



HETEK

Guidelines for Repairs during
the Construction Phase



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Abstract: The guidelines contains procedures for registration and evaluation of defects and non-conformities in the construction phase. Recommendations for specifications of routine repair methods and working instructions are described including quality control methods and programs.

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1. Introduction

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1.1 Scope

The report describes guidelines for the contractors of how to make repairs in the construction phases of non-conformities and defects on high quality concrete: High quality concrete is in this context defined as concrete prepared according to the specifications in the Danish Road rules, concerning Bridges in aggressive environments.

The guidelines are divided into 3 parts:

- Guidelines for inspection and planning of repairs, which is intended to be used when the contractors are registering defects and finish works, evaluating the registrations and planning the repair methods
- Guidelines for specifications of repairs, which gives criterias for specifying repair materials and methods including quality control.

- Guidelines for working procedures, which gives instructions for the handcrafts of how to prepare the repairs and apply the repair methods.

Disposition of the guidelines is coordinated to the guidelines for surface treatment from the Road Directorate, re. 22.

The economic aspects of the repairs are described with reference to the experiences from the maintenance of bridges in Denmark.

The guidelines only consider routine repairs. The guidelines should only be used on the basis of detailed considerations in each projects and by persons who are experienced in this field.

The guidelines are supplemented by the report HETEK, Repairs during the construction Phase. Illustrations, which describes defects and non-conformities and discuss the evaluations and planing of repairs.

1.2 Background

The report is based on initial studies including the reports:

HETEK Repair in the construction phase: State of the Art. Road Directorate 1996. Re 25.

HETEK Repair in the construction phase: Field studies. Road Directorate 1996. Re 24.

The guidelines are described with references to current standards such as draft for European Standard prEN 1504-1, -3 and -9, re. 28. and ZTV-SIB 90 re. 27.

The report is also correlated to other works such as:

BPS Typiske beskrivelsesafsnit for renovering af armerede betonkonstruktioner, re 23.

2. Guidelines for inspection and planning of repairs

- Inspection and planning of repairs of concrete structures concern procedures for:
- registrations of defects and non-conformities
 - evaluation of the registrations
 - planning of repair methods and working procedures.

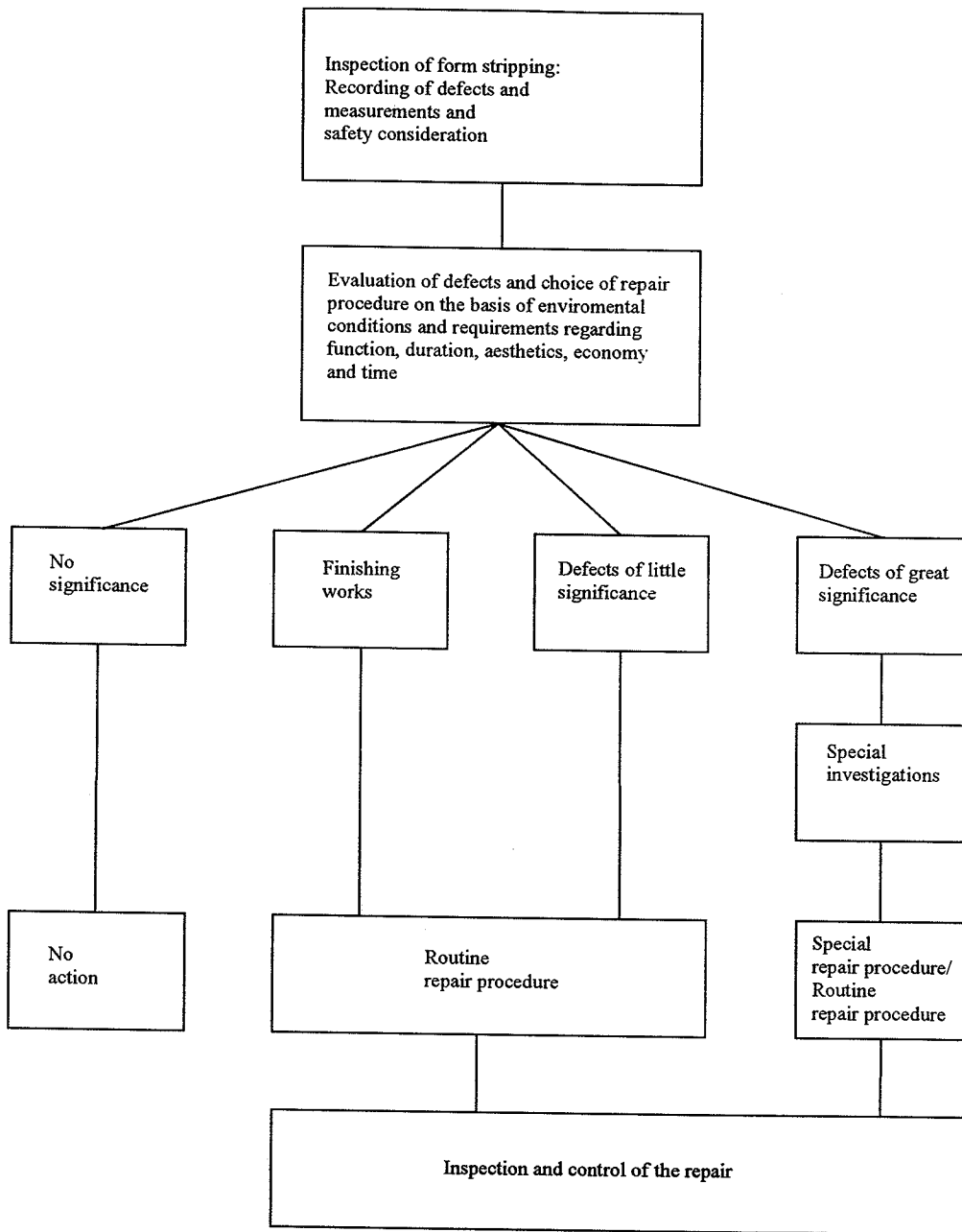


Figure 1: *Guidelines for inspection and repairs during the construction phase.*

2.1 Inspections

Inspections and registrations of defects comprise the following routines:

- Immediately after the form stripping the defects are registered and located and the extent of the defects are measured. The registration must be described on drawings, in a way that it is possible to reinspect the defects or repairs.
- Cover control is carried out with non-destructive measuring equipment in combination with measurements in drilled holes. (\varnothing 20 mm)
- Variations of the crack-width over the time and with temperature variations are recorded. Min. cracks width of 0.1 mm are recorded. Cracks are inspected after significant temperature variations after hardening of the structure - e.g. when the concrete temperature varies more than 10°C.
- Tolerance control
- Reinforcement in the joint - position and need for cleaning.
- Condition of the casting joint and need for cleaning.

Typical defects and non-conformities recorded after form stripping are :

- Cracks
- Holes and honeycombs
- Wrong dimensions
- Too little or too much cover
- Depressions/cavities
- Lack of alignment at casting joints
- Cavities around waterstops
- Air voids
- Minor surface defects such as damages from forms, damages on edges

Other repairs considered as finishing works include:

- Injection of cooling pipes
- Repairs of clamp holes
- Repairs of holes from lifting anchors
- Repairs of holes from drilled cores
- Repairs of holes from other testings
- Repair of block-outs made for construction purposes.
- Repair of drilled holes from testing of concrete cover.

2.2 Evaluation of defects and non-conformities

The defects and non-conformities are evaluated on the basis of the following parameters:

- **Bearing capacity** should be evaluated in connection with all kinds of defects. Large defects may require supplementary investigations and calculations to ensure that the safety and function of the construction are preserved.
- **Aesthetic demands** are included in the assessment of damages localized on visible construction parts, e.g. sidebeams and columns.
- **Durability and environmental impacts** are already defined as a required lifetime required to be at least 100 years in an aggressive environment, but there might be a need to evaluate the location of the actual construction part in the construction, as the local conditions of exposure are important in the classification of the non-conformity.
- **Economic consequences** for the scheduled construction work are assessed on the basis of an evaluation of the repair work.

On the basis of these considerations, it is evaluated whether the defects are of little or great significance or of no importance at all.

Finishing works are also registered.

The inspection records and evaluations should be considered by the owner before the repair processes are planned.

2.3 Planning of repairs

The work procedures can be divided into routine repair procedures or special repair procedures:

Routine repair procedures:

Routine repairs procedures include the following:

- procedures for preparations of repairs - working procedure 1-4 concerning removing of defect concrete, cleaning of surfaces and ducts
- procedures for concrete restorations - working procedures 5-7 concerning replacing of the original concrete by bonding hand-applied mortar, spraying concrete or mortar or recasting with concrete
- procedures for injection - working procedure 8 injection for filling for stopping the ingress of water e.a. and working procedure 10 injection of cooling pipes
- procedures for other ingress control - work procedure 9 concerning surface coating.

Table with guidelines for routine repair procedures - the routine repairs must be registered and considered in each case:

Defect or non-conformities/ Finishing works	Preparations Working procedures	Repair procedures	Principles according to European Standard pr EN1504
Cracks	Preparation of cracks (Working procedure 4)	Injection of cracks (Working procedure 8)	Concrete injection
Holes and honeycombs	Cleaning of surfaces (Working procedure 2)	Repairs made with mortar, shotcrete or concrete (Working procedures 5, 6 and 7)	Structural and non-structural repairs
Wrong dimensions	Removal of defect concrete or wrongly placed concrete (Working procedure 1)	Repairs made with mortar, shotcrete or concrete (Working procedures 5, 6 and 7)	
Too little cover	Cleaning of surfaces (Working procedure 2)	Repairs made with mortar, shotcrete (Working procedures 5, 6 and 9) or surface cooling or no repair	
Too much cover	Removal of defect concrete or wrongly placed concrete (Working procedure 1)	Repairs made with mortar (Working procedure 5) or other methods	
Depressions/ cavities	Cleaning of surfaces (Working procedure 2)	Repairs made with mortar (Working procedure 5)	
Cavities around water stops	Removal of defect concrete or wrongly placed concrete (Working procedure 1)	Repairs made with mortar or injection (Working procedure 5 and 8)	
Air voids	Cleaning of surfaces (Working procedure 2)	Repairs made with mortar (Working procedure 5)	
Cooling pipes	Cleaning of cooling pipes (Working procedure 3)	Injection of cooling pipes (Working procedure 10)	
Clamp holes	Cleaning of surfaces (Working procedure 2)	Repairs made with mortar (Working procedure 5)	
Minor surface defects	Cleaning of surfaces (Working procedure 2)	Repairs made with mortar (Working procedure 5) or surface coatings (Working procedure 9).	
Holes from drilled core, lifting anchors and other testings	Cleaning of surfaces (Working procedure 2)	Repairs made with mortar (Working procedure 5)	

The repair procedures are planned on the basis of the recorded and evaluated defects and non-conformities. The planned repairs procedures must be confirmed by the owner or his representative before the repairs are executed.

