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"An Experimental Investigation On Properties Of Concrete With Partial Replacement Of Cement By Silica Fume, Marble Dust By Fine Aggregate And Coarse Aggregate By Plastic Waste"

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ABSTRACT: To address cost concerns, a viable strategy involves blending a small proportion of silica fume with cement, thereby maintaining concrete's desirable properties while optimizing overall system economics. Silica fume, owing to its chemical and physical attributes, serves as a highly reactive pozzolan, enabling concrete to achieve exceptional strengths and durability. This approach enables the utilization of silica fume's beneficial properties without incurring prohibitive expenses, making it an economically feasible solution for concrete production. The test results of the design mix proportion for M25 concrete revealed a ratio of 112 for cement, sand, and coarse aggregates, respectively, with a water-to-cement ratio of 0.55. Subsequently, six distinct mixes were denoted as MC-5 (5% replacement of cement with Silica, 5% replacement of fine aggregate with Marble Dust, and 5% replacement of coarse aggregate with plastic waste), MC-10 (10% replacement of cement with Silica, 10% replacement of fine aggregate with Marble Dust, and 10% replacement of coarse aggregate with plastic waste), MC-15 (15% replacement of cement with Silica, 15% replacement of fine aggregate with Marble Dust, and 15% replacement of coarse aggregate with plastic waste), MC-20 (20% replacement of cement with Silica, 20% replacement of fine aggregate with Marble Dust, and 15% replacement of coarse aggregate with plastic waste), and MC-25 (20% replacement of cement with Silica).From the above analysis, we conclude that replacing silica fume with cement up to 15%, fine aggregate with marble dust up to 15%, and coarse aggregate with plastic

KEYWORDS: Compressive strength, Workability, Concret strength, specific gravity.

I. INTRODUCTION

Concrete stands as the most extensively employed man-made construction material globally, trailing only water in terms of overall usage. Procuring aggregates for concrete and managing waste from diverse commodities currently poses a significant challenge. Today, sustainability takes precedence in the construction industry. In this study, recycled plastics were utilized to create coarse plants exist world, yet with each recycling iteration, plastics progressively lose their strength. Consequently, these plastics often end up as landfill material. In such a scenario, repurposing them to create aggregates for concrete could offer significant benefits to the construction industry. Many concrete structure failures stem from aggregate crushing. Polymer-coated aggregates, with their low crushing values, are less susceptible to such failure compared to traditional stone aggregates.Construction relies heavily on natural resources like sand and stone, whose extraction often alters rivers and streambeds, posing environmental challenges. Despite global efforts in the construction industry to promote recycled materials in concrete production to reduce aggregate consumption, regulatory processes remain inadequate in many regions. Studies worldwide indicate significant potential in utilizing waste materials for construction purposes. However, recycled aggregate can exhibit impurities, irregularities, and porosity that affect material properties, including reduced compressive and tensile strength due to increased rock porosity and weak particle-matrix bonding. Adjustments like adding over 30% water reducing agent or increasing cement content are necessary for recycled concrete mixes, which require more water than conventional mixes to maintain workability and affect concrete quality and strength. Notably, despite equal water-cement ratios, recycled materials exhibit proportionally lower electrical and physical properties.

[1].Ajileye's (2012), research in found that substituting cement with silica fume up to 10% increased the compressive strength of M30 grade concrete. However, beyond 10%, there was a decrease in strength during the 3, 7, 14, and 28-day curing periods. The compressive strength varied between an increase of 16.15% to 29.24% and a decrease of 23.98% to 20.22%.

[2].A.M. Boddy, R.D. Hooton, and M.D.A. (2012), Thomas conducted experimental research on the impact of silica fume's product form on its ability to mitigate alkali-silica reaction. Their findings revealed that slurried silica fumes are notably more effective at controlling the expansion of reactive siliceous limestone aggregates compared to densified or pelletized silica fume.

[3].Amudhavalli and Mathew (2012), examined the effects of silica fume on the strength and durability of concrete, particularly focusing on M35 grade concrete with varying levels of cement replacement by silica fume. Their experiments showed improvements in both strength and durability with the addition of silica fume.

