EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF CONCRETE WITH PARTIALLY REPLACEMENT OF RIVER SAND WITH SEA SAND

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Article History: Received: 06-05-2023 **Revised:** 13-06-2023 **Accepted:** 23-06-2023

ABSTRACT: An experimental study was carried out to evaluate the Effects of using sea sand partially replacement as fine aggregate of concrete on mechanical properties has been presented in this paper. The sand is partially replaced with sea sand with the dosage of 20 % ,30 % and 40% of river sand. The sea sand used was untreated which enhanced the mechanical properties of concrete compare to ordinary concrete. The workability was maintained with addition of superplasticizer, the water cement ratio adopted was 0.48 for all mix of concrete. Based on the results the compressive strength, split tensile strength, flexural strength, ultra pulse velocity and rebound hammer test were performed and results were obtained optimum at 30 % dosage of Sea sand as 9.94 %, 22.66%, 21.34%, 11.81%, and *12.81% respectively.*

KEY WORDS: Sea sand, compressive strength, split tensile strength, flexural strength, ultra-pulse velocity (UPV) and rebound hammer.

1. INTRODUCTION

The significant environmental concerns arising from the widespread use of raw materials, notably river sand and freshwater, in concrete production have prompted attention. Extracting river sand as a fine aggregate adversely impacts river ecosystems, navigation, and flood control. Recognizing the scarcity of river sand, numerous countries have sought alternatives such as sea-sand and crushed stone fines to address these challenges. In the UK, for instance, sea-sand has been adopted as a substitute for river sand in construction projects. Globally, a staggering 90% of dredged sea-sand has been employed as a raw material within the construction industry, with approximately 45% of it utilized as fine aggregate in concrete production. The use of sea-sand as a substitute for river sand presents a potential solution to address the environmental concerns associated with river sand extraction [1]. However, it is crucial to ensure that sea-sand extraction is conducted sustainably, taking into consideration the impacts on marine ecosystems and coastal areas. Implementing regulations and adopting proper management practices are essential to mitigate any adverse effects and ensure responsible utilization of sea-sand in construction activities.

The utilization of sea-sand as an alternative to river sand offers a potential remedy for the environmental issues linked to river sand extraction. However, it is vital to ensure that the extraction of sea-sand is conducted in a sustainable manner, with careful regard for the impacts on marine ecosystems and coastal regions. The implementation of regulations and the adoption of appropriate management practices are critical to minimize any negative consequences and ensure the responsible use of sea-sand in construction. To achieve sustainable sea-sand extraction, a balanced approach is necessary, considering both the construction industry's needs and the preservation of marine environments. This entails conducting comprehensive environmental impact assessments, identifying vulnerable areas, and implementing measures to safeguard marine habitats, biodiversity, and water quality during the extraction process. Additionally, strict monitoring and regulation of extraction operations are crucial to prevent overexploitation and disturbance of coastal ecosystems. Effective collaboration among stakeholders, including government authorities, environmental agencies, construction companies, and research institutions, is essential [2]. It is possible to develop and enforce sustainable practices across the sea-sand extraction and construction supply chain. Through prioritizing environmental protection, the benefits of sea-sand can be harnessed while minimizing ecological impacts, ensuring responsible and sustainable utilization in construction activities.

2. EXPERIMENTAL PROGRAM

2.1 Materials Used

The concrete containing Sea Sand 30% replacement specimens had a compressive strength of 43.45 MPa. The concrete consisted of 413 kg/m^3 of 53 grade ordinary Portland cement, 624.20 kg/m^3 of fine aggregate with a specific gravity river sand and sea sand of 2.61 and 2.65 of Zone-III, 1198.613 kg/m^{3}of coarse aggregate with a specific gravity of 2.80, 0.45 W/C ratio (IS 10262:2019).

2.2 Cement

OPC 53 grade Ramco cement, which complies with the specifications of IS 12269 (2013), was utilized for all concrete mixes employed in this research investigation. The cement's characteristics are outlined in Table 1 & Fig.1 below

Fig.1 OPC 53 grade Cement

Table 1 Properties of Cement

Properties	Observations
Specific Gravity	3.16
Initial setting time	45 minutes
Final setting time	383 minutes
Specific surface area	300

2.3 Aggregate

Crushed granite, with a maximum nominal size of 20mm and 12mm and an angular shape that satisfies the specifications of IS 383:2016, has been employed. The specific gravity of the granite is recorded as 2.80 and shown in Table 2.

