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The Nordic Method: Performance Tests for Protective Sacrificial Coatings on Mineral Surfaces

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Abstract

The paper describes the development of a performance test for sacrificial coatings used on mineral surfaces, in particular for protection against graffiti. The method considers both the type of surfaces and of possible graffiti paints, and specifies the method as well as the evaluation techniques for the performance of the protective coating. The purpose of the project was to develop a Nordic test method for evaluation of the performance of anti-graffiti coating on different mineral surfaces such as natural stones, bricks and concrete. The performance of the anti-graffiti was determined by comparing the colour and gloss changes of reference surfaces versus anti-graffiti treated surfaces after cleaning of the applied graffiti paints. It was demonstrated that different mineral surfaces responded differently to the graffiti protective coating. This confirmed the assumption that porosity, type of material and surface finish influence the behaviour of the applied coating. Consequently, mineral materials require different approaches, i.e. different anti-graffiti and application techniques. However, there are graffiti paints that penetrate through the graffiti protection coating which means that further development of protective surface coatings is needed. The cleaning of graffiti must be performed by a professional team that has knowledge about the properties of the surface and its vulnerability to both water pressure and chemicals.

Keywords: sacrificial coating, anti-graffiti, Nordic test method, mineral substrates, colour, gloss, porosity, Karsten pipe

1 Introduction

Graffiti defaces building facades and other surfaces all over the world. The cost for cleaning them is estimated at about 100 M Euro per year just in Sweden. Removal of graffiti is a very difficult task with a high risk potential for damaging the surface. As a result of this, many protective coatings facilitating graffiti cleaning are on the market; however their performance on different mineral surfaces has been poorly investigated. This is in part the result of a lack of standardised evaluation methods.

The term graffiti can be defined as a deliberate unauthorised defacement of a surface by words or drawings. Many different markers such as chalk, felt tip pens, aerosol paints, lipstick, wax crayons, etc. have been used to deface many different surfaces. If the surface material is porous, e.g. limestone, sandstone or brick, graffiti removal is much more difficult because the marker can penetrate into the pores of the substrate and thus becomes harder to dislodge. Therefore, it has been assumed that the efficiency of the applied treatments against graffiti is strongly dependent upon the surface parameters.

The aim of anti-graffiti treatment is primarily to protect the surface from graffiti attack and to facilitate its cleaning after attack. An additional advantage of the treatment is the reduction of the average moisture content within the substrate thus reducing its eventual deterioration.

Modern sacrificial anti-graffiti products are developed as an attempt to solve the problem of impervious barriers. The products are based on organic compounds such as waxes and carbohydrates that are removed by using hot water at high-pressures or are dissolved by application of cleaning chemicals. The microcrystalline waxes that are produced from crude petroleum or synthetically from ethylene gas are physically permeable to water vapour due to their branched and non-linear carbon chains. They are durable for about 5 years on a vertical surface. The products are non-toxic and environmentally friendly water dispersions. They are applied as a colourless coating to the surface, usually in two separate applications. The coating prevents graffiti paints from penetrating into the substrate. A requirement for these coatings is that there should be no change of colour or appearance of the surface after treatment. It is also assumed that in order to achieve a total protection the coating layer should be evenly distributed over the surface.

To date there are no standardised or commonly recommended methods for the testing of anti-graffiti performance in Nordic countries. The available recommendations (e.g. Road Administration in Sweden) only focus on possible deteriorating effects of the graffiti protective coatings to the substrate, normally concrete. And in particular, with regard to frost action of treated to non-treated substrates with anti-graffiti coatings. Therefore, an evaluation system for the performance of anti-graffiti coatings is advantageous both for producers of the coatings who give the recommendations for suitable applications and for the contractors performing the application thus ensuring good results for the owner of the object. The aim of the project was to develop a test method for evaluation of the performance of the sacrificial anti-graffiti coatings on different mineral surfaces such as natural stone, brick and concrete based on quantitative optical methods.

