Strength Parameters of Alkali Activated High Volume Fly Ash Concrete

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Abstract- In the modern world, the construction field is facing immense strain to uncover replacements for conventional material for construction. Fewer than 57.93 percentage of the total amount of fly ash that is generated throughout the country has been reused in the initially occurring half of 2020–2021. The remaining material had been disposed of in landfills, unleashing potentially dangerous substances onto the vicinity. Throughout the globe, plenty of creative approaches are being developed with the objective of boosting the average quantity of fly ash utilized during construction. The utilization of high volume fly ash concrete and geo polymer are two of the most intriguing sectors. This investigation incorporates the research that many professionals from across the world have done regarding each of these topics. Their efforts paid off, generating concrete with minimal heat build up during the process of hydration, minimal drooping, increased adaptability, and a moderate density using a significant amount of fly ash. The results of using geo polymer concrete in construction included exceptional durability, acidic barriers, and a high fly ash content—a property that was similar to that of RCC components. Moreover, it is expected that a project-specific strategy prescription would be produced.

Keywords: Fly ash, Geo polymer, High volume concrete, and Alkali-activated concrete

I. INTRODUCTION

The heightened requirement to satisfy the demands of society, alongside rising commodity prices and way of life, have all been influencing towards the building process profession's extremely fast spike. Because of a direct consequence of this swift growth, resources from nature are being devoured more and more frequently, and this is drastically alleviatingthem lacking any means for restoring them as well. As a consequent consequence, people mainly characterize the assetsthat remain immediately following the flourishing regarding an entire neighborhood considered rubbish. The team of country's citizens have become more concentrated around the ideologies of 3Rs . The philosophy of repurposing is assisting the building services sector come up with a range of suggestions that replace standard manners consisting of as paintwork & concrete installation. The 3 greatest cutting-edge methods involve the use of incorporated cements and mortars employing mountainous sands as opposed to riverbed sand, as well as utilising fly ash as the substitute of cement on proportion. A greater number of individuals have been starting recognising such options through the course of the pastten decades. Plenty of individuals from every corner of this globe are carrying out investigation in order to create new materials that can be utilised within the framework existing building components which have no impact on ecosystems. Proposals that include employing fly ash in lieu of cement & reclaimed gravel alternatively for coarse rocks have been put into practice. Numerous research projects are at the moment being carried out with the objective to come up with a more durable and competent outcome that is capable of competing alongside ordinary asphalt along with other supplies. Since our building the business sector continues to grow, so does its detrimental effect on the environment. intensified cement, for instance, contributes to higher production rates. It has become widely acknowledged that in relation to every metric tonnes of cement delivered, a comparable proportion of greenhouse gases gets released onto the natural world.

II. LITERATURE REVIEW

Song X. J., et al, (2005) investigated the durability property of geo polymer concrete exposed to sulphuric acid corrosion. It was concluded that GPC is highly resistant to sulphuric acid; in terms of a very low mass loss, less than 3%. Moreover, Geo polymer cubes were structurally intact and still had substantial load capacity even though the entire section had been neutralized by sulphuric acid.

Palomo et.al (2004) investigated the mechanical characteristics of FA based GPC concrete. It was found that the characteristics of the material were mostly determined by curing methods especially the curing time and curing

temperature. Their study also reported some limited number of tests carried out on possible use of GPC concrete for the production of pre stressed sleeper specimens.

Bakharev, et al., (2003) investigated the durability of alkali-activated slag(AAS) concrete exposed to sulphate attack. AAS concrete was immersed in 5%sodium, 5%magnesium and 5% sodium + magnesium sulphate solution. The main parameters studied were the compressive strength, products of degradation, and micro structural changes. It was found that in AAS concrete the material prepared using sodium hydroxide had the best performance due to its stable cross-linked alumina silicate polymer structure.

Douglas, et al., (1992) reported that the changes in dynamic modulus of elasticity, pulse velocity, weight and length of sodium silicate-activated slag cement concrete after 120 days of immersion in 5% sodium sulphate solutions. They noticed that the changes are even smaller than those in the controlled specimens immersed in lime-saturated water.

III. METHODOLOGY

From the literature study, it is found that high volume fly ash concrete exhibited decrease in strength, low erosion resistant and also geo polymer concrete exhibited high strength, high acid resistance, and similar behaviour to RC elements. The objective of the project is to improve high volume fly ash concrete by alkali activation. The alkali activation is carried out through solution of sodium hydroxide and sodium silicate. The behaviour of HVFA concrete under different strength of sodium hydroxide solution with constant fly ash

replacement, constant sodium hydroxide and sodium silicate ratio. The strength of sodium hydroxide solution which is to used in the future work are 6M, 12M, and 18M. The constant fly ash replacement, constant sodium hydroxide and sodium silicate ratio were obtained from the previous works done. Design mix calculation will be made to obtain target strength of30MPa.The water cement ratio required for the design mix calculation will be obtained through consistency test. Initially trial will be casted to obtain the correct mix ratio. Then the replacement of cement by fly ash will be made in that mix ratio by volume. After replacement the design mix has to be revised. The alkali activator solution of different strength is to be added to the mix ratio with fly ash replaced. Then the setting time of the new design mix is to be identified. The compressive strength and flexure strength of alkali activated high volume fly Sash concrete is compared with that of control mix. Then based on the results obtained from the above comparison, beam element is casted. The behaviour of the beam element casted using conventional concrete, high volume fly ash concrete and alkali activated high volume fly ash concrete.

