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Compressive and Tensile Strength of Concrete Using Lateritic Sand and River Sand as Fine Aggregate

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Abstract--This paper is part of a study investigating the structural characteristics of concrete using various combinations of lateritic sand and river sand as replacement for conventional fine aggregate. Samples of concrete (eg. Cubes ,Cylinders) were made using varying contents of laterite and river sand as fine aggregate. The quantity of laterite was varied from 0% to 100%. The samples were cured for specified periods and tested in the laboratory for compressive strength. Workability tests were earlier carried out to determine the optimum water/cement ratios for three different water/cement ratios, namely. It was found that 0.48 water/cement ratio produced higher compressive strengths, Specifically compressive strength ranged from 32-37.932 N/mm2 for the mixes considered. These results compare favourably with those of conventional concrete. The concrete was found to be suitable for use as structural members for buildings and related structures, where laterite content did not exceed 60%.

Keywords: Laterite, river sand, workability, compressive strength, conventional concrete.

1. INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc, to meet the requirements of globalization, in the construction of buildings and other structures concrete plays a vital role and a large quantum of concrete is being utilized. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce.in the backdrop of such a bleak atmosphere, there is a large demand for alternative materials.

The environmental impact of concrete is a complex mixture of not entirely negative effects while concrete is a major contributor to green house gas emissions, recycling of concrete is increasingly common in structures that have reached the end of their life. Structures made of concrete have a long service life. As concrete has high thermal mass and very low permeability, it can make for energy efficient housing.

Laterite is a pedogenic and highly weathered natural material formed by the concentration of hydrated oxides of iron and aluminium, further oxidized to form an insoluble precipitate of fine particles. Further concentration and dehydration and subsequent cementation forms hard concretionary nodules or the coalescence of particles into a hard vesicular mass of honeycomb structure where cavities may contain the host soil [2]. The soluble hydrated ferrous oxide (FeO) dissolves in water and is leached from parent rock together with aluminium oxide into a host soil. Further oxidation occurs to the ferrous oxide resulting in ferric oxide (Fe_2O_3), which is insoluble and precipitates into fine particles. Concentration of the oxides is either by residual accumulation or by solution, movement and chemical precipitation. Increased concentration due to loss of moisture results in the formation of discrete soft nodules of soil cemented with the precipitate. This process and the subsequent hardening of the nodules are referred to as concretionary development. The presence of oxides of iron and aluminium together with silica and kaolinite clay minerals in various different proportions gives laterite the distinct ochre, yellow, purple or red colour of which red is the most predominant emanating from the red iron oxide [2,6,8].

2. EXPERIMENTAL PROGRAM

The Objective of the project is to study the properties of concrete using lateritic sand as partial replacement to fine aggregate and also to compare the results between lateritic sand as fine aggregate with conventional river sand as fine aggregate.

2.1 Materials Used:

1. Cement: Ordinary Portland Cement confirming to IS: 8112-1989 was used. Ultratech cement 53 grade procured from single source, properties of which are tested in laboratory are given in Table 1.

Table 1:

Sl. no	**Character**	**Experimental results**	**As per Is:8112 1989**
1.	Consistency of cement	26%	-
2.	Specific gravity	3.156	3.15
3.	Initial setting time	50mins	>30min
4.	Final setting time	230mins	<600mins
5.	Compressive strength		
	3days	23.5N/mm^2	>23
	7days	35.8N/mm^2	>33
6.	Fineness of cement	1.2%	10%

2. Basalt aggregate:

In this present investigation aggregate available from local crusher was used. Size of the aggregate used was 20mm down size as one fraction and 12.5mm down size as another fraction of basalt coarse aggregate was used.

Different tests such as specific gravity, fineness modulus, bulk density etc were carried out in the laboratory for basalt aggregate. The result are presented in Table.2, Table 3,Fig 1.

Table 2. Physical properties of coarse aggregate.

Sl.No.	Properties	Basalt aggregate
1.	Shape of coarse aggregate	Angular
2.	Specific gravity	2.89
3.	Bulk density	1.65 g/cm^3
4.	Free surface moisture	Nil
5.	Fineness modulus	7.06
6.	Water absorption	1.667%

Grading of coarse aggregate:

Table 3: Sieve analysis results of basalt aggregate

Sieve size (mm)	Cumulative % passing finer for Basalt aggregate
40	100
20	94.9
12.5	64.3
10	34.72
4.75	0.04

Sieve analysis test is carried out in the laboratory for the basalt aggregate and results are presented in Fig.1.

