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Experimental Investigation on Strength of Concrete in Presence of Waste Marble Powder

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Abstract:

Concrete has been used in construction for over 2,000 years, perhaps first by the Romans in their aqueducts and roadways. The Romans used a primitive mix for their concrete. Mortar consisted of small gravel and coarse sand mixed together with hot lime and water. The marble stone industry produces both solid waste and slurry. Whereas solid waste is the product of waste at the mine site or at the processing plant, stone slurry is a semi-liquid material composed of particles resulting from sawing and polishing processes and water used to cool and lubricate sawing and polishing machines. The slurry produced during processing corresponds to about 20% of the final product of the stone industry. The scientific and industrial world must also dedicate itself to more sustainable practices. There are several re-use and recycling solutions for this industrial by-product, both in experimental phases and in practical applications. As such, the growth of the country can only be accomplished by a sustainable integrated industrial enterprise. The rapid social, economic and environmental changes in World have recently highlighted human society's unprecedented challenges. New methods that consider industrial waste as alternative raw materials are therefore of value, both technologically and economically, for a wide range of applications. The use of WMP in the cement industry as a replacement for limestone for the development of clinker is of particular interest to us. This thesis is aimed to research the possibility of utilization of waste marble powder for the production of concrete and study the characteristics of concrete.

Keywords — **Waste marble powder, Cement, Concrete, Strength, Durability, Sustainability.**

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I. INTRODUCTION

The Concrete is a mixture of several ingredients such as cement, fine aggregate, coarse aggregate, additives and water in vital proportions [1]. This mixture when poured in forms and allowed to cure becomes hard like stone. The hardening is a result of a chemical reaction between cement particles and water, owing to which concrete grows stronger with age [2]. The characteristics such as strength, durability of concrete etc. depend upon the properties of its ingredients, mix proportion, as well as the method of compaction and controls during placing, compaction and curing [3]. Concrete retains a high degree of compressive strength and is generally more cost effective than steel and is resistant to corrosive, which can be easily prepared with locally available materials [4]. Hence, due to the ease in the use of concrete it is widely used in all present-day constructions. Concrete is generally a mixture of granular materials of diverse sizes and the size range of the created solid mix, covers varied intervals [5]. The properties of the concrete in the fresh state (flow properties and workability) are governed by the particle size distribution (PSD), however the properties of the concrete mix in the hardened state, such as strength and durability, are largely affected by the mix grading and the resultant particle packing. Although, literature reports utilization of various nanomaterials for strength enhancement of concrete. This is because nanotechnology has brought innovations in all industrial sectors [6]. However, with the growing concern of waste accumulation, new techniques are required for waste recycling and reuse [7]. Many researchers have also worked on utilization of waste materials in concrete industry.

The raw stone block is cut using diamond blades during the stone processing, as per requirement i.e. either into tiles or slabs of various thickness (usually 2 or 4 cm) [8]. While stone blocks are cut to obtain sheets of varying thickness, during the cutting operation, water is showered on blades that cools the blades and absorbs the dust produced. It results into a mass of marble waste (approx. 20% of total quarried Marble) in amount gathered as high as millions of tons [9]. The such a large marble waste remained as unattended mass consists of very fine particles and has formed today's one of the major environmental issues around the world. Both solid waste and stone slurry is generated by Marble stone industries [10]. The marble solid waste thus results from the byproducts at the mine sites or also at the processing units [11]. On the other hand, semi liquid substance known as stone slurry usually consists of particles that originate from the various processes. Stone slurry forms around 20% of the product i.e. generated during processing from stone industry [12]. Hence, the commitment towards use of more sustainable practices is must by scientific and industrial communities. This industrial by-product has several reuse and recycling solutions that can be used both in form of experimental phase and/or in form of practical applications [13].

The marble stone industry produces both solid waste and slurry [14]. Whereas solid waste is the product of waste at the mine site or at the processing plant, stone slurry is a semi-liquid material composed of particles resulting from sawing and polishing processes and water used to cool and lubricate sawing and polishing machines [15]. The slurry produced during processing corresponds to about 20% of the final product of the stone industry. The scientific and industrial world must also dedicate itself to more sustainable practices. There are several re-use and recycling solutions for this industrial by-product, both in experimental phases and in practical applications [16].

