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Mechanical Properties of M60 Grade SCC with Cement Partially Replaced by GGBS, Lime Powder, and Metakaolin

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Abstract

The manufacture of cement emits greenhouse gases, hence contributing to climate change. Conversely, the use of unprocessed materials like limestone. Utilizing alternate resources may decrease cement manufacturing. At now, the majority of researchers are concentrating on substituting cement with alternative mineral admixtures, including ground granulated blast furnace slag (GGBS), metakaolin, and lime powder, while maintaining mechanical properties and durability. Self-compacting concrete needs no vibration for curing and consolidation. This research presents the findings on the mechanical properties of self-compacting concrete using ordinary Portland cement, ground granulated blast-furnace slag, lime powder, and metakaolin as binding agents in concrete formulation. The characteristics of hardened concrete, including compressive strength, splitting tensile strength, and flexural strength, were assessed by experimental methods and compared to those of regular concrete.

INTRODUCTION

1.1 GENERAL:

Self-compacting concrete (SCC) developed to solve cast-in-place concrete problems is a major construction innovation. Due to its fluidity and segregation resistance, self-compacting concrete may be transported long distances (Bartos, 2000). Professor Hajime Okamura proposed self-compacting concrete in 1986, and Professor Ozawa of the University of Tokyo produced the first prototype in 1988. Self-compacting concrete was created to prolong concrete construction. After research, prominent Japanese construction businesses employed SCC in actual builds.

The project aimed to establish a systematic mix formulation and self-compactability testing procedure for concrete standards. Cast self-compacting concrete compacts without internal or external vibration. Its viscosity is like "honey" and produces a smooth surface. Like vibrated concrete, self-compacting concrete contains cement, aggregates, water, and chemical and mineral admixtures. Superplasticizers and viscosity-modifying agents are common chemical admixtures that change concrete's rheology. Mineral additives improve fine materials and even replace cement. Fly ash, slag cement, and silica fume were used to partially replace cement in this study, improving concrete flow and strength.

SELF COMPACTING CONCRETE

SCC has low yield stress, high deformability, excellent segregation resistance (preventing particle separation), and moderate viscosity (essential for uniform solid particle suspension during transportation, installation without external compaction, and concrete setting). SCC is a highly fluid mixture that flows smoothly within and around formwork, navigates obstructions and corners ("passing ability"), is nearly self-leveling (though not entirely), does not require vibration or tamping after pouring, and cures to a mold's shape and texture. Self-compacting concrete (SCC) requires less work than standard concrete mixes. Self-consolidating concrete (SCC) hardens and cures similarly to ordinary concrete, developing strength and durability. SCC may have less water than traditional concrete mixes to obtain fluidity. SCC is fluid due to a high amount of fine material, usually sand (approximately 50%), superplasticizers, and viscosity-modifying admixtures.

Concrete is thick and viscous, therefore vibration or other compaction procedures are needed to remove air bubbles (cavitation) and honeycomb-like spaces, especially near pouring surfaces. In contrast to aerated concrete, air damage concrete if not treated. Vibration removal is difficult and time-consuming, and poor vibration control may cause undiscovered complications. Many complex structures are hard to vibrate. Self-consolidating concrete eliminates compaction, saving labor, time, and technical and quality control issues.

SUMMARY:

When in forms, self-compacting concrete (SCC) may overcome barriers without vibration. Since 1988, SCC has been

popular in Japan, Europe, and the US due to its benefits. SCC simplifies concrete pouring on problematic locations, its principal benefit. Eliminating concrete quality control testing saves time. Construction and placement are simplified. Noise is reduced without vibration. Fills dense structural parts better. In members with reinforcing congestion, SCC decreases permeability and increases concrete durability. SCC's water absorption, shrinkage, and sulfate resistance are examined to determine its usage. An extensive literature review analyzed self-consolidating concrete durability, incorporating current understanding. Due to its higher binder and chemical additive costs, it is 20–50% more expensive than standard concrete, limiting its utilization. Further research suggests that employing high volumes of mineral admixtures and micro fillers as partial Portland cement substitutes in self-compacting concrete (SCC) may save money. SCC must seem permanent.

