Studies On Flexural Behaviour Of Beams Using Non-Conventional Aggregates

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ABSTRACT

Common river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. As environmental transportation and other constraints make the availability and use of river sand less attractive a substitute or replacement product for concrete industry needs to be found. River sand is most commonly used fine aggregate in the production of concrete poses the problem of acute shortage in many areas. Whose continued use has started posing serious problems with respect to its availability, cost and environmental impact.

This paper is part of a study investigating the structural characteristics of concrete using various combinations of Quarry rock dust, Sawdust and Vermiculite as complete replacement for conventional river sand fine aggregate. The quantity of Saw dust and Vermiculite used as a replacement percentage of 20% and 25% and quarry rock dust as hundred percent replacement. Concrete samples were prepared (cube, cylinder, and beam) and cured for7, 14, 28 days and tested in the laboratory to destruction in order to determine their compressive, flexural and tensile strength properties. These results compare favourably with those of conventional concrete. Vermiculite Insulation test is also proposed to find out the insulating properties of vermiculite. Design mix of M20 and M30 grades are used.

Keywords: compressive strength, Quarry rock dust, Saw dust, Vermiculite, Split tensile test, Flexural strength.

1. INTRODUCTION

Green concrete has nothing to do with color. It is a concept of thinking environment into concrete considering every aspect from raw materials manufacture over mix design to structural design, construction, and service life. Green concrete is very often also cheap to produce because for example waste products are used as a partial substitute for cement charges for the disposal of waste are avoided, energy consumption in production is lower and durability is greater. Waste can be used to produce new products or can be used as admixtures so that natural sources are used more efficiency and the environment is protected from waste deposits In India the extract activity of decorative sedimentary carbonate rocks, commercially indicated as Marbles and "Granites", is one of the most thriving industry. Marble sludge powder is an industrial waste containing heavy metals in its constitutes. Stone slurry generated during processing corresponds to around 40% of the dimension stone industry final product. This is relevant because dimension stone industry presents an annual output of 68 million tons of processed product [2]. Pravin Kumar et al used quarry rock dust along with fly ash and micro silica in self compacting concrete (SCC) and reported satisfactory strength gain. Quarry dust has been identified as possible replacement for sharp sand in concrete works. Jayawardena and Dissanayake [5, 6] in their paper "Use of quarry dust instead of river sand for future constructions in Sri Lanka" identified quartz, feldspar, biotite mica, hornblende and hypersthenes as the major minerals present in fresh rock which show mica percentages between 5% and 20%. They added that mica percentages in charnocktic gneiss and granitic gneiss are always less than 5%, similar to sand and therefore suitable for use in civil engineering construction. They reported that sand mining had been banned in some areas of major rivers in Sri Lanka because of its negative environmental impact. Granite rock is abundant in Nigeria giving rise to many quarry sites with large heaps of quarry dust. Hence, quarry dust can be reasonably used as alternative to river sand.

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Sawdust can be defined as loose particles or wood chippings obtained as by-products from sawing of timber into standard useable sizes. Timber is one of the oldest structural materials used by man. Temples and monuments built several years ago, which still remain in excellent condition show the durability and usefulness of timber (Kullkarni, 2005). Clean Sawdust without a large amount of bark has proved to be satisfactory. This does not introduce a high content of organic material that may upset the reactions of hydration.

Vermiculite is a light-weight and cheap product that, because of its thermal resistance has become a valuable insulating material. Used as an aggregate with Portland cement it forms an ultra lightweight concrete with an open structure ideal for void filling, suitable for use in most light industrial and domestic applications where thermal insulating and fireproof properties are required. Use around flue linings, behind fire backs and around pipes when fitting room heaters.

2. MATERIALS USED

Cement

The Ordinary Portland Cement (OPC) of 53 Grade is used for the production of Concrete. Standard Consistency, specific gravity and fineness as percentage retained on 90 microns sieve were found.

