Critical Study of Sheet Molded Compound (SMC) panel elevated water tank of 25,000 liters capacity in various wind and seismic zones.

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Abstract - *This study analyzed and designed Sheet Molding Compound (SMC) Panel water tank having capacity 25,000 liters and height of staging 6 meters in various wind and seismic zone as per Indian Standards. Water tank is modelled and analyzed on SAP 2000 software based on FEM. Wind load on structure is calculated as per IS 875- Part 3, static analysis is done because the structure has frequency greater than 1 Hz. Earthquake load on the structure is calculated as per IS 1893-Part 1 & Part 2, the system is considered as Single Degree of Freedom System. The SMC Panel Water tank is considered as mass body placed on steel staging. This structure is analyzed for different load combinations as per IS 875-Part 5. Structure is designed as per IS 800-2007.The lateral loads acting on the structure in various wind and seismic zones are compared.*

Key Words: SMC Panel Water Tank, Steel Staging , Analysis and Design of Water Tank ,SAP 2000.

1. INTRODUCTION

Sheet molding compound (SMC) or sheet molding composite is a ready to mold glass-fiber reinforced polyester material primarily used in compression molding. The sheet is provided in rolls weighing up to 1000 kg. Alternatively, the resin and related materials may be mixed on site when a producer wants greater control over the chemistry and filler.

SMC is both a process and reinforced composite material. This is manufactured by dispersing long strands (usually >1") of chopped fiber, commonly glass fibers or carbon fibers on a bath of thermoset resin (typically polyester resin, vinyl ester resin or epoxy resin). The longer fibers in SMC result in better strength properties than standard bulk molding compound (BMC) products. Typical applications include demanding electrical applications, corrosion resistant needs, structural components at low cost, automotive, and transit.

SAP2000 means Structural Analysis Program2000. SAP2000 is a structural analysis and design software produced by Computer and Structures, Incorporated (CSI), a structural and earthquake engineering company.

Types of Water Tank

Based on Position:

Based on the position of tank steel water tank is divided into 3 types underground tank, ground resting tank and overhead tank.

Fig -1: SMC Panel Tank.

Based on Shape:

Based on Shape of tank its types are circular tank, rectangular tank, square tank and spherical tank.

Objective of study

Present study will be carried out for following objectives:

To make a study about guidelines for the design of liquid retaining structure according to IS Code.

To make a study about the analysis and design of elevated steel water tank of various capacities in various wind and seismic zone.

To study the dynamic behavior of elevated steel water tank under wind load and earthquake load.

To study the sloshing effect.

To study the effect of shape and size of water tank on staging.

2.LITERATURE REVIEW

For this job various literature have been studied which will be helpful in orienting present work.The related literature review is mentioned below:

El Damatty et al., (1998) Conical steel vessels, having an higher cylindrical segment and supported by using a bolstered concrete shaft, are becoming broadly used for water containment in elevated tanks. However, the contemporary codes of practice for water structures in North America do no longer consist of any rational method for designing such vessels. In this look at, a simple and rational design system that considers instability, yielding, large deformations, geometric imperfections, and residual stresses is developed for those hydrostatically loaded metallic vessels.

Tom H. Hale (2004) This paper describes the seismic evaluation and layout strategies used for the seismic improve of an present 3,000,000 gallon (11,355,000 liters) steel improved water tank supported by a metallic framework in Sacramento, California. The preliminary seismic upgrade design consisted of a base isolation gadget. The final seismic improve design carries a passive power dissipation machine inside the braces of the framework to create a friction damped braced frame.

