EXPERIMENTAL STUDY ON STRENGTH OF CONCRTE BY USING SAND STONE WASTE

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ABSTRACT:- The world is facing challenges in developing the infrastructure to meet the expectation of the growing population. The demand for concrete is very high. Production of concrete results in a rapid increase in demand for aggregates, natural resources of aggregates are depleting at an alarmingly fast rate. Thus, there is an urgent need to look for an alternate source of aggregates. This waste causes severe environmental and health hazards after being dumped in landfills and open land.

There is a need to comprehensively study sandstone cutting wastes in concrete from strength and durability considerations. The present study explores the possibility of using sandstone cutting waste as a partial replacement of fine aggregates with varying w/c ratios to represent all grades of concrete. Microstructural studies have further elaborated concrete's rheological, mechanical, and durability properties with sandstone cutting waste.

The study was conducted by preparing thirty-one concrete mixes using four different w/c ratios, i.e., 0.3, 0.35, 0.40, and 0.45, and all concrete mixtures were designed according to provisions laid in IS 10262-2009. The fine aggregates were replaced by 10%, 20%, 30%, 40%, 50%, and 100% sandstone cutting waste (SCW), besides an additional mix proportion of 25% for a w/c ratio of 0.35, 0.4, and 0.45 was also prepared. The mechanical attributes of concrete with SCW in view of compressive strength, flexure strength, and tensile strength have shown encouraging results. There was an increase in strength of concrete samples up to an optimum level of 30% replacement of sandstone cutting wastes compared to the control concrete.

INTRODUCTION

Concrete is utilized to a great extent worldwide as a fast consuming material in construction, made up of cement, fine aggregates, coarse aggregates, and water. The development of any nation depends upon construction activities which have been increased tremendously in a few decades, resulting in an encouraging demand for concrete. Extraction and mining of natural aggregates are rapidly increasing to cater to the demand for production of concrete, which further resulting in depletion of resources, causing accumulation of stone wastes and slurry wastes. These wastes are becoming dumping yard in the vicinity of the mining area and further emission of dust causing the associated occupational exposure, deteriorates the baseline respiratory health status of workers and nearby human-being. Continual depletion of these natural resources imposing threats associated with the disposal of waste and health hazards, further indicating necessary utilization of the sustainable waste materials as a substitute for conventional fine and coarse aggregates in concrete. Raw materials like coarse aggregates and fine aggregates comprising 70%–80% of the concrete volume are the most important constituents of concrete, the studies were carried out in optimizing of sustainable waste materials in concrete based on various researchers' findings. Variety of waste materials including sludge waste, ground granulated blast furnace slag, Kota stone slurry, fly ash, granite powder, limestone slurry, ceramic waste & rubber waste, marble powder is being utilized in concrete production. Crushed rock dust acts as a filler and helps to reduce the total voids in concrete.

These wastes have shown aided benefits on properties of concrete and these include improvement in performance in terms of mechanical aspects as well as durability aspects of concrete besides conserving earth life balance & eco-friendly approach in construction .

The use of waste materials in place of virgin materials results in considerable energy savings by reducing the various engineering process for manufacturing the end product.

Sandstone have variation in composition depending upon locations, types & their occurrence and their effect is observed differently towards the compressive strengths. The compressive strength of concrete comprising of sandstone approximately reduces 50% owing to clay content while the presence of carbonates in sandstones results in better links between cement paste and aggregate with further improvement in strength.

Nominal strength is significantly affected by ageing & size effect of sandstone & different sizes of sandstone would have a variable effect on corresponding strength by taking consideration of correct grading analysis of sandstone.

Preliminary studies of Compressive strength indicate increasing trends while using quartz sandstone aggregates for varied ratios of combined aggregates, however, the strength decreases after achieving specific gradation owing to an increase in void spaces in bigger size aggregates and segregation .

Variation of strength properties of crushed limestone sand concrete under high temperature was very similar to that of natural sand concrete.

Quantity of sustainable stone fillers & powder waste generation has increased tremendously to a large extent . The cutting wastes of sandstone exclusively account for 30% of the mining waste reserves. Sand can be replaced by rock flour up to 40% without affecting strength and workability.

