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Strength of Concrete Grade M30 & M35 by Partial Replacement of Cement with Paper Ash and Fly Ash

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Abstract

In this paper identify utilizations of waste paper ash to produce on economic concrete by blending various proportion of cement with waste paper ash along with fly ash there by and to reduce disposal and related pollution problems. In this innovative use of waste paper ash in concrete as a supplementary cementitious material along with fly ash explored. In this thesis main study to evaluate the effects on the proportion of concrete with paper 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 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 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to partially replace OPC which varies from 0% to 15% at interval of 5% by total weight of OPC and similarly cement has been replaced by fly ash which varies 0% to 15% at interval of 5% by total weight of cement in the equal proportion and prepared for M30 & M35 grade of concrete. This study investigates the performance of concrete under the influence of paper 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.

Keywords: Concrete, paper ash, Fly ash, Workability, Compressive Strength, Flexural Strength, Splitting Tensile Strength.

Introduction

Cement

Table 1: Properties of Cement OPC 43 grade

Chemical Composition	Values
Surface Area	3000 (cm^2/gm)
Calcium oxide (CaO)	63%
Silicon dioxide (SiO_2)	18%
Aluminium oxide (Al_2O_3)	6%
Ferric oxide (Fe_2O_3)	4%
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

Table 2: Chemical Properties of Paper Ash

Properties	Approximate Value
Surface Area	3300(cm^2/gm)
Specific Gravity	2.62
Calcium oxide (CaO)	14.61%
Silicon dioxide (SiO_2)	47.79%
Aluminium oxide (Al_2O_3)	0.08%
Magnesium oxide (MgO)	6.34%
Sulfur trioxide (SO_3)	0.18%
Ferric oxide (Fe_2O_3)	0.74%
Sodium oxide (Na_2O)	0.2%

Table 3: Physical and Chemical Properties of Fly Ash

Properties	Approximate Value
Surface Area	3500 (cm^2/gm)
Specific gravity	2.3
Silica (SiO_2)	52.0%
Aluminum (Al_2O_3)	31.0%
Iron (Fe_2O_3)	4.0%
Calcium (CaO)	5.0%
Magnesium (MgO)	2.0%
Sodium (Na_2O)	0.5%
Potassium (K_2O)	0.8%
Sulphur (SO_3)	0.2%

Table 4: Final Mix Proportion (M30 Grade of Concrete)

% Mix (Cement + Paper Ash + Fly ash)	Corrected Cement (Kg/ m^3)	Corrected Coarse Aggregate 20mm (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 +WPA (100+0+0)	414.43	708.76	434.43	693.42	0	162	4.14
OPC + FA +WPA (100+5+5)	373.97	678.40	415.78	663.72	41.44	162	3.72
OPC + FA +WPA (80+10+10)	330.52	637.89	390.76	624.38	82.89	162	3.31

OPC + FA +WPA (70+15+15)	290.28	617.66	378.58	604.26	124.39	162	2.90
OPC + FA +WPA (70+0+30)	290.08	617.65	378.53	604.27	124.33	162	2.90
OPC + FA +WPA (70+30+0)	290.08	617.65	378.57	604.25	124.37	162	2.90

Table 5: Final Mix Proportion (M35 Grade of Concrete)

% Mix (Cement + Paper 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+WPA(100+0+0)	445.41	676.88	414.35	693.43	0	162	4.45
OPC + FA+WPA(100+5+5)	400.05	678.40	415.79	663.71	44.95	162	4.0
OPC + FA+WPA(80+10+10)	356	637.89	390.96	624.08	89.41	162	3.56
OPC + FA+WPA(70+15+15)	311.50	617.65	378.54	604.27	131.91	162	3.11
OPC + FA	311.50	617.65	378.54	604.27	131.91	162	3.11

Results of fresh Concrete Compressive Strength Compressive strength of concrete mixes with the replacement of paper 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 6: 7 & 28 Days Compressive Strength of Cube on Replacement of OPC by Paper Ash & Fly Ash for M30

