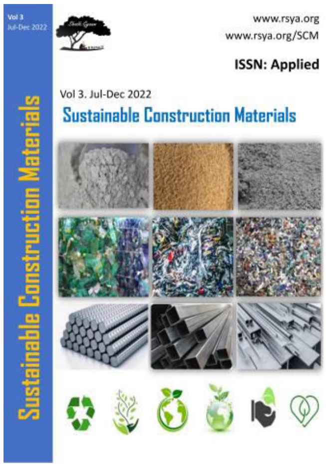

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The Analysis of Fly Ash Effect on the Mechanical Properties of Concrete Using Hooked Steel Fibers

Md. Jawed Khan*, Atar Ahmad
Anna University Chennai - 600 025 TN, India
**Corresponding Author:mdkhanjawed786@gmail.com*

Abstract: This study's goal was to assess the effects of replacing cement with fly ash and adding hooked steel fibres on the mechanical properties of concrete. For the M30 grade, samples of fly ash concrete with replacement percentages of 5, 10, 15, and 20 were employed. The results showed that the mechanical strengths rose up to 10% FA replacement and thereafter started to decrease. After 28 days, it was discovered that for FA10 samples, 10.06 percent, 15.38 percent, and 9.83 percent, respectively, of the split tensile, compressive, and flexural strength had been improved. To samples of ideal fly ash concrete (FA10), hooked steel fibres were added. At 1% use of steel fibre, the flexural, compressive, and split tensile strengths of hooked steel fibre samples were increased by 13.27 percent, 18.87 percent, and 27.14 percent, respectively.

Keywords- Fly ash, Compressive strength, hooked steel fibers, flexural strength, tensile strength

INTRODUCTION

The most typical building material used to construct homes, bridges, highways, dams, and a variety of other constructions is concrete[1]. As the need for regular Portland cement increases due to infrastructure needs, concrete will continue to be the most often used building material in the future[2]. The production of cement consumes a lot of resources and produces a lot of CO2. Because concrete has several unwanted characteristics, such as brittleness, poor fracture resistance, large weight, and low impact resistance, it must have its attributes strengthened[3]. Numerous studies have been conducted with the goal of partially or totally substituting OPC for other minerals, including as fly ash, bagasse ash, rich husk, and other pozzolans materials, in the manufacturing of concrete in order to retain concrete consistency[4]–[8]. Utilizing such materials reduces building costs, prevents pollution, and contributes to environmental preservation. Sandpaper, paints, chemical solvents, paper products, hazardous waste, and natural and bagasse ash fibres are some examples of non-biodegradable solid wastes from manufacturing processes[9]–[12]. Due to its high stress resistance and long-term dependability, steel fibre reinforced concrete (SFRC) is increasingly being used in heavy duty pavement, tunnelling, precast, mining, and residential constructions. Concrete mixes often use steel fibre aspect ratios between fifty and one hundred. The volume fraction values for concrete mixtures are taken between 0.5 and 2.5 percent by volume[13]. The composition of the concrete as well as the kinds, geometry, propagation, orientation, and concentration of the fibres all affect the qualities and effectiveness of reinforced fibre concrete[14]. While there have been numerous studies on the impact of fibre inclusion on concrete mixtures' strength and toughness properties, there have also been some studies on the impact of fibre inclusion in pozzolan-containing concrete[15]. Topcu and Canbaz looked into how steel and polypropylene fibres affected the tensile characteristics of fly-ash concrete. The study's conclusions indicate that adding fibres to concrete makes it more consistent, and adding fly ash will make it stronger and easier to work with [16]. Eren and Celik studied how steel fibres and silica flume affected a few high-strength concrete qualities, and their findings suggest that workability declines as fibre and flume volume increases. The researchers found that while silica fume has an impact on compressive power, the volume % of steel fibres has no impact[17]. In this study, two stages of the strength characteristics of fly ash concrete with steel fibres were explored. In the first stage, fly ash was used to partially replace cement at five percent, ten percent, fifteen percent, and twenty percent. The ideal replacement percentage was then determined. In the second process, different percentages of hooked steel fibers—0, 0.5, 0.75, 1.0, and 1.25—were introduced at the highest fly ash content.

