EXPERIMENTAL ANALYSIS OF FLEXURAL BEHAVIOR OF RC BEAMS BY USING HIGH STRENGTH STEEL

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Abstract – *Usually concrete, a mixture of cement, sand and aggregate, is considered by far as the most stable of building compounds. But it has negative also low tensile strength and ductility. This means that concrete ability to stretch and to withstand pressure at an angle without breaking is very less. Steel in the form of bars has great tensile strength and ductility. It can reinforce concrete. Thus, the quality of steel has an important role in deciding the quality of concrete. TMT steel means Thermo Mechanically Treated steel. TMT reinforcement steel is used in reinforced concrete construction to provide better strength in tension, bending and shear as well as in compression. TMT manufacturing process is expected to improve properties such as yield strength, ductility and toughness of TMT bars. With above properties, TMT steel is highly economical and safe for use. TMT steel bars are more corrosion resistant than Tor steel. TMT bars are earthquake resistant.*

As a present scenario carried out on RC Beams by using High Strength steel (Fe600) yet not found. This study will therefore focus on concrete beams reinforced with High Strength Steel. Twelve specimen of deep beam having size 1200 X 100 X 200 mm were casted. After 28 days they were tested by using UTM of 1000 KN under two-point loading with dial gauge for central deflection. Possibility and feasibility of High Strength Steel as reinforcement for RC beams are determined.

***Key Words*: TMT bars, High Strength Steel, Fe 600, Fe 500, Flexural strength,**

1. INTRODUCTION

1.1 Rebar

Rebar (short for reinforcing bar), collectively known as reinforcing steel and reinforcement steel, is a steel bar or mesh of steel wires used as a tension device in reinforced concrete and reinforced masonry structures to strengthen and hold the concrete in compression. Concrete is strong under compression, but has weak tensile strength. Rebar significantly increases the tensile strength of the structure. Rebar's surface is often patterned to form a better bond with the concrete.

The most common type of rebar is carbon steel, typically consisting of hot-rolled round bars with deformation patterns. Other readily available types include stainless steel, and composite sections made of glass fiber, carbon fiber, or basalt fiber. These alternate types tend to be more expensive or have lesser mechanical properties and are thus more often used in specialty construction where their physical characteristics fulfill a specific performance requirement that carbon steel does not provide. In practice, any material with sufficient tensile strength that is materially compatible with concrete could potentially be used to reinforce concrete, for example bamboo might be considered a viable substitution in regions where steel is not available. Steel and concrete have similar coefficients of thermal expansion, so a concrete structural member reinforced with steel will experience minimal stress as the temperature changes.

1.2 Fe 500

Fe 500 grade steel means the reinforcement steel rods (or bars) that can safely withstand a yield stress of 500 N/mm^2 which is stronger than 415 N/mm^2 by ~20 %. Fe 500 grade TMT bars were introduced as a one step up technological marvel over conventional Fe 415 grade product. Fe500 TMT Steel rods are ideally used for buildings in India. The "Fe" represents Iron that is used in the manufacture of TMT rods, while 500 represents the maximum yield stresses it can bear.

1.3 Fe 600

Reinforced concrete, these days, in synonymous with construction globally. Be it the world highest building, biggest metro viaduct or longest bridge, they are all built using reinforced concrete. Improvement in concrete (up to M80) thereby making the structural member leaner. Constrained by land availability and enable by enhancement in design capability, engineers are opting for leaner structure with high load carrying capabilities. Such improvements in technology have been coherent with this requirement. However, with high-strength carbon-alloyed steel reinforcing bars, the biggest challenging has been managing the compatible ductility together with enhanced strength. Ultra premium & ultra high strength TMT re-bars. Typically used in construction of high rise structures, structures subjected to high service loads, heavy duty infrastructure projects and in cases where the maximum area of reinforcement steel is to be reduced. Fe 600 (Indus) rebars are envisaged to provide the best both worlds. These reinforcement bars are suitable micro-alloyed to achieve better ductility along with higher strength. Fe 600 as shown in fig.1.1 can be used in buildings, bridges, marine facilities and many others to create leaner structure with lesser steel congestion improving construction quality and saving cost.

