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Performance Evaluation of Cement Mortar by Using Fly Ash and Lime as Partial Replacement for Cement

[1] Ranjan S N, [2] S.M.Maheswarappa, [3] J.K.Dattatreya

[1]M.Tech, [2]Associate Professor,[3]Research Professor

Department of civil engineering

Siddaganga Institute of Technology

Tumkuru, Karnataka

India

ABSTRACT

As global demand for mortar follows a growth in this century, energy-efficient, economical and durable building materials are essential for sustainable construction practices. In the present investigation fly ash and lime is replaced with cement in different proportions to study various properties like water demand, compressive strength, split tensile strength on different mortar specimens. Specimens were tested on 7th and 28th day of curing.

Keywords: Fly ash, Lime, Water demand, Compressive strength, Spilt tensile strength.

1. INTRODUCTION

Due to the rapid growth in construction activities, demand for cement follows the growth in this century. The present cement industries face one defining challenge to increase the availability of cement at the same time reducing the environmental impact. The liberation of CO_2 is significant in the manufacturing of Portland cement. Fly ash is widely available in India. One method to reduce the amount of CO_2liberation and energy consumption is to replace cement with fly ash. From very ancient days lime has been used in India as construction material. The manner in which lime structure about 2000 years old have withstood all environmental effects is the evidence to the durability of lime mortars. Although lime mortars are forgotten today, they still remain important construction material.

2. MATERIAL PROPERTIES

2.1Cement: Ordinary Portland cement 53 grade tested according to IS: 8112-1989 and the physical properties of the cement tested and results obtained were as follows: Normal consistency 30%, Initial setting time 140min and final setting time 255 min, Specific gravity 3.15 and Density of cement 3.10 gm/cc. The test done for 53 ordinary Portland cement tested for physical properties was confirmed to IS 8112-1989 for all the above tests and it was within limit. The initial setting time of cement was more than 80 minutes as specified in standards and specific gravity obtained was higher.

2.2 Sand: The sand was sieved using 4.75mm and the fraction passing 4.75mm was used for all experiments. The physical properties (specific gravity and gradation of sand) were tested according to IS: 383-1970. The sand belongs to zone -II as per IS: 383-1970.The specific gravity of sand is 2.67, bulk density 1497kg/m^3.

2.3 Lime: The lime is extracted from locally available lime stone, which is hydrated from atmospheric air. Lime was sieved using 300micron and the fraction passing through it was used for all the experiment. The physical properties tested and results were specific gravity 2.2and density of lime 1.98gm/cc. As the lime has ability to bind the other particle and has to increase the water content when mixed in mortar.

2.4 Fly Ash: Fly ash was procured from Udupi thermal power station, Karnataka and was used in experiments. The physical properties tested and results obtained were lime reactivity 2.0 N/mm^2, specific gravity 2.4 and density 2.13 gm/cc. As per IS: 1727-1967, the reactivity of fly ash with lime was carried out and the result obtained was 2.0 N/mm^2. The specific gravity was 2.4 which confirm to IS 3812-1981.

3. RESULTS AND DISCUSSIONS

In this investigation five different proportions of mortars were used. In masonry mortar (1:3) lime and fly ash is replaced with cement in different proportions. In cementitious materials 60% of total weight is cement and lime and fly ash were replaced in various percentages up to40% of total weight. These mortars were tested for their water demand (200% flow), Compressive strength and Split tensile strength.

3.1 Water Demand:

The water demand to produce a flow diameter 195mm was recorded. A truncated cone was placed in the centre of the flow table. It was filled and the excess mortar was struck off. After 10 seconds, the mould was lifted and the mortar was spread by jolting the plate 25 times, at one jolt per second. The mean value of the diameter measured in two perpendicular directions, was reported and the test repeated 3 times for each mix.

Table 1 Water demand for initial flow 195 mm (200% flow).

Sl no	**Cementitious materials**			**Sand(g)**	**Water(ml)**	**Required Water for 200% flow(ml)**	**Water Demand (% of total weight)**
	Lime (g)	**Fly ash(g)**	**Cement(g)**				
1	13.6	40.9	81.8	410	54.5	89	14.83
2	27.2	27.2	81.8	410	54.5	94	15.66
3	40.9	13.6	81.8	410	54.5	105	17.5
4	54.5	0	81.8	410	54.5	110	18.33
5	0	54.5	81.8	410	54.5	80	13.33
6	0	0	136.3	410	54.5	75	12.5

