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Reinforced Cement Concrete (RCC) Dome Design

SHAIK TAHASEEN

II M.TECH, DEPARTMENT OF CIVIL ENGINEERING, VISVODAYA ENGINEERING COLLEGE, KAVALI

ABSTRACT: **A dome may be defined as a thin shell generated by the revolution of a regular curve about one of its axes. The shape of the dome depends up on the type of the curve and direction of the axis of revolution. The roof is curved and used to cover large storey buildings. The shell roof is useful when inside of the building is open and does not contain walls or pillars. Domes are used in variety of structures such as roof of circular areas, circular tanks, exhibition halls, auditoriums etc. Domes may be constructed of masonry, steel, timber and reinforced cement concrete. In this paper we design RCC dome roof structure by using manual methods which gives detail design of RCC domes. The procedure of designing RCC domes was clearly explained and from the Analysis and design we get the Meridional Reinforcement, hoop Reinforcement of a dome and ring beam Reinforcement**

Keywords: **Dome, wind load, live load and dead load, Analysis, diameter of dome.**

1. INTRODUCTION

In the past and recent years, there have been an increasing number of structures using RCC domes as one of the most efficient shapes in the world. It covers the maximum volume with the minimum larger volumes with no interrupting columns in the middle with an efficient shapes would be more efficient and economic. Dome roofs are the lightest structure to cover circular shape.

A dome is an element of architecture that resembles the hollow upper half of a sphere. Dome structures made of various materials have a long architectural lineage extending into prehistory. Corbel domes and true domes have been found in the ancient Middle East in modest buildings and tombs. The construction of the first technically advanced true domes began in the Roman Architectural Revolution, when they were frequently used by the Romans to shape large interior spaces of temples and public buildings, such as the Pantheon. This tradition continued unabated after the adoption of Christianity in the Byzantine (East Roman) religious and secular architecture, culminating in the revolutionary pendentive dome of the 6th-century church Hagia Sophia. Squinches, the technique of making a transition from a square shaped room to a circular dome, were most likely invented by the ancient Persians. The Sassanid Empire initiated the construction of the first large-scale domes in Persia, with such royal buildings as the Palace of Ardashir, Sarvestan and Ghal'eh Dokhtar. With the Muslim conquest of Greek-Roman Syria, the Byzantine architectural style became a major influence on Muslim societies. Indeed the use of domes as a feature of Islamic architecture has gotten its roots from Roman Greater-Syria (see Dome of the Rock). An original tradition of using multiple domes was developed in the church architecture in Russia, which had adopted Orthodox Christianity from Byzantium. Russian domes are often gilded or brightly painted, and typically have a carcass and an outer shell made of wood or metal. The onion dome became another distinctive feature in the Russian architecture, often in combination with the tented roof. Construction of domes in the Muslim world reached its peak during the 16th – 18th centuries, when the Ottoman, Safavid and Mughal Empires, ruling an area of the World compromising North Africa, the Middle East and South- and Central Asia, applied lofty domes to their religious buildings to create a sense of heavenly transcendence. The Sultan Ahmed Mosque, the Shah Mosque and the Badshahi Mosque are primary examples of this style of architecture.

Stone and brick domes are one of the oldest architectural forms. However, reinforced concrete domes are more common now a days .since they can be constructed over large spans.

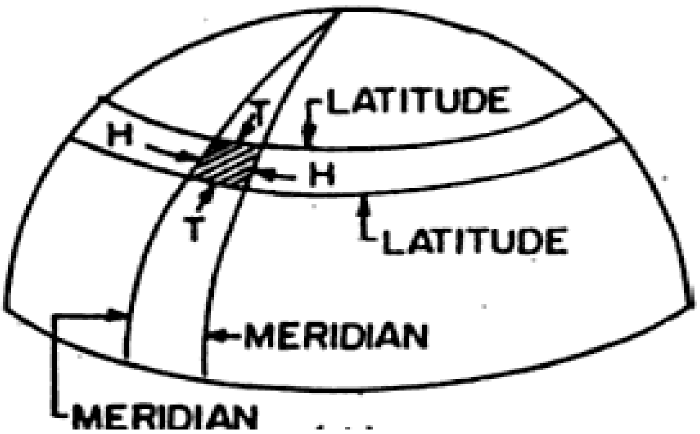
SCOPE AND OBJECTIVE OF THE WORK:

- The scope and objective of the dome is to analyze and design a RCC dome
- The minimum thickness we take 125mm for RCC dome
- Dead load and Live load as pwer IS 456:2000 are considered

THIS STUDY HELPS THE LONG SPAN CONSTRUCTION OF RCC DOMES THE KEY OBJECTIVE OF RCC DOMES IS TO BUILT A STRONG AND SAFE ROOF STRUCTURE.

