B-2-4 Anti-graffiti protection of concrete elements and structures

Michel Donadio
SIKA SERVICES AG, Tüffenwies 16, 8048 Zürich, Switzerland.
donadio.michel@fr.sika.com

Nikos Anagnostopoulos
SIKA HELLAS SA, 15 Protomagias str., Kryoneri, GR-14568, Greece.
anagnostopoulos.nikos@gr.sika.com

Lerri Meng
SIKA HONGKONG LTD., Rm 1507, Block A, New Trade Plaza, 6 On Ping Street, Shatin, N.T., Hong Kong, China. meng.lerri@hk.sika.com

ABSTRACT: Graffiti and fly-posters in Greece as well as in many other countries, cause many problems for the appearance and image by disfiguring and damaging the surfaces of many buildings, monuments and civil engineering structures on road and rail networks. As soon as a new structure is built or an existing structures is cleaned, so-called 'taggers' can start to take pleasure in defiling them. Different techniques are available to remove this graffiti and clean the surfaces, such as chemical cleaners and / or over-painting etc. However most of these techniques are not very durable and only last until the next graffiti attack occurs. With regards to fly-posters, these can generally only be removed by mechanical means (water jetting or sand blasting). A new type of anti-graffiti coating system was therefore developed in an attempt to overcome these issues, which was based on polysiloxane polymers, and this was applied on some concrete railway structures in Greece. This paper presents this new 'Anti-graffiti' technology, including the laboratory development and trial applications, plus the results and conclusions from its practical use on structures.

KEY-WORDS: Railways structure projects, anti-graffiti protection, and concrete surface protection

INTRODUCTION

Background

Today graffiti is also closely related to crime such as that which broadcasts gang related turf wars, illegal drug activities, racial hatred and social intolerance. Not only it is an unwelcome intrusion, graffiti is vandalism and delinquency, plus it is also a significant and increasing cost burden to communities and authorities around the world. Protecting their buildings and infrastructure against unsightly graffiti has become an important goal for many.

In the USA, the State of California alone estimates their annual graffiti removal and its associated costs at $167m annually The California Association of Realtors [1] estimate areas and neighborhoods with graffiti suffer a decrease in property values that is in the range of around 20%. The total USA graffiti removal costs are now estimated at $1.3 billion annually. In Europe, the City of London [2] spends more than £100m a year to remove graffiti, whilst in France [3], the total cost even as long ago as 2001, was in excess of 10m €, and this Fig. has risen substantially year on year ever since. With regards to illegal fly-poster removal and cleaning, this is also more than a visual disFig.ment and nuisance; it also now costs every city authority to remove theses. For example, in Paris alone, more than 100'000 posters are now removed every year and this costs the city more than 3m € per year and rising.

Graffiti removal techniques

Various techniques are available to remove graffiti and their effectiveness is generally dependent on if the substrates were initially / originally protected or not. Chemical cleaning may pose problems if the substrate is painted. Abrasive blast cleaning may leave an unpleasant "print" or rough profile, especially if the substrate is made of soft render refer to Fig. 1**.** Over-painting is only a temporary solution as soon, graffiti are re-applied on the freshly painted areas – refer to Fig. 2.

Fig.1. Results of grid-blasting cleaning

Fig. 2. Over-painting approach is often useless

Types of anti-graffiti coating
Typically, there are three types of anti-graffiti coating:

Sacrificial: After the removal of any graffiti from the treated surface, a refresher coat is re-applied in order to restore and maintain the protective capability. Typically, these materials are products based on soft polymers or waxes.

Semi-sacrificial: With this type of material the graffiti removal can be carried out a few times before the treatment is no longer effective anymore, and a new refresher coating is again required. Typically, we found here products made of combination of polymer and wax.

Permanent: These allow graffiti removal operations (cold/hot pressure water-jetting, chemical cleaning, etc.) can be carried out many times on the treated surfaces. Typically, there are two types of such products: Aliphatic polyurethane resin based coatings with reduced water vapor permeability, or modified silicone resin based products.

Scope
Today graffiti is also closely related to crime such as that which broadcasts gang related turf wars, illegal drug activities, racial hatred and social intolerance. Not only it is an unwelcome intrusion, graffiti is vandalism and delinquency, plus it is also a significant and increasing cost burden to communities and authorities around the world. Protecting their buildings and infrastructure against unsightly graffiti has become an important goal for many.

THE EVALUATION / TEST PROJECT

Description
The owner of this structure, ERGA OSE SA is a subsidiary of Hellenic Railways Organization OSE in Greece, founded in 1996 in order to undertake the management of OSE's Investment Program projects, particularly those co-funded by European Union Programs.

