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Physical Characteristics of Cement Mortar Containing WPS Ash and PF as Partial Replacement of Cement and Sand

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ABSTRACT

The Waste Paper Sludge (WPS) discharged from paper mills is creating environmental pollution, like, air pollution and land pollution. Hence it is suggested to reuse the paper sludge in the form of ash after incinerating at high temperature for the replacement of cement and sand in cement mortar. In this research works, it is planned to ascertain the physical performance of the cement mortar containing paper sludge. On the basis of the results obtained by conducting several tests, it is concluded that when the sand and cement replaced by waste paper sludge ash, the flow properties of the cement mortar containing paper sludge are improved by adding the Superplasticizer. The water absorption and weight reduction of the cement mortar containing paper sludge are enhanced by adding Polypropylene Fibre.

KEYWORDS: *Waste Paper Sludge, Superplasticizer, Polypropylene Fibre, Slump, Water Absorption, Weight Reduction*

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1. INTRODUCTION

At present the concrete is the important construction materials. The concrete production is about 12 billion tons a year [1]. It is almost nearly 1m^3 per person per day and correspondingly the production of cement is 3 billion tons per year [1]. The recycling process of paper produces ash which has potential useful application in construction. The WPS contains cementitious properties. Hence the waste paper sludge ash is used as a construction material [2-8]. Addition of waste paper sludge to geopolymer mortar reduces flow properties, primarily due to dry sludge absorbing water from the binder mix. The average 91-day compressive strength of mortar samples incorporating 2.5 wt% and 10 wt% wastepaper sludge respectively retained 92% and 52% of the reference mortar strength [9]. The brick with 5–20% addition of cement to Recycle Paper Mills Waste exhibits a compressive strength of 9 MPa which is three times greater than the conventional clay bricks (3 Mpa) and satisfies the requirements in BS6073 for a building material to be used in the indoor structural applications [10]. WPS is a cementitious material in which some constituents hydrate faster than others. The free lime in the WSA reacts with water immediately upon soaking and provides a highly alkaline pore solution, which then results in the release of more reactive phases such asAl_2O_3 and SiO_2 into the system[11].

Therefore, it is suggested to reuse the WPS in the form of ash for replacement of Sand and Cement in the Cement Mortar.

The type of Paper Sludge is NG Kraft. This research works aims to investigate the physical properties such as Flow ability, water Absorption and Weight Reduction of Cement Mortar Containing Paper Sludge with and without incorporated Polypropylene Fibre.

2. MATERIALS USED IN THE RESEARCH WORK

The basic materials used in the present research work are: Ordinary Portland Cement (OPC) Grade 33, Fine Aggregate, WPS ash, Polypropylene Fibre, Superplasticizer and tap water.

2.1. Cement

The purpose of using the cement is to obtain strength and provide cohesion with other constituent materials which is used in the Cement Mortar. The cement used in the research work is OPC 33grade. The Specific Gravity of Cement used is 3.10. The cement contains large amount of Oxides of Calcium, Silicon, Aluminium and Iron.

2.2. Fine Aggregate

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The river bed sand is used in this research work. The size of the river sand is varying from 0.1mm to 2mm. The specific gravity and Fineness modulus of sand are 2.644 and 2.823 respectively.

2.3. Waste Paper Sludge (WPS)

WPS becomes a new innovation material that can be used as material for masonry to support the green technology due to less presence of Potassium at only 0.87% of the total weight. Oxides of Sodium and Sulphur emission also can be reduced since less cement productivity is involved. The chemical and physical properties of the WPS were determined by comparing it with the Ordinary Portland Cement (OPC). The chemical compositions of the WPS ash are mentioned in the table 1. It contains large amount of Oxides of Calcium (CaO), Silicon (SiO_2) and Aluminium (Al_2O_3). The WPS ash is used as a binder material for the replacement of Cement and Sand in the form of ash after burning the Sludge at 300°C in the incubator. The purpose of using the waste paper sludge in this research work is to reduce the self weight of member and avoid the air pollution as well as land pollution. The specific gravity of WPS is 3.163 and density is 636.62 kg/m^3.

2.4. Polypropylene Fibre

The total demand for polypropylene fibres in North America was 3,750 million pounds in 1998. The demand for PF is projected to grow at the rate of 5.2% annually for the next five years. The total demand for PF in Western Europe was about 3,520 million pounds in 1998, and it is projected to grow at 3% annually for the next five years.

