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Utilization of Marble Waste and Ceramic Waste as Partial Replacement of Fine and Coarse Aggregate in Manufacturing of Concrete to be Used for Rigid Pavement

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ABSTRACT- Concrete is a widely used and versatile building material worldwide. Its appealing characteristics, such as elevated resistance to compression and favourable malleability, consistently allure constructors for its cost-effective usage as a building material. Rising population and technological progress in the manufacturing industry have resulted in the extensive usage of consumer goods, thereby posing challenges in managing the waste generated, particularly for non-decomposable materials. In this study work parameters chosen as variable was marble and ceramic waste. The compressive and flexural strength were ascertained after 7 days and 28 days. Marble and ceramic waste were utilized to partially replace sand and coarse aggregate at different replacement levels, while maintaining a constant water-cement ratio. The mix design M25 has been designed in accordance with the IS 10262. The compositions were identified as a combination of different proportions of marble and ceramic waste, from 0%, 10%, 20% and 30%, to assess diverse characteristics.

KEYWORDS- Marble Waste, Ceramic Waste, Coarse Aggregate, Rigid Pavement

I. INTRODUCTION

Concrete is a commonly utilized construction material due to its adaptability as it can be cast to any form and shape at site very easily. So everyday millions and millions of cubic meter concrete is being made and used globally. Cement, fine and coarse aggregate are the three main elements of concrete. These constituents were produced solely using cement, and the fine and coarse aggregates were procured from natural sources. This has caused significant environmental destruction. Another issue was the massive amount of demolition material that needed to be disposed of [[1]]. To come up both these problem use of waste materials which are also become a problem for environment if disposed of openly in environment like rice husk, ceramic waste, concrete waste, marble waste, pond ash and quarry waste etc.

Numerous investigations have been carried out on utilizing waste substances to partially or completely substitute concrete as a construction material. Likewise in this research the waste of marble and ceramic tiles as sand and coarse aggregate has been used in a concrete to enhance the properties of concrete. Why I used these constituents? The reason behind the use of these components is that while when the marble has been carried out from the mines as well as cutting big blocks into desirable size a lot of waste product has been obtained in the form of powder and aggregate as shown in Figure 2 and Figure 1 respectively. But this waste has no use and it is left behind as waste which covers a lot of space for disposal and hindrance for environment as well. And in the same way ceramic is also a kind of waste occurred when the tiles has been broken during manufactured and during the construction time.These materials also have the advantages of being readily available and affordable. Despite the fact that both of these wastes had already been utilized in concrete in earlier experiments. However, in previous research, the two materials were utilized separately. For example, some studies only used sand or coarse aggregate as a partial replacement; however, in this study, both materials were used in parallel at an equal percentage [[2]].

A. Marble

Marble is a metamorphic rock that is typically composed of recrystallized carbonate minerals, usually calcite or dolomite. It is known for its beauty, durability, and versatility, and has been used for various purposes such as sculpture, flooring, and building construction for thousands of years. Marble powder is generated from cutting and polishing of marble blocks. In India Rajasthan is the biggest state which produces the marble and during cutting the big blocks in small pieces lot of marble powder obtained during this process. In relation to the research on marble waste, it has been discovered that roughly one-quarter (25%) of the treated marble is converted into a fine powder or dust, and a total of approximately 7,000,000 tons of marble has been manufactured on a global scale. The worldwide disposal of 180,000 tons of marble powder waste generated by the marble industry is currently one of the prevalent ecological issues [[3]][[4]][[5]]. In India, the disposal of Waste Marble Powder (WMP) involves sedimentation and subsequent disposal, which leads to ecological contamination and the production of dust, impacting both the agricultural and public health domains during the summertime. Therefore, the adoption of WMP in several fields, could aid in safeguarding the environment. The waste substance can be utilized as an admixture to improve the efficient use of natural resources and prevent waste deposition, thus preserving the environment [[6]].

B. Ceramic Tiles

There is enough discarded ceramic tile on the globe to utilize as both fine and coarse aggregate in concrete. Natural materials are fused at high temperatures to produce ceramic tile. Tile doesn't contain any dangerous substances. The only danger posed by used tiles is pollution. Everywhere that some tiles are used as flooring in cotto and also as flooring in various sorts of structures, such as tennis courts, sidewalks, bicycle pathways, and gardens as a ground material [7] [[12]] [[14]]. Waste tiles are therefore kept in industrial fields due to their economic worth. Although 100 million tiles are used for restorations, over 250,000 tonnes of tiles are washed out annually. Fine and coarse aggregate can be made from ceramic waste. In the ceramics sector, an approximation has been made that around one-third of the daily output was wasted [[8]][[9]][[10]][[11]]. Currently, there is no recycling of this waste in any way.

