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QUALITY ASSESSMENT TESTS OF TMT STEEL ROUND BARS USED IN JORHAT DISTRICT OF ASSAM

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Abstract: The process of designing a building structure starts with the selection of construction materials based on their mechanical properties and the type of stresses to be supported. For the design of reinforced concrete structure, which is one of the most built structures around the world, the choice will fall on concrete and steel reinforcing bars. The quality of TMT (Thermo-Mechanically Treated) bars chosen must have adequate tensile strength to guarantee a ductile behaviour expected of reinforced concrete structure, so that the structure will be safe and functional to fulfil the purpose for which it is built. Possible causes of the failures of reinforced concrete structures are many including the quality of steel and concrete adopted. In this research work, various quality assessment tests such as Ultimate Tensile Strength test, Bend & Re-band test and Elongation have been performed on TMT steel reinforcing round bars used in local areas of Assam. Samples of 10 mm, 12 mm and 16 mm diameter bars of different brands namely JINDAL, SATYAM, TISCON and VISCON were collected from different stages of construction, including reinforcement procurement and onsite storage of Jorhat district and tested in the Material Testing Laboratory, Civil Engineering department of H.R.H. The Prince of Wales Institute of Engg. & Technology, Jorhat, Assam. Results obtained shows that all the samples considered met the IS 1786 (2008) code specifications.

Keywords: Concrete, TMT (Thermo-Mechanically Treated) Bars, Reinforced Concrete, Ultimate Tensile Strength, Elongation and Bend& Re-bend.

1. Introduction: TMT (Thermo-Mechanically Treated) bars are high-strength reinforcement bars having a tough outer core and a soft inner core. Today, TMT bars are widely used in a variety of construction projects, including residential buildings, commercial complexes, bridges, dams, highways, and urban infrastructure. Their versatility, reliability, and cost-effectiveness have made them the preferred choice for reinforcing concrete structures in the modern construction industry. The major Indian TMT steel bar manufacturing industry such as TATA Tiscon, Jindal Steel and Power Limited (JSPL), VICON DURGAPUR, SATYAM STEEL, JSW Neosteel, Kamdhenu TMT, SAIL TMT HCR, Shyam Steel TMT, etc. plays a vital role in supporting downstream sectors, such as construction, real estate, and infrastructure development, further boosting economic growth and development. The TMT bar industry in Assam has been steadily growing in response to the region's infrastructure development and construction activities. While Assam may not have as large a footprint in the steel industry as some other states in India, it still plays a significant role in meeting the local demand for TMT bars and reinforcing steel. The TMT bar industry in Assam comprises a mix of manufacturers, including large-scale steel plants, medium-sized mills, and smaller local producers. Moreover, the TMT bar industry in Assam contributes to the local economy by generating employment opportunities and supporting ancillary industries. In recent years, there has been a growing emphasis on quality and sustainability within the TMT bar industry in Assam. Manufacturers are investing in modern technologies and quality control measures to ensure that their products meet national standards and customer expectations.

In this research approach, Tensile strength Test, Bend Test and Reband Tests have been conducted to assess the quality of TMT bars of diameters 10 mm, 12 mm, & 16 mm from the manufacturers such as SATYAM Steel, VICON Steel, JINDAL Steel, and TATA Tiscon as per IS Code 1786-2008.

2. Objectives: The objectives of this study are to achieve the following goals:

- To assess the mechanical properties of TMT bars.
- To compare the quality of TMT bars with national standards.
- To identify any deviations from quality standards.

3.Significance of the study: The study on the assessment of the quality of steel reinforcing bars used in the Jorhat region holds significant importance for several reasons. Firstly, the quality of these reinforcing bars directly impacts the structural integrity, safety, and durability of concrete constructions, including buildings, bridges, and infrastructure projects. By evaluating the chemical composition, mechanical properties, and adherence to national standards, the study ensures that the TMT bars used in construction projects meet necessary quality requirements, thereby reducing the risk of structural failures and enhancing the longevity of infrastructure. Furthermore, the findings of the study can inform stakeholders, including government agencies, construction companies, engineers, and policymakers, about the current state of TMT bar quality in the Jorhat district of Assam. This knowledge can guide decision-making processes related to procurement, construction practices, and quality assurance protocols, ultimately leading to improved construction standards and enhanced public safety. Additionally, the study contributes to the body of knowledge on construction materials testing and quality assessment, facilitating knowledge dissemination and fostering a culture of continuous improvement within the construction industry.

