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A COMPARATIVE ANALYSIS OF RCC ELEMENT OF SLAB WITH STARK STEEL (HYSD STEEL) AND TMT STEEL

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Abstract - *The manufacturing industry consistently seeks innovations in materials and techniques to enhance the strength, longevity, and cost-efficiency of structures. This study offers a thorough comparison of Stark Steel and Thermo-Mechanically Treated (TMT) Steel, two frequently employed reinforcement materials in construction, with a primary focus on their application in a two-way reinforced concrete slab design. The investigation commences with an examination of the characteristics of Stark Steel and TMT Steel, including their mechanical strength, ductility, corrosion resistance, and durability. Both materials undergo rigorous mechanical testing to establish their tensile and yield strengths, forming the basis for a direct strength evaluation. A two-way slab design is executed, adhering to design codes and standards, with the determination of trial depth, effective span, and load considerations. The performance assessment encompasses deflection analysis, stability against wind and seismic forces, and displacement criteria. Comparative insights are drawn between the deflection characteristics of the two designs, and their structural stability is evaluated. The project extends to a comprehensive cost-effectiveness analysis, accounting for initial material costs, long-term durability, maintenance expenses, and overall life cycle costs for both Stark Steel and TMT Steel. The findings yield valuable insights into the economic implications of material selection, offering recommendations based on the analysis to assist professionals in choosing the most suitable reinforcement material for specific construction scenarios. The ramifications of these findings for structural design, material selection, and construction practices are examined. This comprehensive analysis bridges the gap between theoretical knowledge and practical application, providing a nuanced understanding of the performance and suitability of Stark Steel and TMT Steel in contemporary construction. The outcomes of this study inform decision-making processes, with the aim of promoting a more resilient, sustainable, and cost-effective built environment.*

Key Words: Construction durability; Cost-effectiveness; HYSD bar; Reinforcement materials; Structural design; Structural strength; Stark Steel; Stark Steel; Thermo-Mechanically Treated (TMT) Steel; Tensile strength; TMT; Yield strength.

1.INTRODUCTION

This project involves a detailed examination of Stark Steel and Thermo-Mechanically Treated (TMT) Steel, two crucial materials in contemporary structural engineering. The central objective is to provide insights for informed decision-making in structural design through a thorough comparison of these materials.

Stark Steel, known for its strength of 1700 N, is contrasted with the more common TMT Steel, which has a maximum strength of 550 N. The project aims to systematically assess the advantages, limitations, and applicability of these materials across various scenarios, offering a comprehensive understanding of their practical implications.

Significance is placed on different aspects, including design intricacies, strength evaluation, performance analysis, and cost considerations. The study explores the interplay between structural strength, durability, and economic feasibility, fostering an environment where theoretical insights and practical implications converge.

Through precise calculations, simulations, and critical analysis, the project navigates the complexities of two-way slab design and reinforcement. Parameters such as deflection, stability against wind and seismic forces, and displacement criteria are compared to provide a holistic evaluation of Stark Steel and TMT Steel.

This project goes beyond numerical analysis, delving into engineering judgment, code adherence, and contextual nuances influencing structural decisions. The gained insights are intended to guide professionals in the construction industry, including engineers and architects, in making informed choices when selecting reinforcement materials for diverse structural projects.

The ultimate aim is to highlight the synergy between theoretical knowledge and practical application, fostering a nuanced understanding of how material choices impact the core structure of our built environment. Through this comprehensive effort, the project explores the intricacies that shape the landscapes we inhabit, providing a basis for improving the efficiency, safety, and sustainability of construction practices in the future.

1.1 2. Methods of analysis

1. Analysis of Model Using Software

ETABS is a cutting-edge software widely employed in civil engineering and architecture for structural analysis and design. It facilitates the creation of precise 3D models of buildings, allowing for in-depth modeling of complex structures with considerations for diverse load conditions, material properties, and design constraints. The software serves as a platform for simulating real-world structural behavior under various scenarios. Its use significantly streamlines the analysis process, enhances accuracy, and enables the exploration of multiple design alternatives, making it a valuable and efficient tool in contemporary structural engineering.