MATERIALS

In this investigation, OPC of grade 43 with a specific gravity of 3.18 was employed. The initial and final periods of setting took 54 and 465 minutes, respectively, and the cement had a soundness of 2.18mm. This information has been verified by IS: 8112-2013[18]. F class This study employed fly ash that came from the Bathinda thermal power facility in India. Fly ash has a fineness of 3.477cm2/g and a density of 2.20 g/cm3. The concrete mixture contained dry, clean river aggregate. At saturated surface dry circumstances, the gravel had a maximum nominal size of 20 mm, a water absorption value of 1.12%, and a relative density of 2.72. Table 1 lists the chemical make-up of cement and fly ash. The utilised sand had a 1.23 percent water absorption and a 2.64 percent relative density at a saturated dry surface (SSD). The usage of fine and coarse aggregate complied with IS 383-2016. In this investigation, steel fibres were acquired from STEWOLS INDIA (P), Nagpur. Hooked steel fibres (HSF) are the smallest and have a length of 34 and 0.50 mm. Aspect ratio and density of steel fibres are 78 and.00785 mg/m3, respectively. An industrial carboxylic hyperplasticizer was employed to preserve the quality of new concrete. On a bulk basis, the dose of the hyper plasticizer has been kept at 1% of the concrete binder ingredient. The plasticizer's impact on the characteristics of hardened concrete would be overlooked if it were kept constant.

Table1: Chemical composition of Cement and Fly Ash

S.N	Oxide Compound	Cement%	Fly Ash%
1	Silicon dioxide	21.89	62.15
2	Calcium oxide	65.10	0.73
3	Magnesium oxide	0.95	0.64
4	Aluminum oxide	4.85	26.48
5	Ferric oxide	2.87	6.68
6	Sodium oxide	0.16	0.89

PREPARATION OF SAMPLES

The split tensile ability was determined in the first stage examination using a total of 15 cylinders with a 150 mm diameter and 300 mm height. The compressive and flexural strengths of 30 150 mm3 cube samples and 15 100 mm x 100 mm x 500 mm beams were tested using fly ash substitution percentages of 0, 5, 10, 15, and 20. For the second stage investigation's compression test, 24 cube specimens of the hooked type of steel were made in FA10 at replacement rates of 0.50, 0.75, 1.0, and 1.25 percent. Fly ash hooked steel fibre concrete was tested for flexural and split tensile strength using twelve beams and twelve cylinders. The specimens were tightly packed or appropriate packed to make sure there were no gaps that would cause slurry leakage. The M30 concrete grade served as the subject of the current study. According to IS: 516-1959, compressive strength was measured. The mean compressive capacity was determined by adding the three values together. According to IS: 516-1959[19], cylindrical concrete samples underwent split tensile strength testing. Each mixture was poured into three concrete cylinders and given 28 days to cure. In line with IS: 516-1959[19], concrete flexural capacity was determined using beam specimens. The flexural strength of concrete was evaluated using the three point load method. The load at which the test beams failed, which was recorded, was used to compute the flexural strength.

RESULTS AND DISCUSSION

Between 0 and 20% of the OPC in the first stage study is replaced by FA. In the second stage, fly ash and hooked steel fibres (HSF) were separately included into the concrete. While the flexural and split tensile strengths of concrete are only determined after 28 days, the compression strength of concrete was measured after seven and twenty-eight days.

Impact on compressive strength

All sample forms compression strength has been determined using a compression testing manufacturer in compliance with IS: 516-1959[19]. As can be observed in Fig. 1, the strength of concrete in compression improved initially when fly ash replaced cement to a 10 percent replacement level. However, at 7 and 28 days, the compressive intensity started to deteriorate in contrast to the nominal concrete. Fly ash is a slow-reacting pozzolan, which delays the hydration process[20][21], which may be the cause of the decrease in compressive capacity. For FA10 tests, the overall improvement in strength was roughly 18.38 percent after 7 days and 15.38 percent at 28 days.

