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Compressive Strength Performance Of Slag-Based Geopolymer Mortar As A Sustainable Construction Material

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ABSTRACT
The high environmental cost associated with the production of Ordinary Portland Cement (OPC), particularly its contribution to carbon dioxide emissions, has driven the search for alternative binders in construction. This study evaluates the compressive strength characteristics of slag-based geo-polymer mortar as a sustainable substitute for conventional cement mortar. Ground granulated blast furnace slag (GGBFS) was utilized as the primary binder and activated using a combination of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3). The influence of alkaline activator concentration (8M, 10M, and 12M), curing regime (ambient and elevated temperature), and curing duration (7, 14, and 28 days) was investigated. The results revealed a steady improvement in compressive strength with increasing curing age and activator concentration. The maximum strength of 42.70 MPa was achieved under oven curing at 28 days, which significantly exceeded that of OPC mortar. The findings indicate that slag-based geo-polymer mortar is a viable and environmentally friendly alternative for structural applications.
Keywords: Geo-polymer mortar, slag, compressive strength, sustainable materials, alkaline activation.

INTRODUCTION

The construction sector remains one of the major contributors to global greenhouse gas emissions, largely due to the widespread use of Ordinary Portland Cement (OPC). The production process of OPC is energy-intensive and releases significant amounts of carbon dioxide into the atmosphere. Consequently, there is increasing interest in the development of sustainable and low-carbon construction materials.

Geo-polymer technology has emerged as a promising alternative, utilizing industrial by-products such as slag and fly ash to produce cementitious materials with reduced environmental impact. Among these, slag-based geo-polymers have gained attention due to their rapid strength development and enhanced durability. However, their performance is strongly influenced by parameters such as alkaline activator concentration and curing conditions. This study aims to evaluate these factors and assess the suitability of slag-based geo-polymer mortar for practical construction use.

MATERIALS AND METHOS

Materials

The materials used in this study include ground granulated blast furnace slag (GGBFS) as the primary binder, river sand as fine aggregate, sodium hydroxide (NaOH), sodium silicate (Na_2SiO_3) as alkaline activators, and potable water for mixing.

1. Mix Proportions

A constant sand-to-binder ratio of 2:1 was adopted for all mixes. Sodium hydroxide solutions with molar concentrations of 8M, 10M, and 12M were prepared and used in combination with sodium silicate.

2. Specimen Preparation

Mortar specimens of dimensions 50 mm × 50 mm × 50 mm were cast in steel molds. Proper compaction was ensured to eliminate air voids, and the samples were allowed to set before curing.

3. Curing Regimes

Two curing conditions were considered:

Ambient curing at room temperature

Oven curing at 60°C

4. Compressive Strength Testing

Compressive strength tests were conducted at curing ages of 7, 14, and 28 days in accordance with standard procedures (ASTM C109).

RESULS AND DISCUSSION

1. Strength Development with Age

The compressive strength of all geo-polymer mixes increased progressively with curing time. At 28 days, strengths of 30.13 MPa, 35.17 MPa, and 37.90 MPa were recorded for mixes with 8M, 10M, and 12M NaOH concentrations, respectively. The oven-cured mix achieved the highest strength of 42.70 MPa. This trend indicates that the geo-polymerization process continues with time, leading to improved material performance.

2. Effect of Alkaline Activator Concentration

An increase in NaOH molarity resulted in a corresponding increase in compressive strength. This can be attributed to the enhanced dissolution of aluminosilicate materials at higher alkalinity, which promotes stronger polymeric bonding within the matrix.

3. Influence of Curing Conditions

Samples subjected to elevated temperature curing exhibited superior strength compared to those cured under ambient conditions. The application of heat accelerates the chemical reactions involved in geo-polymer formation, leading to a denser and more compact structure. Nevertheless, ambient curing still produced satisfactory strength levels, suggesting its suitability for practical field applications.

4. Comparison with OPC Mortar

The compressive strength of OPC mortar at 28 days was recorded as 28.80 MPa, which is lower than that of all geo-polymer mixes. The best-performing geo-polymer sample demonstrated approximately 48% higher strength than OPC, highlighting its potential as a superior alternative.

