A Review on Study of Partial Replacement of Cement by Metakaolin and GGBS on High Strength Concrete

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Abstract – *In Construction field, Concrete is one of the most important composite material. Among the types of concrete, High strength concrete have more benefits when compared to normal concrete. The main benefits of high strength concrete are for improving durability properties, reducing self weight of structures and creep. The present study reviews the results of various experimental investigations conducted by various authors to examine the effect of Metakaolin and GGBS on high strength concrete by partially replacing cement by different percentage levels. The optimum percentages of metakaolin and GGBS replacement as the cementitious materials improves durability, better workability and of high compressive strength.*

Key Words: *Ground Granulated Blast Furnace Slag, High strength concrete, Metakaolin.*

1. INTRODUCTION

High strength concrete (HSC) may be defined as concrete with specified characteristic cube strength above 40 Mpa. The applications of HSC are in making high rise buildings, columns for tall buildings, bridges, aqueducts and other highway structures. 43 grade or 53 grade of OPC can be used in the production of HSC. It increases the modulus of elasticity of concrete and reduces creep that control short term and long term deflections and improves workability. Admixtures are used in concrete in order to improve the quality of concrete during the operations. Mineral admixtures like Ground granulated blast furnace slag (GGBS), metakaolin (MK) which possess certain characteristics through which they influence the properties of concrete in different manner. Ground-granulated blast furnace slag is highly cementitious material and high in CSH (calcium silicate hydrates). They improves the strength, durability of the concrete. Metakaolin is a pozzolan which is used as a cementitious material in concrete. Particle size of metakaolin is small when compared to cement particles.

High strength concrete is a type of High performance concrete with specified compressive strength above 40 N/mm^2. High strength concretes can be made using carefully by using selected cementitious materials, sand, admixtures with low water cement ratios.

1.1 Advantages of High strength concrete

- Reduced maintenance and repair.
- Reduces the size of members.
- Reduce the cost of formworks.
- Improves long term durability of structures.
- Increases rental space.
- High compressive strength.

1.2 Disadvantages of High strength concrete

- Requires expertise in selection of ingredients.
- High–vibration is required for better compaction.
- High–strength concrete requires proper proportioning and careful material selection.
- Requires special curing and installation.
- Use of high–strength concrete may provide slender elements but they show low stiffness and it may cause stability problems.

2. LITERATURE REVIEW

S. Mounika et.al, (2016) carried out the study involving the replacement of cement with ground granulated blast furnace slag, replacement of cement with Metakaolin and also replacement of cement with ground granulated blast furnace slag & Metakaolin using different percentages of supplementary materials. 15% replacement of the cement by Metakaolin resulted in satisfactory mean target compressive strength and workability and durability and 40% replacement of cement by GGBS results in satisfactory target strength for M-80 grade concrete with glenieum B233 as super plasticizer. In this study, the strength properties were studied at 7 days and 28 days. From their experimental investigation, addition of Metakaolin and GGBS results in increased strength properties. Glenium B233 increases the workability of concrete by reducing the water content. The increase in compressive strength for metakaolin is 3% greater than GGBS and combination of metakaolin and GGBS is getting 3% more strength compared with Metakaolin. From the study it can be concluded that combination of GGBS and Metakaolin can be used as a alternate material for cement and safe to environment.

P. Dinakar et.al, (2013) conducted an experimental investigation for studying the effect of incorporating metakaolin (MK) on the mechanical and durability properties of high strength concrete for a constant water/binder ratio of 0.3. Cement is replaced at 5, 10 and 15 % for designed target strength of 90 MPa and slump of 100 ± 25 mm. From the test results, it was found that 10 % replacement level was the optimum level in terms of compressive strength. Beyond 10 % replacement levels, the strength was decreased but remained higher than the values of control mix. Compressive strength of 106 MPa was achieved at 10 % replacement level . Splitting tensile strength and elastic modulus values showed the same trend. In durability tests MK concretes shows high resistance and the resistance increases as the percentage of metakaolin increases. This investigation has shown that metakaolin has the potential to produce high strength concrete.