TYPE OF STRESSES INDUCED IN A DOME:

THE FIGURE SHOWS THE LATITUDE AND MERIDIAN OF A DOME



The circle of each ring is called attitude. The reactions between the rings are tangential to the curved surface, giving rise to the compression along the medians. The compressive stress is called meridional thrust or meridional compression.

Therefore

Two types of stresses are induced in a dome.

They are:

1) MERIDIONAL THRUST (T) ALONG THE DIRECTION OF MERIDIAN

2) HOOP STRESS (H) AONG THE LATITUDE

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ANALYSIS OF DOME:

Let us now analyze stresses developed in a dome of uniform thickness.

R=RADIUS OF THE DOME

T=MERIDIONAL THRUST

H=HOOPSTRESS (CIRCUMFERENTIAL STRESS)

D=DIA OF BASE

r = CENTRAL RISE =1m

ASSUME

THICKNESS OF THE SLAB =125mm

LOADS ON DOME

LIVE LOAD

DEAD LOAD

FLOOR LOAD

WIND LOAD IS TAKEN IN TO ACCOUNT BY ADDING AN EXTRA LOAD IN LIVE LOAD.

DEAD LOAD = THICKNESS OF SLAB * UNIT WEIGHT OF RCC

= 0.125M *25KN/M^3

=3.125KN/M^2

LIVE LOAD = 2 KN/M^2

FCLOOR FINISH TAKEN (0.75-1.5) IN BETWEEN WE TAKE 1.

TOTAL LOAD W = DEAD LOAD – 3.125 KN/M^2

+ LIVE LOAD - 2 KN/M^2

+ FLOOR LOAD -1 KN/M^2

W =6.125 KN/M^2

$$R = \frac{(D/2)^2 + r^2}{2r}$$

$$R = \frac{(12/2)^2 + 1^2}{2*1}$$

R=18.5

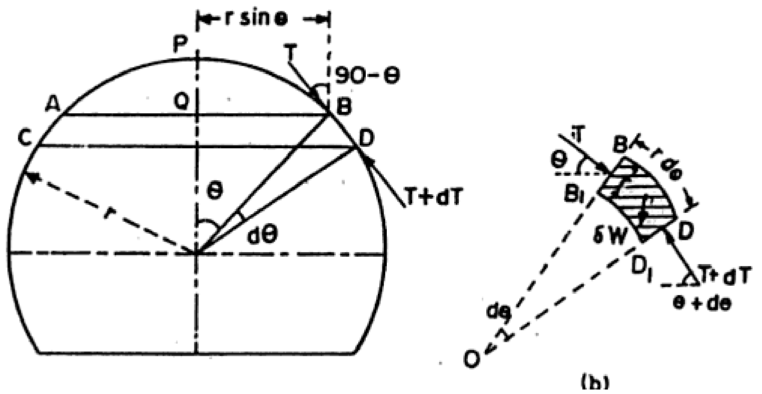


FIG 1

2. MERIDIONAL THRUST

Fig shows the sections through the vertical axis of revoluations of a thin sperical dome .les us consider the equilibrium of a ring ABCD between horizontal planes AB and CD .The extremitity of the horizontal plane AB makes an angle θ with the vertical at the centre while the extremity of the horizontal plane CD makes an angle θ+dθ.The ring thus subtends an angle dθ at the the centre.The following are the forces acting on the unit length of the ring.

i) The meridional thrust T per unit length of the circle of latitude AB,acting tangentially at B (or at right angles to the radial line OB)

ii) The reaction or thrust T+dT per unit length of the circle of latitude CD,acting tangentially at D

iii) The weight δw of the ring itself ,acting vertically down. It should be noted that the reaction T +dt will be greather than the thrust T due to the effect of the weight of the ring and due to the change in the inclination from θ of (θ+dθ) of the radial lines .The meridional thrust T is caused due the weight of the dome shell APB above the horizontal plane AB.

