WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Review Paper on Experimental Studies of Concrete using Silica Fume, Fly Ash and Steel Fibers

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A B S T R A C T

Concrete is most widely used man made construction material. Different types of experiments done on concrete every day to improve the properties of concrete. To modify the properties of the concrete different types of cementitious material are used with admixtures. Main advantage of using cementitous material is to lower down the consumption of cement and also it modifies the mechanical properties of concrete. Among all cementitious material Silica Fume and Fly Ash give best performance in strength and durability aspect of concrete. Use of fiber along with cementitous material in concrete is not new but there is considerably change in types of fibers which are used in concrete. The main advantage to use fibers with cementitious material is that properly distribution fibers in concrete. In this paper combination of different types of steel fibers with Silica Fume and Fly Ash are studied on strength aspect of concrete. The most thorough study of the mechanical, physical, and durability-related characteristics of concrete to date is presented in this publication. This literature review seeks to give a thorough examination of the mechanisms of compressive and tensile strength (TS). In general, adding fibres to high-performance concrete, along with silica fumes and Fly Ash, has been shown to improve the mechanical properties of the material, particularly tensile strength, flexural strength, and ductility. Furthermore, the addition of fibres to concrete reduces shrinkage and creep deformations.

Keywords: Compressive Strength, Flexural Strength, Aspect Ratio, Steel fibers, cementitious material, Silica Fume, Fly Ash ,Mechanical properties of concrete.

INTRODUCTION

Researchers are now developing concrete with natural or artificial fibers and mineral admixtures for buildings. High Strength concrete can made using silica fume as addition or as a cement substitute. As results, combining fly ash and silica fume is an intriguing option. The mechanical qualities of concrete are improved by cementitious materials such as fly ash and silica fume.

The use of fly ash in concrete provides a number of advantages. The inclusion of fly ash improves long-term strength and durability. The insertion of fibres improves structural characteristics like as tensile strength and toughness. The addition of fly-ash in concrete has many advantages. The addition of fly ash improves durability as well as long-term strength. The structural characters like tensile strength and toughness are improved by addition of fibres. Because of its numerous technical advantages in both the fresh and hardened states, the use of fly ash in concrete for structural applications has expanded in recent years. The use of fly ash improves the long-term strength of silica-fume concrete.

Concrete technology has advanced significantly in the previous fifty years, owing to a renewed interest in supplemental cementing materials as well as the introduction of new generation chemical additives for concrete. The use of supplemental cementitious materials in the development of low-cost construction materials for developing countries is critical. The different qualities of concrete, including as workability, durability, strength, crack resistance, and permeability, can be increased by adding some pozzolanic elements. When high-purity quartz is reduced with coal or coke and wood chips in an electric arc furnace to make silicon metal or silicon alloys, silica fume is produced as a by-product. Concrete's mechanical characteristics and durability have both been found to be improved by silica fume.

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Silica fume serves as a filler in concrete, filling the gaps between cement grains in the same manner as sand fills the spaces between coarse aggregate particles and cement grains fill the spaces between sand grains. This extremely active pozzolana reacts more quickly than ordinary pozzolans in terms of chemical reaction due to its high surface area and high proportion of amorphous silica in silica fume.

Fly ash concrete is crucial in these times of economic and environmental concerns about concrete in the construction industry. According to studies, up to 20% fly ash replacement in OPC is viable in terms of strength and durability, resulting in cheaper concrete and better utilisation of fly ash, which is an industrial by-product..But the mechanism of strength attainment of such a mix relies on the pozzolanic action of the fly ash particles, which is a rather slow process.

The addition of fibres to concrete produces a dense, homogenous material that is isotropic. It helps to improve the microstructure of concrete and to control the formation of micro cracks in the early stages of concrete. When concrete fractures, the randomly arranged fibres begin to work, stopping the crack from spreading and improving the tensile qualities of the concrete. As a result, the consistency and integrity of concrete will be improved, which is important for the safety and long-term durability of concrete structures.

