

Development of polymer modified cementitious (polycem) tiles for flooring

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Abstract

The novel polymer modified tiles are the combination of portland cement, fine and coarse sand, developed water dispersible interpolymer complexes alongwith some additives and modifiers required for enhancing the surface texture and finish. High pressure compaction technique has been designed and used for the development of novel tiles which have the excellent physico-mechanical properties. To assess the reaction mechanism during the hydration of cement in presence of water dispersible polymers, DTA and SEM studies were conducted. From these studies, it is observed that water dispersible polymers interact with the Ca^{2+} formed during the hydration of cement and coalesce to form a continuous film which imparts improved physico-mechanical properties to the tiles.

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1. Introduction

Tiles made with portland cement and aggregate has been recognized as a popular construction material and has satisfied several performance requirements. However, it possesses certain inherent drawbacks like low flexural and tensile strength, poor chemical resistance, impact resistance and wear resistance. Although portland cement based tiles are highly versatile construction material, a definite need exists for improving tensile strength, toughness and ductility. One valid approach is to combine the cement mortar with water dispersible polymers [1–8] and develop new components and technologies. Since addition of polymer reduces the water content in the mix resulting into a less permeable hardened matrix [9,10]. Keeping the above merits into views, Central Building Research Institute Roorkee has worked on the systems in which modification of the existing systems was initiated which resulted into the

development of *Polymer Modified Cementitious Tiles named as polycem tiles*. These developed tiles have substantial improvement over the existing one and are suitable for floors of residential, commercial and industrial buildings, where mild chemical resistance is required.

2. Experimental

2.1. Development of polycem tiles

In this study, polycem tiles were developed by using white cement with siliceous aggregates to which water dispersible interpolymer complex, i.e., SBR latex and acrylic emulsion (A) and modified epoxy system (B) alongwith some additives are added prior to casting of tiles. High pressure compaction technique has been used to get highly compacted/dense tiles. The polymer content, pressure, temperature and mix designs are the main variables. All the parameters such as mix design (content of materials to be used), curing conditions, compacting pressure, etc., were optimized for the development of

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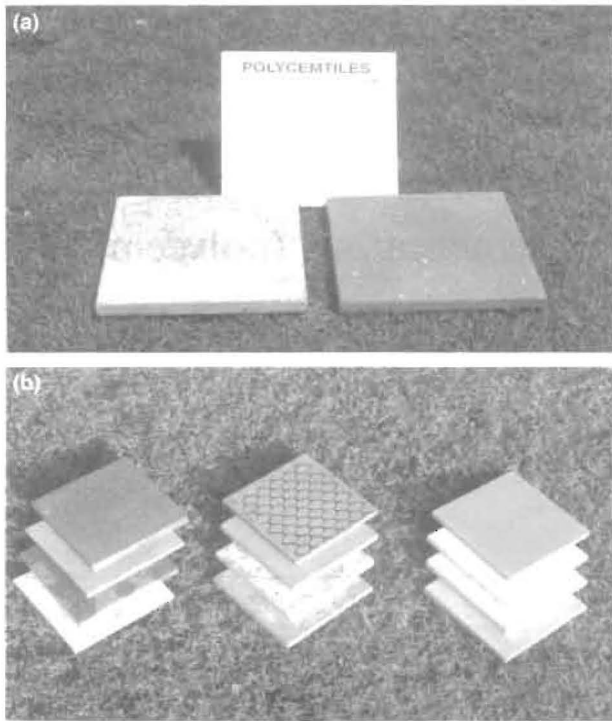


Fig. 1. (a) Photograph showing polycem tile. (b) Different polycem tiles showing variety of texture.

tiles. Tiles thus developed are shown in Fig. 1(a) and (b). These tiles were subjected for determining the following properties, viz., density, water absorption, wear resistance, flexural strength, compressive strength, etc., as per IS:1237-1997 [11] and have been compared with the conventional commercially available tiles. Results are reported in Table 1.

2.2. Reaction mechanism

To understand the reaction mechanism during hydration of cement with polymer, differential thermal analysis (DTA) and scanning electron microscope (SEM) have been utilized.

