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ENHANCING CONCRETE STRENGTH AND DURABILITY THROUGH PARTIAL CEMENT REPLACEMENT WITH MARBLE DUST

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Abstract: Marble powder, a byproduct of the marble industry, is garnering significant attention in research circles due to its potential applications in civil engineering and design. Despite advancements in manufacturing processes, the marble sector continues to generate substantial waste, with 30 to 40 percent of production ending up as waste material. This waste poses environmental challenges, contributing to contamination in modern society. In an effort to address this issue of waste generation, this study explores the partial replacement of cement with marble powder in concrete production. Specifically, varying percentages of marble powder (5%, 10%, 15%, 20%, and 25%) are substituted for cement in Grade M40 concrete. The objective is to assess the compressive strength of the resulting concrete mixtures after 7 and 28 days of curing. Experimental results indicate that the compressive strength of Grade M40 concrete remains largely unaffected when 15% to 20% of cement is replaced with marble powder. This suggests that incorporating marble powder into concrete mixtures at these percentages does not compromise strength. However, substituting a portion of concrete with marble powder may slightly impact the durability of the concrete. For this study, Grade 53 Ordinary Portland Cement (OPC) and 20 mm heavy aggregate were utilized. Notably, substituting 15% of cement with marble powder resulted in improved compressive strength compared to ordinary concrete mixtures. This research sheds light on the potential of marble powder as a sustainable alternative in concrete production, offering both environmental and performance benefits.

Key words: Marble dust, Cement, Fine aggregate, Coarse aggregate.

1. INTRODUCTION

Concrete is a major contribution to the globe in the current stage of development. Many magnificent buildings have been made with the use of this concrete from antiquity to the present

(1) With the aid of this concrete, constructions such as buildings, old buildings, roads, bridges, highways, dams, and others are erected

(2) Cement is the primary constituent in each of the several primary components that make up concrete. Cement is being used up quickly in concrete as a result of the expanding demands brought on by

(3)

industrialization. Cement use is relatively high, and this has a negative impact on the environment. The gas released by cement, such as CO2, is the primary cause of the environment's negative consequences.

Concrete is a composite material comprised of weak, loose pieces called aggregates that are combined with water and a cement-based binder to create a homogeneous slurry that can withstand a range of loads. The ability to make concrete from recycled waste material gives construction a new dimension and improves the sustainability of the built environment. In the construction of infrastructure for housing, transportation, and energy, Portland cement is widely employed. Together, business and academia have developed filler, admixture, and aggregate raw materials that are stronger than concrete. Each component of concrete serves to provide the necessary strength and maintain favorable design characteristics during the course of the material's lifespan. River sand is used for fine aggregates in PCC, whereas granite stones are used for coarse aggregates. All of these raw materials are in short supply due to their widespread use in construction. New building methods must be developed as a result of the overexploitation of various resources and the resultant lack of replenishment. By utilising more affordable and recyclable materials, the building industry hopes to cut costs and lower disposal costs for used garbage from other industries. Certain components that are used in concrete produce greater results than traditional concrete while having less of an adverse effect on the environment and the economy. To help meet the rising demand, cementous ingredients are added.

The focus of this work is on the potential for employing leftover materials from various industrial operations in preliminary mortar and concrete preparation. Stone mortar and solid waste are both produced by the marble industry. Environmental issues may result from the atmospheric emission of waste materials. By encouraging particular breakthroughs, we can consume less natural resources and energy sources and worry less about air pollution. We discuss the viability of partially substituting marble mortar for concrete in the manufacturing of concrete. The structure and microstructure of the wetted object are greatly improved by these products' involvement in hydraulic reactions. Natural stone cleaning facilities currently produce a lot of marble dust, which has an impact on both the environment and individuals.

This study illustrates the viability of partially substituting concrete in the manufacturing of concrete with marble mortar. Processing marble and granite is one of the most lucrative industries in INDIA. Investigations have been done into how various marble slurry compositions affect the physical and mechanical performance of residential and commercial structures composed of freshly-poured and hardened concrete. Utilizing alternative products results in lower energy expenses, electricity cost savings, potential special considerations, and reduced atmospheric concerns. Our main goal in this experiment was to examine the compressibility of marble powder and study the effects of replacing some of the concrete with it.

