Concrete Made by Byproduct Materials

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***Abstract*—Concrete is the most commonly used construction material globally, yet producing it has a significant carbon footprint. A labor- and energy-intensive process used to make traditional concrete produces a lot of carbon dioxide, which raises greenhouse gas emissions. As the world concentrates on reducing carbon emissions, recycled-materials-derived environmentally friendly concrete is becoming more and more popular. The elements that are left over from other industries are known as byproducts, and they can entirely or partially replace traditional concrete components. In this article, the potential for employing several environmentally friendly concrete variants made from waste materials to lessen the carbon footprint of the building industry is studied. Moreover, Fly Ash/ Marble Dust mixed Portland Cement based Concrete are fabricated. Furthermore, characterization of fabricated concrete samples after 28 and 56 days are performed respectively. Finally we compared Fly Ash-Portland cement and Marble dust-Portland cement on various properties.**

Keywords—Eco-friendly Concrete, Fly Ash Concrete, Marble Dust, Portland Cement

I. Introduction

The construction industry is a significant contributor to carbon dioxide emissions. The production of concrete accounts for 7% of all worldwide carbon dioxide emissions [1-2]. In recent years, there has been a greater focus on environmentally friendly concrete made from waste materials. These things originate from several industries and are regularly discarded in landfills [3-4]. Working in the concrete industry, however, may help people reduce waste and the environmental impact of the building industry. This research examines the possibilities for several environmentally friendly concrete variants made from waste materials to reduce the carbon footprint of the building industry [5-6].

Sustainable concrete offers a number of benefits. The use of green concrete made from waste materials can significantly lower the carbon footprint of the construction industry. Byproduct materials are typically viewed as trash and deposited in landfills. Utilizing these materials in the production of concrete reduces waste generated by other industries, making construction more environmentally friendly. Environmentally friendly concrete made from waste materials has been shown to function on par with or even better than regular concrete. It has been proven, for instance, that GGBFS concrete performs better than traditional concrete in terms of sturdiness and corrosion resistance [7-8].

II. Literature Study

The study outlined in [9] aims to determine if coal fly ash cement blocks are suitable for use in building construction as well as a workable and efficient solution to the coal fly ash problem in fluidized bed boilers. Crushed queen scallop is what Dauvin et al. [10] like to use. Aequipecten opercularis shells to enhance the utilization of by-products from shellfish in the creation of a material appropriate for artificial reefs in the environment. By using waste materials in place of standard components, the amount of carbon emissions generated during the production process is reduced [11-12]. Fly ash is utilized as a binder and GBS is used as the fine aggregate in an experimental investigation of the characteristics of foam concrete [13]. Bhairappanavar et al. [15] examine the practicality of using dredge material from a controlled disposal facility close to Cleveland, Ohio, to make ecologically friendly bricks. Studies have demonstrated that construction materials like concrete and steel may be replaced with cardboard scraps if they have the right compressive strength. Old corrugated cardboard panels created without adhesives were utilised for building rather than garbage corrugated cardboard. These panels were put between the wooden parts of the supporting framework. For a residential structure, we looked at the most workable eco-design and construction techniques [19]. Alkaline activating solutions are made by combining sodium silicate with sodium hydroxide at molarities of 8, 10, and 12.

The basic ingredients used are easily accessible industrial waste wastes, and because they produce a lot less carbon dioxide than cement, they are ecologically friendly materials [20]. The goal of authors [21] is to construct a coarse aggregate replacement using GGBS clinker, or Ground Granulated Blast Furnace Slag, and to determine the hardened properties of M20 Grade unusual concrete. The cradle-to-gate life-cycle assessment (LCA) is investigated by researchers using ternary mixed alkali-activated mortars made from industrial waste. The objective of research was to observe the possibility of utilizing marble powder in concrete manufacturing. It was observed that compressive energy and flexural strength improved up to 23% 24% and 17.82% respectively when they were changed by 10% of marble powder. It was additionally determined there is a decrease in chloride penetrations but a new big exchange in water absorption in comparison to conventional concrete.

