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Strength and Durability Characteristics of Laterite Sand Mixed Concrete

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Abstract: In this project the attempt was made to use of laterite sand as a fine aggregate in concrete. Sand is demanded ingredient of concrete which is costly too due to availability. Laterites are rich in silica and it is a locally available material of low cost.The major advantage is that it can be replaced with fine aggregate in concrete. The physical properties of laterites are investigated namely specific gravity, particle size distribution and density. The specific gravity of cement, sand, laterite and coarse aggregate are 3.1, 2.6, 2.55 and 2.7 respectively. Uniformity coefficient (Cu) and coefficient of curvature (Cc) of laterite is 4.375 and 1.09 respectively. The quantity of laterites varies from 0 percentage to 100% at interval of 25 percentage in this study. The 1:1.5:3 mix of concrete is used for determining the mechanical strength and durability characteristics. The density of laterite mixed concrete increases when percentage of laterite increases. The results of laterite sand mixed concrete is compared with conventional concrete. At 50 percentage replacement of sand by laterite sand produces high compressive strength. The tensile and flexural strength increases when the percentage of laterite sand increases. While 28 days of HCL acid curing, the compressive strength decreases. The compressive strength decreases after curing when percentage of laterite increases. As a result of sorptivity test the water absorption increases, when the percentage of laterite sand increases.
Keywords: Laterite, Sand, density, durability, compressive strength, split tensile strength, flexural strength.

1. Introduction

India is growing country and so the construction industry is growing very fast. The difficulty to get building materials in market is increasing day by day, especially the concrete ingredients. We thought to replace one of ingredient with readily available source and cheap in cost. Our Tanjore region is located in south part of India which is higher producer of rice and this region is rich source for laterite sand also. Hence we thought to use the laterite sand to replace sand in concrete. The strength and durability of sand mixed concrete depends on multiple factors whereas we tried to use laterite sand to increase the durability and strength of concrete. There were multiple projects done based on the laterite sand mixed concrete and we thought to analysis deeply to demonstrate the usage of laterite sand in our region. End of this project, we would like to demonstrate the strength and durability of laterite sand mixed concrete which can be made with low cost laterite sand. Also we found that the strength and durability of laterite sand mixed concrete is superior to other existing ingredients which are being added in concrete.

2. Previous Work

The laterite is been investigated many times around the world to substitute the aggregate. Also some researchers tried to use in bricks work. But they tried to use by clubbing with quarry dust, granite fines etc. While using the laterite in place of regular aggregate, the strength of concrete increases but there is no proof or result about durability characteristics of concrete. We have taken confident and believe from the people's previous work

to prove the laterite as a perfect substitute for aggregate and to prove the same, we have studied the different shapes of specimens by measuring the durability characteristics & strength of concrete.

Laterite sand is a well graded soil. For laterite concrete, the modulus of elasticity is greater than modulus of deformability (1). The density of laterite mixed concrete is lesser than normal concrete. The heat resistance of laterite mixed concrete is higher than normal concrete (2). Compressive strength of laterite concrete is closer to traditional concrete (3). Sand was replaced by laterite up to 40 % at an interval of 10%. The 25 % of laterite concrete beam provides acceptable performance (4). Water and air curing give more compressive strength for laterite concrete (5). The 25 % of laterite concrete is giving higher strength at temperature up to 500degC (6).The combination of 25% of laterite and 5% of quarry dust give higher compressive strength (7). The tensile and flexural strength of quarry dust mixed laterite concrete decreases, while the % of quarry dust increases (8). The concrete which contained 20 % of laterite as a coarse aggregate has more acid resistance(9). The tensile strength of laterite decreases while adding of granite fines(10)

3. Experimental Work

To prove the superiority of laterite sand in concrete, we decided to compare both conventional concrete & laterite mixed concrete. The three type of specimen (cubes, cylinders & prisms) are considered to check the properties by using both type of concrete. The average result of three specimen are considered for conclusion making.

3.1. Materials Used

We have used normal ingredients of concrete for making specimens as listed below whereas the table indicating the details of materials used, the sourcing and properties too. We used these materials with different combination to make 69 specimens and the average result of these specimen have been considered as result.

