Research Paper Engineering

Use of Micro Steel Fibers in Concrete with Innovative Supplementary Material Silica Fume- A Review

* Khelan Parikh ** Dhruti J Dhyani

* Research scholar, M.E Structure, SVIT, Vasad

** Assistant Professor, M.E Structure, SVIT, Vasad

ABSTRACT

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 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 are studied on strength aspect of concrete.

Keywords : Steel fibers, cementitious material, Silica Fume, Mechanical properties of concrete.

1. Introduction :

In the last fifty years, there has been significant progress in concrete technology, mainly owing to the revival of the interest in supplementary cementing materials, as well as because of the advent of new generation chemical additives for concrete. The use of supplementary cementitous materials is fundamental in developing low cost construction materials for use in developing countries. By addition of some pozzolanic materials, the various properties of concrerteviz, workability, durability, strength, resistance to cracks and permeability can be improved. Silica fume is a by-product resulting from the reduction of high – purity quartz with coal or coke and wood chips in an electric arc furnace during the production of silicon metal or silicon alloys. Silica fume is known to improve both the mechanical characteristics and durability of concrete. The principle physical effect of silica fume in concrete is that of filler, which because of its fineness can fit into space between cement grains in the same way that sand fills the space between particles of coarse aggregates and cement grains fill the space between sand grains. As for chemical reaction of silica fume, because of high surface area and high content of amorphous silica in silica fume, this highly active pozzolana reacts more quickly than ordinary pozzolans. The main problem in concrete is develop crack due to plastic shrinkage, drying shrinkage and other reasons of changes in volume of concrete. The development of these micro cracks causes elastic deformation of concrete. Plain concrete is a brittle material and having the value of modulus of rupture and strain capacities are low. The addition of fibres in the plain concrete will control the cracking due shrinkage and also reduce the bleeding of water.

2. EXPERIMENTAL RESEARCH:

Romualdi and Batson (1963) after conducting impact test on fibre reinforced concrete specimens, they concluded that first crack strength improved by addition of closely spaced continuous steel fibres in it. The steel fibres prevent the adverting of micro cracks by applying pinching forces at the crack tips and thus delaying the propagation of the cracks. Further, they established that the increase in strength of concrete is inversely proportional to the square root of the wire spacing.

Krishna Raju et al. (1977) after conducting experimental investigation on the compressive strength and bearing strength of steel fibre reinforced concrete with fibre content varying from to 0% to 3%, they concluded that, both compressing and bearing strength increases with increase in fibre content. Also the experimental results were predicted by theoretical method.

Jain-Tong Ding and Zongjinli (2002) investigated the properties of concrete by incorporating 0% to 15% cement replacement by silica fume. They concluded that by incorporation of Metakaolin and Silica fume, they can reduce the free drying shrinkage and restrained shrinkage cracking width. Also they can reduce the chloride diffusion rate significantly.

Preeti P Patel, Elizabeth George and Deepa A Sinha (2008) studied effect of silica fume on concrete. The work was carried out for two grades M20 and M30 of concrete. For the grades of concrete the cement content, sand, grit, coarse aggregate and w/c ratio is kept constant. Only the percentage of silica fume has been changed 0%, 7.5%, 10% and 12.5%.The results have shown the considerable improvement in compressive strength, modulus of elasticity and durability with respect to sulphate. Split tensile strength is observed to be nearly same with or without the use of silica fume for both the grades.

Wei-Ting Lin, Ran Huang, Chin-Lai Lee, and Hui-MiHsu (2008) carried out experimental program to evaluate the mechanical properties of cement-based composites. Test variables included water to cementitious ratio, dosage of silica fume and volume fraction of steel fiber. Compressive strength test, direct tensile strength test, splitting tensile strength test, abrasion resistance test and drop weight test were performed and the results were analysed statistically. The found that Cement-based composites containing 10% silica fume demonstrates better compressive strength, splitting tensile strength, direct tensile strength and abrasion resistance, and worse impact resistance than composites containing 5% silica fume.

Yu-Wen Liu, Chin-Chun Lee, K.S. Pann (2009) studied on Abrasion resistance of concrete containing different fibers with silica fume. Three different types of fibers, containing

steel fiber, carbon fiber, and Polypropylene fiber, were added to repair concrete, also the abrasion resistance was measured with waterborne sand flow testing method and compared with plane silica fume concrete. Test results show that optimized fiber–silica fume combinations can better improve the abrasion resistance of repair concrete. At the silica fume–cement ratio of 20%, the fiber concrete can remarkably enhance the abrasion and impact resistance. When hit by waterborne sand flow, the abrasion resistance was better for silica fume concrete combine with carbon fibers, steel fiber and glass fiber than plain silica fume concrete. In addition, the carbon fiber and glass fiber concrete have rather high impact resistance than silica fume concrete.

Chung-Hao Wu, Yu-Wen Liu, Chung-Ho Huang, Tsong Yen, and Tsao-Hua Hsu studied Abrasion resistance of concrete with steel, Carbon and Glass fiber with different standards. Test results show that the steel fiber concrete performed better abrasion erosion resistance than that of the carbon fiber concrete and glass fiber concrete when the fiber content keeps 1.0 %. It was found from the underwater abrasion test that the carbon and the glass fiber concrete demonstrate quite similar abrasion erosion resistance, while the steel fiber concrete exhibits the best abrasion resistance. It was also found from the crack impact test that for the concrete containing 1.0 % fiber the glass fiber concrete can present the best impact resistance, subsequent by the carbon fiber concrete, and the steel fiber concrete is the worst.

