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Behavior of Concrete Utilizing Silica Fume as a Partial Replacement of Cement and Plastic Waste as a Partial Replacement of Fine Aggregates

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Abstract:
Now a day environmental problems become big issue in the world. Various wastes are generated from various sources. Plastic waste is one of the major wastes which are generated from various outputs. Disposal of the plastic waste is difficult and the combustion of plastic waste generates various harmful gases. Present study is aimed to use of plastic waste in concrete as a partial replacement of fine aggregates (0%, 5%, 10%) and use of silica fume in concrete as a partial replacement of cement (0%, 5%, 10%). Cement industry is major source of gases emissions. Slump test was performed for fresh concrete, compressive strength and flexural strength test was performed for hardened concrete. Various properties were evaluated at different replacement levels and results were compared with control mix. It can be concluded from results that combination of silica fume and plastic waste can be used in concrete. It will be beneficial for concrete industries.

Keywords: Silica Fume, Plastic Waste, Slump, Compressive Strength, Flexural Strength.

1. INTRODUCTION

Now a day different types of plastics are generated from modern lifestyle and it leads into large waste disposal problem (**Batayneh *et al.*, 2007**). Plastic is a polymer of hydrocarbon monomers so it can be used as food packing materials, cutting boards, water bottles, containers, polythene bags, electrical appliances, furniture, vehicles, etc. in everyday life. (**Williams and Williams, 1997**). In the present time, plastic has become a basic part of life. Thus the uses of plastic products are increasing gradually (**Suganthy *et al.*, 2013**). Plastics waste leads to poor soil fertility, reduction in water percolation, emission of harmful toxic gases, health hazards to animals and birds consuming plastic waste as mistaken food, poor drainage due to landfill, pollution of groundwater due to leaching of chemicals from these waste products, etc. Thus it is very harmful to environment and all over (**Malak, 2015**). Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. Literatures show that plastic waste can be used in concrete as a partial replacement of fine aggregates. The utilization of plastic waste in the construction industry has got two advantages, one, environmental impact caused by disposal of the waste can be minimized up to some extent and second, the economic impact as these wastes are available in large quantity at low costs (**Sadiq and Khattak, 2015**).

Concrete industries consume huge amount cement. In cement production there is generates harmful gases and required energy. So therefore it is required to reduce the consumption of cement in construction industry. Literature shows that silica fume can be used in concrete as a partial replacement of cement. Silica fume improves the properties of concrete (**Kumar 2014**). The presented research aimed to study the properties like optimum percentage of silica fume as a partial replacement of cement and plastic waste as a partial replacement of fine aggregates.

2. MATERIAL AND METHODOLOGY

2. 1. Materials: In this systematic study cement, fine aggregates, coarse aggregates, water, plastic waste and silica fume have been used to produce concrete. Suitability of these materials have been checked in the laboratory by the performing various tests.

2.1.1 Cement: The ordinary Portland cement (OPC) of 43-grade was used for casting the specimens of all the concrete mixes. Cement was bought from the same source throughout the research work. Cement was free from the moisture and also free from any lumps.

2.1.2 Silica Fume: Silica fume for the present investigation was obtained from M/s NAVPAD SALES, Surat. The silica fume was sieved and the fraction passing 100µ IS sieve was used in the experiments. The following physical properties of silica fume were observed during experimental studies.

Table.1. Physical properties of silica fume

Specific Gravity	**2.28**
Consistency	**30%**
Colour	**Light gray**

2.1.3 Fine Aggregates: The aggregate which passes through 4.75 mm sieve and is retained on 75 µm sieve, is called as fine aggregate. The locally available river fine aggregate passing 4.75 mm sieve as per IS: 383-1970 was used as fine aggregate for this study.

2.1.3 Course Aggregates: The aggregate which passes through 80 mm sieve and is retained on 4.75 mm sieve, is called as coarse aggregate. In this Study, coarse aggregates of 20 mm and 10 mm were used. The gradation of coarse aggregates was as per IS: 383-1970. The specific gravity of coarse aggregate was found to be 2.71.

2.1.4 Plastic Waste: Waste PET bottles were used for this study which was collected from local waste supplier. Waste PET bottles were than shredded using a shredding machine. Plastic waste was shredded in two sizes, i.e., between 0-4.75mm for fine aggregate replacement and between 4.75-20mm for coarse aggregate replacement. The waste was not given any special treatment except the normal water wash cleaning and sun light drying. Sieve analysis of plastic waste to replace fine aggregates is describe as follows:

Table.2. Sieve analysis of plastic waste to replace fine aggregate

Sieve size (mm)	Aggregate retained on each sieve (gm)	% retained	Cumulative % retained	% Passing
4.75	0	0	0	100
2.36	220	44	44	56
1.18	230	46	90	10
0.600	21	4.2	94.2	5.8
0.300	24	4.8	99	1
0.150	5	1	100	0
Pan	0	-	-	-
Total	500	**-**	427.2	**-**
Fineness modulus = 427.2/100 = **4.27**				

2.1.5 Water: Potable water was used throughout the investigation and was taken from the same source throughout. It was used for mixing, casting and curing the concrete specimen as per IS 456-2000.

