International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** V **Month of publication:** May 2020

DOI: http://doi.org/10.22214/ijraset.2020.5199

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue V May 2020- Available at www.ijraset.com

Mechanical Properties of High Volume Fly Ash based Fiber Reinforced Self Compacting Concrete: A Review

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Abstract: Self-pressing of concrete is gaining popularity these days, because durability, quality and compactness of the concrete become more important. Compared to the normal vibration concrete (SPC), self-pressing concrete (SCC) has an improved qualities and increases the productivity and working conditions due to elimination of compaction. SCC generally has a higher powder content. Practice of using extremely low water/connective ratio for high volume Fly Ash (HVFA) concrete mixtures in order to realize the adequate early forces is common. Typically, the heavy-dose high-range water reducer (i.e. Superplasticizer) must make such a mixture serviceable. Concrete is the most widely used building materials in the world. Fly Ash use is a global mindset as a supplement to cement concrete additives for durable concrete. The present work consists of the literature related to the fiber reinforced self compacting concrete.
Keywords: High volume fly ash concrete, Compressive strength, Fly ash, plasticizer & Workability

I. INTRODUCTION

Fly Ash is a non-organic, non-flammable product from coal plants. Since coal is burned at high temperatures, carbon is burned, and most mineral impurities are carried out using flue gases in the form of ash. Fly Ash is a pozzolanic material that has no cealting, but which will be in finely divided form and in the presence of moisture, chemically reacts with calcium hydroxide at room temperature, forming compounds possessing cement properties. In the presence of moisture, spent within the fly ash reacts to the ions of calcium in the form of calcium silicate. In today's construction industry has a general tendency to replace a higher level of Portland cement with flight in concrete. Elevated pressure on the use of higher levels of Fly Ash in concrete is associated with three main aspects.

In most markets, Fly Ash is less costly than Portland cement. Therefore, since the replacement level of Fly Ash increases, the costs of concrete production are decreasing. The second aspect is the environment. Fly Ash is an industrial product, much of which is deposited in landfills, if it is not used in concrete. In terms of environment, the more ash fly used in specific leads to less Portland cement intake. Thus, in turn, reduced emissions of C02. The third aspect is the technical advantages of the high volume of Fly Ash (HVFAC). HVFAC has improved performance over conventional Portland cement concrete, especially in terms of longevity when used properly. Although there are clearly economic and environmental benefits associated with using high-level Fly Ash in concrete, there is pretty little information about the nature of this concrete and virtually no indication of its production or use.

Self-pressing of concrete (SCC) is one of the most revolutionary events in recent years. Modern application of self-pressing of concrete (SCC) is focused on high performance, better and more reliable quality, dense and homogeneous surface texture, improved durability, high durability and faster construction. According to the European Federation of National Associations representing concrete (EFNARC) ' SCC is an innovative concrete that does not require vibration for placement and sealing. It is able to flow under its own weight, fully filling the formwork and reaching the full seal, even in the presence of overloaded reinforcement. Hardened concrete is dense, homogeneous and has the same engineering properties and durability, as well as traditional vibroton. The main steps in the production of SCC to determine the appropriate material, its dosage and evaluation of concrete properties developed.

Therefore, many initial works and studies have been made around the world to develop self-pressing concrete using different materials. However, there are a lot of uncertainties associated with the dosage self-pressing of concrete mixtures using different types of fillers. With all these uncertainties and to have a better understanding on the use of self-pressing concrete in India, there is a need to develop a self-pressing concrete using locally available materials for its adoption. Therefore, in this paper it is planned to study the properties of self-pressing concrete with a high volume of thin aggregate (sand). Efforts have been made to develop self-pressing concrete using Fly Ash as a substitute of cement in various proportions and quantitatively its basic properties.

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Additional cementious or inert material also known as fillers, such as Fly Ash, stone dust, lower ash, etc. can be used to increase viscosity and reduce the cost of SCC and normal concrete. RILEM Technical Committee 174-SCC informed at its employees the report that bulking is one of the interesting and complex topics for training for further development of technology, optimize the composition, increase production of machinery and increase the cost/benefits of self-pressing concrete.

