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Flexural Behaviour of RC Beams Reinforced with C - Bars

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ABSTRACT: Mild steel of low carbon content has been used as reinforcement instead of conventional reinforcement in RCC. High strength tensile steel are manufactured from the hot treatment and cold treatment of mild steel. Hence for High yield strength deformed bars, the ductile property will be reduced. Therefore, mild steel of lower tensile strength shows higher ductility.

In the present investigation, C – Bars known as curved mild steel bars of Fe 250 has been used as reinforcement. The MS bars were bend to different degrees such as 10° , 15° and 20° . The RC beams reinforced with C - bars tested for flexural strength and compared with conventional RC beam reinforced with Fe 500 grade steel. Mild steel has higher resistance to breakage and is quite malleable even when cold. Higher carbon steels usually shatter or crack under stress, while MS bends or deforms. If the flexural strength of beam with C- bar reinforcement shows better result than beam with conventional reinforcement, then it can be applied for practical purpose for construction as a structural component which also reduces the manufacturing process and production cost which also prove to be economic.

KEYWORDS: Mild steel, C - Bars, Tensile strength, Beam and Flexural test.

I. INTRODUCTION

Steel Reinforcement: In India, the history of RCC structures is more than 100 years old. Rebar 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 tension. Rebar's surface is often patterned to form a better bond with the concrete.

Any material with sufficient tensile strength could potentially be used to reinforce concrete. The most common are steel, glass fiber, basalt fiber, and fiber-reinforced plastic. 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.

Both stiff reinforcement and steel bars can be used in reinforced concrete members. Stiff reinforcement includes shape steels (e.g., angle steel, channel steel, I-shape steel, and pipe) and the skeletons fabricated by welding several pieces of shape steel together. Due to its large stiffness, stiff reinforcement can be used in construction as forms or supports to bear the self-weight of structures and construction loads. This can facilitate shuttering (also known as formwork) and speed construction. Also, structural members reinforced by stiff reinforcement possess higher loading capacity than those reinforced by steel bars.

However, steel bars are more frequently used in ordinary reinforced concrete members. As steel bars are flexible, they are treated as axially loaded elements, while their own stiffness is meaningless in design. Most design codes and textbooks (including this book) are referring to steel bars when discussing reinforced concrete structures.

Steel bars can be classified as plain bars and deformed bars or rebars according to their surface profiles. Deformed bars are the bars with longitudinal and transverse ribs rolled into the surfaces (sometimes without longitudinal ribs). The ribs, which may be in the shape of a spiral, chevron or crescent, etc., can effectively increase the bonding between steel bars and concrete. The cross-sectional area of a deformed bar varies with its length, so the diameter of the deformed bar is a nominal dimension, i.e., an equivalent diameter is the same as that of a plain bar of identical



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weight. Generally, the diameters of plain bars are 6mm, 8mm, 10mm, 12mm, 14mm, 16mm, 18mm, 20mm and 22 mm, while the diameters of deformed bars are 6mm, 8mm, 10mm, 12mm, 14mm, 16mm, 18mm, 20mm, 22mm, 25mm, 28mm, 32mm, 36mm, 40mm and 50 mm. Reinforcement bars of small diameter (<6 mm) are called steel wires, whose surface is generally smooth. If indentations are rolled into the surface of a steel wire to improve the bond, the steel wire is called indented wire.

Mild Steel Bars : Plain mild steel (MS) rebar's of grade Fe - 250 were used widely till about 1967 in India. But for economic reasons, the need for reduction in the steel used in RCC structures was felt which consequently led to increase the yield strength of rebar's.

Mild steel are low carbon steels and contains up to 0.30% carbon. Mild steel is general purpose steel grade, basically used for remelting, alloying and manufacturing of fabrication of various structures. Mild steel is one of the most commonly used construction materials. It is known as mild steel because of its relatively low carbon content. C - Bars refer to the curved mild steel rod. Mild steel has high resistance to breakage and is quite malleable even when cold. Higher carbon steels usually shatter or crack under stress, while mild steel bends or deforms. Higher the tensile strength of bar ductility property is reduced.

