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USE of FLYASH as PARTIAL REPLACEMENT of SAND in CEMENT MORTAR

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Abstract: The experimental studies on mortar containing flyash as a partial replacement of sand by weight as well as by volume were carried out to quantify its utilization. Both the types of pond and bottom flyash in various ratios were used in preparing cement mortar and their strengths in compression and tension were tested.

Out of the various proportions the mortar mix 1:2.5:2.5 (cement: coarse sand: pond flyash) designed by method of volume is found satisfactory as for as the strength is concerned. The maximum utilization of flyash almost 75% and cost saving about 58% were ascertained with the plain mortar of ratio 1:5 (cement : sand). The utilization of flyash in mortar designed by weight provides 50% to 60% financial saving while 9% to 16% by method of volume. However, the flyash mortar mix 1:1:5 (cement:flyash:sand) by weight consumes about 20% less quantity of cement and overall consumption of flyash is also less.

Keywords: dry ash, method of volume, maximum utilization of flyash

I. INTRODUCTION

Presently about 105 million tons flyash is generated every year in India as a by-product of coal consumed in the thermal power plants. The thermal power plant is only the source to produce 65% of the total electricity produced in our country. Investigation on utilization of flyash in cement mortar is carried out by many authors (1,2) reported in the literature. Several million tons of coal for generating the electricity is being consumed in India out of which 40% of coal is accounted for generating of flyash as a bye product. By the year 2010 more than 180 million tons of flyash would be generated every year (1). The type of flyash collected at the bottom of boiler furnace having lesser fineness & high carbon content is called bottom flyash (3). The finest flyash is called dry flyash, collected from different electrostatic precipitators (ESP) in dry form. While the ash mixed with water, forming slurry and drained out in ponds is referred as pond flyash (3).

The mineralogical studies of flyash reveals that silica is present in crystalline forms of quarts (sio_3) and partly is associated with alumina as mullite ($2AL_2O_32Sio_2$), the rest being mostly in the glassy phase.

The huge amount of flyash imposing challenges for its disposal and management. At present flyash is disposed in slurry form in large ponds managed by Thermal power corporation plant units. A small percentage that is 3% to 5% of flyash is being used in India while in other countries the percentage of utilization is 30% to 80%, whatever be the type of flyash, it causes types of pollution (4) and air born diseases such as silicoses, fibrosis of lungs, bronchitis etc. Due to the presence of toxic metals in flyash, it causes water pollution through percolation.

Its disposition on agricultural land affects the horticulture and also made the soil infertile. It also affects adversely the civil and mechanical structures. It also causes silting and other problems for human and aquatic life, therefore, it cannot be disposed in sea or river (4). Flyash is being consumed (tones/day) by several organizations in production of cement, bricks, cellular blocks, asbestos sheets, filling low lying areas and construction of roads as shown in Table 1.

The impacts of flyash usage in road works including embankments are wind erosion, surface water erosion and leaching of toxic heavy metals into water bodies including underground aquifers. The sub base/base layers of road pavements constructed using flash need to be covered with black top to prevent percolation of rain water to avoid ground water intrusion and to keep sub grade dry as per standard road construction practices. It is to be ensured that leaching of heavy metals is minimized.

Flyash may sometimes accidentally comes in contact with running water and ground water and the flyash water mixture is basic in nature ($8<PH<10$) which tends to restrict the heavy metal leaching.

In view of the above utilization scenario of flyash, present study aims at its utilization in mortar for brick laying and plastering. For the purpose following methods have been adopted.

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II. EXPERIMENTAL INVESTIGATIONS

The methodology adopted for experimental study has fully been described by selecting four different ratios of mortar consisting flyash in different proportions such as 1:0.5:4:5, 1:1:4, 1:2:3, 1:2.5:2.5 (cement : coarse/fine sand: pond/bottom ash) were considered for experimentation. Keeping water cement ratio a constant of 0.8 adopting both the methods of mix design (by weight and volume), replacing sand by flyash partially. Cubes and briquettes were prepared for compressive and tensile strength tests of mortar. Their strengths were compared with the standard mortar mix 1:5 (cement: sand) for 7, 28 and 96 days of curing as dipected in Tables 2, 3, 6 and 7. Likewise, a comparative study of compressive strength of the same mix by the same method of design is shown graphically in Fig. 1 and 2. The ratio of mortar mix 1:1:5 (cement : flyash : sand) adopting both the methods of mix design (by weight and volume), replacing cement by flyash partially, cubes were also prepared for compressive strength tests of mortar. Their strengths were compared with the strengths of cubes prepared replacing sand by flyash as depicted in Tables 4 and 5. Likewise, a comparative study of compressive strength of the same mix by the same method of design in shown in Fig. 3 and 4.

