Research Paper Engineering

Use of Industrial Waste and Recron 3s Fiber to Improve the Mechanical Properties of Concrete.

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ABSTRACT

Concrete is a versatile engineering material used in most of the civil engineering structures, so that considerable attention is taken for improving the property of concrete with respective to strength and durability. In the present scenario, waste materials from various industries and admixtures are added to the mix. Over 400 million tones of waste materials are being produced by various industries every year. Use of industry waste like fly ash to partly replace cementing material in concrete system addresses the sustainability issues and its adaptation will enable the concrete construction industry to become more sustainable. Hence it can be used as an economical building cementations material thus reducing the disposal and air pollution problems caused by the industry. Recron-3s is a polypropylene monofilament, discrete, discontinuous short fiber that can be used in concrete to control and arrest cracks. During the present study, an attempt is made to study the various mechanical properties of concrete containing sludge and Recron 3s fibers. Fly ash was used as a replacement to cement. Replacement percentages used during the present study were 10%, 20%, 30%, 40%, 50%. For each replacement percentage of cement with, 0.0%,0.2%, 0.3%, 0.4% of Recron 3s fibers were added and specimens were cast to determine the mechanical properties. Compressive strengths of cubes were found on the 7th day and 28th day. The 7th day and 28th day split tensile strength of the specimens was found on the cylinders. The flexural strength of the specimens was found on the 7th day and 28th day. It is found that addition of fly ash and Recron 3s fibers have beneficial effects on the mechanical properties of concrete.

INTRODUCTION

Concrete plays a vital role as a construction material in the world. Its popularity as a basic building material in construction is because of its economy, good durability, ease with which it can be manufactured, the ability to mould it into any shape and size and its high compressive strength. Many researchers have made attempts to use the waste materials to reduce the disposal problems and to improve the mechanical properties of concrete. Fly ash, silica fume, metakaolin, blast furnace slag etc., are some of the waste materials used for making concrete. Ordinary concrete, when subjected to the rigorous test of time and extreme weather conditions, tends to crack and lose its strength. It can lead to seepage and corrosion of primary steel and spauling of concrete. Fiber reinforcement concrete is considered as a material of improved properties and not as reinforced cement concrete wherein reinforcement is provided for local strengthening of concrete in tension reason. Since in fiber reinforcement concrete, fibers are uniformly dispersed (Recron 3s) which has better properties to resist internal stress due to shrinkage. Also reduces segregation and bleeding and also results in a more homogeneous mix. This leads to better strength and reduced permeability which improves durability. During the present research, an attempt has been made to utilize the sludge and Recron 3s fibers for making concrete.

Literature Review

H.S.Chore, et.al, determined the compressive strength of fibre reinforced fly-ash concrete using the regression model. The compressive strength of the fibre reinforced concrete containing flu-ash was predicted by creating a mathematical model using statistical analysis for the concrete data obtained from the experimental work.[1]Ashish Kumar Dash, et.al, used Recron 3s fibre and silica fume for making concrete. The compressive strength and the flexural strength of the concrete specimens were determined. The optimum strength was obtained at 0.2% fibre content.[2] Machine Hsie, et.al, used polypropylene hybrid fibre for making concrete. It was reported that the strength of concrete with polypropylene hybrid fibre was better than that of the single fibre reinforced concrete.[3] R.Srinivasan, et.al, determined the optimum percentage replacement of cement with hyposludge. The optimum replacement percentage was found to be 30%.[4]A Sivakumar and Manu Santhanam found that among hybrid fibre combinations, only the steel polypropylene combination performed better in all respects compared to the mono-steel fibre concrete.[5] Qian and Stroeven [6] studied the fracture properties of concrete reinforced with polypropylene fibre and three sizes of steel fibres with fibre content ranging from 0 to 0.95% by volume of concrete. Wu, Li and Wu [7] compared the mechanical properties of three different types of hybrid composite samples prepared by using the combinations of polypropylene- carbon, steel-carbon and polypropylene- steel fibres. Mechanical properties of hybride composites produced by using carbon and aluminum whiskers in addition to polypropylene fibres were studied in detail by Mobasher and Li[8]. Banthia and Sappakittipakron [9] investigated three fibre hybride with carbon and polypropylene micro fibres added to macro steel fibres and showed that steel macro fibers with highly deformed geometry produce better hybrids than those with a less deformed geometry. Also composites with a lower volume fraction of fibre reinforcement were seen as having a better prospect for hybridization than composites with a high volume fraction of fibres.