IV. MATERIALS APPLIED

A. *Cement*

Ordinary Portland Cement (OPC) of grade 53
Initial setting time : 26 minutes
final setting time : 7 hrs

B. *Coarse Aggregate*

Grade : 10 mm to 20 mm
Specific Gravity : 2.64
Water absorption : 0.5%

C. *Fine Aggregate*

Source : Local source
Zone : III

D. *Fly Ash*

Source : Class F Fly ash

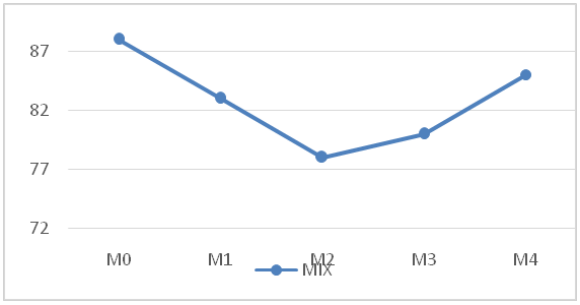
E. *Alkaline Activator Solution*

The alkaline activator solution (AAS) plays an important role in Geo polymer concrete. The AAS is the combination of sodium hydroxide and sodium silicate solutions. The concentration of NaOH solution can vary in the range between 8M to 16M; in this study, 8M, 12M, 16M is considered. Preparation of NaOH for 12M is 12x40 (Molecular weight) = 480gms should dissolve in 1 litter of water. After mixing the NaOH flakes in water its molecular weight reduces to 361gms for 12 Molarity. For 12M NaOH solution, for 1 litter of water we require 36.1% of NaOH flakes and 63.9% of water. The solution must be prepared at least 24 hours before to use.

V. EXPERIMENTAL INVESTIGATION

A. Workability Test

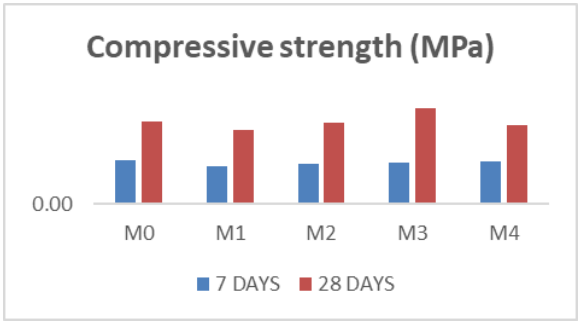
Workability of the concrete has to be determined in order to determine its ability to fill congested spaces and form the required shapes. Workability of conventional and high volume fly ash concrete was determined at different NaOH concentration level.



Variation in slump for design mix proportion

B. Compressive Strength Test Of Concrete

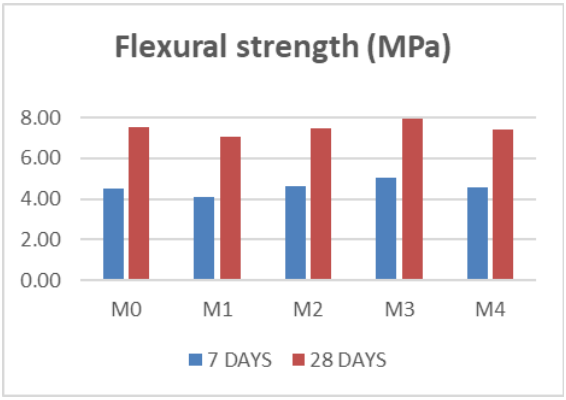
Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen. To obtain optimum compressive strength in concrete, a design mix proportion has been designed. Compressive strength of different batch of concrete was tested for 7 days & 28 days, through compressive testing machine.



Variation in compressive strength for design mix

C. Flexural Strength Test Of Concrete

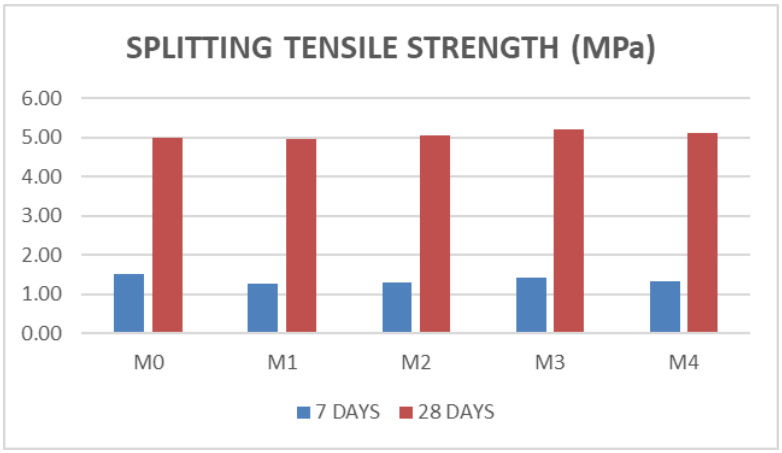
In order to determine the effectiveness of the high volume fly ash concrete in practical application, it has to be tested for any one of the structural element.



