Evaluation of Compressive Strength of Concrete by Replacing Coarse and Fine Aggregate with Laterite

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Abstract- *The Indian construction industry has seen a boom in the past two decades and with new infrastructure projects being approved every year this growth will continue for the near future. This creates a unique problem where the supply of raw materials required for construction (cement, sand, steeletc.) is falling short of demand. The government and other large construction companies source raw materials in huge quantities and can tolerate the increase in material prices to an extent but the smaller scale builders of residential buildings and other local works will have to bear the brunt of the resource scarcity.*

This research attempts to focus on providing a local solution to small scale construction firms by utilizing an indigenous material for local works that will be well known to local builders and masons and will not create logistical and technical problems that are usually associated with integrating a new material into the construction process. In most parts of Konkan region of India laterite is abundantly available, extracted and processed on an industrial scale the authors have chosen this material for the above mentioned reasons and have performed tests on its suitability for use in concrete as a substitute for conventional aggregates. Further testing of laterised concrete has been performed to observe and measure its behavior under compressive tests.

Keywords- Konkan laterite, Laterite Coarse Aggregate (L.C.A), Laterite Fine Aggregate (L.F.A)

I. INTRODUCTION

Laterite is a red colored rock found mostly in regions that have a tropical climate mostly between the tropic of cancer and tropic of Capricorn. It was first identified in South India and is formed due to prolonged weathering of Parent rock due to which most laterites are rich in minerals like iron and aluminum oxide which impart it a characteristic rusty color.

Laterite occurrences are widespread in India. Major share of about 87.5% resources was distributed in two states namely Madhya Pradesh (61%) and Rajasthan (26%). The remaining 13% of resources are spread over in the states of Andhra Pradesh, Kerala, Gujarat, Maharashtra and Jharkhand[4]

Andhra Pradesh was the leading state in laterite production contributing 77% of the total production, followed by Madhya Pradesh (11%), Karnataka (5%) and Gujarat (3%). The remaining 4% was contributed by Kerala &Maharashtra[4]

1.1 Problem statement

River sand or crushed sand is an integral part in every construction project recent scarcity of this sand has led to formation of illegal sand mining mafias and restrictive government policies.

“Last month, Maharashtra started importing sand from Indonesia and the Philippines. One ship with 50,000 tonnes of sand has landed, and more are coming”-Times of India (November 2015)

“Mumbai builders say the sand scarcity has sent its price soaring from Rs 5,000 to Rs 13,000 per 100 cu ft. Imported sand will cost Rs 20,000, but there is no legal alternative. Sand shortage is now affecting all construction, and even the balance of payments.” -Times of India (November 2015)

This is taking place in Maharashtra which is a producer of laterite and also surrounded by some of the largest laterite producing states in the country like Andhra Pradesh & Karnataka. It is estimated that about 2.83 cum (100 ft3) of the laterite stone scrap is generated during excavation of about 11.33 cum (400 ft3) of the laterite stone. This laterite stone scrap creates problem in quarries and needs removal for further excavation [9]. Hence there is ample quantity of waste laterite available for use in local works.

1.2 Objective

The primary goals of this research areto:-

- Perform testing on laterite coarse aggregate and laterite fine aggregate according to IS methods for use in concrete.

- Find an optimal percentage for replacement of conventional aggregates by laterite such that it maintains the engineering properties of concrete while improving sustainability.

II. LITERATURE REVIEW

Research has been done on use of laterite in concrete in tropical countries like Nigeria and Malaysia which has established laterite as a sustainable material for use in construction. The main obstacle to utilizing this research in India has been the great variation in regional properties of laterite in India, even this paper has narrowed its scope to Konkan laterite but previous research has been referred to establish a scientific process as well as to predict performance of laterised concrete.

In a study by K.Muthusamy and N.W.Kamaruzman Granite aggregate was replaced by laterite coarse aggregate the conclusion reached was the increasing addition of laterite aggregate reduced overall strength, even thoughup to 30% replacement of L.C.A was possible for their target strength of 30 Mpa.

