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Enhancing Structural Performance of Water Tank Stands: A Finite Element-Based Approach and Real-World Fabrication Using ASTM A36

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ABSTRACT

This study addresses the structural challenges associated with 1000-litre Sintex water tank stands, particularly the risks of deformation and failure in non-concrete roof structures. Finite Element Analysis (FEA) was used to evaluate two design configurations using identical L-section dimensions under various loading conditions. ASTM A36 mild steel was selected for its strength, affordability, and ease of availability. The results showed that the modified design (Design 2) demonstrated significantly lower deformation and stress levels compared to the conventional Sintex design, despite both using the same L-section sizes (40x40x6 mm, 50x50x6 mm, and 60x60x6 mm). Design 2, implemented as a real-world application model, offered enhanced structural stability and safety. The findings underscore the importance of optimized design and material selection in creating reliable, durable, and cost-effective support systems for rooftop water tanks.

Keywords: Finite Element Analysis, Mild Steel ASTM A36, L-Section Design, Structural Analysis, Water Tank Stand, Load-Bearing Capacity.

1.INTRODUCTION:

The failure of 1000 L Sintex tank stands is a significant real-world problem, especially in structures that rely on these stands for water storage. While reinforced concrete (RC) buildings can support Sintex tanks on their rooftops, roof structures without concrete reinforcements require dedicated tank stands to bear the load. However, many of these stands experience excessive deformation and failure over time, leading to structural instability and potential hazards.

This study seeks to offer a comprehensive solution to the issues of deformation and failure in 1000 L Sintex tank stands by identifying the most suitable design through detailed Finite Element Analysis (FEA). It involves evaluating various design alternatives and comparing their deformation and stress responses under applied loading conditions.

By adding the stiffness the deformation can be reduced [2],but high stiffness material does not have good weldability so the different sizes of the materials were used .Additionally, the research examines ASTM A36, a common grade of mild steel, to determine its effectiveness as a material choice ,it has an good mechanical property and easily available [3],the stiffner variants can use for the reinforcement but the cost of the structure increases[1]. By analyzing the structural behaviour of different designs and materials, the study identifies the most optimal combination that ensures strength, stability, and durability, offering a practical and reliable solution to prevent excessive deformation and failure in Sintex tank stands.

2.EXPERIMENTAL PROCEDURE:

The L-section was chosen for the 1000 L water tank stand because it is strong, cost-effective, and can handle heavy loads. After conducting Finite Element Analysis (FEA) to determine the best design, the suitable L-sections were selected for fabrication. The fabrication process involved several steps, starting with cutting the L-sections to the required measurements. After cutting, the sections were welded together using arc welding to form the tank stand. Once the welding was completed, grinding was done to smoothen the joints and ensure a strong and stable structure. The final stand was evaluated based on deformation and stress analysis, which helped determine the best design and size of the L-section to use. This process ensured that the tank stand was properly fabricated to support the 1000 L water tank effectively.

3.DESIGN OF WATER TANK STAND USING SOLIDWORKS:

The two designs are identical in size; one is the conventional design, and the other is a novel design that has a big impact on the structural performance. This is the most widely used model in the current scenario, and structural analysis is carried out for various L-section sizes by observing the deformation in real time.

Fig.1 Sintex Tank Stand 1000L Design (1)

Dimensions of the L-sections used in Design (1)

The water tank stand is designed as per the regular usage with the L-sections to ensure optimal strength and stability. The L-sections employed in design (1) include a 40 mm × 40 mm × 6 mm section, a 50 mm × 50 mm × 6 mm section, and a 60 mm × 60 mm × 6 mm section.[4]