The total demand for PF in Japan was 338 million pounds in 1998, and it is projected to grow at 4.5% per year for the next five years. The excellent properties and the process ability of polypropylene resins triggered the replacement of some synthetic as well as natural fibres.

The size of the PF used in the research work is 12mm length and orientation of the fibre is random. The product name of the fibre used is Recron 3S. The dosage of fibre is 0.5% by weight of Cement.

2.5. Superplasticizer

In this investigation, Superplasticizer Conplast SP 430, based on sulphonated naphthalene polymers, complies with IS 9103-1999, BS: 5075 part 3 and ASTM C – 494, Type F was used. Commercially available high performance super plasticizing admixture, Conplast SP430, conforming to ASTM C 494 (1992) was used to maintain the slump of the concrete. The properties, supplied by the manufacturer, are given in Table 1.

Table 1: Properties of Superplasticizer

Properties	Conplast SP430
Composition	Sulphonated naphthalene formaldehyde condensate
Active solids (% by wt.)	40
Appearance	Brown liquid
Specific gravity	1.20 at 20°C
Air entrainment (%)	< 2
Chloride content (%)	Nil
pH value	7.0 - 8.0

2.6. Properties of CM containing WPS

The Cement paste blended with 0%, 2%, 4%, 6%, 8%, 10% &, 15%, 20% and 25% were prepared to investigate their Physical Performance. The Initial and Final setting time, Slump, Water absorption and Weight reduction of the Cement Mortar for the replacement of Sand and Cement of Various proportions were examined.

2.7. Mix Design

The mix design for all the mortars is indicated in the table 2. The Cement (binder): Sand ratio kept as 1:3 and Water: Cement (binder) ratio was 1:2 for all mortars. The Superplasticizer Conplast SP 430 is used to improve the flow property at the rate of 1 litre per m^3 of CM.

3. RESULTS AND DISCUSSIONS

3.1. Initial and Final setting time

The initial and final setting time of the Cement Mortar containing WPS are given in the table 3. The setting time of the Cement Mortar containing paper sludge was decreased with the increasing the percentage of replacement of paper sludge. The reason for increasing the setting times of the Cement Mortar containing Paper Sludge is due to the presence of Sulphur, Potassium, Iron and Antimony in the form of Oxides in the paper sludge ash.

Table 2: Mix Design of Cement Mortar samples containing WPS

Sl. No	% of WPS Ash	For replacement of Sand				For replacement of Cement			
		Wt. of Cement in g	Wt. of sand in g	Vol. of water in ml	Wt. of WPS Ash in g	Wt. of Cement in g	Wt. of sand in g	Vol. of water in ml	Wt. of WPS Ash in g
1	0	450	1350	225	0	450	1350	225	0
2	2	450	1323	225	27	441	1350	225	9
3	4	450	1296	225	54	432	1350	225	18
4	6	450	1269	225	81	423	1350	225	27
5	8	450	1242	225	108	414	1350	225	36
6	10	450	1215	225	135	405	1350	225	45
7	15	450	1147	225	203	383	1350	225	68
8	20	450	1080	225	270	360	1350	225	90
9	25	450	1012	225	338	338	1350	225	113

Table 3: Initial and Final setting time for the Cement paste sample containing Paper Sludge Ash

Sl. No.	% of WPS Ash	For replacement of Sand		For replacement of Cement	
		Initial Setting Time in min.	Final Setting Time in min.	Initial Setting Time in min.	Final Setting Time in min.
1	0	69	515	59	463
2	2	65	503	57	461
3	4	62	484	54	455
4	6	56	472	51	451
5	8	53	466	50	448
6	10	51	461	49	445
7	15	50	457	47	432
8	20	48	451	43	420
9	25	46	443	41	415

3.2. Slump

Table 4 shows the relationship between the percentage of replacement of Paper Sludge and percentage of Slump reduction in the fresh Cement Mortar. The slump value is decreasing with increasing the percentage of replacement of Paper Sludge.

The reason for decreasing the Slump value while increasing the percentage of Paper Sludge due to the size of mineral admixture available in the Paper Sludge ash is very finer than the size of mineral admixture of Ordinary Portland Cement and it demands more water. The slump value has controlled by adding the Superplasticizer. The brand of Superplasticizer is Conplast SP430 and dosage of Superplasticizer is 1 litre per m^3 of Cement Mortar.

