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SPECIFICATION & GUIDELINES

FOR

POLYMER-MODIFIED CEMENTITIOUS FLOORING

as wearing surfaces

for industrial and commercial use

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INTRODUCTION

EFNARC was founded in March 1989 by five national trade associations representing producers and applicators of specialist construction products. Membership has since been widened to include major European companies who have no national body or institution to represent their interests. EFNARC provides a common voice for the industry to make known its comments and views to the European Commission, CEN Technical Committees and other groups dealing with European Harmonisation of Specification and Standards. Its Members are active in all European countries.

EFNARC has achieved a fine international reputation for its excellent work in preparing authoritative Specifications and Guidelines firstly for Sprayed Concrete and then for Industrial Flooring. These specifications have become recognised as essential reference documents by specifiers, contractors and material suppliers throughout Europe and beyond, and have formed the basis for new national product standards.

The **EFNARC 'Specification for Synthetic Resin and Polymer-modified Cementitious Floorings for Industrial Use'** was published in November 1997 as a draft for public comment. Since that time many copies of the draft version have been issued and it has also been registered as a formal document by the CEN committee (TC 303) responsible for European standards for flooring. As requested, many users have submitted comments and these have been taken into account in the production of this definitive specification. A major change from the draft stage is that separate specifications have now been produced for Polymer-modified Cementitious and Synthetic Resin Floorings respectively. This recognises that the two types of specialist floorings generally have different end uses.

Another significant change is the removal of requirements for Identification tests. The requirement that manufacturers should operate a formal independently-certified quality control scheme will give the customer assurance of continuity of formulation. Also it is believed that the performance requirements are a better check that the product will give satisfactory service than a series of analytical tests that may not in themselves be conclusive.

Acknowledgements

EFNARC wishes to acknowledge gratefully all the contributions and comments made by users of the draft Flooring Specification published in 1997 and to the subsequent extensive work undertaken by members of its Flooring Technical Committee.

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1 INTRODUCTION

This specification provides minimum standards of performance and methods of installation for Polymer-modified cementitious (PCC) floorings intended to form a wearing surface. These floorings are based on Polymer-modified cementitious systems that cure by hydration of the hydraulic cement component with the added polymer enhancing the properties of the set material.

Concrete wearing surfaces can give satisfactory service under many industrial conditions but become less effective where there are specific requirements of hygiene, cleanliness, chemical resistance, resistance to impact or abrasion. The main advantages of PCC floorings when compared with unmodified concrete wearing surfaces include the following:

a] stronger permanent bond to the substrate
b] improved resistance to some aggressive chemicals
c] increased resistance to absorption of liquids and greases
d] increased toughness, durability, resilience, and resistance to impact or abrasion
e] reduced dusting
f] more hygienic, easily cleaned surfaces
g] greater resistance to cracking
h] lower applied thickness

2 SCOPE

This Specification covers the performance, design and installation of flow-applied or trowel-finished Polymer-modified cementitious floorings (PCC), to be applied in situ as a wearing surface to a direct finished concrete base or fine concrete screed.

Cementitious floorings modified with reactive resins are not included although many of the requirements in this document may be relevant to them.

3 REFERENCED STANDARDS

The following standards are referred to in the specification. However, any subsequently published or revised European Standard (EN) should always take preference over standards referred to herein. The hierarchy of authority is EN standard, ISO standard, National standard.

EN 1008	Mixing water for concrete
EN 1542	Products and systems for the protection and repair of concrete structures - Test methods - Measurement of bond strength by pull-off
EN 1766	Reference concretes for testing
EN 12086	Permeability to water vapour
EN 12504-2	Testing concrete in structures: Determination of rebound number
EN 13036-4	Test method for skid resistance
EN 13454-2	Method of test for screed materials - Determination of consistency
EN 13892:	Methods of test for screed materials
EN 13892-2	Determination of flexural and compressive strength
EN 13892-4	Determination of wear resistance BCA
EN 13892-5	Determination of wear resistance to rolling wheel
EN 13892-8	Determination of bond strength
ISO 178	Determination of elastic modulus in flexure
EN ISO 6272	Determination of impact resistance
BS 8204:	In situ floorings:
BS 8204-1	Code of practice for concrete bases and screeds to receive in situ floorings
BS 8204-2	Code of practice for concrete wearing surfaces

Note: Some of these standards may be in preparation and only available as prEN versions.

4 DEFINITIONS

4.1 Mix components

4.1.1 Admixture
Material added in small quantity during a mixing process to modify the properties of a cementitious screed material in the fresh and/or hardened state.

4.1.2 Pigment
Finely dispersed insoluble solid material that provides colour and opacity to the flooring products and systems.

4.1.3 Primer or Bonding agent
A liquid product applied to a substrate, either subfloor or base, prior to the application of the final flooring, to seal and consolidate the surface of a porous substrate and aid adhesion of the final flooring.

4.1.4 Synthetic resin
A reactive organic polymer binder for a flooring system comprising one or more components that react at ambient temperature.

4.2 Construction components

4.2.1 Curing compound
Product applied to a newly laid concrete surface to reduce loss of moisture by evaporation.

4.2.2 Insulation material
Material placed within a floor structure to provide either acoustic and/or thermal insulation.

4.2.3 Reinforcement
Bars, wires, meshes or fibres added to screeds.

4.3 Construction

4.3.1 Base
Building element which provides the support for a screed and any other flooring system.

4.3.2 Screed
Layer of material or materials laid in situ, directly onto a base, bonded or unbonded, or onto an intermediate layer or insulation layer, to achieve one or more of the following purposes.
- to obtain a defined level.
- to carry the final flooring.
- to provide a wearing surface.

4.3.3 Flooring
Uppermost layer of a floor that is designed to provide a wearing surface: this layer may consist of a product or system of products.

4.3.4 Bay
Area of screed or flooring bounded by joints or free edges.

4.3.5 Channel
Longitudinal recess in the floor surface designed to collect liquid flowing over the surface and direct it to the drains.

4.3.6 Day-work joint/ Construction joint
Joint incorporated where work is interrupted either by design or accident so that subsequent work will provide discontinuity in the surface.

