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Waterproofing treatment for masonry and lime concrete surfaces

(111)

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Low-cost waterproofing treatment for exposed masonry structures and lime concrete surfaces based on indigenous raw materials has been developed. The waterproofing efficacy of the treated surfaces of unplastered burnt clay bricks, and porous sandstone and lime concrete tiles was tested by permeability, weathering and water absorption tests. The artificial field rain-penetration test was performed on various full-size masonry panels made of burnt clay bricks, stoneblock work and flat lime concrete roofs. Treated specimens were found to possess remarkable water resistance compared to the silicone treatment, aside from being many times cheaper. The treatment was given on certain leaky office and residential buildings and has proved quite effective during the heavy monsoons of the last three years.

Masonry structures of brickwork or stonework, are very often left unplastered for aesthetic or financial reasons. Permeability studies on brick mortar masonry have shown that such structures usually fail to resist rain penetration and generally require waterproofing treatment to check water seepage and water vapour transmission [1 to 12]. A composition based on sodium silicate has been reported for waterproofing as well as strengthening of building components[13]. Sodium and potassium silicates act as integral waterproofing agents through the deposition of silica in mortar and concrete pores. The hardening in such systems is considered to be due to coagulation of silica gel which is stabilised by the alkali[12]. Although the treatments based on these silicates have been found effective in waterproofing and protecting concrete and masonry surfaces, no explanation of their action is yet known except that probably a glassy film is formed on the surfaces[14].

The criteria for effective waterproofers for masonry surfaces are ease of application, good transparency, water, as well as weather resistance and good durability. Generally, seepage in the brick and rubble masonry, is caused by infiltration of rain water through three points; through the masonry units, through the mortar and in between the masonry units, and through the jointing mortar. An effective waterproofing treatment will be one which seals the entry of moisture through all these three points[15]. The waterproofing action of silicones is due to the deposition of a colourless and hydrophobic film on the pores. Although silicones are recognised as good water-repellents for concrete and masonry surfaces, there have been adverse reports on their performance on roofs under laboratory and field conditions[16]. The water-based silicones can be applied on both dry and wet surfaces while solvent-based silicones are suitable only on dry surfaces. Further, the silicones also involve foreign exchange also as they are manufactured from imported ingredients.

A silicate based waterproofing treatment for plastered and concrete surfaces was developed at this Institute[17]. This was, however, found unsuitable for exposed brick masonry structures. Investigation on the development of indigenous waterproofing composition suitable for exposed masonry and lime concrete surfaces was, therefore, taken up and the results are reported in the paper.

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Experimental procedure

(*i*) *Preparation of material:* The waterproofing treatment is a two-component system; *i.e.*, an undercoat and a finishing coat. The undercoat is composed of a fine bentonite clay and two other chemicals and is obtained by dispersing them in a specified ratio in tap water. The finishing coat consists of particular grade of sodium silicate and two other watersoluble chemicals. It is prepared from these constituents by dissolving in distilled water and controlling its pH at 10.5, particle size at 0.1 to $1m\mu$ and density of 1.36. The finishing composition is finally filtered through a fine muslin cloth. Both undercoating and finishing compositions are stable and can be stored in airtight containers in a cool place for one year without damage.

(*ii*) *Preparation of surfaces and waterproofing treatment:* For laboratory tests full size burnt clay bricks were cut into four pieces of the size 120×70×50-mm slabs. These slabs were cleaned with hair brush and dried in the oven at 110°C to constant weight. Out of these dry brick pieces some experimental masonry wallets of the size 600×500×50mm were constructed with 1 : 6 cement-

