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**Research Article**

# Evaluation of RCC building performance with stainless steel hysd reinforcements replacing conventional HYDS steel

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High yield strength deformed (HYSD) steel

**Abstract:**

AbstraThe objective of this investigation is to evaluate and contrast the performance of solid concrete (RC) structures that are reinforced with brushed stainless steel HYSD and common HYSD steel reinforcements. The study focuses on how corrosion impacts building durability and maintenance, and it investigates the viability of stainless steel as an option owing to its greater corrosion resistance, mechanical strength, and durability. ETABS software was used to assess RCC building models of varied heights (G+2, G+5, G+8) under various loading conditions, including seismic forces, in accordance with IS:1893:2016 requirements. Tensile and torsion tests on HYSD550 and SS550 reinforcement bars were carried out to confirm the computational results. The results show that stainless steel reinforcements provide comparable structural performance to conventional reinforcements, with the additional benefits of increased ductility, longer service life, and lower maintenance costs. This study shows stainless steel as a sustainable reinforcement material for important infrastructure, particularly in harsh conditions.

## 1. Introduction

In today's world corrosion is the main destroyer of buildings, and thus to eliminate this corrosion and increase the life of building we are going to need a corrosion resistant material. Stainless steel is becoming more prevalent in construction projects due to its aesthetic appeal, exceptional mechanical and physical properties, and resistance to corrosion (Baddoo, 2008). The present paper pertains to the utilisation of such substances in steel-concrete composite structures, a novel application. The material called stainless steel is being utilised in construction when the 1920s, with the primary application being its use in building facades (Gedge, 2008). Stainless steel has gained popularity in a variety of development and load-bearing sectors due to its superior mechanical properties, including better retention of stiffness and force at high temperatures, superior corrosion resistance, and increased strength and ductility in comparison to carbon steel. Stainless steel does not necessitate the application of coatings, which results in life-cycle cost reductions in comparison to carbon steel, particularly for offshore steel structures (Gardner et al., 2007). Additionally, repair and maintenance costs are reduced. Concrete that has been reinforced (RC) is a combination of materials that enhances the strength and durability of concrete by combining it with reinforcement. Consequently, concrete is susceptible to fracturing under tensile stresses due to its inherent weakness in tension and strength in compression. The tensile strength necessary to withstand external forces is achieved through the incorporation of reinforcement, which is typically bars of steel (referred to as rebar). Reinforcements are used in conjunction with building materials to improve the general stability of structural components, including beams, slabs, pillars, and walls. The grade of the reinforcement employed significantly influences the functionality of RC structures (Mechtcherine, 2012). Reinforcement enhances the durability, stability, and strength of concrete, rendering it suited to a wide range of construction projects.

### 1.1. Tor-Steel

The abbreviation "TOR steel" is Torsional Steel is a powerful deformed steel bar that is frequently employed in construction using reinforced concrete due to its exceptional Tensile Strength and sturdy bond with concrete. The product is offered in a variety of strength categories to accommodate a variety of construction requirements, including Fe 415, Fe 500 words, Fe 550, and Fe 600. Additionally, it is available in specialized variants such as Fe 415D, Fe 415S, Fe 500D, Fe 500S, and Fe 550D, which provide improved properties for specific applications. The material's chemical composition is tailored to meet the requirements of durability and performance in concrete reinforcement (Chang et al., 2001). Due to its high yield strength, ductility, and great bonding properties with concrete, HYSD Steel is a regularly utilised reinforcement material in RC. Cold working (deforming) steel bars improves their mechanical properties. The ribbed surface of HYSD steel bars aids in ensuring a strong connection with the surrounding concrete (Fayed et al., 2023). The strength, longevity, and cost-effectiveness of these bars render them suitable for a variety of construction applications, such as bridges, structures, and dams. However, one of the most significant issues with typical HYSD steel is corrosion resistance, especially in areas exposed to adverse environmental conditions such as high humidity, seawater, and industrial pollutants. Corrosion may drastically erode steel over time, resulting in structural weakness and high maintenance costs.

### 1.2. Stainless-Steel

Steel made from stainless steel constitutes a corrosion-resistant alloy that is predominantly composed of iron, chromium, and other elements. It is highly valued for its ability to provide strength, durability, and an aesthetic surface finish. For concrete reinforcement, stainless steel is employed in a variety of high-strength grades, including SS 500, SS 550, SS 600, and SS 650, each of which is further divided into numerous subcodes (A to G). Each strength grade undergoes a standardised set of tests to establish quality and reliability, with the intention of representing a varying level of performance (Brożek et al., 2009). The steel made from stainless steel is an efficient steel alloy with a reputation primarily recognised for its durability and resistance to corrosion. It comprises iron, chromium, and nickel, molybdenum, and oxygen as alloying elements. Together, they react to create a thin oxide layer on the steel's surface, which prevents corrosion caused by liquids, substances, and environmental contamination. Stainless Steel HYSD Positive reinforcement offer a variety of advantages over conventional HYSD in the context of concrete reinforcement (Nair & Pillai, 2020). They are an excellent choice for use in severe environments due to their high capacity to withstand corrosion, fatigue, elevated temperatures, and chemical attacks. In addition to enhancing the overall durability of brick buildings, bridges, and various other infrastructure, stainless steel reinforcements also extend the tenure of RC structures. Builders may be able to utilise long-term performance, low maintenance, and environmental sustainability by using stainless steel reinforcements in lieu of conventional form of HYSD reinforcements, especially in areas where corrosion and/or service life is a major concern (Rabi et al., 2022). Reinforced Concrete (RC) buildings and other structures have commonly been the major construction material due to its durability, strength, cost-effectiveness, etc. However, the use of traditional HYSD (High Yield Strength Deformed) steel in RC buildings may have corrosion challenges, especially in humid areas, areas that have frequent salt water, or severely adverse environments. One solution that prevents corrosion challenges would be to incorporate Stainless Steel HYSD Reinforcements into the RC buildings for a long term solution (Ahmed E S & Ganesh, 2022). Villa stainless steel will enhance the structural integrity and service life of structures made of reinforced concrete due to its high resistance to corrosion and increased durability, in addition to its long-term performance. The performance of RC constructed structures will be assessed when regular HYSD steel reinforcements are substituted with chrome-plated HYSD reinforcements in this research. This research aims to evaluate the advantages and disadvantages of utilising stainless steel reinforcements in RC structures. The mechanics, strength, load-bearing its limit, and general effectiveness of RC structures reinforced using either pure steel or traditional iron reinforcements will be evaluated (Attia et al., 2023). Using machine learning and experimental studies, the purpose of this research is to compare and analyse the performances of reinforcement-concrete (RC) structures filled with stainless-welded HYSD reinforcements and RC structures reinforced via conventional HYSD reinforcements. The research will examine the structural performance, mechanical properties, corrosion resistance, and loading conditions, including tectonic loading conditions. The field trial component will evaluate the computing results to evaluate the benefits of employing metal HYSD reinforcements in the context of sustainable and ongoing construction (Qin & Kaewunruen, 2023). Finally, the research project will introduce novel concepts regarding the utilisation of stainless steel braces in reinforced concrete structures. It may provide a future pathway to additional sustainable and durable construction building practices that can also be economically sustainable.