Fine Aggregate (River sand)

The fine Aggregate used in this investigation is natural river sand and it has a fineness modulus of 2.65. The specific gravity and unit weight are found to be 2.52 and 1510kg/m^3 respectively.

Quarry Rock Dust

Quarry Rock dust has been used for different activities in the construction industry such as road construction and manufacture of building materials such as light weight aggregates, bricks, and tiles. Quarry dust has rough, sharp and angular particles, and as such causes a gain in strength due to better interlocking. High percentage of dust in the aggregate increases the fineness and the total surface area of aggregate particles. The use of quarry dust in concrete is desirable because of its benefits such as useful disposal of by products, reduction of river sand consumption as well as increasing the strength parameters and increasing the workability of concrete. The Quarry rock dust was obtained from local crusher at Madukkarai, Coimbatore District. The specific gravity of the quarry rock dust is 2.677. Moisture content and bulk density of waste are less than the sand properties.

Figure-1.Quarry Rock Dust sample

Saw Dust:

Sawdust is one of the major underutilized by products from sawmilling operations, generation of wood wastes in sawmill is an unavoidable hence a great efforts are made from the utilization of such waste. Sawdust can be defined as loose particles or wood chippings obtained as by-products from sawing of timber into standard useable sizes. The sawdust concrete are offers considerable reduction in weight of the structure, thereby reducing the dead loads transmitted to the foundation , high economy when compared to normal weight concrete.

The Saw dust was obtained from local saw mill at Aalandurai, Coimbatore District. The specific gravity of the saw dust is 2.27.

Figure-2. Saw Dust sample.

Vermiculite

Vermiculite is a light-weight and cheap product that because of its thermal resistance has become a valuable insulating material. Used as an aggregate with Portland cement it forms an ultra lightweight concrete with an open structure ideal for void filling, suitable for use in most light industrial and domestic applications where thermal insulating and fireproof properties are required. Use around flue linings behind fire backs and around pipes when fitting room heaters. Vermiculite was directly taken from kuniamuthur, Coimbatore District. The specific gravity of the Vermiculite is 2.6.

Figure-3. Vermiculite sample.

Coarse Aggregate

The nominal maximum size of the coarse aggregate is of 20mm. The sieve analysis of the coarse aggregates is presented in Table 5. The sieve analysis revealed that the coarse aggregate falls in the Zone I as per IS 383:1972.The Specific gravity and fineness modulus of the Coarse Aggregate was 2.66 and 2.412 respectively.

Admixture

Commercially available Super-plasticizer has been used to enhance the workability of fresh concrete for selected proportions of ingredients.

3. METHODOLOGY

For each test that was conducted, cubes and cylinders were prepared as per BS 1881: Part 108:1983. Due to the compressive force, the cylinder is subjected to a large magnitude of compressive stress near the loading region. The rate of loading applied is 1.4 to 2.1N/mm2 for 150x300 mm cylinders.

The split tensile strength was computed by using expression $f_{ct} = 2p/\pi ld$, where fct is the split tensile strength in Mpa, p is the maximum compressive load on the cylinder (Newton) applied along length of cylinder (mm) and D is the diameter.

Automatic universal testing machine was used for Flexural test according to BS1881-118[12]. Beam samples measuring 500×100×100mm were moulded and stored in water for 28days before test for flexural strength. Three similar samples were prepared for each mix proportion. The casting was made by filling each mould with freshly mixed concrete in three layers. Each layer was compacted manually using a 25mm diameter steel tamping rod to give 150 strokes on a layer. The hardened beam was placed on the universal testing machine simply supported over a span 3times the beam depth on a pair of supporting rollers. Two additional loading rollers were placed on top the beam. The load was applied without shock at a rate of 200m/s.

4. RESULTS AND DISCUSSION

This section presents the results and discussions of laboratory tests conducted on then Quarry dust, Sawdust and Vermiculite as well as the concrete derived from them in their fresh and hardened states. The analysis is carried out in tables and graphs, while the results are discussed in comparison with properties of normal concrete including works of previous researchers.