LITERATURE REVIEW

Gurpreet Singh (2020) The current study is based on an analysis of the strength and durability of concrete structures, in which the modified concrete is made by adding a portion of cement (by weight) with Silica Fume. From the studies, it has been found that Steel Fibers are an excellent material with reinforcing properties that help in reducing the matrix, which is why it improves concrete structures. Therefore, for the requirements of structure and durability, it was decided to reinforce the steel fibers in standard cement concrete by a certain percentage. Mechanical parameters including compressive strength, split tensile strength, and flexural strength, as well as durability factors like water absorption, were tested for batches indicated for healing, and the results were compared to control combinations.

Suseela Alla, M. Jayaram b, S.S. Asadi (2020) The major goal of this research is to find a cement substitute and conduct an experimental investigation on the durability qualities of concrete using silica fume and fly-ash instead of cement. Six samples of M80 and M90 grade cubes, cylinders, and beams with targeted Robosand percentages of 0, 25, 50, 75, and 100 and fly-ash of 20% and 5% silica fume with cement were compared to the control mix in this research (CM). Sulfate attack solution was used to investigate the durability qualities (H2SO4 & HCL). At 7 days, 28 days, and 30 days after being cured with H2SO4 solution and HCL solution, the compressive strengths of the concrete samples varied. The results show that, the increase in the strength of mixes is due to the increase in age and not due to the durability attacks.

M.D. Ikramullah Khan, G. Swamy Yadav, S. Haripriya Varma (2020) This experiments is done to find out the mechanical behavior of concrete by adding fiber at a range 0.02%, 0.04%, 0.06%, 0.08% and 0.1% by weight of cement and fly ash partially replaced with cement by 10% by weight of cement. The results which is found, were then compared with M35 grade normal concrete. The results were found that when compared to normal concrete, the fly ash binds the concrete mix to make it dense.

Poojari Yugendar, Kampilla Vishnu (2020) The strength behaviour of concrete containing various percentages of fly ash and fibre was investigated in this research. The purpose of these tests is to determine the workability, compressive strength, and split tensile strength of concrete. Fly ash was used in the following proportions: 0%, 5%, 10%, 15%, and 20% by weight. Fiber proportions of 0 percent, 0.5 percent, 1.0 percent, 1.5 percent, and 2.0 percent were also used. The results of the tests revealed that when the steel fibre content increases, compressive and split tensile strength improves up to 1.0 percent before decreasing. The workability of concrete is shown to diminish as the fibre concentration increases. The purpose of this study was to determine the impact of fly ash and fibre on the compressive strength of concrete. Steel fibres and fly ash content have an effect on concrete strength, according to the study.

Piotr Smarzewski (2019) The primary goal of this research is to measure the fracture energy of silica fume-containing high-performance concrete (HPC) (SF). The addition of silica fume to six high-performance concretes resulted in changes in mechanical parameters such as compressive strength, splitting tensile strength, modulus of elasticity, fracture energy, and characteristic length. By mass of cement, silica fume additions were 0 percent, 5 percent, 10 percent, 15 percent, 20 percent, and 25 percent. The ratio of water to binders was 0.25. Increases in the mechanical qualities of concrete are aided by the use of silica fume. When cement was replaced with silica fume in concrete, the mechanical qualities of HPC were greatly enhanced at 28 days, according to this study. 10% replacement of cement with silica fume results in a 26% increase in tensile splitting strength, and a 13% increment in compression strength of concrete. The results suggested that silica fume can effectively replaced by cement. it is concludes that the replacement of silica fume with cement should should not more then 10%.

