Optimizing Concrete Properties with Stone Dust and Banana Peel Admixture

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Abstract - Concrete's widespread use has intensified the demand for river sand, leading to scarcity and environmental concerns. This project investigates stone dust and brick crusher dust as sustainable fine aggregate replacements in M35 concrete. Stone dust, a byproduct of quarrying, and brick crusher dust, from construction waste, offer viable alternatives.
The study aims to evaluate their impact on concrete strength and workability. Replacing river sand with stone dust (0%, 50%, 60%, 70%) demonstrated a 10% increase in compressive and tensile strength up to a 60% replacement. Additionally, brick crusher dust shows potential as a cost-effective, eco-friendly fine aggregate.
Furthermore, dried banana peel powder (DBPP) is explored as a natural admixture. Its cellulose content may enhance workability and reduce shrinkage, offering a sustainable alternative to synthetic additives. However, proper treatment is essential for durability. This research highlights the effectiveness of stone dust and brick crusher dust as fine aggregate replacements, maintaining design strength while promoting waste utilization. The incorporation of DBPP presents an innovative approach to sustainable concrete production. This project aims to contribute to eco-friendly construction practices by demonstrating the viability of these alternative materials

Key Words: Compressive strength, Durability, Workability improvement, Waste material utilization, Eco-friendly construction.

INTRODUCTION

The escalating demand for concrete, coupled with the environmental repercussions of excessive river sand extraction, necessitates the exploration of sustainable aggregate alternatives. This project investigates the viability of stone dust and brick crusher dust as partial replacements for conventional river sand in M35 grade concrete, aiming to mitigate resource depletion and promote waste utilization. Additionally, we explore the potential of dried banana peel powder (DBPP) as a natural admixture to enhance concrete properties.

The core objective is to evaluate the performance of these waste materials, focusing on compressive strength, workability, and durability. Stone dust, a quarrying byproduct, and brick crusher dust, derived from construction debris, present abundant and readily available resources. Utilizing these materials not only reduces the reliance on natural sand but also contributes to circular economy principles by repurposing waste.

Furthermore, this study examines the incorporation of DBPP, rich in cellulose, hemicellulose, and lignin, which may improve concrete workability and reduce shrinkage. By leveraging agricultural waste, we aim to further enhance the sustainability of concrete production.

This research addresses the critical need for eco-friendly construction practices by demonstrating the potential of waste materials as viable aggregate substitutes. The transition from conventional sand to these sustainable alternatives offers significant environmental and economic benefits.

The project employs rigorous experimental methods, adhering to Indian Standards (IS codes), to assess the physical and chemical properties of the materials and evaluate the performance of concrete mixes. M35 grade concrete specimens will be prepared with varying percentages of stone dust, brick crusher dust, and DBPP, and subjected to compressive strength tests.

The findings of this study will provide valuable insights into the optimal mix proportions and the impact of these waste materials on concrete properties, contributing to the advancement of sustainable construction practices and minimizing the environmental footprint of concrete production.

OBJECTIVES

Material Characterization:

· To determine the physical and chemical properties of stone dust, brick crusher dust, and DBPP, ensuring their suitability for concrete production according to relevant Indian Standards (IS codes).

To analyze the gradation, specific gravity, and fineness modulus of the aggregates and dust materials.

Mix Design and Preparation:

· To design M35 grade concrete mixes with varying percentages of stone dust and brick crusher dust as partial replacements for conventional river sand.

To incorporate different proportions of DBPP into the concrete mixes to assess its impact on workability and strength.

To create control mix with 0% replacement of the fine aggregate.

Performance Evaluation:

· To assess the compressive strength of concrete specimens at 7 and 28 days of curing.

To evaluate the split tensile strength of the concrete mixes.

To evaluate the flexural strength of the concrete mixes.
To analyze the workability of the fresh concrete mixes.
To evaluate the density of the hardened concrete.
To evaluate the effect of DBPP on the workability and shrinkage of the concrete.

Sustainability Assessment:

· To evaluate the potential environmental benefits of utilizing waste materials in concrete production, including reduced river sand consumption and waste diversion.
To assess the cost-effectiveness of incorporating stone dust, brick crusher dust, and DBPP into concrete mixes.