The WMP forces genuine dangers to environment, physical, concoction and organic parts of condition. Issues experienced are: It antagonistically influences the profitability of land because of diminished porosity, water ingestion, water permeation and so on [17]. At the point when dried, it becomes air borne and cause serious air contamination. Presents word related medical issues, it likewise influences hardware and instruments introduced in modern zones [18]. Influencing nature of water during blustery season, and lessening stockpiling limits and harming sea-living life. It adversely affects the social and industrial activities of individuals, as a lot of powder stay scattered all over the country is a watchful and spoils the aesthetics of the entire region. It is therefore the collective duty of government and industry to address the problem of WMP emissions [19]. As such, the growth of the country can only be accomplished by a sustainable integrated industrial enterprise [20]. The rapid social , economic and environmental changes in World have recently highlighted human society's unprecedented challenges [21]. New methods that consider industrial waste as alternative raw materials are therefore of value, both technologically and economically, for a wide range of applications [22]. The use of WMP in the cement industry as a replacement for limestone for the development of clinker is of particular interest to us. In the current experimental study is aimed to Investigate the feasibility of using leftover marble powder in the manufacture of concrete and To investigate the effect of replacing cement and sand with waste marble dust in various percentages on the compressive strength of concrete.

II. MATERIALS AND METHODS

The properties of material used for making concrete mix are determined in laboratory as per relevant code of practice [23]. Different materials used in present study were cement, coarse aggregates, fine aggregates, waste marble powder. Description of various materials which were used in this study include cement, coarse aggregates, fine aggregates, water and waste marble powder [24]. Design of concrete mix and proportion has been given in Table 1 and 2 respectively.

TABLE I
MIX DESIGN

Mix designation	Water	Cement	Fine aggregate	Coarse aggregate
MD-0	190 lt/m³	422 kg/m³	645.78 kg/m³	1209.95 kg/m³
	0.450	1.0	1.53	2.87

TABLE III
Mix Proportion

S. No	Mix designation	%age of WMP	Water lt/m³	Cement kg/m³	Fine aggregate kg/m³	Coarse aggregate kg/m³	Waste Marble Powder
1.	M0	0	190	422	645.78	1209.95	0.0
2.	M1	5	190	400.9	645.78	1209.95	21.1
3.	M2	10	190	379.8	645.78	1209.95	42.2
4.	M3	15	190	358.7	645.78	1209.95	63.3
5.	M4	20	190	337.6	645.78	1209.95	84.4

Standard cubical moulds of size 150 mm x 150 mm x 150 mm made of cast iron were used to manufacture concrete specimens to test compressive strength of concrete, cylindrical moulds of size 150 mm dia x 300 mm length were casted for testing of split tensile strength and beams of size 500 x 100 x 100 mm were casted for measurement of flexural strength [25]. Casted specimens were cured under normal lab conditions for 7 and 28 days in a curing tank filled with tap water [26]. Workability of concrete mixtures was measured by performing slump test as per procedure given in Indian standard BIS: 1199-1959 [27]. The strength test was performed on various specimens as per guidance provided in IS 516-1959 [28].

