An Experimental Investigation on Strength of Concrete by Using Hypo Sludge and Fly-Ash with Several Stages

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Abstract- Their general disposal in landfills leads to environmental pollution. Also, cement production causes global warming by releasing carbon dioxide. The objective of the present project work is to develop low cost concrete from paper industry waste. It is made with M30 grade concrete with w/c ratio of 0.45 as a control sample and hypo sludge is replaced by different percentages such as 10%, 20% and 30% by weight of cement. Cubes of size 150 mm x 150 mm and cylinders of 100 mm diameter and 200 mm height were hammered to obtain normal concrete and RPH (replacement of hypo mud by weight of cement) test specimen, respectively. Tests are conducted to study the mechanical properties of concrete, such as compressive strength and tensile strength. The duration of treatment should be between 7 and 28 days.

Keywords: Cement, Hypo Sludge, Compressive strength, Split tensile Strength.

1. INTRODUCTION

Energy plays an important role in the development of developing countries like India. In the context of the low availability of non-renewable energy resources as well as the need for large amounts of energy for construction materials such as cement, the importance of industrial waste utilization cannot be overstated. During the manufacturing of 1 ton of Ordinary Portland Cement, we require about 1 ton of land resources like limestone etc. Also, the same amount of carbon dioxide is released into the atmosphere during the manufacture of 1 ton of ordinary Portland cement. Carbon dioxide emissions act as a silent killer on the environment in many ways. In such a situation, it is necessary to find a cheaper alternative to OPC.

In the present work, slaked lime is used instead of cement. Lime sludge (hypo sludge) is a substance obtained from the process of chemical recovery in paper production. Hypo sludge is available in large quantities all over the world, but so far its use is very limited. In our project, we used lime sludge instead of cement. Lime sludge (i-hypo sludge) is a by-product of the chemical recovery process in paper production.

Paper waste (hypo sludge) is a waste of the paper and board industry. It is estimated that paper waste accounts for 0.7% of all municipal waste generated in India. Paper sludge is a major economic and environmental problem in the paper industry. Paper sludge varies with strong and weak fibers. The strong fibers of the waste are taken for recycling and the weak fibers are taken to landfill. Due to this dumping it causes a huge problem of air pollution, water pollution and soil pollution. Paper sludge is replaced to reduce the waste problem. Hypo sludge is used instead of sludge production and its mechanical, physical and chemical properties are investigated. Waste substitution will save resources and avoid ecological and environmental damage caused by mining and exploitation of raw materials for cement production. The demand for concrete is increasing across the world at a low cost, by producing this concrete it will reduce the demand for concrete and reduce CO2 emissions from the cement industry. This project summarizes the technical and environmental benefits of using additional cement additives and researches the parameters of concrete incorporating paper waste as a partial replacement for cement.

Concrete is the most widely used man-made building material and the largest product of all materials used in the construction industry. Concrete is basically made of cement material which must bind together well, and other ingredients to form a strong mass. Concrete or mortar is made of cement, water and aggregates (coarse and fine aggregate) and sometimes necessary impurities. Concrete has reached the status of a major building material in all branches of modern construction. It is difficult to identify any other building material as flexible as concrete. Concrete is the best material of choice when strength, durability, impermeability, fire

resistance and absorption resistance are required. Compressive strength is considered as an index to evaluate the overall quality of concrete and it is generally believed that improvement in compressive strength leads to improvement in all other properties. Therefore strength tests usually focus on compressive strength. Although concrete mixes are rated on the basis of achieving the desired compressive strength at a specified age, flexural strength often plays an important role in concrete performance. Hypo sludge (waste from paper industry) has great potential in this context and it is well documented that the use of hypo sludge in concrete leads to significant improvement in rheological properties [Chavan et al. (2020)]. Various processes in the paper industry generate various wastes during the production of paper. Due to the low calcium content in the first waste called hypo sludge, it has been removed for our project instead of using cement in concrete. There, this hypo mud contains low calcium and high calcium chloride and a small amount of silica. Hypo sludge behaves like cement due to the properties of silica and magnesium. This silica and magnesium improve the setting of concrete.