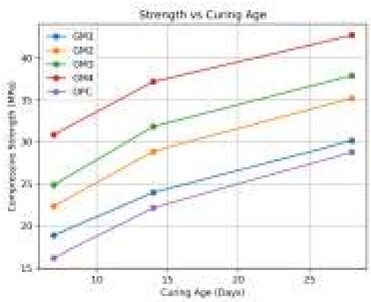


Figure 1: Compressive Strength Vs Curing Age

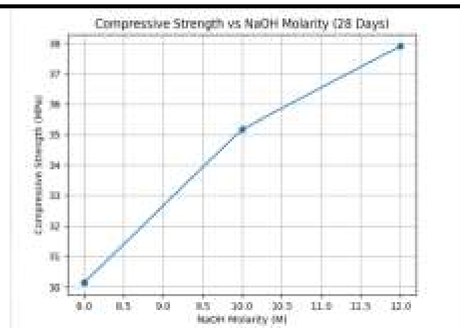
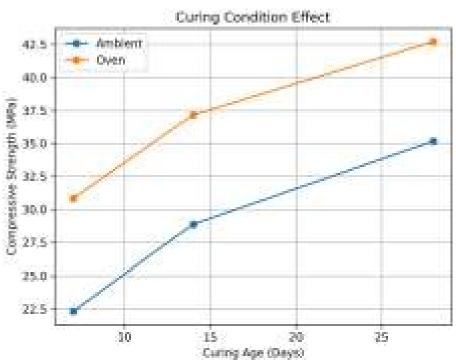


Figure 2: Compressive Strength vs NaOH Molarity (28 days)



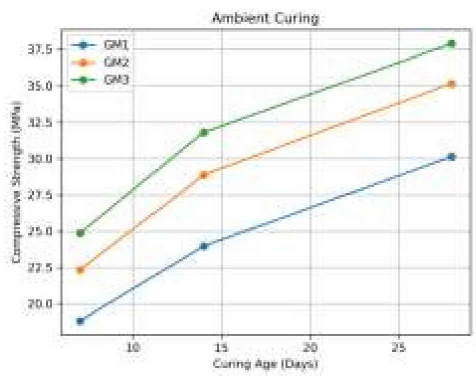


Figure 3: Strength Development under Ambient Curing

CONCLUSION

The experimental results confirm that slag-based geo-polymer mortar exhibits excellent compressive strength and can serve as a sustainable replacement for conventional OPC mortar. Strength development is influenced by curing duration, activator concentration, and curing temperature. The superior performance and reduced environmental impact make geo-polymer mortar a suitable material for modern construction practices.

RECOMMENDATIONS

Optimal performance can be achieved using NaOH concentrations between 10M and 12M.

Heat curing is recommended for precast applications requiring high early strength

Ambient curing can be adopted for in-situ construction.

Increased utilization of industrial by-products such as slag should be encouraged to promote sustainability.

REFERENCES

ASTM C109/C109M (2020). Standard Test Method for Compressive Strength of Hydraulic Cement Mortars. West Conshohocken, PA: ASTM International

Davidovits, J. (1999). Chemistry of geopolymeric systems, terminology. Proceedings of the 2nd International Conference on Geo-polymer, Saint-Quentin, France, pp. 9–40.

Davidovits, J. (2008). Geopolymer Chemistry and Applications (3rd ed.). Saint-Quentin, France: Institute Géopolymère.

Duxson, P., Fernández-Jiménez, A., Provis, J.L., Lukey, G.C., Palomo, A. and van Deventer, J.S.J. (2007). Geopolymer technology: the current state of the art. *Journal of Materials Science*, 42(9), pp. 2917–2933.

Hardjito, D. and Rangan, B.V. (2005). Development and Properties of Low-Calcium Fly Ash-Based Geo-polymer Concrete. Perth: Curtin University of Technology.

Mehta, P.K. and Monteiro, P.J.M. (2014). *Concrete: Microstructure, Properties, and Materials* (4th ed.). New York: McGraw-Hill.

Neville, A.M. (2011). Properties of Concrete (5th ed.). Harlow: Pearson Education Limited.

Provis, J.L. and van Deventer, J.S.J. (2009). *Geo-polymers: Structure, Processing. Properties and Industrial Applications*. Cambridge: Wood head Publishing.

Turner, L.K. and Collins, F.G. (2013). Carbon dioxide equivalent (CO_2-e) emissions: A comparison between geo-polymer and OPC cement concrete. Construction and Building Materials, 43, pp. 125–130.

Van Jaarsveld, J.G.S., van Deventer, J.S.J. and Lukey, G.C. (2003). The effect of composition and temperature on the properties of fly ash- and kaolinite-based geo-polymers. *Chemical Engineering Journal*, 89(1–3), pp. 63–73.