4.3.7 Joint
Formed discontinuity in either the whole or a part of the thickness of a screed or other building element.

4.3.8 Movement joint
Joint between building elements or screed bays which can absorb dimensional changes or movements.

4.3.9 Perimeter isolating joint
Isolating strip placed between a screed and vertical elements of the building.

4.3.10 Skirting
Continuation of the floor surface up the lower part of a vertical wall, kerb or plinth, generally coved.

4.3.11 Wearing surface
Upper surface of a screed designed to be used as a final floor.

4.3.12 Core
Cylindrical specimen cut from a hardened screed.

4.4 Product

4.4.1 Bonded screed
Screed which is bonded to the base.

4.4.2 Cementitious screed
Screed where the binder is a hydraulic cement.

4.4.3 Damp-proof membrane
Layer or layers in a floor to resist the passage of moisture.

4.4.5 Flowing screed
Highly fluid screed composition with self-smoothing (or self-levelling) properties.

4.4.6 Levelling screed
Screed applied to compensate for unevenness in the base or to accommodate pipes or provide a defined slope.

4.4.7 Monolithic screed
Cementitious screed laid onto the still plastic surface of a fresh concrete base.

4.4.8 Polymer-modified cementitious screed (PCC - Polymer cement concrete)
Screed where the binder is a hydraulic cement and which is modified by the addition of polymer dispersion or re-dispersible powder polymer with a minimum content of dry polymer of 1% by mass of the total composition, excluding aggregate particles larger than 5 mm.

4.4.9 Reinforced screed
Screed containing reinforcement.

4.4.10 Sealer
A liquid product applied to the surface of a flooring product to seal any porosity and generally to enhance the chemical resistance, aesthetic appearance and/or reduce dusting of the flooring.

4.4.11 Synthetic resin flooring
Mixture of synthetic resin, aggregates and pigments that hardens on curing by means of chemical reaction but excluding oxidative drying. (PC - Polymer concrete)

4.4.12 Synthetic resin screed
Screed where the binder consists of synthetic resins.

4.4.13 Synthetic resin coating
Fluid synthetic resin based composition that can be applied as a thin layer to a concrete or other substrate, which then sets to provide a coherent wearing surface.

4.5 Properties

4.5.1 Working life
The time following mixing during which the flooring material can be applied and finished without detrimental effect on its properties such as adhesion, compaction and surface finish.

4.5.2 Abrasion resistance
Resistance to wear by mechanical action of a flooring surface.

4.5.3 Chemical resistance
The capacity of the flooring surface to withstand exposure to chemicals without significant change to its service characteristics.

4.5.4 Consistency
A measure of fluidity of fresh screed or flooring material that characterises its ease of use.

4.5.5 Crazing
Network of irregularly shaped micro-cracks formed on the surface of a flooring.

4.5.6 Electrical resistivity
A measure of the ability of the flooring system to conduct electricity.

4.5.7 Identification test
Procedure to characterise a product in order to check its compliance with a reference sample batch used for initial type testing or customer acceptance test.

4.5.8 Levelness
Conformity of the surface of a flooring layer to a fixed datum plane within allowable tolerance.

4.5.9 Performance
Ability of a flooring product or system to provide a durable floor with effective service characteristics.

4.5.10 Performance requirements
Required mechanical, physical and chemical properties of a flooring product and systems

4.5.11 Porosity
Ratio between the volume of pores within a material to the total volume.

4.5.12 Pull-off strength
The tensile force per unit area which has to be applied perpendicularly and centrally to the surface of a bonded screed or flooring in order to cause failure.

4.5.13 Self-levelling
Capacity of fresh screed or flooring material to spread out unaided to form a flat horizontal surface.

4.5.14 Self-smoothing
Capacity of fresh screed or flooring material to form a smooth surface unaided.

4.5.15 Surface hardness
Resistance of the surface of a screed or flooring to indentation by a loaded steel device.

4.5.16 Surface regularity
A measure of the flatness of the floor surface.

4.5.17 Time before service
The period required to attain sufficient mechanical strength to withstand the exposure characteristic of the intended use.

4.6 Process

4.6.1 Bonding/Priming layer
Layer which improves the adhesion of a screed or flooring to the base.

4.6.2 Compaction
Manual or mechanical treatment of freshly spread screed material which increases its density.

4.6.3 Datum level
Reference level for fixing the height of building elements.

4.6.4 Direct finish base slab
Base slab that is suitably finished to receive the flooring to be applied directly without the need for a levelling screed.

4.6.5 Grinding
Mechanical treatment of a surface using rotary abrasive action to provide a texture or to eliminate irregularities.

4.6.6 Screed laid to fall
Screed laid to provide a defined slope to promote drainage.

4.6.7 Surface dressing
A scatter of fine aggregate or other particulate material spread evenly into the surface of a synthetic resin flooring while it is still mobile.

4.6.8 Trowelling
Finishing and smoothing the surface of the fresh screed, using a trowelling tool operated manually or mechanically.

4.6.9 Underfloor heating
Heating system incorporated in a floor.

5 PRODUCT REQUIREMENTS

5.1 Performance requirements

General and Special requirements are summarised in Table 1. The requirements shall be based on tests undertaken at laboratory conditions of 21±2°C and 60±10% R_H. Unless otherwise stated, all results are for 28 days cure.

Table 1: Performance requirements

Classification for intended use*	Performance characteristic	Specified test method	Requirement
A	Compressive strength	EN 13892-2	**≥ C20**
A	Flexural strength	EN 13892-2	**≥ F5**
A	Abrasion resistance	EN 13892-4 (BCA) or EN 13892-5 (Rolling wheel)	AR 2, or better RWA 10, or better
A	Pull off strength to the substrate	EN 1542, using reference concrete to EN 1766 as substrate (nature of failure to be reported).	**≥ 1.0 MPa**
A	Impact resistance	ISO 6272 (when bonded to a concrete surface in accordance with EN 13892-1)	**≥ 4 Nm**
B	Consistency (for pumpable mixes)	EN 13454-2 or EN 12706	**≥ 220 mm** **≥ 130 mm**
B	Resistance to slipping (wet)	Pendulum Slip resistance tester to EN 13036-4	**≥ 40, when tested wet** (see section 8.2 for detailed requirement)
B	Permeability to water vapour	EN 12086	**≤ 4 g/(m^2**.d)

* Classification for intended use:

A Mandatory requirement for all intended uses - standard test method and performance limits are specified.

B Special requirement for particular situations - standard test method is specified and performance limits are to be met or the result declared on request.

5.2 Declaration of Conformity

5.2.1 Testing

Initial type testing shall be carried out by the manufacturer to prove the conformity of each product, covered by this specification, with the requirements of Table 1.