The powder content required by the SCC ranges from 380-600 kg/m³ of concrete, which is much more than conventional concretes. Due to the rheological requirements, filler additions both reactive and inert) is widely used in SCC to improve and maintain efficiency, control of the cement content and reduce heat transfer. Mineral supplements like Fly Ash can effectively replace part of this content powder

Figure No.1: Coal fly ash from industry

In addition, Kurita Nomura introduced that the inclusion of Fly Ash improves the rheological properties and lowers the cracking potential of concrete because it reduces heat transfer by cement by the effect of replacing cement partly with Fly Ash (0-80%) On properties like compressive strength, performance, absorption, ultrasonic pulse speed * Shrinkage of SCC was investigated. The results showed that a large volume of Fly Ash replacing 40% OPC resulting in strength of more than 65 N/mm ² in 56-days. Between the 56-day shrinkage and the FA, there is a linear relation to the composition. The correlation between strength and absorption has pointed out a dramatic decrease in strength as absorption increased from 1 to 2%, and the strength decreases at a much slow speed.

A. Fiber Reinforcement

Fiber-reinforced concrete self-pressing (FRSCC) is a new building material that combines the advantages of SCC with positive fiber effects complemented by fragile materials (concrete). This is a plastic material, which in its fresh state works in the interior of the formwork, filling it in a natural way, passing through obstacles, and consolidation under the influence of its own weight. FRSCC can reduce the two opposite weaknesses: cracking resistance in simple concrete and poor work in fiber reinforced concrete (FRSCC). FRSCC has found a huge application in the construction of tunnel lining and rail sleepers. The rest of the FRSCC program in highway repairs and airfield sidewalks.

The use of steel fibers reinforced by self-pressed concrete (SFRSC) in the construction of structural elements is regarded as an alternative solution to complications when placing the rebar and sealing the normal Vibletton. The main advantage of SFRSC is the ability to fill properly in place by filling the corners of the formwork and shallow voids between the amplifiers fittings, using your own weight. Many studies have been done in researching the structural characteristics of SFRSC through advanced engineering and mechanical properties. The inclusion of steel fibers in the mixture was set to enhance hardened properties of self-pressing concrete in terms of its strength, plasticity, durability, absorption of energy and power, as well as the strength of fractures.

B. Self Compacting Concrete

The self-pressing of concrete (SCC) is regarded as concrete, which can be placed and compacted by its mass with little or no hesitation efforts, and which at the same time, cohesive enough to be processed without segregation or bleeding. It is used to facilitate and ensure proper filling and good design characteristics of restricted areas and strongly reinforced structural members. SCC was developed in Japan (1) At the end of the 1980's mainly used for highly congested structures in the seismic regions.

Recently, this concrete has become widely used in many countries for various applications and structural configurations. SCC can also provide a better working environment while eliminating vibrations of noise. There are many advantages to using SCC, especially when the cost of the material is minimized.

These include:

1) Reduction of construction time and cost of labour;
2) Eliminating the need for vibration;
3) Noise reduction;

II. LITERATURE REVIEW

In this paper the environmental indicators were assessed, fresh state and long-term mechanical properties of high-volume concrete Fly Ash (HVFA) of high efficiency of self-pressing (SCCs). SCCs were trained with 40-60% replacement of Portland cement with three ash ashes from two sources, with varying subtlety. SCCs ' rheological properties were evaluated using a specific working ability test. The effectiveness of fines to promote fresh state stability is investigated. Compressive strength, elasticity module and binder index have been identified on 28, 91, 180 and 365 days. In addition, the Life Cycle Analysis (LCA) was performed to assess the impact of cement replacement by flying the Ashes on CO2 emissions for concrete production.The results showed that the cement replacement on the fly Ash reduced the viscosity and superplasticizer SCCs content, and improved their passing ability. SCCs requires a minimum surface area of fines of 120 x 106 m2/m3 of concrete to achieve fresh state stability. The best summer ash is obtained by grinding was most effective in promoting stability and led to the highest compressive strength in any age. Concretes showed a significant compressive strength and the elasticity module increases to 180 days(Paulo Ricardo de Matos et al 2019).

With the development of SCC, limited data is available on the use of high volume sand and fly ash at the SCC as an alternative to the gross aggregate and cement respectively. Therefore, in this study conventional concrete M30 Grade upgraded to SCC high sand use for the total population (S/A) ratio to 0.56 by using 1.4% superplasticizer and 0.3% viscosity agent changes (VMA) of total powder content. Exposure to high S/ratio to 0.58 and replacement of cement @ 0%, 15%, 25% and 35% with Fly Ash on fresh and hardened SCC properties were found. It is found from this study that the SCC can be developed with an increase of S/A ratio of 0.56% using Superplasticizer and VMA without sacrificing strength properties. The use of Fly Ash has a significant impact on the reduction of cement content to SCC up to 25% of the replacement level effectively. (Priyanka et al 2016).

