STUDIES ON THE INTERACTION OF POLYPROPYLENE FIBER WITH MORTAR MADE OF CEMENT AND BOTTOM ASH

Mr. Prabakaran V[1*], Dr. Ramadoss P[2],

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Abstract:
This paper investigates on analyzing studies on effect of Polypropylene fiber with bottom ash-based cement mortar. An experimental study was conducted on the cement mortar reinforced by the different percentages of polypropylene fiber (0, 0.25, 0.5, 0.75 &1%) with partial replacement of sand by bottom ash (0%, 5%, 10%, 15% & 20%) of cement mortar 1:2. Different tests have been carried out to determine mechanical properties like the flow table test, compressive strength and flexural strength at age of testing 3, 7, 28 days was conducted on reference and polypropylene fiber reinforced with bottom ash based cement mortar specimens. The results show that the use of polypropylene fiber gives an unambiguous improvement in these properties and bottom ash thus the optimum percentages for this fiber have been taken into consideration. The results show a significant increasing in compressive strength and flexural strength with the increment of fiber content in cement mortar. It is also observed that addition of bottom ash and Polypropylene fiber leads to reduction in workability of cement mortar.

Keywords–Bottom ash, Polypropylene fibre, Compressive strength, Flexural strength.

[1*]Associate Professor Department of Civil Engineering, Puducherry Technological University, Puducherry.
[2]Professor, Department of Civil Engineering Puducherry Technological University, Puducherry

***Corresponding Author**: Mr. Prabakaran V
*Associate Professor Department of Civil Engineering, Puducherry Technological University, Puducherry.

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I. INTRODUCTION

Mortar is a paste that hardens to connect building elements like stones, bricks, and concrete masonry units, fill irregular gaps between them, distribute their weight evenly, and on sometimes provide lovely colors or patterns to masonry walls. a mortar that is fluid enough to be used easily without crumbling; additives called plasticizers can increase plasticity. To drastically reduce the consumption of natural resources and safeguard the interests of coming generations, it is now essential to develop new sustainable materials. High natural resource use led to increased creation of industrial waste and environmental damage. Researchers have come up with solutions in response to these difficulties since sustainable development is essential. The largest man-made substance in the entire globe, is cement mortar and concrete.

Cement mortar serves as the sacrificial element in masonry while also acting as a weaker component than the building blocks because it is easier and less expensive to repair than building blocks. Cement mortar hardens and dries to form a stable aggregate structure. Ordinary Portland Cement mortar, also known as OPC mortar or simply cement mortar, is created by mixing Ordinary Portland Cement (OPC) powder, fine aggregate, and water. The most important function of the fine aggregate is its ability to contribute to the workability and uniformity of a mixture. The study demonstrated that the behavior of cement mortar can be significantly changed by adding bottom ash, and that durable concrete can be made by improving cement mortar behaviour cement undergoes a curing process during construction.

II. CHARACTERISTICS OF MATERIALS

a. Cement

OPC 53 Grade cement is required to conform to BIS specification IS: 12269-1987with a designed strength for 28 days being a minimum of 53 MPa or 530 kg/sqcm. 53 Grade OPC provides high strength and durability to structures because of its optimum particle size distribution and superior crystallized structure.

b. Fine aggregate

Manufactured sand (M-Sand) is used as the final aggregate. High-quality M-sand that can pass through a 4.76 mm screen and is free of silt and other contaminants is used in this investigation. The strength of the cement mortar is significantly influenced by the strength of the fine aggregate. In this project, the locally available M-sand Zone II is used. The fine aggregate complies with the requirements of the Indian standard specification. The results of a few experiments on m-sand are displayed in the table below.

c. Bottom ash

Coal and lignite fired thermal power plants have created tremendous volumes of coal bottom ash (LBA) and coal fly ash (CFA) (20–80% respectively) for years. LBA and CFA are the by-products of pulverized lignite and coal combustion. Lignite Bottom ashes have angular particles with a very porous surface texture. Bottom ash particles range in size from a fine gravel to a fines and with very low percentages of silt-clay sized particles. The dried bottom ash is then sieved and the desired size is taken for the replacement of M-sand. The bottom ash is usually a well graded material, although variations in particle size distribution may been countered in ash samples taken from the same power plant at different times. It has low specific gravity and has porous or vesicular texture.

