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TO STUDY THE STRENGTH AND DURABILITY OF TERNARY-BLENDED SELF-COMPACTING CONCRETE CONTAINING FIBER

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ABSTRACT

One of the key elements to take into account in order to get the necessary strength of the concrete is the compaction of the concrete. The concrete is primarily compacted on site using mechanical vibrators. However, improper compactions on construction sites compromise the concrete's strength and durability. Self-Compacting Concrete (SCC) is the term used to describe concrete that compacts under its own weight. Self-compacting concrete can be created or introduced to increase the flow ability of ordinary concrete. However, due to the high cementitious content and super plasticizer, SCC is quite expensive. The use of Supplementary Cementitious Materials (SCMs) can reduce this high cost. These SCMs' extremely small particle sizes allow for the refining of the concrete's pores, which enhances the material's mechanical and durability capabilities. By combining two SCMs and using them in place of some of the cement in regular concrete to create ternary mixed concrete. When SCMs are combined, the flaws in one SCM can be overcome by another SCM. SCC has poor impact strength and low tensile stress, making it a brittle material. Concrete is enhanced with fibers to correct these flaws. The fibers, which are the tiny particles of reinforcing material, can improve the concrete's mechanical qualities and decrease shrinkage cracks. The creation of ternary mixed self-compacting concrete with additional cementations elements is the main focus of this work. The glass fiber in SCC also improves the concrete's tensile and impact strength.

KEYWORDS: Self-Compacting, Concrete, Construction, Mechanical Vibrators

INTRODUCTION

One of the most often utilized building materials worldwide is concrete. By combining some locally accessible cement, fine aggregate, coarse aggregate, and water, casting concrete is a very simple process that achieves the requisite strength. However, the qualities of undesigned concrete, both when it is fresh and after it has hardened, are unpredictable, and this leads to serious problems with all of the concrete's properties.

One of the key elements to take into account in order to get the necessary strength of the concrete is the compaction of the concrete. The concrete is primarily compacted on site using mechanical vibrators. However, improper compactions at construction sites compromise the concrete's strength and durability. Self-Compacting Concrete (SCC), a new type of concrete, has been created to eliminate all these compaction-related issues.

SELF-COMPACTING CONCRETE

Self-Compacting Concrete (SCC) is the name given to concrete that flows under its own weight. Self-compacting concrete can be created or introduced to increase the flow ability of ordinary concrete. Due to the SCC's great flow capacity, concrete may flow past crowded reinforcement elements and into any type of architectural structure. The SCC was initially created in Japan to address concrete faults brought by insufficient compaction and a shortage of competent laborers. In the 1990s, SCC was the subject of numerous studies in Japan and Europe. Comparatively speaking, SCC was easier to place than traditional concrete. The key distinction in the SCC design is that the coarse aggregate content is significantly lower than the fine aggregate content. This lessens the concrete blockage in the crowded reinforcement.

PROPERTIES OF SCC

Self-compacting concrete must meet three fundamental criteria, including segregation resistance, passage ability, and filling ability. The filling capacity demonstrates how quickly the concrete moves on its own, without the assistance of any outside power. SCC's passing skill is a crucial characteristic. Without any segregation, the concrete can simply flow between the crowded reinforcements. When mixing and pouring concrete into a structure, SCC must remain homogeneous to prevent segregation and bleeding.

TYPES OF SCC

According to Hajime and Masahiro (2003), self-compacting concrete can be divided into three types: powder type SCC, viscous moderating agent (VMA) type SCC, and combination type SCC.

TERNARY BLENDED CONCRETE

By combining two SCMs and using them in place of some of the cement in concrete, ternary blended concrete is created. When SCMs are combined, the flaws in one SCM can be overcome by another SCM. By consuming a significant portion of the waste materials, the ternary blended concrete contributes to lessening the environmental effects. The manufacturing cost of the ternary mixed concrete using limestone (LS) and natural pozzolana/FA is reduced, and the environmental benefits are increased. The durability characteristics of the concrete are improved by the ternary blended concrete with SF and low reactivity BFS. The addition of BFS assisted in lowering the need for water and, thus, the amount of super plasticizer that was. The PCE-based super plasticizer in the self-compacting concrete achieved strong flow retention at low temperatures. Due to the reaction between the alkali and silica, the ternary blended concrete with MK and FA (Class C) had a noticeable expansion. The early hydration process and subsequent creation of C-S-H due to pozzolanic reaction were promoted by the ternary blended SCC with FA (class C) and SF, which decreased the size of the pores in the concrete. Strength, shrinkage cracking, and permeability can all be improved by partially substituting OPC for SF and MK in concrete. By adding 8–10% SF or FA, the mechanical qualities of QPD blended concrete can be enhanced.

