EXPERIMENTAL INVESTIGATION FOR PARTIAL REPLACEMENT OF CEMENT WITH WASTE GLASS POWDER ON PERVIOUS CONCRETE

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Abstract: *Glass powder is one of the most active research areas that encompass a number of disciplines including civil engineering and construction materials. Waste glass locally available and it has been collected and made into glass powder. Before adding glass powder in the concrete it has to be powdered to required size. Glass is widely used in our lives through manufacturing products such as bottles, glassware. Most waste glasses have been dumped into landfill sites. The Land filling of waste glasses is undesirable because they are not biodegradable, which makes them environmentally less friendly. So we use the waste glass in concrete to become the construction economical as well as eco-friendly. In this research study the (OPC) cement has been replaced by glass waste powder accordingly in the range of 10% and 20% by weight of cement for 0.30, 0.35, and 0.40 water/cement ratio. The compressive strength test and flexural strength test was carried out for 7, 14 and 28 days to measure the compressive strength and flexural strength of concrete. So the aim of the investigation is to study the behaviour of pervious concrete while replacing the waste glass powder with different proportions in concrete. Test results have reflected, the compressive strength and flexural strength achieved up to 20% replacement of cement with waste glass powder will be optimum without effecting properties of fresh and hardened concrete.*

Keywords: Glass Waste, Compressive Strength, Flexural Strength, Eco-Friendly, Pervious Concrete, Industrial Waste, Low Cost, OPC Cement.

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I. INTRODUCTION

Pervious concrete is a unique and effective solution to reduce the runoff from paved areas and recharging the ground water. Pervious concrete can uproot storm water more rapidly than conventional concrete. It is directly recharging the ground water so it eliminates the need of retention pond, swales and storm water management devices. It is also eliminate costly storm water detention vaults and piping systems. Thus reduce construction expenses, safety issues and maintenance cost. The waste management problem has already become severe in the world. The problem is compounded by the rapidly increasing amounts of industrial wastes of a complex nature and composition. Energy plays a crucial role in the growth of developing countries like India. In the context of low availability of non-renewable energy resources coupled with the requirements of large quantities of energy for building materials like cement, the importance of using industrial waste cannot be underestimated. Many research organizations are doing extensive work on waste materials concerning the viability and environmental suitability. Therefore, the main objective of this study is to use waste glass powder materials to develop a pervious concrete mixture proportion and to improve the compressive strength and flexural strength of pervious concrete. In 2005, approximately 12.8 million tons of waste glass were generated in the United States, and only about 20% of it was recycled. The global market for glass in 2009 was approximately 52 million tonnes. This is dominated by Europe, China and North America, which together account for around three-quarters of global demand for glass in India 75% of the total glass industries are concentrated in Uttar Pradesh, Maharashtra, Gujarat, Karnataka and Andhra Pradesh. The highest share in the number of factories of the glass industry is Uttar Pradesh with a share of 36.9%, followed by Gujarat at 15%, Andhra Pradesh and Tamil Nadu at 5.6% and Karnataka with 4%. The highest employment in the glass industry is in Gujarat followed by Uttar Pradesh, Maharashtra and Andhra Pradesh. The per capita glass usage in India is 1.2 kg compared with 8-9 kg in developed countries and 30-35 kg in the US.

II. EXPERIMENTAL MATERIALS

A. Waste Glass Powder

Waste Glass Powder is produced from locally available glass industry. Before adding glass powder in the concrete it has to be powdered to desired size. Chemical properties of Waste

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Glass Powder is given in Table 1 and physical properties of glass powder is given in Table 2. This glass powder is collected from Shaalu Glass Beads, Ahmedabad, Gujarat.