In [22] waste foundry sand and marble dirt powder used as partial alternatives for sand and cement respectively and examined for power traits. It is found that higher consequences are at 10% of marble dirt powder and waste foundry sand at 25% replacement and after that electricity decreases. Research additionally indicates that waste marble powder represents good overall performance due to gifted micro filling potential. This work in [23] makes a specialty of strengthening concrete by means of changing cement via marble powder within the maximum low-priced way for m20 grade. Studies indicate marble powder has excellent cohesiveness of mortar and concrete. 20% of substitutes gives fantastic results in energy and great. Concrete having 20% substitution of marble powder with cement has high compressive power and improvement of houses related to sturdiness. Authors in [24] on this research waste marble dirt becomes utilized in cement and concrete production. Marble dust up to 15% as cement substitute has positive results on steel concrete bond power and most become at 10%. It was also found that porosity also decreases with addition of marble dust in concrete. There has been a large trade in ultrasonic pulse speed with use of marble dirt in concrete.

Following are the major contributions of this work:

- Fabricated Fly Ash/ Marble Dust mixed Portland Cement based Concrete.
- Perform characterization of fabricated concrete samples
- Compared Fly Ash-Portland cement and Marble dust-Portland cement

III. METHODOLOGY

A. Fabrication Process

The most prevalent way of characterizing the properties of Portland cement with fly ash and marble dust is by casting cubes. The conventional method for casting cubes is given below.

First step is preparation of the materials. The required supplies, such as Portland cement, fly ash/marble dust, water, and any other admixtures, are obtained and transported to the building site. The components are then combined to make a consistent mixture. The second step is cube molds. Steel cube molds measuring 150 mm by 150 mm by 150 mm are used to cast the cubes. Followed by lubrication of Cube Moulds. The interior surfaces of the cube molds are lubricated with a thin layer of petroleum jelly or any other suitable substance to permit effortless removal of the cubes after casting.

Followed by the filling of the Cube Moulds. Three equal layers of the homogenous material produced in step 1 are poured into the cube molds. A compacting rod is rotated 25 times over each layer to properly distribute the mixture and minimize voids. Next step is to give finishing to the formed cube molds. Using a trowel, the mixture's top surface is smoothed after the last layer has been crushed. The cube molds are then placed in a damp atmosphere at 27 2°C for 24 hours to cure. Then cube molds are removed after 24 hours, and the cubes are then dipped into water that is 27 2°C-hot to cure. The final step in the fabrication process is testing. Following a 28-day curing period, the cubes are examined for their compressive strength, tensile strength, elastic modulus, permeability test, workability, and other essential properties.

To gather data for characterization, this technique is carried out for different ratios of fly ash/marble dust mixed Portland cement.

B. Characterization

Characterization is performed to evaluate the formed concrete samples. A series of tests are used in this analysis after 28 days of fabrication including Tensile Strength Test (ASTM C496/C496M), Compression test (ASTM C39/C39M), air content test (ASTM C231), setting time test (ASTM C191), modulus of elasticity test (ASTM C469), permeability test (ASTM C1202), and workability test (ASTM C143). The tensile strength of the combination can be assessed by creating cylindrical or prismatic specimens. On ready cylindrical or prismatic specimens, the compression test may be carried out. A pressure meter may be used to calculate the quantity of air in the mixture. A device called a Vicat can be used to calculate the mixture's setting time. An evaluation of the mixture's elastic modulus can be done by compression testing. The combination's workability can be assessed using a slump test.

C. Materials Used

Fly ash, a fine, powdery debris, is created when pulverized coal is burnt in coal-fired power plants. Most of it is composed of iron oxide, aluminum oxide, and silicon dioxide. Marble dust, marble powder, or marble fines are waste products that are produced during the cutting, polishing, and processing of marble stone. Cement, a binding chemical, is the major ingredient used to make concrete. Silica, a kind of finely broken rock, makes up the majority of sand's granular composition. Aggregates are granular substances like sand, gravel, or crushed stone that are used in concrete. The majority of concrete's structural strength is provided by coarse aggregates with particle sizes more than 4.75 mm. Because it keeps concrete moist, water is a crucial component of concrete.