5.2.2 Quality control system (or Factory production control system)

The manufacturer shall operate a quality control system in accordance with the principles of EN ISO 9000 at each facility where products covered by this specification are produced.

Compliance with this requirement should preferably be verified by an approved certification body which shall issue a certificate to each production facility where procedures have been verified.

After initial certification, an audit of each production facility shall be carried out by the approved certification body not less than once per year. If any non-compliance with the requirements of EN ISO 9000 is found, the certification body shall either:

(i) require correction of non-compliance within a stated time which, if not carried out, shall result in withdrawal of the certificate, or
(ii) immediately withdraw the certificate, if correction is not possible.

5.2.3 Declaration of Conformity by the Manufacturer

Provided the requirements of **5.2.1** and **5.2.2** have been fulfilled, a declaration of conformity with this specification shall be made available by the manufacturer for each product or system which satisfies the appropriate requirements in this specification.

A new declaration of conformity shall be provided following any change in formulation or in constituent materials which results in a change of the characteristics of the product.

The time between repeat conformity tests shall be not more than 3 years.

5.2.4 Declaration of Conformity by the Contractor

The Contractor shall make available a declaration of conformity that all work will be undertaken to a quality plan and the flooring will be installed by trained operatives in accordance with this specification.

6 EXCHANGE OF INFORMATION AND TIME SCHEDULE

6.1 General

Consultations and exchange of information between all parties concerned with the building operations should be arranged so that each has full knowledge of the particulars of the flooring work and be able to co-operate in producing the conditions required to complete a satisfactory installation.

Some of the items listed in 6.3, 6.4 and 6.5 may need additional precautions or procedures: responsibility for these should be determined in advance of the work.

6.2 Selection of flooring to be applied

It is essential that, in the design and construction stages, there should be full consultation with all interested parties to ensure that the product to be selected is entirely suited for the conditions both during application and in subsequent service. Consideration should therefore be given to whichever of the following are applicable:

a) intended use of the flooring including the type, extent and frequency of trafficking;
b) type of loading, static or dynamic, and severity of impact;
c) details of any chemicals, including those used for cleaning or sterilising, which could come into contact with the floor, and extent, frequency and temperature of spillage;
d) temperatures that the flooring is required to withstand in normal service or as part of the cleaning operations and whether exposure is by radiant or conductive heat or by direct contact;
e) colour, uniformity and retention, aesthetics and decorative effects
f) extent to which the flooring will be exposed to direct sunlight or ultra-violet light;
g) compliance with hygiene or food industry requirements;

h) special requirements, such as slip resistance or anti-static characteristics;
i) expected life of the flooring;
j) thickness of flooring to be installed;
k) time available for the application and curing of the flooring;
l) age, specification where known and nature of the base, including information about any previous use of the floor which could affect adhesion, and any preparatory treatment required;
m) health & safety and environmental issues during application and in service.

6.3 Information to be provided to the flooring contractor

All relevant information should be provided in good time to those responsible for installing the flooring and to others whose work could be affected, including whichever of the following are applicable:

a) description, situation and address of site and means of access;
b) those conditions of contract which could practically affect this particular work;
c) location and area of flooring to be installed;
d) finished floor level, falls and maximum permissible departure from datum in each location;
e) class of surface regularity of the finished flooring;
f) type of damp-proofing and insulation if present;
g) type and thickness of any levelling screed proposed, and whether any curing compound is to be applied;
h) type of finish of concrete base or screed;
i) any work consequent upon services passing through the floor;
j) treatment of joints;
k) treatment of channels;
l) treatment of skirtings and kerbs;
m) treatment of junctions with adjacent floorings and doorway thresholds;
n) any special requirements related to underfloor heating;
o) the timing of the introduction of heating in the building;
p) date for the completion of the concrete base or screed to receive the flooring;
q) dates for the start and completion of various sections of the floor;
r) details of any compliance testing required;
s) any potential restrictions on working hours;
t) any limitations on installation due to production or other activities.

6.4 Information to be provided by the flooring contractor

The flooring contractor should provide in good time to those responsible for the building, details of the conditions needed for the installation of the flooring, including whichever of the following are applicable:

a) the extent of weatherproof areas to be provided for storage of raw materials and mixing of the flooring product and whether any temperature control is necessary;
b) ambient temperature requirements in the area where the flooring is to be installed;
c) power and lighting requirements to facilitate the laying operation;
d) protective screening to isolate the working area from adjacent facilities;
e) minimum time intervals after the flooring is installed before allowing foot traffic, vehicular traffic and water or chemical exposure respectively;
f) extent and type of surface preparation necessary.
g) protection necessary for the flooring between installation and final handover.

6.5 Time schedule

Allowances should be made for the following:
a) curing and drying of the concrete base or screed, and/or polymer-modified cementitious levelling screed, when applicable;
b) time between commencement and completion of work;
c) period necessary for curing and protection of the completed flooring from damage by other trades, including restriction of access.

7 MATERIALS

Polymer-modified cementitious flooring systems are generally supplied pre-packed, either in one or two pack form:

a) *Two-pack* in which one pack, consisting mainly of a dry blend of cement, graded aggregates and other constituents, is mixed with the second pack containing the correct dosage of polymer dispersion. In some cases the second pack contains sufficient liquid to mix with the dry component, otherwise the second pack has to be diluted with a specified quantity of water.

b) *One-pack* consisting mainly of cement, dried fine and coarse aggregates, powdered polymer in re-dispersible form and other constituents, which is mixed with a specified quantity of water on site.

In either case the coarser aggregate may be supplied dry in an additional separate pack. For both types the use of part packs is not permitted because of the consequent difficulties of ensuring uniform composition and performance.

Each type of pre-packed material shall be used in accordance with the manufacturer's instructions.

Site batching may be acceptable, providing the constituents are of known quality and performance and that site quality control is operated by the Contractor in full accordance with **5.2.**

All water used for mixing the flooring shall be of potable quality or shall comply with the requirements of EN1008 or be from a supply which has been shown by tests to be of suitable quality.

8 DESIGN

8.1 Selection Parameters

Factors influencing the selection of a flooring system should include amongst others:

type and degree of traffic
temperatures to which flooring will be exposed
nature and duration of any chemical contact with the floor
texture of surface expected
wet or dry service conditions
slip resistance requirements
colour and appearance
ease of cleaning (including hygiene requirements)
site conditions at time of laying
cost

The most appropriate flooring for any situation will depend upon the particular conditions to which it will be subjected, and the choice should be made in discussions between all the interested parties, including client, designer, contractor and supplier. It is not possible to provide a simple guide as to where to use different flooring types, since so many parameters can affect the decision for a particular situation.

