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Innovative Use of Paper Industry Waste (Hypo Sludge) in Pervious Concrete

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Abstract: *Hypo sludge is also known as paper industry waste. Paper making generally produces a large amount of solid waste. This paper mill sludge consumes a large percentage of local landfill space for each and every year. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. The quantity of sludge varies from mill to mill. This hypo sludge contains low calcium and maximum calcium chloride and minimum amount of silica. Hypo sludge behaves like cement because of silica and magnesium properties. So Hypo sludge may be used as partially replacement of cement. So we can use Hypo sludge as a partial replacement of cement in pervious concrete. In this research study the (OPC) cement has been replaced by hypo sludge accordingly in the range of 10% and 20% by weight of cement for 0.30, 0.35, and 0.40 water/cement ratio.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 hypo sludge with different proportions in concrete. Test results have reflected, the compressive strength and flexural strength achieved up to 20% replacement of cement with hypo sludge will be optimum without effecting properties of fresh and hardened concrete.*

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

1. 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 research study is to use hypo sludge materials to develop a pervious concrete mixture proportion and to improve the compressive strength and flexural strength of pervious concrete. The share of India to the world's total production of paper and paper products have been rising from 0.68 % in 1981 to 0.84 % in 1990. This has increased further to 1.00 % in 2000. In 2010, it accounts for about 2.25 % of world's production contributed by the impressive growth of all varieties of paper and paperboard driven by multiple policy initiatives undertaken by the government.

2. EXPERIMENTAL MATERIALS

2.1. Hypo Sludge

Hypo Sludge is a waste material collected from the Paper Industry. It is used as cement replacement in producing concrete and was investigated on its chemical and physical properties. Construction

material with natural resources now become limited and causes of air pollution and environmental problems. Hypo Sludge becomes a new innovation material that can be used as material to support the green technology. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete. Its chemical investigation is done by Geo-test house Baroda. Chemical properties and physical properties of hypo sludge are as per Table 1 and Table 2. Figure 1 show the hypo sludge which is collected from Rainbow Papers Limited, Gujarat.

Figure1. *Hypo Sludge*

Source: *Rainbow Papers Limited, Gujarat*

Table1. *Chemical properties of hypo sludge*

Sr. No.	Particulars	Proportion
1.	Silicon dioxide (SiO_2)	9.27%
2.	Aluminum oxide (Al_2O_3)	1.45%
3.	Iron oxide (Fe_2O_3)	1.68%
4.	Calcium Oxide (CaO)	29.83%
5.	Magnesium Oxide (MgO)	4.28%
6.	Loss on Ignition	49.24%

Source: *Geo Test House, Baroda, Gujarat, India*

Table2. *Physical property of hypo sludge*

Sr. No.	Particulars	Proportion
1.	Specific gravity	2.82

Source: *Geo Test House, Baroda, Gujarat, India*

2.2. Cement (OPC)

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

Table3. *physical properties of ordinary portland cement*

Property	Value for Cement	IS 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

Table4. *Chemical compositions*

OF ORDINARY PORTLAND CEMENT 53 GRADES (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*

2.3. 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 are 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.

Table5. *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

2.4. 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.

3. DESIGN MIX

The mix proportion by using hypo sludge powder is given in Table 6. The design mix of pervious concrete using hypo sludge 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.

Table6. *Mix proportion by using hypo sludge*

Mix	**Aggregate Content**	**Cement Content**	**W/C Ratio**	**Cementitious Material**
$Mix_{0.30}$	1500 kg/m^3	375kg/m^3	0.30	0% Hypo Sludge
H Mix1				10% Hypo Sludge
H Mix2				20% Hypo Sludge
$Mix_{0.35}$	1500 kg/m^3	375kg/m^3	0.35	0% Hypo Sludge
H Mix3				10% Hypo Sludge
H Mix4				20% Hypo Sludge
$Mix_{0.40}$	1500 kg/m^3	375kg/m^3	0.40	0% Hypo Sludge
H Mix5				10% Hypo Sludge
H Mix6				20% Hypo Sludge

Table7. *Design mix using hypo sludge*

Concrete Design Mix Proportions (kg/m^3)						
Mix	**W/C Ratio**	**Quantity Requirement**				
		Cement (kg)	**Hypo Sludge (kg)**	**Aggregate 10 mm (kg)**	**Aggregate 20 mm (kg)**	**Water (litter)**
$Mix_{0.30}$	0.30	375.00	00.00	750	750	112.50
H ix1		337.50	37.50	750	750	
H ix2		300.00	75.00	750	750	
$Mix_{0.35}$	0.35	375.00	00.00	750	750	131.25
H ix3		337.50	37.50	750	750	
H ix4		300.00	75.00	750	750	
$Mix_{0.40}$	0.40	375.00	00.00	750	750	150.00
H ix5		337.50	37.50	750	750	
H ix6		300.00	75.00	750	750	

W = Water, C = Cement

4. EXPERIMENTAL METHODOLOGY

The evaluation of hypo sludge for use as a replacement of cement material begins with the concrete testing. Pervious concrete contains cement, water, coarse aggregate and hypo sludge. In previous concrete 10% and 20% of the cement is replaced with hypo sludge. 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.