Special repair procedures

Special repairs procedures relate to non-conformities which are significant with regards economy, time schedules, durability, structural integrity and aesthetics and where routine repair procedures are not appropriate. Such methods are :

- Sheltering and overcladding
- Structural strengthening
- Cathodic protection

3. Guidelines for specifications of repairs

Guidelines for specifications of repairs in the constructions phase include a description for each relevant routine repairs including:

- Application and properties
- Material specifications

which is the basis for the choice of methods and materials.

It might be necessary to establish a testfield, in which the demanded characteristics of the repair materials are proved and to demonstrate the skills of the workers.

The specifications are divided into groups conforming to the European Standard re. 28 and with correspondings to the working procedures which are described in section 4 of this report:

Preparations of repairs:

Working procedure 1. Removal of defect concrete and wrongly placed concrete

Working procedure 2. Cleaning of concrete surfaces

Working procedure 3. Cleaning of cooling pipes

Working procedure 4. Preparation of cracks for injections

Structural and non-structural repairs:

Working procedure 5. Repairs made with mortar

Working procedure 6. Repairs made with shotcrete

Working procedure 7. Repairs made with concrete

Concrete injection:

Working procedure 8. Injection of cracks

Working procedure 10. Injection of cooling pipes

Surface protection

Working procedure 9. Surface coating

3.1 Removal of defect concrete or wrongly placed concrete

Application and properties

The method is used to remove concrete layers up to approximately 100 mm from areas of up to approximately 2 m².

Removal of concrete is done by cutting with pneumatic or electrical handheld hammers.

Other demolition procedures include the following alternatives:

- Cutting with handheld diamondsaw
- Grinding with a cup-stone on a rotating handheld machine
- Cutting with high pressure water jet (more than 1000 bar).
- Demolition with hydraulic scissors handheld or machine mounted.
- Cutting with machinemounted pneumatic hammers.
- Cracking or splitting with mechanical tools.
- Blasting with explosives.
- Blowing (not explosives) with expansion mortar
- Cutting and drilling with diamondsaws or drills - machine mounted
- Mill cutting

Decisions concerning demolition methods should be approved by the owner or his representative.

Materials specifications

Before the work is initiated the necessary protections against dust, noise and shielding and scaffolding to support loose parts must be taken. Health and security precautions are required according to the "Arbejdsministeriets bekendtgørelser" re. 1-21.

Special precautions shall be taken when working close to prestressing steel. The prestressing cables must be located precisely before cutting of the concrete. Reinforcement must not be damaged by the demolition process.

When using water it must be of the same quality as drinking water.

The surface of the casting joint may be roughened by pneumatic cutting in order to approve the adhesion.

3.2 Cleaning of concrete surfaces

Application and properties

The method is used as preparation of concrete surfaces before filling out with mortar, shotcrete or concrete or before surface coating.

The method is used after the necessary removal of defect concrete or wrongly placed

concrete.

The surface is cleaned by water jetting at a pressure between 400 and 700 bar.

The surfaces are alternatively cleaned by the following methods:

- Blowing with compressed air.
- Sandblasting with water, at pressure 400-700 bar and sand 0,4-0,8 mm.

Materials specification

Before the work is initiated the necessary protections against dust, noise and shielding and scaffolding to support loose parts must be taken. Health and security precautions are required according to re. 1-21.

When using water it must be of the same quality as drinking water.

When using compressed air it shall be free of air.

3.3 Cleaning of cooling pipes

Application and properties

The method is used as preparation before injection of cooling pipes and prestressing ducts.

The ducts and pipes are kept dry by establishing drains and using compressed air. Before injection the ducts and pipes are checked for obstacles, using compressed oil.

Materials specification

Health and security precautions are required according to re. 1-21.

When using compressed air it shall be free of oil.

3.4 Preparations of cracks

Application and properties

The method is used as preparations of the concrete surface near cracks before sealing and placing of packers which is glued over the cracks.

The cracks at the surface are cleaned with water jetting at a pressure not exceeding 200 bar.

The cracks may be investigated by inspection of cores or injection of coloured water as outlined in the guidelines for Working procedure 8 Injection of cracks.

Materials specifications

Health and security precautions are required according to re. 1-21.

Water shall be of the same quality as drinking water.

3.5 Repairs with mortar

Applications and properties

The method can be applied, when repairing settlements, honeycombs, limited cavities and holes from cores etc.

Repair mortar can be applied on vertical, horizontal and undersides surfaces.

Repair mortar can be used for layers of up to 40 mm or less - the layers shall correspond to the size of aggregates in the mortar.

Repairs with mortar and bonding primer is not allowed to be made below +5°C and when exposed to direct sun and strong wind.

Materials properties

Health and security precautions are required according to re. 1-21.

Material safety code not higher than 0 - 4, re. 2.

The repair-system may consist of mortar and primer. The materials must be declared in REPTON and possess the listed demands:

Mortar and primer are not allowed to contain aluminum cement according to DS 411. Content of water soluble chromate must not exceed 0.2 mg/kg cement determined according to DS 1020.

Chloride must not have been mixed in and the chloride content must not exceed 0.1 % of the binding mass (cement, flyash etc).