2 Tested inorganic materials

The testing was carried out on various surfaces that are representative for the most common materials used outdoors in Nordic countries. The materials are presented in Table 1. The test specimens were shaped as a 120 x 60 x 30 mm^3 prism. Four samples of each type of material were coated on one surface and one sample was uncoated and used as a reference.

Table 1: Characteristics of the tested materials

Sample	Porosity	Surface finishing
Granite: finely crystalline, dark brown	low (0.1%)	sawn
Granite: coarsely crystalline, green-white	low (0.2%)	sawn
Marble: finely crystalline, white	low (0.1%)	sawn
Marble: finely crystalline, light pink	low (0.2%)	polished
Limestone: fine grained, light beige	medium (4.3%)	sawn
Sandstone: fine sedimentary rock, beige	medium (5.2%)	sawn
Natural stone masonry units: dark grey	medium (3.2%)	rough
Concrete: dark grey	medium (2.2%)	sawn
Concrete: light grey	medium (6.5%)	sawn
Brick (without holes): terracotta	high (16 %)	cast
Brick (with holes): terracotta	high (15 %)	cast

2.1 Sample preparation

All samples were conditioned at 65 % relative humidity (RH) and 20^{o} C for 24 h. After testing alternative coating application techniques, brushing was selected. Three coats of a microcrystalline wax were applied with one hour drying between each application.

The assumption was made that graffiti are usually applied to the surface some time after the application of the coating. Therefore the response of an altered coating to graffiti paints would give more reliable results than a freshly protected surface. For that reason, one week after the application of the anti-graffiti coating, the samples were artificially aged [1] (Table 2).

Table 2: Artificial ageing conditions [1].

Black standard temperature (BST)	65 ±3 °C
Air temperature	40 ±3 °C
Relative humidity	50 ±5 % RH
Rain cycle	18 min rain / 102 min dry
Light source	Water cooled xenon lamp with boron silicate filter
Light intensity	60 ±6 W/m^2 (UV, 290-400 nm) 550 ± 60W/m^2 (UV/Vis, 290-800 nm)

2.2 Analytical methods

Colour and gloss measurements were performed on all samples before and after application of the anti-graffiti; after artificial ageing of the coated samples; and after the removal of the graffiti paints. Ten measurements were taken for each sample and a mean value was calculated. The evaluation of colour followed the CIEL*a*b* theory assuming that:

ΔE94 < 1 the chromatic changes are not visible by a human eye
ΔE94 = 1 the chromatic changes are visible for some colours (red and yellow)
ΔE94 > 1 the chromatic changes are visible by a human eye

The ASTM method [2] specifies measurement of gloss. The angle used in this study was 60° as it is supposed to give the best results for most materials.

Water absorption measurements [3] were made for all samples before application of the anti-graffiti coating. This test was aimed to describe the physical properties of the materials concerning water absorption ability as this is related directly to the graffiti sensitivity of a surface. Rougher surfaces and high water absorbing materials make the removal of graffiti harder because the graffiti paints penetrate into pores and interstices more easily. Differences in water repellence and absorption were also evaluated with the Karsten testing pipe [RILEM] [4]. An absorption time of 5 min was used in this study.

2.3 Application of graffiti paints

After a thorough examination of the frequently found graffiti in Nordic countries eight graffiti paints were selected. The chosen graffiti paints represent a spectrum ranging from easy to hard to remove graffiti paints. The graffiti paints tested were: *Tectyl* rust protection (a mixture of wax and tar); *spray* paints (black, red and blue); *felt tip pen* (black and blue); *leather dye* aniline (red and blue).

Two layers of graffiti paint were applied on the surfaces one right after the other (Fig.1). Aniline was applied by a pipette. One drop of each colour was used. After the application of these paints, the samples were left at room condition to dry for one week.

2.4 Cleaning procedure

The samples were fixed to a wooden frame. The cleaning procedure was performed indoors at a temperature of 22°C and approximately 60% RH. High-pressure water cleaning was used for the graffiti removal. The water flow-rate was 20 l/min. The pressure was set to 12-13 MPa and the water temperature was 90°C. The lance nozzle spread angle was 25° and the jet angle 45° working from top to bottom. The distance from lance nozzle to the samples was 10 cm.