This overall project involves the construction of a new twin railway line, approximately 7.1 km long, in the section from the new Kiato RS to Rododaphni, after the Aigio RS and this includes several different railway superstructures and tunnels. The total budget is 920 million Euros.
The particular aspect of this project for graffiti protection is to protect the concrete facades of the new railway superstructure elements. The requirement for this project was to select and apply a 'Permanent' type of anti-graffiti system.

THE ANTI-GRAFFITI PROTECTION PRODUCT

Description
The anti-graffiti protection product selected for use on this project is a clear, one-component, moisture-cured, silicone elastomer coating. The product is based on polysiloxane polymers that are extremely resistant to oxidation. Traditional silicone elastomer coating does contain Oxime or tin catalysts both being harmful substance. The new

product placed in the market does contain a new, unique and harmless hardening system. Material does contain ~10% organic solvent but does require some dilution with white spirit on site to ease the application process.

This material provides a tough but elastic protective film that does not require chemical cleaning or hot water-jetting to easily remove the graffiti. Cleaning is simply carry out by low pressure water (80 to 100 bars).Additionally, posters illegally stuck on the protected surface will simply fall down under their own weight, once their glue has dried out.

Performance

Anti-graffiti coating - Gloss retention

Due to the higher internal bond of the Si-O backbone of this material by comparison with the C-C bond of other modern polymer coatings; this type of polysiloxane coatings are extremely resistant to weathering, gloss and color retention (refer to Fig. 3).The test was carried out as follow:

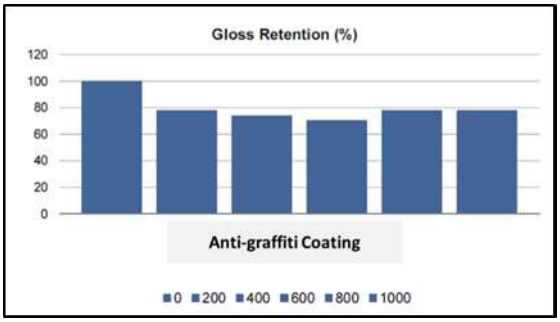

Fig.3. Gloss retention over time (in hours)

Anti-graffiti coating was applied at 250 g/m2 on a concrete plate and placed in QUV-A chamber for different period of time (up to 1000 hours).Upon removal of the plate, the gloss was measured with a standard gloss meter (leaning on DIN ISO 2813). The angle used for the measurement was 60°.

Permanent anti-graffiti system

The anti-graffiti coating was applied diluted with 20% white spirit on limesandstone substrate. 1 week after application, graffiti were placed on the treated surface (solvent based Acrylic paint from MIPA, solvent based Alkyds resin paint from DUPLI Color and Marker from Molotow) and allowed to dry for 1 week. Cleaning was done using water jetting at 80 to 100 bars without the help of any cleaning agent.

In order to assess the behaviour of the coating after the cycle of graffiti application and cleaning, the same specimen treated with the anti-graffiti coating was subjected to 23 cycles of cleaning by water-jetting (using a pressure of around 80 to 100 bars each time).

After the final test cycle, the coating was still not damaged. Therefore, after thorough drying, posters and stickers were bonded to the test surfaces and the glue allowed hardening, but they could all still be removed very easily, thus also demonstrating that even after so many cycles of repetitive cleaning, the integrity of the coating was not affected. To further assess and confirm the long term behaviour of this new protective coating system, 2 sets of these experiments were undertaken.

Limesandstone specimens were treated with the anti-graffiti coating (same dilution and consumption as the previous test) and: A set (referred to in fig. 6) was positioned for outdoor weathering (At a 60° angle, in a South West exposure to the German weathering by rain and UV – South west of Germany, near the Austrian border), then after cleaning, they were 'tagged' with graffiti and permanent marker – these tags were left for 1 month to weather and then cleaned by cold water-jetting (at up to 100 bars). The second set of specimens (referred to in Fig. 7) was tagged 1 day after the protection was applied and the tagged specimens were placed for weathering (as the first set) for 1 year. Cleaning operations were again only done by cold water-jetting (at up to 100 bars).