IV. RESULT & DISCUSSION

In this section the evaluation of fabricated concrete is presented. A series of characterization techniques are performed to evaluate the strength, elasticity, air content, workability, and permeability of the formed concrete.

Table (1-2) displays the findings of a study on Portland cement blended with fly ash at various fly ash to cement ratios (0%, 10%, 20%, 30%). Megapascals (MPa) units were used to quantify the tensile and compressive strengths, air content in percentage, setting time in hours and minutes, as well as the modulus of elasticity, permeability, and workability.

The fact that workability increased as fly ash content increased suggests that adding fly ash enhanced workability. The finer fly ash particle size compared to cement, which results in better particle packing and increased flowability, may be the cause of the improvement in workability.

Table 1 Characterization (Tensile strength, compressive strength, permeability, and workability) readings of Fly Ash-Portland Cement concrete in different ratios after 28 days

Fly Ash to Cement Ratio	Tensile Strength (MPa)	Compressive Strength (MPa)	Permeability (m/s)	Workability (cm)
0%	4.5	26.7	3.68E-12	16.3
10%	4.8	25.5	3.20E-12	18.5
20%	5.1	24.0	2.98E-12	20.2
30%	5.4	22.5	2.75E-12	21.8

Table 2 Characterization (Air content, setting time, modulus of elasticity) readings of Fly Ash-Portland Cement concrete in different ratios after 28 days

Fly Ash to Cement Ratio	Air Content (%)	Setting Time (hours:minutes)	Modulus of Elasticity (GPa)
0%	1.5	2:50	28.7
10%	1.7	2:55	29.2
20%	2.0	3:00	29.7
30%	2.3	3:10	30.2

Table 3 Characterization (Tensile strength, compressive strength, permeability, and workability) readings of Marble Dust-Portland Cement concrete in different ratios after 28 days

Marble Dust to Cement Ratio	Tensile Strength (MPa)	Compressive Strength (MPa)	Permeability (m/s)	Workability (cm)
0%	4.5	26.7	3.68E-12	16.3
10%	4.6	25.3	3.45E-12	17.5
20%	4.8	23.9	3.22E-12	18.7
30%	5.0	22.5	3.00E-12	19.9

Table 4 Characterization (Air content, setting time, modulus of elasticity) readings of Marble Dust-Portland Cement concrete in different ratios after 28 days

Marble Dust to Cement Ratio	Air Content (%)	Setting Time (hours:minutes)	Modulus of Elasticity (GPa)
0%	1.5	2:50	28.7
10%	1.6	2:55	29.0
20%	1.8	3:00	29.3
30%	2.0	3:10	29.6

The quantity of fly ash had some effect on the modulus of elasticity, a measure of the material's rigidity. This exemplifies how the addition of fly ash affects the material's overall rigidity. In agreement with the lower values of permeability with increasing fly ash content, permeability experiments showed that the addition of fly ash may drastically reduce permeability. The pozzolanic reaction of fly ash, which results in a denser and more compact concrete mixture, is what causes this decrease in permeability.

In Table (3-4), marble dust has been utilized in place of fly ash along with the same parameters as the previous one, including tensile strength, compressive strength, air content, setting time, elastic modulus, permeability, and workability.

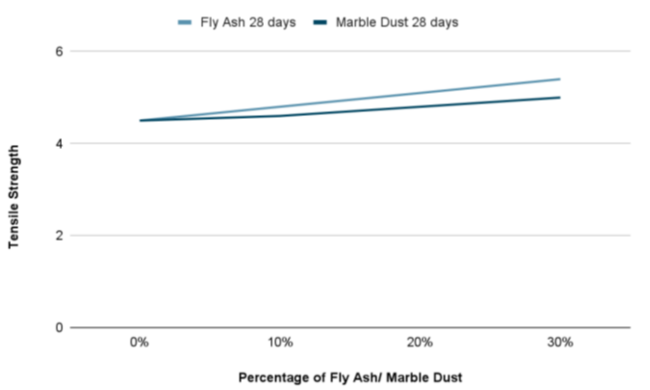

Fig. 1 Comparison between tensile strength of fly ash/ marble dust blended comcentre samples

