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Experimental study on Magnesium Silicate Hydrate Cement Blended with Partial Replacement of GGBS

PADMANABAN I AND SATHYANATHAN V
Sri Krishna College of Technology, Coimbatore, Tamil Nadu, INDIA
***Email:** sathyaakv@gmail.com, 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 (CO_2) gas which is a major contributor in greenhouse 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 concrete 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, characterize 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. The hardened concrete of various mix of 20%,30%,40%and 50% was performed. The flexural behavior will be monitor in beam by casting it with optimum percentage mix of Magnesium silicate hydrate cement.

***Keywords:** M-S-H Cement, GGBS, Material Properties, Hardened Concrete 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 CO_2 emission. It is weak in tension, haslimited 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 CO_2 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.

Magnesium-silicate-hydrate (M-S-H) gels form as a result of sulphate attack of concrete in the presence of magnesium ions. M-S-H is present during the later stages of sulphate attack and hence M-S-H gels are generally believed to be of limited strength. As a result, M-S-H gel has received little attention as a potential cementing phase.

2. Material Properties

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

2.1 M-S-H Cement

Magnesium silicate hydrate cement can be prepared by reacting magnesium oxide (MgO) and silica fume (SF) using sodium hexametaphospate (NaHMP) as a dispersant.

2.2 Fine Aggregate

The sand sieved through 4.75 mm sieve is used having specific gravity of 2.6. The fine aggregates belonged to grading zone I.

2.3 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 2.67

2.4 Silica Fume

Silica fume is used as a replacement for cement. The specific gravity of silica fume was taken as 2.22.

2.5 Magnesium oxide

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

2.6 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.

3. Experimental Investigation

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

3.1 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.
3.2 Hardened properties of Concrete:

In order to find the mechanical properties Compressive strength tests were conducted at 7days and 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 for 7 days and 28 days of cylinder (150 X 300 mm) specimen are cast. For each combination, two specimens were tested.

3.2.1 Compressive strength test

Compressive strength of various mix proportion of 20%, 30%, 40% and 50% was calculated and described below.

Figure 1.*Compressive strength test*

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

Table 1.*Compressive strength of concrete with GGBS*

S. No	Percentage replacement of GGBS	Compressive Strength 7 days (N/mm^2)	Compressive Strength 28 days (N/mm^2)
1	20	20.5	27.4
2	30	25.4	32.7
3	40	29.5	38.2
4	50	27.3	36.7

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

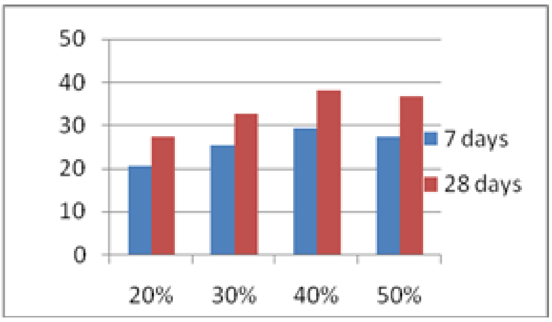

Figure 2.*Chart for compressive strength of concrete with GGBS*

3.2.2 Split Tensile Strength test

The split tensile strength of various mix proportion of 20%, 30%, 40% and 50% was calculated and described below.

Figure 3.*Split tensile strength*

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

Table 3.*Split tensile strength of concrete with GGBS*

S.No	Percentage replacement of GGBS	Split Tensile Strength 7 days (N/mm^2)	28 days (N/mm^2)
1	20	2.31	3.18
2	30	2.62	3.27
3	40	2.86	3.51
4	50	2.72	3.34

The following graph shows the variation in the split tensile strength of concrete with GGBS:

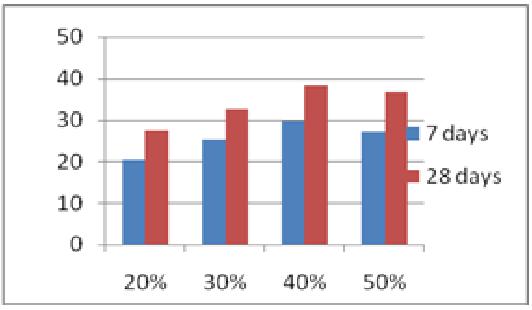

Figure 4.*Chart for split tensile strength of concrete with GGBS*

3.2.3 Flexural Strength behavior test

Based on the result obtained from compressive strength test the optimum value attained at 40% replacement. So for that result the flexural strength of beam was found and described below.

The following table shows the flexural strength of concrete with GGBS.

Table 4.*Flexural strength of concrete with GGBS*

Nominal Mix		40% Replacement	
Load (KN)	Deflection (mm)	Load (KN)	Deflection (mm)
0	0	0	0
10	0.14	10	0.12
20	1.21	20	1.23
30	2.13	30	2.37
40	2.87	40	3.06
50	3.61	50	3.67
60	4.16	60	3.94
55	8.22	70	4.21
		65	7.6

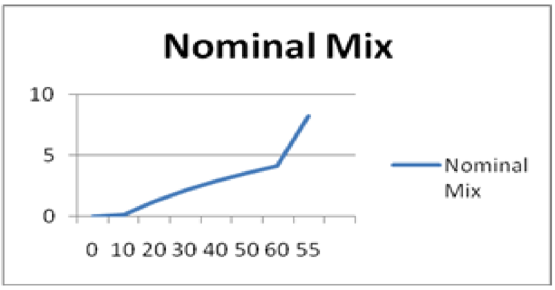

Figure 5.*Chart for flexural strength of nominal mix concrete*

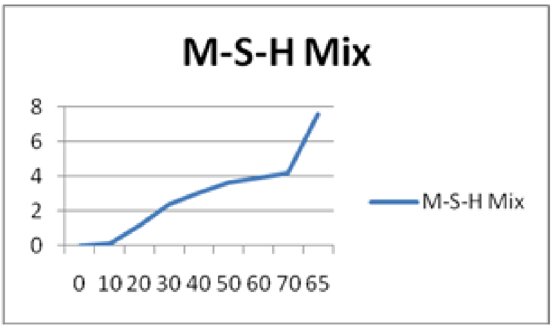

Figure 6.*Chart for flexural strength of M-S-H concrete with GGBS*

4. Conclusion

This paper has described the variation of compressive strength, and tensile strength, also workability and durability of different specimens having different percentage of GGBS 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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