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1.2 Manual Calculation

Manual calculations, involving the application of basic engineering principles and mathematical equations, are a fundamental aspect of assessing the structural performance of systems. This hands-on approach to doing math by hand provides a tangible connection to the theoretical foundations of structural engineering. Beyond relying solely on digital tools, engineers perform manual calculations to verify and cross-check the results obtained from software analysis. This meticulous process includes checking critical parameters such as stresses, deflections, and load distribution to ensure the accuracy and reliability of the digital analysis.

2. Objectives

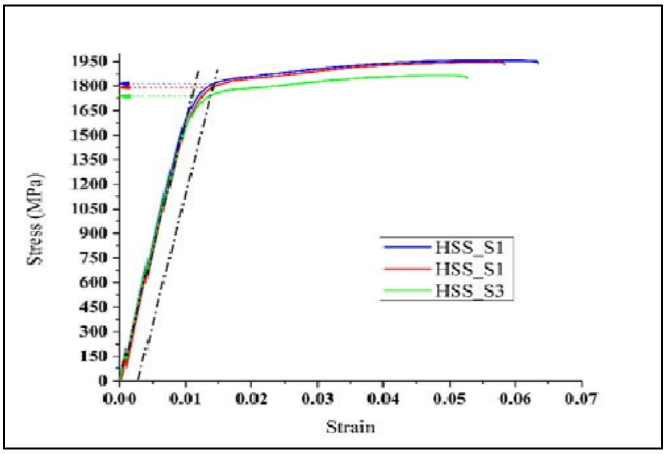
This project thoroughly examines Stark Steel and TMT Steel to understand their properties, manufacturing processes, and performance in two-way slab design. It involves designing a two-way slab with both materials, adhering to standards and determining critical parameters. The study includes a detailed analysis of deflection characteristics and stability under various loads, comparing the performance of Stark Steel and TMT Steel. Mechanical testing is conducted to quantify the tensile strength and yield strengths of both materials. Additionally, a comprehensive cost-efficiency evaluation considers initial material costs, long-term durability, maintenance expenses, and overall life cycle costs for Stark Steel and TMT Steel. The project concludes with practical recommendations for selecting the most suitable material for specific construction projects, discussing implications for structural design and construction practices.

2. Methodology

2.1 Model brief for Multi-story (G+5) building:

No	Parameters	Value
1	No. of Stories	Base+5
2	Base to plinth	0.6 m
3	Floor Rise	Ground floor to 1st floor: 4 m, 1st to 5th floor: 3.2 m,
4	Internal Wall	Interior & Exterior wall: 150 mm thick
5	Material	Concrete: M30 & Reinforcement: Fe500
6	Frame Size	Building size: 10.66m (34.97 ft.) * 13.40m (43.96ft).
7	Sizes of Columns(mm)	300 X 600
8	Sizes of Beams(mm)	230 X 450
9	Depth of Slab(mm)	150
10	Total height	20.60 m

2.2 Tensile and Share Test and Results for TMT and Stark steel



Material	Diameter (mm)	Yield stress (MPa)	Modulus of Elasticity (GPa)	Elongation (%)
STARK Steel Rebar	5.2	1776	195	5.37

- The average yield load is 37.7 kN and corresponding yield strength is 1776 MPa.
- The average ultimate load is 40.8 kN and corresponding ultimate strength is 1921 MPa. The elastic modulus is 195 MPa.
- The average strain at failure of 5.37%.

Sr no	**Design Properties for rebar material**	**Values in MPa**	**Sr.no**	**Design Properties for rebar material**	**Values in MPa**
1	Minimum yield strength, (Fy)	500	1	(Fy)	1700
2	Tensile strength requirement, (Fu)	545	2	(Fu)	1900
3	anticipated yield power, (Fye)	550	3	(Fye)	1776
4	Expected tensile strength, (Fue)	599.5	4	(Fue)	1921