3 Results and discussions

3.1 Water absorption

The difference in water absorption measured with the Karsten pipe between uncoated and coated samples, reflects the hydrophobic effect of the anti-graffiti agent (Table 3). The best hydrophobic effect is expressed by water absorption equal to 0 ml. It should be pointed out that for some of the samples the difference was zero, because the initial water adsorption of the uncoated samples was zero. This does not imply that these samples are naturally resistant to graffiti attack. Dark coloured low-porosity granites perform normally well without any anti-graffiti protection but this theory does not apply to the light coloured low-porosity granites or marbles.

Figure 1: Application of graffiti

Table 3: Water absorption results.

Type	EN 13755 Fresh samples Weight %	Karsten pipe [ml]			
		without anti-graffiti	with anti-graffiti	after artificial ageing	after cleaning
Paving unit	3.2	1.1	0.0	0.0	0.8
Brick	16.2	4.5	0.3	0.3	3.8
Concrete light	6.5	0.3	0.1	0.1	0.3
Concrete dark	2.2	0.0	0.0	0.0	0.0
Marble white	0.1	0.0	0.0	0.0	0.0
Marble pink	0.2	0.0	0.0	0.0	0.0
Granite white	0.2	0.1	0.0	0.0	0.0
Granite dark	0.1	0.0	0.0	0.0	0.0
Sandstone	5.2	0.2	0.0	0.0	0.0
Limestone	4.3	0.2	0.1	0.1	0.2

The water absorption results revealed that no change in the water uptake of the treated samples occurred after artificial weathering. Cleaning of the graffiti resulted in water absorption properties comparable to the untreated samples, although for very porous samples, some rest of the coating remained on the substrate even after the cleaning.

3.2 Gloss

There are no general rules on how to interpret gloss changes. The gloss scale ranges from 0 (no gloss) to 100 (high gloss). Based on the gloss metre measurements and visual observations by two persons an interpretation scale was prepared and proposed. The following categorisation for gloss difference was proposed :

< 2 units the gloss change is invisible to the human eye.

= 2 units the gloss change is visible to some people.

> 2 units the gloss change is visible for most people and to a degree depending on the surface characteristics.

4 -10 units very small gloss changes for matt surfaces.

< 20 units very small gloss changes for polished surfaces.

>20 units high gloss changes for polished surfaces.

The samples were divided into four groups: matt (<2), semi-matt (<10), low-gloss (<20) and high-gloss samples (>20). The results from the study were used for calculations of changes of gloss due to application of anti-graffiti coating and cleaning of graffiti for reference and coated samples.

No gloss changes were measured between coated samples before and after artificial weathering and therefore they are not included in the results.

Table 4 presents the gloss evaluation results between: reference samples before and after cleaning; reference and coated samples before cleaning; and, coated samples before and after cleaning.

Table 4: Gloss measurement results and, (between brackets) visual gloss changes between samples. The visual changes are classified as following: ”0” the change is negligible; ”-” small decrease in gloss ”- -” large decrease in gloss,; ”+” small increase in gloss and ”++” large increase in gloss.

Type	Reference samples before cleaning	Reference samples after cleaning	Coated samples before cleaning	Coated samples after cleaning
Paving unit	1 matt	1 (0)	1 (0)	1 (0)
Brick	2 matt	1 (0)	7 (+)	1 (0)
Concrete light	2 matt	1 (0)	2 (0)	1 (0)
Concrete dark	4 semi-matt	2 (-)	4 (0)	2 (0)
Marble white	2 matt	2 (0)	4 (0)	2 (0)
Marble pink	99 high gloss	81 (-)	42 (--)	50 (--)
Granite white	7 semi-matt	1 (0)	11 (+)	6 (0)
Granite dark	2 matt	1 (0)	2 (0)	1 (0)
Sandstone	18 low gloss	2 (-)	14 (0)	7 (-)
Limestone	2 matt	2 (0)	6 (+)	2 (0)

The results can be summarized as follows:

After the application of the graffiti protective coating and artificial ageing:

1) For matt samples (0-2 units) gloss does not change, except for brick and limestone where a slight gloss increase occurs.
2) For semi-matt samples (4-7 units) dark concrete showed no change while white granite showed a slight increase in gloss.
3) For low gloss samples (18 units) no visible change in gloss.

