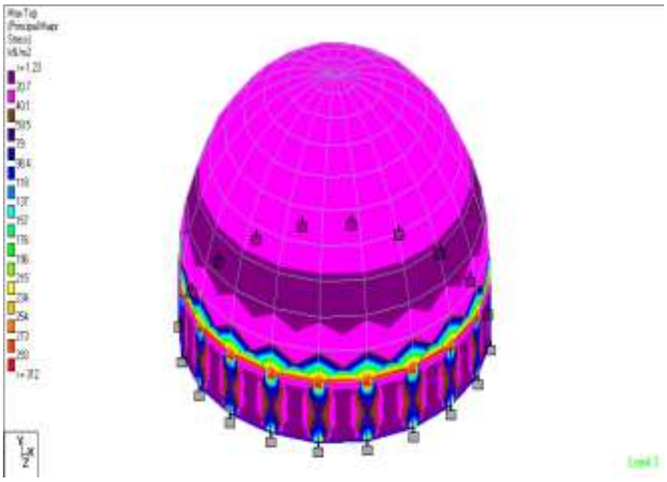

Figure. 15 – Major Principal Stress

Design

- Inside diameter of room =11m
- Rise of dome = 4.5m

Let the radius of the dome be 'r', the diameter of the dome be 11m and rise is 4.5 m.

(2r-height of dome) ×height of dome = (diameter ÷2) ^{2}

$(2r-4.5) \times 4.5 = (11\div2)^2$

$r = 5.61$

Cos ϕ = (r- height of dome)/r | sin ϕ = (diameter/2r)

Cos ϕ = (5.61- 4.5) / 5.61 | sin ϕ = 11/ (2*5.61)

Cos ϕ = 0.1978 | sin ϕ = 0.9804

ϕ = 78° 59" > 51° 49"38" | ϕ = 78° 59" >51°49"38"

The circle of latitude at which the angle ϕ = 51° 49'38" , the hoop stress is 0.If the angle is greater, then hoop compression will be developed while for the portion below this plane , hoop tension will be developed will go increasing further towards the base of the dome.

Load calculation

There is no opening at crown. Let us assume the thickness of the dome be 100 mm.

i) Self weight of dome = thickness × wt. of concrete

= 0.1m × 25 kN/m^3

= 2.5 kN/m^2

ii) Live load due to wind, snow = 1.5 kN/m^2

Total wt. (w) = 4 kN/m^2

Dead load =1.5 × 4 = 6 kN/m^2

Total load (W) = 4+6 =10 kN/m^2

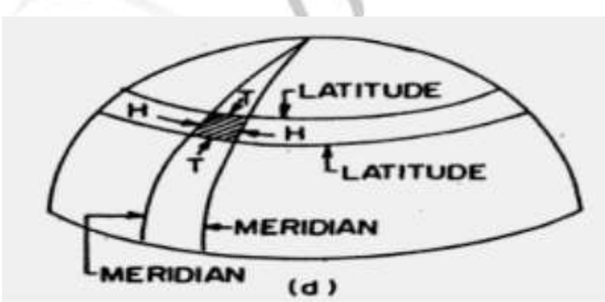

Figure. 16 – Stress acting on the Dome

Calculation of stresses due to combined load

There are two types of stresses are induced in dome.

1. Meridional thrust (T) along the direction of meridian.
2. Hoop stress (H) along the latitudes.

The stress at any horizontal plane will be equal to the algebraic sum of stresses due to the two loading and the dome will be designed for the maximum of these stresses.

