Experimental Analysis of GGBS filled Steel Tubular Column under Uniaxial

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Abstract— Concrete filled steel tubular column is currently being widely used in the construction of modern buildings and bridges. Concrete filled steel tubular column resisting the lateral force when suddenly earthquake occurs. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive, this leading to usage of economically alternative materials in its production. This requirement is drawn the attention of investigators to explore new replacements of ingredients of concrete. This paper deals with the behaviour and performance of partial and fully replaced GGBS filled steel tubular column under uniaxial loading condition. The present paper focuses on investigating characteristics of M40 grade concrete with partial replacement of cement with ground granulated blast furnace slag (GGBS) by replacing cement via 0%, 50%, 100% and alkaline liquids are used for the binding of materials. The alkaline liquids are Sodium hydroxide and sodium silicate. The external diameter of the steel tubular column is 100mm , thickness of the steel tube is 3.5mm and height of the steel tubular column is 600mm. Therefore the results revealed that in 50% replacement of cement by GGBS the load carrying is high and deflection is less when compare to 0% and 100% replacement.

Key words: Steel tube, Ground granulated blast furnace slag (GGBS), Alkaline liquids (Sodium hydroxide and sodium silicate)

I. Introduction

Environmental pollution is the biggest menace to the human race on this planet today. It means adding impurity to environment. It has a severe effect on the ecosystem. There are many reasons which cause pollution. In our construction industry, cement is the main ingredient/ material for the concrete production. But the production of cement means the production of pollution because of the emission of CO2 during its production. There are two different sources of CO2 emission during cement production. Combustion of fossil fuels to operate the rotary kiln is the largest source and other one is the chemical process of calcining limestone into lime in the cement kiln also produces CO2. In India about 2,069,738 thousands of metric tons of CO2 is emitted in the year of 2010. The cement industry contributes about 5% of total global carbon dioxide emissions. And also, the cement is manufactured by using the raw materials such as lime stone, clay and other minerals. Quarrying of these raw materials is also causes environmental degradation. To produce 1 ton of cement, about 1.6 tons of raw materials are required and the time taken to form the lime stone is much longer than the rate at which humans use it. On the other side the demand of concrete is increasing day by day for its ease of preparing and fabricating in all sorts of convenient shapes. So to overcome this problem, the concrete to be used should be environmental friendly. To produce environmental friendly concrete, we have to replace the cement with the industrial by products such as fly-ash, GGBS (Ground granulated blast furnace slag) etc.

Concrete-filled steel tube columns have many advantages in terms of their high strength, high ductility, high stiffness and full usage of construction materials. In recent years, stainless steel tube members have become popular due to their high corrosion resistance, ease of construction and maintenance as well as aesthetic appearance. There are limited test data on concrete-filled stainless steel tube columns. The behaviour of stainless steel sections is different from that of carbon steel sections. Recent experimental investigations of stainless steel columns without concrete in filled were conducted while experimental investigations of high strength stainless steel columns were conducted. A parametric study was performed to investigate the effects of concrete strength and cross-section geometry on the behaviour and strength of axially loaded concrete-filled cold-formed high strength stainless steel tube columns. The column strengths obtained from the parametric study were compared with the design strengths calculated using the general design guides specified in the American specifications and Australian /New Zealand standards for stainless steel and concrete structures.

The main objective of the study is experimenting and comparing the load carrying capacity of concrete infilled steel tubular column which contain replacement of cement by Ground granulated blast furnace slag. The percentage of replacement are 0%, 50% and 100%.

II. Experimental program

A. Materials

The mix design proposed for the column is given below. Ordinary Portland cement of grade 53 was used as the binding material. Coarse aggregate as crushed stones in the size 20mm was used. River sand of size passing through 4.75mm was used as fine aggregate.

Cement/GGBS	350
Fine aggregate	773.11
Coarse aggregate	1262.20
Water	140
W/C ratio	0.4

Table 1: Mix design of concrete (Kg/m3)

1) Ground Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag is a slag based geopolymer is a by-product of iron and steel making industry.

2) Physical And Chemical Properties

The Ground cement powder is near-white in color and is a hydraulic cement that is it has a property of setting and hardening through chemical reaction with water.

