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Experimental Study on Effect of Waste Polyethylene Terephthalate Bottle Fibers and Silica Fume on Concrete

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Abstract: ***The problem of recycling waste materials of different kinds is and will be, unquestionably, one of the main problems that will most trouble to the society in the future and that we must address and resolve in all feasible ways. Waste plastic bottles are a vital cause of solid waste disposal. Polyethylene Terephthalate (PET) is typically used for effervescent drink and water bottles. The waste plastic bottles are strenuous to biodegrade and involve processes either to recycle or reuse. The construction industry is in want of finding cost-efficient materials for increasing the strength of concrete structures.***
In this experimental study, the waste PET bottle fibers in a proportion of 0.5 %, 1%, 1.25% and 1.5% to the weight of the cement are added to the Concrete and optimum percentage of PET fibers is founded. Then Silica Fume in the percentage of 10%, 12.50%, 15%, and 20% is replaced with cement in concrete and optimum percentage of silica fume is drawn. The studies were conducted on an M30 mix and investigation process will be carried out as per the recommended procedures by relevant codes. Finally, the combined effect of optimum percentage of PET fibers i.e. 1% and Optimum percentage of silica fume i.e.10% is studied on the fresh concrete, and then properties of fresh concrete are improved.
Keywords: Polyethylene Terepthalate (PET), Silica Fume, Concrete, fiber reinforced concrete, compressive strength

I. INTRODUCTION

The quantity of plastics of all types consumed annually all over the world has increased substantially. The problem of recycling waste materials of various types, is, and will be, certainly, one of the major problems that will most trouble the society in the future and that we must have to resolve in all possible ways. It is needed to be done that the researchers will find solutions to the reuse of the waste. Waste plastic bottles are major reason of solid waste disposal. The lack of space for landfilling and due to an ever increasing cost, the consciousness is towards the reuse of waste as alternative to disposal. With a continuous growth for over 50 years , the global production of plastics rose from 204 million tons in 2002 to 299 million tons in 2013 (Plastics the Facts -2014) and is ever increasing. The worldwide production of PET exceeds 6.7 million tons/year and shows a dramatic increase in the Asian region due to recent increasing demands in China and India (M. L. Anoop Kumar et.al. 2014). In India approximately 40 million tons of solid waste is produced every year. This is increasing at a rate of 1.5 to 2% annually. Plastics comprise 12.3% of total waste produced most of which is from discarded PET water bottles [6]. PET bottles are extensively used as containers for beverage, water, household cleaners and oil and are thrown away after single usage. Disposed PET bottles are treated by landfill and burning, which creates serious environmental problems and hence creates waste disposal and management issues. It is well recognized that the use of supplementary cementitious materials, such as silica fume (SF), metakaolin, rice husk ash, ground granulated blast furnace slag and fly ash, are indispensable. Most of these supplementary cementitious materials are by products; thus, their inclusion not only serves as an in estimable means to protect environmental resources but also improves concrete construction properties, including its sustainability. Although it has been found, various by product and waste product can enhance or even maintain the characteristic strength of concrete, besides of that it is a feasible solution for improving recycling process of by products and waste products, environmental condition, land pollution and its fertility. Over the last two decades, the suitable usage of plastic in concrete and replacement in constituents of concrete is being evaluating which gave a little possibilities of using it in concrete.

The construction business is in want of finding cost effective materials for increasing the strength of concrete structures. Research is constantly more interested in the use of such products in the concrete. All over the globe, several researchers are inventing materials which can be appropriately added into concrete for enhancing its properties. The incorporation of materials like waste PET bottle fibers in cementitious matrix improve the mechanical response of the resulting product. Research is constantly more interested in the use of such products in the concrete.

