Experimental Investigation on Split Tensile and Compressive Strength of Concrete Replacing Fine Aggregate with Sea Sand and Copper Slag

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Abstract

Limitations have been laid on the large scale mining of river sand from river beds. In this context there was a need to consider an alternate solution to prevent erosion of river bed. Sea sand which is present in abundance and copper, a metal with high toughness property is considered for replacement. This paper mainly presents the practical study of the compressive strength and tensile strength of the concrete. In this study, M25grade concrete was used and tests were conducted for different mix proportions of sea sand and copper slag. The obtained results were compared with those of control concrete made with river sand. The tensile and compressive strength of concrete specimens for respective mix proportions were tested at 7, 14 and 28 days of water curing. The compressive strength of hardened concrete is reduced with increased percentage of replacement of sea sand, which is controlled by addition of copper slag.

Keywords— *Copper slag, Sea Sand, Split Tensile strength, Compressive strength.*

I. INTRODUCTION

Concrete is one of the most widely used construction material in the world. Cement and aggregate which are the most important constituents used in the concrete production, are then vital materials needed for the construction industry. This inevitably let to a continuous and increasing demand of natural materials used for their production. In this research study was carried out on the use of sea sand and copper slag as a partial replacement for fine aggregates in concrete construction. The work was carried out by conducting tests on raw materials to determine their properties and suitability for the experiment. Concrete mix designs are prepared using IS method for M25 grade of concrete. The specimens were cast with percentage replacement of fine aggregate by 25% and 50% of sea sand and copper slag. Moreover control mixes with no replacement of fine aggregate were cast to make comparative analysis. The prepared sample consists of concrete cubes and cylinders. Laboratory tests were carried out on the prepared concrete specimens. The lists of test conducted are slump, compressive strength and split tensile strength.

In our world today, concrete has become ubiquitous. It is hard to imagine modern life without it. Approximately five billion tonnes of concrete are used around the world each year. The increasing popularity of concrete as a construction material is placing a huge burden on the natural sand reserves of all countries.. In view of the environmental problems faced today considering the fast reduction of natural resources like sand and crushed granite aggregate, engineers have become aware to extend the practice of partially replacing fine aggregate with waste materials. In this practical study, the tensile and compressive strength of concrete made by using sea sand and copper slag as a partial replacement to fine aggregate is determined by replacing river sand in various percentage sent is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website.

II. OBJECTIVE OF THE STUDY

The objective of the current study is to analyse the compressive strength and split tensile strength of concrete made by utilizing sea sand and copper slag and cites their comparison with control concrete. The study consists of 5 parts:

1. Concrete casted with 100% river sand as fine aggregate
2. Concrete casted with 50% river sand and 50% sea sand as fine aggregate
3. Concrete casted with 50% river sand and 50% copper slag as fine aggregate
4. Concrete casted with 50% river sand, 25% sea sand and 25% copper slag as fine aggregate
5. Concrete casted with 50% sea sand and 50 % copper slag as fine aggregate.

III. MATERIALS AND PROPERTIES

A. Portland Pozzolana Cement

Pozzolans are siliceous material than can be added to concrete mixtures, potentially lower the mix cost without harming the performance characteristics. In long term, PPC cements typically achieve strengths equal to or greater than OPC. It makes concrete more impermeable and denser. PPC produces less heat of hydration and offers greater resistance to the attack of aggressive waters. PPC needs enough moisture for sustain pozzolanic activity little longer curing is desirable. It mainly reduces the leaching of calcium hydroxide liberated during the setting and hydration of cement.

B. Fine Aggregate

Aggregates are inert granular materials such as sand, gravel, or crushed stone that, along with water and Portland cement, are an essential ingredient in concrete. Natural gravel and sand are usually dug or dredged from a pit, river, lake, or seabed. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large-size gravel. In this Experimental Investigation three distinct types of aggregates are been used

1. River sand
2. Sea sand
3. copper slag

1) River sand: Locally Available Free of debris River bed sand is been used. Among Various characteristics, the most important one is its grading coarse may be preferred as Fine aggregate, increase the water demand of concrete and very fine sand may not be essential as it usually has larger content of thin particles in the form of cement. The sand particles should also pack to give minimum void ratio, higher voids content lead to requirement of more mixing of water. Properties such as void ratio, gradation, specific gravity and bulk density has to be assessed with optimum cement content and reduced mixing of water. Table I indicates the properties of River sand

Table I: Properties Of River Sand

S.No	Test Analysis	Value	Remarks
1	Fineness Modulus	3.1	Tested Results are satisfactory
2	Specific Gravity	2.612	
3	Bulk Density	1.42	
4	Percentage of voids	45.6	

2) Sea sand: Due to the recent growth in the construction industry, the demand for fine aggregates is escalating rapidly. River sand has been the most widely used fine aggregate, In order to overcome the demand for river sand and to prevent erosion over the river bed, we have focused on using sea sand as an alternative. The material has been collected from the coastal region of Kanyakumari. Physical properties of coastal soils are scarce in number. Usually these properties are studied together with the other soil characteristics. The texture of coastal soils may vary in a wide range from loose sandy deposits to heavy soils. Table II indicates the properties of Sea Sand.

