# Analysis And Design of Sheet Molded Compound Panel Water Tank for Different Satging Height

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***Abstract— The paper provides a comprehensive overview of the analysis of steel staging for sheet molded compound panels in water tanks. It delves into the various properties of sheet molded compound (SMC) that alter with height, specifically focusing on parameters such as bending moment, base shear, and displacement in relation to staging height. Notably, the energy-absorbing capacity of SMC composite surpasses that of steel and aluminum due to its lower density, with a specific energy absorption of approximately 50 KJ/KG. As staging height increases, there is a 3% rise in seismic force and base shear value. Tensile tests conducted using a Zwick tensile tester with an optical 3 extensometer revealed that composite SMC boasts a tensile strength of 85 MPA and 38 MPA in its weakest dimension, whereas standard SMC and composite SMC exhibit similar tensile strengths. Furthermore, the presence of geometrical discontinuity at the junction of cylindrical-conical shells is observed to induce compressive and bending stresses within the structure. These stresses can be mitigated through various measures, such as adjusting the inclination angle or incorporating a ring girder at the base of the structure. The literature shows that SMC also be used water tank material due to high compressive & tensile property.***

***Index Terms-steel staging, SMC, water tank, analysis.***

## I. INTRODUCTION

Sheet molding compound (SMC) or sheet molding composite is a glass-fiber reinforced polyester material designed for compression molding processes. The material is typically supplied in rolls weighing up to 1000 kg, providing convenience for manufacturers. Alternatively, producers can opt to mix the resin and related materials on-site to have better control over the chemistry and filler composition.

SMC is a versatile material that combines a specific manufacturing process with reinforced composite properties. It involves dispersing long strands of chopped fibers, such as glass or carbon fibers, within a thermoset resin bath, commonly polyester, vinyl ester, or epoxy resin. The longer fibers in SMC contribute to superior strength properties compared to standard bulk molding compound (BMC) products.

Common applications of SMC include demanding electrical uses, requirements for corrosion resistance, cost-effective structural components in automotive and transit industries. Water tanks serve various purposes, such as storing water for drinking, irrigation in agriculture, and other applications requiring water storage.

## II. PROPERTIES OF SMC

### *2.1* COMPRESSION:

Compression testing is crucial for understanding how composite materials behave. It helps assess how the materials change when a load is applied to them. To do this, the materials are placed in a compression test machine, where load and displacement are measured. This data is then used to calculate the stress-strain relationship, which in turn helps determine the materials' compressive strength and modulus of elasticity.

Compression tests were conducted on Std-SMC and Flex-SMC specimen of dimensions 80 mm x15 mm x 3 mm. The tests were performed at a constant crosshead speed of 1 mm/min in a Darter servo hydraulic test machine with 250 KN capacity. [10].

Strengths are in general much higher in compression compared with tension. Flex-SMC B is significantly weaker than Std-SMC. The reason is the softening and weakening effect from hollow glass spheres and lower CaCO3 content.[10]

Crush test on SMC tubes were carried out using MTS universal testing machine with a crush speed of 500 mm / min with tube length 100 mm for SMC-S & SMC -T. [3] SMC-T has higher crushing strength than SMC-T due to energy absorbing capacity of SMC-T is better than SMC-S. [3] The energy absorbing capacity of SMC composite is better other than steel & aluminum due to its low density. The specific energy absorption of SMC is 50 KJ/KG.[3]

2.2 TENSILE PROPERTY:
The tensile test is important for determining the tensile properties of composite materials. It measures the force needed to break a specimen and how much it stretches before breaking. This test helps in understanding the material's characteristics and can be used for material specification, part design, and quality control.