Fig. 2 Aggregate

Table 2 Properties of Aggregate

Aggregate	Specific Gravity	Grading Zone
Fine aggregate	2.61	Zone III
Coarse aggregate	2.80	-

2.4 Water

For the preparation of the design mix of M30 grade concrete, portable water is utilized. The water content used is 0.45, as specified in Table-5 of IS 10262-2019. The desired workability of the concrete is set at a slump value ranging from 50mm to 70mm.

2.5 Super plasticizer

Fosroc Conplast SP 430 Super Plasticizer, as indicated in Table 3, possesses the necessary properties to allow for the reduction of water content by up to 30% in concrete mixes while preserving workability.

Table 3 Properties of Super plasticizer

Properties	Observed
Colour	Dark brown
Form	Liquid

2.6 River sand and Sea Sand

a) River sand

River Sand of Zone III (As per IS 10262-2019)is used as fine aggregate as partial replacement of Sea sand and properties are presented in Table 4(a) & Fig.3(a).

Table 4(a) Properties of River Sand

Properties	Observed
Specific Gravity	2.61
Zone	III
Bulk Density	1585 kg/m^3

Fig. 3(a) River Sand

b) Sea Sand

Sea Sand of Zone III is used as fine aggregate as partial replacement of river sand and properties are presented in Table 4(b) & Fig.3 (b).

Table 4(b) Properties of Sea Sand

Properties	Observed
Specific Gravity	2.65
Zone	III
Bulk Density	1589 kg/m^3

Fig. 3(b) Sea Sand

2.9 Test Specimens

The investigation includes laboratory tests such as Compressive Strength test (IS 1959-2004 Reaffirmed), Flexural Strength test (IS 1959-2004 Reaffirmed), Split Tensile Strength (IS 1959-2004 Reaffirmed), Rebound Hammer (IS 13311-1992) and Ultra Pulse Velocity (IS 13311-1992). The details of specimens are presented in Table 5. The designation of all concrete specimens is presented in Table 6.

Table 5 Test Specimens

Experiment	Specimen	Size(mm)	No. of specimens
Compressive Strength Test (IS 1959-2004 Reaffirmed)	Cubes	150X150	12
Split Tensile Strength (IS 1959-2004 Reaffirmed)	Cylinder	150X300	12
Flexural Strength Test (IS 1959-2004 Reaffirmed)	Prism	100X100X700	12
Rebound Hammer (IS 13311-1992)	Cubes	150X150	12
Ultra Pulse Velocity (IS 13311-1992)	Cubes	150X150	12

Table 6 Designation of Test Specimens

Sl. No	Test Specimen	Description
1	CC	Control Specimen
2	S20	Sea Sand with Partially Replacement 20% of River sand
3	S30	Sea Sand with Partially Replacement 30% of River sand
4	S40	Sea Sand with Partially Replacement 40% of River sand

3. RESULTS AND DISCUSSIONS

3.1 Compressive Strength

Table 7 and Fig. 5, which present the outcomes of compressive strength tests conducted on specimens and the rate of strength development observed in various concrete mixes with a water-cement ratio of 0.45. The specimen containing 30% of sea sand showed 9.94% enhanced in compressive strength Compare to control specimen. The replacement of sea sand with regular sand in concrete has demonstrated an enhancement in compressive strength. Numerous studies have indicated that utilizing sea sand, either partially or entirely, as a substitute for regular sand can result in an increase in the concrete's compressive strength [5]. Fig.4 shows the experimental Test setup.

Fig. 4 Test Setup for Compressive Strength

This increase in compressive strength can be attributed to several factors. Firstly, sea sand typically possesses a higher fineness modulus compared to regular sand. The fineness modulus measures the fineness or coarseness of the aggregate utilized in concrete. With sea sand having a higher fineness modulus, it contains smaller particles in comparison. These smaller particles can fill the gaps between larger particles within the concrete mixture, leading to a denser and more compact structure. Consequently, this enhanced density contributes to improved compressive strength.