DTA studies: The thermal analyser STA-1500 PL, Stanton Redcroft model (UK) was used for this study. The calibration was done with Al_2O_3 as standard. All

the scans were carried out at a heating rate of $10\text{ }^\circ\text{C}/\text{min}$ and chart speed $200\text{ mm}/\text{hr}$. All the scans were run in static air. Two types of water dispersible polymer were utilized for this study, i.e., copolymer of SBR latex and acrylic emulsion (A) and water dispersible modified epoxy system (B). Thermograms of hardened portland cement mortar alone as well as with above mentioned polymer loaded cement mortars, have been recorded. All the DTA scans are shown in Fig. 2.

SEM studies: To study the morphology of the Ca-polymer latex complexes, scanning electron microscopic studies of the cement mortar along with polymer loaded cement mortars were carried out on SEM-501. For this fractured and unfractured specimen of size $10 \times 10 \times 5\text{ mm}$ were cut from the tiles prepared by using the cement mortar alone as well as with different polymer loaded cement mortar. These cut samples were fixed on the stud with silver paint, afterward gold coating was applied on the specimens in the vacuum apparatus, i.e., in sputter coater unit. These coated specimens were placed in SEM apparatus and were moved vertically and horizontally with the help of rotating knobs for taking the SEM micrographs at the different locations. Fig. 3(a) and (b) shows the micrograph of hardened matrix having no polymer, whereas Figs. 4(a),(b) and 5(a),(b) show micrographs of hardened matrix having water dispersible polymers.

3. Results and discussion

Perusal of Table 1 shows the mechanical properties of polymer modified cementitious tiles are much more superior as compared to unmodified tiles (having no polymer) and conventionally used commercial tiles. Flexural strength increases from 4.0 to 9.0 MPa, compressive strength from 40.0 to 65.0 MPa, wear resistance from 2.6 to 0.9 mm. Percent water absorption decreases appreciably, i.e., from 12% to 6.0%. This is due to pore filling characteristic of water dispersible polymer when incorporated in cement mortar compositions. Wear resistance increases as the polymer bridge the microcracks propagation inside the matrix and at the aggregate-matrix interface. Increase in strength properties can be

Table 1
Physio-mechanical properties of polycem tiles

Property	Plain coloured tiles	Modified tiles		
		Without polymer	With polymer A	With polymer B
Density (g/cc)	2.05	2.02	2.15	2.16
Water absorption (%)	12.0	9.5	6.0	5.0
Compressive strength (MPa)	38.5	50.1	64.7	68.5
Flexural strength (MPa)	4.2	6.2	9.5	10.0
Wear resistance (mm)	2.7	2.90	0.95	0.90

Values given are the average of five values.