The above literature studies suggest the influence of different sustainable waste on concrete properties and further coarse aggregates of quartz sandstone were utilized by many researchers in past so the author has felt to attempt the use of fine aggregates in form of sandstone cutting waste with objectives of the economy to scale in construction, conserving river beds and sustainable development.

Materials utilized in research:-

Cement :-Portland Pozzolana Cement confirming to IS 1489:2015 (Part-1) was utilized in our research program for all concrete mixes designed in the laboratory.

Fine Aggregates (Natural Sand and Sandstone Cutting Waste) :-Fine aggregates used in studies are River sand and SCW.

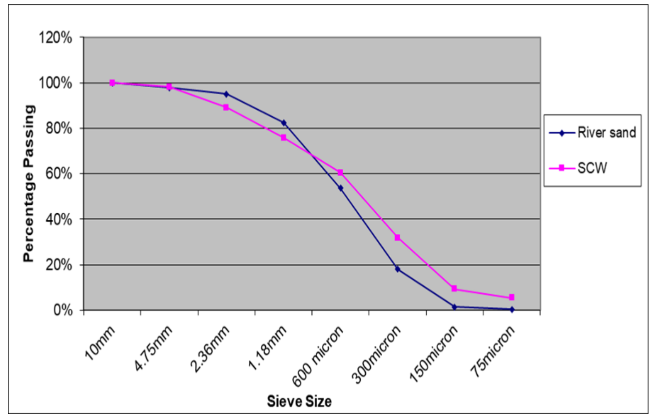

Figure 1 Graphs showing gradation of studied fine aggregates

Table 1 Chemical Composition of SCW and River Sand

Chemical Composition (%) by weight		
Chemical Compound	**SCW**	**Natural Sand**
SiO_2	94.68	80.78
CaO	Nil	3.21
Al_2O_3	0.24	10.52
Fe_2O_3	4.90	1.75
MgO	Nil	0.77
Loss on Ignition (LOI)	0.17	0.37

Coarse Aggregates:- The crushed aggregates of 20 mm and 10 mm were used in concrete obtained from a local crusher in, and the sampling was carried out as per IS 383-2016. Coarse aggregates were tested for gradation, moisture, impact value, and other tests as per the codal provisions for making concrete mix proportion. Most of the concrete mixes tested using different w/c ratios had an approximate 60% proportion of 20 mm size and 40% proportion of 10mm size coarse aggregates.

Chemical Admixture :- The percentage increase of SCW in concrete mixes indicates the workability loss due to the demand for higher water than natural sand. The loss of workability in concrete mixtures was improved by incorporating the modified polycarboxylic ether (Master Glenium SKY 8233) with a relative density of 1.08 and

0.1% chloride content as per the specification of IS 9103-1999.

Water:- The water utilized for all concrete mixes was clean and potable and free from impurities such as suspended solids, organic matter, dissolved salts, and the requirement specified in IS 456- 2000.

Description of Mix Proportion:- The research methodology comprised of detailed analysis by using the following approach:

- Water/cement ratio proposed in the research Series of 0.3, 0.35.0.4 and 0.45 w/c ratios.

- Fine aggregates (river Sand) were replaced in experimental program at interval of 0%, 10%, 20%, 30%, 40%, 50% and 100% by SCW. The replacement percentage was decided based on the trends shown by the literature survey and further the trial testing carried out in the laboratory with varying w/c ratios for understanding the effect of SCW on concrete properties. SCW mixes with 25% replacement were also prepared except at 0.3 w/c ratios.