LITERATURE REVIEW

1. S. Arivalagan (2012)

Title: Study on Strength and Efficiency of Concrete with Partial Replacement of Cement by GGBS

Summary: This research examines the advantages of using GGBS as a partial substitute for cement in concrete, concentrating on replacement levels of 20%, 30%, and 40%. The study determined that substituting 20% of cement with GGBS had optimal results for compressive, split tensile, and flexural strengths, particularly after 28 days. This is mostly attributable to the filler action of GGBS, which enhances the density of the mixture and promotes hydration. Although elevated GGBS concentrations somewhat diminished strength, workability enhanced universally. In addition to performance, the environmental aspect is significant—utilizing GGBS lowers cement use, so effectively lowering carbon emissions and expenses.

2. Reshma Rughooputh and Jaylina Rana (2013)

Title: Effects of GGBS on Strength and Durability of Concrete

Summary: This study investigated the impact of substituting 30% and 50% of cement with GGBS. Initial strength growth was gradual, although strength at later ages shown substantial improvement. For example, flexural strength improved by 22% with 30% replacement and by 24% with 50% replacement. Tensile strength

exhibited significant improvements, however a little increase in drying shrinkage was seen. GGBS improved the long-term performance and durability of concrete, rendering it an astute selection for constructions necessitating enduring strength. Furthermore, the ecological advantages of recycling GGBS as an industrial by-product enhance its attractiveness.

MATERIALS USED AND PROPERTIES

3.1 Materials used

In the present study, materials such as cement, fine aggregates, coarse aggregates, GGBS, metakaolin, and lime are utilized. Prior to discussing the experimental investigation of both fresh and hardened properties, it is essential to evaluate the material properties in accordance with the Indian standard systems.

3.1.1 Cement

Cement serves as a binding material commonly utilized in construction. It is crucial to select high-quality cement to achieve optimal strength. In the current investigation, we have employed OPC 53 Grade cement, as illustrated in the subsequent figure 3.1.

EXPERIMENTAL INVESTIGATION

In this examination considers the Effectiveness on Mechanical properties of M60 grade Self-Compacting Concrete with Partial substitution of Cement by various Mineral Admixtures like GGBS, Lime powder and Metakaolin at different rates Here, at different rate substance of mineral admixtures keeping up 25% of concrete substance substitution five blends are concentrated as appeared in table 1. While Mix M1 proceed as ordinary cement for examination between blends in with 25% GGBS and 75% concrete substance in it.

3.1 Mix Design for M60 grade for SCC

Blend plan technique utilized in this task is Nansu strategy, one of the advantages among SCC could pull out blend plan of cement by any standard Mix Design procedure. Experimentation technique applied to get last blend extents in blend plan. In this undertaking at ninth path test the last blend configuration is acquired with 25% pozzolana content is considered satisfactory functionality. While utilizing Nansu technique in blend plan it is specific that to check climate that satisfy EFNARC rules for SCC. Not just Nansu strategy, for solid like SCC it ought to withstand the adequate rules in rules.

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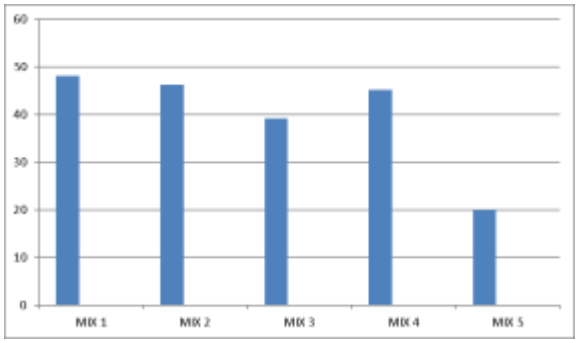
EXPERIMENTAL RESULTS AND DISCUSSIONS