4. Scopes of the study:

a. The study focuses specifically on the Jorhat district of Assam, India, and the quality of steel reinforcing bars used in construction projects within this geographical area.

b. The assessment covers various quality parameters of TMT bars, including mechanical properties (tensile strength, yield strength, elongation) compliance with national standards (e.g., IS 1786:2008).

c. The study includes a diverse range of construction projects in the Jorhat district, such as residential buildings, commercial complexes, bridges, and infrastructure developments, to provide a comprehensive understanding of TMT bar usage.

5. Limitations of the study:

a. The study's findings may be influenced by the sample size and representativeness of the TMT bars collected from construction sites, which may not fully reflect the entire spectrum of TMT bars used in the region.

b. Limitations in terms of time, budget, and access to specialized equipment or expertise may constrain the extent of laboratory testing and analysis conducted as part of the study.

c. External factors such as weather conditions, transportation issues, and cooperation from construction site managers or stakeholders may affect the smooth execution of the study and the collection of samples.

d. While the findings provide insights into the quality of TMT bars in the Jorhat district, they may not be directly generalizable to other regions or contexts without considering specific local factors and variations in construction practices.

6. Research Methodology: The methodology of the present study is as follows:

6.1. Area of the Study: The State Assam is situated in the north-eastern part of India. Jorhat is an administrative district of the Indian state of Assam situated in the central part of the Brahmaputra Valley. The district is bounded by Lakhimpur on north, Nagaland state on the south, Sibsagar on the east and Golaghat on the west. On the north of the district, the river Brahmaputra forms the largest riverine island of the world. Map of Jorhat district is given below:

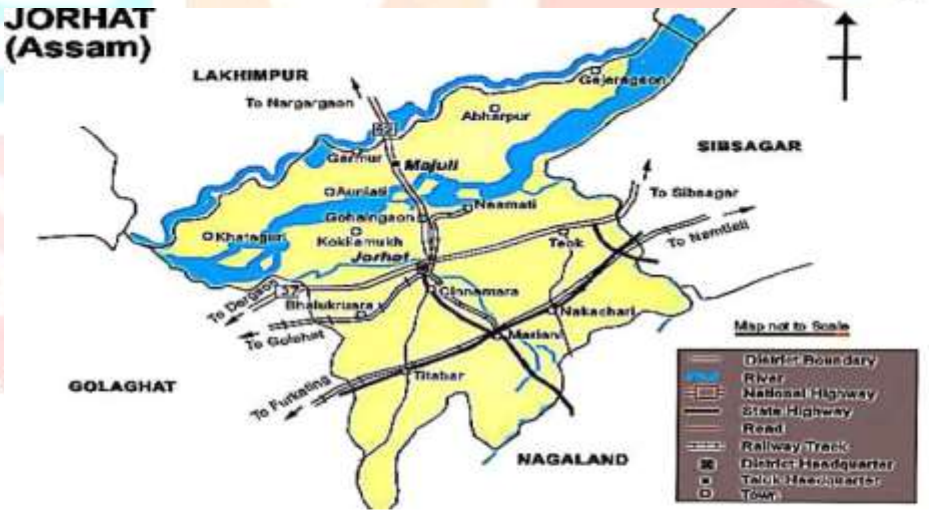

Fig.-1: Map of Jorhat

6.2. Sampling Strategy: To ensure a representative analysis of TMT bar usage in the Jorhat district, a random selection of construction sites was undertaken. This selection encompassed a diverse array of construction projects, including residential, commercial, and infrastructure developments. By incorporating this variety, the study aims to capture the broad spectrum of TMT bar applications and usage patterns unique to each project type. This approach ensures that the findings reflect the true distribution and consumption of TMT bars across different construction sectors within the region, providing a comprehensive understanding of their role and performance in various structural contexts.

6.3. Sample Collection: TMT bar samples were collected from various stages of construction, including the initial reinforcement procurement and onsite storage phases. Throughout this process, strict adherence to standard protocols was maintained to prevent any contamination or damage to the samples during transportation. This meticulous approach ensures the integrity of the samples, allowing for accurate analysis and reliable results in assessing the quality and performance of TMT bars used across different construction projects.

6.4. Laboratory Testing: Mechanical properties testing of the TMT bars was conducted in the Material Testing Laboratory under Civil Engineering Department at HRH The Prince of Wales Institute of Engineering & Technology, Jorhat, Assam, utilizing universal testing machines to evaluate their strength and ductility properties. This comprehensive assessment involved performing tensile, yield, and elongation tests, which are critical in determining the mechanical performance of the TMT bars. By using these precise and standardized testing methods, the study ensures accurate and reliable measurements of the bars' capacity to withstand various stresses and strains encountered in construction applications.

