INVESTIGATION OF SUSTAINABILITY OF STONE DUST IN CONCRETE AS A PARTIAL AND COMPLETE REPLACEMENT OF SAND

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Abstract

In present days natural sand of good quality are becoming scarcer and costlier due to non-accessibility of river during entire year, illegal dredging, rapid growth of construction activities etc. So it is necessary to search an alternative material to use as natural sand in construction activities. Stone dust is such an alternative material which can be effectively being used in construction as partial replacement of natural sand. Hence present study taken a view to verify the suitability and potential use of stone dust in concrete mix as fine aggregate. To accomplish this an experimental programme was planned for cast specimen cubes at an interval of 10 percent replacement of fine aggregate with stone dust in concrete. Results shows natural sand can be effectively replace with stone dust and maximum strength attains at 60 percent replacement of natural sand with stone dust based on compressive strength.Concrete is one of the most widely used construction materials, with annual global consumption exceeding one cubic meter per capita. Recently, there has been an increasing motivation in the study of sustainable concrete, as a result of awareness of environmental degradation, resource depletion and global warming. This research work examines sustainable concrete, that is, stone dust concrete or "sandless concrete", aimed at increasing concrete sustainability with respect to the use of fine aggregates. In stone dust concrete, the natural sand is replaced by stone dust. Major properties were investigated for cement-based mortar and concrete containing stone dust. All the mortar and concrete properties were found to be not harmfully affected, even at 100 % sand replacement. Instead, stone particles could enhance the concrete properties, such as strength and impermeability, due to pozzolanic reaction. Emphasis is on alkali-silica reaction (ASR) in stone dust mortar and concrete. The influence of stone colour, content and particle size on ASR was thoroughly examined. It was found that stone dust with a size between 1.18 and 2.36 mm, would exhibit the highest ASR expansion. Different ASR mitigation methods, including cement replacement by supplementary cementitious materials (SCM), and addition of fiber reinforcement and lithium compounds, have also been examined. It is recommended that the combined use of fly ash or slag would significantly restrain ASR expansion. In "stone dust concrete", the sand is totally eliminated and replaced by the other ingredients, that is, coarse aggregates, cement and water. Stone dust, up to 50% replacement, is used as cement alternative to avoid the high cement content in "sandless concrete". Mix design is achieved by the approache based on mix design of no-fines concrete. Diverse properties, in hardened states, were studied. From the results, "stone dust concrete" was found to show comparable characteristics as normal concrete, while its workability could be further improved. In addition, the durability of "sandless concrete" with stone dust is substantially improved because of the densified micro-structure. Also, the mix design for "sandless concrete" could be further optimized. Overall, this research work provides guidance for the practical application of stone dust concrete or "sandless concrete", from the perspective of mix design, mechanical properties and durability. The stone dust concrete or "sandless concrete" could be new options for construction industry, in view of sustainability issues.

Keyword: *concrete, course aggregate, cement, stone dust, compressive strength test.*

1. Introduction

Concrete is the most widely used building material in the world, as well as the largest user of natural resources with annual consumption of 12.6 billion tons [Mehta, 2002]. Fundamentally comprised of coarse and fine aggregates, cement and water, concrete in some cases also contains additional chemical or mineral admixtures for specific purposes. Most of the ingredients, produced from

virgin resources, are non-renewable, or strictly speaking non-sustainable. Recently, there has been an increasing awareness of environmental protection, resource and energy conservation, and sustainable development globally. Many research works have been initiated and developed to make concrete more sustainable, mainly in reducing its negative impacts on environment and reserve natural raw materials. Higher degree of sustainability of concrete can be achieved by replacing its virgin ingredients, including cement and aggregates, by other materials, such as reclaimed materials from old structures, by-products from industrial process and recycled solid wastes. Apart from saving raw materials and protecting environment, additional benefits are usually accompanied with the production of sustainable concrete, such as reduced landfills and dumping volumes, decreased amount of energy and CO2 emission, as well as enhanced life cycle performance and lowered cost in maintenance during the whole life of structures. Quantities of studies have proved the successful substitution of cement in concrete by some pozzolanic by-product materials, like pulverized fly ash and ground granulated blast-furnace slag (GGBS) [Malhotra, 1999; Mehta, 2001]. Besides the reduction in cement content and cost, workability, long term mechanical properties and durability can also be improved for such concrete, resulting in higher sustainability. Also, recycled coarse aggregates and manufactured coarse aggregates have been widely accepted in construction as alternative virgin coarse aggregates. However, the research and development of fine aggregate (sand) substitution is relatively slow.

The definition of fine aggregate is the aggregate passing the 9.5-mm sieve and almost entirely passing the 4.75-mm sieve and predominantly retained on the 75-µm sieve, either in a natural condition or after processing. Sand refers to fine aggregate resulting from natural disintegration and abrasion of rock or processing of completely friable sandstone, while manufactured sand means fine aggregate produced by crushing rock, gravel, iron blast furnace slag, or hydraulic concrete.

