Wollastonite Partial Replacement of Cement : An Experimental Research

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Abstract: Construction uses concrete because it is a strong and reliable binding substance. Cement production in India is second-to-none. The amount of raw materials needed to produce one tonne of cement is around 1.5 tonnes. Additional cementitious elements are utilised in the manufacturing of concrete in order to reduce the amount of cement required. One such naturally occurring mineral is wollastonite, which is produced when silica and limestone combine in hot mogmas. In the current work, concrete contains 0%, 5%, 10%, 15%, and 20% Wollastonite in place of cement. Wollastonite's impact on concrete's strength characteristics for the M30 grade mix is investigated. The Mix Design is determined using IS 10262:2019. To measure workability, the slump cone, compaction factor, and vee-bee consistometer are used. For various concrete mixtures. Strengths in compression, split tensile, and flexural are The outcomes of the various combination mixes are then contrasted with those of a standard concrete mix.

Keywords— concrete, additional cementitious substance, wollastonite, workability, strengths in Compression, strengths in split tensile and strengths in flexural

1. INTRODUCTION

Water, aggregate, and cement make up the majority of concrete. After water, concrete is the second most consumed man-made resource worldwide. Concrete requires cement as a key component because it bonds the particles to create a sturdy building material. For each tonne of cement produced, raw materials are needed in the range of 1.5 tonnes. It causes environmental issues and emits 0.8 tonnes of CO2. In the manufacturing of concrete, additional cementitious ingredients are employed to cut down on cement use.

Using additional cementitious substance and other: additives such as admixtures, minerals and fibres have made the research field active during last few decades. Concrete's weakness in tension could be remedied by adding metal, mineral, or synthetic fibres, although doing so raises the price of the material. To increase the robustness and endurance properties, Portland cement is largely replaced with mineral admixtures such as fly ash, silica fume, metakaolin, etc.. Among the admixtures, wollastonite is one of the substances that has not been thoroughly studied.

Wollastonite

An industrial mineral called wollastonite contains elements like calcium, silicon, and oxygen. Wollastonite has the molecular formula $CaSiO_3$, and its roughly theoretical composition is composed of 48.28% CaO and 51.72% SiO_2. Various metal ions, including those of aluminium, iron, magnesium, potassium, and sodium, may be present in trace or insignificant levels in natural wollastonite.

Fig 1 wollastonite powder

2. OBJECTIVES

- To look into the new characteristics of wollastonite concrete..
- Examine the solidified properties of concrete, like compressive strength, split elasticity, and flexural strength.
- To determine the ideal amount of wollastonite.

3. MATERIALS AND METHODOLOGY

A) MATERIALS

- OPC 43grade cement
- Using river sand as a Fine Aggregate
- Coarse aggregate made of crushed stone
- Wollastonite
- Water

B) METHODOLOGY

The approach has been used to research the properties of wollastonite-incorporated materials both when they are soft and when they have hardened (in place of cement). The following process is part of the research work.
According to the codal provisions of IS 10262:2019, the M30 grade mix design was created. In order to build different concrete mixtures, wollastonite content is modified to 0%, 5%, 10%, 15%, and 20% by weight of cement. The prepared mixes' properties—both while they are soft and when they have hardened—are examined.

Following are the Tests conducted in laboratory for fresh and hardened concrete.

For fresh Concrete

- Slump cone test
- Compaction factor test
- VeeBee consistometer test

For Hardened Concrete

- Compressive Strength
- Split Tensile strength
- Flexural Strength test.

4. RESULTS AND DISCUSSION

➢ **Basic Tests on Collected Materials**

1. **Tests on cement**

s n	Material property	Test Results obtained
1	Fineness %	4.8
2	Normal Consistency %	33
3	Specific gravity	3.2
4	Initial setting time(min)	32
5	Final setting time(min)	569
6	Compressive Strength (N/mm^2) (7days)	24
	(28days)	42

2. **Tests on Fine aggregate**

SL .No	Material property	Test Results obtained
1	Specific gravity	2.4
2	Fineness modulus (%)	2.68
3	Density in Bulk (kg/m^3)	1600
4	Absorption of water (%)	1.70

3. **Tests on Coarse Aggregate**

SL .No	Material property	Test Results obtained
1	Specific gravity	2.8
2	Fineness modulus (%)	7.60
3	Density in Bulk (kg/m^3)	1660
4	Absorption of water (%)	0.65

4. **Tests on Wollastonite**

SL .No	Material property	Test Results obtained
1	Specific gravity	2.9

➢ **Tests on Fresh Concrete**

1. **For fresh Concrete**

The findings of the vee bee test and the slump compaction factor are displayed in Table 1 below.