Materials	**Source**	**Properties**
Cement	Ordinary Portland cement 43 grade	Specific gravity is 3.1
Laterite	Locally available	Specific gravity is 2.55
Coarse Aggregate(CA)	Crushed granite metal	Specific gravity is 2.7
Fine Aggregate(CA)	Locally available river sand	Specific gravity is 2.6
Water	Potable water	pH value is 7.2

3.2. Chemical Components of Laterite Sand

Chemical components of laterite sand is essential to measure for finding the composition of laterite. Chemical components of laterite is determined by using XRF (X-Rays Fluorescence) analysis. The components are found in both oxide and element form which are listed in Table2.

Table 2. Chemical components of laterite sand

Element in oxide	**Concentration (%)**	**Element**	**Concentration (%)**
SiO_2	55.81	Si	74.04
Al_2O_3	28.36	Al	15.01
Fe_2O_3	11.44	Fe	8.00
TiO_2	1.78	Ti	1.07
K_2O	0.73	K	0.61
CaO	0.67	Ca	0.48
MgO	0.27	Mn	0.21
MnO	0.27	Mg	0.16
P_2O_5	0.16	Na	0.07
Na_2O	0.10	P	0.07
ZrO_2	0.10	Zr	0.07
SO_3	0.09	Ba	0.05
BaO	0.05	S	0.04

V_2O_5	0.004	Cr	0.02
Cr_2O_3	0.04	V	0.02
Cl	0.02	Cl	0.02
NiO	0.02	Ni	0.01
CuO	0.01	Cu	95 PPM
ZnO	0.01	Ru	91 PPM
PbO	98 PPM	Pb	91 PPM
Ru	91 PPM	Zn	83 PPM
SrO	39 PPM	Rb	35 PPM
Rb_2O	38 PPM	Sr	33 PPM

3.3. Details of Test Specimen

Test specimens used for the investigation are cubes, cylinder and prism specimens. The dimension of the cubes used is 150 X 150 X150mm, the dimension of the cylinder is 150mm dia and an depth of about 300mm and the dimension of prism is 700 X 150 X 150mm have been used. All the specimens used for investigation are of uniform size. The details of the test specimen are shown in below table.

Table3. Details of test Specimen

Notation	% of laterite	% of sand
C	0	100
L1	25	75
L2	50	50
L3	75	25
L4	100	0

Table 4(a).Quantity of Ingredients

S.No	Material	Control specimen			L1 mix			L2 mix		
		Cube	Cylinder	Prism	Cube	Cylinder	Prism	Cube	Cylinder	Prism
1	Cement	1.58	2.50	7.50	1.58	2.50	7.50	1.58	2.50	7.50
2	Laterite	0	0	0	0.585	0.938	2.813	1.17	1.875	5.625
3	Fine Aggregate	2.34	3.75	11.25	1.755	2.812	8.437	1.17	1.875	5.625
4	Coarse Aggregate	4.75	7.50	22.50	4.75	7.50	22.50	4.75	7.50	22.50

***All quantity are in Kg**

Table 4(b). Quantity of Ingredients

S.No	Material	L3 mix			L4 mix		
		Cube	Cylinder	Prism	Cube	Cylinder	Prism
1	Cement	1.58	2.50	7.50	1.58	2.50	7.50
2	Laterite	1.755	2.812	8.437	2.34	3.75	11.25
3	Fine Aggregate	0.585	0.938	2.813	0	0	0
4	Coarse Aggregate	4.75	7.50	22.50	4.75	7.50	22.50

4. Results And Discussions

5. 4.1.Density

6. Density of specimen or material is one of the important factor in building industry. The weight & volume of specimen is measured to calculate density and it is increased while increasing the % of laterite in concrete.