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This paper presents an experimental study of the waste PET bottle fibers in proportion of 0.5% , 1%,1.25% and 1.5% to the weight of the cement is added to the Concrete and optimum percentage of PET fibers is founded. Then Silica Fume in the percentage of 10%, 12.50%, 15% and 20% is replaced with cement in concrete and optimum percentage of silica fume is drawn. The studies were conducted on a M30 mix and investigation process will be carried out as per recommended procedures by relevant codes. Finally the combined effect of optimum percentage of PET fibers i.e. 1% and Optimum percentage of silica fume i.e.10% is studied on the fresh concrete.

II. MATERIALS

A. Cement

Ordinary Portland cement was used throughout this experimental investigation. The cement was obtained from local cement dealer and kept in dry location. The manufacturer of cement is Ultratech and the grade of cement was 53 grades. The properties are as follows:

TABLE I
PROPERTIES OF CEMENT

Property	**Value**
Fineness	1.4
Standard Consistency	27.41%
Specific gravity	3.00
Initial Setting Time	57
Final Setting Time	365
Soundness	04

B. Fine Aggregate

The natural river sand passing through IS 4.75mm sieve having specific gravity 2.6 and the average silt content 5.26% is used throughout this experiment.

C. Coarse Aggregate

Machine crushed coarse aggregate obtained from natural stone passing through 20mm sieve having fineness modulus 3.34, abrasion value 18.59%, impact value 13.35%, crushing Strength 2.57N/mm2 and water absorption 0.5% is used in this experimental study.

D. PET Fibers

In this experiment**,** Straight PET fibers (Fig.1) of dimension 50 mm x 2 mm were used which is obtained by cutting the waste mineral water bottles.



Fig. 1 Fibers of aspect ratio 50mm x 2mm

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E. Silica Fume

Silica fume (Fig.2) as mineral admixture in dry densified form obtained from ELKEM INDIA (P) LTD, Mumbai conforming to ASTMC-1240 is used in this experimental investigation.



Fig 2 Silica Fume

III.EXPERIMENTAL INVESTIGATIONS

In this Experimental work M30 grade concrete is designed as per IS: 10262-2009 & the water cement ratio 0.42 was used throughout. Cube casting specimens of dimension 150 mm X 150 mm X 150 mm & beam of dimension 150 mm X 150 mm X 700 mm was used. The tests on fresh concrete & hardened concrete are carried out. Initially 09 Cubes 09 beams were casted of Plain M30 grade concrete. Then to find the optimum percentage of PET fibers, PET bottle fibers in a proportion of 0.5 %, 1%, 1.25% and 1.5% to the weight of the cement were added to the M30 Concrete and 09 cubes for each proportion was casted .Similarly, Silica Fume in the percentage of 10%, 12.50%, 15%, and 20% was replaced with cement and optimum percentage of silica fume was drawn by casting 09 cubes of each proportion. Then to study the combined effect of Silica fume and PET fibres,09 cubes & 09 beams were casted with optimum percentage of Silica Fume & PET fibers. Total 90 cube specimens & 18 beams were casted & tested throughout this experimental investigation. The specimens were cured for 7, 14 and 28 days and the test for compressive strength was carried out in compression testing machine & test for flexural strength was conducted on UTM.

IV. RESULTS AND DISCUSSION

Results of fresh and hardened concrete with partial replacement of silica fume in various percentage and with various percentages of PET fibers and also the combination of Silica fume and PET fiber concrete are discussed here in comparison with those of normal concrete.

TABLE II

COMPRESSIVE STRENGTH TEST RESULTS OF M30 CONCRETE

Sr. No.	7Days Compressive strength (N/mm2)	14Days Compressive strength (N/mm2)	28 Days Compressive strength (N/mm2)	Average (N/mm2)
1	24.97	33.33	37.33	37.65
2	24.88	33.11	37.95	
3	25.11	33.2	37.68	

From Table 2 Compressive strength test results of 7days, 14 days and 28days for M30 concrete is obtained. The specimen is tested after curing in water for 7, 14 and 28 days.

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Figure 3 shows the increase in compressive strength of concrete after the curing of specimen in water after 07 days, 14 days & 28 days.