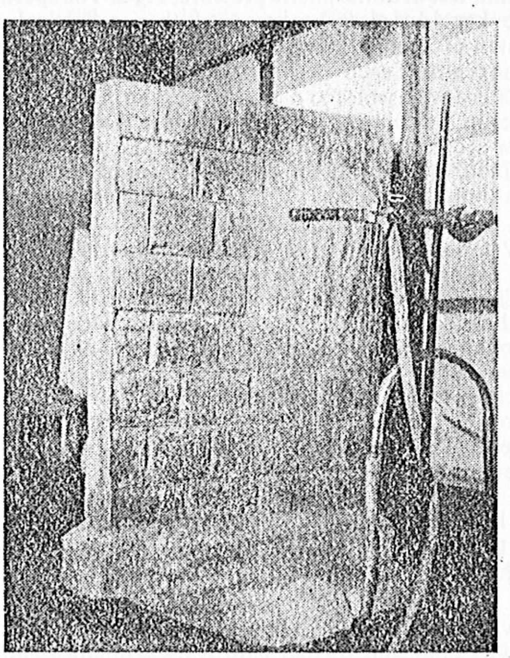

Fig 1 Cut brick masonry wallet 600 x 500 x 50mm with 1 : 6 cement-sand mortar joints under spray test

mortar, *Fig* 1. Some of the slabs were left as such for control and other tests. Some porous sandstone tiles of the size 100×100×25-mm were cut by the stone cutting machine and dried in the oven at 110°C to constant weight.

Beside these, few lime concrete slabs of the size 600×600 ×100-mm were cast according to standard methods and cured for 28 days. These slabs were cut into the size 100×100×50-mm, cleaned with hair brush and dried in the oven at 110°C to constant weight. Some normal full size bricks were also taken. These bricks were cleaned and plastered on five sides with 1 : 6 cement-mortar, cured for 28 days at 27±2°C and then dried completely in the oven at 110°C to constant weight.

All these dried specimens were given a surface waterproofing treatment with the help of a brush in the following manner: first an undercoat was given on the smooth surface of each specimen, and soon after, a finishing coat was applied over it. This constituted the first treatment. A second treatment of similar composition was applied after 24 hours. A final finishing coating was given after 24 hours of the second treatment and left for at least one week for complete drying.

For field tests, four sets (six in each set) of full size brick masonry walls, 2.4×1.2×0.24m and stone block masonry walls, 1.7×0.95×0.10m with 1 : 6 cement-sand and 1 : 1 : 6 lime-pozzolana-sand mortar joints were constructed. These were properly cured with water and then left in the sun for two weeks. Out of these, two walls with a pointed smooth surface were applied with waterproofing treatment as described above, the next two were treated with silicone, and remaining two were left untreated for control and comparison purposes.

Testing of waterproofing properties

Laboratory tests: Permeability test—The treatment applied on flat surfaces of 50-mm thick burnt clay brick tiles, 25-mm thick porous sand stone tiles and 50-mm thick lime concrete slab was tested by vertical permeability column test at atmospheric pressure, *Fig* 2. The specimens were kept on glass beakers and then a vertical glass column of 25-mm diameter and 750mm length was fixed at the centre of each specimen with the help of an adhesive and filled with water to a head of 600mm. To avoid water losses in the column, the water surface was covered with a few drops of mustard oil. The fall in the water head and the moisture appearance at the bottom of the specimen with time were noted.

Water-absorption test—Water absorption on one side exposed brick work was investigated on the brick specimens plastered on five sides as described above. Out of these specimens, three were treated with the water-proofing treatment and dried in air for 10 days, the next three were treated with silicone and other three specimens were left untreated. Now both treated and untreated specimens were immersed completely in the water at 25 ± 2°C for 6 hours. Then specimens were taken out and surface moisture was wiped off by cotton and weighed. These were then dried in the oven at 110°C for 16 hours and again weighed. The difference between the two weighings offers the water absorption values of both the treated and untreated bricks.

Weathering test—Three specimens of bricks plastered on five sides and treated with waterproofing treatment, three applied with silicone treatment and three untreated specimens were exposed to alternate wetting and drying

