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Development of New Composites Using Industrial by Products

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ABSTRACT- In this paper thesis describes an experimental investigation of magnesium based cement mortar which consists of fly ash, magnesium oxide (MgO), magnesium Phosphate (MgPO4) and Phosphate tailings. This magnesia based cements are emerged as a viable alternative to Portland cement, with both technical and sustainability advantages. This study aims to use the mixture of cement, fly ash and magnesia. The major drawback of delayed setting time can be eliminated with the use of magnesia based cement. Hence, in this study different admixtures such as magnesium oxide, magnesium phosphate, phosphate tailings are attempted. Initial and final setting time of plain cement, fly ash cement and magnesia based cement are determined and found that the small dosage of magnesium compound reduced the setting time. Further, magnesia based cements are reported to be used along with sea water without much negative effect. In view of all these, this study proposed a magnesia based cement as an alternative for conventional Portland cement. Industrial wastes such as fly ash, and phosphate tailings are used in this study.

KEYWORDS- Magnesium Based cement, Phosphate tailings, Fly ash

I. INTRODUCTION

The global construction materials industry, which was historically based on an extremely wide range of materials suitable for local conditions and specific applications, moved through the latter half of the 20th century to become almost a monoculture based on the use of Portland cement (PC), with other materials essentially sidelined. With the push for increasing environmental sustainability in the construction industry in the 21st century, we are now facing a situation where the global industry is rediscovering largescale interest in materials that held largely niche or curiosity value. This has led to the reinvention of a large quantity of information that was previously more widely understood. The key purpose of this review is to bring this information to light in the surrounding of the modern use of MgO- based cements, integrated with results generated more recently as these materials have come back into focus and utilization. In particular, this synthesis of information demonstrates the value of high-quality chemical and analytical data in designing and specifying these materials. The cement consists primarily of hydraulic calcium silicate phases, which are produced in a kiln at elevated temperature to produce "clinker", which is then cooled and inter ground with gypsum. The resulting powder is a hydraulic cement that will hydrate when combined with water, forming a cohesive, strong, and dimensionally stable monolith. Hydrated PC has a high internal pH, generally around 12−13, that holds embedded mild steel reinforcing in a passive state, offering some degree of protection from the corrosive action of aggressive agents such as chlorides In typical usage, PC is blended with sand to form a mortar, or with fine and coarse aggregate to form a concrete, and can also be blended with a variety of "supplementary cementitious materials", including coal fly ash, blast-furnace slag, and other finely divided silicate and alum inosilicate powders, to enhance technical properties, cost, and/or environmental credentials. There is however an ongoing search for alternatives to PC because of its large CO2 emissions footprint, which comprises around 8% of global anthropogenic greenhouse-gas emissions at present.

II. MATERIALS

A. *Ordinary Portland cement*

The cement used in this work is ordinary Portland cement of grade 53 conforming to IS 12269:1987 specifications.

Figure 1: OPC

B. *Fly Ash*

Class F fly ash used in this work and confirms to ASTM C618-12a. The Physical and chemical properties of fly ash.

Figure 2: Fly Ash

C. *Magnesium Oxide*

Magnesium oxide is used as partial replacement of the cement/ fly ash content. Magnesium oxide is an inorganic compound that occurs in nature as the mineral periclase

Figure 3: Magnesium Oxide

D. *Magnesium phosphate*

Magnesium phosphate is used as partial replacement of the cement/ fly ash content. Magnesium phosphate is based on a cementitious system that is different from Portland cement. These can be placed at temperatures as low as 0°C. The material has good bond strength to Portland cement and low permeability.

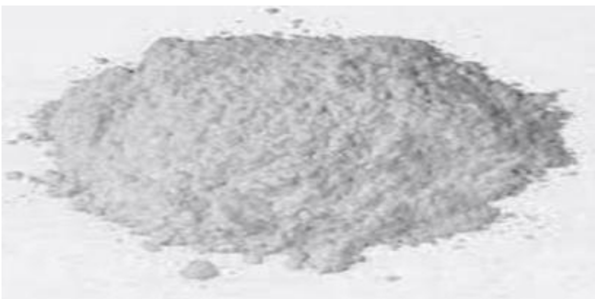

Figure 4: Magnesium Phosphate

E. *Phosphate Tailings*

Phosphate tailings is used as partial replacement of the cement/ fly ash content. Phosphate tailings of grade TS mag very fine powder is used this study as it

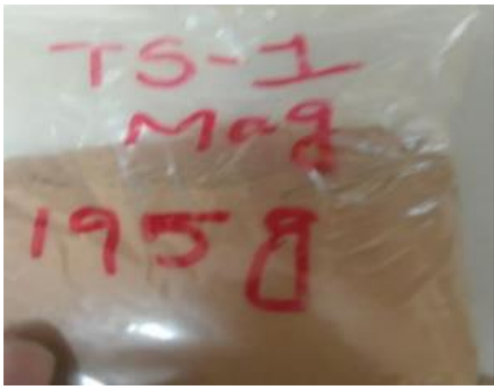

Figure 5: Phosphate Tailings

III. RESULTS & DISCUSSIONS

A. *Tests conducted*

- *Setting time of cement*

The sample must be mixed with the correct amount of water to give a standard consistency. The standard consistency is determined by means of the Vicat apparatus fitted with the plunger, a 10mm diameter blunt-ended, metal cylinder weighing 9.0± 0.5 g. The freshly mixed cement paste is placed in the mould and levelled off with a trowel. The plunger is brought into contact with the surface of the paste and then released. The paste is at the correct consistency when the plunger penetrates to a points 5± 1 mm. from the bottom of the mould. The depth of penetration is shown on the scale. Fresh samples of paste with varying water contents should be tested until the desired consistency is achieved. Normally, a weight of water between 26 and 33 percent of the weight of the dry cement is required to obtain the standard consistency.

