International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 06 | Jun 2024 www.irjet.net p-ISSN: 2395-0072

Durability Properties of Cement Concrete Using Laterite as Partial Replacement for Natural Aggregates

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Abstract – *The coarse aggregates obtained from laterite wastes are gaining importance in recent decades in view of scarcity of natural coarse aggregates. In this present study, concrete is designed for M30 mix proportion and the concrete mixture was developed using laterite waste as a partial replacement of natural aggregates at varying percentages (5%,10%,15% and 20%) as partial replacement of natural coarse aggregates. Also, the Laterite can be used as fine aggregates in concrete composites, hence the replacement is considered for fine aggregates too. These blends' hardened properties, such as compressive strength and flexural strength were investigated. Among the said proportions of replacements, 15% replacement of natural coarse aggregates yielded promising results. 10% of fine aggregate provides satisfactory results. From the durability point of view, prepared samples were immersed in sea water and satisfactory results were obtained.*

Key Words: Laterite, Eco friendly, Rigid pavements.

1.INTRODUCTION

Construction of rigid pavements is increasing rapidly in India especially for low volume roads. The production of concrete mix involves materials like fine aggregate or river sand and coarse aggregate, stone quarry. Also these natural resources are not widely available abundantly and hence procurement of these materials is a challenging task due their non-availability. These demands for the use of alternate natural resources as a partial replacement/complete elimination of non-renewable natural resources. More number of studies are occurring for developing environment friendly sustainable materials are achieved with the replacement of natural aggregates with laterite soil. A quantum amount of laterite is available in western parts of Karnataka and also other regions of India where rate of rainfall is heavy. Also the concept of recycling is very essential for the present day construction activities. As mentioned above the laterite, after utilizing for various construction activities can be used as fine aggregate. Very less number of research works are available on the application of laterite for the production of concrete.

In a nutshell the Laterite can be used effectively along with the natural coarse aggregate and fine aggregates.

Significance of present study

This research article primarily focuses on study, analysis and comparison of the compressive strength, flexural strength and durability behavior of concrete mixer at longer duration. Very limited studies were carried out by the researchers, however the current research work involves the combined effect of laterite as coarse aggregate and fine aggregate for the assessment of strength parameters and also durability parameters. This particular study provides a path towards sustainable construction practices which helps in the reduction of global warming and protecting natural resources

2. MATERIALS AND METHODS

The details of the material used in the study for the production of concrete mix is shown in Fig1.(a),(b) & (c).

Cement

Ordinary Portland cement of grade 53 (OPC 53) which satisfies the requirements of IS 269:2015 was used, physical properties test examined as per IS 4031 and the results are represented in table 1.

Table -1: Properties of Cement

(a) Chemical composition of cement							
Constituent	Cao	SiO2	Al2O3	Fe2O3	MgO	SO3	Alkali
Percentage	62.1	21.1	5.0	3.4	2.29	2.44	1.5
(b) Physical properties of cement							
Initial setting time (mins.)			Final setting time (mins.)		Normal consistency (%)		
110			195		31.1		

Natural aggregates

The natural coarse aggregate used in this study were of standard sand quarry and the fine aggregate was the natural river sand, these aggregate were tested for physical properties as per IS 2386 part 3 and corresponding test results are shown in table 2. The particle size distribution test was conducted as per IS 383 and the fine aggregate belongs to zone 2.

Table -2: Physical properties of aggregates used in the study

Properties	CA	Laterite	FA
Specific gravity	2.65	2.6	2.62
Water absorption	0.15	0.55	1.10
Crushing value	25.1	-	-
Impact value	10.8	-	-

CA – Coarse aggregates
FA – Fine aggregates

Laterite

Laterite is a red mud which is abundantly available in western parts of Karnataka and other parts of India. Laterite after using for the various building activities, were collected for the experiment purpose. Size of the Laterite particles converted as fine aggregate grain size. The physical properties of laterite were represented in Table 2.

Fig. 1 (a) Coarse aggregates

Fig. 1 (b) Fine aggregates

Fig. 1 (c) Laterite

3. MIX PROPORTIONS

M30 concrete mix proportion is adopted for the testing purpose as per IS 10262 codal provisions.