Sand consumes around 20~27% of concrete by volume, thus playing an important role in fresh and hardened properties of concrete [Neville, 1995]. The reserve of natural sand is depleting and the conventional sand mining, quarrying and river and ocean dredging is being criticized for their negative influences on environment, such as drinking water degradation, land and coast corrosion, flood and species depletion. Therefore, the necessity to seek sound replacements of natural sand for concrete is compelling to satisfy the sustainable development in concrete.

2. Materials and Methods

Materials:

Cement -
Portland Pozzolana Cement (fly ash based) brand name Birla Gold confirming to IS 1489 (Part 1) - 1991 was used in this study.

Fine Aggregate -
River sand available in Allahabad confirming to IS 383-1970, zone II used in the study. It was completely passed by 4.75 mm IS sieve. Fineness modulus and specific gravity was 2.76 and 2.3 respectively.

Coarse Aggregate -
Locally available coarse aggregate having two fraction 20mm and 10mm sizes individually sieved was used in the present study. One fraction completely passed through 20 mm sieve and another 10 mm sieve. For mix the ratio of these aggregates was 60:40 respectively.

Stone dust -
Grey colour stone dust was purchased from local stone crushing units. It was initially dry in condition and thoroughly retained on IS 150 µ sieve before preparation of mix. Fineness modulus and specific gravity was 2.85 and 2.4 respectively.

Methods
Stone dust, Aggregate and Cement were purchased from hardware shop form market and they are bring directly to concrete technology laboratory. About 20 kg of stone dust were bought and 20 kg of course as well as fine aggregate and 1 sac (50 kg) of cement was purchased. The demand of such building material is high in the market that is why they are easily available at any of the hardware shop. The stone dust will be mix in the fine aggregate in the ratio of 50% and 100% by weight. As the study is about partial replacement and complete replacement so for partial replacement mixing of stone dust with fine aggregate was necessary.After the mixing of stone dust with fine aggregate then preparation of concrete was started and the M20 grade ratio was followed for making concrete. The prepared concrete is now subjected to the casting of cube. About 20 cubes will be casted

and then it will be immerse in the curing tank for 3, 7, 14, 21 & 28 days.Compressive strength test will be performed on the casted and cured cube on the specified days. On the casted cube this is the only test which will provide the strength gain by the cube at specified days.

Results

The sample preparation as well as analysis of the cured concrete cubes were done according to the IS 456:2000.
The results for compressive strength test are:-

Stone dust ratio / Testing days	25 %	50%	100%
3 day	6.99 N/mm^2	7.24 N/mm^2	7.95 N/mm^2
7 day	11.23 N/mm^2	12.36 N/mm^2	12.88 N/mm^2
14 day	17.53 N/mm^2	17.07 N/mm^2	18.00 N/mm^2
21 day	18.00 N/mm^2	18.43 N/mm^2	18.93 N/mm^2
28 day	19.05 N/mm^2	19.50 N/mm^2	19.95 N/mm^2

Conclusion-

In the experimental study stone dust, the cubes were tested for 3 days, 7days, 14days, 21 days and 28 days compressive strength 25%, 50% and 100% replacement of fine aggregate by stone dust in M20 grade concrete. The 3 days, 7days, 14days, 21 days and 28 days compressive strength is shown in tables respectively. The result of cube that were tested for 28 days is shown tables. It has been observed that the results obtained in all compressive strength are comparable with that of concrete with stone dust.

The test results shows that the sample having 25% stone dust content showed its maximum strength on 14 day test with 17.53 N/mm^2. The test result of sample of sample 2 having 50% stone dust content showed its maximum strength on 21 as well as 28 day test with 18.43 and 19.50 N/mm^2. The test result of sample of sample 3 having 100% Stone dust content showed its maximum strength on 14, 21 and 28 day test with 18.00, 18.93 and 19.95 N/mm^2.

The compressive strength test results shows that the sample containing 50% and 100% stone dust content show good compressive strength on 28 days but on comparing test results of both the sample, sample containing 100% Stone dust is showing better result than other one.

The following conclusions were drawn from the present experimental study.
1. The compressive strength of concrete for grade M20 with stone dust as fine aggregate were found to be comparable with the concrete.
2. With the increase in stone dust content in the concrete there is a gain in strength upto 98%
3. Stone dust can effectively be used in plain cement concrete in place of fine aggregate.
4. The Physical and chemical properties of stone dust is satisfied by the requirements of code provision in properties studies Natural river sand, if it is replaced by hundred percent Quarry Stone Dust from quarries, may sometimes give equal or better than the reference concrete made with Natural Sand, and in the terms of flexural and compressive strength studies.
5. From this test, replacement of OPC cement with this stone waste material provides maximum compressive strength at 100% replacement.
6. Non- availability of sand at reasonable costs as fine aggregate in cement concrete for various reasons, search for alternative material stone crusher dust qualifies itself as a suitable substitute for sand at very low cost.

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