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Review on Study and Analysis of High-Performance Concrete Using Metakaolin and Silica Fume

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Abstract : In this paper, the study and analysis of metakaolin based High Performance Concrete (HPC) is to be shown. Firstly various materials used for making of HPC are identified and then later with the help of mix design, quantities of materials are to be found out. Metakaolin has good durability making HPC more durable and also silica fume is added to it to enhance HPC properties. As metakaolin has enhanced properties, it is used as partial replacement of cement. Various tests are to be performed on the sample cubes, cylinders and beams made from these materials.

Keywords :- High-performance concrete, metakaolin, silica fume

INTRODUCTION

The purpose of improving the durability and strength of the structure, High performance concrete was invented in late 1960s by the invention of water reducing admixtures lead to high strength structures and structural elements. High performance concrete is a concrete mixture that has higher durability and high strength than conventional concrete. This concrete consists of one or more cementitious materials such as fly ash, silica fume, or ground granular blast furnace slag usually a super plasticizer. The use of certain mineral and chemical admixtures such as silica fume and superplasticizer greatly enhances strength, durability, and practical properties.

In comparison to nominal concrete, HPC has a number of benefits like low permeability, great resistance to chemical assault, low heat of hydration, etc. HPC can also be developed to have increased strength, durability, and workability, making it appropriate for use in a variety of applications.

Metakaolin is a calcined variety of the clay substance kaolinite. They have historically been employed in the manufacture of porcelain. The metakaolin grain size is smaller than the cement grain size. Yet, because it exists in copious mineral form, concrete can be reinforced with it. Moreover, it has ties to binding. It offers a number of characteristics, including better durability, increased flexural and compressive strength, decreased permeability, improved processability, and increased resistance to chemical attack.

In summary, High performance concrete enhances properties of concrete making it highly durable and more strength as compared to normal concrete. And with addition of metakaolin and silica fume to it, its overall performance could be improved drastically

LITERATURE REVIEW

Osama Zaid, Faisal M. Mukhtar, Rebeca M-García, Mohammad G. El Sherbiny, Abdeliazim M. Mohamed, "Characteristics of high-performance steel fiber reinforced recycled aggregate concrete utilizing mineral filler"

Now a days, lot of construction is destroyed to construct new building over it. As this waste is of no use, in this paper, recycled aggregates are used for construction purpose with utilizing mineral filler. As this destroyed buildings produce waste and as pollution is increasing in world, using recycled aggregates can help lowering the pollution. This research aims to utilize and evaluate the performance of high performance concrete by using steel fibers with recycled aggregates. In this research, four high strength mixes were produced with Portland cement with 15 different geopolymer concrete mixes. Compressive strength, tensile strength, flexural strength and modulus of elasticity at 3, 7, 28 and 91 days were also measured and analyzed as mechanical properties. Water permeability coefficient, durability properties of 3, 7, 14, 21, 28, 56 and 91 days and temperature studies from 100° to 700° were investigated. mixtures of cement and geopolymer concrete were analyzed by scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX). Regarding fresh performance, the results showed that the geopolymer concrete based on 500 kg/m3 of slag had a slump of 225 mm, while in terms of hardened performance, the mixture containing 200 kg of metakaolin and 300 kg The cases all have the maximum compressive strength of, and the early and late ages are 63.3 and 82.6 MPa respectively also has the maximum tensile strength of of 6.2 MPa, and the bending strength reaches 9.2 MPa, while the modulus of elasticity of is 37.68 GPa. Also, the coefficient of permeability decreases as the granulated blast furnace slag increases.

G.M. Sadiqul Islam, Suraiya Akter, Tabassum Binte Reza "Sustainable high-performance, self-compacting concrete using ladle slag"

G.M. Sadiqul Islam, Suraiya Akter, Tabassum Binte Reza researched the experimental study on high performance concrete using ladle slag. High Performance Concrete (HPC) satisfies unique specifications like low shrinkage and low permeability, high strength and improved durability, and uniformity specifications above and beyond those of standard concrete. Because Self-Consolidating Concrete (SCC) is fluid enough to travel through crowded reinforcement areas and prevent total segregation, it is applied by weight. Ladle slag is substituted for cement in the production of HPSCC to reduce the amount of cement required and related CO2 emissions. The material's chemical makeup suggests that it has pozzolanic and self-adhesive capabilities. In place of cement, slags (5%, 10%, 15%, and 25%) were utilized, and the concrete samples' freshness, mechanical, and durability characteristics were compared to control samples (no waste). Using Slump Flow, T 500, V-Funnel, and L-Box, test and confirm freshness characteristics. The results obtained generally show that the properties of freshness, mechanics and durability of the artificial concrete containing up to 15% slag are improved compared to the control concrete. A cost analysis shows that industrial waste can be a promising green material for HPSCCs by economically reducing carbon footprints.