2. LITERATUREREVIEW

Abhishek (2017) Concrete is a strong and durable material but it is a porous material that interacts with the environment. The strength of concrete is highly dependent on the flow of water and gas in and out. Mixing different proportions of cement and hypo sludge to produce low cost concrete and reduce the problems of waste and pollution caused by hypo sludge is very important for making hypo sludge a profitable construction material. Making good quality paper that can be recycled many times can use paper fibers that generate a lot of solid waste. Explored new uses of Hypo Sludge in concrete manufacturing as a cementitious material as an alternative to conventional concrete.

Devi et al. (2018) Rapid increase in construction activities leads to effective shortage of common construction materials such as cement, fine aggregate and reinforcing aggregate. Mixing various proportions of fine aggregate with hypo sludge is very important to produce low cost concrete and reduce the problems of waste and pollution caused by hypo sludge, making hypo sludge a profitable building material. These tests are designed to test the subjects' durability after 28 days. This research work deals with the strength test of concrete by adding fine amounts of 5%, 10%, 15%, and 20% Hypo Sludge and investigation of total percentage of component replacement.

Chavnet al. (2020) The increasing amount of waste is a reality related to the emergence of environmental sustainability issues. About 300 million tons are produced annually. Their general disposal in landfills leads to environmental pollution. Also, cement production causes global warming by releasing carbon dioxide. So the new use of industrial waste in the manufacture of concrete (reinforced pavement) as an additional cementitious material can help to reduce the environmental problem. This research work deals with the investigation of strength test of concrete mixed with hypo sludge. Instead of cement, hypo sludge is added in the range of 10% to 40% by weight of cement. The concrete mix was produced, tested and compared with conventional concrete mix in terms of workability, compressive strength and tensile strength. Tests were done after 7 and 28 days. A gradual increase in compressive strength and tensile strength of concrete mixed with 10% to 40% hypo sludge content was observed for all cure ages. Also there is a huge drop in power. The ultimate compressive strength and ultimate tensile strength of the M20 concrete mix were 31.6 N/mm2 and 3.5 N/mm2. And the cost analysis shows that with the installation of Hypo Sludge it reduces the cost of concrete.

Arvind Rajet al. (2020) Concrete is a strong and rigid material, but it is also durable and interacts with the environment. The strength of concrete is highly dependent on the water and gas running in and through it. Mixing different proportions of cement and hypo sludge to produce low cost concrete and reduce the problems of waste and pollution caused by hypo sludge is very important for making hypo sludge a profitable construction material. Making good quality paper that can be recycled many times can use paper fibers that generate a lot of solid waste. Explored new uses of Hypo Sludge in concrete manufacturing as a cementitious material as an alternative to conventional concrete. These tests are designed to test mechanical properties such as compressive strength for up to 28 days. This research work is related to strength test of concrete by replacing cement with 5%, 10%, and 15% hypo sludge and investigation of maximum percentage of component replacement. The grade of concrete was

M25. Keeping all this consideration in mind, the object of investigation is the behavior of concrete when adding waste with different proportions of hypo sludge in concrete using tests like compressive strength and tensile strength.

3. MATERIALS USED AND THEIR PROPERTIES

CEMENT

Ordinary Portland Cement (OPC) confirming to IS 12269 (53 Grade) was used for the experimental work.

FINE AGGREGATE

Local river sand was used. Laboratory tests are performed on a microscopic scale to determine various physical properties. The fine aggregate used conforms to the specifications of IS 383:1970 (Part II).

COARSE AGGREGATE

An aggregate size between 20 mm and 4.75 mm is considered coarse aggregate. Laboratory tests are carried out on rough samples to determine various physical properties as per IS 383 (Part III)-1970.

4. HYPO SLUDGE

Hypo sludge is also known as paper industry waste. It is a by-product of paper waste. This hypo mud contains less calcium and a small amount of silica. Hypo sludge behaves like cement due to the properties of silica and magnesium.

WATER

Water is an important in gradient of concrete as it actually participates in the chemical reaction with cement.

5. EXPERIMENTAL PROGRAM

The assembly design was optimized for a maximum size of 20 mm. The grade of ready concrete for the experimental study was M30. The mix ratio was (1:1.065:2.45) with a water cement ratio of 0.45. The cement content in the concrete was 438 kg/m3. Cubic specimens of size (150 x 150x 150) mm and cylindrical specimens of size (100 x 200) mm were used in the study to determine the compressive strength and tensile strength. After 24 h of casting the samples were recrystallized and placed in a cooling tank for water cooling. The samples to be tested were drawn from the cooling tank on days 7 and 28.

