Fundamentals

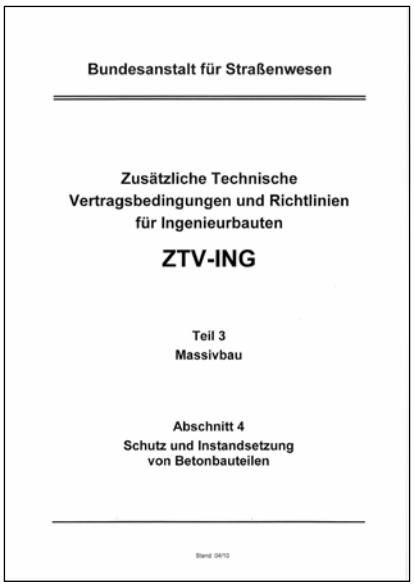
The particular properties and reliable performance of concrete have established it as an indispensable material in all fields of construction.

Despite the exceptional "friendliness" and easy workability of the material, which combines high structural strength with aesthetic appeal, external actions may make it susceptible to damage in the long term.

Concrete comes in many guises: it is used for major engineering structures such as bridges or tunnels, but also for balcony slabs and parapets, stair flights and landings, which are equally vulnerable to damage, e.g. spalling.

Given that concrete invariably assumes a structural function – typically in tandem with embedded steel reinforcement, which accommodates the tensile forces in the element – such damage must not be ignored, but carefully monitored and rectified in good time. Concrete repair is governed by statutory regulations.

In Germany, concrete maintenance works are covered by the ZTV-ING (Special technical conditions and guidelines for engineering structures) and the SIB (Protection and repair of concrete elements) guidelines issued by the DafStb (German Committee for Reinforced Concrete).

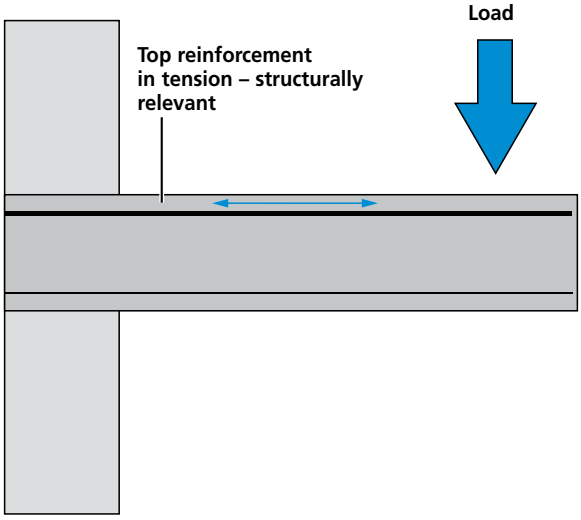

Bundesanstalt für Straßenwesen

Zusätzliche Technische Vertragsbedingungen und Richtlinien für Ingenieurbauten

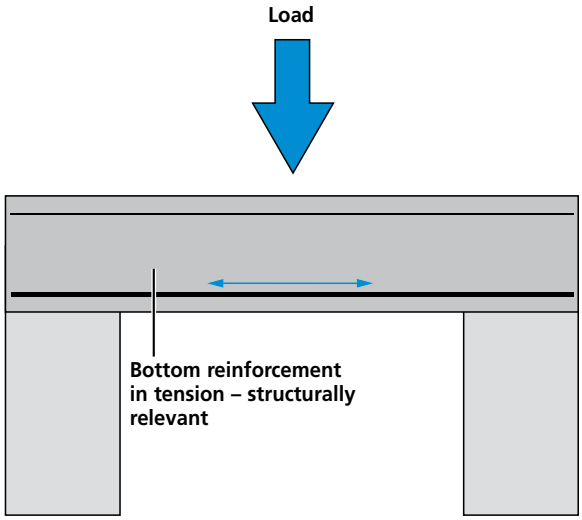
ZTV-ING

Teil 3
Massivbau

Abschnitt 4
Schutz und Instandsetzung von Betonbauteilen



Balcony reinforcement



Concrete beam or slab

Fundamentals

A distinction may be drawn between age-related refurbishment and remedial works to new building elements necessitated by concreting problems, e.g. inadequate concrete compaction (honeycombing, open-pored patches/ blowholes, exposed reinforcement, transportation damage such as chips and spalls etc.).

