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Performance Evaluation of High-Performance Concrete with Steel Fiber

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Abstract. Cement concrete is a composite and widely used construction material. The motive of this analysis is based on examination of the use of steel fiber in high performance concrete to enhance the mechanical properties of concrete. The utilization of steel fiber strengthen the concrete by resisting the tensile cracking, enhance the mechanical properties, durability and the serviceability of structure. But higher the utilization of steel fiber can decrease the workability of concrete. In such case, fly ash is used in a range of 20-30% to enhance the workability. Also, the use of fly ash can reduce the greenhouse gas emissions. Thus it creates a sustainable environment. Tests were conducted by preparing the mixes and were compared with the normal conventional concrete properties.

Keywords: Steel Fiber, High Performance Concrete, Fly Ash

Introduction

Concrete is one of the most important, highly utilized building material in the world. Concrete is a mixed material which contains cement, water, aggregates(gravel, sand). When these materials are mixed together, they form a workable paste which then gets hardened over a period of time. Though concrete is an important material, it has it's own consequences. Concrete is a brittle material because of its low tensile strength. The use of plain concrete may also lead to the formation of cracking, spalling, scaling etc. In order to overcome these defects, different types of concrete have been introduced. One such concrete is the HPC.

HPC is generally a quasi brittle material. Utilization of HPC was came into practice in the early 80's. Based on data collected, the life circle of high performance concrete was up to 500 years. High strength, volume stability, low absorption, low heat of hydration, low porosity, good workability and high durability are the features of HPC. With these characteristics, when steel fiber is added to high performance concrete, it is more delicate to loading rate when compared to standard concrete because it's strength gain is greater for the expanding strain rate.

The purpose of adding steel fiber to the concrete is to enhance the durability and toughness of concrete and mortar. Fibers utilized for concrete helps in reducing the shrinkage cracks, increase the overall strength, increasing the energy absorption and decreases the spalling at rise in temperatures. Percentage of steel fiber in concrete should be limited to about 2% of volume because of the reduction in workability. Flexural strength is found to be increased as amount of steel fiber is greater. Compressive and tensile strength also increases with the optimum percentage of steel fiber. Higher percentage addition of steel fiber leads to congestion of fiber which causes balling effect and reduces the bonding with the concrete. It also reduces workability of concrete.

Fly ash is a pozzolan containing siliceous and aluminous materials. This material forms cement when it comes in contact with water. Fly ash in concrete enhance the strength as well as the segregation of concrete and makes it much easier to pump. Concrete which is created with fly ash

tends to be more stable and exhibits a higher grade of overall strength than concrete made with conventional cement products. Fly ash enhances workability of plastic concrete, strength , durability of hardened concrete.

OBJECTIVE:

- To determine the mechanical properties of concrete when steel fibers are utilized in concrete.
- To find the viability of using fly ash as a substitute of cement in concrete production.