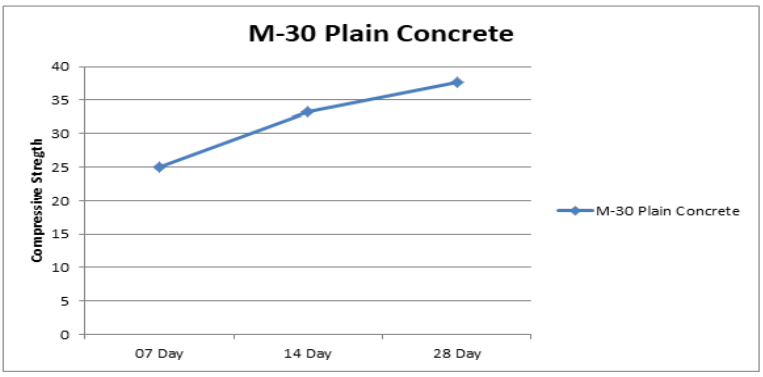


Fig 3 Compressive Strength of M30 Concrete

TABLE III
COMPRESSIVE STRENGTH TEST RESULTS OF SILICA FUME CONCRETE

Sr. No.	Silica Fume %	7Days Comp. Strength (N/mm2)	14 Days Comp. Strength (N/mm2)	28 Days Comp. Strength (N/mm2)	Average (N/mm2)
1	10 %	38.22	50.44	58.66	58.66
2		38.66	51.55	59.11	
3		37.33	52.00	58.22	
4	12.5%	36.44	49.77	56.88	56.73
5		37.33	50.22	56.22	
6		36.66	51.11	57.11	
7	15 %	35.77	48.88	55.55	55.10
8		35.11	48.88	55.11	
9		35.55	49.33	54.66	
10	20 %	32.88	47.55	52.88	52.73
11		32.00	49.33	52.00	
12		32.44	48.44	53.33	

From Table 3 Compressive strength test results of 7days, 14 days and 28days for various percentage silica fume concrete is obtained. The specimen is tested after curing in water for 7, 14 and 28 days.

Figure 4 shows the increase in compressive strength of concrete with various percentage of silica fume after the curing of specimen in water after 07 days, 14 days & 28 days. It is found that the optimum percentage of silica fume is 10%.

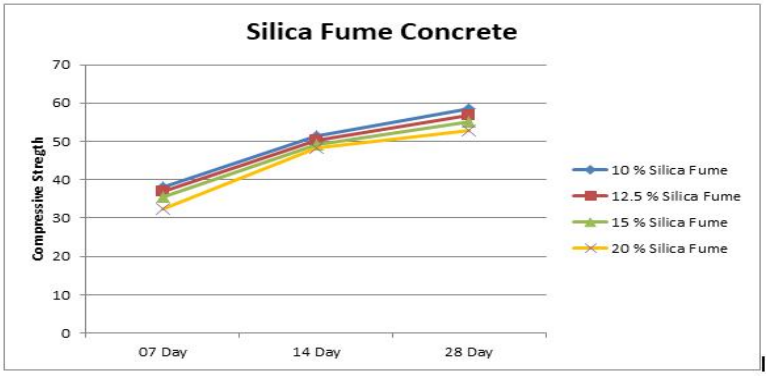


Fig 4 Comparison of Compressive Strength of Various % of Silica Fume in Concrete

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TABLE IV
COMPRESSIVE STRENGTH TEST RESULTS OF PET FIBRE CONCRETE

Sr. No.	PET fibres %	7 Days Comp. Strength (N/mm2)	14 Days Comp. Strength (N/mm2)	28 Days Comp. Strength (N/mm2)	Average (N/mm2)
1	0.50%	32.88	44.88	51.55	51.55
2		33.33	43.55	51.11	
3		33.77	44.44	52.00	
4	1.00%	36.22	48.88	55.55	55.92
5		36.44	49.77	56.44	
6		37.33	50.66	55.77	
7	1.25%	34.00	47.55	52.88	52.29
8		33.77	45.33	51.55	
9		34.22	46.66	52.44	
10	1.5%	31.11	44.44	50.22	49.62
11		31.55	45.33	48.88	
12		32.44	44.00	49.77	

From Table 4 Compressive strength test results of 7days, 14 days and 28days for various percentage PET fiber concrete is obtained. The specimen is tested after curing in water for 7, 14 and 28 days.