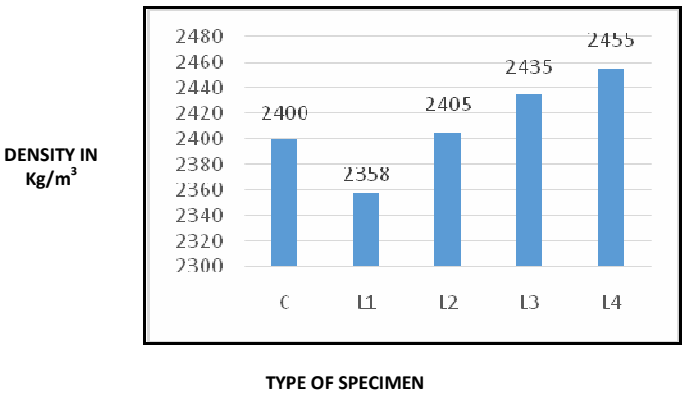

Fig.1. Comparison of density results

4.2. Mechanical Strength Characteristics

Compressive strength is the capability of structure to bear axially loaded which is determined by using compression testing machine. The compressive strength of specimens shown in Fig.3, whereas the compressive strength of specimen decreased than the conventional concrete, while laterite % increases more than 50% and the further study to be done to find out the optimum % of laterite to be used in concrete.

Fig.2. Test setup for compressive strength

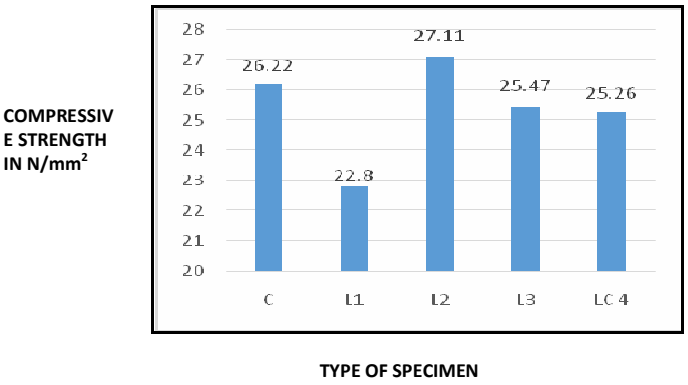

Fig.3. Comparison of compressive strength

Split Tensile strength of specimen(Fig.5) is also been determined by using the compression testing machine. Split tensile strength is only calculate because the specimens are concrete.

Fig.4. Test setup for split tensile strength

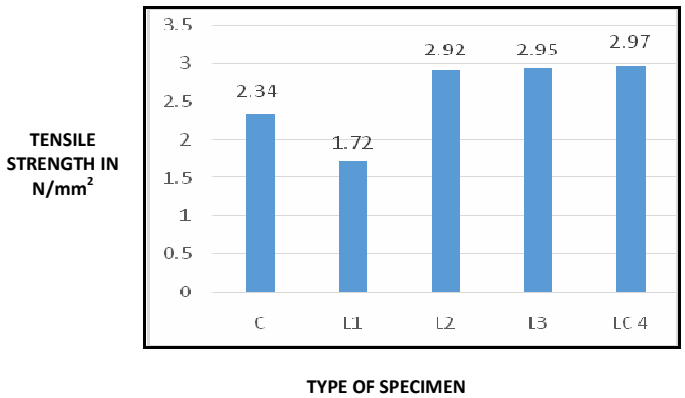

Fig.5.Comparison of tensile strength

Flexural strength is also calculated to find out the resistance of deformation for the specimens by using universal testing machine. The results are shown in Fig.7

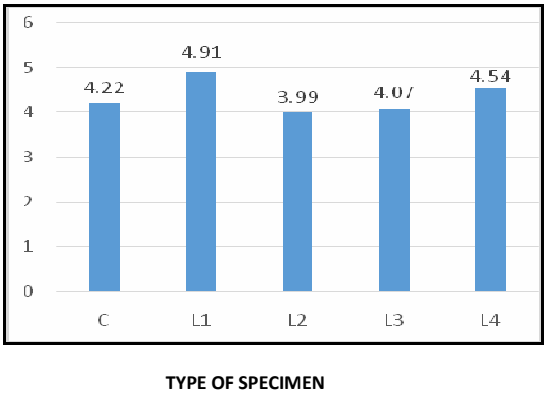

Fig.6. Test setup for flexural strength Fig.7. Comparison of flexural strength

Durability Characteristics

Compressive strength of specimens aredetermined to compare the results of before and after acid curing. The compressive strength decreased after acid curing while comparing with the strength before acid curing. Thecompressive strength decreases, while the % of laterite increases in concrete.