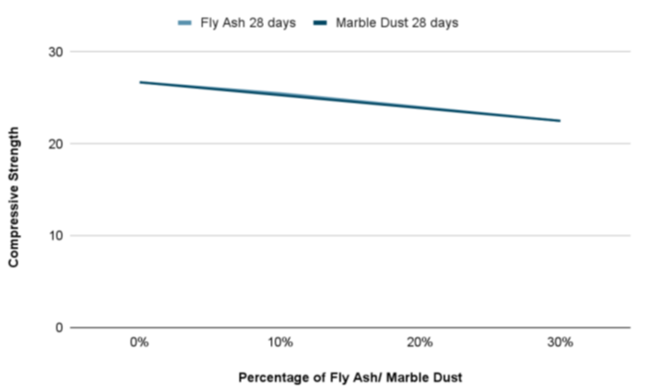

Fig. 2 Comparison between compressive strength of fly ash/ marble dust blended comcentre samples

The fact that workability increased as fly ash content increased suggests that adding fly ash enhanced workability. The finer fly ash particle size compared to cement, which results in better particle packing and increased flowability, may be the cause of the improvement in workability. The quantity of fly ash had some effect on the modulus of elasticity, a measure of the material's rigidity. This exemplifies how the addition of fly ash affects the material's overall rigidity. In agreement with the lower values of permeability with increasing fly ash content, permeability experiments showed that the addition of fly ash may drastically reduce permeability. The pozzolanic reaction of fly ash, which results in a denser and more compact concrete mixture, is what causes this decrease in permeability.

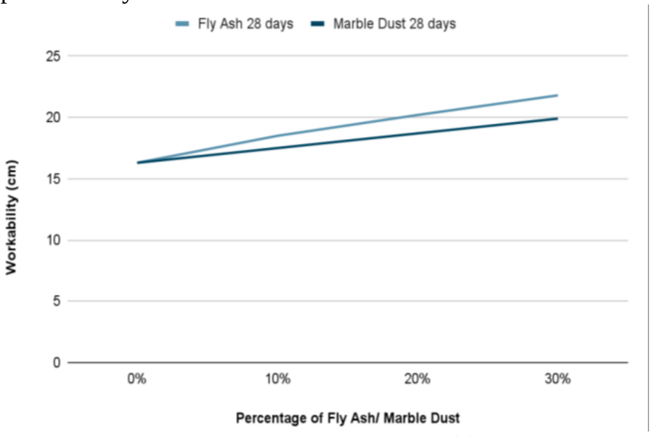

Fig. 3 Comparative analysis between workability of fly ash/ marble dust blended comcentre samples