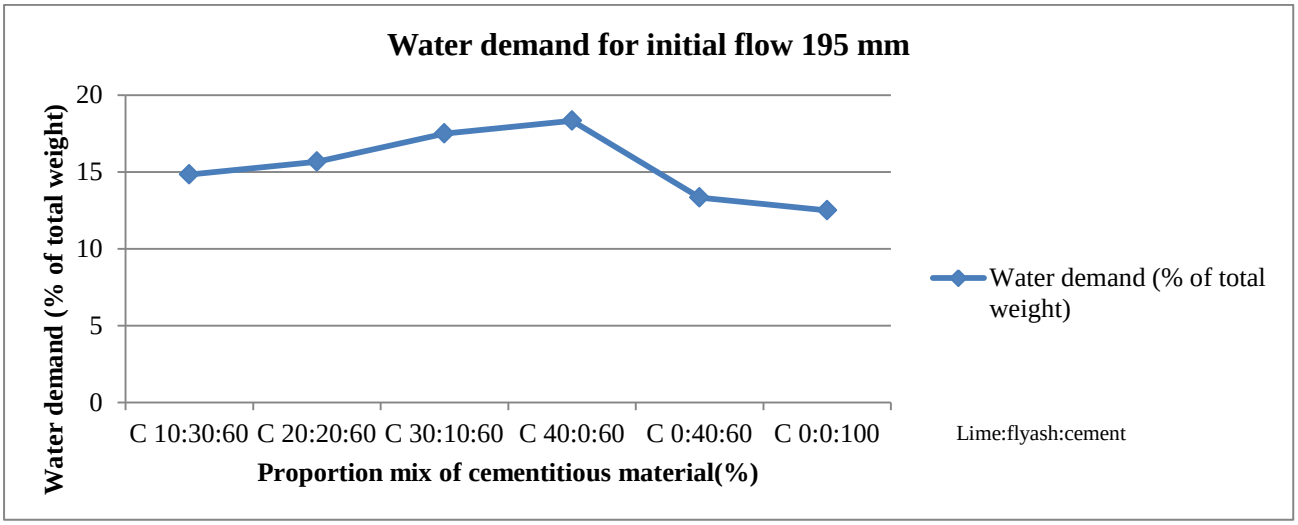

Figure.1 Water demand for 200% flow

3.2 Compressive Strength

As per IS: 2250-1981 masonry mortar cubes were casted and cured. The compressive strength of the cubes was determined. Compressive strength for all proportions of mortar was compared with reference mortar (1:3). Water to binder ratio used is 0.4. Mortar cubes were tested for their compressive strength at 7^{th} and 28^{th}day. The results are obtained for compressive strength and the graph of compressive strength versus proportion mix of cementitious material was plotted for all different mortars.

Table 2 Compressive strength of mortar 1:3

Sl.no	Cementitious materials			Sand(g)	Compressive strength(N/mm^2), 7days	Compressive strength(N/mm^2), 28 days
	Lime(g)	Fly ash(g)	Cement(g)			
1	23.86	71.58	143.16	716	7.15	17.05
2	47.72	47.72	143.16	716	9.946	20.26
3	71.58	23.86	143.16	716	8.33	16.06
4	95.44	0	143.16	716	9.7	16.2
5	0	95.44	143.16	716	11.4	29.22
6	Reference mortar		238.6	716	12.67	26.5

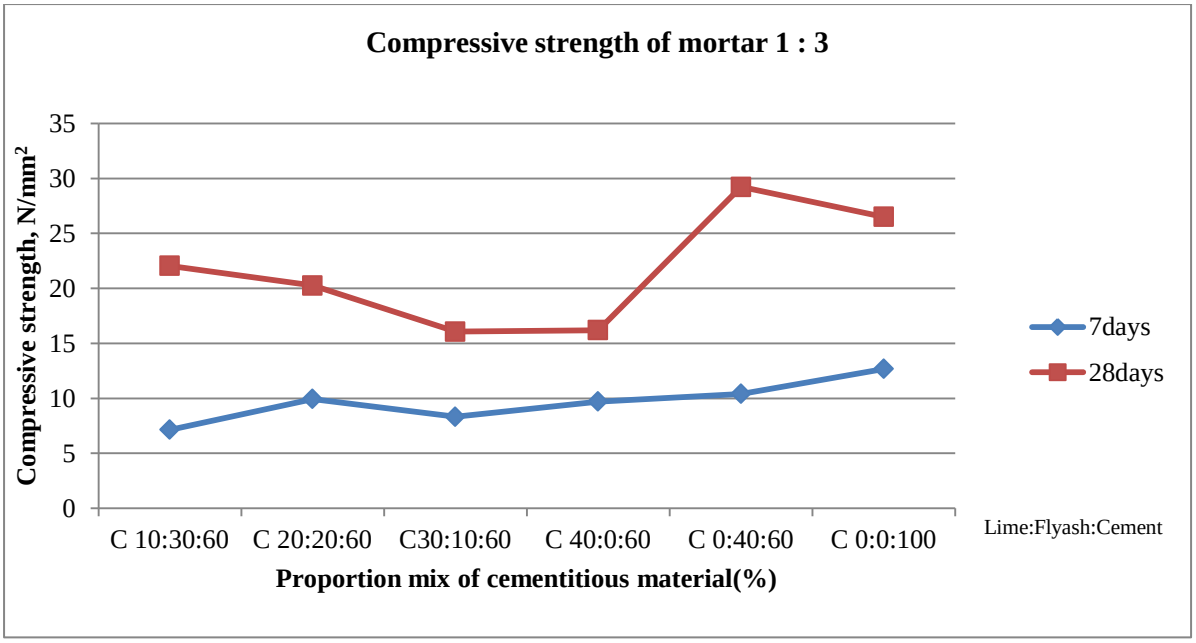

Figure.2. Compressive strength of mortar 1:3

3.3 Split Tensile Strength:

The split tensile strength of the cylinders (75mm diameter,150 mm height)was determined. Split tensile strength for all proportions of mortar was compared with reference mortar (1:3). Water to binder ratio used is 0.4. Mortar cylinders were tested for their split tensile strength at 7^{th} and 28^{th} day. The results are obtained for spilt tensile strength and the graph of split tensile strength versus proportion mix of cementitious material was plotted for all different mortars.