## 2. Background Study

The lateral cyclic efficacy of circular strong concrete beams that were bolstered with stainless steel was examined by Moodley et al. (2024). They observed significant enhancements in energy dissipation, ductility, and strength in comparison to steel with carbon reinforcements. Guo et al. (2024) are currently developing a demountable steel bar connecting the components of precast concrete pavement. Their findings underscore the significance of optimising connection performance through the utilisation of high-quality steel plates, and which leads to an increase in load-carrying capacity (Dissanayake et al., 2025). Zheng et al. (2024) investigate the ductile breaking behaviours of austenitic in the form of S30408 under ultra-low-cycle loading conditions. The findings underscore the superior fracture resistance of steel made of stainless in contrast to carbon steel (Li et al., 2021). Ding et al. (2024) investigate the seismic retrofitting of concrete columns made from RC using grid-reinforced stainless- steel Ultra-High Achievement Concrete (UHPC) jackets. These jackets significantly enhance seismic resistance along with energy dissipation. Chen et al. (2024) examine the mechanical characteristics of a duplex stainless steel, also called or S22053, in high-temperature and post-fire environments. Their research provides critical insights in the relationships between stress and strain, as well as reduction formulae for the durability of materials under bombardment (McKenzie, 1993). Duan et al. (2024) run numerical research on the behaviours and aesthetics of S35657 nickel-plated welded stub columns. Their findings compare a variety of design codes for submerged steel components. Xi et al. (2024) implemented an experimental investigation to evaluate the fire behaviours of circular hollow-piece stub columns composed of aluminium. The investigation assessed a variety of design methodologies for the purpose of estimating the ultimate level of protection (Twisdale et al., 1994). Hwang et al. (2024) examine the seismic modification potential of austenitic aluminium slit dampers, observing advantages in fire and corrosion resistance. Using European and American manufacturing standards, Meza et al. (2024) compute material criteria for stainless steel, emphasising the disparities in minimum strength requirements between the two countries. Li or Aoude (2023) investigate the influence of corrosion-resistant rebar and segments on the bending behaviour of concrete posts that are exceedingly robust and resilient to ambient and explosion loading (Elkafrawy et al., 2024). They discover substantial improvements in blast resistance. Rabi et al. (2022) conduct a comprehensive examination of the structural performance and long-term cost savings of stainless steel in order reinforcement in concrete structures.

Yang et al. (2023) investigate the long-term durability of metal reinforcing rods in chloride-rich environments, demonstrating that they exhibit superior corrosion resistance in comparison to conventional carbon steel (Yuan et al., 2025). Kim et al. (2023) examine the performance of stainless-steel high-load lattice girders under the age of combined load conditions, demonstrating an increase in efficiency and a decrease in deflections. Zhang et al. (2023) investigate the mechanical load behaviours of steel-based composite columns under the age of axial loading by comparing their properties to those of carbon steel and a variety of alternative materials. Wong et al. (2023) execute a life cycle analysis of metallic materials in construction, which illustrates the reduced environmental impact and decreased energy consumption that occur over the course of the structures' lifespan. Park et al. (2023) conducted an investigation into the fatigue actions of stainless steel the weldments and discovered that they exhibit a prolonged service life and a greater resistance to fatigue splitting. Li et al. (2023) evaluate the economic feasibility of metallic structural elements in bridge design by providing a cost-benefit analysis along with return on investment. The first study into the seismic effects on stainless steel horizontal elements was conducted by Liang et al. (2023), who identified significant enhancements in energy utilisation and equilibrium under seismic strain. The long-lasting strength and cost advantages of stainless steel are promoted by Rojas et al. (2023) in their evaluation of carbon- steel and titanium steel support in concrete. Kumar et al (2023) examine the influence of physical attributes on the strengthening of elevated steel in viaduct platforms, which leads to a decrease in fracture spreading and a bump in strength. Choi et al. (2023) conduct a comprehensive examination of the applications of stainless steel in maritime environments, with an emphasis on long-term structural stability and corrosion resistance. Chen et al. (2023) examine the behaviour of the stainless steel hollow portions under compressive loading, demonstrating that they are more ductile and strong than conventional materials. Paulo et al. (2023) assess the influence of extreme temperatures on aluminium frame components, thereby providing valuable insights into fire resistance and structural strength. The study reveals a variety of gaps in the current corpus of knowledge concerning the use of structural steel structure in RCC buildings. The limited stated use of titanium reinforcements outside of particular G+2 hostel project is a significant lacuna (Haile et al., 2022). The current body of research does not offer a comprehensive examination of the extent to which these reinforcements influence the building's energy absorption, ductility, and strength, particularly in earthquake-prone regions. Further research is required to evaluate the prevalent use of aluminium reinforcements that are their impact on diversified construction concepts, and their function in enhancing seismic resistance in order to address these gaps.

The bar chart summarises important research priority areas for stainless steel in construction based on studies conducted between 2022 and 2024. The results are organized into the following six themes:

- Strength and Durability: The most studies (6) were recorded in this area and indicate promising interest in improving energy dissipation, ductility, and resistance to mechanical loads with stainless steel.
- Seismic Effectiveness: Four studies investigated the seismic activity of stainless steel, emphasising the advantages of seismic information and retrofitting options (Di Sarno et al., 2006).
- Corrosion Resistance: Four studies demonstrated superior corrosion resistance compared to common steel, particularly when in chloride-rich or marine environments.
- Fire Resistance: Three studies showcased behaviour under elevated temperatures and elevated temperatures post-fire, an increase in stainless steel properties were evident.
- Economic viability: Four studies examined long-term cost reductions and economic advantages of stainless steel -especially with bridges and infrastructure (Walbridge et al., 2013).
- Environmental Impact: Two studies investigating the life cycle impact of stainless steel fell to a lower environmental impact compared to traditional materials in construction.

The chart demonstrates the various benefits and flexible nature of stainless steel in construction from mechanical properties all the way to economic and impact factors. This reinforces growing value of including stainless steel in current engineering and design aspects.