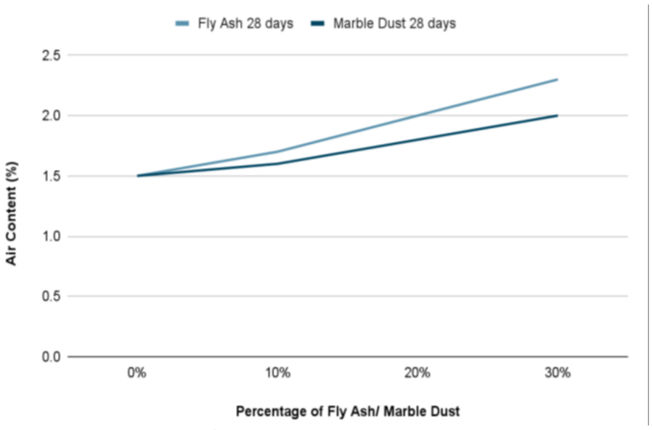

Fig. 4 Air content in fly ash/ marble dust blended comcentre samples

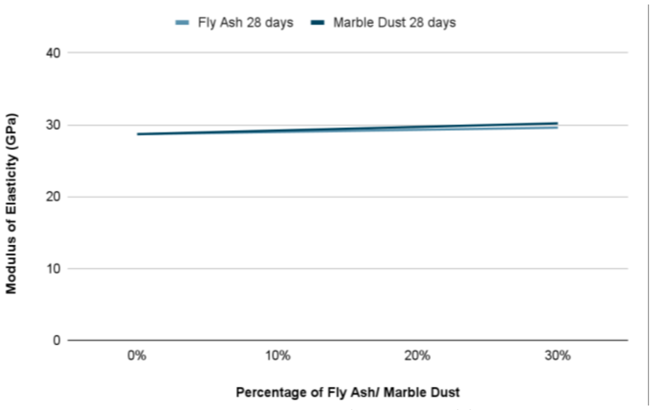

Fig. 5 Comparison between modulus of elasticity of fly ash/ marble dust blended comcentre samples

Similar to how the fly ash mixture changed as the amount of marble dust rose, the addition of marble dust made the combination more stable. The marble dust's smaller particle size, which enhances particle packing and boosts flowability, contributes to the improvement in workability. Further evidence that marble dust raises the material's overall stiffness is provided by the modest rise in modulus of elasticity that was caused by the concentration of marble dust. Based on the lower values of permeability with increasing content, permeability experiments have shown that the addition of marble dust can reduce permeability. The finer marble dust particles and their pozzolanic interaction with cement, which results in a denser and more compact concrete mixture, are to blame for the reduction in permeability.

Table 5 Characterization (Tensile strength, compressive strength, permeability, and workability) readings of Fly Ash-Portland Cement concrete in different ratios after 56 days

Proportion of Fly Ash (%)	Tensile Strength (MPa)	Compression Strength (MPa)	Workability (mm)
0	3.15	52.3	106
10	3.35	53.8	104
20	3.50	54.7	102
30	3.70	56.2	100

Table 6 Characterization (Tensile strength, compressive strength, permeability, and workability) readings of Marble Dust-Portland Cement concrete in different ratios after 56 days

Proportion of Marble Dust (%)	Tensile Strength (MPa)	Compression Strength (MPa)	Workability (mm)
0	2.98	51.2	104
10	3.15	53.5	102
20	3.25	55.2	100
30	3.95	57.3	98

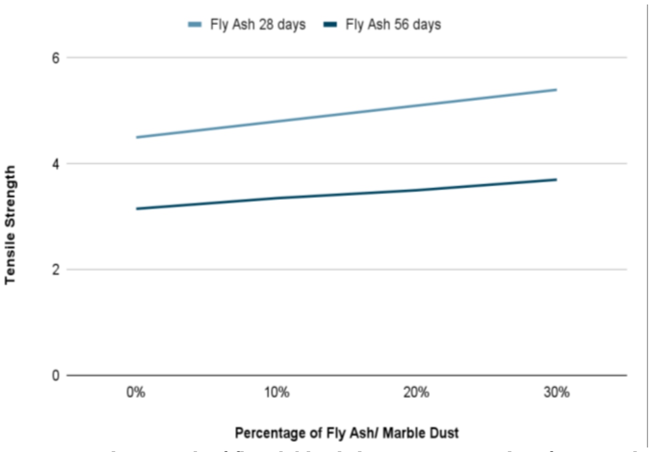

Fig. 6 Tensile Strength of fly ash blended comcentre samples after 28 and 56 days

A similar analysis is performed in Fig. (3-5). In Fig. 3 the workability analysis of fly ash and marble dust blended concretes is analyzed, just like tensile strength fly ash concretes showed supreme performance in workability as well. A similar trend is seen for air content in Fig. 4, however very close results are performed in case of modulus of elasticity in Fig. 5.

Further, in Fig. (1-2) comparison between tensile and compressive strength of fly ash/ marble dust blended concrete sample in different proportions is shown. The fly ash blended samples showed higher tensile strength, however they both have almost similar compressive strengths.

