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A Study on Use of Stone Dust and Demolition Waste in Concrete

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ABSTRACT

In this world of rapid urbanization the demand for natural construction materials is increasing day by day which has created a necessity for alternative construction materials. The reduction in the sources of natural sand and aggregate and the requirement in the cost of concrete production has resulted in the increased need to identify substitute material to sand as fine aggregates and recycled aggregate as course aggregate in the production of concretes. Quarry dust and recycled aggregate are waste products which are released directly into the environmental and can cause environment pollution. Quarry dust a waste from the stone crushing unit accounts 25% of the final product from stone crushing unit. Recycled aggregate is a waste from demolition of concrete from buildings or structures consisting of concrete.

INTRODUCTION

The recycling of Construction and Demolition Wastes has long been recognized to have the potential to conserve natural resources and to reduce energy used in production. In some countries it is a standard alternative for both construction and maintenance, particularly where there is a shortage of construction aggregate.

The benefits and weaknesses of using recycled aggregate in concrete have been broadly studied.

The use of recycled aggregate generally increases the drying shrinkage and creep and decreases the compressive strength and modulus of elasticity of concrete compared to those of natural aggregate concrete.

The undesirable effects of recycled aggregate on concrete quality limit the use of this material in structural concrete. However, the weaknesses of using recycled aggregate can be mitigated by incorporating a certain amount of fly ash into the concrete mixture since fly ash is known to be able to reduce the creep and drying shrinkage of concrete.

The Waste & Resources Action Programs (WRAP) in the UK classified aggregates from primary, recycled and secondary material resources. Recycled aggregates encompass industrial by-products and reused construction products, all of which were once considered wastes and dumped in landfill.

The recently introduced European Standards for aggregates do not discriminate between different sources, and are for ‘aggregates from natural, recycled and manufactured materials’.

The focus is on fitness for purpose rather than origin of the resource. The purpose of this report is to review the various sources of aggregate and examine their potential use in concrete and/or road construction materials.

Objective of Research

The study has been carried out with the following objective:

1. To study the effect of replacement of stone dust and recycled aggregate on the compressive, split and flexural strength.
2. To study compressive, split tensile and flexure strength of concrete with partial replacement of stone dust and recycled coarse aggregate.
3. Comparison of compressive, split tensile and flexure strength with zero replacement with that of partial replacement of stone dust and recycled coarse aggregate.

REVIEW OF LITERATURE

Nagaraj and Zahida (1996) have examined the effect of replacement of fine aggregate in cement concrete by quarry dust and manufactured sand. It was observed that sand and 50% quarry dust combination gives higher strength when compared than the conventional concrete due to the sharp edges of stone providing stronger bond with cement compared to the rounded shape of ordinary sand.

Shukla and Sachan (2000) studied environmental hazardous stone dust utilization in building construction. It is found that partial replacement will not affect the strength and also solve the problem of disposal of stone dust.

Sahu et al (2003) have reported that concrete containing quarry dust as fine aggregate is promising greater strength, lower permeability and greater density which enable it to provide better resistance to freeze/thaw cycles and durability in adverse environment.

Naidu et al (2003) have conducted an experimental study to investigate the influence of partial replacement of sand with quarry dust in the compressive strength and pull-out force of concrete. Four types of concrete, with two water-binder ratios of 0.40 and 0.45 were undertaken in this study.

Rao et al. (2006) studied the problem beginning with a brief review of the international scenario in terms of C & D waste generated, recycled aggregates (RA) produced from C & D waste and their utilization in concrete and governmental initiatives towards recycling of C&D waste.

Eguchi et al. (2007) investigated the characteristics of strength, durability, fire-resistant property, structural performance, and workability of the recycled concrete. The necessary data for establishing a mix proportion design and a quality control method are obtained.

Etxeberria et al. (2007) studied the four different recycled aggregate concretes; made with 0%, 25%, 50% and 100% of recycled coarse aggregates, respectively. The mix proportions of the four concretes were designed in order to achieve the same compressive strengths.

Tsujino(2007)investigated the material tests on recycled aggregates with low quality and middle quality. In the test, two types of surface improving agent, an oil-type improving agent and a silane-type improving agent, were used.

Binici et al. (2008) studied the durability of concrete made with granite and marble as coarse aggregates. River sand and ground blast furnace slag (GBFS) were used as fine aggregates. The results were compared with those of conventional concretes.

Gomes and Brito (2008) Found that the viability of incorporating coarse aggregates from concrete and ceramic brick wall debris, in the production of a new concrete, with properties acceptable for its use in new reinforced and pre-stressed structures.

Appukutty and Murugesan (2009) Examined the Substitution of crusher dust for sand in cement mortar for brick masonry is experimented with brick masonry prisms cast in different ratios of 1:8, 1:6, 1:5 and 1:4. Bricks with basic compressive strength above 3.5 N/MM2and 7.5 N/MM2were used to cast brick masonry prisms.