Specification of repair mortar:

Properties	Test method	Specification
Service time	NT Build 197	1 hour (20° C) (recommandation)
Consistency and workability	Visual evaluation	The workability shall make it possible to apply the mortar on vertical surfaces or undersides if necessary (recommandation)
Compression strength	DS 423.23 (Cube strength)	Equal to the structural concrete, ± 10%
Adhesion strength	NT Build 365 (Adhesion)	Min. 1,2 MPa, average 1,5 MPa according to re. 22
Deformation	NT Build 366 (Shrinkage) NT Build 367 (Temperature deformation) DS 423.25 (Modulus of elasticity)	Shrinkage max 0.10 % Temperature deformation max 1,5 10-5 pr°C Elasticity equal to the structural concrete, ± 10%
Durability	NT Build 443: Chloride permeability Frost-resistance:NT Build 376 or SS 13 72 44	Equal to the structural concrete, ± 10%

Specification of bonding primer:

Properties	Test method	Specification
Service time	NT Build 197	1 hour (20° C) (recommandation)
Adhesion strength	NT Build 365 (Adhesion)	Min. 1,2 MPa, average 1,5 MPa according to re. 22

The chosen product has to be approved by the owner or his representative before the repair is started.

The pot-life of the mortar and bonding primer is affected by temperatures. In the summertime it must be noticed that the pot-life is reduced.

In order to obtain the best possible repair, the mortar must be compacted, in order to avoid cavities in the repair mortar.

The repair must be protected from sun and rain. In hot and dry weather it is important that careful protection against evaporation is made immediately after the repair.

When applying more layers - the previous layer must be sufficiently hardened.

3.6 Repairs with shotcrete

Applications and properties

For repairs of large-scale honeycombs and cavities or repairs of incorrect concrete cover thickness, the method of filling in with shotcrete can be applied.

Shotcrete can be applied on vertical, horizontal and undersides surfaces.

The layers of the shotcrete shall correspond to the size of aggregates.

Shotcrete is not allowed to be made below +5°C and exposed to direct sun and strong wind.

Materials specifications

Health and security precautions are required according to re. 1-21.

Material safety code not higher than 0 - 4, re. 2.

The reinforcement applied has to be steelmesh 3 x 50 x 50 mm or stainless steel 5 x 100 x 100 mm.

The materials must be declared in REPTON and possess the listed specifications

Water shall be of the same quality as drinking water.

The shotcrete is not allowed to contain aluminum cement according to DS 411. Content of water soluble chromate must not exceed 0.2 mg/kg cement determined according to DS 1020.

Chloride must not have been mixed in or the chloride content must not exceed 0.1 % of the binding mass (cement, flyash etc).

Properties	Test method	Specification
Compression strength	DS 423.23 (Cube strength)	Equal to the structural concrete, \pm 10%
Adhesion strength	NT Build 351 (Bond strength)	Min. 1,2 MPa, average 1,5 MPa according to re. 22
Deformation	NT Build 352 (Shrinkage)	Shrinkage max 0,10 %
Durability	NT Build 443: Chloride permeability or ASSHTO T277-832 Rapid Chloride Permeability Test Frost-resistance:NT Build 376 or SS 13 72 44	Equal to the structural concrete, \pm 10%

3.7 Repairs with concrete

Application and properties

Concrete is applied when repairing large settlements, honeycombs and cavities.

Concrete can be applied on vertical surfaces in forms and on horizontal surfaces.

Repair concrete is used for layers of more than 40 mm.

Casting of concrete is not allowed to be made below +5°C. The fresh concrete shall be protected against direct sun or strong wind.

Materials specification

Health and security precautions are required according to re. 1-21.

Material safety code not higher than 0 - 4, re. 2.

The applied repair concrete should be identical to the construction concrete. If the repair concrete not is mix identical to the structural concrete the materials, must be declared in REPTON and possess the specifications of the construction concrete.

The repairconcrete may need more workability, because it is somewhat difficult to compact this particular repair.

3.8 Injection of cracks

Applications and properties

This method is applied for water tightening of cracks exposed to water. The cracks may vary from 0.1 mm.

The method may also be used for dried cracks.

When using foaming polyurethane, temperatures may go down to 0°C, provided no ice inside the crack. When using 2 component polyurethane temperatures may go down to 3°C. With temperatures are here temperatures 20 - 30 mm inside the concrete to be considered.

Materials specification

Health and security precautions are required according to re. 1-21.

Material safety code not higher than 0 - 6, which means the materials must be solvent free. Re. [2].

The injection fluid is chosen among the following:

- Polyurethanes, foaming or 2-component.
- Acryl modified.

Alternatively epoxy is used for dry cracks and structural purposes.

Properties	Test method	Specification
Viscosity	According to ZTV-RISS 93	Acrylic gel: Min 50 mPas at 20°C Polyurthane: Min. 100 mPas at 20°C
Gel time	According to ZTV-RISS 93	Acrylic gel: 1 s-4 hours (20°C) Polyurthane: 50 s-2 hours (20°C)
Corrosive	—	Must be of anti-corrosive type
Dehydration	Visual inspection of dry samples which are exposed to water	Full expansion after dehydration. (Acrylic gel)
Durability	—	Durable in alkaline and aggressive water environment

3.9 Surface coating

Application and properties

Surface coating can be applied when there is a need for reducing the chloride permeability of the concrete, the carbon dioxide permeability and reducing the water permeability without entrapping damp.

