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Performance of Fiber Reinforced Self-Compacting Concrete Containing Different Pozzolanic Material: State of the Art

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Abstract: **Self-compacting concrete (SCC) is a kind of concrete mix that eliminate the required for the vibration tools as their high fluidity and moderate viscosity during the fresh qualities Fiber reinforcement mainly enhances the post-cracking qualities of concrete and gains inside a more ductile material behavior, several studies have produced a brand new idea to increase the concrete ductility and it is energy absorption capacity, to be able to improve overall ductility. The fiber reinforced self-compacting concrete (FR-SCC) is concrete mix getting the benefits of both SCC using the fibers to enhancing and increasing its properties. This research project aimed to study the effect of different fibers such as steel, polyvinyl alcohol (PVA) and chopped basalt fiber on the properties of self-compacting concrete (SCC); the properties are workability and hardened while the work have been extended to replacing the cement content by different cement replacement material (CRM) to form different binder content and that to reduce the total cost and improve the fresh behavior of FR-SCC with increasing the strength after long time.**

Key word: **Self-Compacting Concrete, Fly ash, Silica fume, Fibers.**

I. INTRODUCTION

1.1 DEFINITION AND PROPERTIES OF SCC

Growth and development of self-compacting concrete (SCC) is really a desirable achievement within the construction industry to be able to overcome problems connected with cast-in-place concrete. Self-compacting concrete isn't impacted by the abilities of employees, the form and quantity of reinforcing bars or even the arrangement of the structure because of its high-fluidity and potential to deal with segregation it could be pumped longer distances [1].
Self-compacting concrete (SCC) is a type of concrete mix that avoid the needed for the vibration equipment because their high fluidity and moderate viscosity at the fresh properties. The motivation to develop SCC was to solve the durability problems in concrete started in Japan at the end of eighteen century which, with the rapid reduction in the number of labor skilled in Japan's construction industry. SCC contains same constitutes a material as in vibrated concrete but the difference is the high powder content and lower amount of aggregates in the SCC design mix[2]. Okamura (1986) starts his research project on the new type of concrete called later self-compacting concrete (SCC) at 1986, the SCC can flow easily under its own weight. Okamura begins his study depend on the flowability of concrete without needing to equipment of vibration due to the shortage in the number of labor at that time in Japan. In his study, Okamura focusing on the use of coarse aggregate as content in mix as 50% of the solid volume and fine aggregate content as 40% of the mortar volume and he was adjusting the water –cement ratio in the range of 0.38 to 0.42 also he was included the super plasticizer dosage to increase the viscosity of the mixture [3, 4].

Ozawa (1988) studied the improvement of characteristic of SCC suggested by Okamura and in 1989 he completed the first prototype of SCC using material available on the market by using different types of superplasticizer, he was starting the research by studying the workability of the mixture which is important parameter and play vital role in the fresh properties of SCC, also he was studying the viscosity of the SCC mixture and test it by V-funnel which gave good permeability in the result. After that at 1989 Ozawa started his other research on SCC focused on the study the effect of mineral admixtures like fly ash and blast furnace slag on the flowability and segregation resistance of SCC, he found out that the flowability of the mixture can improve by replacing the Portland cement partially by the fly ash and blast furnace, he concluded that 10-20 % of fly ash and 25-45% of slag cement showed the high flow ability and strength properties [5].

Self-compacting concrete (SCC) signifies probably the most outstanding advances in concrete technology throughout the final decade. Because of its specific qualities, SCC may lead to some significant improvement of the standard of concrete structures and open new fields for the use of concrete. SCC describes a concrete having the ability to compact itself only by way of its very own weight without the advantages of vibration. It fills all recesses, reinforcement spaces and voids, even just in highly strengthened concrete people and flows free from segregation nearly to level balance. While flowing within the formwork, SCC has the capacity to desecrate almost completely [6].

