EFFECTS ON STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH AND PAPER SLUDGE ASH

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Abstract

In this dissertation study on utilizations of waste paper sludge ash to produce on economic concrete by blending various ratios of cement with waste paper sludge ash along with fly ash there by and to reduce disposal and related pollution problems. The innovative use of waste paper sludge ash in concrete as a supplementary cementitious material along with fly ash explored. The main aim of this study is to evaluate the effects on the proportion of concrete with paper sludge ash & fly ash (as partial replacement of cement) in concrete when it is mixed in cement concrete for workability, and strength of concrete using OPC (43 grade). Paper sludge ash is supplementary cementitious material and fly ash is pozzolanic materials that can be utilized to produce highly durable concrete composites. In this study waste paper sludge ash has been used to partially replace OPC which varies from 0% to 15% at interval of 5% by total weight of OPC and similarly cement has been replaced by fly ash which varies 0% to 15% at interval of 5% by total weight of cement in the equal proportion and prepared for M25 & M30 grade of concrete. This study investigates the performance of concrete under the influence of paper sludge ash and fly ash in terms of slump and compressive strength at 7 days and 28 days, flexural strength of beam at 28 days and splitting tensile strength of Cylinder at 28 days respectively. The required of specimens of cubes, cylinders and beams were casted for testing to study the influence of paper sludge ash & fly ash on concrete. These Concrete specimens were deep cured in water under normal atmospheric conditions in laboratory On the basis of result that paper sludge ash and fly ash mix concrete was found to increase in all strength (Compressive, Flexural & Splitting Tensile strength) of various mix of concrete at all age when compared to normal concrete. Its use should be promoted for better performance as well as for environmental sustainability. Test results indicate that use of waste paper sludge ash in concrete has improved the performance of concrete.

Keywords: *Cement1, Paper Sludge Ash2, Fly Ash3, and Workability4 etc…*

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1. Cement

Cement is a binder, a substance that sets and hardens and can bind other materials together Cement used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water. The OPC cement of brand uses for this dissertation work.

Table 1: Properties of Cement (OPC 43 grade)

Chemical Composition	**Value**
Surface Area	3000 (cm^2/gm)
Calcium oxide (CaO)	64%
Silicon dioxide (SiO_2)	17%
Aluminium oxide (Al_2O_3)	5%
Ferric oxide (Fe_2O_3)	3%
Magnesium oxide (MgO)	1%
Sulfur trioxide (SO_3)	1.5%
Sodium oxide (Na_2O)	0.5%
Gypsum ($CaSO_4.2H_2O$)	2.5%
Specific Gravity	3.15

1.1 Waste Paper Sludge Ash (WPSA)

Waste Paper Sludge Ash (WPSA) is a waste material collected from the Paper Industry. WPSA is used partially replacement of cement in producing concrete and was investigated on its chemical, physical and mechanical properties. Construction material with natural resources now a day's become limited due to environmental problems. The chemical composition of paper sludge ash is presented where shows proportion waste paper sludge ash, in Fig.3.4. As per proportion it shows that it near to the chemical properties of OPC. The total percentage of the three combinations of SiO_2, Al_2O_3, and Fe_2O_3 was 45% and expected to possess low pozzolanic reactivity (50%).

Table 2: Chemical Properties of Paper Sludge Ash

Properties	**Approximate Value**
Surface Area	3300(cm^2/gm)
Specific Gravity	2.61
Calcium oxide (CaO)	14.60%
Silicon dioxide (SiO_2)	47.89%
Aluminium oxide (Al_2O_3)	0.09%

Magnesium oxide (MgO)	6.41%
Sulfur trioxide (SO_3)	0.19%
Ferric oxide (Fe_2O_3)	0.73%
Sodium oxide (Na_2O)	0.2%

1.2 Fly Ash

Fly ash is a by-product, manufactured during combustion of powdered coal in Power plants. In general, depending on the chemical composition, fly ash can be classified as Class F or Class C. Class C fly ash has higher amount of CaO so it possesses more cementing characteristics and is less pozzolanic than Class F. ASTM 618 states that Class F fly ash is normally produced from burning anthracite or bituminous coal, while Class C fly ash is "normally produced from lignite and sub-bituminous coal". Class F fly ash is mostly composed of silicate glass containing aluminum, iron, and alkalis. At least 70% of the chemical composition is made up of SiO_2, Al_2O_3, and Fe_2O_3. For this dissertation work fly ash of class F form kota thermal power plant has been used which has used pozzolanic effects

Table 3: Physical and Chemical Properties of Fly Ash

Properties	**Approximate Value**
Surface Area	3500 (cm^2/gm)
Specific gravity	2.2
Silica (SiO_2)	51.0%
Aluminum (Al_2O_3)	30.0%
Iron (Fe_2O_3)	3.0%
Calcium (CaO)	6.0%
Magnesium (MgO)	2.0%
Sodium (Na_2O)	0.5%
Potassium (K_2O)	0.8%
Sulphur (SO_3)	0.2%

1.3 Fine Aggregate Grading

Gradation of fine aggregate was performed as per IS-383:1970. Banas Sand was used for this study. The Sieves taken for gradation of Banas Sand are 10mm, 4.75mm, 2.36mm, 1.18mm, 600 micron, 300 micron and 150 micron.