Figure 2.1 Lignite Bottom Ash (LBA)

Table 1: Physical Properties of Raw Materials

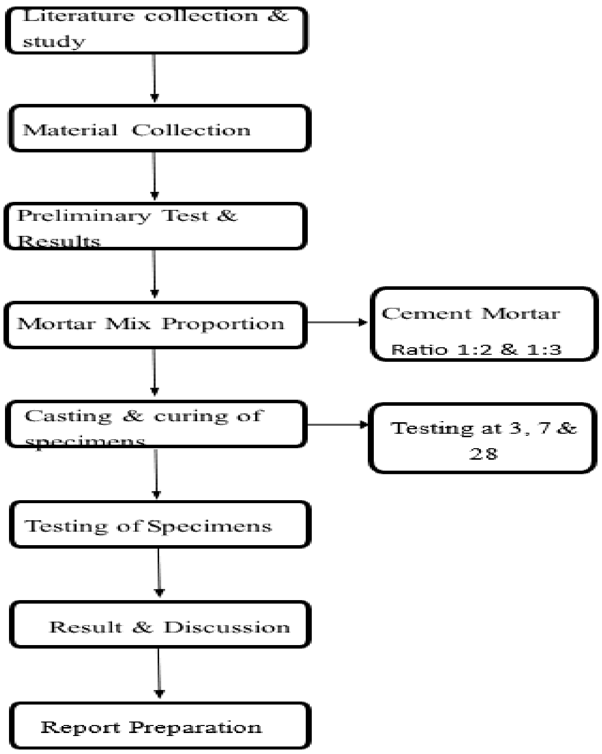
S. No.	Raw Materials	Property	CodalProvisions	Result
1.	OPC	Specificgravity	(IS2720-PartIII1980)	3.14
		Standardconsistency	(IS4031-PartV1988)	30%
		Settingtime	(IS4031-PartIV1988)	Initial:120minutes Final:360minutes
2.	Fine Aggregate	Sieveanalysis	IS383:2016&IS2386PartI:1963	ZoneII
		Finenessmodulus	IS383:2016&IS2386PartI:1963	2.9
		Specificgravity	IS2386PartIII:1963	2.7
		Bulkdensity	IS2386PartIII:1963	1922kg/m^3
3.	Bottom Ash	Finenessmodulus	(IS5816-1959)	2.57
		Specificgravity	(IS5816-1959)	3.0
		Bulkdensity	(IS3812-PartI:2013)	1050Kg/m^3

d. Polypropylene fiber

Polypropylene(PP),alsoknownaspolypropene,is athermoplasticpolymerusedin a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene. Chemical formula $(C3H6)_n$ Density 0.855g/cm3, amorphous0.946g/cm3, crystalline. Melting point 130 to 171°C (266 to 340°F; 403 to 444K). Polypropylene is similar to polyethylene in many ways, particularly in terms of solution behavior and electrical characteristics. Although the chemical resistance decreases, the methyl group improves mechanical properties and thermal resistance. The molecular weight and molecular weight distribution, crystalline, type and amount of monomer (if employed), and isotacticity of all influence the characteristics of polypropylene. The methyl groups in isotactic polypropylene, for example, are orientated on one side of the carbon backbone. This arrangement produces more crystallinity and a stronger material that is less susceptible to creep than polyethylene.

