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Mechanical Properties of Concrete Specimens Containing Steel Fiber

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Abstract: In industry application, the steel reinforced are needed to carry the tension forces in the concrete. The problems that had been faced are cracking occurring in concrete and can the steel fiber control the cracking. This study describes an experimental analysis on grade 30 concrete mixtures by adding steel fiber with different percentages. The purpose of this study is to identify the mechanical strength and also the controlling of cracking that occurs in the concrete by adding steel fiber. Two types of mechanical properties are tested for the concrete specimen and they are the compressive strength test and the flexural strength test. Total of 16 cube samples had been carried out for compressive strength testing and 6 prisms for flexural strength by applying 0 %, 0.1 % and 0.3 % steel fiber to the concrete sample for flexural strength. The curing method that been used in this experiment is water curing for 7 days and 28 days. The concrete specimen size that been used for compressive strength test is 100mm x 100mm x100mm cube and for flexural strength test is 1000mm x 150mm x 100mm. In this experiment, 22 total concrete samples were cast and tested. Control specimen (0%) shows the less compressive strength compare to 0.1% and 0.3% of steel fibreDuring flexural test for control prism, the maximum load had been applied before it fails is 9.62 kN for sample 1 and 9.67 kN for sample 2. The maximum load applied for steel fibre containing 0.1% to reach its failure for sample 3 is 12.02 kN, sample 4 is 12.25 kN and for 0.3% of steel fibre sample 5 is 13.24 kN and sample 6 is 13.11 kN. The result form this research shows that by adding steel fibre into the concrete, the mechanical strength can be increased, and it can delay the cracking.

Keywords: Steel Fibre, Compressive Testing, Flexural Testing

1. Introduction

Concrete is one amongst the foremost widely used construction material in developed and developing countries. The performance of concrete depends on its ingredients. It's well-known that plain concrete is brittle and weak in tension. one amongst the objectionable characteristics of the concrete as a brittle material is its low strength, and strain capacity. Therefore it requires reinforcement so as to be used because the most generally construction material [1].

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Fiber strengthened concrete is cement- primarily based totally composite fabric that has been advanced in current years. It has been efficaciously utilized in production with its top notch flexural-tensile power, resistance to spitting, effect resistance and top notch permeability and frost resistance. It is an powerful manner to growth durability, surprise resistance and resistance to plastic shrinkage cracking of the concrete [2]. In the mortar-mixture interface, the presence of micro cracks is liable for the intrinsic weak spot of simple concrete. By having fibres with inside the blend, the weak spot may be eliminated. It is feasible to feature exclusive forms of fibres, including the ones utilized in traditional composite materials, into the concrete combination to growth its ability. Sturdiness or ability to face up to the increase of cracks. The fibres permit the inner micro cracks to byskip loads. Such a concrete is known as concrete strengthened with fibre (FRC) [3].

Steel fiber has a wide variety of concrete, bridge deck, industrial surface, precast commodity and associated field applications. [4] Due to its increased resistance to cracking, fatigue, abrasion, impact, toughness, and conventional reinforced concrete, the use of steel fiber concrete in civil construction is the most important [5]. However, several studies have done research on this field in this aspect, such as referring to [6], the steel fiber can be considered to increase the ability of durability energy absorption, decrease cracking area, and also enhance the concrete's impact resistance. In this research to enhance the flexural and compressive strength, different percentage of steel fiber were utilized. Throughout this respect, subsequent to the application of steel fiber, the tensile and flexural strength of concrete is also greatly improved. Nevertheless, the amount of steel fiber tension affects the concrete enhancement. The application of fibers in 2004, according to Khaloo, does not substantially improve the overall flexural strength of steel fiber slabs. However, it increases the ability of specimens for load transfer. The resistance load after cracking is comparatively minimal in specimens with low fiber volumes of 0.5 percent. With increases in fiber quality, the rate of change in energy absorption decreases. He proposed that fiber volumetric ratios be used in the range of 0.75 to 1.75 and that longer fibers have better energy absorption in concrete specimens, based on his study.

The purpose of this study is to identify the mechanical strength and also the controlling of cracking that occurs in the concrete by adding steel fiber. Two types of mechanical properties are tested for the concrete specimen and they are the compressive strength test and the flexural strength test. Total of 16 cube samples will be carried out for compressive strength testing and 6 prisms for flexural strength by applying 0 %, 0.1 % and 0.3 %t polypropylene fiber to the concrete sample for flexural strength. The curing method that been used in this experiment is water curing for 7 days and 28 days. The concrete specimen size that been used for compressive strength test is 100mm x 100mm x100mm cube and for flexural strength test is 1000mm x 150mm x 100mm. In this experiment, 22 reinforced concrete prototypes were cast and tested in total. The result form this research shows that by adding steel fibre into the concrete, the mechanical strength can be increased and can control the cracking in the concrete.

