



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 10, October 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

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An Experimental Study on Behaviour of Concrete due to Partial Replacement of Cement by Wollastonite

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ABSTRACT: This paper presents an investigation to explore the influence of Wollastonite on strength and durability properties of concrete. A total of 6 mixes were prepared with varying Wollastonite percentage of 0%, 10%, 12%, 14%, 16% and 18% by weight of cement. The water cement ratio is 0.44, constant throughout the experiment. Workability of concrete was decreased with increase in Wollastonite addition. The peak value of compression strength was observed at 14% and 16% addition of Wollastonite respectively. The maximum flexural strength for specimens were observed at 16% addition of Wollastonite.

KEYWORDS: Wollastonite, Compressive strength, Flexural strength.

I. INTRODUCTION

Concrete is composed mainly of water, aggregate and cement. It is highly used construction material which is durable and efficient binding material. The second consumed man-made material in the world after water is concrete. Cement is an essential ingredient of concrete, which binds aggregates to form strong building material. In order to reduce the consumption of cement, supplementary cementitious materials are used in concrete production. Since concrete is weak in tension, it could be overcome by adding metal, mineral or synthetic fibers, but addition of these increases the cost of concrete. To increase the strength and durability properties, partial replacement of Portland cement is done by mineral admixtures such as fly ash, silica fume, metakaolin etc. Wollastonite is one of the materials among the admixtures which has not been investigated in detail, it is called as calcium metasilicate (CaSiO_3) and is a natural mineral. The color is naturally white. It is formed when impure dolomite or limestone is exposed to very high temperature. It is largely available in the states such as Rajasthan, Tamil Nadu, Uttarakhand and Andhra Pradesh.

II. EXPERIMENTAL PROGRAM

Materials Used:

Ordinary Portland cement of 43 grade as mentioned in code IS 10262 (2019) is used. Wollastonite for the project is procured from Wolkem India Ltd. Udaipur, Rajasthan. Fine aggregate used here is M-sand obtained from local quarry conforming to grading zone III of IS383 (2016). coarse aggregate used are 20mm down size as per code IS 383(2016). Chemical admixture used here is 'Conplast SP430', obtained from FOSROC Company.

Concrete Mix Design:

Mix design is the process of proportioning the materials of concrete for the required physical properties like strength, workability and durability. Here the design is carried out on M30 grade as per IS10262 (2019).



Mixing and Casting:

The following procedure is adopted while mixing and casting of specimens.

- 1.The material required for the specimen is calculated using the mix proportion by mass and W/C of 0.44.
- 2.The Cement is replaced by Wollastonite, with varying percentages.
- 3.The mixing is done using mechanical mixer.
- 4.Cement, Wollastonite and Fine aggregate are mixed dry to form a uniform mix and then the Coarse aggregate is added to form a uniform mix.
- 5.Then water is added after super plasticizer is mixed thoroughly with water and the whole mix is mixed thoroughly to get homogeneous wet mix.
- 6.Place the specimens on the vibrating table and put the wet concrete mix inside the mould in three layers.
- 7.Vibrate the concrete both through table vibrator and by hand compaction using tamping rod.
- 8.Vibration should not be more, otherwise segregation will take place.
- 9.After filling the moulds with wet concrete, level the surface and give the designation to each specimen.
- 10.Demould the specimen after 24 hours.

Table 1: Mix identity for M30 grade concrete

Sl. No.	Mix Identity	Content (%)	
		Cement	Wollastonite
1	M0	100	0
2	M10	90	10
3	M12	88	12
4	M14	86	14
5	M16	84	16
6	M18	82	18

Superplasticizer is maintained at 3.75ml for all the mixes and w/c ratio with 0.4

Table 2: Mix design proportion

Mix	Cement (kg/m ³)	Wollastonite (kg/m ³)	FA (kg/m ³)	CA (kg/m ³)
M0	375	0	670.33	1134.69
M10	337.5	37.5	669.76	1133.72
M12	330	45	669.64	1133.53
M14	322.5	52.5	669.53	1133.33
M16	315	60	669.41	1133.14
M18	307.5	67.5	669.3	1132.95



III. RESULTS AND DISCUSSION

Table 3: Test results of Fine aggregate (4.75 mm down)

Property	Value		Remarks
	IS sieve designation (mm)	Percentage passing	
Sieve analysis			Conforms to grading zone I of IS 383 (2016)
	10	100	100
	4.75	100	90-100
	2.36	82.21	60-95
	1.18	56.61	30-70
	0.6	33.11	15-34
	0.3	13.61	5-20
	0.15	1.67	0-10
Specific gravity	2.46		-
Water absorption (%)	1.2		

Table 4: Test results of fresh concrete

Mix	Slump (mm)	Compaction Factor
M0	70	0.910
M10	52	0.875
M12	48	0.856
M14	47	0.814
M16	42	0.805
M18	38	0.792

