Validation and improvement of procedures for performance testing of anti-graffiti agents on concrete surfaces

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ABSTRACT: Graffiti on concrete structures is an ongoing, costly and increasing problem. A number of various anti-graffiti agents available on the market are intended to be resistant to graffiti attack or provide a treatment that aids the removal of graffiti. In several European countries the testing of anti-graffiti agents on concrete structures is following the EN 1504-2. This method is not appropriate for the aimed result. The method tests if an anti-graffiti agent damages a concrete structure and focuses on drying index and frost resistance in comparison with untreated samples. The aspects of the efficacy against graffiti attack, other types of dirt and aesthetic changes due to anti-graffiti protection are not evaluated by the present method. Therefore a validation and improvement of the current method is proposed.

1 INTRODUCTION

The aesthetic values of concrete surfaces are of great social and economic importance and therefore they should be included in maintenance planning. The costs for cleaning graffiti are unnecessary high in all European urban areas. A variety of anti-graffiti agents is available on the market but their efficiency on a concrete surface is not properly evaluated. The scope of the project supported by the Swedish Road Administration was to elaborate a method for a complete evaluation of the efficiency of anti-graffiti protections on concrete surfaces. In Europe the testing of an anti-graffiti protection on concrete structures is made according to EN 1504-2. However, this method is not appropriate for a complete analysis of the efficiency of an anti-graffiti protection. In several countries, e.g. Belgium and Germany (TL AGS and TP AGS), various guidelines or methods including visual examinations exist. The ASTM D 7089-06 and ASTM D 6578-00 present optional methods, however involving chemical cleaning agents. EN 1504-2 tests if an anti-graffiti protection influences properties of concrete such as drying index and frost resistance. The aspects of the efficacy against graffiti paints and aesthetic changes due to impregnation are not evaluated. EN 1504-2 should be complemented with measurements of gloss and colour changes before and after application of anti-graffiti agents, after an ageing test and after graffiti removal. Thereafter the efficacy of the used protections can be optically evaluated.

The expected result from this project will be a method that can be used as a tool for calculation of maintenance costs of concrete constructions subjected to graffiti and dirt attacks. It will also prevent the use of anti-graffiti agents that are not effective for the aimed application.
2 SCOPE

The scope was to develop an evaluation method based on optical measurements of gloss and colour changes of a concrete surface subjected to anti-graffiti treatments, outdoor weathering and cleaning of graffiti. The goal was to propose the test as a complement for evaluation of anti-graffiti agent’s efficiency on a concrete surface according to EN 1504-2.

3 TEST PROCEDURE

3.1 Concrete specimens

Commercially available standard concrete panels for paving were used. The w/c ratio for the panels was 0.4. The recommended w/c ratio is 0.4 -0.5. Ten samples per each anti-graffiti protection were used. The dimensions of the samples were 500 x 250 x 40 mm³. Due to practical handling of the samples it is recommended to use dimension of at least 250x250x30 mm.

3.2 Anti-graffiti agents

Four different anti-graffiti agents were used:
W- sacrificial agent based on micro crystalline wax
LW- elastic cement latex for protecting of concrete coated with micro crystalline wax
S - sol-gel based coating based on organo functionalized oligosiloxanes with hydro- and oleophobic properties that comes from perfluoroalkyl chains
P- permanent agent based on cyclosilazanes

3.3 Graffiti paints

After a thorough examination of commonly used graffiti in Nordic countries eight graffiti paints were selected. The chosen graffiti represent a spectrum of easy to remove and hard to remove graffiti and should be used as standard graffiti for further testing.

Figure 1. Graffiti paints - one type of graffiti in each opening in the template.

1: Red felt-tip pen ‘Snowman 600, Dries instantly, waterproof, permanent’
2: Blue felt-tip pen ‘S-Marker, Medium point’
3: Red spray ‘Improvement colour’
4: Blue spray ‘Hobby lack’
5: Black spray ‘Rust protection’
6: Black spray ‘Auto lack’
7: Green felt-tip pen ‘Whiteboard marker, Marvy’s, No7200c’
8: Black felt-tip pen ‘Corporate express, Permanent marker, Black, 2100950’
The binding agents in the spray paints were alkyd resin, acrylic, mixture of wax and tar and nitrocellulose resin. The felt-tip pens were solvent-based ink markers.