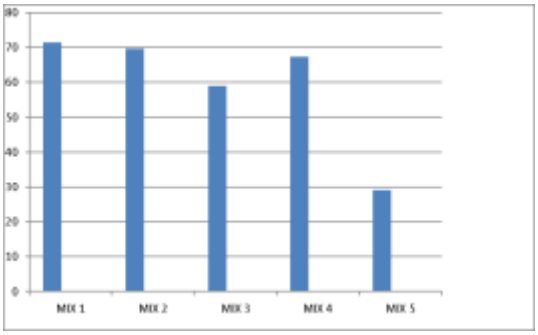
5.1 Testing Procedure

Along these lines, the solid here is Self-Compacting Concrete need to direct test on both new and solidify concrete. Consequently, to accomplish satisfactory usefulness of solid it ought to satisfy the passing capacity, filling capacity and obstruction against isolation. These tests are led according to EFNARC rules for SCC. After different experimentation tests the last blend extents fixed according to blend plan the extent of blends



Inference:

- compressive strength among blends these shows that by adding metakaolin won't Among all blends Mix 1 had higer compressive strength when contrasted with other blends these demonstrates that SCC with concrete and GGBS will build the compressive strength for 7 days.
- Mix M2 and Mix M4 had additionally expanded their solidarity however less when contrasted with Mix M1 these shows that furthermore of Lime powder to GGBS alongside concrete will build the compressive strength of cement upto some degree.
- Mix M5 had least increment compressive strength as much has other blends.
- Among all blends Mix M1 had higher compressive strength when contrasted with any remaining blends for 7 days.

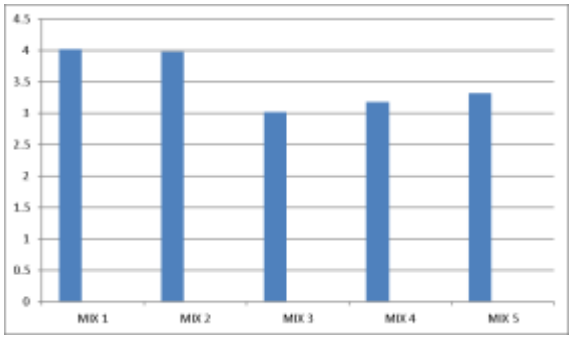


Inference:

- Mix M1 had higher compressive strength when contrasted with other blends for 7 days compressive strength likewise Mix M1 had higer compressive strength it demonstrates that expansion of just

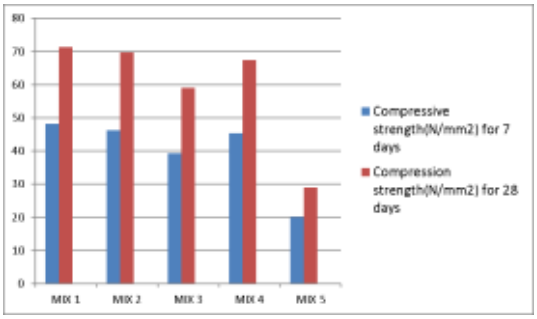
GGBS increments compressive strength of SCC.

- Mix M2 and Mix M4 are likewise expanded in their compressive qualities which shows that expansion of lime powder will likewise build the compressive strength yet less when contrasted with GGBS.
- Mix M5 had less compressive strength among all blends which shows that expansion of metakaolin won't expand the compressive strength when contrasted with GGBS and Lime powder.
- Mix M1 had got higher compressive strength in 7 days and 28 days when contrasted with other blends.



Inference:

- Mix M1 has more part rigidity among all blends. In pressure test additionally Mix M1 had high pressure strength among all blends which shows that by adding GGBS alone with concrete will build pressure and split rigidity.
- Mix M2 had additionally having more elasticity after M1 in which alongside concrete 15% GGBS and 10% LP is there. Lime powder additionally increses split rigidity after GGBS upto some degree.
- Mix M3 had most reduced part strength among all blends which indictes that metakaolin alongside GGBS have a less part elasticity when contrasted with any remaining blends.