II. AIM AND COVERAGE OF RESEARCH

A. Aim of the Research

Tests and evaluations on Marble Powder and Ceramic Waste Tile concrete prepared by marble powder and ceramic waste tile optimum replacement with fine aggregates and coarse aggregate. 7 days and 28 days compressive strength and flexure strength of marble powder and the suitability of concrete made with ceramic tiles need to be evaluated.

B. Scope of work

The subsequent steps need to be carried out for this task:

- Collected the items from the market.
- The physical properties of ingredients are found out.
- The materials must be blended in appropriate ratios and moulded in a cube and beams.
- In this research, ordinary cement must be used to create concrete using marble powder and ceramic waste by mixing the materials with a maximum amount of substitution of sand and coarse aggregate. 10% to 30% of the weight of sand & coarse aggregate was replaced with marble powder and ceramic waste in various mixing proportions for the preparation of the specimens.
- These various specimens of marble powder cement concrete and the compressive strength of concrete containing ceramic waste will be assessed, with particular emphasis on the 28-day strength test.
- Analyzing tests result.

III. EXPERIMENTAL PROGRAM

A. Materials

The following materials were utilized for the entire experimental study as shown in Table 1:-

Table 1: Material Description

Sr. No	Material	Make
1	Cement	Binani
2	10 mm	Pathankot Crusher
3	20 mm	----------do---------
4	Sand	Zone II
5	Marble	Kishangarh, Rajasthan
6	Ceramic Tile	Waste Kajaria and Somany tiles from Market

B. Cement

The study utilized Ordinary Portland cement (OPC) that adheres to the IS 8112-1989 standard. The following physical characteristics of the cement have been verified in accordance with the IS code. All the tests on the cement samples were carried out as per recommendations of IS 4031:1988. Results are shown in Table 2.

Table 2: Physicals properties of the Cement

Sr. No.	Test	Result
a.	Initial Setting Time	32 Minutes
b.	Final Setting Time	600 Minutes
c.	Normal Consistency	27%
d.	Specific Gravity	3.15

C. Coarse Aggregate

The concrete mix included coarse aggregate obtained from crushing stones from the Pathankot quarry, which had a maximum nominal size of 10 mm and 20 mm. Sieve analysis results are shown in Table 3, Table 5, Table 7 and other physical properties of the aggregates are given in Table 4 and Table 6. The grading curves have also shown below next to this. The coarse aggregate was sieved through a 2.36 and 4.75 mm sieve is used for 10 mm and 20 mm aggregate to remove dirt and other foreign matters and after that the aggregates washed and dried naturally in the laboratory of the college before being utilized for molding the concrete mixture [[13]].

Table 3: Particle size test of the 20 mm Coarse Aggregate

IS Sieve (mm)	% Passing	Requirement
40	100	100
20	98.2	85-100
10	13.9	0-20
4.75	2.2	0-5

Table 4: Characteristics of 20 mm Coarse Aggregate

Characteristic	Results
Aggregate Impact Value	15.7%
Water Absorption	0.68%
Free Moisture Content	0.70%

Table 5: Particle Size test for 10 mm Coarse Aggregate

IS Sieve (mm)	% Passing	Requirement
12.5	100	100
10	90.2	85-100
4.75	11.5	0-20
2.36	1.6	0-5

Table 6: Physical characteristics

Characteristic	Results
Free Moisture Content	0.6%
Water Absorption	0.52%

D. Coarse aggregate (Combined)

Table 7: Particle size test of Coarse Aggregate (Combined)

S Sieve (mm)	% Passing	Requirement
40	100	100
20	97.4	95-100
10	38.4	25-55
4.75	2.8	0-10

E. Fine Aggregate

Sieve analysis of the fine aggregates having specific gravity 2.52 is given in Table 8 and the grading curve and graph is shown below. Physical properties of the aggregates are given in Table 9 and Table 10.

