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A STUDY ON STRENGTH CHARACTERSTICS OF SELF COMPACTING CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH METAKOLIN AND FLYASH

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ABSTRACT- The greatest challenge before the construction industry is to serve the two pressing needs of human society namely the protection of the environment and meeting the infrastructure requirement of our growing pollution and consequential needs of industrialization and urbanization, it is looking for the ways and means to develop building products, which will increase the span and quality. In this regard the merits of using certain industrial by-products such as Metakaolin and Fly ash have been recognized by the construction industry. Therefore, it should be obvious that certain scale cement replacement with industrial by-products is highly advantageous from the stage point of strength, economy, energy efficiency, durability and overall ecological and environmental benefits.

Now we are going to measure and compare with 0%, 10% and 15% of admixtures like Metakaolin and Fly ash with replacing cement and also we are interested to find the influence of that admixtures on strength aspects like compressive strength, split tensile strength, flexural strength and workability tests (Slump flow, L-Box, V-Funnel) for masterglenium mineral admixture.

Fresh self-compacting concrete properties viz. Slump flow, V-funnel, V- funnel at T5 min and L-Box test were carried out. Cubes of size 150mmx150mmx150mm, cylinders of size 150mmx300mm were casted. The specimens were tested for compressive strength, split tensile strength respectively for 7 days, and 28 days of curing period.

INTRODUCTION

Introduction: Self-compacting concrete (SCC) is a highly flowable and stable concrete that eliminates the need for compaction, saving time, reducing labor costs, and conserving energy. This study aims to determine the mechanical properties of SCC by compression strength and split tensile strength. Evaluating.

Necessity of the Work: The durability of concrete structures has been a major concern for several years. The use of SCC can help achieve durable concrete structures independent of the quality of construction work. The increase in the usage of SCC has led to the need for studying its mechanical properties.

Objectives of the Study: The primary objectives of this study are to evaluate the compression strength and split tensile strength of SCC cubes and cylinders, respectively, at 7 days and 28 days.

Scope of the Study: The SCC used in this study was made by partially replacing ordinary Portland cement with fly ash and metakaolin (0%, 10%, and 15%). Hard concrete tests such as compressive strength for cubes of standard size 150×150×150 mm, flexural strength for beams of size 500×110×100 mm, and split tensile strength of cylinders of size 150×300 mm were casted and tested for 28 days.

Concrete: Concrete is a widely used construction material made of cement, fine and coarse aggregates, and water. The strength, durability, and other characteristics of concrete depend on the properties of its ingredients, proportion of mix, method of compaction, and other controls during placing and curing. The search for materials that can be used as an alternative or supplement to cement has led to the use of pozzolanic materials such as fly ash, ground granulated blast furnace slag, rice husk ash, high reactive metakaolin, and silica fume.

Self-Compacting Concrete: Self-compacting concrete (SCC) is a type of concrete that can be compacted into every corner of a formwork purely by means of its own weight and without the need for vibrating compaction. SCC flows easily around reinforcement and into all corners of the formwork, eliminating the need for vibration. This saves time, labor, and energy and produces a smooth surface finish. SCC has been successfully used in France, Denmark, the Netherlands, UK, and Japan.

History of SCC: The modern SCC was introduced in Japan in the late 1980s in pursuit of better quality concrete. The primary factor responsible for poor concrete quality was identified as the lack of uniform and complete compaction. SCC was developed to eliminate the need for compaction and produce high-quality concrete.

.LITERATURE REVIEW

Introduction

This chapter presents a literature review related to self-compacting concrete. It highlights the work of various authors, including their studies, findings, and recommendations.

Review

Manz (1982) proposed the term "mineral admixtures" to describe all classes of slags, ashes, pozzolans, and other cement supplements. Sharma (1990) reported that specific gravity had no direct influence on the reactivity of fly ash, but rather helps to define the ash quality in terms of the presence of carbon and iron contents, which can be deleterious to concrete. Nagataki and Fujiwara (1992) conducted the slump flow and segregation tests of SCC mix to determine its workability, where a value ranging from 500-700 mm is considered as the required slump for self-compacted concrete. Malhotra and Rarnezaniaripour (1994) reported that the water required for workability of mortar and concrete depends on the carbon content of fly ashes, and that higher carbon content (2-10%) is quite common in low-calcium fly ashes. Sabir et al. (2001) studied the utilization of Metakaolin as a pozzolanic material for mortar and concrete, where they reported that the usage of Metakaolin can help in the development of early strength and improvement in long-term strength. Nan Su et al. (2001) proposed a new mix design method for self-compacting concrete, where the amount of aggregates required was determined first, and the paste of binders was then filled into the voids of aggregates. Subramanian and Chattopadhyay (2002) described the results of trials carried out to arrive at an approximate mix proportioning of self-compacting concrete, where self-compatibility was achieved for water-to-powder ratio ranging from 0.9 to 1.1. R.V. (2003) found that the use of fine fly ash for obtaining self-compacting concrete resulted in an increase of the 28-day compressive strength of concrete by about 38%, and self-compacting concrete was achieved when the volume of paste was between 0.43 and 0.45. Safiuddin (2008) observed that drying shrinkage in SCC does not differ significantly from that of normal concrete, and that it could even be lower. Jiping Bai and Albina Gailius (2009) developed statistical models for predicting the consistency of concrete incorporating Portland cement, fly ash, and Metakaolin from the experimental results of standard consistency tests.