Table 7 Cube Compressive Strength Test Results

Ratio	Compressive Strength MPa
CC	39.52
S20	41.91
S30	43.45
S40	40.15

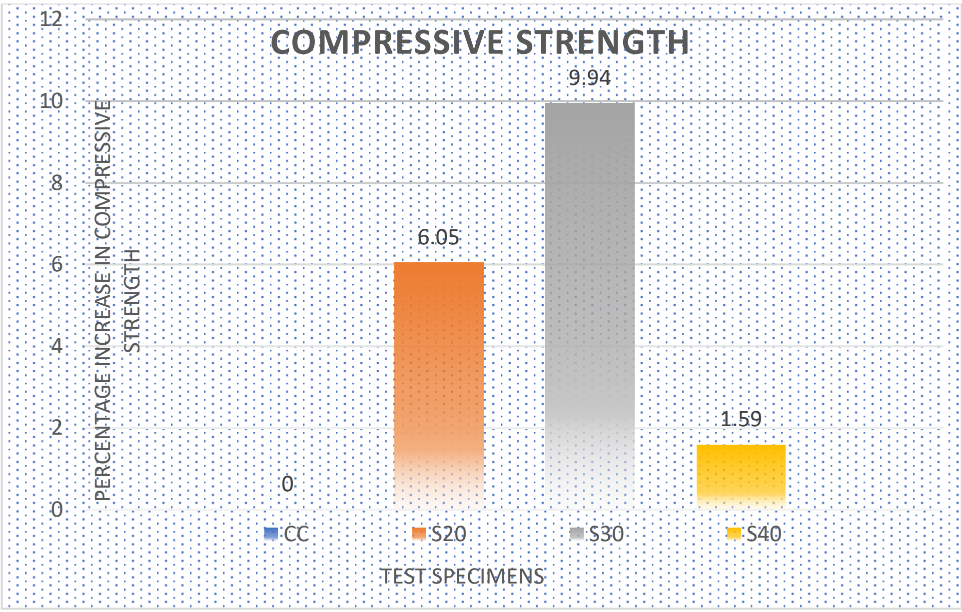

Fig.5 Effect of Sea Sand on Compressive Strength

3.2 Split Tensile Strength

Fig. 7 displays the splitting tensile strength of various concrete mix specimens. The highest tensile strength recorded was 22.69%, achieved by the specimen with a 30% replacement of sea sand. The increase in tensile strength was the shape of sea sand particles is a critical factor in determining the packing density and interlocking within concrete. When using alternative sands with angular or rough-shaped particles, the interlocking is enhanced, leading to improved tensile strength in the concrete [4]. The Table 8 shows Effect of Sea Sand on Split Tensile Strength and test setup in Fig.6.

Fig.6 Experimental Test Setup for Split Tensile Strength

Table 8 Split Tensile Strength Test Results

Ratio	Split Tensile Strength MPa
CC	4.72
S20	5.12
S30	5.79
S40	4.86

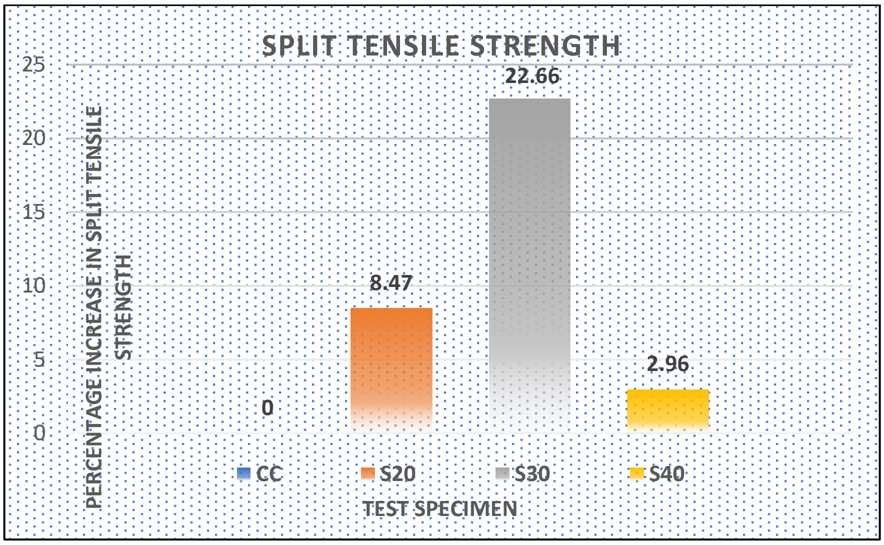

Fig.7 Effect of Sea Sand on Split Tensile Strength

3.4 Flexural Strength

Fig.8 & Table 9 exhibits the flexural strength results of all concrete mix specimens. Highest flexural strength for the specimens at 30% replacement of sea sand showed an increase of 21.34% this is due to the smaller particles of sea sand can fill the gaps between larger particles within the concrete mixture, leading to a denser and more compact structure.

