Experimental Study on Fibre Reinforced Concrete with Waste Paper Sludge Ash As Apartial Replacement of Cement

Ch.Lakshmi Aishwarya[1], K.S.Sai Kumar[2],P Ravi Kishore[3]
[1] Dept of Structural Engineering
[2, 3]Asst. Professor, Dept of Civil Engineering
[1, 2, 3] Aditya Engineering College, Surampalem, Andhra Pradesh, India.

Abstract- *Concrete is the most commonly used building material in the world for its outstanding strength and durability properties. One of the most important constituent in preparing concrete is cement. The production of cement leads to release of harmful gases like Carbon dioxide into environment which thereby depletes our natural resources. Waste paper sludge ash, which is a byproduct from paper industry produces 6%ash from the sludge. In the present study, it is aimed to produce a green fibre reinforced concrete using partial replacement of cement with WPSA, addition of steel fibres and glass fibres at various proportions for M30 grade of concrete. Initially WPSA is altered at 5%,10% and 15% to get the optimum and then steel fibres added at 0.5%, 1%,1.5% and 2% and glass fibres at 0.1%, 0.2%, 0.3% and 0.4%. The strength characteristics of this special concrete are compared with the conventional concrete. Durability studies are also carried out using 5% HCl. The test results showed that the strength of the concrete is enhanced to the WPSA fibre reinforced concrete compared to conventional concrete.*

Keywords- Waste paper sludge ash, fibre reinforced concrete, steel fibres, glass fibres, Durability of concrete, Conventional concrete.

I. INTRODUCTION

Waste Paper sludge is a waste material that is produced during the processing of wooden pulp in paper manufacturing.

The waste paper sludge ash gives a remains of 6% ash as a byproduct. Mineral configuration of the waste paper sludge is having a rich cellulose content, calcium carbonate, china clay and some residual chemicals bond with a moisture content of about 40%.

To reduce crack propagations and to enable the concrete to have a better performance in tension and flexure, fibres are proposed to be added to the nominal concrete mix. This process of adding fibres to the plain concrete is referred asFibre reinforced concrete.

The addition of fibres has also clearly shown that, it will arrest the cracks and controls the development of cracks, penetration of the cracks because of which the toughness and ductility of the concrete will be improved to a greater extent which results in the change of failure criteria of the concrete from brittle to ductile considerably. Some of the fibers in practice are Glass fibres, Carbon fibres, Steel fibres, Synthetic fibres, Nylonfibres.

II. OBJECTIVES OF THE STUDY

Concrete industry is one of the largest consumers of natural virgin materials. Production of concrete is depleting our natural resources in our day to day life. So in order to produce green fibre reinforced concrete as a result to reduce harm to environment and also as a best solution for disposing waste from paper industry, waste paper sludge ash is used as partial replacement of cement in fibre reinforced concrete and to determine optimum percentage of WPSA that is needed to be replaced in concrete without affecting its functionalities.

III. MATERIALS USED

- Ordinary Portland cement 53 grade (KCP cement) with specific gravity of 3.15
- Locally available river sand with bulk density of 1712 kg/m^3 and specific gravity of 2.613 and confirming to zone-2 ofIS:383
- Coarse aggregate with bulk density of 1682 kg/m^3 and
- specific gravity of2.822
- Waste sludge ash with specific gravity of2.61
- Water confirming to the requirements of water of concreting and curing as per IS:456-2000
- Steel Fibres: Mild Steel Hooked End (length- 30mm and diameter-0.5mm)

- Glass Fibres: AR-glass(length-50mm and diameter-0.1mm)

IV. METHODOLOGY

In this study waste paper sludge ash is partially replaced as 5%, 10%, 15% and 20% in place of cement in concrete for M30 mix to identify the mechanical properties of the concrete at 28 days of age and compared with conventional concrete. To the optimum of waste paper sludge ash obtained, steel fibres are added at 0.5%, 1%,1.5% and 2% and glass fibres at 0.1%, 0.2%, 0.3% and 0.4% and strengths are determined by performing the tests. The strength characteristics of this special concrete are compared with the conventional concrete

V. EXPERIMENTAL INVESTIGATION

By taking different percentages of Waste paper sludge ash, along with steel & Glass fibres individually as a partial replacement of cement will be replaced accordingly with the different percentages by weight of ash and different percentages by weight of steel fibre and Glass fibre. Tests are conducted by casting cubes, cylinders and beams.

