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Experimental Investigation on the Effects of Using Soil as Replacement Sand in Concrete

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Abstract:
Use of locally available soil in partial and full replacement of fine aggregate for concrete making is an attractive proposition in view of the prevailing scarcity of good quality sand. The experimental investigation involves establishment of suitability or otherwise of soil as replacement of sand in concrete making through preliminary tests like sieve analysis, compressive strength of cubes, split tensile strength and modulus of rupture after classifying the soil proposed to be used as replacement. Two samples of soil (S1) and (S2) collected from two different places are used in the investigation. The test results reveal that soil can be used as partial (50%) and full replacement of sand for making M30 concrete. However the test results indicate that the characteristics of the soil have a definitive impact on the development of strength of concrete which are also correlated.

Keywords:
Fine aggregate replacement, local soil

I.INTRODUCTION:

Concrete is the most popular building material in the world [2]. In construction, sand has been used as a unique raw material. River sand has been one of the most popular options for the fine aggregate of concrete in the past, but over use of the material has led to environmental concerns [2]. Local soil is present and the paper explores the use of fine aggregate in place of river sand used traditionally in the production of concrete. The properties have to be established by extensive testing and it is to be shown that it conforms to the requirement of relevant Indian standards related to concrete making. In the selection of soil for the manufacture of concrete it has become mandatory to check that it satisfied the properties of fine aggregate as prescribed by the relevant codes. The main properties of soil are that it should conform to the grading curve, similar to that of sand, since this curve indicates the particle size distribution of the sample. It is very important, since all sizes of particles will fill the gaps and avoid porosity in concrete and increased its density and gives good strength. The particle should not be clay. The local soil was collected from the SRM Potheri Lake and a construction site within the campus of our institute. It has become a normal practice in the country to dump excavated soil, when not used at construction site on the roadside as a waste. Instead, it was proposed to recycle this waste soil in developing useful building material. Also this will avoid dumping of waste soil in low lying areas which might cause a lot of problems to society. So, the use of local soil as fine aggregate was explored because its property could be established by testing. However, little is known on the use of local soil as fine aggregate in the production of concrete. Therefore the research reported in this investigation is first of its kind and have literature on this topic.

II.NEED FOR THE REPLACEMENT OF SAND:

Due to continue use of the aggregate, river sand is becomes scare and the production of concrete is degrading the environment. It affects the living organism of river severely because the surface of river sand goes downwards in the river bed. This will affect the storage capacity of river and leads to severe water scarcity during lean season. So there is an imperative need to develop alternative materials for replacing

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natural river sand in concrete [1]. For reducing the usage of the raw material large replacement is done using the various by-product materials that are available in the present day. Many studies are made with several other materials which gave the concrete to be a material made of r e c yc l e d m a t e r i a l [1]. The properties of concrete in fresh and hardened state are studied in the various papers that are used as a reference for this. Some of the properties are compressive strength are the major one that are considered [1] [2] [4].

III. OBJECTIVES & SCOPE:

- To establish the suitability or otherwise of soil as replacement of sand in concrete making through preliminary tests.
- If found suitable, study the behaviour of beams cast out of such concrete, by carrying out laboratory controlled tests.
- The experimental investigation involves establishment of suitability or otherwise of soil as replacement of sand in concrete making through preliminary tests like sieve analysis, compressive strength of cubes, test for modulus of rupture after classifying the soil proposed to be used as replacement; soil collected from three different places within SRM University campus are used as replacement.
- Once suitability is established, beam specimens are cast and subjected test till ultimate failure and compared the results obtained with that of control specimen made out of ordinary concrete. Three beams with soil as replacement of sand are tested.

IV. MATERIALS USED:

A. Cement:

The cement used for this study is Portland Pozzolanic Cement is conforming to Indian Standard IS 12269 – 1987 of grade 53.

B. Fine Aggregate:

The sand is used as fine aggregate and it is collected from nearby area. The sand has been sieved in 4.75 mm sieve.

C. Coarse Aggregate:

The coarse aggregate is choosen by shape as per IS 2386 (Part I) 1963, surface texture characteritics of aggregate is classified as in IS 383 - 1970.

D. Soil:

These two soil samples S1 and S2 are used as replacement material for sand as fine aggregate and the sample is collected around SRM Potheri Lake has shown below fig.1 and fig.2. The sand has been sieved in 2.35 mm sieve.

Fig.1 Soil sample 1(S1) Fig.2 Soil sample 2 (S2)

As the particle size is less, pycnometer is used for sand. The empty weight of the pycnometer is measured and then it is filled with sand up to a mark and the weight is measured. Then water is filled with water and the weight is measured. Then weight of the pycnometer only with water is measured and the specific gravity of the fine aggregates used is calculated. The same method is used for determining the specific gravity of the raw soils.

