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An Experimental Investigation on Properties of Concrete by Using Dredged Sand and Weathered Rock Sand as Fine Aggregate

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***Abstract* —** *The most used construction material in the world is concrete because of its strength, stability and durability. It comprises of four major constituents such as cement, coarse aggregate, fine aggregate and water. From early days onwards river sand is used as a fine aggregate. Due to Scarcity of river sand nowadays M-sand, pit sand etc are used as fine aggregate. Since pit sand is only available at certain regions and due to the scarcity and high cost of river sand and M-sand, it has become necessary to find an alternative for fine aggregate. In this research work weathered crystalline rock sand (WCRS) and dredged sand (DS) are used as alternative for fine aggregate. M40 grade of concrete is selected for this study. Paper discusses mechanical properties of concrete mixes with both WCRS and DS as fine aggregate. Among these mixes, mix with 100% WCRS as fine aggregate showed better results in terms of compressive strength, splitting tensile strength and flexural strength.*

***Keywords*—** *Fine aggregate, Weatherd crystalline rock sand, Dredged sand.*

I. INTRODUCTION

A. General

Cement concrete is a widely used construction material around the world, and its properties have been undergoing changes through technological advancement. It is an extremely versatile material and can be used for all types of structures. Concrete is one of the mainly used material throughout the globe in the various field, which basically consists of cement, sand and crushed quarry stones are locally and naturally available, then sand and crushed stone are used as a filler material in concrete and cement is used for bonding and strength parameter of the concrete.

Aggregate occupy almost 70-75% of the total volume of concrete. The civil engineering construction particularly in the field of reinforced concrete has increased and as a consequence the availability of aggregate has reduced by a large amount. To meet the global demand of concrete in the future, it is becoming a more challenging task to find suitable alternatives to natural aggregates for preparing concrete.

In the present scenario the scarcity of river sand and increasing cost of M- sand are causing the impediment in construction activity. Hence an alternative construction material which can fully or partially replace the fine aggregate without affecting the property of concrete would be desirable. In this study weathered crystalline rock sand and dredged sand (DS) are used as a replacement for fine aggregate. Weathered crystalline rocks are abundantly seen in Kerala. Hence, this is study attempt to examine the suitability of weathered crystalline rock sand (WCRS) and fine marine aggregates resulting from maintenance dredging activities as substitutes for fine aggregates.

B. Objectives of the study

The main objectives of the study is, to assess the mechanical properties of concrete with both weathered crystalline rock sand and dredged sand as fine aggregate. M40 grade of concrete is selected for the study. Four mixes were prepared for the study, such as control mix with M-sand as fine aggregate, mix with dredged sand as fine aggregate, mix with weathered rock sand as fine aggregate and mix with both weathered rock sand and dredged sand as fine aggregate by 50% each. Various parameters like compressive strength, flexural strength and splitting tensile strength were carried out to find the mechanical properties of concrete mixes.

II. PROPERTIES OF MATERIAL

A. Cement

Ordinary Portland cement (53 grade) cement conforming to IS 8112 was used. The different laboratory tests were conducted on cement to determine standard consistency, initial and final setting time as per IS 4031 and fineness. The result are tabulated in table I the results conforms to the IS recommendations.

TABLE I. Properties of cement.

S.No	Test conducted	Result
1	Specific gravity	3.14
2	Standard consistency	34%
3	Initial setting time	120 min
4	Fineness	5%

B. Fine Aggregate

M sand passing through 4.75 mm sieve and confirming to Zone II was used for the study. Physical properties of fine aggregates determined as per IS 2386-1968 and the results of tests are shown on table II

TABLE II. Properties of fine aggregate.