Figure 5 shows the increase in compressive strength of concrete with various percentages of PET fibers after the curing of specimen in water after 07 days, 14 days & 28 days. It is found that the optimum percentage of PET fiber is 1%.

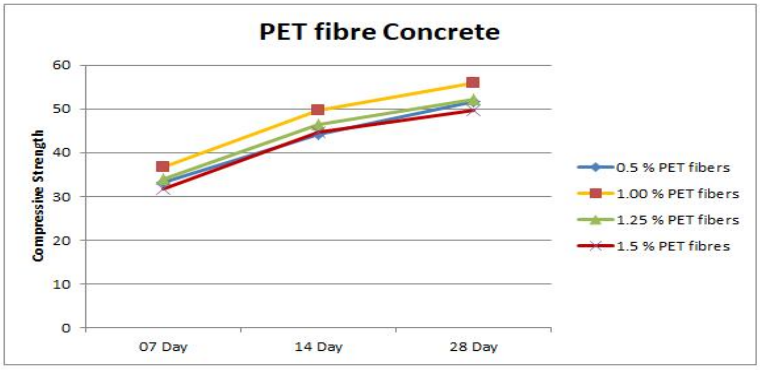


Fig 5 Comparison of Compressive Strength of Various % of PET fibers in Concrete

TABLE V
COMPRESSIVE STRENGTH TEST RESULTS OF COMBINATION OF SILICA FUME CONCRETE & PET FIBER CONCRETE

Sr. No.	7 Days Comp. Strength (N/mm2)	14 Days Comp. Strength (N/mm2)	28 Days Comp. Strength (N/mm2)	Average (N/mm2)
1	37.33	53.33	59.11	59.55
2	38.66	52.88	60.00	
3	37.77	53.33	59.55	

From Table 5 Compressive strength test results of 7days, 14 days and 28days for Combination of optimum percentage of silica fume & optimum percentage of PET fibers is obtained. The specimen is tested after curing in water for 7, 14 and 28 days.

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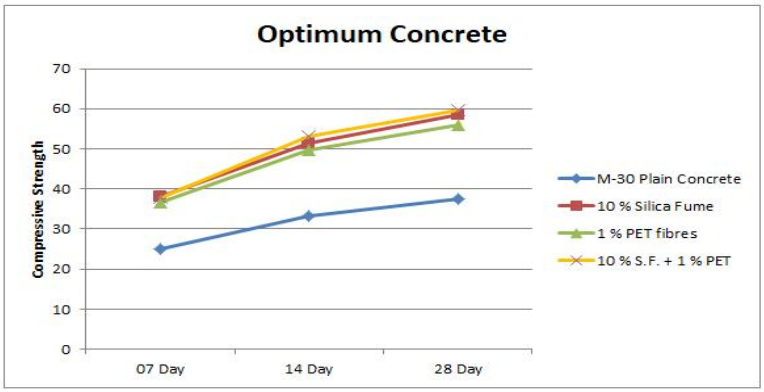


Fig 6 Comparison of Comp. Strength of M30, optimum % of Silica Fume, optimum % of PET fibers Combination of optimum % of Silica fume & PET fibers concrete

Figure 6 shows the Comparison of compressive strength of M30, optimum percentage of Silica fume, optimum percentage of PET fiber & the combination of optimum % of Silica fume & PET fibers concrete after the curing of specimen in water after 07 days, 14 days & 28 days. From this comparison it is found that there is increase in compressive strength of combination of silica fume & PET fiber concrete than the other type of tested concrete.