Figure 1: Waste Glass Powder

Source: Shaalu Glass Beads, Ahmedabad

Table 1: Chemical Properties of Waste Glass Powder

Sr No.	Particulars	Proportion
1.	Silicon Dioxide (SiO_2)	66.56 %
2.	Aluminum oxide (Al_2O_3)	01.02 %
3.	Potassium Oxide (K_2O)	01.06%
4.	Calcium Oxide (CaO)	11.50 %
5.	Magnesium Oxide (MgO)	03.02 %
6.	Sodium Oxide (Na_2O)	12.32 %
7.	Boron Trioxide (B_2O_3)	02.45 %

Source: Shaalu Glass Beads, Ahmedabad

Table 2: Physical Property of Waste Glass Powder

Sr No.	Particulars	Properties
1.	Colour	White
2.	Particle size	< 75 micron
3.	Specific gravity	2.5

Source: Shaalu Glass Beads, Ahmedabad

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B. Cement (OPC)

The Ordinary Portland Cement of 53 grade Hathi Cement conforming to IS: 12269 - 1987 is been used. Physical property and chemical composition of cement is as per Table 3 and Table 4.

Table 3: Physical Properties of Ordinary Portland Cement

Property	Value for Cement	IS CODE : 12269 - 1987
Specific Gravity	3.15	3.10-3.15
Consistency	28%	30-35(%)
Initial setting time	35 min	30 minimum minutes
Final setting time	178 min	600 maximum minutes

Table 4: Chemical Compositions of Ordinary Portland Cement 53 Grade (OPC)

Sr No.	Particulars	Proportion
1.	Silicon Dioxide (SiO_2)	21.77 %
2.	Aluminum oxide (Al_2O_3)	2.59 %
3.	Sulphur Trioxide (SO_3)	02.41%
4.	Calcium Oxide (CaO)	57.02 %
5.	Magnesium Oxide (MgO)	02.71 %
6.	Ferric Oxide (Fe_2O_3)	0.65 %

Source: Geo Test House, Baroda, Gujarat, India

C. Aggregate

Aggregate occupies most of the volume of the concrete show they are the important constituents of concrete. They give body to the concrete, reduce shrinkage and effect economy. Two sizes of aggregate were used in this research work. Coarse aggregate used in the study were sieved to obtain required range. The physical properties of aggregate is describe in Table 5.

Two different sizes are listed below:

a. Aggregate with 100% passing 20 mm sieve and 100% retained on 10 mm sieve.

b. Aggregate with 100% passing 10 mm sieve and 100% retained on 4.75 mm sieve.

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Table 5: Physical Properties of Coarse Aggregate

Property	Aggregate	
	20 mm	**10 mm**
Fineness Modulus	7.52	3.19
Specific Gravity	2.75	2.65
Water Absorption	1.82	1.30

D. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

III. DESIGN MIX

The mix proportion by using glass waste powder is given in Table 6. The design mix of pervious concrete using glass waste powder is shown in Table 7. For the design mix aggregate content is 1500 kg/m^3 and Cement: Aggregate ratio 1:4 is kept constant.

Table 6: Mix Proportion by using Glass Waste Powder

Mix	Aggregate Content	Cement Content	W/C Ratio	Cementitious Material
Mix$_{0.30}$	1500 kg/m^3	375kg/m^3	0.30	0% Glass Waste
G Mix1				10% Glass Waste
G Mix2				20% Glass Waste
Mix$_{0.35}$	1500 kg/m^3	375kg/m^3	0.35	0% Glass Waste
G Mix3				10% Glass Waste
G Mix4				20% Glass Waste
Mix$_{0.40}$	1500 kg/m^3	375kg/m^3	0.40	0% Glass Waste
G Mix5				10% Glass Waste
G Mix6				20% Glass Waste

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Table 7: Design Mix using Glass Waste

Concrete Design Mix Proportions (kg/m^3)						
Mix	W/C Ratio	Quantity Requirement				
		Cement (kg)	Glass Waste (kg)	Aggregate 10 mm(kg)	Aggregate 20 mm(kg)	Water (litter)
Mix$_{0.30}$	0.30	375.00	00.00	750	750	112.50
G Mix1		337.50	37.50	750	750	
G Mix2		300.00	75.00	750	750	
Mix$_{0.35}$	0.35	375.00	00.00	750	750	131.25
G Mix3		337.50	37.50	750	750	
G Mix4		300.00	75.00	750	750	
Mix$_{0.40}$	0.40	375.00	00.00	750	750	150.00
G Mix5		337.50	37.50	750	750	
G Mix6		300.00	75.00	750	750	