[4].Ashish Shukla, Nakul Gupta (2016), In today's era, "concrete" is proving to be a very important component of the level of construction, due to which 6 million tonnes of concrete is being produced annually. Due to the continued development, cement is being consumed very fast in the field of construction. This component of concrete, such as cement and other raw materials, is emitting CO2, which is proving to be very harmful for those living in our environment and environment. Along with this, there is a great impact on the economy. Keeping in view the growing need for development and the environment, the cement is being changed in different ratios with different types of pozzolans. In this research, cement has been partially substituted in different proportion with Marble Dust and various types of tests have been done. In this test, the marble dust has been altered with cement ratio of 0%, 5%, 7.5%, 10%, 12.5%, 15% and 20%, and as a result (concrete two grade M-25 and M-30) Tensile Strength and Compression Strength of the concrete, The test has been done in 7 days, 28 days and 56 days intervals. Keyword Concrete M25 & M30grade, Marble Dust Powder, Compressive Strength, Tensile Strength, Workability.

[5] Abdulaziz Ibrahim Almohana, Mohanad Yaseen Abdulwahid, Isaac Galobardes, and Jasir Mushtaq (2015), explore the utilization of recycled plastic in concrete to enhance sound and thermal insulation. Their study indicates that replacing a portion (50% to 75%) of the total aggregate with plastic waste significantly improves the efficiency of thermal and sound insulation in lightweight concrete. Moreover, the reduced manufacturing cost and ease of installation due to plastic's lightweight nature make it an attractive option for non-structural components in building construction.

II. METHODOLOGY

During the process of test mixing, laborers combine the concrete in accordance with the specified design and conduct a slump test to assess its viscosity. However, the first mixture does not attain the anticipated 75 mm slump. Subsequently, they exercise authority over the water-cement ratio and fine-tune the combination by augmenting the water content by 3%. Notwithstanding this correction, they still fail to meet the anticipated decline. The reformation procedure persists as they augment the moisture content by 9% till they ultimately achieve the required slump. Put simply, they ascertain all the essential data for a 1 m³ volume of concrete as a blend.

III. PROPORTIONS OF THE MIXTURE

Concrete specimens were cast according to the parameters specified in the IS code in order to determine the appropriate mix proportions. The determined mixture ratio for M25 concrete was 112 for cement, sand, and coarse aggregates, respectively, with a water-to-cement ratio of 0.55. Following that, there were six other mixtures labeled as MC-0, which involved replacing cement with 0% Silica, replacing fine aggregate with 0% Marble Dust, and replacing coarse aggregate with 0% plastic waste.The proposed modification involves substituting 5% of cement with Silica, replacing 5% of fine aggregate with Marble Dust, and replacing 4% of coarse aggregate with plastic waste in MC-5. The MC-10 mixture involves substituting 10% of cement with Silica, replacing 10% of fine aggregate with Marble Dust, and replacing 6% of coarse aggregate with plastic waste. MC-15 involves substituting 15% of cement with Silica, replacing 15% of fine aggregate with Marble Dust, and replacing 8% of coarse aggregate with plastic waste. The MC-20 mixture involves substituting 20% of cement with Silica, replacing 20% of fine aggregate with Marble Dust, and replacing 10% of coarse aggregate with plastic waste. The formulations were modified by substituting cement with silicon, replacing fine aggregate with marble dust, and using plastic waste as a replacing for coarse aggregates.

IV. EXPERIMENTATION

SIEVE ANALYSIS TEST

FINE AGGREGATE (MARBLE DUST WASTE)

Figure Sieve Analysis of Marble Dust

Table Sieve Analysis of Fine Aggregate

S.No	Is Sieve	Percentage Passing
1	10mm	100
2	4.75mm	95.6
3	2.36mm	81.27
4	1.18mm	59.81
5	600mic	38.93
6	300mic	12.32
7	150mic	0.83
8	Pan	0