Total meridian stress (T) $= [\,wr\,(1-\cos\phi) \div t\times \sin^2\phi\,] + [W \div (2\pi rt\times \sin^2\phi\,]$

$= [4\times5.61(1-\cos78^\circ 59') \div (0.1\times\sin^2 78^\circ 59')] + [10\div (2\pi\times5.61\times0.1\times \sin^2 78^\circ 59'\,]$ kN/m^2

$=191.3425 \times 10^{-3}$ N/ mm^2

T = 0.1913 N/mm^2

Hoop stress (H) = $(wr \div t)[(\cos^2\theta+\cos\theta-1)\div(1+\cos\theta)]-[(W\div 2\pi rt \times(1\div \sin^2\theta)]$

$= (4\times 5.61\div 0.1)[(\cos^2 78°59'+\cos 78°59'-1) \div(1+\cos 78°59')]- [(10\div 2\pi\times 5.61\times 0.1) \times (1\div \sin^2 78° 59')]$ kN/m^2

$= -149.46 \times 10^{-3}$ N/ mm^2 **H= -0.1495 × 10^{-3} N/ mm^2**

Hoopstress in absence of live load

Hoop stress should also be found in absence of love load. This will increase the tensile stresses in the upper portion of the dome, especially near the periphery of the opening. However, meridional thrust will not increase by omitting the live load.

w = 0.1×25000 = 2500N = 2.5kN

Wt. of latern (W) = 10-2.5 = 7.5 kN

Thus the hoop stresses due to w calculated above will be decreased in the ratio of (250÷400)=0.625 while the hoop stresses due to w will be increased by a ratio of (10÷7.5)=1.333.

The maximum hoop tension at the opening has been increased from ***0.098 N/mm^2*** to ***0.195 N/mm^2***

Provision of reinforcement

Max. Compressive stress	= 0.354 N/mm^2 [safe]
Max. hoop tensile stress	= 0.195N/mm^2
Max. hoop tension per metre length of meridian	= 0.195×100×1000=*19500N*
Area of steel	= 19500/140 = 139 mm^2
Reinforcement for temp etc	= 0.15% of thickness
	= (0.15/100)×100×1000
	= 150 mm^2/m
Total reinforcement	= 139+150 = 289 mm^2
Using 8mm Φ bars, spacing	= (1000×50)÷289 =173 mm

However ***provide 8mm bars @ 160mm c/c*** where hoop tension is developed.

In the portion where no hoop tension is developed, minimum area of steel @ 0.15% will be 150mm^2. Hence ***provide 8mm Φ bars @ 300mm c/c.***

Design of ring beam

Meridional thrust per metre length of the dome at its base

=0.19×100×1000=19000N/m.

Horizontal component T per metre length	= 9000×cos 78°59'=3630.80 N/m.
Hoop tension, trying to rupture the beam	= 3630.80× (11/2) =19969.38N.
Area of steel reqd.	= 19969.38/140 =142.63mm^2
Using 10mm Φ bars, No. of rings	= (142.63/78.53)
	=1.8 ~ 2 nos. (approx)

Hence ***provide 2 rings of 10mmΦ bars***.

Equivalent area of composite section of beam of area of cross-section A.

$= A+ (m-1) \times A_{st}$

$= A+18\times 78.53\times 2$

$= A+2827.08$

Allowing tensile stress of 1.2 N/mm^2 in the composite section, we have

$19969.38 / (A+2827.08) =1.2$

From which A= 13814.07 mm^2

However, provide a ring beam of 200mm×200mm. Provide 6mm Φ Striupps @ 160mm c/c to tie the rings in the ring beam.

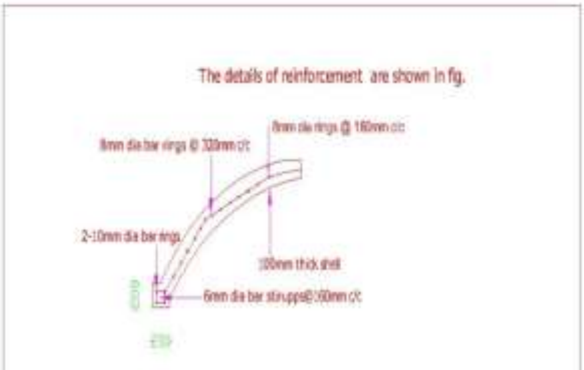

Figure. 17 – Reinforcements in Dome

IV. COST ESTIMATION

The detailed cost estimation of normal conventional building and monolithic concrete dome housing of same size are compared below

