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Feasibility of Composite Reinforcement for Heavy Structure

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Abstract: *Composite sections are often used for tall bridge columns to reduce their mass, reduce seismic inertia forces, and reduce foundation forces. However, the seismic performance of Composite columns is still not fully understood although a few experimental works were conducted previously. The behavior of nine flexure-dominant circular Composite reinforced concrete cubes, under axial loading is investigated through a experimental studies. Comparison between test results of nine Composite and nine solid reinforced concrete cubes is presented. All of the 18 cubes were designed as Composite sections to resist combined load of bending, torsion and shear. Every pair (one Composite and one solid) was designed for the same load combinations and provided similar reinforcement. Test results showed that average 15% rise in Composite circular bar's compressive strength compare to regular bar. All solid beams cracked and failed at higher loads than their counterpart Composite beams. The smaller the ratio of torsion to bending the larger the differences in failure loads between the Composite and solid beams. The longitudinal steel yielded while the transverse steel experienced lower strain values.*

I. INTRODUCTION

The raw materials of concrete, consisting of water, fine aggregate, coarse aggregate, and cement, can be found in most areas of the world and can be mixed to form a variety of structural shapes. The great availability and flexibility of concrete material and reinforcing bars have made the reinforced concrete a very competitive alternative. Deformed steel bars are commonly employed as reinforcement in most reinforced concrete bridge construction. The surface of a steel bar is rolled with lugs or protrusions called deformations in order to restrict longitudinal movement between the bars and the surrounding concrete. Reinforcing bars, rolled according to ASTM are widely used in construction. Low-alloy steel deformed bars are specified for special applications where extensive welding of reinforcement or controlled ductility for earthquake-resistant, reinforced concrete structures or both are of importance. The Composite columns also enable to reduce foundation dimensions and thus save the construction cost substantially. A Composite concrete section is often used for column design, particularly for very tall bridge columns in seismic areas the Composite columns also enable to reduce foundation dimensions and thus save the construction cost substantially. Therefore, these advantages have promoted the use of Composite columns instead of similar solid members. On the other hand, the seismic behavior of the Composite columns has been controversial due to a lack of understanding. The effect of the Composite section should be adequately assessed in the seismic design, because the structural response of the Composite column under seismic loading may be significantly different from that of solid column due to existence of a void section.

II. Literature review

Dr.Alaa K. Abdal Karim et al (2013) aimed at presenting simplified approach to enable construction of new design charts for Composite section reinforced concrete columns subjected to an axial compressive load and uniaxial bending. These charts can be directly used in design of Composite columns sections, to determine required amount of steel in addition to column dimensions and estimation of column load capacity.

Yan Zhao et al (2013) evaluated seismic performances of the model piers and the factors affecting the seismic performance of the model piers by comparing their failure mechanism, bearing capacity, ductility, energy dissipation capacity, etc. Two large-scale experimental models of the Composite reinforced concrete bridge piers were built to study the seismic performance of the piers subjected to biaxial bending under constant axial load.

Y.-K. Yeh et al (2002) performed experimental results for two prototype and four scaled model Composite bridge columns. Primary parameters considered for the specimens were axial load, the amount of lateral reinforcement, and height-to-depth ratio. In this study a specially designed test setup was used to subject the Composite bridge columns to a constant axial load, as well as cyclic transverse shear and bending. An analytical model is also presented that is verified by experimental results. A specimen with greater axial force has less ductility. When the columns are satisfied by the ACI code, their failure mode is flexure due to rupture of longitudinal rebars. When the amount of lateral reinforcement is less than one half of that required by the ACI code, the failure mode may become flexureshear or shear. The analytical model satisfactorily predicts the moment-curvature relationship and load-displacement relationship of all specimens with acceptable accuracy.Y. L. Mo et al (2002) investigated the seismic performance of Composite high-strength concrete bridge columns, six specimens were tested under a constant axial load and a cyclically reversed horizontal load. Based on the results of these tests an analytical model was developed in order to predict the moment-curvature curve of sections and the load-displacement relationship of the bridge columns. A specimen with greater axial force has less ductility. When the columns are satisfied by the ACI code, their failure mode is flexure due to rupture of longitudinal rebars.

III. NEEDS OF STUDY

The fundamental problem in current concrete industry is to improve productivity and efficiency. Heavy reinforcement is required in tall structure and bridge piers can not to withstand strength and capability to bearing load of the superstructure. So change is required in shape and design of regular reinforcement.Furthermore, the effects of concrete on behavior and ultimate load of reinforced concrete beams subjected to combined load of bending, torsion and shear are presented. The construction of tall bridge piers using cylindrical Composite reinforced concrete columns is an attractive means by which the superstructure weight, seismic load will be minimized. There are more chances for RC members with a Composite section which may not have enough plastic deformation capacity and energy dissipation since it is generally difficult in thin web for shear resistance of the members. Before decades tall buildings were placed on one another such that they form an interlocking mass in at least in two horizontal dimensions. If we try to interlock in three dimensions with normal reinforcement then it gives less bearing capacity and strength.

