iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** X **Month of publication:** October 2021

DOI: https://doi.org/10.22214/ijraset.2021.38447

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue X Oct 2021- Available at www.ijraset.com

Effect of Wollastonite Mineral on Fresh and Mechanical Properties of Concrete

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Abstract: ***The wollastonite mineral are the main source of solid-state reaction from limestone and silica sand. Wollastonite is used as replacement of both sand and cement depending on size of wollastonite. Present study will provide better understanding of mechanical and durability properties of concrete in which cement is partially replaced with wollastonite. The present paper would contribute to the efforts being made in the field of concrete technology towards development of concretes possessing good strength and durability properties along with economic and ecological advantage. Based on the study, valuable advice will be given for concrete structures. It was found that with increase in amount of wollastonite, in concrete with workability of concrete decreases. It was also found that initial day's strength is less for wollastonite concrete compare to control mix, but as the age increases they show good improvement in strength due to pozzalanic reaction. Optimum dosage is observed to be 15% WP which shows more strength compared to control mix.***

Keywords: wollastonite mineral, workability, compressive strength, split tensile strength.

I. INTRODUCTION

Wollastonite is a naturally occurring calcium meta-silicate (CaSiO3) mineral, formed due to interaction of limestone with silica in hot magmas. Wollastonite primarily consists of Calcium Oxide (CaO) and Silica Oxide (SiO2) with a specific gravity ranging from 2.87 to 3.09. Effective utilisation of natural minerals and industrial by products are to be used to produce economical concrete. The advancement of concrete technology can reduce the consumption of natural resources, energy sources and lessen the burden of pollutants on environment. This project describes the feasibility of using the wollastonite in concrete production as partial replacement of cement by weight. Present day world is witnessing the construction of very challenging and difficult civil engineering structures. Quite often, concrete being the most important and widely used material is called upon to possess very high strength and sufficient workability properties. Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. World production data for Wollastonite are not available in most countries and are often available from 2 to 3 years of age. Estimated production of crude wollastonite ore in the world in 2016 ranged from 700,000 to 720,000 tons.

Fig: 1.1 wollastonite

II. LITERATURE REVIEWS

Kalla et.al (2018) Studies on Depletion of natural resources and emission of carbon dioxide are the major factors associated with cement production. Also, conventional concrete often fails to prevent the ingress of moisture and aggressive ions adequately. The concern for concrete durability surfaced globally by the time the structures built with high grade concretes started yielding to distress. Several materials such as fly ash, metakaolin, silica fume, stone waste, rubber tyre, slag, wollastonite etc. which are either industrial wastes or natural minerals, have been examined to make durable concrete. Among the various admixtures studied in the past, the effect of wollastonite on concrete has not been investigated in detail.

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Wollastonite is a calcium meta-silicate ($CaSiO_3$) mineral with particles similar to cement particles by size. In the present investigation, eighteen concrete mixes at three *w/b* ratios (0.45, 0.50 and 0.55) were prepared, by substituting Portland cement with wollastonite at varying replacement levels (0–25%). Substitution of 10–15% cement by wollastonite resulted in improved strength and durability of concrete. SEM and MIP results indicated that substitution of cement by wollastonite upto 15% reduced porosity and densified the concrete microstructure%. **Reddy and Sastry (2016)** Studies on Wollastonite, a naturally occurring mineral can be utilized in concrete as partial replacement of cement. The strength properties of M35 grade concrete are studied with different percentages of replacement of cement by wollastonite (WOL) for 0%, 5%, 10%, 15% and 20%. The optimum percentage of wollastonite in concrete corresponding to maximum strength will be identified. Keeping this optimum percentage of wollastonite replacement as constant, cement is further replaced with mineral admixtures such as silica fume (5%, 7.5%, 10% and 15%) and fly ash (5%, 10%, 15%, and 20%). The maximum increase in strength properties compared to conventional concrete was achieved at 10% replacement of wollastonite. Test results indicated that replacement of 10% wollastonite with silica fume showed better performance than with fly ash. The maximum increase in strengths was observed in a mix which consists of 10% wollastonite with 10% silica fume.