The dimension of cube specimen is 15 cm x 15 cm x 15 cm,
cylinder specimen is 15 cm x 30 cm and
beam specimen is 50 cm x 10 cm x 10 cm.

Tests Results on Ordinary Portland Cement

Table 1:Results of tests on OPC

Physical Properties of Materials	Results
Normal Consistency of Cement	29 %
Setting Times of cement Initial Final	 51 minutes 390 min
Specific Gravity of cement	3.15
Fineness of cement	4%
Specific Gravity of aggregates of Coarse aggregates Fine aggregates WPSA	 2.822 2.613 2.61
Fineness Modulus of Fine Aggregate Fineness Modulus of Coarse Aggregate	2.78 6.88

Table 2 :Chemical composition of WPSA

CHEMICAL COMPOSITIONS	OPC (%)	WPSA (%)
Silicon Dioxide (SiO_2)	20.1	59.47
Alumina and (AL_2O_3)Ferric Oxide (Fe_2O_3)	7.1	10.45
Calcium Oxide (CaO)	65	8.69
Magnesium Oxide (MgO)	3.1	3.13
Sodium Oxide (Na_2O)	0.2	0.22
Potassium Oxide (K_2O)	0.4	0.16
Sulphur Oxide (SO_3)	2.3	1.07

Table 3:Mix Proportion of M30grade concrete

S. No	Material	Weight of material (Kg/m3)	Mix ratio with respect to cement
1	Cement	448.00	1
2	Fine Aggregate	638.91	1.42
3	Coarse Aggregate	1237.40	2.76
4	Water	175.00	0.39

CASTING OF SPECIMENS: The concrete is filled into the moulds in layers approximately 5cm deep. Metal moulds, preferably steel or cast iron, strong enough to prevent distortion is required. For each trail 6 beam, cylinder and cube specimens were casted for calculating 7 days and 28 days strengths. Test cubes should be demoulded between 16 and 24 hours after they have been made. The water or solution in which the specimens are submerged are removed every seven days and are maintained at a temperature of 27±2°C. The specimens are not allowed to become dry at any time until they have been tested. By taking out the specimens from the curing tank, the specimens were exposed to sun light for surface drying. After the drying process, the specimens are processed for testing.

In order to check the workability of the concrete, slump cone test is performed.

After 28 days curing, in order to test the strength of the cube specimens casted, compressive strength is calculated for 7,28days

Compressive strength = P/A N/mm²

Where, P= Compressive strength Maximum load A= Area of specimen.

After 28 days curing, cylinder specimens are placed on tensile strength machine having a maximum capacity of 1000kN and split tensile strength is determined

Split tensile strength =2P/πLD

After 28 days curing, beam specimens are placed on flexural strength machine and flexural strength is determined.

Flexural Strength f_{cr}= PL/bd^2

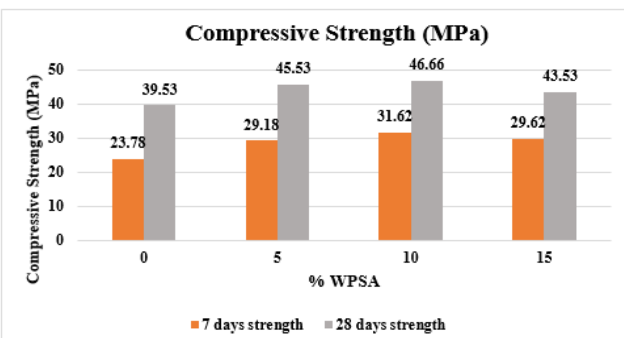
Durability tests are also performed after strength is calculated.

VI. RESULTS

6.1 COMPRESSIVE STRENGTH

Table 4: Compressive strength for different WPSA optimum percentages

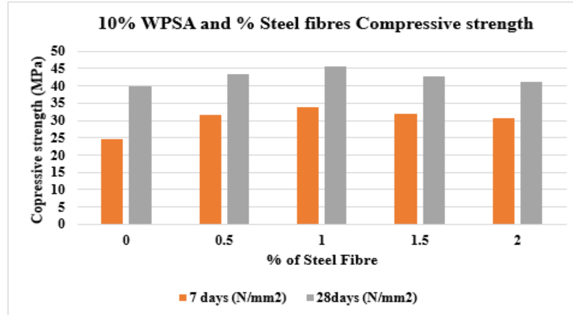
Compressive Strength (Mpa)			
S.NO	% of WPSA	7 days strength	28 days strength
M1	0	23.78	39.53
M2	5	29.18	45.53
M3	**10**	**31.62**	**46.66**
M4	15	29.62	43.53