FIBER REINFORCED SELF-COMPACTING CONCRETE

Concrete has strong compression strength and weak tension strength. The strength of the concrete is reduced by shrinkage cracks, which appeared in the early stages of concrete development. Concrete is a weak material with low impact strength and tensile stress. The fibers are added to the concrete to correct these flaws. The fibers, which are the tiny particles of reinforcing material, can improve the mechanical properties of concrete and decrease shrinkage cracks. A fiber reinforced self-compacting concrete is created when self-compacting concrete and fiber reinforced concrete are mixed. The mechanical and durability qualities of the concrete are enhanced by the fiber reinforced self-compacting concrete. The diverse sizes and aspect ratios of the fibers are categorized as either natural (coir, cotton, jute, etc.) or artificial (steel, glass, polypropylene, etc.). Concrete using an alkali-resistant glass fiber lowers fracture propagation and improves the concrete's durability qualities. According to Manohar et al. (2012), adding glass fiber to concrete can boost efficiency by up to 0.8% by weight of cement and decrease SCC's propensity to flow.

NEED FOR THE PRESENT STUDY

The creation of ternary mixed self-compacting concrete with additional cementitious elements is the main focus of this work. The partial replacement of cement with additional cementitious elements may improve the longevity of the concrete and lower the amount of carbon dioxide released into the atmosphere. The ternary mixed SCC lengthens the life of the building and lowers maintenance costs. By including fibers in the ternary blended SCC, the brittleness property of the concrete can be overcome. The glass fiber in SCC also improves the concrete's tensile and impact strength. The fresh, mechanical, durability, micro level, and flexural properties of fiber reinforced ternary blended self-compacting concrete are currently the subject of very few studies. The mechanical and durability characteristics of ternary blended self-compacting concrete containing fibers should therefore be studied.

REVIEW OF LITERATURE

Kovler et al. (2000) investigated the silica fume-blended concrete's characteristics. Study was done on the relationship between W/C ratio, silica fume, mechanical performance, and durability performance of concrete. They claimed that the strength was influenced by the amount of silica fume in the concrete and was only tangentially related to the concrete's age. In concrete with high performance, silica fume replacement was optimized at 10%. Similar to this, the ideal ratio for regular concrete was 20% cement substitution with silica fume.

Bhanja and Sengupta (2003) investigated the ideal range of water cement ratios for silica fume replacements, which ranged from 0 to 30%. They deduced from the findings that, while other parameters stayed the same, the strength was not constant for the ideal silica fume values. They also came to the conclusion that, depending on the water cement ratio, silica fume can replace cement to a maximum of 15 to 25%.

Yajun & Cahyadi (2003), is a significant factor in the compressive strength of the hardened cement. They came to the conclusion that the type of silica fume had a significant impact on the strength and pore refining procedure. To find the best replacement for cement, they investigated the physical characteristics of silica fumes. They came to the conclusion that silica fume blended concrete's compressive strength performed better than that of young concrete.

Mateusz and Jan (2012) investigated the chemical and physical impacts of ordinary portland cement. The concrete mix with fly ash and silica fume added increased the hydration products C- S-H and CH phases. Fly ash and silica fume in the concrete had a combination impact that decreased voids and enhanced density.

The characteristics of silica fume and metakaolin-infused high strength concrete were researched by Arfath et al. in 2013. For concrete classes M60 and M80, silica fume at a dosage of 10% increased compressive strength by up to 20.94 and 10.36%, respectively. However, silica fume substitution in high strength concrete beyond

10% had a detrimental effect on the concrete and greatly decreased its compressive strength in comparison to regular concrete.

Suresh and Ramakrishnan (2015) looked into the use of metakaolin and silica fume in concrete. OPC, silica fume, and metakaolin were used to create the high performance concrete mix (M50 grade). When compared to regular cement concrete, the mixed mix improved the fresh, mechanical, and durability qualities.

Waseem Khairi Mosleh Frhaanet al. (2017) The workability, flow ability, compressive strength, and segregation resistance are all improved by the use of admixtures (mineral or chemical) and other aggregate. The mineral addition silica fume (SF) initially improves mechanical properties while decreasing permeability. Second, the super-plasticizer (SP), a chemical admixture, is used to lessen water, increase cohesiveness, and enhance the ability of SCC to pass through and fill. On the other hand, if SF is used excessively in cement, it may affect the physical characteristics of SCC.

OBJECTIVES OF THE STUDY

1. To acquire the ideal mix ratio for self-compacting concrete with careful material selection.
2. To research the fresh characteristics of glass fiber reinforced ternary blended self-compacting concrete and ternary blended self-compacting concrete.

RESEARCH METHODOLOGY

The research's technique at the moment following an examination of the literature, the materials was assembled, and their qualities were evaluated. Using IS: 10262 -2019, the mix proportion of SCC was calculated, and ternary blended SCC mix proportions were obtained. The mechanical and durability experiments led to the discovery of the optimal ternary blended SCC mix. The optimum ternary mixed SCC mix received the addition of the glass fibers. Finally, experimental research into the micro- and flexural behavior of Glass Fibers (GF) reinforced ternary blended SCC was conducted.

PROPERTIES OF MATERIALS

Cement

In this study, 53-grade cement (OPC) was employed in accordance with IS 12269-2013. According to the standards in IS 12269-2013, the physical characteristics of OPC (specific gravity, consistency, start and final setting time) were assessed. OPC's physical and chemical characteristics. Using a Le Chatelier flask, the specific gravity and density of OPC were determined in accordance with the requirements of IS: 4031 (P11) - 1988. Utilizing equipment of the Blaine type with variable air permeability, the fineness of OPC was determined in accordance with the requirements of IS: 4031 (P2) - 1999.