Roja A. Nambiar, M.K. Haridharan "Mechanical and durability study of high performance concrete with addition of natural fiber (jute)"

The study is aimed to determine the properties of high performance concrete (HPC) by partially replacing silica fume (10%) and fly ash (20%) with concrete. In this analysis, the compressive strength values of concrete were determined for different test mixes on days 7, 14 and 28. According to the compressive strength of the test mix, determine the proportion of materials. With this outcome, cast the specimen with a reserve for curing at a constant water-to-cement ratio (w/c = 0.28). This study's primary goals are to investigate and establish the ideal dosage of superplasticizer to use in place of cement in mixtures containing various ratios of silica fume and fly ash, as well as to assess the mechanical characteristics of HPC, such as resistance to compression and tensile strength. Study durability factors such adsorption, acid attack, etc. after adding natural fiber (jute). The following results confirm that concrete with 1% jute also outperforms any other concrete in terms of mechanical properties and durability.

Venkatesh Kodur and Wasim Khaliq "Effect of Temperature on Thermal Properties of Different Types of High-Strength Concrete"

This study determines effect of temperature on thermal properties of different types of high-strength concrete. The specific heat, thermal conductivity and thermal expansion of three types of concrete, namely HSC, self-consolidating concrete (SCC) and fly ash fly ash concrete (FAC), were measured in the temperature range of 20 to 800 °C. It was also investigated how steel, polypropylene, and mixed fibres affected the thermal characteristics of HSC and SCC. According to experimental findings, in the temperature range of 20 to 800°C, SCC has higher thermal conductivity, specific heat, and coefficient of thermal expansion than HSC and FAC. In order to describe different thermal properties as a function of temperature, simplified relationships have been developed using the data produced from the experiments. A concrete structure's reactivity to fire conditions can be assessed using the proposed thermal property relationship as input data.

Mohamed Amin, Yara Elsakhawy, Khaled Abu el-hassan, Bassam Abdelsalam Abdelsalam "Behavior evaluation of sustainable high strength geopolymer concrete based on fly ash, metakaolin, and slag"

In this paper industrial wastes such as fly ash, metakaolin and granulated blast furnace slag were used as the base for High Strength Geopolymer Concrete (HSGC). Four high strength concrete (HSC) mixes containing Portland cement were produced for comparison with fifteen different geopolymer concrete mixes. All compounds are poured, cured and tested. Measurement of sag and air content as fresh properties of HSC and HSGC blends. Compressive strength, ultimate tensile strength, flexural strength and modulus of elasticity at 3, 7, 28 and 91 days were also measured and analyzed as mechanical properties. Water permeability coefficient, durability properties of 3, 7, 14, 21, 28, 56 and 91 days and temperature studies from 100° to 700° were studied mixtures of cement and geopolymer concrete were analyzed by scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX). Regarding the fresh performance, the results showed that the geopolymer concrete based on 500 kg/m3 of slag had a slump of 225 mm, whereas in terms of hardened performance, the mixture containing 200 kg of metakaolin and 300 kg Both cases have the maximum compressive strength of in the early and late stages, which are 63.3 and 82.6 MPa respectively, and also have the maximum tensile strength of 6.2 MPa, bending strength in the range of 9.2 MPa, modulus of elasticity is 37.68 GPa.

MATERIALS USED

The materials used in HPC are fine aggregates, coarse aggregates, cement, water, mineral admixtures and chemical admixtures.

Cement

Conforming from IS: 12269, ordinary Portland cement (OPC) to be used. Physical and chemical property identified by the requirement of SCC properties.

Fine aggregate

River sand is used ass fine aggregate. For avoid the problem of bulking sand was dried before use.

Coarse aggregate

Locally available granite with maximum size of 20mm is used as coarse aggregate.

Water

The Purpose of mixing and curing, portable water was used.

Mineral admixtures

Mineral admixtures are useful to reduce cost of cement and also for improve fresh and hardened properties of cement. The mineral admixtures are Fly ash, Metakaolin, Silica fume.

Chemical admixtures

Superplasticizer as Polycarboxylate Ether was used.

MIX DESIGN

The mix design process for HSC involves several steps:

1. Determine the design requirements and specifications, such as the desired strength, workability, and setting time.
2. Select the appropriate type and amount of cement, fine and coarse aggregates, metakaolin, water, and superplasticizer.
3. Conduct laboratory tests, such as flowability, passing ability, and segregation resistance tests, to evaluate the mix's performance and adjust the proportions of ingredients if necessary.
4. Prepare trial batches of concrete and evaluate the properties, such as flow, filling ability, stability, and strength, to fine-tune the mix design.
5. Repeat the trial and adjustment process until the desired properties are achieved.

CONCLUSION

Because of a lack of awareness, high performance concrete is used very little in India. HPC improves the workability, structural performance, and durability of concrete, but in India, a lack of information in the IS code results in complicated material. For mix design of HPC in India, IS code: 10262: 2019 is most frequently utilised. Yet, the lack of information in IS code 10262: 2019 makes work challenging for high strength. Research papers are therefore highly helpful.

The conclusion regarding materials are below :

1. Metakaolin reduces workability but by use of admixtures workability will be achieved.
2. Silica fume and metakaolin both increase strength while replacing with cement.
3. Metakaolin gives higher strength because it increases concrete density resulting in an increase in strength.
4. Approximate 30% replacement of fly ash gives the best result in strength.
5. Approximate 10% replacement of metakaolin gives appropriate results.

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