Older elements and structures require a more comprehensive survey and analysis prior to refurbishment.

So-called "high-quality" reinforced concrete, through its inherently high alkalinity, provides the reinforcement with some degree of corrosion protection (passivation) against the limited moisture penetration that may affect the concrete.

As concrete ages and continues to harden over many years, the carbonation process comes into play: the calcium hydroxide in the concrete reacts with atmospheric carbon dioxide to push the material's normal pH value of 12 down to 9 or even less.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$$

If this carbonation level reaches the steel bars or fabric, which are provided with only a few centimetres of concrete cover, any moisture migration into the concrete will trigger reinforcement corrosion. This process will ultimately reduce the cross-sectional area of the steel and thereby impair the element's loadbearing capacity. At the same time, the volume increase due to rust formation may cause the concrete cover to spall away – with fully exposed reinforcement, unprotected against further corrosive action, as the consequence.

Spalling on a facade due to inadequate concrete cover.

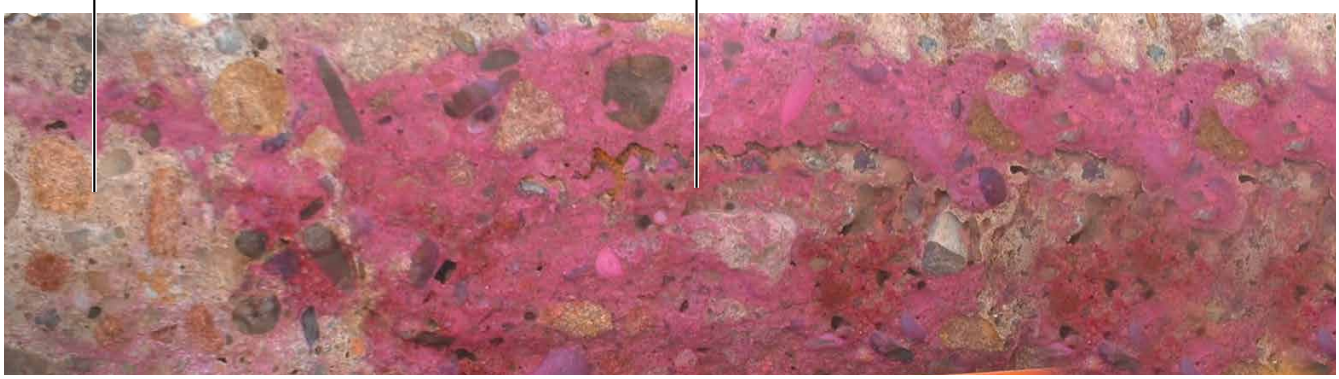
Corrosion damage to a stair soffit caused by lack of waterproofing and inadequate concrete cover.

Carbonation survey

The use of (spray-applied) phenolphthalein indicator solution allows determination of the degree of carbonation at a freshly chipped edge of a concrete element.

Carbonated concrete with loss of passivation effect (no discoloration)

Passivation (anti-corrosive) effect of concrete still intact (reddening)



Modified mortar systems

Various options, all taking the form of **modified mortar systems**, are available for the repair of concrete elements.

Cementitious systems featuring polymer-modified products, so-called PCC or concrete repair mortars, are widely adopted for refurbishment work.

The abbreviation stands for:

P Polymer (dispersion)
C Cement
C Concrete

PCC **P**olymer **C**ement **C**oncrete

The ZTV-ING (Special technical conditions and guidelines for engineering structures) distinguishes between two classes of PCC:

PCC I Trafficable, dynamically loaded surfaces (e.g. bridges)
PCC II Non-trafficable, dynamically and non-dynamically loaded surfaces (e.g. abutments, columns, facades etc.)

The Sopro PCC concrete repair system comprises:

1. PCC corrosion protection (passivation)
2. PCC bonding layer
3. PCC reprofiling mortar
4. Fine PCC filler

Reaction resin-modified or reaction resin-based mortar systems are adopted in some cases.