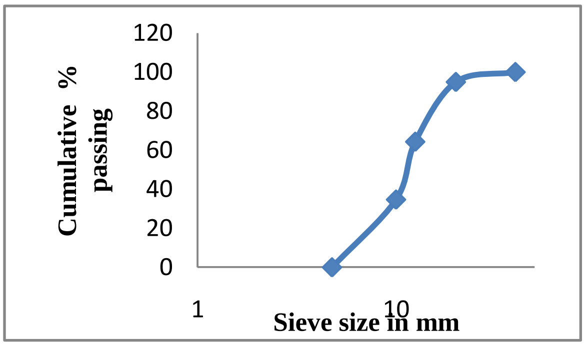

Fig 1: Sieve analysis for Basalt aggregate.

3. **River sand:**
   Good quality zone II fine aggregate was used. The various test results are shown in Table 3.
4. **Lateritic sand:**
   Lateritic sand (4.75mm - 150µm size) of Humnabad was used in the present study for replacement of fine aggregate.

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Table 4: Physical properties of lateritic sand and river sand.

Sl.No.	Properties	River sand	Lateritic sand
1.	Specific gravity	2.74	2.73
2.	Fineness modulus	3.137	4.43
3.	Water absorption	2.5%	2.57%
4.	Bulk density	1.43 gm/cm3	1.703 gm/cm^3
5.	Bulking	-	37.5%
6.	Silt content	-	1%

Grading of fine aggregates

Table 5: Sieve analysis results of natural sand and Lateritic sand.

Sieve size (mm)	Cumulative % finer for laterite	Cumulative % finer for sand
4.75	99.50	97.303
2.36	87.83	91.233
1.18	44.10	81.116
600µm	18.51	36.603
300µm	4.73	6.590
150µm	2.24	0.857
Pan	0.004	0.014

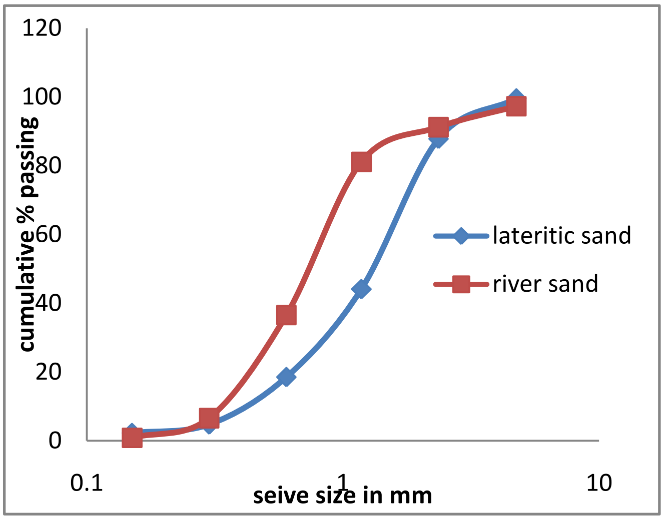


Fig 2: Sieve analysis for lateritic sand and river sand.

2.2 Workability test:

Concrete using lateritic sand and river sand as fine aggregates exhibit three basic forms of slump depending on the water/cement ratio just like normal concrete (i.e True, Shear and Collapse). This can be seen in the slump results shown in the table.7 below (a to c). The slump is between 0 and 120 mm.

Workability tests are analyzed in the fig3. It can be seen that workability increases with corresponding increase in laterite content.

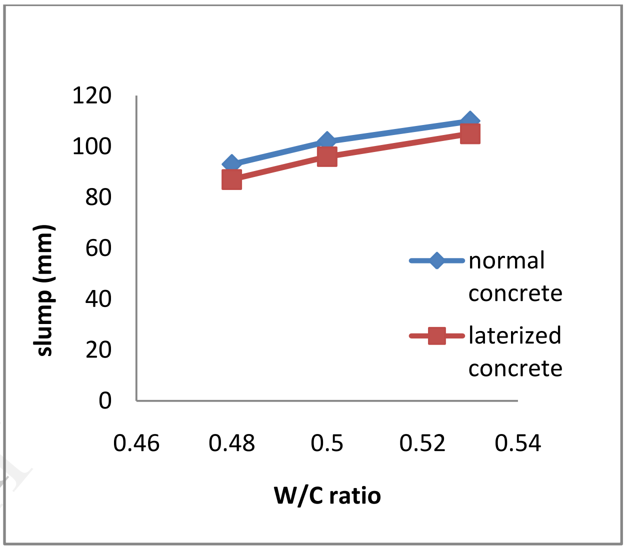


Fig 3. Comparison of Slump Values For Different Water/Cement Ratios.