Table 8: Particle size test of the fine aggregate

IS Sieve (mm)	% Passing	Requirement
10 mm	100	Confirming to Grading Zone II of IS: 383-1970
4.75 mm	96.8	
2.36 mm	85.4	
1.18 mm	77.9	
600 Micron	48.1	
300 Micron	17.4	
150 Micron	5.8	

Table 9: Characteristic of Fine Aggregate

Characteristic	Results
Free Moisture Content	0.6%
Specific Gravity	2.52
Water Absorption	0.52%

Table 10 Physical Properties of other materials

Characteristic properties	Results
Specific Gravity(Marble)	2.62
Specific Gravity(Ceramic Tiles)	2.47

IV. RESULTS AND DISCUSSIONS

Materials which are used in this study

- Marble Waste
- Ceramic Waste
- Cement
- Sand
- Coarse Aggregate

A. Marble Waste as Partial Replacement

The substitution of marble waste for sand and 10 mm aggregate presents several positive benefits. Firstly, it promotes sustainable development by reducing waste generation and the depletion of natural resources. Secondly, marble waste is a low-cost alternative that can significantly reduce the overall cost of construction projects. Additionally, it can lead to a reduction in carbon dioxide emissions, as the production of cement, which is a major contributor to carbon dioxide emissions, can be minimized. Overall, the use of marble waste in construction can result in a more sustainable, cost-effective, and eco-friendly building practice. Table 11 illustrates the replacement of sand and 10 mm aggregate with marble waste.

Table 11: Substitution of marble waste for sand and 10 mm aggregate

Sr No	Denotation	Cement	Sand	Coarse Aggregate		Marble Waste	
				10 mm	20 mm	Sand	10 mm
1	M.W-0	100%	100%	100%	100%	0%	0%
2	M.W-10	100%	90%	90%	100%	10%	10%
3	M.W-20	100%	80%	80%	100%	20%	20%
4	M.W-30	100%	70%	70%	100%	30%	30%

Figure 1: Marble Waste 10 mm Aggregate

Figure 2: Marble Sand

The testing of concrete compressive strength was carried out at varying percentages of marble waste to determine the impact of its incorporation on the strength of the concrete. As demonstrated in Table 12 and Fig 3, the results showed a gradual increase in the compressive strength of the concrete as the percentage of marble waste increased.

These findings suggest that marble waste can be utilized as a promising alternative to sand and 10 mm aggregate in concrete production. Overall, the substitution of marble waste for sand and 10 mm aggregate has great potential for enhancing the sustainability and performance of concrete.

Table 12: Concrete compressive strength at varying percentages of marble waste

Sr no.	Denotation	7 Day Compressive Strength (N/mm2)	28 Day Compressive Strength (N/mm2)
1	M.W-0	22.40	32.30
2	M.W-10	22.91	33.04
3	M.W-20	23.69	34.35
4	M.W-30	24.96	35.09