Dahiphale et.al (2020) Wollastonite is a naturally occurring mineral known as calcium metasilicate (CaSio3). It contains silica which reacts with water to form calcium-silicate-hydrate (CSH). CSH is also responsible for imparting strength to cemented material when Portland cement hydrates. In this study wollastonite was used to replace cement in concrete mix up to 30 %. There were 9 concrete mixes prepared with different wollastonite percentages which are 0%, 5%, 10%, 12.5%, 15%, 17.5%, 20%, 25%, 30% by weight of cement. Water cement ratio used was 0.44. It was observed that there was a rise in compressive strength at 10%, 12.5%, 15% wollastonite replacement as compared to control mix. Highest rise was observed at 15% wollastonite replacement.

III. MATERIALS AND METHODOLOGY

A. Cement

Ordinary Portland cement (OPC) from a single lot was used throughout the course of the investigation. The physical properties of the cement as determined from various tests 30 conforming to Indian Standard IS: 1489-1991(Part-1) are listed in Table 3.1. All the tests were carried out as per recommendations of IS: 4031-1988. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture.

B. Fine Aggregate

Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate. The specific gravity of sand is 2.61.

C. Course Aggregate

Coarse aggregate with a maximum size 12.5mm having specific gravity 2.65 Angular aggregates from a local Source were used as coarse aggregate.

D. Wollastonite Minerals

It was sieved by IS-90 micron sieve before mixing in concrete.

E. Admixture

Water-reducing and set-retarding admixtures are permitted in order to increase the workability of the concrete. Super plasticizer Gelenium hky 8765 was used for the workability.

IV. RESULT AND DISCUSSION ON EXPERIMENTAL TESTS

A. Workability of Concrete Mixes

The workability of concrete mixes was found out by slump test as per procedure & the compaction factor was found out using the procedure as given in chapter 3. Water-binder (w/b) ratio was kept constant 0.4 for all the concrete mixes.

Table 4.1 Workability & Compaction factor values for different concrete mixes

Description	Slump (mm)
100%OPC	57
95%OPC+5%WP	55
90%OPC+10%WP	53
85%OPC+15%WP	47
80%OPC+20%WP	45

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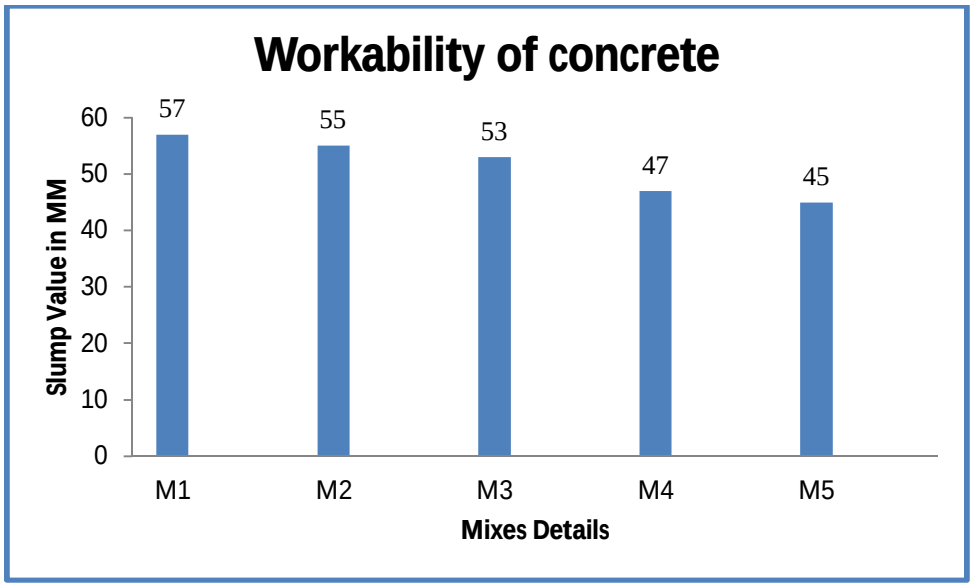

Fig. 4.1 Variation of slump value in mm

B. Compressive Strength

The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test was conducted at curing ages of 7, 14, 28 days.

