AN EXPERIMENTAL ANALYSIS ON USAGE POTENTIAL OF LATERITIC SOIL AS PART/FULL REPLACEMENT FOR FINE AGGREGATES IN CONCRETE

[1]K Narendra Brahmaji, [2]B Ganesh, [3]GVLN Murthy, [4]K Chandrika
[1]M.tech, Roll no-14961D8721, Lenora Engineering College, Rampachodavaram, Andhra Pradesh
[2]Assistant Professor, Department of Civil Engineering,
Lenora Engineering College, Rampachodavaram, Andhra Pradesh
[3]Assistant Professor, Department of Civil Engineering,
Sri Vasavi Engineering College, TP Gudem, Andhra Pradesh
[4] Assistant Professor, Department of Civil Engineering,
Sri Vasavi Engineering College, TP Gudem, Andhra Pradesh

Abstract
The provision of affordable housing units from indigenous building materials has been the focus of most researchers in recent times. Sand has traditionally been used as fine aggregate in structural concrete. It is usually brought/transported from relatively distant places at high costs, and this increases the overall cost of making concrete. Also, river sand is slowly running out, leading to scarcity and price rise. This study investigates the suitability of lateritic aggregates a s part/full replacement for fine aggregate and evaluate its mechanical performance in laterized concrete. Aprocedure is standardized for obtaining lateritic sand (meeting either zone – II or zone – III) from laterite blocks. To study its performance in concrete, 150 mm cubes were cast and 28 days water cured for cases of 0%, 25%, 50%, 75% and 100% river sand being replaced by lateritic sand. These cubes were later tested to determine compressive strength of laterized concrete. Important results are discussed and presented in this work.
Key Words: Lateritic aggregates, laterized concrete.

1. LATERITE

In general, laterite can be considered as a material, highly weathered, rich in secondary oxides of iron, aluminum or both formed in hot and wet tropical areas. Laterites vary in colour but are generally bright. The usual shades are pink, red and brown, mainly due to the iron oxides in various states of hydration. Francis Buchanan – Hamilton first described and named a laterite formation in southern India in 1807. He named it laterite form the Latin word "later", which means a brick; this highly compacted and cemented soil can easily be cut into brick-shaped blocks for building. When moist laterites can easily be cut with a spade into regular - sized blocks. Laterite is mined while it is below the water table, so it is wet and soft. Upon exposure to air it gradually hardens as the moisture between the flat clay particles evaporates and becomes resistant to atmospheric conditions. The art of quarrying laterite material into masonry suspected to have been introduced from the Indian subcontinent.

2.0 NEED FOR THE STUDY

A major factor affecting the construction industry in developing countries is the cost of building materials most of which have to be imported from other parts of the country. Frequent increase in prices of building materials across India has reawakened serious awareness to relate research to production, especially in the use of local materials as alternatives for the construction of functional but low-cost dwellings both in the urban and rural areas. One such local material that is being researched is lateritic soils.

Lateritic blocks have been one of the major building materials in India for a long time. The main reason is because it is readily available and the cost of procuring it is very low.
This study is continuing effort to investigate the properties of lateritic soils with the view to improving such properties. Specially, the study looks in to the effect of replacement of the conventional fine aggregate, sand with lateritic soils in the Mangalore region on the compressive strength of laterized concrete blocks.

3.0OBJECTIVES

- A procedure to characterize lateritic sand from lateritic soil is attempted.
- To evaluate its suitability for use either in part/full replacement to sand in concrete.

4.0 MATERIALS AND THEIR PROPERTIES

4.1 Fine Aggregates (River Sand)

The various physical properties and sieve analysis of fine aggregates – sand are tabulated in table 1, table 2.

Table 1: Properties of fine aggregates

S.no.	Physical property		Result
1	Specific gravity		2.65
2	Bulk density	Loose	1463 kg/m^3
		Compact	1661 kg/m^3
3	Water absorption		1%

Table 2: Gradation of fine aggregates (sand)

IS sieves	Weight Retained (kg)	Cumulative weight retained (kg)	% weight retained	% Finer
4.75 mm	0.072	0.072	0.96	99.04
2.36 mm	0.420	0.492	6.59	93.49
1.18 mm	1.108	1.600	21.44	79.56
600 μ	1.228	2.828	37.90	62.10
300 μ	1.702	4.530	60.71	39.29
150 μ	2.487	7.017	94.04	5.96
PAN	0.445	7.462	100	0

4.2 Lateritic Aggregates

The various physical properties of lateritic aggregates are tabulated in table 3.

