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Recycled Aggregate Concrete Filled Steel Tube (CFST) and Concrete Filled Plastic Tube (CFPT)

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Abstract

Recycled aggregates are used worldwide as the replacement of the natural aggregate in different ratios causing significant reduction on concrete strength and other properties. In this research recycled aggregate concrete filled tubes were used along with lumps of recycled aggregate taken from demolished waste. These lumps (50mm to 90 mm) of recycled aggregate were used as a replacement of coarse aggregate in different proportions (0%,10%,20% and 30%) for casting control specimen, CFST (concrete filled steel tube) and CFPT (concrete filled plastic tube) cylinders. Various tests were conducted such as slump test, water absorption test, fresh concrete density test, compressive and indirect tensile tests. Upon 30% replacement of the recycled aggregate reduction in concrete strength for recycled aggregate CFST, CFPT and simple cylinders (without any confinement) was to be found 9.22% ,43.2% and 54.14%, respectively when compared with control specimen.

Keywords: Recycled aggregate CFST, Recycled Aggregate CFPT

1. INTRODUCTION:

Concrete is utilized more generally than some other substance after water, on account of its numerous points of interest. The global material extraction is 48.5 billion tons/year, out of which the share of construction material is 16.2 billion tons/year (Steinberger et al., 2010). The Building demolition rate is always expanding, making it fundamental to successfully reuse destruction waste to save the non-renewable natural resources. Nowadays, a large proportion of demolition waste and useable construction material is discarded in landfill destinations, making natural issues because of the shortage of such sites, unplanned transfer of disposal, and the ecological expense of transporting demolition waste. In a concrete mixture, aggregate represent about 80% of concrete. Therefore, the replacement of NCA (natural coarse

aggregate) in various percentages with the RCA (recycled coarse aggregate) can be really helpful to make a traditional concrete as a sustainable material (Safiuddin et al., 2011). Panda et al studied that up to 30% replacement of aggregate in SCC (self-compacting concrete) there is no noticeable decrease in strength and other properties were found. Increment in RCA above 30% will inversely affect concrete properties(K C Pandaa 2013).

Recycled aggregates additionally reduces the amount of virgin aggregates to be made, consequently less evacuation of natural resources. While being smashed into smaller particles a lots of carbon dioxide is absorbed. This diminishes the amount of CO_2 is the air. The utilization of reused aggregates isn't easy but difficult to utilize on the grounds because their properties are not quite the same as natural coarse aggregates. That's the reason the nature of RCA can vary when gathered from various sources. The qualities of RCA ought to be low density, low mechanical strength, and high water absorption, more noteworthy porosity when compared with NCA (P. Saravana Kumar and G. Dhinakaran, April 1, 2012, Etxeberria et al., 2007). However, the cost of crushing RCA is still expensive.

The CFST (concrete-filled steel tubular) structures have many structural benefits, which includes high load bearing capacity and fire resistances, large energy absorption and ductility capacities. It also reduces the construction cost and time required for shuttering because of no need for shuttering (Han et al., 2014).Several researchers come up with the result that most of the mechanical properties of recycled aggregate CFST are similar to that of the ordinary concrete CFST; however, reduction in its strength and modulus was found. Steel tabular columns with concrete filled are vulnerable to degradation due to corrosion, which results in the reduction of strength. For the GFRP (Glass Fibre Reinforce Plastic), the brittle failure of hoop break led to the failure of GFRP confined concrete(Xiao et al., 2012). The exceptional properties which includes higher resistance to environmental attacks and electromagnetic transparency make the plastic attractive for various structural applications. Compressive strength of CFPT (concrete filled plastic tube) increased between 1.18 to 3.65 times the unconfined strength(Gathimba Naftary K, 2014).

In this study, recycled aggregate CFST and CFPT confined concrete were investigated for mechanical and durability assessment by using various percentages of Recycled aggregate (0%,10%,20% and 30%) as a replacement of coarse aggregate. Various tests were performed and results were compared with the control specimen.

2. Materials and Methodology:

The materials that were used were: Coarse Aggregate, Fine Aggregate, Water, Cement (OPC), Recycle Coarse Aggregate (Lumps), Steel Cylinders/tubes and Plastic Tube.

2.1 Coarse Aggregate:

Coarse Aggregates are obtained from the ware house located near CUI, Abbottabad Campus, Pakistan. Specific gravity, fineness modulus and water absorption of CA was found to be 2.68, 2.9 and 3.07% respectively.

2.2 Fine Aggregate:

Fine Aggregates are obtained from the shop located near CUI, Abbottabad Campus, Pakistan. Specific gravity, water absorption and fineness modulus of FA was found to be 2.43, 2.04% and 2.65 respectively.

2.3 Cement:

Ordinary Portland cement (OPC) ASTM C150 Type-I was used throughout the research. Density, Initial and the Final setting time was found to be 3.15g/cm^3, 66 min and 335min respectively. Fineness and surface area of Cement was 97.76% and 2827 cm^2 /g.