The graphic illustrates the percentage distribution of studies in six research priority areas (2022-2024). It shows that studies focused on "Strength and Durability" represent the greatest number of studies followed by studies on several of the remaining areas of interest which included; seismic performance, corrosion resistance and economic feasibility. The aim of this research project is to conduct a thorough examination and resolution of these deficiencies by first examining the features of stainless steel (K. Zhang et al., 2014). Consequently, the ETABS developing analysis application was employed to generate models of concrete reinforced with cement (RCC) structures (G+2), (G+5), and (G+8) that were composed of stainless steel soft fortifications (SS550) and HYSD550 replacements in accordance with the specified specifications. Lastly, analysis of a range of loading conditions for reinforced concrete construction (RCC) should be complete and the performance of reinforced stainless steel reinforcements compared to HYSD reinforcements under different loading conditions (Hassan & Elmorsy, 2021).

## 3. Methodology

### Research Design

The methodology applied in this study to fulfill the research objectives. It is a step-by-step framework work that highlights how to gather data, run analyses, and evaluate results. Chapter 3 begins with an introduction that contextualizes the research, providing the purpose of the study and the problem being addressed within the study. It describes the research design, data collection, and analysis to uphold to accuracy, reliability, and validity in the study conclusions. The methodology has a combination of theoretical and practical elements, which includes modelling a structure, material properties, loading conditions, and utilizing more developed simulation and analysis instruments (Theodossopoulos & Sinha, 2013). Chapter 3 provides a template by capturing each element of the methodology to understand how the research was undertaken and what was done to ensure complete and worthwhile outputs.

In this research, the models (G+2, G+5 and G+8) have been modeled using HYSD550 and SS550 reinforcement types. The material properties used include: M30 grade concrete and various rebar types including, HYSD550 and SS550. The columns have sizes of 350 mm × 350 mm forG+2, 400 mm × 400 mm for G+5, and 450 mm × 450 mm for G+8 (Tadele, 2023). The beams have sizes of 250 mm × 350 mm, while the slabs are 150 mm thick. Shear walls are 250 mm thick, and diaphragms are modeled as rigid. The structure uses M30 grade concrete for all elements. Reinforcement materials include HYSD 550 and SS 550. Column sizes vary based on building height: 350×350 mm (G+2), 400×400 mm (G+5), and 450×450 mm (G+8). Beams are 250×350 mm, and slabs have a 150 mm thickness. The shear wall thickness is 250 mm, and the diaphragm is considered rigid (Huang et al., 2023). The stresses that are administered are as follows: DL (Dead Load), Dds (Super deceased load), LL (Live Start), RLL (Roof Live Eat), and earthquake forces in both the X and Y dimensions (EQ X, EQ Y). The analysis takes into account the following loads: self-weight, finished floor loads, live loads, top live loads, and vibrations in both the left and right orientations. The study examines Zone-III with Building Type-II and a Value Factor of 1 for seismic loading (EQ X and EQ Y). The time periods are contingent upon the building's height, and the Response Mitigation Factor is 5. The time periods for G+2, G+5, and G+8 models are 0.176, 0.353, and 0.530, respectively, according to IS:1893:2016 standards.

## 4. Findings and analysis

The findings and examination The simulations and experiments conducted in this chapter provide the comprehensive results of the evaluation of the performance of buildings for the RCC reinforced with standard HYSD reinforcement made of steel and Stainless Steel HYSD reinforcements (Reddy et al., 2021). The results are an essential component of this investigation. This chapter conducts a systematic analysis of the seismic performance of properties with varying configurations (G+2, G+5, and G+8) in relation to their potential actual building performances, which are determined by structural characteristics (displacement, drift, place shear, time period, and amount) under varying loading configurations. Several advanced seismic modelling instruments such as ETABS have helped to demonstrate if and how seismic- decisions impact major structural parameters of significant scope (Masciotta & Lourenço, 2022). In each structural detail, special headings show purposefully and large consequences for seismic performance, durability and long term sustainability. This chapter illustrates the distinct advantage of integrating steel alloy buttresses to improve the durability and robustness of RCC constructions, and it evaluates the predicted results with the actual performance.

- HYSD 500 and SS 550 show identical storey displacement results.
- Maximum displacement occurs at the top storey and decreases towards the ground.
- Both materials provide similar structural behavior under the given loading conditions.
- Material selection does not impact storey displacement in these buildings (Medhekar & Kennedy, 2000).
- Structural stability depends on overall design rather than material type.
- HYSD 500 and SS 550 exhibit identical storey drift behavior.
- Maximum storey drift occurs at upper storeys and decreases towards the ground.
- Both materials provide equal resistance to storey drift under lateral loading.
- Material selection does not impact storey drift results.
- Structural drift behavior is governed by overall building design rather than material type (Zou & Chan, 2005).
- HYSD 500 and SS 550 show identical base shear values in both X and Y directions.
- The maximum base shear is attained at lowest point and diminishes as the height increases.
- The increase in base shear towards the ground follows the expected cumulative mass and stiffness distribution (Son & Cording, 2007).
- Strong foundation and lower storey reinforcement are crucial to resist base shear.
- Material selection does not impact base shear distribution or overall structural stability.
- HYSD 500 and SS 550 show identical time period and frequency values, indicating no impact on dynamic behavior.
- Time periods decrease as mode numbers increase, leading to faster oscillations in higher modes.

- Natural frequencies increase with mode number, showing more rapid and complex vibrations.
- Higher modes exhibit quicker oscillations, crucial for seismic performance assessment.
- Dynamic behavior is primarily governed by building geometry and structural configuration, not material type (Devin & Fanning, 2019).
- Both HYSD 500 and SS 550 exhibit identical modal mass participation, indicating no effect of material choice on dynamic response.
- Initial modes have low mass participation.
- Mass participation increases sharply in subsequent modes.
- Higher modes capture nearly all mass, leading to saturation.
- UX Direction: Minimal mass in the first mode, with rapid increase to near-saturation by higher modes.
- UY Direction: Early modes capture a significant portion of mass, stabilizing at ~96-99% in later modes.
- The majority of mass is engaged in lower modes, crucial for understanding lateral force distribution and seismic resilience (Christopoulos & Zhong, 2022).