IV. OBJECTIVES OF STUDY

- To calculate the compressive strength of Composite reinforcement by casting them in standard mould size of 15x15x15 cm.
- To compare of results of regular reinforcement and Composite reinforcement.
- To check the feasibility of Composite circular bar in bridge construction.

V. METHODOLOGY

In this study 15cm x15cm x 15cm size 6 cubes were used. 3 cubes are made by using regular reinforcement and 3 cubes were made by using Composite reinforcement. Diameter of regular reinforcement was 8 mm where as 10 mm outer and 6 mm inner diameter bars were used as Composite reinforcement. Diameter of Composite bar and regular bar was chosen based on area requirement. Calculation for area is as follows:

1) Area of Composite Reinforcement

Outer diameter D = 10 mm

Inner diameter d = 6 mm

Area = $\pi / 4 (D^2 - d^2)$

= $\pi / 4 (10^2 - 6^2)$

= 50.26 mm^2

2) Area of Regular Reinforcement

Diameter D = 8 mm

Area = $\pi / 4 D^2$

= $\pi / 4 \times 8^2$

= 50.26 mm^2

After being selection of the regular and Composite bars were cut to a definite length, and tied by tie bar with 6mm diameter. This reinforcement assembly was kept in cubes and after that cubes were filled with M20 grade concrete. Same concrete grade was used for both type reinforcement. Figure 1 (a) & (b) shows the top view and sectional view of Composite reinforcement beam

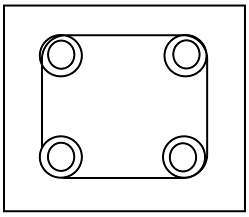

Figure 1 (a): Top view of Composite reinforcement beam

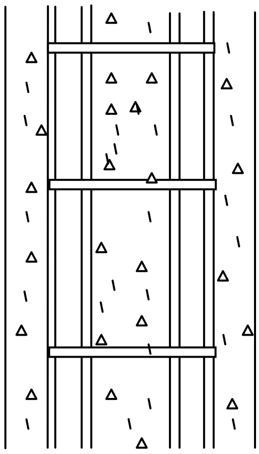

Figure 1 (b): Sectional view of Composite reinforcement beam.

VI. OBSERVATION AND ANALYSIS

The properties of concrete depend on the properties of its ingredients and their proportion. Composite reinforced concrete cubes and regular reinforced concrete cubes were tested for compressive strength by using compressive testing machine after 7, 14 and 28 days successful curing. Results of compressive strength for regular bar are as per table 1 and figure 2.

Sr. No	No. of Days	Compressive strength of Regular bar (KN)			
		Sample 1	Sample 2	Sample 3	Average
1	7	440	434	431	435
2	14	594	459	553	535
3	21	566	601	572	580

Table:1 Compressive strength of regular reinforcement

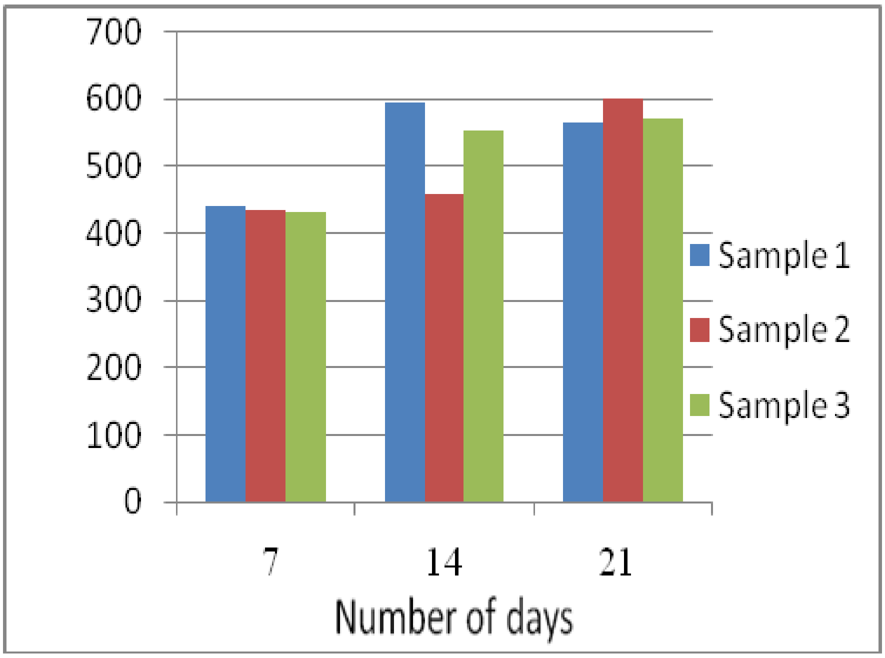

Figure 2 : Compression strength of regular reinforcement

The above chart shows the comparison of three different sample of compressive strength v/s number of days. A result of Composite reinforcement is as per table 2 and figure 3.