Table 4: Slump of the Cement Mortar containing Paper Sludge

Sl. No.	% of WPS Ash	Without adding Superplasticizer				With adding Superplasticizer			
		For replacement of Sand		For replacement of Cement		For replacement of Sand		For replacement of Cement	
		Slump in mm	% of reduction	Slump in mm	% of reduction	Slump in mm	% of reduction	Slump in mm	% of reduction
1	0	191	0.00	191	0.00	191	0	191	0.00
2	2	188	1.57	189	1.05	188	1.57	189	1.05
3	4	184	3.66	187	2.09	186	2.61	187	2.09
4	6	181	5.24	184	3.67	184	3.66	185	3.14
5	8	175	8.38	181	5.24	182	4.71	184	3.67
6	10	171	10.47	178	6.81	178	6.81	181	5.24
7	15	162	15.18	172	9.95	173	9.42	178	6.81
8	20	151	20.94	161	15.71	165	13.61	172	9.95
9	25	138	27.74	148	22.51	154	19.37	167	12.57

3.3. Water absorption and Weight reduction

The test for water absorption and Weight reduction of the Cement Mortar containing Paper Sludge for the replacement of Sand and Cement was carried out by casting 3 Nos. of 70.7 x 70.7 x70.7 mm cubes in each replacement of Paper Sludge. The percentage of replacement is 0%, 2%, 4%, 6%, 8%, 10% & 15%, 20% and 25% . The water absorption of Cement Mortar containing Paper Sludge for replacement of Sand and Cement was noted at the age of 1 day, 7 days and 28 days curing.

The Figure 1 and 2 show that the percentage of water absorption for the various percentage of Paper Sludge for Sand and Cement respectively. The result shows that the percentage of water absorption is increasing by increasing the percentage of Paper Sludge in both Sand and Cement replacement with respect to age of curing. The water absorption of the Cement Mortar has controlled by adding the Polypropylene Fibre with Paper Sludge. The percentage of water absorption is more in the replacement of Sand than Cement. The water absorption of the Cement Mortar for the replacement of Sand without adding of Polypropylene Fibre at the rate of 25% of replacement is 4.24% higher than that of Cement replacement. At the same time for the same replacement, when the Polypropylene Fibre added the percentage of water absorption of Cement Mortar for the replacement of sand and Cement is reduced by 0.8% and 2.87% respectively.

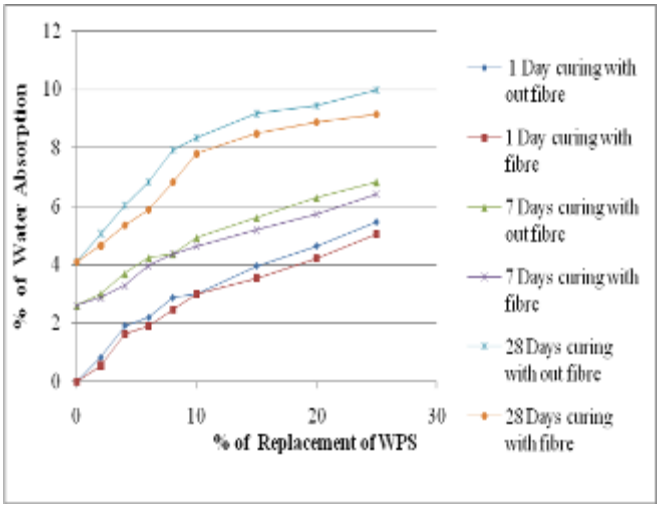

Fig.1: Water Absorption of Paper Sludge Mortar for replacement of Cement.

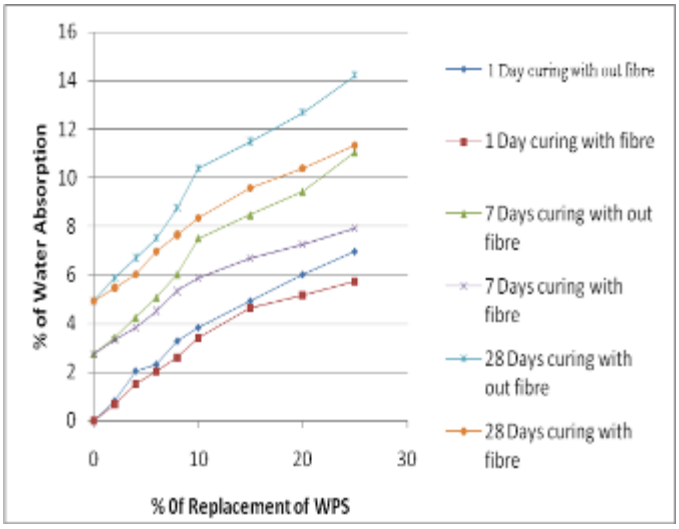

Fig.2: Water Absorption of Paper Sludge Mortar for replacement of Sand.

