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Evaluation of Mechanical Strength of Concrete by Partial Replacement of Cement and Coarse Aggregate with Sugarcane Bagasse ash and Ceramic Tile waste

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***Abstract*—Concrete, being the most widely used construction material globally, contributes significantly to carbon emissions due to the production of cement. By replacing cement with SBA, and coarse aggregate with ceramic waste not only can the environmental impact be minimized, but also the economic burden associated with waste disposal can be alleviated. The utilization of sugar cane bagasse ash in concrete offers a promising solution for sustainable waste management. The construction industry generates a substantial amount of waste, including ceramic waste, which is derived from the demolition of buildings, tiles, and sanitary ware. Effective management of ceramic waste is essential to reduce environmental impacts and promote sustainable practices. This study discusses the potential benefits and challenges associated with the partial replacement of conventional coarse aggregates with ceramic waste in concrete production. It not only reduces the environmental impact associated with waste disposal but also enhances the properties of concrete, leading to more durable and eco-friendly construction practices. Continued research and adoption of such waste utilization strategies can contribute to a more sustainable and resource-efficient construction industry. In this present research work has various objectives to evaluate the behavior of waste material in concrete. M25 grade of concrete were prepared using Sugarcane bagasse Ash as a partial replacement of cement in variation of 10, 20, & 30% and coarse aggregates were replaced by ceramic tile waste at percentage of 5%, 10% and 20%. Different tests have been performed on fresh and hardened concrete in the laboratory. The mechanical properties such as compressive strength, split tensile strength test, flexural strength test was evaluated at 28 days. The Sample 20SBA10CTA (20% of Sugarcane bagasse Ash & 10% i.e. TWA) of concrete shows more average value of compressive strength, Split Tensile Strength and Flexural Strength at 28 days than other two samples having Sugarcane bagasse Ash & Ceramic tile waste i.e. 10SBA5CTA (10% of Sugarcane bagasse Ash & 05% of CTWA), 30SBA20CT (30% of Sugarcane bagasse Ash & 20% of CTWA) and Conventional Mix Concrete. According to a study it is recommended to use 20% of Bagasse Ash and 10% of Ceramic Waste Aggregates to obtain the maximum strength of concrete of grade M25.**

***Keywords*—Sustainable Concrete, Waste utilization, SCBA, Ceramic Tile Waste, Compressive Strength, Flexural Strength, etc**

I. INTRODUCTION

Concrete is one of the most widely used construction materials in the world, valued for its versatility, durability, and strength. It plays a crucial role in the construction of buildings, bridges, roads, dams, and various infrastructure projects. Concrete is a composite material composed of a mixture of cement, aggregates (such as sand and gravel or crushed stone), water, and often, admixtures.

The construction industry is increasingly focusing on sustainable practices and reducing the environmental impact of construction materials. In this context, the utilization of industrial waste materials as alternative resources in concrete production has gained significant attention. Two such waste materials that show promise as potential additives in concrete are sugarcane bagasse ash and ceramic waste.

Sugarcane bagasse ash (SBA) is a byproduct obtained from the combustion of bagasse, the residue left after extracting juice from sugarcane stalks in sugar mills. It is a finely divided

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pozzolanic material that exhibits cementitious properties when combined with lime or cement. SCBA has shown potential as a partial replacement for cement in concrete, offering advantages such as waste management, reduced environmental impact, and improved performance.

Ceramic waste, on the other hand, is generated from the demolition or manufacturing processes of ceramics, including tiles, sanitary ware, and other ceramic products. It is often discarded in landfills, posing challenges for waste management. However, ceramic waste can be recycled and used as a partial replacement for conventional coarse aggregates in concrete. This practice not only reduces waste generation but also conserves natural resources and improves the sustainability of concrete structures.

