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High-performance, marble-like plaster coatings

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Abstract

Conventional plaster coatings based on lime wash, cement paints, and resins offer decorative look with varying degree of water proofing. However, these coating surfaces usually undergo weather-induced deteriorations due to chemical and physical changes that lead to chipping, peeling off, and development of shrinkage cracks. To overcome these problems, a composite formulation, which contains more than 80% marble powder as inorganic graded filler with small amount of hydraulic components, has been developed. The uniform application of these composite pastes on masonry-plastered surfaces, result in a marble-like surface after the hardened coat is polished. The Mohs hardness of the developed, hardened, and polished coating surface was found to be >5. The coating was observed to retain dimensional stability and hardness when exposed to elevated temperature conditions (∼60°C) over long periods. After 2 years of exposure to various weather conditions, the external wall plasters did not shown any sign of deterioration. The mineralogy and morphology of the coating surfaces have been found to be comparable to that of an eggshell.

Keywords: Curing; Microstructure; Aging; Durability; Composite

1. Introduction

Finishing surface coats, as applied to masonry-plastered surface, are generally based on lime wash, cement, and organic paints [1–3]. Coatings provided by lime and cement are plastic and, when weather-dried, may show permanent chemical and physical changes. These coatings are applied both on interior as well as exterior plastered surfaces. Coatings based on organic composites such as paints are elastic and undergo permanent chemical change on weathering but the physical changes are small due to volume flexibility. Consequently, these coatings can bear changes in the base plaster in the form of drying and carbonation cracks without exhibiting surface defects, which are generally seen in plastic-coated surfaces. Since the elastic coatings are temperature-sensitive, these are applied exclusively on interior wall plasters. On account of predominant weather effects, these coatings undergo rapid deterioration and, consequently, have limited durability [3].

The present paper reports on studies concerning the development and durability of inorganic coating formulations under different curing conditions.

2. Methods

The raw materials used for the development of composites were commercial grade lime, Portland cement, and coarse-grained inorganic fillers such as limestone (∼30% residue on 170 mesh). These raw materials were evaluated for oxide constituents using chemical analytical technique. The mineralogical compositions were determined by X-ray diffraction technique using the characteristics CoK_{α} radiation (∼1.788A°). Dry mixes of different compositions were prepared and their pastes were evaluated for setting and hardening characteristics.

Freshly prepared masonry plastered surface hardened for 7 days was selected and free-flowing slurry of the composite mixes were applied on these surfaces using a spreader and allowed to set and harden. After the final set, these layers were smoothened and pressed by a trawler; upon hardening, they were polished with the help of a metallic sheet and spreading the soap powder on the wet surface. Coloring pigments were also used before polish-

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ing by touching with the help of a brush for the purpose of decorative designing. After a gap of 2–3 days, sprinkling of water cured these layers. Cement tiles (12 × 12 in. size) were also coated in similar manner. The hardness of coated surfaces was determined periodically on the Mohs hardness scale [4]. In order to study the effect of various curing conditions, the tile (having hardened coating surface) was kept under ambient condition for 2 months and immersed in water at 60°C for 4 months. Another specimen of coated tile was periodically immersed in water overnight and then kept at elevated temperatures in an oven continuously for 2 months. The coated surface was studied for crack formation and hardness. The hardened layer was also studied for mineral phases and surface morphology using XRD and SEM techniques. Since the coated layer had a surface finishing resembling that of an eggshell, a comparative study of mineralogy and surface morphology was also carried out on eggshell using XRD and SEM.

3. Results and discussions

Tables 1 and 2 present the chemical and mineralogical analysis of constituents used in developing the composites. The limestone is rich in dolomite, containing ~20% MgO, the cement has low iron content and lime is predominantly Ca $(OH)_2$. The optimized composition containing 10% white cement, 10% lime, and 80% limestone powder was prepared as workable paste and applied both on the surface of cement tiles as well as plastered walls as shown in Fig. 1a and b. Fig. 1a and b shows the developed coating-polished surface with marble-like appearance. Polishing of the coating brought out shining surface, which was retained even after more than 2 years' exposure to ambient conditions. The polished coating also has an advantage of water repellence owing to surface gloss. Consequently, the effects of the corrosive elements were also reduced, which led to improved durability. The coating formulation contained more than 80% inert filler material of controlled size gradation and no significant chemical changes were found on weathering. The layers,