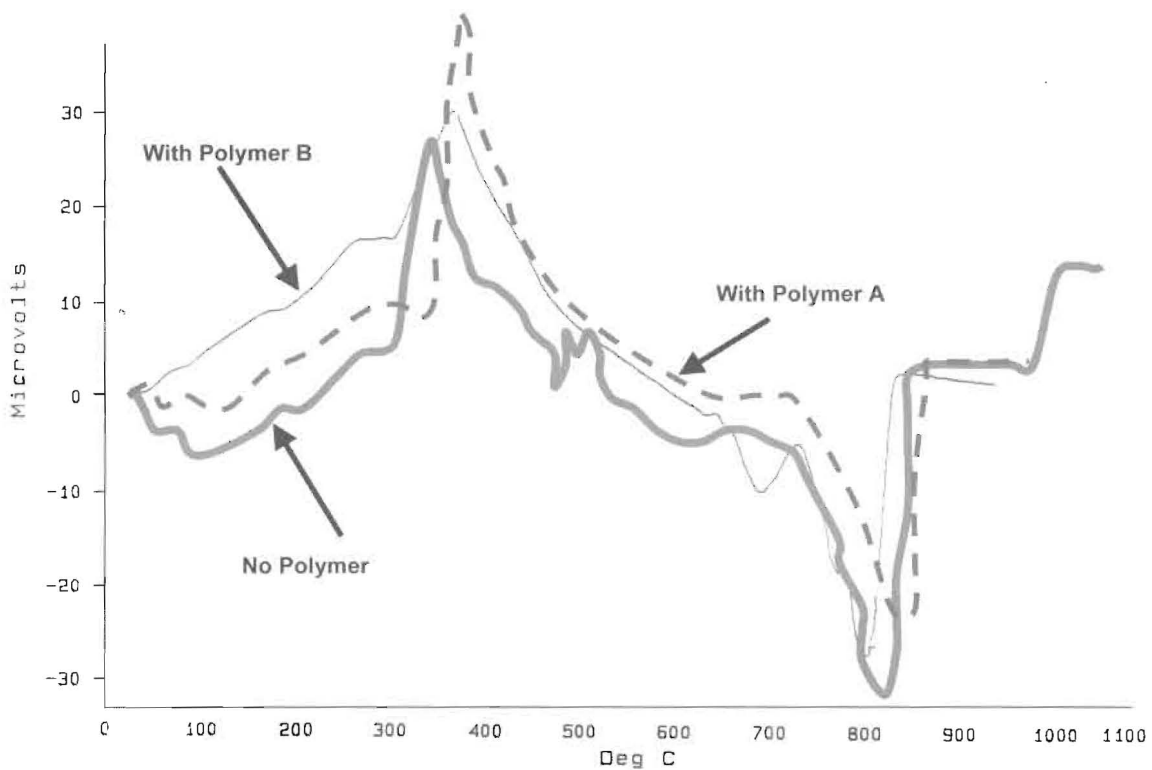


Fig. 2. DTA scan of polycem tile having no polymer, polymer A and polymer B.

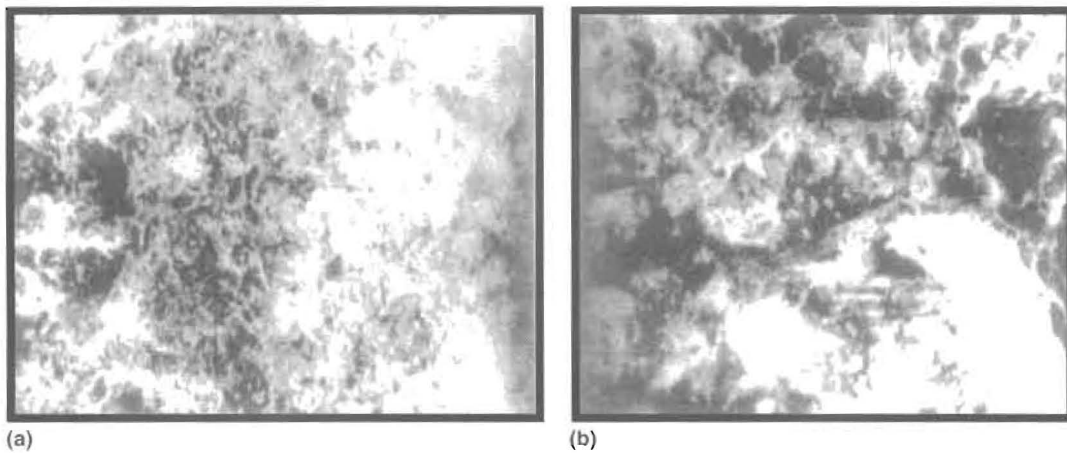


Fig. 3. Micrograph of polycem tile having no polymer: (a) surface view; (b) bulk view.

attributed to the microcrack arresting action of polymers and also to the bonding provided between the aggregate and matrix.

3.1. DTA studies results

Perusal of different thermograms show that in case of cement mortar (Fig. 2) endothermic peak below 200 °C corresponds to expulsion of water from CSH phase and next endotherm at 470 and 490 °C is due to decomposition of $\text{Ca}(\text{OH})_2$ while peak at 605, 690 and 815 °C on

the DTA curve represents the dehydration of highly crystalline $\text{Ca}(\text{OH})_2$ and highly crystalline CSH, respectively. Thermograms of polymer loaded cement mortar, endotherms at 90, 190, 260 °C correspond to the expulsion of capillary water and water of CSH phase which is still present in polymer cement mortar but they have changed little in shape and size in comparison to cement mortar alone. Endothermic peak in polymer cement thermogram at 315 °C (Polymer A) and 700 °C (Polymer B) can be attributed due to decomposition of polymers. Disappearance of endothermic peak at 470,