Chemical composition : According to chemical composition, steel bars can be categorized as carbon steel bars and ordinary low-alloy steel bars.

Carbon steel contains ferrum and other trace elements, such as carbon, silicon, manganese, sulfur, and phosphorus. Experimental results show that the strength of a steel bar increases with carbon content, but at the cost of plasticity and weld ability. Generally, carbon steels with a carbon content of less than 0.25 %, 0.25–6 %, and 0.6–1.4 % are called low- carbon steel, medium-carbon steel, and high-carbon steel, respectively. Low- carbon steels and medium-carbon steels are mild steels, while high-carbon steel is hard steel.

Ordinary low-alloy steel contains added carbon steel alloying elements such as silicon, manganese, vanadium, titanium, and chromium to efficiently increase strength and improve steel properties.

Strength of reinforcement : Reinforcement undergoes large plastic strain after yielding. The resulting excessive deformation and crack widths of structural members violate the serviceability requirement. So when the capacity of a reinforced concrete member is calculated, yield point (or conditional yield point) is taken as the upper bound. Reinforcement strength is obtained by tests. But the strengths of different specimens, even when of the same classification or type, are generally different due to the inherent variability of reinforcement materials. Therefore, measured strength with a certain degree of confidence can be taken as the standard strength of reinforcement. Because reinforced concrete design codes in different regions and different engineering professions are based on diverse criteria, such as the allowable stress design method, ultimate strength design method, and limit state design method, they cannot ensure structural members the same safety margin or reliability. Hence, the same reinforcement may be given different strength values under different specifications or even a different name, are introduced

II. EXPERIMENTAL INVESTIGATION

A total number of 6 specimens of span 1700 mm x 100 mm x 150 mm corresponding to 6 test series were cast and tested under flexural cyclic loading. The RCB reinforced with 2 numbers of 8 mm diameter bars at the top and 3 numbers of 8 mm bars at the bottom. Two legged stirrups of 6 mm diameter at 100 mm c/c have been used as shear reinforcement. The reinforcements are designed to ensure flexural failure in beams. The overall dimensions and the reinforcement details for beams are shown in Fig 1.



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All dimensions are in mm

Fig. 1 (a) Reinforcement details for RCB M15⁰



Fig 1.(b) C-Bar reinforcement for RCB M15⁰

The RCB M1 reinforced with 2 numbers of 12 mm diameter bars at the top and 3 numbers of 12 mm bars at the bottom. The RCB M10⁰, RCB M15⁰ and RCB M20⁰ reinforced with 2 numbers of 12 mm diameter bars at the top and 3 numbers of 12 mm C-bars at the bottom. The RCB M2 reinforced with 2 numbers of 12 mm diameter C- bars at the top and 3 numbers of 12 mm C-bars at the bottom. Two legged stirrups of 6 mm diameter at 100 mm c/c have been used as shear reinforcement. The reinforcements are designed to ensure flexural failure in beams. The overall dimensions and the reinforcement details for beams.



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Details of Cast Specimen

S. No	Description	Specimen ID
1	Conventional Reinforcement	RCB
2	Mild Steel Reinforcement on both sides	RCB M 1
3	Mild Steel Reinforcement on both sides with 15 ⁰ bent bars	RCB M 2
4	Mild Steel Reinforcement with bars at 10 ⁰	RCB M10 ⁰
5	Mild Steel Reinforcement with bars at 15 ⁰	RCB M15 ⁰
6	Mild Steel Reinforcement with bars at 20 ⁰	RCB M20 ⁰

III. TENSILE STRENGTH

In a tension test of mild steel specimen, usually a round or flat bar is gradually pulled in a testing machine until it breaks. Two points, called gauge points, are marked on the central portion. The distance between these points, before the application of the load, is called gauge length of the specimen. The extensions of the gauge length and the values of the corresponding loads are required at frequent intervals. The extensions are measured by an instrument called an extensometer.