The performance of different percentages of conventional concrete and premixed concrete Hypo Sludge is measured before sampling. The performance of concrete is continuously decreasing due to % increase in hypo sludge within the concrete. The test is carried out due to uniform pressure after the sample is concentrated in the test machine. It is loading till the needle of the dial gauge returns to its speed. A reversal in the direction of movement of the needle indicates that the sample has failed. At that point the dial gauge reading was marked as the final burr. The ultimate load divided by the cross-sectional area of the specimen equals the ultimate compressive cube strength. The ingredients are thoroughly mixed until a homogeneous mixture is obtained. Then water was added and the mixing was repeated. The new concrete mix was then placed in a mould, compacted and left for 24 hours before testing. The compressive strength of the samples was tested at 7 and 28 days of age.

Table 1 Material for $1m^3$ Concrete with Ingredients

Sl. No.	Ingredients	Mix Design			
		CC	WP S1	WP S2	WP S3
1	Cement (kg/m^3)	440	398	357	334
2	Fine aggregate (kg/m^3)	700	700	700	700
3	Coarse aggregate (kg/m^3)	1120	1120	1120	1120
4	Hypo sludge (kg/m^3)	0	45	90	125

Workability

The workability of various mixes were assessed by determining the Slump value as per the IS 1199:1959.

Table 2 Slump Value for Various Concrete Mixes

Sl. No.	Name of Mix	Slump value in mm
1	MIX 1 (Normal concrete)	56
2	MIX 2 (5% hypo sludge)	53
3	MIX 3 (10% hypo sludge)	53