Mr. Omprakash Devenda, Mr. Ramanuj Jaldhari (2019) In this work evaluate the performance of concrete with silica fume and also replaces cement by steel fiber.. In this study silica fume has been replaced in ordinary Portland cement(43 Grade) cement, with different percentages 2.5%, 5%,7.5% and 10% and also steel fiber replaced with cement which varies 2.5% to 10% by weight of cement. A total 24 mixes (trial mix, control mix and variation mix) were prepared for M35 concrete & M40 of concrete. In this study examine the performance of Cube Compressive strength for 7 days and 28 days, Beam

Flexural strength 28 days and Cylinder Splitting tensile strength for 28 days respectively. Total number cubes specimen140, cylinders 60 and beams 60, which were cast for influence of silica fume and steel fiber on concrete. These Concrete cubes, beams, cylinders specimens were cured in water. On the basis of result that silica fume and steel fiber concrete was found to increase in all strength and durability of variation mix of concrete on all age when compared to normal concrete.

Zemei Wua, Kamal H. Khayata, Caijun Shib (2019) This study investigates the effect of silica fume is studied, silica fume contents varies from 0 to 25%, by weight of cementitious materials, non-fibrous UHPC matrix and UHPC made with 2% micro-steel fibers. This work is done to find out the mechanical properties include Compressive strength, flexural strength, and tensile behavior of concrete. Test results showed that UHPC made with 10% to 15% silica fume obtained the higher strength.

S Yeshwanthi Roy, K Thiagarajan and N Umamaheswari (2019) This experimental study is aimed at finding the effect of reducing the usage of conventional materials for concrete. In this work mechanical properties of concrete is modified with manufactured sand (M-sand), silica fume and steel fiber and tested and compared with that of conventional concrete. For modification of new advanced concrete, cement is replaced by silica fume, river sand by manufactured sand and steel fibers are also added in the concrete. The benefits of using silica fume is to increases the strength of concrete. In this work steel fibers are added to concrete to increase the tensile strength of the concrete. The percentage replacement of river sand by M sand is 40%, cement with silica fume is 5% and hooked end fibers are added at 0.6% to concrete mix during concrete mix preparations. This experiments shows that use of silica fume and steel fibers is economical and good for future work.

Amit, Akash batra, Pappu Sharma, (2019) This research represents the effect of silica fume and steel fibers on normal concrete and will also help in results. In this research, Experimental investigations and analysis of results were done to study the Compressive strength and flexural behavior of concrete with different percentage of silica fume and steel fibers. The concrete mix of M40 were adopted with varying percentage of the silica fume from 0%, 5%, 10%, 15% & 20% in the replacement of cement weight and stainless steel fibers of diameter and length 0.50 mm and 40 mm respectively with the aspect ratio 80 at various percentages of 0%, 0.4%, 1.4%, 2.4% & 3.4% by weight of the cement were adopted. On the basis of results it shows that adding silica fume and steel fibers in concrete help in improving strength and durability of concrete.

Prakash, Maneeth P D, Dr.ShreenivasReddy S (2018) In this work hybrid fiber concrete were casted by replacing cement with fly ash by 25% 30% and 35% and 5%, 10% and 15% of silica fume. A percentage of 0.5% Steel and 0.5% polypropylene fiber are used for all three mixes. The density of concrete increases by adding micro silica and steel fiber to concrete which improves the strength of concrete, Compressive strength, Split tensile and flexural strength of HFRC of mix-2 increases. The steel fiber results increases in tensile strength of concrete. The use of silica fume is also recommended for mass concrete work.

Miss Akshata A Mulgund, Dr dilip k kulkarni (2018) Current research has been done on concrete due to the effect of silica fire with steel fibers outside and outside the Portland pozzolana cement. In this study the concrete mix with 20% silica fire, with the inclusion of steel rods of 0.5mm diameter and 60 cm, by various percentages such as 0%, 0.5%, 1.0% and 1.5%, 2.0% concrete volume in M 30 grade concrete. The effect of mixing minerals (silica smoke) such as cement and non-ferrous metals in machine structures was analyzed and compared with conventional concrete. In comparison, with standard concrete the return of 20% cement by silica fire showed a 6%, 8.5% and 10.75 increase in Compressive strength within 28 days of treatment. The proposed model was found to have excellent accuracy when estimated for 28 days of Compressive strength, separated strength strength and flexural strength of concrete.