The strains corresponding to the recorded extensions are calculated by dividing the latter by the gauge length, while the stresses are calculated by dividing the loads by the original area of cross-section of the specimen. Stresses so arrived at is called nominal stress to distinguish it from actual stress which is obtained by dividing the load at a particular instant by the area of the cross-section at that instant. Actual stress is greater than nominal stress in a tensile test because the load increases, and correspondingly the area of the specimen decrease. Tension test results of typical MS bar and C bars tested using universal testing machine are shown in

	1.00	1.00	1 70	200	T 5 00
OUTPUT DATA	MS	10°	15°	20°	Fe 500
T 1 / 111NT	10.00	C7 1 4	54.71		
Load at yield kin	40.68	57.14	54.71	56.75	55.65
Elongation at vield mm	6.070	56.65	57.14	70.41	57 14
Elongation at yield min	0.070	50.05	57.14	/0.41	57.14
Yield stress N/mm2	359.69	505.23	483.74	501.78	492.2
Load at peak kN	61 300	60.15	62.16	63.03	61.16
Load at peak kiv	01.500	00.15	02.10	03.03	01.10
Elongation at peak mm	105.100	90.14	105.35	123.06	105.35
0 1			_		

Tension test results of typical MS bar and C bars



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Tensile Strength N/mm2	542.011	531.84	549.62	557.31	540.76
Load at break kN	42.230	44.45	48	46.88	48
Elongation at break mm	115.130	99.32	114.86	131.84	114.86

IV. RESULT AND DISCUSSION

Figures shows the two-point flexural loading system was adopted for testing the specimens. Specimens were tested in a 500 kN capacity loading frame. All the specimens were subjected to forward cyclic loading. The load was increased and decreased up to the specified loading for each cycle. The load cycles were continued till the final failure or collapse of the specimen. At each stage of loading, the deflection was noted using LVDT.

Fig. 3. The test setup for beams is shown (a) Failure of RCB M1 (b Failure of RCB M10⁰ (c) Failure of RCB M15⁰ (d) Failure of RCB M20⁰ (e) Failure of RCB M2







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Fig. 4. Load – deflection curve for cyclic loading is shown (a) Load deflection curve for cyclic loading of RCB M1 (b) Load deflection curve for cyclic loading of RCB M10⁰ (c) Load deflection curve for cyclic loading of RCB M15⁰ (d) Load deflection curve for cyclic loading of RCB M15⁰ (e) Load Deflection curve for cyclic loading of RCB M2



Comparison of Ultimate Load of Beams





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VI. CONCLUSION

From the tension test conducted for Fe 500, Mild steel and C – Bars of 10^{0} , 15^{0} and 20^{0} , C – Bars 10^{0} shows the maximum results on yield stress and yield load. The flexural behaviors of RC beams reinforced with mild steel bars (bent with different profiles) were investigated. It was observed that RCB M 1and RCB M10⁰ showed 10% increase in ultimate load than RCB. The deflections corresponding to ultimate load were also lower in RCB M 1and RCB M10⁰ compared to RCB.

From the results it was also concluded that there is 50% decrease in ultimate load of RCB M15⁰, RCB M20⁰ and RCB M 2. It was observed that the deflections at these ultimate loads are higher and first crack load was lower than the other beams. These beams undergone failure at third and second crack of cyclic loading.

The RCB and RCB $M10^{0}$ had undergone bending failure with maximum load at first crack of cyclic loading whereas in RCB M1 the failure occurred at fifth crack of cyclic loading. But compared to RCB the first crack load was higher in RCB M1and RCB $M10^{0}$.