8.2 Surface smoothness and slip resistance

The flooring shall be finished in a manner that produces reasonable slip resistance appropriate for the circumstances of use.

As a general rule, the smoother and less porous a floor surface, the easier it is to keep clean. However, whilst these specialist floorings can be formulated to produce smooth, non-porous surfaces with excellent slip resistance under dry conditions, the surface may have to be textured if it is to have adequate slip resistance under wet conditions. Such texturing can be achieved by selective grading of the larger aggregate particles in the flooring composition, or by a surface scatter of special polish-resistant aggregate into the surface of the flooring composition whilst it is still mobile.

The heavier the likely build up of contaminants, the coarser the surface texture has to be to retain the required level of slip resistance. However coarse textured surfaces are more difficult to clean, so where both slip resistance and ease of cleaning are important, a compromise must be made. Flooring should be selected with sufficient texture to suit specific working conditions and hygiene standards, and the frequency and type of cleaning must be organised to retain these properties.

In areas where the floor will be frequently wet during service, the slip resistance value (SRV) of the flooring should preferably be not less than 40 in the wet state, except for situations where ease of cleaning is more critical than slip resistance and/or where all who use or are likely to use the floor will wear specially provided slip resistant boots or shoes. In these circumstances, a slip resistance value in the wet of not less than 33 may be deemed acceptable.

8.3 Chemical resistance

Polymer-modified cementitious floorings will ultimately, that is on prolonged exposure, have similar chemical resistance to an unmodified concrete wearing surface. However in practice their lower permeability and absorption will mean that the rate of attack by many chemicals will be effectively retarded and such floorings can give good service provided they are washed down regularly to remove any spillages. In addition they are very effective where there is contamination by oils and greases which do not soak into the surface as they would with conventional concrete.

8.4 Temperature resistance

Polymer-modified cementitious floorings generally have excellent heat resistance under normal service conditions, and may be cleaned with steam lance or hot water systems without any problems of softening or debonding. The thermal expansion characteristics of such systems are very similar to those of the base concrete so the bond should be little affected by differential stresses.

8.5 Taint

Correctly formulated and fully cured Polymer-modified cementitious floorings should be entirely satisfactory for use in the proximity of all food stuffs. The critical period for tainting is during the application of the floorings and in general all food stuffs should be removed from the area where the flooring is to be laid and care taken that air from such areas is not vented towards storage or working areas where food may be present.

8.6 Curing time

The final floor system shall be allowed to cure according to the manufacturer's instructions. These generally require 1-3 days at 15 - 20°C before allowing significant use by traffic and 3 to 7 days at 15 - 20°C before allowing contact with chemicals or sterilising agents. Adequate curing should always be allowed before wet testing the flooring for drainage or ponding.

At site temperatures below 10°C cure times will be substantially increased unless some form of external heating is used.

8.7 Damp proof membranes

8.7.1 New construction

In new buildings a damp proof membrane may be incorporated within the base design, where ground supported. The membrane is then preferably installed directly below the base. In some fast-track construction an additional membrane may be bonded to the top of the concrete base, to prevent subsequent operations from being affected by water remaining in the base.

8.7.2 Existing buildings

In existing buildings, the absence of a functioning damp proof membrane would not necessarily lead to problems unless there is suspicion of rising dampness, when the following may need to be considered:

a) installation of a sheet membrane followed by the polymer-modified cementitious screed, which will inevitably be unbonded. In this case the flooring manufacturer's recommendations for minimum screed thickness should be carefully followed. The minimum thickness needs to be specified taking account of the service use of the floor.

b) surface-applied membrane: a liquid applied resin system can act as both membrane and then primer for the polymer-modified cementitious screed. Generally two coats of the resin system would be necessary to assure a complete membrane. In all cases the compatibility of membrane and flooring material must be first established.

c) Hydrostatic pressure may, under certain circumstances, cause adhesion failure between the flooring and the substrate. Where this is likely to occur, such as in areas where the ground water table is higher than the substrate, and where external tanking has not been applied, pressure relief must be provided, eg by directed drainage.

8.8 Tolerances

8.8.1 General

The agreed standards for flatness and regularity should preferably be produced in the base concrete or levelling screed as far as possible. When upgrading existing floors, the means of obtaining the required levels and flatness need to be agreed in advance. This is particularly important where the polymer-modified cementitious flooring is to be applied thinly.

8.8.2 Tolerance to datum plane

The designer should specify the maximum permissible departure of the level of the wearing surface from an agreed or specified datum plane, taking into account the area of the floor and its end use. For normal purposes a departure of ± 15 mm from datum will be found to be satisfactory. Greater accuracy to datum could be required along the line of partition walls, in the vicinity of door openings and, where specialised equipment is to be installed directly on the floor.

The datum plane for the majority of floors will be horizontal but, on occasions, sloping. In the latter case, departure from datum should be measured from the sloping plane.

8.8.3 Surface regularity

The class or category of surface regularity required for a floor surface will depend upon the use of the floor. Insistence on a higher tolerance than needed for the operating conditions will result in unnecessary higher costs and this should be borne in mind in selecting a surface regularity standard.

The straightedge method given in BS8204: Part 1 is generally satisfactory for the majority of floor uses and, where appropriate, the designer should specify one of the classes of local surface regularity given in Table 2. Alternatively the method of DIN 18 202 may be used.

Table 2: Classification of surface regularity for wearing surfaces of normal and high standard flooring

Class	Maximum permissible departure from a 3 m straightedge in contact with the floor	Application
SR1	3 mm	High standard: special floors
SR2	5 mm	Normal standard: normal use in commercial and industrial buildings
SR3	10 mm	Utility standard: other floors where surface regularity is less critical

Where the floor is to be used frequently under wet conditions, a high class of surface regularity may be necessary to minimise ponding.

Where the straightedge method of specification is used it will be necessary for the various interested parties in a contract to agree the sampling rate for testing the floor to check conformity, before the floor is constructed.

The simple straightedge method of specifying floor surface regularity is only suitable for floors finished by conventional finishing techniques that will produce a smoothly undulating surface rather than an irregular 'washboard' finish.

