Effect of Extenders on the Shrinkage Cracking of Cement Paint Film

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SUMMARY

An evaluation of indigenous cement paints carried out in this Institute revealed that they required repainting in 10-15 months because of loss of decorative value. The most serious defects observed were map-cracking and discolouration due to dirt retention and lime blooming. Lime, sand, asbestos and diatomaceous earth are known to decrease shrinkage cracks of cement mortar and mixes. It was therefore considered worthwhile to study the effect of these extenders on cement paints.

Ten cement paint formulations incorporating these extenders were exposed for natural weathering. After 18 months, it was found that lime addition was effective in reducing map-cracking upto 12-15 months. Thereafter the paint film developed cracks. Sand and asbestos did not bring about any reduction in map-cracking. On the other hand they encouraged dirt retention. Formulations containing the lowest proportion of extenders gave the best performance. This can only be explained on the basis of the water repelling aluminium stearate having maximum water repelling action in these formulations. The effect of higher proportions of water repellent on cement paint film is under investigation.

INTRODUCTION

Cement paint is most commonly applied on exterior masonry walls and is particularly suitable for application on walls of new construction which are damp at the time of painting. Being an inorganic composition it is not liable to degradation by sun light, micro-organisms, etc., which destroy paints based on oils and resins. Its service life depends very much on the substrate also. Cement plasters invariably show hair crazing in hot climate due to lack of proper curing. Cement paint film which is hard, rigid and relatively brittle does not accommodate drying shrinkage and movement in masonry. It results in the development of checking of the film which is sometimes called "map-cracking". Other defects with this paint are lime blooming, loss of colour and dirt retention. Repainting is necessitated by these defects rather than by film failure.

An evaluation of eight indigenous cement paints carried out in this Institute revealed that they required repainting after a service life of about 10-15 months.[1] The most serious defect noticed was map-cracking and discolouration. Lime, sand, powdered asbestos and diatomaceous earth are some of the extenders known to decrease shrinkage cracks of cement mortar and mixes. To evaluate the effect of these extenders in reducing the map-cracking of cement paint films, a number of formulations were subjected to exposure tests in this Institute. The results obtained in 18 months trial are reported in this paper.

EXPERIMENTAL

For outdoor exposure test four brick wall panels of size 3.75m. x 15m x 0.11m. were constructed facing south and north. They were smoothly finished with 1.6 cement sand mortar. The mortar used for the joinery was 1:1:6 cemen : lime : sand. A damp proof course at the base and a coping at the top were also provided. After six weeks of drying the surface of the panels were cleaned free from dust and loosely adhering mortars. The rectangular surface of each panel was divided into 10 equal parts and the application of the treatments were carried out following the scheme given in Table I.

The composition of the ten formulations tried are given in Table 2. All the ingredients were weighed

TABLE 1

DESIGN OF THE EXPERIMENTAL LAYOUT

Treatments	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10
Block No. 1	2	3	4	5	6	7	8	9	10	1
Block No. 2	10	1	2	3	4	5	6	7	8	9
Block No. 3	8	9	10	1	2	3	4	5	6	7
Block No. 4	4	5	6	7	8	9	10	1	2	3

TABLE 2

COMPOSITION OF CEMENT PAINTS

Constituents	No. 1	2	3	4	5	6	7	8	9	10
Cement	65	65	65	75	75	75	85	85	55	70
Lime	—	12.5	25	—	7.5	15	—	5	30	5.5
Sand	25	12.5	—	15	7.5	—	5	—	5	5.5
Powdered Asbestos	—	—	—	—	—	—	—	—	—	11
Cr_2O_3 (Green)	3	3	3	3	3	3	3	3	3	3
TiO_2	3	3	3	3	3	3	3	3	3	3
$Cacl_2$	2	2	2	2	2	2	2	2	2	2
Al. Stearate	1	1	1	1	1	1	1	1	1	1

separately, mixed and ground in a ball mill to the same fineness. The sand used was passing 20 B.S. mesh and retained on 100 B.S. mesh. The cement paint powder was mixed with water to form a thick paste and was finally diluted with water in the proportion of 1:1 by volume. The slurry was then vigorously stirred for a few minutes till it was of uniform consistency and all the particles were thoroughly wetted.