Optimization and Recommendations:

· To determine the optimal mix proportions for achieving desired concrete strength and workability while maximizing the utilization of waste materials.
To provide practical recommendations for the adoption of these sustainable concrete practices in the construction industry.
To provide data that may be used in future studies.

MATERIALS USED AND TESTING

the materials used in the investigation and their properties are briefly discussed below This chapter deals with the physical and chemical properties of various materials used in the preparation of concrete in this project .The constituent materials are:
1.Cement
2.Fine aggregate
3.3.Coarseaggregate
4.Stone dust
5.Dried banana peel powder
6..Water

CEMENT

Cement is a key to infrastructure industry and is used for various purposes and also made in many compositions for a wide variety of uses. Cements may be named after the principal constituents, after the intended purpose, after the object to which they are applied or after their characteristic property. Cement used in construction are sometimes named after their commonly reported place of origin, such as Roman cement, or for their resemblance to other materials, such as Portland cement, which produces a concrete resembling the Portland stone used for building in Britain. The term cement is derived from the Latin word Caementum, which is meant stone chippings such as used in Roman mortar not-the binding material itself. Cement in the general sense of the word, described as a material with adhesive and cohesive properties, which make it capable of bonding mineral fragments in to a compact whole. The first step of reintroduction of cement after decline of the Roman Empire was in about 1790, when an Englishman, J.S.meaton, found that when lime containing a certain amount of clay was burnt, I would set under water. This cement resembled that which had been made by the Romans. Further investigations by J. Parker in the same decade led to the commercial production of natural hydraulic cement.

An OPC 53 grade K.C.P cement was used in this investigation. The quality required for this work was assessed and the entire quantity was purchased and stored property in casting yard.The following tests were conducted in accordance with IS codesSpecific gravity (Le- Chatelier flask) (IS: 1727-1967)Sieve Analysis (IS : 2306 -1959)Compressive Strength test of concrete (IS: 516-1959)

Ordinary Portland cement (OPC) is by far the most important type of cement. The OPC was classified into three grades, namely 33 grade 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. If the 28 days strength is not less than 33N/mm2, 43N/mm2 and 53N/mm2 it called 43 grade and 53 grade cement respectively. OrdinaryPortlandcementof53GradeconformingtoIS8112-1989,and the specific gravity of cement were found to be 3.15.The cement for the whole work was procured in a single consignment and properly stored. Deccan Cement of 53Grade of brand name, available in the local market was used for the investigation. Care has been that the procurement was made from the single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 269-1989 and for chemical requirement in accordance IS:4032-1988andIS:12269-1987.

Fine Aggregate

River sand was used as fine aggregate. The specific gravity of sand was 2.60 and fineness modulus of fineness was 2.72. The aggregate wasted for its physical requirements such as gradation, fineness modules, specific gravity and bulk density in accordance with IS:2386-1963.The sand was surface dried before using.

The fine aggregate used in this investigation was clean river sand and the following tests were carried out on sand as per IS: 2386- 1968.

Sieve Size	**IS:383– 1970**			
	% Passing for			
	Zone I	Zone II	Zone III	Zone IV
10.00 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600micron	15-34	35-59	60-79	80-100
300micron	5-20	8-30	12-40	15-50
150micron	0-10	0-10	0-10	0-15

Specific gravity

Sieve analysis and fineness moulds find Aggregates and fine sand were purchased for a nearby fresher in gunture area which are typically the same materials used and normal concrete mixtures. The gradation test conducted on aggregates showed that day met specification requirement

The aggregate size is lesser than 4.75 mm is consider as fine aggregate .The sand particles should be free from any clay or in organic materials and found to be harden durable. Silt test is carried output specify the limits of presence or organic matter and silt in fine aggregates. It was stored in open space free from dust and water.

Figure: Fine Aggregate

STONE DUST

Stone dust used in the laboratory investigations was procured from "chimakurthy" crushing plant. The specific gravity of stone dust was 2.596 and fineness modulus Stone dust, also known as rock dust or quarry dust, is a byproduct of crushing stones into smaller pieces. It consists of fine particles and is often used as a base material for paving, landscaping, and construction. Stone dust helps improve stability, provides a smooth surface, and enhances drainage when used in pathways, driveways, and as a filler between pavers. It can also be used in agriculture to improve soil health. Stone dust is used in concrete as a partial or full replacement for sand to improve strength, durability, and sustainability. It enhances compressive strength, reduces voids, and increases density. However, excessive use can lower workability and increase water demand. Proper mix design ensures balanced performance, making stone dust a cost-effective alternative in construction.