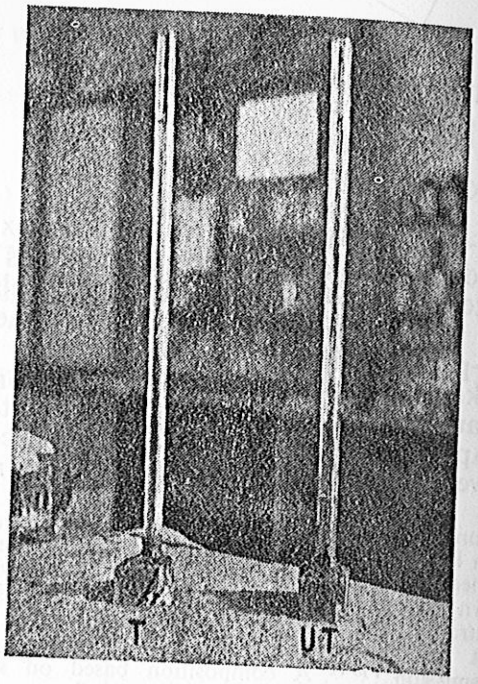

Fig 2 Permeability test on 100-mm thick lime concrete cut pieces; T=treated; UT=untreated

tests according to Indian Standard specification, *Fig* 3[19]. Twenty cycles of alternate wetting and drying as described above were operated. After completing 20 cycles, water absorption was determined and condition of the film formed on the treated exposed surface was noted.

Field test: An artificial rain penetration test according to Canadian standard was undertaken on the treated and untreated full size masonry walls of brickwork and stone masonry block work with different mortar joints as described above[20]. Two walls treated with the water-proofing treatment, two walls with silicone treatment and two untreated walls of both types of masonry walls were exposed to the above artificial rain penetration test. The test was applied with completely automatised water shower at the rate of 22.5 lit/min under compressed air at pressure of 10.5kg/cm² and impinging on 0.5m² area in each case, *Fig* 4. The test provides an equivalent

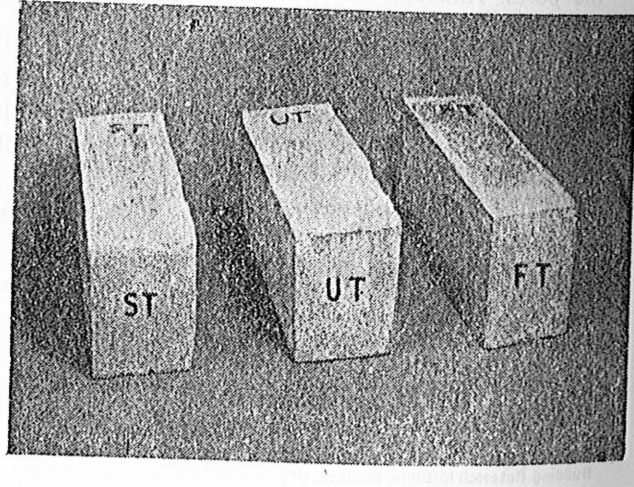

Fig 3 Three full size brick specimens plastered on five sides; FT=formulation treated; ST=silicone treated; UT=untreated

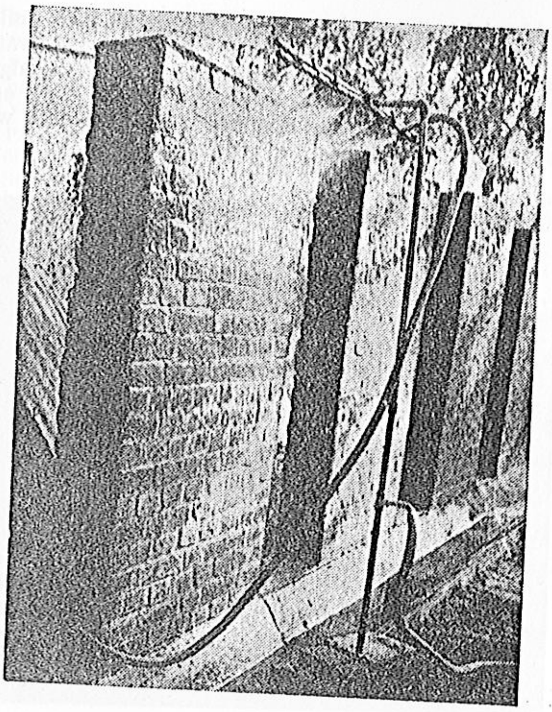

Fig 4 Artificial rain penetration test on full size brickwork masonry walls constructed with cement and lime surkhi mortar joints

rainfall of 60mm per minute. The moisture appearance on the other side of the walls, white washed previously, where noted against time. This test was repeated on all treated and untreated masonry walls which provided fair comparison.