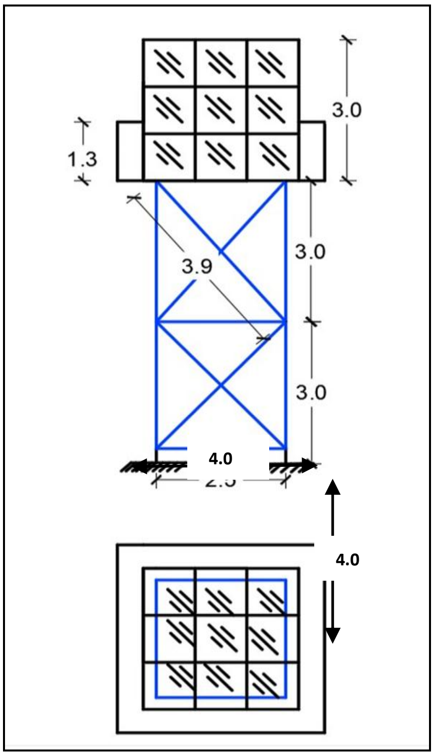
Norris et al.,(2014) Elevated water tanks are normally placed at better elevations within a particular geographic place. The locations and top of those structures often makes them ideal for siting wi-fi and mobile communications antennas. The effect of this exercise on the long-time period serviceability overall performance of the primary shape isn't clean and will be an important attention deserving further evaluation.

Jena et al., (2016) A meshfree molecule approach, to be specific moving molecule semi-certain (MPS) technique is utilized to examine the sloshing conduct in a to some degree filled fluid compartment. The legitimacy of the mathematical model is checked by looking at the sloshing movement in tanks going through sinusoidal and seismic tremor excitations with the distributed outcomes. An exhaustive investigation of seismically invigorated vicious sloshing movement and wave influence utilizing a molecule technique, not revealed in open writing, were taken up in the current review.

3. METHODOLOGY

3.1Mathematical Modelling.

The SMC Panel Water tank is modelled as mass acting on bearers. The load is applied as uniformly distributed load. The dimension of the tank is 3 m x 3m x 3 m. The dimension of the tank is given by SMC Panel Company. The steel I-section is used as bearer and lower beam. For columns and bracings angle section is used. The joints assigned is fixed joints as it assumed to be rigid connections. The plan and elevation is shown in Figure 2.



All Dimensions are in meters.

Fig -2: Elevation and Plan of Tank.

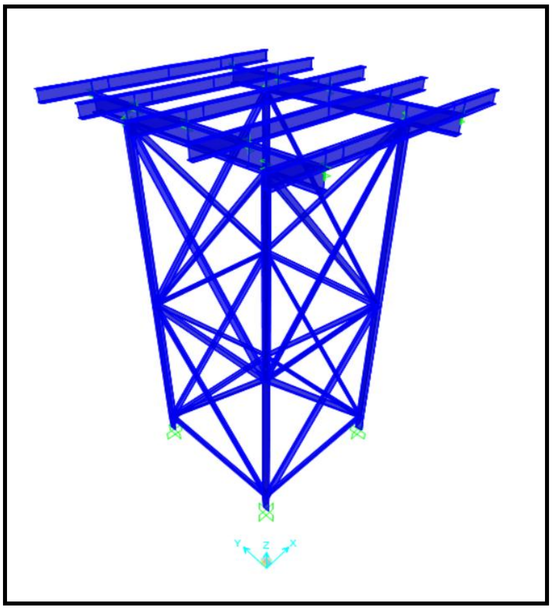


Fig -3: Mathematical Modelling of SMC Panel Tank.