Fineness Modulus (FM)

$$= \frac{\text{Sum of Cumulative Weight Retain}}{100}$$

FM = 3.11%

Hence, the marble dust is pass as the range lie between 2.5 – 3.9

COARSE AGGREGATE (PLASTIC WASTE) EQUIPMENT PREPARATION

Figure Sieve Analysis of Plastic Waste with Coarse Aggregate

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Table 5.2 Sieve Analysis of Coarse Aggregate

S.No	Is Sieve	Percentage Passing
1	40mm	100
2	20	87.1
3	10	2.47
4	4.75	0.14
5	PAN	0

IMPACT VALUE TEST OF COARSE AGGREGATE (PLASTIC WASTE)

Impact value analysis often evaluates material size in fields such as materials science, engineering, and geotechnical studies. This process helps you understand the characteristics and behavior of materials. Below is an overview of the sieving process

MATERIALS REQUIRED

- Sieves Use a set of sieves that vary in mesh size from coarse to fine.
- Mechanical shaker or hand strainer Break up any lumps in the sample. Ensure you have enough material for analysis and mix well to maintain consistency. Let the sample cool before continuing.

Figure Impact Value on Plastic Waste

Table 5.3 Impact Value Test for Coarse Aggregate

Impact Value Classification

< 10% - Exceptionally Strong
10 – 20 % - Strong
20 – 30 - Satisfactory for road surfacing

Hence, the value of AIV is 2.11 which shows Satisfactory result.

SPECIFIC GRAVITY TEST

A. FINE AGGREGATE (SAND, CEMENT, AND MARBLE DUST)

$$\text{Sp. Gravity } (G_s) = \frac{(W2 - W1)}{((W2 - W1) - (W3 - W4))}$$

B. SPECIFIC GRAVITY OF SILICA FUME

3. CALCULATION

The specific gravity is calculated using the formula

$$\text{Specific Gravity} = \frac{\text{Weight of the Sample}}{\text{Volume of Sample Displaced}}$$

SG = 100/45 = 2.20

Specific gravity is 2.20

C. SPECIFIC GRAVITY OF COARSE AGGREGATES

Thoroughly cleanse approximately 2 kilograms of material. Extract the substance, deplete its contents, and deposit it into metallic containers. Make sure that the top of the basket is submerged in water by a minimum depth of 50 mm. Temporarily release the baskets for a duration of one second. Immerse the baskets and aggregates in water for a duration of 24 ± 0.5 hours.

$$\text{Specific Gravity } (G_s) = \frac{(W4)}{((W3) - (W1 - W2))}$$

Table No. Specific Gravity of Sample

S.No.	Material	Equipment	Reference Standard Liquid	S.G.
1.	Cement	Pycnometer	Kerosene	3.16
2.	Silica Fume		Water	SG = 2.20
3.	Sand		Water	2.66

5.5. COMPRESSIVE STRENGTH TEST

Figure Compressive Strength Test

Table Compressive Strength Test at 7 Days

Replacing the Cement with silica Fume percentage	Avg. Comp. Strength (N/mm^2)
MC-0	20.15
MC-5	24.14
MC-10	29.25
MC-15	33.38
MC-20	29.31

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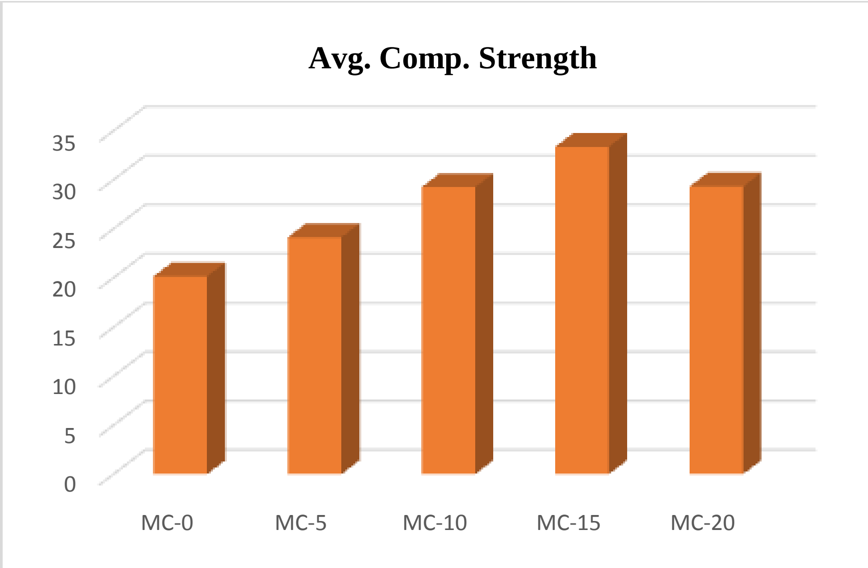