Coarse aggregates

Aggregates were first considered to simply be filler for concrete to reduce the amount of cement required. However, it is now known that the type of aggregate used for concrete can have considerable effects on the plastic and hardened state properties of concrete. They can form 80% of the concrete mix so their properties are crucial to the properties of concrete. Aggregates can be broadly classified into four different categories: these are heavyweight. normal weight lightweight and ultra-lightweight aggregates. However in most concrete practices only normal weight and lightweight aggregates are used. The other types of aggregates are for specialist uses, such as nuclear radiation shielding provided by heavyweight concrete and thermal insulation using lightweight concrete. On the other hand, there are some properties possessed by the aggregate but absent in the parent rock: particle shape and size, surface texture, and absorption All these properties have a considerable influence on the quality of the concrete, either in fresh or in the hardened state. It has been found that aggregate may appear to be unsatisfactory on some court but no trouble need be experienced when it is used in concrete

In this present investigation ,locally available crushed blue granite stone aggregate of size 20mm and down was used and the various tests carried out on the aggregates, are given below specific gravity (IS 2386- 1968)

Table-: Sieve Analysis of Coarse Aggregate

S.NO	I.S Sieve destination	Weight of sample retained	Percentage retained	Cumulative %retained	Percentagep assed
1	40mm	0	0	0	100
2	20mm	7.4	29.61	29.61	90.41
3	10mm	16.38	65.52	95.12	4.88
4	4.75mm	0	4.88	100	0
5	Pan	0	0	100	0

Sieve analysis and fineness modulus (IS : 2386-1968)

The aggregate size bigger than 4.75mm , is consider as coarse aggregates. It can be found from original bed rocks .coarse aggregate is available in different shape like rounded, irregular or partly round, angular , factory etc. It should be free from any organic impurities and the dirt aggregate or rounded aggregate will make better concretes. They suggest that if at all the rounded aggregate is required to be used for economical reason ; It should be broken and then used. But the angular aggregate is superior to rounded aggregate from following two points

1.It exhibits a better interlocking effect in concrete

2.The total surface of rough textured angular aggregate is more than smooth rounded aggregate for the given volume.

3.Dried angular coarse aggregate of 20mm maximum sized and 10mm minimum size locally available for used for experimental work.

Water

Water plays vital role in achieving the strength in concrete. For complete hydration it requires about 3/10 of its weight of water. It is practically proved that minimum water cement ratio of 0.38 is required for conventional concrete. Water participates in chemical reaction with cement and when this cement paste is used, segregation and bleeding takes place, which makes the concrete weak. If less water is used, the required workability is not achieved. PH table water fit for drinking which is free from acid and organic substance , was used for mixing the concrete is required to be used in the concrete and it should have a pH value ranges between 6 to 8.

Banana peel powder : Dried banana peel powder (DBPP) is being explored as a sustainable additive in concrete, offering potential environmental and mechanical benefits. Rich in cellulose, hemi cellulose, and lignin, banana peels can enhance concrete properties when used in small proportions. Research suggests that replacing up to 5% of cement with DBPP can improve compressive strength, workability, and durability while reducing carbon emissions from cement production. However, excessive amounts (above 10%) may weaken the concrete due to the organic content interfering with hydration. Proper drying and fine grinding of banana peels are essential for effective integration into the mix. While DBPP promotes waste utilization and eco-friendly construction, further studies are needed to assess its long-term performance, particularly in structural applications.