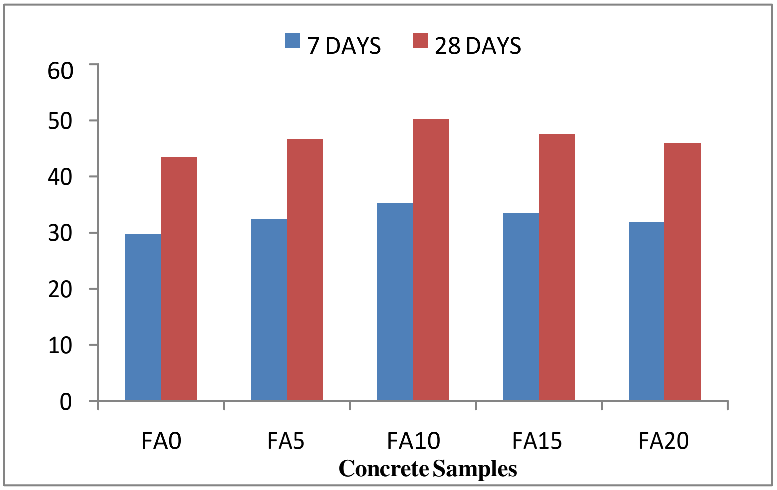

Figure 1: compressive strength of standard and fly ash concrete

Figure 2 displays the results of compression strength tests on samples that had FA10 concrete mixed with steel fibres at rates of 0.5 (FAHSF-1), 0.75 (FAHSF-2), 1 (FAHSF-3), and 1.25 (FAHSF-4) percent. With the addition of hooked fibres, the strength increased by up to 1% before starting to decline additional HSF content augmentation. For FAHSF-3 samples, the increase in compressive strength is 18.87% after 7 days and 14.45% at 28 days. The addition of HSF increased the strength of the concrete samples by 1% because the presence of steel fibres prevented the development of cracks in the concrete [22].

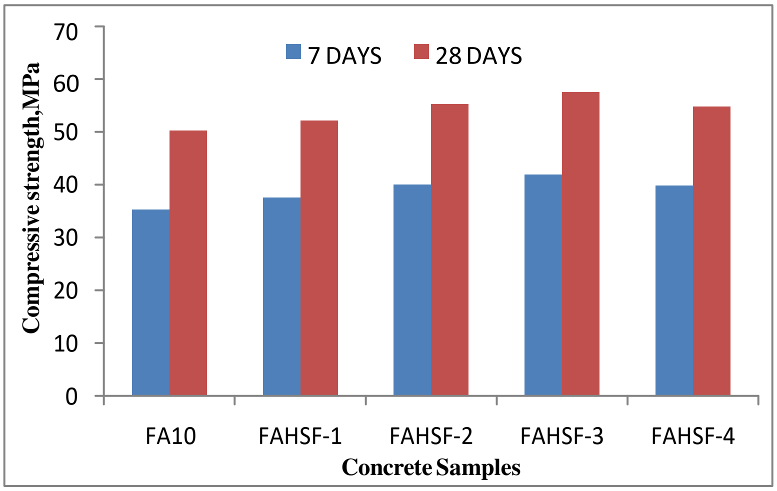

Figure2: compressive strength hooked steel fiber and optimum fly ash concrete

Impact on Flexural strength

After twenty-eight days of testing, the flexural strength of the concrete samples was calculated in accordance with IS:516-1959 utilising a universal measuring machine and the three point load technique. The effects of fly ash alone and fly ash combined with hooked steel fibre are shown in figures 3–4 correspondingly. As seen in Fig.3, the concrete beams' flexural and compression strengths also increased, with the FA10 study experiencing the greatest increase in flexural strength. Up until FA10 samples, the strength of the concrete mix was increased; nevertheless, it decreased for the FA15 and FA20 specimens. The cement replacement rate of 10% produced the strongest strength increase, which was roughly 9.83 percent. The substitution of fly ash up to 10% in CSH gel may be the cause of the improvement in strength[23].