Suhail Rashid Dar and Er Ankit Mahajan (2018) In this research a total of 90 samples have been cast in which 30 was cubes with 150mm x150mm x150mm dimensions, 30 were beams of dimensions 500mm x100mm x 100mm and 30 were cylinders of 150mm diameter and 300mm height used for experiments. On the basis of present investigation it shows that, replacement of cement with silica fume up to 10% and steel fiber 0.5% by weight of cement in concrete, increases the Compressive strength, splitting tensile strength, flexural strength of concrete up to:
Compressive strength increases by 3% - 5%.
Flexural Strength increases by 5% - 10%.

S. Mahmoud Motahari Karein, A. Ramezanianpour, Taghi Ebadi (2017) In this study, the density of silica fume was increased by producing silica fume granules mixed with a solid super plasticizer. The effects of silica fume on durability of concrete and as well as on mechanical properties of concrete were tested. Results shows that, there is increase in strength and surface electrical resistivity, and a decrease in permeability for both silica fume and granule, compared to the control sample.

P.Prathap, T.Naresh kumar, Dr.S.M.V Narayana (2017) This investigation carried out on concrete due to the effect of silica fume with and without steel fibers on 53-Grade Portland cement. In this study concrete mixes with silica fume of different percentage at 0%, 5%, 10% and 15% by the weight of cement for M35 grade of concrete. The optimum percentage of silica fume which give maximum Compressive strength was found to be 10%. Adding steel fibers of diameter 0.5mm and length 12mm with aspect ratio 24, at the various percentages as 0.2%, 0.4%, 0.8%, 1.0% and 2%. The mechanical properties of mineral admixture as a cement replacement material with and without steel fibres were investigated and compared to convectional concrete.

When compared to convectional concrete, the inclusion of silica fume increases the compressive strength. At the age of 28 days, the greatest improvements in compressive strength were up to 10%. When steel fibre is added for the optimum content of silica fume, the compressive strength increases up to 28 days. At 28 days, the insertion of steel fibres boosts the concrete's split tensile strength substantially. The flexural strength of concrete increases significantly due to the addition of steel fibers at the age 28 days.

Rahul Dogra, Ankit (2016) The mechanical properties of concrete were studied when cement was replaced by silica fume at varied percentages of 0%, 5%, 7.5, and 10%, while polypropylene fibre was employed at 0%, 0.5 percent. Compressive strength, flexural strength, tensile strength, and abrasion resistance were discovered in this work. The strength attributes of high strength concrete of M40 grade at 7 days, 14 days, and 28 days characteristic strength with various levels of cement replacement with silica fume are used in this study. Standard cubes of 150mm X 150mm X 150mm, standard cylinders of 150mm diameter X 300mm height, and standard beams of 100mm X 100mm X 500mm were employed to get the desired results. The study found that using silica fume in concrete improves the concrete's strength qualities.

F.N. Okoyea, J. Durgaprasada, N.B. Singh (2015) In this research paper fly ash based geopolymer concrete with different percentages of silica fume were cast by using NaOH/sodium silicate. Mechanical properties of concrete such that workability, Compressive strength, Flexural strength and tensile strength of concrete were determined. Sodium hydroxide and sodium silicate were used as alkali activator. The results shown that adding silica fume in concrete improved the Compressive strength of the geopolymer concrete. Tensile strength and Flexural strength of concrete also increased as the amount silica fume content increased.