Where a very high degree of accuracy is required, e.g. for high level racking or television studios, specialist test equipment should be used to govern the level of the floor as it is laid and to check its conformity.

The difference in height across any joints in the finished flooring should be less than 1 mm.

Testing to check surface regularity and level conformity should be made within 24 h of the first area of flooring being laid to establish at an early stage that the method of laying can meet the specification requirement. Surface regularity and level testing should not be left to be checked until all the flooring is completed.

8.9 Falls

A floor, particularly one with a coarse surface texture, will not drain water satisfactorily unless sufficient falls are introduced. A minimum slope of 1.5% should be specified to produce a free draining floor. However, slopes greater than this may lead to problems of slumping if the eventual finish is to be flow-applied.

8.10 Joints

The number of joints designed into the floor should be kept to a minimum consistent with stability in order to maintain the seamless nature of the surface which will then be easy to maintain.

The spacing of movement joints must be determined by the design of the subfloor. All movement joints in the subfloor must be carried through the flooring. In areas where regular trucking occurs it is desirable to reinforce the screed edges at the movement joints: stainless steel or other suitable metal angles may be used or prefabricated joints suitable for this purpose. Alternative methods for forming such joints are shown in **Figure 1**.

In all instances the necessity for movement joints and their type and positioning should be agreed at the design stage between all parties concerned.

8.11 Perimeter design

Where the new flooring has to finish level with an existing floor or around the outside perimeter of the area, feather edges must be avoided. This reduces the risk of early mechanical wear at the edge or of seepage of liquids under the flooring. This can be achieved by forming or cutting a groove in the surface of the concrete floor into which the flooring is then applied.

For heavy traffic this groove should be to a minimum specification of twice the thickness of the screed in depth and two to four times the thickness of the screed in width, e.g. for a screed of thickness 12 mm, the joint cross-section should be 25 mm deep and 25 to 50 mm wide.

8.12 Channels

Channels are normally incorporated in floor systems to carry liquids such as spillages and washing water to suitable drains. By the very nature of their purpose and design they may be subject to more stringent and diverse chemical duty than the individual floor areas from which they receive their contents. The channels must be formed with sufficient slope to ensure complete and rapid flow of any discharge to the drains.

Channel design detail can take a variety of forms and in new installations should be designed in conjunction with the specialist contractor. Frequently a preformed stainless steel channel is inset into the underlying concrete. These are inherently flexible, but should have a formed joint between the flooring and the channel to accommodate vehicular traffic or thermal shock.

Typical joint details

Figure 1: Movement joint

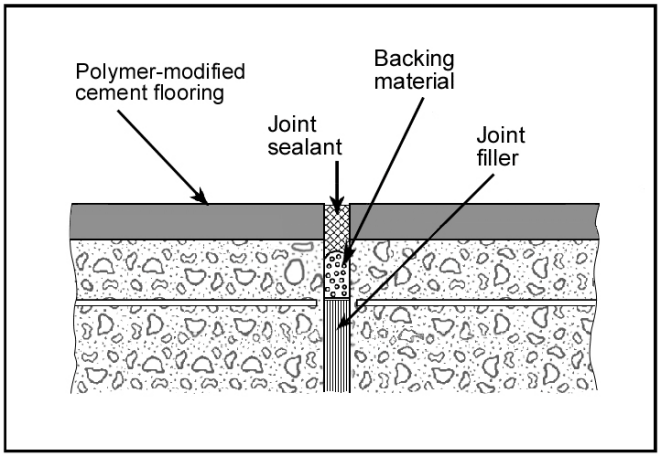


Figure 2: Perimeter / Threshold detail

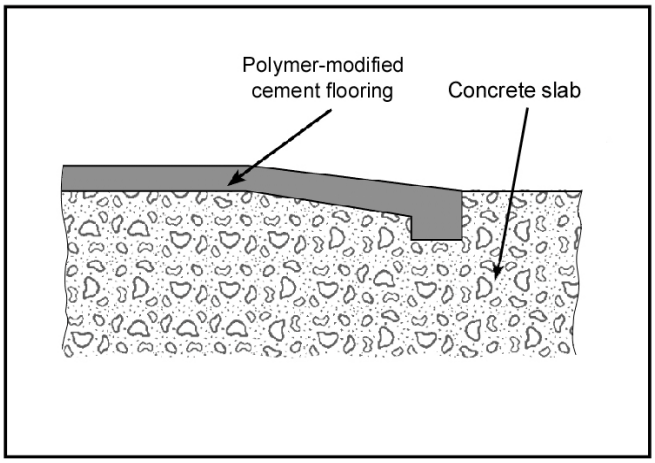
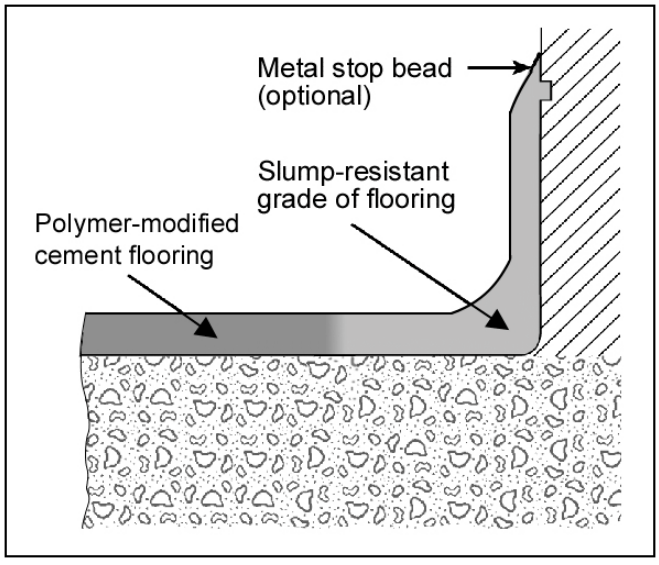


Figure 3: Skirting detail



8.13 Skirtings

Where the floor is to be washed regularly or where chemical attack is possible it is essential that the flooring is correctly terminated at perimeters, upstands, columns, etc, to prevent ingress of liquid. Frequently a cove is formed using the flooring material: generally with a thixotropic or fine aggregate version which is finished preferably in a single operation.

Where no movement joint is necessary, a simple vertical extension of the flooring may be applied.

Simple skirting details may be extended to related situations such as kerbs or plinths.