Other studies carried out on laterite sand that can be utilized as fine aggregate have found it to be a very efficient substitute as summarized by L.O.Ettu, O.M. Ibearugbulem in Nigeria and further studies in India have concluded that laterite sand up to 20 % is optimum replacement value. The gain in compressive strength for concrete with laterite content as a fine aggregate in 7 days is approximately 62% of its 28th day compressive strength.(Biju Mathew, Dr. Benny Joseph ,2003) this research shall attempt to validate the above two variations of up to 30 % for L.C.A and up to 20 % for L.F.A for Konkan laterite.

III. METHODOLOGY

We obtained the scrap laterite blocks from Dapoli region of Maharashtra where they had been locally mined.Most blocks was 390x190x190mmof deformed shape with fractures and cracks. The blocks were broken by hand into aggregates passing through 20mm IS sieve and retained o

n 12 mm IS sieve,these were used as the coarse aggregate, the left over scrap was converted into fine aggregate passing through 2.36mm IS sieve and retained on 1.44mm IS sieve and silt was passed through 90 micron sieve and removed.

Standard tests for Aggregates as recommended by IS codes(were performed on LCA and LFA

The water absorption for laterite aggregates was found to be exceptionally high,laterite coarse aggregates are by nature not as tough as conventional aggregates

The following process was chosen.

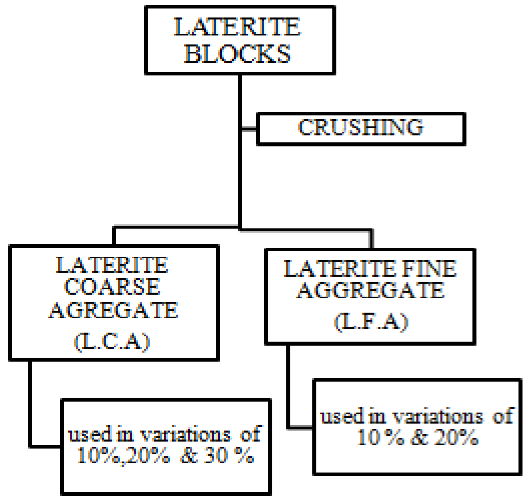

Fig 1 Process Flowchart

Table 1: Properties of Aggregates

Properties	Laterite Coarse Aggregate	Conventional C.A	Laterite Fine Aggregate	Conventional F.A
Water absorption	8.4%	1.3%	14%	2.5%
Specific gravity	2.74 (E.g method)	2.9	2.6	2.74
	2.4 IS method	2.7	2.24	2.64
Compressive strength of laterite block	2.35 N/mm^2			
elongation	11.96%	7.8%	-	-
flakiness	1.3%	11.40%	-	-
Crushing value	34.8%	-	-	-
Fineness modulus	-		3.2	3.15

Table 2 summary of replacements

LCA %	LFA %	No of cubes (7 days)	No of cubes (28 day)
0%	0%	3	3
10%	10%	3	3
20%	10%	3	3
30%	10%	3	3
10%	20%	3	3
20%	20%	3	3
30%	20%	3	3

The concrete will be machine mixed and vibrated using a vibrating table and placed into mould for curing.The standard size of cube is 150x150x150 mm.

IV. MIX DESIGN

The mix design was prepared as per IS 10262-2009 with Target strength equivalent to M20 grade concrete.

- Grade designation-M20
- Type of Cement-OPC (53 grade)
- Max.nominal size of aggregate-20mm
- Exposure conditions-severe
- W/C ratio : 0.5

Mix proportion:

Table 3: mix proportions

Cement	Fine aggregate	Coarse Aggregate
1	1.9	2.9

For one cubic metre:

Table 4: summary of quantities

Cement	384 kg
Water	192 lit.
Fine Aggregate	725 Kg
Coarse Aggregate	1112 Kg

Fig 3: 20mm laterite coarse aggregate.

Fig 4: Laterite fine Aggregate.

Fig 5: Laterite Aggregate in concrete.

