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Design of High Strength Concrete Using Stone Dust

Aqsa Muzaffar Bulbu[1], and Brahamjeet Singh[2]

[1]M.Tech. Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India
[2]Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

Correspondence should be addressed to Aqsa Muzaffar Bulbul; aqsamuzaffarbulbul@gmail.com

ABSTRACT- The purpose of this paper is to investigate the effect of stone crushed dust on the specific properties of fresh and toughened concrete (M25). These experimental trails for fresh and toughened concrete properties for M-25 grade are investigated and the results are compared to normal concrete. It has the potential to be used in concrete as a partial replacement for natural river sand. The utilization of stone dust in concrete not as it were moves forward concrete quality but moreover makes a difference to protect characteristic waterway sand for future generations. An exploratory program was carried out within the current ponder to explore the workability and compressive strength of concrete made utilizing stone clean as a fractional substitution of fine of concrete made using stone dust as a partial replacement of fine aggregate in the range of 10% - 100%. M25 grade for referral concrete, a concrete grade was designed using OPC. Workability and compressive quality were decided at different substitution levels of fine total versus referral concrete, with compressive quality deciding the ideal substitution level. In comparison to all other replacement levels, the results showed that replacing 60% of fine aggregate with stone dust allows for the production of concrete with the highest compressive strength.

KEYWORDS- Concrete, M25, Fly Ash, Slump retention, Compressive Strength, Compaction factors.

I. INTRODUCTION

The work reported herein is a part of a research project entitled "DESIGN OF HIGH STRENGTH CONCRETE USING STONEDUST". Typical Concrete is a mixture of cement, fine aggregate, coarse aggregate, and water. Aside from increased development activities, the construction industry is currently growing at an exponential rate. As a result, construction materials are in high demand. Aggregates, which are usually found naturally, are important components of concrete. Fine aggregate used in concrete is typically river sand found locally or nearby [2]. Because of the widespread use of concrete, the demand for river sand in the construction industry has increased, resulting in a reduction in sand sources and an increase in price. The widespread depletion of natural sand sources causes environmental issues such as river bank erosion and failure, river bed lowering, and saline water intrusion into the land [2]. This investigation is required to identify a suitable substitute that is eco-friendly, inexpensive, and performs better in terms of strength and durability. We used stone dust as an alternative source to fine sand, which may be a promising alternative in concrete production. Quarry dust can be utilized as a great substitute for normal stream sand in concrete blends, giving higher quality at 50% substitution. When smashed stone clean is utilized as fine total in concrete, the compressive, flexural, and pliable quality of the concrete increases (Nagpal et al., 2013). It has been discovered that 40% fine aggregate replacement with stone dust is adaptable (Franklin et al., 2014). The replacement of natural sand by crusher dust increased the compressive strength of concrete by 5-22%, and the highest compressive strength was obtained for the 40% replacement of sand by crusher dust among all mixes (Quadric. 2013) [3].

A. Stone dust

Stone dust is a dynamic yard construction material. Stone Dust is an excellent sub-base material for laying paving blocks and slabs, as well as for jointing natural stone such as slate. Banking must be considered during installation because a stone dust surface is extremely compact and waterproof properties. Stone dust is a by-product of crushing, with a typical grain size of 0 – 3.4mm or 0 – 6.8mm. As the stone dust has very fine mineral grains thus it forms a hard and better load bearing surface [1]. Stone dust is a byproduct of crushing stone for other purposes. It was considered a waste material, but it’s now being used in agricultural practices to increase soil fertility and change the pH level of the soil. It utilizes as a base material for paved surfaces has fallen out of favor among a few arranging companies since the tidy can be fine sufficient to hold water, which can damage paving materials during the freeze and thaw cycle.

B. Effects on Fresh Concrete

The workability of concrete depends on the following factors:

- Initial slump
- Type and amount of cement type
- Relative humidity
- Mixing conditions etc.

Mixes with a lower initial slump require more stone dust. There is disagreement about the effect of initial slump on the rate of slump loss after the addition of stone dust. In general, mixes with a higher initial slump had a more gradual rate of slump loss. The mix's workability can also be affected by the cement type and cement content.

Mixtures with a higher cement content are known to be more fluid, even in the absence of an admixture. Furthermore, mixes with a higher cement content lose slump at a slower rate.