K. H. Khayat stated that the Self-consolidating concrete (SCC) is actually a highly flowable concrete which could spread into position under its very own weight and achieve good consolidation even without the vibration while not exhibiting defects because of segregation and bleeding. Self-consolidating concrete is known as a product of technological improvements in the spot of underwater concrete technology in which the mix is proportioned to insure high fluidity in addition to high resistance to water dilution and segregation [7]

V. Corinaldesi .et al, reported that the creation of self-compacting concrete is regarded as a landmark achievement in concrete technology as a result of several advantages: good performance of both fresh and hardened concrete (high flowability and segregation resistance, low porosity, high strength and durability, etc.); larger applications (components and structures with complex shape and highly congested by steel reinforcements); worthwhile (increased works' speed and reduced costs for energy, equipment and workmanship); improvement towards modernization of construction process; environment protection due to high utilization of industrial by-products and better working environment by reduced noise and health risks [8].

Kuroiwa (1993) developed new type of concrete called super-workable concrete using materials normally found in normal concrete such as aggregate, portend cement, water, mineral and chemical admixtures. The newly type of concrete showed good resistance to segregation and excellent de formability, it could fill the heavily reinforcement without need of any vibration. The super-workable concrete exhibited good properties in both fresh and hardened state [9]. Peter,et al. mentioned that self-compacting concrete terminate the condition for internal or exterior vibration because of being able to freely flow around dense reinforcement and fills the mold completely with no obstructions. SCC could be a perfect material for impossible flowing position of ordinary concrete .Usually the needed flow of fresh concrete are accomplished using new generation superplasticizer to minimize the water-binder ratio. Additionally extra filler material ,which are usually inert in character , for example lime stone powder , natural pozzolans , and fly ash will also be brought to boost the viscosity and lower the price of concrete [10]. To be able to attain the rheology of self-compacting concrete, a higher quantity of cementations materials are needed. It's generally known that concretes with bigger paste volumes along with a lower aggregate volume exhibit greater shrinkage. Therefore, Self compacting concrete continues to be assumed to possess more shrinkage than conventional concrete. The significance of concrete is available in the truth that if there's significant shrinkage of concrete, it will have significant cracking in concrete. Therefore, reducing shrinkage is essential with SCC [11].

1.2 FIBER REINFORCED SELF-COMPACTING CONCRETE (FR-SCC)

The word fiber reinforced concrete (FRC) can be explained as a concrete that contains spread at random oriented materials. Normal concrete is brittle under tensile loading and mechanical characteristics of concrete might be enhanced by at random oriented discrete materials which prevent or control initiation, propagation, or coalescence of cracks. Fiber-reinforced concrete (FRC) is extremely a cement-based composite material strengthened with discrete, usually at random distributed fibers. Fibers of numerous shapes and dimensions created from steel, synthetics, glass, and natural materials may be used. However, for many structural reasons, steel fibers are the most famous of fiber materials, whereas synthetic fibers (e.g.

polypropylene and nylon material) mostly are familiar to control the first cracking (plastic-shrinkage cracks) in concrete slabs [12].

Fiber reinforcement mainly improves the post-cracking properties of concrete and gains in a more ductile material behavior. The high ductility is because the capability of the fibers to transfer tensile stresses across a cracked section, potentially resulting in a decrease in crack depth. The extent from the crack-depth reduction is based on the quantity of fibers added and to their physical qualities (e.g. surface roughness and chemical stability) and mechanical qualities (e.g. tensile strength) [13]

Plain concrete has two major inadequacies a minimal tensile strength and occasional strain at fracture. The tensile strength of concrete is extremely low because plain concrete normally consists of numerous micro-cracks .it's the rapid propagation of those micro-cracks under applied stress that's responsible for that low tensile strength from the material. These inadequacies have brought to considerable research targeted at developing new methods to modifying the brittle qualities of concrete [14].

Several researches have created a new idea to increase the concrete ductility and it is energy absorption capacity, in order to improve overall ductility. this new generation technology utilizes fibers, which if at random spread through the concrete matrix, provides better distribution of both internal and exterior stresses by using multi-reinforcing network[15 ,16].