Normal conventional building

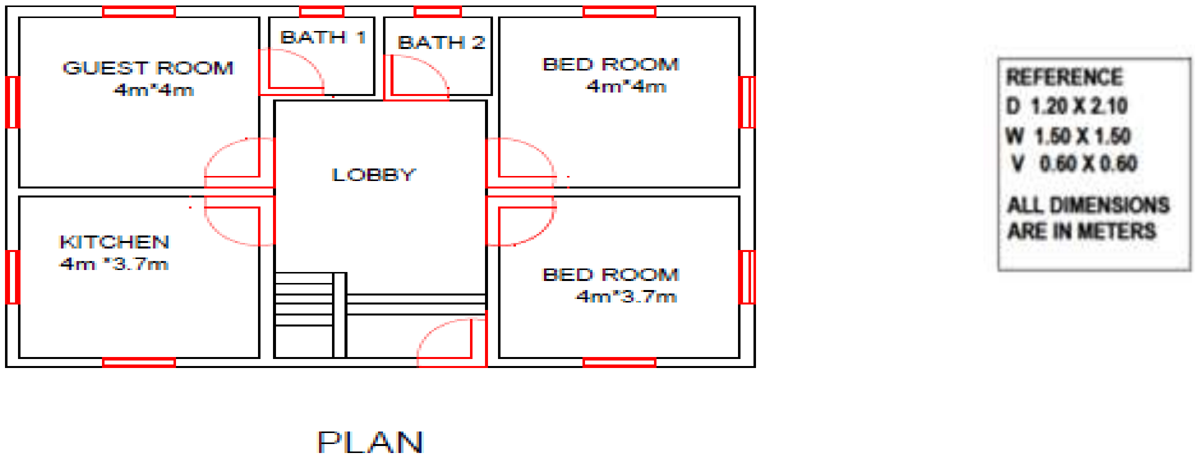

Figure18 – Plan of the conventional one story house

Estimation of normal conventional house

1 .Earth work Excavation for foundation in Hard Gravel soil including 10m lead and lift etc complete.

DESCRIPTION	NO'S	L[M]	B[M]	D[M]	QTY[M^3]
For Columns	1x12	1.2	1.2	1.82	31.10
For Plinth Beam	1x1	73.01	0.45	0.23	7.55

					38.65 CUM

Qty 38.65 CUM [1364CFT] Rate Rs.6.00/cft **Rs. 8,184**

2 . Sand filling for foundation and basement including cost and conveyance of all materials and labour charges etc complete.

For Column	1x12	1.2	1.2	0.15M	2.592
For Plinth beam	1x1	73.01	0.45	0.15M	4.92
For Basement	1x1	13.15	8.39	0.91M	100.39

					107.90 CUM

Qty.107.90CUM[3807CFT] Rate Rs.45.00/ cft **Rs. 1,71,315**

3. Cement concrete 1:5:10 using 40 mm size ISS HBG metal including cost and Conveyance of all materials and labour charges Etc complete.

For Column	1x12	1.2	1.2	0.15M	2.592
For Plinth beam	1x1	73.01	0.45	0.10M	3.28
For Basement	1x1	13.15	8.39	0.10M	11.03

					16.902CUM

Qty. 16.902CUM[597CFT] Rate Rs. 65.00/ cft **Rs. 38,805**

4. RCC 1:2:4 mix using 20 mm size ISS HBG metal including cost and conveyance of all materials and labour charges etc complete.

For Columns	1x12	0.23	0.23	3.96	2.51
For Lintel	1x1	73.01	0.23	0.23	3.86
For Sunshade	1x8	1.82	0.60	0.076	0.66

For Loft	1x4	3.04	0.60	0.076	0.55
Roof slab	1x1	13.15	8.39	0.38	41.92

					49.5 CUM

Qty. 49.5CUM[1747CFT]　　Rate Rs.110.00/cft　　Rs. 1,92,170

5..Supplying and fabrication of steel including cost and conveyance of all materials cutting, bending, tying grills etc, complete.

