VOLUME 2 HIGHWAY STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES) MATERIALS

SECTION 4 PAINTS AND OTHER PROTECTIVE COATINGS

PART 3

BA 85/04

COATINGS FOR CONCRETE HIGHWAY STRUCTURES AND ANCILLARY STRUCTURES

SUMMARY

This Advice Note covers the use of coatings on new concrete highway structures and those in service, and ancillary structures such as service buildings.

INSTRUCTIONS FOR USE

This Advice Note is to be incorporated in the Manual.

1. This document supersedes BE 8/75.
2. Remove Contents pages for Volume 2, dated February 2004.
3. Insert new Contents pages for Volume 2, dated May 2004.
4. Insert BA 85/04 into Volume 2, Section 4, Part 3.
5. Please archive this sheet as appropriate.

Note: A quarterly index with a full set of Volume Contents Pages is available separately from The Stationery Office Ltd.

THE HIGHWAYS AGENCY

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THE DEPARTMENT FOR REGIONAL DEVELOPMENT
NORTHERN IRELAND

Coatings for Concrete Highway Structures and Ancillary Structures

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REGISTRATION OF AMENDMENTS

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Contents

1. INTRODUCTION

1.1 This Advice Note supersedes BE8/75, which is withdrawn.

Purpose and scope

1.2 The Advice Note comprises guidance on the use of surface coatings on concrete highway structures. It also deals with coatings to be applied to the internal and external surfaces of ancillary structures, such as service buildings. Appendix A consists of a review of technology and practice outlining the basic principles of coatings technology, and describes how the constituents can be combined to produce the wide variety of paints and other treatments that are commonly used to decorate and protect cement-based substrates. It also deals with substrate characteristics that are relevant to coating performance, and how they affect coating selection. Finally a synopsis of the current best practice guidance for the specification of coatings for concrete and associated substrates is given.

Implementation

1.3 This Advice Note is to be implemented forthwith for all schemes currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. Design and Maintenance Organisations should confirm its application to particular schemes with the Overseeing Organisation, and include within technical approval procedures and Approval in Principle documentation where appropriate.

2. GUIDANCE

General issues and policy

2.1 Overseeing Organisations receive numerous proposals to paint or coat concrete structures. The reasons for this are many and varied: cosmetic (as part of refurbishment and regeneration schemes on existing and new structures), decorative (murals), protective (to provide enhanced durability or as part of measures to mitigate graffiti) and to address technical issues such as improved light reflectance and cleaning properties in specialist structures such as tunnels.

2.2 Previous guidance given in BE8/75 advised that in general concrete should not be painted, primarily because:

- inspection may be hampered;
- structural defects may be obscured;
- additional maintenance liability may be incurred - recoating and cleaning;
- coating performance was not generally very satisfactory;
- limited service life of paints and coatings;
- painted surfaces tended to appear dirty and shabby after a short period;
- monitoring of remedial treatments may be hampered.

2.3 The philosophy behind BE8/75 is still appropriate, and although there have been many advances in coating technology in the interim period, the current guidance is that in general it is not advisable to utilise coatings on external exposed concrete surfaces of highway structures. The use of paints or any other applied coatings for coverage of concrete surfaces on highway structures will only be permitted in exceptional circumstances, and should be supported by technical justification, whole life costing and assessment of risks, based on a developed and agreed management strategy for the structure. Where they are justified and are to be adopted by agreement with the Overseeing Organisation, Appendix A of this Advice Note provides some technical guidance to assist with the preparation of a specification for the coatings. However, where necessary, specialist technical advice should also be sought from suppliers and manufacturers of coatings, and reference made to coating data sheets.

2.4 A smooth dense concrete surface with compliant cover to steel reinforcement enhances durability, without the need to resort to coatings, other than the appropriate use of a pore lining impregnant, in aggressive environments where structural elements are subject to deicing salt spray or in marine environments. (Surface protection using a pore lining impregnant is not specifically dealt with in this Advice Note - reference should be made to BD43 and the MCHW Volume 1 Specification for Highway Works and the related Volume 2 Notes for Guidance). Concrete is best left with a natural smooth defect free ‘as struck’ finish (no further surface treatment after removal of the shuttering), albeit that in some situations special concrete surface treatment finishes may be required and can be used. Contrasts can be provided by the use of moulding, features and textures in the concrete surface to give areas of light and shade or by using different aggregates and cements. Further advice is available in the ‘Appearance of Bridges and other Highway Structures’ produced by Highways Agency and published by HMSO.

2.5 The main circumstances where coatings may be considered and used are as follows:

- anti-graffiti coatings (as part of a management strategy to deal with specific graffiti problems on new or existing structures);

  (Although detailed policies on graffiti will vary between Overseeing Organisations, general requirements will be to remove obscene, blasphemous or offensive graffiti as soon as practicable after it has been observed. However discretion is required in the handling and timing of the removal of other graffiti. Non-contentious graffiti should be removed, to meet set levels of service or intervals prescribed or agreed in particular contracts, or in combination with other work where appropriate. Where graffiti is persistent or widespread in environmentally sensitive areas, consideration should be given to different options, other than by frequent removal or obliteration. Possible strategies are initiatives involving local schools, Neighbourhood Watch,

local councils, and the Police. Physical measures include the use of anti-graffiti coatings, special cleaning materials, gritblasting, and the provision of alternative surfaces such as tiling, and murals. Care must be taken to ensure compatibility of applied materials and cleaning techniques, with the concrete substrate, and to avoid surface deterioration. The remedial action should not encourage further graffiti, eg Overpainting with light coloured coatings is often seen as providing a 'new blank canvas'. It may be appropriate in some circumstances where a coating or mural has been applied to also use an anti-graffiti coating. More information is provided in 'Appearance of bridges and other Highway Structures').

- anti-carbonation coatings (in association with specific remedial treatment such as electrochemical chloride removal, or where carbonation has been identified as a specific and significant risk);

- tunnel finishes (tunnel walls or tunnel approaches where light reflectance and suitability for use with washing detergents are prime considerations - whilst the principles of coatings are dealt with in this Advice Note more specific requirements are included in the Tunnel Specification and related Notes for Guidance Volume 5 MCHW, BD78 and BA72);

- buried concrete surfaces;

- other inaccessible surfaces subject to potential water and deicing salt damage such as ends of decks and ballast walls;

- environmental schemes including the use of murals in subways or on retaining walls (other treatments such as tiling could also be considered). In this case a careful study will be required to assess the potential aesthetic and social benefits, as against technical considerations and costs, including future maintenance liabilities;

- specialist applications such as anti-climb and anti-bill posting coatings.

2.6 Where coatings are considered they should be assessed in whole life cost terms as well as by development of a technical specification, to meet the design requirements. They should be reviewed as part of the developed management strategy for the structure concerned.

2.7 The guidance in this Advice Note applies both to new construction and in-service structures. However where consideration is being given to the application of coatings on in-service structures, the existing condition of the structure must be assessed. Key issues to be addressed are the identification of the cause of any pre-existing defects in the concrete, their method of rectification, desired service life, costs and appearance. Coatings are only one of a number of remedial options available, either used alone or in combination with other techniques and materials.