Bhikshma et al.(2010) Studied that stone dust—a byproduct of crushers can be used as partial or full replacement of river sand as fine aggregate without altering the strength, workability or setting characteristics of concrete.

Reddy (2010) An attempt has been made to assess the suitability of stone dust and ceramic scrap in concrete making. In the laboratory stone dust has been tried as fine aggregate in place of sand and ceramic scrap has been used as partial/full substitute to conventional coarse aggregate in concrete making.

Mahzuz et al. (2011) Study the relative performance of concrete by using powder sand. From laboratory experiments, it was revealed that concrete made of stone powder and stone chip gained about 15% higher strength than that of the concrete made of normal sand and brick chip.

Srivastava and Mishra (2011) Found that if some of the waste materials are suitable in concrete making not only cost of construction can be reduced but also safe disposal of waste materials can be achieved. Nearly 20-20% rock is converted into stone dust and 12mm metal while crushing rock into aggregate at stone crushing plants

MATERIALS AND METHOD

Cement

Portland pozzolana (fly ash based) cement was used. It was tested as per Indian standard specification (BIS-1489 part 1:1991). Test results are given in Table 1.

Table 1: Physical Properties of Pozzolana Cement

Physical Properties	BIS-1489:1991	Test Result
Soundness Le-chatelier expansion	10.0 mm (Max)	1.00 mm
Setting Time (minutes)		
Initial	30 (Min.)	165
Final	600 (Max)	215
Fineness of cement (% retained on 90 micron IS sieve)	10%(Max)	3.77%
Specific gravity of cement	3.15	2.67
Compressive strength (MPa)		
7 days	22	34
28 days	33	44
Specific gravity of cement	2.67	3.15

Fine Aggregates

Locally available natural sand with 4.75mm maximum size was used as fine aggregate. Its sieve analysis are given in table

Sieve Analysis of Fine Aggregates

Weight of the sample taken =1.0 kg

Avg. Split Tensile Strength of cylinder specimens for 20% replacement of course aggregate with recycled aggregate at different replacement of fine aggregate with stone dust:

Avg. Flexural strength of beam specimens for 20% replacement of course aggregate with recycled aggregate at different replacement of fine aggregate with stone dust:

Line diagram for Avg. Compressive Strength of cube specimens for 10% replacement of course aggregate with recycled aggregate at different replacement of fine aggregate with stone dust.

RESULT AND DISCUSSION

Compressive Strength with different replacement of stone dust at 10% replacement of recycled aggregate:

The result of compressive strength of concrete having partial replacement of fine aggregate with stone dust and coarse aggregate with recycled aggregate for 7 & 28 days are noted in table 4.1 and its line diagram 4.1. It was observed that increase in replacement of fine aggregate with stone dust at 10% of replacement of coarse aggregate with recycled aggregate, the value of compressive strength of concrete is first increases upto 60% and then decrease with further increase of replacement of stone dust. At 0% of replacement i.e, referral concrete, the compressive strength of concrete is 22.8 N/mm^2& 33.4 N/mm^2 at 7 & 28 days respectively.

Result shows that with 60% replacement of stone dust and 10% replacement of recycled aggregate, the compressive strength of replaced concrete is increased by 8% at the age of 28 days as compared to referral concrete. While, at 50% & 70% the values are 30.3 N/mm^2& 33.0N/mm^2 respectively. As we increase the replacement factor of stone dust with same replacement factor of recycled coarse aggregate compressive strength reduces because of low water absorption capacity of recycled aggregate.

Compressive Strength with different replacement of stone dust at 20% replacement of recycled aggregate:
The result of compressive strength of concrete having partial replacement of fine aggregate with stone dust and coarse aggregate with recycled aggregate for 7 & 28 days are noted in table 4.1 and its line diagram fig.4.1. It was observed that increase in replacement of fine aggregate with stone dust at 20% of replacement of coarse aggregate with recycled aggregate, the value of compressive strength of concrete is decreases as replacement of stone dust increases . At 0% of replacement i.e, referral concrete, the compressive strength of concrete is 22.8 N/mm^2& 33.4 N/mm^2 at 7 & 28 days respectively.

Result shows that with 0% replacement of stone dust and 20% replacement of recycled aggregate, the compressive strength of replaced concrete is decreased by 6% at the age of 28 days

as compared to referral concrete. While, at 30%, 40%, 50%, 60%& 70% the values are 31.2 N/mm^2, 30.2N/mm^2, 29.0N/mm^2, 31.2N/mm^2, 29.2N/mm^2& 33.0N/mm^2 respectively.

Table.4.2. Avg. Compressive Strength of cube specimens for 20% replacement of course aggregate with recycled aggregate at different replacement of fine aggregate with stone dust.