S.No	Test conducted	Result
1	Zone	II
2	Fineness modulus	3.04
3	Specific gravity	2.67
4	Water absorption	1.5%
5	Bulk density	1.86 kg/l
6	Percentage of air voids	33.7%

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C. Coarse Aggregate

Coarse aggregates collected from approved quarry and aggregates having size ranging from 10mm to 20mm are used. The tests are carried out or coarse aggregate as per is 2386-1968 and the results are given in table III.

TABLE III. Properties of coarse aggregate.

S.No	Test conducted	Result
1	Specific gravity	2.67
2	Water absorption	0.85%
3	Flakiness index	17.7%
4	Elongation index	25.4 %
5	Bulk density	1.63 kg/l
6	Percentage of air voids	44.56%
7	Crushing value	22.5

D. Weathered crystalline rock sand (WCRS)

Weathered Crystalline Rocks are metamorphic rocks seen in the tropical areas like Kerala. They are formed by the weathering action on the rocks. Weathered crystalline rock is the outer layer of the underlying hard rock. Hence excessive mining is not required to obtain these types of rocks. In Kerala, weathered crystalline rock is used for the construction of small compound walls instead of random rubble and laterite bricks. Tests are carried out on WCRS as per IS 2386-1968 and the results of test are shown on table IV

TABLE IV. Properties of WCRS.

S.No	Test conducted	Result
1	Zone	II
2	Fineness modulus	3.04
3	Specific gravity	2.65
4	Water absorption	2.6%
5	Bulk density	1.59 kg/l
6	Percentage of air voids	42.83%

E. Dredged sand (DS)

Due to the demand of fine aggregate in construction industry, river sand has been exploited unconditionally from the various parts of our country. It leads to the various environmental issues. Hence we want to restrict the mining of river sand by introducing suitable alternative for this.

The dredged sand for this project work was obtained from the cochin. The offshore sand dredged to increase the sea bed depth of the cochin airport for the accessibility of mother ships. Tests are carried out on DS as per IS 2386-1968 and the results of test are shown on table V.

TABLE V. Properties of DS.

S.No	Test conducted	Result
1	Zone	IV
2	Fineness modulus	2.87
3	Specific gravity	2.61
4	Water absorption	4.1%
5	Bulk density	1.58 kg/l
6	Percentage of air voids	45.78%

F. Super Plasticizer

Master Glenium SKY 8233 was used as super plasticizer for the study. It is an admixture based on modified polycarboxyllic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. It is free of chloride and low alkali. It is compatible with all types of cements. Physical properties of super plasticizer as shown on table VI.

TABLE VI. Physical property.

Test conducted	Results
Aspect	Light brown liquid
Relative density	1.08 at 25^0C
Ph	>6
Chloride ion content	0.2%

III. Mix Design

The main objective of experimental work is to investigate compressive strength, split tensile strength and flexural strength of concrete. M40 grade of concrete is used to examine the mechanical properties of concrete. The Mix Design Of Concrete carried out as per IS 10262:2009. The Constituents of control concrete mix and concrete with WCRS and DS as fine aggregate are as shown in table VIII.

The different mixes were labeled as CM, MDS100, MWS100 and MDW50. Table VII shows designation of different mixes with varying percentage of dredged sand and weathered rock sand.

TABLE VII. Mix designation.

Mix	Designation
CM	Control mix(M-sand)
MDS100	With 100% of fine aggregate as DS
MWS100	With 100% of fine aggregate as WCRS
MDW50	With 50% DS and 50% WCRS as fine aggregate

TABLE VIII. Design mixes for 1 m^3 concrete.

Mix	Cement (kg)	FA (kg)	DS (kg)	WCRS (kg)	CA (kg)	Water (kg)	SP (%)
CM	415	803	0	0	1090	173	0.3
MDS100	415	0	715	0	1159	173	0.4
MWS100	415	0	0	797	1090	173	0.35
MDW50	415	0	376	381	1125	173	0.4

IV. Results and Discussions

The test results of various parameters like compressive strength using cube, split tensile strength using cylinder and flexural strength using beam specimens are shown below.