2.2 Methodology: In this experimental investigation M25 grade of concrete has been used. Slump test has been used to determine the workability of concrete, compressive strength, flexural strength test have been used for hardened concrete.

The concrete mix design of M25 grade was made as per the guidelines given in the Indian standards namely IS: 10262 (2009) and IS: 456 (2000). The water to cement ratio was maintained at 0.45 (assuming moderate exposure conditions from IS: 456 (2000)). Following is the mix with 0% plastic waste with water contents 0.45.

0.45: 1: 1.54: 2.76 {Water: Cement: Fine aggregate: Coarse aggregates (20mm and 10mm)}. Cement was partially replaced with silica fume at 5%, 10%, 15% and fine aggregates was replaced in this study with plastic waste in different percentage, i.e., 0%, 5%, 10%, to check the various properties of concrete. Mix details for the concrete are given as follows:

Table .2. Concrete Mix Proportion with Plastic Waste and Silica Fume

Mix No.	**Cement**	**Silica Fume (%)**	**Fine aggregate**	**Coarse aggregate**	**Plastic waste (%)**	**w/c ratio**
A0	1.00	0	1.54	2.76	0	0.45
A1	1.00	0	1.46	2.76	5	0.45
A2	1.00	0	1.39	2.76	10	0.45
B0	0.95	5	1.54	2.76	0	0.45
B1	0.95	5	1.46	2.76	5	0.45
B2	0.95	5	1.39	2.76	10	0.45
C0	0.90	10	1.39	2.76	0	0.45
C1	0.90	10	1.31	2.76	5	0.45
C2	0.90	10	1.23	2.76	10	0.45

The specimens of standard cube of (150mm×150mm×150mm) were casted to determine the compressive strength of concrete. 27 specimens were tested for 7, 28 and 90 days with each proportion of silica fume and plastic waste. Totally 81 cubes were cast for the compressive strength. The materials were weighed and mixed by mixer machine. The concrete was filled in different layers and each layer was compacted. The cubes were de moulded after 24 hrs. Cured in water for 7, 28 and 90 days, and then tested for its compressive strength as per Indian Standers. Flexural strength test was performed on beam specimens of size 500mmx100mmx100mm at 28 days of curing.

3. RESULTS AND DISCUSSION

3.1 Workability: Workability of control concrete and the concrete containing silica fume and plastic waste was determined slump cone test (slump test as per Indian standard procedure IS: 1199-1959).

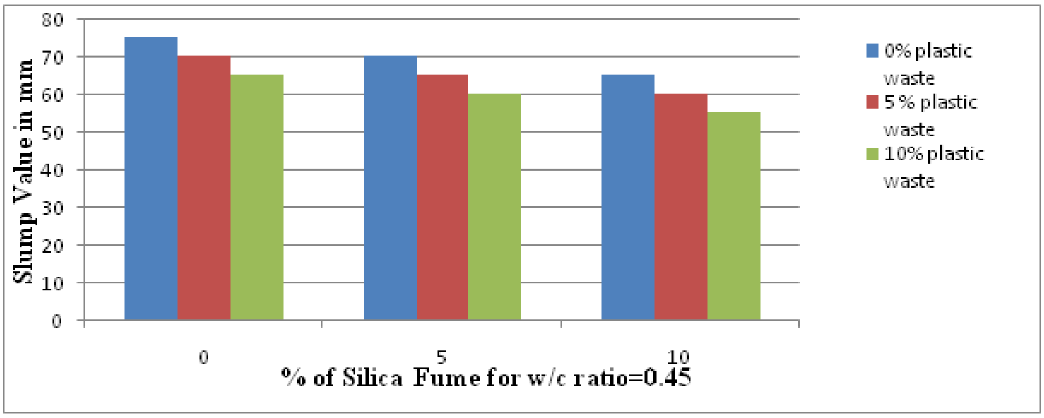

Figure .1. slump values for concrete at various replacement levels

Figure 3.1 shows the results of the slump test for the concrete at various replacement level at w/c ratio of 0.45. The slump value for the control mix was obtained as 75mm at w/c ratio 0.45. The slump value of concrete was decreased with increase in the percentage of silica fume. Concrete containing 10% silica fume has slump value 65mm. similar variation was found for sand replacement by plastic waste. Slump value for the concrete containing 10% plastic waste was found as 65mm.

3.2 Compressive Strength: Fig. 3.2 shows the compressive strength of concrete for w/c ratio 0.45 with replacement of fine aggregate and coarse aggregate by 0%, 5%, 10%, 15% and 20% plastic waste tested for three different curing intervals of 7, 28 and 90 days.