Physical properties of materials

The results of physical properties of Quarry dust, Sawdust and Vermiculite are first presented in this chapter followed by those of both fresh and hardened concrete produced using Quarry dust, Sawdust and Vermiculite concurrently as fine aggregates.

The specific gravity of materials namely: Quarry dust, Sawdust and Vermiculite and coarse aggregate were found to be 2.67, 2.12, 2.6 and 2.71, respectively.

Workability

The slump value had been measured during the casting of specimen. The slump value decreases as the percentage of Quarry dust increases. This reflects as percentage of quarry dust increases the water requirement increases and thus slump value decreases which may due texture of quarry dust. Generally quarry dust has rough texture than sand. The aggregate having rough texture requires more water for surface weighting. Thus some water is consumed for surface weighting of quarry dust and the net water available get decreases for workability. As per the IS 15658:2006 concrete cubes may be prepared with concrete having zero slumps. If the water requirement increases and slump decreases, addition of quarry dust may solve the problem which will not affect the physical properties.

Compressive strength

The compressive strength results of standard cubes are compiled in Tables 1. The Indian standard method resulted in highly conservative results of compressive strengths for all the two grades of concrete mainly due to high cement content used in conjunction with low aggregate/cement and water/cement ratio in comparison with other advanced by other countries methods in both cases. The overall strength reported 10 to 15 percent increases for five methods of concrete mixes of Natural sand when fully replaced by Quarry Rock Dust.

Figure-5. Compressive test

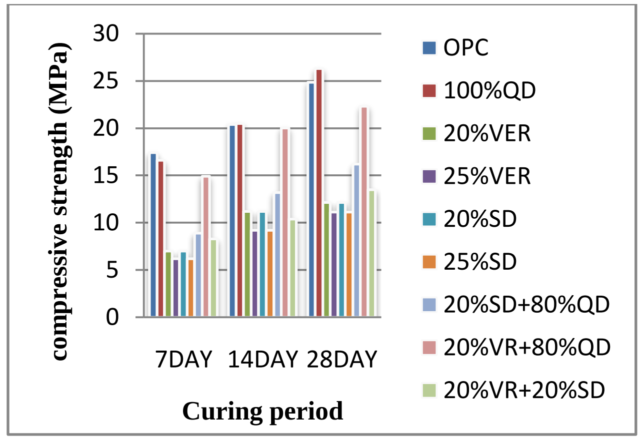

Figure-6. Compressive test result for M20 Grade Concrete.

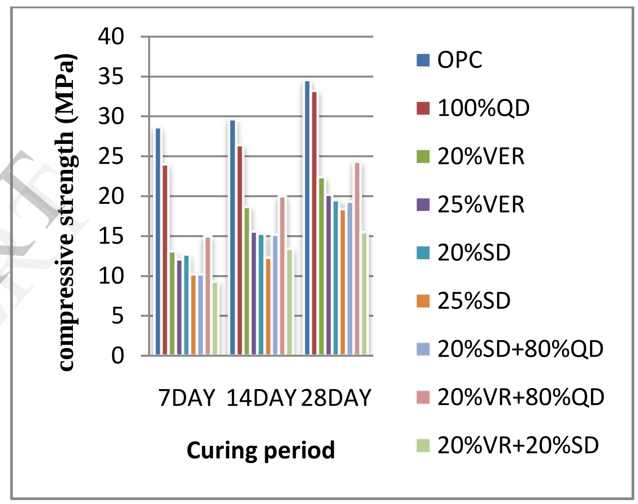

Figure-7. Compressive test result for M30 Grade Concrete

Split tensile strength

The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. The test consists of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis. The magnitude of this tensile stress Osp (acting in a direction perpendicular to the line of action of applied loading) is given by the formula:

$$Osp = \frac{2P}{\prod dl} = 0.637\ P/dl$$

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The ratio of the split tensile strength to cylinder strength not only varies with the grade of the concrete but is also dependent on the age of concrete. This ratio is found to decrease with time after about a month. The air-cured concrete gives lower tensile strength than that given by moist-cured concrete. The flexural strength as obtained by rupture test is found to be greater than the split tensile strength.

