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Experimental Study On Partial Replacement Of Cement With Wollastonic Powder

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Abstract - This study focuses on the experimental investigation of partial replacement of cement with wollastonite powder in concrete. The main aim is to evaluate the suitability of wollastonite powder as an alternative material by studying its effect on the mechanical properties of concrete. Different mix proportions were prepared by replacing cement with varying percentages of wollastonite powder, and their strength-to-weight ratio was analyzed to identify an appropriate mix proportion. The experimental program includes the determination of compressive strength and split tensile strength of concrete specimens with different replacement levels. Standard cube specimens of size 150 × 150 × 150 mm were cast and tested for compressive strength at replacement levels of 0%, 10%, 13%, 16%, and 18%. Additionally, beam specimens were considered to study the flexural behavior with wollastonite replacement ranging from 15% to 45% at intervals of 5%. The strength parameters of wollastonite mixed concrete were studied and compared with conventional concrete to understand the variation in performance. This study aims to assess the feasibility of using wollastonite powder as a partial replacement for cement and to determine a suitable percentage of replacement based on experimental observations.

Keyword: Wollastonite powder, Partial replacement of cement, Concrete, Compressive strength.

I. INTRODUCTION

Concrete is a widely used construction material for various types of structure due to its structural stability and strength. The usage, behavior as well as the durability of concrete structure, built during the last first half of the century with ordinary Portland cement and plane round bar of mild steel, the ease of procuring the constituents material (whatever may be their qualities) of concrete and the knowledge that almost any combination of the constituents leads to a mass of concrete have bred contempt. Strength was stressed without a thought on durability of structure. As a consequence of the Liberty station, the durability of concrete and concrete structures is on southward journey; a journey that seems to have gained momentum on its path to self-destruction. The ordinary Portland cement is one of the main ingredients used for the production of concrete and has no alternative in the civil construction industry. Unfortunately production of cement involves emission of large amount of carbon dioxide gas into the atmosphere a major contributor for greenhouse effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. Sustainable energy and cost saving can result when industrial by-products are used as a partial replacement of cement. Fly ash, ground granulated blast furnace slag, rice husk Ash, silica fume are some of the pozzolanic material which can be used in concrete as partial replacement of cement. A number of studies are going on in India as well as abroad to study the impact of use of these pozzolanic materials as cement replacement and the results are encouraging.

Wollastonite is a mineral blessed with many unique characteristics. Till 1970, the primary use of Wollastonite was as a decorative stone. Since the past 4 decades, one of the uses has been as a replacement for asbestos in products like insulating board and panels, paint, plastics, roofing tiles, and in friction devices such as brakes and clutches. wollastonite is one of the most versatile functional filler and reinforcement agents. Wollastonite increases the performance of products like polymers, plastics, paints and coatings, construction materials, friction devices, ceramic, etc. It also been employed for metallurgical applications.

A. Wollastonite Powder

Wollastonite is infrequently found in pure form and generally contains other minerals namely calcite, garnet and dropsied as gangue minerals or impurities those removed during extraction process. Optimum performance can be obtained by properly toning suitable pairing agent at the suitable concentration level to the polymer formulations. It possesses properties like lower moisture content and oil absorption with low volatile content. Surface modification of Wollastonite enhances its physical properties. It also results in improved processing and improved dispersion if implemented in resin. wollastonite find it's plenty of applications which includes valid like ceramics, paints etc.

Fig 1 Wollastonite Powder

Table 1 Physical properties of Wollastonite Powder

Property	Details
Color	White to off-white (depending on purity)
Form	Fine powder or acicular (needle-like) crystals
Hardness (Mohs)	4.5 – 5
Density	2.8 – 3.1 g/cm³
Specific Gravity	2.9

B. Problem Statement:

An investigation, the effect on the performance of the wollastonite powder as in admixture in concrete mixed. In wollastonite concrete production, Portland composite cement, coarse aggregate, fine aggregate, water, and wollastonite. The experiments will be used to investigate slump test, compressive strength, flexural test, water absorption test and water penetration test on wollastonite. Thus, the amount of wollastonite can be used as admixture in concrete production. Besides that, it also will decrease the construction cost. Some test and experiments are proposed to be performing to determine the performance concrete strength and wollastonite ash. This wollastonite must be grinded into fine powder. This test will be tested at 7 day, 14 day and 28 days to get the strength.

