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Article

A Comparative Analysis: River Sand vs. Sea Sand in Concrete Performance

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Abstract: River sand is broadly used in the building industry, River sand has been the most used fine aggregate in the construction industry, but its excessive extraction has caused environmental issues and meeting the demand has resulted in several negative repercussions, including increased riverbed depth, a lower water table, and saline intrusion into rivers. As a result, there was an instant demand for substitutes for river sand, such as manufactured sand. An experiment is undertaken to test the strength and durability of cement concrete of M20 grade after partially replacing sea sand with river sand as fine aggregate. This compares the material properties of sea sand (SS) and river sand(RS).

Cement concrete blocks were evaluated for compressive strength after 7, 14, and 28 days of curing, with partial substitution of sea sand with river sand at intervals of 0%, 25%, 50%, 75%, and 100%. Concrete blocks were tested. Where the compressive and flexural strength values compiled for replacement (RS+SS) were tabulated and graphs are plotted to show compressive strength versus curing period.

Corrosion Test When performed on a concrete prism to detect the presence of these chlorides, the concrete may be damaged by modifying the time of set, increasing drying shrinkage, significantly increasing the risk of steel reinforcing corrosion, and causing efflorescence.

The compressive and flexural strength of a 50% substitution of sea sand with river sand is comparable to conventional concrete. There is little effect of corrosion on sea sand concrete.

Keywords: Sea sand, Concrete, Compressive strength, Flexural strength, Corrosion test.

1. Introduction

The excessive extraction of river sand for use as fine aggregate in concrete has raised serious environmental concerns, including riverbed damage, soil erosion, and ecological imbalance. As a result, the construction industry is actively looking for alternate resources like sea sand. Sea sand is readily available in coastal areas and can reduce shipping costs; nevertheless, its use in concrete is debatable due to the existence of chlorides and moisture, which might influence strength and durability. [1, 2]

Previous research on sea sand concrete has mostly focused on fundamental mechanical qualities including compressive strength and workability. [3] While a few researchers evaluated the qualities of sea sand and river sand, most studies focused solely on limited replacement levels or short-term performance. Furthermore, insufficient emphasis has been made to systematically measuring chloride content and its impact on durability utilizing standardized testing procedures. [4] Existing literature provides limited comparisons of numerous replacement percentages under Indian Standard (IS) code restrictions.

As a result, the research gap exists in the absence of a comprehensive scientific inquiry that assesses different volumes of sea sand restoration. Quantifies chloride content using standard titration methods and compares workability and strength attributes in line with IS codes. [7]

The current research work fills this gap by examining sea sand replacement amounts of 0%, 25%, 50%, 75%, and 100% in concrete. Workability, compressive strength, and chloride content were assessed in accordance with applicable IS criteria. Dissimilar with previous studies that Centered on specific replacement ratios or attributes, this work presents a structured comparison across several replacement levels under standardized settings, allowing for a more accurate assessment of the feasibility of sea sand as an alternative fine aggregate. [5]

2. Materials and Methods

2.1 Ordinary Portland cement of grade 53 has been utilized in the current study. Table 1 provides the physical properties of cement according to IS 4031: Part 6: 1988 Reaffirmed 2005.[8]

Table 1. Physical properties of Cement.

Sl. No.	Physical Characteristics	Standard values (As per IS 4031: Part 6: 1988)	Obtained Values
1.	Normal consistency	26 – 34%	32%
2.	Initial setting time	No less than 30 minutes	80 minutes
3.	Final setting time	Not greater than 600 minutes	270 minutes
4.	Fineness	<10%	5 %
5.	Specific Gravity	2.9 to 3.15	3.0

2.2 River sand as per IS 2386 Part III 1963 Reaffirmed 2002[9] as given in Table 2 below.

Table 2. Properties of Fine aggregates.

Sl. No.	Physical Characteristics	Standard values (As per IS 2386 (Part 3):1963 and IS 2386 (Part 1).	Obtained Values
			River Sand
1.	Specific Gravity	2.65 to 2.67.	2.4
2.	Silt Content	< 8%,	4 %
3.	Fine Modulus	2.2 and 3.2	2.5 Zone II
4.	Total water absorption	1% to 3%	2.1 %
5.	Bulking of sand	10% to 30%	14.5%

2.3 Sea sand: The sea sand is obtained from the beach in Tannirbhavi, Mangalore**,** Karnataka. Which contains soluble salts, notably chlorides, which can reduce the strength and durability of concrete. As a result, the sea sand is washed and desalinated before being used as fine aggregate.