The materials which can be used according to the Road Directorate re. 22. Surface treatment are:

- Acrylic high build paint
- Elastic acrylic cement based layer
- Unelastic acrylic cement based layer
- Elastic acrylic based layer

Impregnation is not allowed on the bridges.

The systems are described in details in "Udbud og anlægskforskrifter". Betonbroer. Overfladebehandling af betonoverflader re. 22". As a summary of the recommendations the following can give some indications:

Elastic acrylic high build paint is not recommended for concrete surfaces with cracks and surfaces exposed to traffic.

Elastic acrylic based layer can be used on concrete surfaces with small cracks, but not on surfaces exposed to traffic.

Unelastic acrylic cement based layer is not recommended for surfaces with cracks, but there are no limitations to light traffic.

Elastic acrylic cement based layer can be used on concrete surfaces with small cracks, but not on surfaces exposed to traffic.

Materials specification

Health and security precautions are required according to re. 1-21.

Materials safety code not higher than 0 - 3 and for primers max 1-3, re.2

As a summary the following specifications can be described:

- Alkali durability in 5 years determined by inspections and by testing of adhesion tests VDPRØV 04/93. Re 29.
- Weathering. Durability in 3 years. Visual inspection and DIN 54003, DIN 54001 and DIN 16624.
- Dirt and cleaning. Easy to clean by water jetting at 60 bar. Visual inspection

- Maintaining. Easy to maintain according to the supplier's specifications.
- No pores. Visual inspection.
- Effects equivalent as 10-20 mm of concrete according to test method APM 402.
- Adhesion strength min 1.2 Mpa according to VDPRØV 04/93.
- Water resistance: NT Build 342 Class 1 after 24 hours. Classified as very water resistant.
- Water-damp-permeability: ASTM E96-80 max $Z_{H_2O}=2.5 - 10$ Gpasm²/Kg.
- Carbondioxide resistivity more than $Z_{CO_2}=3000$ Gpasm²/Kg (NT-BUILD 300) or effect equivalent as 20 mm of concrete according to test methos NT-BUILD 372.
- When cracks are to be covered with elastic coating min. crack width are 0,8 mm tested according to re. 22.

3.10 Injection of cooling pipes

Application and properties

The method is applied when injecting cooling pipes.

Materials specifications

Health and security precautions are required according to re. 1-21. Materials safety code not higher than 0-4.

The grout shall consist of Portland cement, water and admixtures and must not contain aluminum cement according to DS 411. Content of water soluble chromate must not exceed 0.2 mg/kg cement determined according to DS 1020.

Chloride must not have been mixed in or the chloride content must not exceed 0.1 % of the binding mass (cement, flyash etc.).

The fluidity of the grout during the injection period shall be sufficiently high for it to be pumped effectively and adequately to fill the pipe, but sufficiently low to expel the air and any water. When tested according to EN 445 Grout for prestressing tendons - Test methods, the results shall meet the specification in EN 447 Grout for prestressing tendons - specification for common grout.

The bleeding of the grout shall be sufficiently low to prevent excessive segregation and settlement of the grout materials. When tested according to EN 445 Grout for prestressing tendons - Test methods, the bleeding shall be less than 2 % of the initial volume of the grout after 3 hours.

The strength of the grout shall be not less than 30 Mpa at 28 days or 27 Mpa at 7 days, when tested according to EN 445 Grout for prestressing tendons - Test methods.

4. Guidelines for working procedures of repairs

The guidelines include the following working procedures, which is divided into groups conforming to the drafts in European Standard re. 28:

Preparations of repairs:

- Working procedure 1. Removal of defect concrete and wrongly placed concrete
- Working procedure 2. Cleaning concrete surfaces
- Working procedure 3. Cleaning of cooling pipes
- Working procedure 4. Preparations of cracks

Structural and non-structural repair:

- Working procedure 5. Repairs made with mortar
- Working procedure 6. Repairs made with shotcrete
- Working procedure 7. Repairs made with concrete

Concrete injection:

- Working procedure 8. Injection of cracks
- Working procedure 10. Injection of cooling pipes

Surface protection

- Working procedure 9. Surface coating

The guidelines must only be used by skilled labourers.

Operators and handcrafts must have been trained by the suppliers. Skills should be demonstrated on trial repairs before applications on the structures.

The guidelines must only be used after inspections, evaluations and planning according to the guidelines outlined in part 2 and 3 of this report.

4.1 Working procedure 1 removal of concrete with defects or non-conformities

Safety and health

Health and security precautions are required according to re 1-21 and the instructions from the suppliers: The operators must wear goggles, gloves, protection of the face and ear protection when using noisy tools.

Application instructions

The water must be of the same quality as drinking water.

Compressed air must be free of oil.

The area where concrete shall be removed must be marked before hand and approved by the designer or other competent authority. Areas outside this part must not be damaged.

The edges are cut with a diamondsaw in an angle of 90° in the depth of 20 mm.



Figure 2: *Casting joints*

The concrete is removed by cutting with pneumatic scaling hammer or alternative methods depending on the situation in question - amount of defects, design of reinforcement and other conditions.

The reinforcement must not be knocked on directly with the hammer.

After the removal of the concrete with defects the surface is treated with water jetting with a pressure between 400 and 700 bars. Water is removed from the building site without damaging the surroundings. The concrete is treated until a sound and clean base without any loose particles is observed.

Where reinforcement is exposed the concrete must be removed min. 20 mm behind the bars. The reinforcement is also cleaned by water jetting of up to 700 bars.