2. LITERATURE REVIEW

Amitkumar D. Rawal1, Dr. Indrajit N. Patel and Prof. Jayeshkumar Pitroda (2013) The use of waste ceramic powder in various industries, especially construction, agriculture, glass and paper industry, will help to protect the environment. In this study, cement (OPC) was replaced by ceramic waste at the rates of 0%, 10%, 20%, 30%, 40% and 50% by weight for concrete grade M-30. Concrete samples are tested and compared for compressive strength with conventional concrete. These tests are performed to evaluate compression resistance for 7, 14 and 28 days. The test results show that the compressive strength achieved when replacing cement with ceramic waste up to 30% is optimal without affecting the properties of fresh concrete and hardened concrete.

Monogna and M. Sri Lakshmi (2015) partial replacement of tile powder in cement in the range of 0%, 10%, 20%, 30%, 40% and 50% by weight respectively for M30 grade of concrete. For this, samples of tile concrete are tested and compared with ordinary concrete. The following tests are carried out i.e. compressive strength, tensile strength and flexural strength for 7, 28 and 56 days. Test results show that compressive strength, splitting strength and flexural strength can be achieved by replacing cement with tile powder by 30% without affecting the strength characteristics of M30 concrete.

Kutegeza and Alexander (2004) from the standpoint of sustainability, use of recycled materials as aggregates provides several advantages. Landfill space used for disposal is decreased, and existing natural aggregate sources are not as quickly depleted.

Leonard John Murdock 1991 Clean broken brick of good quality can provide satisfactory aggregates, the strength and density of concrete depending on the type of brick; engineering and allied bricks when crushed make quite good concrete of medium strength.

3. RESULTS AND CONVERSATION

Slump Cone Test

Table.No. 4.2 compares slump for various marble powder concentration percentages. It has been shown that when marble powder content in concrete increases, slump decreases and workability decreases as a result. Therefore, the workability of concrete with 0% marble powder is the greatest, while that with 25% marble powder is the worst.

Table.No.3.1.1: Slump Values of Concrete

Type of Mix	% of Marble Powder	Slump Values (mm)
Normal Concrete	0%	72

Mix 1	5%	69
Mix 2	10%	62
Mix 3	15%	55
Mix 4	20%	43
Mix 5	25%	38

Graph.No.3.1.1: Slump Values of Concrete

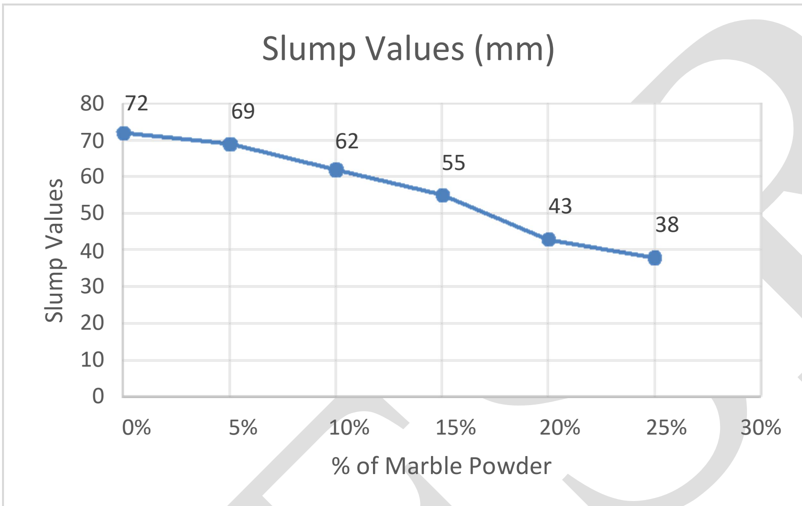


Chart 1:- showing the compressive strength of cube with AGE 1 recycled aggregate by replacing it with 30%, 60% and 100.

