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Study on Strength of Concrete using Lateritic Sand and Quarry Dust as Fine Aggregates

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Abstract: - **Currently India has taken a major initiative to developing many infrastructure such as buildings, 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 rightful 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 scare. In the backdrop of such a bleak atmosphere, there is large demand for alternative for normal concrete from any other wastes. This project aims contribute information of the use of wastes in concrete applications by exploring the engineering properties of the naturally occurring lateritic sand and stone dust for use in structural concrete. These alternative aggregates can be used in concrete production as they are economical and naturally available.**

This paper is part of a study investigating the structural characteristics of concrete using various combinations of lateritic sand and quarry dust as complete replacement for conventional river sand as fine aggregates. Samples of concrete specimens (Cubes, Cylinders and Prisms) were cast using varying contents of lateritic and quarry dust as fine aggregates from 0% to 100%. Workability tests were carried out for different w/c ratios for each M_{20} mix and M_{25} mix. It was found that for M_{20} mix W/c ratio of 0.55 with proportion of 1:2.15:3.32 produced higher compressive strength of 32.12 N/mm^2 and for M_{25} mix W/C ratio of 0.52 with proportion 1:1.98:3.14 yielded maximum compressive strength of 34.27 N/mm^2 for cubes, which are favourable with that of conventional concrete. Split tensile strength of M_{20} mix was maximum for 100% quarry dust and it was 52% higher compared to normal concrete and for M_{25} mix, maximum value for 100% quarry dust is 15.6% higher than normal concrete. Flexural strength of prisms for both M_{20} and M_{25} mix was maximum at 100% quarry dust and increase in strength was about 14% and 11% respectively compared to normal concrete.

Key words: Quarry dust, Lateritic sand, Compressive strength, Tensile strength, Flexural strength.

1. INTRODUCTION:

A view from past history of the construction industry, river sand has been used as one of the major components of the building materials due to the ready availability and its well-graded nature with the sand grains of different sizes well distributed. River sand is mainly used for all kinds of civil engineering constructions. The excessive excavation of river sand is becoming a serious environmental issue. Intensive river sand mining results in the failure of river banks, lowering of river beds, damages to the bridge foundations and other structures situated closer to the river, saline water intrusions and coastal erosion. Hence it is necessary to explore possible alternatives to minimize the use of river sand.

Recent development in construction industry is witnessing an increase in the use of river sand which leads to scarcity of river sand in future. A number of attempts have been made to replace the river sand with other materials which are waste in the environment and to utilize those materials which are disposed without being used. The proposed topic gives an idea of properties of concrete for various combinations of lateritic sand and quarry dust as complete (100%) replacement for conventional river sand as fine aggregates. The quality of lateritic sand and quarry dust were varied from 0% to 100% at different intervals. The samples were cast and cured for 28 days and tested in laboratory for their strength.

The focus of a good national development is to look inwards with intent to mobilize all natural resources for economic purposes. One of the policy thrusts of the present government is to provide affordable housing for the people. The use of lateritic sand in combination with quarry dust can help to achieve this purpose and impact positively in reducing the cost of building materials. This study aims at proper documentation of the materials to support their specification in design and construction.

Many experiments were carried out on replacement of sand by lateritic sand and quarry dust during recent years. Quarry dust has been identified as possible replacement for sharp sand in concrete works. Lateritic sand can also be used for structural concrete.

