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Properties of Concrete Containing Wollastonite as Partial Replacement of Cement with Graphene Oxide

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ABSTRACT: This paper presents investigation was conducted to explore the influence of Wollastonite and Graphene Oxide 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 and constant Graphene Oxide percentage of 0.04% by weight of cement. The water cement ratio is 0.45, constant throughout the experiment. Workability of concrete was decreased with increase in Wollastonite addition. The peak value of compression strength and flexural strength were observed at 12% and 10% addition of Wollastonite respectively. The maximum compressive strength for specimens immersed in Sulphuric acid and Hydrochloric acid was observed at 14% and 10% addition of Wollastonite. No carbonation was observed for the cubes tested for carbonation.

KEYWORDS: Wollastonite, Graphene Oxide (GO), Compressive strength, Flexural strength, Cabonation.

I. INTRODUCTION

Concrete is a composite material of aggregates and binder where combination of Portland cement, pozzolonic material and water are primarily used as binding materials. The main component material used for production of concrete is Ordinary Portland cement. A large amount of Carbon-di-Oxide gas is emitted to the atmosphere during the cement production process which is one of the main reason for global warming and green house effect. Therefore it is necessary to find another material or partially replace it with some other material which should minimize the environmental impact and achieve global sustainable development. Wollastonite is one such material which is also called as calcium metasilicate (CaSiO₃) 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. Graphene Oxide (GO) is additive used here. It is formed by oxidation of graphite, which is cheap and available abundantly. GO is formed by oxidation of graphite, which is cheap and available in water it can be easily processed and it can also be used to produce Graphene. It is commonly available in powder form.

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. Mineral admixture used here is Graphene Oxide (GO). It is oxidized form of graphite which is cheap and easily available.

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).

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Mix identity for M30 grade concrete is presented in table 4.5, showing the contents of cement, Wollastonite and Graphene Oxide.

Table 1: Mix Identity

| SI. No. | Mix Identity | Cement content (%) | Wollastonite Content (%) | Graphene Oxide (% of cement) | |
|------------|-----------------|--------------------------|-----------------------------|---------------------------------|--|
| 1 | M0 | 100 | 0 | 0.04 | |
| 2 | M10 | 90 | 10 | 0.04 | |
| 3 | M12 | 88 | 12 | 0.04 | |
| 4 | M14 | 86 | 14 | 0.04 | |
| 5 | M16 | 84 | 16 | 0.04 | |
| 6 | M18 | 82 | 18 | 0.04 | |

Table 2: Mix Proportion

| Mix | Cement (kg/m ³) | Wollastonite (kg/m ³) | FA (kg/m ³) | CA (kg/m ³) | Graphene Oxide (g/m ³) | Super plasticizer (ml) | w/c ratio |
|-----|--------------------------------|--------------------------------------|----------------------------|----------------------------|---------------------------------------|------------------------------|--------------|
| M0 | 380 | 0 | 601.00 | 1182.00 | 152 | 3.8 | 0.45 |
| M10 | 342 | 38 | 602.00 | 1183.58 | 152 | 3.8 | 0.45 |
| M12 | 334.4 | 45.6 | 599.40 | 1178.47 | 152 | 3.8 | 0.45 |
| M14 | 326.655 | 53.2 | 599.40 | 1178.47 | 152 | 3.8 | 0.45 |
| M16 | 319.2 | 60.8 | 599.40 | 1178.47 | 152 | 3.8 | 0.45 |
| M18 | 311.6 | 68.4 | 598.40 | 1176.77 | 152 | 3.8 | 0.45 |

III. RESULTS AND DISCUSSION

Figure 1 and 2 represents the slump and compaction factors values of fresh concrete to measure workability.



Fig. 1. Slump

Fig. 2. Compaction Factor

The compressive strength of hardened concrete cube specimens cured in portable water is calculated at 28, 56 and 90 days and the results are graphically shown in the fig. 3.

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Fig. 3. Compressive Strength

The flexural strength of concrete mixes at the age 28, 56 and 90 days cured in portable water is graphically shown in fig. 4.



Fig. 4. Flexural Strength

The durability test in terms of carbonation is carried out according to the procedure in IS 516-05 (2021).Carbonation in concrete is found by using alkalinity indicator, Phenolphthalein solution. The specimen is cut at the center and the indicator is sprayed on freshly exposed surface, the carbonated area remains colorless and the uncarbonated area turns pink. The depth of carbonation is measured.



Fig. 5. Specimens Showing No Carbonation

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The compressive strength of concrete cube specimens immersed in Sulphuric Acid (H_2SO_4) and Hydrochloric Acid (HCl) for 28 days is graphically represented in the fig. 6



Fig. 6. Compressive Strength of Cube Specimens Immersed in H₂SO₄ and HCl for 28 Days

IV. CONCLUSIONS

In the present work, the effect of Wollastonite and Graphene Oxide on strength parameters and durability parameters of concrete for M30 grade is studied. The mix design is carried out using IS 10262 (2019). Workability is measured using slump and compaction factor tests. Compression and flexural strengths are determined for various concrete mixes. Durability of concrete is calculated by conducting sulphate and chloride resistance test by immersing cubes in H_2SO_4 and HCl solutions and carbonation test.

- 1. Workability of fresh concrete mix of M30 grade decreases with increase in percentage of Wollastonite.
- 2. At 12% replacement of cement by Wollastonite and addition of 0.04% Graphene Oxide gave the maximum compressive strength, hence it is considered as optimum value. The maximum increase in compressive strength is 28% of nominal mix.
- 3. The optimum percentage of Wollastonite addition with Graphene Oxide at which the study indicated maximum flexural strength is 10%. Maximum increase in flexural strength with respect to reference mix is 7.9%.
- 4. For the carbonation test conducted no carbonation has been observed.
- 5. The peak value for durability of specimens immersed in Hydrochloric acid (HCl) is observed at 10%. The maximum increase in compressive strength observed is 21.8% of reference mixes there by increases the durability property.
- 6. The peak value for durability of specimens immersed in Sulphuric acid (H_2SO_4) is observed at 14%. The maximum increase in compressive strength observed is 8.4% of reference mix there by increases durability property.

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