Performance criteria

2.8 In specifying a coating for concrete, key considerations will be the suitability of the proposed material for application on concrete, durability, effect on the performance characteristics of the concrete, performance characteristics of the coating, appearance, maintainability, costs, application constraints, and health and safety issues. These topics are discussed in more detail in Appendix A.

2.9 When specifying coatings it is essential to ensure that the physical, chemical and electrochemical condition of the substrate material, and the environmental conditions for the coating application are appropriate. Some general guidance is given in Appendix A, however as there is a wide range of materials available, used for different purposes, it is usually necessary to seek specialist advice from an experienced materials consultant, or directly from coating suppliers. Where necessary detailed technical specifications should be consulted and research data sought. On larger schemes trials would be prudent and are strongly recommended, and also where appearance and performance are critical. Additional testing may also be required to assess the performance of proposed coatings.

2.10 Many coatings provide some form of physical barrier, which prevents ingress of chlorides and carbon dioxide, and allows concrete to breathe, and reduces its moisture content. In addition to economic requirements such as ease of application, ease of overcoating and long service life, the main selection criteria for coatings can be summarised as follows:

- chemical resistance (eg to salt);

- diffusion resistance (eg to water, CO_2, O_2, chloride ions);

- weathering resistance (eg to UV light, variable temperature and humidity, water);

- resistance to expansive forces (eg to freezing and thawing, alkali aggregate reaction);
- aesthetic appearance;
- crack bridging ability;
- adhesion strength;
- abrasion resistance.

Appearance

2.11 Where a coating has been agreed, consideration should be given to the final appearance. This will depend on the purpose of the coating, the location of the structure and its environment. Colour and texture may be issues to be addressed and whether a matt or glossy finish is required. Further guidance on the subject is available in the reference document 'The appearance of bridges'. Trials to assess the appearance of the coating insitu on the structure may be required.

Anti-graffiti coatings

2.12 Unless there is a proven or anticipated problem with vandalism and graffiti, it is still preferable to avoid the use of coatings wherever possible. As indicated in 2.5 above, and if there are no other options, anti-graffiti measures including the use of coatings may be necessary. In selecting a suitable coating care must be taken. Appendix A section A12 indicates that some materials, particularly permanent coatings based on urethane may alter the appearance of the concrete surface, and so should only be considered where appearance is not critical. So called 'sacrificial coatings', often wax based, are removed or partially removed when cleaning and removing graffiti, and therefore incur additional liabilities for cleaning and renewal of the materials in the future. They generally have less visual impact and are preferred where appearance matters.

2.13 Issues to be considered are the need to make special arrangements for the procurement of services for graffiti removal and coating replacement, and the technical and health and safety aspects of the use of solvents and other cleaning materials and the need for compatibility of materials. If extensive use of anti-graffiti coatings is to be made, and particularly where appearance is important it is worth undertaking a trial, to assess appearance and performance of the material when subject to graffiti. Combination materials may also become available which will address the requirement for pore-lining impregnants and provide an anti-graffiti capability.

2.14 In many United Kingdom locations, in areas prone to graffiti, community schemes have been set up, often involving schools and local artists to produce murals on retaining walls and subways. This has often been carried out in the design of new schemes, but has also been applied to in-service structures. The emphasis has usually been on the design aspects rather than the choice of materials, but both are important. Designs which have large blocks of colour, particularly light colours, may still be the target of graffiti. Persistent graffiti may also deface good designs, unless the source of the problem is addressed, or unless an anti-graffiti coating is used as well. Also some paints used for murals have not proved durable and far from enhancing a neighbourhood, present a shabby appearance. Murals do present some difficulties in terms of maintenance of the mural itself, and inspection and repair of the concrete substrate.

Anti-carbonation coatings

2.15 Anti-carbonation coatings are usually only used in association with specialised remedial treatments such as electrochemical chloride removal, or if concrete deterioration by carbonation is likely or has occurred. The latter is a relatively rare occurrence on highway structures. Some generalised guidance on anti-carbonation coatings is given at Appendix A clause A13.

Tunnels

2.16 When selecting coatings for use within concrete tunnels the key criteria is the ease of cleaning and the colour and reflectivity to enhance the tunnel lighting. Impermeability to aggressive agents is also important and thought should also be given to the type of detergents to be used for tunnel cleaning operations. Areas of the tunnel walls extending to not less than 4 metres above the carriageway level shall be of a consistent light colour and have a reflectance of not less than 0.6 (the method of measurement of reflectance is given in MCHW Volume 5). Above the light area shall be a consistent dark colour. It is also necessary to demonstrate that the surface finish will avoid problems of excessive specular reflection or 'glare' due to the reflection of daylight, vehicle lights, or illuminated signs. Smooth finishes are preferable, as textured surfaces may not be suitable as they will tend to retain dirt.

Buried concrete surfaces

2.17 Buried concrete surfaces, or faces of walls below ground, or in contact with soil or groundwater should receive a waterproof coating before backfilling - refer to Appendix A clause A11. Straight run bituminous and tar based compounds are generally effective, economic and durable. In the past bituminous emulsions have been used, but may be susceptible to failure in damp, wet or cold conditions. The acceptable materials must be carefully applied in accordance with the manufacturer's recommendations, generally with a primer and two coats, to provide a defect free surface without holidays. These coatings should comply with MCHW1 Clause 2004 and be applied in accordance with Clause 2006. Similar coatings may also be required in inaccessible areas of bridges, which may be subject to water and other contaminants, such as bearing shelves, deck ends and ballast walls.

2.18 Where concrete is at risk of attack from contaminants in the ground or from sulfates, specialist advice should be sought and reference made to BRE Special Digest SD1 'Concrete in aggressive ground'. The Digest gives guidance on Protective Measures to be applied to different mixes of concrete in varying ground conditions, including the use of waterproofing coatings.

Box sections

2.19 Generally it is not necessary to coat accessible interior surfaces of concrete box sections such as beams, tanks and cellular abutments. It is more important to provide a stable and benign environment, and consideration needs to be given to the provision of adequate ventilation and drainage. If a coating is required then the use of a pore lining impregnant is preferred.

Concrete in contact with water

2.20 Unless there is a specific chemical problem, then concrete in contact with above ground non-potable water will generally not require the use of a coating. The emphasis should be on the use of good design and detailing of the concrete surfaces and drainage, materials selection and good construction techniques to ensure durability. Routine maintenance is also important. Where a coating is deemed necessary, specialist advice must be sought and contact made with and approval sought from the relevant responsible water authorities.

Other applications

2.21 There may be other specialised applications which require the use of a coating on concrete. They will need to be assessed on their merit, based on the principles and guidance in this Advice Note. In most cases they will require detailed discussions with the manufacturer or supplier, and examination of research evidence to ensure their suitability in meeting the performance requirements, and in achieving the desired durability.

Other substrates

2.22 Although this Advice Note deals specifically with the application of coatings on concrete, many of the principles relate to other substrates, such as masonry, brickwork and other cement based finishes. Appendix A provides some general advice, but it is recommended that guidance is sought from specialists or suppliers.

Historic structures

2.23 Where a coating is to be used on the concrete surface of a historic structure, and particularly if it is listed or scheduled, the relevant planning and heritage authorities should be consulted, and any necessary approvals obtained. Appearance and colour will be important, as will be the respect to the historic fabric of the structure, and the selection of appropriate coating material and its compatibility with the substrate.