4	MIX 4 (15% hypo sludge)	53
5	MIX 5 (20% hypo sludge)	52
6	MIX 6 (25% hypo sludge)	51
7	MIX 7 (30% hypo sludge)	49

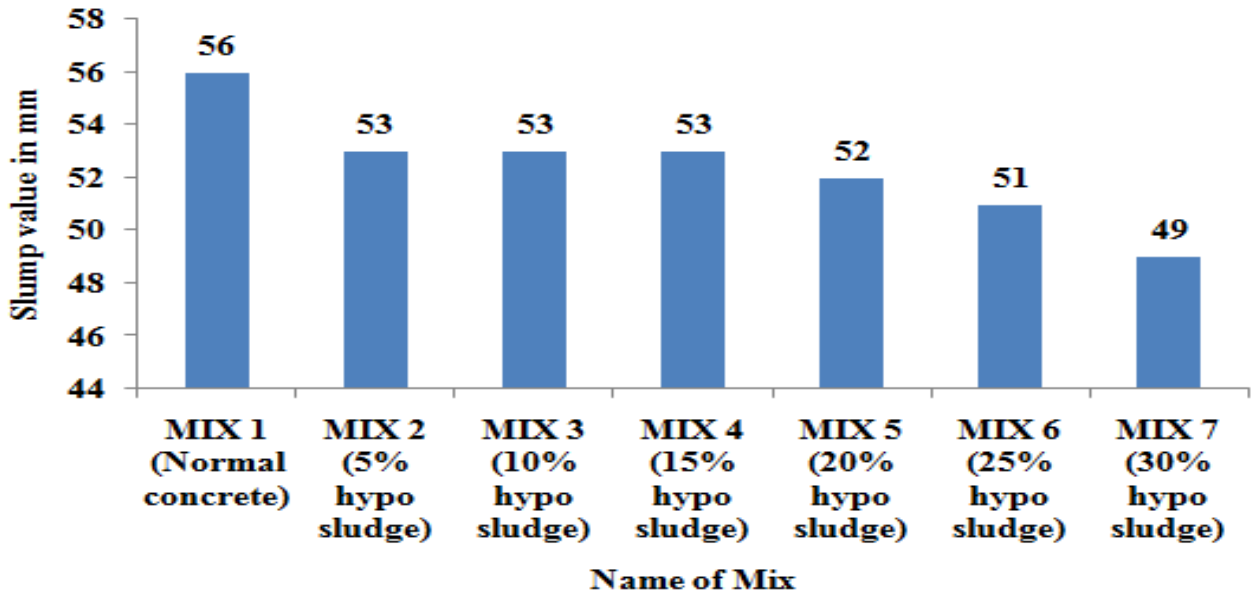

Figure 1 Slump Value for Various Concrete Mixes

Table 3 Slump Value and Compact Factor for Various Concrete Mixes

Sl. No.	Name of Mix	Slump value in mm	Compact Factor
1	MIX 1 (Normal concrete)	56	0.88
2	MIX 2 (5% hypo sludge)	53	0.87
3	MIX 3 (10% hypo sludge)	53	0.87
4	MIX 4 (15% hypo sludge)	53	0.86
5	MIX 5 (20% hypo sludge)	52	0.86
6	MIX 6 (25% hypo sludge)	51	0.84
7	MIX 7 (30% hypo sludge)	49	0.81

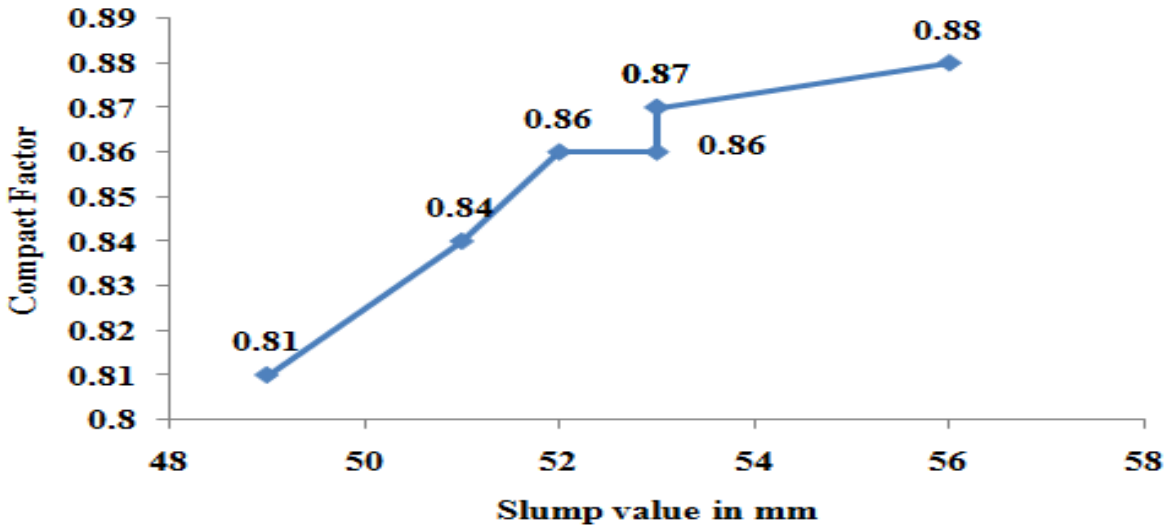

Figure 2 Slump Value and Compact Factor for Various Concrete Mixes

Compressive Strength

Cement, fine aggregate, coarse aggregate and hypo sludge are mixed in a dry state and then desired amount of water is added and the whole concrete is mixed for 5 minutes, the concrete is poured into the mold which is screwed tightly Is. Concrete poured in 3 layers by poking with a tamping rod for cubes of size 150 x 150 x 150 mm was tested for compression. The cast specimens are removed after 24 hours and immersed in a water tank. The samples are tested for compressive strength after 7th and 28th days of curing period.

Table 4 Compressive Strength of Hypo Sludge Replacement Concrete

Sl. No.	Name of Mix	Compressive strength (N/mm^2)	
		7 days	28 days
1	MIX 1 (Normal concrete)	24.99	30.89
2	MIX 2 (5% hypo sludge)	25.52	31.87
3	MIX 3 (10% hypo sludge)	27.21	31.84
4	MIX 4 (15% hypo sludge)	25.10	29.61
5	MIX 5 (20% hypo sludge)	22.94	25.85
6	MIX 6 (25% hypo sludge)	20.34	23.61
7	MIX 7 (30% hypo sludge)	18.32	21.36

The test results presented using Hypo Sludge show the enhancement of the compressive strength of cement by 10% Hypo Sludge as compared to the compressive strength of normal concrete. The compressive strength of conventional concrete was found to be 30.47 N/mm2 at 28th day of setting, 31.82 N/mm2 for 10% replacement of hypo sludge. On the 28th day, with 10% replacement of hypo sludge, the compressive strength was enhanced as compared to conventional concrete. Compressive strength decreased by 20% and 30% replacement of hypo mud.