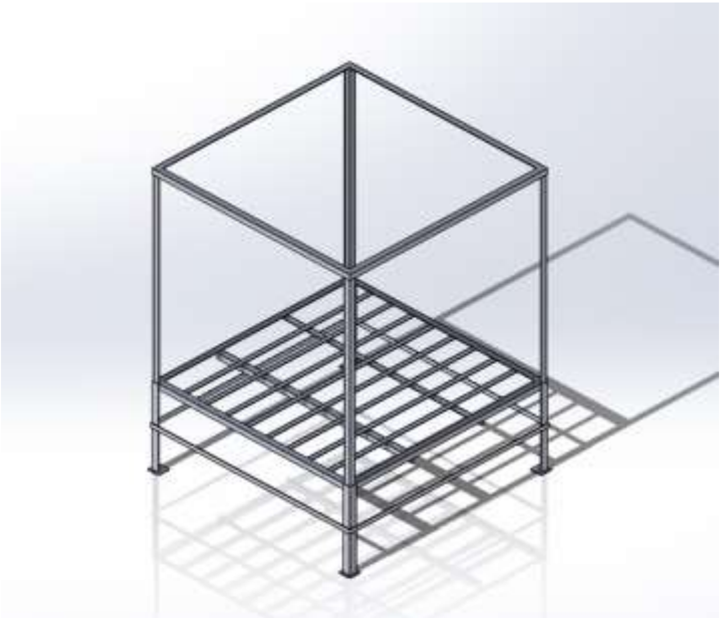


Fig.2 Sintex Tank Stand 1000L Design (2)

Dimensions of the L-sections used in Design (2)

The water tank stand with the new design of L-sections to ensure optimal strength and stability. The L-sections employed in design (2) include the same 40 mm × 40 mm × 6 mm section, a 50 mm × 50 mm × 6 mm section, and a 60 mm × 60 mm × 6 mm section.[4]

Material properties:[5],[6]

Material properties	**ASTM A36**
Ultimate Tensile Strength	460MPa
Yield Tensile Strength	250MPa
Young's Modulus	200GPa
Poisson's Ratio	0.3
Elongation at Break	≥20%
Shear Strength	160-200MPa

4.CALCULATIONS:

Formulas used,

- Total weight of the water in the tank (W) = Volume of the water in tank (V) X Unit weight of the water (w)
- Volume of the water in tank (V) =Area of the tank (A) X Height of the tank (H)
- Uniformly Distributed Load (P) = Total weight of the water in the tank /Surface area

Specifications of the tank

Height of the water tank (H) = 2.5m

Diameter of the tank (D) = 1.5m

Tank Capacity (L)	**Volume (m^3)**	**Total Weight (KN)**	**Uniformly Distributed Load (KN/m^2)**
250	1.104	10.83	6.13
500	2.208	21.65	12.25
750	3.313	32.47	18.37
1000	4.42	43.34	24.53

5.RESULTS AND DISCUSSION

MILD STEEL ASTM A36-MATERIAL BEHAVIOUR

Here the Uniformly distributing load is given to the Water tank stand to study the Design and behaviour of the material **ASTM A36.** The Deformation and the Equivalent stress occur according to the 1000 Litres of the water weight. (Deformation-14.265mm and Equivalent stress-253.05 MPa) for Design-1.