It was observed that the crack due to bending failure was straight in case of RCB and RCB M1 with conventional reinforcement whereas the C – Bar reinforced Beams (RCB $M10^{0}$, RCB $M15^{0}$, RCB $M20^{0}$ and RCB M 2 showed curved pattern of crack during bending failure. Hence from this investigation, it can be concluded that mild steel reinforcement (bent with different profiles) has significant effect on the flexural behavior of beam.

REFERENCES

- [1] Aiman Hasan Hamood Al-Masoodi, Ahmed Kawan, Mudiono Kasmuri, R.Hamid, M.N.N.Khan (2016) "Static and dynamic properties of concrete with different types and shapes of fibrous reinforcement", Construction and Building Materials 104, pg 247-262.
- [2] C.A.Apostolopoulos, V.G.Papadakis (2008) "Consequences of steel corrosion on the ductility properties of reinforcement bar ", Construction and Building Materials 22,(2008), pg 2316-2324.
- [3] Dejian Shen et al (2016) "Experimental study of early-age bond behavior between high strength concrete and steel bars using a pull-out test", Construction and Building Materials 152, (2017), 240–249.
- [4] Jee-Hyung Sim, Yong-Soo Kim, et al. (2017) "Corrosion behavior induced by LiCl- KCl in type 304 and 316 stainless steel and copper at low temperature", Nuclear Engineering and Technology (2017), 49, 769-775.
- [5] Jinxia Xu, Linhua Jiang, Weilun, Yu Jiang "Influence of CaCl2 and NaCl from different sources on chloride threshold value for the corrosion of steel reinforcement in concrete", Construction and Building Materials 25, pg 663-669.
- [6] Matthew Davis, Neil A. Hoult, Allan Scott (2017) "Distributed strain sensing to assess corroded RC beams ", Engineering Structures 140,(2017), pg 473-482.
- [7] Nasim Sharat, Hasan Katkhuda, Mu'tasim Abdel-Jaber, Maha Alqam (2016) "Experimental investigation of reinforced concrete beams with spiral reinforcement in shear ", Construction and Building Materials 125, pg 585-594.
- [8] Rasha T.S. Mabrouk, Ahmed Mounir (2017) "Behavior of RC beams with tension lap splices confined with transverse reinforcement using different types of concrete under pure bending ", Alexandria Engineering Journal.
- [9] Rita Maria Ghantous, Stephane Poyet, Valerie L'Hostis, Nhu-Cuong Tranb, Raoul Francois (2016) "Effect of Crack Openings On Carbonation Induced Corrosion", Cement and Concrete Research 95, (2016), pg257–269.
- [10] Stefania Imperatore, Zila Rinaldi, et al., "Degradation relationships for the mechanical properties of corroded steel rebars", Construction and Building Materials (2017), 148, 219-230.
- [11] V.Talakokulaa, S. Bhallab, R.J. Ballc, et al., "Diagnosis of carbonation induced corrosion initiation and progression in reinforced concrete structures using piezo- impedance transducers", Sensors and Actuators A (2016), 242, 79–91.
- [12] Wenjun Zhu, Raoul Francois, Qian Fang, Dingli Zhang (2016) "Influence of long term chloride diffusion in concrete and the resulting corrosion of reinforcement
- [13] Wenjun Zhu et al (2017) ""Propagation of corrosion and corrosion patterns of bars embedded in RC beams stored in chloride environment for various periods", Construction and Building Materials 145, (2017), 147–156.
- [14] BIS (Bureau of Indian Standards), Plain and reinforced concrete Code of practice, IS 456-2000, New Delhi, India, (2000).
- [15] BIS (Bureau of Indian Standards), Concrete mix proportioning Guidelines, IS 10262-2009, New Delhi, India, (2009).
- [16] BIS (Bureau of Indian Standards), Design aids for reinforced concrete to IS: 456-1978 Guidelines, SP 16: 1980, New Delhi, India.