# Effect of Water Absorption and Sorptivity on Durability of Pozzocrete Mortar

**Rushabh A. Shah, Jayeshkumar Pitroda**

***Abstract- After evaporation of excess water in the mortar, voids inside the mortar creates capillaries which are directly related to porosity and permeability of the mortar. Proper selection of ingredients, adequate mix proportioning & followed by good construction practices lead to almost impervious mortar. Due to incomplete compaction; mortar may consists gel pores & capillary pores, which leads to low strength of mortar. Due to problems associated with the absorption test and permeability test; which are measuring the response of mortar to pressure which is rarely the driving force of fluids entering in to mortar; hence there is a need for another type of test. Such tests should measure the rate of absorption of water by capillary suction; "sorptivity" of unsaturated mortar. In this paper, an attempt is made to study sorptivity and water absorption properties of Pozzocrete mortar. The mix design was carried out for 1:3 proportion cement mortar on the basis of IS 269:1970.***

***Key words*-capillary suction,sorptivity, water absorption, Pozzocrete, mortar**

## I. INTRODUCTION

Mortar is a material having tiny spaces through which liquid or air may pass.The durability of mortar depends largely on the movement of water and gas enters and moves through it. The permeability is an indicator of mortar's ability to transport water more precisely with both mechanism that is controlling the uptake and transport of water and gaseous substances into cementitious material. whileSorptivity is materials ability to absorb and transmit water through it by capillary suction.

Uptake of water by unsaturated, hardened mortar may be characterized by the sorptivity. This is a simple parameter to determine and is increasingly being used as a measure of mortar resistance to exposure in aggressive environments.

Sorptivity, or capillary suction, is the transport of liquids in porous solids due to surface tension acting in capillaries. It is a function of the viscosity, density and surface tension of the liquid and also the pore structure (radius, tortuosity and continuity of capillaries) of the porous solid. It is measured as the rate of uptake of water.

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Transport mechanisms act at the level of the capillary pores and depend on the fluid and the solid characteristics. The porous structure of mortar is intimately related with its permeability. A low water/cement ratio results in mortar structures which are less permeable because they are characterized by having small pores which are not interconnected.

**TABLE 1**
**ACCEPTANCE LIMITS FOR DURABILITY INDEXES**

| Acceptance Criteria | | OPI (log scale) | Sorptivity (mm/h) |
|---|---|---|---|
| Laboratory mortar | | >10 | < 6 |
| As-built Structures | Full acceptance | > 9,4 | < 9 |
| | Conditional acceptance | 9,0 to 9,4 | 9 to 12 |
| | Remedial measures | 8,75 to 9,0 | 12 to 15 |
| | Rejection | < 8,75 | >15 |

## II. DESIGN MIX MATERIALS

### *a) Supplementary cementitious material: Pozzocrete*

***Pozzocrete (P40, P60 and P100)***

Pozzocrete (P40, P60 and P100) is a high efficiency pozzolanic material, obtained by selection, processing and testing of 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- 2**
**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% |



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| | | | |
|---|---|---|---|
| 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 |

### *b) Cement*

The cement used is SANGHI OPC 53 grade cement. The Ordinary Portland Cement of 53 grade conforming to IS: 8112-1989is be use. Tests were conducted on cement like Specific gravity, consistency tests, setting tests, soundness, Compressive strength N/mm$^2$ at 28 days.


**Fig 1: SANGHI CEMENT**

**TABLE –3**
**PROPERTIES OF CEMENT**

| Sr.no. | properties | 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 | 58 N/mm$^2$ | 53 N/mm$^2$minimum |

### *d) Fine aggregate*

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

**Fig 2: Fine aggregate (River sand)**

**TABLE- 4**
**PROPERTIES OF SAND**

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

### *e) Water*

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

## III.DESIGN MIX METHODOLOGY

### *a) Design Mix*

A cement mortar mix 1:3 was designed as per IS: 269 methods and the same were used to prepare the test samples. The design mix proportion is done in Table 5,6 and 7.