Figure Compressive Strength test for 7 Days

Figure Compressive Strength Test

Table Compressive Strength Test for 28 Days

Replacing the Cement with silica Fume percentage	Avg. Comp. Strength (N/mm^2)
MC-0	30.00
MC-5	32.14
MC-10	37.11
MC-15	49.56
MC-20	40.38

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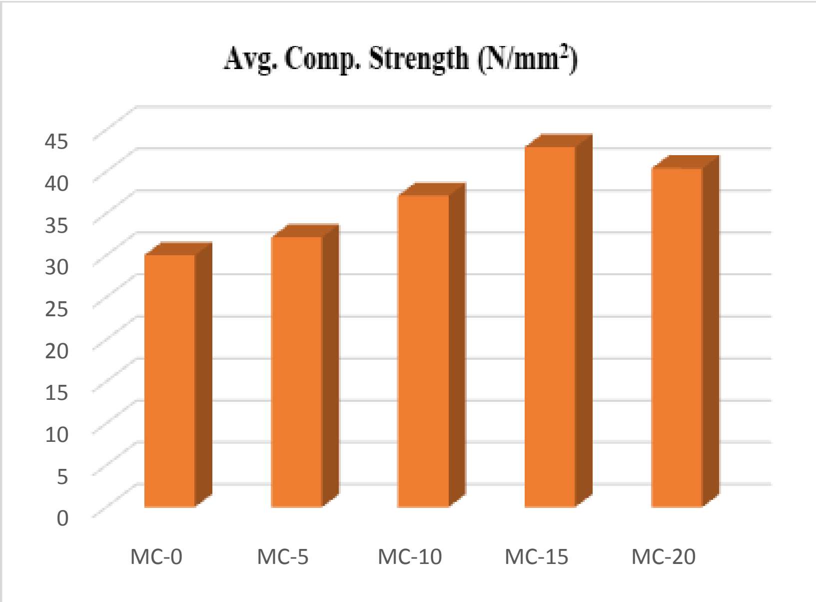

Figure Compressive Strength test for 28 Days

SLUM CONE TEST

Figure Slump Cone Test

Table Slump Cone Test Result

Replacing the Percentage	Slump Cone Value (mm)
MC-0	73
MC-5	68
MC-10	65
MC-15	65
MC-20	59

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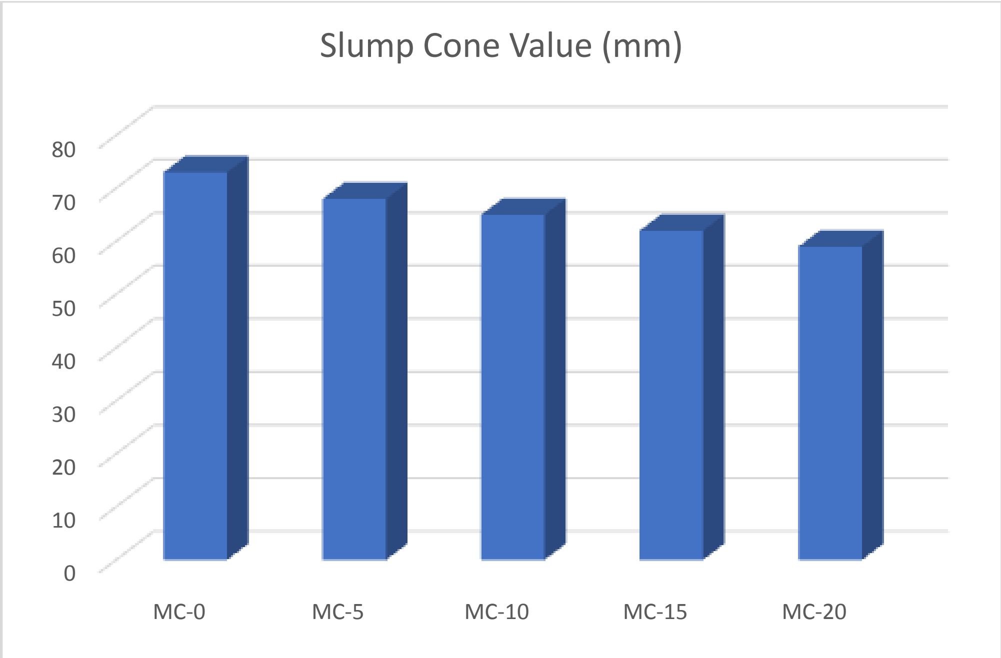