Compaction Factor Test

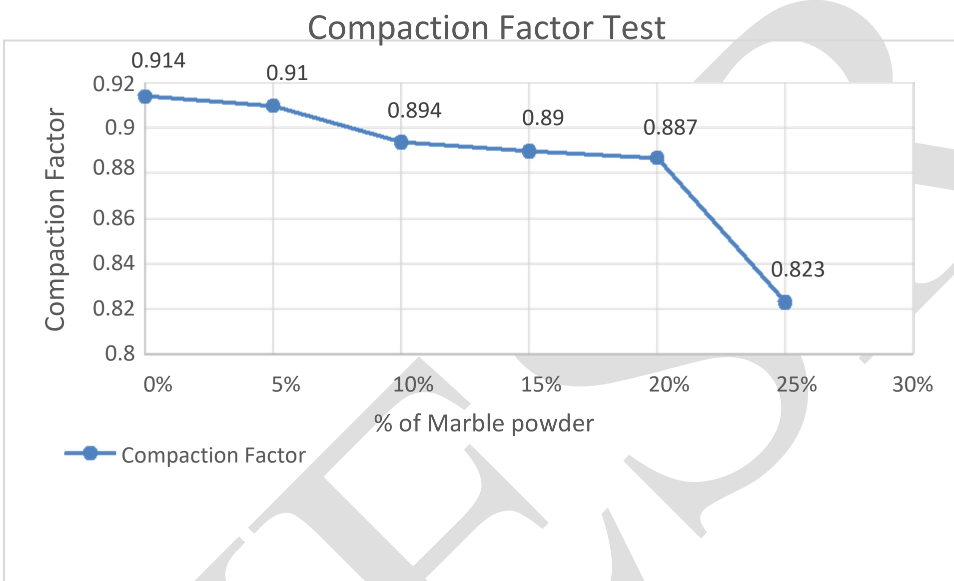
The compaction factor test is a standardized laboratory test used to assess the workability of fresh concrete.

Table.No.3.1.2: Compaction Factor Values of Concrete

Type of Mix	% of Marble Powder	Compaction Factor
Normal Concrete	0%	0.914
Mix 1	5%	0.91
Mix 2	10%	0.894

Mix 3	15%	0.89
Mix 4	20%	0.887
Mix 5	25%	0.823

Graph.No.3.1.2: Compaction Factor Values of Concrete



Compressive strength test

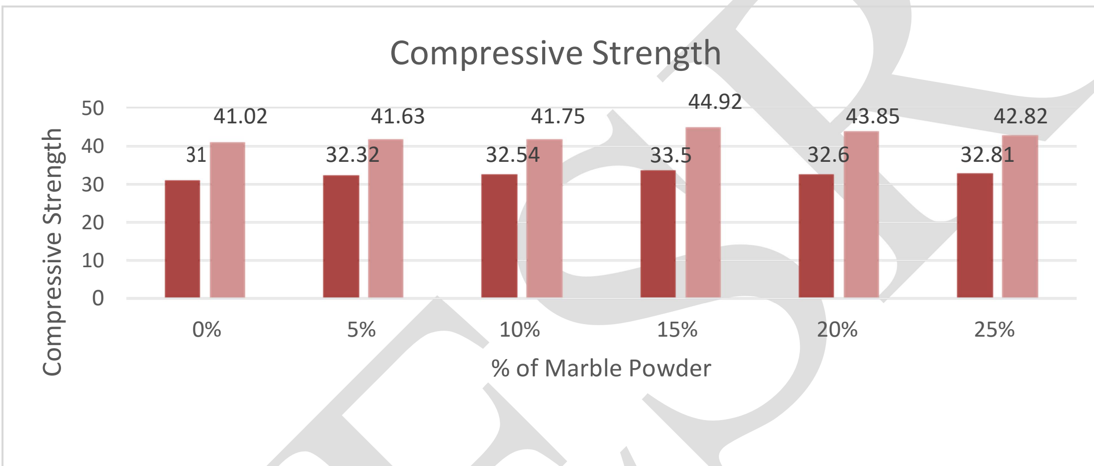
Three cubes of same mix proportion but different % variation of Marble powder. These are kept at a temperature of 27±2ºC for 24 hours. At the end of the period cubes are immersed in clean fresh water. The cubes are kept in water until time of testing. These cubes are tested for their compressive strength after 7 and 28 days curing in compression testing machine. The load at failure is noted and compressive strength is calculated. For 7 days and 28 days are as follows.