MATERIALS USED

1. Cement

The cement used during the present research is Ordinary Portland cement of Grade 53. Physical Properties of the cement used are given in "Table1". The cement was confirming to IS: 12269-1987.

Table 1 Physical Properties of Cement

Fineness modulus	2%
Standard consistency	34.5%
Specific gravity	3.15
Initial setting time	48 min
Final setting time	220 min

2. Fine aggregate

The most important function of the fine aggregate is to assist in producing workability and uniformity in mixture. The fine aggregate used is locally available river sand. The bulk density of fine aggregate as found to be 1700 kg/m^3. By conducting sieve analysis, it was found that sand confirms to grading zone-III as per IS 383-1970.

3. Coarse aggregate

Aggregates are the important constitutes in concrete. They give body to the concrete, reduce shrinkage and effect economy. The aggregates occupy 70-80 percent of the volume of concrete. It must be clean and free from impurities. From the sieve analysis, it was found that the course aggregate was confirming to single sized aggregates of nominal size 20mm as per IS 383-1970. Bulk density of the coarse aggregate was found to be 1590 kg/m^3.

4. Fly Ash

Class F fly ash from Eklahere Thermal Power station, Maharashtra which confines as per IS 3812-2000 was used in present case study .Its physical properties and chemical composition are given in Table 2 (a),(b)

Table 2(a), Chemical Properties of Fly ash

Sr. No.	Characteristic	Result obtained in %
1	Silicon dioxide + Aluminum oxide+ Iron oxide in %by mass minimum	95
2	Magnesium oxide in %by mass maximum	0.50
3	Total sulphur as sulphur tri oxide in %by mass maximum	0.30
4	Available alkalis as sodium oxide in %by mass maximum	0.90
5	Total chlorides in %by mass maximum	0.035
6	Loss on ignition in %by mass maximum	1.20
7	Calcium oxide	22.15
8	Moisture content	1.30

Table 2(b), Physical properties of Fly ash

Sr. No.	Name of the Tests	Observations
1	Fineness-specific surface in m^2/kg	395
2	Lime reactivity ,N/mm^2	2.50
3	Compressive Strength N/mm^2	79.00
4	Drying Shrinkage	0.21
5	Soundness	0.33

5. Recron 3s fiber

Recron 3s fiber was used as a secondary reinforcement material. It arrests shrinkage cracks and increases resistance to water penetration, abrasion and impact. It makes concrete homogenous and also improves the compressive strength, ductility and flexural strength together with improving the ability to absorb more energy.

Use of uniformly dispersed Recron 3s fibers reduces segregation and bleeding, resulting in a more homogeneous mix. This leads to better strength and reduced permeability which improves the durability. The used Recron 3s Fiber's test results are given in Table 3

Table 3, Test Results of Recron 3s Fiber,

Sr. No.	Property	Specification
1	Product code /Material	CTP 2012 / Polyester
2	Packing type	Pouch
3	Dispersion	Excellent
4	Application	Concrete
5	Shape	Triangular
6	Cut length	12.5 mm
7	Aspect ratio (length/ diameter ratio)	300
8	Specific Gravity	0.91
9	Melting Point	200-250° C
10	Elastic Modulus	500-700 psi
11	P H	7.3±0.5 @10%
12	Colour	White
13	Solubility in water	Not soluble in water
14	Water absorption	Nil
15	Alkaline Resistance	Good
16	Acidic Resistance	Excellent
17	UV Stability	Higher UV Resistance
18	Tensile Strength	6000kg/cm^2

6. Super plasticizer

7. A commercially available high range water reducing admixtures based on sulphonated naphthalene formaldehyde based super plasticizer (CONPLAST SP 430)was used as chemical admixture to enhance the workability of concrete. Table 4, Test Results of Super plasticizer

Table 4, Test Results of Super plasticizer

Colour	Brown
Specific Gravity	1.22
Chloride Content	Nil
Solid Content	40%

8. Water

The water, which is used for making concrete should be clean and free from harmful impurities like oil, alkalis, acids etc. Ordinary potable water available in the laboratory was used for making and curing concrete. The quality of water was found to satisfy the requirements of IS: 456-2000.

Experimental Investigation

The experimental investigation consisted of making M25 concrete containing different proportions of fly ash and Recron 3s fiber. M25 concrete was designed as per IS 10269:2009 and the mix proportions are given in Table 5.