The incorporation of sugarcane bagasse ash and ceramic waste in concrete offers several benefits. Firstly, it reduces the demand for traditional raw materials like cement and natural aggregates, mitigating the environmental impacts associated with their extraction and processing. Secondly, it provides an effective solution for waste management by diverting these materials from landfills and converting them into useful resources. By utilizing these waste materials in concrete production, the construction industry can contribute to a circular economy and reduce its carbon footprint. When added to concrete mixtures, sugarcane bagasse ash enhances the strength and durability of the resulting concrete. It improves workability, reduces the heat of hydration, and mitigates issues such as alkali-silica reaction. Similarly, ceramic waste, when used as a replacement for coarse aggregates, can exhibit comparable or even improved mechanical properties, contributing to the overall performance and longevity of concrete structures.

II. MATERIAL AND METHODOLOGY

2.1 Cement: OPC 43 grade cement was used in present study which confirms to IS: 8112. Various parameters such as initial and final setting time, fineness of cement was determined in laboratory.

Table 1: Physical Properties of Cement

S No	Physical Property	Value
1	Specific Gravity	3.15
2	Initial Setting Time (min)	120
3	Final Setting Time (min)	210
4	Standard Consistency (%)	34

2.2 Fine Aggregate: Fine aggregate plays a vital role in the composition and performance of concrete. It is one of the essential components in concrete mixtures, alongside cement, coarse aggregates, water, and often admixtures. Fine aggregate constitutes a significant portion of the total volume of concrete, influencing its workability, strength, durability, and other key properties.

Fine aggregate typically consists of natural sand or crushed stone with particle sizes smaller than 5mm. It is obtained from sources such as riverbeds, quarries, or crushed rock. As per the guidelines of IS: 383-1970, physical properties of fine aggregate was determined and represented in the below table:

Table 2: Physical proprieties of fine Aggregate

S No	Physical Property	Value
1	Specific Gravity	2.68
2	Fineness modulus	2.41

2.3 Coarse Aggregate: Coarse aggregate is an essential component of concrete that provides strength, durability, and structural integrity to the material. It is one of the main constituents of concrete mixtures, along with cement, fine aggregate (typically sand), water, and often admixtures. Coarse aggregate comprises particles larger than 5mm, such as gravel, crushed stone, or recycled concrete.

The primary function of coarse aggregate in concrete is to provide a skeleton or framework within which the cement paste can bind. It forms the bulk of the concrete volume, contributing to its mechanical properties and load-bearing capacity. The size, shape, and grading of coarse aggregate have a significant impact on the workability, strength, and durability of concrete. In this present work 20 mm size of coarse aggregate were used and physical properties such as specific gravity, water absorption test were determined in the laboratory.

Table 3: Physical properties of Coarse Aggregate

S No	Physical Property	Value
1	Specific Gravity	2.71
2	Water absorption (%)	0.58

2.4 Sugarcane bagasse ash (SBA): Sugarcane bagasse ash (SBA) is a valuable byproduct generated in the sugar industry, and its utilization in concrete production offers both waste management benefits and improvements in concrete properties. By reducing waste generation and promoting sustainable practices in the construction industry, the incorporation of SBA contributes to a more environmentally friendly and resource-efficient approach to concrete production. In this study sugarcane bagasse ash were collected from online, and the specific gravity of SBA is 2.2.

2.5 Ceramic Tiles waste aggregate: Ceramic tiles waste aggregate refers to the byproduct or waste material generated during the manufacturing, demolition, or recycling processes of ceramics, including tiles, sanitary ware, and other ceramic products. Ceramic waste aggregate can be obtained from various sources, including construction and demolition sites, ceramic manufacturing plants, or recycling facilities. Ceramic waste material was obtained from Pooja Ceracon Company. The specific gravity of ceramic tiles waste aggregate is 2.50 g/cc and water absorption value was 4.5%.