C. Effects on Hardened Concrete

Compressive Strength: The strength of concrete with stone dust was found to be greater or at least equal to the strength of the same concrete made with sand. Being much more adequate stone dust improves the properties like workability and compressive strength up to a greater extent

APPLICATIONS

Despite the cost guide the use of mineral dust, overall cos t funds in agreements of good likelihood ofsubstance and no cost in repairing work are attained. Moreover, the rock dust admits the result of extremesubstance and longlasti ng actual bearing shortened permeability and decrease and a revised surface finish [5].

There are three main uses for mineral 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 reducing the amount of water required by up to 20 % while keeping the same workability. This allows a significant decrease in the water/cement ratio and therefore an increase in strength.

II. STATEMENT OF THE PROBLEM

Since the use of stone dust is the need of an hour to account for the shortage of sand at certain places under certain circumstances and its acceptance around the world [7]. The difficulty in using stone dust results from the fact that its effect on concrete depends on a number of factors including mix proportions, ambient temperature, time of addition, the dosage of addition, and mixing time. In order to produce quality durable concrete guidelines, have to be developed.

This research is a complete study of Robust-quality stone dust and its properties on concrete. It also provides guidelines for engineers to follow in the field to achieve the desired properties. In course of this consider, the taking after factors were examined:

III. OBJECTIVE OF THE STUDY

- To investigate the feasibility of using stone dust as a replacement for traditional coarse aggregate in high strength concrete.
- To evaluate the effects of stone dust on the mechanical properties of high strength concrete, including compressive strength, tensile strength, and flexural strength.
- To determine the optimal mix design for high strength concrete using stone dust, taking into account the effects of water-to-cement ratio, aggregate-to-cement ratio, and curing conditions.
- To investigate the durability of high strength concrete using stone dust, including resistance to freeze-thaw cycles, corrosion, and abrasion.
- To evaluate the environmental impact of using stone dust in high strength concrete, including energy consumption and carbon emissions during production and construction.

IV. MATERIALS USED

OPC Cement 43 Grades: The quality of the building materials (such as cement) can be used to assess the construction's quality. Figure 1 implies the brand of OPC used. Moreover, the cement grade's chemical and physical characteristics determine its quality. Recently obtaining any cement, it is profoundly suggested to check whether the cement properties of that brand follow to the Indian Standard codes.

Figure 1: Sample of cement used

Fine Aggregate (Stone Dust/Crushed Stone): Stone dust that complied with grading zone 2 was utilized as the fine aggregate in all of the mixes after sieve analysis in accordance with IS-383-1970. It exhibited a fineness modulus ranging from 2.910 to 2.940 and a bulk specific gravity of 2.69 at SSD as shown in the Figure 2.

It might serve as a partial substitute for real river sand in concrete. Concrete made with stone dust has higher quality overall and helps protect natural river sand for future generations. Quarry tidy can be utilized in concrete blends as a great substitute for common stream sand, giving 50% substitution quality. When pulverized stone clean is utilized as fine total in concrete, the compressive, flexural, and malleable quality of the concrete increments. [4]

Figure 2: Same of stone dust used

Coarse Aggregate: Coarse aggregates are irregular broken stones or naturally occurring round gravels that are used to make concrete, coarse aggregates for structural concrete consist of broken stones of hard rock like granite and limestone (angular aggregates) or river gravels (round aggregates). Aggregates greater than 4.75 mm in size are described as coarse aggregates. Please check Figure 3 for refence. For the purpose of building concrete, coarse aggregates are naturally occurring rounded gravel or irregularly fractured stone. Coarse aggregates are substances that are too big to pass through a 4.7 mm screen, with a maximum size of 63 mm. In stone quarries, coarse totals are regularly created by impacting, breaking by hand, or utilizing crushers. Stones that have been smashed by a machine come in a few sizes, but totals that have been broken by hand as it were come in one measure.

Figure 3: Sample of coarse aggregates used

Grading of Stone Dust: Testing was done on the stone dust with weight sample of 2000 grams, under the following sieve analysis

- 10 mm
- 4.75mm
- 2.36mm
- 1.18mm
- 0.60mm
- 0.30mm
- 0.15mm
- -0.15mm

All the analysis was done under prescribed limits meeting Zone I, Zone II, Zone III, Zone IV

Water: Water which has relatively free from harmful ingredients like oils, acidic and alkaline impurities as well objectionable organic matter determined to describe quality of cement. In general, water used for concrete mixing should be as such as fit for drinking [8]. Water from lakes as well as streams that contain marine life and free from any industrial pollution is also suitable. Water polluted by sewage, industrial wastes and other harmful ingredients should be rejected if its use is inevitable; it must be subjected to proper treatment [8].