Fiber-reinforced self-pressing of concrete (FRGTK) is a new building material that combines the positive characteristics of the labor of self-pressing (SCC) with the increased characteristics of hardened concrete by fibers adding . In literature, metal and synthetic fibers are used as reinforcement of SCC. From literature it can be found that efficiency of SCC properties more adversely affects the use of metal fibers. In addition, metal fibers are more effective than synthetic fibers in an increase in mechanical properties of SCC (Subhan Ahmad et al 2018). In most cases, fiber-reinforced concrete (FSCC) contains only one type of fiber. The use of two or more types of fibers in the appropriate combination can potentially not only improve the workers properties of the self-pressing concrete, but can also lead to synergy performance. In this paper the combination of fibers, often called hybridization, is investigated. The control, single, two-fibre hybrid composites have been cast using various types of fiber steel and polypropylene with different sizes. Flexible shock viscosity has been performed, and results have been extensively analyzed to identify interactions, if any, are associated with various combinations of fibers. Based on different analysis schemes, the document defines combinations of fibers that demonstrate maximum synergy in terms of bending strength (H.Oucief et al 2006).

We made nine mixtures of SCC: one mixture only with cement from 500 kg/m3 (reference), four with bituminous content 500 kg/m3 (200 and 150 kg/m3 of cement), and four with bituminous content in 400 kg/m3 (160 and 120 kg/m3 of cement). Cement replacement with FA and MK, with or without addition HL has been tested in both GBS-LC: Binder 500 kg/m3 (B500) and binder 400 kg/m (B400). The normal Vibreroeton (SPC) with cement content of 300 kg/m3 was made only for comparison of its compressive strength from SCC low cement content (B500 and B400). The substitution reduces cement reduction by the equivalent of 60% – 70% compared to the reference line (C500). SCC was evaluated with a recession test, T500 best, V-Test, L-Box and J-ring tests(Marcos A.S. Anjos et al 2020).

This work aims to promote research on the use in concrete with a high volume of fly ash, with high loss on ignition value, aiding in a steady low-carbon design footprint. To this end, the work explores the benefits that can be achieved in terms of long-term concrete execution from the inclusion of fly ash along with the chemical activator. Strength tests are carried out on the concrete with activated hybrid system: Portland cement (PC) and high volume of Fly Ash with sodium sulfate. The diffusion coefficient of chloride significantly decreased over time for the activated system (50% PC-50% Fly Ash with the addition of sodium sulfate) in comparison with the control samples (100% PC and 80% PC-20% Fly Ash) at the same water to the cement ratio of the material. This behaviour is particularly evident in samples, cured under controlled laboratory conditions (100% RH and 23 °c) (Diego F. Velandia et al 2018).

Self-pressing of concrete (SCC) is widely used in the prefabricated concrete industry. Currently, the demand for concrete with high quality is permanent. In the production of such mixtures are often used expensive additives and a very large amount of cement. But such concrete was, as a rule, lower strength and difficult to obtain. This led to the development of self-pressing concrete. The operability of the SCC properties such as filling abilities, conveying the ability and segregation of resistance are evaluated by means of labor tests such as recession flow, V-funnel and L-Box tests. The ability to flow and segregation resistance to SCC provides a high level of homogeneity, minimal emptiness and uniform concrete, providing the potential for higher processing levels and thus the durability of the structure (Pravej Akhtar et al 2017).

Self-pressing of concrete (SCC) has gained popularity in recent years for the fact that it requires very little or no compaction and flows into every corner under its own weight. It is a special kind of high performance concrete that has a good ability, passing the ability and resistance to segregation. This article focuses on variations in the fresh and hardened properties of high-volume Fly Ash high-strength self-pressing concrete (HVFAHSSCC) with the inclusion of steel fibers in the concrete mix. Conventional SCC includes high costs of material costs and therefore a high percentage of cement has been replaced with mineral supplements like fly ash, Earth granulated blast furnace slag, silicon vapor, etc. In its fresh state concrete is characterized as SCC If it satisfies the guidelines EFNARC. Devolution ability and ability is significantly reduced with increasing volume fraction of steel fibers in the mix for high volume Fly Ash high strength SCC from M60 grade (Ved Amonkar et al 2018).