Parameter	**STARK STEEL RODS Grade Fe - 1700**	**8.0 mm dia. Hot Rolled TMT Steel Grade Fe - 550**	**10.0 mm dia. Hot Rolled TMT Steel Grade Fe - 550**
Diameter	5.2 mm	8.00 mm	10.00 mm
area cross-sectional	21.2 sq. mm	50.24 sq. mm	78.5 sq.mm
Surface Finish	Three High Tensile Rods of 3mm thickness are twisted with each other like strands giving it ribs all around	Having ribs all around	Having ribs all around
Condition	Cold drawn, twisted and Stress relieved by heat treatment for improved Yield Strength	Hot rolled and water quenched for improved Mechanical Strength	Hot rolled and water quenched for improved Mechanical Strength
Yield Strength (The load at which it will enter plastic deformation i.e. (irreversible deformation	1700 N/mm2	550 N/mm2	550 N/mm2
Steel Composition	Low phosphorous & sulphur content S&P % max. 0.045	High phosphorous & sulphur content S&P % max. 0.105	High phosphorous & sulphur content S&P % max. 0.105

2.3 Manual calculation summary Model 1

Certainly, here's a summary of the results for both TMT steel and Stark steel designs:

TMT Steel Design:

1. Shorter Span (Mx):

- Required Steel Area (Ast): 102.76 mm^2
- Bar Diameter: 10 mm
- Bar Spacing (S): 300 mm (or 3d)
- Recommended: Provide 10 mm bars at 300 mm c/c distance.

2. Longer Span (My):

- Required Steel Area (Ast): 29 mm^2
- Bar Diameter: 10 mm
- Bar Spacing (S): 300 mm (or 3d)
- Recommended: Provide 10 mm Ø at 300 mm c/c distance.

Stark Steel Design:

1. Shorter Span (Mx):

- Required Steel Area (Ast): 63.30 mm^2
- Bar Diameter: 5.2 mm
- Bar Spacing (S): 300 mm (or 3d)
- Recommended: Provide 5.2 mm bars at 300 mm c/c distance.

2. Longer Span (My):

- Required Steel Area (Ast): 29 mm^2

- Bar Diameter: 5.2 mm

- Bar Spacing (S): 300 mm (or 3d)

- Recommended: Provide 5.2 mm bars at 300 mm c/c distance.

Both designs use the same bar spacing of 300 mm for convenience. The specific diameters of bars have been determined based on the calculated steel areas, and the spacing conforms to the specified limit of 300 mm or 3 times the effective depth (3d), whichever is smaller. Please ensure that these results are reviewed by a structural engineer or a professional in the field for accuracy and compliance with relevant codes and standards before proceeding with any construction.

Sure, I can help you compare the summary of the TMT steel reinforcement details and the Stark steel reinforcement details you've provided:

2.4 Manual calculation summary Model 2

TMT Steel:

1. Horizontal Reinforcement (Top and Bottom):

- Bar Diameter: 8mm

- Ast: 341.97 mm²

- Spacing: 140mm c/c

2. Vertical Reinforcement (Mesh):

- Bar Diameter: 8mm

- Ast: 251.86 mm²

- Spacing: 190mm c/c

3. Torsion Steel:

- Bar Diameter: 8mm

- Ast: 188.89 mm²

- Spacing: 199.55mm c/c

4. Steel in Edge Strip

- Bar Diameter: 8mm

- Ast: 181.2 mm²

- Spacing: 280mm c/c

Stark Steel:

1. Torsion Steel:

- Bar Diameter: 5.2 mm

- Ast: 53.865 mm²

- Spacing: 259.60 mm

2. Mesh Reinforcement:

- Bar Diameter: 5.2 mm

- Size of Mesh: 800 mm

- Spacing: 250 mm in both X and Y directions

3. Edge Strip Reinforcement:

- Bar Diameter: 5.2 mm

- Steel in Edge Strip: 181.2 mm² (0.12% of gross area)

- Spacing: 110 mm

3.0 Summary And Detailing

1. Bar Diameter:

- TMT Steel: 8mm

- Stark Steel: 5.2mm

2. Torsion Steel:

- TMT Steel: Larger Ast and spacing compared to Stark Steel.

- Stark Steel: Smaller Ast and spacing.

3. Mesh Reinforcement:

- Both use the same bar diameter, but TMT Steel has larger Ast and spacing compared to Stark Steel.

