EXPERIMENTAL INVESTIGATION USING PEG-400, A SELF-CURING AGENT AND MARBLE DUST POWDER TO PARTIALLY REPLACE CEMENT IN CONCRETE

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Abstract - *Strong and durable, concrete is a popular building material. Making cement, an essential component of concrete, involves significant energy consumption and greenhouse gas emissions. Marble dust powder, a byproduct of the production of marble, serves as filler material in cement when making concrete. Conventional curing methods generally don't work as expected in practice; the problem of surface water on vertical parts still exists. The primary objective of this study is to substitute cement in M30 grade concrete with marble dust powder and self-curing agent (PEG-400). The experimental assessment of concrete's strengths and usability, together with the appropriate replacement rate, is the study's basic focus. Two test mixtures were proportioned to see if marble dust powder and a self-curing agent were appropriate for use in concrete. In proportions of 0%, 5%, 10%, and 15%, Mix-1 substitutes marble dust powder for cement in M30 grade concrete. A 0.5% self-curing agent (PEG-400) is also present. In Mix-2, marble dust powder is substituted for cement at rates of 0%, 5%, 1%, and 15%. A 1.0% self-curing agent (PEG-400) is also present. The workability of concrete is ultimately improved by adding more marble dust powder and self-curing agent (PEG-400). Concrete mixtures' compressive strength and split tensile strength have been measured after 7, 14 and 28 days. Consequently, the results of the experiment, replacing cement marble dust powder with self-curing agent PEG-400 0.5% up to 5.0% will enhance compressive strength, while replacing marble dust powder 10% with self-curing agent PEG-400 1% will increase split tensile strength.*

***Key Words*: Marble dust powder (MDP), Self curing agent, PEG-400.**

1. INTRODUCTION

There is a robust substance called concrete, a flexible construction component that may be employed in a range of forms and dimensions. Additionally, it is adaptable and widely utilized. Water, aggregates (such as sand, gravel, or crushed stone), and cement make up the majority of the three components of this composite material. On occasion, additional admixtures or additives are added to improve specific qualities. Its versatility makes it a vital component of modern construction, enabling the creation of durable and practical structures that have an impact on our built environment. It's important to keep in mind that cement, despite the fact that concrete is frequently referred to as "cement" in ordinary speech, is actually quite important to the building sector. However, the manufacture of cement greatly increases carbon dioxide emissions and environmental degradation. Any materials used to replace concrete must.

Marble dust powder, often known as marble dust or marble powder, is a finely crushed byproduct of the manufacturing and processing of marble. It is a byproduct of the marble industry and has grown in popularity because of the diversity of industries in which it is used. This fine material, which is mostly composed of calcium carbonate, encompasses a few traits which renders ideal for a range of projects, from construction to artistic creation.

Concrete with self-curing agents is a significant advancement in construction technology that addresses the urgent need for efficient curing to guarantee the long-term performance, strength, and durability of concrete structures. Curing is a crucial process that involves keeping the newly placed concrete in suitable moisture and temperature conditions to promote proper hydration and the development of its desired properties. Self-curing agents provide a self-sustaining method of curing that reduces the need for external curing methods and any potential drawbacks related to conventional curing techniques. In the production of concrete, self-curing agents are substances or additives incorporated into the mix. These substances both release and trap moisture inside the concrete, establishing a controlled environment for internal curing. The cement particles can continue to hydrate over time. thanks to this self-sustaining moisture supply, which frees the concrete from having to rely solely on external water curing techniques like wet burlap, ponding, or continuous spraying. Consequently, the concrete can maintain its intended strength and durability.

2. MATERIALS

2.1 Cement: Whilst integrated alongside distinct substances and water, cement serves as a binding agent. OPC 43 grade cement was operated in the experiment.

Fig 2.1 Cement

2.2 Fine aggregate: Sand, often known as fine aggregate, is a crucial element in the building sector. The piece is a granular substance made up of tiny particles that emanate from places like riverbeds, quarries, or broken stone. Sand has a specific gravity of 2.56.

Fig 2.2 Fine aggregate

2.3 Coarse aggregate: An essential aspect of construction materials, especially concrete, comprises coarsely crushed stone. Larger particles make up this material, which is frequently derived from surroundings like quarries, crushed stone, or gravel. In order to improve the strength, stability, and durability of concrete mixtures, coarse gravel is essential. The coarse aggregate's specific gravity is 2.67.