The samples for tensile test were of dimensions 300 mm x50mm and machined from molded Plate of 2 mm thickness. The specimens were conditioned according to DIN 50014 (normal climate) at 23 ^ 2 8C and 50 ^ 5% relative humidity for at least 24 h prior to testing. Tensile tests were performed using a Zwick tensile tester with optical extensometer and the grip to grip separation was about 220 mm. The gauge length was set to 180 mm for the cyclic tensile tests and 100 mm for the monotonic tensile test.[10]

Disregarding the highly anisotropic Flex-SMC A, the maximum tensile strength is 85 MPa. This is slightly higher than data for another standard SMC [2]. One may note that the tensile strength of Flex-SMC A in its weakest direction was only 38 MPa. Std-SMC and Flex SMC were observed to have similar tensile strengths.[10]

Addition of hollow glass spheres was found to reduce not only stiffness, but also strength.[10]

Tensile test were performed on ASTM D 638 at across speed of 1 mm/ min & ASTM D 790 at speed of 2.7 MM/MIN. [3] The geometry of specimen 60x60x10mm with a notch length of 20mm. [3]

Tensile strength of SMC T [293 mpa] is higher than SMC S[254 mpa].[3]

FIG.1. Sheet Molded Compound Tank (https://productimages.withfloats.com/actual/603898919e6b3300010aa6bb.jpg)

Fig. 2.SMC Steel Water Tank. (https://4.imimg.com/-panel-water-tanks-500x500.jpg)data4/UR/TT/MY-2/smc)

## III. EFFECT OF STAGING HEIGHT ON WATER TANK

3.1 BENDING MOMENT:
Staging height & base width effect on water tank on the basis of different parameter. [4] The analysis of water tank is done on STAAD PRO software.[4]

Following the analysis, comparisons are made for bending moment, shear force, and displacement variations across different columns and bracing beams.[6][4] The STAAD Pro model is meticulously developed and applied to all loading combination scenarios.[4]

Noteworthy findings include a 3.1% increase in bending moment with higher staging heights.[4] Additionally, a significant 31% rise in bending moment is observed when cylindrical wall height decreases and base width increases.

Its observed that base moment for tanks supported on frame staging is less than that of tanks supported on concrete shaft.[6]

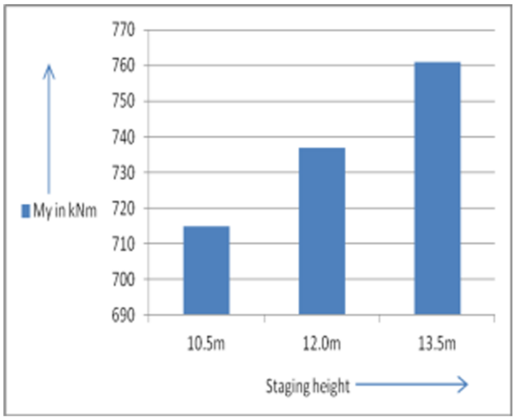


Fig.3 BM vs Staging Height (https://www.irjet.net/archives/V5/i6/IRJET-V5I697.pdf)

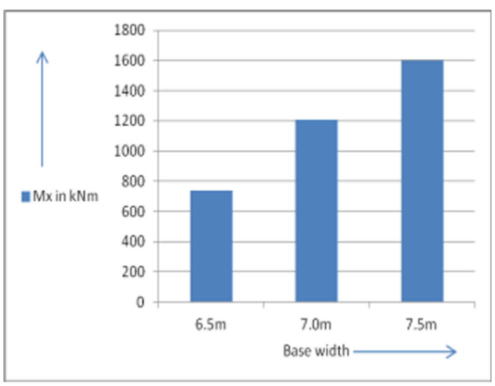


FIG. 4 BM vs Base Width ((https://www.irjet.net/archives/V5/i6/IRJET-V5I697.pdf)

3.2 SHEAR FORCE:

The study also reveals a 3% increase in base shear value with height increment. Remarkably, a drastic 45.0% and 47.0% increase in base shear values is noted as cylindrical wall height decreases and base width increases.[4]

Total base shear (V), the horizontal force which acts at the bottom at the staging is resultant of two different case base shears, one for impulsive mode (Vi) and for convective mode (VC). It represents the increase in base shear with increase in capacity of tank.[6]

Base shear for elevated tanks, supported on concrete shaft is greater than that of elevated tanks supported on frame staging.[6]