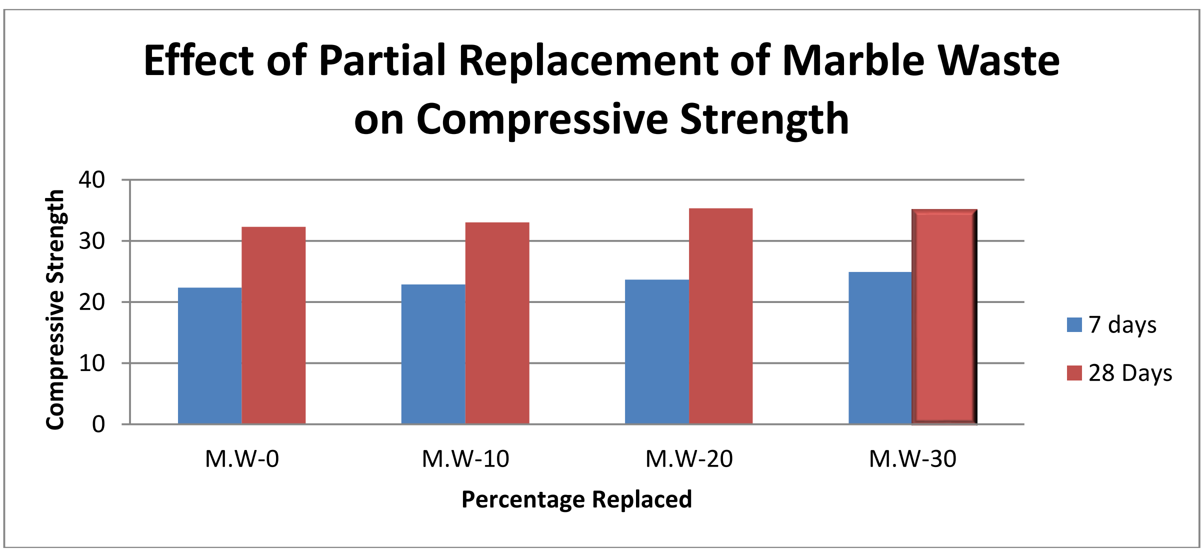

Figure 3: Compressive Strength Graph with Marble Waste Partial Replacement

The flexural strength of concrete was tested at varying percentages of marble waste to determine the effect of its incorporation on the strength of the concrete. The results are shown in Table 13 and Figure 4 that as the percentage of marble waste increased, there was a slight increase in the flexural strength of the concrete. This indicates that marble waste can be effectively used as a partial replacement for sand and 10 mm aggregate in concrete mixtures without compromising the overall flexural strength of the resulting concrete.

Table 13: Flexural Strength of concrete at varying percentages of marble waste

Sr No.	Denotation	28 Days Flexural Strength (N/mm2)
1	M.W-0	6.02
2	M.W-10	6.27
3	M.W-20	6.40
4	M.W-30	6.48

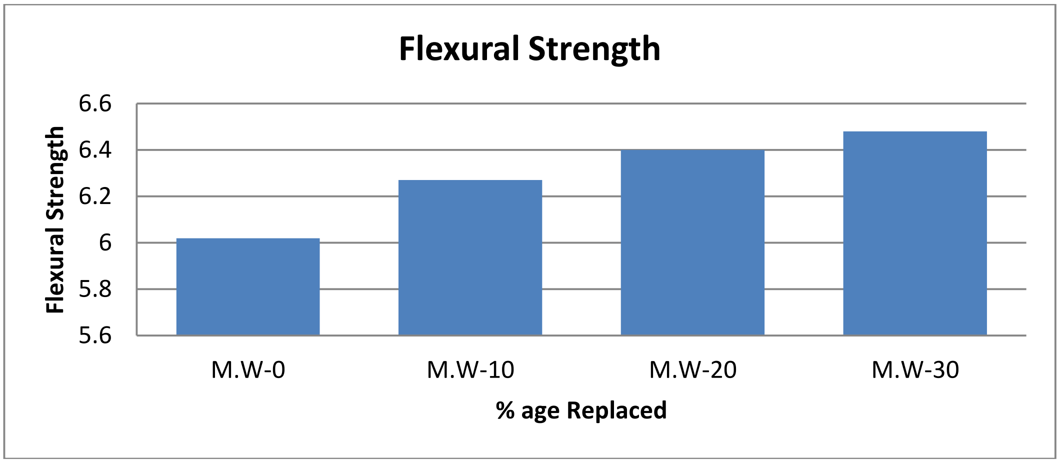

Figure 4: Flexural Strength Graph with Marble Waste Partial Replacement

B. Ceramic Waste as Partial Replacement

The substitution of ceramic waste for sand as shown in Figure 5 and 10 mm aggregate as shown in Figure 6 is an innovative and sustainable approach to the production of concrete. Ceramic waste, which is generated from industrial processes and post-consumer sources, has the potential to replace traditional aggregates in concrete production, thereby reducing waste and promoting sustainability. In this study ceramic waste is used at varying percentage as 10%, 20% and 30% for sand and 10mm aggregate as shown in Table 14.

Table 14: Substitution of ceramic waste for sand and 10 mm aggregate

S. No	Denotation	Cement	Sand	Coarse Aggregate		Ceramic Waste	
				10 mm	20 mm	Sand	10 mm
1	C.W-10	100%	90%	90%	100%	10%	10%
2	C.W-20	100%	80%	80%	100%	20%	20%
3	C.W-30	100%	70%	70%	100%	30%	30%

Figure 5: Ceramic waste Sand

Figure 6: Ceramic waste 10mm Coarse aggregate

The compressive strength of concrete was tested at different percentages of ceramic waste to evaluate its impact on the strength of the resulting concrete. The results are shown in Table 15 and Figure 7 that as the percentage of ceramic waste increased, there was a gradual increase in the compressive strength of the concrete. This indicates that ceramic waste can be effectively used as a partial replacement for sand and 10 mm aggregate in concrete mixtures without compromising the overall compressive strength of the resulting concrete.