4) For high gloss samples (99 units) a high decrease in gloss was observed.

After cleaning:

1) For matt and semi-matt *reference* samples, no change in gloss (except a small decrease in the dark concrete) was observed. For the *coated* samples, no change in gloss was observed.
2) For low gloss samples, the same slight gloss decrease was observed both for the *reference* and the *coated* samples.
3) For high gloss *reference* samples, there is a slight gloss decrease whereas the *coated* samples show a high decrease in gloss. .

3.3 Colour

The colour measurements were taken on reference, coated before and after artificial ageing, and after graffiti cleaned samples. For the latter, the measurements were taken on the places where graffiti traces were most visible. The leather dye left the most pronounced traces but these were not included in the comparison since they would bias the results. Leather dye traces were present on several surfaces where no visible traces of other graffiti were visible by a naked eye. To date there are no efficient anti-graffiti coatings that can prevent penetration of leather dye.

No colour differences were observed between coated samples before and after artificial ageing.

The colour differences between the various sets of samples are summarized as follows:

Reference and coated samples: The colour differences are small and barely visible for the light samples, however dark samples get slightly lighter after the application of the anti-graffiti coating. ΔE94 for all samples varied between 0.29 – 8.7.

Reference and coated samples after graffiti cleaning: ΔE_{94} varies between 0.4 – 11.2. A correlation between water absorption and colour changes has been found (see Figure 2). Samples with low water absorption have lower changes in colour than samples with high water absorption.

Reference samples before and after graffiti cleaning: The difference in colour before and after the cleaning is large. ΔE_{94} varies between 21 and 37 indicating that the samples are getting darker which means that graffiti paints are not being removed from the sample.

Coated before and after graffiti cleaning: The colour change before and after the cleaning is low. The difference corresponds to the colour change due to application of the coating. However, for leather dye staining the ΔE_{94} varies between 22 and 42. This means that the leather dye penetrated through the anti-graffiti coating.

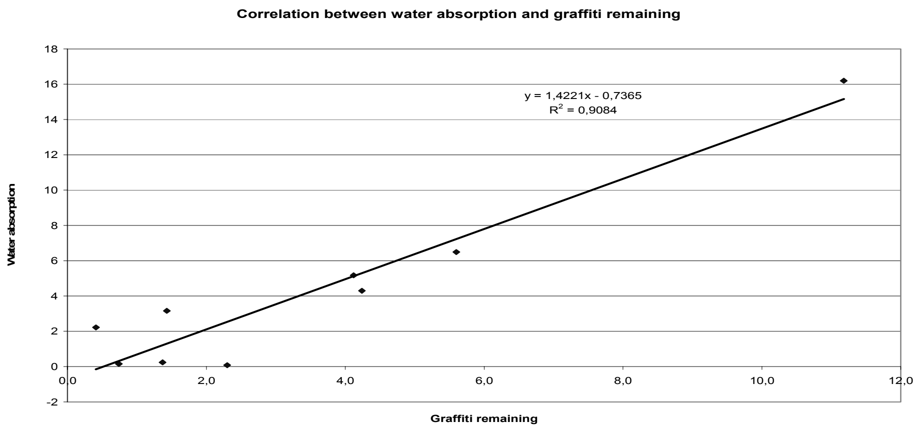

Figure 2: Correlation between water absorption and colour changes (expressed as ΔE94) between reference and coated samples after graffiti removal.