3.2 Governing Lateral Load Comparison.

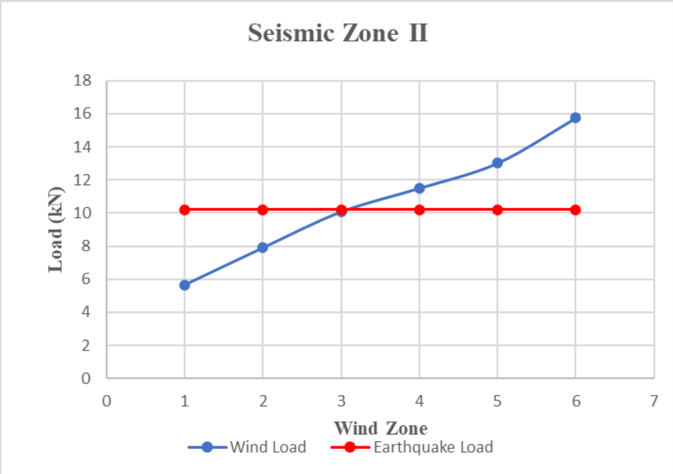


Chart -1: Comparison of Lateral load in Seismic zone II

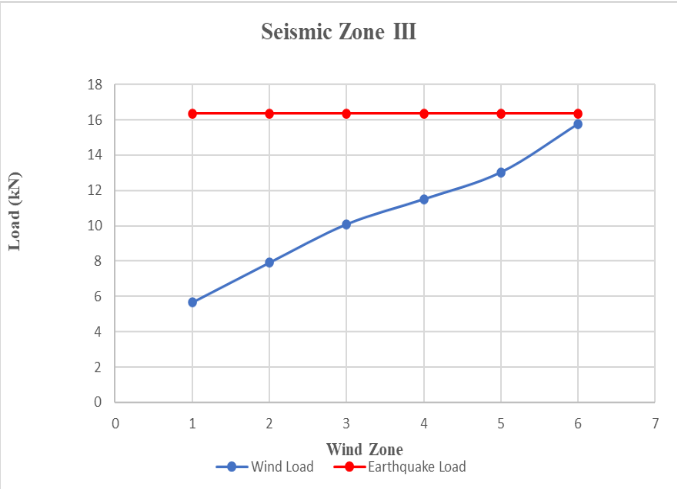


Chart -2: Comparison of Lateral load in Seismic zone III

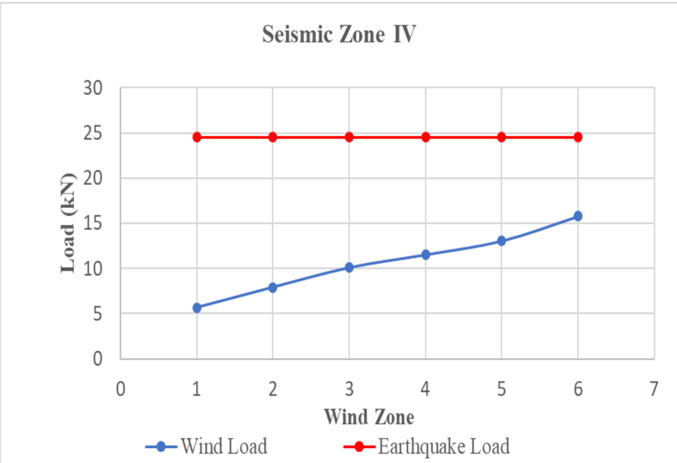


Chart -3: Comparison of Lateral load in Seismic zone IV

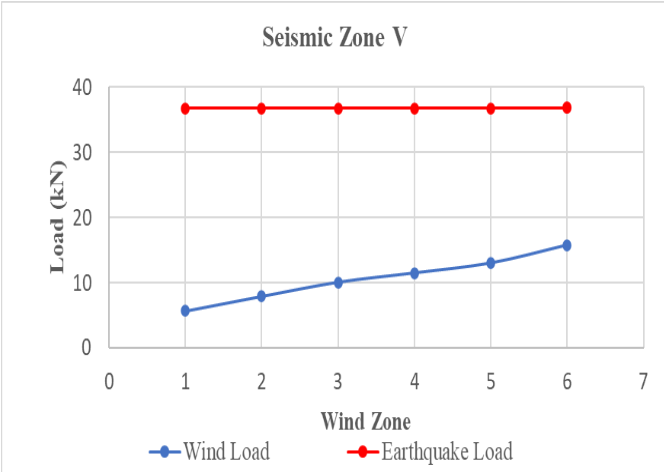


Chart -4: Comparison of Lateral load in Seismic zone V

The load combinations are assigned as per IS 875.

1. 1.2(DL-EQ X)
2. 1.2(DL+EQ Y)
3. 1.2(DL- EQ Y)
4. 1.2(DL+EQ X)
5. 1.5(DL-EQ X)
6. 1.5(DL+EQ Y)
7. 1.5(DL+EQ Y)
8. 0.9DL-1.5EQ X
9. 0.9DL+1.5EQ Y
10. 0.9DL-1.5EQ Y
11. 0.9DL+1.5EQ X
12. 1.2(DL+WL X)
13. 1.2(DL+WL Y)
14. 1.2DL+0.6WL X
15. 1.2DL-0.6WL X
16. 1.5(DL+WL X)
17. 1.5(DL+WL Y)
18. 0.9DL+1.5WL X
19. 0.9DL+1.5WL Y.