Sn.	% Mix (Cement + Paper Ash + Fly Ash)	Average for Compressive Strength M30 (N/mm^2)	
		7 Days	28 Days
1	OPC + FA +WPA (100+0+0)	24.55	38.62
2	OPC + FA +WPA (100+5+5)	27.07	39.87
3	OPC + FA +WPA (80+10+10)	29.44	41.73
4	OPC + FA +WPA (70+15+15)	31.24	41.67
5	OPC + FA +WPA (70+0+30)	28.45	37.00
6	OPC + FA +WPA (70+30+0)	26.33	34.28

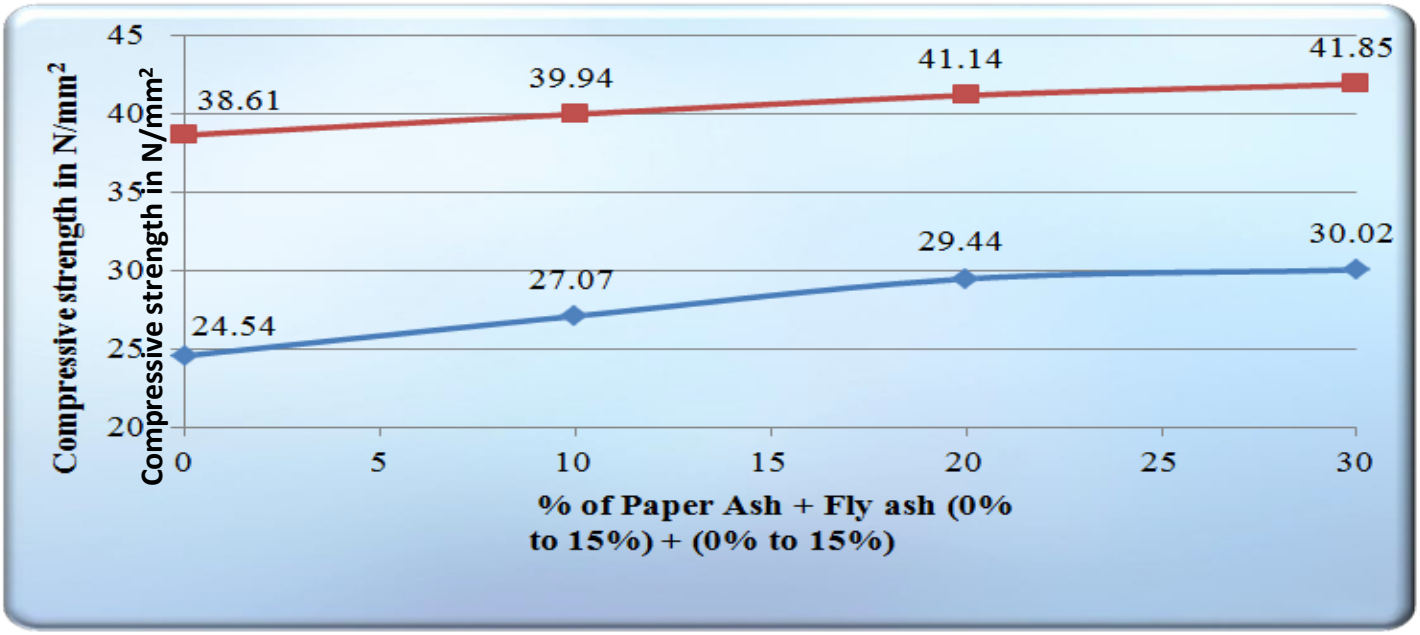

Figure 1: Effects of Paper Ash + Fly Ash on Concrete of M30 Grade

Table 7: 7 and 28 Days Compressive Strength of Cube on Replacement of OPC by Paper Ash & Fly Ash for M35

