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Effect of stone dust on the specific properties of fresh and Hardened Concrete: A review

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Abstract

This project is aimed at studying the effect of stone dust on the specific properties of fresh and hardened concrete (M25). The experimental tests for fresh and hardened properties of concrete for M25 grade are studied and the results are compared with normal concrete. - Stone dust is a waste material obtained from crusher plants. It has potential to be used as partial replacement of natural river sand in concrete. Use of stone dust in concrete not only improves the quality of concrete but also conserve the natural river sand for future generations.

Keywords: Concrete, Compressive strength, Replacement, Stone dust.

Introduction

Stone dust is a waste material and is generated during blasting and aggregate crushing. The damping of this waste material is also a big problem by using these waste materials in construction work it is very easy to dispose these waste materials. These wastes produce different type of pollutions like air pollution, water pollution, land pollution, etc. Due to these pollutions various types of diseases are produced to the life on the earth. These pollutions are increasing day-by-day due to this waste production so the disposal of these wastes is an serious issue and also the matter of concern.

Concrete is a composite material made of cement, fine aggregate, coarse aggregate and water. At present construction industry is growing exponentially due to several other factors besides increasing developmental activities. This results in huge demand of construction materials. Concrete is most widely used construction material. Major components of concrete are aggregates which are usually available in natural form. Fine Aggregate used in concrete is usually river sand available locally or at nearby location. The naturally available source of fine aggregate is limited as such conservation of the same is inevitable. Going for alternative and supplementary material which can be used as partial or full replacement of conventional material

can play a vital role in conservation of natural resources. The demand for river sand in the construction industry has consequently increased due to the extensive use of concrete resulting in the reduction of sand sources and increase in price.

Stone dust is a multipurpose material for yard construction. A compacted layer of stone dust is well suited to a yard or passageway surface. It is also a great choice for the sub-base in laying paving blocks and slabs, and for jointing natural stone, such as slate. As a stone dust surface is extremely compact and waterproof, banking must be taken into consideration during installation.

Review of literature

(Bonavetti & Irassar, 1994) studied "The effect of stone dust content in sand" and found that the influence of the stone dust content in sand on mortar properties are presented in this paper. Three stone dusts (quartz, granite and limestone) were incorporated in percentages ranging from 0 to 20% as replacement for equal weights of sand. The water demand, compressive and flexural strength, porosity and drying shrinkage were analyzed on portland cement mortars at constant flow (110±5%) The results showed an improvement in strength of mortars containing stone dust at early ages, while water demand and porosity increased with increasing dust content. This gain of strength is attributable to the acceleration of the cement hydration at early ages due to effect of the stone dust. At later ages, no detrimental effects were observed. © 1994.

(Kumar, 2019) studied "The Effect of Stone Dust & Steel Fibre on Strength Properties of Concrete" and found that nowadays, there's associate increasing interest within the development of eco-friendly materials. The properties of Stone dust and Sand are almost same so it can be easily used as partial replacement of sand in concrete. Steel Fiber is also added to the concrete that it increases the crack resistance, ductility, energy absorption or toughness of concrete. Thus, this paper addresses the results of change of Stone dust and Steel fiber on the strength properties of concrete. The replacements are done at 0%, (30%, 1%), (40%, 1%), (50%, 1%) of fine aggregate with Stone dust and addition of Steel fiber 1% by the weight of cement. Design mix is prepared on M30 grade of concrete. The result showed that at fixed W/C ratio (0.40) the strength and durability increased initially at small percentages and the cost for production is also cheaper.

(Celik & Marar, 1996) studied "Effects of crushed stone dust on some properties of concrete" and found that crusher dust is a fine material formed during the process of comminution of rock into crushed stone or crushed sand. This dust is composed by particles which pass 75 μm BS

sieve. Effects of dust content in aggregate on properties of fresh and hardened concrete are not known very well. An experimental study was undertaken to find out the effects of various proportions of dust content on properties of fresh concrete, and hardened concrete.