Inference:

- In all Mixes compressive strength increments from 7 days to 28 days roughly from 45% to half.
- Increase in compressive strength for Mix M2 from 7 days to 28 days is

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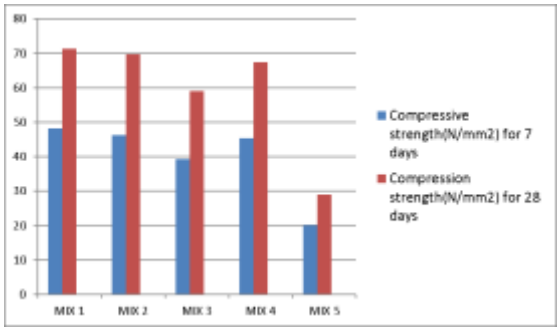
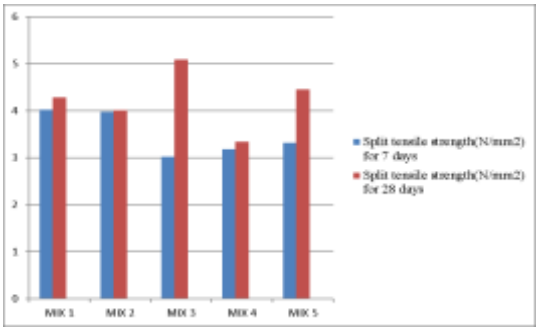
more when contrasted with other blends.

- Among all blends Mix M1 has higher compressive qualities for 7 days and 28 days when contrasted with other blends.
- Mix M5 has lesser compressive qualities for 7 days and 28 days utilization of Metakaolin alongside GGBS won't expand a lot of compressive strength.



Inference:

- In all Mixes compressive strength increments from 7 days to 28 days roughly from 45% to half.
- Increase in compressive strength for Mix M2 from 7 days to 28 days is more when contrasted with other blends.
- Among all blends Mix M1 has higher compressive qualities for 7 days and 28 days when contrasted with other blends.
- Mix M5 has lesser compressive qualities for 7 days and 28 days utilization of Metakaolin alongside GGBS won't expand a lot of compressive strength.



Inference:

- Among all blends there is a quick development in split elasticity from 7 days to 28 days in Mix M3.
- There isn't a lot of expansion in split tractable from 7 days to 28 days in Mix M2 when contrasted with other blends.
- In all blends there is increment in split rigidity from 7 days to 28 days however there is more expansion in split elasticity for Mix M3 for 28 days.

- Mix M4 has less part rigidity for 28 days when contrasted with other blends from M1 to M5.

CONCLUSIONS

1. The examination results show that compressive strength is expanded in Mix M2 when contrasted with Mix M1.It contains 15% GGBS and 10% Lime powder.

2. Almost there is increment in compressive strength of Mix M2 from 7 days to 28 days is about half.

3. Split elasticity of Mix M2 is more when contrasted with other blends other than Mix M1.Addition of lime powder alongside GGBS will expand split rigidity.

4. There is an abrupt expansion in split rigidity in Mix M3 from 7 days to 28 days when contrasted with pace of increment of solidarity in other blends.

5. Flexural strength of Mix M3 is more when contrasted with other blends aside from Mix M1.whereas Mix M1 has most elevated flexural strength among all blends.

6. The rate at which flexural strength increment in Mix M5 is more when contrasted with other blends other than Mix M1.

7. In all blends Mix M1 has most noteworthy pressure flexure and part elasticity for 7 days also has 28 days.

8. In instance of compressive strength we are getting greatest compressive strength by adding 15% GGBS with 10% lime powder.

9. By adding 10% Metakaolin to the 15% GGBS there is increment in split elasticity among all mixes.Therefore by considering split rigidity Mix M3 is superior to other blends.

10. Adding 15% Lime powder to 10% of GGBS will increment flexural

strength when contrasted with other blends.

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