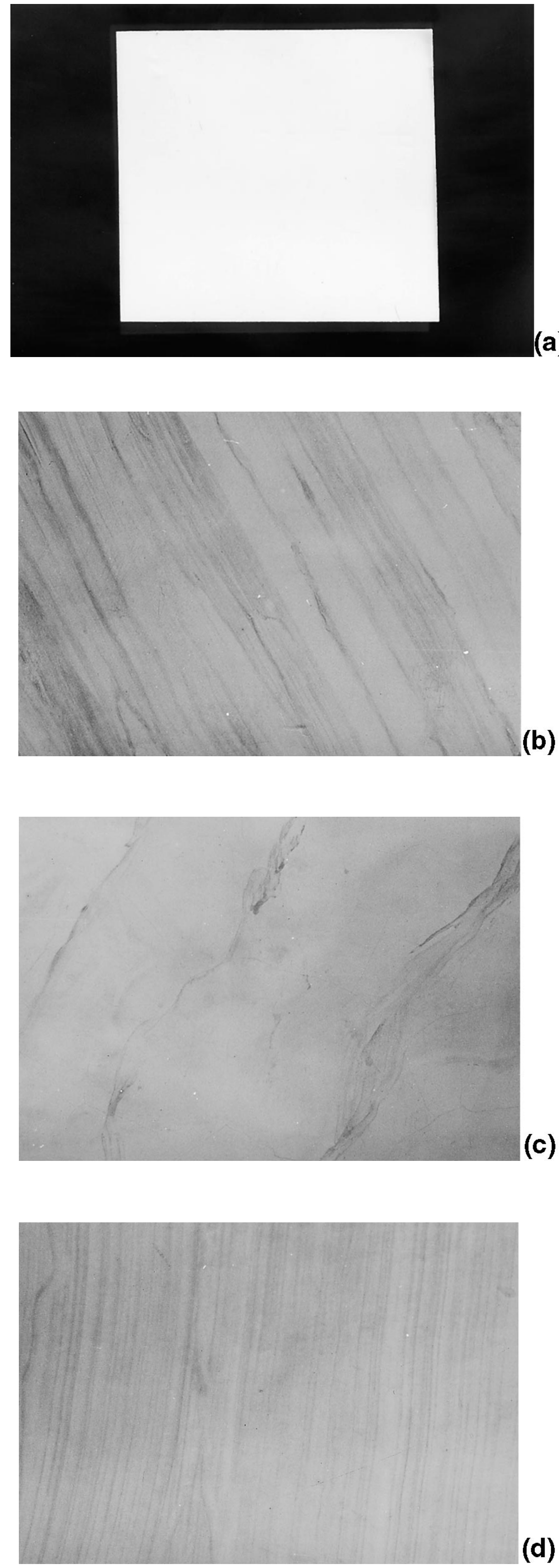

Fig. 1. Marble finish plaster coatings (a,b) composite applied on cement tile and (c,d) plaster wall.

Table 1
Chemical analysis of constituents used

Constituents	LOI	SiO_2	Fe_2O_3	Al_2O_3	MgO	CaO
Limestone	44.45	3.62	0.64	0.47	20.33	30.07
Cement	7.72	19.76	0.40	3.16	3.28	60.02
Lime	22.50	1.20	0.20	0.20	3.55	72.16

Table 2
Mineralogical analysis of constituents used

Constituents	Major phases	Minor phases
Limestone	Dolomite, Calcite	α-quartz
Cement	Alite, Belite, and C_3A	α-quartz
Lime	Portlandite	Calcite

