Experimental Behavior of Steel Encased Square Composite Column Under Axial Loading

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Abstract- *Concrete encased column which is developing rapidly in the construction field because of its advantages such as light in weight, faster in construction and no need of bar bending. This paper presents the behavior of the concrete encased steel tube column (CEST) by partially replacing the fine aggregate with the quarry dust, further shear connectors are also used to check whether they influence the strength of the column. Experimental investigations are done. Result showed that the partial replacement of quarry dust with shear connectors proved to have good axial load carrying capacity*

Keywords- Mild steel, Quarry dust, River sand, Shear connectors

I. INTRODUCTION

Composite columns are a combination of two traditional structure forms structural steel and structural concrete. As composite columns were generally developed after steel columns and reinforced concrete columns, their design based on either steel or concrete design methods .The most common types of composite columns are Concrete filled tubes, fully encased composite column and partially encased column. Concrete encased columns have been widely used extensively in bridges and building construction for many years. Investigation showed that the composite columns lead to the reduction in the weight and the deformation of the structure. It involves the infilling of concrete within the steel tube and outside the tube. Further it is Economical and lightweight. Shear connectors on the top flanges of the steel girders provide the means to achieve composite action between the slab and the girders, thus increasing both stiffness and strength. Concrete is prepared by using the river sand and the quarry dust, to determine which has high effective axial load carrying capacity. In the present work M20 grade was used for casting the composite column. Cement used was 53 grade, uniform color i.e. grey with a light greenish shade and was free from any hard lumps. Sieve Analysis of the Fine Aggregate was carried out in the laboratory as per IS 383-1970. The river sand and quarry dust was first sieved through 4.75mm sieve to remove any particle greater than 4.75 mm sieve. According to IS 383:1970 the fine aggregate is being classified in to four different zone, that is Zone-I, Zone-II, Zone-III, Zone-IV. Sieve Analysis of the Fine Aggregate and coarse aggregate was carried out in the laboratory as per IS 383-1970. It is sieved through 4.75mm IS sieve. Coarse aggregate used in this work is 12.5mm chips and the shear connectors used here 12.7mm. The building industry frequently uses mild steel in construction because of its ductility and malleability. Mild steel specimen used here has yield strength of 240Mpa. Here mild steel is incorporated into concrete instead of the reinforcing bar elements. Theoretical calculations are done by using the code books IS 456:2000

II. OBJECTIVES

The main objective of this experiment is to find the behavior of composite column with shear connectors and without the shear connectors and also when it is partially replaced with quarry dust and compared with conventional models.

Three types of shear connector models is prepared i.e. (shear connectors with 50mm spacing, shear connectors with 100mm spacing, without shear connectors) and their compressive strength is determined.

The mix design and proper materials were collected for this experiment.

III. MATERIALS USED

A. Cement

Ordinary Portland cement (OPC) is the basic Portland cement and is best suited for use in general concrete construction. In this study OPC 53 grade cement is used. One of the important benefits is the faster rate of development of strength.

Table 1: Test results of cement

S. no	Description	Obtained value
1	Specific gravity	3.15
2	Fineness	4.67%
3	Standard consistency	32%
4	Initial setting time	30
5	Soundness	Sound

B. Aggregates

Aggregate properties greatly influence the behavior of concrete, since they occupy about 80% of the total volume of concrete. Fine aggregates used throughout the work comprised of clean river sand with maximum size of 4.75mm conforming to zone II as per IS383-1970 [9] with specific gravity of 2.32. Quarry dust can be defined as the residue tailing or other non-voluble waste material after the extraction and processing of rocks to form fine particles less than 4.75mm is used. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 16mm IS sieve and retained on 4.75mm IS sieve.

Table 2: Test results of coarse aggregate

S.no	Description	River sand	Quarry dust	Coarse aggregate
1	Fineness modulus	3.37%	3.37%	5.61
2	Specific gravity	2.32	2.71	2.77
3	Aggregate impact test	-	-	3.582%
4	Water absorption	-	-	0.25%

C. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Thus the quantity and quality of water added to be noted carefully.

