An Experimental Study on Behaviour of Steel Concrete Composite Beams

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***Abstract*— A member composed of two or more dissimilar materials joined together to act as a unit, in this a new reinforcement to be used to reinforced concrete members. This new reinforcement is patent pending and is developed and evaluated in this research. The proposed reinforcement, termed prefabricated Cage System (PCS), functions as both the longitudinal and transverse reinforcement connected and working compositely with the surrounding concrete to resist applied loads. Prefabricated cage reinforcement is fabricated by angle sections. The confinement provided by the prefabricated beams effectively improves the flexural strength and deformation characteristics of prefabricated cage. Various methods could be used to fabricate the cage reinforcement such as punching, cutting methods, welding and casting. Prefabricated cage reinforcement is prefabricated off-site and then placed .It can eliminating the time consuming and costly labor associated with cutting, bending, and tying steel bars in construction. Prefabricated cage reinforcement can be used to reinforce almost any kind of concrete member which involves reinforcement and concrete.**

Keywords*— *Prefabricated Cage System (PCS), Angle sections, Composite beam, Welded wire fabric system.

I. INTRODUCTION

Plain cement concrete has high compressive strength; its tensile strength is relatively low. Normally, the tensile strength of concrete is about 10% to 15% of its compressive strength. Hence, if a beam is made of plain cement concrete, it has a very low load carrying capacity since its low tensile strength limits its overall strength. It is, therefore, reinforced by placing steel bars in the tensile zone of the concrete beam so that the compressive bending stress is carried by concrete and strength of concrete, tensile bending stress is carried entirely by steel reinforcing bars.

Reinforced concrete (RC) has been used in construction of different structures for centuries. Reinforced concrete is defined as concrete which is a mixture of cement, sand, gravel, water, and some optional other admixtures, combined with a reinforcement system, which is usually steel. Concrete is strong in compression but weak in tension, therefore may result in cracking and failure under large tensile stresses. Steel has high tensile capacity and can be used in areas with high tensile stresses to compensate for the low tensile strength.

A. Objective

It is proposed to provide deformed and prefabricated welded steel reinforcement angles are used as reinforcement.

1. To investigate the flexural behavior, ultimate strength, deflection of beams.
2. To eliminates some of the possible weaknesses and detailing problems inherent in traditional RC construction.
3. To reduce the labor cost for fabrication of reinforcing steel bar cage including cutting, bending, and tying bars in RC construction.
4. Comparison of conventional rebar beam with PCS beams like vertical stirrups, diagonal stirrups, 3D-truss by experimentally and using ABAQUS.

B. Advantages of Composite Beams

1. The concrete and steel is utilized effectively.
2. More economical steel section is used in composite construction than conventional non-composite construction for the same span and loading.
3. Depth and weight of steel beam required is reduced. So, the construction depth also reduces increasing the headroom of the building.
4. Composite beams have higher stiffness, thus it has less deflection that steel beams.
5. Composite construction is faster because of using rolled steel and pre-fabricated components than cast-in-situ concrete.
6. Encased steel beam have higher resistance to fire and corrosion.