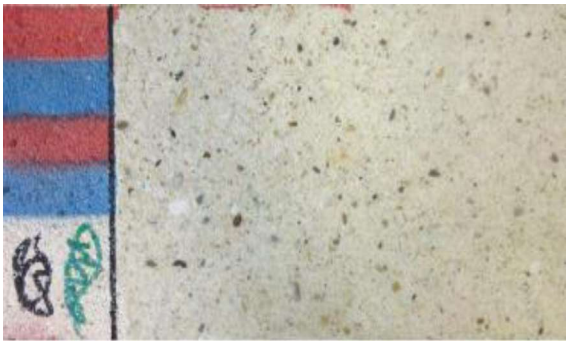

Fig.4. Surface aspect after the first cleaning operation

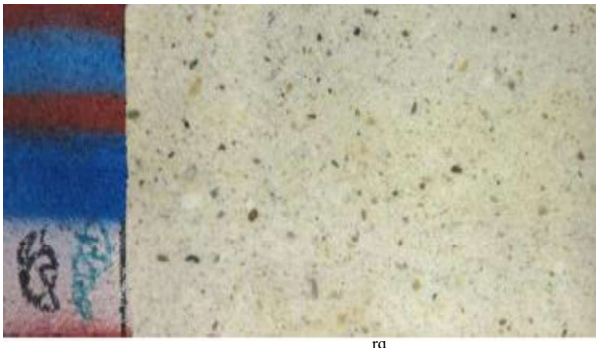

Fig.5. Surface aspect after the 23ra cleaning operation

Before outdoor weathering | After 1 year of outdoor weathering | After cleaning

Fig.6. Results after 1 year's exposure to the repeated cleaning operations

Before outdoor weathering | After 1 year of outdoor weathering | After cleaning

Fig.7. Results of cleaning to remove the graffiti after 1 year's exposure

In both sets of these experiments, the graffiti/tags were easily removed by simple cold water-jetting.

Water vapor diffusion - Cup method (EN ISO 7783:2012) [4]:
Three cylindrical test specimens were prepared, each with an approximate surface = 0.0079 m^2 (100 mm diameter), to test. After curing for 28 days in controlled laboratory conditions, the test specimens undergo 3 cycles of immersion in water and drying.

Ambient conditions: 23ºC and 50% R.H.
Saturate in capsules: Ammonium dihydrogen phosphate (93%RH).
Pressure difference (Δp): 1210 Pa.

To create an atmosphere of 93%R.H. inside the capsule, a saturate with the dissolved ammonium dihydrogen phosphate is used, whereby a 50% humidity is attained outside the capsule, with the 93% inside. In accordance with EN 1504-2, the polysiloxane based test coating is classified as breathable (Sd < 5m). Additionally, based on the classification of coating materials and coating systems for exterior masonry and concrete according to European Standard EN 1062-1, it is classified as medium diffusion (≥0.14 & < 2.4) – and is close to the highest diffusion limit of this class.

Table 1: Water vapor diffusion

Sample No.	DFT (µm)	Water vapor flow rate G (g/h)	Water vapor transmission rate V (g/m2 x day)	Diffusion equivalent air layer thickness Sd (m)	Water vapor resistance factor µ
1	432	0.015	45.9	0.4	942
2	439	0.014	43.3	0.5	963
3	419	0.011	32.8	0.6	1354
Average	430	0.013	40.7	0.5	1086

Liquid water permeability (EN 1062-3: 2008) [4]:
Ceramic specimens were used as the support/substrate (approximate size 150 x 150 mm, 30 mm thick, density 1650 kg/m^3 and a measured liquid water transmission index of 7,5 kg/(m^2·h$^{0.5}$).

The product is applied and after 28 days curing in controlled laboratory conditions, the test specimens undergo 3 water immersion and drying cycles, and then a final drying process.

Table 2: Water permeability

Specimen number	W (kg/m^2 h$^{0.5}$)
1	0.00009
2	0.00009
3	0.00008
Average	0.00009

Graffiti removal and cleaning
In order to demonstrate the use and ease of graffiti removal / cleaning on concrete substrates treated with this polysiloxane based anti-graffiti coating, site trials were organized.

In the presence of the contractor METKA and the project owner ERG OSE, the coating material was applied in 2 coats, the first diluted (~30%) with white spirit, as a priming / impregnating coat, then this was followed by a top coating of the undiluted material in accordance with the manufacturer's instructions.

Fig.8. Application trials

Fig.9. Graffiti applied

Fig.10. Cleaning in progress

One week after the coatings application, graffiti was spray applied over the treated surface, and then the week after that the surfaces were quickly and easily cleaned to remove the graffiti by simple cold water jetting.

CONCLUSIONS

To protect concrete structures against graffiti, an innovative coating based on "green" hardening technology (Oxime and tin-free) polysiloxanes was used. Its main feature is to allow the graffiti to be removed easily using simple cold water-jetting to clean the surfaces, without the need for aggressive chemical cleaners or more complex hot water & steam cleaning.

Additionally, as well as providing protection that allows easy removal of graffiti, this new coating system also protects the structure against water ingress, whilst still allowing the substrate to 'breathe' in accordance with normal building physics.

REFERENCES

[1] Survey by the Norgraf Network Inc
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[4] Technical report, Applus Laboratories; reference: 17/14156-666; dated: 25th April 2017