Surface area of the dome shell APB $=2\pi r \times PQ$

But $PQ=OP-OQ= r - r\cos\theta = r(1-\cos\theta)$

Weight of dome shell above AB $= 2\pi r \times PQ \times w$

$$= 2\pi r^2 w(1-\cos\theta)$$

Since the sum of vertical components of thrust T acting along the circumference of the circle of latitude must be equal to the total weight of the dome shell APB , we have $T(2\ 2\pi \times QB)\sin\theta=2\pi r^2 w(1-\cos\theta)$

Or $T \times 2\pi \times r\sin\theta \times \sin\theta = 2\pi r^2 w(1-\cos\theta)$

$T= wr(1-\cos\theta) / \sin^2\theta$

$T = wr/1+\cos\theta$

MERIDIONAL THRUST:

$T = wr/1+\cos\theta$

T = MERIDIONAL THRUST

W=TOTAL LOADS WHICH ARE ACTING ON THE DOME

R= RADIUS OF DOME

$\cos\theta = 12/\sqrt{12}$

$12^2 + 3^2$

$\cos\theta = 0.970$

$T = \frac{6.125*18.5}{1+0.970}$

T = 57.51 KN

MERIDIONAL STRESS:

Tu /b*D

$= \frac{1.5*57.51*10^3}{1000*125}$

HERE D= THICKNESS OF SLAB

$=0.690 N/MM^2$

$0.690\ N/MM^2 < 20 N/MM^2$

HENCE SAFE

THE MINIMUM % OF STEEL IN MERIDIONAL STRESSES IN DOMES

(0.3 % FOR DOMES)

HENCE SAFE 0.690

CIRCUMFERENTIAL FORCE:

H =WR (cosØ- 1/1+cos Ø)

= 6.125*18.5 (0.970-1/1+0.970)

=113.3 (0.970-1/1.97)

=53.2KN

CIRCUMFERENTIAL STRESSES (HOOP STRESSES)

Tu /bD

$= \frac{1.553.2*10^3}{1000*125}$

$=0.639 N/MM^2$

$0.639 N/MM^2 < 20 N/MM^2$

The stresses in the dome are within in the safe permissible limit.

Provide min% of steel in circumferentially

(0.3%) for domes.

Here both circumferentially and meridionally the % of steel (min % of steel) is 0.3% for dome

Ast = 0.30/100 *1000*125

=375

Spacing S = 1000ast/ Ast

$S = \frac{1000*50.24}{375}$

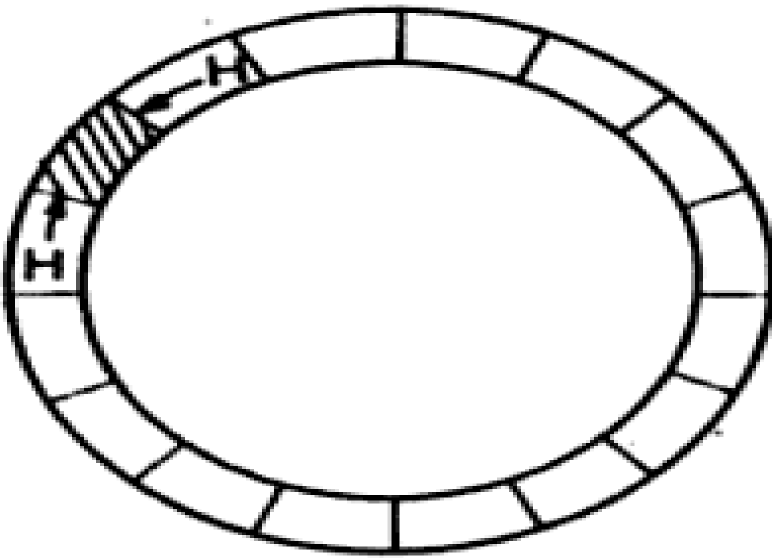
S=133.94

S=134mm

Provide 8mm@134mm c/c

3. DESIGN OF RING BEAM

FIGURE SHOWS THE ROUGH PLAN OF A RING BEAM



PROVISION OF RING BEAM:

The meridional thrust at the support will have a horizontal component which will cause the supporting walls to burst outwards, causing its failure. In order to bear this horizontal component of meridional thrust, a ring beam is provided at the base of the dome.