Table 5 Quantity of Materials for M25 concrete

Water	191.58 lit/m^3
Cement	445.53 kg/m^3
Fine aggregate	516.35 kg/m^3
Coarse aggregate	1212.01 kg/m^3

The various percentages sludge and Recron 3s fiber used during the investigation are given in Table 6.

Table 6 Various Percentages of Materials Used

% replacement of cement with fly ash	% addition of Recron 3s fiber			
0	0	0.2	0.3	0.4
10	0	0.2	0.3	0.4
20	0	0.2	0.3	0.4
30	0	0.2	0.3	0.4
40	0	0.2	0.3	0.4
50	0	0.2	0.3	0.4

The concrete specimens were cast with 10%, 20%, 30%, 40% and 50% replacement of cement with sludge. For each replacement, 0.2%, 0.3% and 0.4% of Recron 3s fibers were added. For each mix, three cubes of size 150mm x 150mm x 150mm, three cylinders of diameter 150mm and height 300mm and three prisms of size 500mm x 100mm x 100mm were cast. Altogether, 18x4=72x6=432+5% extra =21.60 say 22, finally (432+22) =**454** specimens were casted. The specimens were cured in a curing tank for 7 Days and 28 Days. After the curing period, the compressive, split tensile and flexural strengths of various specimens were found.

Compressive strength test on cubes

The cube compressive strength of concrete was determined on 150mm x 150mm x 150mm cube specimens using a 2000kN capacity on compressive testing machine. After centering the specimens on the machine, the load was applied at a uniform rate of 14 N/mm²/min till the failure of the specimens.

The 7 Days and 28 Days compressive, split tensile and flexural strength of various specimens are given in Table 7.

Table 7 Compressive, Tensile and Flexural Strength of Various Specimens at 7 Days and 28 Days.

% replacement of cement with fly ash	% addition of Recron 3s fiber	Compressive strength of Cubes (N/mm^2)		Split tensile strength of cylinders (N/mm^2)		Flexural strength of cylinders (N/mm^2)	
		7 days	28 days	7 days	28 days	7 days	28 days
0%	0 %	15.46	32.89	0.86	1.92	3.22	7.31
	0.2 %	14.99	31.89	0.79	1.75	3.54	8.05
	0.3 %	14.19	30.20	0.73	1.62	3.91	8.88
	0.4 %	13.38	28.46	0.68	1.51	4.30	9.77
10%	0 %	15.50	32.97	0.93	2.06	3.72	8.44
	0.2 %	14.62	31.11	0.84	1.87	3.32	7.54
	0.3 %	15.82	33.66	0.88	1.95	3.63	8.25
	0.4 %	16.44	34.97	0.94	2.09	3.98	9.05
20%	0 %	15.96	33.96	1.13	2.52	4.37	9.94
	0.2 %	16.31	34.70	0.92	2.05	3.76	8.55
	0.3 %	16.63	35.38	0.96	2.14	4.41	10.02
	0.4 %	17.54	37.32	1.03	2.30	5.33	12.11
30%	0 %	16.23	34.54	1.23	2.73	4.61	10.47
	0.2 %	12.71	27.04	0.82	1.82	3.19	7.26
	0.3 %	13.99	29.77	0.84	1.87	3.43	7.81
	0.4 %	12.90	27.45	0.88	1.95	3.81	8.66
40%	0 %	15.04	32.00	0.89	1.98	3.54	8.05
	0.2 %	11.91	25.35	0.56	1.24	2.91	6.62
	0.3 %	12.27	26.11	0.58	1.30	3.26	7.42
	0.4 %	13.47	28.65	0.60	1.33	3.54	8.04
50%	0 %	14.20	30.22	0.65	1.44	3.28	7.46
	0.2 %	9.49	20.20	0.28	0.63	2.55	5.79
	0.3 %	10.59	22.53	0.34	0.77	2.69	6.12
	0.4 %	11.33	24.11	0.41	0.91	2.82	6.41

The variations in the cube compressive strength of concrete containing various proportions of Fly Ash and Recron 3s fiber are shown in figure 1.