(Singh, Srivastava, & Agarwal, 2015) studied "Stone Dust in Concrete: Effect on Compressive Strength" and found that radon is a type of radioactive gaseous element that is considered as an extremely harmful element to people's health by the World Health Organization (WHO). The study is radon gas within the framework of construction. Radon is a radioactive element that is present in building materials as in all fields where human construct the buildings. This element is present both in the lives of people and according to the World Health Organization is an element of risk in cancer formation in the body of human beings. The purpose of the article is to list the different forms of radon entry into buildings and the different exposure level representing the land or the materials and construction techniques, which are developed with houses. In Spain, the Technical Building Code (CTE) still does not provide the dose of radon can contain up a building and as contain, unlike other countries with different laws at the level of health and in terms of building, have tools and engaged in trying to curb the existence of radon inside buildings.

(Structures, 2015) studied "Strength aspect of concrete using stone dust as a partial replacement of sand" and found that due to the auspicious attribute of concrete such as durability, availability, versatility, good compressive strength, it is one of the most commonly used building materials throughout the world. The demand for infrastructural facilities is increasing day by day which creates a tremendous pressure on concrete as well as on natural aggregates. Apparently it becomes unavoidable to look for alternative materials. On the other hand, disposal of stone dust generated from stone crusher is becoming a problem. Substituting sand by stone dust will serve the waste management as well as the alternative material in concrete. The present research's aim is to find out the strength aspect of concrete by using stone dust as a partial replacement of sand. The test specimens were made from three different grades of concrete i.e. mix ratios 1: 1.5: 3, 1: 2: 4, 1: 2.5: 5 and both compressive as well as tensile strength tests were conducted. The basic strength properties of concrete were investigated by replacing natural sand by Stone dust at replacement levels of 0%, 10%, 20%, 30%, 40%, 50% & 60%. For the different grades of concrete studied, the value of the compressive strength are observed to be maximum at 30%

replacement level of sand whereas the maximum tensile strength occurs at 20% replacement level. The result shows that the maximum increase in compressive and tensile strength are 15% and 12% respectively in comparison to normal concrete (0% sand replacement level) for the concrete mix-ratio 1: 1.5: 3.

(Ashit Kumar & Dr. Anil Kumar Saxena, 2016) studied "Combined use of Stone Dust as Partial Replacement of Sand and Glass Powder as Cement" and found that in this research we analyze the strength of concrete made with using locally available fly ash based Cement by using two waste materials one is Glass Powder and Other is Stone dust. The Glass Powder is used as 20% replacement of the cement and Stone Dust as the partial replacement of Fine Aggregate from 0%, 10%, 20%, 30% and 40%. The grade of the concrete here is M25 and M30 grade. Slump Test was carried out for the fresh concrete whereas Compressive Strength, Flexure Strength and Split Tensile Tests were carried for the Hardened concrete. All tests are done at 7, 14, 28, and 56 days with 0 to 40% replacement of sand at an interval of 10%. Again above tests are carried out with 20% replacement of cement by glass powder. It is observed that the glass powder improve the strength and stone dust can be used as sand. This is great saving in costly material.

(Rajput, 2018) studied "An Experimental study on crushed stone dust as fine aggregate in cement concrete" and found that the deficit of natural sand arise the need of alternative materials for replacement of natural sand. This experimental study explores in detail the crushed stone dust which is locally available industrial solid waste material in India as alternative material to natural sand that is being conventionally used as fine aggregate in cement concrete. The nominal mixes were prepared for grades M-20 and M-30 of cement concrete as per Indian Standards codes using natural sand (NS) and replacement of NS sand to crushed stone dust (CSD) in different proportions. In each case proportion the slump cone test, compaction factor test, density test, compressive strength test and Ultra-sonic pulse velocity test were carried out. The results of the study show that, the strength properties of cement concrete using crushed rock sand is higher and homogeneous to the conventional concrete. The study has present that crushed stone dust can be used as readily available solid waste as an alternative to natural sand in cement concrete construction work and it can reduce the cost of material and construction cost and can helpful to mend the environment issues.