3. TRIAL CASTING

Trial casting are carried out for the replaced concrete (fine aggregate by lateritic sand) and for conventional concrete for M_{25} grade of concrete using accelerated curing method and compressive strengths are tabulated in the Tables below. (Table 6 and Table 7).

Table 6: Mix proportion for combination of lateritic sand and natural sand for M_{25} grade concrete.

Sl.No	W/C	Cement	Fine Aggregate	Coarse aggregate
1.	0.48	1	1.756	3.080
2.	0.50	1	1.863	3.212
3.	0.53	1	2.025	3.405

Table-7: Workability Results

Sl.No.	W/C Ratio	Slump (mm) Normal concrete	Slump (mm) Lateritized concrete
1.	0.48	93	87
2.	0.50	102	96
3.	0.53	110	105

Table 8: Trial casting results for for conventional concrete (i.e 0% replacement of F.A)

Sl. No .	W/C	Slump value(mm)	Compressive strength (N/mm^2)	Average value (N/mm^2)
1.	0.48	93	30.876	
			31.748	31.510
			31.094	
2.	0.50	102	24.336	
			25.426	24.620
			24.099	
3.	0.53	110	28.696	
			27.824	28.042
			27.606	

Table-9. Trial casting results for laterized concrete (i.e 50% replacement of F.A)

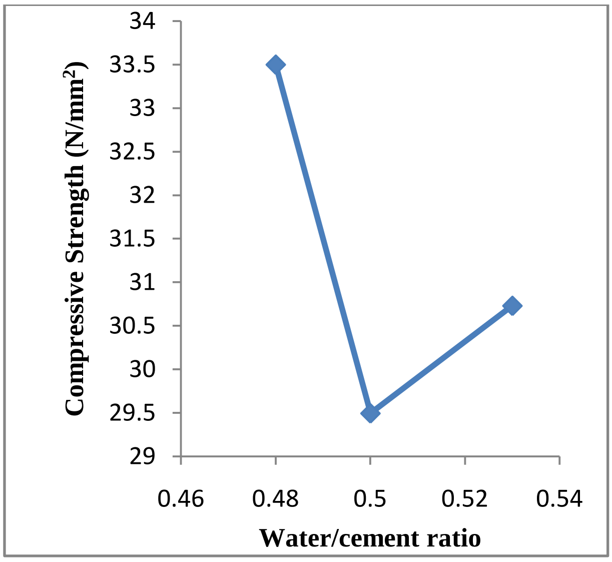


Fig 4: Relationship between compressive strength and water/cement ratio for Trial casting.

Based on the results of trial castings presented in Table 5 and 6, it is observed that for M_{25} grade concrete W/C 0.48 with 50% conventional sand and 50% lateritic sand resulted in good workability and compressive strength. Therefore the mix proportion presented in Table 10 were finalized for further casting.

Table-10. Mix proportion for combination of lateritic sand and conventional sand for M_{25} grade concrete.

SL.NO	Grade of concrete	Cement	Fine aggregate	Coarse aggregate	W/C
1.	M_{25}	1	1.756	3.080	0.48

Total number of cubes cast for compressive strength test of size 150mm×150mm×150mm = 30.

Total number of cylinders cast for split tensile test of size 150mm diameter and 300mm height = 15.

4. CASTING

Cube specimen of 150mm×150mm×150mm were casted using the obtained mix proportion for compressive strength test. For split tensile test, cylinders of size 150mm diameter and 300mm height were cast as per IS standards. The moulds were filled in three layers and each layer is compacted by giving 25 blows with standard rod.