Quality control

1. No delaminations must be found when the prepared concrete surfaces are controlled by acoustic testing with a hammer. The sound must not vary from the areas of concrete with no defects.
2. No delaminations, cracks or inhomogenities must be found by visual examinations of cores which are drilled out of the prepared surfaces after each 10 repairs.

4.2 Working procedure 2 cleaning of concrete surfaces

Safety and health

Health and security precautions are required according to re 1-21 and the instructions from the suppliers: The operators must wear goggles, gloves, protection of the face and ear protection when using noisy tools.

Application instructions

The water must be of the same quality as drinking water.

The concrete surfaces are treated with water jetting with a pressure between 400 and 700 bars. Water is removed from the building site without damaging the surroundings.

Quality control

1. No loose particles or dirt must be found when the prepared concrete surfaces are controlled by observation of set-offs on a black cotton cloth, which has been rubbed against the cleaned concrete surface according to VDPRØV. 03/93.
2. The adhesion strength of the cleaned surface, determined according to VDPRØV 04/93 shall have a min. 1.2 Mpa and average 1.5 Mpa, re.29 and 22.

4.3 Working procedure 3 cleaning of cooling pipes

Safety and health

Health and security precautions are required according to the re. 1-21 and the instructions from the suppliers: The operators must wear ear protection when using noisy tools.

Instructions

Before injection of the cooling pipes, the pipes are kept dry by establishing drains and using compressed air. The compressed air must be free of oil.

It must be ensured that water is not entrapped in the ducts and risks of freezing damages shall be avoided.

Quality control

No water must be entrapped in the ducts. This may be controlled by blowing the pipes with compressed air.

4.4 Working procedure 4 preparation of cracks for injections**Safety and health**

Health and security precautions are required according to re. 1-21 and the instructions from the suppliers: The operators must wear goggles, gloves, protection of the face and ear protection when using noisy tools.

Application instructions

The water must be of the same quality as drinking water.

Holes for packers are treated with water jetting with a pressure between 20 and 100 bar.

Surfaces near the cracks which are going to be sealed are cleaned with water jetting with a high pressure not higher than 200.

Water is removed from the building site without damaging the surroundings.

Quality control

No loose particles or dirt must be found when the prepared concrete surfaces are controlled by observation of set-offs on a black cotton cloth, which has been rubbed against the cleaned concrete surface according to VDPRØV. 03/93.

4.5 Working procedure 5 repairs made with mortar**Safety and health**

Materials code 0-4, re. 2. Health and security precautions are required according to re. 1-21 and the instructions from the suppliers: The repair materials contain cement and the uncured materials are caustic. Use gloves and protective goggles whilst mixing and during application.

Application instructions

The repair system is mortar based on cement combined with a bonding primer. The materials may be delivered as one or several components.

The materials must be kept dry and in a frost-free store.

The materials are to be mixed according to the manufactures instructions of mixing ratio and mixing time.

The concrete surface at the casting joint must be solid, free of loose particles and

proper preparations must be made according to the preparation in working procedures 1 or 2. Water must be applied to the concrete surface in such a way that the surface is mat damp. Very dry concrete may be prewetted the day before.

A primer is applied with a brush and with great care in such a way that the construction joint is covered with a layer of approx. 1 mm. The filling with mortar is applied with a float board within the mortars pot life and while the primer is still wet. Correct compaction of the mortar without cavities is of great importance.

When the filling is accomplished, the mortar must be protected from drying out, from sunshine and wind for at least 5 maturity days. Protection can be made with curing-compound, plastic etc.

Quality control

1. Climate demands: Air- and concrete-temperatures below +5 °C are not allowed until the mortar has hardened. The min. temperature of the day must be registered.

2. Surface specifications: Surface geometry: +/- 3 mm measured on a 1.0 m long straightedge. The repair-surface must be smooth and without cracks, holes or other faults.

3. Adhesion control: Pull-off strength according to NT Build 365 must be min. 1,2 MPa and an average of 1,5 MPa. 3 tests per 10 repairs. Re. 22.

4. Control by inspection of cores per every 10 repairs. One core is drilled in the centre of the repair and one at the construction joint. Cracks are not allowed, neither are signs of inhomogeneous mixing, air voids or lack of adhesion and delaminations.

4.6 Working procedure 6 repairs made with shotcrete

Safety and health

Material code 0-4, re. 2. Health and security precautions are required according to re. 1-21 and the instructions from the suppliers: The repair materials contain cement and the uncured materials are caustic. Use gloves and protective goggles whilst mixing and during application.

Application instructions

Materials must be kept dry in a frost-free store and mixed according to the manufacturer's instructions.

The concrete surface must be solid, free of loose particles and proper preparations must be made according to the preparation working procedures 1 and 2. Reinforcement is arranged if the thickness of the repair is more than 30 mm. The reinforcement is fixed to existing reinforcement, to drilled-in anchors fixed with glue or to hammered-in plugs. The anchors are not allowed to be in contact with the cast-in

reinforcement.

Water must be applied to the concrete surface in such a way that the surface is mat damp. Very dry concrete may be prewetted the day before.

The area to be filled in has to be framed and adjoining areas are to be covered.

Shotcrete is sprayed on by means of special equipment. The shotcrete is built up from the bottom and upwards. Normally the nozzle is operated in rotating movements, almost perpendicular to the surface. Applied distance is normally the one which results in the least rebound-material.