Sn.	% Mix (Cement + Paper Ash + Fly Ash)	Average for Compressive Strength M35 (N/mm^2)	
		7 Days	28 Days
1	OPC + FA +WPA (100+0+0)	33.54	43.91
2	OPC + FA +WPA (100+5+5)	34.67	44.54
3	OPC + FA +WPA (80+10+10)	35.54	45.24
4	OPC + FA +WPA (70+15+15)	36.22	46.75
5	OPC + FA +WPA (70+0+30)	31.65	44.10
6	OPC + FA +WPA (70+30+0)	30.13	40.28

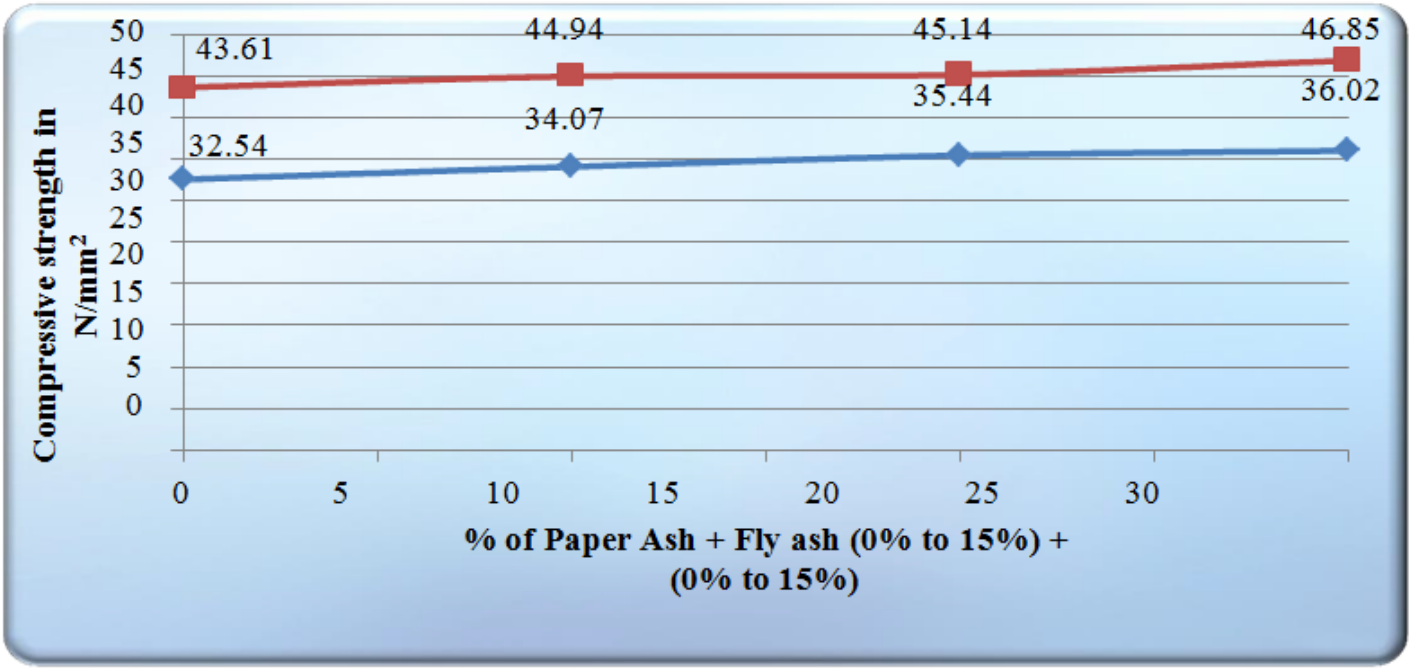

Figure 2

Flexural Strength

Flexural strength of concrete mixes with the replacement of Paper 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 8: 28 Days Flexural Strength of Beam on Replacement of OPC by Paper Ash & Fly Ash for M30

Sn.	% Mix (Cement + Paper Ash + Fly ash)	Average Flexural Strength M30 (N/mm^2)
1	OPC + FA +WPA (100+0+0)	5.16
2	OPC + FA +WPA (100+5+5)	5.57
3	OPC + FA +WPA (80+10+10)	5.40
4	OPC + FA +WPA (70+15+15)	6.23
5	OPC + FA +WPA (70+0+30)	5.37
6	OPC + FA +WPA (70+30+0)	5.37