**TABLE - 5**
**MIX DESIGN PROPORTIONS**

| | Water | Cement | Fine aggregate |
|---|---|---|---|
| **By Weight, [gms]** | 86 | 200 | 600 |
| **By Volume, [m$^3$]** | 0.43 | 1 | 3 |

**TABLE- 6**
**CEMENT REPLACEMENT BY POZZOCRETE (P40, P60 AND P100)**

| Sr. No. | Types of Mortar | 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- 7**
**MIX PROPORTION FOR MORTAR**

| M.T. | W/C ratio | Design Mix Proportions For Mortar (1:3) | | | | |
|---|---|---|---|---|---|---|
| | | C | F.A. | P 40 | P 60 | P 100 |
| A1 | 0.45 | 1 | 3 | - | - | - |
| B1 | 0.45 | 0.9 | 3 | 0.1 | - | - |
| B2 | 0.45 | 0.7 | 3 | 0.3 | - | - |
| B3 | 0.45 | 0.5 | 3 | 0.5 | - | - |
| C1 | 0.45 | 0.9 | 3 | - | 0.1 | - |
| C2 | 0.45 | 0.7 | 3 | - | 0.3 | - |
| C3 | 0.45 | 0.5 | 3 | - | 0.5 | - |
| D1 | 0.45 | 0.9 | 3 | - | - | 0.1 |
| D2 | 0.45 | 0.7 | 3 | - | - | 0.3 |
| D3 | 0.45 | 0.5 | 3 | - | - | 0.5 |

M.T. =Mortar Type, W/C ratio= Water/Cement Ratio,C= Cement, F.A. = Fine Aggregate,

***b) Water absorption test***

The 70.7 mm x 70.7 mm x 70.7mm size cubeafter casting were immersed in water for 28 days curing.These specimens were then oven dried for 24 hours at the temperature85°C until the mass became constant and again weighed. This weightwas noted as the dry weight (W1) of the cylinder.After that the specimen was kept in water at 85°c for 24 hours. Then this weight was noted as the wet weight (W2) of the cylinder.

% water absorption = [(W2– W1) / W1] x 100
Where,
W1 = Oven dry weight of cubes in grams
W2 = After 24 hours wetweightof cubes in grams.

**Fig 3: Setup of Oven**

**Fig 4: Setup of Hot Water Curing**

***c) Sorptivity test***

The sorptivity can be determined by the measurement of the capillary rise absorption rate on reasonably homogeneous material. Water was used of the test fluid. The cubes after casting were immersed in water for 28 days curing. The specimen size 70.7 mm x 70.7 mm x 70.7mm after drying in oven at temperature of 85 °C were drowned as shown in figure 6 with water level not more than 5 mm above the base of specimen and the flow from the peripheral surface is prevented by sealing it properly with non-absorbent coating. The quantity of water absorbed in time period of 30 minutes was measured by weighting the specimen on a top pan balance weighting upto 0.1 mg. surface water on the specimen was wiped off with a dampened tissue and each weighting operation was completed within 30 seconds.
Sorptivity (S) is a material property which characterizes the tendency of a porous material to absorb and transmit water by capillarity. The cumulative water absorption (per unit area of the inflow surface) increases as the square root of elapsed time (t)

$I=S.t^{½}$ therefore $S=I/ t^{½}$
Where;
S= sorptivity in mm,
t= elapsed time in mint.

$I=\Delta w/Ad$

Δw= change in weight = W2-W1
W1 = Oven dry weight of cylinder in grams
W2 = Weight of cylinder after30 minutes capillary suction of water in grams.
A= surface area of the specimen through which water penetrated.
d= density of water

**Fig 5: Setup of weight**

**Fig 6: Setup of Sorptivity**

## IV.EXPERIMENTAL RESULTS

Table-8 and 9gives the water absorption and Sorptivity test results of % replacement of fly ash in mortar for 28 days curing. The % replacement vs % water absorption and Sorptivity results are graphically shown in figure 7 and 8.