A. Compressive strength

This is one of the most important properties of concrete, as it will affect many other properties of hardened concrete. Because, concrete is strong in compression but relatively weak in tension and bending. The testing was done in the compression testing machine and the failure load was noted and compressive strength was calculated. The test results for cube compressive strength are shown in the table IX. Test was conducted as per IS 516: 1959.

TABLE IX. Compressive strength.

Mix designation	Compressive strength (N/mm^2)		
	3 Days	7 Days	28 Days
CM	27.85	43.40	53.63
MDS100	27.03	40.20	49.94
MWS100	36.29	46.22	61.11
MDW50	34.66	40.88	57.77

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Figure I shows the graphical variation of compressive strength of different concrete mixes with curing periods.

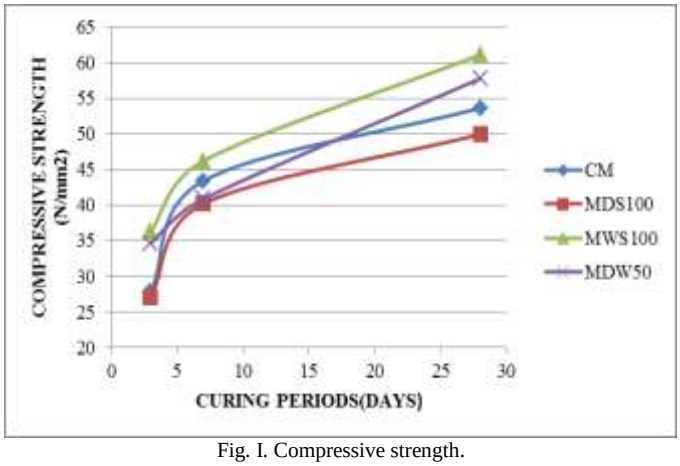

Fig. I. Compressive strength.

Figure I shows the variation of compressive strength of different mixes with varying curing periods such as 3, 7 and 28 days. According to the test results there is an increase in the compressive strength of concrete mixes with fully replacement of fine aggregate with WCRS and mixes with 50% each WCRS and DS. Maximum value of compressive strength obtained for mix with 100% WCRS (MWS100). There was an increase of 14% compressive strength than control mix (CM) for mix with 100% WCRS at 28 days of curing. But in case of mix with 100% replacement of fine aggregate by dredged sand (MDS100) showed lesser compressive strength value than mix CM. About 7% of decrement in compressive strength is noticed. But the value of compressive strength is higher than that of target mean strength of M40 concrete. As in the case of mix MDW50, containing both WCRS and DS by amount of 50 % each showed comparatively higher value than mix CM. The strength increment is about 8%. So from the obtained results of compressive strength test at 28 days of curing period, it can be concluded that both WCRS and DS can be effectively replace fine aggregate by 100%.

B. Flexural Strength

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. Beams of size 500mm×100mm×100mm were tested after 7 days and 28 days from day of curing. Table X shows the flexural strength values obtained for the concrete mixes. The test was conducted as per IS-516: 1959.

TABLE X. Flexural strength.

Mix designation	Flexural strength (N/mm^2)	
	7 Days	28 Days
CM	4.61	6.08
MDS100	3.875	5.75
MWS100	5.375	7.5
MDW50	4.875	6.25

Figure II shows the graphical variation of flexural strength of different concrete mixes with curing periods.

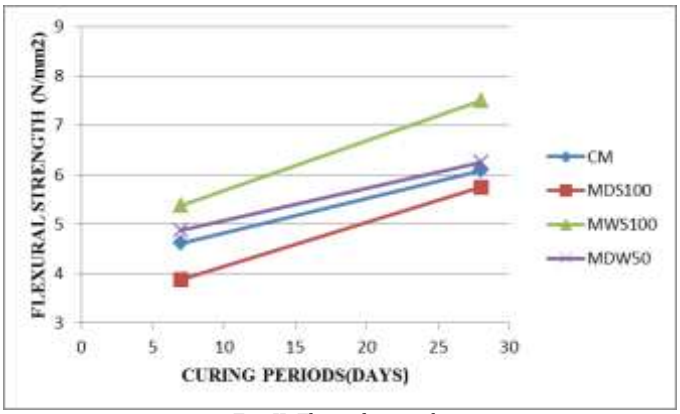

Fig. II. Flexural strength.