III. RESULTS AND DISCUSSIONS

1. Compressive strength

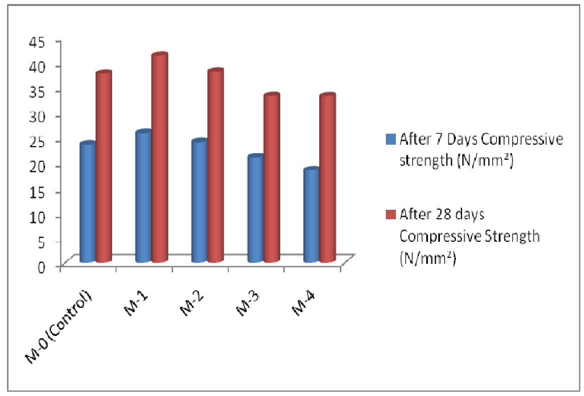

Fig. 1 Comparison between 7 and 28 days Compressive strength

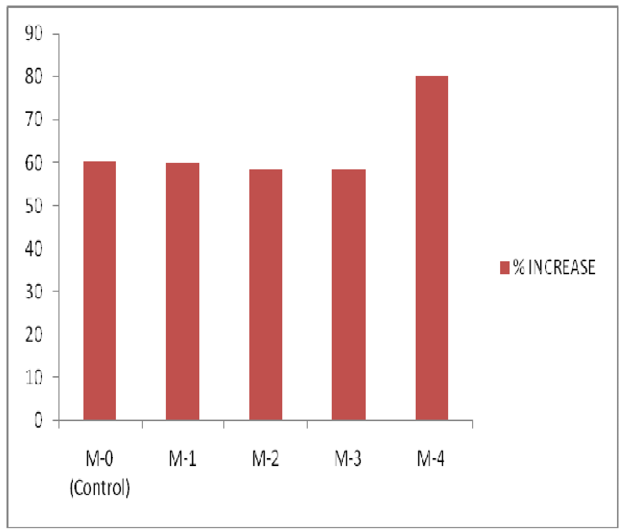

Fig. 2 Comp. strength relative to controlled mix after 7 days

Figs. 1 to 5 show the variation of compressive strength of waste marble powder mixed Concrete due to variation in the replacement at the curing ages of 7 and 28 days. The experimental investigations show that by the partial replacement of cement with 5% of waste marble powder, the compressive strength increases by 10% for curing age of 7 days and 9% at curing age of 28 days, also when partially replaced with 10%, it increased by2% but at 28 days curing age it increased by 1% with respect to its nominal mix i.e., no mixing of marble powder. When the cement is partially replaced by 15% it decreases the compressive strength by 11% for curing age of 7 days and 12% at curing age of 28 days, when cement is replaced by 20% the compressive strength decreases by 22%

and 12% at a curing age of 7 days and 28 days respectively.