3.3 Analysis result of SMC Panel Water Tank

a) Design of Tank for earthquake zone II

The water tank is designed in SAP 2000 for earthquake load with considering wind load of different wind speed. The result of these 6 wind zones are shown in Table 1. Computational results include bending moments of members for all load combinations.

Table-1: Maximum Members Axial Loads for various zones (kN).

Member	Wind Zone					
	1 V_b = 33 m/s	2 V_b = 39 m/s	3 V_b = 44 m/s	4 V_b = 47 m/s	5 V_b = 50 m/s	6 V_b = 55 m/s
Column	-134.5	-134.4	-134.4	-134.4	-138.7	-139.2
Hori. Bracing	3.2	3.2	3.2	3.24	3.3	3.4
Incl. Bracing	-14.1	-14.12	-14.12	-14.41	-14.15	-14.60

(+ = Tension, - = Compression)

The members are designed as per IS 800-2007 by taking into consideration the maximum reactions. This design is checked on SAP 2000.The sections assigned for members are shown in Table 2.

Table-2: Design Sections for Members as per IS 800-2007.

Members	Wind Zone					
	Zone 1 V_b= 33 m/s	Zone 2 V_b= 39 m/s	Zone 3 V_b= 44 m/s	Zone 4 V_b= 47 m/s	Zone 5 V_b= 50 m/s	Zone 6 V_b= 55 m/s
Column	ISA 110 110 10	ISA 110 110 10	ISA 110 110 10	ISA 110 110 10	ISA 110 110 12	ISA 110 110 12
Horizontal Bracing	ISA 60 60 10	ISA 60 60 10	ISA 60 60 10	ISA 60 60 10	ISA 60 60 12	ISA 60 60 12
Inclined Bracing	ISA 60 60 10	ISA 60 60 10	ISA 60 60 10	ISA 60 60 10	ISA 60 60 12	ISA 60 60 12

b) Design of Tank for earthquake zone III

The water tank is designed in SAP 2000 for earthquake load with considering wind load of different wind speed. The result of these 6 wind zones are shown in Table 3. Computational results include bending moments of members for all load combinations.

Table-3: Maximum Members Axial Loads for various zones (kN).

Member	Wind Zone					
	1 V_b= 33 m/s	2 V_b= 39 m/s	3 V_b= 44 m/s	4 V_b = 47 m/s	5 V_b= 50 m/s	6 V_b = 55 m/s
Column	-141.4	-141.4	-141.4	-141.4	-141.4	-141.4
Hori. Bracing	3.4	3.4	3.4	3.4	3.4	3.4
Incl. Bracing	-15.3	-15.3	-15.3	-15.3	-15.3	-15.3

(+ = Tension, - = Compression)

The members are designed as per IS 800-2007 by taking into consideration the maximum reactions. This design is checked on SAP 2000.The sections assigned for members are shown in Table 4.

Table-4: Design Sections for Members as per IS 800-2007.

Members	Wind Zone					
	Zone 1 V_b= 33 m/s	Zone 2 V_b= 39 m/s	Zone 3 V_b= 44 m/s	Zone 4 V_b= 47 m/s	Zone 5 V_b= 50 m/s	Zone 6 V_b= 55 m/s
Column	ISA 110 110 12	ISA 110 110 12	ISA 110 110 12	ISA 110 110 12	ISA 110 110 15	ISA 110 110 15
Horizontal Bracing	ISA 60 60 12	ISA 60 60 12	ISA 60 60 12	ISA 60 60 12	ISA 65 65 8	ISA 65 65 8
Inclined Bracing	ISA 60 60 12	ISA 60 60 12	ISA 60 60 12	ISA 60 60 12	ISA 65 65 8	ISA 65 65 8

c) Design of Tank for earthquake zone III

The water tank is designed in SAP 2000 for earthquake load with considering wind load of different wind speed. The result of these 6 wind zones are shown in Table 5.