Figure2. *Specimens of Pervious Concrete*

4.1. 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 hypo sludge as 10% and 20%. Table 8 describe compressive strength of pervious concrete.

4.2. 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 hypo sludge as 10% and 20%. Table 9 describe flexural strength of pervious concrete.

Figure3. *Testing of Pervious Concrete*

Table8. *Compressive strength of cubes*

(150X150X150) AT 7, 14 AND 28 DAYS

Concrete Mix	W/C ratio	% Replacement of Cement	Average Compressive Strength (N/mm^2)		
			7 Days	14 Days	28 Days
$Mix_{0.30}$	0.30	0 %	06.72	07.40	08.02
H Mix1		10 %	7.95	8.47	9.12
H Mix2		20 %	9.47	10.15	10.55
$Mix_{0.35}$	0.35	0 %	07.13	08.20	09.42
H Mix3		10 %	8.40	9.23	10.50
H Mix4		20 %	9.87	10.74	11.75
$Mix_{0.40}$	0.40	0 %	08.57	09.40	10.35
H Mix5		10 %	9.68	10.63	11.25
H Mix6		20 %	10.79	11.12	12.43

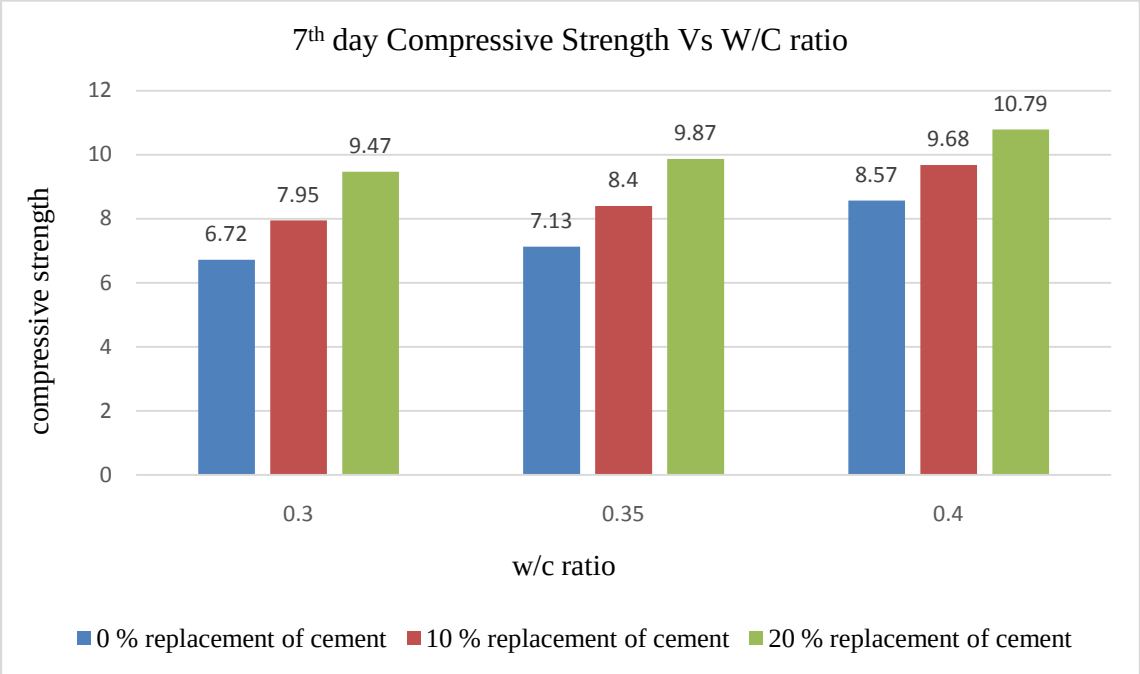

Figure4. *7th day Compressive Strength Vs W/C ratio*

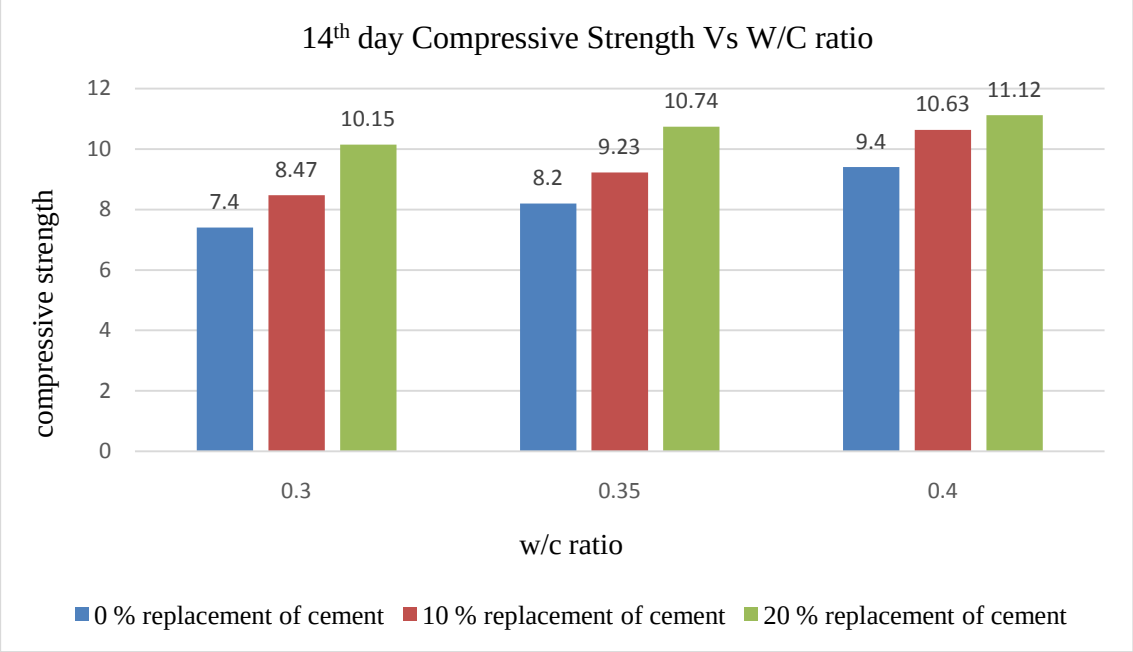

Figure5. *14th day Compressive Strength Vs W/C ratio*

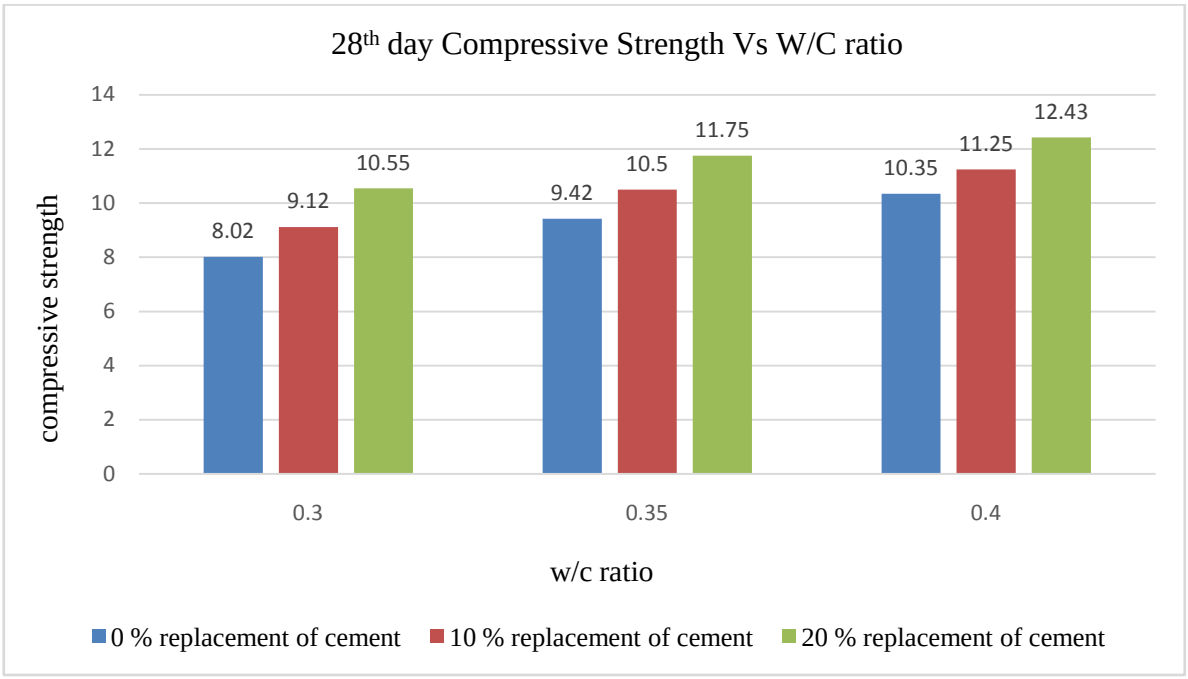

Figure6. *28th day Compressive Strength Vs W/C ratio*

Table9. *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
H Mix1		10 %	1.25	1.55	1.98
H Mix2		20 %	1.47	1.98	2.52
$Mix_{0.35}$	0.35	0 %	1.40	1.58	1.85
H Mix3		10 %	1.52	1.87	2.15
H Mix4		20 %	1.85	2.05	2.56
$Mix_{0.40}$	0.40	0 %	1.89	2.15	2.43
H Mix5		10 %	2.12	2.55	3.12
H Mix6		20 %	2.75	3.07	3.52