2.4 Recycled Aggregate:

Demolished building waste was taken which includes (slab, beams and columns) opposite to Daewoo Bus stand Abbottabad and then with the help of crushing plant crushed the demolished waste into lumps (having size 50mm to 90mm). These lumps were used as recycled aggregate and replaced with natural aggregate different proportion (0%,10%, 20% and 30%). Water absorption and Specific gravity of RCA was found to be 8.34% and 2.50 respectively.

2.5 Steel Tube and Plastic Tube:

Diameter (inner to inner) and the wall thickness of steel and plastic tubes were 6in x0.0662in and 6in x 0.19in respectively, while the height of both tubes were 12in.

2.6 Testing Procedure:

Concrete cylinders used had height and diameter (12in x 6in) and therefore volume (339.29in^3) and concrete mix was M20 (Mix whose compressive strength after 28 days curing is 20N/mm^2) while mix proportion was 1:1.5:3. The Steel tube and plastic tube were used in which concrete was cast and properties of the recycled aggregate concrete filled tubes (plastic and steel) were observed. Recycled aggregate lumps (50mm to 90mm) were replaced with natural aggregate in different proportion (0%,10%, 20% and 30%). After the selection of material, we had casted 3cylindres for each replacement of recycled aggregate for each test. Different tests, such as the slump test for workability, compressive and indirect tensile tests for strength were conducted for checking structural performance and mechanical properties. Recycled aggregate simple cylinder, CFST and CFPT results were compared with the control specimen (without any recycled aggregate used).

3. Results and Discussion:

3.1 Workability Test:

This test was conducted as per ASTM C 143. Reduction in slump value was noticed with the increment of recycled aggregate proportion that's may be due to high water absorption of recycle aggregate. R0, R10, R20 and R30 shows recycled aggregate replacement percentages with natural coarse aggregate.

Figure-1: Workability Test by Slump method

3.2 Fresh Concrete Density:

An increase in a percentage of recycled aggregate reduces the fresh concrete density. By the replacement of the recycled aggregate up to 30%, fresh concrete density decreased by 7.84% as compared to natural aggregate concrete. Values ranges from 2269.77 kg/m^3 to 2447.836 kg/m^3.

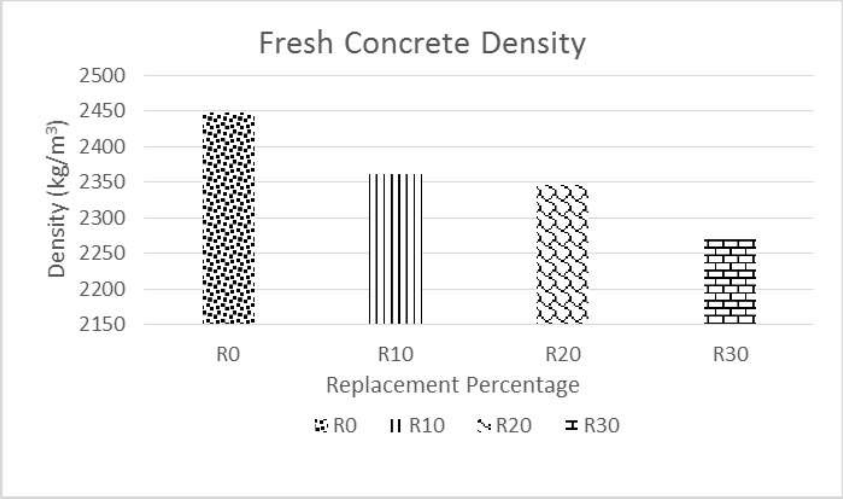

Figure-2: Fresh Concrete Density

3.3 Water Absorption Test:

The rate of water absorption was increasing with an increase in recycled aggregate proportion that's may due to the quantity of mortar attached (because it has porous structure) with it, and also recycled aggregate initial water absorption was 2.74 times (174%) higher than natural coarse aggregate.

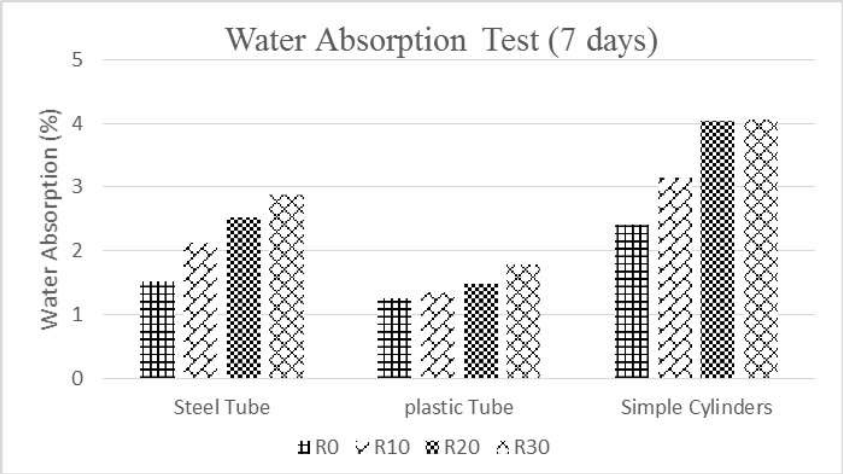

Figure-3: Water Absorption Test (7 days)