TABLE II: PROPERTIES OF SEA SAND

S.No	Test Analysis	Value	Remarks
1	Specific gravity	2.629	Tested Results are satisfactory
2	Chloride content	3545 mg/l	
3	Hardness	7100 mg/l	

3) Copper slag: It is found in past researches that untreated sea sand will give a lower compressive strength than control mix. Whereas copper slag increases the strength, so these two materials of alternative behaviour is combined. Copper slag can use as a partial fine aggregate in concrete. Copper slag is by product of the manufacture of copper. Large amount of copper slag are generated as waste worldwide during the copper smelting process. The world copper production is currently about 14.98 million tons and it is estimated that for every ton of copper produced, about 2.2 tons of copper slag is generated as a waste. Many researches have been carried out studies on long-term stability of the slag in sea water. Table III indicates the properties of Copper Slag.

TABLE III: PROPERTIES OF COPPER SLAG

S.No	Test Analysis	Value	Remarks
1	Specific gravity	3.65	Tested Results are satisfactory
2	Fineness modulus	4.62	
3	Water absorption	0.3	

IV. EXPERIMENTAL STUDY

A. Compression test

The experimental investigation has been carried out on the test specimens to study the strength properties as a result of replacing fine aggregate i.e River sand by sea sand and copper slag in various percentages namely 25% and 50%. The inside of the mould was applied with oil to facilitate the easy removal of specimens. The sand and copper used was clean from all inorganic impurities and passes through 2.36mm sieve and retained on 150 micron .The mixing of raw material was continued until a uniform colour was obtained. Fresh concrete was placed in mould in three layers, and each layer was compacted using tamping rod. The size of the cube mould is 150

× 150 × 150 mm. After 24 hours, the specimens were taken out from the mould and placed in curing tank. Compressive strength test were carried out after 7 days, 14 days and 28 days using compression testing machine *Figure 1*.

Table IV Indicates the Compression Test Results.

Fig I. Compressive Strength Test

B. SPLIT TENSILE STRENGTH TEST:

The split tensile test is done with a cylinder of size 150mm diameter and 300mm length. Specimens with 25 % and 50% replacement of fine aggregates were utilized for test. The cylinders were kept in curing for 7,14 and 28 days after curing the specimens are tested in compressive testing machine. Load is applied along the length and the load at which the cylinders split into two halves is noted *FigureII*

Tensile Strength = 2P/(3.14 x D x L)

P - Crushing load ; D - Diameter of the cylinder ; L - Length of the cylinder

Table V indicates the Tensile Test Results.

Fig II. Split Tensile Strength Test

V. RESULTS AND DISCUSSION

The specimens containing different percentage of aggregates were tested using the above tests and the following result is been obtained.

TABLE IV: COMPRESSIVE STRENGTH OF M25 GRADE CONCRETE

CUBE NOTATION (%)			COMPRESSIVE STRENGTH (N/mm^2)		
RIVER SAND	SEA SAND	COPPER SLAG	7 DAYS	14 DAYS	28 DAYS
100	Nil	Nil	16.5	22.33	25.5
50	25	25	17.2	32.91	39.86
Nil	50	50	22.1	33.7	41.7
50	50	Nil	13.2	15.13	16.2
50	Nil	50	27	37.21	43.23

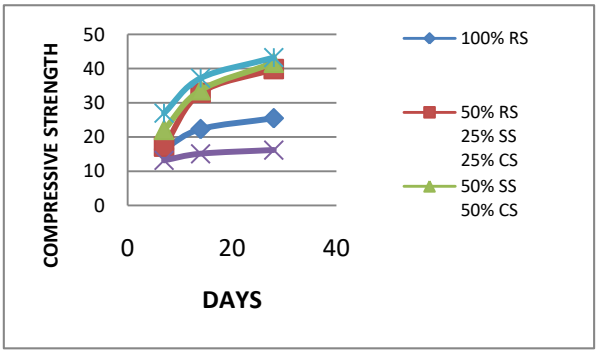

Fig III. Comparison of compressive strength

TABLE V: SPLIT TENSILE STRENGTH OF M25 GRADE CONCRETE

CUBE NOTATION (%)			TENSILE STRENGTH (N/mm2)		
RIVER SAND	SEA SAND	COPPER SLAG	7 DAYS	14 DAYS	28 DAYS
100	Nil	Nil	2.3	2.6	3.25
50	25	25	1.9	2.39	2.1
Nil	50	50	1.6	2	2.6

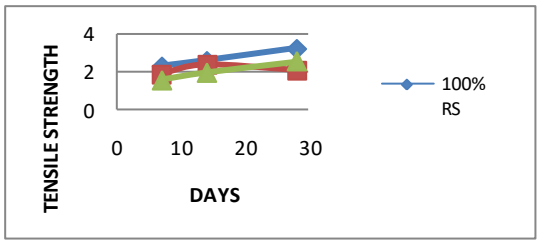

Fig IV Comparison of Tensile Strength

Note : Rs-River Sand, Ss-Sea Sand , Cs-Copper Slag

VI. CONCLUSION

Based on Experimental Study, The following conclusions were drawn ,

1) The tests on hardened concrete showed that the use of sea sand in concrete mixes produce a significant reduction in compressive strength with increased composition of sea sand as aggregate content.
2) The use of copper slag as a replacement of fine aggregate increases the compressive strength.
3) It is also visible that the retarding compressive strength due to usage of sea sand is compensated by the agitating behaviour of copper which have high toughness strength.
4) The high chloride content in sea sand is an evidence for affecting the Structural behaviour of the building. From this it can be noted that sea sand holds the property to cause corrosion in Reinforced Concrete Structures.
5) Though copper have a high strength property, it tends to decrease the strength of concrete when it is added beyond 60%. Economically this replacement is beneficiary but the environmental drawbacks have to be studied.

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