FIGURE 1 POLYPROPYLENE FIBERS

III. METHODOLOGY OF THE RESEARCH WORK



IV. MIX METHODS AND TESTING

Mix proportion used in this study was 1:2 with water-cement ratio of 0.45. Weight batching and manual mixing areadopted in this study for cement mortar production. In each mix for workability, compressive and flexural strength were determined on 40x40x160 mm specimens at 3,7, 28 days. The lignite bottom ash was used to replace partially sand, the replacement levels from 0%,5%, 10%, 15% & 20%,and addition of polypropylene fibre 0.25%, 0.5%,0.75%, 1% respectively. To study the strength aspects the various cement mortar mixes of bottom ash and polypropylene fibre mortar standard moulds of size (40X40x160mm) were used for preparing the mortar prisms. For each type ofmix, 12 mortar prisms were casted, 3 specimens were considered for each age (i.e., at 3 days, 7 days and 28 days).

a. Flow table test

Flow table test for each and everymix was carried out and thew/b ratio requiredfor gauging to produce a flow of (110±5) was measured. This test procedure was followed as per IS PART 7-1988.

$$\text{Flowvalue}(\%)=[(D_{avg}-D_0)/D_0]\times 100$$

FIGURE:2 Casting and testing of specimens

V. RESULTS AND DISCUSSIONS

a. Flow characteristics

Flow measurement of cement mortar 1:2 showed highest workability of about when compared to all the mortar mixes. The workability was reduced, when the mortar was partially replaced with bottom ash. The addition of 20% of by product as fine aggregate replacement material resulted in poor workability compared to control mortar and this could be attributed to the porous nature and angularity of the bottom ash particles that could absorb more water, thereby decreasing the flowability. Table 3 summarizes the workability of fresh mortar. The effect of fibres on the flow of the four mortar mixes is highlighted. It is easy to note that the inclusion of polypropylene fibre in cement mortar reduces the flowing ability. On the other hand; a higher amount of polypropylene fibre makes less flow ability. In summary, the effect of bottom ash and polypropylene fibre on either the flowing or working capacity is much less than the references cement mortar.

b. Hardened concrete properties

Compressive strength*:* The graph/ Figure 4.2 illustrates the compressive strength of cement mortar (1:2) with BA-PPF. The results indicate that when the BA-PPF content was increased to 10% and 0.25%, the compressive strength increased by 16.62%. However, when the BA-PPF content exceeded 10% and 0.25%, the compressive strength decreased. The optimal range for BA-PPF fiber content was found to be between and 10% and 0.25% Beyond this range, an increase in BA-PPF content resulted in decreased workability, increased porosity, and decreased compressive strength. Specifically, the cement mortar (1:2) mixture with 10% bottom ash and 0.25% PPF had compressive strengths of 22.274, 34.038, and 47.276 MPa, respectively.

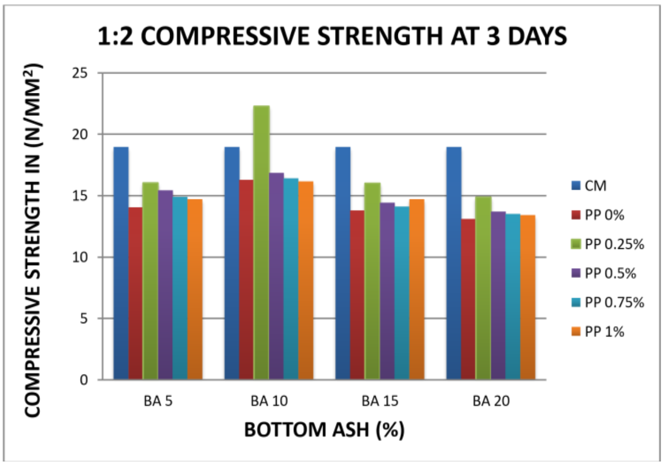
Table 2: Mix details for compression and flexure specimens