V. RESULT & DISCUSSION

The compressive strength tests on specimens of different mixes were tested after 7 days and 28 days of curing is analyzed and represented in this section, Table 1 and Figure 4 demonstrates testing and initial strength Achieved. For the construction work, the size of 15 cm x 15cm x 15 cm was selected. Then the concrete mix prepared is poured into the mould is thoroughly tampered to eliminate voids. After 24 hours cube specimens are carried out and then immersed in water for curing. To procure smooth surface, cement paste is spread uniformly on the surface area of specimen. The rate of loading is 350 kg/cm2/minute and uniform. Concrete cube specimens were tested after 7 days and 28 days of curing. Table 2 and Figure 5 demonstrates Final Compressive Strength Achieved. Specimens stored in water should be tested immediately after they are taken from water. Compression test was performed on standard compression testing machine of 2000 kN capacity in the usual manner as per Indian Standard guidelines. Table 3 refers to slump value tests for time period initial 0 to 30 mins. Compaction factor obtained from initial to final strength are showcased in the Table No 4 with different trails graph shown in Figure 6.

A. Comparison between two trails with and without stone dust (at constant w/c ratio)

Table 1: Different trails and tests performed

Mix	Description of Trail Mix	Unit	Trail Mix No T1	Trial Mix No T2S
1	Grade of Concrete Mix	Mpa	M-25	M-25
2	Target Mean Strength	Mpa	33.25	33.25
3	Grade of Cement	-	43Grade OPC	43Grade OPC
4	Name & Source of Aggregate	-	CA-SSM College FA-SSM College	CA&FA-SSM College Stone dust-SSM College
5	Water-Cement Ratio	-	0.60	0.60
6	Date of Casting	-	08-10-2022	08-10-2022
7	Specific gravity	-	CA:2.68 FA:2.69	CA:2.68 FA:2.69
8	Water absorption	-	CA:0.5% FA:0.6%	CA:0.5% FA:0.6%
9	**Trial Mix** FOR 9 CUBES Volume of 9 cubes=9 x 0.15x.15x. 15			
	Cement	Kg	16.20	16.20
	Water	Kg	9.72	9.72
	Coarse Agg-20mm	Kg	18.72	18.72
	Coarse Agg-10mm	Kg	12.48	12.48
	Stone Dust	Kg	15.2 Sand	15.2 Stone dust
10	Slump Data			
	Initial	Cm	25	25
	After 30 mins	Cm	20	19
11	Compressive Strength			
	7- days Strength	Date of testing	15-10-22	15-10-22
		Mpa	Average=21.7	Average=24.5
	28 – days Strength	Date of testing	13-11-2022	13-11-2022
		Mpa	Average=30.83	Average=34.81
13	Compaction factor		Initial: 0.61 Final: 0.75	Initial: 0.953 Final: 0.985

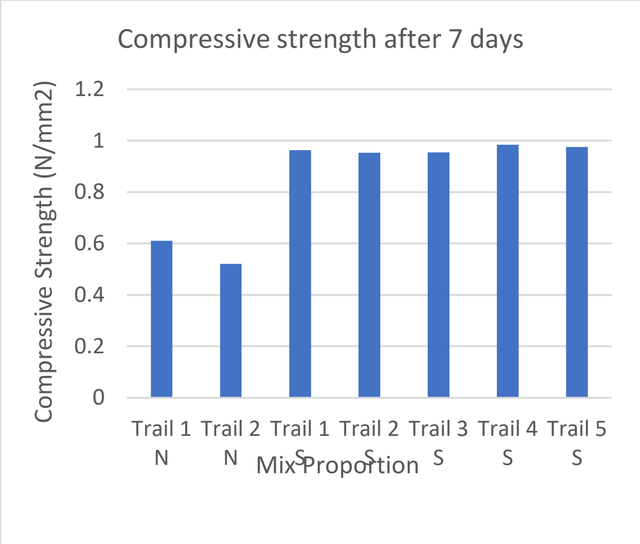

Figure 4: Compressive strength after 7 days

B. *Compressive Strength After 28 days*

Table 2: Compressive strength after 28 days

Mix	Water/Cement Ratio	Compressive strength after 28 days (N/mm2)
Trail 1 N	0.60	30.83
Trail 2 N	0.60	29.66
Trail 3 N	0.55	31.36
Trail 4 N	0.55	33.81
Trail 5 N	0.50	31.50
Trail 6 N	0.50	32.66
Trail 7 S	0.60	34.86
Trail 8 S	0.60	33.81
Trail 9 S	0.55	36.86
Trail 10S	0.55	37.13