Buildings

2.24 This Advice Note is not intended to provide guidance in relation to the use of coatings on the internal and external surfaces of buildings, although the technical guidance provided in Appendix A may assist in the formulation of the requirements.

Compatibility with impregnants

2.25 Where silane or another pore-lining impregnant has been used, and a coating is also proposed, then it should be ensured that there is compatibility between the materials. It is particularly important to assess that the vapour transmissibility and hydrophobic properties of the impregnant are not adversely affected or impaired, and that the performance of the coating, particularly long term adhesion, is effective. Any maintenance of the coating should not adversely affect the impregnant.

Specification

2.26 The use of pore lining impregnants (clause 1709) and buried concrete coatings (clauses 2004/2006) are covered by the Specification for Highway Works and Notes for Guidance. Specification clauses for anti-graffiti coatings are in preparation, and it is intended to add these clauses to the published Specification in due course. All other coatings are not covered by the Specification for Highway Works and Notes for Guidance, and will be subject to agreement with the Overseeing Organisation, using departure procedures or as otherwise agreed.

Testing and trials

2.27 Where the use of coatings is being considered it may be necessary to undertake performance trials to ensure that the specification requirements are met. Such trials should be described in the specification, and specific requirements identified.

2.28 Where manufacturer's data sheets and test information are insufficient it may on occasion be necessary to subject the coating material to additional testing. These tests must be related to the specification requirements, and the tests described in the specification.

Substrate preparation

2.29 It should be ensured that concrete surfaces to which coatings are to be applied are dry and free from contamination, such as dirt, spillages, salts, leachates and rust staining, as well as residues of curing membranes and mould oils. Where required repairs to the concrete should be carried out. The subsequently applied coating should be compatible with the concrete substrate and the repair materials used.

Workmanship

2.30 Details of the method and standard of application of coatings is generally outside the remit of this Advice Note, but must be considered in terms of the development of the specification requirements. Where possible the specification should be performance based, but for some specialist materials this is impractical and it will be necessary to produce a method and material based specification, on a generic basis to allow as wide a range of materials to be offered for selection.

Health and safety

2.31 Some of the materials referred to in this Advice Note and Appendix A may be injurious to health if adequate precautions are not taken. The Appendix only refers to technical suitability and performance requirements, and in no way absolves the designer, producer, supplier or the contractor from statutory obligations relating to health and safety at any stage in the manufacture or use of the coatings.

2.32 A particular consideration will be the need for protection of the substrate and other structural components, third parties, the local environment and the workforce. Environmental considerations may also affect the selection of coatings and the method of application.

Records

2.33 Any structure to which a coating has been applied, whether new construction or in service shall be especially noted in the as-built records and Health and Safety file. The structural elements coated shall be recorded, together with requisite details of the materials used, manufacturer's certificates and test data, Safety Data Sheets, source of supply, and details of any in service requirements or restrictions, such as inspection, testing and replacement

Inspection

2.34 Concrete structural elements that have been coated should be inspected as part of the normal structural inspection regime (BD63/BA63). Inspectors should be alert to signs of deterioration in the coatings such as colour fading, dirt build up, graffiti, physical damage, chemical damage, loss of adhesion, cracking, peeling, moisture and leachates, and mould growth etc. Assessment of the continued satisfactory performance of some coatings may require specialist tests to be carried out.

Maintenance

2.35 Concrete structural elements which have been coated should be maintained as necessary to ensure continued fitness for their intended purpose. Graffiti should be removed in accordance with the prescribed service levels. Where defects in coatings have been noted during inspections, maintenance should be planned and undertaken as soon as practicable, and would normally be carried out whilst other maintenance operations are undertaken.

3. REFERENCES

Design Manual for Roads and Bridges

DMRB Volume 2 BD 43 Criteria and material for the impregnation of concrete highway structures

DMRB Volume 2 BE 8/75 Painting of concrete highway structures

DMRB Volume 1 BD 57/BA57 Design for durability

DMRB Volume 3 BD 63/BA63 Inspection of highway structures

DMRB Volume 3 BA 72 Maintenance of Road Tunnels

DMRB Volume 2 BD 78 Design of road tunnels

Model Contract Document Highway Works

MCHW Volume 1 Specification for Highway Works for Roads and Bridges

MCHW Volume 2 Notes for Guidance for Highway Works for Roads and Bridges

MCHW Volume 5 Specification for Highway Tunnel Construction and Maintenance (Civils Works) (in preparation)

MCHW Volume 5 Notes for Guidance on Specification for Highway Tunnel Construction and Maintenance (Civils Works) (in preparation)

Other references

'Appearance of Bridges and other Highway Structures' published by HMSO

Concrete Society Report TR50 'Guide to surface treatments for protection and enhancement of concrete'

BRE Special Digest SD1 'Concrete in aggressive ground'

4. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:

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APPENDIX A: SURFACE COATINGS TECHNOLOGY

INDEX

A1. Basic principles

A1.1 Surface coatings comprise an extremely diverse range of product types designed to decorate and/or protect substrates to which they are applied or to provide information. They are often known generically as “paints”, though strictly this defines a product that contains colouring and opacifying materials. Clear coatings such as varnishes, lacquers and water-repellents are also produced and can be considered to be non-pigmented “paints”.

A1.2 A wide variety of terms are used to describe coatings products. These are often based on the use to which they are put, examples being “car finishes”, “marine coatings” and “decorative gloss paints”, descriptors that are so wide as to be meaningless except in the most general of terms. Coatings are produced for two main sectors: the decorative/trade market and the industrial market which, in the UK, is split approximately 50:50 in terms of volumes produced per annum. Industrial coatings include all those that are applied by controlled processes or operations, usually within a factory environment. Coatings used in industrial applications are often based on exceptionally complex technologies, generally applied using sophisticated equipment, and are produced for an extremely diverse range of substrates and end-use applications. Coatings for the decorative/trade market are applied on site or in-situ to buildings and other structures by professional painters and decorating contractors (trade) or by the general public (do-it-yourself). These coatings are inherently simpler in composition, tend to be applied by traditional methods such as brush or roller, and are used on a more restricted range of substrate types than their industrial counterparts.

A2. Composition of surface coatings

A2.1 Coatings can be considered as composed of a polymeric binder (resin) which is normally dissolved or dispersed in a liquid carrier phase (solvent); a paint coating will also contain finely dispersed particulate materials (pigments). These basic constituents would form the bulk of the composition, though all coatings contain minor additives to control and modify the properties of the final product.

A3. Binders

A3.1 The binders used in coatings are polymeric complexes which provide integrity to the dried film and bond it to the surface to which it is applied; binders are often referred to as resins or polymers. A wide variety of binders are used in the manufacture of coatings and, with some exceptions, these are all organic in composition. Binders can be divided into two broad groups of convertible and non-convertible types. Convertible binders are materials that are used in an unpolymerised or partially-polymerised state and which, following application, undergo a reaction to form a polymerised (solid) film. Non-convertible binders are pre-polymerised materials that are dispersed or dissolved in a carrier solvent; following application, the carrier evaporates to leave a coherent film on the substrate surface.

A3.2 Examples of the main types of convertible and non-convertible binders used in surface coatings, together with an indication of their end-use applications, are summarised in Table A1.

A3.3 Two other resinous materials are of importance in paint technology although they are not strictly classified as polymers, namely bitumens (USA: asphalts) and inorganic silicates.