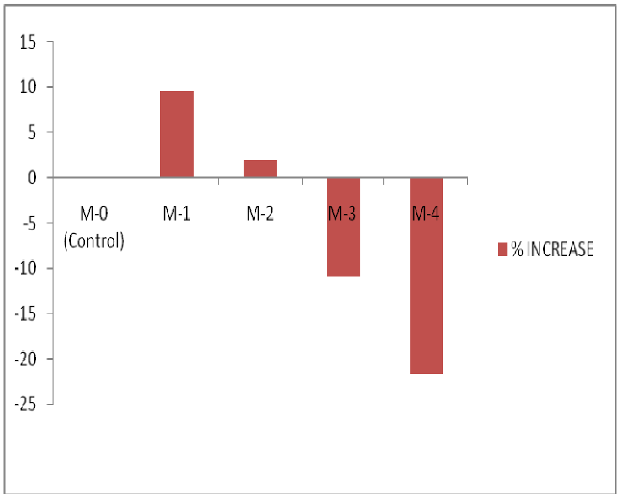

Fig. 3 % variation in Comp. strength relative to controlled mix after 7 days

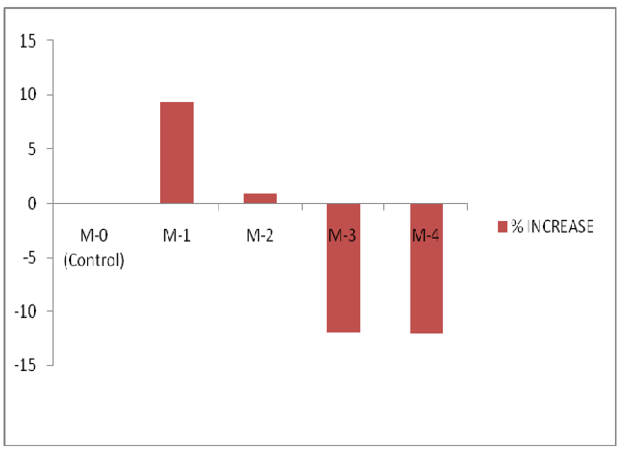

Fig. 4 % variation in Comp. strength relative to controlled mix after 28 days

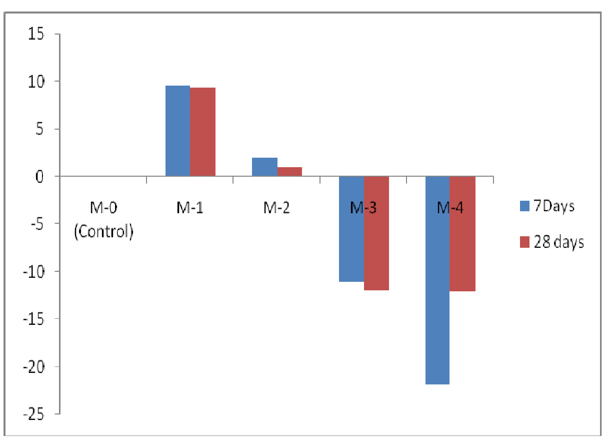

Fig. 5 Comparison between 7 and 28 days % variation in Compressive Strength

2. *Split tensile strength test*

Figs. 6 to 10 show the variation of split tensile strength of waste marble powder mixed Concrete due to variation in the replacement at the curing ages of 7 and 28 days. The experimental investigations show that by the partial replacement of cement with 5% of waste marble powder, the split tensile strength increases by 4% for curing age of 7 days and 8% at curing age of 28 days, also when partially replaced with 10%, it decreased by 3.0% but at 28 days curing age it increased by 2% with respect to its nominal mix i.e. no mixing of marble powder.

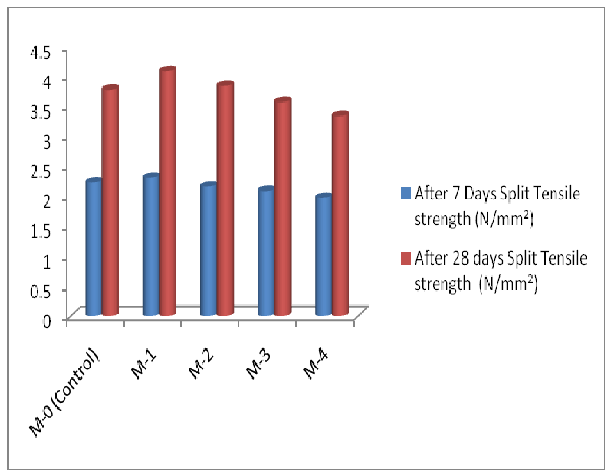

Fig. 6 Comparison between 7 and 28 days Split Tensile Strength

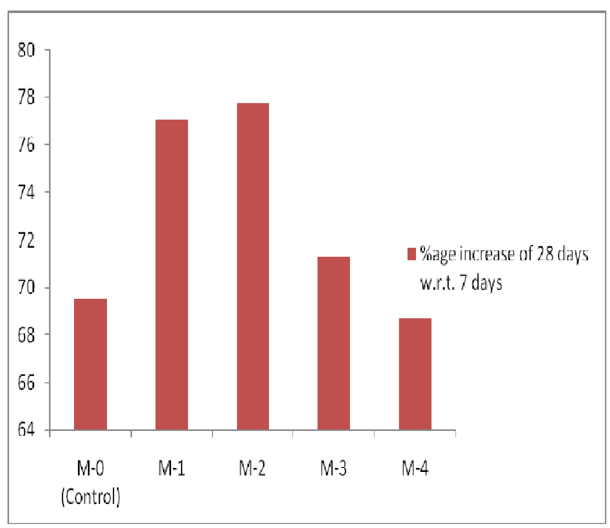

Fig. 7 Percentage increase in Split Tensile strengths of 7days to 28 days

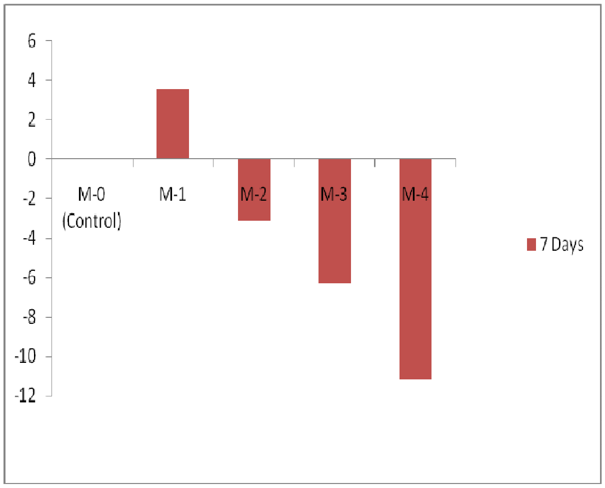

Fig. 1. % variation in Split Tensile strength relative to controlled mix after 7 days