Adding fibers to concrete has numerous important effects. Most noticeable during the enhanced mechanical qualities of fiber strengthened concrete are its superior fracture resistance and potential to deal with impact and impulsive or dynamic loads. Next they impact additional strength under all modes of loading including, direct tension , shear, flexural and torsion loading .The quality of improvement from the mechanical qualities of fiber reinforcing concrete (FRC) , are affected by specimen size, loading configuration , type and size of fibers[17,18,19].

Despite the fact that reinforcing brittle matrix with discrete fibers is definitely a time tested concept, modern-day utilization of fibers in concrete began in early sixties. At first, only straight steel materials were utilized. The main improving happened within the regions of ductility and fracture toughness, despite the fact that some flexural strength increase was observed .The regulation of mixtures was selected to analyze and evaluate the fiber contributions. Fibers to be created from steel, glass and natural fibers in a variety of shapes and dimensions [20]

The structural and performance of FRC varies, regarding the characteristics of concrete as well as the materials. The characteristics of materials that are usually of desire are fiber concentration, fiber geometry, fiber orientation, and fiber distribution. In addition, employing a single type of fiber may boost the characteristics of FRC with a limited level. However the thought of hybridization, adding a variety of fiber into concrete, can offer more desirable engineering characteristics as the presence of one fiber enables the higher efficient using the chance characteristics in the other fiber [21, 22].In other hand the fiber reinforced self-compacting concrete (FR-SCC) is concrete mix having the advantages of both SCC with the fibers to enhance and increase it is characteristics [23].

Using Fiber-Reinforced Self-Compacting Concrete (FR-SCC) has gotten a significant impulse within the last years in an effort to push forward the limitations of top end structural applications of both Fiber-Strengthened Concrete (FRC) and Self-Compacting Concrete (SCC). Interesting purposes to partly structural and fully structural are recorded within the literature [24]. Adding fibers improves the mechanical characteristics as well as the ductility of SCC in much the same manner just like vibrated concrete. However, the fibers greatly harm the workability of SCC because of their elongated shape and large surface area. The volume of fibers that might be put in a SCC mix thus remains limited and it is dependent round the fiber type used as well as the composition in the SCC mix. Optimum amount of the fibers should be determined such a method regarding result in the least decrease in the workability, although maintaining good flow and passing ability. To be able to result in the best utilization of the fibers, they should be homogeneously distributed within the mix without clustering [25].

The addition of fibers to SCC may take advantage of its superior performance in the fresh state to achieve a more uniform dispersion of fibers, which is critical for a wider structural use of fiber-reinforced concrete. Some useful, mainly empirical, guidelines are available for mix design of fiber-reinforced SCC. Also other experimental study demonstrated that materials utilized in concrete in a wide range of application areas enhance the mechanical properties of concrete such as flexural strength, compressive strength, tensile strength, creep behavior, impact resistance and toughness [26, 27].

The workability of fiber-reinforced self-compacting concrete (FR-SCC) concrete is basically a significant challenge. The main factors determining the level of workability would be the paste volume fraction, the fiber dosage rate, and also the fiber aspect ratio. Typically, fibers decrease slump, but this doesn't always make fiber mixes harder to compact with vibration. Fibers make mixes relatively less wet because of their high specific area [28]. According to many parameter for instance maximum aggregate size, fiber volume, fiber type, fiber geometry, and fiber aspect ratio, fiber inclusion to concrete decreases

the workability of concrete. Reduction in workability in FRC can be a handicap for on-site applications. However, the mix of hybrid FRC and SCC together can provide an approach to developing a hybrid fiber increased self-compacting concrete (HFR-SCC) with superior characteristics in not only hardened condition but furthermore fresh condition [29, 30].

Different short fibers like steel, polymeric, glass and carbon ones may be used however the workability of SCC could be considerably affected with respect to the type and also the content of fibers used as well as on the rheological qualities from the binder. Steel fibers are broadly accustomed to reinforce SCC (SFRSCC). The results from the steel fibers on both fresh and hardened SCC and also on its durability have been reviewed in a several studies [31].