Results and discussion

The results on water absorption, permeability and weathering performance of the waterproofing treatment on different specimens are given in *Table* 1. The water absorption of the treated brick, sandstone and lime concrete was found to be 3.5 to 4.5 percent, 2.8 to 3.0 percent and 2.5 to 2.7 percent, respectively as against 19.0 percent, 15.5 percent and 12.0 percent of the untreated specimens, respectively. This showed that water absorption was greatly reduced in treated specimens and was comparable to the silicone treated specimen.

The water permeability data in *Table* 1 on untreated brick tiles, sandstone and lime concrete specimens indicated that the dampness appeared on the bottom of the specimens in 20 seconds, 10 minutes and 25 minutes, respectively, whereas, no moisture appeared on the other side of the treated specimens even one month after the test. The whole water column of 600mm got completely percolated through the untreated specimens in 3 minutes, one hour and 1.5 hours, respectively. The fall of miniscus in the column on treated specimens in one month was found to be merely 75mm, 65mm and 50mm, respectively. These results confirmed the results of water absorption tests.

TABLE 1 Permeability, water-absorption and weathering results

Masonry surface	*Thickness,* mm	*Treatment*	*Water absorption,* percent	*Water absorption after 20 cycles*	*Water head in permeability test,* mm	*Failure time in first 24 hours*	*Fall in miniscus in 1 month under test*
Brick	50	untreated	18.0 to 19.0	—	600	20 sec	600mm in 3 min
	50	treated	3.5 to 4.2	3.8 to 4.2	600	nil	75 mm
	50	silicone	4.5	4.5	600	nil	75 mm
Porous sandstone	25	untreated	15.5	—	600	10 min	600mm in 1 hour
	25	treated	2.8 to 3.0	2.8 to 3.0	600	nil	65 mm
	25	silicone	3.2	3.2	600	nil	75 mm
Lime concrete	50	untreated	12.0	—	600	15 min	600 mm in 1 hour, 30 min
	50	treated	2.5 to 2.7	2.5 to 2.7	600	nil	50 mm
	50	silicone	3.0	3.0	600	nil	55 mm

TABLE 2 Artificial rain penetration test

Masonry surface	*Mortar composition*		*Treatment*	*Time of moisture appearance at the back of wall, minutes*	*Average area of the wall wetted in* 2 hrs	5 hrs	10 hrs
					percent	percent	percent
Brick	1:6	cement/sand	untreated	30	100	—	—
		cement/sand	treated	120	—	15	70
		cement/sand	silicone	100	15	100	—
	1:1:6	lime/surkhi/sand	untreated	45	50	100	—
		lime/surkhi/sand	treated	130	Nil	10	60
		lime/surkhi/sand	silicone	110	5	20	60
Sandstone blocks	1:6	cement/sand	untreated	5	100	—	—
		cement/sand	treated	30	15	40	80
		cement/sand	silicone	20	20	50	80
	1:1:6	lime/surkhi sand	untreated	20	80	100	—
		lime/surkhi sand	treated	45	5	20	70
		lime/surkhi sand	silicone	40	10	30	70

Notes: Size of brick masonry 2·4×1·2×0·24m
Size of stone block masonry 1·7×0·95×0·10m

The weathering tests on differently treated specimens showed that there was no change in water absorption values even after 20 cycles of alternate wetting and drying *Table* 1. Further, there was no weathering and peeling off of the coating and it was found comparable to silicone treatment. It was also found that efflorescence was checked substantially. All these laboratory tests showed that this treatment imparts sufficient degree of protection not only to the porous burnt clay bricks and sandstone but also to the more porous lime concrete slabs.