Table 4: Sieve Analysis of Fine Aggregate (IS 383/2386)

Sieve Size	**Retained (gm)**			**% Retained Weight**	**Cumulative % Retained**	**% Passing**	**Limit as per IS 383 Zone-II**
	Sample 1	**Sample 2**	**Average**				
10 mm	0	0	0	0	0	100	100
4.75 mm	12.5	10.5	11.5	1.15	1.15	98.85	90-100
2.36 mm	17.5	16.5	17	1.7	2.85	97.15	75-100
1.18 mm	73	74	73.5	7.35	10.2	89.80	55-90
600 Micron	520	495	507.5	50.75	60.95	39.05	35-59
300 Micron	275	356	315.5	31.5	92.45	7.55	8.0-30
150 Micron	89	43	66	6.6	99.5	0.5	0-10
PAN	11.5	6.0	8.75	0.875	**267.1**		
Total	1000	1000	1000	100			

Fineness Modulus = 267.10/100 = 2.67
Grading Zone = II

1.4 Coarse Aggregate Grading (10mm)

As per IS-383:1970, The Sieves recommended for gradation of gunawata coarse aggregate are 12.5 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, and 150 micron.

Table 5: Sieve Analysis of 10 mm Aggregate (IS 383/2386)

Sieve Size	**Retained (gm)**			**% Retained weight**	**Cumulative % Retained**	**%Passing**	**Limit as per IS 383**
	Sample 1	**Sample 2**	**Average**				
12.5 mm	0	0	0	0	0	100	100
10 mm	34	47	40.5	2.01	2.01	97.99	85-100
4.75 mm	1360	1366	1363	68.15	70.16	29.84	0-20
2.36 mm	492	493	492.5	24.62	94.79	5.21	0-5
1.18 mm	104	104	104	5.2	100	0	0
600 Micron	0	0	0	0	100	0	0
300 Micron	0	0	0	0	100	0	0
150 Micron	0	0	0	0	100	0	0
PAN	0	0	0	0	**566.96**		
Total	2000	2000	2000	100.00			

Fineness Modulus = 566.96/100 = 5.67

2.1 Final Mix Proportion (M25 Grade of Concrete)

% Mix (Cement + Paper Sludge Ash + Fly Ash)	Corrected Cement (Kg/ m^3)	Corrected Coarse Aggregate 20 mm (Kg/ m^3)	Corrected Coarse Aggregate 10 mm (Kg/ m^3)	Corrected River Sand (kg/ m^3)	Corrected Fly ash + Paper Sludge Ash (kg/ m^3)	Corrected Water (kg/m^3)	Admixture (Kg/ m^3)
OPC + FA +WPSA (100+0+0)	371.25	718.90	440.63	703.33	0	162	3.71
OPC + FA +WPSA (100+5+5)	334.13	688.52	422.00	673.61	37.13	162	3.34
OPC + FA +WPSA (80+10+10)	297	658.14	403.38	643.90	74.25	162	2.97
OPC + FA +WPSA (70+15+15)	259.88	627.77	384.76	614.13	111.37	162	2.59
OPC + FA +WPSA (70+0+30)	259.88	627.77	384.76	614.13	111.37	162	2.59
OPC + FA +WPSA (70+30+0)	259.88	627.77	384.76	614.13	111.37	162	2.59

2.2 Final Mix Proportion (M30 Grade of Concrete)

% Mix (Cement + Paper Sludge Ash + Fly ash)	Corrected Cement (Kg/ m^3)	Corrected Coarse Aggregate 20 mm (Kg/ m^3)	Corrected Coarse Aggregate 10 mm (kg/ m^3)	Corrected River Sand (kg/ m^3)	Corrected Fly ash + Paper Sludge Ash (kg/ m^3)	Corrected Water (kg/ m^3)	Admixture (Kg/ m^3)
OPC + FA +WPSA (100+0+0)	414.41	708.78	434.40	693.43	0	162	4.14
OPC + FA +WPSA (100+5+5)	372.97	678.40	415.79	663.71	41.44	162	3.72
OPC + FA +WPSA (80+10+10)	331.52	637.89	390.96	624.08	82.88	162	3.31
OPC + FA +WPSA (70+15+15)	290.08	617.65	378.54	604.27	124.32	162	2.90
OPC + FA +WPSA (70+0+30)	290.08	617.65	378.54	604.27	124.32	162	2.90
OPC + FA +WPSA (70+30+0)	290.08	617.65	378.54	604.27	124.32	162	2.90

2.3 Result of Concrete in Fresh Stage

2.3.1 Workability

The slump of all mixes was obtained and shown in graphical form. The design slump was 113 mm and the minimum slump value founded was 96 mm for M25 grade concrete with 30% replacement of cement by fly ash and paper sludge ash. In the case of M30, the design slump was 105 mm and the minimum slump value founded was 86 mm with 30 % replacement of cement by fly ash and paper

sludge ash. Many variations have been seen while checking for a slump of different concrete mixes. The variations had been made in cement by replacing percentage of cement with paper sludge ash and fly ash which varies from (paper sludge ash 0% to 15% at interval of 5%) and (fly ash 0% to 15 % at interval of 5%) for both concrete mixes of M25 & M30.

2.3.2 Compressive Strength

The compressive strength of concrete mixes with the replacement of paper sludge ash and fly ash by weight of OPC was measured with cube specimen of size 150mm (length) x 150mm (width) x 150mm (depth). The specimens were tested after curing for 7 days and 28 days fully immersed in a water tank as per IS 516:1959 for a method of tests for strength of concrete.

