



Effect of Pozzocrete as Partial Replacement with Cement in Mortar

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ABSTRACT

Pozzocrete (P40, P60 and P100) a processed quality assured fly ash, investigated for its use as a partial replacement for cement in cement mortar (1:3). The utilization of Pozzocrete (P40, P60 and P100) as cement replacement material in mortar or as additive in cement introduces many benefits from economical, technical and environmental points of view. This paper presents the results of the cement mortar of mix proportion 1:3 in which cement is partially replaced with Pozzocrete (P40, P60 and P100) as 0%, 10%, 30% and 50% by weight of cement. Four set of mixture proportions were made. First were control mix (without Pozzocrete (P40, P60 and P100) with regional fine aggregate (sand)) and the other mixes contained Pozzocrete (P40, P60 and P100) obtained from DIRK India Private Limited, nashik, Maharashtra state. The compressive strength has been obtained with partial replacement of Pozzocrete (P40, P60 and P100) with cement. Test results indicate the decreases in the strength properties of mortar with Pozzocrete (P40, P60 and P100) for early strength at 7 days as partial replacement with the cement in the cement mortar 1:3. So it can be used in non-structural elements with the low range compressive strength where early strength is not required and low cost temporary structure is prepared.

KEYWORDS: Pozzocrete (P40, P60 and P100), Partial replacement, Early Compressive strength, Cement, Fine aggregate, Cost

I. INTRODUCTION

Masonry is a globally accepted construction material in all types of civil engineering structures. Stone and Brick masonry construction is very much preferred one for load bearing structures and high rise buildings, especially in the developing and under developed countries because of its ease in construction and economy. It has been used for the construction of a number of historical and traditional buildings. Though these masonry is not much understood in the aspect of strength and other parameters, because of its non-homogeneity. Most of the walls of buildings and residential houses are masonry walls, made of stones, bricks or concrete blocks, with rendering on both sides. Even though mortar makes up as little as 7% of the total volume of a masonry wall, it plays a crucial role in the performance of the structure. Due to the environment concern and the need to conserve energy, various research efforts have been directed toward the utilization of waste materials.

The cost of cement is also steadily increasing. With ever-increasing environmental problems because of industrial waste products comes a great need to use these products in an appropriate manner to reduce health and environmental problems.

For this purpose, experimental investigation is carried out to develop the data on the compressive strength development of mortar with time and with different percent replacement of Pozzocrete (P40, P60 and P100).

The objectives of the present study are:

- To select the Pozzocrete (P40, P60 and P100) mix proportion for cement mortar.
- To investigate change in compressive strength of cement mortar with Pozzocrete (P40, P60 and P100) replacement.
- To perform the experiments on the time-dependent compressive strength of cement mortar with Pozzocrete (P40, P60 and P100). The strengths were measured at the age of 7 days.

II DESIGN MIX MATERIALS

A. Cement

The cement used is SANGHI OPC 53 grade cement. The Ordinary Portland Cement of 53 grade conforming to IS: 8112-1989 is be use. Tests were conducted on cement like Specific gravity, consistency tests, setting tests, soundness, Compressive strength N/mm² at 28 days.



Fig 1: SANGHI OPC 53 Grade Cement

TABLE – 1
PROPERTIES OF CEMENT

| Sr. No. | Physical properties of SANGHI OPC 53 cement | Result | Requirements as per IS:8112-1989 |
|---------|---|----------------------|----------------------------------|
| 1 | Specific gravity | 3.15 | 3.10-3.15 |
| 2 | Standard consistency (%) | 31.5 % | 30-35 |
| 3 | Initial setting time (hours, min) | 91 min | 30 minimum |
| 4 | Final setting time (hours, min) | 211 min | 600 maximum |
| 5 | Compressive strength N/mm ² at 28 days | 58 N/mm ² | 53 N/mm ² minimum |

B. Fine aggregate

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand is be used as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.



Fig 2: Fine aggregate (River sand)

TABLE- 2
PROPERTIES OF FINE AGGREGATE

| Property | Fine Aggregate (River sand) |
|----------------------|-----------------------------|
| Fineness modulus | 3.1 |
| Specific Gravity | 2.767 |
| Water absorption (%) | 1.2 |
| Bulk Density (gm/cc) | 1.78 |

C. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

D. Pozzocrete (P40, P60 and P100)

Pozzocrete (P40, P60 and P100) is a high efficiency pozzolanic material, obtained by selection, processing and testing of power station fly ash resulting from the combustion of coal at electricity generating power stations. It is subjected to strict quality control procedures. P60 confirms to IS: 3812 part-1 fly ash and P40 confirms to ASTM 618 fly ash for use as component of cement with Portland clinker.