Table 2 Test samples matrix for mechanical attributes of concrete

Test	Samples each mix	Curing Period
Compressive strength	9 cubes (100×100×100)	[7, 28 and] [90 days]
Split tensile strength	6 cylinders (150×300)	[28 days] [90 days]
Flexural strength	6 Beams (100×100×500)	[28 days], [90 days]

Table 3The test samples matrix for durability attributes of concrete

Test	Samples for each mix	CuringPeriod
Abrasion Resistance	Three cubes (100×100×100)	28 days
Corrosion	1 sample	28 days
Shrinkage	3 beams (75x75x300)	28 days
Chloride Penetration	3 sample (50x 100)	28days
Water permeability	3 cubes (150×150×150)	28 days
Water absorption	Six cubes (100×100×100)	24 hrs.
Carbonation	12 cubes (100×100×100)	28 days
Acid resistance	Six cubes (100×100×100)	28 days
Sulphate resistance	9 cubes (100×100×100)	28 days
Electrical Resistivity	2 sample of beam	90 days
Ultrasonic Pulse Velocity (UPV)	3 sample of beam	90 days
Sorptivity	3 sample (50x100)	28 days

RESULTS

Workability (Slump):- The Slump was measured by slump cone apparatus, and as per observations, it was identified, as the percentage replacement of sandstone cutting waste increases, the workability of concrete decreases. It could be attributed to the higher amount of water absorption by these fine particles and internal friction in sub-angular particles of SCW. The slump values for control mix were 115,115,100,110 mm and for 100% replacement of fine aggregates were 90,90,90,85 mm for 0.3,0.35,0.4 ,0.45 w/c ratio respectively (shown in Figure 4.1). However, the target slump was achieved in our research by adding a new generation modified super-plasticizer, Master Glenium SKY 8233. The target slump (100±15) mm was obtained for all mixes. Quartzite sand has positively influenced the workability of concrete, as it reduces the workability at a higher replacement level in concrete. Similarly, slump loss was observed when the quartz sandstone waste was added, and it was due to the higher water absorption tendency of quartz sandstone powder than natural sand.

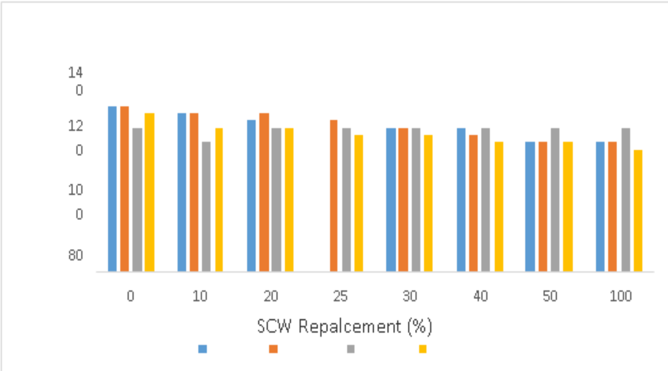

Figure 4.Slump Values versus SCW replacement

Compressive Strength:- The compressive strength results for varying w/c ratios at 7, 28, and 90 days are presented in Figures 4.2, 4.3, and 4.4, respectively. The variation in compressive strength value was observed in the samples. It was observed that replacing Sandstone cutting waste up to 10 percent resulted in an increase in 7 days' compressive strength for 0.3 and 0.45 w/c ratios compared to the control concrete. However, the rise of compressive strength was up to 30% for w/c 0.35 and 0.45 w/c ratio. Densification of concrete was also observed while adding the SCW in the above cases. The replacement of sandstone cutting waste in concrete up to 30% indicated an increase in strength (38.85 MPa, 44.58 MPa) at 0.4 w/c ratios and an increase in strength (37.2 MPa, 37.56 MPa) at 0.45 w/c ratio for 28 and 90 days, respectively when compared with control mix concrete.

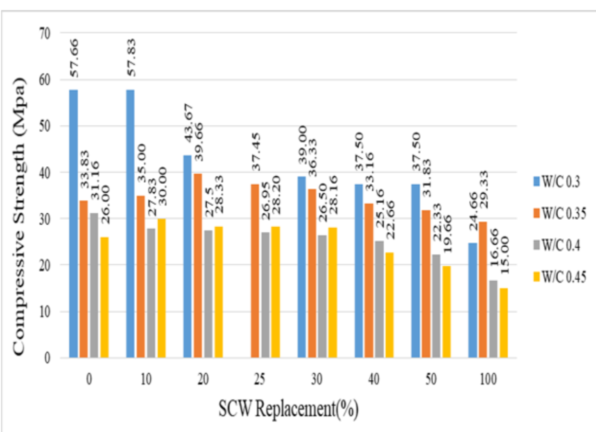

Figure 5 Compressive Strength Values versus SCW replacement (7-days)