G. V. Rama Rao et.al (2014) conducted study in which cement is replaced with 0, 10, 15, 20, 25 and 30% of Metakaolin to observe the compressive strength. Workability of concrete decreases with increase in metakaolin content. Compressive, flexural and split tensile strength of conventional and concrete with MK as partial replacement are compared and observed that strength of conventional concrete is slightly lower than the concrete with metakaolin. The strength properties increased at 15% replacement. The stress strain relationship is similar to the conventional concrete and MKC behavior at room temperature. The results conclude that, the use of metakaolin concrete has improved the performance of concrete at various conditions.

S. Immanuel Dorai et.al, (2019) conducted the study involving hybridization technique to enhance the performance of HSC. The mixing of different fibers having different properties comes under hybridisation technique. The hybrid fibers used in the present study are polypropylene fibers and hooked end steel fibers in the presence of metakaolin for 70 Mpa grade concrete. HSC specimens with different fiber proportions of 0.25%, 0.50 %, 1% are casted for testing mechanical and durability properties. At 15% of metakaolin as cement replacement and total hybrid fiber of 1 % has an increase of 24% compressive strength, the tensile strength at an increase of 12 % and durability properties are high when compared to conventional concrete. From the present investigation, the steel and polypropylene fibers are used in addition to cement improves the mechanical properties of HSC.

Sreejith Haridas et.al, (2017) conducted study on M60 concrete by partially replacing cement by GGBS at 30, 40 and 50%. Properties of concrete were studied with OPC for control mix and partial replacement of GGBS for GGBS mix. Fresh properties of HSC are tested for slump and compaction factor test. Hardened properties of HSC are studied for compressive, flexural and split tensile strength. GGBS increases the workability. Compressive strength shows 3.53% higher strength than control mix. Split tensile strength shows 7.34% higher value. Flexural strength shows 16.98% lower strength than control mix.

Santhosh Kumar (2015) focuses on investigating characteristics of M20 & M40 with partial replacement of cement with GGBS at 30, 40 and 50%. Cubes, prisms and cylinders are tested for compressive strength, flexural strength and split tensile strength. Durability tests are done using sulphuric acid and hydrochloric acid. Compressive, flexural and split tensile strength of concrete increased for both grade and maximum at 40%. The effect of acid on concrete decreases with increase of GGBS and at 40% replacement of GGBS the resistance power of concrete is more.

Thavasumony D et.al, (2014) carried out the study compared with the compressive strength of PCC and GGBFS, used concrete. Here the amount of cement is reduced and that amount of cement is replaced by GGBS. Cement is replaced by GGBS at 10%, 20%, 40% and 60%. Sieve analysis is also done to determine the fineness modules of cement, fine aggregate of GGBS. The fibre is added in the increase in percentages of 0.5, 1.0, 1.5 and 2.0 with respect to the weight of cement added. There was no replacement in cement for the addition of fibre. There are total 20 cubes including the conventional one. Four cubes are made at each percentage of fibre added. From the results and discussions GGBS is used to make durable concrete structure in combination with ordinary Portland cement and/or other pozzolona materials.

Vishal Patel et.al, (2015) describes a review of the potential use of High Strength Concrete with Ground Granulated Blast Furnace Slag and Steel Fiber Reinforced Concrete used in construction industry which is used to improve the structural strength and reduce steel reinforcements requirements. Blast furnace slag (GGBS) has been used as a supplementary material in concrete. It helps in increasing the durability as well as strength of the concrete. The experimental work done was reviewed which mainly deals with mechanical and durability properties of high strength concrete with steel fibres based on normal curing. Ground Granulated Blast Furnace Slag and steel fibers can be used in concrete as a suitable replacement of cement to make the concrete more stronger in compression and tension, for making concrete more economical and proper utilization of industrial waste to reduce the impact on environment.