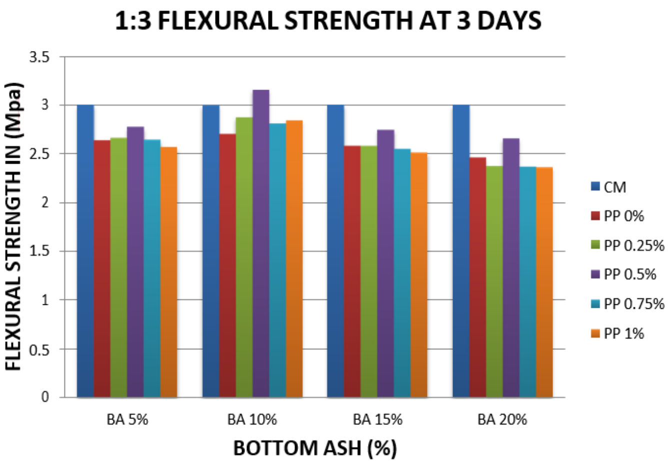
Mix Designation	FibreDosage (%)	Bottomash (%)	3 days	7 days	28 days
ControlMix	0%	0%	6	6	6
BA5 PP0	PPfibre0%	5%	6	6	6
BA10PP0		10%	6	6	6
BA15PP0		15%	6	6	6
BA20PP0		20%	6	6	6
BA5PP0.25	PPfibre0.25%	5%	6	6	6
BA10PP0.25		10%	6	6	6
BA15PP0.25		15%	6	6	6
BA20PP0.25		20%	6	6	6
BA5PP0.5	PPfibre0.5%	5%	6	6	6
BA10PP0.5		10%	6	6	6
BA15PP0.5		15%	6	6	6
BA20PP0.5		20%	6	6	6
BA5PP0.75	PPfibre0.75%	5%	6	6	6
BA10PP0.75		10%	6	6	6
BA15PP0.75		15%	6	6	6
BA20PP0.75		20%	6	6	6
BA5 PP1	PPfibre1%	5%	6	6	6
BA10PP1		10%	6	6	6
BA15PP1		15%	6	6	6
BA20PP1		20%	6	6	6
		Total	**450**		

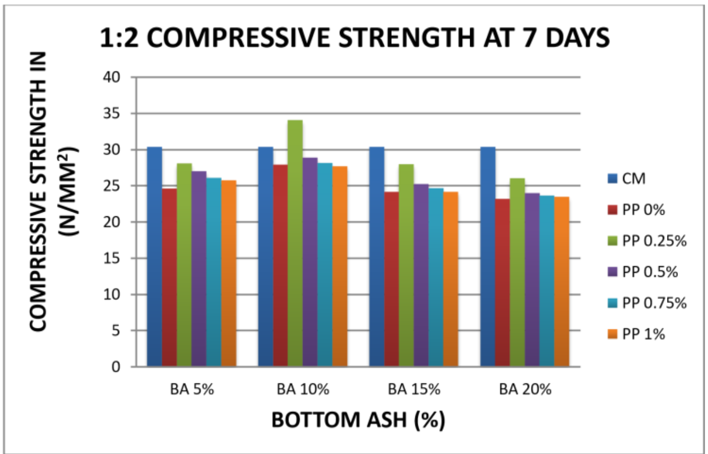
Table 3: Compressive strength of mortars

