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Nonmetallic protective coatings for precast concrete members used in process plant units
Design and preparatory treatment of substrates

DIN 28052 Part 2

Chemischer Apparatebau; Oberflächenschutz mit nichtmetallischen Werkstoffen für Bauteile aus Beton in verfahrenstechnischen Anlagen; Anforderungen an den Untergrund

In keeping with current practice in standards published by the International Organization for Standardization (ISO), a comma has been used throughout as the decimal marker.

References made to DIN 1045 relate to the July 1988 edition.

1 Scope and field of application

This standard specifies requirements for the design of precast concrete members used in process plant units to which a protective coating in compliance with DIN 28052 Part 1 is to be applied, and provides recommendations with regard to the preparatory treatment of concrete, screed or plaster substrates.

2 Concepts

2.1 Joints

2.1.1 Construction joint

A construction joint is a joint in a building element formed in situ when continuity is not possible.

2.1.2 Expansion joint

An expansion joint is a joint that accommodates movement of structural members caused by the expansion or contraction of the structure.

2.1.3 Dummy joint

A dummy joint is a joint formed by using a crack inducer to reduce depth in the concrete surface, thereby determining the location of arising cracks that may form.

2.2 Tensile strength

For the purposes of this standard, the tensile strength is a measure based on the maximum load which a concrete structure can accommodate when subjected to uniaxial tension.

3 Design of concrete members

3.1 General

In addition to the standard load cases described in DIN 1055 and DIN 1072, the following factors shall be considered when analysing precast concrete members:

restraint caused by deformation as a result of thermal movement;

restraint caused by differential settlement;

restraint caused by shrinkage, hydration heat or changes in moisture content.

Plain and reinforced concrete shall satisfy requirements for at least strength class B 25 as specified in DIN 1045.

Unless protection is provided by cladding being tied to the structure (cf. DIN 18516 Part 1), the inner side of the coating shall be protected from the adverse effects of water, water vapour pressure and hydrostatic pressure. Water vapour is deemed deleterious if it is likely to cause the protective coating to disbond under service conditions.

Disbonding may also be caused by frost, moisture accumulating under the coating, capillary forces or water-soluble substances creating osmotic pressure. If the structure is exposed to groundwater infiltration, waterproofing is to be provided (cf. DIN 18195 Parts 1 to 6).

3.2 Defining limit states of cracking

Care shall be taken to minimize cracking, as the performance of the protective coating may be impaired by the formation of cracks in the concrete surface. All limit states resulting from the erection of a process plant and its subsequent operation shall be considered in the analysis.

In addition to deformation as a result of static or dynamic loads, deformation may also be caused by unstable bearing conditions, shrinkage, creep or thermal movement. Such stresses may be accidental or permanent.

Adverse deformation should not arise if the supporting structure has been built in compliance with DIN 1045.

The risk of crack formation shall be minimized by choosing the appropriate design. The cross section of precast concrete members shall be continuous throughout, i.e. it shall have no notches. The maximum crack width shall be designed to suit the expansion characteristics of the coating system selected.

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The design crack width will not exceed 0,25 mm if reinforcement as specified in table 14 or 15 (line 3) of DIN 1045 is provided and 0,2 mm where an analysis in accordance with *DAfStb-Heft* (DAfStb Brochure) 400 *Erläuterungen zu DIN 1045* (Explanatory notes to DIN 1045) is made. For specifications regarding the adequate concrete cover, see subclause 13.2, table 10, of DIN 1045.

In certain cases, prestressing should be considered.

The following limit states of cracking have been defined for the assessment of new or existing precast concrete members to which a protective coating is to be applied.

Group A: Substrates with very narrow cracks

Discontinuous cracks of a width less than 0,1 mm (crazing) are permissible. New cracks or existing cracks that have widened after the coating system has been applied shall not exceed a width of 0,1 mm.