Table.No.3.1.3: Compressive strength of concrete for 7 days and 28 days

Compressive Strength (N/mm^2)			
Type of Mix	%of Marble Powder	7 Days	28 Days
Normal Concrete	0%	31	41.02

Mix 1	5%	32.32	41.63
Mix 2	10%	32.54	41.75
Mix 3	15%	33.5	44.92
Mix 4	20%	32.6	43.85
Mix 5	25%	32.81	42.82

Graph.No.3.1.3: Compressive Strength of Concrete For 7 Days And 28 Days



Split Tensile Strength Test

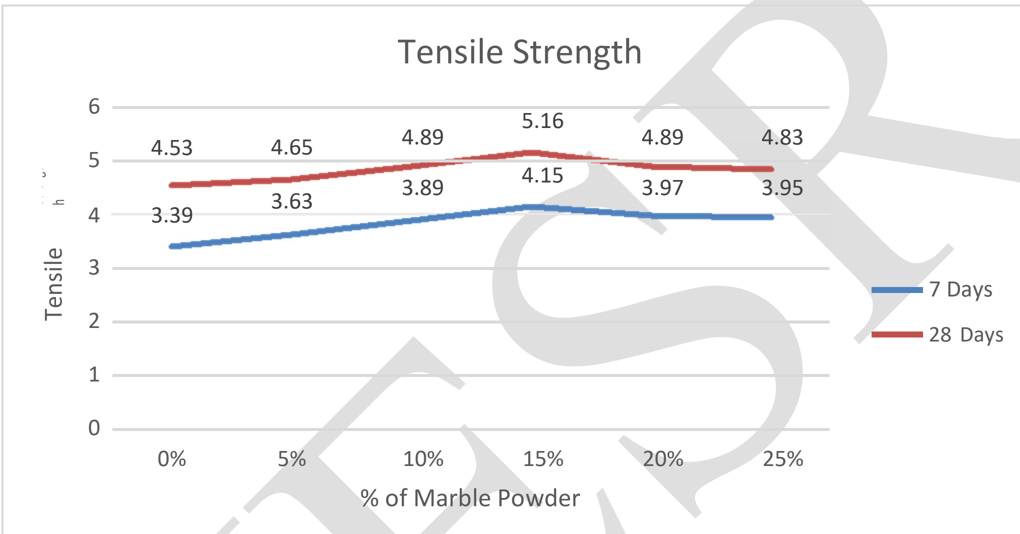
Because concrete is weak in tension, tensile strength testing of cylinder specimens is essential. On universal testing equipment, cylinders with dimensions of 150mm in diameter and 300mm in length were cast and tested for split tensile strength.

Table.No.3.1.4: Split tensile strength of concrete for 7 days and 28 days

Split Tensile test(N/mm^2)			
Type of Mix	% of Marble Powder	7 Days	28 Days
Normal Concrete	0%	3.39	4.53
Mix 1	5%	3.63	4.65
Mix 2	10%	3.89	4.89

Mix 3	15%	4.15	5.16
Mix 4	20%	3.97	4.89
Mix 5	25%	3.95	4.83

Graph.No.3.1.4: Split Tensile Strength of Concrete for 7 Days And 28 Days



Flexural Tensile Strength Test

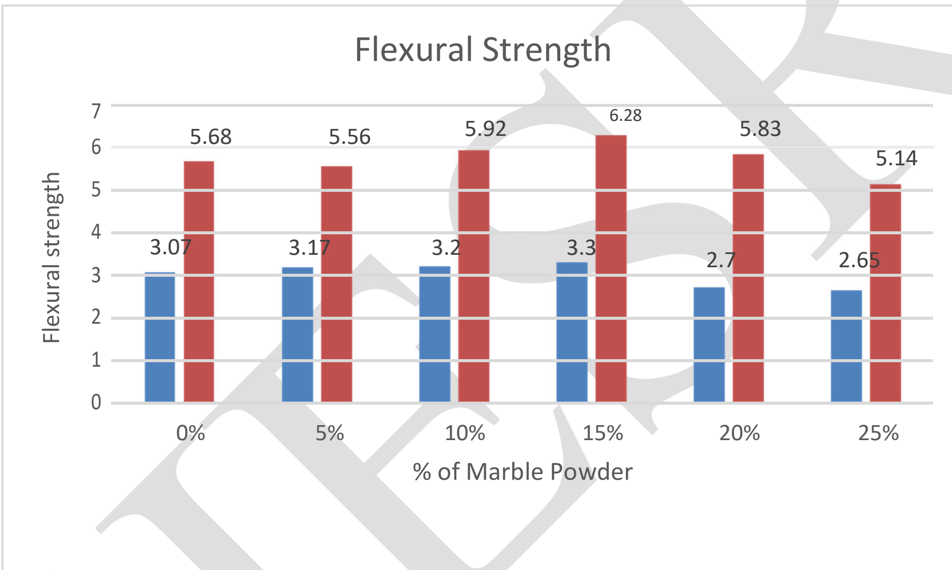
The tensile strength of concrete is measured in several ways, one of which is flexural strength. It is the ability of an unreinforced concrete beam or slab to withstand bending failure. For the flexural strength test, 150x150x500 mm beams were cast and tested on a flexural testing equipment.