8.14 Service penetrations

Although not desirable, in some circumstances services may be required to pass through the flooring surface. A suitable method of achieving this is to install a sleeve through the concrete slab, which permits the services to pass through without direct contact with the floor screed. This is particularly important if the services include pipes carrying liquid at temperatures other than ambient. The sleeve also acts as an upstand to prevent liquids flowing down through the floor.

8.15 Stairs

Flooring to the treads can be formed from the normal grade of flooring material. For the risers special thixotropic grades or renders derived from the flooring products may be necessary. The structural concrete should have been formed to the precise profile of the stairs less the thickness of the flooring. Before commencing application of the flooring the surfaces of the treads and risers should be prepared as described in **9.2** for new bases or in **9.3** for old bases.

9 PREPARATION OF CONCRETE BASES AND FINE CONCRETE SCREEDS

9.1 General

Because of the wide variety of types of product available commercially, this specification can only provide the basic principles which should govern the necessary preparatory work. It is imperative therefore that the flooring manufacturer's instructions are followed precisely.

From the point of view of structural design of the substrate, whether it is slab or screed, the main function of the flooring is to provide a wearing surface. The substrate should therefore be designed independently of the flooring to withstand all structural, thermal and mechanical stresses and loads that will occur during service. It should remain stable whilst protected by the flooring and be provided with all necessary expansion, contraction and crack inducement joints to enable it to do so. Failure of the substrate to remain stable will invariably affect stability of the finish. In particular, cracking of the substrate, however caused, is likely to reflect in the finish.

The surface strength of the base concrete or fine concrete needs to be sufficient to restrain any stresses that occur during the setting and hardening of the Polymer-modified cementitious flooring.

The surface tensile strength of the base concrete or fine concrete screed should be determined by the method given in prEN1542 and should normally exceed 1.0 MPa. Where the mean surface tensile strength is less than 1.0 MPa, specialist advice should be sought.

Alternatively the surface strength of the base or screed may be assessed using a rebound hammer (Schmidt) in accordance with EN 12504-2. This method has the benefit of allowing a more rapid evaluation of large areas with a greater number of point tests than the pull-off method. The rebound hammer readings should generally be above 25, but a lower reading may be acceptable if the surface tensile strength of the base concrete or fine concrete screed exceeds 1.0 MPa.

Assessment of the hardness or strength of a concrete base surface with a rebound hammer should only be made at locations having a smooth and clean surface. If a concrete surface has been mechanically roughened as preliminary to bonding the flooring, any test area should be smoothed by grinding before testing.

9.2 New concrete bases and fine concrete screeds

A direct finished base slab, or fine concrete screed, should be designed and constructed as described in BS 8204-1 and laid to falls as necessary. The concrete should not contain a water repellent admixture. All services should be confined within the base concrete or screed and not allowed to penetrate into the flooring. The substrate needs to be finished with a strong even surface and should incorporate such falls as necessary.

In order to achieve sufficient tensile strength in the surface of the base concrete, it should preferably be designed to have a minimum characteristic compressive strength of 30 MPa, and adequate workability to allow full compaction.

Unmodified cement : sand screeds are unsuitable to receive Polymer-modified cementitious floorings because of low tensile strength, but a polymer-modified cement:sand screed or fine concrete may be acceptable subject to the approval of the product supplier.

Care should be taken that during the hardening and curing of the base slab or screed it does not suffer mechanical damage or become contaminated with grease, oil etc. If such problems do arise the slab or screed should be treated as for old bases (see **9.3**).

The concrete and laying technique used should achieve the surface strengths given in **9.1** before the flooring is laid. Unless otherwise specified by the manufacturer the base should be at least 28 days old.

The surface regularity of the base should be such as to match the requirement for the final flooring, unless the intended thickness of the polymer-modified cementitious screed can compensate.

Surface preparation is a most vital aspect of all flooring application. The quality and condition of the interface between the substrate and the flooring determine its ability to transfer loads imposed by use. Failure to transfer loads adequately results in loss of adhesion and hollowness.

The laitance on in-situ bases and any surface sealer or non-bonded curing compound should be entirely removed by suitable mechanised equipment, e.g. shot-blasting, scarifying, scabbling or high pressure water jetting to expose cleanly the coarse aggregate. High intensity scabbling is not normally recommended as it may cause micro-cracking and so weaken the underlying substrate. For the thinner floorings, light contained shot-blasting is generally preferred.

The surfaces of precast units should be left as cast and should be thoroughly prepared to remove all adhering dirt and laitance. The use of contained abrasive blasting equipment is more suitable than mechanical scabbling which could damage the precast units.

After surface preparation all loose debris and dirt should be removed by vacuum equipment. The preparation operations should be delayed until shortly before the flooring is to be laid to avoid the risk of fresh contamination or further accumulation of dirt.

9.3 Old concrete bases

All surface contamination, e.g. oil, rubber and flaking paint, should be removed and adequate mechanical preparation carried out to achieve a sound and stable surface with exposed coarse aggregate.

When dealing with heavily compacted oil or grease deposits, the bulk of the contamination should first be removed mechanically. A liberal application of a degreasing solvent should then be thoroughly scrubbed into the surface by the use of a mechanical scrubber. Sufficient time should be allowed for penetration followed by thorough washing with clean water before wet vacuum cleaning the entire surface. If necessary these procedures will need to be repeated until the substrate is clean.

Alternatively a more rapid method which may be used in some situations is high temperature burning, often known as HCA (hot compressed air) followed by the immediate application of a penetrating primer.

Where oil or grease contamination has been severe or of long duration none of these methods may prove satisfactory in preparing the base to allow full bonding of the flooring. In such cases removal of

the affected base would be necessary followed by reinstatement with new concrete or polymer-modified cement : sand screed.

Existing floor paints should preferably be removed by mechanical abrasion or contained shot blasting. If this is not feasible because of other restrictions on noise, vibration, etc, chemical paint strippers may be used. However their use requires particular care because of the risk of leaving residues on the surface or within the pores of the concrete base or screed. When all existing coatings have been chemically removed the entire surface must be thoroughly rinsed with clean water. All use of chemical strippers shall comply with local environmental regulations.

When clear of all surface contamination, the concrete should be prepared to remove all laitance and expose a fresh surface. This can be achieved with suitable mechanised equipment, e.g. shot-blasting, planing, grinding, to expose the coarse aggregate cleanly. Care should be taken to ensure that high intensity mechanical treatment does not cause micro-cracking to weaken the underlying substrate. For the thinner floorings, light contained shot-blasting or diamond grinding is preferred so that the profile does not reflect in the finish.