Group A includes prestressed and reinforced concrete members in state I as specified in DIN 1045 or DIN 4227 Parts 1, 2 and 6, as well as reinforced floor slabs in full contact with their support and the upper surface of single-span, non-projecting slabs.

Group B: Substrates with narrow cracks

The width of cracks shall not exceed 0,25 mm. This also applies to new cracks or to existing cracks that have widened after the coating system has been applied and where the coating system is to cover the tension side of reinforced concrete members.

Group B includes reinforced members as specified in table 14 or 15 of DIN 1045.

Group C: Substrates with wide cracks

The width of cracks shall not exceed 0,5 mm.

This group includes cracks of widths exceeding those specified for group B, regardless of whether such cracks have been allowed for in the analysis or have accidentally occurred in service.

The application of a coating system to concrete members belonging to this group requires particular care.

Specifications given for groups A to C apply to cracks caused by tension or flexure as the result of mechanical or thermal loading. Cracks that have been caused by shear shall not be bridged by a protective coating.

3.3 Joints

As joints generally present a risk to the watertightness of the concrete structure and coating system, the number of joints designed to accommodate the expansion and contraction movements should be limited.

Joints should be straight, located at the upper end of slopes and detailed so as to suit the coating system selected.

Certain types of coating systems cannot be applied to jointed concrete members.

3.4 Inclined surfaces

Inclined concrete surfaces that are exposed to liquids shall be laid to a fall of not less than 1,5 %. In order to allow for tolerances, a further 0,5 % should be added, with a maximum of 30 mm over the length of the surface. The slope should be directed away from main girders and tank foundations, walls and expansion joints, thus providing adequate drainage.

3.5 Flatness

The flatness of the substrate shall be in compliance with the values specified in table 3 (line 3) of DIN 18202, May 1986 edition, i.e. deviation from flatness shall not exceed 9 mm over the length of a 4 m levelling rod.

3.6 Gutters and channels

Gutters and channels shall not be run over surfaces which may be subject to deformation and subsequent cracking. Their slope shall generally be of 1 %, however, not less than 0,5 %. As joints in gutters and channels present a risk to watertightness, their number should be limited. They require a particular design.

The channel width shall be designed as a function of the maximum depth to ensure appropriate lining of the invert.

3.7 Pits and tanks

Buried pits and tanks shall be insulated against the ingress of moisture. See DIN 18195 Parts 1 to 6 for means of damp-proofing.

3.8 Components

Components such as sockets, drainage outlets, ties and penetration sleeves shall be fastened to the concrete member so that they are not dislodged as a result of loading. Means shall be provided to prevent the components from being exposed to dynamic stress.

When selecting materials for components, the type of coating system to be used shall be taken into account. If ties are to be fixed to concrete members, ceramic sockets may be provided.

3.9 Concrete, screed or plaster on inclined surfaces

The risk of cracking in inclined concrete, screed or plaster surfaces shall be minimized by providing additional reinforcement. It shall be ensured that all movements resulting from temperature changes, vibration, traffic, etc. are accommodated.

Adequate bond strength and surface hardness are requisite features of any levelling layer applied to the substrate.

Cement/sand screed shall be at least of class ZE 30 in compliance with DIN 18560 Part 1. Plaster shall be mixed according to requirements for mortar group P III, as specified in DIN 18550 Part 1, and shall have a minimum compressive strength of 20 N/mm^2.

A protective coating may also be applied to masonry, providing it has been given a permanently adhesive layer of plaster.

The substrate shall have a tensile strength in accordance with the specifications in table 1. The number of tensile tests required depends on the evenness and size of the surfaces to be coated.

Table 1: Tensile strength of substrates

Type of substrate	Tensile strength, in N/mm^2	
	Average	Minimum
Cement/mortar (modified or unmodified)	> 1,5	>1,0
Polymer concrete or mortar (for surfaces not exposed to traffic loads)	> 1,5	> 1,0
Epoxy coatings up to 1 mm thick	> 1,5	> 1,0
Epoxy coatings thicker than 1 mm, for grade 2 loading or more, as in subclause 4.5 of DIN 28052 Part 1.	> 2,0	> 1,5

4 Workmanship

Unless otherwise specified, clause 1 of the *DAfStB-Richtlinien für Schutz und Instandsetzung von Betonbauteilen* (DAfStB Code of practice on protection and repair of concrete members) shall apply.