3.4 Sample preparation

All samples were cleaned by a light brushing of the surface in rinsing water. Thereafter they were stored at room temperature for one week.

3.5 Preparation of mask

In order to be able to perform replicable measurements three masks for measurements of gloss, colour and application of graffiti were prepared. Each mask had eight areas for testing. Masks for gloss and colour were adjusted to the size of the used equipment. Mask for graffiti application was slightly larger than the mask for colour measurement.

3.6 Application of anti-graffiti

Application of the anti-graffiti was performed according to the instructions given by the producers. After the application of the anti-graffiti the samples were stored at room temperature for three days.

3.7 Field exposure and laboratory storage of the samples

The goal with the field exposure was to analyze the influence of natural weathering on the durability of the anti-graffiti agents. Ten samples per anti-graffiti were prepared of which six samples were placed at a field exposure site in Sweden. Three of these samples were exposed for three months and three samples for ten months including winter period. The samples were placed on special racks at 45° angle in order to promote water run off and prevent any accumulation of snow. Four reference samples were also used. Three samples were stored at room temperature for three months and used for testing. One sample was left as a reference for visual observation.

Figure 2. Masks for gloss (left) and colour (middle) measurement and application of graffiti paint (right).

Figure 3. Field exposure of the samples.
3.8 Colour and gloss measurements

A human eye can register more than 10 million different colours and every human being has different perception of colours. By use of standard equipment it’s possible to measure the absolute colour and its changes. Colour and gloss measurements were performed on all samples before and after application of anti-graffiti agents, after field and laboratory exposure (3 and 10 months), and after the cleaning of the graffiti. All measurements were done on the surfaces designed by the templates.

Colour was measured by use of Chroma Meter CR – 410 (Fig.2 middle). Three measurements were taken for each opening in the template and a mean value calculated. The measurement method was based on the CIEL a* b* theory, however only the L–value was used for the evaluation. The L-value describes the changes in grey scale from light to dark colour showed most relevant results and is therefore recommended for the proposed method.

Gloss was measured with a Multi Gloss 268 (Fig.2 left). Ten measurements for each opening in the template were taken and a mean value calculated. Gloss measurements quantify the amount of light reflected at the specular angle from an object’s surface. This specular light is responsible for the highlights visible on shiny materials and therefore, gloss measurements quantify how shiny an object is. ASTM D523-89 specifies how gloss is to be measured. The angle used in this study was 60° what is assumed to give best results for most materials.

3.9 Application of graffiti paints

The paints were applied to the surface either by spraying or by painting. The paint was covering totally the area of the designed opening in the template. In each opening in the template different graffiti paint was used (Fig.2 right). All painted samples were left for drying at room temperature for at least 4 days before cleaning.

Application of graffiti paints on the samples taken from the field exposure site was done after previous superficial cleaning with a soft brush and stored at room temperature for one week. The samples stored at the laboratory conditions were painted at the same time as the samples taken from the field exposure site.

3.10 Cleaning

All samples were placed on a wooden frame. The cleaning procedure was performed indoors. High-pressure cleaning, ALTO (KEW), was used. The flow rate for the machine was 20 litre/minute. The pressure was set to 120-130 bars and the water temperature was 60 °C. The lance nozzle spread angle was about 25° and the jet angle approximately 45° working from top to bottom. The distance from lance nozzle to the slabs was approximately 10 cm. All samples were documented with a digital camera and video before and after cleaning.

![Figure 4. Cleaning of the graffiti.](image)
4 RESULTS AND DISCUSSION

4.1 Gloss measurements

The results for gloss measurements are presented in Tables 1-2. The values are mean values of ten measurements. Standard deviation was assumed to be negligible for all measurements. Gloss measurement is normally not dependent on the discoloration of concrete panels; therefore a mean value of all measurements per each anti-graffiti treated panel was taken.