Physical properties of stone dust

Stone dust, also known as quarry dust or crusher dust, is a fine-grained material produced during the crushing of stones. It has a particle size typically smaller than 4.75 mm, with a rough and angular texture, which enhances its binding properties in construction. With a high density (1.6–1.8 g/cm³) and low porosity, stone dust provides excellent compaction, making it a strong base material for roads and pavements. Its moisture content can vary, affecting workability in concrete and mortar. Additionally, when used as a partial replacement for sand, it can improve the compressive strength of concrete while reducing costs and environmental impact .Stone dust, when used in concrete, exhibits physical properties that influence its strength and durability. It has a fine particle size (≤4.75 mm) and rough texture, which enhances the bonding between cement and aggregates. With a high density (1.6–1.8 g/cm³) and low porosity, it improves compaction and reduces permeability, making concrete more durable. Its moisture retention capacity affects workability, requiring adjustments in water-cement ratios. When used as a partial sand replacement, stone dust can enhance the compressive strength of concrete while promoting sustainability by reducing dependence on natural sand. However, excessive use may affect workability and increase brittleness.

Sieve Analysis of Stone dust

S. NO	I.S Sieve	Weight of sample retained Gm	Percentage retained	Cumulative %retained	Percentage passed
1	40mm	0	0	0	100
2	20mm	0	0	0	100
3	10mm	0	0	0	100
4	4.75 mm	6	0.6	0.06	99.94
5	2.36 mm	100	10	10.6	89.4
6	1.18 mm	207	20.7	31.3	68.8
7	600 microns	124	12.4	43.7	56.4
8	300 microns	193	19.3	63	37.2
9	150 microns	294	29.4	92.4	7.8
10	Pan	78	7.8	-	0
			Total	241	

Fineness modulus of Stone dust = total cumulative percentage retained/100

=241/100 = 2.41

Chemical properties of stone dust

Stone dust primarily consists of silica (SiO_2), calcium oxide (CaO), aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3), and magnesium oxide (MgO), which influence its behavior in construction applications. The high silica content enhances bonding in cement it materials, while calcium oxide aids in hydration and setting. Aluminum and iron oxides contribute to the strength and durability of concrete and mortar. With a low organic content, stone dust is chemically stable and does not decompose over time. However, its alkaline nature may slightly affect the pH of concrete mixtures, requiring proper mix design adjustments. These chemical properties make stone dust a valuable material for concrete, road construction, and masonry applications. Stone dust in concrete contains various chemical compounds that influence its performance. Primarily composed of silica (SiO_2), calcium oxide (CaO), aluminum oxide (Al_2O_3), and iron oxide (Fe_2O_3), it contributes to the pozzolanic reaction, enhancing the strength and durability of concrete. The presence of silica improves bonding with cement, while calcium oxide aids in the hydration process, promoting better setting and hardening. Additionally, stone dust has a low organic content, reducing the risk of decomposition over time. However, its alkalinity may slightly affect the concrete's pH balance, requiring proper mix adjustments. Overall, its chemical composition supports improved strength and sustainability in concrete applications.

EXPERIMENTAL RESULTS

This chapter deals with the various mix proportions adopted in carrying out the experiments and experimental results obtained with respect to their strength, split tensile strength and flexural strength.

Size of Test Specimen Used:

The specimens were used according to the specifications laid down in IS516:1959.Cube size :150×150×150mm3

Compaction of Concrete:

Compaction of concrete is process adopted to remove air voids from the concrete. In the process of mixing, transporting and placing of concrete, air is likely to get entrapped in concrete. If this air is not removed fully, the concrete losses strength considerably .In order to achieve full compaction and minimum density, table vibration is used in the experiment.

Curing Of Test Specimen:

After casting, the specimens were stored in the laboratory free from any disturbances or vibration at room temperature and humid conditions for 24 hours after which they were remolded and submerged in cleaned fresh water of the curing tank. The specimens were cured 28 days in present work.

TESTS TO BE CONDUCTED

Testing Of Cube Specimens For Compressive Strength:

Compressive strength is defined as the ability of the material to resist compressive stress without failure. The specimen was tested in accordance with IS 516:1969. The testing was done on a compressive testing machine of 1000KN capacity. The machine has the facility to control the rate of loading with a control value. The platens are cleaned. After the required period of curing, the cube specimen are removed from the curing tank and cleaned to wipe off the surface water, it is placed on the machine such that the load is applied centrally. The smooth surfaces of the specimen are placed as the bearing surfaces. The top plates are brought in contact with the specimen by rotating the handle and the machine is switched on. A uniform rate of loading of 140Kg/sq.cm/min. is maintained. The maximum load at which the specimen fails is noted. The test is repeated for the three specimens and the average value is taken as mean strength. The compressive strength is given by the load applied on the specimen divided by the area of the bearing surface of the specimen (P/A).The results of the test are tabulated.