After surface preparation all loose debris and dirt should be removed by vacuum equipment. Very fine dust may need to be removed by detergent washing. The preparation work should be delayed until shortly before the flooring is to be laid to avoid the risk of fresh contamination or further accumulation of dirt.

Prior to applying the flooring a close visual examination should be made to verify cleanliness, soundness of the surface and freedom from soft deleterious materials such as lignite and iron pyrites. Any weak or suspect earlier patching should be removed.

When the base is dust free and reasonably dry, a water droplet test is useful to check that any water repellence has been removed and to assess porosity. The procedure is as follows: a droplet of water from a laboratory wash bottle or syringe is applied to the floor from a height of about 10 mm. If the droplet remains intact and does not spread laterally or soak into the concrete within a few minutes, this indicates that materials might be present that could reduce the bond of the flooring. In this case, further floor preparation would be necessary to remove the residual contamination. Very densely trowelled high quality concrete bases can be highly impermeable to water penetration and give a similar effect to the presence of water repellents, etc. Where difficulties in bonding the flooring are anticipated special advice on bonding methods could be necessary. Alternatively a trial area should be applied, allowed to cure and the degree of bond assessed by the method of EN 1542.

9.4 Other substrates

Comparable procedures are available for other substrates and the flooring manufacturer's instructions shall be strictly followed.

10 WORK ON SITE

10.1 General

Because of the wide variety of types of product available commercially, this specification can only provide the basic principles that should govern the site application procedures. It is imperative therefore that the manufacturer’s instructions are studied in advance of the work starting, since particular recommendations or restrictions may influence the overall programme, and are then followed precisely.

10.2 Materials storage

Storage should be arranged so that consignments can be used in the order of their delivery dates. It is important that labels do not become detached from their containers.

10.2.1 Powder components and aggregates (including any pigments)

Bags of product components should be kept dry and stored preferably in a weatherproof building. If the floor is concrete, the bags should be stacked on timber pallets away from walls.

10.2.2 Liquid components

The containers of polymer dispersions should be stored in a weatherproof building, unless the Manufacturer has stipulated other storage conditions for the stated shelf life. The polymer dispersions must be protected from frost at all times.

10.3 Batching

All materials should be accurately proportioned and mixed in the correct sequence in accordance with the manufacturers recommendations. It is usual to mix the liquid components thoroughly together before blending in the powder components and aggregates.

The usable life of the mixed materials depends upon the temperature of the mixed materials. Manufacturers' literature should give an indication of the working life of the properly mixed product at one or more temperatures. As a rough guide, a 10°C rise in temperature may halve the working life and a 10°C fall may double the working life. It is essential to ensure that the product has been designed to be used in the expected ambient temperature range.

If the mixing area is not adjacent to the laying area, allowance should be made for the time taken to transport the mixed material, so that there is sufficient time for the product to be installed within its stated working life.

10.4 Mixing

10.4.1 Bonding agents or primers

The bonding agent or primer may be a two pack formulation supplied in pre-weighed quantities ready for site mixing, or alternatively a polymer dispersion used either alone or after dilution with water.

A two component formulation should be thoroughly mixed mechanically to form a homogenous mix. The two components should be mixed preferably using a slow speed (200-500 rpm) drill fitted with a mixing paddle, taking care not to entrain excessive air in the mix.

It is important to ensure that any material adhering to the sides and bottom of the mixing vessel is always thoroughly mixed in. It is good practice to transfer the mixed material into a clean container and stir well before application. This procedure prevents the use of partially mixed material.

With synthetic resin primers, it may be beneficial to apply a scatter of fine dry aggregate over the liquid primer, but avoiding localised saturation, in order to provide a key for adhesion of the flooring and to reduce slippage under the trowel.

10.4.2 Flooring mix (including trowel-applied mixes and self-smoothing mixes)

All mixes should be mixed mechanically. Forced action mixers of the rotating pan, paddle or trough type shall be used for all flow applied and trowel applied screeds. Free fall mixers are not recommended because there is insufficient shear action to disperse all the dry materials.

The liquid components are first thoroughly mixed together and then the powders and/or aggregates are added gradually whilst continually stirring. After all the powders and/or aggregates have been added, sufficient mixing time (typically 3-4 minutes) must be given to ensure thorough 'wetting' out of all the powders and/or aggregates by the binder. Excessively vigorous mixing shall be avoided as this can lead to undesirable air entrainment. Care should be taken to ensure that any material adhering to the sides, bottom and corners of the mixer is thoroughly blended in.

Continuous mixer-pumps may be used for pumpable or flowing cementitious mixes. The water flow rate must then be regulated in accordance with the capacity of the machine and the consistency of the mixed material shall be checked at frequent intervals to confirm the proportions are correct.

10.5 Laying polymer modified cementitious flooring

10.5.1 Priming/Bonding

When using a blend of polymer dispersion and cement as a bonding agent, concrete bases should be thoroughly wetted with clean water several hours before applying the bonding agent. Excess water should be removed by vacuum, taking care to remove all of the water from depressions such as produced by scabbling. The surface should be free of glistening water when the bonding agent is applied.

Mixes of polymer dispersion and cement should be scrubbed vigorously into the surface of the concrete base with a stiff bristled broom. The area of concrete base which can be coated with bonding agent prior to the laying of the flooring will depend on the open time of the bonding agent. It is essential that the bonding agent is still wet or tacky when the flooring mix is compacted on to it.

In some cases a polymer dispersion diluted with water can be used as a primer. However it is essential that the manufacturer's recommended procedures are then strictly followed. Some polymer dispersions may act as a release agent if allowed to dry out before overcoating with the flooring mix.

In certain situations, e.g. oil contaminated or dense surfaces, a purpose-designed resin primer may be used.

10.5.2 Applying the flooring

For trowel applied products, the mixed material should be spread out in such a way as to ensure the required minimum thickness throughout. The mixed materials should be well consolidated in order to produce the optimum strength in the finished floor. A vibrating or screeding bar can be used to spread the mixed materials evenly and produce a level surface minimising surface irregularities. Finally after compaction a smooth finish should be obtained by using a steel or wood float. Some mixes are suitable for finishing with a power float. Trowels, tools and mixers should be kept clean by washing thoroughly with water as work progresses.