D. Mild steel

Mild steel consists of iron alloyed less than 0.3% carbon, most commonly used between 0.1 to 0.25%. The building industry frequently uses mild steel in construction because of its ductility and malleability. Some of the properties of mild steel are Buckling, ductile, good tensile strength, and tough. The test conducted for the mild steel is brinell hardness number test and the result found to be 118.3 BHN

IV. EXPERIMENTAL INVESTIGATION

A. Casting of specimen

The specimens are casted as square composite column with M20 grade concrete. The dimension of column is 95x95x95mm and the mild steel tube size is 50×50mm. 24 specimens were casted. Casting schedule is prepared. Casting is done for the with/without shear connectors. Two types of shear connection is provided type1 100mm spacing, type2 50mm spacing, type3 without shear connection and type 4 conventional reinforcement.

Table 3: Number of specimens

Materials		Steel tube	Steel tube with Shear connector 1	Steel tube with Shear connector 2	Conventional
OPC cement	sand	3	3	3	3
	Q-dust	3	3	3	3

B. Curing:

After 24 hours of casting the moulds are removed and specimens are kept for curing. Curing is done by immersing the specimens in clean water for 28 days.

C. Testing of specimens

1. Compressive strength test

Compressive strength test is done by placing the column in the compression strength testing machine and load was applied. The ultimate load at which the specimen fails is noted. The compressive strength is calculated and is given in table 4.

Table 4: Compressive load test of river sand specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CER 1.1	194.2	149	160
CER 1.2		160	
CER 1.3		171	
CER 2.1		170	152.7
CER 2.2		124	
CER 2.3		164	
CER 3.1	133.7	148	186
CER 3.2		204	
CER 3.3		205	

Here the first two letters CE represents the concrete encased column respectively and the third letter represents the river sand

And the numbers 3.1, 2.1, 1.1 represents the type no, and number of specimen respectively.

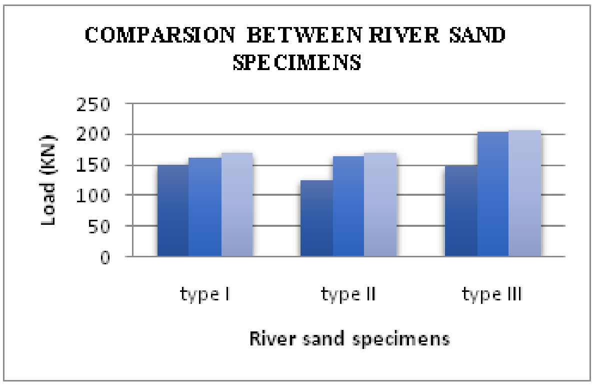

Figure 1: Compressive strength test graph between river sand specimens

Table 5: Compressive load test of Q dust specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CEP1.1	194.2	186	193.4
CEP 1.2		194	
CEP 1.3		200	
CEP 2.1		215	202
CEP 2.2		191	
CEP 2.3		220	
CEP 3.1	133.7	182	200.3
CEP 3.2		203	
CEP 3.3		213	

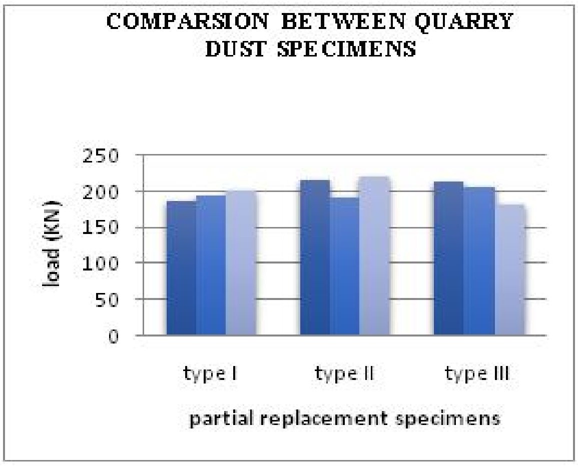

Figure 2: Compressive strength test graph between Q dust specimens

Here the first two letter CP represents the concrete encased column respectively and the third letter represents the Partial replacement of quarry dust

And the numbers 3.1, 2.1, 1.1 represents the type no, and number of specimen respectively.