Materials Used:

Cement: Cement is a hydraulic material made primarily of lime obtained from limestone and clay. Two types of cement used in this project are Ordinary Portland Cement (OPC) and Portland Slag Cement (PSC). OPC is best suited for general concrete construction and is available in three grades: 33, 43, and 53. PSC is obtained by mixing Portland cement clinker, gypsum, and granulated blast furnace slag and can be used for all purposes like OPC. In this project, K.C.P of 53 grade was used.

Aggregates: Aggregates are classified as fine and coarse. Fine aggregates provide workability and uniformity in the mixture, helping the cement paste hold the coarse aggregate in suspension. According to IS 383:1970, fine aggregate is classified into four zones: Zone-I, Zone-II, Zone-III, and Zone-IV. Coarse aggregate forms the main matrix of the concrete, and maximum 20mm coarse aggregate is suitable for concrete work. In the case of close reinforcement, 10mm size is also used.

Flyash: Fly ash is a byproduct of coal combustion, composed of fine particles driven out of the boiler with flue gases. It is used as a pozzolan to replace some Portland cement in concrete and achieves energy and cost savings while imparting specific engineering properties to the finished product. Fly ash concrete generally shows improved workability, pumpability, cohesiveness, finish, ultimate strength, and durability.

Metakaolin: Metakaolin is produced from sources containing kaolinite, such as high purity kaolin deposits, kaolinite deposits or tropical soils of lower purity, and paper sludge waste. It enhances the workability and finishing of concrete, reduces permeability, and increases compressive and flexural strengths, resistance to chemical attack, and durability.

Super Plasticizer: The materials used in Self-Compacting Concrete (SCC) are the same as in conventional concrete, but with an excess of fine material and chemical admixtures, including a viscosity-modifying agent (VMA) to prevent instability due to slight variations in water or aggregate and sand proportions. The powdered materials used are fly ash, silica fume, limestone powder, glass filler, and quartzite filler, which improve SCC flow. SCC is designed with limits on nominal maximum size (NMS) of the aggregate, amount of aggregate, and aggregate grading to achieve high workability and avoid obstruction by closely spaced reinforcing. A high-range water-reducing admixture (HRWRA) helps alleviate segregation and loss of entrained air voids. Commonly used superplasticizers include Modified Lingo sulfonates (MLS), Sulfonated Melamine Formaldehyde (SMF), Sulfonated Naphthalene Formaldehyde (SNF), Acrylic Polymer based (AP), Copolymer of Carboxylic Acrylic Acid with Acrylic Ester (CAE), and Cross-Linked Acrylic Polymer.

THEORETICAL ASPECTS AND EXPERIMENTAL SET UP

Experimental Study of Self-Compacting Concrete with Partial Replacement of Cement with Fly Ash and Metakaolin

Objective: Investigate the behavior of self-compacting concrete with partial replacement of cement with fly ash and metakaolin, compared to regular mix.

Experimental Set-Up: Collect materials and data required for mix design through sieve analysis and specific gravity tests. Carry out sieve analysis and specific gravity tests for fine and coarse aggregate, fly ash, and metakaolin. Use raw materials such as cement, fly ash, metakaolin, fine aggregate, coarse aggregate, and water.

Cement: Use KCP cement of 53 Grade ordinary Portland cement.

Determination of Specific Gravity of Cement: Use kerosene and a specific gravity bottle to find the specific gravity of cement. The specific gravity of kerosene is 0.79 g/cc, while the specific gravity of water is 1g/cc.

Fly Ash: Use fly ash taken from NTPC.

Determination of Specific Gravity of Fly Ash: Use the density bottle method to determine the specific gravity of fly ash. Heat the mixture in a sand bath to remove entrapped air.

Metakaolin: Use metakaolin.

Determination of Specific Gravity of Metakaolin: Use kerosene and a specific gravity bottle to find the specific gravity of metakaolin.