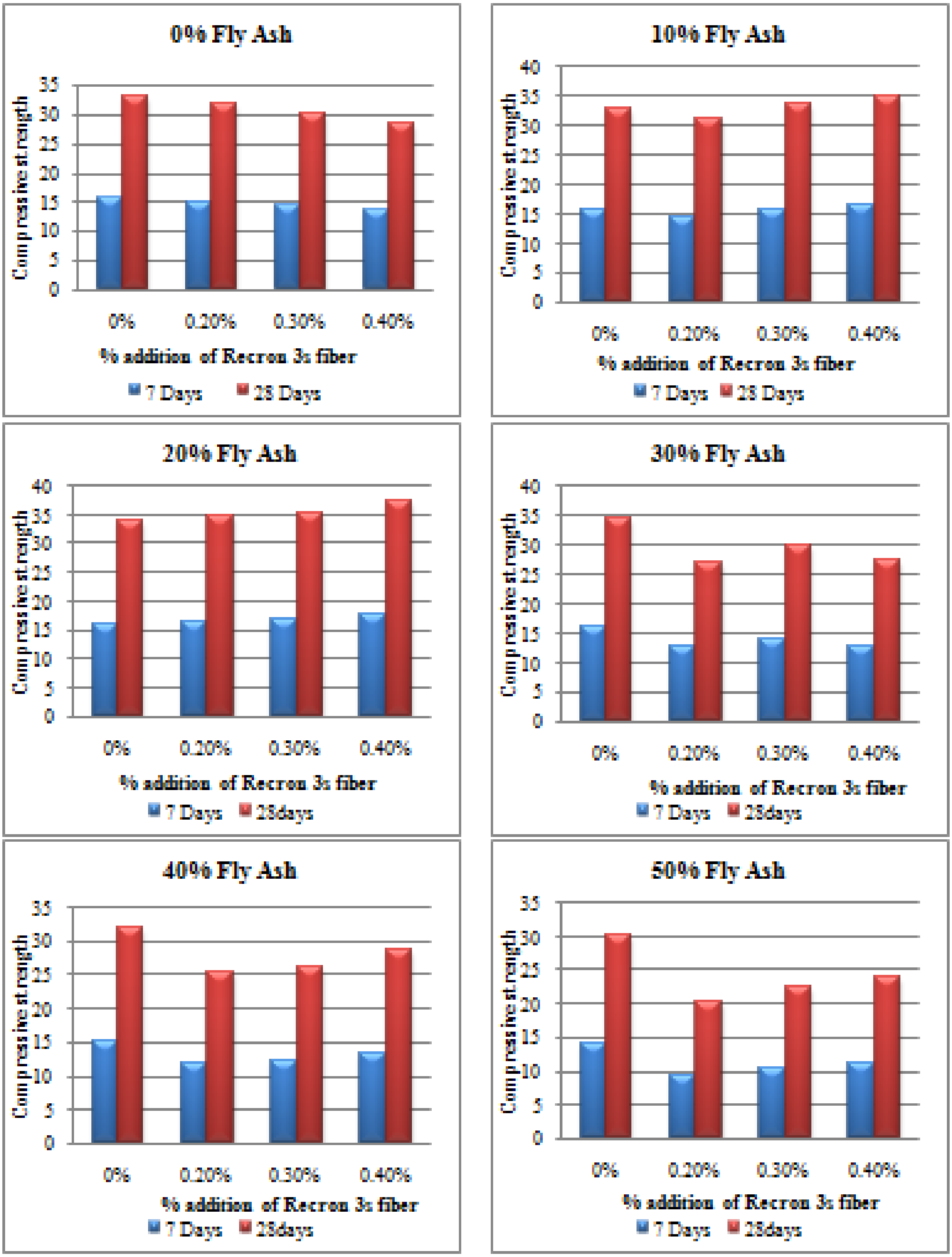

Figure 1-Variations in the 7 days and 28 days Compressive strength of specimens with different percentage of fly ash and Recron 3s fiber.

From figure 1, it can be seen that optimal replacement percentage of cement with sludge is 20% and the optimal percentage of Recron 3s fiber content is 0.4%.

Split tensile strength test of cylinders

Direct tensile strength of concrete is seldom determined owing to difficulty in preparation of test specimen and applying truly axial tensile load. Split tensile strength is an indirect method of finding out the tensile strength of concrete. It is found on cylinders of 150mm diameter and length 300 mm.

The variations in the split tensile strength of concrete containing various proportions of sludge and Recron 3s fiber are shown in Figure 2.

