STUDY ON MAGNESIUM SILICATE HYDRATE CEMENT BLENDED WITH PARTIAL REPLACEMENT OF GGBFS

Sathyanathan V1, Dr. Padmanaban I2
1(Structural Engineering, Sri Krishna College of Technology, Coimbatore, India, sathyaaav@gmail.com)
2(Department of civil Engineering, Sri Krishna College of Technology, Coimbatore, India, padmanaban.i@skct.edu.in)

Abstract—One of the main ingredients used for the production of concrete is the Ordinary Portland Cement (OPC). Carbon-dioxide (CO2) gas which is a major contributor in green house effect and the global warming, is produced in the production of cement, hence it is needed either to search for another material or partially replace cement by some other material. In recent years ground granulated blast furnace slag (GGBS) when replaced with cement has emerged as a major alternative to conventional concrete and has rapidly drawn the industry attention due to its cement savings, energy savings, and cost savings, environmental and socio-economic benefits. Magnesium silicate hydrate (M-S-H) cement is formed by the reaction of brucite with amorphous silica during sulphate attack in concrete and M-S-H is therefore regarded as having limited cementing properties. The aim of this work was to form M-S-H pastes, characterise the hydration reactions and assess the resulting properties. It is shown that M-S-H pastes can be prepared by reacting magnesium oxide (MgO) and silica fume (SF) at low water to solid ratio using sodium hexametaphosphate (NaHMP) as a dispersant.

Keywords— M-S-H Cement, GGBFS, Hardened properties, Mechanical properties.

1. INTRODUCTION

Concrete is an absolutely essential component of construction materials used in infrastructure and most buildings. Despite its versatility in construction, it is known to have several limitations. It produce heat of hydration and CO2 emission. It is weak in tension, has limited ductility and little resistance to cracking. Based on the continuous research carried out around the globe, various modifications have been made from time to time to overcome the deficiencies of cement concrete. However, concrete is sometimes exposed to substances that can attack it and cause deterioration.

In order to reduce the heat of hydration and CO2 emission GGBS are blended with Magnesium-silicate-hydrate (M-S-H) cement. GGBS a by-product of iron manufacture, is a glassy, non-metallic granular material which exhibits cementitious properties on its own while others do so in the presence of Portland cement and calcium sulphate which are activators. Thus, GGBS acts as pozzolans and is therefore combined with Portland cement has more of smaller gel pores and fewer larger capillary pores than that of normal Portland cement which consequently results in lower permeability and hence greater durability.

Magnesium silicate hydrate (M-S-H) gel is formed by the reaction of brucite with amorphous silica during sulphate attack in concrete and M-S-H is therefore regarded as having limited cementing properties. The aim of this work was to form M-S-H pastes, characterise the hydration reactions and assess the resulting properties. It is shown that M-S-H pastes can be prepared by reacting magnesium oxide (MgO) and silica fume (SF) at low water to solid ratio using sodium hexametaphosphate (NaHMP) as a dispersant.

2. AIM AND OBJECTIVES

The primary objective of the work is to experimentally study the effect of the replacement of M-S-H cement with Ground Granulated blast furnace slag (GGBFS) for M30 mixtures of concrete to obtain the optimum percentage of replacement of M-S-H cement in concrete. The main objective is to study the effect of M-S-H concrete by workability and compressive strength of concrete at the age of 7, 14 and 28 days.

3. MATERIAL PROPERTIES

The properties of materials used in the concrete are discussed below:

A. M-S-H Cement
Magnesium silicate hydrate cement can be prepared by reacting magnesium oxide (MgO) and silica fume (SF) using sodium hexametaphosphate (NaHMP) as a dispersant.

B. Fine Aggregate
The sand sieved through 4.75 mm sieve is used having specific gravity of 2.74. The fine aggregates belonged to grading zone III.

C. Coarse Aggregate
Locally available coarse aggregate having the maximum size of 12.5 mm is used. The specific gravity of coarse aggregate that was taken was 2.74.

D. Silica Fume
Silica fume is used as a replacement for cement. The specific gravity of silica fume was taken as 2.22.
E. Water
    Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Potable water available in the laboratory was used.

F. Magnesium oxide
    Magnesium oxide is used as a replacement for cement. The specific gravity of magnesium oxide was taken as 2.96.

4. EXPERIMENTAL INVESTIGATION

In this investigation the hardened properties of M-S-H concrete for various replacement percentages of fly ash as partial replacement of M-S-H cement.

A. Mix proportions
    Recommended guidelines of concrete mix design using Indian Standard Code (IS:10262-2009) the mix proportions of concrete were prepared for M30 grade.

B. Hardened properties of concrete

In order to find the mechanical properties Compressive strength tests were conducted at 28 days of cube (150 X 150 X 150 mm) specimens. For each combination, two specimens were tested. In order to find the split tensile strength of concrete 28 days of cylinder (150 X 300 mm) specimen are cast. For each combination, two specimens were tested.

The following tables show the Compressive strength of Concrete with GGBFS:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Percentage replacement of GGBFS</th>
<th>Split Tensile Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7 days (N/mm²)</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>2.31</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>2.62</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>2.84</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>2.73</td>
</tr>
</tbody>
</table>

The following graph shows the variation in the Compressive strength of concrete with GGBFS:

The following table shows the split tensile strength of concrete with GGBFS:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Percentage replacement of GGBFS</th>
<th>Compressive Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>7 days (N/mm²)</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
<td>20.57</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>25.49</td>
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<tr>
<td>3</td>
<td>40</td>
<td>29.54</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>27.32</td>
</tr>
</tbody>
</table>
The following graph shows the variation in the split tensile strength of MKPC concrete with Fly ash:

![Graph showing variation in split tensile strength of MKPC concrete with Fly ash](image)

**Fig 4. Chart for split tensile strength of MKPC concrete with fly ash**

5. CONCLUSION

This paper has described the variation of compressive strength, and tensile strength, also workability and durability of different specimens having different percentage of GGBFS as a partial replacement of M-S-H cement. From the results following conclusions are concluded:

- Addition of 1wt.% of NaHMP reduces the water required for MgO/SF systems, which in turn improves the compressive strength dramatically.
- The workability of the concrete increases with the increase in the replacement levels.
- When GGBFS is added to the concrete, it increases the hardened properties of concrete.
- From results of test conducted on Compressive strength and Split tensile strength, we can conclude that the addition of GGBFS by 40% increases strength with increases in age of concrete and obtain high early strength.
- The most important aspect followed in the project is to reduce the environmental hazards.

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REFERENCES