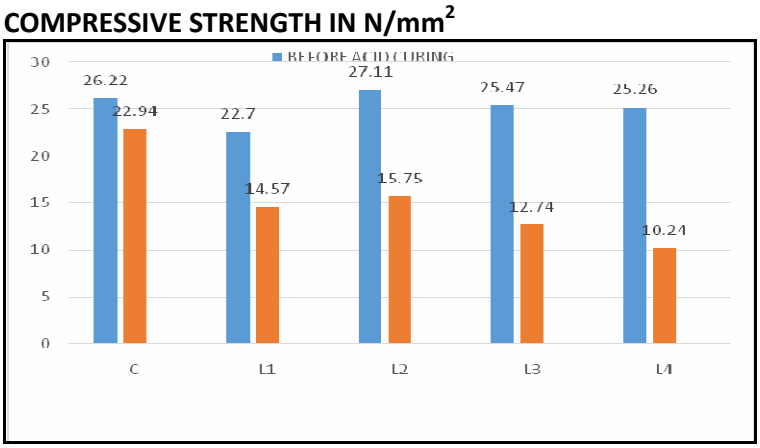

Fig.8.Comparision of Compressive Strength beforeand After Acid Curing

The water absorption of laterite sand mixed concrete is determined by sorptivity tests (ASTM C1585-13). The bottom of specimen is only in contact with water, other sides are protected from water by using the water proof material. The water absorption increases, while the % of laterite increases. Water absorption (I) is determinedby following formula $I=M_t/ad$. Where M_t - increase in mass of test specimen, a - exposed area and d - density of water.The graph between absorption (I) and √Time is drawn, which is shown in Fig.10.

Fig.9. Sorptivity test

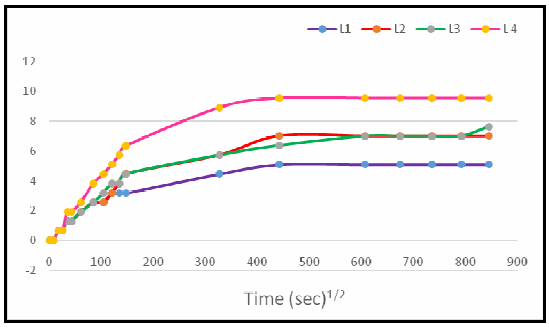

Fig.10. Sorptivity results

5. Conclusion

- The following physical properties are investigated namely specific gravity, particle size distribution and density. The specific gravity of cement, sand, laterite and coarse aggregate are 3.1,2.6,2.55 and 2.7 respectively. Uniformity coefficient(Cu) and coefficient of curvature(Cc) of laterite is 4.375 and 1.09 respectively. The density of laterite mixed concrete increases when percentage of laterite increases.
- The mechanical properties of laterite sand mixed concrete is compared with conventional concrete. At 50% replacement of sand by laterite sand, it produces high compressive strength compared to conventional concrete(FIG.4.1). The tensile strength increases when the percentage of laterite sand increases. At 25% of sand by laterite, the tensile strength is lower than conventional concrete. But further increasing % of laterite the tensile strength is higher than conventional concrete.At 25% and 100% of sand replacement by laterite sand,it gives high flexural strength compare to the conventional concrete.
- Durability characteristics of concrete is also investigated. Two tests are conducted to determine the durability characteristicswhich are acid attack test and sorptivity test.
- HCL acid is used for acid curing. After 28 days curing, the compressive strength of specimens decreases. The % of acid attack increases with % of laterite sand.
- After acid curing, the compressive strength decreases into 12.5%(C), 35.8%(L1), 41.9%(L2), 49.9% (L3) and 59.5% (L4)
- In sorptivity test results, the water absorption increases while the percentage of laterite increases.

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