**Towards Experimental Verification of Computational Results**

The ETABS study provided valuable insights into the fundamental efficiency of RCC structures that were reinforced with stainless metal HYSD and common HYSD steel buttresses. The results demonstrated equivalent responses of the structure in the form of displacement, move base shear, and fluid characteristics under a variety of loading conditions. In computational models, both materials demonstrated comparable performance. However, the stainless- steel HYSD has internal advantages, including superior resistance to rust and long-term durability, who warrant further investigation (Xu et al., 2024). In order to confirm the computational findings and conduct a more thorough examination of the reinforcement bars' mechanical behaviour, experimental testing was implemented. Subsequent The subsequent section emphasises the experimental results, with a particular emphasis on the reinforcement bars' tensile and torsional properties. For all tensile and torsion testing, test specimens of the reinforcement bars had to be prepared. Test specimens were selected and then prepared in a manner that would ensure that test specimens were prepared consistently and could be tested and evaluated per the testing criteria. The specimen that was created for the tensile evaluation had an initial length ($l_1$) of fifty microns, which is approximately five times the diameter, and a previous diameter ($d_1$) of 10 mm. The specimen's total parallel length was 1000 mm, which is sufficient for the testing (Liu et al., 2019). Upon completion of the tensile testing, the specimen's final diameter ($d_2$) was 5.4 mm, which indicates that the tensile force had caused necking. A universal tester (UTM) was employed to conduct the tensile test, which also included an extensometer for precise elongation measurement. The gauge length ($l_1$) was evaluated at the test by quantifying the specimen's increased length using the lengthening scale on the instrument. The test produced linear stress readings in comparison to strain data until the point at which it breaks, which signifies the switch from elastic contract to deformation of plastic. The elongation of the specimen during the plastic region increased net elongation significantly, and the SS550 reinforcement bars demonstrated increased elongation in comparison to the HYSD550 bars. For instance, at a load of 150 kN, the SS550 had a strain of 2.1 as opposed to 0.197 for the HYSD550, indicating its superior ductility. In the torsion test, specimens were loaded with torque to obtain angular deformation. The gauge's length and original size of the test model were documented in order to ascertain the angle of pressure and shear strain. The measurement can be used to determine the torque (T), angles of rotation (θ), shear pressure (τ), shear load (γ), and modulus of shear (G) of each specimen (Wang et al., 2016). While the shear modulus of the HYSD550 was measured consistently to be 147 GPa, the shear modulus of the SS550 was measured consistently to be lower at 92 GPa, meaning the SS550 has greater angular flexibility. SS550 also had greater angle of twist for the same torque applied, with maximum twist observed to be 2.4° and 300 Nm of torque applied for SS550 as compared to 1.5° for the HYSD550 at the same torque.

**Observations from Specimen Testing**

**1. Before Testing:**

-Original Diameter ($d_1$): 10 mm

- Cross-sectional Area: $\pi d_1^2/4 \approx 78.53$ mm²

- Original Gauge Length ($l_1$): 50 mm

- Parallel Length: 1000 mm

**2. After Testing:**

- Final Diameter ($d_2$): 5.4 mm

- Final Gauge Length ($l_2$): 62.80 mm

- Cross-sectional Area: Calculated using the reduced diameter after testing.

The considerable decrease in both diameter and the increase in gauge length representing SS550's ability to undergo substantial plastic deformation prior to failure was an important characteristic for high ductile applications. The mechanical and torsional behavior of Stainless Steel HYSD550 (SS550) and ordinary HYSD550 reinforcement bars were evaluated in the experimental study to complement computational evaluations and provide more detailed insight about the performance of reinforcement materials. Tensile tests were performed through the Universal Testing Machine (UTM) to examine stress strain relationships, elongation behavior and regions of deformation (Ramli et al., 2022). The torque, angle of rotation, shear stress, strain caused by shear, and shear modulus were all examined through torsion tests. In a tensile test, both reinforcement varieties were evaluated. Both types of reinforcement were given a progressive loading to investigate the behavior through the linear elastic region to the fracture point. Stress-strain data indicated HYSD550 showed to be higher in stress values at equivalent strain level suggesting it was stiffer and stronger, while SS550 showed higher elongation and strain capacity, as well as the ability to sustain larger deformations before failure. As outlined in the tensile results, at maximum tensile strength, SS550 had very much higher strain compared to HYSD550, indicating the ductility and plastic deformation characteristics of it as well. This is a critical property for reinforcement where flexibility and energy absorption may be desired.

The stress-strain plot compares the performance of the two materials, HYSD550 and SS550. The HYSD550 produces greater stress values for the same strain levels, it therefore possesses greater strength (Yang et al., 2019). The SS550 has higher strain at comparable stress levels. For this reason, SS550 shows a greater ductility and ability to bend plastically/ deform before failure. While HYSD550 can therefore be useful where high strength is required, SS550 would be preferred in applications where there is potential for greater deformation before rupture.

**Stress and Strain Analysis**

The following formulas were employed to determine the stress and strain values:

- Stress: $\sigma = F / A$, where F is the applied force, and A is the cross-sectional area.
- Strain: $\varepsilon = \Delta l / l_1$, where $\Delta l$ is the change in length, and $l_1$ is the original gauge length.

For HYSD550, the maximum stress ever obtained was 2.55 MPa at the 200 kN load before failure. SS550 recorded a lower value of stress, at 2.8 MPa at the same load, but with a much higher set of strain values, demonstrating an ability to absorb energy and deform plastically.

**Torsion Test Observations**

In the torsion test, the behavior of the materials under angular deformation was observed:

- HYSD550: Showed higher stiffness with a steeper torque-angle relationship and less angular deformation.
- SS550: Demonstrated higher ductility with a gradual torque-angle relationship and greater angular deformation.

The outcomes of the tensile and torsion tests conform to the predicted computational analysis, confirming the superior performance of SS550 in terms of ductility and flexibility. These characteristics make SS550 ideally suited for applications where dynamic loading, seismic conditions, or greater corrosion resistance are of concern. In summary, the experimental study shows that SS550 reinforcement bars has better ductility, deformation capacity and versatility for dynamic loading circumstances compared to HYSD550. Although HYSD550 is still a valid alternative for conventional construction practices, SS550's greater flexibility and corrosion resistance provides a practical means of producing durable constructions in tough conditions and environments. The experimental results were comparable to the computational results, and promoting SS550 has the opportunity to disturb the traditional methods of reinforcement used in heavy infrastructure projects (Fawzy et al., 2024).