Qty as per item no. 4 = 1747CFT x 3.00 kg/cft　　= 5241

5241

Qty 5241 kg　　Rate Rs. 65.00/ kg　　Rs. 3,40,665

6.Brick work with CM 1:5 Mix using chamber burnt bricks including cost and conveyance of all materials and labour charges etc complete.

For Superstructure	1x1	73.01	0.23	3.96	66.4
Deduct for Doors	1x4	0.91	0.23	2.13	(-) 1.78
WINDOWS	1x8	1.2	0.23	1.2	(-) 2.69
Ventilator	1x2	1.21	0.23	0.76	(-) 0.42
For Parapet wall	1x1	43.08	0.23	0.91	44.22

					105.73 CUM

Qty: 105.73CUM[3731CFT]　　Rate Rs. 75.00/cft　　Rs. 2,79,825

7.Ceiling plastering with CM 1:3 mix 10mm thick including cost and conveyance of all materials and labour charges etc complete.

Ceiling	1x1	1.69	7.93	-100.63
Sunshades	1x8	1.82	0.68	-9.9
Loft Bottom	2x2	3.04	0.60	-7.2

				117.73SQM

Qty 117.73SQM[1267SFT]　　Rate Rs. 18.00/sft　　Rs.22,806

8. Wall plastering with CM 1:4 mix, 12mm thick including cost and conveyance of all materials and labour charges etc complete.

GUEST ROOM	1x1	16	-	3.04	48.64
Kit	1x1	15.4	-	3.04	46.81
Bed	1x1	16	-	3.04	48.64
BED	1x1	15.4	-	3.04	46.81
Outer alround	1x1	43.08	-	3.96	170.59
Deductions	**as per item no. 6**				(-) 4.89

					356.6SQM

Qty 356.6SQM[3838SFT]　　Rate Rs. 18.00/sft　　Rs. 69,084

9. Supplying and fixing Country wood doors and windows with safety grills including cost and conveyance charges etc complete.

Door	1x4	0.91	-	2.13	7.75
Window	1x8	1.21	-	1.21	11.71
Ventilation	1x2	1.21	-	0.76	1.83

					21.29SQM

Qty 21.29SQM[230SFT]　　Rate Rs.400.00 / sft　　Rs. 92,000

10.Floor finishing with **2'x2' Vitrified Tiles** Flooring Laying with Ordinary cement including cost and conveyance of all materials and labour charges etc complete.

Flooring	1x1	12.69	7.93	100.63

				100.63SQM

Qty 100.63SQM[1083SFT] Rate Rs. 80.00 / sft Rs. 86,640

11**.** Weathering coarse with brick bats and lime powder and top finished with pressed tiles in cm 1:4 mix including all charges etc complete.

For Terrace	1x1	13.15	8.39	110.32

				110.32SQM

Qty: 110.32SQM[1182SFT] Rate Rs. 55.00/sft Rs. 65,010

12**.** Provision of staircase arrangements LS **Rs. 20,000**

Total Est. Rs.13, 86,600/-

(Rupees Thirteen Lakhs and eighty six Thousands and six hundred only)

Estimation of concrete dome housing

1 .Earth work Excavation for foundation in Hard Gravel soil including 10m lead and lift etc complete.

DESCRIPTION	NO'S	L[M]	B[M]	D[M]	QTY[M^3]
For Plinth Beam	1x1	73.01	0.23	2	33.58

					33.58 CUM

Qty 33.58 CUM [1185CFT] Rate Rs.6.00/cft **Rs. 7,110**

2 . Sand filling for foundation and basement including cost and conveyance of all materials and labour charges etc complete.

For Plinth beam	1x1	73.01	0.45	0.15M	4.92
For Basement	1x1	13.15	8.39	0.91M	100.39

					105.31CUM

Qty.105.31CUM[3716CFT] Rate Rs.45.00/ cft **Rs.1,67,220**

3. Cement concrete 1:5:10 using 40 mm size ISS HBG metal including cost and Conveyance of all materials and labour charges Etc complete.