OzgurErena, KhaledMararb (2010) investigated the effect of fiber volume and aspect ratio of hooked steel fibers on plastic shrinkage cracking behaviour together with some other properties of concrete. Naturally concrete shrinks when it is subjected to a drying environment. If this shrinkage is restrained, tensile stresses develop and concrete may crack. One of the methods to reduce the adverse effects of shrinkage cracking of concrete is by reinforcing concrete with short randomly distributed fibers. They produce concrete with 3 different volume of fibre of 3 different aspect ratio. Hook-end steel fibres are used. They observed that these steel fibers can adversely affect some other properties of concrete during fresh and hardened states. They observed that addition of fibres increases VeBe time and wet density of fresh concrete. Fiber aspect ratio and fiber volume have no clear effect on water evaporation rate and first crack initiation time. It seems that fiber aspect ratio does not influence total crack length significantly. There is a critical fiber volume content of fibers to reduce the total crack length.

Prashant y. pawade (2011) In their investigation a series of compression tests were conducted on 150mm, cube and 150mm x 300mm, cylindrical specimens. Using a modified test method that gave the complete compressive strength, static, dynamic modulus of elasticity, ultrasonic pulse velocity and stress-strain behaviour. Using 8% silica fume with and without steel fiber of volume fractions 0, 0.5, 1.0, and 1.5 %, of 0.5mm Ø and 1.0mm Ø with a constant aspect ratio of 60 on Portland Pozzolona cement of M30 grade of concrete. They used crimpled steel fibres. As a result the incorporation of steel fibers, silica fume and cement has produced a strong composite with superior crack resistance, improved ductility and strength behaviour prior to failure.

Farnoud Rahimi Mansour, Sasan Parniani, and Izni Syahrizal Ibrahim(2011) investigated the effects of fiber volume on the compressive, splitting, and flexural behaviours of SFRC, and secondly to compare modes of failure. A series of 108 specimens (cube, cylinder and prism) with four different steel fiber volumes are used by a ratio of 0, 0.7, 1.0 and 1.5%. All specimens are cured in a water tank for 7, 14 and 28 days, respectively to provide same conditions. Hooked-ended steel fibers with a length of 30mm and a diameter of 0.75 mm are used. From the observations addition of steel fiber has a little reduction in compression strength. Also, steel fiber has a little increase on splitting tensile strength and greatly influences the flexural strength. In comparison with 3%fiber, 1.0 % was recognized as the best fiber volume for both economical and strength aspects. Steel fibers enhanced the capacity of the matrix to hold together during post cracking stage, thus prevent spalling even at failure.

DasariVenkateswara Reddy, PrashantY.Pawade(2012) used concrete mixes with Silica Fume of 0%, 4%, 8%and 12%, with addition of crimped steel fibers of diameter 0.5 mm Ø with a aspect ratio of 60, at various percentages as 0%, 0.5 %, 1.0 % and 1.5 % by the volume of concrete on M35 grade of concrete. The effect of mineral admixture (silica fume) as cement replacement material with and without steel fibers on mechanical properties were analysed and compared with normal concrete.The weight density of concrete increase with increase in the steel fiber content. Super plasticizer with dosage range of 0.75 to 1.80% by weight of cementations materials (Cm = PPC + SF) has been used to maintain the adequate workability of silica fume concrete and silica fume with steel fiber concrete mixes. The compressive strength increases significantly due to addition of silica fume compared with normal concrete. The maximum increase in compressive strength was up to 15.84% and15.68% at 28 days and 90 days of curing for 8% of silica fume replaced by PPC cement.

3. CONCLUSIONS

- From the various researches we concluded that both Silica Fume and Steel Fiber have significant effect on mechanical properties of concrete.
- Addition of Silica Fume decreases the workability of the concrete. To improve the workability of concrete containing Silica Fume use of super plasticizer is necessary.
- Addition of Silica Fume in concrete improves the mechanical properties of the concrete.
- Due to less permeability of concrete containing Silica Fume it makes the durable concrete.
- Main advantage of Silica Fume is fineness of itself. Because its fineness can fit into space between cement grains in the same way that sand fills the space between particles of coarse aggregates and cement grains fill the space between sand grains. As for chemical reaction of silica fume, because of high surface area and high content of amorphous silica in silica fume, this highly active pozzolan reacts more quickly than ordinary pozzolans.
- Main purpose of using fibers in concrete is to eliminate or lower down the shrinkage cracks developed. It cannot be used as reinforcement but it can lower down the requirement of reinforcement.
- Addition of Steel fibers in concrete containing Silica Fume also improves the properties of concrete. Due to addition of Silica Fume in concrete there is well dispersion of fibers in concrete which directly affects the mechanical properties of the concrete.
- Variety of Steel fibers is available in the market based on material and aspect ratio of fiber. Strength of concrete containing the fibers is depending on aspect ratio and volume of fibers in concrete.
- Higher the aspect ratio of the fiber there is good bond between the fiber and concrete which directly affects the mechanical properties of concrete and give good results. But problem associate with it is to difficult handle them because of problem of balling in concrete. Thus it cannot use in larger percentage.
- Smaller the aspect ratio of the fiber which also called micro fibers there is not proper bonding between the fiber and concrete which not give good results compare to higher aspect ratio but not worst one. But using of this fiber in concrete is quite easy compare to higher aspect ratio because of there is no problem of balling. It can also use in higher percentage. Problem of developing micro cracks in concrete are easily lower down due to small size of its which directly enhance the performance in durability and also improve the flexural and tensile properties of concrete. It decreases the compressive strength slightly.
- Lots of work is done higher aspect ratio of fiber but there is also need to study on behaviour of micro fibers in concrete both on strength and durability aspectbecause of its advantageous in many ways.

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