The test procedure aims to understand the behavior of alternate material to natural coarse and fine aggregates. The laterite aggregates included with the various percentages to determine the optimum strength parameters. To determine optimum dosage of additive, i.e, laterite, a test samples with 5%, 10%, 15% and 20% inclusion were done for both coarse and fine aggregate alternates.

Further the quantity of composition of each material is represented in table -3. Laterite with 20 mm downsize and 4.75 mm downsize are considered as coarse and fine aggregates respectively. Table 3 represents mix proportions used for the experimental work.

Table -3: Mix proportion of materials

Mix Number	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Laterite (kg)
M1	1.48	2.09	4.53	0
M2	1.45	1.98	4.53	0.104 (5%)
M3	1.48	1.88	4.53	0.209 (10%)
M4	1.48	1.78	4.53	0.313 (15%)
M5	1.48	1.67	4.53	0.418 (20%)
M6	1.45	2.09	1.98	0.104 (5%)
M7	1.48	2.09	1.88	0.209 (10%)
M8	1.48	2.09	1.78	0.313 (15%)
M9	1.48	2.09	1.67	0.418 (20%)

In the above table, M1 represents normal conventional concrete mix. M2 to M5 represents replacement of fine aggregate with Laterite with varying percentages. Similarly, M6 to M9 represents replacement of coarse aggregates with Laterite with varying percentages.

Compression test

Concrete cube specimens were prepared for varying percentages of additive materials to check the compression strength at different ages as per IS 516. In this study, concrete cubes were casted for a dimension of 150 x 150 mm and curing was done for 7 days, 28 days and 84 days. A total of 27 cube specimens were casted and tested. Laterite incorporated as coarse as well as fine aggregate and separate proportions were considered and tested.

Flexural strength test

To check the flexural strength of concrete, three-point bending test was adopted, as per IS 516. A beam specimen of dimension, 100 x 100 x 500 mm was selected for the test procedure.

4. RESULTS AND DISCUSSIONS

Compressive strength test was conducted on all the prepared cube samples at 7 days, 14 days and 28 days curing. Also, the cubes were soaked for sea water curing for an age of 84 days.

The results represent in below table shows, 15% of inclusion of Laterite as coarse aggregates gives satisfactory results and 10% of inclusion of Laterite as fine aggregate gives good results at normal water as well as sea water curing. Compared to normal water curing, as sea water contains dissolved salt, the concrete cube sample gives lesser strength at longer duration.

During flexural testing also at 15% replacement of natural aggregate with Laterite provides good results and also at 28 days curing beam samples provides 10% replacement of fine aggregates gives satisfactory results.