6.5. Compliance Assessment: The test results were meticulously compared with relevant national standards, specifically IS 1786:2008, to assess the compliance of the TMT bars with specified quality requirements. This comparison allowed for the identification of any deviations or nonconformities, highlighting potential implications for construction quality and safety. By evaluating the TMT bars against these stringent standards, the study aims to ensure that the materials meet the necessary criteria for reliability and performance, thereby safeguarding the structural integrity of construction projects.

6.6. Data Analysis: The test results obtained from different brands and sizes of TMT bar are tabulated for making analysis and interpretation of data.

7.0. Quality Analysis on TMT Steel Round bar: TMT steel round bars must meet appropriate quality certifications and standards like ISO, ASTM, or BIS. These certifications confirm the quality and performance of the bars, guaranteeing they meet industry standards. Various grades of TMT steel round bars, such as Fe 415, Fe 500, Fe 550, and Fe 600, are offered with each indicating a specific minimum yield strength. A greater level of achievement requires increased power. According to IS Standards, Fe 500d Grade steel reinforcement bars are considered top quality in terms of both tensile strength and ductility.

For this investigation, I used 10 mm, 12 mm, and 16 mm of diameters of TMT steel bars of grade Fe500d from manufacturers such as SATYAM Steel, VICON Steel, JINDAL Steel, and TATA Steel. To ensure that the TMT steel round bars meet the required criteria, it is essential to assess their mechanical characteristics. When evaluating the quality of a product, characteristics like yield strength, tensile strength, and elongation are crucial. In this study, tensile tests, bending and Re-bending tests were conducted to assess the quality of TMT round bars.

7.1. Tensile Test: A typical mechanical test used on materials to ascertain their mechanical characteristics, especially their strength and elasticity, is the tensile test. A sample of the material is put through a controlled tensile force until it breaks or fails in a tensile test. The test evaluates a number of characteristics, such as modulus of elasticity, elongation at break, yield strength, and ultimate tensile strength.

The procedure of tensile test is given below:

- A specimen of the material, typically in the form of a cylindrical, is taken according to the standardized dimensions.
- The specimen is inserted into the testing apparatus, which is equipped with grips to ensure a firm hold. During testing, the grips make sure the specimen doesn't slip and stays aligned.

- The specimen is subjected to a tensile tension that is steadily increased over time by the testing apparatus. The specimen elongates as a result of this force being applied along its longitudinal axis.
- During the test, a number of parameters are measured and noted, including the force that is applied and the specimen's subsequent elongation.
- The mechanical properties of the material, including its tensile strength, yield strength, and elongation characteristics, are ascertained through analysing the data gathered during the test.
- The specimen will eventually approach its breaking point, at which point the force needed to shatter it is noted. To comprehend the maximum strength of the item, this aspect is essential. Fig.-2 and Fig.-3 shows the Tensile test on TMT bar in Universal Testing Machine and TMT bar after Tensile test.


Fig.-2: Tensile Test on TMT bar in Universal Testing Machine Fig.-3: TMT bar after Tensile Test

7.2. Bend Test: A bend test is a technique for determining a material's ductility, soundness, and suitability for welding, especially metals. A bend test is frequently carried out to guarantee the material's quality in the context of TMT steel round bars, which are frequently employed in construction due to their increased strength, ductility and durability. The procedure of performing bend test on TMT round bars is given below:

- A representative sample of TMT round bars is taken based on appropriate standards or specifications. Usually, these bars need to be trimmed to a predetermined length.
- Marking is given on midpoint of each sample bar. The bar will be curved around this mark, which serves as its centre.
- One end of the sample bar is secured by using a bending equipment. Load is applied gradually on the free end of the bar until the two ends of the bar meet or the desired bending angle is reached. Care should be taken during the bending process to prevent abrupt or extreme deformation that could lead to fracture.
- The sample is examined visually for any indications of fracture, cracking, or other flaws after it has been bent. Fractures or cracks could be a sign of weak ductility or other problems with the material.

- It is determined whether the bar satisfies the given bending angle without breaking, as well as the look of the bent portion and the degree of any cracking or other defects, using predetermined criteria to assess the quality of the bend.
- All measurements and observations made throughout the bend test are noted along with the outcome. These findings can be used to evaluate the TMT steel round bars' quality and ascertain if they adhere to the necessary requirements or norms. Fig.-4 shows the Bending Test on TMT bar in Universal Testing Machine.