2. LITERATURE REVIEW

Prabir C. Basu, Shylamoni P, Roshan A.D (2004): Steel is the time proven match for reinforcing concrete structures. Reinforced concrete structure is designed on the principle that steel and concrete act together to withstand induced forces. The properties of thermal expansion for both steel and concrete are approximately the same; this along with excellent flexural property makes steel the best material as reinforcement in concrete structures. Another reason steel works effectively as reinforcement is that it bonds well with concrete. When passive reinforcement (steel bars) is employed, the structure is known as reinforced concrete (RC) structure. Passive steel reinforcing bars, also known as rebars, should necessarily be strong in tension and, at the same time, be ductile enough to be shaped or bent. Now-a-days, alloy steels are also being introduced as reinforcing steel. Three grades of rebar are presently available in India for structural use. The rebars are graded according to their specified yield strength. These are Fe415, Fe500 and Fe550. CTD rebars of grade more than Fe415 are scarcely available in market. However, TMT rebars of Fe500 grade are easily available in the market.

Robert F. Mast, Mina Dawood, Sami H. Rizkalla, Paul Zia (2008): this paper presents a methodology for the flexural strength design of concrete beams reinforced with high-strength reinforcing steel that conforms to the requirements of ASTM A1035-07. The design method is based on simple analysis techniques that satisfy fundamental principles of equilibrium and compatibility. Strain limits for tension-controlled sections and compression-controlled sections are proposed that are consistent with the approach of the current and past ACI 318 Codes. The proposed method is compared with experimental results previously reported by others. The stress-strain characteristics of the reinforcement are quite different from conventional Grade 60 (400 MPa) steel reinforcement. The new steel is considerably stronger than conventional reinforcing steel and lacks a well-defined yield point. There are several practical advantages to using this new high strength material, including reduction of congestion in heavily reinforced members, improved concrete placement, savings in the cost of labor, reduction of construction time and, in some cases, enhanced resistance to corrosion. The flexural behavior of concrete beams reinforced with high-strength reinforcing bars has been investigated experimentally by a number of researchers. The available research indicates that, when properly designed, beams reinforced with high-strength reinforcing bars will achieve similar strength characteristics to beams reinforced with conventional steel reinforcements.

Saifullah, M. Nasir-uz-zaman, S.M.K. Uddin, M.A. Hossain, M.H. Rashid (2011): Experimental based analysis has been widely used as a means to find out the response of individual elements of structure. To study these components finite element analyses are now widely used & become the choice of modern engineering tools for the researcher. In the present study, destructive test on simply supported beam was performed in the laboratory & load-deflection data of that under-reinforced concrete beams was recorded. Finally results from both the computer modeling and experimental data were compared. From this comparison it was found that computer-based modeling is can be an excellent alternative of destructive laboratory test with an acceptable variation of results. In addition, an analytical investigation was carried out for a beam with ANSYS, SAS 2005 with different reinforcement ratio (under, balanced, over). The observation was mainly focused on reinforced concrete beam behavior at different points of interest which were then tabulated and compared. From these observations it shows that 1st cracking location is 0.43L ~ 0.45L from the support. Maximum load carrying capacity at 1st cracking was observed for over reinforced beam but on the other it was the balanced condition beam at ultimate load. Maximum deflection at failure was also observed for the beam that balanced reinforced.

S Tejaswi, J Eeshwar Ram (2015): Concrete is the material which is rapidly used in various conditions to sustain the compression loads and the corresponding bending and shear stress due to the applied compressive loads. The major drawback in concrete is that it is poor in tension though it is very efficient in compression. Hence to overcome this major drawback the concrete must be reinforced such that to make a homogeneous substance which can sustain both tension and compression. Steel is the material use as reinforcement for concrete. The stress strain behavior for both concrete and steel are mostly similar. Hence in the combination of both that is in reinforced cement concrete the maximum stress point within the elastic will reach simultaneously. Reinforce cement concrete is a general material which is widely used for various types of constructions and structural elements. For the efficient use of RCC it is necessary to know the properties and the behavior of RCC elements under various constrains. To estimate and analyse the basic properties and behavior of RCC an experimental study is needed. In the present study an experiment in which flexural behavior of RCC under various constrains was the major criteria. For the experimental analysis simply supported beams of under reinforced, balanced and over reinforced sections are considered. When the beam is simply supported and is subjected to some external loading the corresponding deflections are examined such that the flexural behavior of the RCC beams of under reinforce, balanced and over reinforced sections analysed. In order to study the flexural behavior of any material one had needed some basic constant conditions as their limitations. In the present study stress-strain behavior of Concrete and steel are taken as a base and the flexural behavior of the material in various fibers.