II. DIFFERENT SYSTEM OF CAGING

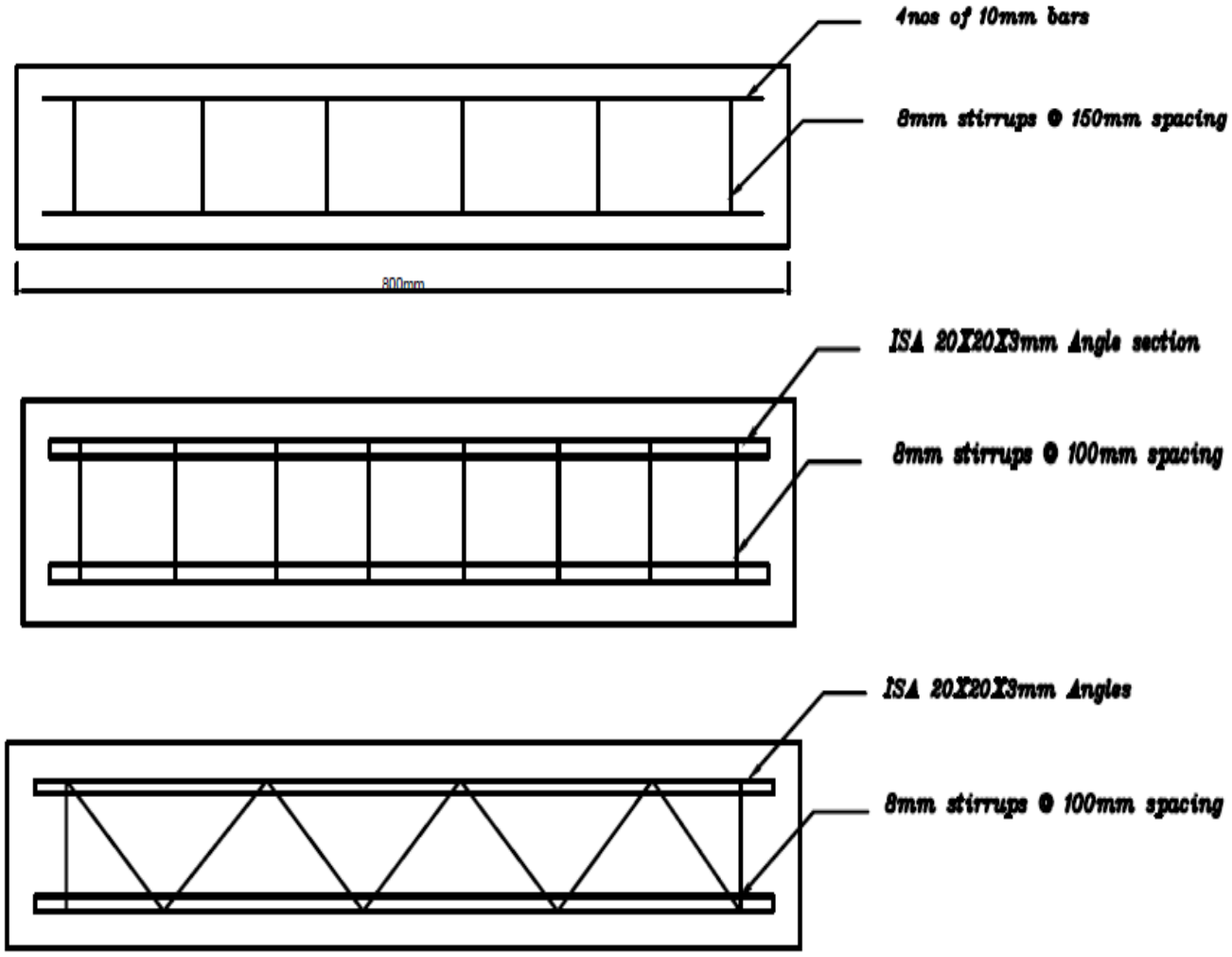
A. Steel-concrete composite system

In steel-concrete composite systems, steel profiles are placed inside concrete to carry most of the axial compressive load. Steel-concrete composite systems are typically used in columns. This system provides high axial-load carrying capacity with a relatively small cross-sectional area where the spacing of the longitudinal bars

may be less than the allowable amount due to space limitations. Concrete encased composite columns are concrete columns reinforced with longitudinal steel rebar in the corners and steel profiles in the centre; however, the amount of the reinforcing steel is also important in this definition. In composite sections, the steel is usually well protected against fire by the thick concrete cover.

B. Need for Alternative Reinforcement Cage

The complimentary characteristics of steel and concrete have made these two materials an excellent combination in structural members for more than a century. Properties of steel such as high tensile strength, high ductility, and availability in conjunction with concrete's strengths including high compressive strength, formability, high temperature and fire resistance, and low cost, makes the combination of these two materials a logical choice for structural members. Traditional rebar reinforced concrete, concrete-filled tubular (CFT) systems, steel-concrete composite sections, and welded wire steel-concrete composite sections, and welded wire volumetric transverse reinforcement ratios, close spacing. Overlapping of hoops, and long column tie end-hooks. An alternative to the rebar transverse reinforcement may be to use welded reinforcement grid, prefabricated to the required size, arrangement, and volumetric ratio of transverse reinforcement. Welded reinforcement grids can offer easy cage assembly, dimensional accuracy, proper support of longitudinal reinforcement, and reduced amount of used materials by eliminating laps at tie ends and bend extensions. Furthermore, using layers of closely spaced grids in the cross-sectional plane will improve the confinement of the concrete core. Different types of PSC beams were shown in Fig. 1.



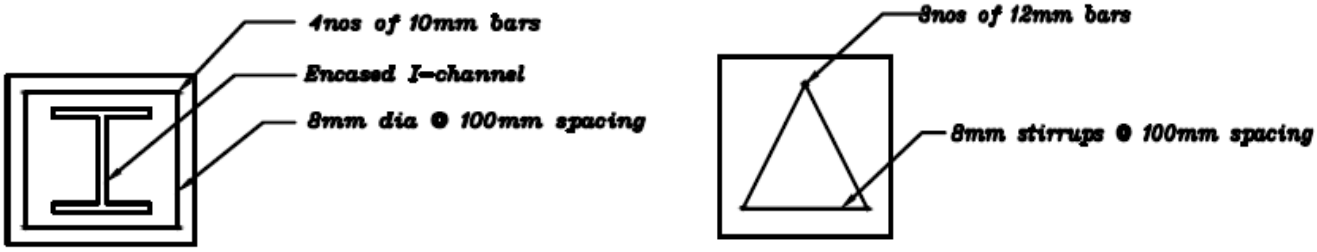


Fig.1 Cross section of PSC beams

III. MIX DESIGN

The mix design was arrived M30 grade of concrete as per IS: 10262-2009. The proportion found from mix design was 1:1.54:2.64:0.45 (Cement: Fine Aggregate: Coarse Aggregate: Water) with a cement content of 438.13 kg/m3.