W = Water, C = Cement

IV. EXPERIMENTAL METHODOLOGY

The evaluation of glass waste for use as a replacement of cement material begins with the concrete testing. Pervious concrete contains cement, water, coarse aggregate and glass waste. In pervious concrete 10% and 20% of the cement is replaced with glass waste. Three cube samples were cast on the mould of size 150*150*150 mm for each concrete mix with partial replacement of cement with a w/c ratio of 0.30, 0.35, and 0.40. Three beam samples were cast on the mould of size 100*100*500 mm for each concrete mix with partial replacement of cement with a w/c ratio of 0.30, 0.35, and 0.40. After about 24 hr the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7, 14 and 28 days for compressive strength test and flexural strength test.

Figure 2: Specimens of Pervious Concrete

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Compressive Strength (IS: 516 – 1959):

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The comparative studies were made on each concrete mix for 0.30, 0.35 and 0.40 W/C ratio of partial replacement of cement with glass waste as 10% and 20%. Table 8 describe compressive strength of pervious concrete. Shown in figure 3. Experimental results shown in table 8 and figure 4, 5 & 6.

Flexural Strength (IS: 516 – 1959):

Flexural strength tests were performed on flexural testing machine using beam samples. Three samples per batch were tested with the average strength values reported in this paper. The flexural studies were made on each concrete mix for 0.30, 0.35 and 0.40 W/C ratio of partial replacement of cement with glass waste as 10% and 20%. Table 9 describe flexural strength of pervious concrete. Shown in figure 3. Experimental results shown in table 9 and figure 7, 8 & 9.

Figure 3: Testing of Pervious Concrete

Table 8: Compressive Strength of Cubes (150x150x150) at 7, 14 and 28 Days

Concrete Mix	W/C ratio	% Replacement of Cement	Average Compressive Strength (N/mm²)		
			7 Days	14 Days	28 Days
$Mix_{0.30}$	0.30	0 %	06.72	07.40	08.02
G Mix1		10 %	07.37	08.70	09.92
G Mix2		20 %	09.78	11.00	12.13
$Mix_{0.35}$	0.35	0 %	07.13	08.30	09.42
G Mix3		10 %	09.21	10.40	11.68
G Mix4		20 %	10.21	11.51	12.73
$Mix_{0.40}$	0.40	0 %	08.57	09.62	10.55
G Mix5		10 %	10.42	11.31	12.33
G Mix6		20 %	11.72	13.11	14.57