The reinforcement provided in the ring beam takes this hoop tension.

Hoop Tension = $T_1 \cos\emptyset \; D/2$

T_1= MERIDIONAL THRUST

D=Dia of base dome

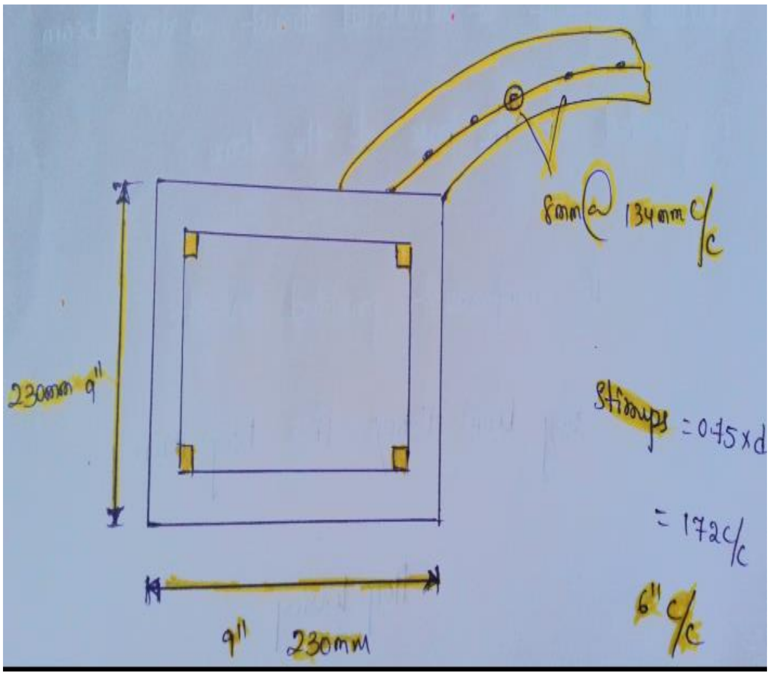
Hoop Tension = $57.51 \frac{*0.970*12}{2}$

$=334.7MM^2$

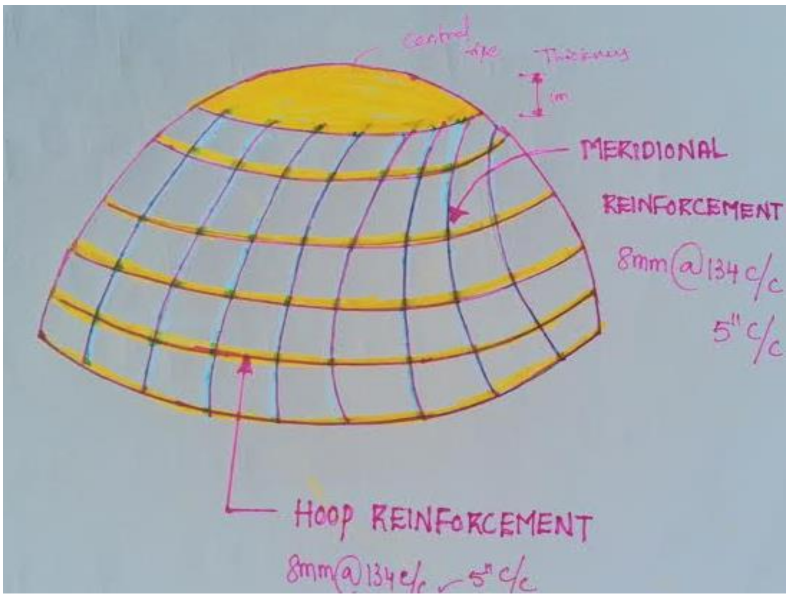
So provide min% =0.2% in beam

4. REINFORCEMENT DETAIL

RING BEAM REINFORCEMENT:



HOOP AND MERIDIONAL REINFORCEMENT:



5. CONCLUSION

In this Rcc dome the results and calculations are discussed based on the MANUAL DESIGN.

Analysis and load calculation are done by manual design.

This design is used for long span of domes.

In this design we get the Reinforcement details of ring beam ,meridional and hoop reinforcement of RCC dome.

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