From the results obtained for flexural strength of concrete, like compressive strength there is increase in flexural strength of concrete mixes with fully replacement of fine aggregate with WCRS and mixes with 50% each WCRS and DS. Mix MWS100 shows better flexural strength value of 7.5 N/mm^2, attained about 23% strength increment over control mix (CM). Mix MDS100 shows comparatively lesser value than control mix. For the mix containing both WCRS and DS each by 50% (MDW50) shows the value flexural strength 6.25 N/mm^2, which is comparatively similar to the control mix with flexural strength value 6.08 N/mm^2.

C. Splitting Tensile Strength

Tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. The splitting tensile strength of concrete cylinder was determined based on IS: 5816-1999. The load shall be applied in the nominal rate within the range of 1.2 N/mm2/min to 2.4 N/mm2/min. Load is applied until the specimen fails, along the vertical diameter. Tensile strength of the concrete design mix was check by casting and testing of 150mm diameter & 300mm depth size after curing period of 7 days and 28 days. Table XI shows the splitting tensile strength values for different mixes.

TABLE XI. Splitting tensile strength.

Mix designation	Splitting tensile strength (N/mm^2)	
	7 Days	28 Days
CM	2.32	3.37
MDS100	2.12	3.05
MWS100	2.51	3.54
MDW50	2.33	3.30

Figure III shows the graphical variation of splitting tensile strength of different concrete mixes with curing periods.

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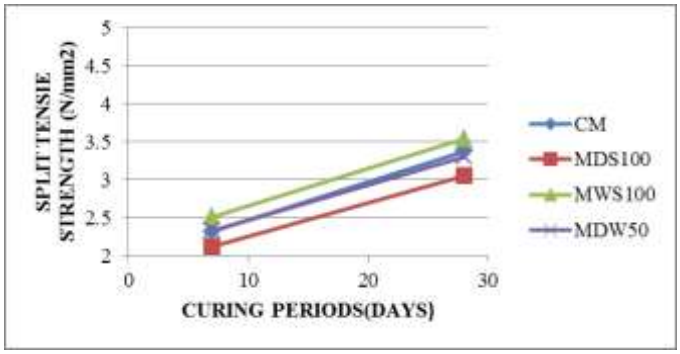

Fig. III. Splitting tensile strength.

V. CONCLUSIONS

Based on the experimental results, following conclusions are made,

- Both Weathered Rock Sand and Dredged sand increases the workability of the concrete mix.
- Mix containing 100% WCRS (MWS100) showed higher compressive strength. Strength increment is about 14% when compared with the strength of control mix.
- Mix containing 100% DS showed lesser compressive strength (7% less) than control mixes though the value is higher than target mean strength.
- In case of mix replaced with 50% WCRS and 50% showed comparatively higher compressive strength value than CM (about 8%).
- All mixes attains compressive strength more than designed strength (40 N/mm^2) at 28 days.
- So both WCRS and DS can be effectively used as fine aggregate.
- Mix MDS100 shows comparatively lesser flexural strength value than control mix. For the mix containing both WCRS and DS each by 50% (MDW50) shows comparatively similar value of control mix CM.
- Results obtained for splitting tensile strength of concrete with replacement of fine aggregate 100% by WCRS (MWS100) shows that higher splitting tensile strength value than control mix CM at 28 days of curing.
- Only mix MDS100 at 28 days of curing showed lesser value than control mix CM.

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