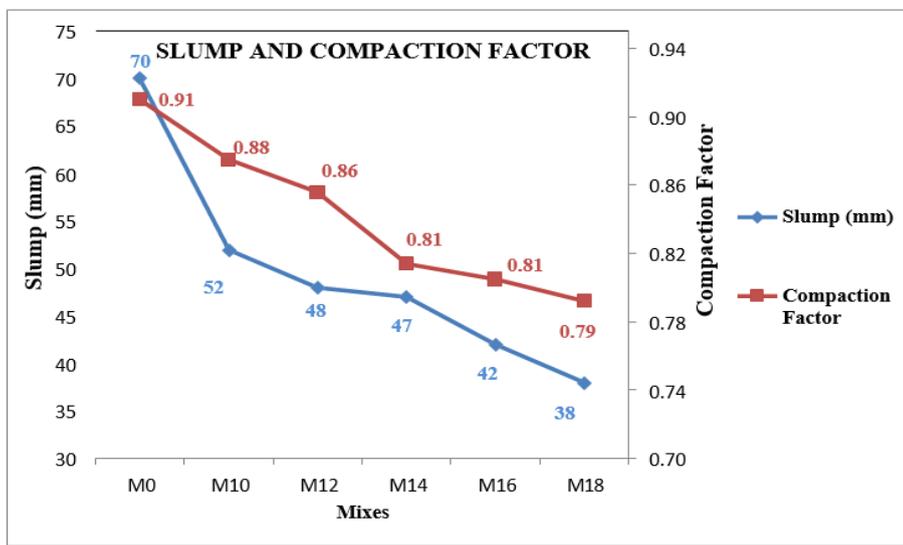




Table 4. Test results of Coarse aggregate

Property	Value	
	IS sieve designation (mm)	Percentage passing
Sieve analysis (20 mm down)	20	100
	16	18.1
	12.5	3.6
	10	0.4
	4.75	0
	2.36	0
	Pan	0
Sieve analysis (12.5 mm down)	12.5	93.2
	10	63
	4.75	2.7
	2.36	1.7
Specific gravity	2.64	
Water absorption (%)	0.16	

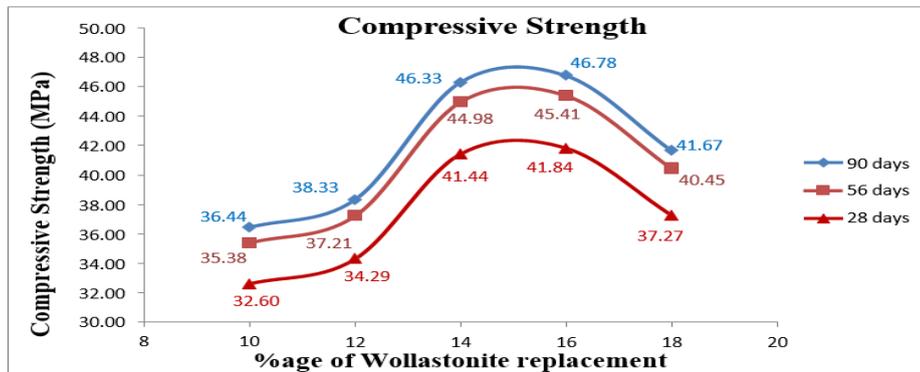


Fig 2: Compressive Strength Graph

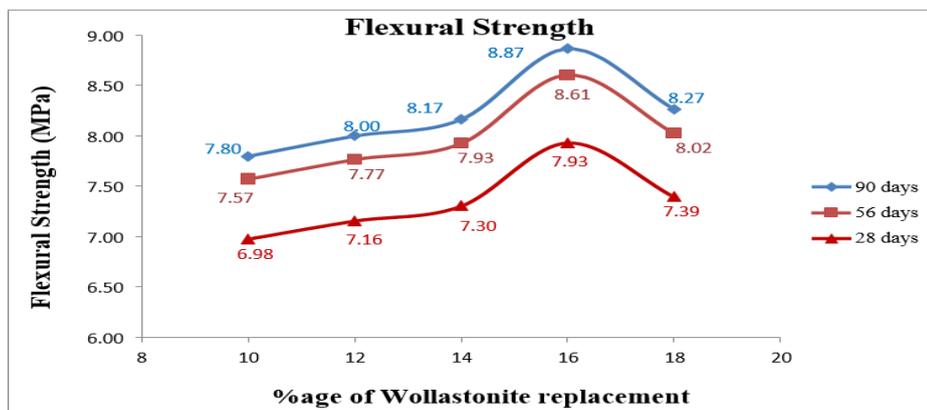


Fig 3: Flexural Strength Graph



IV. CONCLUSIONS

In the present work, the effect of Wollastonite on strength and durability properties of concrete for M30 grade mix is studied. IS 10262 (2019) is used to carry out the Mix Design. Slump and compaction factor are determined to measure workability. For various mixes of concrete, compression and flexural strengths are determined.

The important conclusions drawn from the present study are as follows.

- 1]The workability of fresh concrete for M30 mix indicates increase in stiffness with increase in percentage of Wollastonite addition.
- 2]The optimum percentage of Wollastonite addition at which the study indicates maximum compression strength is observed to be in the range of 14 to 16 percent. The percentage of increase in compression strength with respect to reference mix is 24%.
- 3]The optimum percentage of Wollastonite addition at which the study indicates maximum flexural strength is observed to be at 16 percent. The percentage of increase in flexural strength with respect to reference mix is 2%.
- 4]Compression and flexural strength values for various percentage of Wollastonite addition show to satisfy the stipulation as per code.

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Impact Factor: 8.118



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