At the start spraying of the repair area is not allowed until flow from the nozzle is constant. At start and in reinforced areas the mixture used normally has a higher w/c.

Ingoing corners are sprayed first in order to get the best result.

When building shotcrete in several layers, it is important, that the first layer has achieved the necessary strength. Rebound-material is not to be used, and must continuously be removed from the area.

At reinforcement the shotcrete is filled in from both sides of the bar in order to fill the caves behind the bar properly.

Casting joints in the shotcrete are not allowed.

The work procedure is accomplished by plastering until the surface is 5 mm behind the surrounding concrete surface. Smoothing is not allowed. The shotcreted area is covered with a taped plastic foil and cured for 24 hours.

The following day the foil is removed and the surface is cleaned by light water spraying. A bonding primer is added to the surface and a mortar is applied, according to working procedure 5: Repairs made with mortar. Finally the repair area is sealed with plastic foil. The mortar must be protected from drying out, from sunshine and wind for at least 5 maturity days.

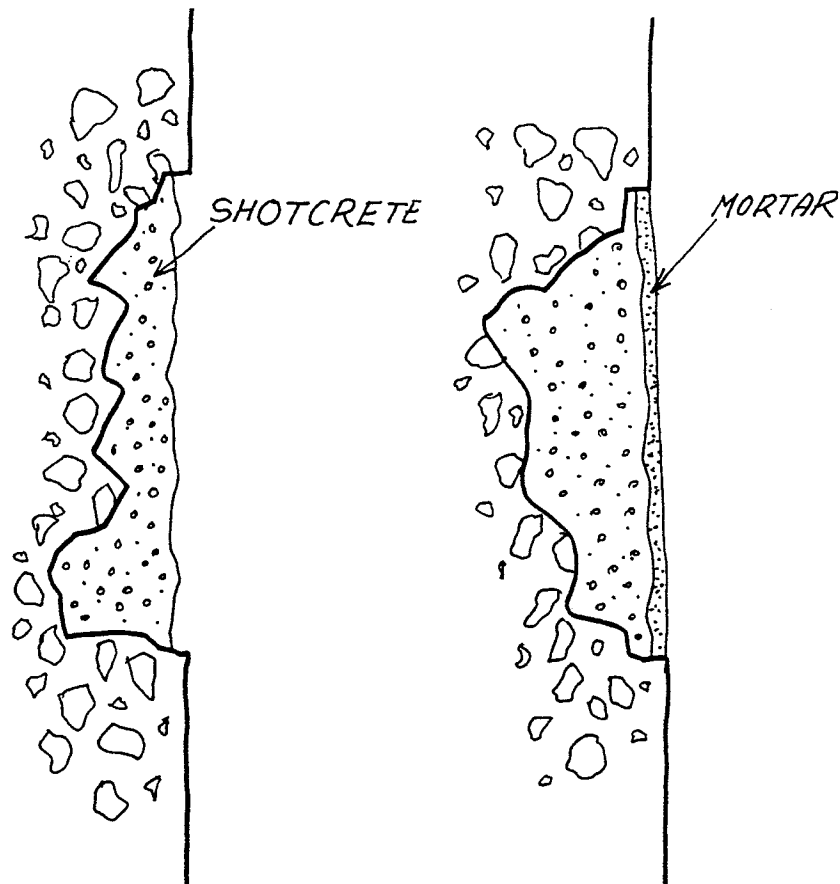


Figure 3: *The shotcrete is finished approx 5 mm from the surfaces, and the repair is finished with mortar applied with float board.*

Quality control

1. Climate demands: Air- and concrete-temperatures below +5 °C are not allowed until the shotcrete has hardened. The min. temperature of the day is to be recorded. VDPRØV 17/93

2. Surface specifications: Surface geometry: +/- 1 mm measured on a 1.0 m long straightedge. The repairsurface must be smooth and without cracks, holes or other faults.

3. Adhesion control: Pull-off strength according to NT Build 365 must be min. 1,2 MPa and an average of 1,5 MPa. 3 tests per 10 repairs. re 22.

4. Control by inspection of cores per every 10 repairs. One core is drilled in the centre of the repair and one at the construction joint. Cracks are not allowed, neither are signs of inhomogeneous mixing, air voids or lack of adhesion and delaminations.

4.7 Working procedure 7 repairs made with concrete

Safety and health

Material code 0-4, re. 2. Health and security precautions are required according to re 1-21 and the instructions from the suppliers: The repair materials contain cement and the uncured materials are caustic. Use gloves and protective goggles whilst mixing and during application.

Application instructions

The dry-mix materials must be kept dry in a frost-free store and mixed according to the manufacturer's instructions.

The concrete surface in the casting joint must be solid, free of loose particles and proper preparations must be made according to the working procedures 1 and 2. Water must be applied to the concrete surface in such a way that the surface is mat damp. Very dry concrete may be prewetted the day before.