S. Arivalagan (2014) In this investigation to study the Flexural Behavior of Steel Fiber Reinforced self compacting concrete incorporating silica fume in the structural elements. The self compacting concrete mixtures have a coarse aggregate replacement of 25% and 35% by weight of silica fume. Total eight mix were investigated in which cement, water, dosage of superplastizers were present. The variable in this study was percentage of volume fraction (1.0, 1.5) of steel fibers. Five beams were cast for study, out of which one was made with conventional concrete, one with SCC (25% silica fume) and other were cast with SCC (25% silica fume + 1% of steel fiber, 25% silica fume + 1.5% of steel fiber) one with SCC (35% silica fume), and other were SCC (35% Silica fume + 1% of steel fiber, 35% Silica fume + 1.5% of steel fiber). In this work Compressive strength, flexural strength of the concrete were determined for hardened concrete for 7 days and 28 days. This investigation is also done to find out the increases in the Compressive strength of concrete by addition of silica fume by varying the percentage.

T.H. Sadashiva Murthy (2014) Investigation done on split tensile strength of steel fiber reinforced concrete with fly ash and silica fume as binary and ternary blend, cured for 150 days under normal water and 5% sodium chloride solutions. Mix proportions of concrete of 1:1.90:2.89 with 0.45 water-cement ratio were adopted. 0.75% volume fraction of steel fibers having 0.5mm diameter and 36mm long were used. Seven different combinations of mixes with replacement level of fly ash (0, 20, 30 and 40%) as binary blend and silica fume (10%) as ternary blend were used. Naphthalene-formaldehyde-sultanate-based super plasticizer were used during mixing. In this work Split tensile strengths of all the mix after curing periods were obtained. All mixes showed higher strengths than that of corresponding binary blended mixes at all ages under both conditions.

Khelan Parikh, Dhruti J Dhyani (2013) In this paper combination of different types of steel fibers with Silica Fume are studied on strength aspect of concrete. From the various researches it concluded that both Silica Fume and Steel Fiber have significant effect on increasing mechanical properties of concrete. Addition of Silica Fume decreases the workability of the concrete, so to increase workability of concrete it is necessary to use super plasticizes. Addition of Silica Fume in concrete improves the mechanical properties of the concrete.

Mehmet Gesoglu, Erhan Güneyisi, Radhwan Alzeebaree, Kasım Mermerdas (2012) This paper reports an experimental study on the mechanical properties of steel fiber incorporated plain and silica fume (SF) concretes produced with artificial fly ash aggregates. In this work two concrete with (w/b) ratios of 0.35 and 0.55 were designed. Silica Fume performance was achieved with 10% replacement of the weight of cement with silica fume. Two types of hooked and long straight steel fibers with aspect ratios of 80 and 40 were used. AFA, was used as coarse aggregate in all the concrete mixtures The mechanical properties of rebar and concrete, such as compressive strength, modulus of rupture, and bonding strength, were examined. The tests were completed after a 28-day water cure phase. The results of the experiments were analysed. The findings reveal that the use of Silica Fume and various types of steel fibre has an impact on the mechanical qualities of concrete.

CONCLUSIONS

Based on the existing research, it may be determined that replacing cement with silica fume increases compressive strength, splitting tensile strength, and flexural strength by up to 15%.

1) Adding silica fume lowers the workability of the material. In some circumstances, though, it improves the workability.
2) The addition of silica fume to concrete greatly boosts its compressive strength. The increment is determined by the level of replacement.

3) Silica fume concrete has tensile and flexural strengths that are nearly same to ordinary concrete**.**

4) The addition of silica fume improves the bond strength of concrete.

5) The modulus of elasticity of silica fume concrete is almost similar to the referral concrete.

6) The density of concrete increases as adding micro silica and steel fiber to concrete which imparts the strength of concrete.

7) Optimum level of silica fume should be 5 % to 10 % for rigid pavement.

8) The optimum level of fly ash replacement should be between 10 to 30% in order to obtain the maximum strength of the concrete.

9) The weight density of concrete increases with the increase in the steel fiber content.

10) Slump will lose at the higher percentage of steel fiber and lesser silica fume.

11) The cost of fly ash is very low, as compared to the cost of cement. Hence, the replacement of cement with fly ash can be economical for mass concreting. It helps in reducing the problem of dumping the fly ash. On the other hand, the presence of fly ash in the concrete has its own advantages in terms of the reduced cracks and dense concrete.

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