Fig.-4: Bending Test on TMT bar

7.3. Re-bend Test: The purpose of the re-bend test for TMT steel round bars is to evaluate the material's ductility and weldability following welding or other fabrication procedures. It is a specialized version of the bend test. This test assists in determining whether the material, even after undergoing mechanical and thermal treatments, maintains the desired mechanical properties. The Re-bend test of TMT steel round bars could be carried out as follows:

- The bent samples have been given some time after the bending test so that the material can stabilize and regain some of its initial ductility and strength.
- The sample bars is repositioned in the bending apparatus and a second bending force is applied analogous to the first bend test, following the recovery interval. The re-bend tests the material's resistance to further distortion following mechanical and thermal treatments.
- The re-bent samples are examined and assessed visually for indications of fracture, cracking, or other flaws. The re-bend's quality is assessed using predetermined standards, which should be comparable to those applied to the original bend test. Any variations are observed from the original bend in the behaviour or characteristics of the material.
- All measurements and observations made during the re-bend test is noted along with the outcome. These findings can be utilized to determine whether the material is appropriate for a given application and to verify that it complies with all applicable rules or regulations. Fig.-4 shows the Re-Bend on TMT bar in Universal Testing Machine.

Fig.-5: Re-Bend Test on TMT bar

7.4. Elongation Test: The Elongation Test is a material testing procedure to measure a material's ability to withstand changes in length under tensile stress. The procedure for the Elongation Test using a Universal Testing Machine is given below:

- The material is cut into a standardized sample size.
- The marking is done in two points on the sample for measuring elongation.
- The sample is placed in the testing machine.
- The tensile force is applied gradually until the sample breaks.
- The distance between the two marked points is measured.
- The percentage of elongation is calculated based on the original and final measurements.

8.0. Quality Assessment Test: In this study, three principal quality assessment tests such as Tensile Test, Bend Test, Re-bend Test and Percentage Elongation was carried out in order to get an idea about quality of TMT bars of four different TMT bar manufacturing industry.

8.1. Tensile test:

Aim: To determine tensile strength of TMT steel round bar.

Apparatus Required: Universal Testing Machine, round bar, slide-wrench, measuring tape, marking tool (chalk).

Theory: Round bar used in construction are generally subjected to Tensile load. Hence it is necessary to find the tensile strength of round bar. It measures the tensile strength, yield strength and elongation of the round bar. In India, strength of typical round bar required is to be at least 415 MPa.

Tensile strength=Maximum load/Original cross-sectional area

Procedure: Twelve (12) steel samples each of 1000 mm from the four (4) sources was prepared for tensile strength test where each source was represented by three (3) samples, each of which are 16 mm, 12 mm and 10 mm respectively. Each sample was cut from different bar obtained from different bundle.

The test specimens were placed one after the other into a tensile test Universal Testing Machine and subjected to tensile load until plastic deformation and complete necking were observed. The testing procedure followed by conventional method stipulated in RS EAS 412-2: 2014 referenced to IS 15630-1 and BS 4447: 1997.

8.2. Bending test

Aim: To determine bending Strength of TMT steel round bar.

Apparatus required: Universal Testing Machine, round bar, slide-wrench.

Theory: As the tensile strength is needed to be check of round bar for construction, it is also required to check the bending strength of round bar. Bending test is required for how long time the round bar will last for. It determines the strength of the round bar.

Procedure: Four (4) TMT steel round bar samples each of 1000 mm from the four (4) sources was prepared for bending test where each source was represented by three (3) samples, one (1) of which is 16 mm Ø, one (1) is 12 mm Ø and other one (1) is of 10 mm Ø. The testing procedure followed by conventional method stipulated in RS EAS 412-2: 2014 referenced to IS 15630-1 and BS 4447: 1997.

8.3. Re-bend test

Aim: To determine the re-bend strength of TMT steel round bar

Apparatus required: Universal Testing Machine, round bar, slide-wrench.

Theory: It is another important test of round bar. The re-bend test determines the durability after bending without affecting the strength of the round bar.

Procedure: Four (4) TMT steel round bar samples each of 1000 mm length is taken from the four (4) sources for bending test where each source was represented by three (3) samples, one (1) of which is 16 mm Ø, one (1) is 12 mm Ø and other one (1) is of 10 mm Ø.

9.0. Test Results: Table-1 illustrates the Tensile test, Bend & Re-band test and percentage of elongation results of the TMT steel round bar of four brands against each sample.