Sr. No.	No. of Days	Compressive strength of Composite bar (KN)			
		Sample 1	Sample 2	Sample 3	Average
1	7	489	530	510	510
2	14	625	664	650	646
3	21	680	661	672	671

Table:2 Compressive strength of Composite reinforcement

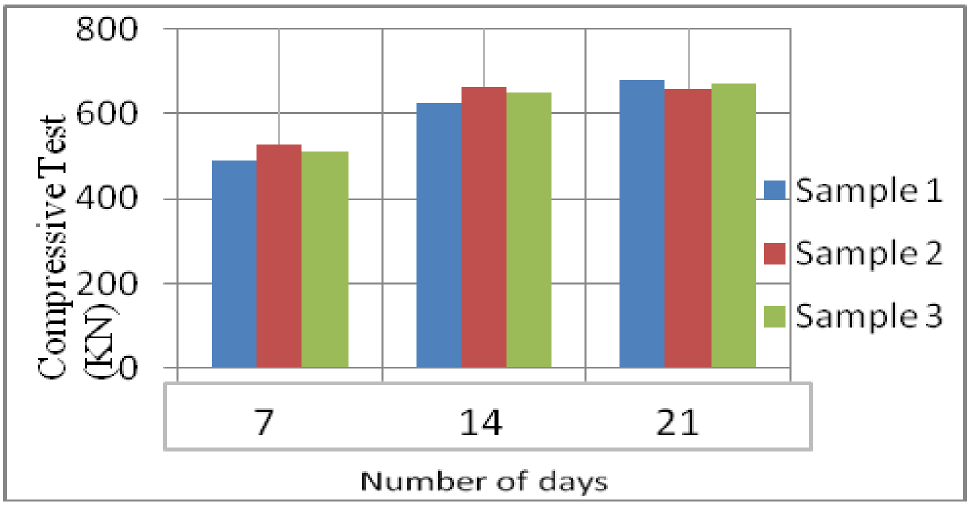

Figure 3: Compression stress of Composite reinforcement sample

The above chart shows the comparison of three different sample of compressive strength v/s number of days. Compression of regular bar and Composite bar is shown in figure 4. The graph shows the relations between the number of days of curing the concrete block and results of compressive strength for Composite and regular reinforcement bar.

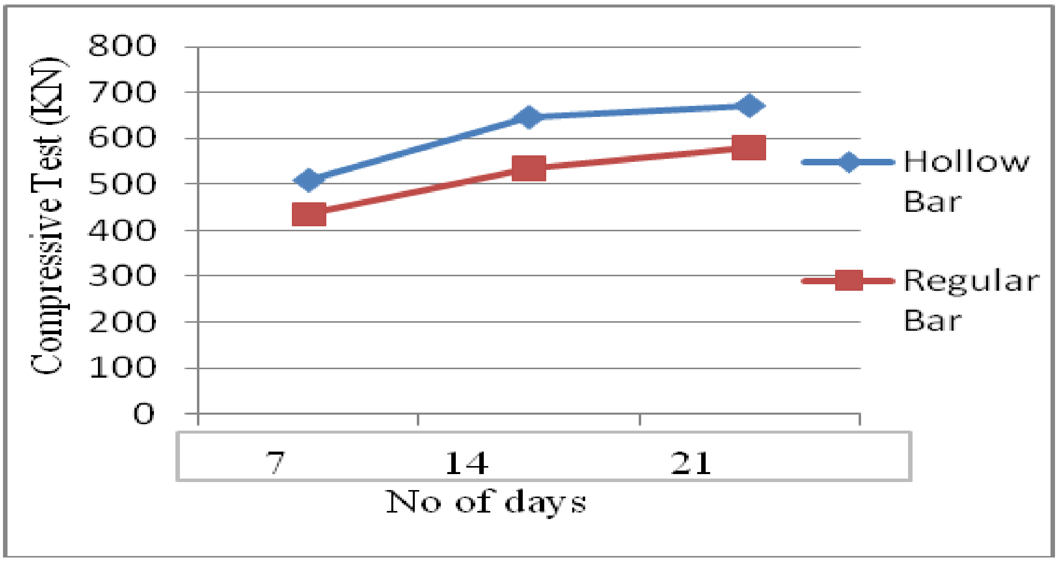

Figure 4: Compression analysis graph of Composite & Regular reinforcement

It is clear from the analysis of bar graph that compressive strength of Composite bar is 15% to 20 % more than regular reinforcement

VII.CONCLUSION

1. The construction of structure with comoposite reinforcement is feasible, since they are able to bear and carry load approximately equal to that of reinforced concrete piers.

2. This research work has attempted to establish a framework for prediction of the inelastic behaviour of composite reinforced concrete bridge columns.

3. A comparison with test data confirms that good prediction were obtain in regards to load capacities and failure modes response of Composite reinforced concrete bridge columns.

4. More efforts should be directed to include certain procedures in the current design codes to direct the engineers towards an acceptable method for evaluation the existing Composite reinforced concrete bridge columns.

5. Composite Reinforced Concrete componants may use as precast concrete elements, which are fabricated at a production plant and then transported for erection at the job site, or cast-in-place concrete, which is formed and cast directly in its setting location.

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8. Yan Zhao et al (2013) evaluated seismic performances of the model piers.

9. Y.-K. Yeh et al (2002) performed experimental results for two prototype and four scaled model Composite bridge columns.