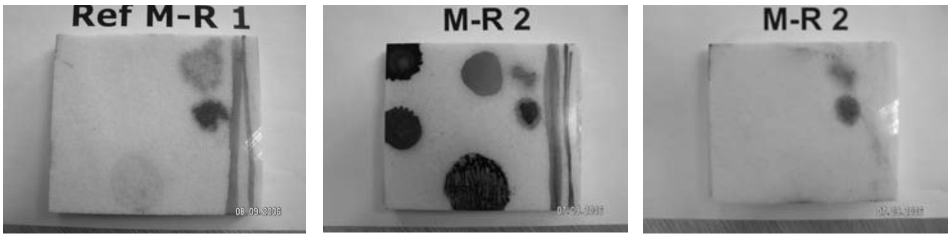

Figure 3: Marble samples: uncoated reference sample after graffiti cleaning (left); coated sample before cleaning (middle) and coated sample after cleaning (right).

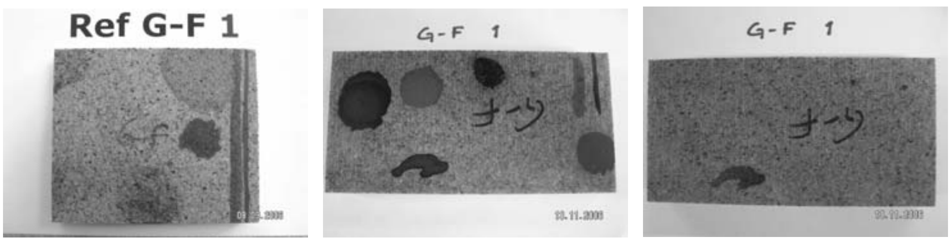

Figure 4: Granite samples: uncoated reference sample after graffiti cleaning (left); coated sample before cleaning (middle) and coated sample after cleaning (right).

Figures 3 and 4 show the appearance of the applied graffiti, after cleaning of the reference sample and before and after cleaning of the coated sample, for the matt white marble and the semi-matt white granite samples, respectively. The pink and blue spherical graffiti are leather dyes (present after the cleaning on the left photo and right photo); the blue and black lines are felt tip pens; the brown round graffiti on the bottom of the sample is Tectyl rust protection; the red, blue and black round graffiti are spray paints.

No chemicals were used in this study for the cleaning or removing of ghosting. Results indicated that the coating was sufficient to resist most of the graffiti paints except leather dyes which penetrated through the coating. It was easy to remove spray paints and Tectyl. Permanent markers demanded a little longer cleaning time than spray paints. Cleaning of leather dyes was problematic. It is not recommended to enhance the pressure to get a clean surface. The surface of light concrete became damaged due to increased pressure. Both pressure and working distance must be adjusted to the type of the cleaned material. Granites and other crystalline stones have higher resistance towards mechanical cleaning than limestones, sandstones or concrete.

4 Conclusions

The method used in this study can be recommended for performance testing of wax-based sacrificial coatings. The evaluation techniques give reliable results concerning aesthetical changes of the appearance of a surface.

The gloss measurements are especially important for evaluation of the surface appearance for polished and susceptible to mechanical erosion surfaces.

The L-value of the CIEL* a*b* system reflects changes in the grey scale from light to dark and gives the most relevant results, therefore it is recommended for the evaluation of the results. The evaluation scale is from 0 to 100 (light to dark). While a human eye can register more than 10 millions different colours, every human being has a different colour perception and thus cannot be standardised. The standard equipment measures absolute colour and its changes and therefore is recommended as the evaluation method.

The water absorption measurements give important indication of the substrate's sensitivity to graffiti paints.

The short artificial weathering did not change the colour, gloss and hydrophobic function of the anti-graffiti coating, therefore it could be omitted in a preliminary evaluation procedure.

The test method should be extended by an investigation of the frost influence on the performance of sacrificial wax-based coatings.

References

[1] ISO 4892-2:2006: Plastics - Methods of exposure to laboratory light sources - Part 2: Xenon-arc lamps

[2] ASTM Designation D523-89. Standard Test Method for Specular Gloss"

[3] EN 13755 Natural stone test method – determination of water absorption at atmospheric pressure.

[4] RILEM: Water Absorption Tube Test. 1980