FIGURE-1: ORDINARY PORTLAND CEMENT 53-GRADE

TABLE 1 PHYSICAL PROPERTIES OF OPC 53-GRADE

Physical properties	Obtained values	IS: 12269-2013 requirement
Specific gravity	3.12	-
Consistency	31%	-
Initial setting time	42 minutes	Not less than 30 minutes
final setting time	220 minutes	Not more than 600 minutes

TABLE 2 CHEMICAL COMPOSITIONS OF OPC 53-GRADE

Chemical compositions	Values (%)
SiO_2	20.56
Al_2O_3	5.05
Fe_2O_3	3.15
CaO	62.54
MgO	2.72
K_2O	0.34
Na_2O	0.38

MIX DESIGN AND TEST METHODS

Mix design is the process of choosing appropriate concrete materials and figuring out their relative proportions with the goal of producing concrete with a specific minimum strength and durability while remaining as cost-effective as possible. The aforementioned definition makes clear that designing serves two purposes. The initial goal is to produce concrete as cheaply as possible.

SLUMP FLOW TEST AND T_{50CM} TEST

SCC's horizontal free flow is evaluated using the slump flow in the absence of impediments. The test procedure is based on the test procedure used to identify the slump. The concrete's capacity to fill a circle is gauged by looking at its diameter. The self-compacting concrete's viscosity and flow rate are both measured by the T 500 time. To conduct the test, approximately 6 liters of concrete must be sampled routinely. The droop cone's inside and base plate have been wet. The droop cone is centered on the base plate and firmly held down. The base plate is set up on a level, sturdy surface. The cone is filled without being tamped and any excess concrete is simply scraped off with a trowel until it is level with the top of the cone. Around the cone's base, any extra concrete is removed. Concrete is allowed to freely flow out of the cone once it has been elevated vertically. The time it takes the concrete to travel to the 500mm spread circle is timed simultaneously and recorded (this is the T50 time).Two perpendicular directions of the concrete's final diameter are measured. The slump flow in mm is equal to the average of the two measured diameters.

The following conclusions have been drawn from the current inquiry, analyses of Fiber Reinforced Self

Compacting Concrete's strength behavior.

1. As a starting point, rice husk ash is added up to 12% starting at 4% and increasing by 2% in each case, at a constant rate of 30% fly ash. The obtained blend complies with EFNARC requirements.
2. Up to 2% with an increase of 0.5 percent, Dramix fibers with an aspect ratio of 80/60 are added. The SFRSCC has met the EFNARC requirements up to 2% by volume of concrete. EFNARC standards are not met above 2%.
3. The compressive strength of ternary blended SCC has increased over time. The greatest value for 7 and 28 days, respectively, was 26.06 MPa and 39.59 MPa. The ideal amount of rice husk ash in percentage is 6%.
4. The SFRSCC's compressive strength has increased with time, regardless of the quantity of fibers added to the concrete. As the percentage of fibers in concrete grew, the SFRSCC increased compressive strength. The ideal percentage of fibers in concrete is 1.5% by volume.
5. The amount of steel fibers has been increasing the flexural strength of SFRSCC. Although aspect ratio might have an impact. In comparison to ordinary SCC, there was a 21.5% improvement in flexural strength.
6. The SFRSCC has demonstrated a rise in split tensile strength in relation to the addition of more Dramix steel fibers. When compared to plain SCC, the split tensile strength increased by roughly 12.2%.
7. The cost difference between SCC and Ternary Blended SCC was not particularly substantial. The cost, however, is based on the material's accessibility.

CONCLUSION

This study demonstrates that rice husk ash can be utilized in SCC in place of cement. Although it is more affordable than regular concrete, RHA reduces the heat of hydration while also showing little variance in cost. The ideal RHA and Fly Ash content for partial cement substitution in SCC mix was discovered to be 6% and 30%, respectively. Ternary mix showed higher consistency in the development of compressive strength, which suggests a synergy of inert particle interaction between Ordinary Portland Cement, Rice Husk Ash, and Fly Ash that improved the compressive strength property. At 7 and 28 days, the SCC acquired compressive strengths ranging from 24 MPa to 29 MPa and from 33 MPa to 40 MPa. Steel fibers from Dramix are appropriate for SCC up to 2% by volume of concrete. The aspect ratio 80/60 Dramix steel fibers have demonstrated overall improvements in all the qualities. At 7 and 28 days, the SFRSCC exhibited compressive strengths ranging from

26 MPa to 35 MPa and from 39.00 MPa to 42 MPa. At 28 days, the SCC had achieved split tensile strengths ranging from 3.25 to 5.13 Mpa. At 28 days, the SCC had reached flexural strengths ranging from 4.69 to 6.62Mpa. This study has demonstrated that FRSCC can also be used locally for the production of concrete base slabs and pavements that don't require a lot more strength.

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