Fig 2.3 Coarse aggregate

2.4 Marble Dust Powder: The cutting process produces a significant amount of MDP. As a result, millions of tons of marble waste or 20% of all marble quarried, have been produced. Marble is a type originated in a rock with metamorphism that underwent pure limestone. The marble's colour and appearance are determined by its purity; it is white if the limestone is entirely made of calcite (100 percent CaCO3). Specific gravity of MDP is 2.51.

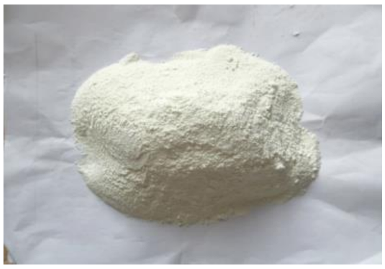


Fig.3.4 Marble dust powder

Table 1 The chemical nature of the powdered marble dust.

Sl No	Constituents	Percentage (by weight)
1	Sio_2	24.4
2	Al_2O_3	0.5
3	Fe_2O_3	8.9
4	MgO	1.48
5	CaO	39.27

2.5 Polyethylene glycol – 400: Ethylene oxide, water combines to carve out condensation polymer known as polyethylene glycol. The average number of oxyethylene groups that repeat is indicated by the universal formula $H(OCH_2CH_2)_nOH$.

Table 2 Properties of Polyethylene Glycol-400.

Molecular weight	400
Appearance	Clear fluid
Odour	Mild
P^H	6
Specific gravity	1.2

2.6 Water: Owing to its crucial role in the mechanism of hydration, water is essential to the creation and functionality of concrete. When water adducted to cement, a chemical process called hydration is triggered. Despite the aforementioned procedure, cement granules and water molecules combine to form a solid matrix that provides concrete its strength and durability.

3. METHODOLOGY

A systematic technique must be followed when making the concrete mix in guaranteeing the quality completed concrete satisfies the required standards for strength, workability, and durability. You can adhere to the general format given here:

3.1 Collect the following materials and tools

Cement (typically Portland cement), Marble dust powder, Aggregates (coarse and fine: sand, gravel, crushed stone), Self curing agent, Water, Testing equipment (compression testing machine, slump cone), and Mixing equipment (mixer).

3.2 Material Testing

Examine the raw materials physical characteristics, such as specific gravity and moisture content (aggregates, cement).

3.3 Mix design

Based on the intended qualities of the concrete, create a mix design to establish the ratios of each element. Determine the ratios of each component tandem with the aggregate-cement and water-cement ratios complying with IS 10262-2019.

3.4 Mixing

According to the mix design, cement, aggregates, and water should be blended in a mixer. Ingredients should be combined to choose sure they emit a uniform texture. Avoid overmixing, which can lead to overbearing air entrainment or loss of strength.

Fig 3.4 Mixing

3.5 Casting

Swiftly following the concrete has finished mixing, pour it into moulds, formwork, or the desired location. Utilize the proper compaction methods (vibration, tamping) to eliminate air voids and guarantee proper consolidation.

Fig 3.5 Casting

3.6 Curing

Prevent newly cast concrete from drying out by chemical curing compounds (PEG-400). To encourage appropriate hydration and strength development, maintain the curing scenarios for the allotted time.

Fig 3.6 Curing

4. EXPERIMENTS

4.1 Slump test

As a way to evaluate functionality and consistency of freshly mixed concrete, the slump cone test a typical laboratory experiment in civil engineering. The concrete's ability to flow and be easily poured is determined by this test. During the slump cone test, a representative sample of freshly blended concrete is put into a slump cone. A test for slump device has three height measurements: 300 mm, 200 mm at the bottom, and 100 mm at the top. To mimic actual construction procedures, the cone is filled in layers and gently tamped to compact it. The concrete's degree of deformation, or "slump," is measured and noted in millimetres. This measurement captures the consistency and workability of the concrete.

Fig 4.1 Slump test

4.2 Compressive Strength

Concrete's ability to withstand axial loads or pressure is largely dependent on its compressive strength. Cubic sample of cast-in-place concrete in the process are carefully prepared and permit healing in a controlled environment. Then, until failure, these specimens are subjected to axial loads that gradually increase. The specimen's maximum load at which it fails is noted, and the formula is used to determine the compressive strength.