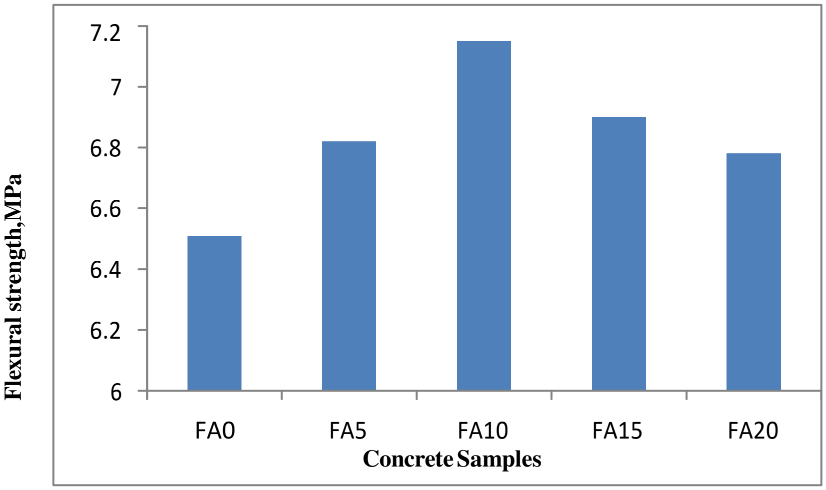

Figure 3: flexural strength of standard and fly ash concrete

Figure 4 displays the flexural strength for a 10% substitution of fly ash with HSF. The use of steel fibres increased the strength of HSF by up to 1%. When compared to FA10 mix, the flexural strength of FAHSF-1, FAHSF-2, FAHSF-3, and FAHSF-4 increased by 8.39%, 10.34%, 13.28%, and 9.37%, respectively. It is evident that FAHSF-3 attained a maximum flexural strength of 8.1 N/mm2. The steel fibres that have been connected up have good tension and stop cracks from spreading.

Impact on Split tensile strength

According to the guidelines in IS: 516-1959, the strength of the cylinder has also been calculated at 28 days. The effects of fly ash and fly ash with hooked steel fibre are shown in figures 5 through 6. Figure 5 showed the concrete's strength after 28 days. Similar to the flexural strength, the split tensile strength exhibits a similar pattern. The split tensile strength of the FA5 and FA10 samples increased by 4.71 and 10.06 percent, respectively. The rise in fly ash concentration for the FA15 and FA20 samples was then lowered to 6.91 percent and 3.45 percent, respectively, when compared to the FA0 mix, and the strength started to decline.