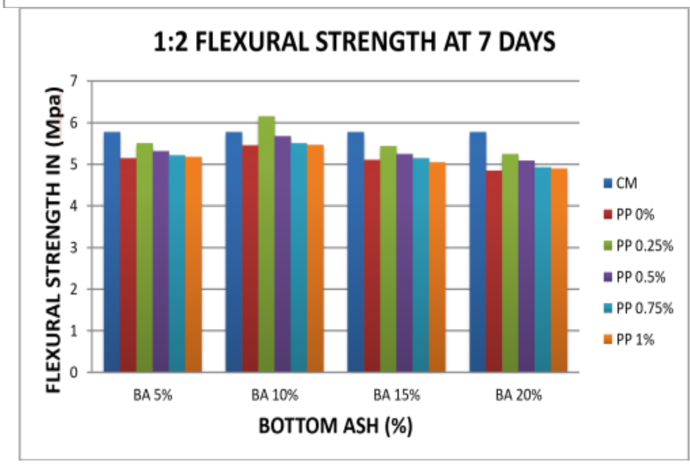
Mix Designation	FibreDosage	Bottomash	3 days N/mm^2	7 days N/mm^2	28 days N/mm^2	3 days N/mm^2	7 days N/mm^2	28 days N/mm^2
			1:2			**1:3**		
ControlMix	0	0	18.956	30.330	42.126	12.501	21.877	31.254
BA5 PP0	PP0%	5%	14.044	24.577	35.110	10.301	18.027	25.753
BA10PP0		10%	16.275	27.901	38.752	12.010	20.589	28.596
BA15PP0		15%	13.791	24.134	34.478	10.644	18.628	26.612
BA20PP0		20%	13.102	23.181	33.596	9.393	16.438	23.483
BA5PP0.25	PP0.25%	5%	16.035	28.062	40.089	10.610	18.568	26.527
BA10 PP0.25		10%	**22.274**	**34.038**	**47.276**	12.174	20.870	28.987
BA15PP0.25		15%	15.985	27.974	39.963	10.230	17.903	25.576
BA20PP0.25		20%	14.862	26.009	37.156	9.496	16.618	23.741
BA5PP0.5	PP0.5%	5%	15.413	26.973	38.534	11.991	20.985	29.979
BA10PP0.5		10%	16.851	28.888	40.123	**14.387**	**24.664**	**34.256**
BA15PP0.5		15%	14.414	25.225	36.037	12.288	21.504	30.720
BA20PP0.5		20%	13.692	23.961	34.230	11.063	19.360	27.658
BA5PP0.75	PP0.75%	5%	14.895	26.067	37.239	10.489	18.356	26.224
BA10PP0.75		10%	16.391	28.099	39.027	12.164	20.853	28.963
BA15PP0.75		15%	14.098	24.672	35.247	10.308	18.039	25.770
BA20PP0.75		20%	13.503	23.630	33.758	9.013	15.773	22.553
BA5 PP1	PP1%	5%	14.694	25.714	36.735	10.193	17.838	25.843
BA10PP1		10%	16.155	27.694	38.465	12.143	20.816	28.912
BA15PP1		15%	14.705	24.158	35.012	10.405	18.209	26.014
BA20PP1		20%	13.417	23.480	33.543	9.546	16.706	23.866

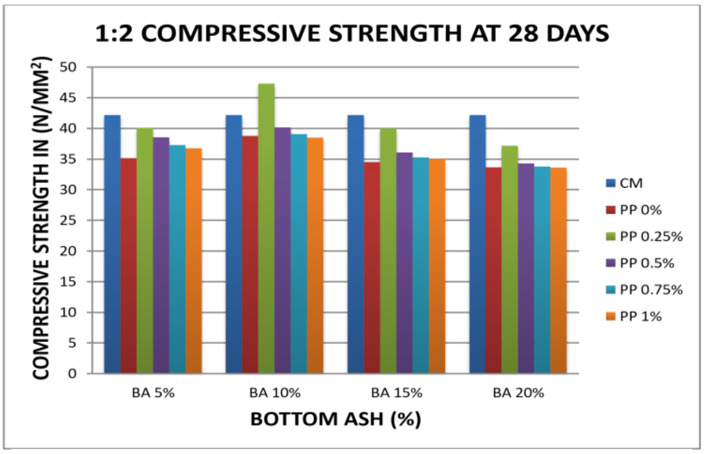
Flexural strength: The results of the flexural strength test for cement mortar (1:2) are shown in Figure 4. The sample with the highest flexural strength was the one containing 10% bottom ash (BA) and 0.25% polypropylene fiber (PPF). The increase in flexural strength up to this optimum content was due to the fibers bridging across cracks. However, when the BA-PPF content exceeded the optimum, the flexural strength gradually decreased due to difficulties in mixing and uneven fiber distribution, resulting in decreased workability and increased porosity. The flexural strength of the cement mortar (1:2) with 10% BA and 0.25% PPF was measured at 3.580, 6.149, and 8.541 MPa, respectively. Additionally, the flexural strength was found to increase with increasing BA-PPF content. The maximum flexural strength of 8.541 MPa was observed in the cement mortar (1:2) with 0.25% PPF and 10% BA.