**TABLE 8**
**AVERAGE % WATER ABSORPTION AT 28 DAYS**

| Mortar Type | DryWt in grams (W1) | Wet Wt in grams (W2) | % Water Absorption |
|---|---|---|---|
| A1 | 772 | 806 | 2.77 |
| B1 | 776 | 806 | 3.08 |
| B2 | 780 | 804 | 3.84 |
| B3 | 769 | 804 | 4.83 |
| C1 | 770 | 798 | 3.67 |
| C2 | 788 | 818 | 3.75 |
| C3 | 752 | 781 | 3.85 |
| D1 | 780 | 812 | 2.90 |
| D2 | 801 | 825 | 3.00 |
| D3 | 783 | 806 | 4.14 |

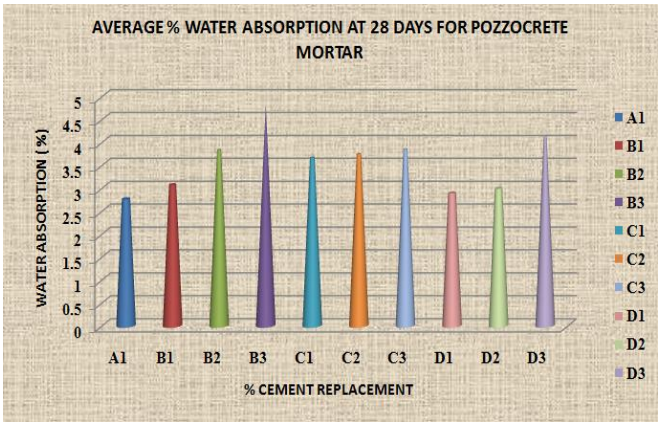


**Fig. 7: % Replacement of cement versus % water absorption**

**TABLE- 9**
**SORPTIVITY AT 28 DAYS**

| Mortar Type | Dry Wt in grams (W1) | WetWt in grams (W2) | Sorptivity value in $10^{-4}$ mm/min$^{0.5}$ |
|---|---|---|---|
| A1 | 793 | 797 | 1.46 |
| B1 | 797 | 800 | 1.10 |
| B2 | 800 | 802 | 0.73 |
| B3 | 797 | 800 | 1.10 |
| C1 | 790 | 792 | 0.73 |
| C2 | 810 | 813 | 1.10 |
| C3 | 772 | 775 | 1.10 |
| D1 | 802 | 804 | 0.73 |
| D2 | 818 | 822 | 1.46 |
| D3 | 799 | 802 | 1.10 |

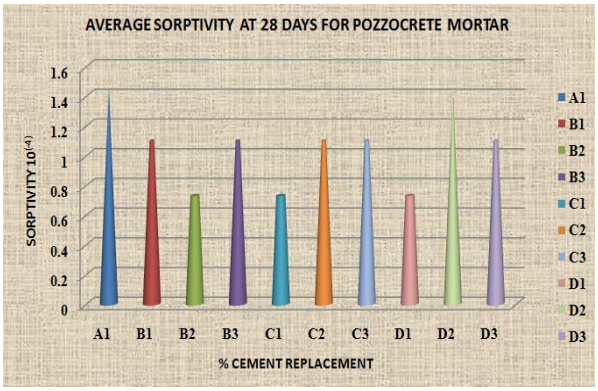


**Fig. 8: % Replacement of cement versus sorptivity**

## V. CONCLUSION

Based on limited experimental investigation concerning the water absorption and sorptivity of mortar, the following observations are made regarding the resistance of partially replaced Pozzocrete1:3 proportion mortar:

(a) The water absorption of Pozzocrete P40, P60and P100 in Pozzocrete 1:3 mortar mix higher than traditional mortar.
(b) Where percentage increase in water absorption is found to be 4.83% for P40, 3.85% for P60, 4.14% for P100 and sorptivity is found to be 1.10 mm/min$^{0.5}$ for P40, 1.10 mm/min$^{0.5}$ for P60, 1.10 mm/min$^{0.5}$ for P100 respect to reference mix.
(c) The water absorption and sorptivity of P40,P60 and P100 Pozzocrete1:3 proportion mortar shows higher water absorption and lesser sorptivity than traditional mortar.
(d) The Pozzocrete can be innovative supplementary cementitious Construction Material but judicious decisions are to be taken by engineers.

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