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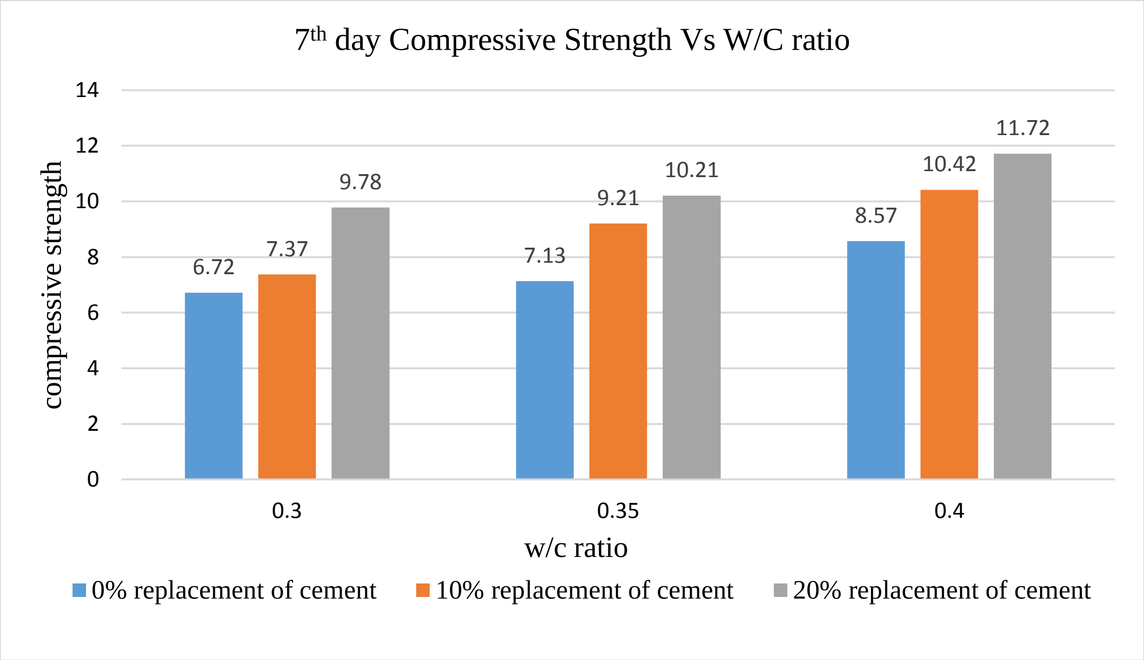