Initially, excess surface moisture was eliminated from the collected sea sand by air drying. The sand was then properly cleaned with portable water in a huge container. The sand was soaked in water for 1 day before being mechanically stirred to help remove soluble salts. After soaking, the supernatant water was drained. To guarantee maximal chloride removal, the operation was done three times.

Following washing, the sand was distributed in thin layers and sun-dried for 48 hours to produce a constant weight. The success of the desalination process was verified by measuring the chloride content before and after washing using the titration method in compliance with applicable requirements. A substantial decrease in chloride content was recorded following treatment, demonstrating that the washing process was effective in decreasing hazardous salts to safe levels. The treated sea sand was then sieved through a 4.75 mm sieve to guarantee adequate grading before being utilized in concrete production.

As per Table 2 shown above, the properties of sea sand (Washed and Unwashed) are compared with river sand, which indicates the properties of sea sand are similar to river sand.

As sea sand consists of chlorine and other minerals which affect the steel, causes corrosion, to measure this we have conducted corrosion tests.

2.4 Coarse Aggregates: With reference to the (IS: 2386 (Part I) 1963 Reaffirmed 2002[10]) as mentioned in Table 3 below

Table 3. Properties of Coarse aggregate.

Sl. No.	Physical Characteristics	Standard values (As per IS 2386 (Part 3):1963 and IS 2386 (Part 1).	Obtained Values
1	Specific gravity	2.52	2.5 – 3
2	Water absorption	0.52	0.5 -1 %

3. Experimental Methodology

In this experimental program, we have designed M20 concrete as per IS 10262 [14] and IS 456. [15]

M20 concrete is designed to have a compressive strength of 20 MPa after 28 days. According to IS codes, the goal mean strength is computed to assure safety. A water-cement ratio of 0.50 is commonly used for strength and durability needs. For 20 mm aggregate and moderate workability, the water content is estimated to be 186 liters per cubic meter, with a cement content of roughly 372 kilograms per cubic meter. The final mix ration by weight is around 1: 1.5: 3 (cement: fine aggregate: coarse aggregate), which is standard for M20 grade concrete.

The workability of fresh concrete was determined immediately upon mixing. The hardened specimens were then cured for 28 days before being tested for compressive and flexural strength. In addition, durability tests were performed in accordance with IS code criteria to assess the concrete's resilience to environmental exposure.

3.1 Workability of concrete (referring IS: 1199 -1959 Reaffirmed 2004)[11]: The sample of fresh concrete mix is used to workability test: Slump test, compaction factor test and Vee-Bee Consistometer test.

3.1.1 Slump test: In this test the fresh concrete sample is filled in slump cone of dimension Top 200 mm, bottom 300 mm and Height 300 mm, then the mould will be removed in vertical and the concrete sample is measured and compared with the height of mould, depending on the shape it is classified into three failure true slump, shear slump and collapse slump.

Figure 1. Slump Test

3.1.2 Compaction factor test: A fresh sample concrete is poured in the top hopper, then in the bottom hopper next to the cylinder, the weight of cylinder with concrete filled (partially compacted) is measured, similarly the weight of cylinder with concrete compacted for 3 layers (fully compacted) is measured.

Compaction factor is measured by the ratio of the value of partially compacted concrete by the value of fully compacted concrete,

3.1.3 Vee-Bee Consistometer test: Fresh concrete is poured in the vee bee slump cone; the height of concrete sample is measured in graduated scale and the time taken for spread concrete is noted which gives consistency of concrete is measured in seconds.

For each mix of proportions of fresh concrete, three specimens were casted and tested for compressive strength, flexural strength, and durability parameters. All results presented in this research work represent the average of three specimens, and the corresponding standard deviation was calculated to indicate variability and ensure reliability of the experimental data.