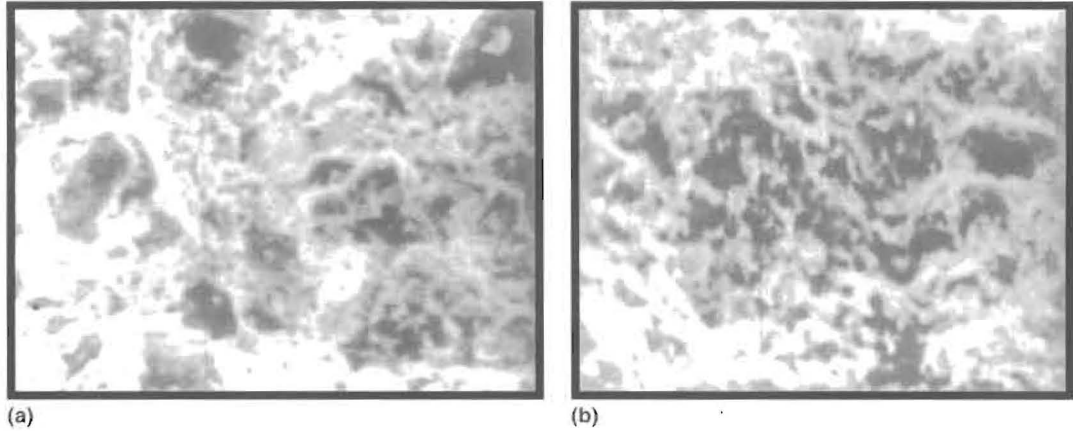


Fig. 4. Micrograph of polycem tile containing polymer A: (a) surface view; (b) bulk view.

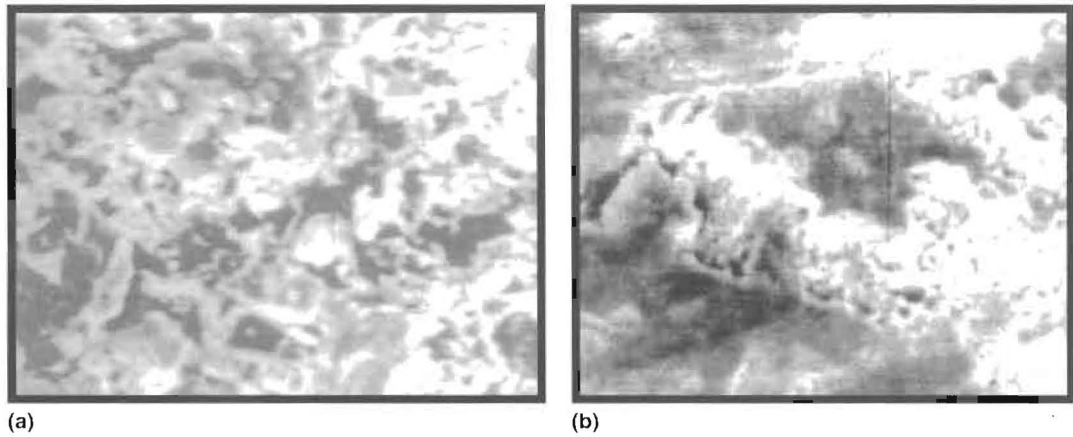


Fig. 5. Micrograph of polycem tile containing polymer B: (a) surface view. (b) bulk view.

490, 605 and 690 °C in case of polymers indicates the possible reaction between the hydrated cement and the polymer. This infers that polymer interact with Ca^{2+} and $\text{Ca}(\text{OH})_2$ released during the hydration of cement and crosslink to COO^- ions of polymer, thus the polymer has considerable influence on the crystallization of $\text{Ca}(\text{OH})_2$, Ca^{2+} react with carboxylate groups, gel formation is possible. Carboxylate group of polymer partly interact with free valences of calcium atoms on the surface of $\text{Ca}(\text{OH})_2$ solid particles.

3.2. SEM studies results

The micrographs having cement + aggregate + polymer clarifies that the nature of hydration product change significantly due to the polymer addition. In the cement + aggregate tile, the needle like and acicular crystallites are predominating (Fig. 3(a) and (b)), whereas for the polymer containing paste the gel seems to be amorphous consolidated into a compact mass in

which $\text{Ca}(\text{OH})_2$ crystallites are embedded (Figs. 4(a),(b) and 5(a),(b)).

The average grain size of the $\text{Ca}(\text{OH})_2$ crystallites was also affected due to presence of polymer as shown in Figs. 4 and 5. The orientation is definitely initiated by chemical bond formation between the polymer and $\text{Ca}(\text{OH})_2$ formed during hydration of cement.

4. Conclusions

On the basis of above studies, it is concluded that with the addition of polymers and modification of process, there is substantial improvement in physico-mechanical properties of the tiles. From the DTA and SEM studies, it is inferred that the polymer interacts with the Ca^{2+} formed during the hydration of cement and coalesce to form a continuous film which may be the reason for getting the improved physico-mechanical properties in the tiles.

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