E Epoxy
C Cement
C Concrete

ECC **E**poxy **C**ement **C**oncrete

Water-emulsifiable epoxy resins with cement mortar

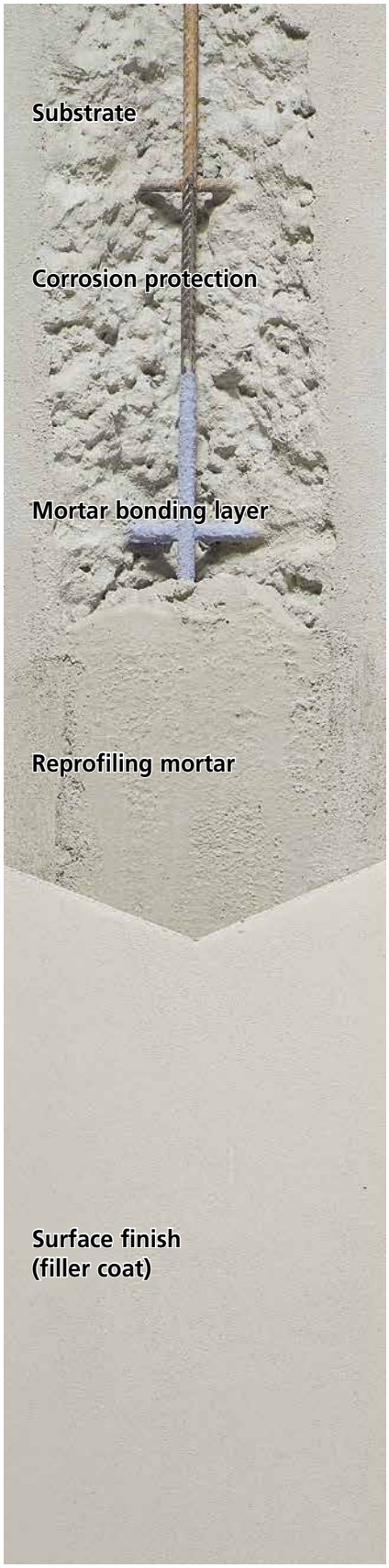
P Polymer
C Concrete

PC **P**olymer **C**oncrete

Pure reaction (epoxy) resin with aggregate without cement and water (e.g. Sopro DBE 500 epoxy tile adhesive)

Product recommendations

System composition



Sopro Repadur KS
corrosion-inhibiting mortar
Quality-controlled

Sopro Repadur MH
PCC mortar bonding layer
Quality-controlled

Sopro Repadur 50
PCC concrete repair mortar
Quality-controlled

Sopro Repadur 5
Fine PCC concrete filler
Quality-controlled

Fast-track products*:

Sopro Repadur 40S
Rapid-set concrete repair mortar

Sopro Repadur 10S
Fine rapid-set concrete filler

* Use of Sopro Repadur 40S necessitates the application of a contact slurry comprising Sopro HE 449 bonding emulsion, water and Sopro Repadur 40S, instead of Sopro Repadur MH.

Application of Sopro Repadur system

Step 1:

Substrate preparation

Following inspection of the failure, the defective concrete is hacked away and the exposed reinforcing steel mechanically derusted, e.g. by sandblasting (cleaning grade SA 2½).

Step 2:

Corrosion protection for exposed reinforcement

The one-component Sopro Repadur KS PCC corrosion-inhibiting dry mortar, comprising high-grade cement, aggregate plus additives, is mixed with water. The smooth, easily workable fresh mortar provides durable protection against corrosion.

- Tested and quality-controlled
- Normal-setting
  (approx. 60 minutes at +20 °C)

Step 3:

Application of bonding layer

The cementitious Sopro Repadur MH PCC mortar bonding layer ensures good adhesion of the subsequent repair mortar coating for overhead work and/or for elements subject to dynamic loads.

- Tested and quality-controlled
- Normal-setting
  (approx. 60 minutes at +20 °C)

Step 4:

Placing of repair mortar

The easily workable, cementitious, fibre-reinforced Sopro Repadur 50 PCC concrete repair mortar is applied wet-on-wet to the slurry in a 10–50 mm thick coat. Suitable both for reprofiling and for large-area coating of concrete substrates.

- Tested and quality-controlled
- Normal-setting
  (approx. 60 minutes at +20 °C)

Step 5:

Final surface finishing

Sopro Repadur 5 fine PCC concrete filler is used to fill pores and blowholes and to prepare substrate for paint systems or other coatings. The filler may be applied in coats up to 5 mm thick.

- Tested and quality-controlled
- Normal-setting
  (approx. 60 minutes at +20 °C)