Table 2.1: 7 & 28 Days Compressive Strength of Cube on Replacement of OPC by Paper Sludge Ash & Fly Ash for M25

Sl. No	% Mix (OPC + Fly Ash + Paper Sludge Ash)	Average Compressive Strength M25 (N/mm^2)	
		7 Days	28 Days
1	OPC + FA +WPSA (100+0+0)	22.76	31.95
2	OPC + FA +WPSA (100+5+5)	24.68	33.28
3	OPC + FA +WPSA (80+10+10)	26.31	34.46
4	OPC + FA +WPSA (70+15+15)	**26.75**	**35.10**
5	OPC + FA +WPSA (70+0+30)	25.87	28.83
6	OPC + FA +WPSA (70+30+0)	24.25	27.51

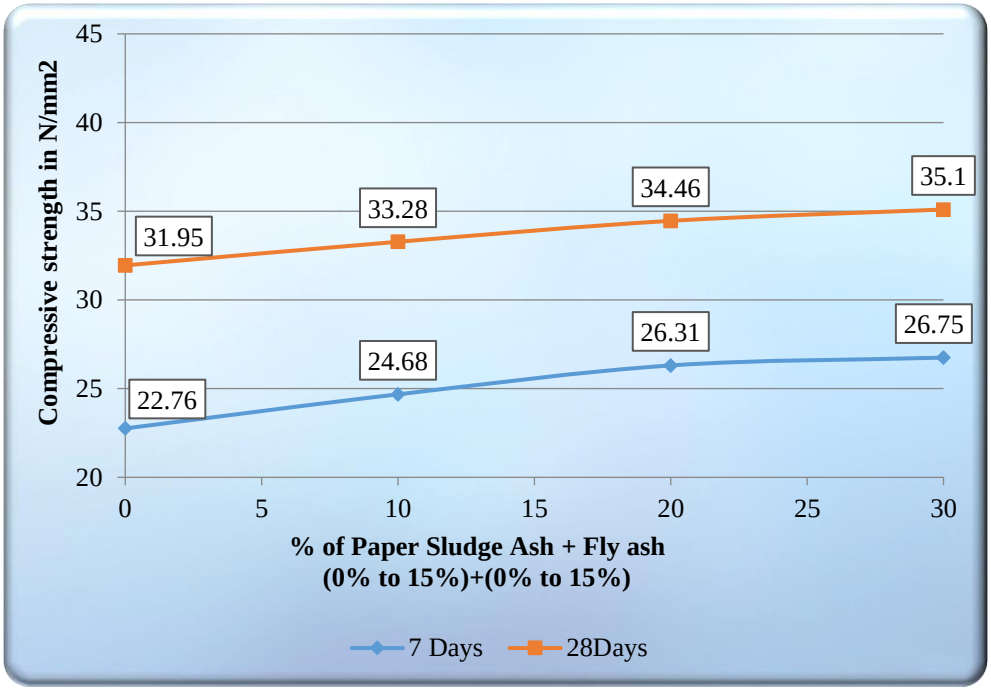
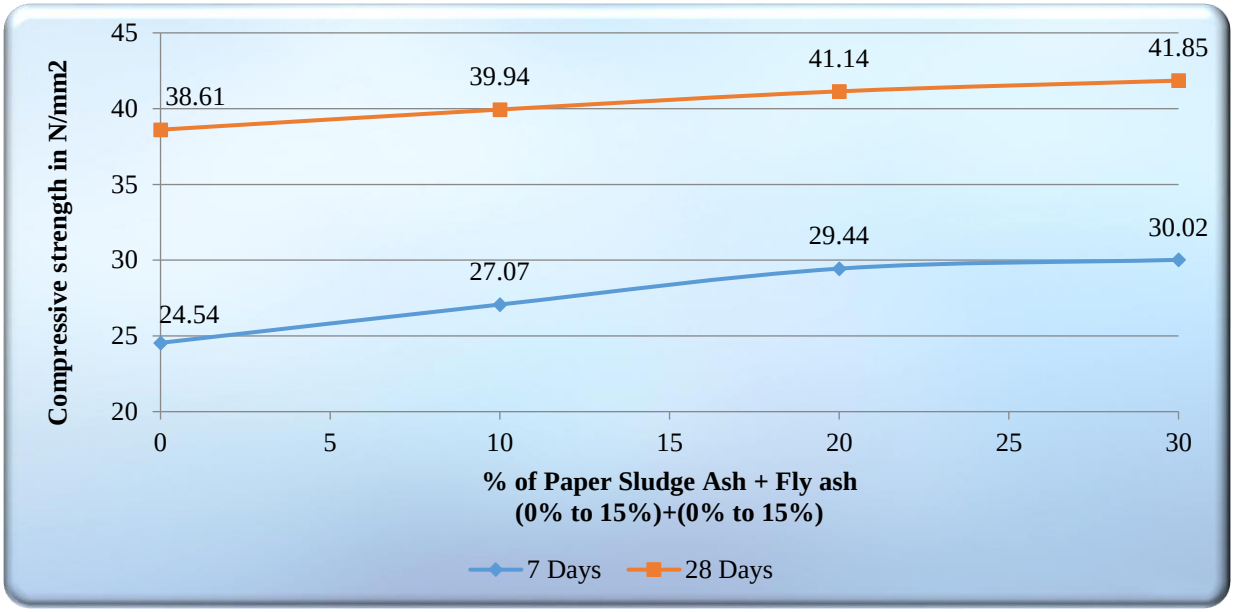


Table 2.2: 7 & 28 Days Compressive Strength of Cube on Replacement of OPC by Paper Sludge Ash & Fly Ash for M30

Sl. No	% Mix (Cement + Paper Sludge Ash + Fly Ash)	Average for Compressive Strength M30 (N/mm^2)	
		7 Days	28 Days
1	OPC + FA +WPSA (100+0+0)	24.54	38.61
2	OPC + FA +WPSA (100+5+5)	27.07	39.94
3	OPC + FA +WPSA (80+10+10)	29.44	41.14
4	OPC + FA +WPSA (70+15+15)	**30.02**	**41.85**
5	OPC + FA +WPSA (70+0+30)	28.55	37.00
6	OPC + FA +WPSA (70+30+0)	26.03	34.18



2.3.3 Flexural Strength

The Flexural strength of concrete mixes with the replacement of Paper sludge ash and fly ash by weight of OPC was measured with beam specimen of size 700mm (length) x 150mm (width) x 150mm (depth). The specimens were tested after curing for 28 days fully immersed in a water tank as per IS 516:1959 for method of tests for strength of concrete. The method used for this testing was centre point loading.