3.2 Compressive strength of concrete: The fresh concrete sample is poured into concrete mould of dimension of 150 mm3, and 7, 14 and 28 days cured, then placed in compressive testing measured and failure load is noted.

Compressive test = Failure load/ Area of specimen gives the strength in N/mm2

Figure 2. Compressive Strength Test

3.3 Flexural test: The fresh concrete sample is poured into a beam of size 150 mm X 150 mm X 300 mm and cured for 28 days and tested. Where the failure load (P) is substituted in the below formula and Flexural strength is calculated.

Flexural strength F = PL/ (bd 2)

3.4 Corrosion test on concrete (As per IS 9077 (1979))13: This test is also called Accelerated Corrosion Test or Electrical Resistance Method or Half-Cell Potential Test. The fresh concrete sample is poured into a beam of size 150 mm X 150 mm X 300 mm, where steel rod of 12 mm is embedded in the concrete, curing after 28 days the beam is kept in NaCl solution and the reaction is measured by ohmmeter.

Figure 3. Corrosion Test on Beam: Electrical resistivity of concrete.

4. Results and Discussion

According to IS code the properties of Sea sand and River sand washed and unwashed is carried[6]. The Unwashed Sea sand exhibited higher specific gravity and silt content compared to washed sea sand and river sand, while washing significantly reduced impurities and water absorption. Both unwashed and washed sea sand are classified as Zone IV, which indicates finer particles than river sand (Zone II). Sea sand showed considerably higher bulking values than river sand. Overall, washing improves the quality of sea sand, making it more suitable for construction applications.

The concrete of grade M20 is tested for fresh properties, harden properties and durability by using sea sand for 25%, 50%, 75% and 100%.

The workability tests are carried out on fresh concrete according to IS: 1199 -1959 Reaffirmed 2004. [11] The slump test, Compaction factor test and Vee – bee consistometer test is performed for both normal concrete and sea sand replaced concrete. The slump test values are mentioned in Table 4, Table 5 and Table 6 given below,

Table 4. Slump results of normal concrete and sea sand concrete.

Sl. No.	Percentage of River Sand with Sea sand	Slump Value cm	Type of slump
1.	RS 100% with SS 0%	28	True slump
2.	RS 25% with SS 75%	28	True slump
3.	RS 50% with SS 50%	26	True slump
4.	RS 25% with SS 75%	27	True slump
5.	RS 0% with SS 100%	25	True slump

Table 5. Compaction factor test results of conventional concrete and sea sand concrete.

Sl. No.	Percentage of River Sand with Sea sand	Compaction factor value cm	Degree of workability
1.	RS 100% with SS 0%	0.98	High
2.	RS 25% with SS 75%	0.95	High
3.	RS 50% with SS 50%	0.95	High
4.	RS 25% with SS 75%	0.9	High
5.	RS 0% with SS 100%	0.92	High

Table 6. Vee – bee consistometer test results of normal concrete and sea sand concrete.

Sl. No.	Percentage of River Sand with Sea sand	Time Seconds	Degree of workability
1.	RS 100% with SS 0%	5	Stiff plastic
2.	RS 75% with SS 25%	5	Stiff plastic
3.	RS 50% with SS 50%	4	Stiff plastic
4.	RS 25% with SS 75%	4	Stiff plastic
5.	RS 0% with SS 100%	5	Stiff plastic

The concrete mix both conventional concrete and sea sand concrete (with 0%, 25%, 50%, 75% and 100% replacement) exhibits good to high workability, confirming their suitability for reinforced concrete applications without requiring extreme compaction effort. The consistent results obtained from the slump, compaction factor, and Vee-Bee tests indicate appropriate mix design and satisfactory fresh concrete behavior.

As per IS: 516-1959 Reaffirmed 2004 [12] Compressive strength of concrete is calculated for all ratios of concrete as mentioned in Table 7 mentioned below.

Table 7. Compressive strength of concrete with and without sea sand (Unwashed).