Figure 6 Compressive Strength Values versus SCW replacement (28-days)

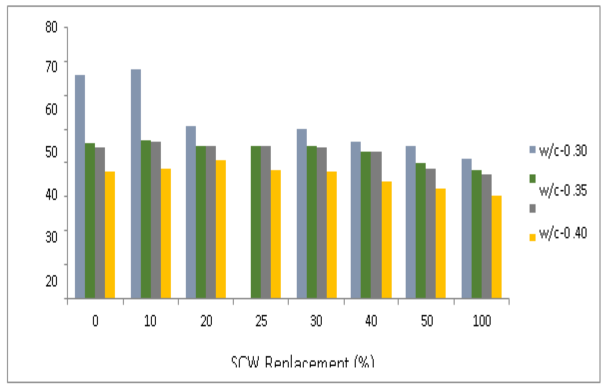

Figure 7 Compressive Strength Values versus SCW replacement (90-days)

Flexural Strength:- Concrete beams of size (10cm x 10cm x 50cm) were cast and tested on a flexure strength machine after 28 and 90 days of curing. Flexure strength test results (Figures 4.5 and 4.6) indicate higher strength values up to 25% to 30% replacement level of SCW in concrete compared to control mix concrete at 0.4 and 0.45 w/c ratio. Higher-strength values up to 10% SCW replacement in concrete at 0.30 and 0.35 w/c ratio were observed. However, the flexural strength was found maximum with 10% replacement of sandstone cutting waste in concrete at all the w/c ratios

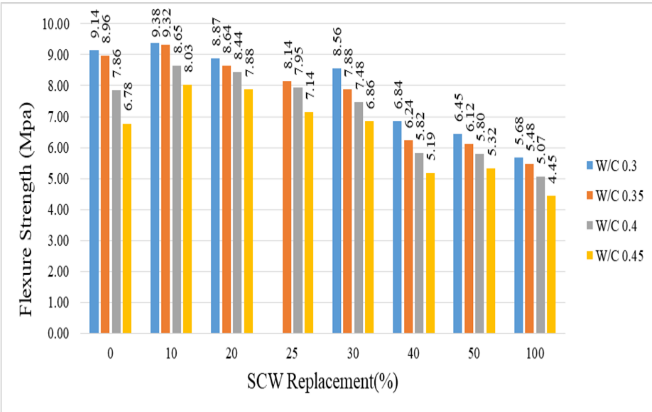

Figure- 8 Flexure Strength Versus SCW replacement (28-days)

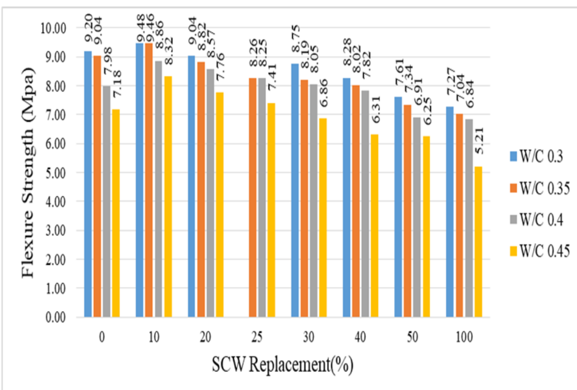

Figure- 9 Flexure Strength Versus SCW replacement (90-days)

Split Tensile Strength:- Concrete cylinders of size (15cm x 30cm) were cast to measure the split tensile strength, and the test was performed on a compression testing machine after 28 and 90 days. Split tensile test results indicate the increase in strength with partial replacement of SCW in concrete and the trends shown in Figures 4.7 and 4.8. These indicate a higher strength value (2.71MPa) up to 30% replacement level at w/c ratio of 0.4 and higher strength value (2.7MPa) up to replacement of 25% at w/c ratio of 0.45, when compared with control mix concrete value (2.67 MPa, 2.67 MPa respectively) for both w/c ratios at 28 days. However higher strength value (3.1MPa) was obtained up to 10% replacement level of SCW in the case of 0.35 w/c ratio and higher strength value (3.98 MPa) up to use of 10% SCW in concrete at 0.3 w/c ratios when compared with control mix concrete values (3.0 MPa,3.96 MPa respectively) at 28 days. Similar increasing trends were observed in split tensile strength at 90 days with partial replacement of SCW in concrete.