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Applications of stone dust

Despite the cost associated with the use of stone dust, overall cost savings in terms of good achievability of strength and no cost in repairing of work is achieved. Moreover, the stone dust allows the production of a high strength and durable concrete having a reduced permeability and shrinkage and an improved surface finish. There are three main applications for stone dust are as under:

- The first use of stone dust is to produce concrete with high compressive strength and workability.
- The second practical use of stone dust in concrete is in the reducing of the amount of water required by up to 20 % while keeping the same workability. This allows a significant decrease in water/cement ratio and therefore an increase in strength.
- The third use of the stone dust is to produce concrete with reduced cement content while maintaining the same water/cement ratio.

Materials and Design mix of concrete (experimental program)

(a) Plain and reinforced concrete code of practice (4th Revision) IS 456 – 2000.

(b) Hand book on concrete mix (Based on Indian Standard) SP 23 – 1982.

(c) Recommended guidelines for concrete mix design. IS 10262 – 2009

(d) Specification for coarse and fine aggregate from natural sources for concrete IS 383 – 1970.

(e) Code for OPC 43 grade IS: 8112-2013

(f) Project Technical Specification

S. No	Name of Materials	Source	Specific Gravity	Water Absorption (%)	Free surface water (%)
1	Cement (OPC 43) Brand–Khyber		3.15	-	
2	Coarse aggregate (20.mm) 60 % by	SSMCOLLEGE BACKYARD	2.68	0.50	0.2

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	weight				
3	Coarse aggregate (10.mm) 40 % by weight	SSMCOLLEGE BACKYARD	2.68	0.5	0.1
4	Fine aggregate (Stone dust - Zone I)	LASJAN PAMPORE	2.69	0.6	1.5
5	Water	Bore well	1	-	-

Target mean strength of concrete: As per IS -10262 -2009 target mean strength of concrete is given by $f_M=f_{CK}+1.65\partial$ where ∂ is standard deviation of samples of cubes strength and f_{CK} is the characteristic mean strength of concrete which means 95% of cube strength will fall under this strength now in our case

Target mean strength=25+1.65x5 = 33.25 MPa

Selection of water cement ratio: From figure – 1 (IS 10262) and Figure 46 (SP 23) the free water cement required for the target mean strength of 33.25 N/mm2 is 0.60

From Technical specification MORTH Table no 1700-3(A) maximum water cement ratio is 0.45 for Normal exposure. Therefore it is decided that water cement ratio for M_{25} grade concrete shall be 0.60.

Selection of stone dust content: The dry mix of coarse and fine aggregate are mixed at a ratio 60% and 40% and checked for all in aggregate as per Table-4 (IS 383). It is found that the above ratio is satisfactory for 20mm graded aggregate. Hence the percent of fine aggregate is considered as 40%.

Determination of water content& cement

Water cement ratio = 0.60

For 20mm, Maximum water = 186L (table 5 IS: 10262-2009)

Add 6% water for additional slump (3% increase for every 25mm slump over)

So, required water = 186+ 6% of 186

=197.16 L

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As w/c=0.60

& w=197.16

So, cement=$\frac{197.16}{0.60}$

=328.6 Kg

As minimum cement =280 Kg/m^3

So, adopt cement= 328.6 Kg/m^3

Determination of coarse and fine aggregate content: From the above table volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) For water-cement ratio of 0.50 =0.60.

In the present case water-cement ratio is 0.60. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10 the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio).

Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.37 = 0.60

.Therefore, volume of coarse aggregate = 0.60

So, $(\frac{0.01}{.05})$x0.13=0.026

Volume of C.A =0.626

Volume of Fine aggregate =1-0.626

=0.374

Calculations of mix proportions;

a) Volume of concrete= 1 m^3

b) Volume of cement =$\frac{Mass\ of\ cement}{Specific\ gravity\ of\ cement}x\frac{1}{1000}$

=$\frac{328.6}{3.15}$x$\frac{1}{1000}$ =0.104m^3

c) Volume of water =$\frac{mass\ of\ water}{specific\ gravity\ of\ water}x\frac{1}{1000}$

=$\frac{190.8}{1}$x$\frac{1}{1000}$ = 0.197m^3

d) volume of all in aggregates= 1-(0.169+.197)

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=0.634m^3

e) Mass of coarse aggregates=d x Volume of coarse aggregate x Specific gravity of coarse aggregate x I 000

= 0.634x0.626x2.68x1000

=1063.64Kg/m^3

f) Mass of fine aggregate=d x volume of fine aggregate x specific gravity of fine Aggregate x 1000