The results on artificial rain penetration tests on various treated and untreated masonry walls are shown in *Table* 2. The test was carried out for 10 hours and the spot of the dampness appearance and the percentage area covered by dampness in 10 hours were noted in each case. It was found that the treatment is quite effective in resisting moisture penetration and comparable to silicone treatment with respect to the first moisture appearance and percentage area wetted in 10 hours. The results further showed that the masonry walls made with 1 : 1 : 6, lime: surkhi: sand mortar joints gave better water-resistance than the walls made with 1: 6 cement-mortar in both treated and untreated masonry walls. This test also showed that the waterproofing efficacy of the treatment was better on brick masonry walls than on stone block masonry walls. This may probably be due to empty spaces available in between the units of the stone blocks which permitted water seepage. The ultimate failure in all the treated masonry walls including the silicone treated walls, was due to the rupture of the protecting film by the impact of high velocity water shower rather than the action of water on the treated surface. This can be concluded because there was no effect of water on the film when it was tested under weathering test.

The waterproofing action of the above waterproofing treatment is due to supply of free calcium and aluminium ions from the undercoat composition which after reaction with silicate ions from the finishing coat composition produce insoluble silicates and aluminates. These insoluble silicates and aluminates seal the pores of the porous surfaces of brick, sand stone and lime concrete and make the surface impermeable to water.

A practical demonstration of the application of this waterproofing treatment was given on some office and residential buildings. The walls and roofs of these buildings were previously affected with dampness and water leakage. The treatment was given after removing algae and repairing the big cracks present on the walls and roofs, *Figs* 5 and 6. The treatment stood well and was found unaffected during the last three years.

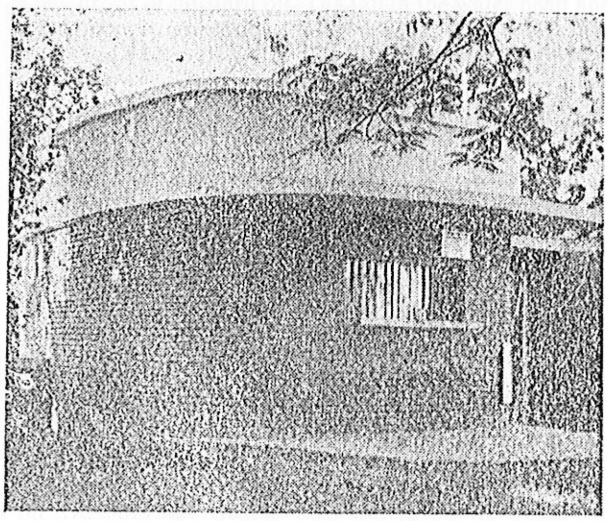

Fig 5 Treated office building

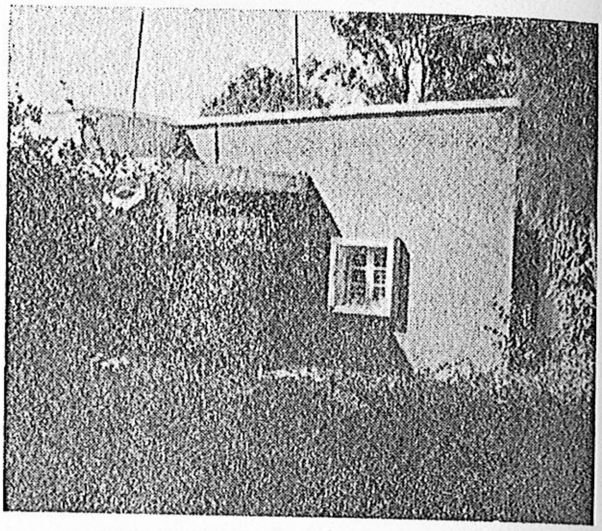

Fig 6 Treated residential building

This surface waterproofing treatment is cheaper than many similar treatments, including the silicone treatment.

Conclusion

An indigenous, transparent and low-cost surface waterproofing treatment has been developed for exposed brick and stone masonry walls and lime concrete roofs. Waterproofing properties of treatment were investigated by laboratory tests, *e. g.* permeability, water absorption, weathering and also by accelerated artificial rain penetration test. The efficacy of the treatment was found comparable to the silicone treatment. The treatment was also given field trials on an office and residential buildings and found quite effective during heavy monsoon since the last three years.

Acknowledgement

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