Salau M.A. (2003) [1], In his studies, he observed that there were not many variations between the creep deformation of laterized concrete and normal concrete. He further recommended replacement of 25% laterite content as the fine aggregate in concrete for long term resistance to creep deformations. Adoga (2008) [2],

Laterite is highly weathered material rich in secondary oxides of iron, aluminium or both. It is nearly devoid of base and primary silicates but may contain large amount of quads and kaolinite. Laterite has been used for the wall construction around the world since it is cheap, environmental friendly and abundantly available. Salau M.A. (2008) [3], He defined laterized concrete as concrete in which stable laterite replace aggregate. He concluded that for high strength and workability only 25% of sand in concrete should be substituted with the lateritic fines. Chaturanga (2008) [4], The use of quarry dust in concrete according to him is desirable because of the benefits such as useful disposal of by-product, reduction of river sand consumption and increase in strength. Quarry dust has rough, sharp and angular particle sand which causes a gain in strength due to better interlocking. Shahul H.M [5], He observed that natural sand is usually not graded properly and has excessive salt while quarry dust does not contain salt or organic impurities and can be produced to meet desired graduation and fineness as per requirement. This consequently contributes to improve the strength of concrete.

The main objective of this project is fully replace the natural conventional river sand fine aggregates with some alternative materials like quarry dust and lateritic sand in concrete and study their influences on structural properties of concrete. These materials are found to be waste in environment hence by proper recycling, they can be easily disposed in concrete structures. Paper also aims to study influences on the mechanical properties of replaced concrete and compare their results with that of concrete produced using conventional river sand. The better option with economy can be selected.

2. MATERIALS AND METHODS:

*Cement:*Ordinary Portland cement confirming to IS 10262-2009 was used. Ultratech cement 53 grade procured from single source, properties of which are tested in the laboratory are given in Table 1.

Table 1: Physical properties of cement

Properties	Test results
Specific gravity	3.12
Normal consistency	34%
Initial setting time	40 minutes
Final setting time	2 hours 30 minutes
Fineness of cement	2%

Super plasticizer:

Super plasticizer used in the project is Fosroc Conplast SP 430. The dosage recommended by the manufacturer is varying between 1-3% by weight of cement. In the present investigation different dosages of super plasticizers were selected for desired workability.

Coarse Aggregates:

In the present investigation locally available aggregates from Prabhudeva crusher was used. Size fractions i.e., 20mm and 10mm down size coarse aggregates were used. Different test such as specific gravity, bulk density and sieve analysis etc were carried out in laboratory for both coarse aggregates. The results are presented in Table 2.

Table 2: Physical properties of coarse aggregates

Properties	20mm	10mm
Shape of coarse aggregate	Angular	Angular
Specific gravity	2.72	2.69
Bulk density(kg/m3)	1.48(compact) 1.39(loose)	1.44(compact) 1.23(loose)

Combined grading of coarse aggregates (20mm and 10mm): The grading was carried out for different proportions and the best results as per the standard grading are as shown in the table 3 below.

Table 3: Sieve analysis results of coarse aggregates (20mm and 10mm)

Sieve sizes	Cumulative % finer for coarse aggregates
40mm	100
20mm	87.78
12mm	56.17
10mm	36.27
4.75mm	0.01
Pan	0

Lateritic sand:

Laterite is a Latin word which means "brick". Laterites are soil types rich in iron and aluminium, formed in hot and wet tropical areas. They develop by intensive and long-lasting weathering of the underlying parent rock. Laterite is extensively used in construction of embankment for roads and earthen dams. Visual observation shows that the laterite being a weathered material is very sharp. As per particle size distribution laterite sand affects the strength properties greatly. Therefore lateritic sand can be used in structural concrete production. Lateritic sand which was used as fine aggregates of size 4.75 IS sieve was found at Hankuni, 7km from Humnabad. The results of different properties are shown in table 4.

Quarry dust:

Quarry dust is formed by the quarrying of the crushed rock aggregates. The use of quarry dust in concrete is desirable as a useful disposal of a by-product, reduction of river sand consumption and increase in strength. Quarry dust has different shaped particles like rough, sharp and angular, helps in better interlocking and to gain strength. It is the waste material remained after crushing of rocks. The materials of particle size less than 4.75 IS sieve were brought from Prabhudeva Constructions, 12km from Gulbarga. The results of different are shown in table 4.