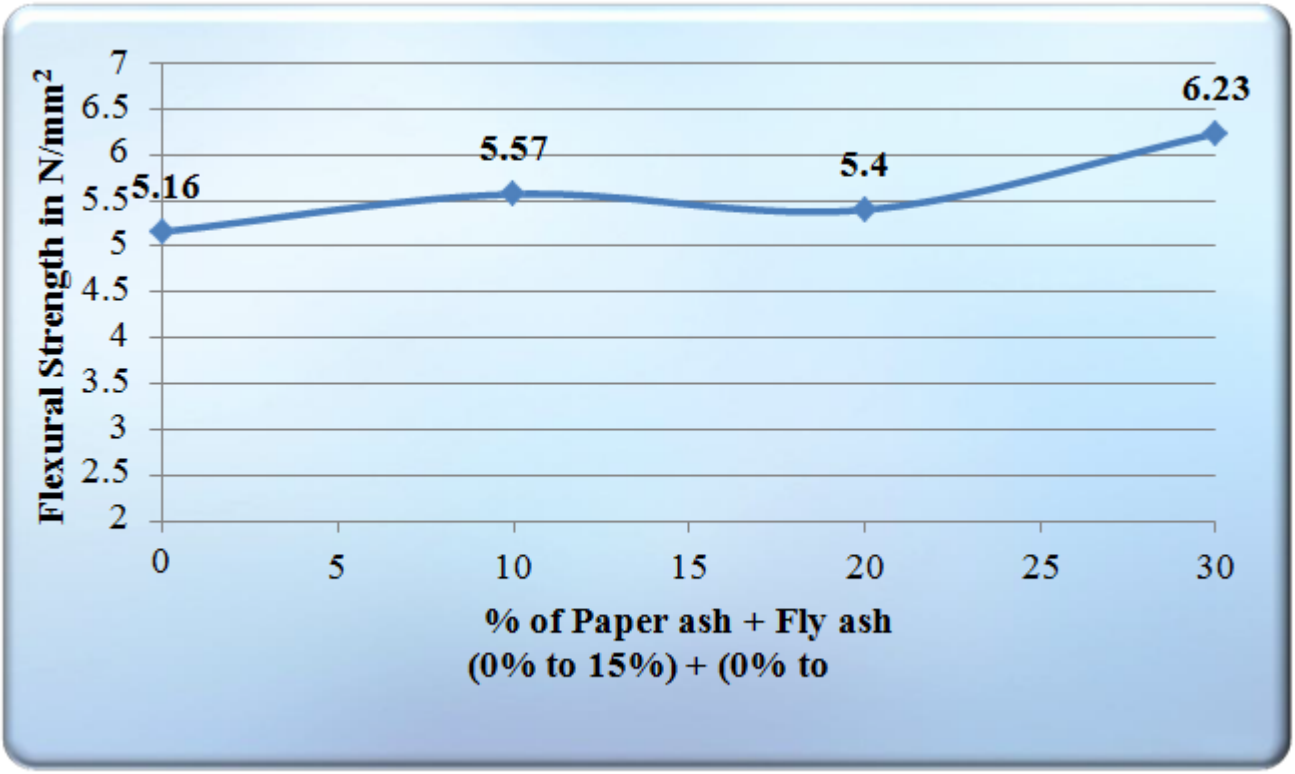

Figure 3: Effects of Paper Ash & Fly Ash on Concrete of M30 Grade on Replacement for 28 Days Flexural Strength of Beam.