1:2 COMPRESSIVE STRENGTH AT 3 DAYS
COMPRESSIVE STRENGTH IN (N/MM²)
25
20
15
10
5
0
BA 5
BA 10
BA 15
BA 20
BOTTOM ASH (%)
CM
PP 0%
PP 0.25%
PP 0.5%
PP 0.75%
PP 1%


1:3 FLEXURAL STRENGTH AT 3 DAYS
FLEXURAL STRENGTH IN (Mpa)
3.5
3
2.5
2
1.5
1
0.5
0
BA 5%
BA 10%
BA 15%
BA 20%
BOTTOM ASH (%)
CM
PP 0%
PP 0.25%
PP 0.5%
PP 0.75%
PP 1%


1:2 COMPRESSIVE STRENGTH AT 7 DAYS
COMPRESSIVE STRENGTH IN (N/MM²)
40
35
30
25
20
15
10
5
0
BA 5%
BA 10%
BA 15%
BA 20%
BOTTOM ASH (%)
CM
PP 0%
PP 0.25%
PP 0.5%
PP 0.75%
PP 1%


1:2 FLEXURAL STRENGTH AT 7 DAYS
FLEXURAL STRENGTH IN (Mpa)
7
6
5
4
3
2
1
0
BA 5%
BA 10%
BA 15%
BA 20%
BOTTOM ASH (%)
CM
PP 0%
PP 0.25%
PP 0.5%
PP 0.75%
PP 1%



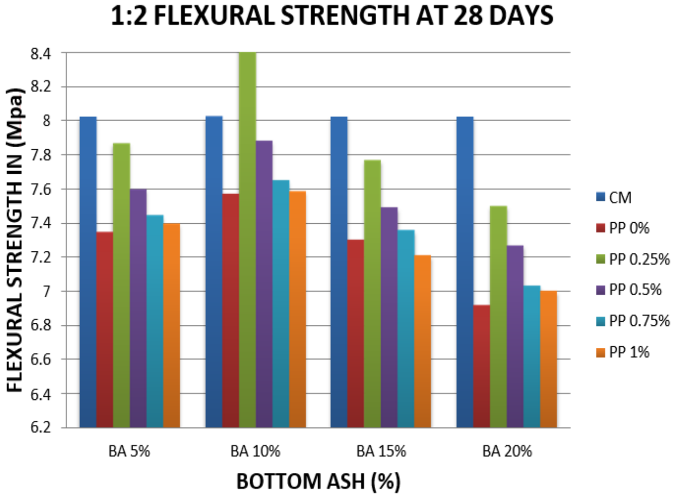


FIGURE:3 Flexural strength of specimens

VI. CONCLUSIONS

Based on the experimental studies carried out on the effect of bottom ash and polypropylene fibre on concrete, the following conclusions are drawn.

- The workability of fibre reinforced mortar is impacted by the use of polypropylene fibre (recron3S) significantly produce tough mixtures.
- Optimum percentage of bottom ash is 10% by partially replacement of fineag gregate after which exceeds mortar specimenstren gthgradually decreases.
- It concludes the compressive strength of fibre reinforced mortar specimens **(1:2)** BA10% PP0.25% have a **12.5%** increased than the control mortar.
- In comparison to normal mortar, cement mortar specimens (1:2) BA10% PP0.5%have a**10.4%** higher compressive strength.
- Flexural strength of fibre reinforced mortar specimens **(1:2)** BA 10% PP0.25%is**6.53%** increased than the conventional mortar.
- Fibre reinforced mortar specimen of flexural strength **(1:2)** BA10% PP0.5% have a **5.2%**higher than the control mortar.

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