Computational results include bending moments of members for all load combinations.

Table-5: Maximum Members Axial Loads for various zones (kN).

Member	Wind Zone					
	1 V_b = 33 m/s	2 V_b = 39 m/s	3 V_b = 44 m/s	4 V_b = 47 m/s	5 V_b = 50 m/s	6 V_b = 55 m/s
Column	-150.6	-150.6	-150.8	-150.8	-150.8	-150.8
Hori. Bracing	3.6	3.6	3.6	3.6	3.6	3.6
Incl. Bracing	-16.8	-16.8	-16.8	-16.8	-16.9	-16.9

(+ = Tension, - = Compression)

The members are designed as per IS 800-2007 by taking into consideration the maximum reactions. This design is checked on SAP 2000.The sections assigned for members are shown in Table 6.

Table-6: Design Sections for Members as per IS 800-2007.

Members	Wind Zone					
	Zone 1 V_b= 33 m/s	Zone 2 V_b= 39 m/s	Zone 3 V_b= 44 m/s	Zone 4 V_b= 47 m/s	Zone 5 V_b= 50 m/s	Zone 6 V_b= 55 m/s
Column	ISA 110 110 15	ISA 110 110 15	ISA 110 110 15	ISA 110 110 15	ISA 130 130 10	ISA 130 130 10
Horizontal Bracing	ISA 65 65 8	ISA 65 65 8	ISA 65 65 8	ISA 65 65 8	ISA 65 65 10	ISA 65 65 10
Inclined Bracing	ISA 65 65 8	ISA 65 65 8	ISA 65 65 8	ISA 65 65 8	ISA 65 65 10	ISA 65 65 10

d) Design of Tank for earthquake zone IV

The water tank is designed in SAP 2000 for earthquake load with considering wind load of different wind speed. The result of these 6 wind zones are shown in Table 7. Computational results include bending moments of members for all load combinations.

Table-7: Maximum Members Axial Loads for various zones (kN).

Member	Wind Zone					
	1 V_b= 33 m/s	2 V_b = 39 m/s	3 V_b = 44 m/s	4 V_b = 47 m/s	5 V_b = 50 m/s	6 V_b = 55 m/s
Column	-164.4	-164.4	-164.5	-164.5	-164.5	-164.5
Hori. Bracing	3.9	3.9	3.9	3.24	3.9	3.9
Incl. Bracing	-19.2	-19.2	-19.2	-19.5	-19.5	-19.5

(+ = Tension, - = Compression)

The members are designed as per IS 800-2007 by taking into consideration the maximum reactions. This design is checked on SAP 2000.The sections assigned for members are shown in Table 8.

Table-8: Design Sections for Members as per IS 800-2007.

Members	Wind Zone					
	Zone 1 V_b= 33 m/s	Zone 2 V_b= 39 m/s	Zone 3 V_b= 44 m/s	Zone 4 V_b= 47 m/s	Zone 5 V_b= 50 m/s	Zone 6 V_b= 55 m/s
Column	ISA 130 130 10	ISA 130 130 10	ISA 130 130 10	ISA 130 130 10	ISA 130 130 12	ISA 130 130 12
Horizontal Bracing	ISA 65 65 10	ISA 65 65 10	ISA 65 65 10	ISA 65 65 10	ISA 75 75 8	ISA 75 75 8
Inclined Bracing	ISA 65 65 10	ISA 65 65 10	ISA 65 65 10	ISA 65 65 10	ISA 75 75 8	ISA 75 75 8

4. CONCLUSION

After the analysis and design of SMC water tank of 25,000 liters capacity and 6 m height of staging for different wind speed and earthquake zones, some conclusions are made. The conclusions from the study are as follows

1. For Earthquake zone II, for wind speed up to 44 m/s earthquake force is governing. For wind speed above 44 m/s wind force is governing.

2. For Earthquake zone III, IV and V earthquake force is governing irrespective of wind zone.

3. After providing section for the column as per maximum reaction obtained by envelope combination, column fails in design. So, we have to provide heavier section for column section.

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