The scale of the gloss is going from 0 (no gloss) to 100 (high gloss). There are no general rules how to interpret the changes in gloss. Based on the measurements and visual observations, done in this and former projects (Nordtest project 04134, 2007), an interpretation scale has been prepared and proposed. The change in gloss is classified according to:

Class G-I  < 2 units - the change cannot be seen by a human eye
Class G-II  = 2 units - the change can be seen by some people, however gives a very small change in gloss
Class G-III a  > 2 units - can be seen by most people however, degree of the change depends on the surface characteristics:
   Class G-III b  4 - 10 units - small changes for matt surfaces
   Class G-III c  > 10 units - high changes for matt surfaces
Class G-III b  < 20 units - small changes for polished surfaces
Class G-III c  > 20 units - high changes for polished surfaces

The measured changes in gloss were very small or none due to application of the anti-graffiti agents. The 0.7 increase in gloss for the microcrystalline wax was not detectable by a naked eye. Gloss was not changed due to the exposure to natural weathering conditions and not due to the storage of the panels in the laboratory. All tested anti-graffiti agents are of Class I.

Table 1. Result for gloss measurements before application of the anti-graffiti, after application, after exposure at field and laboratory (3 months) and after cleaning of graffiti.

<table>
<thead>
<tr>
<th>AGS*</th>
<th>No AG</th>
<th>AGS</th>
<th>After Exposure</th>
<th>After Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
<td>0,6</td>
<td>-</td>
<td>0,7</td>
<td>0,4</td>
</tr>
<tr>
<td>W</td>
<td>0,6</td>
<td>1,3</td>
<td>1,3</td>
<td>0,4</td>
</tr>
<tr>
<td>LW</td>
<td>0,7</td>
<td>0,7</td>
<td>0,8</td>
<td>0,3</td>
</tr>
<tr>
<td>S</td>
<td>0,7</td>
<td>0,7</td>
<td>0,6</td>
<td>0,5</td>
</tr>
<tr>
<td>P</td>
<td>0,7</td>
<td>0,7</td>
<td>0,7</td>
<td>0,7</td>
</tr>
</tbody>
</table>

*AGS – anti-graffiti agents

Table 2. Result for gloss measurements before application of the anti-graffiti, after application, after exposure at field and laboratory (10 months) and after cleaning of graffiti.

<table>
<thead>
<tr>
<th>AGS</th>
<th>No AGS</th>
<th>AGS</th>
<th>After Exposure</th>
<th>After Cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ref</td>
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<td>-</td>
<td>0,8</td>
<td>0,6</td>
</tr>
<tr>
<td>W</td>
<td>0,6</td>
<td>1,3</td>
<td>1,2</td>
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<tr>
<td>LW</td>
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<td>S</td>
<td>0,7</td>
<td>0,7</td>
<td>0,6</td>
<td>0,6</td>
</tr>
<tr>
<td>P</td>
<td>0,7</td>
<td>0,7</td>
<td>1,0</td>
<td>0,9</td>
</tr>
</tbody>
</table>

4.2 Colour measurements

Colour changes were analysed by measurement of the L-value. The L value describes changes in the grey scale from the light to the dark colour, and was assumed to give the most relevant results for colour changes when different graffiti paints is used. The differences in the L-values
for the reference samples due to the application of anti-graffiti and field exposure are presented in Table 3. The L-values for the cleaned samples are summarised in Table 4.

Table 3. Calculated mean differences in the L-values as a function of anti-graffiti treatment and ageing (3 and 10 months field exposure). Plus values mean darkening and minus values mean lightening of the colour.

<table>
<thead>
<tr>
<th>Treatment/Ageing</th>
<th>REF</th>
<th>W</th>
<th>LW</th>
<th>S</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGS</td>
<td>-</td>
<td>0,0</td>
<td>10,0</td>
<td>0,5</td>
<td>19,8</td>
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<tr>
<td>3 months</td>
<td>-1,3</td>
<td>-1,8</td>
<td>4,9</td>
<td>0,9</td>
<td>19,7</td>
</tr>
<tr>
<td>10 months</td>
<td>0,1</td>
<td>-2,0</td>
<td>8,2</td>
<td>6,6</td>
<td>18,5</td>
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</tbody>
</table>

The results showed that the L-value can be influenced by application of an anti-graffiti agent. Microcrystalline wax (W) and siloxane based anti-graffiti (S) had no or very small influence on colour change. The samples treated with grey latex coating (LW) gave clear change of the L-value. The permanent agent etched the surface and resulted in much darker colour.