Table.No.3.1.5: Flexural strength of concrete for 7 days and 28 days

Flexural Strength (MPa)			
Type of Mix	% of Marble Powder	7 Days	28 Days
Normal Concrete	0%	3.07	5.68
Mix 1	5%	3.17	5.56
Mix 2	10%	3.2	5.92

Mix 3	15%	3.3	6.28
Mix 4	20%	2.7	5.83
Mix 5	25%	2.65	5.14

Graph.No.3.1.5: Flexural Strength of Concrete for 7 days and 28 days



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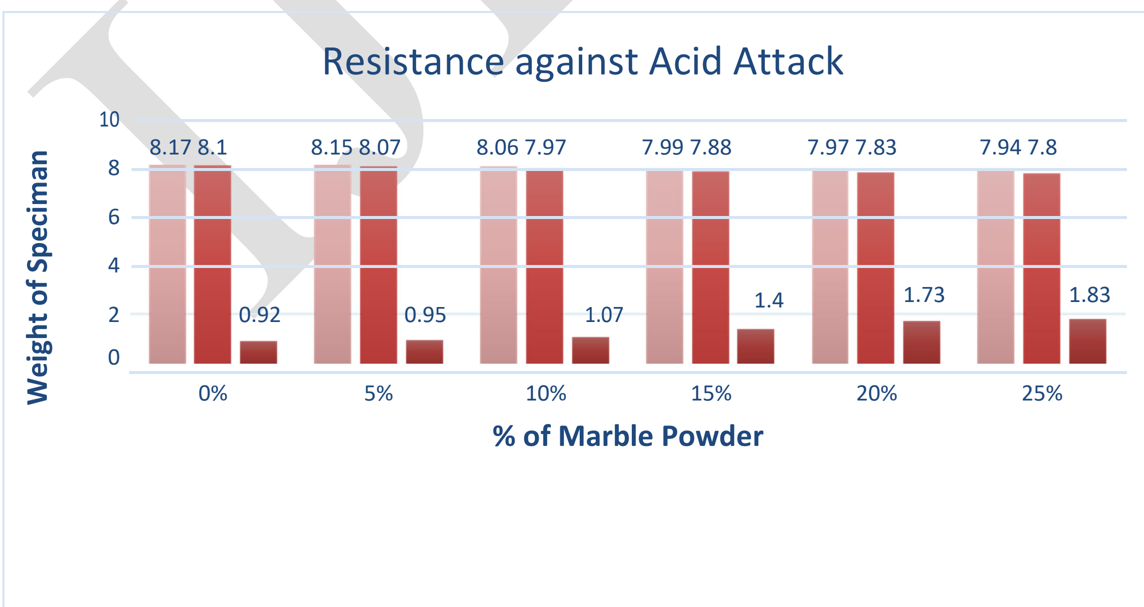
Durability Tests

Observations and Calculations (Resistance against Acid Attack)

Table.No.3.1.6: Resistance against Acid Attack

Mix Combination Designation	Dry weight of cube specimen (W1) in kg	Weight of cube specimen after immersed in solution (W2) in kg	Percent weight loss in kg W1−W2 W1 X 100=%
0%	8.17	8.1	0.92
5%	8.15	8.07	0.95
10%	8.06	7.97	1.07
15%	7.99	7.88	1.4
20%	7.97	7.83	1.73
25%	7.94	7.8	1.83