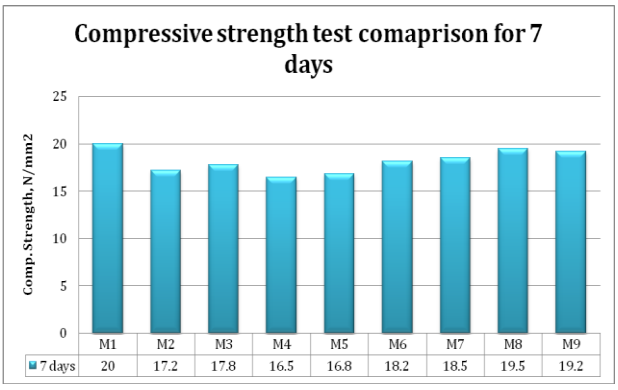

Fig. 2 Compressive strength comparison for 7 days

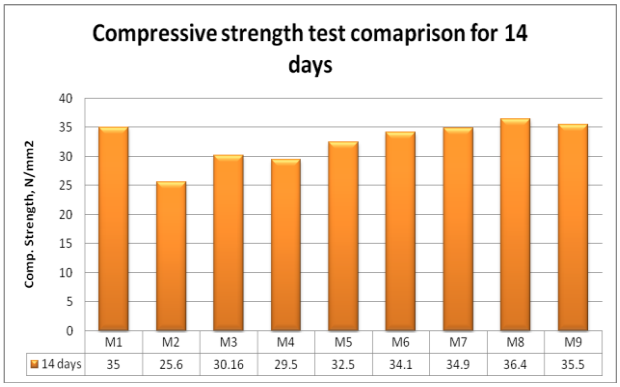

Fig. 3 Compressive strength comparison for 14 days

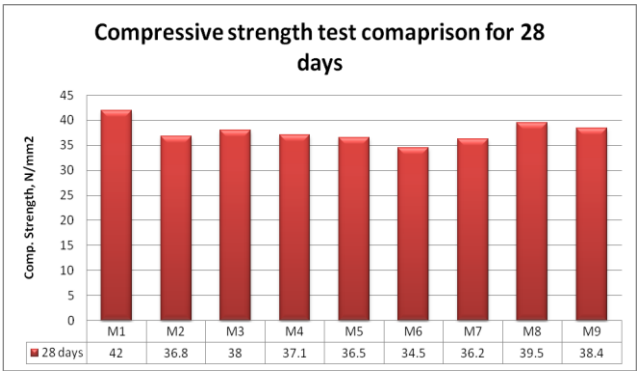

Fig. 4 Compressive strength comparison for 28 days

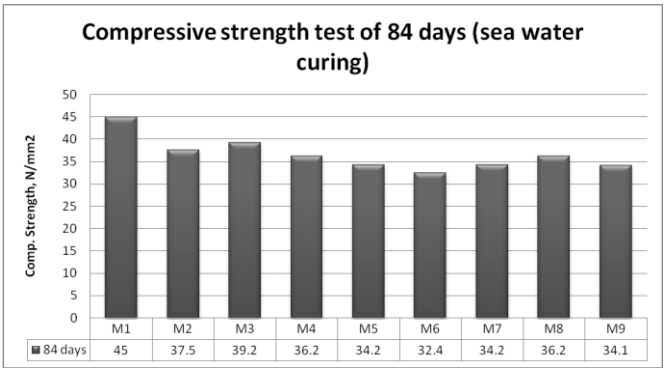

Fig. 5 Compressive strength of 84 days' strength (sea water curing)

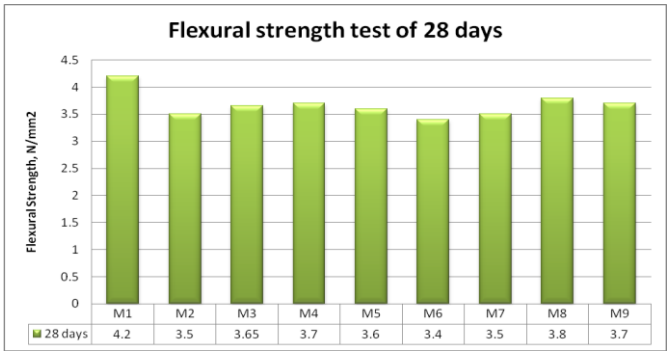

Fig. 6 Flexural strength for 28 days

CONCLUSIONS

Figures 2,3 and 4 represents compressive strength of concrete cubes at various percentages of replacements. Laterite was utilized as an alternate material for natural coarse aggregate and natural river sand.

Laterite waste materials obtained from the construction industry is adopted as coarse as well as fine aggregates separately. Even durability aspect was analysed by soaking the concrete cube samples in a sea water curing for 84 days' duration.

5%,10%,15% and 20% variations were considered for the replacement of natural aggregates.

From the obtained results, it is an evident that, Laterite as a coarse aggregate up to 15% of replacement can be done against natural aggregate without compromising strength parameter. Further, up to 10% of Laterite fines can be replaced with natural fine aggregates.

In this research work, durability aspect was also analyzed by soaking the cube samples in sea water for 84 days, as results the 15% replacement as coarse and 10% replacement as fine aggregates provides satisfactory results.

For the similar proportions of replacement, there is a good result for flexural strength parameter.

By proper utilization of Laterite as an additive environmental benefit can be incorporated.

Figure 5 shows the test results of cube samples immersed in sea water for 84 days and the optimum percentages of 10 to 15% replacements can be done effectively without effecting strength parameters.

Also, Figure 6 represents the flexural strength parameter at 28 days' duration of beam samples.

Hence conclusion can be drawn based on the test results to utilize the Laterite as coarse and fine aggregate during the construction of rigid pavements.

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