On rigorous analysis, it has been observed that method of volume is suited best than the method of weight. Similarly, the inclusion of pond flyash in mortar gives better results than bottom flyash. All the above results (tabular and graphical) presented here with are obtained on the tests carried out on mortar prepared by partial replacement of sand by pond flyash and adopting method of volume for design of the mix. The comparative graphs for strength of different ratio are shown for curing period of 7, 28 and 96 days and compared with the standard plain mortar of ratio 1:5. The tabular form of data showing the compressive strength of different ratio of mortar mix in contrast with the strength of standard mix 1:5.

On experimental analysis, it has also been observed that the mortar of the ratio 1:1:5 (cement : flyash : sand) when the replacement of cement is made by flyash, it gives lesser strength in comparison to the replacement of sand by flyash as shown in Tables 4 and 5. Furthermore, the consumption of flyash is also reduced appreciably. With the aim of higher consumption of flyash and strength, former is preferred.

Table 1 : Flyash Utilization Status (5)

Product	Quantity in tonnes/day
Cement	2781.00
Bricks	16.00
Cellular Blocks	250.00
Asbestos Sheets	130.00
Filling low lying and construction of roads	260.00
Total	3437.00

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Table 2 : Compressive Strength by Weight (kg/cm^2)

S. No.	Mortar Mix	Strength			% Ash added
		7 days	28 days	96 days	
	Cement : Coarse Sand : Pond Ash				
1	1: 5	76	123	155	Plain Mix
2	1 : 0.5 : 4.5	5 (0.07)	20 (0.16)	27 (0.17)	90
3	1: 1 : 4	7 (0.09)	39 (0.31)	68 (0.45)	80
4	1: 2 : 3	48 (0.63)	98 (0.68)	135 (0.87)	60
5	1 : 2.5 : 2.5	51 (0.67)	105 (0.85)	145 (0.93)	50
	Cement : Fine Sand : Pond Ash				
1	1: 5	39	65	90	Plain Mix
2	1 : 0.5 : 4.5	7 (0.24)	15 (0.23)	20 (0.22)	90
3	1: 1 : 4	11 (0.38)	18 (0.27)	35 (0.39)	80
4	1: 2 : 3	28 (0.96)	58 (0.89)	72 (0.80)	60
5	1 : 2.5 : 2.5	34 (1.17)	66 (1.01)	84 (0.93)	50
	Cement : Coarse Sand : Bottom Ash				
1	1: 5	76	123	155	Plain Mix
2	1 : 0.5 : 4.5	5 (0.17)	9 (9.09)	11 (0.07)	90
3	1: 1 : 4	5 (0.08)	7 (0.05)	9 (0.06)	80
4	1: 2 : 3	15 (0.20)	22 (0.18)	27 (0.17)	60
5	1 : 2.5 : 2.5	18 (0.23)	27 (0.22)	30 (0.19)	50
	Cement : Fine Sand : Bottom Ash				
1	1: 5	39	65	90	Plain Mix
2	1 : 0.5 : 4.5	5 (0.17)	6 (0.09)	8 (0.09)	90
3	1: 1 : 4	5 (0.17)	8 (0.12)	9 (0.10)	80
4	1: 2 : 3	15 (0.52)	20 (0.31)	24 (0.27)	60
5	1 : 2.5 : 2.5	17 (0.58)	22 (0.34)	26 (0.29)	50

Values in brackets show the % strength of Plain Cement Mortar 1:5

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Table 3 : Compressive Strength by Volume (kg/cm^2)

S. No.	Mortar Mix	Strength			% Ash added
		7 days	28 days	96 days	
	Cement : Coarse Sand : Pond Ash				
1	1: 5	77	125	155	Plain Mix
2	1: 2 : 3	54 (0.71)	66 (0.53)	142 (0.91)	60
3	1 : 2.5 : 2.5	140 (1.81)	143 (1.14)	170 (1.09)	50
	Cement : Fine Sand : Pond Ash				
1	1: 5	39	65	90	Plain Mix
2	1: 2 : 3	34 (0.87)	64 (0.98)	78 (0.87)	60
3	1 : 2.5 : 2.5	34 (0.87)	70 (1.08)	82 (0.91)	50
	Cement : Coarse Sand : Bottom Ash				
1	1: 5	77	125	155	Plain Mix
2	1: 2 : 3	18 (0.23)	32 (0.26)	45 (0.22)	60
3	1 : 2.5 : 2.5	54 (0.71)	60 (0.48)	85 (0.56)	50
	Cement : Fine Sand : Bottom Ash				
1	1: 5	39	65	90	Plain Mix
2	1: 2 : 3	18 (0.46)	33 (0.51)	42 (0.46)	60
3	1 : 2.5 : 2.5	22 (0.56)	50 (0.77)	53 (0.59)	50