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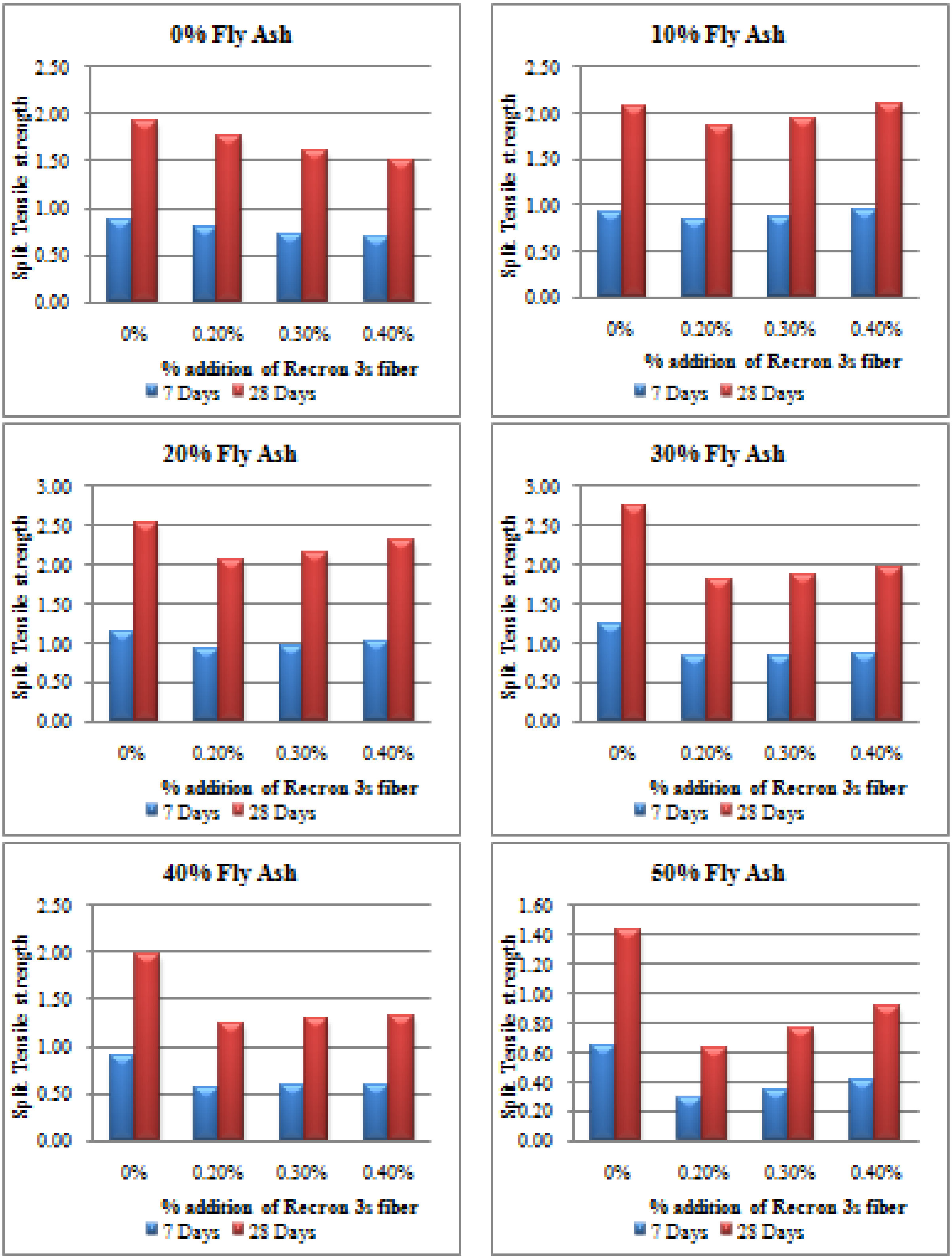

Figure 2-Variations in the 7 days and 28 days Split Tensile Strength of specimens with different percentage of fly ash and Recron 3s fiber.

From Figure 2, it can be seen that optimal replacement percentage of cement with fly ash is 20% and the optimal percentage of Recron 3s fiber content is 0.4%.

Flexural strength test on prisms

The determination of flexural tensile strength is essential to estimate the load at which the concrete members may crack. The flexural tensile strength at failure is called modulus of rupture. Prisms of size 100 x 100 x 500mm are used to determine the flexural strength.

The variations in the cube Flexural strength of concrete containing various proportions of Fly Ash and Recron 3s fiber are shown in Figure 3.