Table 6: Compressive load test of river sand and quarry dust type1 specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CER 1.1	194.2	149	160
CER 1.2		160	
CER 1.3		171	
CEP 1.1		186	193.4
CEP 1.2		194	
CEP 1.3		200	

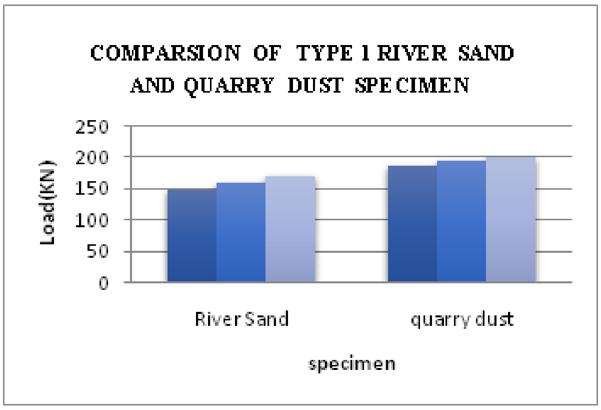

Figure 3: Compressive load test graph between river sand and Q dust type 1specimens

Table 7: Compressive load test of river sand and quarry dust type 2 specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CER 2.1	194.2	124	152.7
CER2.2		164	
CER 2.3		170	
CEP 2.1		191	202
CEP 2.2		215	
CEP 2.3		220	

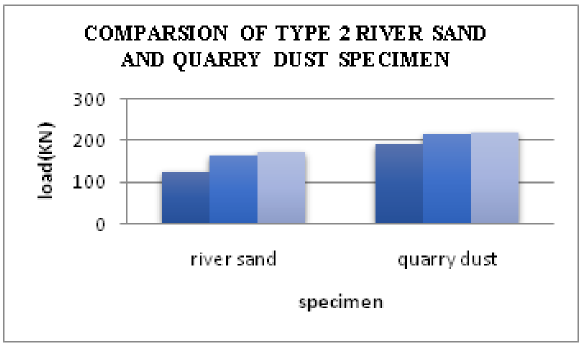

Figure 4: Compressive load test of river sand and quarry dust type 2 specimen

Table 8: Compressive load test of river sand and quarry dust type 3 specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CER 3.1 CER3.2 CER 3.3	133.7	148 204 205	186
CEP 3.1 CEP 3.2 CEP 3.3		182 206 213	200.3

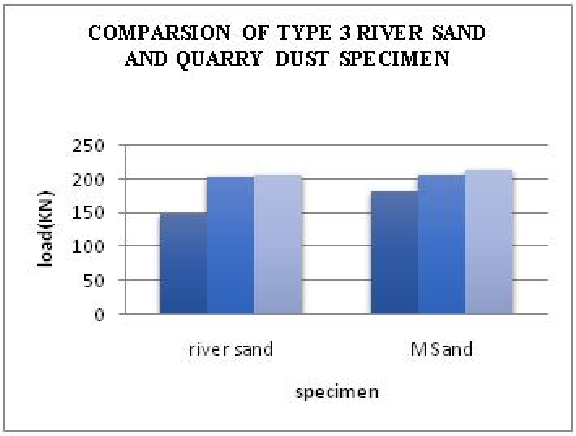

Figure 5: Compressive load test of river sand and quarry dust type 3 specimens

Table 9: Compressive load test of conventional river sand and type 1 specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CCR 4.1 CCR4.2 CCR 4.3	133.3	132 159 170	154
CER 1.1 CER 1.2 CER 1.3	194.4	149 160 171	160