Values in brackets show the % strength of Plain Cement Mortar 1:5

Table 4 : Compressive Strength by Weight (kg/cm^2)

S. No.	Mortar Mix	Strength			% Ash of cement added
		7 days	28 days	96 days	
	Cement : Fly Ash : Coarse Sand				
1	1: 5	76	123	155	Plain Mix
2	1 : 1 : 5	45 (0.59)	71 (0.58)	84 (0.54)	100
	Cement : Fly Ash : Fine Sand				
1	1: 5	39	65	90	Plain Mix
2	1 : 1 : 5	20 (0.51)	45 (0.69)	61 (0.68)	100

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Table 5 : Compressive Strength by Volume (kg/cm^2)

S. No.	Mortar Mix	Strength			% Ash of cement added
		7 days	28 days	96 days	
	Cement : Fly Ash : Coarse Sand				
1	1: 5	77	125	155	Plain Mix
2	1 : 1 : 5	51 (0.66)	76 (0.61)	135 (0.87)	100
	Cement : Fly Ash : Fine Sand				
1	1: 5	39	65	90	Plain Mix
2	1 : 1 : 5	35 (0.90)	59 (0.91)	72 (0.80)	100

Table 6 : Tensile Strength by Volume (kg/cm^2)

S. No.	Mortar Mix	Strength			% Ash added
		7 days	28 days	96 days	
	Cement : Coarse Sand : Pond Ash				
1	1: 5	15.0	17.0	18.2	Plain Mix
2	1: 2 : 3	11.7 (0.78)	11.9 (0.70)	12.2 (0.67)	60
3	1 : 2.5 : 2.5	16.8 (1.12)	18.2 (1.07)	19.3 (1.06)	50
	Cement : Fine Sand : Pond Ash				
1	1: 5	7.5	8.8	9.3	Plain Mix
2	1: 2 : 3	5.9 (0.78)	7.4 (0.84)	8.2 (0.88)	60
3	1 : 2.5 : 2.5	7.8 (1.04)	8.5 (0.96)	8.9 (0.96)	50
	Cement : Coarse Sand : Bottom Ash				
1	1: 5	15.0	17.0	18.2	Plain Mix
2	1: 2 : 3	6.4 (0.42)	6.4 (0.35)	5.7 (0.31)	60
3	1 : 2.5 : 2.5	10.8 (0.72)	11 (0.59)	10.2 (0.56)	50
	Cement : Fine Sand : Bottom Ash				
1	1: 5	7.5	8.8	9.3	Plain Mix
2	1: 2 : 3	6.8 (0.90)	7 (0.80)	6.5 (0.70)	60
3	1 : 2.5 : 2.5	7.6 (1.01)	7.5 (0.85)	7.2 (0.77)	50

Values in brackets show the % strength of Plain Cement Mortar 1:5

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Table 7 : Tensile Strength by Weight (kg/cm^2)

S. No.	Mortar Mix	Strength			% Ash added
		7 days	28 days	96 days	
	Cement : Coarse Sand : Pond Ash				
1	1: 5	15	17	18.2	Plain Mix
2	1: 2 : 3	10.6 (0.71)	10.9 (0.64)	11.3 (0.62)	60
3	1 : 2.5 : 2.5	13.7 (0.91)	14.8 (0.87)	16 (0.88)	50
	Cement : Fine Sand : Pond Ash				
1	1: 5	7.5	8.8	9.3	Plain Mix
2	1: 2 : 3	5.2 (0.69)	6.5 (0.74)	7.2 (0.77)	60
3	1 : 2.5 : 2.5	6.9 (0.92)	7.3 (0.83)	7.6 (0.82)	50
	Cement : Coarse Sand : Bottom Ash				
1	1: 5	15	17	18.2	Plain Mix
2	1: 2 : 3	5.7 (0.38)	5.5 (0.32)	5.3 (0.29)	60
3	1 : 2.5 : 2.5	6.6 (0.44)	7.5 (0.44)	8.3 (0.46)	50
	Cement : Fine Sand : Bottom Ash				
1	1: 5	7.5	8.8	9.3	Plain Mix
2	1: 2 : 3	5.9 (0.79)	6.2 (0.70)	5.8 (0.62)	60
3	1 : 2.5 : 2.5	7.2 (0.96)	7.5 (0.85)	6.4 (0.67)	50