Table A1: Binders used in surface coatings

Binder classification and type	Composition	Application
Convertible		
Alkyd	polyester-oil complex	Main binder in solvent-borne decorative coatings
Amino	eg urea-formaldehyde	Industrial coatings
Epoxy	diglycidyl ethers of epichlorhydrin	Industrial and some specialised site coatings
Oil eg linseed, soya or tung	complex fatty acids	Basis of traditional paints
Phenolic	eg phenol-formaldehyde	Industrial coatings
Polyurethane	complex isocyanates	Industrial and some specialised site coatings
Resins eg rosin or copal	mixtures of complex acids	Combined with oils to produce varnishes
Silicate	'mineral' binder, complex silica-carbonate	Specialised decorative coatings
Non-convertible		
Acrylic	eg polymethyl methacrylate	Water-borne decorative coatings
Cellulose ester	eg nitrocellulose	Industrial coatings
Rubber	eg chlorinated rubber	Specialised decorative coatings
Vinyl	eg polyvinyl acetate	Water-borne decorative coatings

A4. Pigments

A4.1 A pigment can be defined as a solid material in the form of small discrete particles, which remain insoluble in the resin and solvent constituents of the coating. Pigments are added to impart colour and opacity and/or modify the protective efficacy of the coating on the substrate. There is a further class of pigment which, whilst modifying the properties of the coating by, for example, supplying water resistance, confers little or no colour or opacity; these are called extenders. Extenders are inorganic in origin but pigments can be either organic or inorganic. Coatings for cementitious substrates may contain pigments and extenders, though the pigments are most likely to be of the inorganic type due to their greater durability and resistance to chemicals. A summary of the types of pigments and extenders most commonly encountered in coatings for concrete and masonry is given in Table A2.

Table A2: Pigments and extenders used in surface coatings

Classification	Pigments	Extenders
Natural inorganic	Iron oxides (yellows, reds, browns and black)	Barytes Whiting (chalk) China clay Mica Talc
Synthetic inorganic	Titanium dioxide (white) Iron oxides (yellows, reds, browns and black) Chromium oxide (greens) Ultramarine (blues)	Blanc fixe (synthetic barytes) Paris white (synthetic whiting)
Natural organic	None	None
Synthetic organic	Wide variety of yellows, oranges, reds, greens, blues, and blacks	None

A5. Solvents

A5.1 Solvents are low viscosity liquids, often referred to as volatile organic compounds (VOCs), though water is an important "solvent" in many modern coatings and is not considered to be a VOC. The function of solvents is to carry or dissolve the resin component, provide appropriate conditions for pigment dispersion, stabilise the finished product during storage, control application characteristics and aid film formation after application. In some coatings solvents may be the major component of the final product though, increasingly, coatings with low solvent content have been made available to users.

A5.2 The solvents most widely used in coatings are shown in Table A3.

Table A3: Solvents used in surface coatings

Class of solvent	Examples
Aliphatic hydrocarbons	Cyclohexane, mixtures of aliphatic hydrocarbons of specific boiling point ranges
Aromatic hydrocarbons	Toluene, xylene, styrene, mixtures of aromatic hydrocarbons of specific boiling point range
Chlorinated hydrocarbons	Dichloromethane, 1,1,1-trichloroethylene, trichloroethylene
Alcohols and glycols	Methanol, ethanol, iospropanol, butanol, ethylene, diethylene and triethylene glycols, propylene glycols, ether derivatives of glycols
Ketones	Acetone, methyl ethyl ketone, methyl isobutyl ketone, cyclohexanone
Esters	Ethyl acetate, butyl acetate, esters of glycol ethers

A6. Additives

A6.1 Many additives are used in coatings in order to control or modify properties such as viscosity, flow and the drying time of the coating, and to inhibit biological growths. These additives are generally used in low concentrations relative to the main formulation ingredients described above. The uses of some of the important types of additives are summarised below.

Plasticisers: Plasticisers are organic additives that are used to increase the film flexibility of paints, particularly those based on binders that otherwise would yield brittle films.

Driers: Driers, or drying accelerators, are oil-soluble metal salts of organic acid added to oxidation-curing systems, such as alkyd resins, to increase the curing (drying) rate of the applied film.

Bioactive additives: Most coatings are susceptible to attack by micro-organisms such as fungi and bacteria. Apart from the obvious impairment of appearance, paint coatings may suffer degradation by micro-organisms. Bioactive additives are required to prevent this attack.

Biocides or anti-bacterial agents are incorporated within water borne emulsion paints to prevent bacterial (and fungal) attack on the thickener. Biocides function by interfering with bacterium metabolism thereby preventing enzyme synthesis, enzymes (rather than the bacteria themselves) being the active agent in paint degradation.

Fungal growth will contribute to the degradation of a paint coating but more commonly it impairs its appearance. In certain circumstances there may be an associated health hazard, as in kitchens, dairies and breweries. Fungicides are toxic agents that are included in paint formulations to inhibit the colonisation and proliferation of fungi.

Viscosity modifiers and anti-settling agents: Paint formulations may yield liquid paints that are too fluid. With a liquid of low viscosity the flow may be excessive for some purposes, although high flow may be advantageous in some circumstances. Thus low viscosity is desirable in sealers, but not in high-build coatings and brush-applied paints. Settlement of pigments in storage, particularly if they are dense, occurs readily in low-viscosity paints, and heavy settlement can cause problems in redispersing the pigment. These problems of flow and pigment settlement can be offset by adjusting the paint viscosity. In the case of pigments, further adjustments can be made to the formulation to counteract settlement.

Viscosity can be increased by means of thickening agents which increase the viscosity (ie decrease flow) without introducing thixotropy.

Pigment-dispersing agents: Paint formulations obviously require an even dispersion of pigments and extenders throughout the liquid medium. This involves, during paint manufacture, dispersion of the pigments and extenders in the liquid medium to break down agglomerates and uniformly wet all the particles. For this to occur, the medium must displace any moisture, occluded gases and fine debris on the particle surfaces; how readily this process is effected is thus of practical importance. While most (but not all) pigments and extenders are olephilic, that is, they are wetted by solvent-media, only a proportion are hydrophilic or wetted by water: for example, many organic pigments are hydrophobic or water-repellent.

Pigment-dispersing agents, or surface-active agents, are used to facilitate pigment and extender dispersion where wetting by the medium is poor or even non-existent. They are often used routinely even when there is good wetting, to ensure good dispersion.

A7. Coatings for concrete

A7.1 Whilst some cement-based surfaces are inherently weatherproof, durable and aesthetically acceptable, others are painted for a variety of reasons; to provide colour or surface texture, to waterproof them, to reflect or absorb light, to facilitate cleaning or for hygiene.

A8. Substrate considerations - concrete

A8.1 Concrete is considered a durable, permanent material but long-term deterioration, especially in acid-polluted air, is possible; it may, therefore, require protection. Following deterioration and repairs, or even when new in the absence of sufficient cover to protect reinforcement, there is often a requirement to provide protection against penetration by water, carbon dioxide, sulphur dioxide and salts. There is also an increasing need for decorative or colouring treatments to improve the quality of the surroundings where these contain large areas of concrete, or even for colourless waterproofing treatments to prevent accumulation of dirt and biological growths.