**Cost estimation:**

- The chart provides a comparison of total steel area, weight per meter, and cost per meter for stainless steel and high yield strength deformed (HYSD) steel used in beam and column structural elements.
- For stainless steel, the total steel area used in beams is 3,978,777 mm², with it's weight at 31,233.40 kg/m, and cost at 4,685,009.92 per meter. Likewise, for columns, the total steel area is 3,222,932 mm², with weight at 25,300.02 kg/m, and cost at 3,795,002.43 per meter.
- In comparison, for HYSD steel, the total steel area for beams remains the same at 3,978,777 mm², with an identical weight of 31,233.40 kg/m. However, the cost per meter is significantly lower at 1,874,003.97 per meter. Likewise, for columns, the total steel area is 3,222,932 mm², with a weight of 25,300.02 kg/m, and the cost per meter is 1,518,000.97.
- Despite the fact that the consumption of materials in the sense of stainless steel area and the weight remains stable between the two

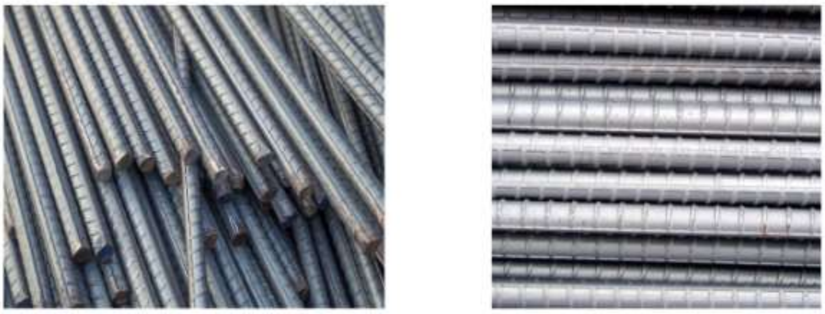
materials and HYSD stainless steel for both supports and beams, the data plainly shows that the cost of gleaming steel is significantly higher than that of HYSD steel (Gardner, 2019). This cost differential highlights the economic implications of material selection, where stainless steel, despite its superior corrosion resistance and durability, incurs significantly higher expenses compared to HYSD steel.

## 5. Conclusion

The efficacy of reinforce concrete (RC) structures fortified with stainless-welded HYSD550 (SS550) and typical HYSD550 bars of reinforcement is comprehensively evaluated in this study. ETABS software was used to conduct a full computational analysis of RCC building models of varied heights (G+2, G+5, and G+8) under various loading conditions, including seismic stresses, in accordance with IS:1893:2016 requirements. The simulation results for the mechanical and torsional behaviour of HYSD550 and SS550 bars were also compared to the experimental the tensile and torsion test results (H. Zhang et al., 2024). This comparison encompassed technical characteristics, stress-strain properties, stretching, torque, angle of twist, and ductility. The results of the comparison enabled a more comprehensive understanding of the material's mechanical motion and torsional behaviour. The structural behaviour of each reinforcement element was comparable in terms of eviction, drift, base shear, duration, and natural frequencies, as indicated by the ETABS analysis. While the simulations indicated that the structural reactions to the materials were effectively identical it was evident from the experimental results that there were substantial differences. The SS550 reinforcement bars have proven to be superior to the HYSD550 reinforcement bars in terms of ductility, deformation capacity, and corrosion resistance, making SS550 the ideal materials for critical applications requiring resistance to dynamic loading or seismic activity and exposure to corrosive conditions. The experimental analysis demonstrates SS550's capacity to withstand greater elongation or plastic deformation prior to collapse, and would be suited to all infrastructure types located in an earthquake prone region or severe climatic environments such as coastal or industrial environments. On the other hand, HYSD550 bars had a higher stiffness; they also expressed a steeper relationship between torque and angle, meaning they will hold up better in an application requiring higher rigidity and less deformation. Stainless steel costs substantially more than HYSD steel, although both have the same steel area and weight. Stainless steel has better durability and resistance to corrosion than HYSD steel, but in structural application where corrosion resistance is not as important, it is clear that HYSD steel is more cost-effective. In this case, the project helped to build a bridge between theoretical and practical applications, specifically in demonstrating the suitability of stainless steel as a reinforcement, whilst demonstrating SS550 reinforcements can meet and exceed structural performance, as well as, durability and sustainability value. Although this study only examined particular building configurations and controlled experimental conditions, future studies should examine a wider selection of building designs and more realistic scenarios (Chen et al., 2018). Performance scenarios should include long-term experiments for resistance to environmental degradation and load changes over time, to validate the findings. Additionally, study of the cost-effectiveness and life cycle costing of SS550 reinforcements in various structural applications will provide additional understanding. In summary, this study highlights the transformational potential of Stainless Steel HYSD reinforcements to modernize building practices, as SS550 mitigates fundamental environmental corrosion and structural sustainability issues, while paving the way for increased strength, durability, and sustainability of RCC structures, with particular impact on infrastructure projects requiring long term endurance and reliability.

**Closing Remarks**

This investigation illustrates the substantial potential of metal HYSD reinforcements to resolve several of the most significant obstacles in contemporary construction. SS550 reinforcements provide a sustainable and durable alternative to conventional HYSD steel, offering greater corrosion resistance, enhanced ductility and a longer service life. This study's results represent a step forward in the transformation of construction techniques, especially for infrastructure projects in harsh environments and seismic zones. Stainless Steel HYSD is a sophisticated material that underscores a dedication to durability and sustainability as our building industry transitions to more ecologically responsible and robust solutions (Rossi, 2014). This study serves as a platform for future research and innovation, assisting engineers, policymakers, and stakeholders in making informed choices that progress the future of construction by prioritizing safety, efficiency, and sustainability.