2.6 Design Mix (M25): In this research work, the cement and coarse aggregates were partially replaced with sugarcane bagasse ash at proportion of 10%, 20%, and 30% and ceramic tiles waste aggregates at proportion range of 5%, 10% and 20%. Different designations of various concrete mixes are represented as Conventional Mix, 10SBA5CTA, 20SBA10CTA, 30SBA20CTA

The following mix design M25 (1: 2.4: 3.5) have been carried out as per the codal provisions of IS: 10262-2009
W/c Ratio=0.44, Cement=328kg/m^3, Fine Aggregate=790 kg/m^3, Coarse Aggregate= 1165 kg/m^3, Water= 144 kg/m^3

III. RESULT AND DISCUSSION

The current section represents the obtained results from various laboratory tests such as slump test, compressive strength test, split tensile test and flexural strength test of control concrete mix and the modified concrete mix containing the replacement material i.e. ceramic tile waste and sugarcane bagasse ash.

3.1 Slump Value Test Result:

The slump test result of concrete provides a simple and practical measure of its workability and consistency. It helps ensure that the concrete mixture is suitable for proper placement and compaction during construction, promoting the desired performance and quality of the hardened concrete structure. The slump flow test was carried out in the laboratory and the following test result of a slump test is shown in figure below.

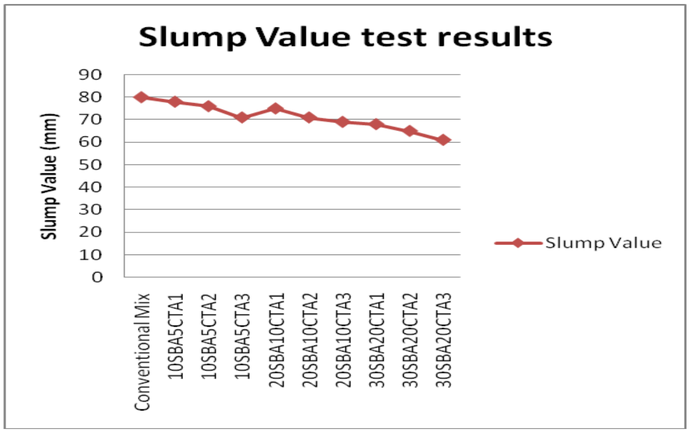

Fig 1: Graphical repsentation of slump value for different concrete mix

3.2 Compressive Strength Test Result:

The compressive strength test is conducted in the compressive testing machine of 2000kN capacity. The cube specimen of 150 mm x 150 mm x 150 mm was used in the present study. Three concrete cube samples of each concrete mix were tested at 7 and 28 days and result were determined.

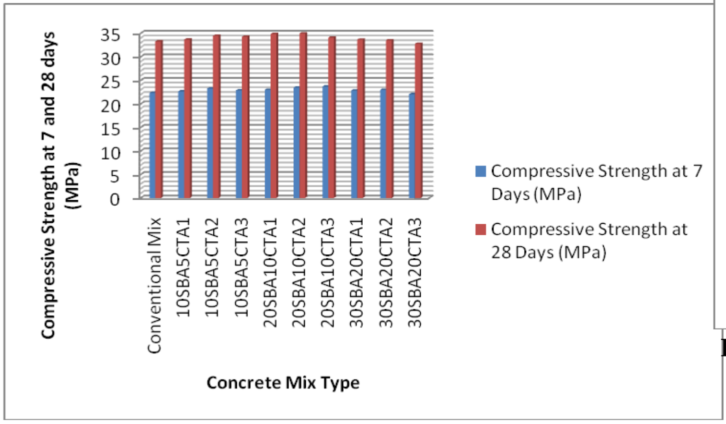

Fig 2: Graphical Representation of Compressive Strength at 7 and 28 days (Mpa)

3.3 Split Tensile Strength Test Result:

To evaluate the split tensile strength of various concrete mixes, Concrete grade 25, 3 cylindrical samples of each concrete mix were casted and tested at 28 days in the laboratory. The following test results have been determined.