Curing Period Days	100% RS (N/mm2)	25% SS (N/mm2)	50% SS (N/mm2)	75%SS (N/mm2)	100% SS (N/mm2)
7	20.5	10.78	14.99	10.32	14.55
14	22.2	14.28	16.16	12.27	12.94
28	24.53	20.77	17.33	15.22	18.33

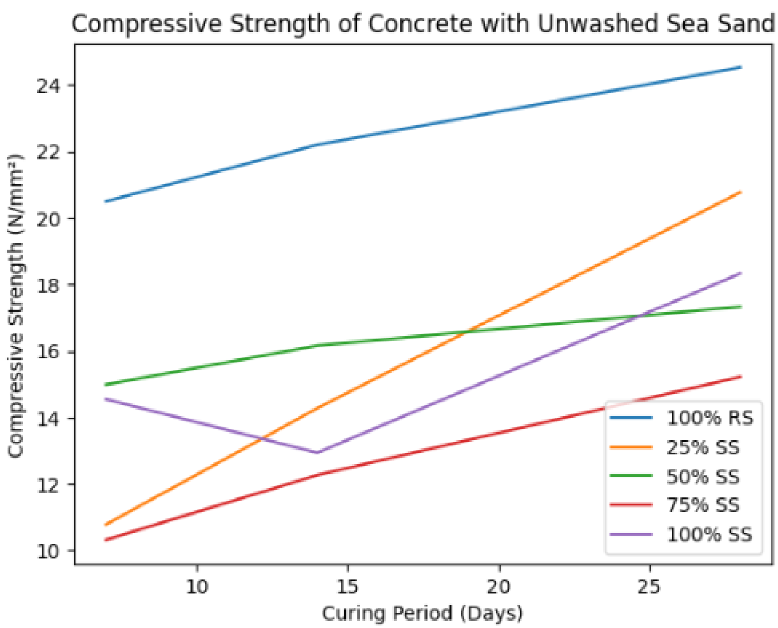

Figure 4. Compressive strength of concrete with and without sea sand(Unwashed).

The compressive strength of all mixes increased with curing age, with 28-day strength being the highest. The conventional concrete with 100% river sand, exhibited the maximum strength at all ages. The strength reducing with increasing percentage of sea sand (Unwashed), although 50% of replacement showed relatively better performance among the sea sand mixes. Overall, treated sea sand can be used as a partial replacement with only a moderate reduction in strength.

Table 8. Compressive strength of concrete with and without sea sand (Washed).

Curing Period Days	100%RS	25% SS	50% SS	75%SS	100% SS
	(N/mm2)	(N/mm2)	(N/mm2)	(N/mm2)	(N/mm2)
7	20.5	12.73	15.9	11.23	16.25
14	22.2	15.23	16.5	13.02	13.02