Table 3.split tensile strength of mortar 1:3

Sl.no	Cementitious materials			Sand(g)	Split tensile strength(N/mm^2), 7days	Split tensile strength(N/mm^2), 28 days
	Lime(g)	Fly ash(g)	Cement(g)			
1	45.22	135.68	271.36	1356.81	2.16	2.693
2	90.45	90.45	271.36	1356.81	1.679	2.565
3	135.68	45.22	271.36	1356.81	1.528	2.962
4	180.90	0	271.36	1356.81	1.264	2.163
5	0	180.90	271.36	1356.81	2.188	3.269
6	Reference mortar		452.27	1356.81	2.81	3.96

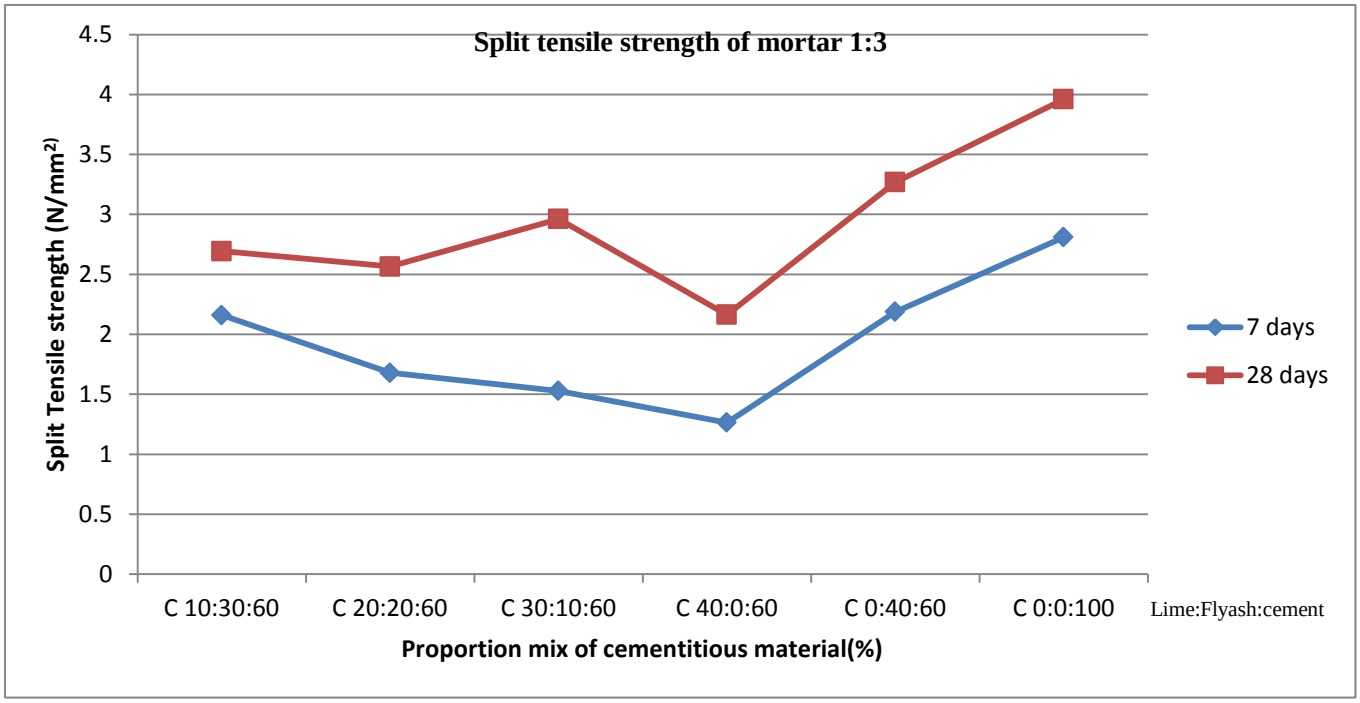

Fig. 3 Split tensile strength of mortar 1:3

4. CONCLUSIONS

1. Water demand increases with increase in lime content.
2. Water demand of replaced cement mortar is more than that of the reference mortar.
3. According to IS,ASTM standards 15MPa compressive strength required for masonry mortar, in the present work we got more than 15 MPa by using lime and fly ash.
4. When the reference mortar is fully replaced by fly ash will give more compressive strength than it is fully replaced by lime.
5. For maximum lime content (40%) the split tensile strength obtained is minimum compared to other proportions.

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