The Deformation of Design –1 is given in the Figure.5.0

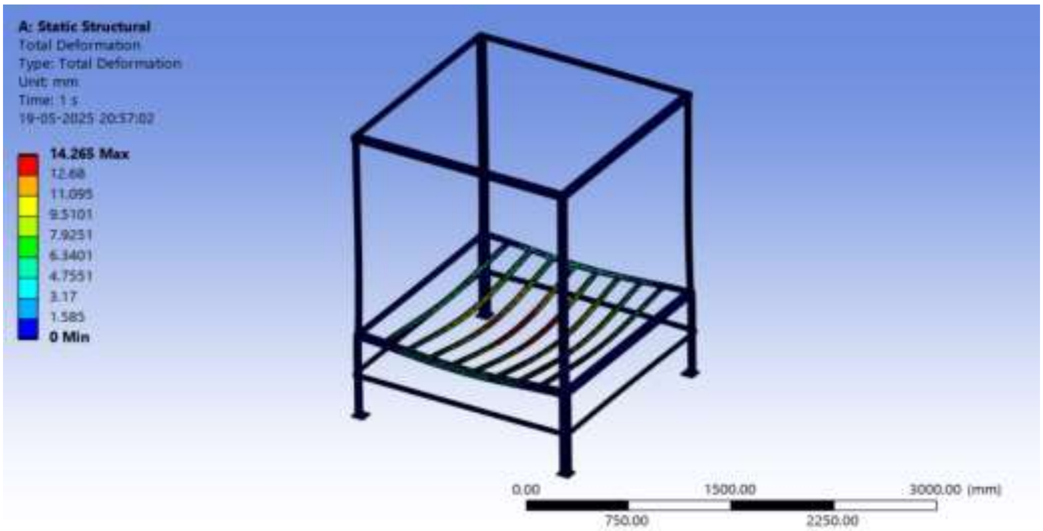


Figure.5.0 Design-1 Deformation

The Equivalent stress of Design –1 is given in the Figure.5.1

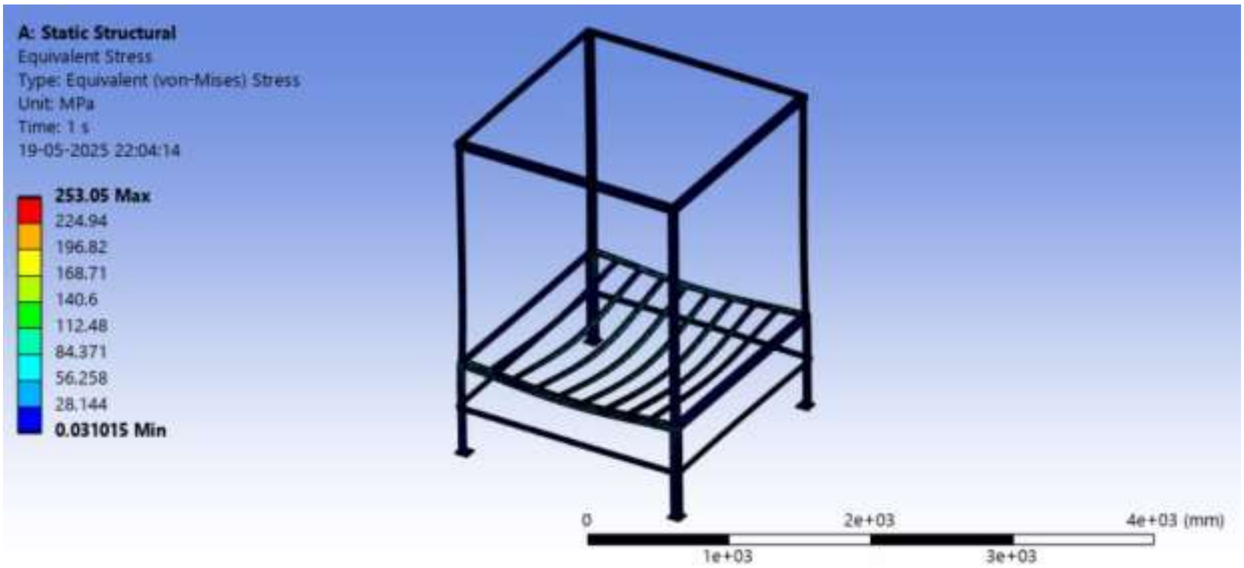


Figure.5.1 Design-1 Equivalent Stress

Here the Uniformly distributing load is given to the Water tank stand to study the Design and behaviour of the material **ASTM A36.** The Deformation and the Equivalent stress occur according to the 1000 Litres of the water weight. (Deformation-6.7948mm and Equivalent stress-138.83 MPa) for the Design-2.