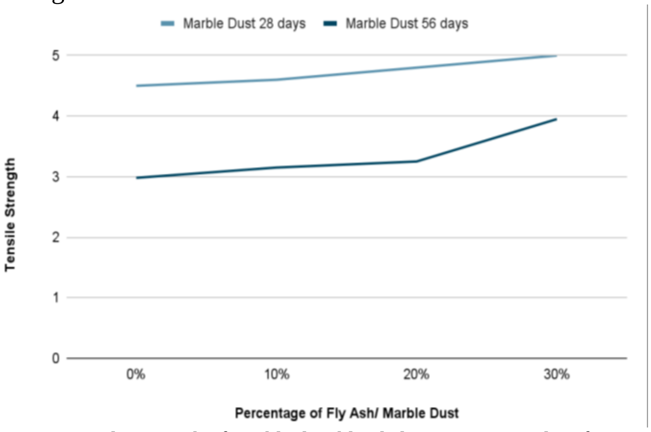

Fig. 7 Tensile Strength of marble dust blended concentre samples after 28 and 56 days

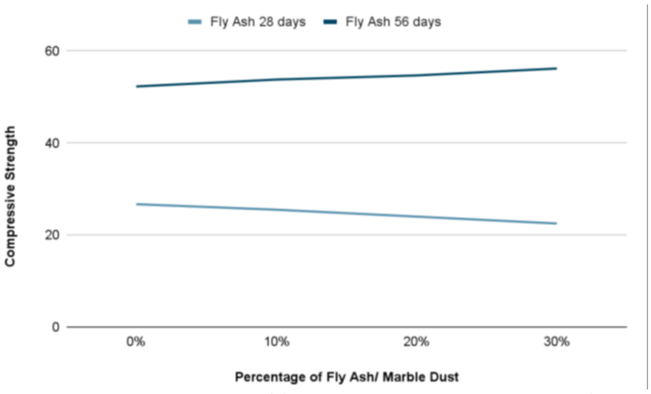

Fig. 8 Compressive Strength of fly ash blended concentre samples after 28 and 56 days

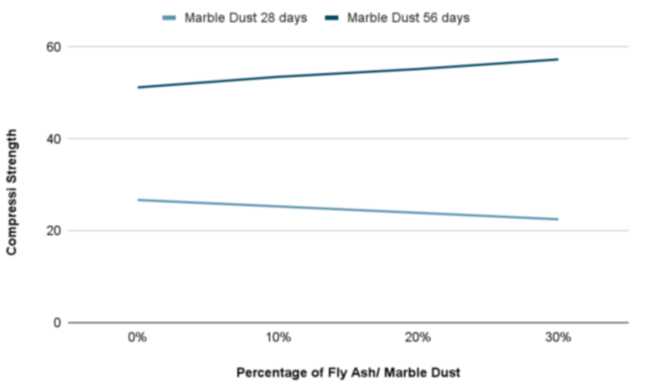

Fig. 9 Compressive Strength of marble dust blended concentre samples after 28 and 56 days

Moreover, Fig. (6-7) the tensile strength of formed concrete samples after 28 and 56 days. Furthermore, the outcomes also demonstrated that the addition of marble dust and fly ash has a remarkable impact on the cement mixture's compressive and tensile strength, setting time, or air content. The findings also imply that fly ash can maintain the better compressive and tensile strengths of Portland cement-based concrete while enhancing its workability, stiffness, and permeability than marble dust blended concrete. Finally Fig. (8-9) presents a comparative analysis between the compressive strengths of fly ash and marble dust blended concretes, after 28 and 56 days.

CONCLUSION

The use of eco-friendly concrete made from byproduct materials has the potential to significantly reduce the carbon footprint of the construction industry. By using waste materials instead of traditional ingredients, the amount of waste generated by other industries is reduced, leading to a more sustainable approach to construction. In this article fly ash and marble dust blended concrete are fabricated in different proportions of fly ash/ marble dust (0%, 10%, 20%, 30%). The findings imply that fly ash can maintain the high compressive and tensile strengths of Portland cement-based concrete while enhancing its workability, stiffness, and permeability. Overall, the findings imply that fly ash as well as marble dust may be utilized to enhance Portland cement-based concrete's workability, stiffness, and permeability while preserving the concrete's strong compressive and tensile strengths.

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