Fig.8 Test setup for Flexural Strength

Table 9 Flexural Strength Test Results

Ratio	Flexural Strength MPa
CC	6.23
S20	6.89
S30	7.56
S40	6.52

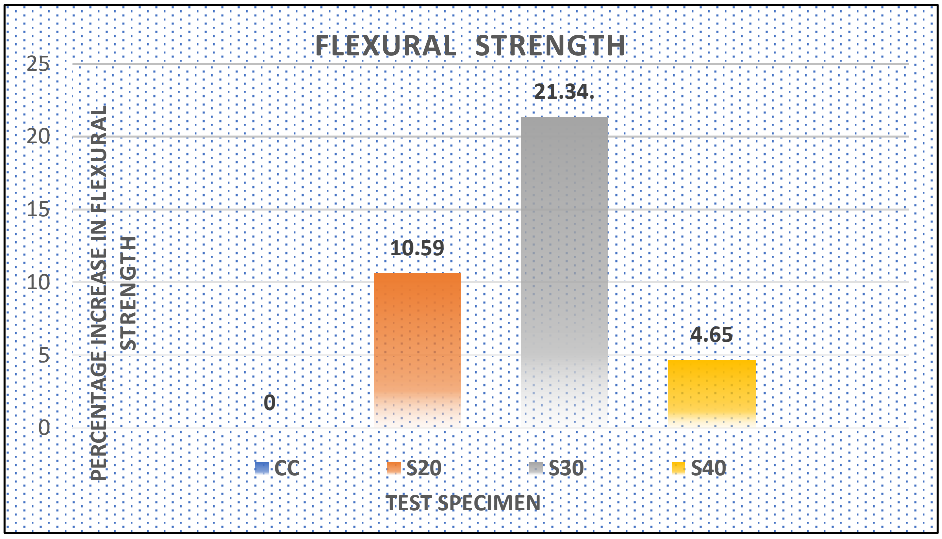

Fig.9 Effect of Sea Sand on Flexural Strength

3.5 Ultra Pulse Velocity

Fig.10 & Fig.11 & Table 10 exhibits the flexural strength results of all concrete mix specimens. Ultra pulse velocity for the specimens at 30% replacement of sea sand showed an increase of 11.81%. The ultra-pulse velocity of sea sand concrete depends on the density and stiffness of the material, which are influenced by the arrangement of particles. Sea sand, with its coarse texture, presents a challenge in achieving ideal particle packing. Inadequate particle packing can result in the formation of voids and air gaps, ultimately decreasing the density of the concrete and consequently impacting its ultra-pulse velocity.