The weight reduction of Cement Mortar containing Paper Sludge for replacement of Sand and Cement was noted at the age of 1 day, 7 days and 28 days drying. The Figure 3 and 4 show that the percentage of weight reduction for the various percentage of Paper Sludge for Sand and Cement respectively. The result shows that the percentage of weight reduction is increasing by increasing the percentage of Paper Sludge in both Sand and Cement replacement with respect to age of drying. The weight reduction of the Cement Mortar has controlled by adding the Polypropylene Fibre with Paper Sludge.

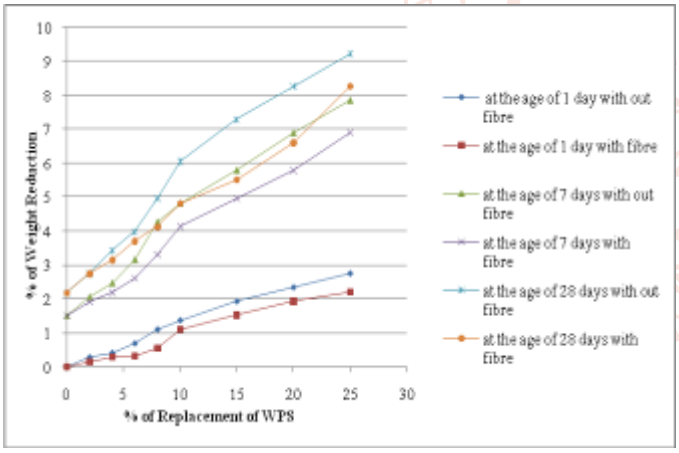

Fig.3: Weight Reduction of Paper Sludge Mortar for replacement of Cement.

The percentage of weight reduction is more in the replacement of Sand than Cement. The weight reduction of the Cement Mortar for the replacement of Sand without adding Polypropylene Fibre at the rate of 25% of replacement is 5.1% higher than that of Cement replacement. At the same time for the same replacement, when the Polypropylene Fibre added the percentage of weight reduction of Cement Mortar for the replacement of sand and Cement is reduced by 0.98% and 1.51% respectively.

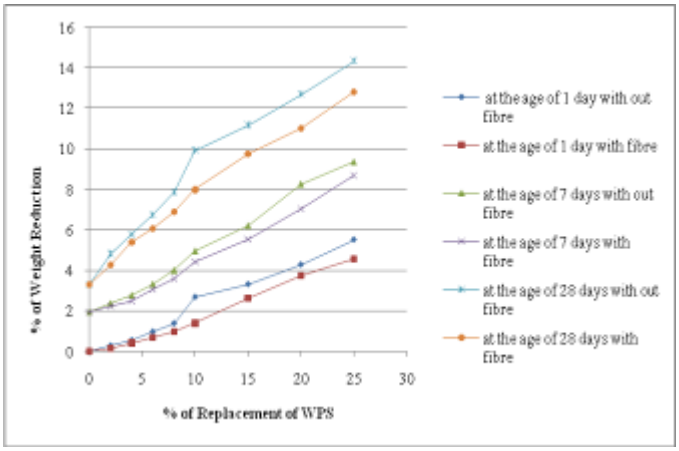

Fig.4: Weight Reduction of Paper Sludge Mortar for replacement of Sand

The reason for increasing the percentage of water absorption and the weight reduction is due to the size of the mineral admixtures present in the paper sludge. The size of mineral admixture is very finer than the size of admixture of Ordinary Portland Cement.

4. CONCLUSION:

- The flow property of the Cement Mortar containing Paper Sludge has improved by adding Superplasticizer Conplast SP430.
- The water absorption and weight reduction of the Cement Mortar containing Paper Sludge is increasing while increasing the percentage of replacement of WPS ash. These two properties has controlled by adding the Polypropylene Fibre.

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