Curing:

- Store test specimens for 24 hours without vibration after adding water to dry ingredients
- Submerge specimens immediately in a curing tank at 27±2°C until removal
- Renew water in curing tank every seven days

Tests for Compressive Strength of Concrete:

- Use a compression testing machine with a capacity of 1000KN for concrete cube compressive strength
- Calculate measured compressive strength by dividing maximum load applied by cross-sectional area calculated from mean dimensions of the section
- Express results to the nearest N/mm2 and take the average of all values as the representation of the batch, with individual variation not more than -15% of average

MIX	7 Days strength		28 Days Strength	
	CUBES (Mpa)	CYLINDERS (Mpa)	CUBES (Mpa)	CYLINDERS (Mpa)
TRAIL MIX	43.54	----------	68.32	----------
CAC	40.85	3.38	68.17	3.69
5% Flyash	50.27	3.73	68.23	3.84
10% Flyash	46.93	3.15	71.21	3.39
15% Flyash	40.44	2.62	69.36	2.68
10% Flyash+5% Metakolin	48.24	3.39	69.72	3.70
10%Flyash+ 10% Metakaolin	50.02	3.54	70.23	3.56
10%Flyash + 15% Metakaolin	53.97	3.76	73.24	3.93

Tests for Split Tensile Strength of Concrete Procedure:

- Keep specimens in water for 24 hours before testing
- Wipe off surface water and grit, and remove projecting fins from surfaces to be in contact with packing strips
- Draw central lines on opposite faces of the cube and note mass and dimensions of specimen
- Place specimen in centering jig with packing strip and/or loading pieces and position carefully
- Apply load without shock and increase continuously at a nominal rate within the range 1.2 N/(mm/min) to 2.4 N/(mm/min)
- Record maximum load applied and note appearance of concrete and any unusual features in the type of failure
- Calculate measured splitting tensile strength to the nearest 0.05 N/mm2 using the formula: $fct=2p/\pi DL$

CONCRETE MIX DESIGNS

Introduction: Self-compacting concrete (SCC) is a current research area with many intrinsic properties yet to be understood.

Requirements of Concrete Mix Design: The basis of selection and proportioning of mix ingredients is determined by minimum compressive strength, adequate workability for full compaction, maximum water-cement ratio and/or maximum cement content for durability, and maximum cement content to avoid shrinkage cracking.

Factors to be Considered for Mix Design: Factors considered for mix design include grade designation, type of cement, maximum nominal size of aggregates, and workability related to section size, reinforcement quantity and spacing, and transportation, placing and compaction techniques.

Mix Design: Mix design for 0% admixture replacement for self-compacting concrete involves several steps, including calculating total cementitious material, determining water-binder ratio, estimating water content, calculating cement and admixture, and determining the percentage of aggregate fractions to be used. The net volume of concrete is determined and the volume of cement, water, chemical admixture, and all in aggregate is calculated. The mass of coarse and fine aggregate is then determined to establish the mix proportion of 1:1.37:1.60.

RESULTS AND DISCUSSIONS

WORKABILITY TEST				
MIX	**Slump(mm)**	**V-funnel (sec)**	**V-funnel at T5 minutes(sec)**	**L-BOX**
TRAIL MIX	**670**	**10**	**12**	**0.85**
CAC	**710**	**8**	**8**	**0.83**
5% Flyash	**660**	**10**	**11**	**0.90**
10% Flyash	**750**	**10**	**11**	**0.87**
15% Flyash	**790**	**9**	**12**	**0.91**
10% Flyash+5% Metakolin	**650**	**10**	**14**	**0.88**
10%Flyash+ 10% Metakaolin	**760**	**8**	**10**	**1.0**
10%Flyash + 15% Metakaolin	**740**	**9**	**12**	**0.89**

CONCLUSIONS AND RECOMMENDATIONS:

INTRODUCTION:

This study discuss an experimental program carried out to investigate the compression strength of cubes of size 150mmx150mmx150mm ,split tensile strength of cylinders 150mmx300mm under three point loading.

CONCLUSIONS:

The following conclusions can be drawn according to the results of this study:

1. A 4.2% of increase in the slump flow value is observed from the mix 10%Flyash +15% Metakaolin to CAC

2. A 7.2% of increase is obtained in compressive strength form the mix 10%Flyash +15% Metakaolin to CAC

3. A 6.5% of increase is obtained in spilt tensile form the mix 10%Flyash +15% Metakaolin to CAC

4. A 12.5% of increase is obtained in V-funnel is observed form the mix 10%Flyash +15% Metakaolin to CAC

5. A 4.7% of increase is obtained in L-box is observed form the mix 10%Flyash +15% Metakaolin to CAC

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