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A case study on Application of Geopolymer in Treatment of Efflorescence affected Masonry Walls

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ABSTRACT
In this paper a case study on effect of geopolymer treatment on an efflorescence affected brick masonry wall is being studied. The wall is subjected to continuous dampness due to toilet on other side, due to which salts leach out creating efflorescence and damage to painting and plaster. To rectify this various moles of sodium hydroxide were coated on each part followed by sodium silicate coating. Geopolymer treatment was finished in march2016. It is evident from the photos taken after2 years and 9 months in December 2018, that this type of geopolymer treatment of efflorescence affected walls is very effective in maintaining appearance and integrity of masonry wall.
KEYWORDS - Brick wall, Efflorescence, Geopolymer, Masonry, Sodium hydroxide, Sodium silicate.

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I. INTRODUCTION

1.1 Efflorescence

Efflorescence is defined as formation of loose white salty patches on the surface of the masonry walls. It is a major problem in masonry walls subjected to damp conditions throughout their life span. Some examples of such walls are walls of bathroom, toilets, water tanks, basement walls during rainy season.

The main effects of efflorescence are bulging and peeling of paints and distemper coating, damage to plaster, damage to bricks and mortar joints. Damage to bricks and mortar joints may lead to structural weakening in load bearing structures.

Fig -1: Efflorescence in Brick wall
(Courtesy: - https://www.waterproofingspecialists.com.au/ efflorescence-rising-damp-crack-injection/ efflorescence-salt-removal-treatment/)

Efflorescence is caused by salts of chloride, sulphate, etc. Wan Ibrahim M. H, et al [1] studied influence of sulphate and chloride on single leaf fired clay masonry wall units. They exposed the walls units to solution containing sodium chloride and sodium sulphate. The concluded that fired clay brickwork is not durable and deteriorate in environment containing sodium sulphate but durable in sodium chloride.

Abu Bakar, et al, [2] in their review paper have explained that masonry structures, when subjected to salt attack or exposed to aggressive environment during their service life may suffer degradation due to the formation of crystallization pressure as a result of the evaporation of soluble salt in clay masonry structures. The crystallization pressures produce normally higher than tensile stress of clay brick and sufficient to damage the masonry structures.

Carlos Rodriguez-Navarro, et. Al, [3] studied influence of evaporation rate, supersaturation, crystallization patterns, kinetics and substrate damage when comparing the growth of mirabilite ($Na_2SO_4 \cdot 10H_2O$) and thenardite (Na_2SO_4) versus halite (NaCl). The crystallization pattern of sodium sulphate was strongly affected by relative humidity (RH), while a lesser RH effect was observed for sodium chloride.

The masonry wall considered in our case study was exposed to water, urine, cleaning phenols and bathroom cleaning acid on the Toilet side. This resulted in peeling of distemper and exposure of plaster in the class room side of the wall.

Fig -2: Peeling of distemper in wall

Fig -3: Peeling of distemper and exposure of plaster

1.2 Sodium Silicate

Fawer, et. Al, emphasize that Sodium silicate [4] is an environmental friendly binder which can improve the properties of adobe materials. The energy requirement for the production of sodium silicate is 500MJ/tone of output, while of cement is 4400 MJ/tone of output.

Concrete treated with a sodium silicate solution [5] helps to significantly reduce porosity in masonry products like concrete and plasters. Applying Sodium Silicate with concrete permanently binds the silicates with the surface making them far more wearable and water repellent. These coatings are known as silicate mineral paint.

1.3 Sodium Hydroxide

Sodium hydroxide (lye) [6] is also called caustic soda. Sometimes it is used instead of acid to clean blocks or masonry.

1.4 Geopolymer

In the late 1970's, Joseph Davidovits, [7]the inventor and developer of geopolymerization, coined the term "geopolymer" to classify the newly discovered geosynthesis that produces inorganic polymeric materials now used for a number of industrial applications. He also set a logical scientific terminology based on different chemical units, essentially for silicate and aluminosilicate materials, classified according to the Si:Al atomic ratio:

Si:Al = 0, siloxo
Si:Al = 1, sialate (acronym for silicon-oxo-aluminate of Na, K, Ca, Li)
Si:Al = 2, sialate-siloxo
Si:Al = 3, sialate-disiloxo
Si:Al > 3, sialate link.

In Geopolymer, alkali based activators are widely used. A combination of sodium hydroxide in moles greater than 8 and sodium silicate solution is used as alkali activator along with any silica materials such as fly ash, metakaolin, rice husk ash etc.

In our case study we have used sodium hydroxide and sodium silicate to remove efflorescence.

II. METHODOLOGY

1. Efflorescence affected wall is divided into 5 portions from slightly affected portion as I to worst affected as V, in January 2016.

TABLE -1: Wall portion details

Name of the Portion	Breadth(in mm)	Height(in mm)	Area(in mm^2)
I	1.00	0.46	0.46
II	0.80	0.46	0.37
III	0.85	0.46	0.39
IV	0.55	1.10	0.61
V	0.65	1.10	0.72

Fig -4: Wall divided into portions

2. Scrub the efflorescence wall portion with emery sheet
3. Prepare sodium hydroxide solution for each portion of wall as in table 2.

TABLE -1: Sodium hydroxide solution for each portion

PORTION NAME	CONCENTRATION OF NaOH SOLUTION(moles)
I	6
II	8
III	10
IV	12
V	14

Fig -5: various moles of Sodium hydroxide

4. Apply sodium hydroxide solution to each portion.

Fig -6: Application of sodium hydroxide solution

5. Sodium silicate is painted on all the portions. Three successive coats are applied so that strong binding is created and porous portions are fully filled by sodium silicate. Sodium silicate forms a glossy surface on wall.

Fig -7: Appearance after sodium silicate coats

6. To apply primer coat for distempering, roughening by emery sheet is necessary.
7. White cement is applied as primer coat.

Fig -7: Appearance after white cement coat

8. Commercial distemper is applied after primer coat. In March 2016

Fig -8: After 2 years

III. CONCLUSIONS

In this paper a innovative method of treating efflorescence by using Sodium Hydroxide and sodium silicate is projected. The concept was obtained from geopolymer technology. The sodium hydroxide is used as alkali activator which neutralizes the chloride and sulphate ions, thereby decreasing the efflorescence in near future. The sodium silicate decreases the permeability of the wall and also binds the rough and powdery surface making it glossy in appearance and decreasing the efflorescence. Only portion IV of wall shows efflorescence of about 10cm wide patch. Other portions are unaffected by efflorescence after 2 years and 9 months.

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