Table 3: Properties of lateritic aggregates

S.no.	Physical property	Result
1	Specific gravity	2.75
2	Moisture content	0%
3	Water absorption	25%

4.3 Cement

OPC 43 grade cement is used for the tests and for sampling. The following tests are conducted to find the properties of cement and the results are tabulated.

Table 4: Properties of cement

S.no.	Test Conducted	Results obtained			Requirements as per IS
1	Specific gravity	2.97			-
2	Normal consistency	30%			-
3	Setting times, min	Initial – 60			Not less than 30 min
		Final - 250			Not less than 600 min
4	Fineness, m^2/kg	330			Not less than 300 m^2/kg
5	Soundness, mm	Expansion: 250			Not more than 10 mm
6	Compressive strength, MPa	3 day	7 day	28 day	
		28	39	52	

4.4 Coarse Aggregate

The various physical properties of coarse aggregates are tabulated in table 5.

Table 5: Properties of coarse aggregate

S.no.	Physical property		Result
1	Specific gravity		2.77
2	Bulk density	Loose	1360 kg/m^3
		Compact	1527 kg/m^3
3	Water absorption		0.5%

5.0 METHODS

5.1 Breaking of Laterite Blocks

Laterite blocks of weight 25 kg each are taken. In order to produce fine aggregates, the laterite rock blocks are broken down into smaller pieces. Each block is placed in the compression testing machine and load is applied till failure. The broken laterite pieces are still too big to be places in the Los Angeles abrasion testing machine in order to crush them into finer particles. So these pieces are then taken and manually broken down into further smaller pieces will the help of a regular ball pin hammer. The required size is taken to be 20 mm diameter particles.

5.2 Crushing of Laterite Blocks

The laterite pieces of 20 mm diameter now need to be crushed in order to obtain the size of fine aggregates. This can be achieved with the help of Los Angeles abrasion testing machine. For the sake of convenience, the broken down laterite of 25 kg is divided into three batches of equal weight (8.33 kg each). Each batch is now placed in the machine in order to be crushed. Through trial and error the number of steel balls to be placed is found to be 20 and the time for which it is to be rotated is 20 minutes at 30 rpm. The diameter of the balls used is 4.2 cm. The laterite pieces are now crushed to the size of fine aggregates. The process of gradation is carried out next through sieve analysis.

5.3 Gradation of Crushed Aggregates

For proper usage of lateritic sand as a replacement for river sand, the grain size should fall either under zone – II or zone – III. This is found out by subjecting the crushed particle to sieve analysis. Sieve analysis is carried out as per IS – 2386 (part I) – 1963.

Two laterite blocks were used for conducting the tests. The 2 blocks each weighing 25 kg. As 3 trials are conducted for each block, a total of 6 trials are conducted. Trial 1 was conducted with Los Angeles machine with 10 balls for 15 minutes. Results obtained were not adequate, so the crushed sample was discarded. The results for the remaining trials are shown below:

Table 6: sieve analysis of Trial 2 with 5 balls for 5 min.

IS sieves	Weight Retained (kg)	Cumulative weight retained (kg)	% weight retained	% Finer
4.75 mm	1.656	1.656	35	65
2.36 mm	0.564	2.220	47	53
1.18 mm	0.624	2.844	60	40
600 μ	0.280	3.124	66	34
300 μ	0.606	3.730	78.66	21.34
150 μ	0.650	4.380	92.67	7.63
PAN	0.362	4.742	100	0

Table 7: sieve analysis of Trial 3 with 8 balls for 5 min.