In India, the construction industry plays an important role in the development of the country's economy. For all construction projects, approximately 60% – 70% of the cost spent on concrete. Annual consumption of concrete is about 10 000 000 tones. At the same time, abundant fly ash has been thrown out as a loss. Fly Ash, a product from power plants, is effectively used in the construction industry as an ecoproduct. The concrete grade, considered for this experimental study, M30 from 53 grade of conventional Portland cement. About 50% and 75% of cement was replaced by Ash fly. The sand is replaced by 5% coconut pitat and 25%, 50% and 75% of quarry dust. The mix design method was adopted to obtain the required concrete strength. Cubes (90), Cylinders (90) and Prism (60) were cast and cured. Cubes were tested for compressive strength of 7, 28 and 56 days. Cylinders were tested for tensile strength on 7, 28, and 56 days (A. Oorkalan et al 2018).

Fly Ash use is a global mindset as a supplement to cement concrete additives for durable concrete. But, most Fly Ash is used and recommended for use in conventional structural concrete, including the concrete of geomolymer is low in calcium-flying ash. High calcium fly ash is more pozzolanic and used only in non-structural applications. Excess calcium, if consumed by pozzolanic material, can be expected to lead to better concrete. This effect was studied replacing the silica fume to a high volume of high calcium flying ash concrete. Considered to be conventional M30 concretes for cement substitution 50% and 60% of Fly-Ash by weight and fly ash by 10% and 20% with silica fume (R.Venkatakrishanaiah et al 2013).

Self-pressing of concrete (SCC) is an innovative concrete to solve the problem of concreting due to dense reinforcement. The SCC adoption offers substantial benefits for improved construction performance, reduced overall cost, and improved working conditions. This work explores the strength of the SCC's compression by replacing large volumes of Portland cement on the fly Ash. Studies are conducted to investigate the impact of various levels of cement replacement (20%, 40%, 60% and 80%) With Fly Ash (class F). Results showed that the fresh and hardened properties of SCC inclusion up to 40% of Fly Ash as a substitute for cement (CE40FA) are not substantially affected. However, it was noticed that the early age of strength was considerably affected even when replacing 40%. To overcome the disadvantages of using a high volume of Fly Ash (HVFA), such additions, like lime, lime limestone and nano $CaCO_3$, etc. are added to the HVFA SCC.(Hemalatha, T et al 2015).

With the development of SCC, limited data is available on the use of high volume sand and fly ash at the SCC as an alternative to the gross aggregate and cement respectively. Therefore, in this study conventional concrete M30 Grade upgraded to SCC high sand use for the total population (S/A) ratio to 0.56 by using 1.4% superplasticizer and 0.3% viscosity agent changes (VMA) of total powder content. Exposure to high S/ratio to 0.58 and replacement of cement @ 0%, 15%, 25% and 35% with Fly Ash on fresh and hardened SCC properties were found. It is found from this study that the SCC can be developed with an increase of S/A ratio of

0.56% using Superplasticizer and VMA without sacrificing strength properties. The use of Fly Ash has a significant impact on the reduction of cement content in SCC to 25% of the replacement level effectively (Rajesh Kumar et al 2016).

The experimental test was conducted to investigate the shift of full-blown rays, which were built with a high fly volume of the ashes of the consolidated concrete (HVFA-SCC). HVFA-SCC-New concrete grade HVFA concrete with rheology self-consolidation concrete, satisfying the quality of construction work, environmental aspects and specific sustainability. Mixes with different levels of cement, replaced on fly Ash and hydrated lime [50%, 60%, and 70% (by weight)] are used. Twelve full-scale reinforced concrete beams were cast and tested using a four-precision load test installer. This study focused on the impact of factors such as cement replacement level, longitudinal reinforcement coefficient and shear gain at radial shear. All beams were 4000 mm (13 ft) long, 457 mm (18 in.) in thickness, and 305 mm (12 in.) in width. Rheological and mechanical properties of mixtures were controlled (Hayder H. Alghazali et al 2017).

Based on the submitted literature, it is concluded that a large volume of flying ash and concrete self-pressing is a building material that can be used to increase volumes due to its long term and better mechanical and Durability of properties than ordinary concrete. High volume flying gums has better durability characteristics such as abrasion resistance, permeability, chemical impact; Creep and shrinkage compared to conventional concrete (CC).

III. CONCLUSION

Compressive strength for the fly of ash in concrete is usually reduced by the addition of ash flies, while the presence of silica smoke in the concrete increases strength. In the current study, cement is replaced by a high volume of fly ash, as well as silica smoke. So the strength of concrete increases to a certain level more silica and fly ash percentages. Replacing the cement on the fly Ash and silica fume in various proportions has led to significant changes in the properties of fresh concrete as a unity, an influx Mixes, segregation and reducing bleeding, etc. In general, the addition of a fly ash to the concrete reduces performance when further addition of silica smoke increases performance and strength characteristics.

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