TABLE- 3
GENERAL PROPERTIES OF POZZOCRETE

| Property | P40 | P60 | P100 |
|---|-----------------------------------|---|--|
| Presentation | Finely divided dry powder | Finely divided dry powder | Finely divided dry powder |
| Specific Gravity | 2.3 | 2.3 | 2.3 |
| Colour | Light grey | Light grey | Greyish white |
| Bulk weight (tonne per m ³) | 1.0 tonne per m ³ | 1.0 tonne per m ³ | 0.65 tonne per m ³ |
| Loss on Ignition | <2.5% | <2.5% | <2.5% |
| Particle size | <25% retained on 45 micron sieve | <18% retained on 45 micron sieve | Zero retention on 45 micron sieve, less than 0.25% retained on 25 micron sieve |
| Particle shape | Spherical | Spherical | Spherical |
| Package | 1 tonne big-bags and bulk tankers | 30 kg bags, 1 tonne big-bags and bulk tankers | 30 kg bags |

III DESIGN MIX METHODOLOGY**Mortar compositions**

A cement mortar mix 1:3 was designed as per IS: 269 method and the same was used to prepare the test samples. The design mix proportion is done in Table 4 and 5.

TABLE - 4
MIX DESIGN PROPORTIONS

| | Water | Cement | Fine aggregate |
|------------------------------|-------|--------|----------------|
| By weight, [gms] | 86 | 200 | 600 |
| By volume, [m ³] | 0.43 | 1 | 3 |

TABLE -5:
CEMENT REPLACEMENT BY POZZOCRETE (P40, P60 and P100)

| Sr. No. | Mortar Type | Description of Mortar |
|---------|-------------|---|
| 1 | A1 | River sand Mortar (1:3) |
| 2 | B1 | 10% Cement Replacement by Pozzocrete (P40) |
| 3 | B2 | 30% Cement Replacement by Pozzocrete (P40) |
| 4 | B3 | 50% Cement Replacement by Pozzocrete (P40) |
| 5 | C1 | 10% Cement Replacement by Pozzocrete (P60) |
| 6 | C2 | 30% Cement Replacement by Pozzocrete (P60) |
| 7 | C3 | 50% Cement Replacement by Pozzocrete (P60) |
| 8 | D1 | 10% Cement Replacement by Pozzocrete (P100) |
| 9 | D2 | 30% Cement Replacement by Pozzocrete (P100) |
| 10 | D3 | 50% Cement Replacement by Pozzocrete (P100) |

TABLE - 6
DESIGN MIX PROPORTIONS FOR MORTAR (1:3)

| Mortar Type | W/C ratio | % Replacement in cement | Design Mix Proportions For Mortar (1:3) | | | |
|-------------|-----------|-------------------------|---|--------------|------|------|
| | | | C | F.A. (River) | P 40 | P 60 |
| A1 | 0.45 | 0 | 1 | 3 | - | - |
| B1 | 0.45 | 10% | 0.9 | 3 | 0.1 | - |
| B2 | 0.45 | 30% | 0.7 | 3 | 0.3 | - |
| B3 | 0.45 | 50% | 0.5 | 3 | 0.5 | - |

| | | | | | | | |
|----|------|-----|-----|---|---|-----|-----|
| C1 | 0.45 | 10% | 0.9 | 3 | - | 0.1 | - |
| C2 | 0.45 | 30% | 0.7 | 3 | - | 0.3 | - |
| C3 | 0.45 | 50% | 0.5 | 3 | - | 0.5 | - |
| D1 | 0.45 | 10% | 0.9 | 3 | - | - | 0.1 |
| D2 | 0.45 | 30% | 0.7 | 3 | - | - | 0.3 |
| D3 | 0.45 | 50% | 0.5 | 3 | - | - | 0.5 |

IV EXPERIMENTAL METHODOLOGY**A. Testing methodology**

The evaluation of Pozzocrete (P40, P60 and P100) for use as a supplementary cementitious material (SCM), i.e., as a pozzolona, begins with the mortar testing. Mortar is similar to concrete in that it contains cement, water and aggregate, except that in mortar graded fine aggregate is the only aggregate present. With the control mortar, i.e. 10%, 30% and 50% of the ordinary Portland cement (OPC) confirming IS 269 IV is replaced with Pozzocrete (P40, P60 and P100). The data from the Pozzocrete (P40, P60 and P100) mortar is compared with data from a "control" mortar without Pozzocrete (P40, P60 and P100). Three cube samples were cast on the mould of size 70.7 x 70.7 x 70.7 mm for each 1:3 cement mortars with partial replacement of cement with Pozzocrete (P40, P60 and P100) with w/c ratio as 0.45 were also cast. After about 48 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7 days for compressive strength.

**Fig 3: Set up of Vibrating Machine and Crucible for Mixing Cement and Fine Aggregate (Sand)****B. Compressive strength**

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm² per min. The comparative studies were made on their characteristics for cement mortar ratio of 1:3 with partial replacement of cement with Pozzocrete (P40, P60 and P100) as 0%, 10%, 30% and 50%.