Figure-8. Split tensile test.

The split tension test results are shown in Table-2. Figure 8 and 9 shows the comparison between normal and combination of three materials.

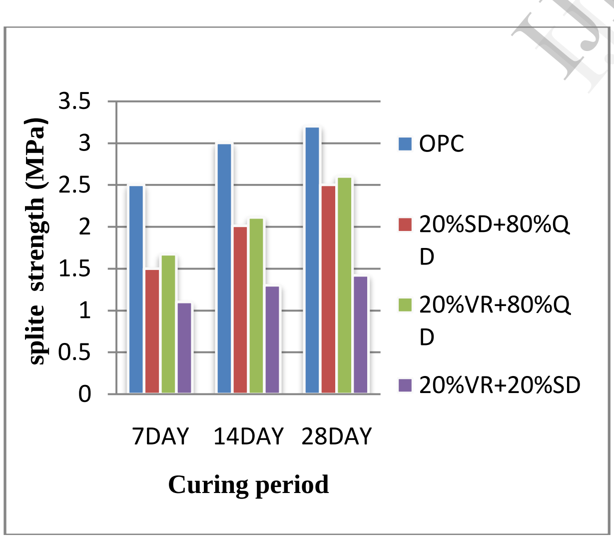

Figure-9. Split tensile strength results for M20 Concrete.

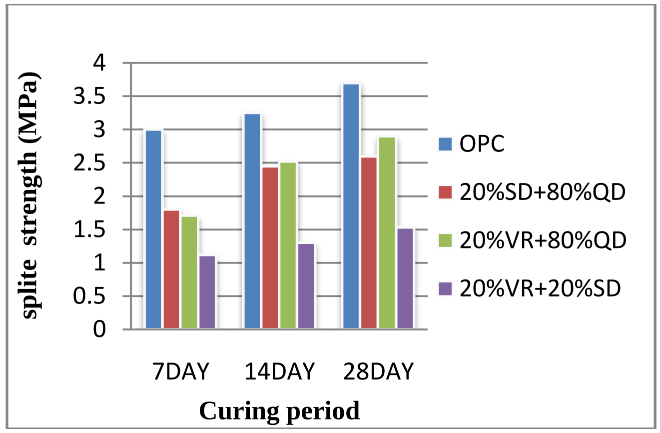

Figure-10. Split tensile strength results for M30 Concrete.

Flexural strength

The specimen is placed in the testing machine such that the load is applied to the uppermost surface as cast in the mould along the two lines placed 13.3cm apart. Apply the load carefully at the rate of 180g/min for 10cm specimen.

1) If 'a' equals the distance between the line of fracture and the nearer support in mm ,then the modulus of rupture
   $Fb = (p \times l)/ (b \times d^2)$

2) When 'a' is less than 13.3cm but greater than 110m
   $Fb = (3p \times a)/ (b \times d^2)$.

Figure-11. Flexural strength test

Flexural strength results are shown in table3. Figure 11 and 12 shows the comparison between normal and combination of three materials