Table 2.3: 28 Days Flexural Strength of Beam on Replacement of OPC by Paper Sludge Ash & Fly Ash for M25

Sl. No	% Mix (Cement + Paper Sludge Ash + Fly Ash)	Average Flexural Strength M25 (N/mm^2)
1	OPC + FA +WPSA (100+0+0)	4.48
2	OPC + FA +WPSA (100+5+5)	4.81
3	OPC + FA +WPSA (80+10+10)	5.17
4	OPC + FA +WPSA (70+15+15)	**5.32**
5	OPC + FA +WPSA (70+0+30)	5.11
6	OPC + FA +WPSA (70+30+0)	4.92

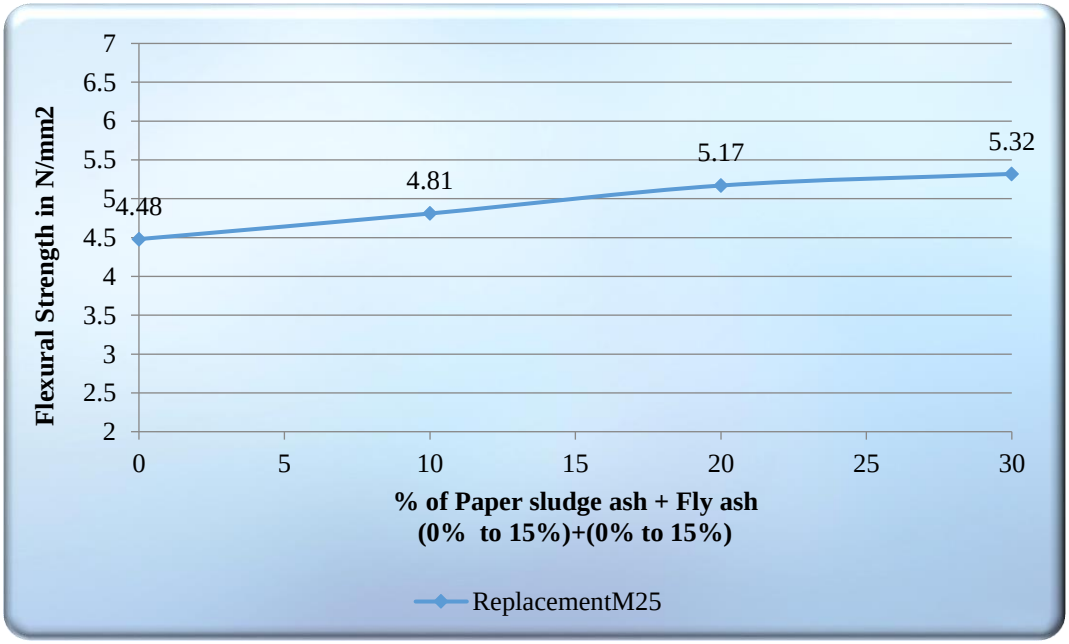
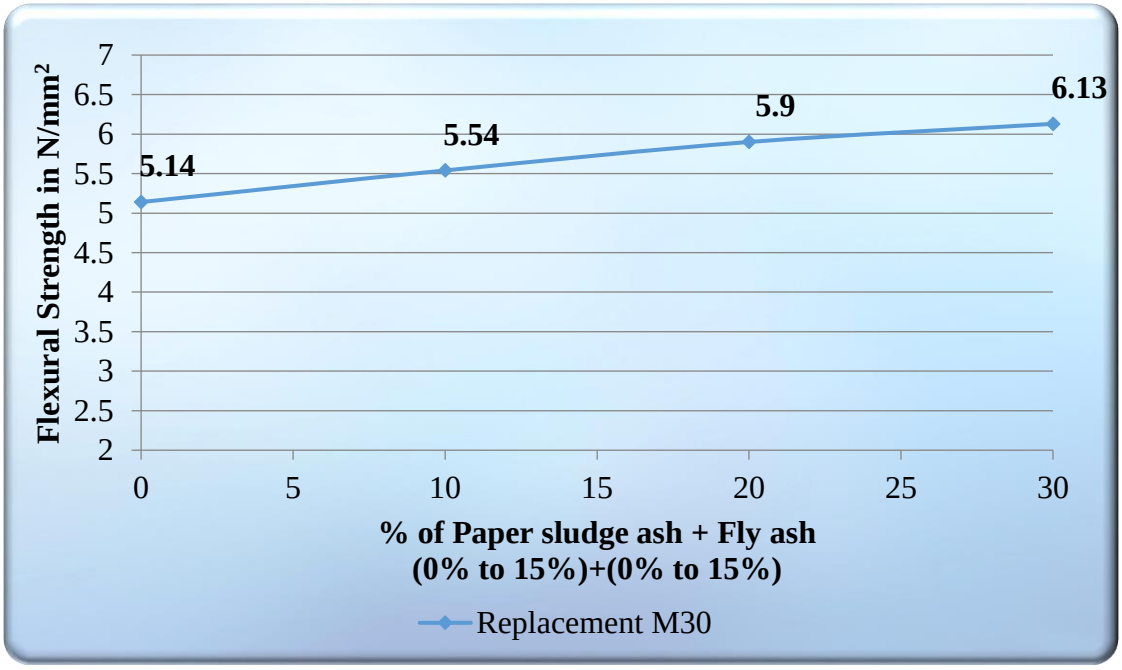


Table 2.4: 28 Days Flexural Strength of Beam on Replacement of OPC by Paper Sludge Ash & Fly Ash for M30

Sl. No	% Mix (Cement + Paper Sludge Ash + Fly ash)	Average Flexural Strength M30 (N/mm^2)
1	OPC + FA +WPSA (100+0+0)	5.14
2	OPC + FA +WPSA (100+5+5)	5.54
3	OPC + FA +WPSA (80+10+10)	5.90
4	OPC + FA +WPSA (70+15+15)	**6.13**
5	OPC + FA +WPSA (70+0+30)	5.67
6	OPC + FA +WPSA (70+30+0)	5.34



2.3.4 Splitting Tensile Strength

The split tensile strength of concrete mixes with the replacement of Paper sludge ash and fly ash by weight of OPC was measured with cylinder specimen of size 300mm (length) x 150mm (diameter). The specimens were tested after curing for 28 days fully immersed in a water tank as per IS: 5816-1999 for method of test splitting tensile strength of concrete.