2. Materials and Methods

It is a angle taken at this study, which dictates how it's far approached. This research explains about the material used and how it is done according to its mixing method. The main material that had been added into the concrete is steel fiber with different percentages and they are 0.1% and 0.3%. In overall there will be 0%, 0.1% and 0.3% of steel fiber added to identify the mechanical strength of the concrete. There are varieties of take a look at taken area to perceive the mechanical strength test and they are compressive strength test and flexural strength test.

2.1 Concrete Mix Design

The concrete were mixed with the water cement ratio of 0.5. There are three different types of mixture whereby one of it is control. In control mixture, there were only Ordinary Portland Cement added with aggregates, sand and water. For other two types of mixture is mixed based on adding steel fibre with 0.1% and 0.3% along with Ordinary Portland Cement, water, sand and aggregates. All the

mixture proportion that had been done is based on the Concrete Mix Design Method. Table 1 show the proportions of all mixture taken place in this study.

Table 1: Proportion of Concrete Mixtures

Quantity	Cement (kg)	Water (kg)	Fine Aggregates (kg)	Course Aggregates (kg)	Polypropylene Fiber (kg)
0.125 m^3	52.5	26.25	66.25	155	-
Control	52.5	26.25	66.25	155	-
0.1%	52.5	26.25	66.25	155	0.108
0.3%	52.5	26.25	66.25	155	0.324
Total	157.5	78.75	198.75	465	0.432

2.2 Materials

The raw substances used to finish this assignment are Ordinary Portland Cement (OPC), corse aggregate, fine aggregate, water and steel fibers.

(i) Ordinary Portland Cement

Ordinary Portland cement (OPC) was used. The specifications for Type I Portland Cement in compliance with MS 522 with a bulk density of 1440 Kg/m3 was used for all the concrete mixtures. Figure 1 indicates the bundle of the portland cement use on this studies.

Figure 1: Ordinary Portland cement

(ii) Sand

Accordance to British standard (BS EN 12620:2013), mining sand have been selected on this research. The sand have to be dried before used because of make certain that the high-quality aggregates are unfastened from moisture content material in order that it doesn't have an effect on the water cement ratio. Figure 2 suggests the mining sand that used for this research.

Figure 2: Sand

(iii) Coarse Aggregates

The coarse aggregate that had been used in this research is according to IS: 383 – 1970, for aggregates which had been referred by K.Bhavya and Dr. N Sanjeev. The aggregates that had been chosen were clean and free from deleterious materials. Figure 3 suggests the coarse aggregates used for this research.

Figure 3: Coarse aggregates

(iv) Steel Fiber

The research was limited to the following matter as the steel fibres of STAHLCON® HE0.55/35 with hooked-end with amount of 0.40% of cement volume were used in this research. Both end hooked glued steel fibers were used in the study wi.th a de.nsity o.f 7850 k.g/m.3 .

Figure 4: Steel fiber

2.2 Methods

The test that had been conducted in this research is slump test, compressive strength test and flexural strength test. For seven days curing process if focused on compressive strength test and total of 8 cubes for 7 days of curing process. After 28 days, there we both test conducted and they are compressive strength test and flexural strength test, 8 cubes for compressive strength test and 6 prisms for flexural strength test.

(i) Compressive Strength Test

There were total of 16 cubes had been tested. Whereby, 8 cubes for 7 days and remaining 8 cubes for 28 days. There were 3 cubes for 0.1% batch, 3 cubes for 0.3% batch and the last 2 cubes for 0% batch where is it called as control. The remaining 8 cubes from 16 cubes are tested after 28 days as the same as 7 days.

Figure 5: Compressive strenght test

(ii) Flexural Strength Test

The specimen that had been used for this study is 1000mm x 150mm x 100mm and there were total of 6 specimen had been tested. The first and second specimen is control, third and fourth specimen containing polypropylene fiber of 0.1% and the fifth and sixth specimen containing 0.3% of polypropylene fiber.

Figure 6: Flexural strenght test

3. Results and Discussion

There have been 3 assessments taken vicinity on these studies and they're slump test, compressive strength test at and flexural strength test at for every 3 batch containing with 0.0%, 0.1% and 0.3% of steel fiber. As been mention before there are total of 16 cubes and 6 prisms that had been tested in this research.

Table 2: List of samples based on polypropylene fiber ratio for cube and prism

No. Samples	**Number of sample for cube and prism contain PP fiber and without PP fiber**		
	0.00%	**0.10%**	**0.30%**
Cube	2	6	6
Prims	2	2	2

3.1 Results

(i) Compressive Strength Test

This test is to determine the maximum compressive strength of the concrete and the artificial whilst subjected to the load. Table 3 shows the result obtained for 7 days and Table 4 shows the result gain for 28 days.