Excessive trowelling should be avoided as this can cause patchiness and blistering in the finished floor.

Similarly trowelling too late after the flooring has been spread out can cause the surface to be disfigured due to disruption of the polymer film that forms on drying out.

Certain compositions are produced as highly fluid mixes which can be pumped into place and then levelled and smoothed with the minimum of effort. Such products should be mixed and applied strictly in accordance with the manufacturer's recommendations.

10.5.3 Curing

Polymer modified cementitious flooring normally does not need any wet curing,

Some manufacturers may specify an initial period of wet curing in order to promote the hydration of the cement. In such cases the curing should begin within two hours of laying the flooring and should be carried out either by covering with polyethylene film for at least 24 hours, but no more than 72 hours: or by using a spray-on curing membrane. In the latter case the curing membrane needs to be either easily removable or fully compatible with any subsequently applied surface treatment. The wet curing should then be followed by a period of drying to enable an inter-penetrating network of polymer films to be formed within the flooring.

10.5.4 Drying out

As the cementitious floor dries it shrinks and this may lead to surface cracking if the rate of drying is excessive. The risk of consequent cracking will be reduced by ensuring that the floor dries out slowly without being forced. After laying, the flooring should be protected from draughts and direct sunlight, both of which will accelerate drying out and lead to localised surface cracking.

10.5.5 Sealer coats

Polymer-modified cementitious flooring is durable and slip resistant. However, in certain situations more hygienic, easily cleanable, chemically resistant and decorative finishes are required and these can be obtained by applying a synthetic resin or polymer coating to the finished surface. This should be achieved by the application of one or more coats of a compatible alkali-resistant coating. This may be either a solvent-free system or a water or solvent-based system applied by brush, spray, squeegee or roller. It should be applied after the polymer-modified cementitious flooring has cured to a visibly dry condition, usually 3 or more days after the curing film or membrane has been removed.

11 HEALTH AND SAFETY PRECAUTIONS

11.1 General

a) Care shall be taken to ensure that all procedures comply fully with national and local Health and Safety and Environmental regulations.
b) Before starting any operations the manufacturer's Materials Safety Data Sheets for all the flooring products to be applied shall be studied and all recommendations followed in addition to those listed here.

11.2 Polymer-modified cementitious flooring

When mixing and/or laying Polymer-modified cementitious floorings, precautions taken should include the following:

a) Full protective clothing should be worn to prevent all contact of the products with the skin. Protective gloves should be worn at all times. Goggles or full face shields should be worn during mixing and at any time when splashing is a risk.
b) It is good practice to apply an appropriate barrier cream on the hands at the beginning of each session.
c) Any splashes of product on the skin should be washed off immediately using soap and water or preferably a proprietary resin-removing cream. Cleaning solvent should never be used on the skin since it de-fats the surface and aids deeper penetration of the contamination.
d) Any splashes of the product in the eye should be treated immediately by washing with copious amounts of water. Medical treatment should then be sought taking full product details so that correct medication can be supplied.
e) None of the flooring materials should be swallowed. If any is accidentally ingested a doctor should be consulted immediately. The consumption of food and drink shall be prohibited in the vicinity of the mixing and laying operations.
f) Smoking should not be allowed in the vicinity of the mixing or laying operations.

12 INSPECTION AND TESTING OF FLOORING

12.1 Inspection

The works should be inspected during progress and after completion, special attention being paid to the following:

a) quality and preparation of the base;
b) levels and surface regularity of the base;
i) climatic conditions, throughout the application stages;
c) priming of the base;
d) mixing/batching of the flooring;
e) laying the flooring, including the applied thickness;
f) levels and surface regularity;
g) sealing, if any;
h) curing;

12.2 Testing

At the appropriate time after laying the flooring, tests may be carried out for the following:

a) levels and surface regularity;
b) adhesion of the flooring to the base;

The following tests are normally made only when there are specified performance requirements and the quality of the flooring is in dispute:

c) slip resistance;
d) abrasion resistance.

12.3 Levels and surface regularity

When the flooring is tested by the methods described in BS 8204-1, the departure from datum should be within the limit specified and the surface regularity should be within the limit given in Table 2 for the appropriate class specified. The number of measurements required to check levels and surface regularity should be agreed between the parties concerned bearing in mind the standard required and the likely time and costs involved.

12.4 Adhesion of the flooring to the base

12.4.1 General

The adhesion between the flooring and the base may be examined by tapping the surface, e.g. with a rod or a hammer, a hollow sound indicating lack of adhesion or possibly, hollowness in the substrate. Tests to check the adhesion of a flooring to its base should be made as late as possible in a construction programme when the flooring will be fully cured. Those areas of flooring that are considered to be unsatisfactory should be treated by isolating the area concerned by sawing, removing and re-laying the affected flooring. When removing an area of flooring, care should be taken to minimise any loss of adhesion of the adjacent part of the flooring.

12.4.2 Quantitative test method

The preferred method of testing the adhesion of the flooring to the base is that of EN1542**.** When tested by this method, a mean bond strength of at least 0.8 MPa with an absolute minimum of 0.5 MPa should be obtained, provided the substrate itself was of at least this quality initially. Slightly lower values may be acceptable provided the failure occurs within the concrete substrate.

12.5 Slip resistance

The floor should be tested in accordance with the method described in EN 13036-4. The slip resistance value should be in accordance with the design value, see **8.2**.

12.6 Abrasion resistance

The floor should be tested for abrasion resistance in accordance with the BCA method described in EN 13892-4 or the Rolling Wheel tester of EN 13892-5. The value obtained should be in accordance with the design value.

14 MAINTENANCE

The designer shall provide full specification for the maintenance procedures to be adopted in order to optimise the life cycle of the flooring.

Under normal circumstances, frequent washing of the surface with a compatible detergent solution should be sufficient to maintain the floor surface in a clean condition. In areas where hygiene is of prime importance regular sterilisation with bactericide solutions should be adopted. Food processing areas, where there is the risk of accumulation of fats or food residues, may need frequent hot water jetting at temperatures of 60 to 80°C. Steam cleaning may be appropriate in some cases.

All potentially corrosive spillages should be immediately mopped up with appropriate absorbents or washed away with copious amounts of water.

Localised damage to the floor surface should be repaired at the earliest opportunity to prevent liquids penetrating to the bond line and causing lateral failure.

A detailed record, including location, extent and date(s), should be maintained of all damage and subsequent repairs.