A8.2 When painting concrete, the substrate surface may be either hard and smooth with poor adhesion for paints (eg pre-cast components) or rough and porous with large voids, as in mass concrete. Residues of mould oil can seriously reduce paint adhesion; they are best removed by abrasion rather than solvents but detergents or emulsifying agents may be useful. Curing membranes tend to degrade rapidly when exposed to light but traces may persist in the pore structure of concrete, where they could interfere with penetration of applied coatings. Abrasion may be the only way of removing such residues, but the issue is best addressed at the specification stage where the choice of coating system and curing methods are jointly considered. (It should be noted that abrasion should be considered as a last resort as it will damage the surface of the concrete and affect durability).

A8.3 The application of cement-based paints, or 'bagging' with a cement/sand mix, will help to fill voids and blowholes. Larger defects may be filled with mortar or epoxy-resin mortars, or, *indoors in dry conditions only*, with gypsum plaster or water-mixed powder fillers. Alternatively, thin-wall plasters (indoors) or textured paints (either indoors or out) may be used to hide surface blemishes. However the acceptability of defects and issues of durability versus appearance must be assessed.

A8.4 Surface treatments can be used to reduce ingress of materials to concrete that may promote corrosion of reinforcements. For reducing ingress of water to concrete impervious coatings based on chlorinated rubber, two-pack epoxy resins or polyurethanes are suitable provided the concrete is fairly dry, with a potential life of seven to 10 years to first maintenance. Their benefit will be more doubtful where chlorides are the cause of corrosion. Coatings which are less impervious, to allow drying-out, but with a claimed degree of resistance to the passage of carbon dioxide to minimise carbonation of concrete, have been used with success. The technology and use of these protective coatings is discussed in detail in later sections of this review.

A9. Substrate considerations - concrete blocks and concrete bricks

A9.1 Dense concrete blocks and bricks may be painted as for concrete. Some lightweight blocks allow rain penetration treatment, which may be complete (eg a thick bituminous coating, with decorative coats if needed) or merely rain shedding and vapour permeable (eg thick textured emulsion paints).

A9.2 Aerated (and lightweight) concrete requires paints with some filling action; emulsion paints may suffice indoors and for purely decorative purposes, but if resistance to rain penetration is a requirement, especially in exposed situations, thick textured relatively impervious coatings may be necessary, with the alternative of a rendering. These will delay drying out and should therefore only be applied when the moisture content of the aerated concrete is at a suitable safe level.

A10. Substrate considerations - Portland cement rendering

A10.1 The alkalinity of Portland cement is, with rare exception, so high that precautions against alkali attack of paints by new cement-based products should always be taken. Because of the caustic alkali present, carbonation of the lime content on ageing is not always sufficient to prevent the saponification of oil-paints and even when the surface pH falls to about 9, there may be further alkali at a greater depth which will affect paints as moisture moves through. The free lime usually present in cement plasters is a cause of the lime bloom which is particularly noticeable on emulsion paints. If carbonation is allowed to occur before painting it can greatly reduce this effect and also reduce surface porosity but may produce shrinkage crazing.

A10.2 Cement paints are suitable for very early decoration; acrylic emulsion or other alkali-resistant porous paints can be used after about four weeks drying. For a glossy finish the moisture content must be down to a safe level and several months drying may be necessary. An alkali-resistant primer is needed under oil paints, hence non-saponifiable (eg chlorinated rubber) paints are preferable. Chemically-resistant wall finishes require a hard base: cement rendering is normally suitable if dry but if a very smooth finish is needed for internal walls, an anhydrous plaster can be used on top.

A10.3 It is often argued that the craze patterns and eventual cracks which develop on painted rendering are unavoidable and not a fault of the paint. However, many comparative tests have shown that paints differ greatly in their ability to retard the crazing, which may appear within one or two years under thin emulsion or masonry paints, but not for many years where the coating is thick, flexible and not highly permeable to moisture and carbon dioxide.

A11. Below ground considerations

A11.1 Buried concrete surfaces, walls below ground and surfaces in contact with soil or groundwater should be sealed on the outside before backfilling; straight run bituminous and tar based compounds are generally effective, economic and durable. In the past bituminous emulsions have been used, but may be susceptible to failure in damp, wet or cold conditions. The acceptable materials must be carefully applied in accordance with the manufacturer's recommendations, generally with a primer and two coats, to provide a defect free surface without holidays. These coatings should comply with MCHW1 Clause 2004 and be applied in accordance with Clause 2006.

A11.2 Where concrete is at risk of attack from contaminants in the ground or from sulfates, specialist advice should be sought and reference made to BRE Special Digest SD1 'Concrete in aggressive ground'. The Digest gives guidance on Protective Measures to be applied to different mixes of concrete in varying ground conditions, including the use of waterproofing coatings.

A12. Anti-vandal treatments

A12.1 Graffiti on untreated plain concrete surfaces can be removed by application of solvents or by high-pressure cleaning with water, but will be more difficult on textured or featured concrete. It is virtually impossible to remove graffiti completely from porous substrates such as brick and stone, without spoiling their appearance. Graffiti and spills may have to be dealt with by painting over, and some manufacturers will supply paints specially matched to the colour of the substrate.

A12.2 To resist graffiti, a surface which will allow removal of most inks and paints can be produced by coatings that form a hard and chemical-resistant film. Polyurethane coatings have been used for this purpose, and are supplied by several specialist manufacturers. Anti-vandal, or anti-graffiti, coatings generally have a high sheen finish; even unpigmented (clear) variants must be expected to cause some alteration to the natural appearance of the substrate.

A12.3 "Sacrificial" treatments based on waxes are also available, which tend to be less visible; when soiled by graffiti the surface is completely cleaned off including some or all of the coating and the wax treatment reapplied. Removal of large areas of graffiti generally requires the use of specialist cleaning contractors.

A12.4 It is advisable to undertake trials of anti-graffiti coatings to check its effectiveness, and the effects on appearance.

A13. Anti-carbonation coatings

A13.1 Carbonation is a process whereby carbon dioxide in the air penetrates the pores of the concrete and reacts with calcium hydroxide forming calcium carbonate and water. In homogeneous concrete, carbonation proceeds inwards from the surface along a front roughly parallel to it. The rate of carbonation depends on several factors, particularly concrete permeability (the more permeable the concrete, the faster it will carbonate) and the relative humidity around the concrete (carbonation occurs most rapidly when the relative humidity is around 55-75%).

A13.2 To minimise the risk of subsequent deterioration, a coating may be applied over the whole exterior surface of the concrete to reduce the rate of carbonation by acting as a barrier to the penetration of carbon dioxide. It should also prevent ingress of liquid water, but allow water vapour to pass through it. This will prevent entrapment of liquid water in the concrete and between the coating and substrate. The coating treatment must, of course, be suitable for application to concrete. Furthermore, for coatings to serve as a barrier to carbon dioxide they must form a defect-free film. The surface of concrete is irregular and uneven; blowholes and other surface imperfections are quite common, so multiple coats reduce the risk of coincident defects.

A14. Performance characteristics

Basic principles

A14.1 The durability of a paint system is its ability to provide decoration and/or protection to its substrate over the period of time known as its effective service life. This period is the interval between the time of application of the paint system and the moment at which, through deterioration, it ceases to perform its required function. The durability of paint films is dependent upon a number of factors. These can be divided into 'internal' factors, such as formulation details and their effects on the physio-chemical characteristics of the coating, and 'external' factors such as the nature of the substrate, substrate preparation, location effects and weather. The latter two factors and their influence on paint durability will be considered in this section, the other factors having already been discussed in other sections of this report.