Table 2.5: 28 Days Splitting Tensile Strength of Cylinder on Replacement of OPC by Paper Sludge Ash & Fly Ash for M25

Sl. No	% Mix (Cement + Paper Sludge Ash + Fly ash)	Average Splitting Tensile Strength M25 (N/mm2)
1	OPC + FA +WPSA (100+0+0)	3.98
2	OPC + FA +WPSA (100+5+5)	4.29
3	OPC + FA +WPSA (80+10+10)	4.60
4	OPC + FA +WPSA (70+15+15)	**4.90**
5	OPC + FA +WPSA (70+0+30)	4.36
6	OPC + FA +WPSA (70+30+0)	4.09

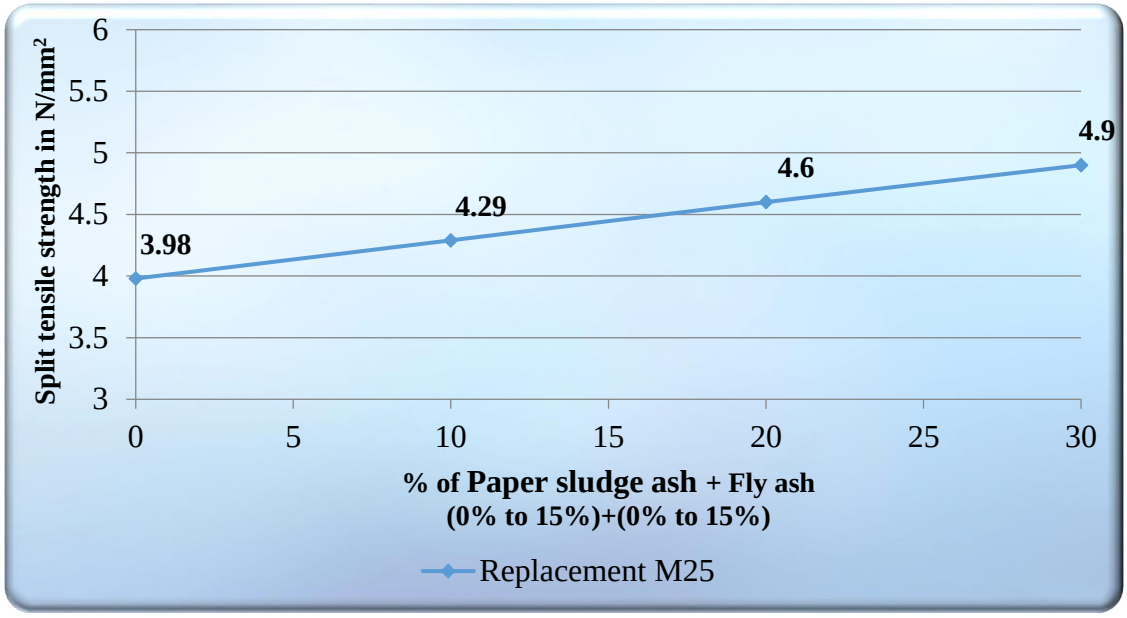
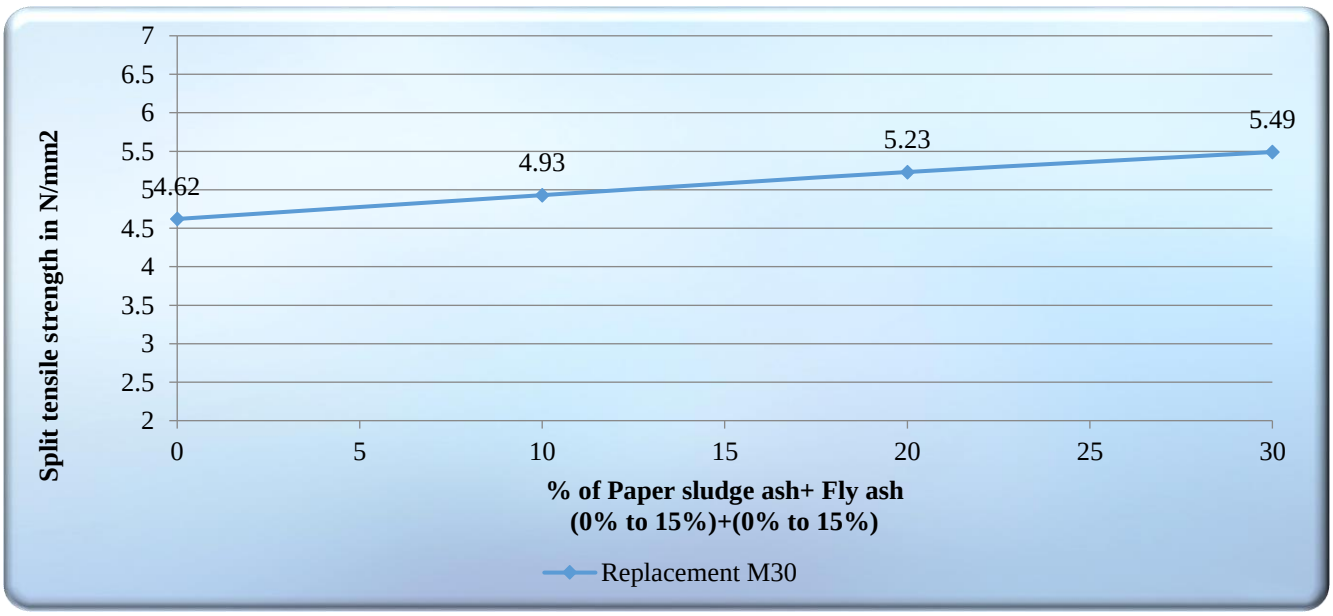