Figure 4: 7th day Compressive Strength Vs W/C ratio

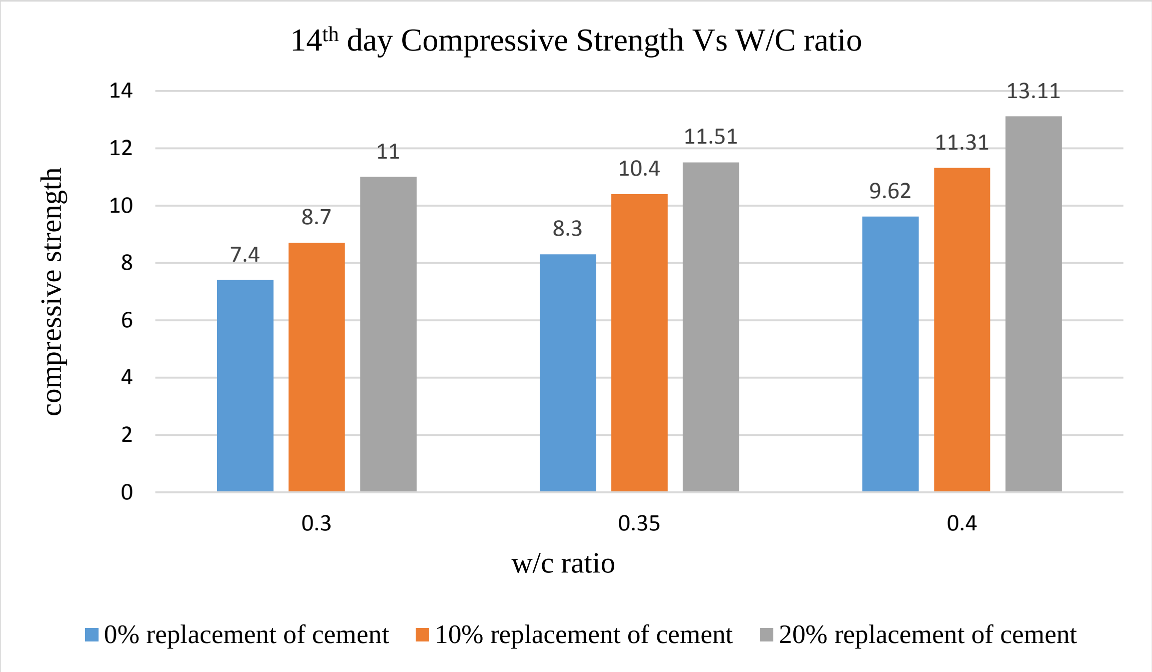

Figure 5: 14th day Compressive Strength Vs W/C ratio

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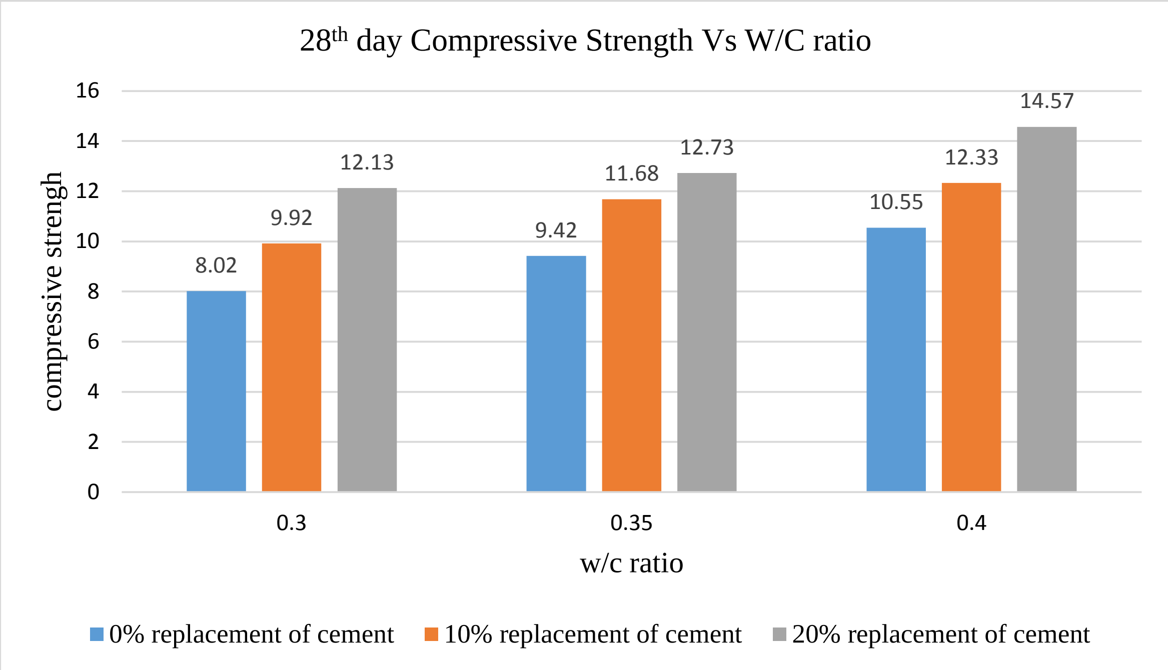

Figure 6: 28th day Compressive Strength Vs W/C ratio

Table 9: Flexural Strength of Beams (100x100x500) at 7, 14 and 28 Days

Concrete Mix	W/C ratio	% Replacement of Cement	Average Flexural Strength (N/mm^2)		
			7 Days	14 Days	28 Days
$Mix_{0.30}$	0.30	0 %	1.14	1.30	1.49
G Mix1		10 %	1.67	1.88	2.13
G Mix2		20 %	2.15	2.50	2.89
$Mix_{0.35}$	0.35	0 %	1.40	1.65	1.85
G Mix3		10 %	2.05	2.30	2.59
G Mix4		20 %	2.65	3.10	3.47
$Mix_{0.40}$	0.40	0 %	1.89	2.15	2.43
G Mix5		10 %	2.65	2.95	3.37
G Mix6		20 %	3.72	3.80	3.95