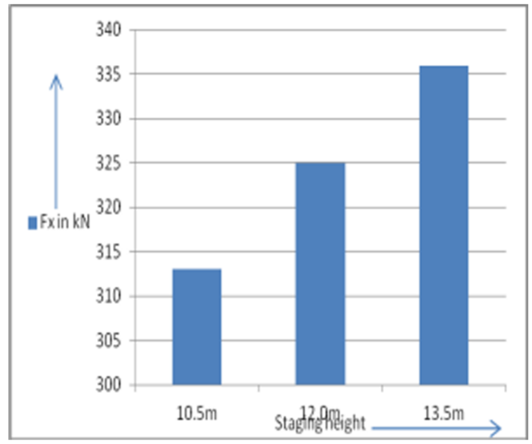


FIG.5 SF vs Staging Height (https://www.irjet.net/archives/V5/i6/IRJET-V5I697.pdf)

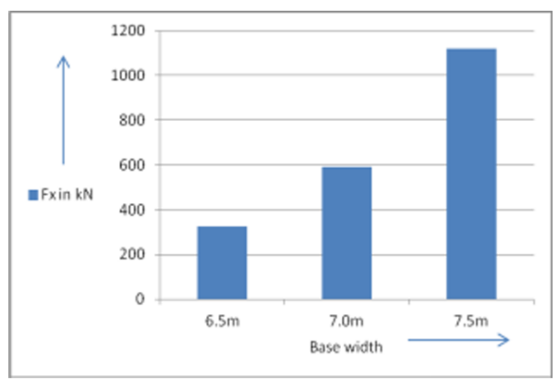


FIG. 6 SF vs Base Width (https://www.irjet.net/archives/V5/i6/IRJET-V5I697.pdf)

3.3 DISPLACEMENT:

The displacement value has drastically increased due to reduced height of cylindrical wall and increase in base width, the displacement is increased by 39.38% and 46.4% respectively.[4]

As the capacity of the staging increases and its staging pattern is altered, there is a discernible decrease in deflection, ultimately resulting in an elevation of its stiffness.[6]

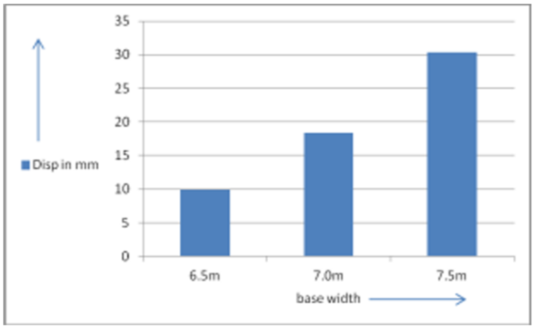


FIG.7 Displacement vs Base Width (https://www.irjet.net/archives/V5/i6/IRJET-V5I697.pdf)

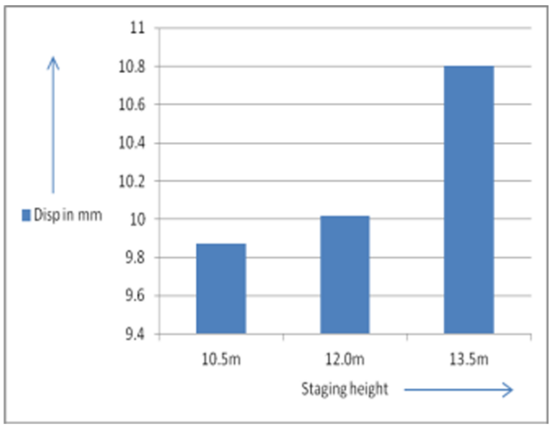


FIG. 8 Displacement vs Staging Height (https://www.irjet.net/archives/V5/i6/IRJET-V5I697.pdf)

3.4 SEISMIC FORCE:

It is observed that seismic forces are directly proportional to the seismic zones and inversely proportional to the height of the supporting system. Consequently, seismic forces increase with the height of the supporting structure for water tanks supported on frame staging. [6]