28	24.53	21.52	17.5	14.09	18.2

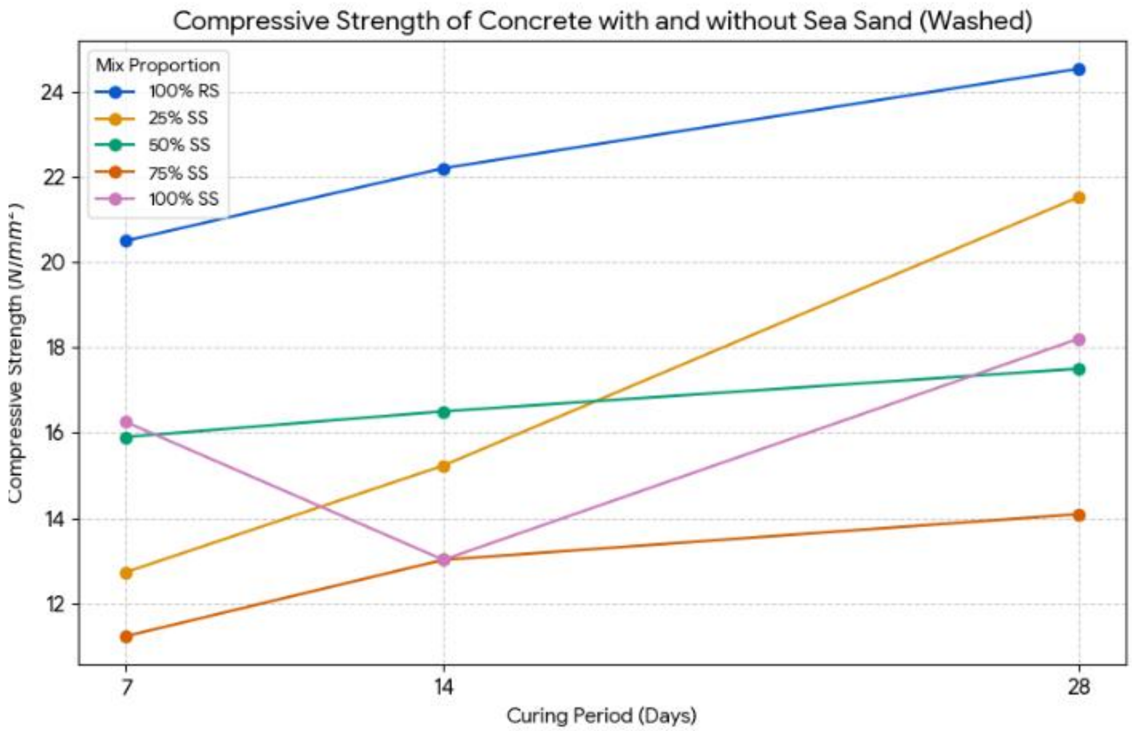

Figure 5. Compressive strength of concrete with and without sea sand(Washed).

Incorporating sea sand (washed) reduces compressive strength compared to river sand, whereas utilizing the unwashed sea sand increases it. Among the sea sand combinations, the 25% replacement found to be the most beneficial, resulting in a considerable gain in strength after 28 days.

Flexural strength of concrete according to IS: 516-1959 Reaffirmed 2004 [12] is calculated for 50% replacement river sand and sea sand of concrete with and without washing after curing for 28 days as mentioned in Table 8 below.

Table 8. Flexural strength of concrete with and without sea sand.

Concrete Specimen after 28 Days	Flexural Strength (N/mm2)
River sand	43
SS Un washed	27
SS Washed	40

The flexural strength results after indicating that conventional river sand concrete achieved the highest strength of 43 N/mm². Concrete prepared with unwashed sea sand shows a significant reduction in flexural strength (27 N/mm²), highlighting the detrimental effect of residual salt content. In contrast, washed sea sand concrete attained a strength of 40 N/mm², demonstrating that proper desalination substantially improves flexural performance and enhances its suitability for structural applications.

The corrosion test of concrete for 50 % replacement with sea sand in normal concrete measured in Ohm meter with reference to IS 1907: 1979 Reaffirmed 2004 [13] is mentioned in Table 9 below.

Table 9: Corrosion test of concrete results.

Samples	Corrosion test results	Possible corrosion rate
RS 100% with SS 0%	15	Moderate to low
RS 50% with SS 50%	10	Moderate to low

The corrosion test results indicate that both the conventional concrete with 100% river sand and the 50% sea sand replacement mix fall within the moderate to low corrosion rate category. However, the 50% sea sand mix exhibited a lower corrosion value compared to the control mix , suggesting improved resistance to corrosion when treated sea sand is partially incorporated. These findings demonstrate that partial replacement with properly treated sea sand does not adversely affect corrosion performance and may enhance durability.

5. Conclusions

Based on the research carried out these are the following findings in which river sand is partially substituted with washed and unwashed sea sand at 0%, 25%, 50%, 75%, and 100%.

1. Washing sea sand significantly reduces silt content and water absorption, improving its quality, although it remains finer (Zone IV) and exhibits higher bulking compared to river sand (Zone II).
2. The 100% river sand control mix achieved the highest compressive strength (24.53 N/mm²), while sea sand replacements reduced strength overall, though a 25% replacement level emerged as the most feasible option by reaching nearly 88% of the control strength at 28 days.
3. River sand reached the highest flexural strength (43 N/mm²), whereas washed sea sand showed comparable performance (40 N/mm²) and unwashed sea sand recorded the lowest strength (27 N/mm²), confirming that washing is essential to enhance its structural suitability.
4. The corrosion test results show that replacing 50% of river sand with sea sand reduces the corrosion value, indicating increased in corrosion resistance and enhanced durability compared to the conventional mix.

6. Future Work

In the future, different cement grades with different goal strengths can be used to calculate the strength, durability, and creep characteristics.

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