TABLE 1 Mix proportion for $1m^3$ of concrete

S. no	Materials	Weight kg/m3
1	Cement	438.13
2	Fine Aggregate	747.25
3	Coarse Aggregate	1034.95
4	Water	197
5	Water Cement Ratio	0.45

IV. CASTING AND TESTING OF BEAMS

Concrete is mixed manually with the proper mix proportion. Oil is applied on all the sides of the mould to aid in easier demoulding. Care is taken to see that the concrete is properly placed beneath and also on the sides of the mould. The concrete is compacted fully with the help of tamping rod and trowel. The concrete is mixed initially and placed immediately inside the mould before the initial setting starts. Loading arrangement for testing of beam was shown in Fig. 2.

V. FLEXURAL TEST RESULTS

The concrete beam of 100x150x1100mm size was cast for finding the load deflection behavior of the beam. The prepared beam was cured in water for 28 days. The cured specimens were taken out and dried. After drying, the specimen is loaded using universal testing machine with a dial gauge kept below the beam at the center of the beam to measure the deflection readings. The load deflection behaviour is shown in Fig. 3. The cracks in the failure specimens was shown in Fig. 4.

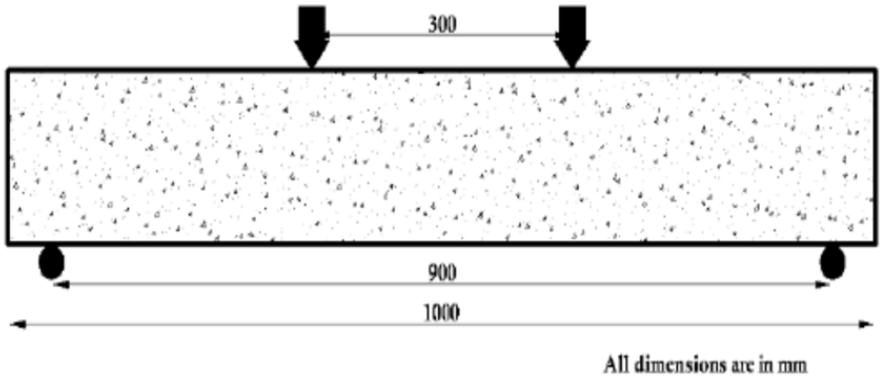


Fig. 2 Loading Arrangement

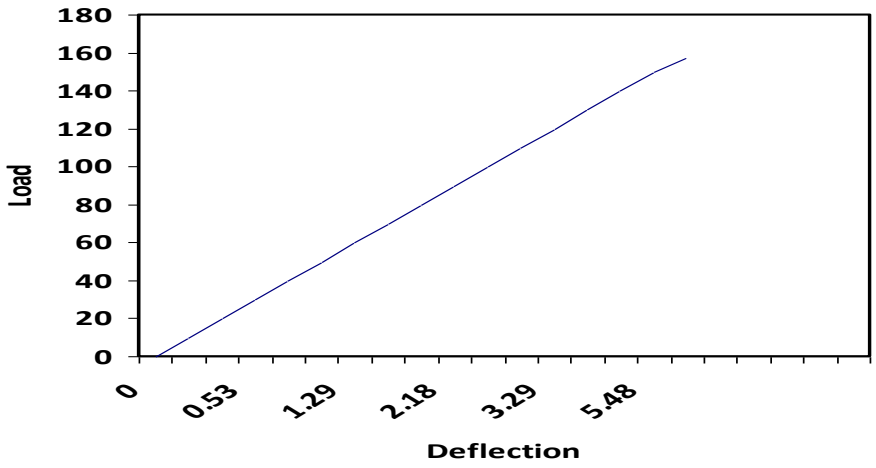


Fig. 3 Load Vs Deflection

Fig. 4 Beam specimen after testing

VI. CONCLUSION

- An experimental study on behavior of RC beam has been presented in this thesis.
- M30 grade concrete was designed using IS: 10262:2009 code provisions.
- The strength properties of concrete has been determined as per IS code provisions.
- A RC beam was cast and tested under three points loading.
- The ultimate load carrying capacity of beam is found by 157kN.
- The ultimate deflection of beam at ultimate load was 6.2mm.
- The theoretical load carrying capacity of RC beam was calculated as 126kN.
- The 1st crack load is predicted as 28kN, where it is observed as 40kN.