Graph 1:Compressive strength for different % of WPSA for 7 & 28 days

Table 5: Compressive strength for steel fibre

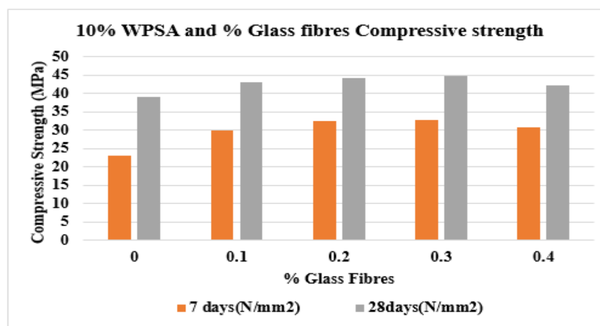
S.NO	WPSA %	% of Steel Fibre	7 days (N/mm^2)	28days (N/mm^2)
1	0	0	24.48	39.85
2	10	0.5	31.6	43.21
3	**10**	**1**	**33.93**	**45.62**
4	10	1.5	31.96	42.72
5	10	2	30.71	41.11



Graph 2: Compressive strength for different % of steel fibre for 7 and 28 days

Table6:Compressive strength for glass fibres

S.NO	WPSA %	% Glass Fibres	7 days (N/mm^2)	28days (N/mm^2)
1	0	0	23.18	39
2	10	0.1	30.1	43.11
3	10	0.2	32.42	44.2
4	**10**	**0.3**	**32.84**	**44.99**
5	10	0.4	30.91	42.21



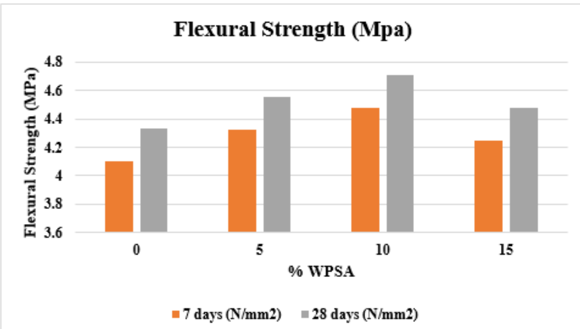
Graph 3: Compressive strength for different % of glass fibre for 7 and 28 days

From the above Graphs 1,2,3, it is observed that the compressive strength value for the mix 10% WPSA with 1% steel fibre and 0.3% glass fibre is found to be higher compared with other mixes

6.2 FLEXURAL TEST

Table 7: Flexural test for different WPSA optimum percentages

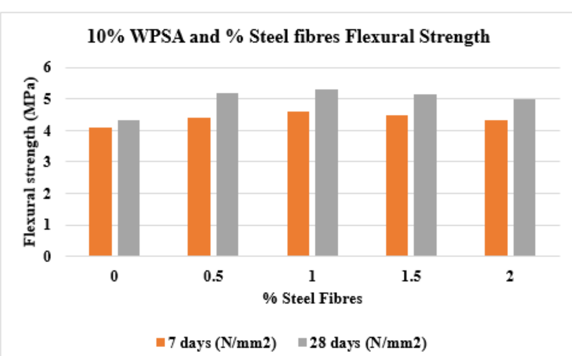
S.NO	WPSA %	7 days (N/mm²)	28 days (N/mm²)
1	0	4.1	4.33
2	5	4.32	4.55
3	**10**	**4.48**	**4.71**
4	15	4.25	4.48



Graph 4: Flexural test for % of WPSA for 7days & 28 days

Table 8: Flexural test for steel fibre

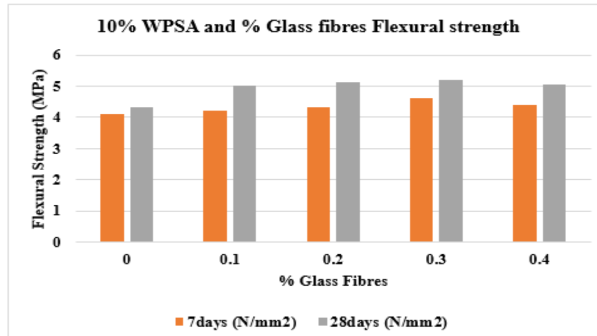
S.NO	WPSA %	% of Steel Fibre	7 days (N/mm2)	28 days (N/mm2)
1	0	0	4.1	4.33
2	10	0.5	4.42	5.18
3	**10**	**1**	**4.59**	**5.29**
4	10	1.5	4.48	5.15
5	10	2	4.31	4.98