IS sieves	Weight Retained (kg)	Cumulative weight retained (kg)	% weight retained	% Finer
4.75 mm	1.102	1.102	14.88	85.12
2.36 mm	0.680	1.782	24.07	75.93
1.18 mm	1.252	3.034	40.97	59.09
600 μ	0.890	3.924	53	47
300 μ	1.858	5.782	78.09	21.91
150 μ	1.140	6.922	93.49	6.51
PAN	0.482	7.404	100	0

Table 8: sieve analysis of Trial 4 with 20 balls for 20 min.

IS sieves	Weight Retained (kg)	Cumulative weight retained (kg)	% weight retained	% Finer
4.75 mm	0.048	0.048	0.60	99.40
2.36 mm	0.270	0.318	3.99	96.01
1.18 mm	1.454	1.772	22.22	77.78
600 μ	1.280	3.052	38.27	61.73
300 μ	2.126	5.178	64.93	35.07
150 μ	1.596	6.774	84.95	15.05
PAN	1.200	7.974	100	0

Table 9: sieve analysis of Trial 5 with 20 balls for 20 min.

IS sieves	Weight Retained (kg)	Cumulative weight retained (kg)	% weight retained	% Finer
4.75 mm	0.026	0.026	0.326	99.674
2.36 mm	0.180	0.206	2.582	97.418
1.18 mm	1.116	1.322	16.57	83.43
600 µ	1.358	2.680	33.60	66.70
300 µ	2.202	4.882	61.21	38.79
150 µ	2.610	7.492	93.93	6.07
PAN	0.484	7.796	100	0

Table 10: sieve analysis of Trial 6 with 20 balls for 20 min

IS sieves	Weight Retained (kg)	Cumulative weight retained (kg)	% weight retained	% Finer
4.75 mm	0.046	0.046	0.60	99.40
2.36 mm	0.333	0.379	4.94	95.06
1.18 mm	1.208	1.587	20.71	79.29
600 µ	1.241	2.828	36.91	63.09
300 µ	1.802	4.630	60.42	39.58
150 µ	2.487	7.118	92.88	7.12
PAN	0.545	7.663	100	0

Table 11: Comparison between last 3 trials

IS sieves	Trial 4	Trial 5	Trial 6	Zone conforming to
4.75 mm	99.40	99.674	99.40	II & III
2.36 mm	96.01	97.418	95.06	II & III
1.18 mm	77.78	83.43	79.29	II & III
600 µ	61.73	66.70	63.09	III
300 µ	35.07	38.79	39.58	III
150 µ	15.05	6.07	7.12	II & III
PAN	0	0	0	-

Table 12: Average % finer values (combining all 3 trials)

IS sieves	Average % finer values	Zone conforming to
4.75 mm	99.50	II & III
2.36 mm	96.16	II & III
1.18 mm	80.16	II & III
600 µ	63.74	III
300 µ	37.61	III
150 µ	9.41	II & III
PAN	0	-

From the above results it can be seen that the sample falls in the zone – III category of fine aggregates. This completes the process of gradation.

5.4 Water Absorption

Since lateritic sand and typical river sand have different properties it becomes imperative to know the properties of laterite which may differ from river sand and which affect the strength of concrete in the future. Water absorption plays a major role in this case. So the amount of water, laterite can absorb in a given amount of time is found out in order to make allowance for the process of hydration of cement. The results for water absorption are tabulated in table 13.

Table 13: Water Absorption results for different samples with varying time

Time	Water absorption (%)
30 minutes	4.28
1 hour	6.98
1 day	25.58
2 days	31.44
3 days	34.23
4 days	34.28

5.5 Slump Test

In order to facilitate the workability and find the water content required for the concrete slump test is performed as per IS 1199 – 1959. For repeatability slump test is conducted for all the cubes. The results for the test are as follows:

Table 14: Slump test results for different samples

W/C	Trial No.	Volume of water added (ml)	Slump (mm)
0.58	1	2900	65
0.62	2	3100	74
0.64	3	3175	75
0.68	4	3375	69
0.79	5	3950	76

5.6 Specimen preparation
The batching of concrete is done by weighing the different constituent materials based on the adopted mix ratio of 1:11/2:3. The fine aggregate portion of the mix is achieved by combining laterite with river sand in ratios starting with 0% laterite and 100% river sand (i.e., 0%-100%, 25%-75%, 50%-50%, 75%-25% and 100%-0%). Quantities of materials required are tabulated as follows in table 15.