Table 4.3. Compressive strength (MPa) values of all mixes at different curing ages

Description	7 Day	14 Day	28 Days
100%OPC	29.05	29.76	32.07
95%OPC+5%WP	30	31.8	36.01
90%OPC+10%WP	32.02	33.45	36
85%OPC+15%WP	39.01	41.5	42.04
80%OPC+20%WP	31.31	36.06	38.5

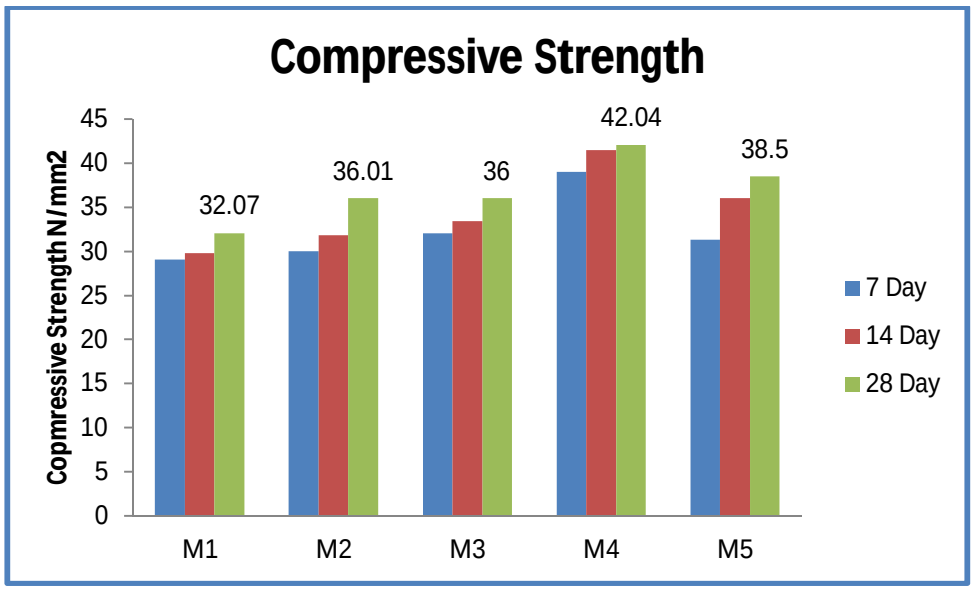

Fig. 4.1 Variation of compressive strength of concrete with age

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C. Split Tensile Strength Test Results

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7, 14, 28 days.

Table 4.4. Split tensile strength test(MPa) values of all mixes at different curing ages.

Description	7 Day	14 Day	28 Days
100%OPC	3.38	3.91	4.5
95%OPC+5%WP	3.41	3.51	3.85
90%OPC+10%WP	3.5	3.65	3.89
85%OPC+15%WP	3.91	4.25	4.99
80%OPC+20%WP	3.2	3.45	4.1

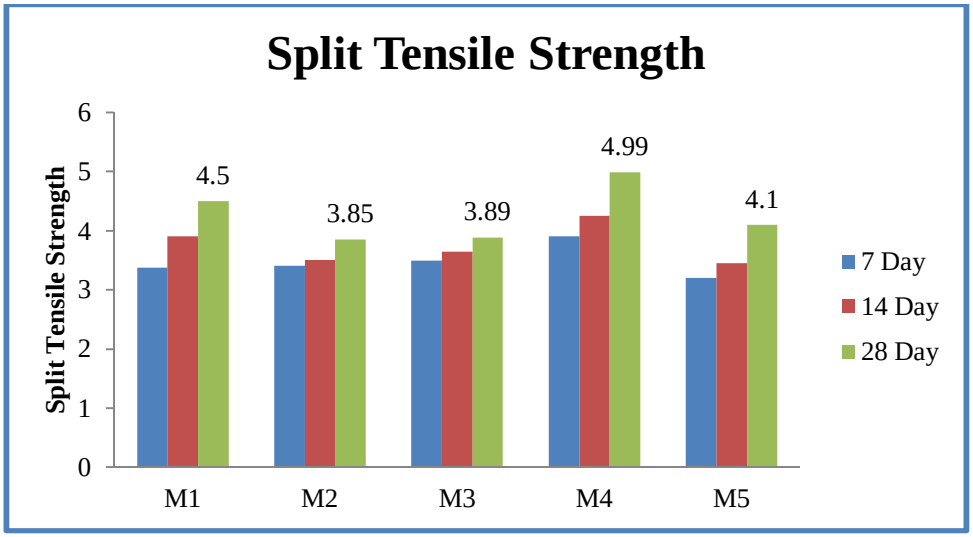

Fig. 4.2 Variation of split tensile strength of concrete with age

V. CONCLUSIONS

In the current investigation, wollastonite powder (WP) was used to examine the strength and water absorption characteristics using test. The experimental data obtained has been analysed and discussed in Chapter-4, to fulfil to the best of ability, the objectives set forth for the present investigation.