Values in brackets show the % strength of Plain Cement Mortar 1:5

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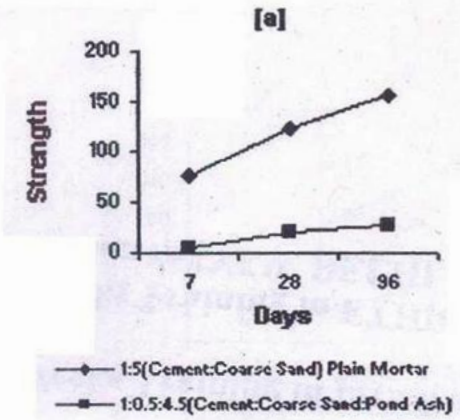

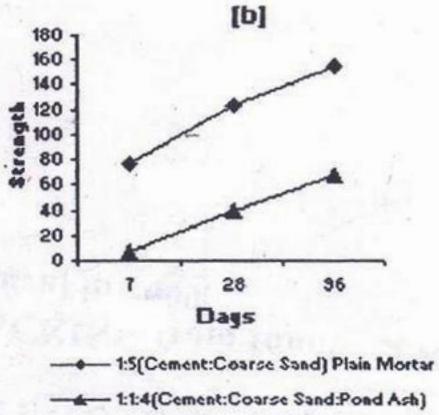

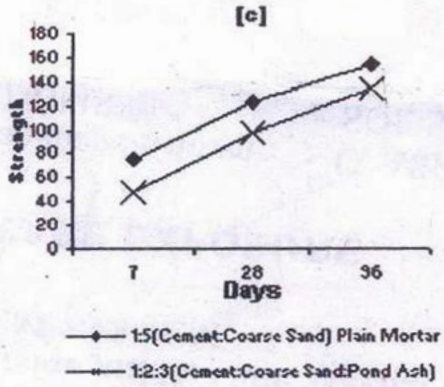