Graph.No.3.1.6: Resistance against Acid Attack



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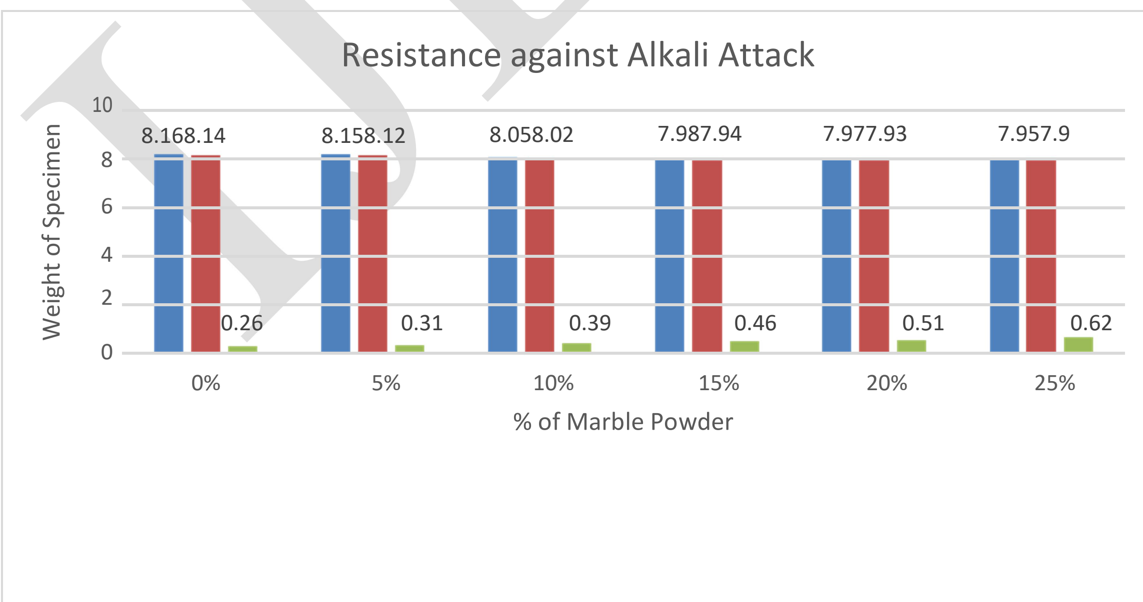
Resistance against Alkali Attack

Observations and Calculations (Resistance against Alkali Attack)

Table.No.3.1.7: Resistance against Alkali Attack

Mix Combination Designation	Dry weight of cube specimen (W1) in kg	Weight of cube specimen after immersed in solution (W2) in kg	Percent weight loss in kg W1−W2 W1 X 100=%
0%	8.16	8.14	0.26
5%	8.15	8.12	0.31
10%	8.05	8.02	0.39
15%	7.98	7.94	0.46
20%	7.97	7.93	0.51
25%	7.95	7.9	0.62

Graph.No.3.1.7: Resistance against Alkali Attack



4.CONCLUSION

Based on experimental investigation the following conclusion are done

- Addition of Marble Powder to the concrete mix decreases the workability as compared to normal concrete mix.
- When marble powder is substituted for 15% of the concrete mix, the compressive strength of the concrete increases; however, when marble powder is substituted for 20% of the concrete mix, the compressive strength of the concrete decreases.
- Up to 15% of marble powder can be replaced for the concrete mix without affecting the concrete's tensile strength; however, at 20% more marble powder, the tensile strength of the concrete is reduced.
- Adding Marble Powder is added to the concrete mix as a partial substitute. When compared to regular concrete, the work is less expensive.

Due to marble dust, it proved to be very effective in assuring very good cohesiveness of mortar and concrete. From the above study, it is concluded that the marble dust can be used as a replacement material for cement and 15 to 20% replacement of marble dust gives an excellent result in strength aspect and quality aspect. The results showed that the substitution of 15 to 20% of the cement content by marble stone dust induced higher compressive strength. Test results show that this industrial waste is capable of improving hardened concrete performance up to 20%, enhancing fresh concrete behavior and can be used in plain concrete.

5. Future Scope of Work

It is recommended for future studies that the research on use of marble powder as to require to extend to a wider perspective in order to know the actual behavior and effective utilization of marble powder which gives an idea to study more parameters and different governing effect of marble powder had engineering properties of fresh and hardened concrete. This study can show an alternative way of use of industrial wastes by incorporating them into concrete construction of course; the concept that the problem emerges from urbanization and the solution goes along with it can also be appreciated.

- Therefore, the aim of this study is introduction of an environmental friendly technology that can benefit the society and the nation.
- Through this study, it is intended to arrive at a suitable mix proportion and percent replacement using industrial wastes locally available by partial replacement of the cement with marble powder.

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