A. Reduction in bleeding is observed by addition of wollastonite powder in the m wollastonite powder concrete mixes.

B. It was observed that as the addition of wollastonite powder to concrete mix increases, the workability of concrete mix was found to decrease as compared to control mix.

C. At dosage of about 15% wollastonite powder the increase in compressive strength of wollastonite powder concrete mixes compared with control mix of concrete at 28 days compressive strength is observed from 18% to 20%.

D. The percentage increase of split tensile strength of wollastonite powder concrete mixes compared with control mix at 28 days is observed varying from 15 to 20% wollastonite by weight of binder

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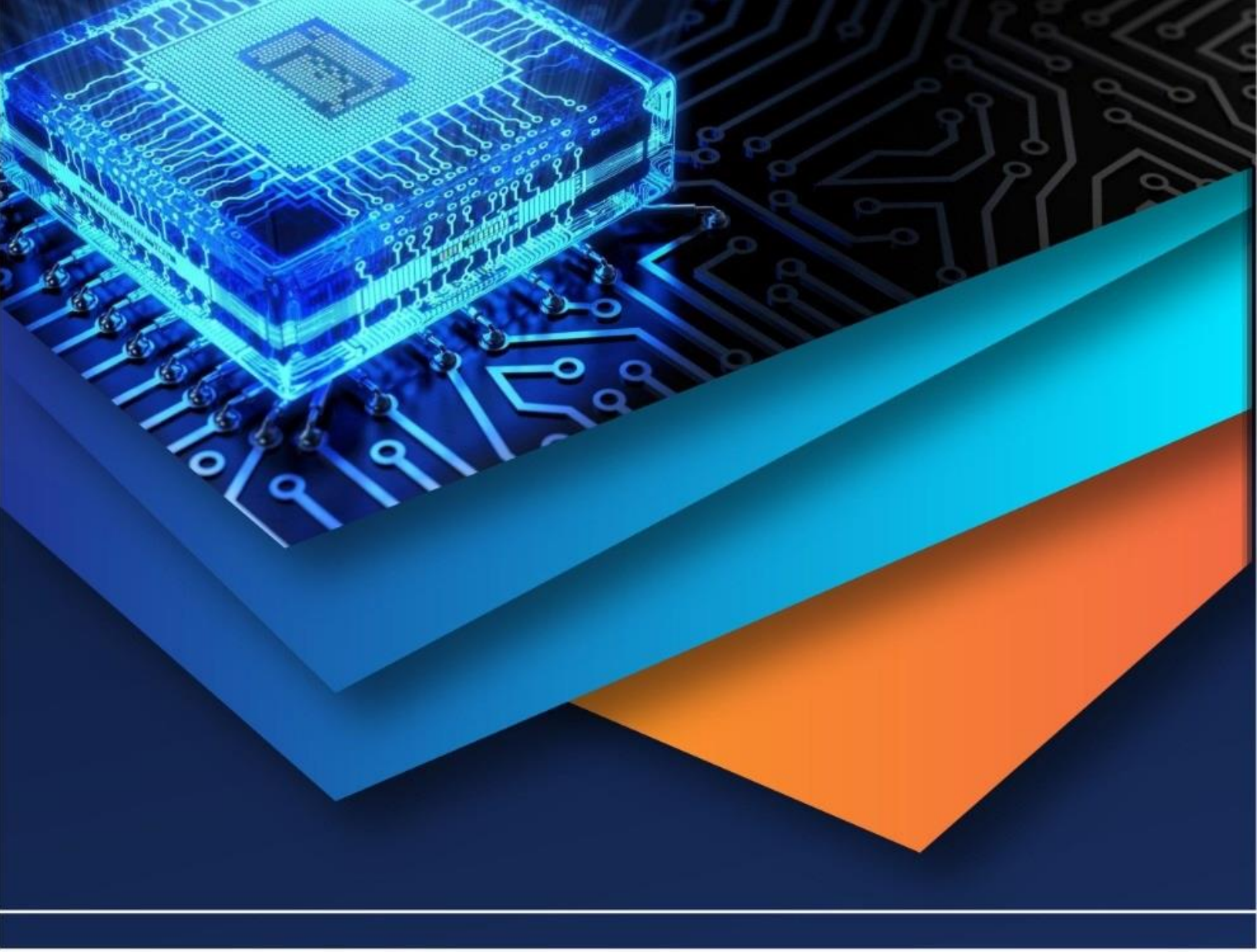

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