Overview

Jacek Katzer [1] describes the most interesting and important applications of steel fiber reinforced concrete used worldwide. Over a period of four decades, SFRC has been continuously developed. Because of this, today SFRC is a commercially available and viable construction material. Sivakumar [2] explains experimental results of tests carried on different properties of different fiber reinforced concrete at the low volume portions of fibers with 0.5%. A major importance of these findings is that the steel fibers present in concrete can be partially replaced with the non-metallic fibers but the ductility should not be compromised. Abhijit Wadekar et. al [3] describes that the high strength concrete is slightly a brittle material so that the steel fibers are added to increase its ductility. From this study it is indicated that utilization of steel fibers can enhance split tensile strength of HSFRC as compared with compressive and flexural strength. Abdul Ghaffer et. al [4] explains addition of steel fibers in structural concrete to increase its mechanical properties. The steel fiber in concrete improve the ductility with higher fiber content and the crack widths are less than in plain cement concrete. But workability gets reduced when % of fiber is higher. Soek-Joon Jang et. al [5] explains the results of hooked end steel fibers on mechanical properties of HPC. It also investigates the feasibility of using steel fibers to simplify the critical complicated reinforcement detailing under high shear stress. Khaled Marar et. al [6] discusses the direct shear performance of simple cement and fiber reinforced concrete. It shows that, when the volume portion of fibers improved (0 to 1.5%), the shear strength also improved about 2 times that of simple cement concrete correspondingly. Jagadeesh Kamboj [7] discusses the effects of different types of steel fibers on ductility and mechanical properties of the cement concrete. It is observed that the flexural strength rises with increase of fiber content but up to optimum value and compressive strength also increases but the workability decreases. Gunduz et. al [8] addresses the effects on type of hooked end fibers on HPC by experimental research. Flexural strength and tensile strength tests were conducted. The results shows that these were significant effects on post cracking behavior and fracture energy. The type of hooked end does not affect the fresh concrete properties, however the slump values get decreases. Sivakumar Anandan et. al [9] investigated the mechanical properties of different types of fibers substituted with high strength concrete. The tests were conducted using displacement control to get post peak force displacement relationship. The results showed the effect on reinforcing efficiency on different steel fiber reinforced concrete. Ingrid Lande Larsen et. al [10] explains the effects of fiber reinforcement regarding tensile strength and compressive strength of UPC. The effect depends on the percentage of fiber, type and hybrid combinations. The use of these fiber combinations has the potential to rise compressive, tensile strength of concrete. Ramadoss et. al [11] uses water cement proportions of 0.3 and 0.4, replacement of silica fume at 10% and 15% and crimped steel fibers with aspect ratio 80. Steel fiber addition to silica fume concrete increase toughness, modulus of rupture and resist cracking. Yanxia Ye et. al [12] addresses, the adding of steel strands to concrete have different effects on toughness and mechanical properties. Micro(M), corrugated(C), and end hooked (H) are the steel

fibers used. From these types, Micro(M) steel fiber has the significant effect. Jae-Jin Kim et. al [13] explains that the average and equivalent bond strength could be increased using different fibers in HPC. Umberto De Maio et. al [14] addresses about failure analysis of model joined with entrenched truss model to simulate the concrete steel rebase contact. These models are used for calculating load carrying capacity of steel bar-reinforcing concrete with nanoplatelets. Wonsik Shin et. al [15] investigates the effects of preformed micro crack properties and immersion duration in 3.5% NaCl solution on erosion degree of steel strands in HPC. Hamdy Shehab El-Din et. al [16] discusses the effects of various types of steel strands on the mechanical performance of UHPC. Addition of steel fibers has various effects on crack designs, postpone the crack presence and imprison the crack growth in test specimen. Ajimon Thomos [17] describes the behavior of fiber reinforced concrete high performance and high performance external beam column junctions exposed to repeated loading. The trial outcomes showed that ultimate weight of steel fiber reinforced high performance concrete external beam column joins were 15.3% greater that HPC beam column joins. Ayyappa et. al [18] discusses the optimum strength of HPC specimen with or without fiber. The test results shows that the concrete with 30% silica fume and 3% of glass and steel fibers gains the optimum strength than the other proportions. Calik Ozyildirim [19] explains that the steel fibers in UHPC provides tensile volume across cracks, ensuing in high shear volume in twisting associates. UHPC beams with steel strands do not need shear reinforcement. Valcachaela Veera Mnikanta Srikal et. al [20] attempted to find out strength related test like compressive, split tensile and flexural strength using steel fibers with volume of 0.5% and 1%. The steel fiber usage improves concretes mechanical properties such as toughness in tension and durability. Jun Yang et. al [21] aims to determine the compression performance of UHPFRC for thin-walled arch unit plan and a evaluation was made with conventional concrete. It describes that the wall width of 50mm with the stirrups efficiently controlled the instability disappointment of thin walled compression column. Abbas et. al [22] examined that adding of steel fiber varies the failure method of ultra-high performance concrete samples from whole injury or the abrupt blast to some ductile performance. These concrete samples exhibits a high flexural strength properties depending on its mix design. Rui Liu et. al [23] describes that adding steel strands to concrete dramatically increases flexural strength. Steel strands on concrete is uniformly distributed in the matrix in front of the cracking, steel fiber and cement matrix bonds together, as the function of concrete by force. Kiranbala Devi [24] identifies the primary function of fibers is to modify micro and macro cracks and infection crack at their origin and inhibit crack growth. Macdonald [25] observed that the fiber reinforced concrete is considered as a new and challenging composite material. Steel fibers are available in different sixes and lengths depending on aggregate sixes and design requirements. Hamid Behbahani [26] describes that the steel fibers are used to restrict the plastic and drying shrinkage in concrete. Steel fibers can be used as secondary reinforcement used with conventional steel bars or prestressing strand as main reinforcement. Concrete with steel fibers has shown significant improvement in flexural strength. Ajay Dahake [27] aims to find the result of addition of fibers to concrete and determine their outcome on the performance and mechanical properties of reinforced concrete beams. The toughness depends on fiber volume fraction, silica fume content, and fiber aspect ratio. Patodi [28] addresses the performance of concrete with unlike kinds of hybrid fibers used in the concrete mixture. Samples were prepared with and without fly ash and varying volume portion of fibers from 0 to 1%. Best improvement in mechanical properties is concrete having 0.3% re corn and 0.7% of steel fiber. Yuanxun Zheng et. al [29] addresses that the expansion of various kind of steel strands effectively affect the mechanical properties and sturdiness of HLAC. The steel strands utilized are Micro(M), end-