HYSD Steel Reinforcements          HYSD Stainless Steel Reinforcements

***Figure 1.*** *HYSD Steel Reinforcement and HYSD Stainless Steel Reinforcement*

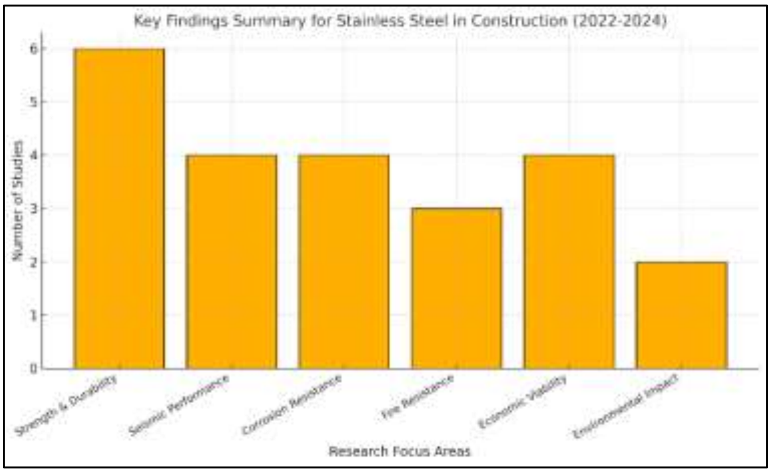



***Figure 2:*** *Key findings summary*

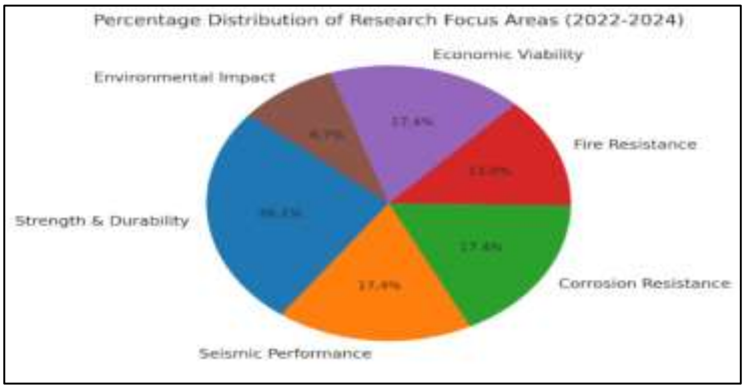



***Figure 3:*** *Percentage distribution of research focus areas*

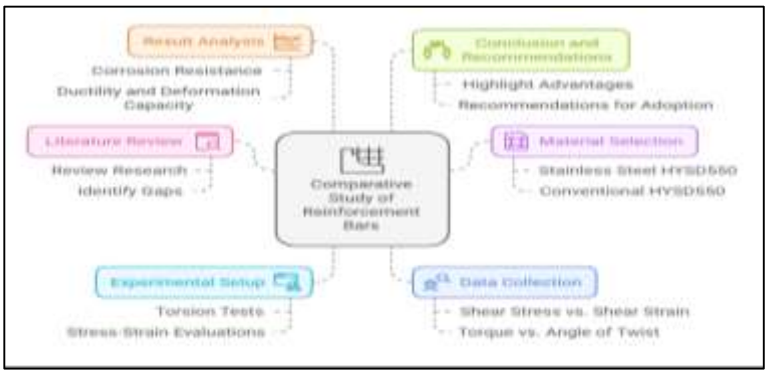



***Figure 4:*** *Process diagram*

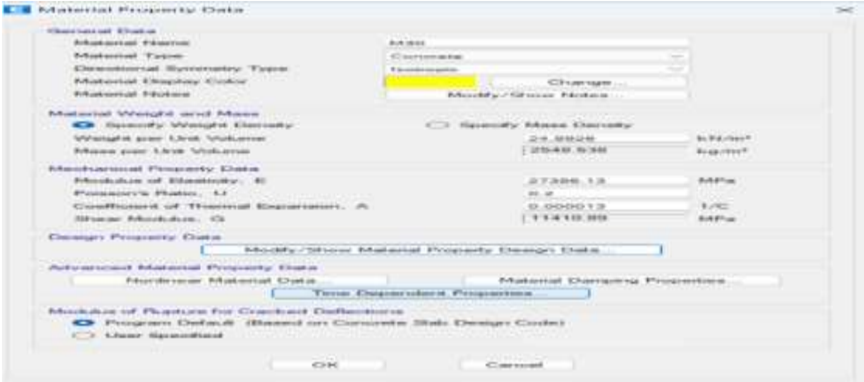


***Figure 5.*** *M30 Grade of Concrete*

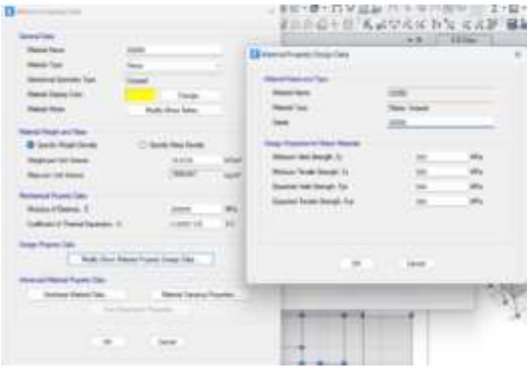


***Figure 6.*** *Input values of SS550 Reinforcements*

***Figure 7.*** *Input values of HYSD550 Reinforcements*

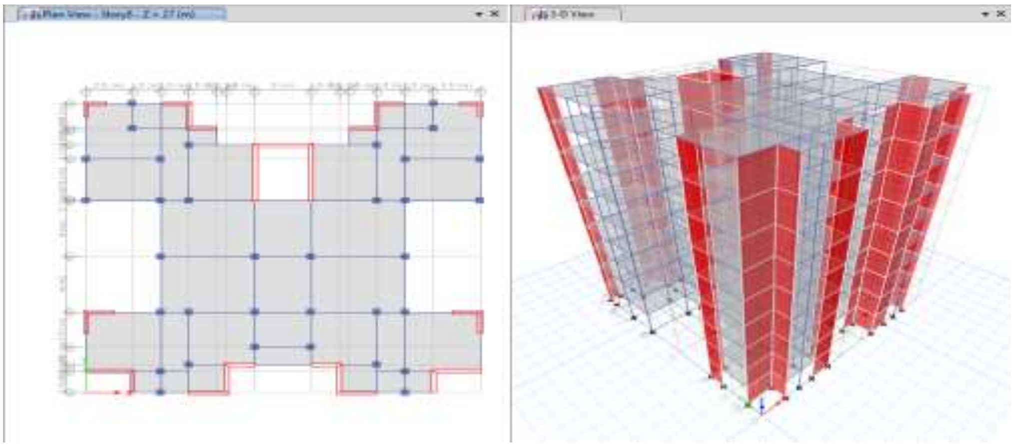


***Figure 8:*** *Plan & 3D view of the building*


***Figure 9:*** *G+2 building storey displacement in X direction*

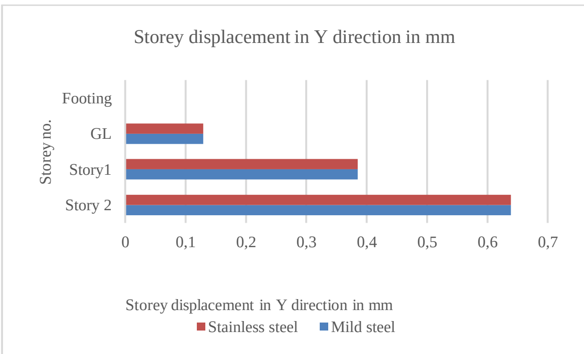



***Figure 10:*** *G+2 building storey displacement in Y direction*

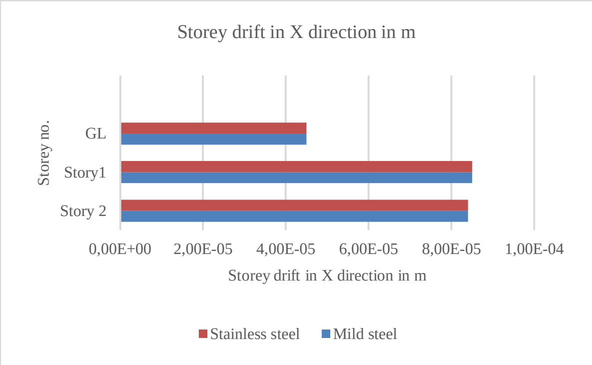



**Figure 11:** *G+2 building storey drift in X direction*

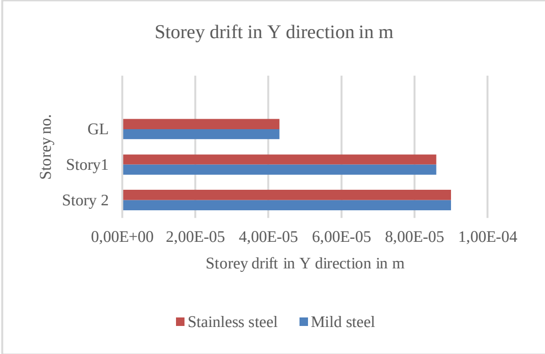



**Figure 12:** *G+2 building storey drift in Y direction*

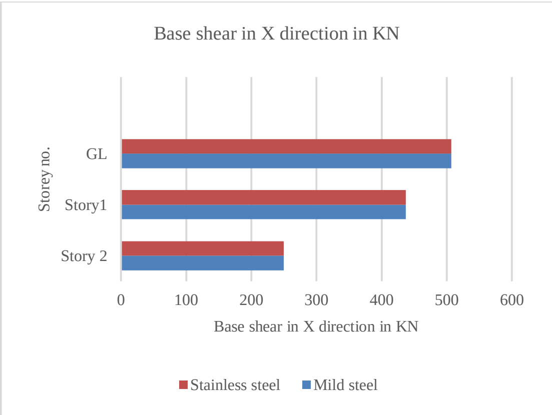