Graph 5:Flexural strength for different % of steel fibre for 7 and 28 days

Table 9: Flexural test for glass fibre

S.NO	WPSA %	% Of Glass fibre	7days (N/mm²)	28days (N/mm²)
1	0	0	4.1	4.33
2	10	0.1	4.21	5.01
3	10	0.2	4.32	5.13
4	**10**	**0.3**	**4.63**	**5.21**
5	10	0.4	4.41	5.06



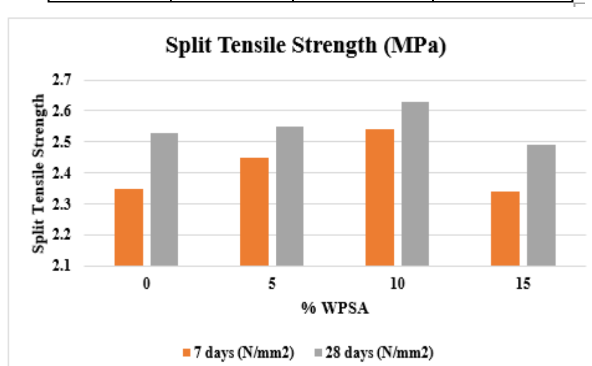
Graph 6 : Flexural strength for different % of glass fibre for 7 and 28 days

From the above Graphs 4,5,6 it is observed that the Flexural strength value for the mix 10% WPSA, with 1%steel fibre and 0.3% glass fibre is found to be higher compared with other mixes

6.3 SPLIT TENSILE STRENGTH

Table 8:Split tensile test for different WPSA optimum percentages

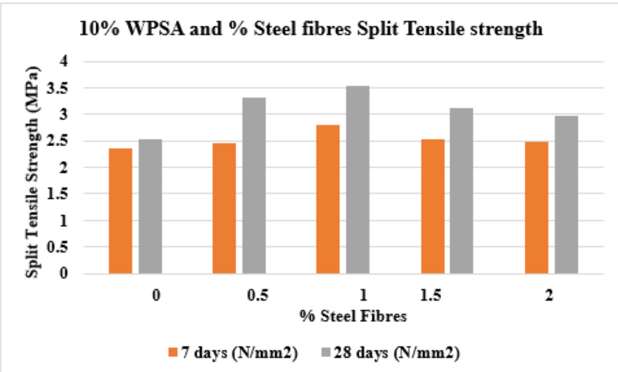
S.NO	WPSA %	7 days (N/mm²)	28 days (N/mm²)
1	0	2.35	2.53
2	5	2.45	2.55
3	**10**	**2.54**	**2.63**
4	15	2.34	2.49



Graph7:Split tensile test for different % of WPSA for 7 & 28 days

Table 10: Split tensile test for steel fibre

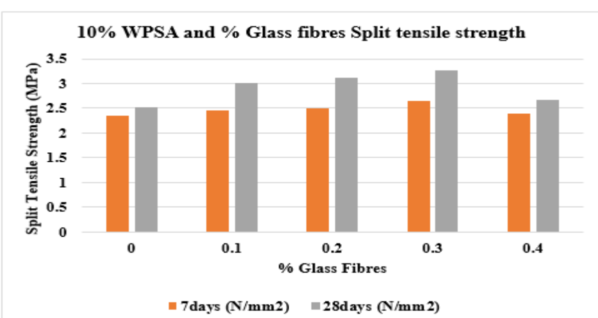
S.NO	WPSA %	% of Steel Fibre	7 days (N/mm^2)	28 days (N/mm^2)
1	0	0	2.35	2.53
2	10	0.5	2.46	3.32
3	**10**	**1**	**2.79**	**3.54**
4	10	1.5	2.54	3.12
5	10	2	2.49	2.98



Graph 8: Split tensile strength for 7 & 28 days for different % of steel fibres

Table 11:Split tensile test for glass fibre

S.NO	WPSA %	% of glass fibre	7days (N/mm^2)	28days (N/mm^2)
1	0	0	2.35	2.53
2	10	0.1	2.45	3.01
3	10	0.2	2.51	3.12
4	**10**	**0.3**	**2.64**	**3.26**
5	10	0.4	2.39	2.67



Graph 9:Split tensile strength for 7 & 28 days for different % of glass fibres

From the above Graphs7,8,9 it is observed that the Split tensile strength value for the mix 10% WPSA, with 1% steel fibre and 0.3% glass fibre found to be higher compared with other mixes.