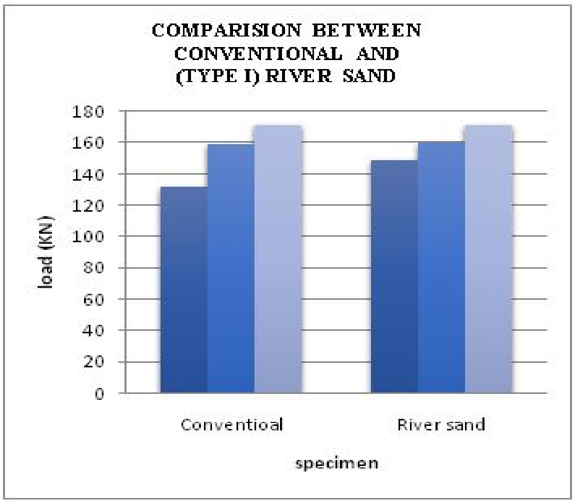

Figure 6: Compressive load test of conventional river sand and type 1 specimen

Table 10: Compressive load test of conventional river sand and type 2 specimens

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CCR 4.1 CCR4.2 CCR 4.3	133.3	132 159 170	154
CER 2.1 CER 2.2 CER 2.3	194.4	124 164 170	152.3

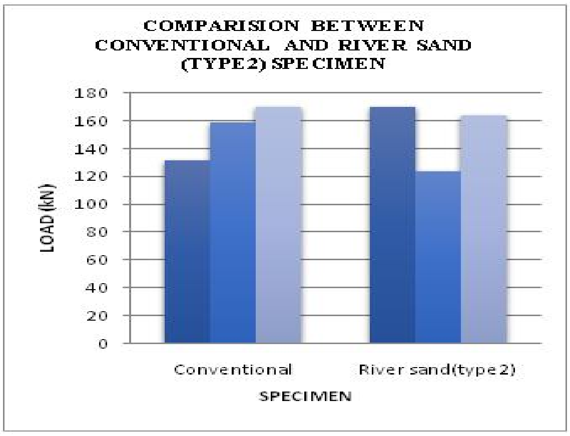

Figure 7: Compressive load test of conventional river sand and type2 specimen

Table 11: Compressive load test of conventional river sand and type 3 specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CCR 4.1		132	
CCR4.2	133.3	159	154
CCR 4.3		170	
CER 3.1	194.4	148	
CER 3.2		204	186
CER 3.3		205	

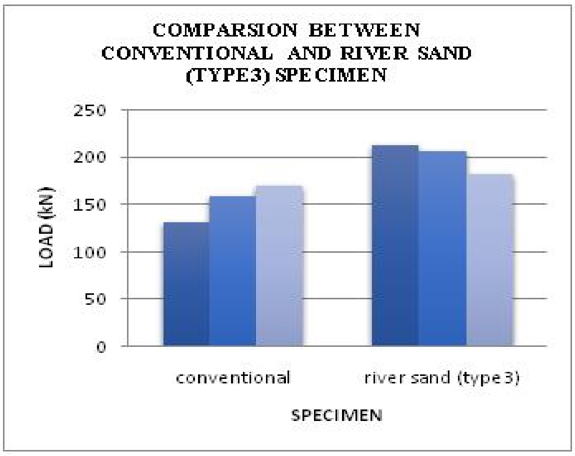

Figure 8 : Compressive load test of conventional river sand and type3 specimen

Table 12: Compressive load test of conventional Q sand and type1 specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CCP 4.1		180.5	
CCP4.2	133.3	184	154
CCP 4.3		186	
CEP 1.1	194.4	186	
CEP 1.2		194	193.4
CEP 1.3		200	

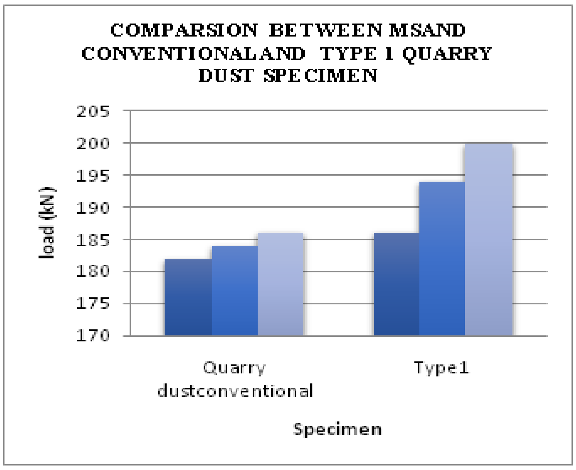

Figure 9: Compressive load test of conventional Q sand and type1 specimen

Table 13: Compressive load test of conventional Q sand and type2 specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CCP 4.1		180.5	
CCP4.2	133.3	184	154
CCP 4.3		186	
CEP 2.1	194.4	191	
CEP 2.2		215	202
CEP 2.3		220	