**Fig 4: Set up of Compressive Testing Machine****V RESULT****TABLE -7**
COMPRESSIVE STRENGTH OF CEMENT MORTAR (N/mm²) AT 7 DAYS

| Types of Mortar | Average Ultimate Compressive Strength of cement mortar (N/mm ²) at 7 days | % change in compressive strength of cement mortar (N/mm ²) at 7 days |
|-----------------|---|--|
| A1 | 33.81 | 0 |
| B1 | 32.01 | -5.32 |
| B2 | 24.34 | -28.00 |

| | | |
|----|-------|--------|
| B3 | 12.47 | -63.11 |
| C1 | 29.01 | -14.19 |
| C2 | 20.07 | -40.63 |
| C3 | 11.80 | -65.09 |
| D1 | 28.14 | -16.77 |
| D2 | 18.74 | -44.57 |
| D3 | 13.20 | -60.95 |

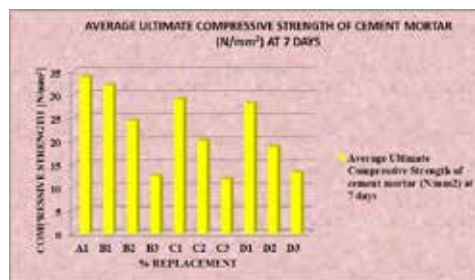


Fig 5: % Replacement of Pozzocrete (P40, P60 and P100) versus Compressive Strength of Cement Mortar (1:3) N/mm²



Fig 6: % Replacement of Pozzocrete (P40, P60 and P100) % Change in Compressive Strength of Cement Mortar (1:3)

VI. ECONOMIC FEASIBILITY

TABLE- 8
COSTS OF MATERIALS

| Sr. No. | Materials | Rate (Rs/Kg) |
|---------|------------------------------|--------------|
| 1 | Cement (SANGHI OPC 53 grade) | 6.00 |
| 2 | Fine aggregate (Regional) | 0.61 |
| 3 | Pozzocrete (P40) | 3.50 |
| 4 | Pozzocrete (P60) | 4.40 |
| 5 | Pozzocrete (P100) | 12.20 |

TABLE - 9
MATERIALS FOR DESIGNE MIX MORTAR (1:3)

| Mortar Type | Materials [kg/m ³] | | | | | Total Cost [m ³] | % change in Cost |
|-------------|--------------------------------|--------------|--------|--------|--------|------------------------------|------------------|
| | C | F.A. (River) | P40 | P60 | P100 | | |
| A1 | 566.57 | 1699.72 | 0 | 0 | 0 | 4504.24 | 0 |
| B1 | 509.91 | 1699.72 | 56.65 | 0 | 0 | 4362.60 | (-) 3.14 |
| B2 | 396.59 | 1699.72 | 169.97 | 0 | 0 | 4079.31 | (-) 9.43 |
| B3 | 283.28 | 1699.72 | 283.28 | 0 | 0 | 3796.03 | (-) 15.72 |
| C1 | 509.91 | 1699.72 | 0 | 56.65 | 0 | 4413.59 | (-) 2.01 |
| C2 | 396.59 | 1699.72 | 0 | 169.97 | 0 | 4232.28 | (-) 6.03 |
| C3 | 283.28 | 1699.72 | 0 | 283.28 | 0 | 4050.98 | (-) 10.06 |
| D1 | 509.91 | 1699.72 | 0 | 0 | 56.65 | 4855.51 | 7.79 |
| D2 | 396.59 | 1699.72 | 0 | 0 | 169.97 | 5558.06 | 23.39 |
| D3 | 283.28 | 1699.72 | 0 | 0 | 283.28 | 6260.61 | 38.99 |

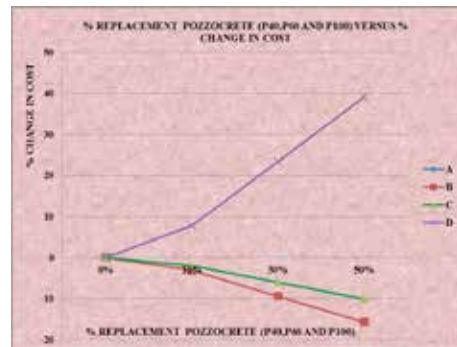


Fig 7: % Replacement Pozzocrete (P40, P60 and P100) versus % Change in Cost

V. CONCLUSION

From this study the following conclusion can be drawn:

- The results presented in this paper, indicate that the incorporation of a Pozzocrete (P40, P60 and P100) in mixed cement is not feasible for making masonry mortars for early age strength.
- Adequate strength developments were not found in mortars made of the mixed cement and Pozzocrete (P40, P60 and P100) as cement replacement for 1:3 mortars at early age i.e. 7 days.
- Pozzocrete (P40, P60 and P100) may be used in masonry mortar to improve the long-term bond strength. Partial replacement of the Portland cement with Pozzocrete (P40, P60 and P100) does not improve the masonry bond strength at early age of 7 days.
- So it can be used in non-structural elements with the low range compressive strength where early strength is not required.
- Pozzocrete (P40, P60) can be used to prepare low cost temporary structure.
- The results indicate that the % change in cost reduces up to 15.72 for 50% replacement of Pozzocrete (P40) and 10.06 for 50% replacement of Pozzocrete (P60).
- The results indicate that the % change in cost increases up to 38.99 for 50% replacement of Pozzocrete (P100).

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