The Deformation of Design –2 is given in the Figure.5.2

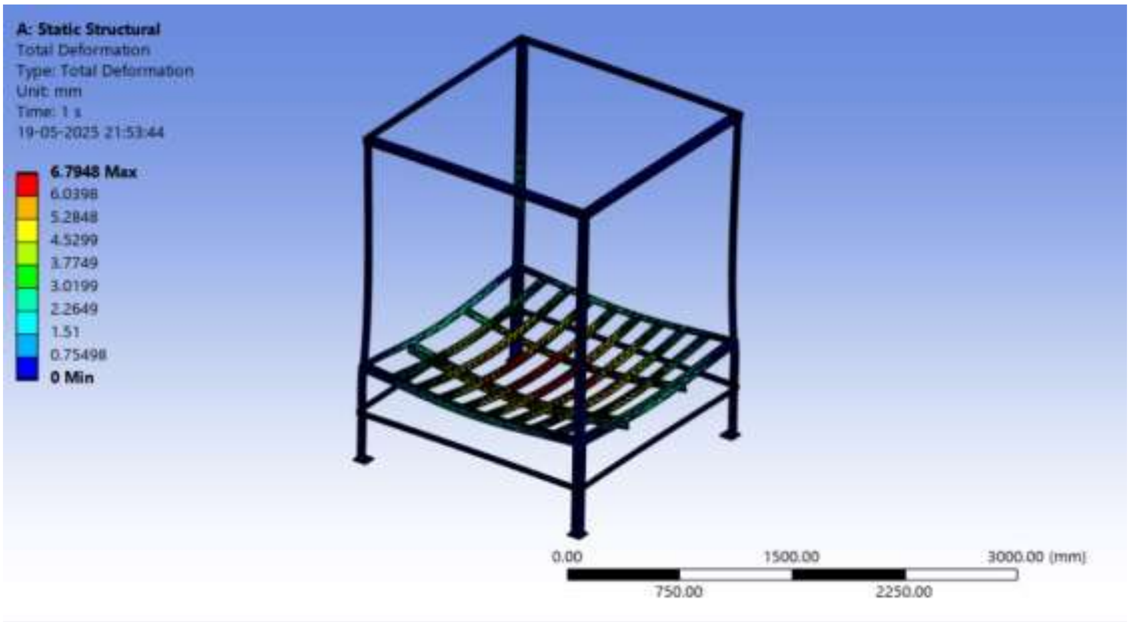


Figure.5.2 Design-2 Deformation

The Equivalent stress of Design –2 is given in the Figure.5.3

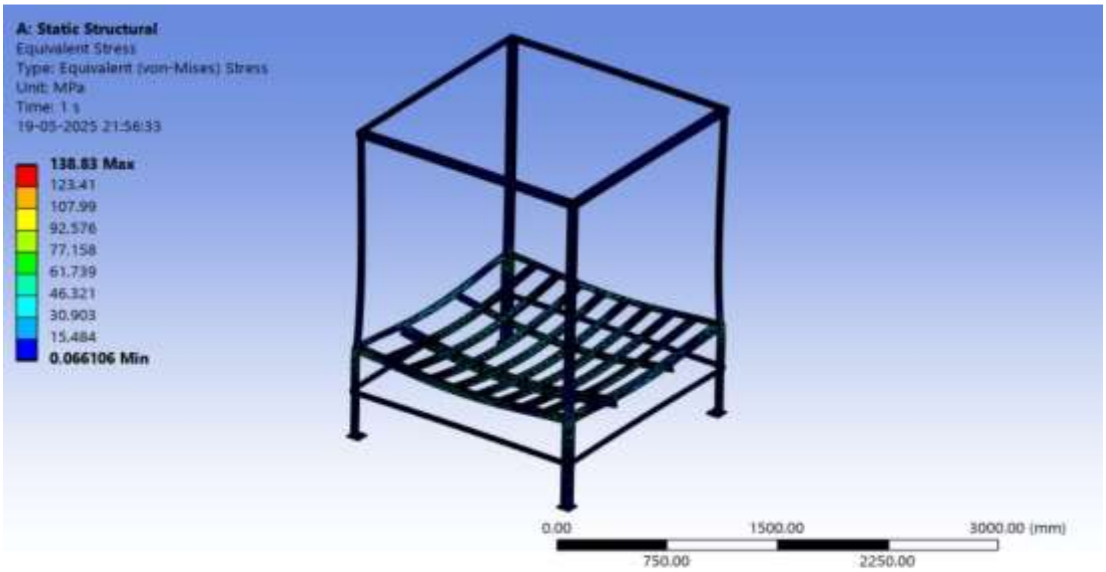


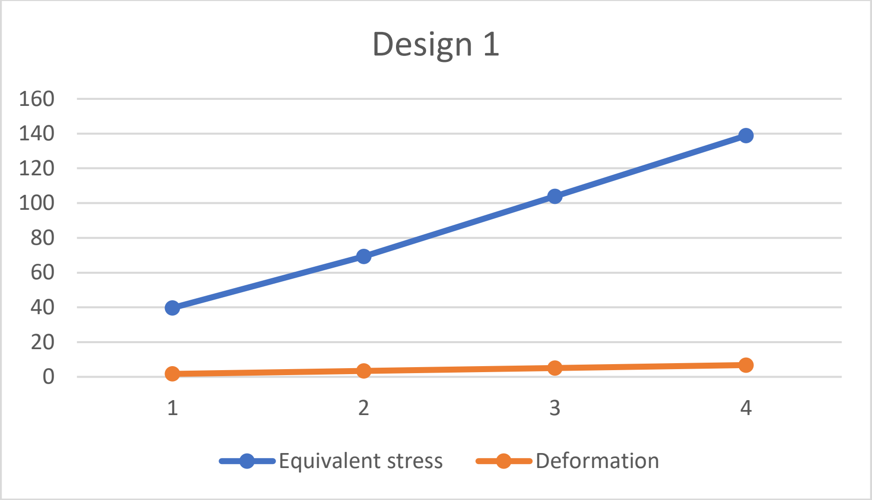
Figure.5.3 Design-2 Equivalent Stress

Results

Equivalent stress and the Deformation Results of Design-1

Weight of water in the tank (Design 1)	Equivalent Stress	Deformation
250 Liters	63.237MPa	3.5648mm
500 Liters	126.37MPa	7.1239mm
750 Liters	189.5MPa	10.683mm
1000 Liters	253.05MPa	14.265mm