Er. N. K. Roy, Er. R. R. Sandhwar (2015): Thermo mechanically treated (TMT) bars were introduced in India during 1980-1985. Thermo mechanical treatment is an advance heat treatment process in which red hot bars coming out of last rolling mill stand are rapidly quenched through a series of water jets. Rapid quenching provides intensive cooling of surface resulting in the bars having hardened surface at top, while core remained red hot. The rebars are then allowed to cool in ambient conditions. During the course of such slow cooling, the heat released from core tempers the hardened surface while core is turned into ferrite-pearlite aggregate composition. TMT process thus changes the structure material to a composite structure of ductile ferrite-pearlite composition with tough surface rim of tempered marten site providing an optimum combination of high strength, ductility, bendability and other desirable properties. Ductility of TMT bars are same as that of mild steel Hence it is very suitable for making hooks, vibrating structures subjected to reversible stresses as in case of machine foundation and for high rise structures subjected to strong earthquake and wind forces. TMT bars of grade Fe 415, Fe500 and Fe550 are now available in India. Most of steel companies in India like SAIL, TATA TISCO and RINL are now a day's producing Fe500 or Fe 550 grade of TMT bars and not Fe-415 grade of steel bars. Design Engineers should accordingly make calculations and drawings taking actual strength of steel into account.

3. OBJECTIVE

The main objectives of this work are summarized as below,

1. The main aim of this investigation is to examine the possibility and feasibility of high grade steel as reinforcement for beam.
2. The objective of this work is to carry out the investigation of RC beams using high strength steel.
3. To study the flexural behavior of reinforced concrete beams.
4. To evaluate the ultimate load carrying capacity of beams reinforced with high strength steel as reinforcement.
5. To compare the experimental results of high strength steel i.e. Fe 500 and Fe 600.

4. METHODOLOGY

For carrying out proposed work following methodology was adopted:

1. Collection of required data to carry out the analysis from journals, technical magazines, reference books and web source.
2. Mix design was prepared for M40 and m50 grade concrete according to IS 10262-1982.
3. Casting cube by using M40 and M50 grade concrete.
4. Casting of RC beam by using M40 and M50 grade concrete with high grade steel Fe500 for analysis of parameters.
5. Casting of RC beam by using M40 and M50 grade concrete with high grade steel Fe600 for analysis of parameters.
6. Preparation of RC beams with three number of specimens for each material.
7. Various test like Compressive Strength, Flexural Strength on casted specimens were performed.
8. Comparison to be made between these analyses to know possibility and feasibility.
9. Drawing final conclusion from the analysis of result.

5. MATERIALS AND EXPERIMENTAL PROCEDURE

5.1 Concrete

The concrete used for casting was prepared in the testing laboratory using a hand mix method of concrete. The concrete was (M40 Grade) & (M50 Grade) with mix proportion was adopted by respectively (1:1.57:2.755) with water/cement ratio 0.45 and (1:1.36:2.25) with water/cement ratio 0.40. The material proportions per cubic meter of concrete:

M40

1) 1138.63kg/m^3 of coarse aggregate (maximum size 20mm)

2) 690.31kg/m^3 of natural river sand (sp.gr=2.74)

3) 437.77kg/m^3 of ordinary Portland cement (53 grade)

4) 197 liters of water

M50

1) 1111.15kg/m^3 of coarse aggregate (maximum size 20mm)

2) 673.65kg/m^3 of natural river sand (sp.gr=2.74)

3) 492.5kg/m^3 of ordinary Portland cement (53 grade)

4) 197 liters of water

5.2 Details of Beam Specimen

While reviewing the literature of RC beam comes to know that the beam size is 1200X100X200 mm. According to the IS (10262-2009) minimum size of specimen for beam mould is 700X150X150 mm. Hence select the beam size as 1200X100X200 mm.