Splitting Tensile Strength

Split tensile strength of concrete mixes with the replacement of Paper 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 9: 28 Days Splitting Tensile Strength of Cylinder on Replacement of OPC by Paper Ash & Fly Ash for M30

Sn.	% Mix (Cement + Paper Ash + Fly Ash)	Average Splitting Tensile Strength M30 (N/mm^2)
1	OPC + FA +WPA (100+0+0)	4.63
2	OPC + FA +WPA (100+5+5)	4.83
3	OPC + FA +WPA (80+10+10)	5.33
4	OPC + FA +WPA (70+15+15)	5.19
5	OPC + FA +WPA (70+0+30)	5.16
6	OPC + FA +WPA (70+30+0)	4.34

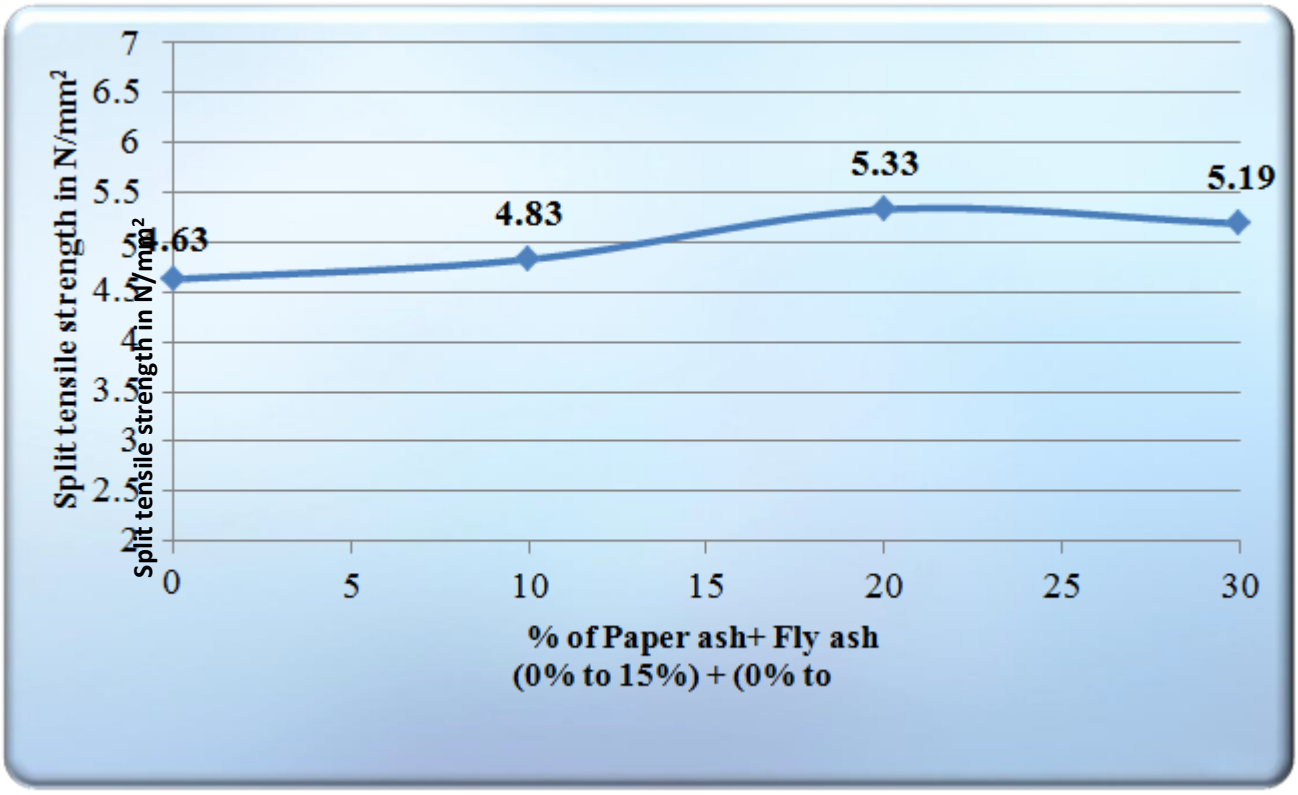

Figure 4: Effects of Paper Ash + Fly Ash on Concrete of M30 Grade on Replacement for 28 Days Splitting Tensile Strength of Cylinder

Table 10: 28 Days Splitting Tensile Strength of Cylinder on Replacement of OPC by Paper Sludge Ash & Fly Ash for M35.