B. Sieve analysis:

Sieve analysis is done as per I S 2 3 8 6 (Part I)-1963. The first step involves arranging the IS sieves in the order of 4.75mm-2.36mm-1.18mm-600µ-300µ-150µ. 2kgs of fine aggregate i s t a k e n and placed on the top most sieves. Sieving is done for fifteen minutes and weight retained on each IS sieve is found. Using the above value fineness modulus is calculated.

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C. Atterberg's Limits:

This test is performed to determine the plastic and liquid limits of a fine- grained soil. The liquid limit (LL) is arbitrarily defined as the water content, in percent, at which a part of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (1/2 in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second. The plastic limit (PL) is the water content, in percent, at which a soil can no longer be deformed by rolling into 3.2 mm (1/8 in.) diameter threads without crumbling.

D. Compressive strength Test:

The standard mould of size 150mm × 150mm × 150mm is used for casting. Curing is done for concrete cubes and the compressive strength test is done as per IS 516:1959 for 7days and 28days for ordinary mix and for the partial replaced samples.

E. Split tensile test:

The standard mould of size 150mm × 300mm is used. Split tensile test is done as per IS IS 5816:1999 for 7days and 28days for ordinary mix and for the partial replaced samples.

E. Mixing of material:

The normal grade of the concrete that is used is M30 for normal construction purposes in India. The mix deign is done separately for the soil using the minimum void ratio methods and maximum density method.

F. Flexural strength test:

The standard mould of size 500mm × 100mm × 100mm is used. Beams are kept for curing and the flexural strength test is done as per IS 516:1959 for 7days and 28days for ordinary mix and for the partial replaced samples.

V. METHODOLOGY

G. Nondestructive test – rebound hammer:

A. Specific Gravity test:

The Specific gravity of the aggregates that are used is tested by following the Indian Standards specification by following IS 2386 (Part III) – 1963. The design parameters of concrete also depend on the specific gravity of materials used. Rebound hammer test is used to find out the compressive strength of concrete by using rebound hammer as per IS: 13311 (Part 2) – 1992.

H. Water absorption test:

One of the important properties of a good quality concrete is low permeability and water absorption test gives considerable information regarding permeability. The test procedure involves drying a specimen to a constant weight, weighing it, immersing the specimen in water for specified amount of time, and weighing it again. The increase in weight as a percentage of the original weight is expressed as its absorption (in percent). The average absorption of the test samples shall not be greater than 5% with no individual unit greater than 7%.

VI. RESULT:

A. Specific Gravity test:

The specific gravity of river sand is 2.782 and the average specific gravity of S1 and S2 are 2.28 and 2.48.

B. Sieve analysis:

The fineness modulus of river sand is 3.09 and that of soil samples S1 and S2 are 4.0917 and 3.7618.

C. Atterberg's Limits:

i) Soil sample 1	
Liquid limit -	37.70
Plastic limit -	23.35
Plastic index -	14.35
ii) Soil sample 2	
Liquid limit -	37.38
Plastic limit -	23.67
Plastic index -	13.71

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D. Mix Proportions:

The mix proportion of the fine aggregate is calculated using IS 10262:2009[6] has shown in Table.1

Table.1 MIX PROPORTION OF FINE AGGREGATE

SAMPLE	RATIO
water cement ratio	0.4
Mix ratio(sand)	1 : 1.52 :2.48
Mix ratio of S1	1 : 1.18 : 2.48
Mix ratio of S2	1 : 1.30 :2.48

F. Split tensile tests:

The compressive strength results as tabulated in Table.3 and FIG.4

Table.3 SPLIT TENSILE TEST RESULTS

Type of fine aggregate	7 days 2 (in N/mm)	28 days 2 (in N/mm)
Sand	2.71	4.20
S1	1.72	3.19
S2	1.97	3.38
S3	2.63	4.09

E. Compressive strength results:

The compressive strength results as tabulated in Table.2 and

Table.2 COMPRESSION STRENGTH TEST RESULTS:

Type of fine aggregate	7 days 2 (in N/mm)	28 days 2 (in N/mm)
Sand	19.25	35.35
S1	12.50	22.50
S2	17.25	25
50% replacement (S3)	24.82	37.55

7) Flexural strength tests:

The Flexural strength results as tabulated in Table.4 and FIG.5

TABLE.4 FLEXURAL STRENGTH TEST RESULT:

Type of fine aggregate	7 days 2 (in N/mm)
Sand	2.92
S1	1.2
S2	2.15
S3	3

VII. CONCLUSION:

- The specific gravity of S1 and S2 is relatively less than river sand; hence the volume required is more than river sand.
- The compressive strength using S1 and S2 is relatively lower than that of compressive strength of cubes cast and tested using river sand. However sample S3, with partial (50%) replacement shows a considerable increase in compressive strength compared to S1 and S2.
- The split tensile strength of concrete using S1 and S2 samples is lower than the split tensile strength of concrete with sand as fine aggregate.
- As per the Atterberg's limits, the S1 and S2 are clayey. But, when soil and sand combines in partial replacement, the high binding capacity of

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concrete gives higher strength compared to full replacement of soil.

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