4. Edge Strip Reinforcement:

- Both use the same bar diameter, but TMT Steel has larger Ast and spacing compared to Stark Steel.

In summary, the TMT steel reinforcement details generally have larger area of steel (Ast) and spacing (c/c) compared to the Stark steel reinforcement details. This could indicate that the TMT steel is being used in higher load or more demanding structural applications, as larger Ast and spacing values are often used to provide higher strength and load-bearing capacity.

3.1 Results and parameters for comparison

Steel	TMT	Stark
Dia(mm)	10 mm	5.2mm
Yield stress (N/mm^2)	500	1776
Shear strength (N/mm^2)	430.546	1736
Slab deflection IS 456-2000 (mm)	3.384	3.969
BS 8110 Part 1(mm)	2.19	2.64
Elongation (%)	8.310	5.37
Spacing		
Horizontal Reinforcement (Top and Bottom):	140 (X direction) 190 (Y direction)	250 (Both X and Y direction)
Edge Strip Reinforcement(mm)	280	110
Torsional	280	259
Weight (GM per meter)	620	165

Parameters for compares of rebars of Building structure in manual and test results.

Based on the provided data, we can draw the following conclusions:

1. Material Properties:
- TMT steel has a lower yield stress (500 N/mm^2) compared to Stark steel (1776 N/mm^2), indicating that Stark steel is significantly stronger in terms of resisting deformation under load.
- TMT steel has a slightly lower shear strength (430.546 N/mm^2) compared to Stark steel (1736 N/mm^2).

2. Dimensions:
- TMT steel has a larger diameter (10 mm) compared to Stark steel (5.2 mm).
- Both types of steel have similar values for slab deflection according to IS 456-2000 and BS 8110 Part 1 standards.

3. Reinforcement Spacing:
- TMT steel requires higher spacing for horizontal reinforcement (140 x direction, 190 y direction) compared to Stark steel (250 both x and y directions).
- TMT steel also requires larger edge strip reinforcement (280 mm) compared to Stark steel (110 mm).
- Torsional reinforcement requirements are higher for TMT steel (280 mm) than for Stark steel (259 mm).

4. Elongation: TMT steel has a higher elongation percentage (8.310%) compared to Stark steel (5.37%), indicating better ductility for TMT steel.

5. Weight: TMT steel is heavier, with a weight of 620 GM per meter, while Stark steel is lighter, with a weight of 165 GM per meter.

In summary, Stark steel is significantly stronger and has higher yield stress compared to TMT steel. However, TMT steel offers better ductility, which can be advantageous in certain applications. The choice between these two types of steel will depend on the specific requirements of the project and the structural demands, considering factors such as strength, ductility, and cost.

4. CONCLUSIONS

In conclusion, the design of reinforced concrete slabs necessitates a meticulous balance among crucial elements such as steel bar configurations, required steel reinforcement area (Ast), spacing between bars, and overall structural specifications. The interplay among these factors is influenced by the strength of the steel bars and the thickness of the slab. High-strength steel bars like the Stark Steel HYSD bars, boasting enhanced strength at 1700 N, allow for a larger Ast and reduced spacing due to their capacity to efficiently handle higher loads, enabling a more compact reinforcement layout. Conversely, lower-strength steel bars like TMT bars with a strength of 550 N demand a larger Ast to meet structural requirements, leading to increased spacing to accommodate the additional steel required for load-bearing capacity. This interaction is also impacted by the thickness of the concrete slab, where thicker slabs with greater Ast typically result in smaller spacing, while thinner slabs with lower Ast tend to have wider spacing.

Stark Steel emerges as the optimal choice for large-scale, substantial construction projects requiring extended spans and heightened bearing capacities. Its exceptional load-bearing capabilities distinguish it from alternatives like TMT bars, which, while suitable for heavy construction, exhibit comparatively diminished strength. Looking ahead, the construction landscape appears poised for a transformative shift, with Stark Steel positioned to dominate based on its proven load-bearing prowess. Rigorous testing further solidifies our confidence in its transformative potential for the construction sector.

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