6.4 DURABILITY TEST:

The durability of concrete in this experimental work was carried out by measuring acid resistance at different ages of curing. The concrete acid resistance was observed by two types of tests named as Acid attack factor test and Acid durability factor test. The concentrations of acids in water are 5% HCL and 5% H_2SO_4 concrete can be attacked by liquids with pH value less than 6.5 and attack is severe when pH value is below 5.5. At pH value below 4.5, the attack is very severe. As the attack proceeds, all the cement compounds are broken down and leached away. Here HCL and H_2SO_4 which are having pH value 3.01 and 2.75 which cause a very severe attack are used to study the durability properties.

Preparation of 5% HCl per 20 Litres of Water:

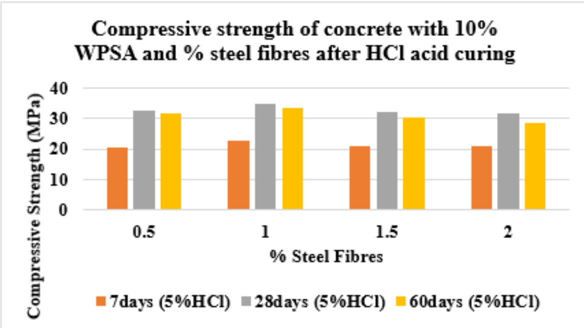
The volume of acid to mix in water is calculated by using the formula

Where, C_1 is the Concentration of HCl = 35% V_1 is the Volume required,C_2 is the required concentration = 5% V_2 is the required volume of acid= 20 lit
Volume of HCl (V_2) = C_2V_2/C_1
= 5×20/35
=2.85 liters

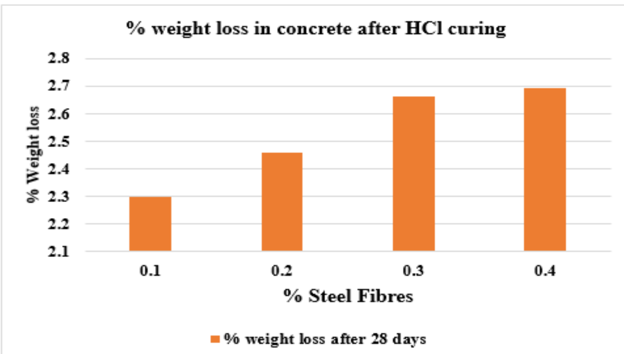
i.e., to prepare 20 lit solutions of HCl, volume of acid required is 2.85 liters

Table 12:Compressive strength for M30 grade concrete with 10% WPSA and % steel fibres after HCl acid curing

S.NO	% of steel fibre	% weight loss after 28 days	Compressive strength(N/mm^2)		
			7days (5%HCl)	28days (5%HCl)	60days (5%HCl)
1	0.5	2.21	20.65	32.64	31.56
2	1	2.35	22.79	34.64	33.67
3	1.5	2.54	21.14	32.35	30.55
4	2	2.64	20.79	31.64	28.44



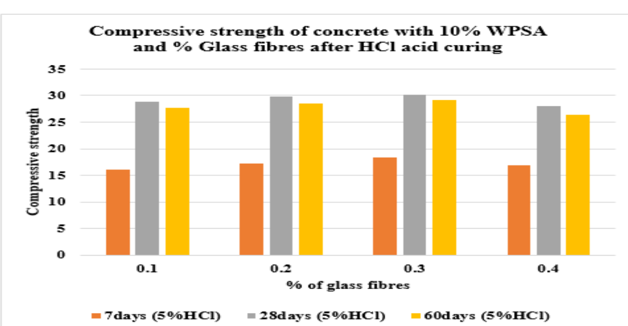
Graph10 : Compressive Strength of 5% HCl cured steel fibre cubes after 7, 28 & 60 days



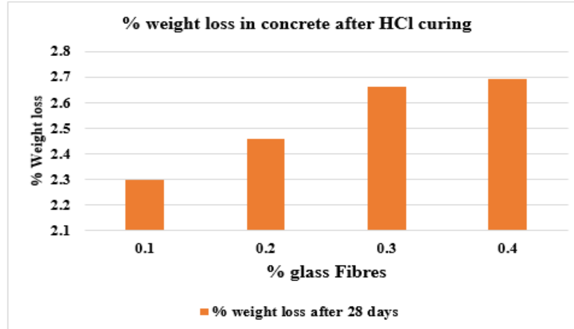
Graph 11:% Weight loss in concrete with 10% WPSA and % steel fibres after 28 days HCl acid curing