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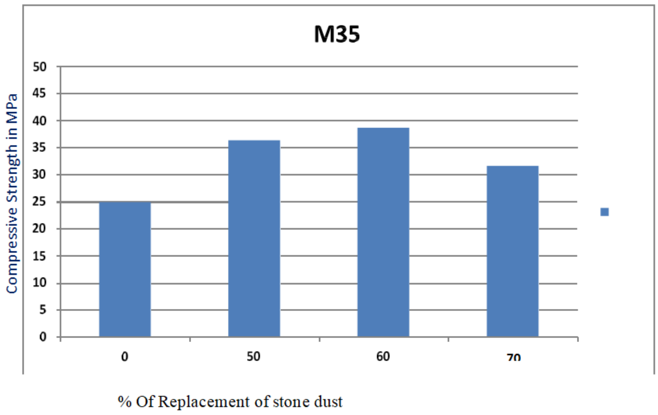
Fig: Compression Testing Machine

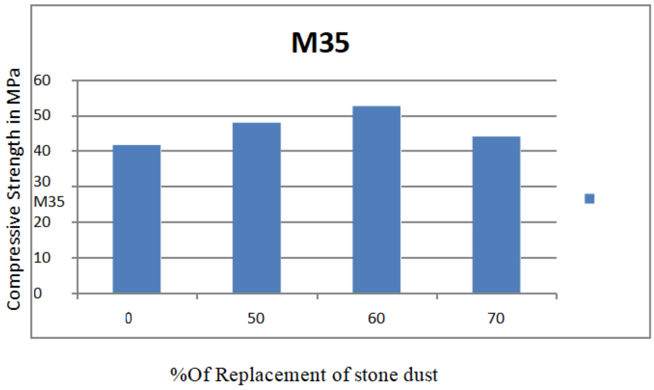
Table:7th Day Compressive Strength of M35Grade Mixes

Name mix	7th Day Compressive Strength in N/mm^2				sand replacement by stonedust
	Cube-1	Cube-2	Cube-3	Average	
Mix–1	24	25.33	25.5	24.94	0%
Mix-2	36.44	36.66	36	36.36	50%
Mix-3	39.22	38.66	38.3	38.72	60%
Mix-4	31.55	32.22	31.11	31.62	70%



Graph:7th Day Compressive Strength of M35Grade Mixes

Name of mix	28 Day Compressive Strength in N/mm^2				Sand replacement by stonedust
	Cube-1	Cube-2	Cube-3	Average	
Mix–1	41.77	42.66	40.44	41.62	0%
Mix-2	47.55	47.77	48.44	47.92	50%
Mix-3	53.77	52.44	51.55	52.58	60%
Mix-4	43.55	44	44.44	43.99	70%



Graph-2: 28th Day Compressive Strength with Replacement of Sand by stone dust for M35

CONCLUSION AND FUTURE SCOPE

Based on the experimental investigations, the following conclusions are drawn. Finally by doing the above project we have concluded that Stone dust have more compressive strength than the sand. Dried banana peels powder can improve compressive strength, workability and durability So, we are preferred Stone dust whenever constructions exposed to more loads in compressive direction (perpendicular direction)

- Stone dust can be effectively used as fine aggregate in place of conventional river sand, in concrete.
- It can be seen that brick crusher dust as fine aggregate has in general no detrimental effect on the strength and performance of concrete when designed correctly.
- It was observed that the density of concrete increases with increase in percentage of dust content. As expected the compressive strength increases with increase in density of concrete.
- The concrete cubes with crusher dust develop higher strength in compression and split tensile strength up to 60% replacement. The differences in strengths are possibly due to the sharp edges of Stone dust providing stronger bond with cement compared to the rounded shape of river sand.

As the stone dust used is very fine, it can fill the apertures between the larger particles of fine aggregate. Hence the use of this material gives a pleasing finish to the concreted surface.

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