In high strength concrete (HSC) structural members, materials are frequently added to overcome the negative effects of fire caused spalling. Since high strength SCC has similar qualities as those of HSC, it's also vulnerable to fire caused spalling, therefore utilization of different fibers, for example steel and polypropylene materials, can also be suggested in SCC [32].

The structural performance of fiber strengthened concrete is dependent on material qualities, production effects and structural boundary issues. When fiber orientation is imagined and could be controlled an enhanced tensile performance of structural element could be covered. The result of fiber on rheological characteristics needs to be taken into consideration for that mix design. The optimum fiber contents are the critical fiber dosage where the workability significantly decreases. The dimensions, the form and also the content of the coarse aggregate together with the geometry plus the volume fraction of steel fibers will modify the workability of fiber strengthened concrete [33].

1.3 Fresh properties of SCC

Fresh properties of self-compacting concrete (SCC) have differed from that of normal vibrated concrete (NVC) , SCC can flow easily under it is own weight without applying any vibration process and can fill fully the form due to their moderate viscosity .The workability properties of SCC can evaluate by the horizontal slump flow test and flow time per second while the viscosity of SCC mixture can be calculated by applying the V-funnel test , generally there are special measurement method to find out the fresh properties of SCC because it is different than that of vibrated normal concrete [34], Fresh properties of SCC play vital rule to characterize the SCC for application and uses , the fresh properties of SCC can be divided into three groups as high , moderate and low according to the Japanese guidelines of mixing the SCC The three workability characteristic keys of SCC are flowability , filling ability and their resistance to segregation [35] .

Filling ability - the potential of the concrete to movement widely under its own weight, both horizontally and vertically in place if recommended, and to completely fill formwork of any dimension and form without the need of making voids. Some persons examine in which rate of flow is a distinct fourth property.

Passing ability - the ability of concrete to pass honestly in and around heavy reinforcement without blocking.

Resistance to segregation - through situation and while moving, the concrete must maintain its homogeneity. There should be no segregation of aggregate from paste or water from solids, and no tendency for coarse aggregate to sink downwards through the fresh concrete mass under gravity.[36]

Ferraris (1999) et al. focusing in their research the workability of self-compacting concretes. Workability can be defined as the main property to define the self-compacting concrete to attain the hardened properties , they have been applied two rheometers to qualify the workability of self-compacting concretes, this two rheometers was v-flow and u-flow to calculate the correlation between them, also they apply in their research the Bingham equation to determine the yield stress and plastic viscosity of self-compacting concrete by using slump cone test, because these two values of yield stress and plastic viscosity can be calculate to define the workability of self-compacting concretes. Bingham equation defined the linear relationship between shear rate and shear stress, they found out that the slump flow test will be not enough in order to examine the flow ability of self-compacting concrete, also they reach to calculate the values of viscosity and yield stress [37].

Chan (2004) study in his research the mechanical-properties due to added discrete discontinues fiber to normal concrete, the addition of fiber will help the mixes of normal concrete to avoid the cracks that developed through it because the concrete is a brittle material with a low strain capacity and a low tensile strength. He found out that the fiber reinforced concrete (FRC) can carry significant stresses over relatively large strain capacity if the fibers are effectively strong and successfully bonded to material [38].

II. CONCLUSION

1. There is very limited information about the maximum different fiber content to be used without affecting the fundamental SCC flow characteristic (flowability , viscosity , filling ability and passing ability) .
2. Little research was investigated the effect of basalt and PVA fiber of SCC in it is ultrasonic pulse velocity (UPV).
3. In spite of a large number of studies on the mechanical properties of FR-SCC under statically applied loads, the literature reveals that there has been partially no study in it is fatigue life.
4. A little research is carried out to investigate the feasibility of producing FR-SCC (without loss in durability).
5. A little research was found related to the study of using fiber in SCC to avoid or to overcome the problem of the porosity.
6. Few previous research has studied the crystal structure of fiber reinforced self-compacting concrete (FR-SCC) or at their interfacial transition zone (ITZ) of aggregate –cement to capture the nature of the fiber modification mechanism.
7. It was observed that not much work has been studied to find the optimum use of PVA and basalt fibers to produce good strength and durable FR-SCC.

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