Variation in flexural strength for design mix

D. Splitting Tensile Strength Test

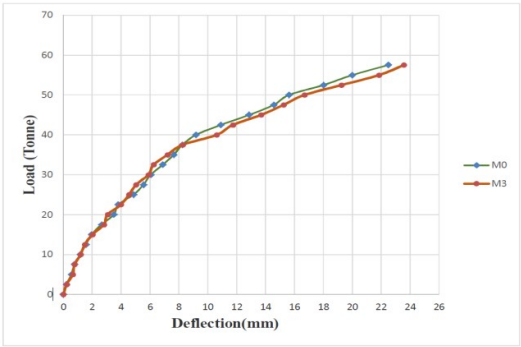
The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.



Variation in splitting tensile strength for design mix

E. Flexural Behaviour Of RC Beam

The beam which is casted as per design calculation is loaded into the loading frame for testing after 28 days curing. The two point loading is done to determine the deflection of the beam. The loading carried out until the beam fails.



Comparison of deflection of RC beam between mix M0 and M3

VI. CONCLUSION REMARKS

Workability of the concrete increases with addition of high volume of fly ash. There is increase in compressive strength of high volume fly ash concrete upon addition of alkali activator solution. However increase in molarity of sodium hydroxide solution results in decrease in strength of concrete. Mix with 10 M NaOH solution has strength higher than that of conventional concrete. In spite of increase in compressive strength, there is an only slight change in flexural strength of concrete. There is no significant change in tensile strength of high volume fly ash concrete with or without alkali activator. Behaviour of high volume fly ash concrete RC element with alkali activator solution acts similar to that conventional concrete RC element.

REFERENCES

[1] Obada Kayali, M.Sharfuddin Ahmed (2013), "Assessment of high volume replacement fly ash concrete – Concept of performance index", Construction and Building Materials, Vol. 39, pp.7176.
[2] Palomo, A.; Fernandez-Jimenez, A; Criado, M. (2004). "Geo polymers: One Only Chemical Basis, Some Different Microstructures", Materials de Construcción,Vol. 54 (275),pp. 77-91
[3] Prabir Kumar Sarker, (2008), "Analysis of geo polymer concrete columns", Materials and Structures, Vol: 42, Issue: 6, pp. 715-724.
[4] Rangan, B. V, and Hardijto, D, [2005], "Development and properties oflow calcium fly ash based geo polymer concrete", Research report GC-1,Faculty of Engineering, Curtin University of Technology, Perth, Australia.
[5] RawazKurda, Jorge de Brito, Jose D. Silvestre(2017), "influence of recycled aggregates and high volume contents of fly ash on concrete fresh properties", Cement and Concrete Composites,Vol 84,pp.198 – 213.

[6] Shuguang Hu, Hongxi Wang, Gaozhan Zhang and Qingjun Ding, (2008),"Bonding and abrasion resistance of geopolymeric repair material made with steel slag", Cement and Concrete Composites, Vol.30, Issue 3,pp,239-244.
[7] Stefanus A Kristiawan, and M Taib M Aditya (2015), "Effect of high volume fly ash on shrinkage of self-compacting concrete", The 5thInternational Conference of Euro Asia Civil Engineering Forum (EACEF-5), pp.705-712.
[8] Song X. J., M. Marosszeky, M. Brungs, R. Munn (2005), "Durability offly ash based Geo polymer concrete against sulphuric acid attack",10DBMC International Conference on Durability of Building Materials and Components LYON [France], pp 369-375.
[9] Suresh .G. Patil, Manojkumar(2013), "Factors Influencing CompressiveStrength of Geopolymer Concrete", International Journal of Research in Engineering and Technology, IC-RICE Conference issue,pp.372 – 375
[10] Van Jaarsveld, J. G. S., Van Deventer, J. S. J. and Lorenzen, L., (1997),"The potential use of geopolymeric materials to immobilize toxic metals: Part I. Theory and applications" Minerals Engineering, Vol.10,Issue.7,pp.659-669.
[11] Van Jaarsveld, J.G.S., Van Deventer, J.S.J. and Schwartzman, A.,(1999), "The potential use of geo polymeric materials to immobilize toxic metals: Part II. Material and leaching characteristics", Minerals Engineering, Vol. 12, no. 1, pp. 75-91.
[12] Yasser Khodair, Bhagiratha Bommareddy (2017), "Self-Consolidating Concrete using recycled concrete aggregate and high volume of fly ash and slag", Construction and Building Materials, Vol.153, pp.307-3
[13] IS 8112: 2013. Specification for 43 grade ordinary Portland cement.
[14] IS 2386(1):1963. Methods of test of aggregates for concrete.
[15] IS 10262:2009. Guidelines for concrete mix design proportioning