5. CURING

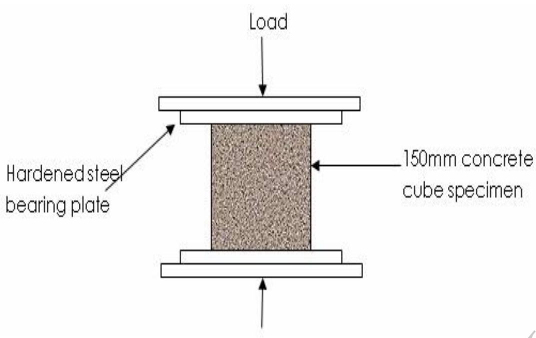
S.NO	W/C	Slump Value in mm	Compressive strength in N/mm^2	Average value in N/mm^2
1.	0.48	87	34.800	
			32.184	33.50
			33.056	
2.	0.50	96	30.004	
			29.568	29.495
			28.914	
3.	0.53	105	30.004	
			30.876	30.73
			31.312	

The cubes and cylinders were demoulded after 24 hours of casting. The cubes and cylinders were kept for curing under water immersion at 27±2°C. The specimens were cured for 28 days.

6. TESTING

6.1 Compressive strength

At the end of curing period, i.e 28 days , the cube specimens were taken out of the tank and kept exposed to environment, till the surface becomes dry. The cube specimens were tested for compressive strength under compression testing machine and load was applied at the rate of 15 N/mm^2 per minutes as specified by the code. Specimens were placed under in a direction perpendicular to the direction in which they were cast. The sample was wiped off from grit and placed centrally with load applied steadily to destruction and the highest load reached was determined. This is used to compute the compressive strength which is the ratio of highest load to the cross sectional area of the sample expressed in N/mm^2. Six samples were used for each test and the average result was adopted as the compressive strength. The results of compressive strength for different percentage replacement are presented in the Table-11.



Load setup

Fig. Compressive strength Test setup

6.2 Split tensile test

At the end of curing period, i.e 28 days , the cube specimens were taken out of the tank and kept exposed to environment, till the surface becomes dry. The cylinders were tested under the compression testing machine for split tensile test as per Indian standard. The load was applied at the rate of 15 N/mm^2 till the fracture occurs and the highest load reached was determined. This is used to compute the compressive strength.

The tensile strength of concrete was obtained by subjecting cylinder to the action of compressive force .the test were carried out as per specifications of IS 58166-1970 on 2 number of cylinders. The specimen was placed between two patterns of compression testing machine .steel strip of 3mm thick, 12mm wide and 300mm wide were placed between the patterns and the surface of the cylinder. The load was applied at a uniform rate of 100 kn/minute till the specimen failed along the vertical diameter. The tensile strength of the concrete was calculated using the formula

Split tensile strength = $2p/(\pi dh)$.

Three samples were used for each test and the average result was adopted as the tensile strength. The results of tensile strength for different percentage replacement are presented in the Table-12.

Fig. Split Tensile Test

Table-11. Results of Compressive Strength Test.

SL.NO	Percentage of laterite replaced	Load in tons	Compressive strength in N/mm^2	Average value
1.	0%	64	27.904	
2.	0%	93	40.548	
3.	0%	70	30.520	35.320
4.	0%	86	37.496	
5.	0%	89	38.804	
6.	0%	84	36.624	
7.	20%	72	31.392	
8.	20%	80	34.880	
9.	20%	66	28.776	32.627
10.	20%	76	33.136	
11.	20%	83	36.188	
12	20%	72	31.392	
13.	60%	74	32.264	
14.	60%	99	43.164	
15.	60%	72	31.392	37.932
16.	60%	93	40.548	
17.	60%	99	43.164	
18.	60%	85	37.060	
19.	80%	81	35.316	
20.	80%	77	33.572	
21.	80%	79	34.444	33.644
22.	80%	80	34.880	
23.	80%	74	32.264	
24.	80%	72	31.392	
25.	100%	68	29.650	
26.	100%	75	32.700	
27.	100%	82	35.752	32.700
28.	100%	93	40.548	
29.	100%	67	29.212	
30.	100%	65	28.340	

Table-12 : Results of split tensile test.

SL. NO.	Percentage of laterite replaced	Load values in tons	Tensile strength in N/mm^2	Average value N/mm^2
1.	0%	40	5.551	
2.	0%	37	5.135	4.95
3.	0%	30	4.164	
4.	20%	26	3.608	
5.	20%	30	4.163	3.747
6.	20%	25	3.469	
7.	60%	36	4.996	
8.	60%	24	3.330	4.163
9.	60%	30	4.164	
10.	80%	20	2.776	
11.	80%	30	4.164	3.192
12.	80%	19	2.637	
13.	100%	24	3.330	
14.	100%	20	2.775	3.052
15.	100%	22	3.053	

7. RESULTS AND DISCUSSION

7.1 Discussion Of Compressive Strength Results:

Fig 5. indicates the relation between compressive strength v/s percentage of lateritic sand added in the concrete for M_{25} grade concrete. From the fig it is clear that the concrete containing the lateritic sand of about 20%, 80% and 100% have resulted in nearly the same strength i.e 32.627 N/mm^2,33.644N/mm^2 and 32.700N/mm^2 respectively. However concrete prepared with lateritic sand 60% has resulted in

higher strength (37.932N/mm^2).