Table 2.6: 28 Days Splitting Tensile Strength of Cylinder on Replacement of OPC by Paper Sludge Ash & Fly Ash for M30

Sl.No	% Mix (Cement + Paper Sludge Ash + Fly Ash)	Average Splitting Tensile Strength M30 (N/mm²)
1	OPC + FA +WPSA (100+0+0)	4.62
2	OPC + FA +WPSA (100+5+5)	4.93
3	OPC + FA +WPSA (80+10+10)	5.23
4	OPC + FA +WPSA (70+15+15)	**5.49**
5	OPC + FA +WPSA (70+0+30)	5.18
6	OPC + FA +WPSA (70+30+0)	4.84



2.3.5 Cost Analysis

By partial replacement of cement by Paper sludge ash and fly ash (Paper sludge ash from 0% to 15% and fly ash from 0% to 15%), the cost of cementations material so reduced has been calculated both M25 & M30 mixes due to the low cost of fly ash and Paper sludge ash.

Cost consideration is as mentioned below:-

Cost of Cement - 6 Rs/kg

Cost of Fly Ash - 1 Rs/kg

Cost of Paper sludge ash - 1.25 Rs/kg

Table 2.7: Cost analysis for M25 Grade (Only Difference of Cost of Cement, Paper Sludge Ash and Fly Ash)

Sl. No.	% Mix (Cement + Paper Sludge Ash + Fly ash)	Cost of Material (Rs.) for M25				% Saving
		Cement	Fly Ash	Paper Sludge Ash	Total	
1	OPC + FA +WPSA (100+0+0)	(371.25*6) = 2227.5	0	0	2227.5	0
2	OPC + FA +WPSA (100+5+5)	(334.13*6) = 2004.78	(18.56*1)= 18.56	(18.56*1.25)= 23.20	2046.54	8.84
3	OPC + FA +WPSA (80+10+10)	(297*6)= 1782	(37.12*1)= 37.12	(37.12*1.25)= 46.40	1865.52	19.40
4	OPC + FA +WPSA (70+15+15)	(259.88*6)= 1559.28	(55.69*1)= 55.69	(55.69*1.25)= 69.61	1684.58	32.22
5	OPC + FA +WPSA (70+0+30)	(259.88*6)= 1559.28	0	(111.38*1.25)= 139.22	1698.50	31.14
6	OPC + FA +WPSA (70+30+0)	(259.88*6)= 1559.28	(111.38*1)= 111.38	0	1670.66	33.33

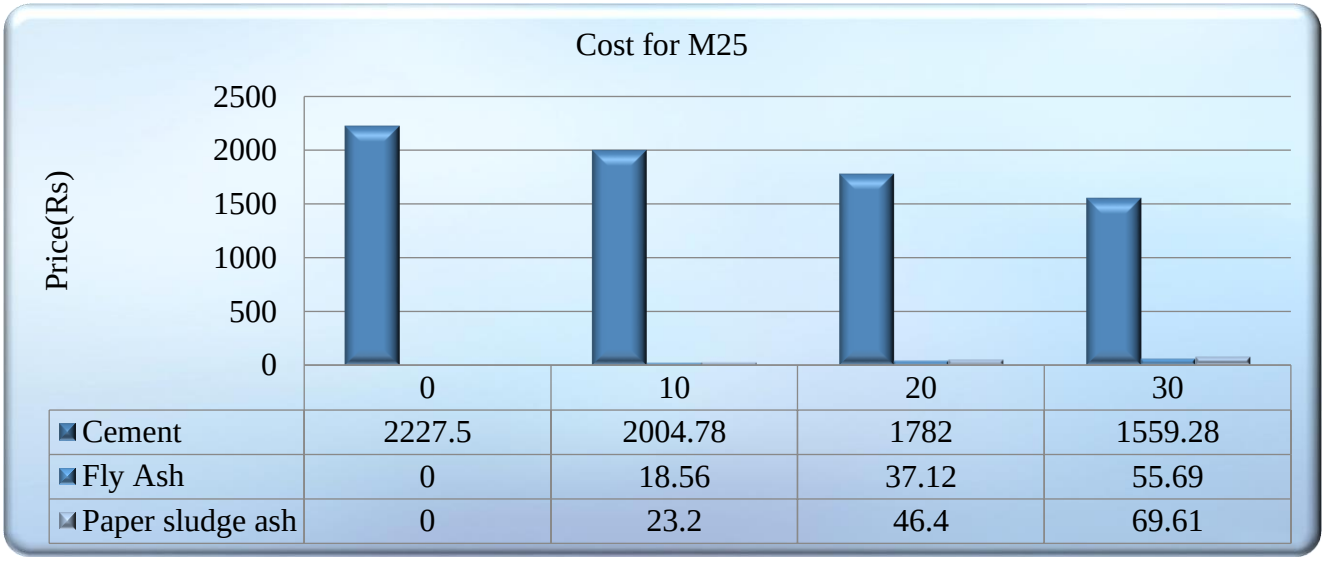
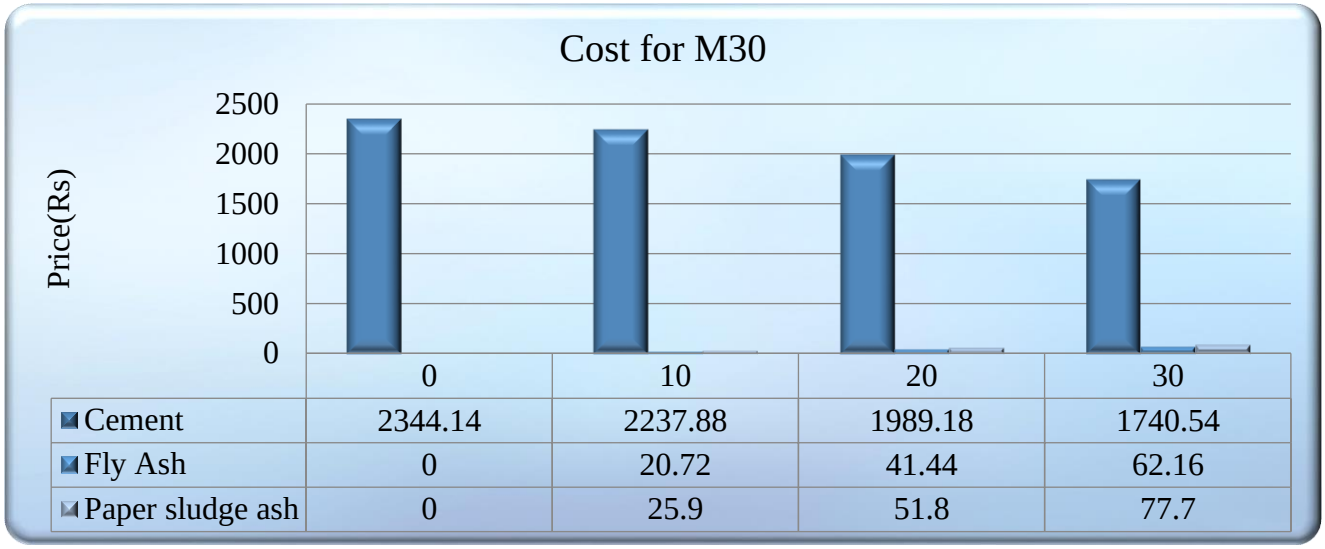