Table 1

SL.No	ID Name
1	OPC
2	75C25FA
3	60C40FA
4	65C35FA
5	40C60FA
6	40C40FA16MgO4PT
7	40C50FA10MgPO4

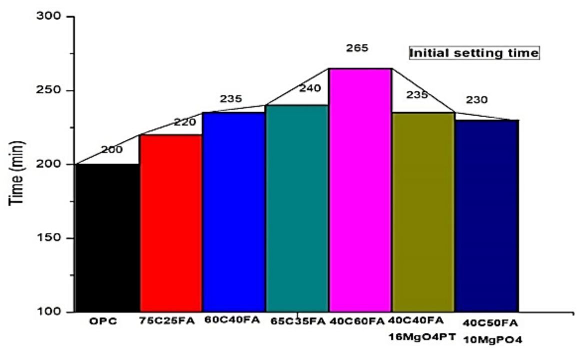

Figure 6: Initial setting time of different mixes

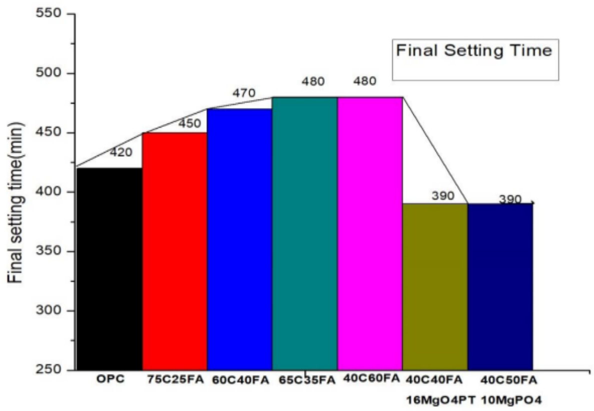

Figure 7: Final setting time with different samples

- *Mix proportions*

Magnesium based cement trial mixes were prepared with cement, fly ash, phosphate tailings, magnesium oxide and magnesium phosphate with cement replaced by 40% and 50% fly ash by weight. Combinations of mixes for casting with fly ash, magnesium oxide, magnesium phosphate and phosphate tailings.

Table 2: Mix proportions

Mix I.D.	Mix Combinations
60C40FA	60%C + 40% F.A.
40C40FA16MgO4PT	40%C + 40% F.A+16MgO+4PT.
40C50FA10MgPO4	40%C + 50% F.A. +10MgPO4.

Firstly, three mixtures (60C40FA, 40C40FA16MgO4PT, and40C50FA10MgPO4) with same water/binder ratios of 0.48was cast.

- *Casting and Curing*

Magnesium based cement mixture was prepared by using a Hobart mixer at controlled laboratory conditions. Preparation time of mortar mixture was 3.5 minutes. Firstly, cement and fly ash is sieved twice to get a homogeneous mix. Secondly, mixture of cement and fly ash, and fine aggregate was mixed for 120 seconds at the low speed. Gradually water was added and mixed for 1 minute at the medium speed. Finally, mixing was performed at high speed for 30 seconds before it is cast into the molds. The aim of applying the high speed mixing was to obtain the homogeneous mix. Mixer used for mixing the ingredients.

- *Hobart mixer used for mixing the ingredients*

Twelve cubes of 50 mm x 50 mm x 50mm, six cubes of 70mm ×70mm × 70mm, and 100 mm height, three prism of size 40mm x 40mm x 160 mm are casted. The specimens are given a proper finishing ensuring uniformity and perfect appearance. The specimens after casting are demoulded after the interval of 24 hours and kept immersed in water for curing and tested at the end of 7 and 28 days. The cubes, cylinders and prisms cast and cured for the determination of basic properties.

Figure 8: Casting and Curing

B. Test Program

- *Compressive strength:*

According to IS 10086:1982, Compression test is carried out on cubic specimens of size 50mm x 50mm x 50mm at 3,7 and 28 days. The average reading of three cubes is recorded as the strength at respective ages. The test is carried out on a compression testing machine of 3000kN capacity. The load is applied at the rate 583 N/sec which is in accordance with the IS code. The ultimate strength is recorded after the specimens failed to resist any more loads. The values are recorded and compressive strength is calculated using the expression below. The results obtained for the tested three specimens and the average value is reported as the compressive strength of at 7 and 28 days

- *Flexural strength*

The test is performed with the prism of size 40 x 40 x 160 mm. The prism is loaded at centre of span. It induces equal reaction same as the loading at both of the supports. The load is applied at the rate 0.1 N/sec. As loading increases, crack occurs at middle of the prism, the maximum tensile stress reached called "modulus of rupture" f_{bt} is computed from the standard flexure formula

$$f_{bt} = \frac{3PL}{2bd^2}$$

Where, P- load at failure
L- Prism span between supports
d - Depth of Beam
b –Width of Beam

IV. CONCLUSIONS

In this study it is attempted to eliminate the major drawback of using fly ash in cement. By using magnesium based admixtures it is attempted to overcome delayed setting time and low early age strength development in fly ash cement. Further, the reaction of cementitious material with sea water is studied. Initial and final setting, mechanical properties tests are conducted to assess the efficiency of magnesium based admixtures in this study.

The following conclusions are made

- Magnesium based admixtures decreased the initial and final setting time of fly ash cements.
- Compressive strength of magnesium based mixes are found to be very low. This may be attributed to the heavy leaching in the specimens.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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