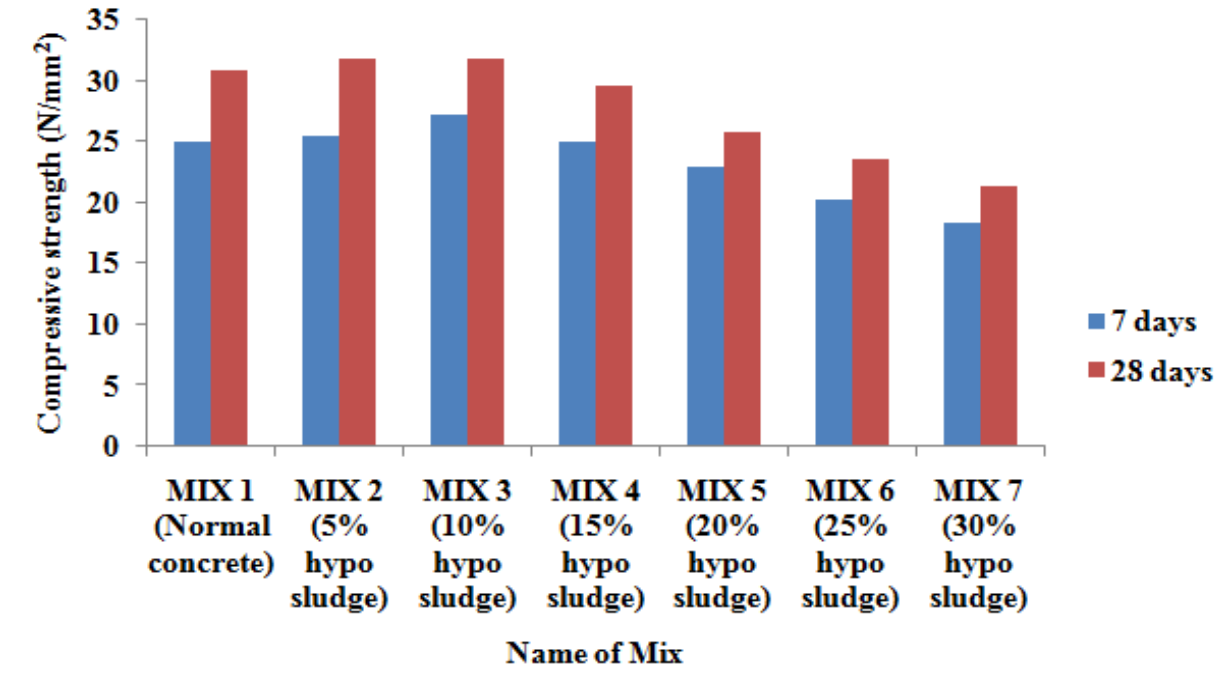

Figure 3 Compressive Strength of Hypo Sludge Replacement Concrete during 7 and 28 Days

Split Tensile Strength

The concrete is poured into the mould in 3 layers by poking with tamping rod for cylinder of 100 mm diameter x 200 mm height size were tested for split tensile strength. The cast specimens are removed after 24 hours and these are immersed in a water tank. After curing period of 7^{th} and 28^{th} days the specimens are tested for split tensile strength and the results are obtained as in Table 4.5. These results are compared with conventional concrete.