Figure Slump Cone Test

By comparing the decrease in different variables, you can observe that the height decreases when the silica content reaches 20%, when the marble dust content reaches 20%, and when the plastic waste content (not concrete) reaches 10%, leading to a decrease in performance. Therefore, while unmodified concrete shows the highest performance, concrete with 19.17% MC20 content shows the lowest performance.

V. CONCLUSION AND FUTURE SCOPE

The test results of the design mix proportion for M25 concrete revealed a ratio of 112 for cement, sand, and coarse aggregates, respectively, with a water-to-cement ratio of 0.55. Subsequently, six distinct mixes were denoted as MC-5 (5% replacement of cement with Silica, 5% replacement of fine aggregate with Marble Dust, and 5% replacement of coarse aggregate with plastic waste), MC-10 (10% replacement of cement with Silica, 10% replacement of fine aggregate with Marble Dust, and 10% replacement of coarse aggregate with plastic waste), MC-15 (15% replacement of cement with Silica, 15% replacement of fine aggregate with Marble Dust, and 15% replacement of coarse aggregate with plastic waste), MC-20 (20% replacement of cement with Silica, 20% replacement of fine aggregate with Marble Dust, and 15% replacement of coarse aggregate with plastic waste), and MC-25 (20% replacement of cement with Silica).

The results contain the following observations

The marble dust passes through Fineness Modulus with FM = 3.11%, falling within the range of 2.5 – 3.9, indicating its suitability as a fine aggregate.

The value of AIV is 2.11, indicating a satisfactory result.

Regarding the workability of concrete

Comparison of slump for different mixing proportions reveals a decrease in slump height as the percentage of silica fume, marble dust, and plastic waste replacements increase. Concrete without any replacements exhibits the highest workability, while concrete with a mix containing 19.17% MC20 content displays the lowest.

Regarding compressive strength

After replacing 20% of silica fume with cement, 20% of marble dust with fine aggregate, and 10% of plastic waste with coarse aggregate, compressive strength decreased for both 7 days and 28 days cube strength. However, when the percentage of silica waste is 15%, marble dust is 15%, and plastic waste is 8%, compressive strength increased from 0% to 30.63% for 7 days and from 0% to 39.46% for 28 days. The ideal percentage increase in concrete compressive strength was found to be 39.46% after 28 days of curing.

From the above analysis, we conclude that replacing silica fume with cement up to 15%, fine aggregate with marble dust up to 15%, and coarse aggregate with plastic waste up to 8% results in an increment of compressive strength, workability, and durability.

FUTURE SCOPE

Possible sources based on the written content include

Optimizing Competition

Further research can identify the best combination of resources to maintain or improve property. Researchers explore the percentages of various compounds and other materials to achieve the desired balance of strength, performance, and durability.

Looking for Other Materials

Researchers may continue to explore the potential of using materials other than silica fume, marble dust, and plastic waste. This could involve using materials such as fly ash, slag, recycled aggregate, and other commercial byproducts, expanding the range of sustainable options for concrete production.

Improving Durability Studies

Long-term studies should evaluate the performance of composite concrete containing various materials in different environments and exposures. This includes assessing resistance to corrosion, sulfate attack, alkali-silica reaction, and other degradation mechanisms to ensure the structure's long-term durability.

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