Table 1.Workability Test Results

Percentage of cement replaced by wollastonite	Fresh properties tested		
	Slump (mm)	Compaction factor	Vee-Bee Degree(sec)
Nominal mix	85	0.84	6
5%	83	0.83	7
10%	80	0.81	7
15%	76	0.78	8
20%	74	0.76	9

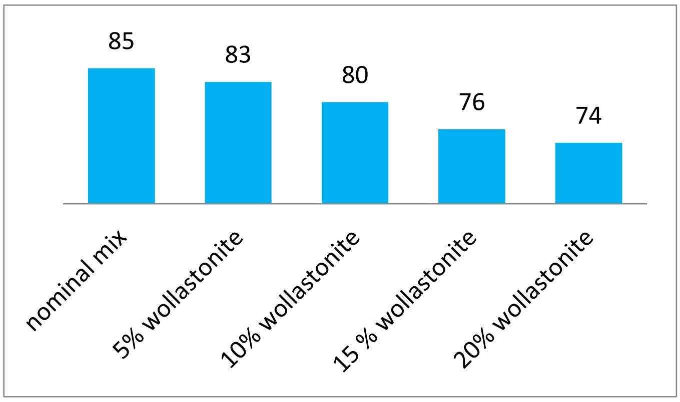

Fig 2: Slump variation

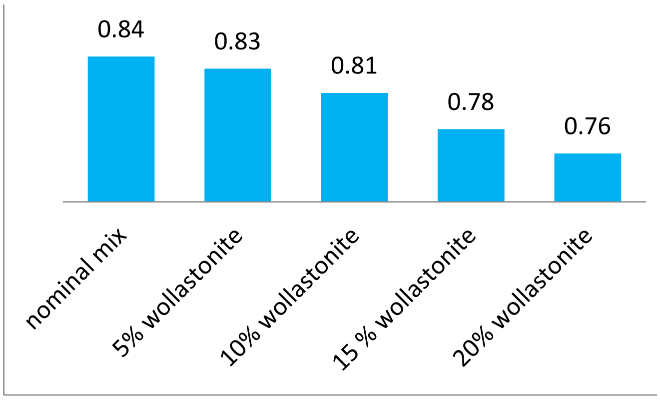

Fig 3: Variation of Compaction factor

The graph shows how the importance of compaction factor varies. The graph shows that the compaction factor steadily decreases as the quantity of wollastonite increases, and that nominal mix yields the highest compaction factor.

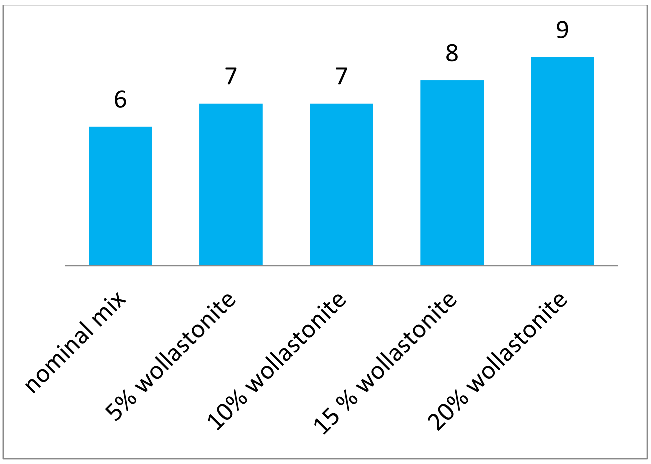

Fig 4: Variation of Vee-Bee Degree (sec)

The graph shows the Vee Bee Time fluctuations. The graph shows that the Vee-bee progressively rises as the amount of wollastonite increases, reaching its maximum value at 20% wollastonite.

2. For Hardened Concrete

i) Test of Compressive Strength

Table 2 shows the overall findings of the Strength in compression.

Table 2: Test Results for 7 Days and 28 Days of Overall Strength in compression

Percentage of cement replaced by wollastonite	7 Days	28 Days
	Strength in compression (N/mm^2)	Strength in compression (N/mm^2)
Nominal mix	20.99	37.2
5%	23.82	38
10%	26.81	39.74
15%	28.65	44.23
20%	22.4	41.28

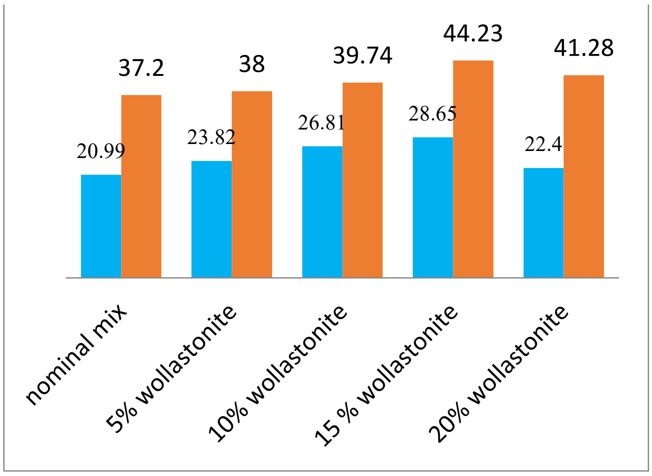

Fig 5: Variation of Strength in compression Test results

Fig 6. Strength in compression test at lab

ii) Test of Split Tensile Strength

The overall findings of the Tensile strength in splits test are listed in the following table 3.