The application of the paint was done in Nov. 1961. The surface of the plaster was soaked with water prior to the application of first coat, to provide a reserve of moisture to aid in the proper hardening of the paint film. After 24 hours when the first coat became hard, water was sprayed 3-4 times and the surface was redampened slightly just in advance of applying the second coat. It was observed that the compositions containing lime had thicker consistency for the same volume of water than others.

OBSERVATIONS

Panels were examined for their performance quarterly with respect to checking, cracking, colour fadation, dirt retention and discolouration, chalking, peeling, erosion and general appearance. Each type of failure was rated as under:

No failure	— 0
Very slight failure	— 1
Slight failure	— 2
Pronounced failure	— 3
and complete failure	— 4

Except formulation 10, all other compositions started checking and cracking after 4 months of exposure (March/April). The extent of checking was less in formulations 3, 6, 8 and 9. During rainy season (July-September) formulation 10 suffered more severely from this defect than the rest. After an exposure period of 12-15 months, formulations 1, 2, 3, 6 and 9, showed more checking than 4, 5, 7 and 8.

Lime blooming and water and weather stains observed in indigenous cement paints were not found in these formulations. Chromium oxide green (Cr_2O_3) appeared to be effective against these types of failures at three per cent level. All the formulations in general exhibited a fair amount of dirt retention. Formulation 10 suffered very badly in this respect while 7 and 8 suffered the least. Among the remaining formulations 3, 6 and 9 showed a greater tendency to hold dirt than 1, 2 and 4.

ASSESSMENT OF THE RESULTS

From time to time attempts have been made by various workers to assess the performance of paint films[2]. Conclusions on the life of paints in service are usually arrived at from a descriptive summary of their behaviour. Sometimes this method fails to give a correct idea of paint life. It may even lead to wrong conclusions. Pass[3] worked out a scheme to express the loss of decorative and protective values separately for exterior grade phenolic paint by giving suitable weightages to various types of failure. The scheme given by Pass, with slight changes has been adopted in the evaluation of the durability of cement paints. Cement paints give matt finish and their decorative value is affected by colour fadation and lime blooming and therefore a progressive scale for this failure was also included in this scheme.

The entire data was averaged for the four replicates of each treatment separately. The net loss of decorative value was calculated for each quarter based on the weightages given in Table 3, for each type of failure and the results are given in Figs. 1 and 2. In the weathering studies of indigenous cement paints it was found that repainting became desirable for the sake of appearance when the loss of decorative value reached 20. From Figs. 1 and 2 it is observed that formulation ten only required repainting after 12/15 months of exposure while other formulations continued to give fair performance.