Table VI
Flexural Strength Test Results Of M30 & Combination Of Silica Fume & Pet Fiber Concrete

Sr. No.	7 Days Comp. Strength (N/mm2)		14 Days Comp. Strength (N/mm2)		28 Days Comp. Strength (N/mm2)		Average (N/mm2)	
	M30	S.F. + PET	M30	S.F. + PET	M30	S.F. + PET	M30	S.F. + PET
1	2.66	2.72	3.60	3.87	4.08	4.17	4.11	4.19
2	2.64	2.74	3.55	3.89	4.00	4.23		
3	2.68	2.79	4.00	3.86	4.26	4.19		

Table VI shows the results of flexural strength test of M30 concrete and Combination of optimum percentage of silica fume & PET fiber concrete carried out on beam specimen. In this test it was observed that as the curing period increases the flexural strength of the concrete was also gradually increased.

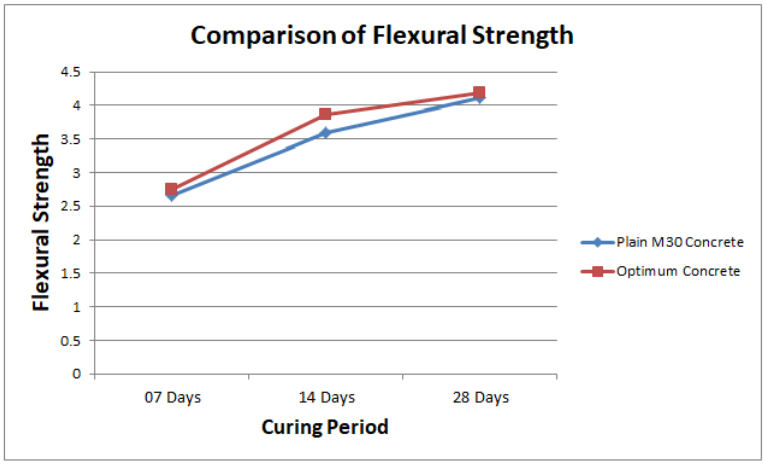


Fig 7 Comparison of Flexural. Strength of M30 and Combination of optimum % of Silica fume & PET fibers concrete

Figure 7 indicates the comparison of Flexural strength between plain M30 concrete and the combination of Optimum percentage silica fume and PET fiber concrete.

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V. CONCLUSIONS

The following are the conclusion obtained from the present study:

It is seen that the value of compressive strength is increased with curing time. There is a slight decrease in workability after the addition of PET fibers. The addition of silica fume reduces workability. However, in some cases, improved workability was also reported. The optimum percentage of silica fume in concrete is obtained as 10 %. It is observed that the percentage increase in compressive strength after 28 days curing of the specimen with 10% Silica fume concrete in comparison with the plain M30 concrete is 55.80 %.

The significant improvements in strengths were observed with the inclusion of PET fibers in concrete. The optimum percentage of PET fibers in concrete is obtained as 1 %. It is observed that the percentage increase in compressive strength after 28 days curing of the specimen with 1% PET fiber concrete in comparison with the plain M30 concrete is 48.52%.

It is observed that the compressive strength of specimen with Combination of 10 % Silica fume & 1 % PET fibers after 28 days curing is increased by 58.16 % than the plain M30 concrete after 28 days curing.

From this experiment, it is found that the compressive strength of the Combination of Silica fume & PET fiber concrete is 1.59 % more than Silica fume concrete and 6.49 % more than PET fiber concrete.