For Plinth beam	1x1	73.01	0.45	0.10	3.28
For Basement	1x1	13.15	8.39	0.10	11.03

					14.31 CUM

Qty. 14.31CUM[505CFT] Rate Rs. 65.00/ cft **Rs. 32,825**

4. RCC 1:2:4 mix using 20 mm size ISS HBG metal including cost and conveyance of all materials and labour charges etc complete.

For Lintel	1x1	73.01	0.23	0.23	3.86
For Sunshade	1x8	1.82	0.60	0.076	0.66
Dome roof	1x1	[$2\pi r^2$]=100.48m^2	0.38		38.18

					42.7CUM

Qty. 42.7CUM[1506CFT] Rate Rs.110.00/cft Rs. 1,65,660

5..Supplying and fabrication of steel including cost and conveyance of all materials cutting, bending, tying grills etc, complete.

Qty as per item no. 4 = 1506CFT x 3.00 kg/cft = 4518

4518

Qty 4518 kg   Rate Rs. 65.00/ kg   Rs. 2,93,670

6.Brick work with CM 1:5 Mix using chamber burnt bricks including cost and conveyance of all materials and labour charges etc complete.

For Superstructure	1x1 73.01	0.23	3.96	66.4
Deduct for Doors	1x4 0.91	0.23	2.13	(-) 1.78
WINDOWS	1x8 1.2	0.23	1.2	(-) 2.69
Ventilator	1x21.21	0.23	0.76	(-) 0.42
For Parapet wall	1x143.08	0.23	0.91	44.22
				105.73 CUM

Qty: 105.73CUM[3731CFT]   Rate Rs. 75.00/cft   Rs. 2,79,825

7.Wall plastering with CM 1:4 mix, 12mm thick including cost and conveyance of all materials and labour charges etc complete.

GUEST ROOM	1x1	16	-	3.04	48.64
Kit	1x1	15.4	-	3.04	46.81
Bed	1x1	16	-	3.04	48.64
BED	1x1	15.4	-	3.04	46.81
Outer alround	1x1	43.08	-	3.96	170.59
Deductions	**as per item no. 6**				(-) 4.89
					356.6SQM

Qty 356.6SQM[3838SFT]   Rate Rs. 18.00/sft   Rs.69,084

8. Supplying and fixing Country wood doors and windows with safety grills including cost and conveyance charges etc complete.

Door	1x4	0.91	-	2.13	7.75
Window	1x8	1.21	-	1.21	11.71
V	1x2	1.21	-	0.76	1.83
					21.29SQM

Qty 21.29SQM[230SFT]   Rate Rs.400.00 / sft   Rs. 92,000

9.Floor finishing with **2'x2' Vitrified Tiles** Flooring Laying with Ordinary cement including cost and conveyance of all materials and labour charges etc complete.

Flooring	1x1	12.69	7.93	100.63
				100.63SQM

Qty 100.63SQM[1083SFT]   Rate Rs. 80.00 / sft   Rs. 86,640

10**.** Weathering coarse with brick bats and lime powder and top finished with pressed tiles in cm 1:4 mix including all charges etc complete.

For Terrace	1x1	13.15	8.39	110.32
				110.32SQM

Qty: 110.32SQM[1182SFT]   Rate Rs. 55.00/sft   Rs.65,010

Total Est.   Rs.   9, 57,015/-

(Rupees Nine lakhs fifty seven thousand and fifteen only)

V. CONCLUSIONS

- The implementation of this project will play a key role in bringing awareness about the construction of MCD's and their use as residential buildings in the earthquake prone areas for the people with median house hold income.
- The project also encompasses various aspects of the constructions of concrete domes which include cost efficiency, disaster resistant nature, earthquake resistant nature and energy efficiency.
- we have analyzed and designed Monolithic Concrete Domes. The structure was designed as per mentioned standards. The design was done in accordance with the codal provisions as provided in the design of reinforced concrete structures.

VI. REFERENCES

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