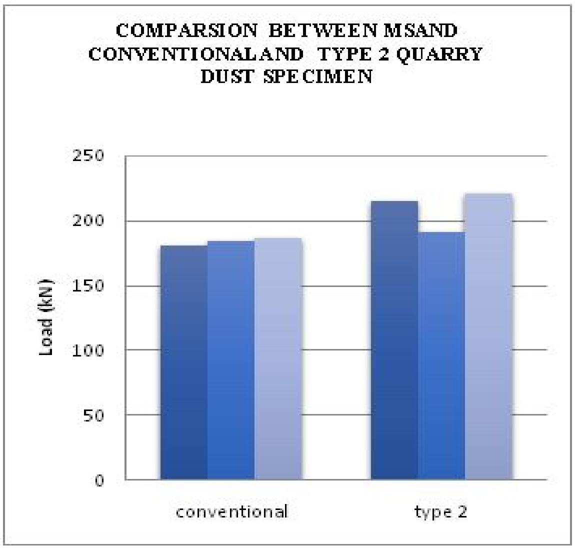

Figure 10: Compressive load test of conventional Q sand and type 2 specimen

Table 14: Compressive load test of conventional Q sand and type2 specimen

Specimen name	Axial load carrying capacity		
	Theoretical load(kN)	Experimental Load (kN)	Average (kN)
CCP 4.1		180.5	
CCP4.2	133.3	184	154
CCP 4.3		186	
CEP 3.1	194.4	182	
CEP 3.2		206	200.3
CEP 3.3		213	

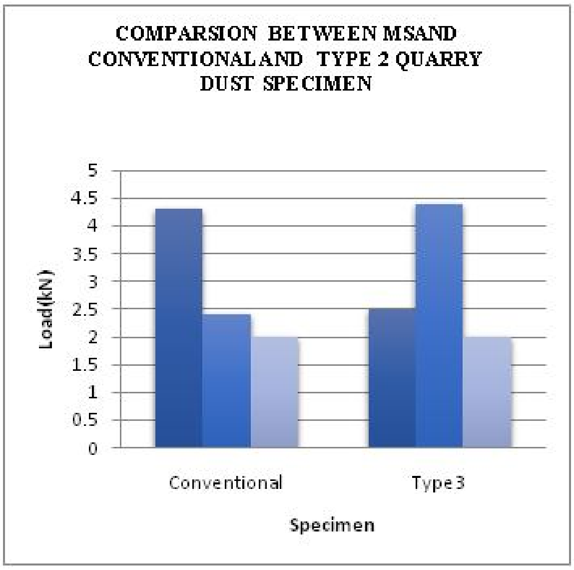

Figure11: Compressive load test of conventional Q sand and type3 specimen

V. CONCLUSION

Based on the above experiment result obtained, we conclude that the

- When comparing the m Sand specimens with the river sand specimens the load carrying capacity of the quarry dust specimen is 0.34% higher than that of the river sand specimen.
- Regarding with the shear connectors, columns with shear connectors are having 0.16% high axial load carrying capacity than that of the reinforced conventional columns.
- When the comparison is done within the river sand specimen having shear connectors it is found that the specimens without shear connectors i.e. type 3 specimens is having 0.44% high axial load carrying capacity than that of other specimens.
- When the comparison is done within the quarry dust specimen having shear connectors it is found that the specimens with shear connectors at 50mm spacing i.e. type 2 specimens is having 0.2% high axial load carrying capacity than that of other specimens.
- Hence from the above discussion it is concluded that the partial replacement of the quarry dust has yielded the good strength when compared to that of the river sand. And the concrete encased steel tube has good strength than that of the conventional.

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