Natural ageing had a small influence on colour change of the reference sample (REF) and anti-graffiti treated samples. In general, the samples became slightly darker. Despite that in the 10 months exposure a winter period was included the difference between the L-values from 3 months and 10 months field exposure was small. Therefore it is not recommended to test the durability against ageing for more than 3 months.

Table 4. Calculated mean differences in the L-values for the samples before the cleaning and after the cleaning of eight graffiti paints as a function of different anti-graffiti treatments. Horizontal numbering 1-8 corresponds to 8 different graffiti paints (see Chapter 3.3).

<table>
<thead>
<tr>
<th>Graffiti</th>
<th>REF</th>
<th>W</th>
<th>LW</th>
<th>S</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23,8</td>
<td>4,8</td>
<td>11,2</td>
<td>30,2</td>
<td>20,6</td>
</tr>
<tr>
<td>2</td>
<td>24,6</td>
<td>7,4</td>
<td>11,8</td>
<td>29,2</td>
<td>23,7</td>
</tr>
<tr>
<td>3</td>
<td>20,2</td>
<td>5,1</td>
<td>8,6</td>
<td>27,1</td>
<td>16,4</td>
</tr>
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<td>22,4</td>
<td>9,4</td>
<td>4,1</td>
<td>27,7</td>
<td>21,8</td>
</tr>
<tr>
<td>5</td>
<td>21,3</td>
<td>6,0</td>
<td>6,1</td>
<td>17,4</td>
<td>17,5</td>
</tr>
<tr>
<td>6</td>
<td>23,3</td>
<td>1,9</td>
<td>13,8</td>
<td>23,4</td>
<td>20,9</td>
</tr>
<tr>
<td>7</td>
<td>20,9</td>
<td>2,5</td>
<td>16,4</td>
<td>20,2</td>
<td>21,5</td>
</tr>
<tr>
<td>8</td>
<td>24,9</td>
<td>1,1</td>
<td>15,6</td>
<td>21,1</td>
<td>27,5</td>
</tr>
</tbody>
</table>

Quality of the performance of anti-graffiti agents is clearly noticeable when it concerns differences in L-values before and after cleaning of the graffiti paints. Typical sacrificial coating based on microcrystalline wax gave the best result. However, the result was different for different graffiti types. There are some graffiti types such as dyes that are difficult to clean even from a protected surface. The mechanism for penetration of the graffiti is not included in this study. Two of the anti-graffiti agents, S and P, gave similar and not satisfactory results as a not protected reference sample. Concrete treated with latex in combination with microcrystalline wax gave intermediate results. However, due to the high pressure cleaning the latex coating was flaking of the surface. These results indicate that not all anti-graffiti agents are suitable for protection of concrete surfaces.

There are no general rules for how to interpret the changes in colour. A classification system for the changes in L-value on a concrete surface is proposed as following:

Class L-I    <5 units - the change cannot be seen by a human eye
Class L-II   5 – 10 units - the change can be seen but is acceptable
Class L-III  >10 units – the change is clearly visible
5 CONCLUSIONS

Gloss and colour measurement methods give objective and reliable results. Although gloss changes were not significant in this study it is an important measurement method for analysis of changes in surface appearance due to an anti-graffiti application.

Three months natural ageing give satisfactory result and this period is recommended for testing of the durability of the anti-graffiti agents.

The L-value describing the changes in grey scale from light to dark colour is showing most relevant results and should be used for the evaluation of the performance of the anti-graffiti agents.

6 REFERENCES

ASTM D 7089-06 2008. Standard Practice for Determination of the Effectiveness of Anti-Graffiti Coating for Use on Concrete, Masonry and Natural Stone Surfaces by Pressure Washing
Bundesanstalt für Strassenwesen. 2006. TL AGS Technische Lieferbedingungen für Anti-Graffiti-Systeme
Bundesanstalt für Strassenwesen. 2008. TP AGS Technische Prüfvorschriften für Anti-Graffiti-Systeme