Calculation: Calculate the splitting tensile strength of the specimen as follows:

T=(2 P)/(PI x L x D)

Where:

T = Splitting tensile strength, Mpa

P = Maximum applied load indicated by the testing machine, KN

l = Length

d = Diameter

Table 5 Split Tensile Strength of Hypo Sludge Replacement Concrete

Sl. No.	Name of Mix	Split tensile strength (N/mm^2)	
		7 days	28 days
1	MIX 1 (Normal concrete)	4.33	6.29
2	MIX 2 (5% hypo sludge)	4.88	6.87
3	MIX 3 (10% hypo sludge)	5.87	7.21
4	MIX 4 (15% hypo sludge)	4.14	6.98
5	MIX 5 (20% hypo sludge)	3.87	4.89
6	MIX 6 (25% hypo sludge)	3.48	4.75
7	MIX 7 (30% hypo sludge)	3.09	3.75

Cylindrical specimens of normal concrete and hypo sludge concrete were tested for split tensile strength and the results obtained. It is observed that up to 10% replacement with hypo sludge, the split tensile strength of the solidified sample increases and the split tensile strength decreases from MIX3 onwards. However the split tensile strength for Mix 2 is higher than that of conventional concrete mix. The maximum split tensile strength is achieved for Mix 2.

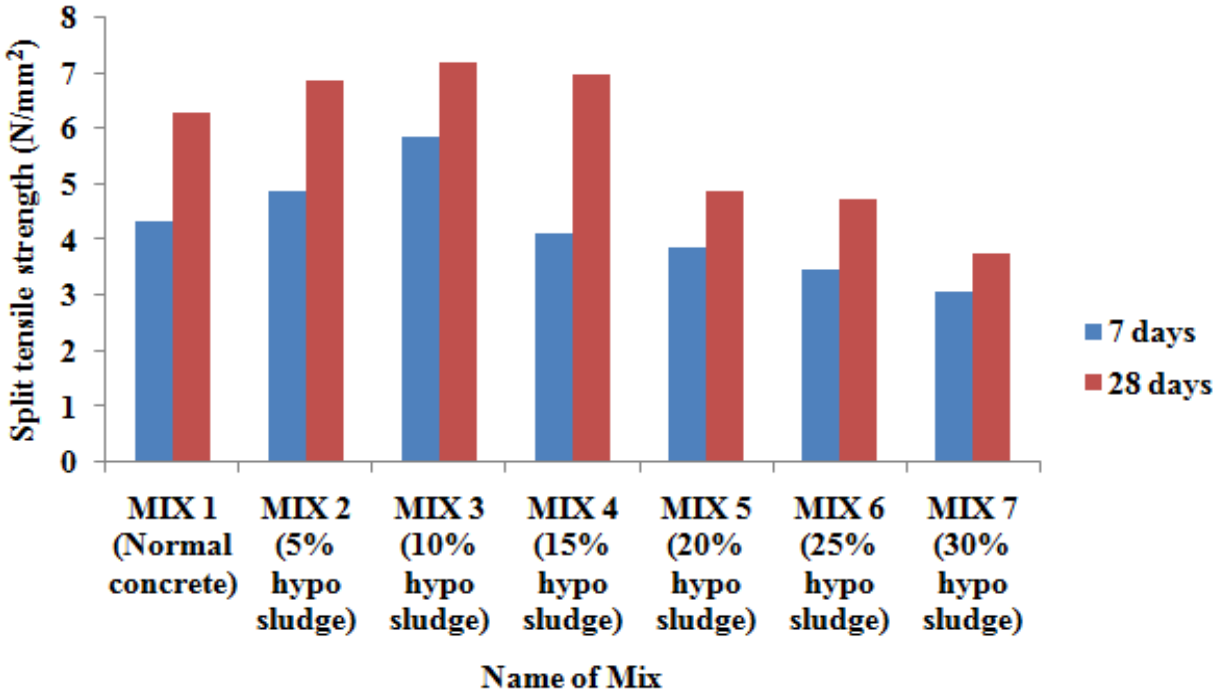

Figure 4 Split Tensile Strength of Hypo Sludge Replacement Concrete during 7 and 28 Days

Flexural strength test

The test results below show the flexural strength test for days 7 and 28. For normal concrete, shall undergo flexural strength test in 28 days as per the acceptance criteria of IS 456-2000. As the replacement of cement with hypo sludge increases up to 10% of normal concrete, the value of flexural strength will increase from that of normal concrete. Furthermore, if the hypo sludge % increases beyond 15% and beyond 15%, the flexural strength test value should continue to decrease.