Table 3: Compressive Strength at 7 Days

Sample of polypropylene fiber (%)	Compressive strength test (Mpa)		
	7 days		
	0%	0.1%	0.3%
Sample 1	14	8.1	18
Sample 2	14	8.6	18.8
Sample 3		8.2	18
Average compressive strength	14	8.3	18.3

Table 4: Compre,ssive Str,ength a,t 28 D,ays

Sample of polypropylene fiber (%)	Compressive strength test (Mpa)		
	28 days		
	0%	0.1%	0.3%
Sample 1	13.2	11.6	26.5
Sample 2	13.1	11.8	27.4
Sample 3		11.3	27.2
Average compressive strength	13.2	11.6	27.03

The compressive strength for seven days and twenty eight days had been shown in Table 3 and Table 4. Based on the result, the highest compressive strength was recorded through 0.3% of steel fibre compare to 0.1% of steel fibre. The highest value of compressive strength is 27.04Mpa and the lowest is 11.3Mpa. For compressive strength test, it is shown that samples with 0.1% of steel fiber increased the strength up to 0.9% compared to control samples for 7 days and samples with 0.3% of steel fiber increased the strength up to 4.7% compared to control samples for 7 days. Whereby, samples with 0.1% of steel fiber increased the strength up to 12% compared to control samples for 28 days and samples with 0.3% of steel fiber increased the strength up to 16% compared to control samples for 28 days.

(iii) Flexural Strength Test

During flexural strength test, the cracking of prism is shown is figure 7 according to its sample containing control, 0.1% and 0.3% of steel fibre. Prism with different percentages containing steel fibre produces different types of cracking pattern. By adding steel fibre, the stroke values gets to the maximum strength of the prism before it fails. The failure load had been shown in table 5. During flexural test for control prism, the failure load had been observe for sample 1 is 9.62 kN and 9.67 kN for sample 2. The failure load observed for steel fibre containing 0.1% for sample 3 is 12.02 kN and sample 4 is 12.25 kN. By comparing control and 0.1% of steel fibre, adding steel fibre is more stiffer then control. Comparing 0.1% and 0.3% of steel fibre, the failure load observed for sample 5 is 13.24 kN and sample 6 is 13.11 kN. From the result, it were validated that through including steelfibre into combined concrete can produce more stiffnes to the prism. Adding steel fibre into the concrete can increase the flexural strenght of the concrete. The content of fibre in the concrete mixture can reduce the crack on the concrete prism and control the prism from falling apart.

Based from the result, the average failure load for control is 9.65kN, 0.1% of steel is 12.14kN and 0.3% of steel fibre is 13.18kN. It can be concluded that adding steel fiber into the concrete can increase the flextural strength.

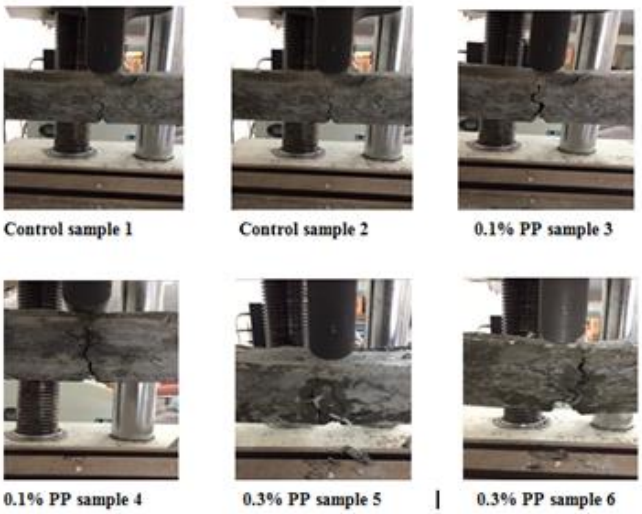

Figure 7: Failure Mode for Prisms

Table 5: The maximum load applied before it fails

Samples	Maximum load applied before failure (kN)	Average load (kN)
Sample 1 (control)	9.62	9.65
Sample 2 (control)	9.67	
Sample 3 (0.1%) PP	12.02	12.14
Sample 4 (0.1%) PP	12.25	
Sample 5 (0.3%) PP	13.24	13.18
Sample 6 (0.3%) PP	13.11	

4. Conclusion

In conclusion, the steel fibre increases its compressive strength form 7 days to 28 days with containing of control, 0.1 % and 0.3 % of steel fiber. For compressive strength test, it is shown that samples with 0.1% of steel reduced the strength to 25.56% compared to control samples for 7 days and samples with 0.3% of steel fiber increased the strength up to 13.31% compared to control samples for 7 days. Whereby, samples with 0.1% of steel fiber reduced the strength to 6.45% compared to control samples for 28 days and samples with 0.3% of steel fiber increased the strength up to 34.38% compared to control samples for 28 days. For flextural strength test, comparing control and 0.1% of steel fiber, the were 11.43 % of flextural strength had been increased after adding steel fiber and comparing control and 0.3% steel fiber had increased 15.46%. Based from the both test, it can be concluded that the mechanical strength can be increased by adding steel fibre into the concrete and also the cracking problem can be controlled due to adding steel fiber holds the prism tightly from cracking when load is applied.

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