RESEARCH ARTICLE OPEN ACCESS

Mechanical Properties of Concrete with Marine Sand as Partial Replacement of Fine Aggregate

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ABSTRACT
The process of depleting sources of natural aggregates challenges the production of technically and environmentally adequate concrete. Alternative material from marine sources is good enough for the replacement of fine aggregate in the concrete. The material was stockpiled in the open air and no washing, drying or decontamination process was carried out. Physical and chemical properties of DMS material were determined. All the materials used in the concrete were selected and tested as per the standard procedures of the Indian standards. A unique design mix will be done based on the entire material test results. Different mixtures were produced using DMS in different proportions from 15% to 100% as per the finalized trial of the design mix. The concrete were submitted to compressive strength testsafter 7, 28 and 90 days of moist curing, as well as flexure and splitting tensile strength tests for M-25 grade.
***Keywords*:** Compressive strength, Concrete Mix, Flexural Strength, Marine Sand, Split Tensile Strength.

I. INTRODUCTION

Most of the aggregates used in the manufacture of concrete come from quarries or alluvial rivers. Nowadays these sources of natural aggregates are in process of depletion and their extraction also has harmful consequences to the environment. There are bans on the dredging of river sand and are strictly monitored by the government also keeping in views of the threat it causes to environment.

It is important to optimize the consumption of natural aggregates and also enhance their replacement by other alternative sources. This research work examines the potential usage of marine sand as the replacement of fine aggregate in the concrete.

Marine sand is already used for different purposes like beach replenishment, coastal defences and land reclamations in various countries. However many countries have opted for the use of marine sand in specific civil constructions. Countries like Netherlands, United Kingdom, Denmark, France and Spain are extensively in use of marine sand for various civil engineering activities. Experimental studies from European and American coasts have shown that these materials are suitable as construction material base and sub base of pavements.

Noted examples are construction of Rotterdam harbor (Netherlands), The Great Belt Bridge (b/w Denmark and Sweden), the Thames Barrier, London's National theatre and remarkable constructions like artificial island of Chek Lap Kok where Hong Kong airport is located or the Palm islands of Dubai.

II. EXPERIMENTAL PROGRAM

II.1 Materials Used

Cement, fine aggregate, coarse aggregate (10mm and 20mm), Water, Marine sand.

II.1.1 Cement

The choice of Portland cement for high-strength concrete is extremely important unless high initial strength is the objective. Proper selection of the type and source of cement is one of the most important steps in the production of high-strength concrete. The tests as per IS: 4031-1988 was done to ascertain the physical properties of the cement.

II.1.2 Fine Aggregate

The grading and particle shape of the fine aggregate are significant factors in the production of high-strength concrete. Particle shape and surface texture can have as great effect on mixing water requirements and compressive strength of concrete as do those of coarse aggregate. Fine aggregates of the same grading but with a difference of 1 percent in voids content may result in a 1 gallon per yd3 difference in water demand. Fine aggregates with a rounded particle shape and smooth texture have been found to require less mixing water in concrete and for this reason are preferable in high-strength concrete.

II.1.3 Coarse aggregate

Coarse aggregates in concrete occupy about 70% of the total volume of the concrete. Smaller aggregate sizes are also considered to produce higher concrete strengths because of less severe concentrations of stress around the particles, which are caused by

differences between the elastic moduli of the paste and the aggregate. The coarse aggregate used in this experimental investigation 10mm size and 20mm size crushed and angular in shape. The aggregates are free from dust before used in the concrete.

II.1.4 Marine Sand

This is the important aggregate for the project work as it was the replacement of regular fine aggregate in the concrete. Marine sand is available in plenty across the globe in the shores of seas. Various tests like specific gravity, sieve analysis, water absorption and chemical analysis have been performed for checking the usability of marine sand in to concrete. Main chemical to be checkedfor is chloride content, as it will be responsible for the corrosion of steel which will be used in concrete. It should be in the permissible limits to be used in the concrete and also alternative methods to be adopted for reducing the chloride content ifpresent above allowable limits. Marine sand will be finer than the river sand and hence the mix design has to be corrected when using this sand.