**Figure 13:** *G+2 building base shear in X direction*

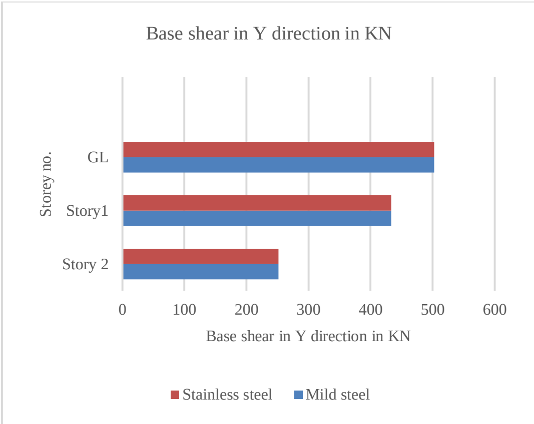



**Figure 14:** *G+2 building base shear in Y direction*

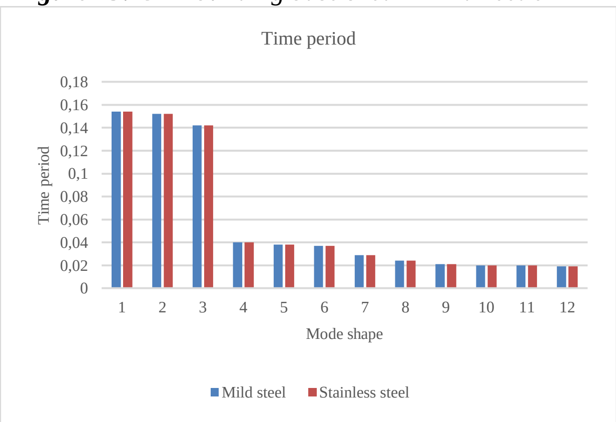



**Figure 15:** *G+2 building time period*

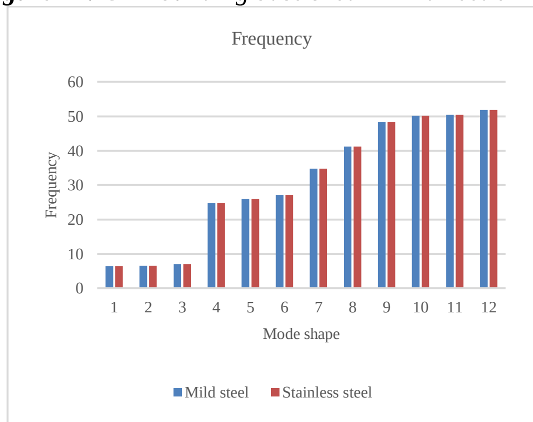



**Figure 16:** *G+2 building frequency*

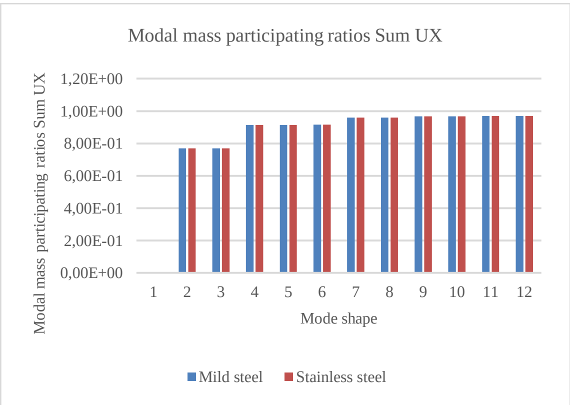



**Figure 17:** *G+2 building modal mass participating ratios sum UX*

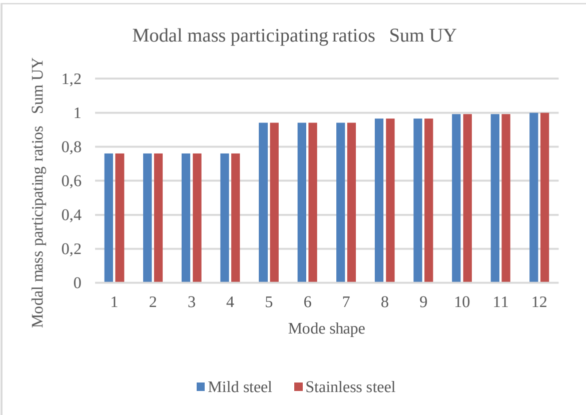



**Figure 18:** *G+2 building modal mass participating ratios sum UY*

***Figure 19:*** *Torsion Test Specimen Inspection Before Testing*

***Figure 20:*** *Torsion Testing Machine Setup*

***Figure 21:*** *setting up a universal testing machine (UTM)*

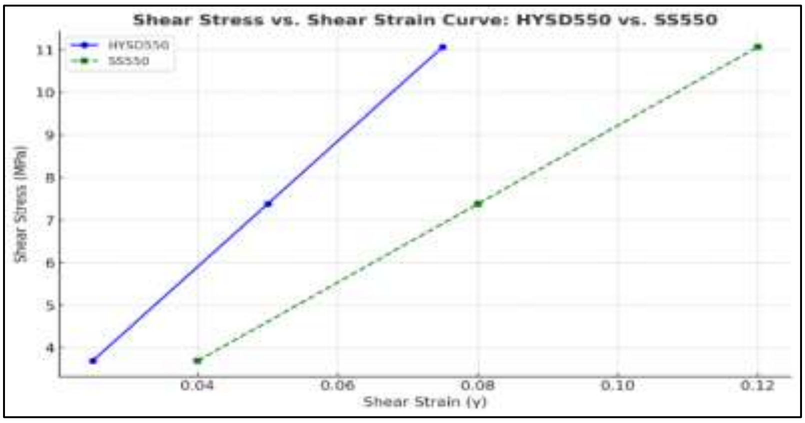



***Figure 22.*** *The shear stress versus shear strain plot*

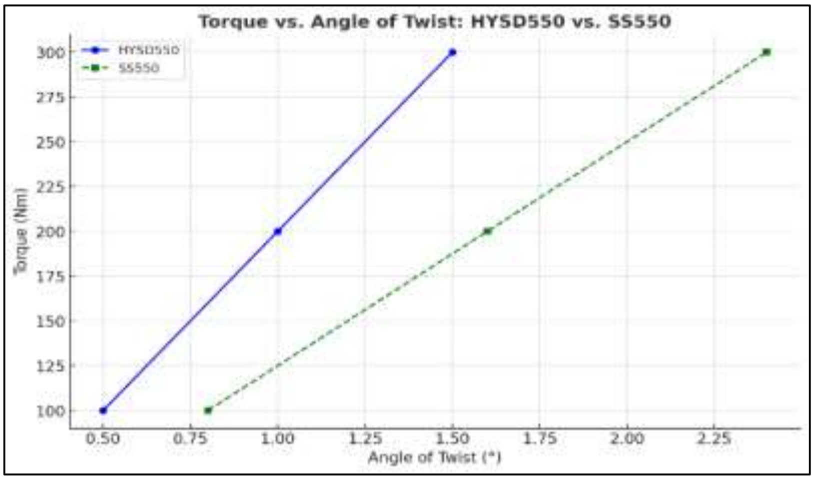



***Figure 23.*** *The torque vs angle of twist for both HYSD550 and SS550. HYSD550 has a steeper slope*.

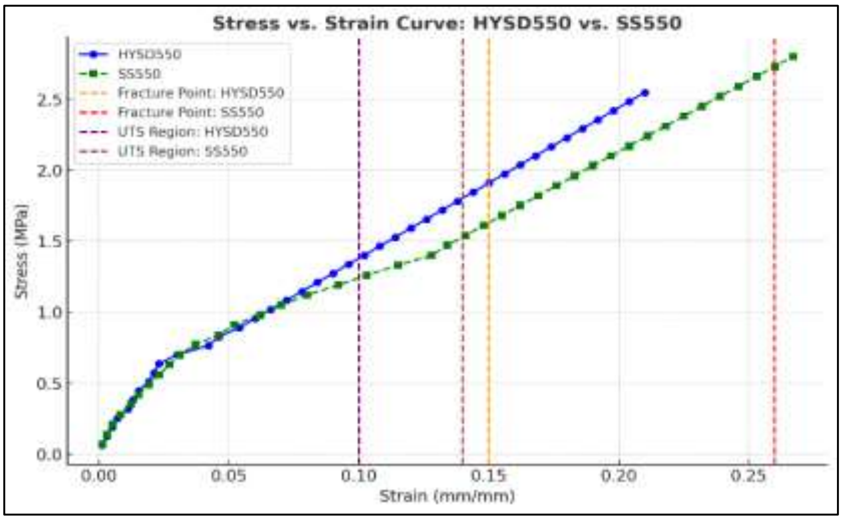