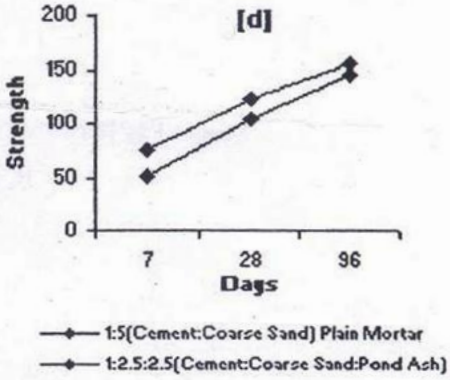

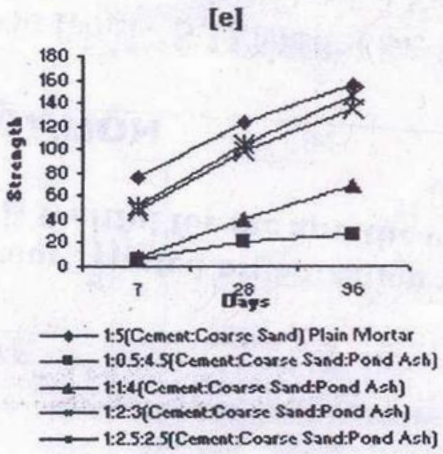

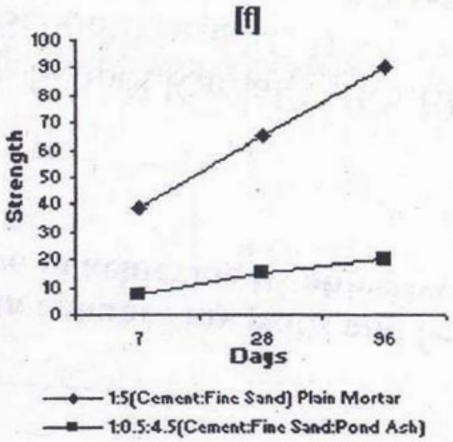

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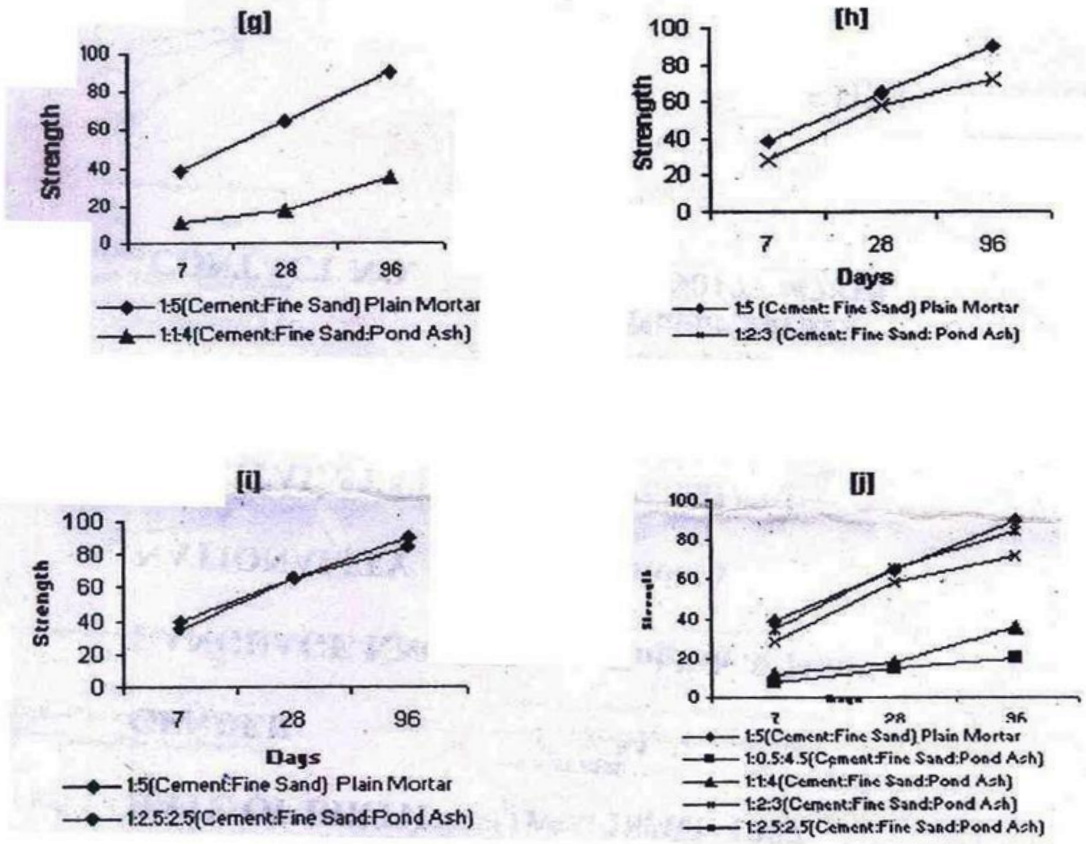
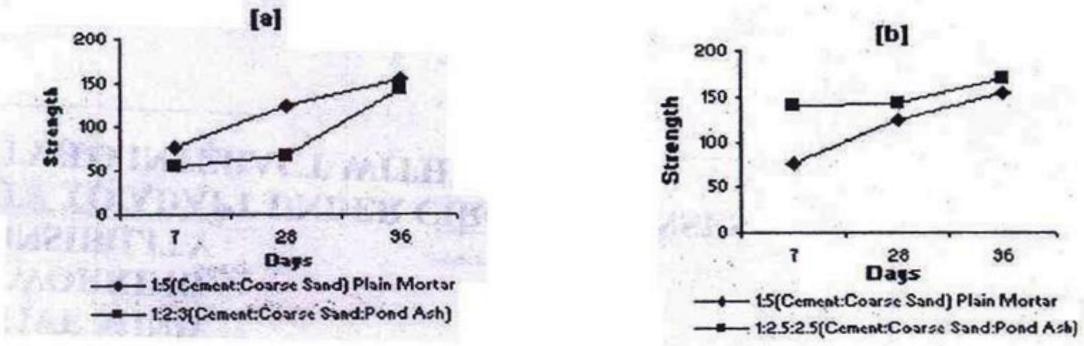