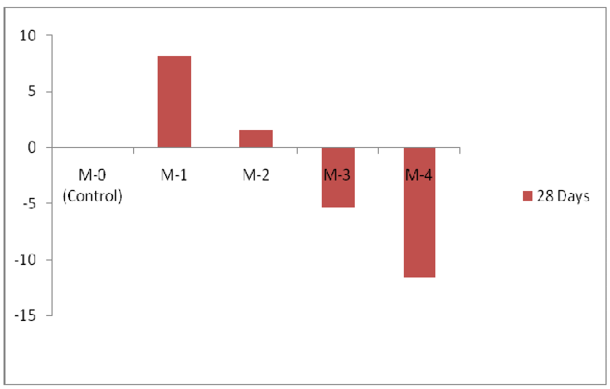

Fig. 2. % variation in Split Tensile strength relative to controlled mix after 28 days

When the cement is partially replaced by 15% it decreases the split tensile strength by 6% for curing age of 7 days and 5% at curing age of 28 days, when cement is replaced by 20% the split tensile strength decreases by 11% and 12% at a curing age of 7 days and 28 days respectively.

3. *Flexural strength test*

Figs. 11 to 15 shows the variation of flexural strength of waste marble powder mixed Concrete due to variation in the replacement at the curing ages of 7 and 28 days. The experimental investigations show that by the partial replacement of cement with 5% of waste marble powder, the flexural strength increases by 3% for curing age of 7 days and 6% at curing age of 28 days, also when partially replaced with 10%, it decreased by 11% at 7 days but at 28 days curing age it decreased by 5% with respect to its nominal mix i.e. no mixing of marble powder.

