

Mechanical Performance Enhancement of Concrete Using SCBA and Quarry Dust

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ABSTRACT

The rapid growth of the construction industry has increased the demand for conventional concrete materials such as cement and natural river sand, leading to environmental degradation and depletion of natural resources. This study investigates the development of sustainable M30 grade concrete by incorporating Sugarcane Bagasse Ash (SCBA) as a partial replacement for cement and Quarry Dust (QD) as a replacement for fine aggregate. Replacement levels ranging from 0% to 30% at 5% intervals were adopted while maintaining a constant water-cement ratio of 0.45.

A total of thirteen concrete mix combinations were prepared and tested for compressive strength, split tensile strength, and flexural strength at curing periods of 7 and 28 days. Experimental results showed that the inclusion of SCBA and QD improved the mechanical properties of concrete up to an optimum level, beyond which the strength gradually decreased. The optimum mix containing 15% SCBA and 15% QD achieved a compressive strength of 46 MPa at 28 days compared to 38 MPa for conventional concrete, indicating an improvement of about 21%. The enhanced performance is mainly attributed to the pozzolanic reaction of SCBA and the filler effect of quarry dust.

KEY WORDS: Sugarcane Bagasse Ash; Quarry dust; Mechanical, etc.

1 INTRODUCTION

1.1 General

Concrete is one of the important and most widely used as construction material. During the production of ordinary Portland cement (OPC) releases the huge amount of carbon-dioxide (CO₂) emissions; this will affect the environment and also causes the global warming. However the cement is the still main binder in the concrete for the construction of structures. In order to minimize the environment effect and pollution caused by the CO₂ from the production of cement. So we need to search the alternative cementations material for the manufacture of concrete.

Cement, is the most important element of construction industry and a durable construction material. Cement industry is the second largest Co₂ emitting industry behind the power generation. Now a day's Agricultural and industrial by-products are used in concrete production as cement replacement materials or as admixtures to enhance both fresh and hardened properties of concrete as well as to save the environment from the negative effects caused by their disposal. Approximately 1500 Million tons of sugarcane is annually produced over all the world which leave about 40-45 % bagasse after juice crushing for sugar industry giving an average annual production of 675 Million tons of bagasse as a waste material. The feasibility of using sugarcane Bagasse Ash (SCBA), a finely ground waste product from the sugarcane industry, as partial replacement for cement in conventional concrete is examined. The utilization of industrial and agricultural waste produced by industrial processes has been the focus of waste reduction research for economical, environmental, and technical reasons.

2 OBJECTIVES OF THE STUDY

This study investigates the use of Sugarcane Bagasse Ash (SCBA), an agricultural waste, as a partial replacement for cement, and Quarry Dust (QD), an industrial by-product, as a substitute for fine aggregate. The objective is to evaluate the mechanical performance of M30 grade concrete with replacement levels varying from 0% to 30% at 5% intervals, while maintaining a constant water–cement ratio of 0.45.

3 MATERIALS CHARACTERIZATION

Materials used for the experimentation:

- **Cement:** Ordinary Portland cement of 43 grade cement was used in this work. It was tested as per IS 8112-1989 recommendation.
- **Fine aggregate:** Natural sand confirming to IS 383-1970 of Zone II is used. Specific gravity 2.64.
- **Coarse aggregate:** Locally available crushed aggregates confirming to IS: 383–1970 is used in this dissertation. Specific gravity 2.73.
- **Quarry Dust:** For the present investigation, quarry dust was procured from a nearby crusher in Karnataka. The sample exhibited a specific gravity of 2.61, and its grading, based on sieve analysis, falls under Zone II in accordance with IS 383:1970.
- **Bagasse ash:** The bagasse ash consists of specific gravity 2.15 and the specific surface area of 2475 cm²/gram. The used bagasse ash was classified as Class F.
- **Water:** Water fit for drinking is generally considered fit for making concrete. Gives the permissible limits for solids as per IS 456:2000.