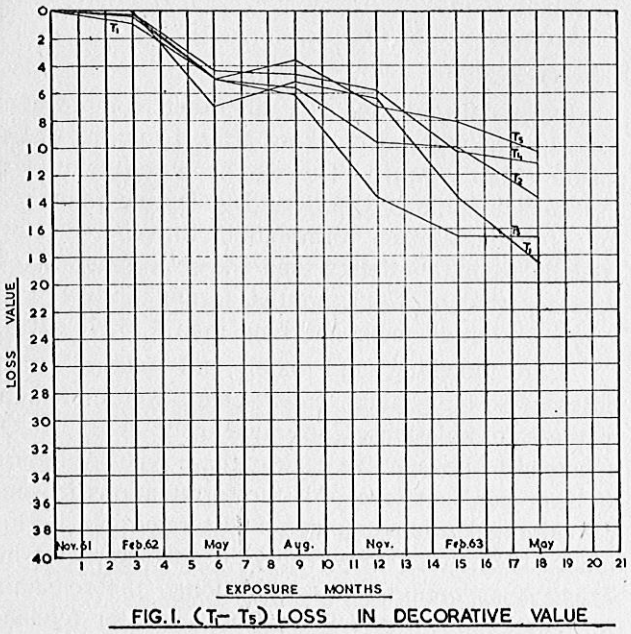

FIG. 1. (T_1 – T_5) LOSS IN DECORATIVE VALUE

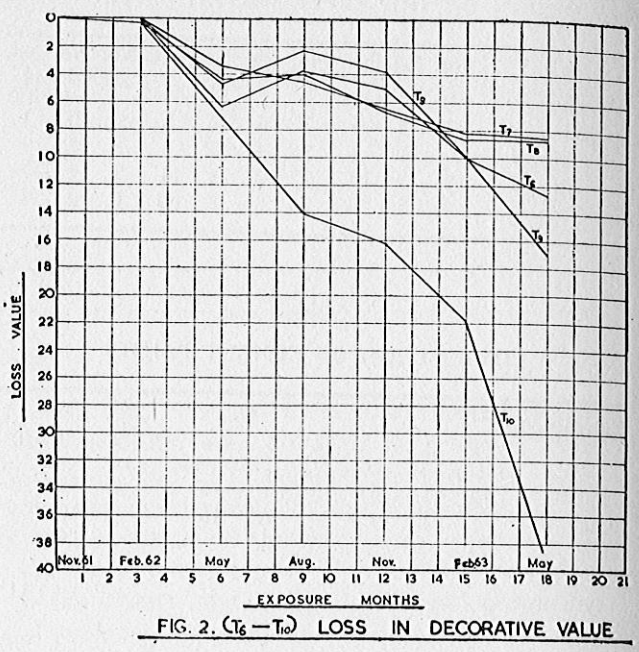

FIG. 2. (T_6 – T_{10}) LOSS IN DECORATIVE VALUE

TABLE 3

Weightages Assigned to Each Type of Failure For the Calculation of Loss of Decorative Value

Checking		D-loss	
Checking	...	$\frac{r^2}{2}$	(Max. 8)
Cracking	...	$2r^2$	(Max. 32)
Erosion	...	$3r$	(Max. 24)
Flaking	...	$3r^2$	(Max. 48)
Dirt retention and discolouration		$3r^{1.5}$	(Max. 24)
Colour fadation	...	$\frac{3r^{1.5}}{2}$	(Max. 12)
Chalking	...	$\frac{r^2}{2}$	(Max. 8)

r=failure rating

DISCUSSION

A straight cement mortar develops pronounced cracks on setting when used as a plaster on walls. The addition of lime gives the mortar more workability and water tightness which with the help of autogenous healing will greatly reduce shrinkage cracks[4]. Volume changes following setting is also progressively reduced as more and more lime is substituted for cement. Actually high lime mortar provides many relief planes so that stresses set up in the plaster due to absorption of solar energy and periodic wetting and drying do not lead to the development of cracks. It is observed from the results that lime addition suppressed shrinkage cracks in the film till 12/15 months of exposure. But surprisingly the formulations containing more than 5% lime by weight showed more cracking afterwards. It appears that compositions containing lime have an advantage only in the early period of exposure and thereafter they yield to stresses set up in the film and plaster due to thermal and moisture changes, just as plain lime washes (85% CaO) develop excessive map-cracking[5]. Again lime addition (formulations 3, 6 and 9) appears to favour the harbouring of more dirt due to soft texture of the film. This is a serious objection to lime addition unless some other modification is made to overcome this defect.

Sand had no effect in reducing the cracks. Use of fine sand in finishing plaster coats is reported to cause high shrinkage[6]. A more coarse sand may have some effect in reducing the shrinkage cracks but its use will result in a rough film which will collect more

dirt. The addition of crysotile variety of asbestos is ineffective in reducing the cracks. Its use rather encourages dirt retention and algal growth.

The formulations containing 85% cement put up the best performance. This can only be explained on the basis of their water repelling quality.

CONCLUSIONS

From the foregoing discussion it can be seen that lime addition in cement paints suppresses map-cracking in the early period of exposure and that fine sand and powdered crysotile asbestos are ineffective in reducing such cracking. Further it appears that the service life of cement paint is mainly dependent on the water repellent quality of the film.

The effect of higher proportions of water repellent on cement paint film is under investigation. It should also prove beneficial to increase the plasticity of the film by the addition of such materials as polyvinyl acetate resin emulsion[7], rubber latex, etc. Works on these lines also is in progress.

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