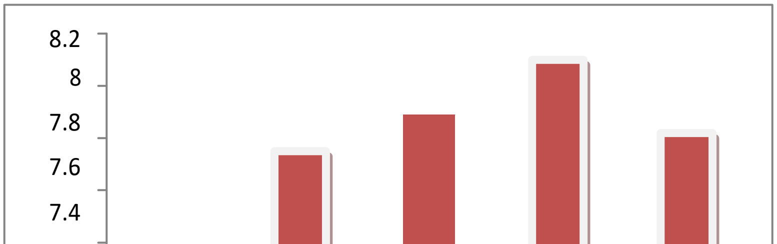

Figure 4: flexural strength of fly ash and hooked steel fiber concrete

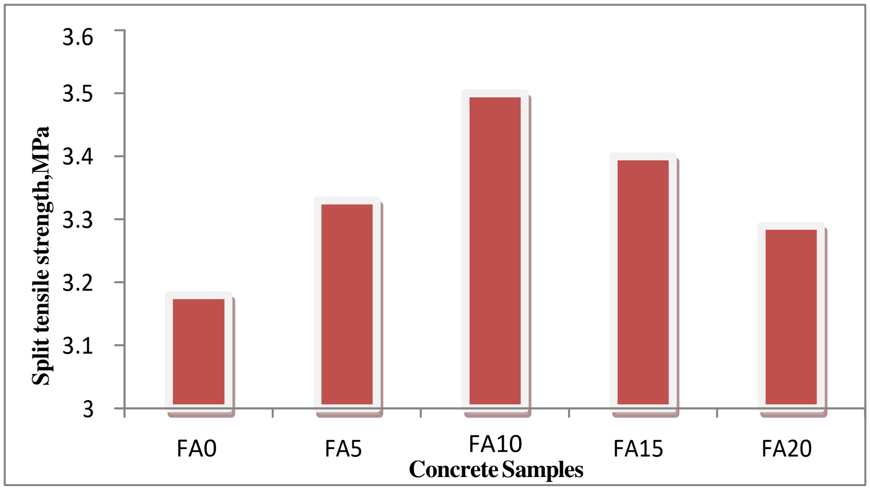

Figure 5: split tensile strength of standard and fly ash concrete

The split tensile strength of samples with HFS added to the FA10 mix is shown in Fig. 6. Up until it reaches 1.0 percent, the strength increases with increased steel fibre content before starting to decline. The largest increase in strength for the FAHSF-3 concrete sample was 27.14 percent at 1% steel fibre content of hooked types.

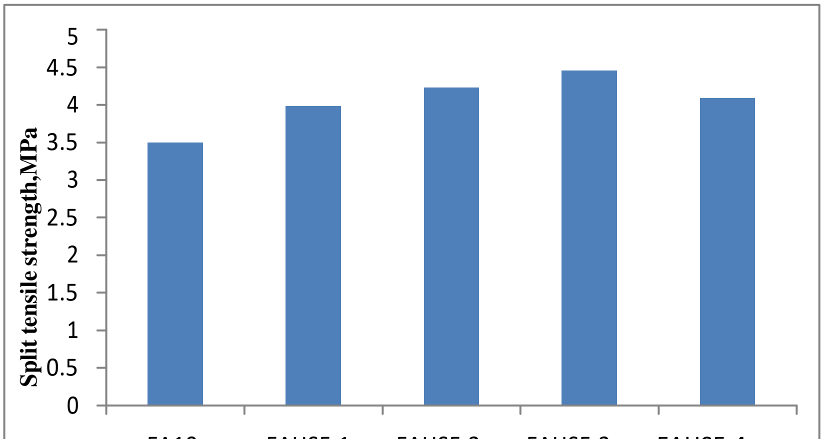

Figure 6: split tensile strength of fly ash and hooked steel fiber concrete

The greatest improvement in strength occurs at a substitution of 10% fly ash, and further increases in split tensile strength owing to the addition of HSF up to 1% are equivalent to increases in flexural strength. The results of all the tests mentioned above showed that 10% fly ash is the ideal dosage for concrete, after which the capacity starts to decline.

1. CONCLUSION

The experiment goal were to determine how the partial replacement of cement with fly ash and the addition of hooked steel fibre influenced the mechanical characteristics of concrete mix for M30 grade. The following findings can be drawn from this investigation. The compressive, flexural, and split tensile strengths rose by 15.38, 9.87, and 10.06 percent in comparison to the 28-day strength of regular concrete, and the maximum strength obtained for the 10% replacement of fly ash. At optimal substitution level after 28 days, the greatest improvements in split tensile, flexural, and compressive strengths are 10.06, 15.38, and 9.83 percent, respectively. At the ideal inclusion amount of hooked steel fibre in concrete containing 10% fly ash, the maximum improvement in split tensile, flexural, and compressive strengths of FAHSF-3 is 13.27 percent, 18.87 percent, and 27.14 percent, respectively. Concrete strength was increased by hooked steel fibres, preventing cracks from forming.

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