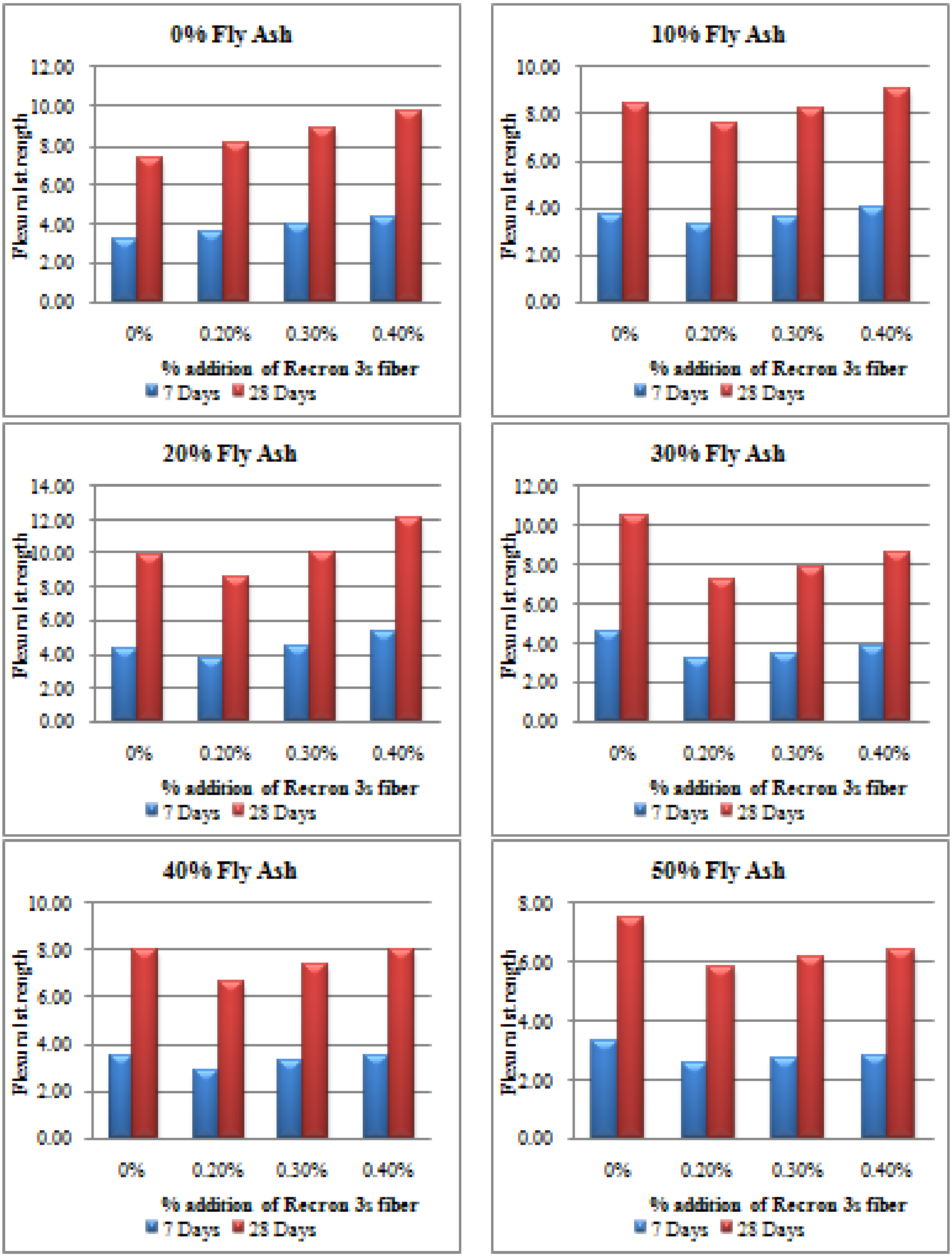

Figure 3-Variations in the 7 days and 28 days Flexural Strength of specimens with different percentage of fly ash and Recron 3s fiber.

From Figure 3, it can be seen that optimal replacement percentage of cement with sludge is 20% and the optimal percentage of Recron 3s fiber content is 0.4%.

CONCLUSIONS

- From the results, it is found that the optimal replacement percentage of cement with fly ash is 30% when Recron 3s fibers are not added.
- On addition of Recron 3s fiber with cement matrix, the compressive strength and split tensile strength decrease with increase in Recron 3s fiber content, however the flexural strength increases with increase in Recron 3s fiber content.

- When sludge and Recron 3s fiber are added, the optimum dosage of fly ash is 20% and optimum Recron 3s fiber content is 0.4%.
- The usage of fly ash will reduce the ill effects on the environment. It is recommended over the ordinary concrete as it considerably saves cement and also prevents environmental pollution.
- Usage of Recron 3s fiber will reduce the cost of maintenance by reducing the micro cracks and permeability and hence the durability will increase. It is found that use of Recron 3s fiber reduces the segregation.

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