7.3

PROTECTIVE COATINGS

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INTRODUCTION

Protective coatings for stone in buildings have been used for hundreds of years. Renders and plasters of various types have served to protect stone masonry in many instances. In these situations, the stone is of course not visible, and serves primarily as a structural element. Paint and whitewash have also been used in a similar manner.

During this century however, a wide range of clear protective coatings have been developed by the chemical industry for use in many different applications. Many of these have found their way into the building industry.

The major use of protective coatings has been as a barrier to water movement through building elements. In the case of stone, this has primarily been as an external application to prevent moisture penetration.

Other functions of protective coatings have included protection against soiling, defence against graffiti and in a few instances, improvement of appearance. However, the primary reason for application of a protective coating remains one of protection against water movement.

WATER IN BUILDINGS

This paper does not attempt to cover the behaviour of water in building materials in any detail. However, the major modes of water movement through porous materials such as stone are summarised below:

(1) penetration of rainwater or runoff into the surface of porous materials will transport soluble salts from the atmosphere or surface of the material into the body. Moderately porous materials can remain damp from rain for several days during cool weather, and highly porous materials (such as some limestones) may allow movement of liquid water through the wall during a particular period of rain. Transmission of liquid water through thin granite is uncommon, although in comparatively porous granites (water absorption greater than 0.35% by weight) this can occur.

(2) rising damp from capillary movement of water up through porous material can occur in all types of stone. Examples are common in sandstone and limestone, but many buildings with granite or marble plinths also exhibit a line of rising damp up to 1 m above external ground level. The marble of the Great Verandah of the New Parliament House in Canberra is one notable example. Rising damp can also present problems with paving, and staining of stone paving due to rising moisture is not uncommon. Such staining tends to be most common around the joints, but can be patchy throughout the stone units.

(3) falling damp from penetration of liquid water at a higher point in the building is a problem in porous masonry of sandstone or limestone, but in granite and marble cladding is derived from leaking joints, windows, copings, etc.

(4) condensation of vapour in or behind stone cladding may result in corrosion of fixings, staining of stone panels or runoff below soffits. Ventilated and drained joints can assist in minimising this problem.

In addition, the surface of stone can deteriorate due to repeated wetting and drying from rain and/or condensation. Such deterioration is generally due to a combination of the effects of moisture, soluble salts and acids from pollution, and thermal cycling.

Problems with cyclic freezing and thawing are virtually non-existent in Australia, although these are of major concern in Europe and parts of the USA.

REASONS FOR APPLICATION OF PROTECTIVE COATINGS

Consideration is generally given to application of protective coatings at either the construction stage or during repairs at a later stage of a building's history.

During construction, protective coatings are more likely to be applied to materials which are known to have a comparatively high porosity, and hence likely to deteriorate or stain due to the interaction of moisture. Alternatively, protection of the stone from other sources of disfigurement such as graffiti or urban soiling may be contemplated at this stage.

Protective coatings are generally applied during repair work to problems associated with moisture-related deterioration. Such coatings may seek to prevent penetrating or falling damp, or may be intended to slow deterioration of the surface of the stone due to repeated wetting and drying. Some application of anti-graffiti coatings also occurs following removal of graffiti or cleaning of older buildings.

TYPES OF PROTECTIVE COATINGS

A wide range of clear protective coatings are commercially available. In general, clear coatings perform less well than opaque coatings such as paints due to the lower percentage of solids present, and the consequent reduced resistance to the UV radiation in sunlight and the ability to fill or bridge large cracks or pores. Further, all coatings are susceptible to deterioration themselves, and few clear coatings are considered likely to perform satisfactorily after 15-20 years. Many in fact fail in less than 5 years.

Two major classes of protective coatings may be distinguished. A water-proofer may be defined as an impervious coating which seals the surface to the infiltration of liquid water and water vapour, whereas a water-repellent is a material that penetrates the surface and permits the movement of water vapour to some extent, but not the infiltration of liquid water (Maslow, 1974).

The major generic types of materials produced as clear protective coatings are as follows:

- silicones or modified silicones (including siliconates)
- silanes
- acrylates
- *modified acrylates (styrene or vinyl toluene acrylates)*
- *urethanes*
- polyesters
- other resin combinations.

Of these, water-proof coatings are generally limited to the urethanes and a few acrylates or polyesters. Most of the coatings however should be classified as water-repellent coatings. The water-proof coatings and some of the water-repellent coatings are film-forming coatings. That is, they produce a layer of material on the surface of the masonry substrate. Such materials include the urethanes, polyesters, and acrylates. Coatings such as clear polyurethanes, acrylic coatings (e.g. Hydron 300) all produce such films. These films may or may not be continuous, thus resulting in either a water-proof coating such as a polyurethane, or a water-repellent coating, such as some acrylates.

The silicones and silanes, along with a very few acrylic-based coatings, are penetrating coatings which act by lining the pores of masonry. The change in pore diameter and surface characteristics affects the capillary movement of water. These coatings are generally not resistant to the penetration of water under force (e.g. driving rain) but will resist the absorption of water due to rising or falling damp. They are usually permeable to water vapour to some degree, although this varies considerably, and will thus allow the movement of water vapour into and out of the substrate. This reduces the potential for condensation of water behind or in the stone.