TABLE-1:TEST REPORT OF TMT STEEL ROUND BAR

Sl	Sample Make	Nominal Dia. (mm)	Gauge Length (mm)	Weight (Kg)	Ultimate Tensile Strength (N/mm^2)	Elongation (mm)	Elongation Percentage (%)	Bend Test	Re-Bend Test
1	SATYAM STEEL; Fe 500 D Density of Rod: 0.00785 kg/mm^2 Length of Rod: 1000 mm	10.00	50.00	0.600	726.89	60.00	20.00 %	Pass OK	Pass OK
		12.00	60.00	0.835	557.06	78.00	30.00 %	Pass OK	Pass OK
		16.00	80.00	1.430	677.00	102.00	27.50 %	Pass OK	Pass OK
2	VICON STEEL;	10.00	50.00	0.556	837.00	63.00	26.00 %	Pass OK	Pass OK

	Fe 500 D Density of Rod: 0.00785 kg/mm^2 Length of Rod: 1000 mm	12.00	60.00	0.820	818.00	75.00	25.00 %	Pass OK	Pass OK
		16.00	80.00	1.380	785.00	93.50	16.87 %	Pass OK	Pass OK
3	JINDAL STEEL; Fe 500 D Density of Rod: 0.00785 kg/mm^2 Length of Rod: 1000 mm	10.00	50.00	0.630	863.00	60.00	20.00 %	Pass OK	Pass OK
		12.00	60.00	0.812	822.00	73.50	22.50 %	Pass OK	Pass OK
		16.00	80.00	1.540	773.00	98.00	22.50 %	Pass OK	Pass OK
4	TATA TISCON Fe 500 SD Density of Rod: 0.00785 kg/mm^2 Length of Rod: 1000 mm	10.00	50.00	0.609	871.668	65.00	30.00 %	Pass OK	Pass OK
		12.00	60.00	0.838	844.371	75.00	25.00 %	Pass OK	Pass OK
		16.00	80.00	1.540	617.994	98.00	31.25 %	Pass OK	Pass OK

10.0 Inferences:

10.1. From Table-1, it is found that the ultimate tensile strength values for all the samples of Satyam Steel, Vicon Steel, Jindal Steel and Tata Tiscon are more than 565 N/mm^2 as per IS Code 1786-2008. So, the results are satisfactory. Tata Tiscon showed a relatively better trend with the values of Ultimate Tensile Strength.

10.2. As per Table-1, it is seen that percentage of elongation of all the samples from Satyam Steel, Vicon Steel, Jindal Steel and Tata Tiscon of diameters 10 mm, 12 mm, & 16 mm are within the acceptable limits in accordance with IS 1786-2008.

10.3. From the Table-1, it is found that all specimens taken from Satyam Steel, Vicon Steel, Jindal Steel and Tata Tiscon of diameters 10 mm, 12 mm, & 16 mm have not cracked beyond the bend section during Bending Test, so the results are 'satisfactory' as per IS Code 1786-2008.

10.4. It is also seen from the Table-1 that all specimens taken from Satyam Steel, Vicon Steel, Jindal Steel and Tata Tiscon of dimeters 10 mm, 12 mm, & 16 mm have not cracked beyond the bend section during Re-Bend Test, so the results are 'satisfactory' as per IS Code 1786-2008.

11. Future scope: This research work was solely focused on different Quality Tests such as Ultimate Tensile Strength, Bend Test, Rebend Test and Elongation Test of some known brands of steel reinforcing bars. The future scopes that can be done through this study are:

(i)The Chemical Analysis Test can be done on TMT bars to ensure the chemical properties which will be the research work for further study as this sort of work have been left untouched.

(ii)Elasticity Test for TMT bars will be another research work which can be used for further study.

(iii)Impact Test can be conducted to determine the strength of TMT bars.

(iv)The TM (Tempered Martensite) - Ring Test can be done to characterised the cross sectional phase distribution in TMT bars.

12. Conclusion: In conclusion, quality assessment and control of steel reinforcing bars is a critical aspect of the construction industry, ensuring the safety, durability, and integrity of structures. The process involves rigorous testing and inspection methods, from dimensional checks to material identification and surface defect detection. The future of this field is promising, with advancements in technology such as Non-Destructive Testing, Artificial Intelligence, and automation set to revolutionize the way quality control is conducted. These technologies will not only enhance the accuracy and efficiency of quality assessment but also enable predictive maintenance and waste reduction. Moreover, the emergence of new materials and manufacturing processes will necessitate the evolution of quality assessment methods. At the same time, the industry is moving towards more sustainable practices, assessing the environmental impact of production and implementing measures to reduce it. Therefore, quality assessment and control of steel reinforcing bars is a dynamic field that is continuously evolving to meet the demands of the construction industry and the environment.

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