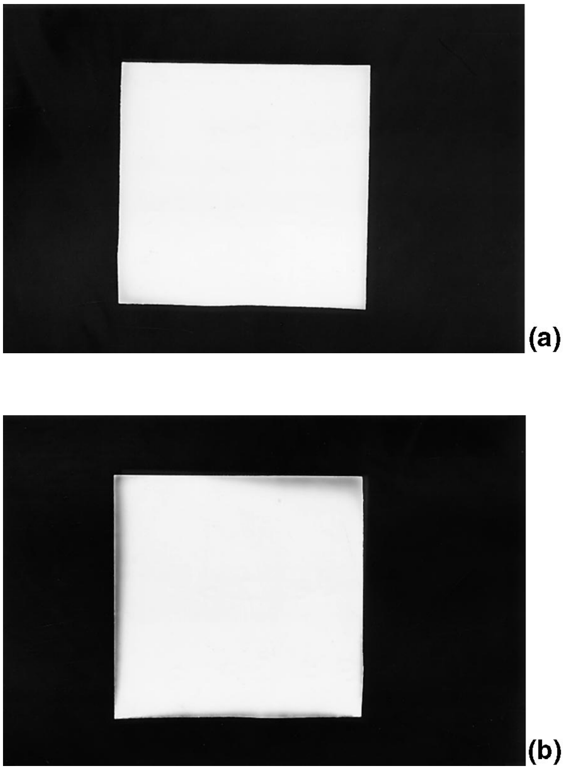

Fig. 2. Coated surface cured (a) at 60°C, and (b) alternate ambient water and oven curing at 60°C.

which was applied on for 2 years on the exterior wall surface, have also not shown any sign of deterioration. The Mohs hardness of the coating developed was observed to be ~5 and was found to be greater than that of an eggshell (3.0 Mohs) of similar thickness.

Surface variations were also studied by exposing the layers to extreme climatic temperature conditions, which were simulated in the laboratory. Maintained in oven at 60°C for 4 months (Fig. 2a), and alternately cured in water and in the oven at 60°C for 2 months (Fig. 2b), the coating surface did not show any kind of deterioration — chipping, peeling off, or surface crack. Similarly, on exposure to elevated curing and fluctuating conditions, the surface hardness was not found to be affected adversely.

The mineralogical evaluation of the coating surface showed the presence of calcite as a predominant phase along with dolomite and portlandite (Fig. 3a). The mineral analysis of an eggshell, as presented in Fig. 3b, also showed the presence of calcite and thus resembled with the coating developed.

The morphological features of the coating were found similar to that of an eggshell as shown in Fig. 4a and b. The white grains were of calcite and dolomite, the light gray of portlandite (Fig. 4a), and the darker regions showed the presence of pore [5]. The morphology of the developed coating revealed relatively larger pore spaces, which were due originally to filled water. The rapid hydration of