Table 13: Compressive strength for M30 grade concrete with 10% WPSA and % Glass fibres after HCl acid curing

S.NO	% of Glass fibre	% weight loss after 28 days	7days (5%HCl)	28days (5%HCl)	60days (5%HCl)
1	0.1	2.3	16.12	28.88	27.66
2	0.2	2.46	17.22	29.76	28.54
3	**0.3**	2.66	18.44	30.23	29.13
4	0.4	2.69	16.81	28.11	26.37



Graph 12: Compressive Strength of 5% HCl cured glass fibrecubes after 7, 28 & 60 days



Graph 13:% Weight loss in concrete with 10% WPSA and % glass fibres after 28 HCl acid curing

VII .CONCLUSIONS

Based on the analysis of experimental results and discussion there upon the following conclusions can be drawn:

- With replacement of 10% WPSA to the cement, the concrete is showing increased strength properties with an increase of 15% in compression strength, 8.5% in flexure and 6 % in split tensile strengths.
- Addition of steel fibres to the above optimum WPSA, resulted in increased properties as 14%, 22% and 39% in compression, flexure and split tensile strengths respectively and the optimum is obtained at 1% addition of steel fibres.
- Addition of glassfibres to the above optimum WPSA, resulted in increased properties as 15%, 20% and 28% in compression, flexure and split tensile strengths respectively and the optimum is obtained at 0.3% addition of glass fibres.
- In case of durability, glass fibres exhibited better properties when compared to steel fibres.

REFERENCES

[1] Sajad Ahmad, M.Iqbal Malik, Muzaffar Bashir Wani and Rafiq Ahmad, ”Study on concrete involving use of Waste paper sludge ash as partial replacement of cement”, IOSRJEN, Vol.3, Issue 11, Nov.2013.

[2] Monte, MC.; Fuente, E.; Blanco, A. & Negro, C. (2009). Waste management from pulp and paper production in the European Union. Waste Management, Vol. 29, pp. 293–308. 2.

[3] Chandramouli K.1,"Strength Properties Of Glass Fibre Concrete" Vol. 5,No. 4, April 2010.Issn 1819-6608 www.arpnjournals.com.

[4] J.D.Chaitanyakumar " Experimental Studies on Glass Fibre Concrete" American Journal of Engineering Research (AJER) 2016.

[5] D.Neeraja,"Experimental Investigations on Strength Characteristics of Steel Fibre Reinforced Concrete", IJSER Volume 2, Issue 07, (February 2013).
[6] Avinash Gornale, S Ibrahim Quadri, Mehmoodquadri, Syed Md Akramali and Syed Sham SuddinHussaini "Strength Aspects of Glass Fibre Reinforced Concrete", IJSER, Volume 3, Issue, (July 2012).
[7] Prof. Jayeshkumar Pitroda, Dr. L.B.Zala and Dr.F.S.Umrigar, "Innovative use of paper industry waste (hypo sludge) in design mix concrete", IJAET, Vol.4, Issue1, Mar.2013.
[8] Abdullah shahbaz khan, Ram panth, Gagan Krishna P.R. and Suresh G.Patil, "Structural performance of concrete by partial replacement of cement with hypo sludge (paper waste)", IJETE, Vol. 1, Issue 7,Aug 2014.
[9] Milind and V. Mohod, "Performance of Steel Fibre Reinforced Concrete", Volume.1, Issue 12(December 2012).
[10] A.Sumathi and K. Saravana Raja Mohan "Study on the Strength and Durability Characteristics of High Strength Concrete with Steel Fibres" IJCR.volume.08 (2015).
[11] A.M.Shende, A.M. Pande and M. Gulfampathan "Experimental study on steel fibre reinforced concrete for M-40 grade", IRJES 4, issue2, (February-2013volume).
[12] Valeria Corinaldesi, Gabriele Fava , Maria Letizia Ruello, "Paper Mill Ash as Supplementary Cementitious Material",vol.23,pp 772-776,2011.
[13] Mamta B. Rajgor and Jayeshkumar Pitroda, "A Study on Paper Industry Waste: Opportunity for Development of Low Cost Concrete in Indian Contest", pp. 90-92, 2013.
[14] Monte, MC.; Fuente, E.; Blanco, A. & Negro, C. (2009). Waste management from pulp and paper production in the European Union. Waste Management, Vol. 29, pp. 293–308. 2.