Table 2.8: Cost Analysis for M30 Grade (Only Difference of Cost of Cement, Paper Sludge Ash and Fly Ash)

Sl. No.	% Mix (Cement + Paper Sludge Ash + Fly ash)	Cost of Material (Rs.) for M30				% Saving
		Cement	Fly Ash	Paper Sludge Ash	Total	
1	OPC + FA +WPSA (100+0+0)	(390.69*6)= 2344.14	0	0	2344.14	0
2	OPC + FA +WPSA (100+5+5)	(372.98*6)= 2237.88	(20.72*1)=20.72	(20.72*1.25) = 25.9	2284.50	2.61
3	OPC + FA +WPSA (80+10+10)	(331.53*6)=1989.18	(41.44*1)=41.44	(41.44*1.25) = 51.8	2082.42	12.57
4	OPC + FA +WPSA (70+15+15)	(290.09*6)= 1740.54	(62.16*1)=62.16	(62.16*1.25) = 77.7	1880.40	24.66

5	OPC + FA +WPSA (70+0+30)	(290.09*6)= 1740.54	0	(124.33*1.25)= 155.41	1895.95	23.64
6	OPC + FA +WPSA (70+30+0)	(290.09*6)= 1740.54	(124.33*1)=124. 33	0	1864.87	25.69



3. CONCLUSION

By evaluating and comparing the results of Slump test, Density test, Compressive Strength test, Flexural Strength test and Split Tensile Strength test, for various concrete mix propitiation following conclusions are drawn.

3.1 Slump

Replacement of cement with Paper sludge ash and fly ash by weight of OPC (Paper sludge ash from 0% to 15% with increment of 5% + fly ash from 0% to 15% with increment of 5%), the slump of the concrete mix was gradually increased up to 15% replacement of Paper sludge ash along with fly ash increased up to 15% by weight of cement for both M25 & M30 mixes due to low water demand and micro particle size of Paper sludge ash and fly ash than OPC at initial stage.

M25 Grade

In case of M25 grade, without replacing OPC by Paper sludge ash and fly ash the slump was 113 mm, at replacement of OPC by combination of 5% Paper sludge ash + 5% fly ash, 10% Paper sludge ash + 10% fly ash, 15% Paper sludge ash + 15% fly ash and Paper sludge ash 30%, and Fly ash 30%' the slump was 105mm, 100mm, 96mm, 89mm and 80mm respectively.

M30 Grade

In case of M30 grade, without replacing OPC by Paper sludge ash and fly ash the slump was 105 mm, at replacement of OPC by combination of 5% Paper sludge ash + 5% fly ash, 10% Paper sludge ash + 10% fly ash, 15% Paper sludge ash + 15% fly ash, Paper sludge ash 30%, and Fly ash 30%' the slump was 98 mm, 91 mm, 86 mm, 83mm and 76mm respectively. The Higher slump was found as 113 mm in M25 (when 0% Paper sludge ash along with 0% fly ash was replaced by weight of OPC). In the case of M30 the slump value was 105 mm (when 0% Paper sludge ash along with 0% fly ash was replaced by weight of OPC).

3.2 Density

The density of M25 & M30 grade concrete was higher compare to control mix M25 & M30 grade (when 15% Paper sludge ash + 15% fly ash was replaced by weight of OPC).

3.3 Compressive Strength

Compressive strength of concrete was increased in mixes M25 & M30, replacing OPC with 'Paper sludge ash + fly ash' (0% to 15% Paper sludge ash with increment of 5% & 0% to 15% fly ash with increment of 5%), maximum compressive strength observed in M25 grade was 35.10 N/mm^2 (when 15% Paper sludge ash + 15% fly ash was replaced by weight of OPC) which was 9.05% greater than control mix M25 and M30 grades and in case of M30, maximum compressive strength observed was 41.55 N/mm^2 (when 15% Paper sludge ash + 15% fly ash was replaced by weight of OPC) which was 8.62% greater than control mix M30.