Figure 1: Compressive Strength (Kg /cm^2) Mix proportion by weight



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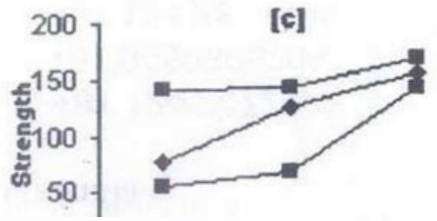
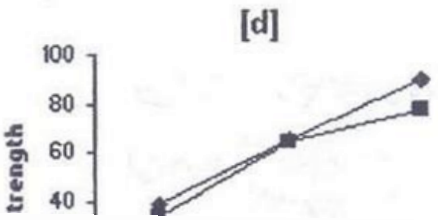
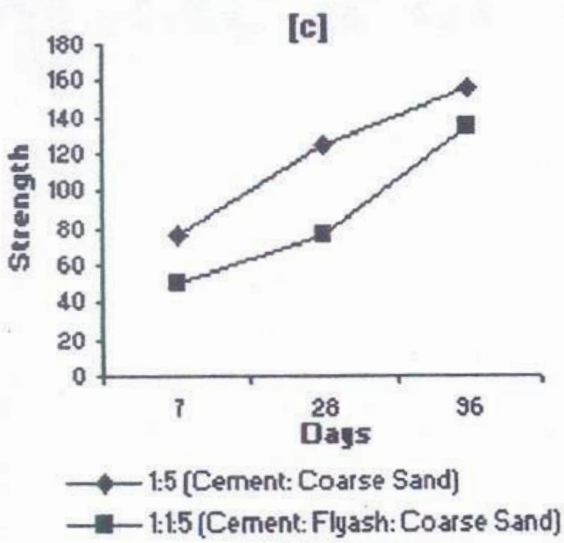




Use of flyash as partial replacement of sand in cement mortar



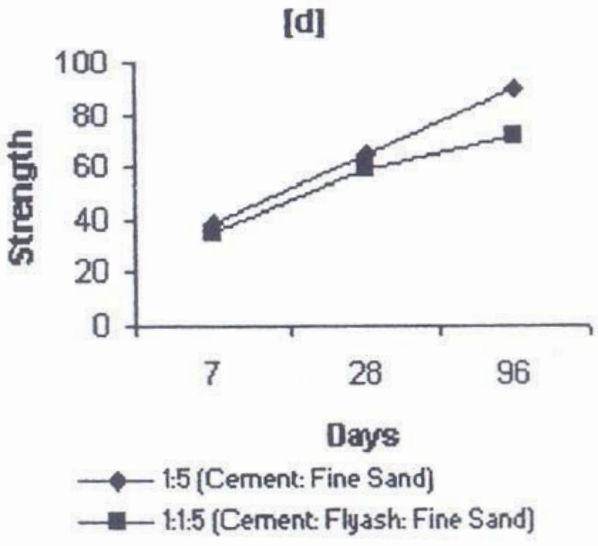


Fig 3 and 4.Compressive Strength (kg/cm2) Mix Proportion by volume

1:1:5 (Cement: Flyash: Coarse Sand)
1:5 (Cement:Fine Sand)
1:1:5 (Cement: Flyash: Fine Sand)

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III. CONCLUSION

Out of the various proportions under study the mortar mix containing 1:2.5:2.5 (cement : coarse sand : pond flyash) by method of volume is observed to satisfy the strength criteria very well whereas the same ratio when considered by the method of weight is found to be most economical. With the view of maximum utilization of flyash almost about 75% and cost saving about 58% are ascertained with 1:2:3 mortar (cement : coarse sand : pond ash) when compared with plain mortar 1:5 (cement : coarse sand). Similarly the mortar containing 1:1:5 (cement : flyash : sand) replacing cement by flyash saves 20% cement. However, the strength of 1:2:3 mortar and 1:1:5 mortar is not as good as the strength of mortar of 1:2.5:2.5 ratio.

In statistical analysis of experimental results reveals that water absorption of flyash mix mortar of ratio 1:2:3 and 1:2.5:2.5 is twice to that of plain cement mix mortar of ratio 1:5.

For workability the flyash, mixed mortar required 5% to 10% more water than that of plain cement mix mortar of ratio 1;5. Utilization of flyash in mortar designed by the method of weight gives 50% to 60% financial savings while the saving is 9% to 16% in case of the method of volume. When the cement is replaced by flyash in mix of 1:1:5 (cement : flyash : sand) mortar, 20% saving of cement is achieved by the method of weight but the strength and consumption of flyash reduced significantly.

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BIOGRAPHY

Abhishek jain is pursuing his B.Tech from Jamia Millia Islamia, New Delhi. He has always been among toppers in both school and college. He has also received a scholarship in 2nd year of B.Tech for his outstanding academic performance. His research interests are design and analysis of structures. Besides being a scholar, he is also associated with NGO's who work for the betterment of the society.