Color	Off-white powder
Bulk density (loose)	- 1.1 tones/ m^3
Bulk density (vibrated)	1.2 – 1.3 tones/ m^3
Relative density	2.83
Surface area	400 – 600 m^2/ kg

Table 2: Physical and Chemical Properties

Chemical constituent	Ordinary Portland Cement	GGBS
CaO	65%	40%
SiO_2	20%	35%
Al_2O_3	5%	10%
MgO	2%	8%

Table 2: Constituents of OPC & GGBS

3) Alkaline Liquid

A combination of sodium silicate solution and sodium hydroxide solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than Potassium-based solutions. In this 8M molarity is used. The molecular weight of sodium hydroxide is 40. To prepare 3M i.e. 3 molar sodium hydroxide solution, 120g of sodium hydroxide flakes are weighed and they can be dissolved in distilled water to form 1 liter solution. For this, volumetric flask of 1 liter capacity is taken, sodium hydroxide flakes are added slowly to distilled water to prepare 1liter solution.

B. Test Specimen

A total of three circular shaped steel tubular column were tested. The external diameter of the steel tubular column is 100mm , thickness of the steel tube is 3.5mm and height of the steel tubular column is 600mm. The steel tubular column is tested in 3000KN capacity of compression testing machine.

III. TEST RESULTS

Specimen	Ultimate load carrying capacity (KN)	Deflection (mm)
100% cement	760	12.58
50% GGBS	800	10.15
100% GGBS	500	23.4

Table 3:

Fig. 1: Column 1- CFST containing 100% cement

Fig. 2: Column 2- CFST containing 50% cement and 50% GGBS

Fig. 3: Column 3- CFST containing 100% GGBS

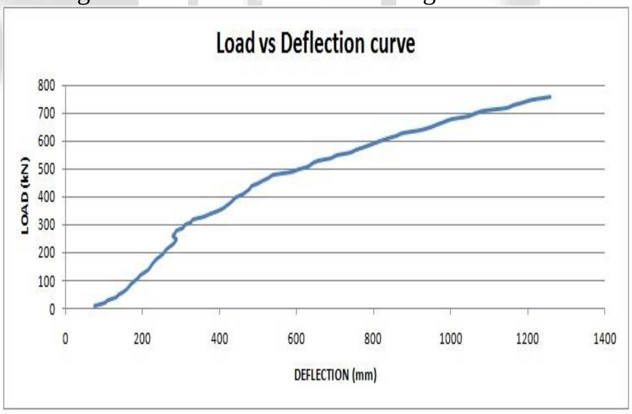

Fig. 4: Load vs deflection chart for 100% cement

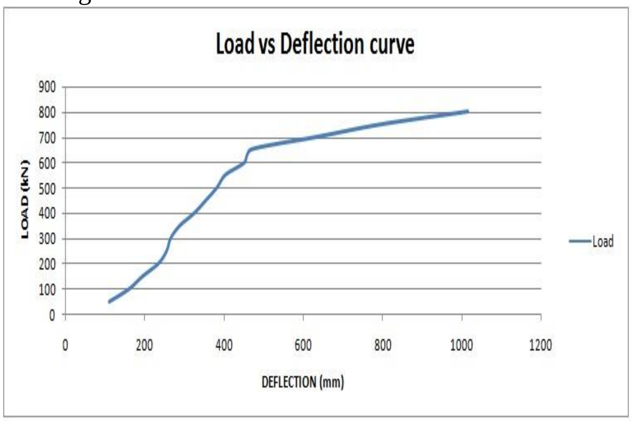

Fig. 5: Load vs deflection chart for 50% cement and 50% GGBS

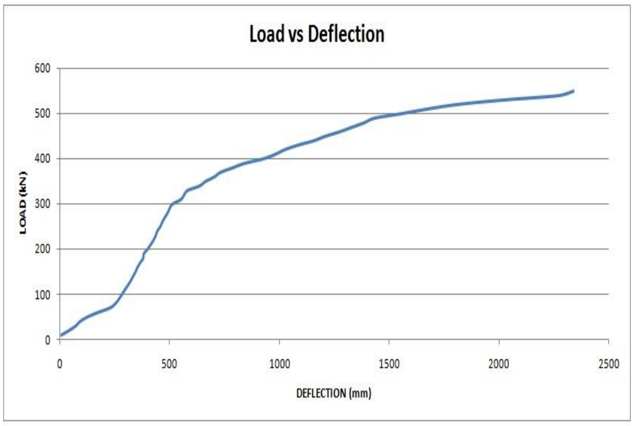

Fig. 6: Load vs deflection chart for 100% GGBS

IV. CONCLUSION

Based on the analysis of experimental results it is observed that the Workability of concrete was found to be increases with the increase in GGBS replacement level. In 50% replacement of cement by GGBS the load carrying is high and deflection is less when compare to 0% and 100% replacement. GGBS is a good replacement to cement in some cases and serves effectively but it can‟t replace cement completely. But even though it replaces partially it gives very good results.

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