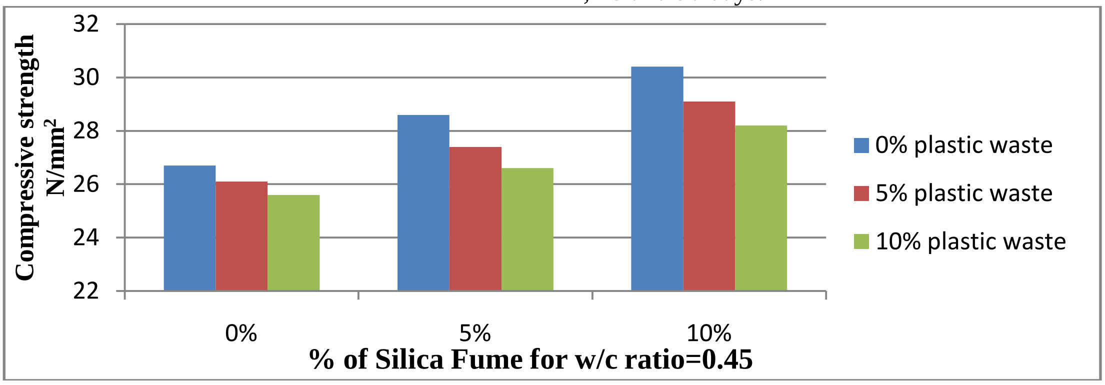

Figure.2. Compressive strength of concrete at 28 days of curing

Figure 3.2 shows the compressive strength of concrete containing plastic waste as a partial replacement of fine aggregates and silica fume as a partial replacement of cement at 28 days of curing. Compressive strength for control mix was obtained as 26.7 N/mm^2 The compressive strength of concrete increases with the increase in percentage of silica fume. The compressive strength increases to 30.4N/mm^2 at 10% replacement of cement by silica fume. The compressive strength decreases with increase in the percentage of plastic waste. The compressive strength for concrete at 10% replacement of fine aggregates by plastic waste was obtained as 25.6 N/mm^2. The compressive for the concrete containing 10% silica fume and 5% plastic waste was observed as 29.1N/mm^2. Compressive strength decreases with 5% additional replacement of plastic waste in previous. But the decrement is only 3%. So it is therefore advisable to use the concrete which containing 10% silica fume and 10% plastic waste due to maximum use of both materials.

3.3 Flexural Strength: Figure 3.3 shows the flexural strength of concrete at 28 days of curing. The flexural strength of concrete for control mix was obtained as 3.55N/mm^2. The flexural strength of concrete increases to 5.89N/mm^2 at 10% replacement level of cement by silica fume. The flexural strength of concrete decreases with the increase in the % of plastic waste. Flexural strength of concrete at 10% replacement level of plastic waste was observed as 3.49N/mm^2. Flexural strength of concrete at maximum replacement level (10% silica fume + 10% plastic waste) was observed as 5.21N/mm^2.

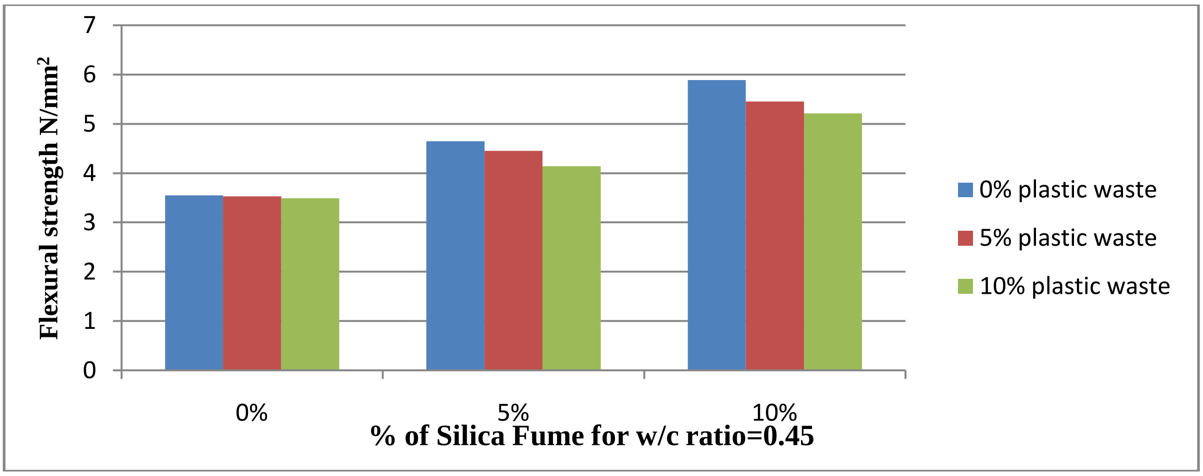

Figure .3. Flexural strength of concrete at 28 days of curing

4. CONCLUSIONS

This study was performed to check the behavior of concrete utilizing silica fume as a partial replacement of cement and plastic waste as a partial replacement of fine aggregates. Slump values of concrete decrease with increase in the percentage of silica fume and plastic waste. It can be concluded from the results that the compressive strength and flexural strength were increases with increase in the percentage of silica fume. Compressive strength and flexural strength decreases with increase in the % of plastic waste. At maximum replacement level (10% silica fume + 10% plastic waste) the compressive strength and flexural strength was more than required strength. So that it is therefore more appropriate to use the concrete which contain maximum replacement to minimize environment effects.

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