Sn.	% Mix (Cement + Paper Sludge Ash + Fly ash)	Average Splitting Tensile Strength M35 (N/mm^2)
1	OPC + FA +WPSA (100+0+0)	5.62
2	OPC + FA +WPSA (100+5+5)	5.93
3	OPC + FA +WPSA (80+10+10)	6.23
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

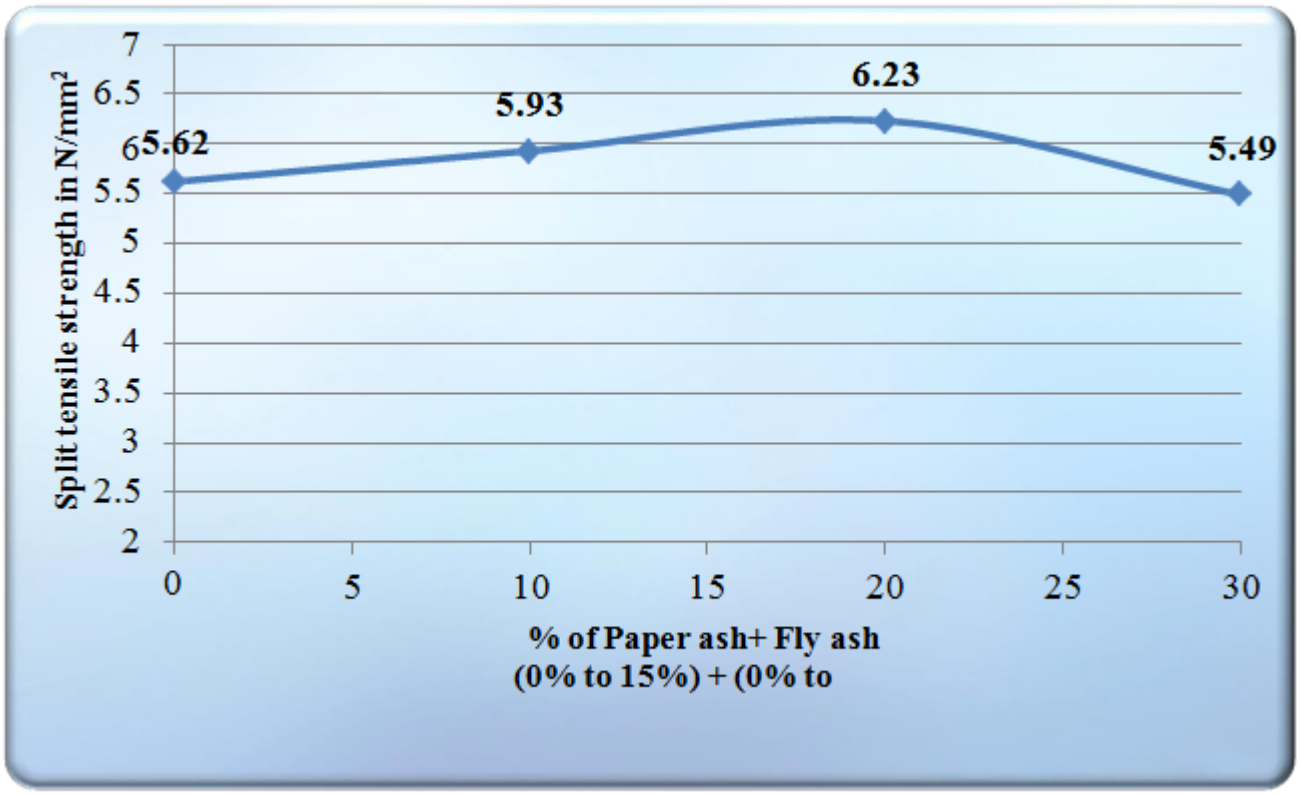

Figure 5: Effects of Paper Ash + Fly Ash on Concrete of M35 Grade on Replacement for 28 Days Splitting Tensile Strength of Cylinder

Conclusion

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

Slump M30: GradeIn the case of M30 grade of concrete without replacing OPC by Paper ash and fly ash the slump was 113 mm, at replacement of OPC by combination of 5% Paper ash + 5% fly ash, 10% Paper ash + 10% fly ash, 15% Paper ash + 15% fly ash and Paper ash 30%, and Fly ash 30%' the slump was 105mm, 100mm, 96mm, 89mm and 80mm respectively.