***Figure 24.*** *The stress vsstrain curve for both HYSD550 and SS550.*

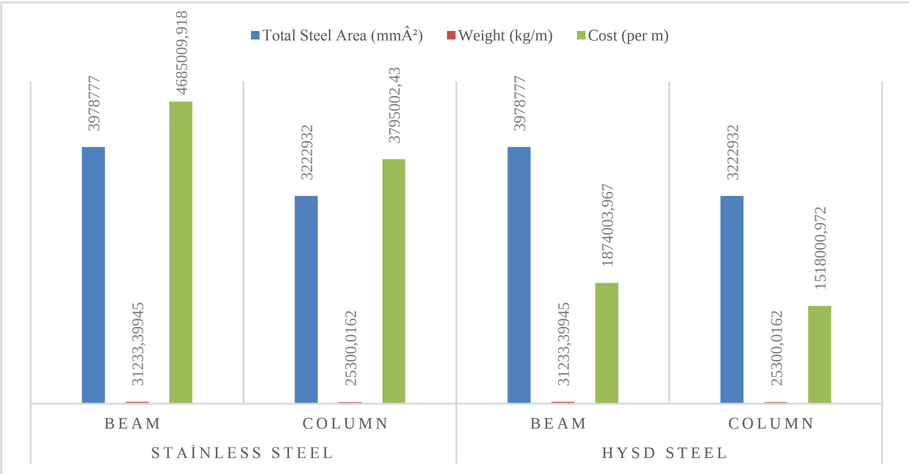



***Figure 25:*** *Cost estimation of both steel*

Figure 22 shows the torsional behaviour between HYSD550 and SS550. The slope of HYSD550 shows a greater angle leading to a greater angular shear modulus (shear to stress), but SS550 shows greater shear strain at comparable stress levels showing greater ductility. Figure 23 illustrates the torque vs angle of twist for both HYSD550 and SS550. HYSD550 has a steeper slope, indicating it is better at resisting angular deformation (angular stiffness) while SS550 has a shallower slope, indicating greater angular deformation for the same force.

## Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.

- **Author contributions:** “All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Mr. Avadhut Makarand Behere] and [Prof. Vrunda Agarkar]. The first draft of the manuscript was written by [Prof. Ruchi Patira] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.”

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- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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