Table 15: Material Quantities

Trial	CA (kg)	Sand (kg)	Laterite (kg)	Cement (kg)	W/C
1	15	7.500	0.000	5	0.58
2	15	5.625	1.875	5	0.62
3	15	3.750	3.750	5	0.64
4	15	1.875	5.625	5	0.68
5	15	0.000	7.500	5	0.79

5.7 Specimen Casting
The concrete after thorough mixing by hand is then poured into moulds of size 15 cm x 15 cm x 15 cm as specified in the IS 10086 – 1982. Three cubes are cast for each combination of laterite and sand in the concrete mix. A total of 15 cubes are cast for the whole process.

5.8 Curing
After 24 hours the moulds are removed from the cubes and the cubes are then placed in water for curing for a period of 28 days as per IS 9013 – 1978.

5.9 Compression testing
The samples are removed from water after curing for 28 days. The bearing surfaces are wiped clean. The cubes are then placed in the compression testing machine. The results of compression test are tabulated in the table 16.

Table 16: Results of the compression test

Trial No. (Based on laterite %)	Cube No.			Average (kN)	Compressive Strength (MPa)
	1	2	3		
R1	570	570	620	586.7	26.076
R2	500	550	560	536.7	23.853
R3	510	510	430	483.3	21.480
R4	440	480	420	446.7	19.853
R5	400	420	360	393.3	17.480

6.0 RESULTS AND DISCUSSIONS
6.1 Gradation of crushed aggregates and repeatability
Aggregates on being crushed in the Los Angeles Testing Machine gave similar results for zoning for trials 4,5 and 6. The results were already tabulated in table 11 and table 12. From the results it is observed that all the trials conform to zone III. Also, the average achieved from these trials conforms to zone III.

6.2 Water absorption
From the water absorption table given in the table 13, it is observed that water absorption increases gradually with time. Steady water absorption is achieved on and after 3 days (72 hours).

6.3 Slump
From the slump values found experimentally, we see that the as the percentage of laterite aggregates added increases, the water added to the concrete mix (for absorption of laterite and for concrete hydration) increases. This is because as laterite content increases the amount of water it absorbs also increases. In order to facilitate water for cement hydration more water is added.

Table 17: w/c ratio variation with % laterite aggregates added

Laterite aggregate (%)	w/c Ratio
0	0.58
25	0.62
50	0.64
75	0.68
100	0.79

6.4 Compressive strength

From the results of the compressive test which are tabulated in table 16, it is clear that the compressive strength of concrete decreases with increase in laterite % in the concrete. At 0% laterite content, the compressive strength of concrete is at 26.08 MPa. At 100% laterite content, it is at 17.48 MPa. This behaviour of decreasing can be attributed to the excess addition of water to the concrete mix in order to cater for the water absorption property of laterite.

7.0 CONCLUSIONS:

1. A method for characterization of lateritic sand from lateritic blocks by breaking, crushing and gradation is proposed. Repeatability of the process is proven. Zone III grading of lateritic aggregates is achievable by the prescribed method mentioned.
2. The maximum water absorption of graded laterite samples is observed to saturate at about 34.2%.
3. In all the samples of different laterite proportions, the slump is maintained in the range of 65-80. The water cement ratio was varied to keep the slump constant. We see that as the percentage of laterite aggregates added increase, the water added to the concrete mix (for absorption of laterite and for concrete hydration) increases.
4. At 0% laterite content, the compressive strength of concrete is at 26.08 MPa. At 100% laterite content, it is at 17.48 MPa. This behaviour can be attributed to the excess addition of water to the concrete mix in order to cater for the water absorption property of laterite. But in practice the water absorption property of laterite is altered when it is mixed with cement. Cement forms a coating around the laterite particles, resulting in decrease in water absorption. Hence, the fall in compressive strength can be accounted for.
5. From these experiments it can be seen that there is scope and enough potential for using lateritic sand from lateritic soil in concrete.

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