Table 6 Flexural Strength Test of Hypo Sludge Replacement Concrete

Sl. No.	Name of Mix	Flexural Strength Test (N/mm^2)	
		7 days	28 days
1	MIX 1 (Normal concrete)	1.258	3.247
2	MIX 2 (5% hypo sludge)	2.753	3.359
3	MIX 3 (10% hypo sludge)	2.425	3.855
4	MIX 4 (15% hypo sludge)	2.215	3.224
5	MIX 5 (20% hypo sludge)	1.852	3.105
6	MIX 6 (25% hypo sludge)	1.610	2.627
7	MIX 7 (30% hypo sludge)	1.235	2.421

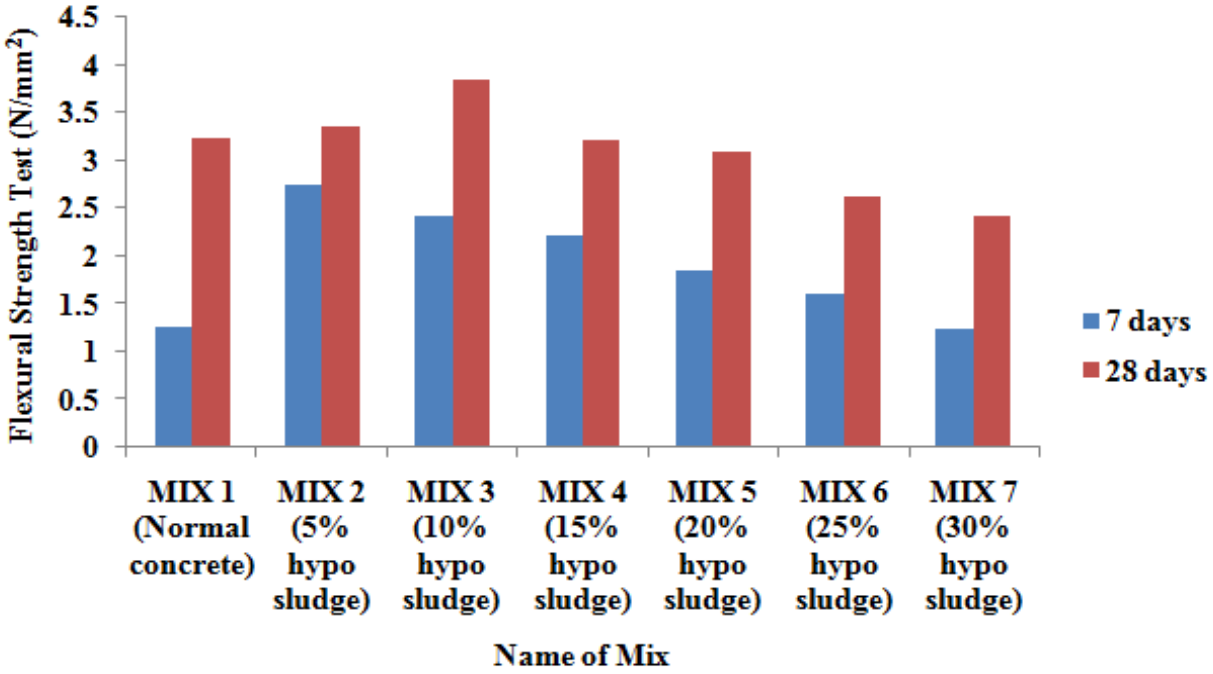

Figure 5 Flexural Strength Test of Hypo Sludge Replacement Concrete during 7 and 28 Days

6. CONCLUSIONS

The replacement of cement with hypo sludge did not significantly affect the performance of the concrete. The compressive strength of concrete mixed with 10% hypo sludge was higher than that of normal concrete mix. Testing for 7 days and 28 days resulted in high power of 10% of the samples. The difference in strength of ready mixed concrete less than normal concrete is about 10% as compared to normal concrete. It is replaced by hypo sludge which is larger than normal concrete mix. The use of hypo sludge in concrete not only reduces environmental pollution. But it also reduces the cost of construction economically; This is the best way to dispose paper waste in normal concrete. Flexural strength test at 28 days is as per IS 456-2000 approval. Since the replacement of cement with hypo sludge increases by 10% over normal concrete, the flexural strength will be higher than the flexural strength of normal concrete. In addition, if the %hypo mud increases by 15% and is greater than 15%, the flexural strength test value should be decreased.

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