Table 4: Properties of lateritic sand quarry dust
Grading of lateritic sand and quarry dust

Properties	Lateritic sand	Quarry dust
Specific gravity	2.78	2.60
Bulk density in kg/m^3	1.66 (compact) 1.49 (loose)	1.62 (compact) 1.32 (loose)
Water absorption	4%	2%

Table 5: Sieve analysis results of lateritic sand and quarry dust

Sieve size	Cumulative % finer for lateritic sand	Cumulative % finer for quarry dust
75mm	100	98.99
2.36mm	62	73.72
1.18mm	38.5	40.41
600µ	18.5	13.645
300µ	9.5	7.08
150µ	5	5.06
Pan	0	0.01

Concrete mix design:

The strength of hardened concrete using quarry dust and lateritic sand as full replacement to river sand was studied by casting different specimens like cube, cylinder and prism. For both M_{20} and M_{25} concrete mixes a total number of 45 cubes, 45 cylinders and 45 prisms were cast and tested under laboratory conditions. The mix proportions of materials were calculated as per IS 456-2000 using Indian Standard Mix Design (IS: 10262, 2009) for grades like M_{20} and M_{25}.

3. RESULTS AND DISCUSSIONS:

Compressive strength, Split tensile strength and Flexural Strength of concrete were tested on Cubes, Cylinders and Prisms with different percentages of laterite and quarry dust for M_{20} and M_{25} are tabulated in table-6 and table-7 and are shown graphically in fig.1, fig.2 and fig.3 respectively. The strength of concrete has been tested after 28 days of normal curing.

Table 6: Test results for M_{20} mix

Fine Aggregates		Test results in N/mm^2		
Quarry dust	Lateritic sand	Cube Compressive Strength	Split tensile strength	Flexural Strength
100%	0%	29.647	3.837	3.662
80%	20%	31.973	2.637	3.074
70%	30%	35.658	2.822	2.6165
60%	40%	34.333	3.331	2.878
50%	50%	33.375	3.42	2.747
40%	60%	30.811	3.238	3.01
30%	70%	27.904	3.262	3.011
20%	80%	32.44	2.933	3.139
0%	100%	31.683	2.359	2.747

Table 7: Test results for M_{25} mix

Fine Aggregates		Test results in N/mm^2		
Quarry dust	Lateritic sand	Cube Compressive Strength	Split tensile strength	Flexural Strength
100%	0%	32.316	4.07	4.317
80%	20%	34.22	2.987	3.454
70%	30%	37.462	3.285	3.401
60%	40%	36.461	3.694	3.24
50%	50%	35.617	3.475	3.122
40%	60%	32.355	3.347	3.122
30%	70%	29.519	3.578	3.187
20%	80%	34.579	3.142	3.264
0%	100%	33.981	2.476	3.327