Fig 4.2 Compressive strength test

4.3 Split tensile strength

Split tension strength is a fundamental mechanical property of concrete that characterizes its resistance to indirect tensile pressures. A cylindrical concrete specimen that experiences a diameter-based compressive load that causes the specimen to break along its diameter is used to test this property. The tensile strength of the split may be calculated using the formula.

Split-tensile Strength = 2 * Maximum Load / (π * Diameter * Height)

Fig 4.3 Split tensile strength test

5. RESULTS and Discussion

5.1 Workability

The concrete mix's water requirement may the increase brought on by the powdered marble dust addition. This is because of the possibility that marble dust particles could absorb multiple the water used in mixing, changing the overall water-to-cement ratio. PEG-400 can function as a plasticizer and a water-reducing agent when added to the concrete mixture. This implies that it can aid in more effective cement particle dispersion, leading to improved flowability and higher slump values. From Fig.6.1 and Fig.6.2 it is observed that indicator of slump is increased by adding more marble dust powder and self-curing agent (PEG-400).

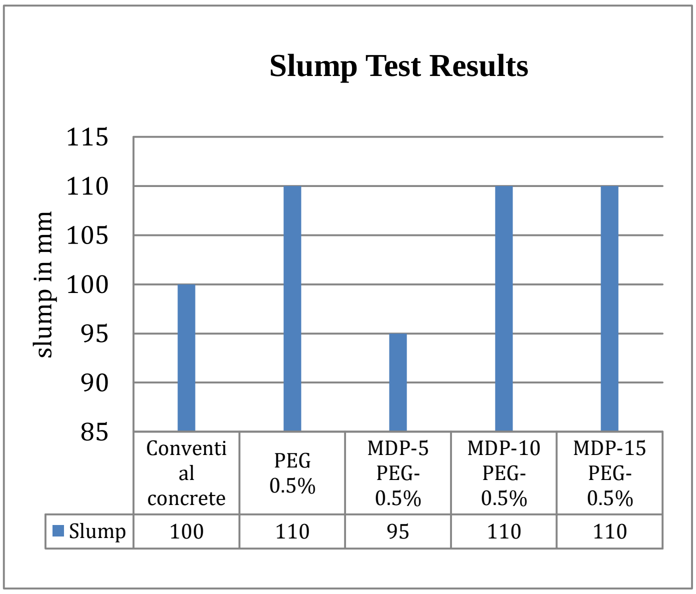


Chart-5.1 Slump values

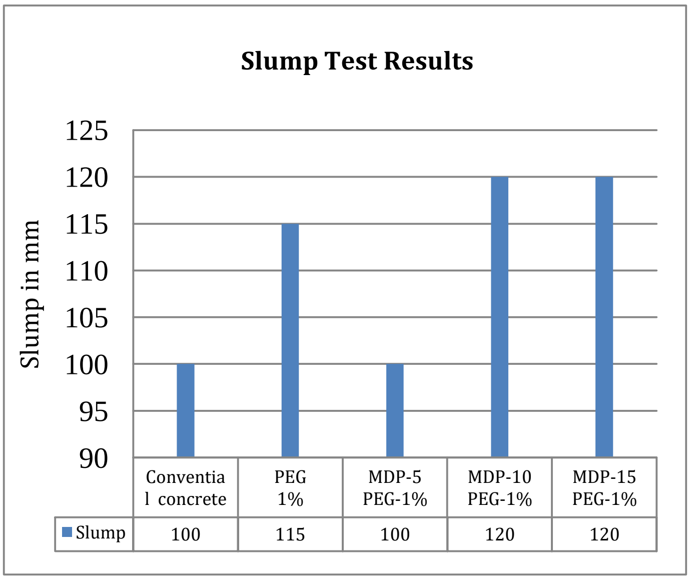
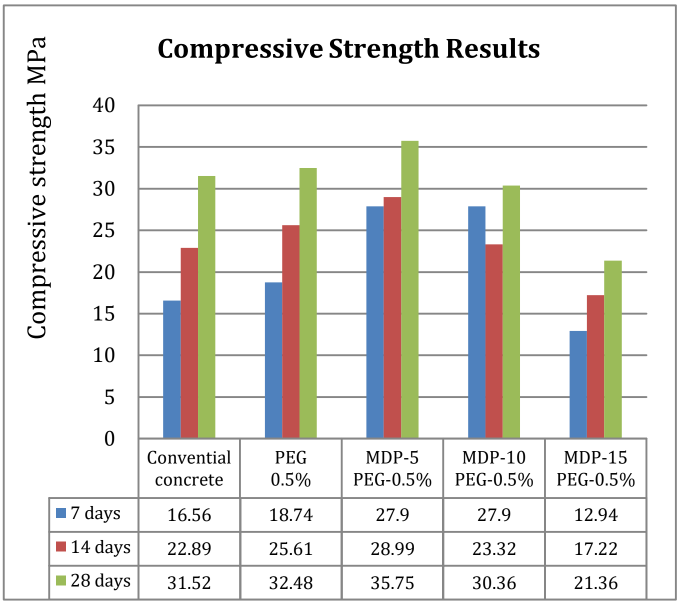