Table 3: Results for the overall Tensile strength in split at 7 and 28 days

Percentage of cement replaced by wollastonite	7 Days	28 Days
	Tensile strength in split (N/mm^2)	Tensile strength in split (N/mm^2)
Nominal mix	1.6	3.03
5%	1.87	3.14
10%	2.37	3.38
15%	2.62	3.98
20%	2.19	3.69

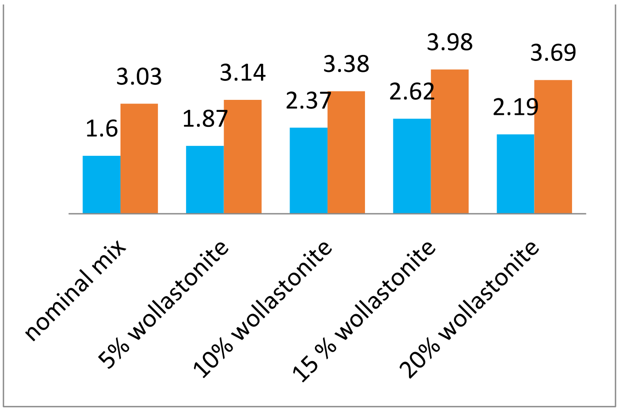

Fig 7: Variation of Tensile strength results

Fig 8. Tensile strength at test

iii) Test of Flexural Strength

The results of the overall strength in flexural test are presented in Table 4 below.

Table 4: In general, Flexural Strength results for 7 days and 28 days

Percentage of cement replaced by wollastonite	7 Days	28 Days
	Flexural strength (N/mm^2)	Flexural strength (N/mm^2)
Nominal mix	4.93	6.62
5%	5.2	7.33
10%	5.41	7.63
15%	6.43	8.16
20%	5.31	7.39

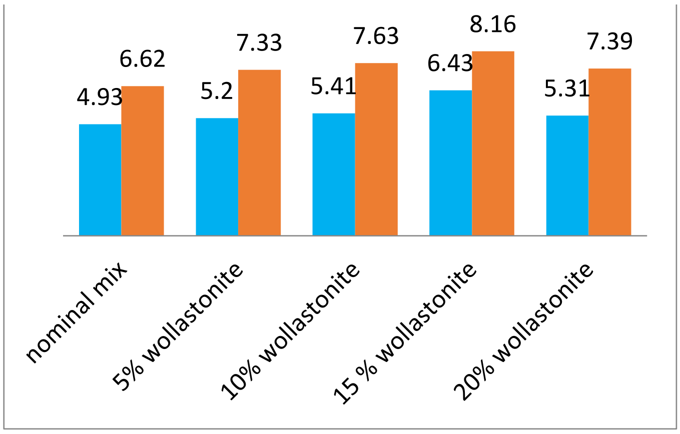

Fig 9: Variation of Flexural Strength Test results

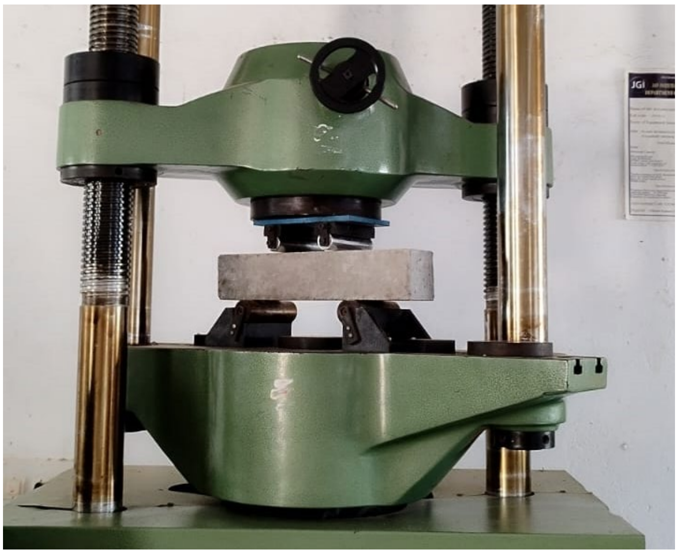

Fig 10. Flexural Strength test at lab

5) CONCLUSION

- In the slump cone test of fresh concrete, the lowest wollastonite percentage results in the largest slump, with workability steadily increasing as the proportion of wollastonite in the concrete rises. The maximum compaction is attained with 0% cement and 100% wollastonite, and as the wollastonite proportion in concrete rises, the compaction factor slowly declines.
- After 7 and 28 days of curing, respectively, the specimens containing 15% wollastonite and 85% cement were viewed as stronger in compression and have compressive strengths of 28.65 and 44.23 higher than that of nominal mix concrete.
- Wollastonite was used in place of cement in concrete to build strength in split. After 7 and 28 days of curing, respectively, for 15% wollastonite + 85% cement, the split tensile strength improved to 2.62 and 3.98 when compared to that of the nominal mix concrete.
- When wollastonite is used in place of cement, good Strength in Flexure was attained. After 7 and 28 days of curing, respectively, for 15% wollastonite and 85% cement, the flexural strength was up to 6.43% and 8.16% more than that of the nominal mix concrete.

After considering the aforementioned information, it has been concluded that the ideal concrete design mix should consist of 15% wollastonite in place of cement.

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