Table 2: Compressive strength of specimens

S. No	Cube Designation	Percentage Replacement		Avg. Compressive Strength	
		Course Agg. to Recycled Agg.	Fine Agg. to Stone Dust	7 Days (MPa)	28 Days (MPa)
	Reference Data	0	0	22.8	33.4
1	A4	20	0	20.6	31.4
2	A5	20	30	20.8	31.2
3	A6	20	40	19.8	30.2
4	A7	20	50	19.3	29.0
5	A8	20	60	18.4	31.2
6	A9	20	70	17.2	29.2

Split tensile strength with different replacement of stone dust at 20% recycled aggregate:
The result of split tensile strength of concrete having partial replacement of fine aggregate with stone dust and coarse aggregate with recycled aggregate for 7 & 28 days are noted in table 4.1 and its line diagram fig.4.1. It was observed that increase in replacement of fine aggregate with stone dust at 20% of replacement of coarse aggregate with recycled aggregate, the value of split tensile strength of concrete is decreases. At 0% of replacement i.e, referral concrete, the split tensile strength of concrete is 1.39 N/mm^2& 1.89 N/mm^2 at 7 & 28 days respectively.

Result shows that with 0% replacement of stone dust and 20% replacement of recycled aggregate, the compressive strength of replaced concrete is increased by 34% at the age of 28daysas compared to referral concrete. While, at 30%, 40%, 50%, 60%& 70% the values are 2.17 N/mm^2, 2.20N/mm^2, 2.09N/mm^2, 2.26N/mm^2& 2.06N/mm^2 respectively. As we increase the replacement factor of stone dust with same replacement factor of recycled coarse aggregate split tensile strength reduces because of low water absorption capacity of recycled aggregate.

Flexural strength with different replacement of stone dust at 10% recycled aggregate:
The result of flexural strength of concrete having partial replacement of fine aggregate with stone dust and coarse aggregate with recycled aggregate for 7 & 28 days are noted in table 4.5 and its line diagram fig.4.5. It was observed that increase in replacement of fine aggregate with stone dust at 10% of replacement of coarse aggregate with recycled aggregate, the value of compressive strength of concrete is first increases upto 60% and then decrease with further increase of replacement of stone dust. At 0% of replacement i.e, referral concrete, the compressive strength of concrete is 1.00N/mm^2& 1.31 N/mm^2 at 7 & 28 days respectively.

Result shows that with 60% replacement of stone dust and 10% replacement of recycled aggregate, the flexural strength of replaced concrete is increased by 19% at the age of 28daysas compared to referral concrete. While, at 50% & 70% the values are 1.25 N/mm^2&1.37N/mm^2 respectively. As we increase the replacement factor of stone dust with same replacement factor of recycled coarse aggregate compressive strength reduces because of low water absorption capacity of recycled aggregate.

Flexural strength with different replacement of stone dust at 20% recycled aggregate:

The result of split tensile strength of concrete having partial replacement of fine aggregate with stone dust and coarse aggregate with recycled aggregate for 7 & 28 days are noted in table 4.1 and its line diagram fig.4.1. It was observed that increase in replacement of fine aggregate with stone dust at 20% of replacement of coarse aggregate with recycled aggregate, the value of compressive strength of concrete is first increases upto 60% and then decrease with further increase of replacement of stone dust. At 0% of replacement i.e, referral concrete, the flexural strength of concrete is 1.00 N/mm^2& 1.31 N/mm^2 at 7 & 28 days respectively.

Result shows that with 0% replacement of stone dust and 10% replacement of recycled aggregate, the compressive strength of replaced concrete is decreased by 8% at the age of 28days as compared to referral concrete. While, at 30%, 40%, 50%, 60%& 70% the values are 2.17 N/mm^2, 2.20N/mm^2, 2.09N/mm^2, 2.26N/mm^2& 2.06N/mm^2 respectively. As we increase the replacement factor of stone dust with same replacement factor of recycled coarse aggregate compressive strength reduces because of low water absorption capacity of recycled aggregate.

CONCLUSION

The study was an experimental attempt to determine the feasibility of replacement of sand with quarry dust as fine aggregates in conventional concrete. The entire data collected during the tenure of the study can be summed up as follows:-

1. Sand obtained from the river beds and the quarry dust obtained from the quarries has almost equal specific gravity but have a large variation in the water absorption. The water absorption of quarry dust which was determined as 3.59% was very high due to which the concrete mix prepared with higher proportion of quarry dust has very low workability.
2. Quarry dust as a material is very much similar to sand in physical properties and is very cheaply available as it is a waste by product from the extraction of aggregates. Cost of quarry dust is almost 10% of the cost of natural sand.
3. The compressive strength of the concrete tends to decrease by the use of quarry dust which is witnessed from the results of the various experiments conducted. The maximum compressive strength was obtained by replacing 50 % (Mix 3) of sand with quarry dust but it was less than the strength shown by the conventional concrete (100 % (Mix 1) sand as fine aggregates).
4. But as the cost of quarry dust is very less in comparison to the current cost of sand due to its shortage, quarry dust can be seen as an effective and optimistic alternative for the replacement of sand in concrete.

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