REFERENCES

[1] Chithra R and Thenmozhi R (2011) "Studies on prefabricated cage reinforced steel–concrete composite beams" Asian journal of civil engineering (building and housing) Vol. 12, no. 1 pp.27-37.

[2] Eom T., Hwang, H., Park, H., Lee, C., and Kim, H. (2013). "Flexural Test for Steel-Concrete Composite Members Using Prefabricated Steel Angles."Journal of Structural Engineering. Vol. 8, No. 5, pp.321-344

[3] Giuseppe Campione (2013) "Simplified Analytical Model for R.C. Columns Externally Strengthened with Steel Cages" Journal of Civil Engineering and Science Dec 2013, Vol. 2 No. 4, pp.212-218.

[4] Guney Ozcebe and Murat Saatcioglu (1987) "Confinement of concrete columns
for seismic loading", ACI Structural Journal, Vol.84 ,No.4, pp.308-315.

[5] Hyeon-Jong Hwang; Tae-Sung Eom; Hong-Gun Park, M.ASCE; and Seung-Hwan Lee (2016). "Axial Load and Cyclic Lateral Load Tests for Composite Columns with Steel Angles" Journal of Structural Engineering, Vol. 51 ,No.22,pp.443-481.

[6] Halil sezen, Mohammad Shamsai, (2007), "Economic evaluation of reinforced concrete structures with columns reinforced with prefabricated cage system", Journal of Construction Engineering and Management, Vol. 11, No.133, pp. 864-870.
[7] Halil S and Shamsai M (2009), "Prefabricated Cage System For Reinforcing Concrete Members" Journal of Structural Engineering, Vol. 144, No. 5, pp.760-767.
[8] Halil Sezen M (2008) "High-Strength Concrete Columns Reinforced with Prefabricated Cage System" Journal of Structural Engineering, Vol. 134, No. 5, May, pp. 750-757.
[9] John Fisher (2007) "Comparison of Prefabricated Cage System with Existing Reinforcement Methods in Concrete Columns" Journal of Construction Engineering and Management, Vol. 129, No. 7, pp.854-870.
[10] Jorg Knablein (1992) "Experimentally investigated about Prefabricated Cage System" Journal of Construction Engineering and Management Sep, Vol. 118, No. 3, pp.488-506.
[11] Mohamed M.Zaira, David Haldane and Atallah S.Kuttab, (1995), "Flexural Behavior of Beams with Confinement", ACI Structural Journal, Vol.92(1), pp103-114.
[12] Oh JY, Lee DH, Lee J, Kim KS and Kim SB (2016) "Experimental Study on Reinforced Concrete Column Incased in Prefabricated Permanent Thin-Walled Steel Form". Advances in Materials Science and Engineering , Vol. 55, pp.415-426.
[13] Rosario Montuori, Vincenzo Piluso and Gianvittorio Rizzano (2004) "Ultimate Resistance of Reinforced Concrete Columns Strengthened with Angles and Battens Theoretical Model and Experimental Validation" 13th World Conference on Earthquake Engineering , Vol. 986, pp.630-645.
[14] Sezen.H and Shamsai.M (2008) "High-Strength Concrete Columns Reinforced with Prefabricated Cage System", Journal of Structural Engineering Dec, Vol. 134, No. 12, pp.1787-1799.
[15] Shamsai.M (2007) , "Behavior of Normal Strength Concrete Columns Reinforced with Prefabricated Cage System" Structures Congress, Vol. 154, No. 7, pp. 620-631.
[16] Selvaraj, P and Arunprakash, N. (2015). "Study on Behavior of Prefabricated Cage Steel Reinforced Concrete Beam Column Joint". The International Journal of Science and Techno ledge, Vol. 3, No.5, pp.56-61.
[17] IS: 10262-2009, 'Indian standard recommended method of concrete mix design' , Bureau of Indian Standards, New Delhi.
[18] IS: 516-1959, 'Methods of Tests for Strength of Concrete' , Bureau of Indian Standards,New Delhi.
[19] IS: 383-1970 (reaffirmed 1997), 'Specification for Coarse and Fine Aggregates from Natural Source for Concrete' , Bureau of Indian Standards, New Delhi.
[20] IS: 12269-1987 (reaffirmed 1999), 'Specification for 53grade Ordinary Portland Cement', Bureau of Indian Standards, New Delhi.
[21] IS: 456-2000, 'Plain and reinforced concrete - Code Of Practice' , Bureau of Indian Standards, New Delhi.