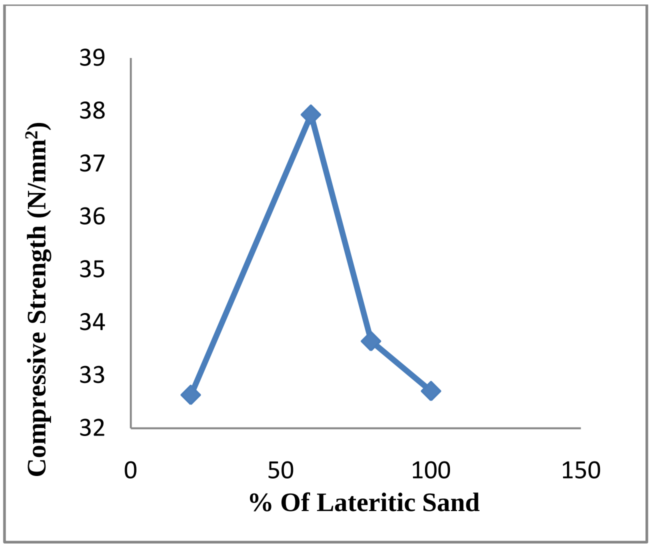


Fig 5: Comparison of Average values of Compressive Strength for Different percentages of Laterite Content in Concrete.

7.2 Discussion Of Splitting Tensile Strength Results:

Fig. 6. Indicates the relationship between compressive strength v/s percentage of lateritic sand added in the concrete of M_{25} grade. From the fig it is clear that concrete prepared with laterite content of 80% and 100% have resulted in nearly the same strength i.e. 3.192N/mm^2 and 3.052 N/mm^2 respectively. The concrete prepared with laterite content of 20% shows a slightly higher strength compared to the above two percentages. However the concrete with laterite content of 60% has resulted in higher strength (i.e 4.163N/mm^2) compared to all above percentages of laterite content.

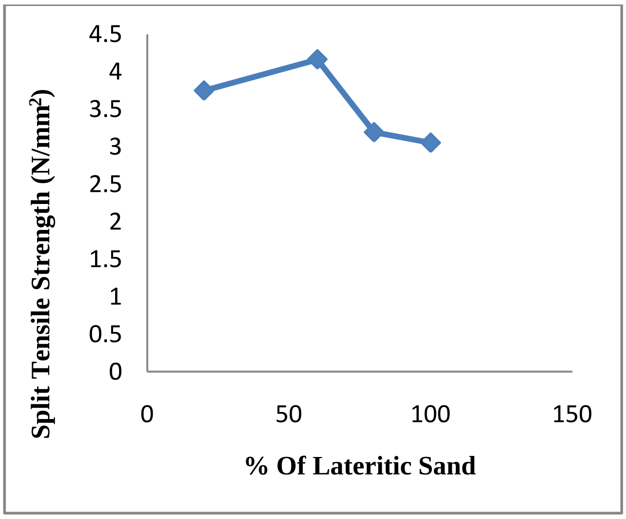


Fig 6: Comparison of Tensile Strength for Different percentage of Laterite Content in Concrete.

8. CONCLUSION

1. The compressive strength and also the split tensile strength increases as the percentage of lateritic sand increases upto 60% and then it starts decreasing if the percentage of laterite increased above 60%. Therefore 60% replacement of river sand by lateritic sand can be used effectively for better results.
2. The 80% and 100% replacements almost gives the same strengths as that of the normal concrete.
3. Therefore 60%,80% and 100% replacements levels can used effectively resulting in good results and workability.
4. The manually sieved lateritic sand can used for the preparation of concrete as it is available freely in abundant quantity and it is also economical.
5. Using lateritic sand as a fine aggregate replacement material in the preparation of concrete makes the mix cohesive and workable.
6. M_{25} grade of the concrete can be prepared easily with good workability without requiring the super plasticizer.
7. The locally available lateritic sand as replacement to river sand in the preparation of the concrete results in good economy.
8. By using this material as fine aggregate we can reduce the demand of the conventional sand in the preparation of the concrete.

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