Ashwini K P et.al, (2017) carried out an experimental investigation on high strength concrete using GGBS and waste foundry sand. Cement and fine aggregates are partially replaced at 10, 20, 30, 40 and 50% and the results are compared with control mix. Grade of concrete used in this experiment is M40. The tests are conducted for 7 days, 28 days, 56 days and 90 days. Mechanical and durability properties were studied. The compressive strength and split tensile strength were increased upto 20% and beyond that, the strength get reduced. Sorptivity is maximum at 10% replacement level. Workability increases with increase in percentage of replacement.

Krishnam Raju et.al, (2019) conducted study in which the metakaolin is replaced partially for cement at 0, 10, 20 and 30% to find initial water absorption, final water absorption in concrete. In acid attack, 3% sulphuric acid solution is used for curing of specimens and the corresponding weight losses were evaluated for curing periods of 7 days, 14 days and 28 days. From the experimental investigation, the reduction in initial water absorption was about 84.4% when the metakaolin content added from 0 to 10%. For 96 hrs of final water absorption, the reduction was about 4% when the metakaolin content augmented from 0 to 10%. Weight loss decreased when metakaolin content varied from 0 to 30%.

3. CONCLUSIONS

Followings are the predominant conclusions that are obtained from the studied literature reviews:

High strength concrete is becoming popular throughout the world because of its superior properties. Supplementary cementitious materials like Metakaolin and GGBS are partially replaced with cement which improves the strength characteristics. The strength properties were increased at 15% of replacement with metakaolin and the workability of concrete decreases with increase in the content of metakaolin. The combination of GGBS and metakaolin can be used as an alternate material for cement and safe to environment. Durability properties also increase with the addition of admixtures. High strength concrete has superior strength properties and durability properties when compared to conventional concrete.

REFERENCES

[1] A. Joshua Daniel., P. Muralinathan., S. Sivakamasundari., (2018), Study of High Strength Concrete Using Metakaolin at elevated temperatures, International Journal of Pure and Applied Mathematics, Vol. 119, pp 1267-1272.

[2] Arvind Nakum., et.al (2015), High Strength Concrete Incorporating Ground Granulated Blast Furnace Slag and Steel Fibres: A Review, International Journal of Structural and Civil Engineering Research, Vol. 04, pp 195-200.

[3] B. S. Divsholi., D. Lim Tze Yang., S. Teng., (2013), Durability and mechanical properties of high strength concrete incorporating ultra fine Ground Granulated Blast-furnace Slag, Construction and Building Materials, Vol. 40, pp 875–881.

[4] D. Sheeba., D. Thavasoumy., Thanappan Subash., (2014), High strength concrete using Ground Granulated Blast Furnace Slag, International Journal of Scientific and Engineering Research, Vol. 05, Issue 07, pp 1050-1054.

[5] D. Viswanadha Varma., G. V. Rama Rao., (2014), Influence of Metakaolin in HSC of M70 grade for various temperatures and acidic medium, IOSR Journal of Mechanical & Civil Engineering, Vol. 11, Issue 03, pp 32-37.

[6] Ganesh., Harshan et.al., (2019), Metakaolin Influence on concrete durability properties, International Journal of Innovative Technology and Exploring Engineering, Volume 08, Issue 11, pp 1109-1111

[7] K. Deepa., et.al, (2018), Strength of High performance concrete with GGBS, International Journal of Engineering and techniques, Vol. 04, Issue 03, 117-122.

[8] Santhosh Kumar., et.al., (2015), Strength and Durability studies on GGBS Concrete, International Journal of Civil Engineering, Vol. 02, Issue 10, pp 34-41.

[9] Shaji M Jamal., Sreejith Haridas., (2017), Study of properties of HSC prepared by partial replacement of cement with GGBS, International Research Journal of Advanced Engineering and Science, Vol. 02, Issue 02, pp 127-130.

[10] S. Mounika., S. K. Asha., (2016), A comparative study on properties of High strength concrete by using Metakaolin and GGBS, International Journal of Research in Engineering, Volume 06, Issue 09, pp 20-26.