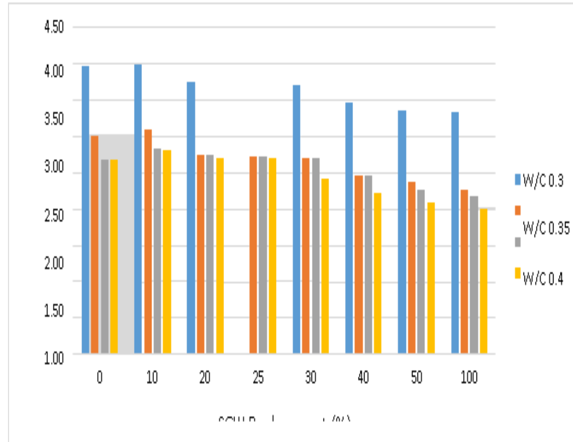

Figure- 10 Split Tensile Strength versus SCW replacement (28-days)

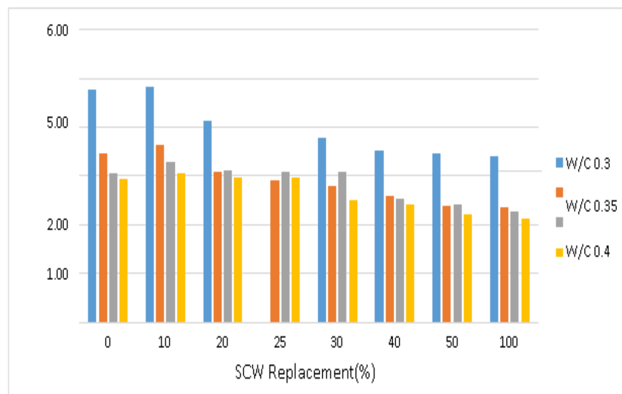

Figure- 11 Split Tensile Strength versus SCW replacement (90-days)

Abrasion:- This test was carried out to measure the average depth of wear on selected cubes of size (10cm x10cm x10cm). The analysis of results with an average abrasion value of 3 specimens is shown in Figure 4.9. It indicates a slight increase in wear depth for 0.3 0.35,0.4 and 0.45 w/c ratio for all replacement levels with SCW compared to control mix concrete. The Increase in the depth of wear was maximum for 100% replacement for all w/c ratios. However, with 40% SCW in concrete at a w/c ratio of 0.35 and 0.4, the wear depth was less with the value of1.13mm

CONCLUSIONS:-

- The assessment of properties of sandstone cutting waste from the literature survey and testing carried out in the laboratory, suggest that 25–30% sandstone cutting waste can be suitably utilized in concrete by replacing river sand.

- The mix comprises of higher sandstone cutting waste requires a higher dosage of super-plasticizer when the water-cement (w/c) ratio is low. This research shows that slump values are decreasing with increasing levels of sandstone cutting waste in concrete when compared.

- Flexure strength test results indicated higher strength values up to 25 to 30% replacement level of SCW in concrete than control mix concrete at 0.4 and 0.45 w/c ratios, respectively, and higher strength value up to 10% SCW concrete at 0.30 and 0.35 w/c ratios.

- Split tensile test results show an increase in strength with partial replacement of SCW up to 30% replacement level at w/c ratio of 0.4 up to replacement of 25% SCW at 0.45 w/c compared with control mix concrete for both w/c ratios at 28 and 90 days. However, higher strength was obtained by up to 10% replacement of SCW in the case of 0.3and 0.35 w/c ratio compared with control mix concrete values at 28 and 90 days.

- The analysis of results with an average abrasion value of 3 specimens indicated a slight increase in wear depth for 0.3 0.35, 0.4, and 0.45 w/c ratio for all replacement with SCW compared to control mix concrete. The higher wear depth was due to the large proportion of sedimentary processed cutting particles and further chipping action of sandstone cutting waste in concrete.

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