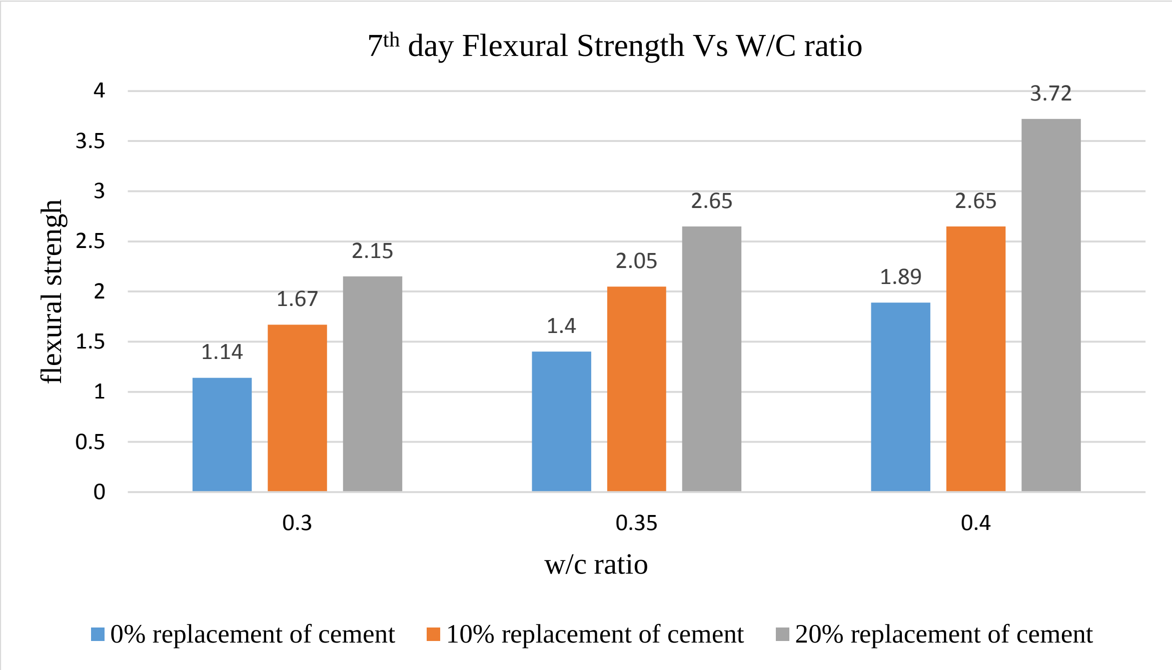

Figure 7: 7th day Flexural Strength Vs W/C ratio

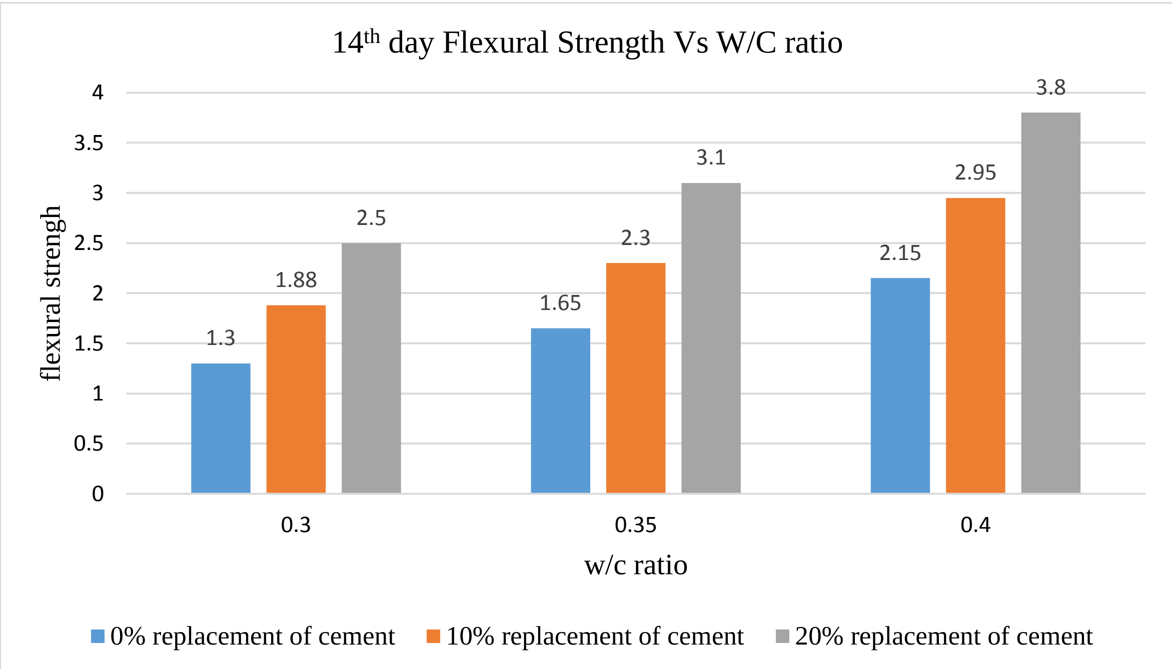

Figure 8: 14th day Flexural Strength Vs W/C ratio

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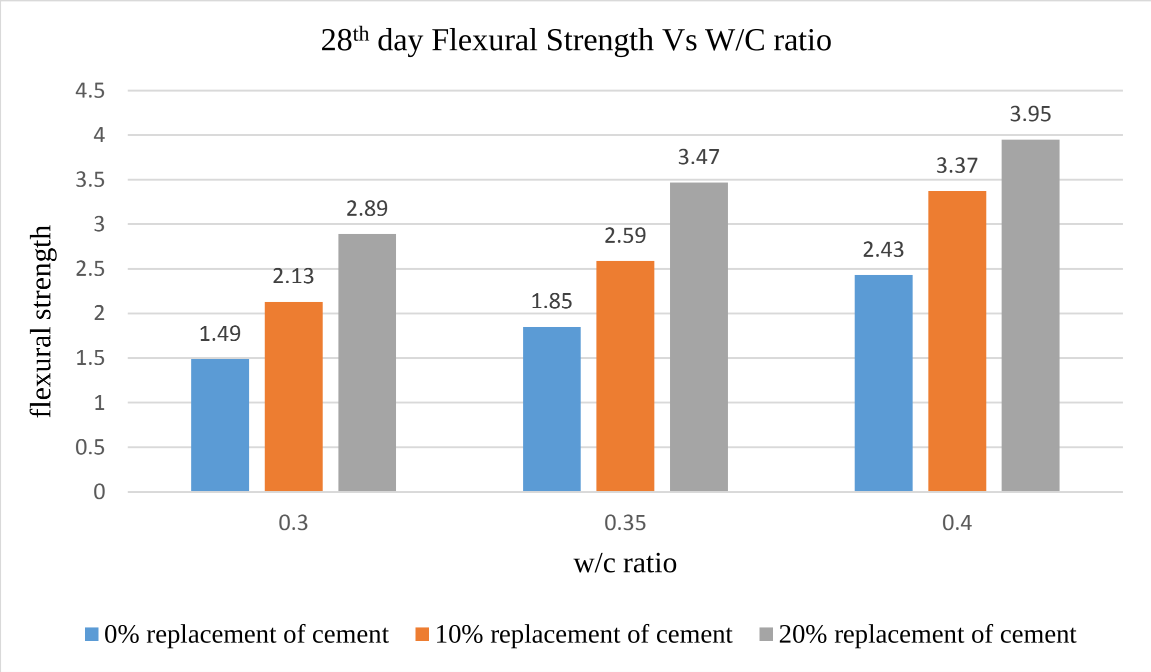

Figure 9: 28th day Flexural Strength Vs W/C ratio

V. CONCLUSION

Based on experimental investigations concerning the compressive strength and flexural strength of concrete, the following observations are made:

[1] W/C ratio is increase respectively compressive strength and flexural strength of pervious concrete is increase.

[2] The Compressive Strength of Pervious Concrete is increases when the replacement of Cement with Glass Powder up to 20% replaces by weight of Cement.

[3] The Flexural Strength of Pervious Concrete is increases when the replacement of Cement with Glass Powder up to 20% replaces by weight of Cement.

[4] Use the Glass Powder as construction material because Glass Powder in concrete can save the disposal costs and produces a 'greener' concrete for construction.

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