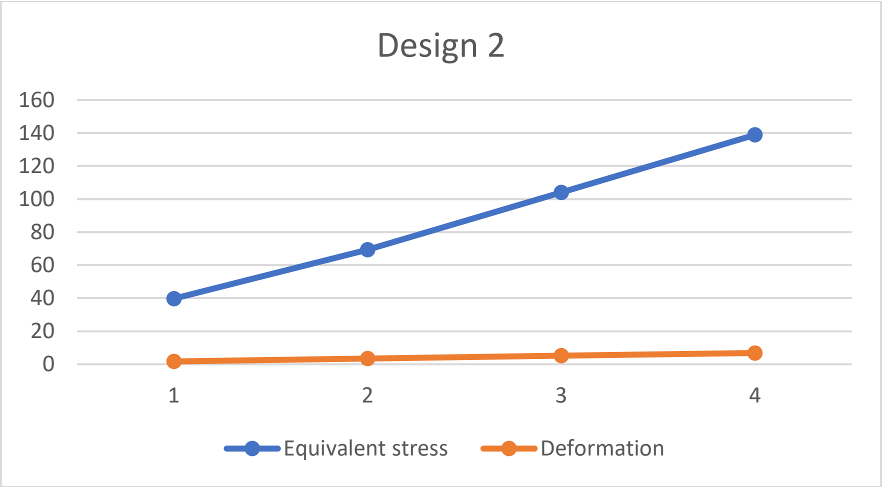
Graph-1



Equivalent stress and the Deformation Results of Design-2

Weight of water in the tank (Design 2)	Equivalent Stress	Deformation
250 Liters	39.694MPa	1.698mm
500 Liters	69.33MPa	3.3932mm
750 Liters	103.97MPa	5.0885mm
1000 Liters	138.83MPa	6.79mm

Graph-2



DESIGN OF SINTEX WITH TANK (SELECTED DESIGN)

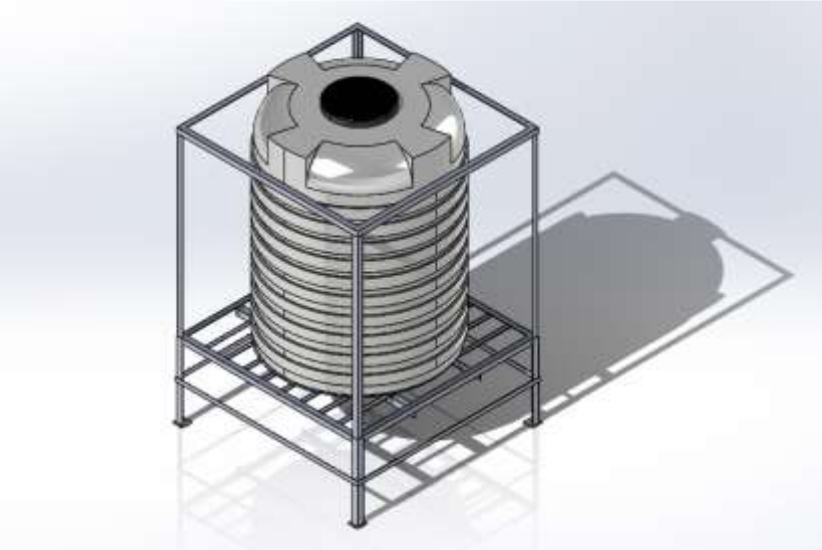


Figure.5.4 Design-2

6.PROCESS OF FABRICATION:

After a comparative structural analysis, Design-2 was chosen for fabrication because the maximum von Mises stress and total deformation under the specified uniformly distributed load (UDL) were each more than 50 % lower than those of Design-1. With confidence in its superior strength-to-weight performance, the build moved to the shop floor.

Figure.6.1 Design-2 (After Fabrication- Entire Model)

Figure.6.2 Design-2 (After Fabrication- Base)

Material preparation

ASTM A36 L-sections were selected for both the base frame and the vertical corner members, balancing weldability, availability, and cost. Using a 14-inch abrasive cutoff wheel on a chop saw, each L-section was cut to precise lengths as detailed in the fabrication drawing. Burrs from the cutting operation were removed with a 4-inch handheld angle grinder fitted with a medium-grit wheel, ensuring clean mating edges for welding.