A14.2 The environmental conditions to which paint films are exposed during service are of great importance in determining their performance. Knowledge of the anticipated service conditions is essential when formulating or specifying paint coatings. Environmental factors can be subdivided into the effects of location, that is, atmospheric pollution, and the effects of weather.

Influence of location on durability

A14.3 The prevailing atmospheric conditions to which a paint film is subject can be categorised into four groups, namely, very severe, severe, moderate and mild.

A14.4 Very severe and severe exposure conditions are experienced in coastal situations, within industrial regions, near to areas of heavy industrial pollution and where complete immersion in water or chemicals may occur. Paint systems required to withstand severe exposure have to possess the highest durability. Typically, this necessitates the use of paints based on chemical resistant binders such as the epoxide, polyurethane, vinyl or chlorinated rubber resins, and these materials are used in situations where limited access makes maintenance difficult or when cost considerations dictate a long maintenance-free service life. However, often conventional alkyd type paints are used, of necessity, in such severe exposure conditions. The durability of these alkyd paints is not normally considered to be of the highest order but improved performance and an initial high degree of protection is conferred on the substrate by the provision of extra film thickness. This is most conveniently achieved by the application of two, rather than one, finishing coats over the undercoat and primer coats. In general however, their use under such conditions should not be encouraged.

A14.5 Moderate exposure conditions are experienced in light industrial and urban regions away from heavy industrial conurbations and coastal areas. Mild conditions are found in sheltered exterior areas away from pollution, and in most interior situations.

A14.6 Paint systems for the moderate and mild exposure conditions are, typically, based on alkyds, oleoresinous varnishes and emulsion resin binders. However, it is not uncommon for a paint system to be required to exhibit a greater durability than suggested by its immediate environment. Typically, interior paints which need to withstand abrasion or frequent washing down fall into this category, and here high durability paints would have to be specified. The ability of paint films to withstand location effects is primarily dependent upon their chemical resistance, a characteristic dictated by the nature of the ingredients used in the formulation.

A14.7 Most types of coating systems are resistant to the dilute acidic environments which can occur in certain exposure conditions, for example, an industrial or urban conurbation where sulphur-containing fossil fuels are burned. However, the presence of sulphur oxides in the atmosphere can cause increased drying times and premature loss of gloss in recently applied air drying, oxidative systems, although, in general, these effects do not reduce the effectiveness of coating performance.

A14.8 The formulation of paints, in particular those based on oleoresinous varnishes and alkyds, are susceptible to attack in dilute alkaline conditions. Where alkali resistance is required, alternative resin types such as the polyurethane, chlorinated rubber and vinyl copolymers have to be used. In situations where air drying oxidative formulations are required, alkyds modified with these more resistant resins can be used to produce resistant paint systems. Resistance to concentrated alkalis, however, is more difficult to achieve since this medium tends to attack all coating types, particularly on prolonged immersion.

A14.9 Coatings resistant to oils and organic solvents are also required in certain service situations and, as a generalisation, coatings with a complex cross-linked structure provide the highest resistance. Paint films can suffer severe attack from solvents, especially the chlorinated hydrocarbons (which are the basis of many paint strippers), ketones, esters and the aromatic hydrocarbons. Non-convertible coatings rarely provide good resistance to solvents.

A14.10 The pigmentation of paints can also be adversely affected by pollutants, in particular, acids and alkalis. Oils and solvents generally have little chemical effect on pigments, although with certain organic pigments the phenomenon known as ‘bleeding’ can occur on overcoating. This effect is caused by solvents in the freshly applied coating solubilising the pigmentation in the underlying film. This solubilised pigment can be carried through the freshly applied film as it dries, usually resulting in a patchy surface discolouration. The phenomenon of ‘bleeding’ is especially prevalent where aromatic hydrocarbon, ester and ketone types of solvents are present in the paint formulation.

Influence of weather on durability

A14.11 The effects of weather on paint films is often marked and can lead to rapid degradation of coating systems. All of the components of weather - temperature, moisture and radiation (sunlight) - can influence paint film performance and, clearly, since weather is a complex of these components, interactions can occur which render particular combinations severe and others relatively mild.

Resistance to ultra-violet radiation

A14.12 Prolonged exposure of many types of paint films to sunlight results in their rapid degradation, and this is primarily attributable to the ultra-violet wavelengths. Ultra-violet degradation of paint films is a complex process involving both an increase in the cross-link density of the internal molecular structure of the film binder and, concomitantly, a tendency for certain constituent structural bonds to rupture. The result of this process is that the film becomes tough during the early stages of exposure. Eventually, however, the film becomes brittle, cracks, and ultimately, as water permeates through the film, it loses adhesion and delaminates (flakes) from the substrate. To offset this process, it is common practice to add pigmentary materials having the ability to absorb ultra-violet radiation to paints designed for exterior exposure. Titanium dioxide is an example of such a pigment and it functions by both absorbing the ultra-violet light and reflecting it away from the film, thus protecting the polymer. Invariably with this pigment, back-scatter from pigment particles in lower levels of the film results in a certain amount of polymer degradation and this process releases small amounts of the pigment from the matrix. This reaction, known as ‘chalking’, is exhibited to varying degrees by all types of titanium dioxide but it can be used to provide a degree of self-cleansing within coatings. It is, of course, detrimental to the performance of coloured paints containing titanium since the colour of the film could alter markedly with prolonged exposure. However, by careful selection of pigments, this chalking process can be reduced to a minimum so that, for example, colour changes attributable to this mechanism will not be detectable for a period of several years.

A14.13 Selection of the binder type is also important in determining the susceptibility of the paint film to ultra-violet light degradation. Polymers containing aromatic ring structures are particularly susceptible to ultra-violet degradation since they strongly absorb in the ultra-violet wavelength region of sunlight, that is 290-350 mm. Binders without these structures are inherently more durable although in many instances, other performance aspects may render them unsuitable for use in exterior situations.

Resistance to moisture

A14.14 Moisture also adversely affects paint film durability, particularly when it is present in the form of rain or condensation. Consideration must also be given to moisture levels within concrete and the location and effectiveness of structural drainage systems. The presence of moisture on a substrate during paint application is, generally, detrimental to paint durability since it will usually reduce the adhesion of the coating system. This effect is particularly marked on ferrous metal substrates, where underfilm corrosion processes can be initiated. With porous substrates such as concrete and other cement-based materials, surface moisture, unless present in excess, is generally not detrimental to durability.

A14.15 Condensation of atmospheric water vapour or rainfall onto the surface of freshly applied paints can effect a premature loss of gloss in all types of coating system due to disruption of the surface. Normally however, this would not result in any long term reduction in paint durability.

A14.16 Painting in conditions of high atmospheric humidity, that is greater than 90%, generally increases the drying times of air drying oxidative paint systems. However, the drying process is not entirely suppressed and provided that the film is not damaged mechanically or by prolonged precipitation of rain, snow, frost, etc. whilst in the wet condition, then subsequent durability is not likely to be affected.