Chart-5.2 Slump values

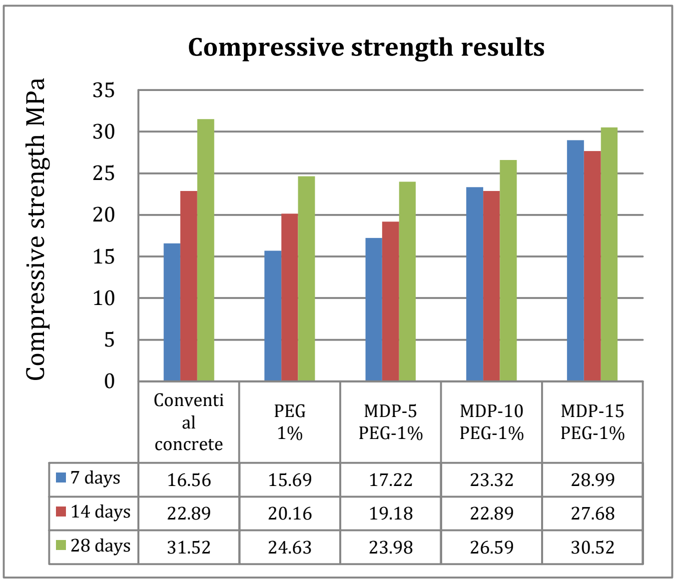
5.2 Compressive strength

The variability of compressive strength for percentage variations of marble dust powder and self-curing agent (PEG-400), as shown in below figures, By acting as a filler, marble dust powder improves packing density and decreases porosity. Due to improved particle interlocking and fewer crack propagation pathways, this denser matrix increases the overall strength of the concrete. PEG-400 molecules adhere to cement particles when PEG-400 is added to the concrete mixture, creating a barrier of protection. This layer slows down the initial hydration reactions, prolonging the time that water is available and allowing cement to continue to hydrate. The additional items that provide hydration that are made possible by delayed hydration increase compressive strength. making use of PEG-400 and marble dust powder together has a cooperative outcome on concrete's compressive strength. PEG-400 speeds up the hydration process while marble dust powder enhances the mechanical properties and particle packing of the concrete matrix. A concrete mixture with improved compressive strength is produced by this dual action.



	Convential concrete	PEG 0.5%	MDP-5 PEG-0.5%	MDP-10 PEG-0.5%	MDP-15 PEG-0.5%
7 days	16.56	18.74	27.9	27.9	12.94
14 days	22.89	25.61	28.99	23.32	17.22
28 days	31.52	32.48	35.75	30.36	21.36