4.1 Construction materials

The requirements for the working of concrete, screed and plaster shall be stated in the specifications of work, in compliance with relevant standards. Concrete admixtures and curing aids shall be compatible with the coating system.

4.2 Concrete surfaces

4.2.1 Casting

Structural concrete should be cast so that its surface is even and free from imperfections, thus rendering the application of additional levelling layers superfluous.

If a protective coating is to be applied to structural concrete, curing as specified in subclause 10.3 of DIN 1045 is indispensable.

Concrete members shall be cast according to the specified surface profile. The surface to be given a protective coating shall not be smoothed. It shall have an almost even, uniform texture providing an adequate key as is obtained by levelling the surface with a wooden hawk.

Concrete surfaces that have been compacted and smoothed by machines shall be roughened. The hardened surface shall be even and free from flash, clusters, as well as flaky or brittle layers.

Sharp edges shall be rounded. Depending on the type of the protective coating used, the channels shall be hollowed to permit adequate adhesion of the coating.

4.2.2 Preparation

Roughening of the concrete surface is generally required. Any cementitious grout, brittle or flaky layers, as well as residues of separating agents shall be removed by appropriate means such as blast-cleaning, grinding, flame cleaning, milling and shot-peening. The degree of roughness required largely depends on the type of coating system to be used. If curing aids have been used, the contractor applying the protective coating shall be notified so that any additional measures required may be taken.

Surface irregularities (e.g. flash, gravel clusters) shall be removed by levelling the surface using a stopper that provides a good key and is suitable for the subsequent application of a protective coating.

Distance pieces and binding wire susceptible to corrosion shall be cut at a depth of at least 20 mm below the surface and the holes filled as prescribed. Preference shall be given to distance pieces with detachable cones.

Concrete surfaces that have been attacked in depth by acids, alkaline solutions, oils or other deteriorating substances shall be stripped down to the sound substrate, and fresh concrete placed. Where only the upper layer has been affected, blast-cleaning or emulsifying may be deemed a satisfactory means of preparing the precast members to receive the protective coating. Appropriate measures shall be taken to neutralize any residues (e.g. by sulfating the surface) in order to prevent subsequent deterioration of the coating.

4.2.2.1 Blast-cleaning and grinding

A conventional means of removing thin layers such as cementitious grout, cement, paint and soiling is blast-cleaning and grinding. However, the removal of brittle concrete layers requires more appropriate means, such as pressurized water blast-cleaning or shot peening.

Shot peening is a dust-free method of blast-cleaning in which an encapsulated self-propelling machine is run over a horizontal or inclined surface directing a stream of metallic shot or grit onto the deteriorated surface which is loosened while the ensuing debris is simultaneously vacuumed.

Given the design of shot peening machines, the edges of concrete members and the areas surrounding components that have been fitted into the concrete will require subsequent manual or mechanical cleaning.

4.2.2.2 Flame cleaning

When flame cleaning is used, the concrete surface is momentarily exposed to an oxyacetylene flame and brought to a temperature of 1500 °C, thus causing flaking and fusion in the upper 5 mm layer. The surface is thus cleansed of oil stains and of any residues of bitumen, paint, coatings and rubber.

As a certain extent of spalling and softening of the underlying layer cannot be avoided, mechanical cleaning as described in subclause 4.2.2.1 is essential. As a consequence, this method is not recommended for cleaning reinforced concrete with a thin cover, fragile members or elements, or screed and other lightweight aggregate surfaces.

This procedure shall be adopted in compliance with the *DVS-Richtlinie* (DVS Code of practice) 0302.

4.2.2.3 Chipping and cutting

In order to cut away thicker layers, a wide chipping or milling cutter should be used.