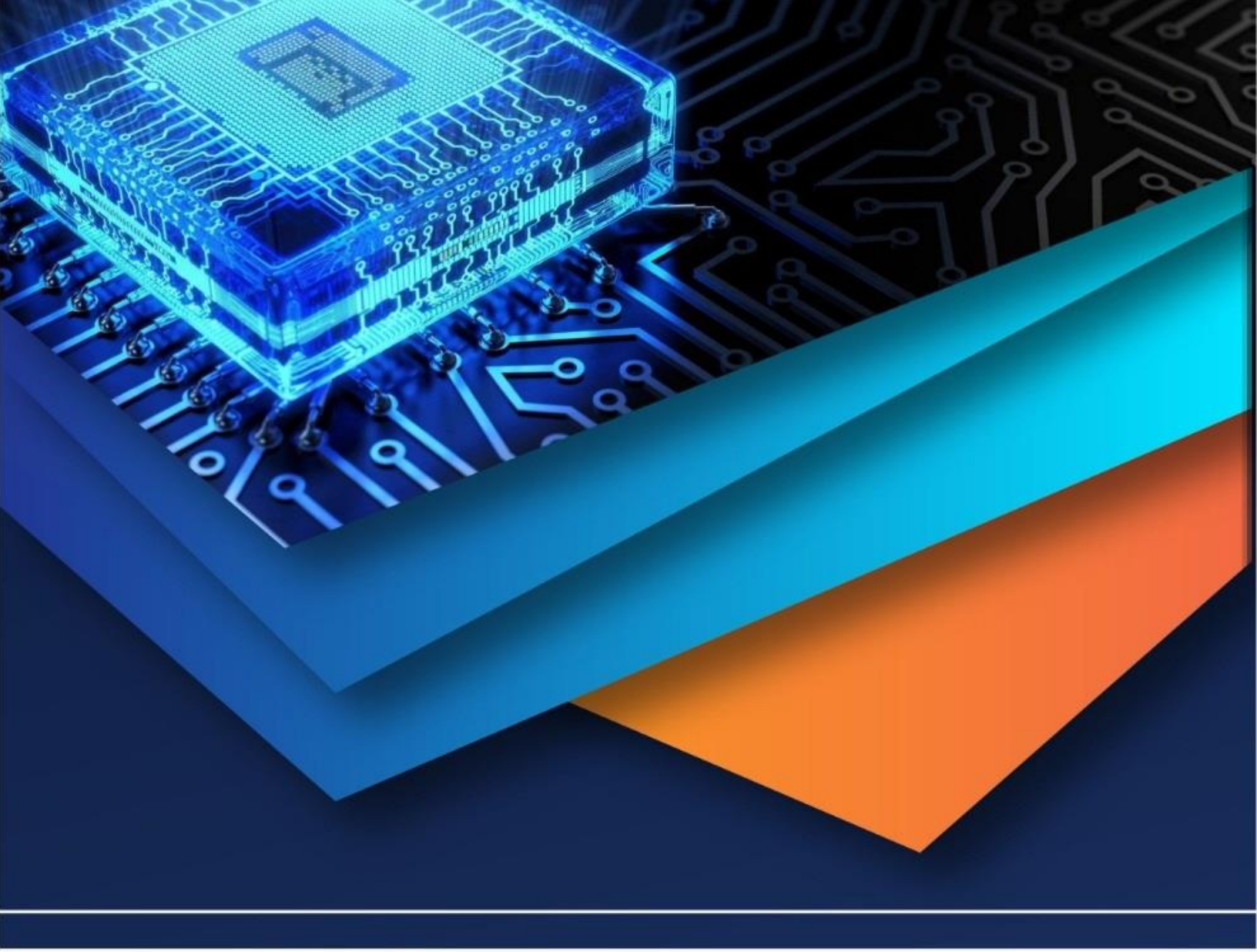
From this experimental study, it is observed that the flexural strength of the concrete with the combination of silica fume and PET fibers is more than the Plain Concrete. The Flexural strength of the concrete with a Combination of Optimum percentage of silica fume & optimum percentage of PET fibers is increased by 2 to 3 % than Plain M30 Concrete.

From this experimental investigation, the PET bottles fume would seem to be inexpensive materials which might facilitate to resolve solid waste **issues** and preventing environmental pollution.

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