II. METHODOLOGY

a) Selection of Materials

The materials used in this study include cement, fine aggregate, coarse aggregate, water, and wollastonite powder. All materials are selected as per standard specifications.

b) Material Testing

Preliminary tests are conducted on cement, aggregates, and wollastonite powder to determine their physical properties such as specific gravity, fineness, and grading.

c) Mix Design

A suitable mix design for conventional concrete is prepared based on standard guidelines. This mix is used as a reference for further modifications.

d) Preparation of Mix Proportions

Concrete mixes are prepared by partially replacing cement with wollastonite powder at different percentages: 0%, 10%, 13%, 16%, and 18%.

e) Batching and Mixing

The required quantities of materials are batched and mixed thoroughly to achieve a uniform concrete mix.

f) Casting of Specimens

Concrete specimens are cast in standard molds:

Cubes (150 × 150 × 150 mm) for compressive strength

g) Curing

The cast specimens are demolded after 24 hours and cured in water for a specified period (7, 14, and 28 days).

h) Testing of Specimens

After curing, the specimens are tested to determine:

Compressive strength.

Table 2 Mix Proportion per CUM. for M30

Grade	Cement	Sand	Aggregates	Water
OPC 53 – M30	**437 Kg**	**735** Kg	**1105** Kg	197 lit

Sample Calculation for Cube Casting:

Cube Size: 150x150x150 mm

= 0.003375 m^3 (wet Volume)

Dry Volume add 54% in wet volume

=1.54 x 0.003375

=0.005198 m^3

Cement = 0.005198 x **437 =2.27 Kg**

Sand =0.005198 x **735 = 3.91 Kg**

Coarse agg =0.005198 x **1105 = 5.74 Kg**

Table 3 Mix Proportion

Wollastonite Powder %	Cement (kg)	Wollastonite Powder (kg)	Sand (kg)	Aggregates (kg)	Water lit
0%	2.27	0	3.91	5.74	1.02
10%	2.04	0.23	3.91	5.74	1.02
13%	1.97	0.30	3.91	5.74	1.02
16%	1.91	0.36	3.91	5.74	1.02
18%	1.86	0.41	3.91	5.74	1.02

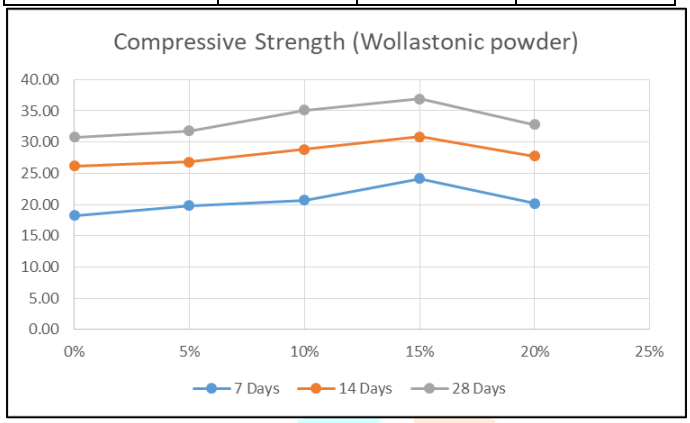
III. RESULTS OF ANALYSIS

A. Compressive strength test

Fig 2 Load application on cube

Table 1 Compressive Strength

Compressive Strength (Wollastonic powder)			
Percentage	**7 Days**	**14 Days**	**28 Days**
0%	18.20	26.13	30.806
10%	19.83	26.81	31.783
13%	20.67	28.82	35.075
16%	24.17	30.84	36.887
18%	20.16	27.72	32.762



Graph 1 Compressive strength N/mm2

VI. CONCLUSION

Based on the experimental investigation carried out on compressive strength of concrete with partial replacement of cement by wollastonite powder, the following conclusions are drawn:

The compressive strength of concrete is significantly affected by the inclusion of wollastonite powder as a partial replacement for cement.

From the test results at 7, 14, and 28 days, it is observed that compressive strength increases gradually with increase in wollastonite content from 0% to 16%.

The maximum compressive strength at 28 days is achieved at 16% replacement, with a value of 36.887 MPa, which is higher than that of conventional concrete (30.806 MPa).

Beyond 16% replacement (i.e., at 18%), a reduction in compressive strength is observed, indicating that excess replacement adversely affects strength.

The improvement in compressive strength up to the optimum level may be due to better particle packing and densification of concrete matrix caused by wollastonite powder.

The results indicate that wollastonite powder can be effectively used as a partial replacement of cement without compromising compressive strength, up to an optimum level.

The optimum percentage of cement replacement with wollastonite powder based on compressive strength is found to be 16%.

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