Chart-5.3 Compressive strength comparison

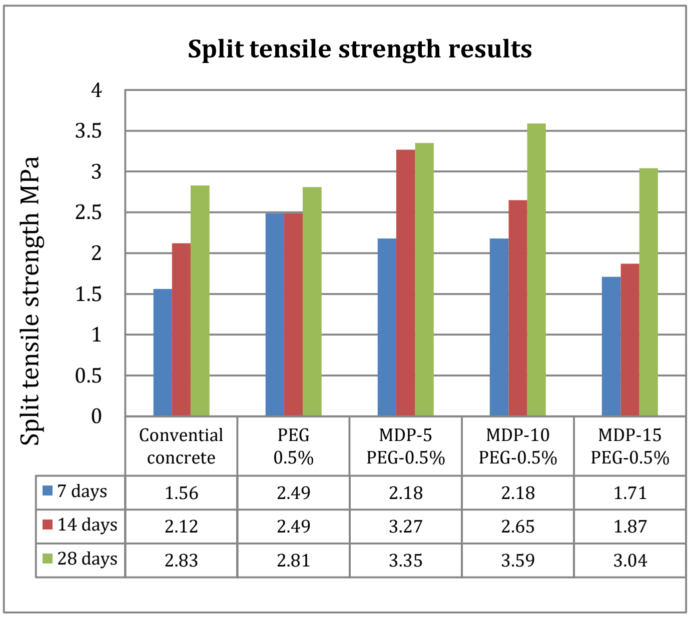


	Conventional concrete	PEG 1%	MDP-5 PEG-1%	MDP-10 PEG-1%	MDP-15 PEG-1%
7 days	16.56	15.69	17.22	23.32	28.99
14 days	22.89	20.16	19.18	22.89	27.68
28 days	31.52	24.63	23.98	26.59	30.52

Chart-5.4 Compressive strength comparison

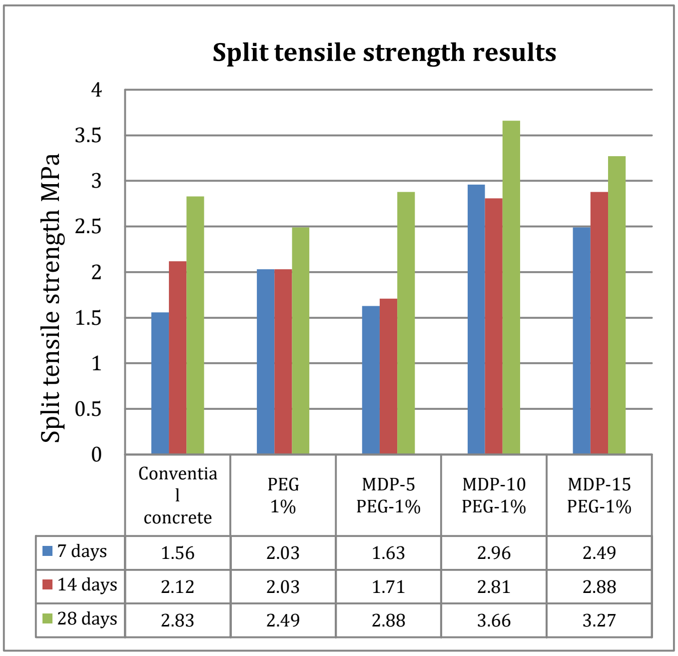
5.3 Split tensile strength

Marble dust and PEG-400 work together to strengthen concrete's split tensile strength, according to experimental studies. Marble dust and PEG-400 work together to create a more refined microstructure with fewer flaws and cracks, which ultimately improves the concrete's resistance to tensile stresses.



	Convential concrete	PEG 0.5%	MDP-5 PEG-0.5%	MDP-10 PEG-0.5%	MDP-15 PEG-0.5%
7 days	1.56	2.49	2.18	2.18	1.71
14 days	2.12	2.49	3.27	2.65	1.87
28 days	2.83	2.81	3.35	3.59	3.04

Chart-5.5 Split tensile strength comparison



	Conventional concrete	PEG 1%	MDP-5 PEG-1%	MDP-10 PEG-1%	MDP-15 PEG-1%
7 days	1.56	2.03	1.63	2.96	2.49
14 days	2.12	2.03	1.71	2.81	2.88
28 days	2.83	2.49	2.88	3.66	3.27

Chart-5.6 Split tensile strength comparison

6. CONCLUSION

Based on a study that used powder made of marble substitute for cement in some cases at weights of 0, 5, 10, and 15%, a chemical additive that is a self-curing agent (PEG-400) at weights of 0.5 and 1% in M30 grade concrete, the characteristics of concrete, including workability and strength, were analyzed. The findings of an experiment are deduced in the manner listed below.

- Using a powdery marble with PEG-400 in concrete. Test findings demonstrate that the slump value increased as the level of replacement increased.
- The strength in compression of concrete rises if cement is substituted with up to 5% powder of marble dust and 0.5% PEG-400 as a chemical addition; however, as a proportion powder of marble dust and PEG-400 rises, the compression strength in concrete diminishes.
- Split tensile concrete's strength was elevated when up to 10% switch of the cement with powdered marble dust and 1% PEG-400 as a chemical addition; however, when the proportion of powdered marble dust is increased the split tensile Concrete's strength drops.
- The powdered form of marble may be utilized as a better selective alternative for cement in concrete to reduce environmental impact.

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