PROBLEMS WITH PROTECTIVE COATINGS

Most of these coatings are susceptible to deterioration. The primary agent of deterioration is ultra-violet radiation, and some coatings have been known to fail within a few years. Such failures generally occur by chalking and/or yellowing of the coating, followed by disintegration. A film-building coating may blister and peel, whilst a pore-lining coating will simply cease to be effective.

Other causes of deterioration include moisture, crystallisation of soluble salts and attack by atmospheric pollutants.

A major problem with all applied protective coatings is the bonding with the surface of the substrate. If the coating is impermeable to water, either in liquid or vapour form, then if moisture accumulates behind the coated layer, the surface of the stone may spall. Alternatively, the coating may blister and 'blow off'. The former is more serious, as the stone itself is damaged.

This spalling can also occur with coatings which are permeable to water vapour if a source of soluble salts is present behind the coating. Moisture movement within the masonry may result in deposition of these salts immediately behind the coating, due to the evaporation of moisture at this location. Accumulation of these salts immediately

behind the surface coating creates forces due to expansion of the salts in crystalline form, resulting in detachment and spalling of the stone and coating.

Care should always be taken with the decision to apply a surface coating to stone to ensure that all potential sources of moisture within the stone have been identified, and appropriate protection against damage due to the effect of the coating on natural moisture movement patterns within the stone provided.

One of the problems which is rarely considered when selecting a coating for use on stone is that of removal at a later date. Many coatings are extremely difficult to remove, either due to their original composition, or due to changes in chemical composition resulting from exposure to ultra-violet radiation or other environmental parameters. In the worst cases, removal of failed coatings may require physical abrasion of the stone surface.

FLOORING

The application of protective coatings to stone used as flooring is often recommended as a means of retaining a polished finish or for reducing the slipperiness of polished stone. This area is dealt with in more detail in the paper on paving (9.1), but the same concerns outlined above with respect to moisture apply. In addition, consideration must be given to the wear resistance of the coating, as well as the maintenance requirements, and ease of removal.

PROTECTION AGAINST GRAFFITI

The protection of buildings against graffiti is an area of concern for many architects and property managers. The removal of graffiti from porous masonry without damage is extremely difficult, and in some cases, may be impossible. One solution is the application of protective coatings which allow the graffiti to be removed more easily.

The same precautions must be taken with selection and application of anti-graffiti coatings as with any other protective coatings. In addition, the performance of the coating with respect to removal of graffiti, and the effect of removal solvents on the coating should be evaluated prior to application. Unfortunately, the best performing anti-graffiti coatings are polyurethanes, which tend to be quite visible when applied to porous masonry such as sandstone or limestone. Other coatings which have been found to perform relatively well as anti-graffiti coatings include Acryline 'Graffiti-Off' and 'Hydron 300'.

Granite, particularly polished granite, is relatively resistant to graffiti, and to removal of graffiti, and is therefore rarely coated. It is difficult to find coatings which will adhere to granite in any case. Similar problems are experienced with adhesion of coatings to marble, but unfortunately due to the fine pores present in marble, this stone can often be permanently defaced by application of felt pen graffiti. Some work with the application of waxes and polishes to external marble has been carried out, but these tend to have a relatively short lifespan, and must be renewed every few months in order to remain effective.

EVALUATION OF PROTECTIVE COATINGS

A range of test procedures have been developed for evaluation of coatings for use as either water-proofing/repellent coatings, floor protection or as anti-graffiti coatings. Unfortunately, many of these are of little value as absolute tests, and are applicable only when a range of coatings can be compared against each other. This is especially so when a range of different types of coatings are to be compared.

Test procedures which are commonly used in the evaluation of protective coatings include the following:

- exposure to ultra-violet radiation;
- resistance to water penetration (under low pressure);
- water vapour permeability;
- depth of penetration into substrate (measure of adhesion to substrate);
- contact angle of liquid water;
- change in appearance of substrate;
- natural exposure.

A large number of standard test procedures (developed for paints) are applicable, some of the most relevant being ASTM D3359 (adhesion) and the Australian Standard AS1580.

Consideration of a suitable coating for application to stone should generally include some form of comparative testing program on a range of coatings which have been selected for the particular situation. Such testwork generally requires a minimum of 3-6 months, and longer periods are preferable in order to maximise the period of natural exposure.

CONCLUSION

In general, the application of protective coatings to stone should be avoided when possible. Stone is a natural material, and if selected correctly, should have a high durability. Most protective coatings are artificial materials with, in many cases, unknown lifespans. Application of protective coatings can result in substantial changes in behaviour of the substrate material.

However, some situations require the application of protective coatings in order to prolong the life of decaying stone, or to minimise potential damage from environmental influences. In general, it will rarely be appropriate to apply coatings to granite. Some situations may require the application of waxes or polishes to marble flooring or cladding in order to minimise staining or to protect against wear.

The sealing of slate, sandstone or limestone, when used as paving, is generally a protection against dust production and staining. In some cases, it also functions to prevent moisture penetration. Sealing of porous stone to prevent moisture penetration when used as veneer cladding is not recommended as it introduces a reliance on the performance of the coating rather than on the stone itself. However, in some situations this may be acceptable. Careful consideration should be given to the long-term maintenance implications of such uses however.

REFERENCES

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