M35 Grade: In the case of M35 grade of concrete without replacing OPC by Paper ash and fly ash the slump was 105 mm, at replacement of OPC by combination of 5% Paper ash + 5% fly ash, 10% Paper ash + 10% fly ash, 15% Paper ash + 15% fly ash, Paper 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 M35 (when 0% Paper ash along with 0% fly ash was replaced by weight of OPC). In the case of M35 the slump value was 105 mm (when 0% Paper ash along with 0% fly ash was replaced by weight of OPC).

Compressive Strengt

M30 Grade: In the case of M30 grade of concrete without replacing OPC by Paper ash and fly ash the compressive strength was 31.6 N/mm^2, at replacement of OPC by combination of '5% Paper ash + 5% fly ash', '10% Paper ash + 10%

fly ash', '15% Paper ash + 15% fly ash, Paper 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.

M35 Grade: In the case of M35 grade of concrete without replacing OPC by Paper ash and fly ash the compressive strength was 43.61 N/mm^2, at replacement of OPC by combination of '5% Paper ash + 5% fly ash', '10% Paper ash + 10% fly ash', '15% Paper ash + 15% fly ash, Paper ash 30%, and Fly ash 30%' the compressive strength was 44.94 N/mm^2, 45.14 N/mm^2, 46.85 N/mm^2, 44.00, and 40.18 respectively.

Flexural Strength M30 Grade: In the case of M30 grade of concrete without replacing OPC by Paper ash and fly ash the flexural strength was 4.48 N/mm^2, at replacement of OPC by combination of ''5% Paper ash + 5% fly ash', '10% Paper ash + 10% fly ash', '15% Paper ash + 15% fly ash, Paper 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.

M35 Grade: In the case of M35 grade of concrete without replacing OPC by Paper ash and fly ash the flexural strength was 6.14 N/mm2, at replacement of OPC by combination of '5% Paper ash + 5% fly ash', '10% Paper ash + 10% fly ash', '15% Paper ash + 15% fly ash, Paper ash 30%, and Fly ash 30%'' the flexural strength was 6.54N/mm2,6.90 N/mm2,7.13 N/mm2 ,6.67 N/mm2, and 6.34 N/mm2 respectively.3.4

Splitting Tensile Strength

M30 Grade: In the case of M30 grade of concrete without replacing OPC by Paper ash and fly ash the split tensile strength was 3.98 N/mm^2, at replacement of OPC by combination of '5% Paper ash + 5% fly ash', '10% Paper ash + 10% fly ash', '15% Paper ash + 15% fly ash, Paper 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.

M35 Grade: In the case of M35 grade of concrete without replacing OPC by Paper ash and fly ash the split tensile strength was 5.62 N/mm^2, at replacement of OPC by combination of ''5% Paper ash + 5% fly ash', '10% Paper ash + 10% fly ash', '15% Paper ash + 15% fly ash, Paper ash 30%, and Fly ash 30%'' the split tensile strength was 5.93 N/mm^2,6.23 N/mm^2, 5.49 N/mm^2 ,5.18 N/mm^2, and 4.84 N/mm^2 respectively.

Final Conclusion

- In this, increasing the value of compressive strength, splitting tensile strength, flexure strength and decrease the value of density slump when percentage increase of paper ash and fly ash.
- Also saving the cost of cement up to 23.33% when use of M30 grade of concrete and 20.69% when use M35 grade of concrete.

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