3.4 Compressive Strength Test:

This test was determined as per ASTM C39. 7-days compressive test shows decrease in concrete strength with increment in recycled aggregate proportion. But recycled aggregate CFST shows strength which is more than double of the no confinement concrete (simple cylinders). Upon 30% replacement of the recycled aggregate reduction in concrete strength for recycled aggregate CFST, CFPT and the simple cylinders (without any confinement) was to be found 9.22% ,43.2% and 54.14% respectively.

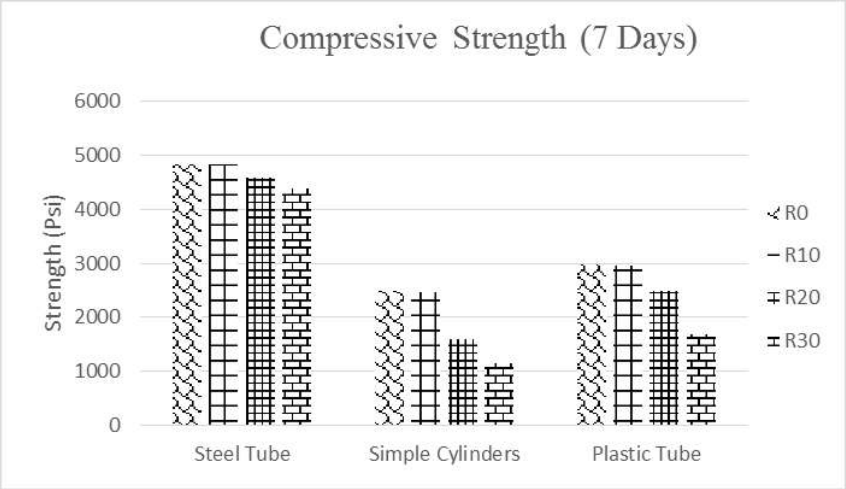

Figure-4: Compressive Test 7days

3.5 Indirect Tensile Test (Plastic Tube & Simple Cylinders):

An indirect tensile test was conducted on recycled aggregate CFPT and the simple cylinders because steel is good in tension so, we did not perform on it. It is found that upon 30% replacement of the recycled coarse aggregate reduction in CFPT and the simple cylinders, reduction in tensile strength was 32.2% and 45.68% respectively.

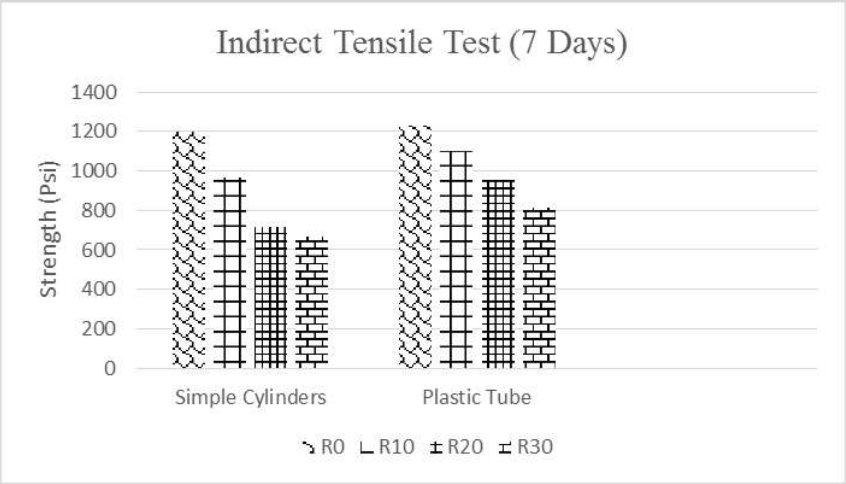

Figure-5: Indirect Tensile Test (Plastic Tube & Simple Cylinders)

4. CONCLUSIONS:

From the conducted study following conclusions can be drawn:

- Recycled Aggregate in CFST and CFPT reduces the amount of demolished waste of construction and reduces the use of virgin materials, which makes it a sustainable step towards the eco-friendly environment.

- 37.5% reduction in slump value was observed upon 30% replacement of the natural aggregate with recycled aggregate.
- Upon 30% replacement of recycled aggregate reduction in concrete strength for recycled aggregate CFST, CFPT and simple cylinders (without any confinement) was found 9.22% ,43.2% and 54.14% respectively.
- It is found that upon 30% replacement of the recycled coarse aggregate in CFPT and simple cylinders, reduction in tensile strength was 32.2% and 45.68% respectively.

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