4. EXPERIMENTAL INVESTIGATIONS

Concrete mixes were prepared for M30 grade with a constant w/c ratio of 0.45. Cement was partially replaced with SCBA and fine aggregate with QD from 0% to 30%. Specimens were casted and cured for 7 and 28 days. Standard testing procedures were followed as per IS codes.

4.1 Compressive Strength Test

The test results for compressive strength of M30 grade concrete different ages is shown in Table 4.1

Table 4.1 Compressive Strength of Concrete Mixes at Different Ages

Mix	SCBA%	QD%	7 Days	28 Days
M1	0	0	22	38
M2	0	5	23	39
M3	0	10	24	41
M4	0	15	25	42
M5	0	20	24	40
M6	0	25	23	38
M7	0	30	21	36
M8	5	5	24	41
M9	10	10	26	44
M10	15	15	27	46
M11	20	20	25	42
M12	25	25	23	39
M13	30	30	21	36



Fig 4.1 Graph of 7 & 28 day's compressive strength v/s different mix proportions

4.2 Split Tensile Strength

The test results for Split Tensile Strength of M30 grade concrete different ages is shown in Table 4.2

Table 4.2 Split Tensile Strength of Concrete Mixes at Different Ages

Mix	7 Days	28 Days
M1	2.2	3.5
M2	2.3	3.6
M3	2.4	3.8
M4	2.5	3.9
M5	2.4	3.7
M6	2.	3.5
M7	2.1	3.3
M8	2.4	3.8
M9	2.6	4.0
M10	2.8	4.3
M11	2.5	3.9
M12	2.3	3.6
M13	2.1	3.3



Fig 4.2 Graph of 7 & 28 days Split Tensile Strength v/s different mix proportions

4.3 Flexural Strength

The test results for Flexural Strength of M30 grade concrete different ages is shown in Table 4.3

Table 4.3 Flexural Strength of Concrete Mixes at Different Ages

Mix	7 Days	28 Days
M1	3.5	5.5
M2	3.6	5.6
M3	3.8	5.9
M4	4.0	6.1
M5	3.8	5.8
M6	3.6	5.5
M7	3.3	5.2
M8	3.9	5.9
M9	4.2	6.3
M10	4.5	6.8
M11	4.0	6.1
M12	3.7	5.7
M13	3.4	5.3



Fig 4.3 Graph of 7 & 28 days Flexural Strength v/s different mix proportions

5. RESULTS AND DISCUSSION

5.1 Mechanical Properties

The experimental results clearly indicate that the incorporation of Sugarcane Bagasse Ash (SCBA) and Quarry Dust (QD) significantly influences the mechanical performance of concrete. The compressive, split tensile, and flexural strengths showed a consistent increase with increasing replacement levels up to the optimum mix of 15% SCBA and 15% QD. This improvement is mainly attributed to the pozzolanic activity of SCBA, which reacts with calcium hydroxide to form additional calcium silicate hydrate (C-S-H) gel, thereby enhancing the strength and bonding within the concrete matrix. At the same time, quarry dust improves particle packing and reduces voids, resulting in a denser and more compact structure.

The combined effect of SCBA and QD leads to improved load-bearing capacity, better resistance to cracking, and enhanced flexural performance. However, beyond the 20% replacement level, a gradual reduction in strength was observed. This is due to the decrease in cement content and incomplete pozzolanic reaction at higher replacement levels, which weakens the bonding within the concrete. Therefore, maintaining an optimum replacement level is essential to achieve maximum mechanical performance without compromising structural integrity.

6. CONCLUSION

- The optimum replacement level was found to be 15% SCBA and 15% QD.
- Mechanical properties such as compressive, tensile, and flexural strength improved significantly up to the optimum level.
- Beyond 20% replacement, strength decreased due to reduced cementitious content and weaker bonding.

- The use of SCBA and quarry dust promotes sustainable and eco-friendly concrete production by utilizing waste materials effectively.

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