COMPRESSIVE STRENGTHS OF CUBES

Table 5 : summary of results

L.C.A %	L.F.A %	Symbol	7 days (KN)	Avg(KN)	N/mm²	28 days(KN)	Avg(KN)	N/mm²
0	0	control	420	420	18.81	640	640	28.43
10	10	LCA10,LFA10	640	635	28.22	850	890	39.56
			630			920		
			635			900		
20	10	LCA20,LFA10	490	496.66	22.07	910	806.66	35.85
			495			750		
			505			760		
30	10	LCA30,LFA10	510	505	22.44	750	690	30.66
			500			560		
			505			760		
10	20	LCA10,LFA20	650	661.66	29.4	930	923.3	41
			660			910		
			675			930		
20	20	LCA20,LFA20	590	603.33	26.8	860	851.66	37.85
			620			800		
			600			895		
30	20	LCA30,LFA20	535	526.66	23.4	765	790	35
			515			795		
			530			810		

Fig 6: testing of cube specimen

Fig 7: Broken Laterite block.

V. OBSERVATIONS &ANALYSIS

5.1 RESULTS OF LFA 10 WITH LCA10, LCA20, LCA 30

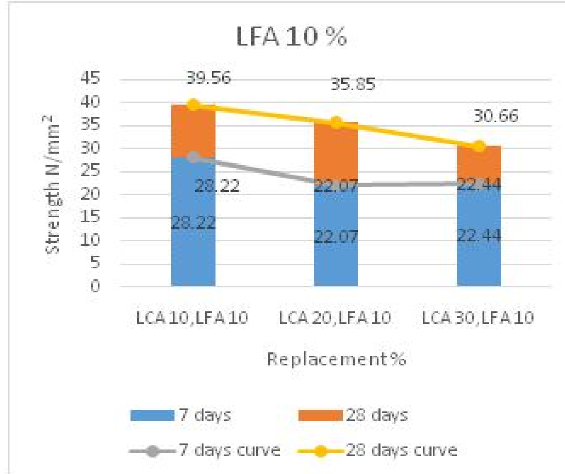

Fig 8 summary of LFA10 cubes.

5.1.1 Observations from results

- There is increased strength in all variations above the conventional strength given below:-
- 7 days M20-18.81 N/mm2
- 28 days M20-28.43 N/mm2
- There is a clear decrease in strength as the percentage of laterite is increased in the concrete.
- Faster gain in 7 days strength in concrete for LCA10,LFA10 and LCA

Table 6: Initial compressive strength LFA 10

Variation	7 days	28 days	% gain
Control	18.81	28.43	66.16%
LCA10,LFA10	28.22	39.56	71.33%
LCA20,LFA10	22.07	35.85	61.56%
LCA30,LFA10	22.4	30.66	73.06%

5.2 RESULTS FOR LFA20 WITHL CA10, LCA20 , LCA30

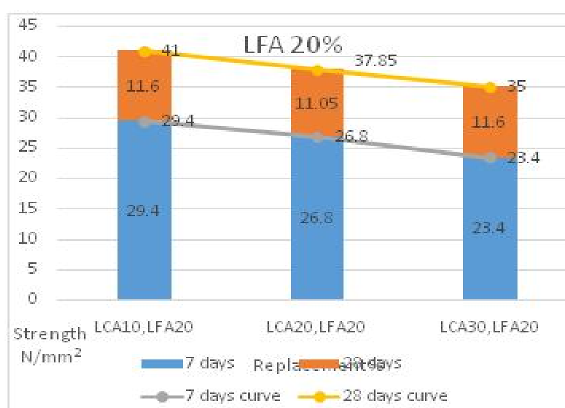

Fig. 9 Summary of LFA20 cubes

5.2.1 Observations from results

- There is increased strength in all variations above the conventional strength of M20 as well as cubes using LFA 10 as shown below
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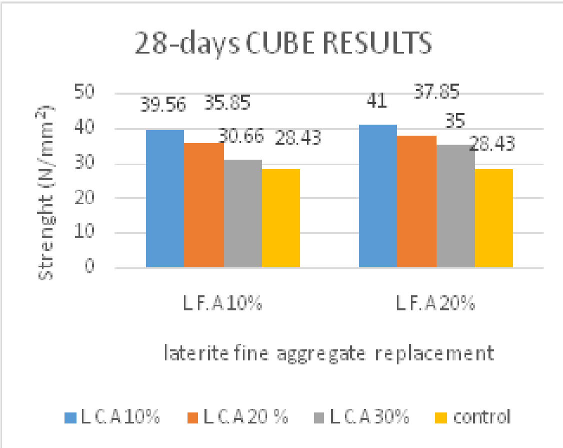