## IV. STRESSES DEVELOPED IN WATER TANK :

Authors mainly focuses on incorporating large deformations, geometric imperfections, and residual stresses into the assessment process. The finite element analysis in conjunction with multiple regression to devise a formula for determining maximum stress levels and required thickness for the steel vessel.[1][5]

By assuming an axisymmetric imperfection shape, the researchers illustrate how these imperfections contribute to the overall stress distribution within the tank, the investigation states that residual stresses arises from welding joints during the design phase.[1] In the case of silos & tank the stresses are developed at the at junction of cylindrical conical shell. [5]

Elevated storage structures such as cylindrical-conical tanks and silos, which are supported by stiff ring girders resting on either a cylindrical skirt or on multiple evenly spaced columns, are thoroughly analyzed within this study.[5]

Analysis was conducted to determine the failure of tanks due to inelastic buckling caused by hoop stresses at the bottom of the tank.[1] The relationship between hoop stresses, thickness, and height was established to determine the maximum stress value.[1][5] The research also explores the impacts of various geometric parameters on the structures, including the conical angle, height/radius ratio of the cylindrical shell, the positioning of the ring girder in relation to the junction, and the effects of incorporating additional ring stiffeners, The geometrical discontinuity present at the junction of cylindrical-conical shells leads to the development of compressive and bending stresses within the structure. These stresses can be mitigated through various measures, such as adjusting the inclination angle or incorporating a ring girder at the base of the structure. It is observed that the positioning of the ring girder relative to the junction significantly influences the deflections and stresses experienced, Placing the ring girder in close proximity to the junction enhances the overall stiffness of the shell system, thereby reducing deflections and stresses. [5]

The research presents offers a comprehensive guideline for designing tanks of varying thicknesses, heights, and hoop stresses resulting from welding processes. [1][5]

The key consideration during the design process was to ensure that the tank can bear the factored load while preventing any section of the steel tank from reaching its yield point, thus maintaining structural integrity, the safety of the tank against yielding was checked.[1][5]

## V. ANALYTICAL IDENTIFICATION OF AN ELEVATED WATER TANK

A detailed analysis is provided on the structural identification of an elevated water tank due to addition of cellular antennas to the structure. Following the installation of these antennas, the tank experienced fatigue cracking during the process of pipe filling. A finite element model is developed to know the source of the structural damage and the impact of the added cellular antennas on its integrity.[8]

The water tank in question has undergone detailed ambient vibration testing, taking into account different variables such as wind speeds and water levels. These tests were conducted to understand the impact of varying operating conditions on the behavior of the water tank. The findings have sparked discussions on how these conditions influence the calibration of the Finite Element (FE) model associated with the tank.[8] Initial assessments have revealed that there is still extensive work to be done. A vast amount of ambient vibration measurement data is available, capturing the tank's performance under diverse conditions including different water levels, wind intensities, and various environmental factors & these analysis has suggest that modifications are required for the FE model to more accurately represent the total steel weight of the structure.[8]


FIG. 9 Exterior view of water tank (https://www.researchgate.net/profile/KirkGrimmelsman/publication/269198325_Structural_Identification_of_an_Elevated_Water_Tank/links/56c8c7a308ae96cdd06bb78f/StructuralIdentification-of-an-Elevated-Water-Tank.pdf)

## CONCLUSION

1] The energy-absorbing capacity of SMC composite is superior to steel and aluminum because of its lower density. The specific energy absorption of SMC is 50 kJ/kg.

2] Tensile tests were performed using a Zwick tensile tester with optical extensometer & result is composite SMC have 85 MPA tensile strength &38 MPA in its weakest dimension. STD. SMC & composite SMC have same tensile strength.

3] Seismic force & base shear value are increased by 3% as per staging height increasing.

4] The displacement value has drastically increased by 40 % due to reduced height of cylindrical wall and increase in base width.

5] Due to axisymmetric imperfection shape, the imperfections contribute to the overall stress distribution within the tank, the paper investigate that residual stresses arises from welding joints during the design phase. In the case of silos & tank the maximum stresses are developed at the at junction of cylindrical conical shell. Hoop stresses are developed at bottom of tank.

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