= 0.634 x 0.374x2.69 x1000 = 637.84Kg/m^3

Water corrections

1)WATER ABSORPTION

A) CA =0.5% = $\frac{0.5}{100}$ x 1063.64=5.31L

B) FA =0.6%=$\frac{0.6}{100}$ x 637.84=3.83 L

Total quantity =9.14L

2) FREE MOISTURE

a) FA= 1.5%=$\frac{1.5}{100}$ x 637.84 = 9.56L

b) CA

20 mm aggregates = $\frac{40}{100}$ x 1063.64 x 0.2%= 0.85

10 mm aggregates = 60% x1063.64 x 0.1%= 0.638

Total quantity= 11.048 kg

∴ Actual amount of water to be used= 197.16+ 9.14-11.048=195.252 Kg

Actual F.A = 637.84 +9.56-3.83=643.57 Kg

Actual CA = 1063.64-5.31+.85+.638=1059.818 Kg

SIEVE ANALYSIS

TESTING OF (F.A./ stone dust)			WEIGHT OF SAMPLE= 2,000 GRAMS					
Sieve Designation	Weight Retained	% Retained	Cumulative % Retained	% Passing	Prescribed Limits meets zone-			
					ZONE-I	ZONE-II	ZONE-III	ZONE-IV

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10 mm	0	0	0	100	100	100	100	100
4.75 mm	0	0	0	100	90-100	90-100	90-100	95-100
2.36 mm	104	5.2	5.2	94.8	60-95	75-100	85-100	95-100
1.18 mm	866	43.3	48.5	51.5	30-70	55-90	75-100	90-100
0.60 mm	702	35.1	83.6	16.4	15-34	35-59	60-79	80-100
0.30 mm	168	8.4	92	8	5-20	8-30	12-40	15-50
0.15 mm	100	0.5	95.5	3	0-10	0-10	0-10	0-15
-0.15 mm	60	3	95.5		Zone I			

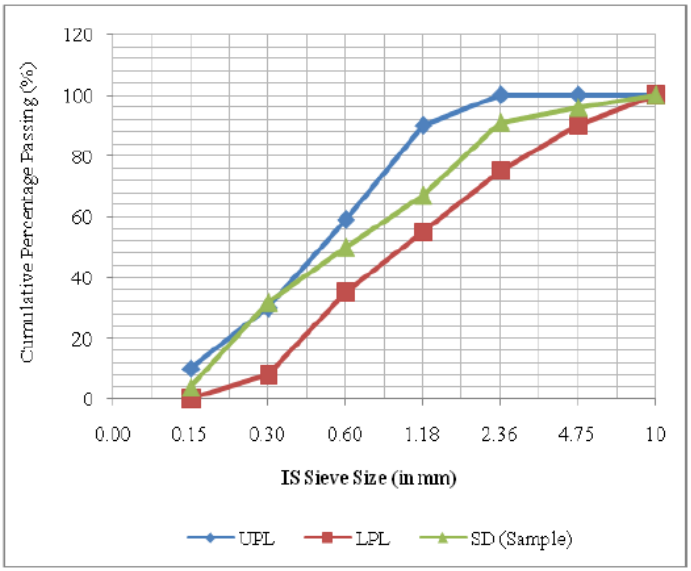

Figure: Grading curve for Stone dust

Conclusion

An experimental study was carried out to find the effect of stone dust on the properties of concrete (M25 at 0.60 w/c ratio) in fresh and hardened state with variable water reduction and constant water reduction.

The properties tested were

- Slump Retention
- Compressive Strength
- Compaction factors

.**The results obtained can be interpreted as**

•The workability of concrete can be increased by addition of stone dust however very high dosage of stone dust tends to impair the cohesiveness property of concrete.

•Compressive strength is improved by stone dust on the other hand its ultimate strength is higher than the desired characteristic strength.

•The strength of concrete without stone dust is found to be greater than the characteristic strength but the slump obtained is less which means that though this concrete will fare well in terms of strength but it is not workable for major works. Stone dust can be used as an opposite substitute for fine aggregate in the case of non-availability of natural river sand at reasonable cost.

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