Fig 1. Compressive strength of concrete mixes for 28 days curing in N/mm^2

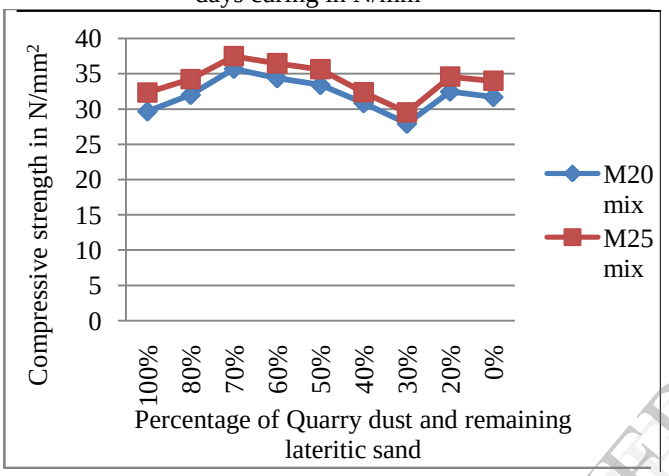
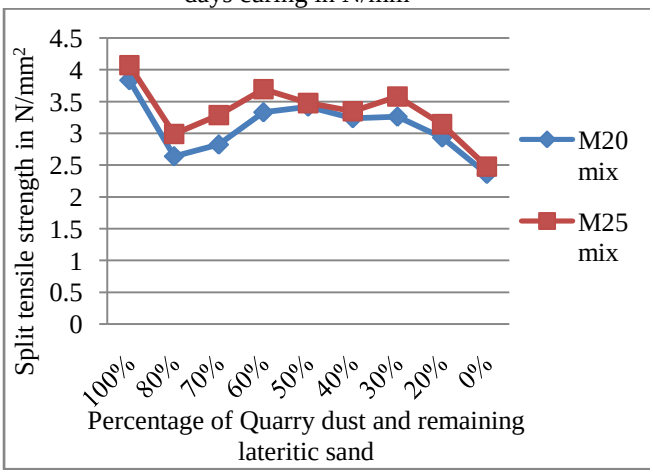


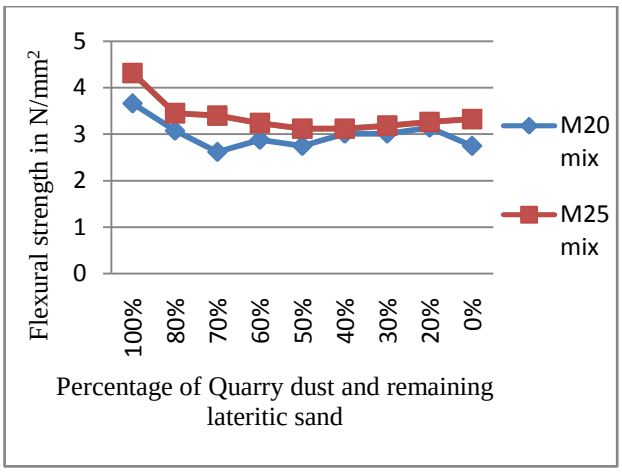
Fig 2. Split tensile strength of concrete mixes for 28 days curing in N/mm^2



DISCUSSIONS:

Aim of the project was to fully replace the river sand by lateritic sand and quarry dust. Since lateritic sand and quarry dust are waste in environment they can be disposed by using in structural concrete. Lateritic sand and quarry dust were varied at different proportions.

Fig 3. Flexural strength of concrete mixes for 28 days curing in N/mm^2



Trial mix design was carried out for different W/C ratios. The W/C ratio giving maximum strength was considered. Combined gradation was done for different proportions of coarse aggregates. The proportion of 60% of 10mm and 40% of 20mm aggregates yielded desired gradation. Since water absorption of lateritic sand and quarry dust are 4% and 2% respectively. To get desired workability super plasticizer was used within a variation of 1.5-3% by weight of cement.

4. CONCLUSIONS:

- Cube compressive strength for different proportions of quarry dust and lateritic sand, the composition of 70% quarry dust and 30% lateritic sand yielded higher compressive strength for both M_{20} and M_{25} mix.
- Split tensile strength of M_{20} mix was maximum for 100% quarry dust and it was 52% higher compared to normal concrete and for M_{25} mix, maximum value for 100% quarry dust is 15.6% higher than normal concrete.
- Flexural strength of prisms for both M_{20} and M_{25} mix was maximum at 100% quarry dust and increase in strength was about 14% and 11% respectively compared to normal concrete.
- Water absorption of lateritic sand is 4% by weight and quarry dust is 2% by weight. So super plasticizer (Forsoc conplast 430) of optimum dosage from 1.5-3% is used to get desired workability.
- The freely available lateritic sand and crushed stone dusts can be widely used for preparation of concrete as they are waste.
- Economy is achieved as material cost for wastes like quarry dust and lateritic sand is much less than compared to conventional river sand available naturally.

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