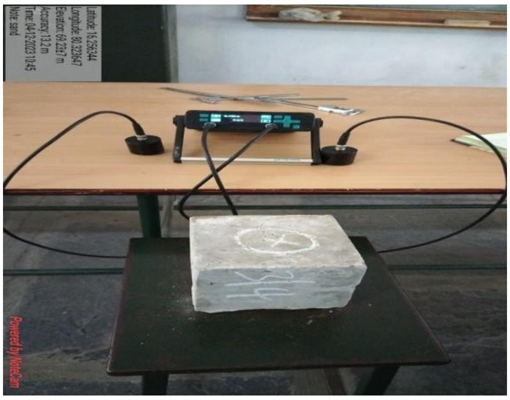

Fig.10 Ultra Pulse Velocity

Table 10 Test Results Ultra Pulse Velocity

Ratio	Ultra Pulse Velocity Test Km/sec
CC	3.985
S20	4.256
S30	4.456
S40	4.06

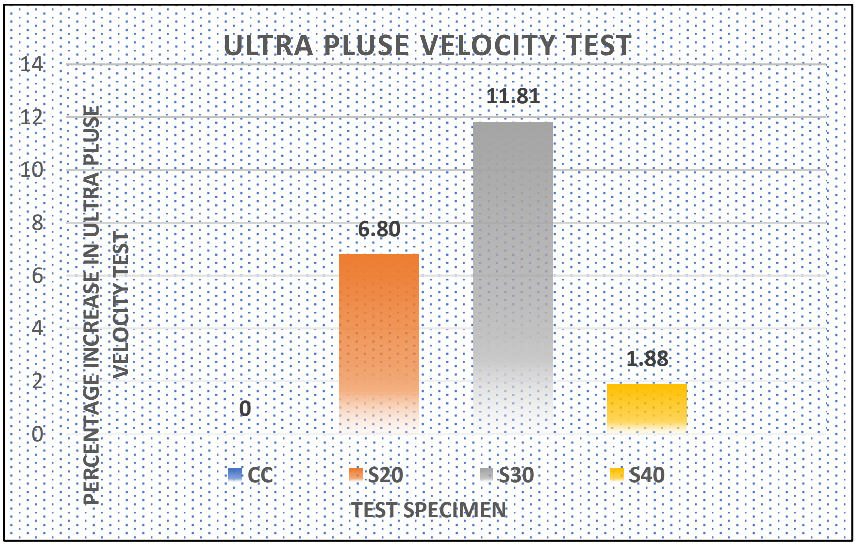

Fig.11 Effect of Sea Sand on Ultra Pulse Velocity

3.5 Rebound Hammer

Fig.12, Fig.13 & Table 10 exhibits the flexural strength results of all concrete mix specimens. The rebound hammer for the specimens at 30% replacement of sea sand showed an increase of rebound hammer to 12.81%. Compared to traditional river sand, sea sand generally has a coarser texture and may consist of irregularly shaped particles. These particle characteristics can influence the surface hardness measurements obtained through the rebound hammer test. The presence of irregular particles in sea sand concrete can introduce variations in the rebound values, potentially differing from those observed in concrete made with regular aggregates.

Fig.12 Test setup for Rebound Hammer

Table 11 Test Results of Rebound Hammer

Ratio	Rebound Number
CC	43.3
S20	46.78
S30	48.85
S40	44.89

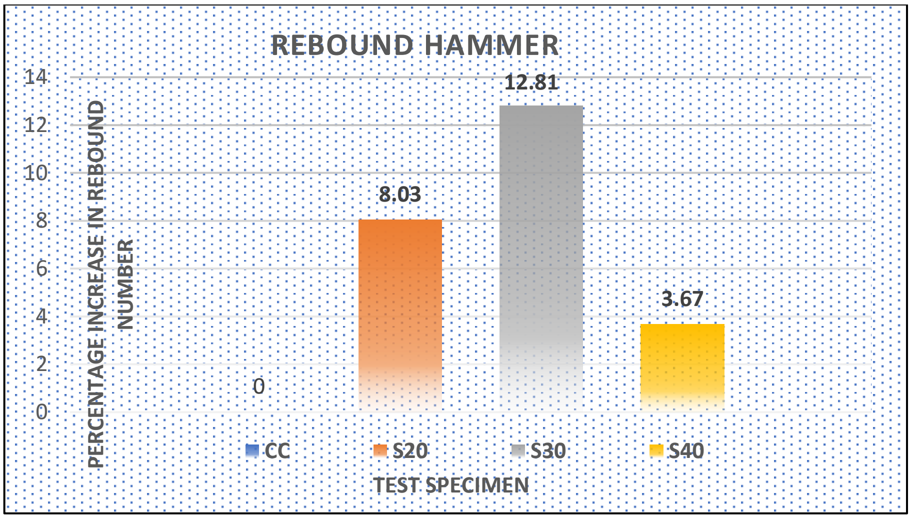

Fig.13 Effect of Sea Sand on Rebound Hammer

4. CONCLUSIONS

This paper addressed the use of sea sand in concrete and effects of sea sand on mechanical properties of concrete.

1. Replacement of sea sand 30% (S30) specimen in concrete showed an enhanced in compressive strength of 9.94 % compare to control specimens.
2. Sea sand 30% (S30) replacement concrete specimen in concrete showed an improvement in Split tensile strength 22.6% compare to control specimens.
3. Flexural Strength for concrete specimen S30 (sea sand 30%) showed enhanced of 21.34% compare to control specimens.
4. Ultra pulse velocity and rebound hammer showed an improved 11.81% and 12.81 % respectively. The enhancement is due addition of sea sand which influenced the densification of concrete matrix.

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