Table 1: Chemical analysis of marine sand

CHEMICAL ANALYSIS OF DMS		
SL NO	DESCRIPTION	OBSERVED VALUE
1	pH value (1:25) at 25ºc	7.76 (base)
2	Conductivity (1:25) at 25ºc	3600 micro Siemens
3	Solvable salts, µg/g of dry soil	5850
4	Chlorides, µg/g of dry soil	2600
5	Sulphates, µg/g of dry soil	330

Table 2: Physical properties of materials

S.No	Property	Test Results
1	Cement: OPC 53 Grade	
	Normal consistency	
	Specific gravity	3.14
	Setting times a)Initial setting time b)Final setting time	78 min 197 min
2	Physical properties of fine aggregate	
	Specific gravity	3.08
	Fineness modulus	2.48
	Bulk density: Loose Compacted	15kN/m^3 16kN/m^3
	Grading	zone-2
3	Physical properties of coarse aggregate (10mm)	
	Specific gravity	2.62
	Fineness modulus	5.26
	Bulk density	1633.8 kg/m^3
4	Physical properties of coarse aggregate (20mm)	
	Specific gravity	2.69
	Fineness modulus	6.02
	Bulk density	1633.8 kg/m^3

Table 3: Physical properties of marine sand

S.No	Property	Test Results
1	Physical Properties of marine sand	
	Specific gravity	2.66
	Fineness modulus	2.93
	Grading	zone-4

Figure 1: Marine sand

II. 2. Mix proportioning:

Material parameters:

- Grade of concrete: M25
- Mix proportion of concrete:
- Type of Cement: OPC 53
- Type of aggregate:
  i) Fine aggregate < 4.75mm
  ii) Coarse aggregate 10mm , 20mm
- Water cement ratio: 0.42
- Time period of curing: 7days, 28 days and 90 days

II.3. Test specimens:

Compression test was conducted on 150mmX150mmX150mm cubes, cylinder specimen is of the size 150 mm diameters and 300mm length is used for split tensile strength and beams of dimension 100mmX100mmX500mm were casted for Tensile strength tests. Total number of 54 cubes, cylinders and beams were casted and tested for 7 days, 28 days and 90 days respectively.

Table 4:Final mix proportioning

Material name	Quantity required
Cement	378 kg/m³
Fine aggregate	797 kg/m³
Coarse aggregate 10 mm 20 mm	482 kg/m³ 743 kg/m³
Water	159 lit

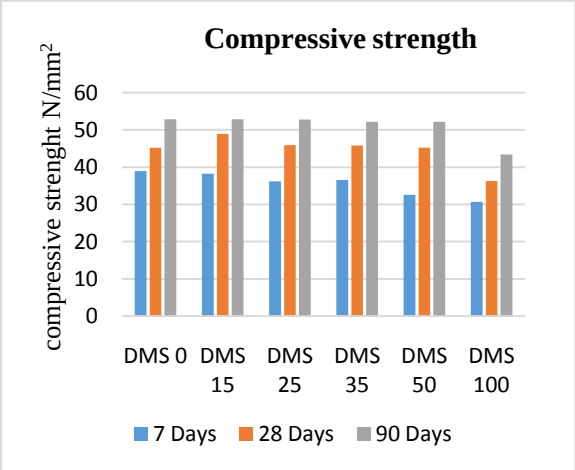
III. RESULTS AND DISCUSSION

Table 5: Compressive strength results

S.no	Mix Id	Compressive strength (N/mm^2)		
		7 Days	28 Days	90 Days
1	DMS 0	38.96	45.19	52.89
2	DMS 15	38.22	48.89	52.89
3	DMS 25	36.15	45.93	52.74
4	DMS 35	36.52	45.78	52.15
5	DMS 50	32.59	45.19	52.15
6	DMS 100	30.67	36.30	43.41

Figure 2. Compression test machine

Observation:



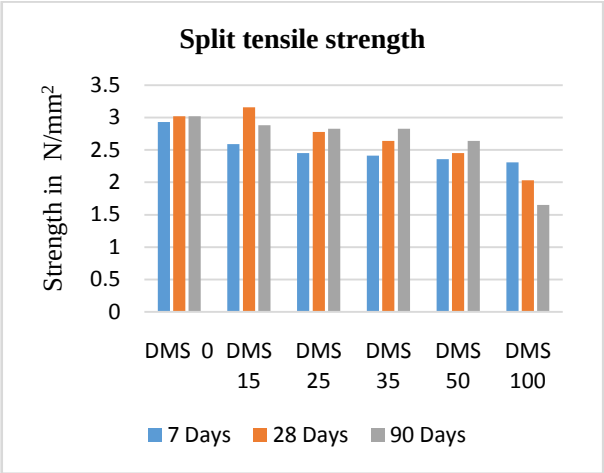
At all the ages of 7, 28 and 90 days maximum value has obtained at 15% replacement. But till 50% replacement the values are not going below the normal mix.

Table 6: Split tensile strength results

S.no	Mix Id	Split tensile strength (N/mm^2)		
		7 Days	28 Days	90 Days
1	DMS 0	2.93	3.02	3.02
2	DMS 15	2.59	3.16	2.88
3	DMS 25	2.45	2.78	2.83
4	DMS 35	2.41	2.64	2.83
5	DMS 50	2.36	2.45	2.64
6	DMS 100	2.31	2.03	1.65

Figure 3. Split tensile strength test

Observation:



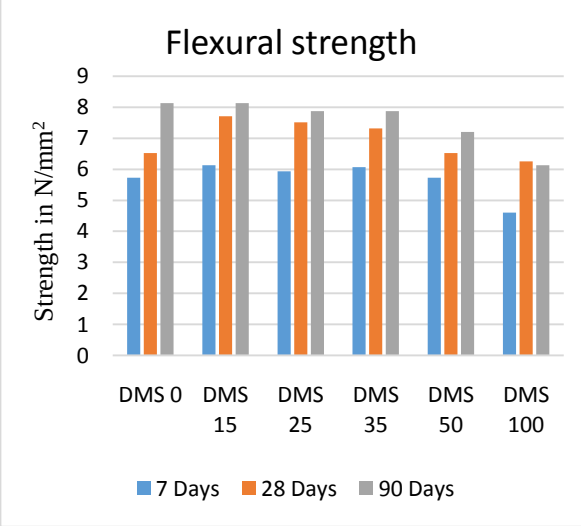
For split tensile strength also 15% replacement is showing the maximum value for 28days. Except an increase of 4.2% in DMS 15% rest of all mixes are observed to be decreasing w.r.t normal mix.

In case of 90 days strength values it is observed that all the mixes are decreasing in strength w.r.t. the normal mix.

Table 7: Flexural Strength results

S.no	Mix Id	Flexural strength (N/mm^2)		
		7 Days	28 Days	90 Days
1	DMS 0	5.73	6.52	8.13
2	DMS 15	6.13	7.71	8.13
3	DMS 25	5.93	7.51	7.87
4	DMS 35	6.07	7.32	7.87
5	DMS 50	5.73	6.52	7.20
6	DMS 100	4.60	6.25	6.13

Figure 4: Flexural strength test Observation:



It is observed that flexural strength is increasing at 90 days of age in all mixes except in 100% replacement.
Here also strength is similar till 50% of replacement and decreased at 100% replacement of marine sand.

IV. CONCLUSION

The following conclusions have been made based on the results obtained from the experimental work.

1. Marine sand can be successfully used as a replacement of fine aggregate in the concrete.
2. For 100% replacement the strength is slightly decreasing and hence it can be inferred that addition of admixture can improve the results.
3. Test results (compressive, flexural, and split tensile strengths) seem better in mixes up to 50% of replacement of marine sand.
4. 50% of replacement can be done without any addition of admixtures for achieving the strength.
5. Marine sand seems to be a good alternative for the fine aggregate which is in danger zone these days.
6. Concrete fabricated with marine sand can be used in many areas like marine structures, residential buildings, profile correction course etc.

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CODE BOOKS

- IS 383: 1970 - Specification for Coarse & Fine aggregates from natural sources
- IS 456: 2000 – Plain and reinforced concrete code of practices
- IS 2386: (Part 1 to 8) - Tests for Aggregates
- IS 10262: 2009 - Recommended guidelines for concrete mix design