Fig 10 comparison between LFA 10 & LFA 20(28d)

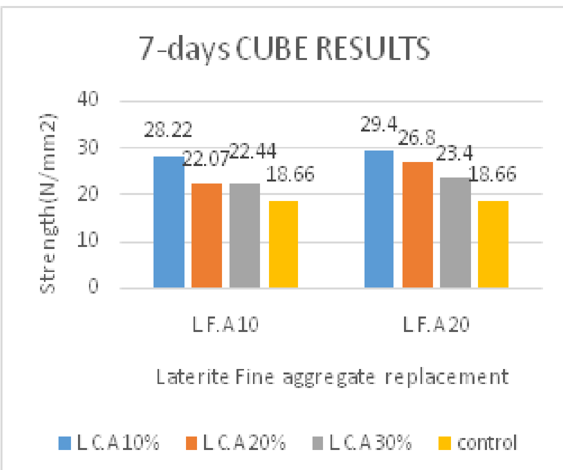

Fig 11 comparison between LFA10 & LFA20 (7d)

As observed previously the compressive strength declines proportionally to the increase in % of laterite coarse aggregate.

- The highest strength of all variations is recorded with LFA 20 % and LCA 10 % at 41 N/mm2
- There is also faster and consistent gain in seven days strength compared to control specimen and LFA 10.

Table 7 Initial compressive strength LFA 20

Variation	7 days	28 days	% gain
Control	18.81	28.43	66.16%
LCA10,LFA20	29.4	41	71.70%
LCA20,LFA20	26.8	37.85	70.80%
LCA30,LFA20	23.4	35	66.86 %

VI. CONCLUSION

- Using Laterite as replacement for conventional aggregates gives better compressive strength than the conventional M20 grade of concrete for all Variations of replacement
- This maybe because of natural cementitious property present in laterite,this property makes laterite an active component in binding of cement as compared to the inert conventional aggregates hence a better chemical bond is formed between the components of concrete as compared to conventional concrete.
- .Early strength gain is observed in concrete containing laterite compared to conventional laterite,
- This gain in initial strength is more rapid for concrete samples where higher % of laterite fine aggregate was used.
- This maybe because the Fine Aggregate increases the contact area for a better bond within concrete, however as we increase the LCA for concrete samples with LFA 20 % replacement the early strength is seen to gradually drop going from 71.7% (LCA10,LFA20) to 66.86% (LCA30,LFA20).
- As we increase the % replacement of coarse aggregate the compressive strength (28 days) is seen to decline for both combinations. This may be due to the fact that laterite is a softer stone than conventional aggregate and also has significantly higher water absorption than conventional aggregate.However laterite also has a property of hardening when it comes in contact with water this may contribute to overall final strength achieved.
- As the water absorption of Laterite aggregates is very high the initial mixtures with relatively low percentage of laterite exhibit good workability and texture but on increasing percentage of laterite in the mixture the concrete becomes very stiff.
- Almost 7% of water was seen to be absorbed by the laterite hence it is recommended that when designing mix proportions a higher water cement ratio be maintained (0.5 for Konkan laterite) to accommodate for the water absorbed by laterite.
- The highest strengths in all variations was achieved by concrete which had lowest LCA content and higher LFA.Though all variations were above the strength of conventional concrete (M20) the highest was recorded for LFA10,LFA20 at 41 N/mm2.
- Hence it is recommended that the optimum percentage of replacement of aggregate for improving sustainability of concrete is 10 % replacement by laterite coarse aggregate and 20% replacement by Laterite Fine aggregate

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