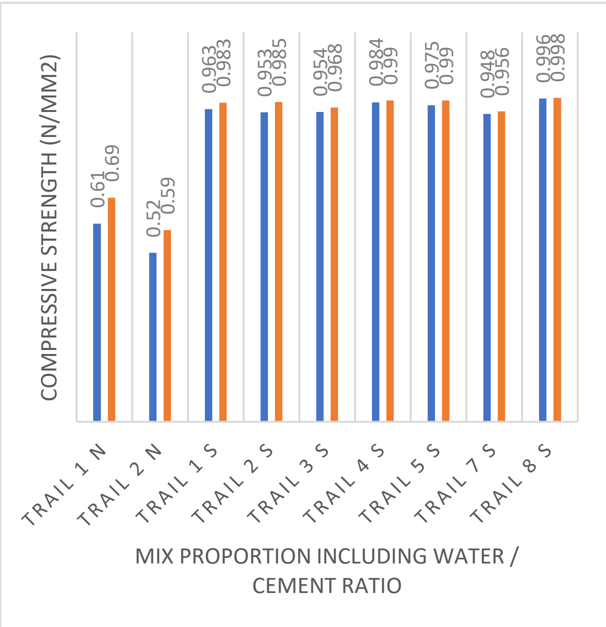

Figure 5: Compressive strength after 28 days

C. *Workability Results (Slump value)*

Now the results considering the workability criteria are:

Table 3: Slump test values (0 mins – 30 mins)

Mix	Slump value (cm)	
Duration	0 minutes	30 minutes
Trail 1 N	25	17
Trail 2 N	25	18
Trail 3 N	25	20
Trail 4 N	25	19
Trail 5 N	25	25
Trail 6 N	25	25
Trail 7 S	25	17
Trail 8 S	25	19
Trail 9 S	25	25
Trail 10S	25	25

D. *Compaction factor*

Table 4: Compaction factors initial to final strength

Mix	Compaction factor (cm)	
Duration	Initial	Final
Trail 1 N	0.61	0.69
Trail 2 N	0.52	0.59
Trail 1 S	0.963	0.983
Trail 2 S	0.953	0.985
Trail 3 S	0.954	0.968
Trail 4 S	0.984	0.990
Trail 5 S	0.975	0.990
Trail 6 S	0.987	0.993
Trail 7 S	0.948	0.956
Trail 8 S	0.996	0.998

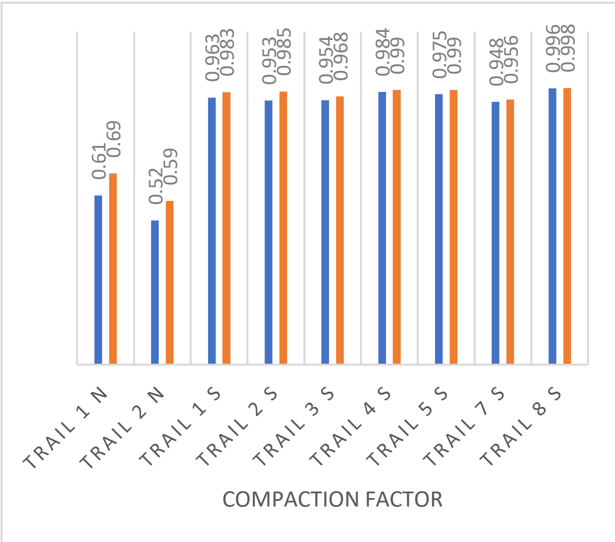

Figure 6: Compaction factor

VI. CONCLUSION AND FUTURE SCOPE

The results obtained can be interpreted as:

- The use of stone dust can increase the workability of concrete; nevertheless, excessively large doses of stone dust tend to harm concrete's cohesion.
- While stone dust increases compressive strength, it has a greater ultimate strength than the intended characteristic strength.
- The strength of concrete without stone dust is found to be larger than the necessary characteristic strength, but the slump achieved is lower, signaling that while this concrete would perform well in terms of strength, it is unsuitable for large-scale construction.

Future Scope and Recommendations

Taking after are few proposals that can be done to encourage upgrade the convenience of the try:

Further study can be made to manufacture a high strength concrete by increasing the water reduction.

Since we have used zone-1 stone dust and boulder crushed coarse aggregate, studies can be carried out utilizing distinctive grades of materials and comparisons can be made in like manner. Consider can be made on the halfway substitution of sand with stone tidy.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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