5.3 Preparation of beam specimens

After all the collection of material next step we go through the specimen making from the collected material. The details of specimen making is enlisted below.

5.3.1 Casting of beam specimens

Twelve wooden molds of the same dimensions were fabricated for casting the deep beam specimens to be tested in this study. The moulds were properly cleaned and greased for easy de-molding after casting. The concrete required for casting was prepared using a concrete hand mix. Before pouring concrete, the reinforcement cages were placed inside the mould with suitable sized cover. The concrete was properly compacted. All the beams were cast to the same dimension of 200 mm depth, 100 mm width and 1200 mm overall length.

Fig 1: Placing of the cage in the mould

Fig 2: Beam cast

5.4 Experimental Set-Up for Beams Testing

The specimens were tested by using the Universal Testing Machine (UTM) which has the loading capacity of 1000 KN by keeping the beam in the horizontal position with two loading system of 33 cm internal loading distance and hinges at a distance of 10 cm from the end support.

The sustained loading was applied from top of the beams until I could identify the hair cracks and I have noted down the deflection at center of beam at each step, further the loading is continued until I get the ultimate load that the steel in tension face can take no more upcoming loads and transfers it to the concrete section ultimately.

Fig 3: Applying load on Beam

Fig 4: Shear failure and ceacks

Fig 5: Data Acquisition on UTM for Beam

6. RESULTS

All the 12 members of beams were tested at UTM machine with capacity of 1000KN and following data were obtained.

Sr. No	Grade of Concrete	Designation of Sample	Size (LXB XD) (mm)	Load Carried (KN)	Average Load (KN)
1	M40	SA1	1200 X 100 X 200	77.05	86.15
2		SA2		102.40	
3		SA3		79.00	
4		SB1		62.40	68.48
5		SB2		70.60	
6		SB3		72.45	
7	M50	PA1		121.00	102.67
8		PA2		97.00	
9		PA3		90.02	
10		PB1		72.00	82.13
11		PB2		96.00	
12		PB3		78.40	