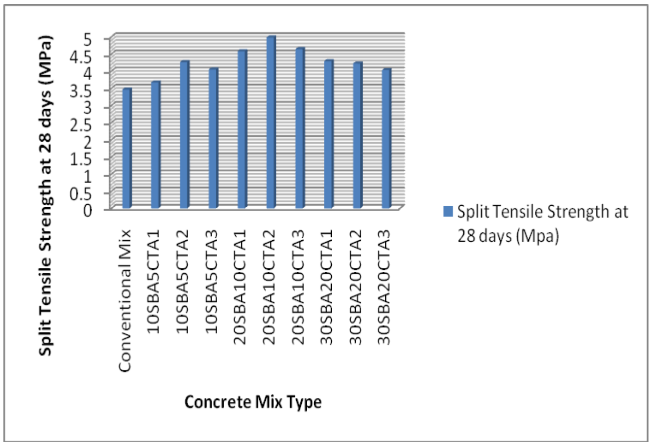

Fig 3: Graphical representation of split tensile strength at 28 days (MPa)

3.4 Flexural Strength Test Result:

To evaluate the split tensile strength of various concrete mixes, M25 Concrete grades 3 beam samples of each concrete mix were casted and tested at 28 days in the laboratory. The following test results have been determined.

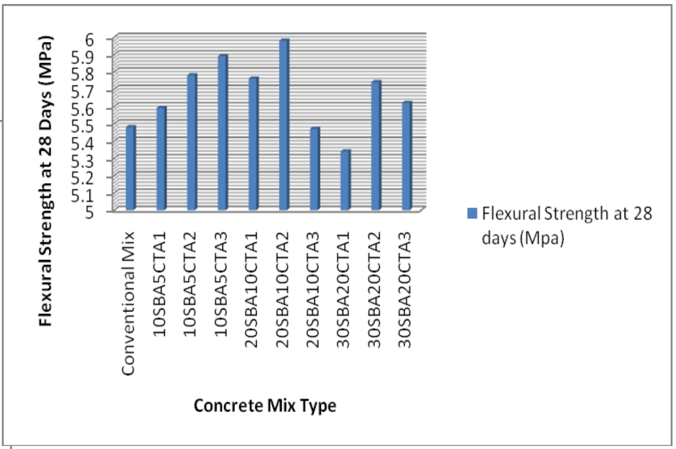

Fig 4: Graphical representation of Flexural strength at 28 days (MPa)

IV. CONCLUSION

From the results determined in this research work, using Sugarcane bagasse Ash as a partial replacement of cement in variation of 10, 20, & 30% and coarse aggregates were replaced by ceramic tile waste at percentage of 5%, 10% and 20% in concrete. The following conclusion is as follows.

By comparing the results with conventional mix, it is observed that the slump value of concrete mix gets reduced with increase in content of Sugarcane bagasse Ash and ceramic tile waste as a partial replacement of cement and coarse aggregates respectively. Slump value results confer that workability of concrete gets increased with partial replacement of cement and coarse aggregate with Sugarcane bagasse Ash and ceramic tile waste. Moreover, compressive strength, Split Tensile Strength and Flexural Strength at 28 days also get increased with the partial replacement of cement and concrete with Sugarcane bagasse Ash and ceramic tile waste.

The Sample 20SBA10CTA (20% of Sugarcane bagasse Ash & 10% of CTWA) of concrete shows more average value of compressive strength, Split Tensile Strength and Flexural Strength at 28 days than other two samples having Sugarcane bagasse Ash & Ceramic tile waste i.e. 10SBA5CTA (10% of Sugarcane bagasse Ash & 05% of CTWA), 30SBA20CT (30% of Sugarcane bagasse Ash & 20% of CTWA) and Conventional Mix Concrete.

Abbreviation:
SBA- Sugarcane Bagasse Ash
CTWA- Ceramic tile waste Aggregate
CM- Conventional Mix
10SBA5CTA- 10% Sugarcane Bagasse Ash and 5% Ceramic Tile Waste,
20SBA10CTA- 20% Sugarcane Bagasse Ash and 10% Ceramic Tile Waste,
30SBA20CTA- 30% Sugarcane Bagasse Ash and 20% Ceramic Tile Waste

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