Base frame assembly

The cut L-sections were laid out on a levelled steel platen table to guarantee squareness and flatness. Magnetic angle clamps and adjustable corner jigs held the members in position. Tack welds were placed at strategic points to lock the geometry before full welding.

Corner and top-frame integration

Four vertical L-sections were aligned perpendicular to the base and tack-welded. Corresponding top L-sections were then positioned, completing the rectangular prism framework. Alignment was continuously checked with a spirit level and steel square.

Welding parameters

A shielded metal arc welding (SMAW) setup was used, operating a 180 A constant-current power source, 3.2 mm (1/8-inch) E6013 electrodes provided deep penetration with moderate spatter, ideal for ASTM A36. Full-length fillet welds were deposited along all critical joints, followed by slag removal and visual inspection for uniform bead profile and absence of discontinuities.

Finishing

Post-weld burrs, spatter, and sharp edges were blended with the 4-inch grinder, giving smooth transitions and preparing the surface for any subsequent coating or machining. Dimensional checks confirmed adherence to tolerance, and the completed frame matched the Design-2 specifications, ready for downstream assembly and testing. Through this systematic sequence precise cutting, controlled fixturing, optimized welding parameters, and meticulous finishing the Design-2 frame was fabricated efficiently, capitalizing on its demonstrably superior mechanical performance.

Corrosion-protection coating

To guard the ASTM A36 steel against atmospheric corrosion, the entire frame was solvent-wiped and lightly hand-abraded to remove any residual mill scale or grease. One uniform coat of red-oxide zinc-chromate primer was applied by spray gun, achieving a dry-film thickness. The primer was allowed to cure for 24 hours at ambient shop conditions before the frame was moved to storage or further assembly, ensuring durable adhesion and long-term rust protection. With the red-oxide primer in place, the Design-2 frame is fully fabricated, finished, and protected for service or additional finishing coats.

7.CONCLUSION:

The structural analysis of the 1000-litre water tank stand highlighted the critical deformation challenges in the initial designs, which could compromise the integrity of the tank and pose safety risks. To address these concerns, ASTM A36 mild steel was selected as the construction material due to its superior mechanical properties, cost-effectiveness, and wide availability. Among the design configurations evaluated, Design 2, incorporating a combination of L-section dimensions (40x40x6 mm, 50x50x6 mm, and 60x60x6 mm), was identified as the most suitable solution. Although both designs used the same L-section dimensions, the new modified design exhibited less deformation and lower stress levels compared to the standard Sintex design. This design exhibited minimal deflection, ensuring enhanced structural stability and tank safety. Given its optimum weight, robust performance, and economic advantages, the mild steel tank stand proved to be ideal for roof-based installations, though less compatible with reinforced concrete (RC) buildings. The new design has also been implemented in real time as figured above. The study underscores the importance of material selection and optimized design combinations in developing cost-effective and structurally sound solutions for water tank support systems.

REFERENCES:

1. Lengvarsky, P., Pastor, M., & Bocko, J. (2015). Static structural analysis of water tank. *American Journal of Mechanical Engineering, 3*(6), 230-234. https://doi.org/10.12691/ajme-3-6-15
2. Morchhale, A. (2017). Study of positioning and dimensional optimization of angled stiffeners using finite element analysis of above ground storage tank. International Journal of Research in Mechanical Engineering, 5(1), 10-19. https://www.iaster.com
3. ASTM A36 Steel. (n.d.). MatWeb. Retrieved February 4, 2025, from https://www.matweb.com
4. Metal Supplies. (n.d.). Mild steel angle. Metal Supplies. Retrieved February 4, 2025, from https://www.metalsupplies.com/products/mild-steel-angle/
5. Metals Handbook, Vol.1 - Properties and Selection: Irons, Steels, and High-Performance Alloys, ASM International 10th Ed. 1990.
6. Engineering Properties of Steels, Philip D. Harvey, editor, American Society for Metals, Metals Park, OH, (1982).
7. R.S. Kurmi - A Textbook of Machine Design - S. Chand Publishing, (2005).
8. Reddy, G. R., & Kalyansundaram, N. (2018). Structural analysis of steel sections for tank support structures. Journal of Structural Engineering, 45(3), 145-156.
9. ASTM International. (n.d.). *ASTM A36: Standard specification for carbon structural steel*. ASTM International.
10. Bureau of Indian Standards. (2007). *IS 800: General construction in steel Code of practice*. BIS.