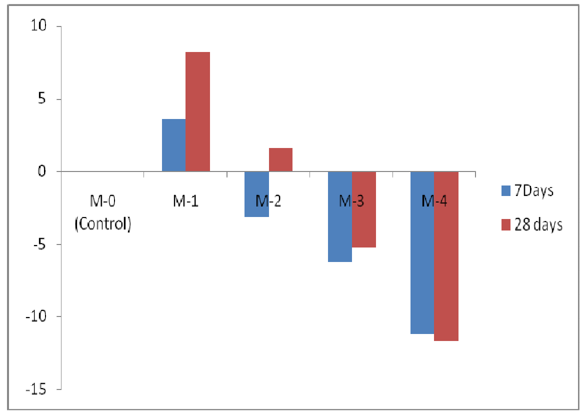

Fig. 3. Comparison between 7 and 28 days % variation in Split Tensile Strength

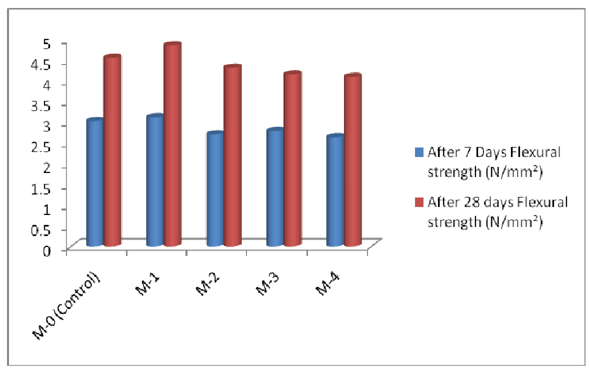

Fig. 4. Comparison between 7 and 28 days Flexural Strength

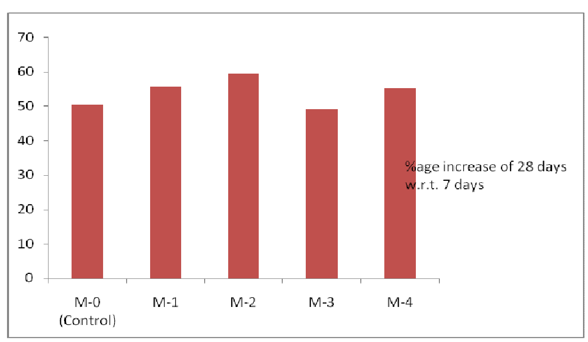

Fig. 5. Percentage increase in flexural strengths of 7days to 28 days

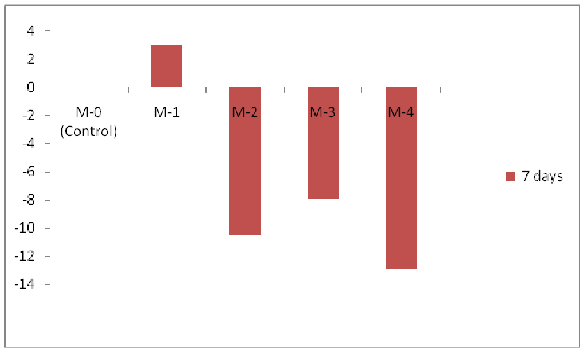

Fig. 6. % variation in flexural strength relative to controlled mix after 7 days

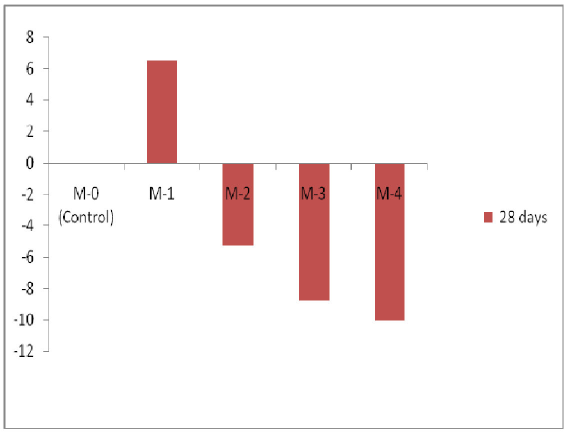

Fig. 7. % variation in flexural strength relative to controlled mix after 28 days

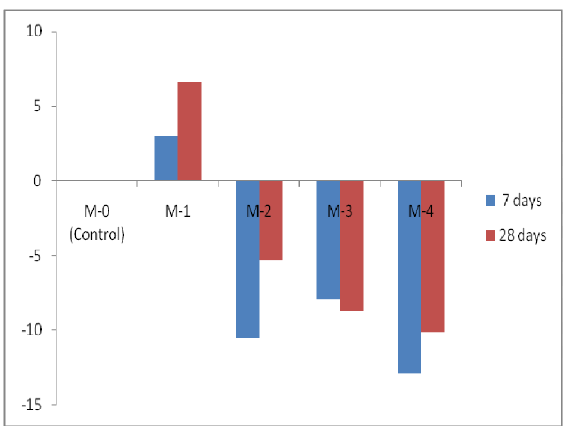

Fig. 8. Comparison between 7 and 28 days % variation in Flexural Strength

When the cement is partially replaced by 15% it decreases the flexural strength by 8% for curing age of 7 days and 9% at curing age of 28 days, when cement is replaced by 20% the flexural strength decreases by 13% and 10% at a curing age of 7 days and 28 days respectively. Thus, optimized quantity of waste marble powder can be used in concrete for strength enhancement [29].

IV. CONCLUSION

The present investigation was undertaken to examine the effect of waste marble powder on the characteristic strength of concrete. To accomplish the aims of the present work, cement was replaced by waste marble powder in different percentages, i.e. 0% (reference mix), 5%, 10%, 15% and 20%. The compressive strength, split tensile strength, flexural strength test was defined for the mixtures at curing age 7 days and 28 days. The solutions obtained for the above mixes were compared to investigate the effect of partial replacement of cement by waste marble powder on the strength parameters of concrete.

From the experimental results, the conclusions of compressive strength, flexural strength and split tensile strength as under:

On the basis of experimental results, it showed that concrete of M_{25} grades with the replacement of cement by waste marble powder up to 5% increases the compressive strength but above 5% content of marble powder decreases the compressive strength.

The flexural strength of concrete for M25 grades of concrete increases with inclusion of waste marble powder up to 10 percent substitution by weight of cement and furthers any introduction of waste marble powder there was minor decrease in strength as opposed to traditional concrete.

From the findings obtained for the split tensile strength of concrete for M25 grades concrete, it is observed that the split tensile strength of concrete increased up to 5 percent replacement of cement by waste marble powder and decreased with further rise, this could be attributed to its filling impact and growth of hydration products in concrete.

Further, the expense of building can be decreased by use of marble powder which is easily or cheaply available and the environmental emissions can be reduced by using waste marble powder as substitute of cement in concrete.

Test results show that these industrial wastes are capable of improving hardened concrete performance. Green concrete enhancing fresh concrete behavior and can be used in architectural concrete mixtures containing white cement.

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