6.1 COMPARISON OF LOAD Vs DEFLECTION RESULT

6.1.1 Load Vs Deflection between M40, Fe 500-Fe600

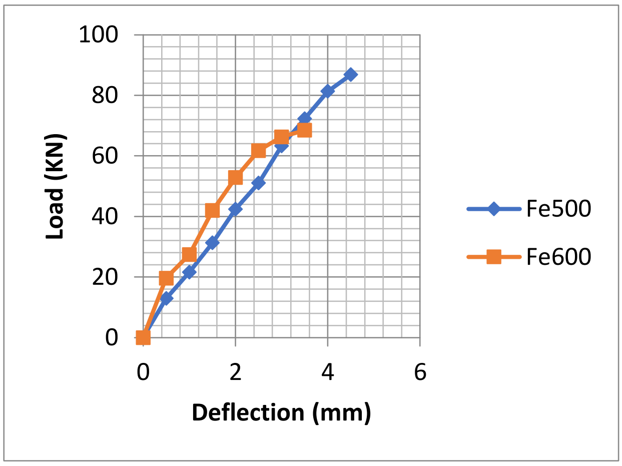

Chart-1: Load Vs Deflection

6.1.2 Load Vs Deflection between M50, Fe 500-Fe600

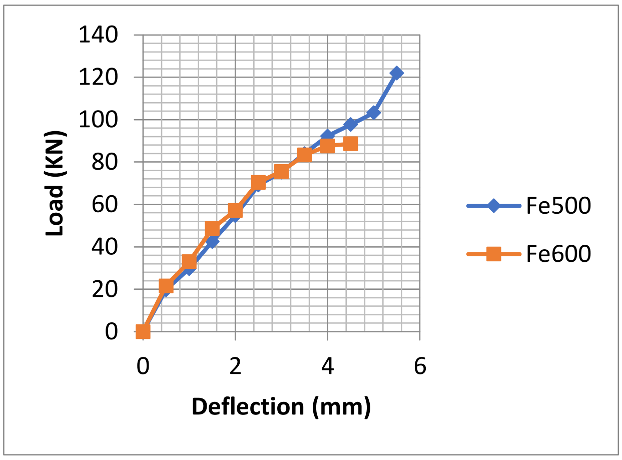

Chart-2: Load Vs Deflection

6.2 COMPARISON OF RESULTS

6.2.1 M40, Fe500-Fe600

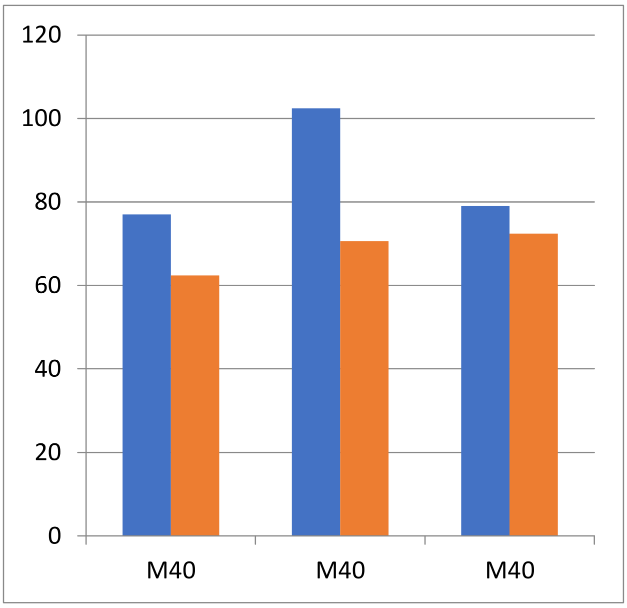

Chart-3: Average Load Carried When Grade of Concrete M40

6.2.2 M50, Fe500-Fe600

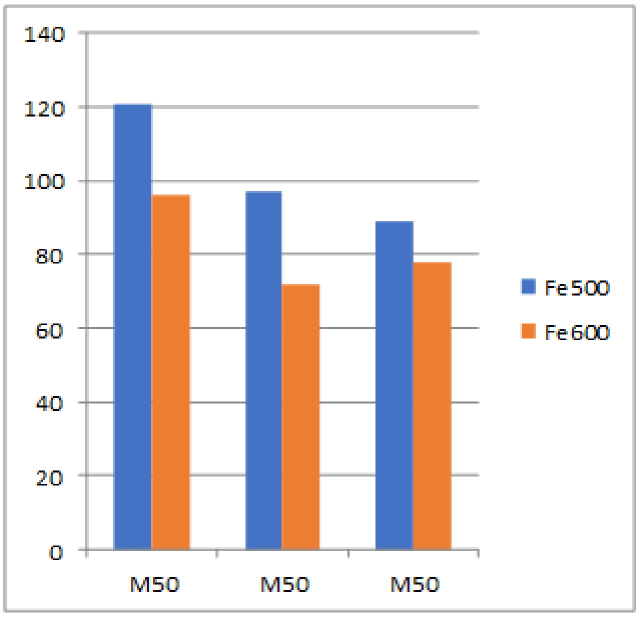

Chart-4: Average Load Carried When Grade of Concrete M50

7. CONCLUSIONS

Based on the experimental result obtained in this study following conclusion are drawn.

1. It is observed that the ultimate load carrying capacity of M40-Fe500 grade RC beams is 0.20 times M40-Fe600 grade RC beams.

2. It is observed that the ultimate load carrying capacity of M50-Fe500 grade RC beams is 0.23 times M50, Fe600 grade RC beams.

3. M40- Fe500 grade RC beams shows 22.22% higher deflection as compare to M40-Fe600 grade RC beams.

4. M50- Fe500 grade RC beams shows 18.18% higher deflection as compare to M50-Fe600 grade RC beams.

5. In all the above cases, the failure pattern is same i.e. shear failure.

8. FUTURE SCOPE OF PRESENT STUDY

Future scope for this study is summarised below so that researcher may got attention for the future study.

1. The data which is attended after the experimental work provide a base for any future study related with high strength steel.

2. The above work can be continued by performing tests on grater span

3. Experimental work can be work out on high performance concrete and high strength steel.

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BIOGRAPHIES

She is an excellent academic person and PG with intend in Research work.

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