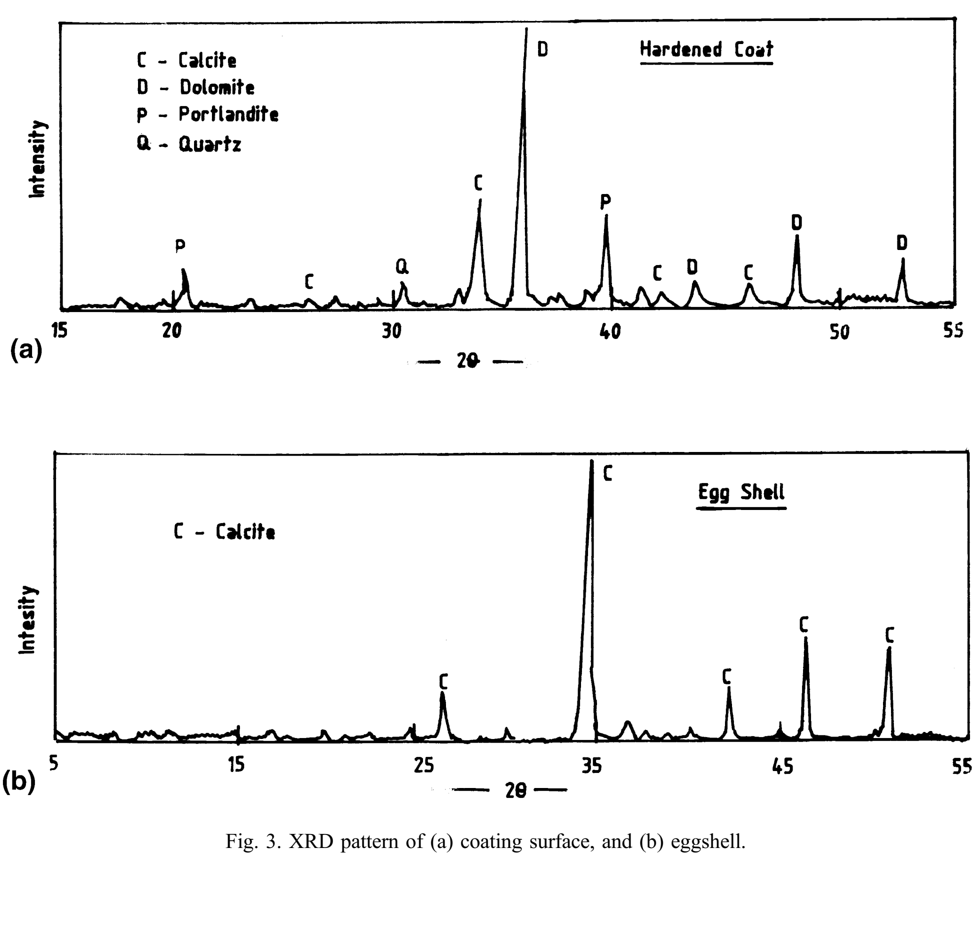

Fig. 3. XRD pattern of (a) coating surface, and (b) eggshell.

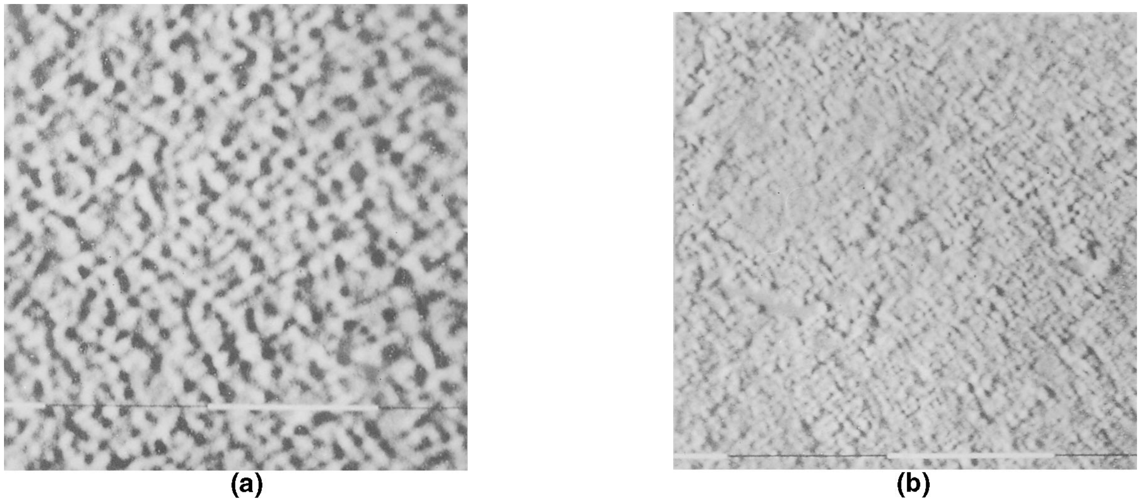

Fig. 4. Morphological features of (a) coating surface, and (b) eggshell.

aluminate and alite phases in the beginning results in larger pore spaces although cement hydration refills the same later on, thus adding to densification [6].

4. Conclusions

1. Coating formulation for finish plastic coat with marble-like surface finish has been developed in the form of thin, densified layer by using graded inorganic fillers cemented with small amount of Portland cement.

2. The coating is decorative, durable, not prone to corrosive ion attack due to surface finish, and hence, suitable both for external as well as interior finish.

3. The hardness of hardened coating is >5 on the Mohs scale, which retained dimensional stability even when exposed to extreme climatic conditions.

4. The synthetic layer of coating was found to be morphologically and mineralogically comparable to that of an eggshell but with much greater hardness and improved surface finishes.

Acknowledgments

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