snared (H) and corrugated(C). Miniature steel strands have the best supporting exhibition on the mechanical properties and strength is additionally awesome with Miniature steel filaments. Pramod Kawde et. al [30] clarifies that, the regular cement doesn't fulfill the need of the world on account of its low rigidity restricted malleability and less obstruction the breaking. It has been demonstrated that diverse sort of fiber included explicit rate to concrete works on the mechanical properties, solidness and workableness of construction. The outcome showed that the expansion of steel fiber builds a definitive strength and pliability.

Future scope

- In future, first the suitable mix design for the project is prepared.
- The percentage of steel fibers are taken as 0.5%, 1.0%, 1.25%, 1.5%, 1.75%, 2.0%.
- Physical properties of the steel strand reinforced high performance concrete are examined.
- Tests namely compressive, tensile , flexural strengths, durability test were carried out on the specimen. At the end, results obtained from the specimen were observed and further discussed.

Conclusion

The utilization of traditional cement can prompt break development, spalling, pop outs and so forth, High execution concrete is a profoundly fragile material and flops abruptly. The weak method of disappointment is changed by expansion of steel strands in high performance concrete, in to a more bendable one. Concrete has low rigidity, low sturdiness and low explicit strength. Concrete accomplishes indicated compressive strength in 28 days subsequent to projecting and relieving. Original capacity requires appropriate encompassing temperature controlled longer than a month. Pressure face of cement has a cover to ensure the building up steel bars. In the event that elasticity at outrageous fiber surpasses the pliable limit of cement, it breaks and prompts erosion of fortifications. It was seen that steel fiber supported cement works on the substantial flexibility, its post-breaking load conveying limit. Steel strands of various rates 0.5%, 1.0%, 1.25%, 1.5%, 1.75%, 2.0% were added to the substantial to lead the different tests. In reference with the gone through papers, it has been gotten that the utilization of steel filaments at pace of 1.25% has invigorated an ideal. Our task is to add fly ash (partial substitution of concrete) and steel strands with the elite cement. Then, at that point, the tests were directed to notice the flexural, split pliable and compressive strength. The utilization of fly debris works on the manageability of the climate.

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