M25 Grade

In case of M25 grade, without replacing OPC by Paper sludge ash and fly ash the compressive strength was 31.6 N/mm^2, at replacement of OPC by combination of '5%

Paper sludge ash + 5% fly ash', '10% Paper sludge ash + 10% fly ash', '15% Paper sludge ash + 15% fly ash, Paper sludge ash 30%, and Fly ash 30%' the compressive strength was 33.28 N/mm^2, 34.46 N/mm^2, 35.10 N/mm^2, 28.83 and 27.51 respectively.

M30 Grade

In case of M30 grade, without replacing OPC by Paper sludge ash and fly ash the compressive strength was 38.61 N/mm^2, at replacement of OPC by combination of '5% Paper sludge ash + 5% fly ash', '10% Paper sludge ash + 10% fly ash', '15% Paper sludge ash + 15% fly ash, Paper sludge ash 30%, and Fly ash 30%' the compressive strength was 39.94 N/mm^2, 41.14 N/mm^2, 41.55 N/mm^2, 37.00, and 34.18 respectively.

3.4 Flexural Strength

Flexural strength of concrete was increased in mixes M25 & M30, replacing OPC with 'Paper sludge ash + fly ash' (0% to 15% Paper sludge ash with increment of 5% & 0% to 15% fly ash with increment of 5%), maximum flexural strength observed in M25 grade was 5.32 N/mm^2 (when 15% Paper sludge ash + 15% fly ash was replaced by weight of OPC) which was 18.57% greater than control mix M25 and M30 grades and in case of M30, maximum flexural strength observed was 6.13 N/mm^2 (when 15% Paper sludge ash + 15% fly ash was replaced by weight of OPC) which was 19.26% greater than control mix M30.

M25 Grade

In case of M25 grade, without replacing OPC by Paper sludge ash and fly ash the flexural strength was 4.48 N/mm^2, at replacement of OPC by combination of ''5% Paper sludge ash + 5% fly ash', '10% Paper sludge ash + 10% fly ash', '15% Paper sludge ash + 15% fly ash, Paper sludge ash 30%, and Fly ash 30%'' the flexural strength was 4.81N/mm^2, 5.17 N/mm^2, 5.32 N/mm^2 , 5.11 N/mm^2 and 4.92 N/mm^2 respectively.

M30 Grade

In case of M30 grade, without replacing OPC by Paper sludge ash and fly ash the flexural strength was 5.14 N/mm^2, at replacement of OPC by combination of '5% Paper sludge ash + 5% fly ash', '10% Paper sludge ash + 10% fly ash', '15% Paper sludge ash + 15% fly ash, Paper sludge ash 30%, and Fly ash 30%'' the flexural strength was 5.54N/mm^2,5.90 N/mm^2,6.13 N/mm^2 ,5.67 N/mm^2, and 5.34 N/mm^2 respectively.

3.5 Splitting Tensile Strength

Split tensile strength of concrete was increased in mixes M25 & M30, replacing OPC with 'Paper sludge ash + fly ash' (0% to 15% Paper sludge ash with increment of 5% & 0% to 15% fly ash with increment of 5%), maximum split tensile strength observed in M25 grade was 4.90 N/mm^2 (when 15% Paper sludge ash + 15% fly ash was replaced by weight of OPC) which was 23.11% greater than control mix M25 and M30 grades and in case of M30, maximum compressive strength observed was 5.49 N/mm^2 (when 15% Paper sludge ash + 15% fly ash was replaced by weight of OPC) which was 18.85% greater than control mix M50.

M25 Grade

In case of M25 grade, without replacing OPC by Paper sludge ash and fly ash the split tensile strength was 3.98 N/mm^2, at replacement of OPC by combination of '5% Paper sludge ash + 5% fly ash', '10% Paper sludge ash + 10% fly ash', '15% Paper sludge ash + 15% fly ash, Paper sludge ash 30%, and Fly ash 30%'' the split tensile strength was 4.29 N/mm^2, 4.60 N/mm^2, 4.90 N/mm^2 4.36 N/mm^2, and 4.09 respectively.

M-30 Grade

In case of M30 grade, without replacing OPC by Paper sludge ash and fly ash the split tensile strength was 4.62 N/mm^2, at replacement of OPC by combination of ''5% Paper sludge ash + 5% fly ash', '10% Paper sludge ash + 10% fly ash', '15% Paper sludge ash + 15% fly ash, Paper sludge ash 30%, and Fly ash 30%'' the split tensile strength was 4.93 N/mm^2,5.23 N/mm^2, 5.49 N/mm^2 ,5.18 N/mm^2, and 4.84 N/mm^2 respectively

3.6 Cost Analysis

M25 Grade

The saving cost in percentage of cementitious material is 8.84, 19.40, 32.22, 31.14 and 33.33 by replacement of Paper sludge ash and fly ash by weight of OPC (Paper sludge ash from 0% to 15% with increment of 5% + fly ash from 0% to 15% with increment of 5%).

M30 Grade

The saving cost in percentage of cementitious material is 2.61, 12.57, 24.66, 23.63 and 25.69 by replacement of Paper sludge ash and fly ash by weight of OPC (Paper sludge ash from 0% to 15% with increment of 5% + fly ash from 0% to 15% with increment of 5%).

Final Conclusion

(1) In my work increasing the value of compressive strength, splitting tensile strength, flexure strength and decrease the value of density slump when percentage increase of paper sludge ash and fly ash.
(2) Also saving the cost of cement upto 33.33% when use of M25 grade of concrete and 25.69% when use M30 grade of concrete.

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BIOGRAPHIES

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