Table 15: Compressive Strength of concrete at varying percentages of Ceramic Waste

S. No.	Denotation	7 Days Compressive Strength (N/mm2)	28 Days Compressive Strength (N/mm2)
1	C.W-0	22.41	32.12
2	C.W-10	22.99	33.07
3	C.W-20	23.78	34.88
4	C.W-30	26.40	35.23

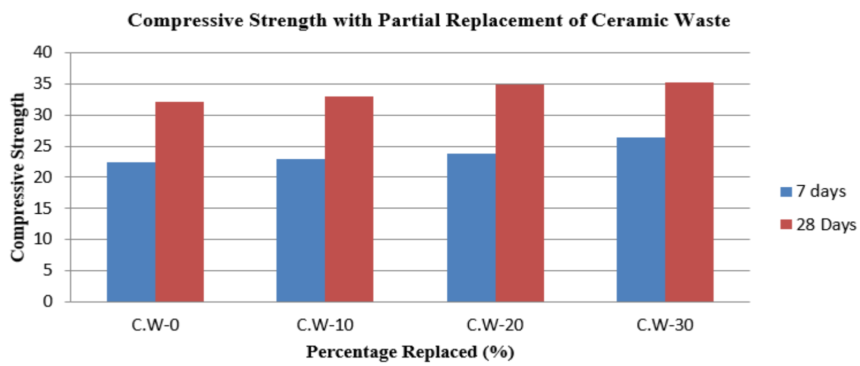

Figure 7: Compressive Strength Graph with Ceramic Waste Partial Replacement

Table 16 and Figure 8 present the results of the testing of flexural strength of concrete at varying percentages of ceramic waste. The findings revealed that there was a gradual improvement in the flexural strength of the concrete as the percentage of ceramic waste increased. These results suggest that ceramic waste can be used as a viable alternative to sand and 10 mm aggregate in concrete production, as it enhances the flexural strength of the resulting concrete. Moreover, incorporating ceramic waste can offer additional benefits such as improved thermal properties, increased durability, and reduced weight, making it a promising material for the construction industry.

Table 16: Flexural Strength of Concrete Incorporating Ceramic Waste

S. No.	Denotation	28 Days Flexural Strength (N/mm2)
1	C.W-0	5.07
2	C.W-10	5.33
3	C.W-20	5.65
4	C.W-30	6.83

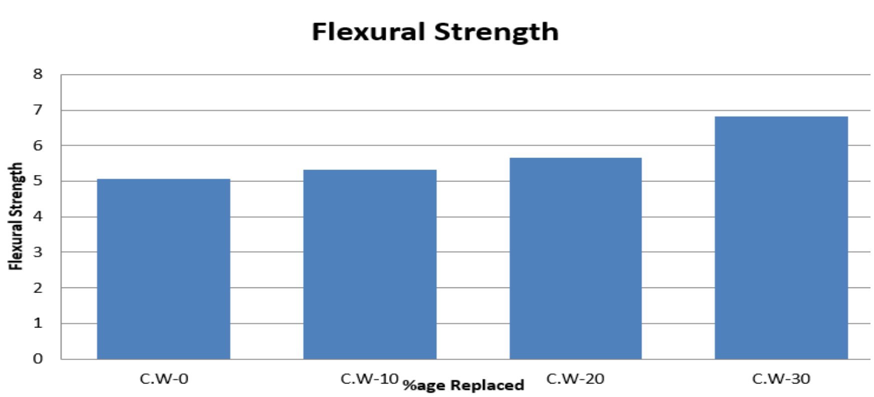

Figure 8: Flexural Strength Graph with Ceramic Waste Partial Replacement

V. CONCLUSION

The goal of this research was to evaluate the applicability of marble waste and ceramic waste as substitutes for a portion of sand and 10 mm coarse aggregate in M25 grade concrete. The experimental findings suggest that both types of waste are appropriate for normal concrete production as partial replacements for sand and 10 mm aggregate. The hardened concrete properties are highly dependent on the constituent components and their appropriate mixing ratios. The research demonstrates that incorporating both waste materials as substitutes for sand and 10 mm aggregate in concrete has an impact on the strength of the hardened concrete. From the results it can be concluded that:

- The incorporation of marble and ceramic waste in concrete results in an increase in its strength.
- Its use will also help in protecting the environment surrounding the sources of both cases.
- Its use as fine and coarse aggregate (10 mm) in concrete will help to reduce the potential impact problem of dwindling natural resources.
- When marble waste used in concrete the color of concrete has been change from dark gray to whitish and while ceramic waste used the color of concrete is light brown.

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