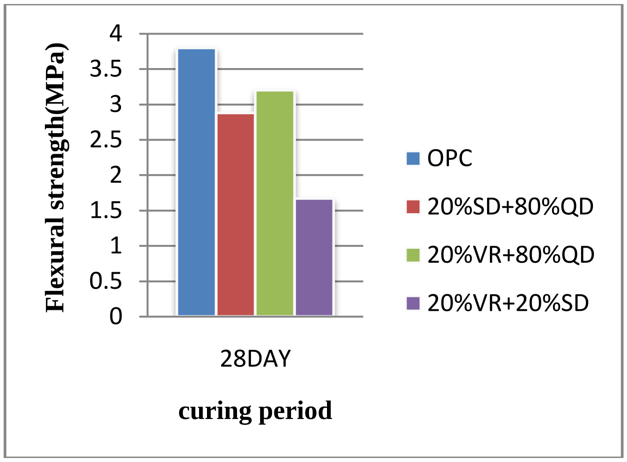

Figure-12. Flexural strength results for M20 Concrete

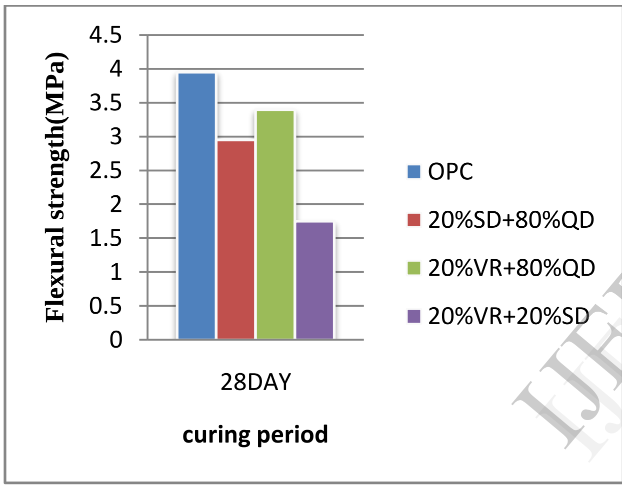

Figure-13. Flexural strength results for M30 Concrete

6. CONCLUSION:

Non availability of sand at reasonable cost as finer aggregate in cement concrete for various reasons, search for alternative material non-conventional aggregates qualifies itself as a suitable substitute for sand at very low cost. From the cost analysis it was found that the cost of non-conventional aggregates concrete was less compared to conventional concrete. The use of saw dust and vermiculite concrete in a structure is usually predicated on lower overall costs. While lightweight concrete may cost more per cubic yard than normal weight concrete, the structure may cost less as a result of reduced dead weight and lower foundation costs. The compressive strength of cubes at 28 days curing for quarry dust increases by 3% compared to normal concrete but the compressive strength of quarry dust concrete continues to increase with age for all the percentage of quarry dust contents. The flexural and tensile strength properties were found to compare closely with those for normal concrete.

REFERENCES:

1. Ahmed, E. Ahmed. and Kourd., A.E., (1989)Properties of concrete incorporating natural and crushed stone very fine sand. ACI Material Journal, 86 (4), 417-424.

2. Hameed M. S and Sekar A. S. 2009, “Properties of green concrete containing quarry rock dust and Marble sludge powder as fine aggregates”, ARPN journal of Engineering and applied Science, Vol.4(4), pp 83-89.

3. Ilangovana, R. Mahendrana, N. and Nagamanib, K., 2008, “Strength and durability properties of concrete containing quarry rock dust as fine aggregates” ARPN Journalof Engineering and Applied Science, V ol.3(5), pp 20-26.

4. Rame Gowda.M, Narasimhan.M.C, Karisiddapa and Rajeeva.S.V, Study of properties of SCC with quarry dust, The Indian Concrete Journal, August 2009, pp.54-60.

5. Udoeyo. and Dashibil, P.U. "Sawdust Ash as Concrete Material", J. Mat. In Civil. Eng. 14(2): 173-176, (2002).

6. Olutoge, F.A.,"Investigations on Sawdust and Palm Kernel Shells as Aggregate Replacement".ARPN Journal of Engineering and Applied Sciences 5(4).

7. Rame Gowda.M, Narasimhan.M.C, Karisiddapa and Rajeeva.S.V, Study of properties of SCC with quarry dust, The Indian Concrete Journal, August 2009, pp.54-60.

8. Taoukil, D.; El-bouardi; A., Ezbakhe, H. and Ajzoul, T. "Thermal Properties of Concrete Lightened by Wood Aggregates". Research Journal of Applied Sciences, Engineering and Technology 3(2): 113-116, (2011).