As a certain extent of spalling and softening of the underlying layer cannot be avoided, mechanical cleaning as described in subclause 4.2.2.1 is essential. As a consequence, this method is not recommended for cleaning reinforced concrete with a thin cover, fragile members or elements, or screed and other lightweight aggregate surfaces.

This procedure shall be adopted in compliance with the *DVS-Richtlinie* 0302.

4.3 Drying

The concrete surface must be dry throughout before the protective coating is applied. The contractor in charge of applying the protective coating shall assess the degree of residual moisture and ensure that the relevant limit values specified by the manufacturer are complied with. The moisture, which is to be measured with an appropriate device, shall not exceed 4 % at a depth of 20 mm. Coating systems tolerating a higher moisture content do, however, exist.

Accelerated drying should be avoided. Where it is indispensable, it should begin no earlier than seven days after the concrete has been cast. Adequate ventilation shall be ensured as the temperature is gradually increased. The temperature of the concrete surface shall not exceed 50 °C. Over-rapid drying may cause damage to the concrete, screed or plaster.

4.4 Temperature

Specifications regarding the temperature conditions required for coating are given in other Parts of this standard.

Standards and other documents referred to

DIN 1045	Structural use of concrete; design and construction
DIN 1055 Part 1	Design loads for structures; materials to be stocked, construction materials and structural members; self-weight and angle of friction
DIN 1055 Part 2	Design loads for structures; soil characteristics; density, angle of friction, cohesion and angle of wall friction
DIN 1055 Part 3	Design loads for structures; imposed loads
DIN 1055 Part 4	Design loads for structures; imposed loads; wind loads on structures not susceptible to vibration
DIN 1055 Part 5	Design loads for structures; imposed loads; snow load and ice load
DIN 1072	Road and foot bridges; design loads
DIN 4227 Part 1	Partially or fully prestressed ordinary concrete structural members
DIN V 4227 Part 2	Prestressed concrete; partially prestressed structural members
DIN V 4227 Part 6	Prestressed concrete; prestressed structural members without composite action
DIN 18195 Part 1	Waterproofing of buildings and structures; general and terminology
DIN 18195 Part 2	Waterproofing of buildings and structures; materials
DIN 18195 Part 3	Waterproofing of buildings and structures; processing of materials
DIN 18195 Part 4	Waterproofing of buildings and structures; damp-proofing against moisture from the ground; design and workmanship
DIN 18195 Part 5	Waterproofing of buildings and structures; waterproofing against water that exerts no hydrostatic pressure; design and workmanship
DIN 18195 Part 6	Waterproofing of buildings and structures; waterproofing against water that exerts hydrostatic pressure from the outside; design and workmanship
DIN 18202	Tolerances in building; buildings
DIN 18516 Part 1	Back-ventilated, non-loadbearing, external enclosures of buildings; requirements and testing
DIN 18550 Part 1	Plastering and rendering; concepts and requirements
DIN 18560 Part 1	Floor screeds; concepts, general requirements and testing
DIN 28052 Part 1	Non-metallic protective coatings and linings for concrete structural elements in process plants; concepts and selection criteria

DAfStb-Richtlinien für Schutz und Instandsetzung von Betonbauteilen (August 1990 edition)

DAfStb-Heft 400 Erläuterungen zur DIN 1045 Beton und Stahlbeton (July 1988 edition)

DVS-Richtlinie 0302 Flammstrahlen von Beton (Flame cleaning of concrete) *)

Other relevant standards and documents

DIN 1053 Part 1	Masonry of simplified design; design and construction
DIN 1053 Part 2	Masonry designed on the basis of suitability tests; design and construction
DIN 18550 Part 2	Plastering and rendering; mortar with mineral binder; workmanship
DIN 18800 Part 1	Structural steelwork; design and construction
DAfStb-Heft 416	*Betonbau im Umgang mit wassergefährdenden Stoffen* (Concrete structures in contact with water pollutants)

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