Temperature effects

A14.17 The combination of low temperature and high humidity can also present drying problems, especially within the aqueous emulsion paint systems where film formation is due to evaporation of the aqueous phase and coalescence of the resin particles. With many emulsion systems, optimum coalescence will not occur at temperatures below about 5°C and since the film formed is not in a coherent state and will not subsequently become so, then the durability will be abnormally low.

A14.18 Low ambient temperatures can also adversely affect the curing rate of many types of two pack epoxy- and polyurethane-based paint systems and certain of

these coating types will not form films at temperatures below 10°C without the use of additional catalysts. Non-convertible coatings, that is those that dry by solvent evaporation such as those based on chlorinated rubber and vinyl resins, will dry at very low temperatures and, as such, are ideally suited for winter use. However, the drying times of these types of coatings will be increased at any temperatures in stagnant air conditions, since under these circumstances, the solvent released by the coating will tend to blanket the surface and impede the evaporation processes.

A14.19 Tropical and high heat/high humidity conditions can also adversely affect the durability of paint coatings. Exposure to high air temperatures, that is, 50°C or above, can result in a rapid embrittlement of paint films. In convertible systems, this would be due to an acceleration in the cross-linking rate, whereas with non-converting coatings, this could be due to a loss of plasticiser or residual solvent from the film. Furthermore, the expansion and contraction resulting from the temperature cycling of the substrate can induce cracking within brittle paint systems.

A14.20 High atmospheric temperature effects can be reduced by the use of white pigmentation. Typically, surface film temperature of paints with a white pigmentation are half those with a black pigmentation under conditions of summer exposure.

A15. Performance assessment of coatings : test methods

Introduction

A15.1 Standard test methods exist for most of the important properties required by coatings for concrete and masonry, and are detailed in European Standards, Table A4.

Table A4: European Standard identification tests for surface treatment of concrete

Test method	CEN test numbers
Specific weight	prEN 1880-1 prEN 1880-2
Infrared spectrum	prEN 1767
Determination of epoxy equivalent	prEN 1877-1
Determination of amine products	prEN 1877-2
Determination of hydroxyl value	-
Determination of isocyanate content	-
Determination of volatile and non-volatile matter	prEN 1768
Determination of ash by direct calcination	prEN 1879
Thermogravimetric analysis	prEN 1878
Determination of flow time by use of flow cups	-
Determination of viscosity	EN ISO 3219
Surface drying - Ballotini method	prEN 1769
Determination of pot life as a function of temperature	EN ISO 9514

A16. Performance specifications

Introduction

A16.1 It is evident from the previous section that European Standards will have a profound impact on the coatings industry and its clients. There will be standard requirements for surface treatments applied to concrete and, for the first time, coatings used by public bodies will be able to be specified by CEN standards, and CE marking will be used by manufacturers.

CE marking

A16.2 Once the relevant European Standards are published, masonry coatings that are CE marked will be made available by manufacturers. The CE mark will demonstrate that the coating conforms to Community legislation in respect of compliance with the essential requirements of the Construction Products Directive, however it is **not** a quality mark as such. Many manufacturers will undoubtedly undertake product certification to provide extra assurance to users, and it is a requirement that any such labelling must be affixed in such a way that it can be distinguished clearly from the CE mark.

A16.3 The general principles for specification of coatings for concrete and masonry are summarised in the following sections.

General principles of coating specification

A16.4 The general principles of best practice in coating specification for concrete and masonry coatings can be summarised as:

- the substrate must be suitably sound and properly prepared;
- the appropriate coating system must be specified;
- the coating must be applied following manufacturers' recommendations;
- the coating must be applied under suitable weather conditions;
- the coating must be maintained at regular intervals.

A16.5 These general principles of specification will vary in detail depending on whether the surfaces to be painted are fresh or aged/weathered.

New surfaces

A16.6 The performance of coatings applied to new cement-containing substrates, such as concrete, can be influenced by the type of mix, type of admixture, time of cure before painting, ambient conditions and type of surface preparation.

A16.7 Assuming that the quality of the concrete is good, and that it is not excessively porous, then the most important factor is the surface preparation carried out before coating. All dirt, grease, and other contaminants must be removed, and there should be no surface laitance. Surface defects such as blow holes should be made good by filling with a purpose-designed filler. The most important factor determining coating selection then are the service conditions to which the coating will be exposed (see later).

A16.8 The other factors will all influence coating selection and performance to some extent, as summarised below:

- The type of mix is likely to be of little importance.
- The type of admixture may have an effect, especially waterproofing additives, which might adversely affect the adhesion of coatings.
- As with any surface to be coated, the ambient conditions may influence coating selection, and will certainly affect coating application. For example, water-borne coatings are more problematic in adverse weather conditions than equivalent but solvent-borne variants.
- Concrete can be successfully coated once it has reached a minimum of 80 per cent of the design strength.
- Saponifiable coatings, such as those based on oil-containing binder systems, should not be used on new cement-containing substrates, unless the alkalinity is low and the substrate unlikely to become wetted in service.
- Coatings of low permeability should not be used on new substrates of high moisture content because of the risk of blistering. Manufacturers' recommendations must be followed.

Aged/weathered surfaces

A16.9 The most important consideration when painting aged, and especially weathered surfaces, is the condition of the surface, as summarised below:

- Surfaces must be thoroughly cleaned to be free of all loose material.
- Moulds, lichens or algal growths must be removed, and the affected areas treated with an approved masonry biocide.
- Graffiti, or other contaminants, which may affect applied coatings, must be removed or effectively sealed in. Specialist advice may be required.
- Defects such as hollow rendering, large cracks, failed pointing, should be made good using an appropriate filler or mortar mix.
- Efflorescence should be brushed off and the source of dampness identified and rectified. No coating will resist efflorescence.
- Coatings should be specified in accordance with the substrate, especially its moisture content, alkalinity and general condition as noted above. Manufacturers' recommendations must be followed.

Coating specification

A16.10 A key factor in deciding on a coating specification is the service environment to which the coating will be exposed. British Standard BS 6150 identifies four categories of climate; Mild, Moderate, Severe, Very severe, with implications for coating selection.

Classification of climatic factors

A16.11 The four climatic categories identified in BS 6150 can be experienced under both interior and exterior exposure conditions, but it is assumed here that the primary interest for the Overseeing Organisations is the exterior situation. General descriptions of the four categories of climate are given below, together with broad indications of the effect of the climatic conditions on coating specification for exterior concrete and masonry.

Mild: Inland areas (more than 10 km from the coast), non-industrial, and with average rainfall. All types of coatings will afford satisfactory service.

Moderate: Semi-coastal areas (3 km to 10 km inland), non-industrial, with average rainfall. Inland areas (more than 10 km from the coast), urban or light industrial, with mild atmospheric pollution, but not in close proximity to the source of pollution. Most coatings of conventional type are likely to afford satisfactory service.

Severe: Coastal areas subject to salt spray (up to 3 km inland), non-industrial, with average rainfall. Inland industrial areas with significant atmospheric pollution. Areas with high levels of rainfall. Conventional coatings can be used but will have significantly shorter service life than in Moderate conditions. The use of specialist coatings may be required if long service intervals without maintenance are required.

Very severe: Coastal or industrial areas with significant atmospheric pollution. Specialist coatings will be required, supported by expert advice from the manufacturers.