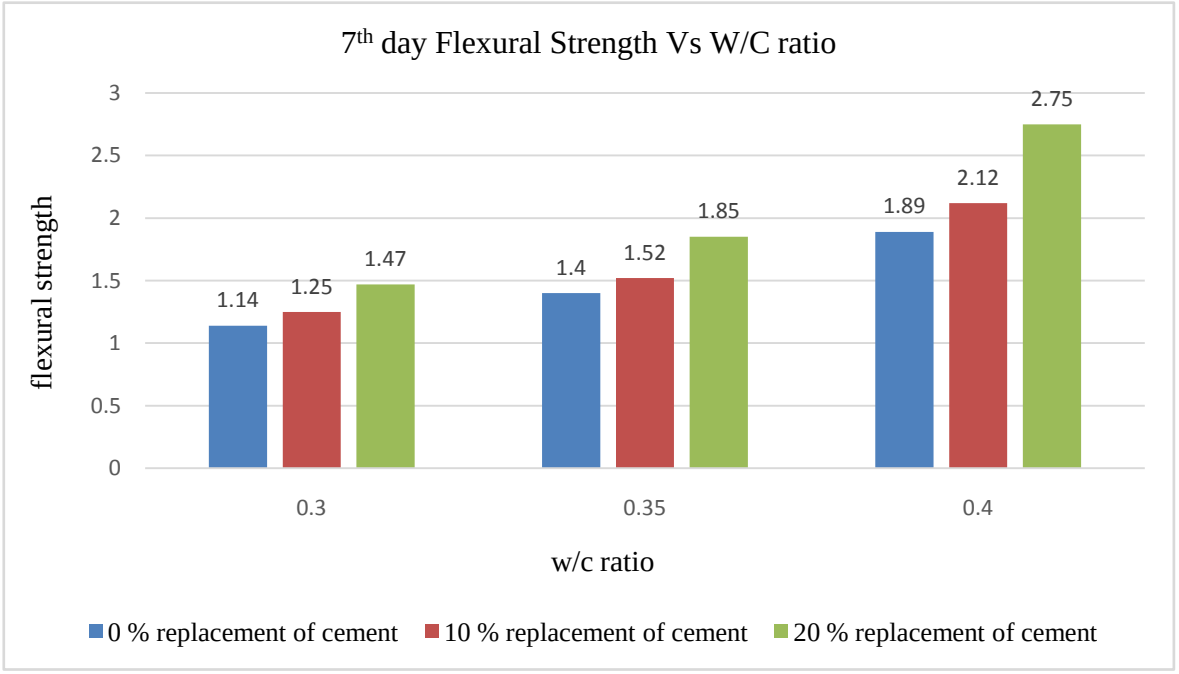

Figure7. *7th day Flexural Strength Vs W/C ratio*

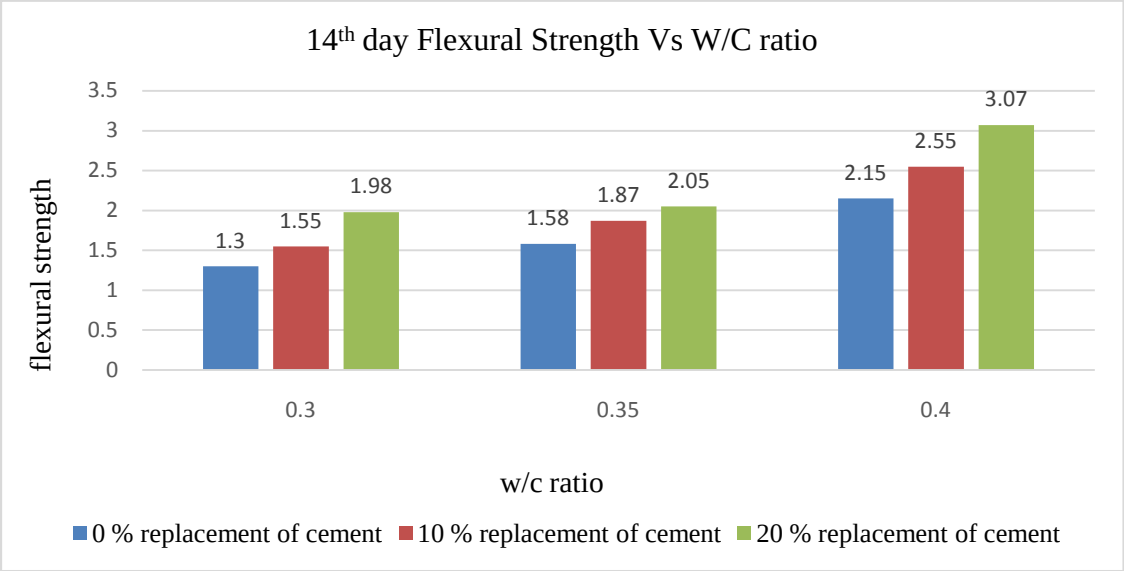

Figure8. *14th day Flexural Strength Vs W/C ratio*

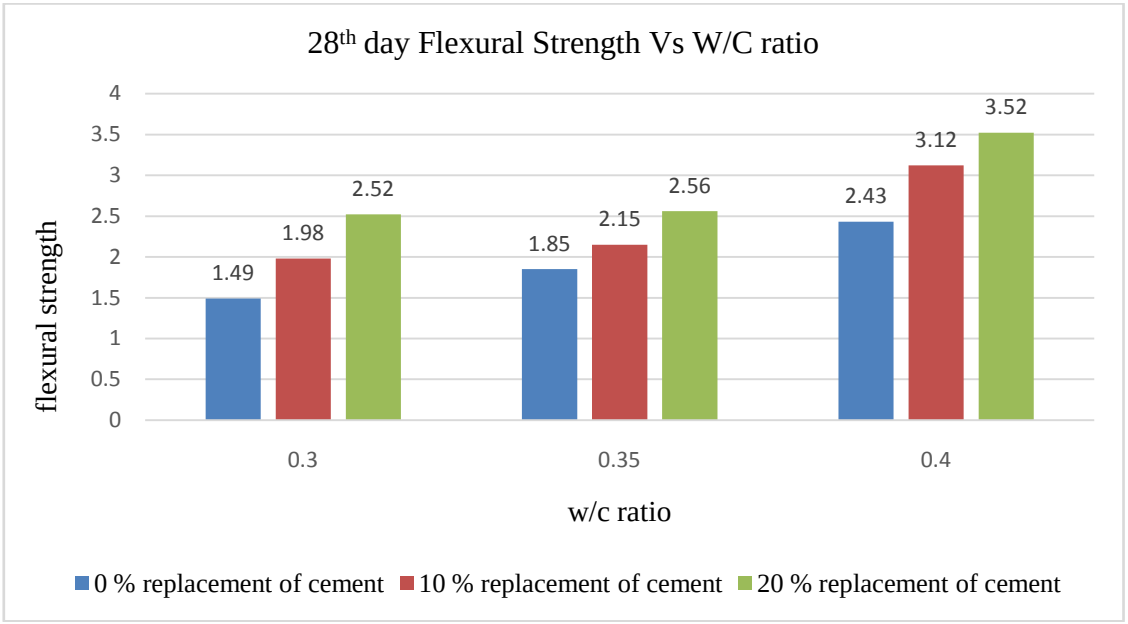

Figure9. *28th day Flexural Strength Vs W/C ratio*

5. CONCLUSION

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

- The Compressive Strength of Pervious Concrete is increases when the replacement of Cement with Hypo Sludge up to 20% replaces by weight of Cement.
- The Flexural Strength of Pervious Concrete is increases when the replacement of Cement with Hypo Sludge up to 20% replaces by weight of Cement.
- When W/C ratio is increase respectively, Compressive Strength and Flexural Strength of Pervious Concrete is increase.
- Hypo Sludge is a better innovative supplementary cementitious construction material which is used in concrete, so it can save the paper industries waste disposal costs and produce a 'greener' concrete for construction.
- This research concludes that hypo sludge can be innovative supplementary cementitious Construction Material in Pervious Concrete but judicious decisions are to be taken by engineers.

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