Specification of coatings for exterior cement-based substrates

A16.12 As outlined in the previous sections the development of coatings specifications is dependant on a number of important factors. This complexity makes establishing generic specifications that are applicable to all circumstances of use extremely difficult. General guidance is possible however, and coating selection in a systematic manner depending on the substrate condition (in respect of moisture content) based on best practice guidance given in BS 6150.

A16.13 Assuming that a substrate is sound, and as the moisture regime in the substrate increases, then the options for coating selection reduce, as indeed must the expected time to first maintenance. There are also clearly benefits in ensuring that the substrate is "dry" at the time of coating, since this condition provides the widest range of coating options, some of which have the potential for providing maintenance intervals of 10 years or more.

Specification of impregnation treatments for cement-based substrates

A16.14 The coatings described so far in this review have been film-forming, that is intended to deposit on the surface a layer of appreciable and measurable thickness. There are some products however, that whilst classed as "coatings" protect by absorption into the outermost layer of the substrate where they confer some extra property; strictly these are impregnation treatments rather than coatings, and are dealt with in BD43 and the Specification for Highway Works and related Notes for Guidance clause 1709.

Specification of anti-vandal treatments

A16.15 Consideration of the need for anti-vandal treatments normally arises after an attack has occurred. Special cleaning products are available that are claimed to be effective at removing graffiti from unprotected concrete and masonry surfaces, the cleaning products being purpose designed to suit the porosity of the substrate. Once cleaned, an enhanced level of protection against further spoilage can then be obtained by application of an anti-vandal treatment.

A16.16 Two main types of treatment are used for protection against graffiti, the so-called "permanent" treatments and the "sacrificial" treatments. Permanent treatments seal the surface and form a coherent coating that is not readily penetrated by graffiti in the form of paint or ink. The graffiti can therefore be removed with cleaning agents leaving the protective coating intact; depending on the type and severity of the graffiti a two stage approach to removal may be required, comprising initial cleaning with solvents or detergents and then use of poultices to remove any residual staining within the coating. Sacrificial products are designed to be easily removed by washing taking any graffiti away in the process. Protection must then be restored by application of fresh coating material.

A16.17 Both types of anti-graffiti treatments are normally supplied in an unpigmented (clear) form thereby leaving the appearance of the surface largely unaffected. The service life of anti-vandal treatments will depend on the exact composition, but some treatments are claimed to remain resistant to vandalism for up to 10 years without re-treatment.

A16.18 Application of anti-vandal coatings generally requires no special skills and can be undertaken by professional painters. However, removal of graffiti, especially from large areas, often requires use of aggressive chemicals and processes and is best undertaken by specialist contractors.

A16.19 Many suppliers of anti-vandal treatments can offer detailed advice on specification based on experience developed over many years. This area of coatings technology is extremely specialised, and though the general advice given here outlines the basic principles of specification and use of anti-vandal treatments, detailed recommendations should be sought from manufacturers if use of such products is being considered.

A17. Health and Safety

A17.1 When specifying coatings consideration should be given to the implications of the relevant Health and Safety legislation. Particular attention is drawn to compliance with the Control of Substances Hazardous to Health (COSHH) requirements, and the need to ensure the Health and Safety of operatives, other site staff and third parties such as motorists, and adjacent animal and plant life. This may entail the use of physical protection and barriers, to ensure adequate protection, as well as controlled environmental conditions during coating application. Where work is proceeding in the vicinity of live traffic, special traffic management measures may be necessary. Work adjacent to railway lines or water courses requires prior consultation with the responsible authorities and inclusion of any special requirements in Contract documents to facilitate safe practices.

A18. References

National, European and International Standards

BS 3900 Part G6 - Methods of Test for Paints: Assessment of Resistance to Fungal Growth

BS 6150 - Code of Practice for Painting of Buildings

DIN 52617 - Determination of Water Absorption Coefficient of Construction Materials

prEN 1062 - Paints and Varnishes: Coating Materials and Coating Systems for Exterior Masonry

EN 1062-1 - Classification for Masonry Coatings
prEN 1062-2 - Determination and Classification of Water Vapour Transmission Rate
prEN 1062-3 - Determination and Classification of Liquid Water Transmission Rate
Parts 4, 5, 6,7.8.9,11 - in development

prEN 1504 - Products and Systems for the Protection and Repair of Concrete Structures

prEN 1504-2 Classification System for Surface Treatment of Concrete
ENV 1504-9 - Guidance Note on the Principles of Repair of Concrete
prEN 1504-10 - Site Application of Products and Systems and Quality Control of the Works

prEN 1542 - Products and Systems for the Protection and Repair of Concrete Structures - Test Methods: The Pull-off Test

prEN 1767- Products and Systems for the Protection and Repair of Concrete Structures - Test Methods: Infrared Analysis

prEN 1768 - Products and Systems for the Protection and Repair of Concrete Structures - Test Methods: Determination of Volatile and Non-volatile Matter

prEN 1769 - Products and Systems for the Protection and Repair of Concrete Structures - Test Methods; Surface Drying Test - Ballotini Method

prEN 1877 - Products and Systems for the Protection and Repair of Concrete Structures - Test Methods; Reactive Function Relating to Epoxy Resins

prEN 1877-1 Determination of Epoxy Equivalent
prEN 1877-2 Determination of Amine Function Using the Total Basicity Number

prEN 1878 - Products and Systems for the Protection and Repair of Concrete Structures - Test Methods; Reactive Function Relating to Epoxy Resins; Thermogravimetry of polymers - Temperature Scanning Method

prEN 1879 - Products and Systems for the Protection and Repair of Concrete Structures - Test Methods; Determination of Ash by Direct Calcination

prEN 1880 - Products and Systems for the Protection and Repair of Concrete Structures

prEN 1880-1 - Test Methods: Specific Weight - The Pkyometer Method
prEN 1880-2 - Test Methods: Specific Weight - Immersed Body Method

EN ISO 2812-1 - Paints and Varnishes - Determination of Resistance to Liquids - Part 1: General Methods

EN ISO 3219 - Plastics: Polymers/Resins in Liquid State as Emulsions or Dispersions - Determination of Viscosity Using a Rotational Viscometer with Defined Shear Rate

EN ISO 6772 - Paints and Varnishes Falling-Weight Test

EN ISO 9514 - Paints and Varnishes - Determination of the Pot Life of Liquid Systems - Preparation and Conditioning of Samples and Guidelines for Testing

ISO 7783-1 - Paints and Varnishes - Determination of Water Vapour Transmission Rate - Part 1: Dish Method for Free Films

EN 196-1 - Method of Testing Cement: Determination of Strength

EN 24624 - Paints and Varnishes: Pull-off Test for Adhesion

ISO 11507 - Paints and Varnishes - Exposure of Coatings to Artificial Weathering - Exposure to Fluorescent UV and Water

ISO 11998 - Paints and Varnishes - Determination of Wet Scrub Resistance and Cleanability of Coatings

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K.W.J. Treadaway and H. Davies, Building Research Establishment, Information Paper IP 14/88, “Corrosion-Protected and Corrosion-Resistant Reinforcement in Concrete”, November 1988.

H. Davies and G.W. Rothwell, Building Research Establishment, Information Paper IP 7/89, “The Effectiveness of Surface Coatings in Reducing Carbonation of Reinforced Concrete”, May 1989.

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