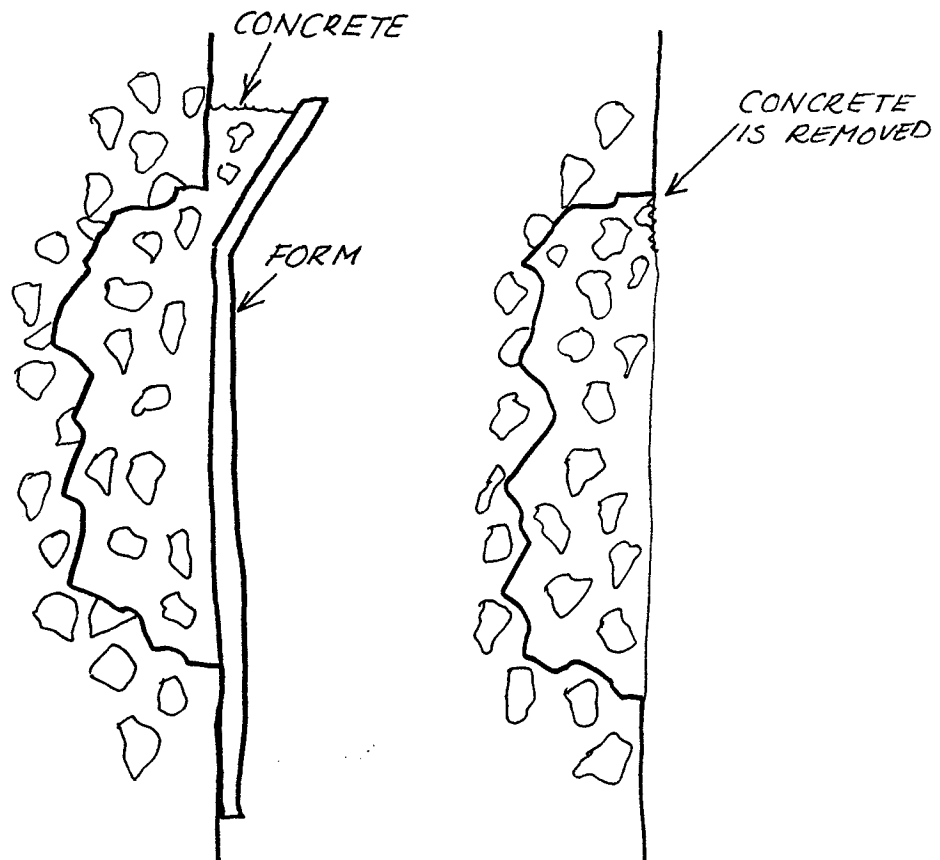


Figure 4: On vertical surfaces a form has to be set up. After removing the form the top joint is repaired with mortar.

A primer is applied, and ordinary concreting is accomplished and the concrete is compacted by vibration.

After filling in the concrete must be protected from drying out, from sunshine and wind for at least 5 maturity days and protected from rain for 24 hours. Protection can be made with curing compound, plastic foil etc. If plastic foil is used, the foil is taped at all sides.

If the repair is to be accomplished at a vertical surface, concrete formwork must be applied. When the form is removed the top joint is repaired: The excess concrete is removed according to working procedure 1. A bonding primer is added to the surface and mortar is applied, according to working procedure 5: Repairs made with mortar. Finally the repair area is sealed with plastic foil. The mortar must be protected from drying out, from sunshine and wind for at least 5 maturity days.

The repairsurface must be smooth and without cracks, holes or other faults.

Quality control

1. Climate demands: Air- and concrete-temperatures below +5 °C are not allowed until the concrete has hardened. The min. temperature of the day is to be registered. VDPRØV 17/93

2. Surface specifications: Surface geometry: +/- 1 mm measured on a 1.0 m long straightedge. The repairsurface must be smooth and without cracks, holes or other faults.

3. Adhesion control: Pull-off strength according to NT Build 365 must be min. 1,2 MPa and an average of 1,5 MPa. 3 tests per 10 repairs.

4. Control by inspection of cores per every 10 repairs. One core is drilled in the centre of the repair and one at the construction joint. Cracks are not allowed, neither are signs of inhomogeneous mixing, air voids or lack of adhesion and delaminations.

4.8 Working procedure 8 injection of cracks

Safety and health

Material code 0-3, re. 2. Health and security precautions are required according to re.1-21 and the instructions from the suppliers: The repair materials may contain acrylic and polyurethane. Use protection of mouth, gloves and protective goggles whilst mixing and during application.

Application instructions

Materials must be kept dry in a frost-free store and mixed according to the manufacturer's instructions.

Cracks are marked on the concrete surfaces and registered according to the example in appendix 2 and approved by the owner or his representative.

The directions and the course of the cracks must be examined e.g. by drilling out cores and/or by injection of coloured water.

Alternatively injection can be made in accordance with the different methods described below:

- Injection through drilled-in packers. Holes are drilled from both sides of the crack at an angle of 45-60° vertical. The holes are drilled 10-20 mm past the crack in the centre of the concrete.
The spacing between the packers is approx. 0.5 x crack-depth, max. 350 mm.
- Injection through drilling in spears to the middle of the cracked cross-section. The crack is not sealed. Holes are drilled from both sides of the crack at an angle of 45-60° vertical. The holes are drilled 10-20 mm past the crack in the centre of the concrete.
- Injection through glued-on packers, and with a sealed crack. The spacing between the packers is approx. 0.9 x crack-depth.

For all the above-mentioned methods, pumping aggregate has to be applied. Pumping pressure shall not exceed 200 bar. For glued-on packers the pressure shall not exceed 60 bar.

The cracks which are going to be sealed and approx. 50 mm at both sides are cleaned according to work procedure 4: Preparation of cracks.

The injection is started at level of 40 bar increasing up to 200 bar.

When the injection-fluid has hardened up, packers and sealing material can be removed.

Injection of cracks are to be made by skilled workers only.

The hardening of the injection materials may be controlled on samples taken from the batch at the injection pump.

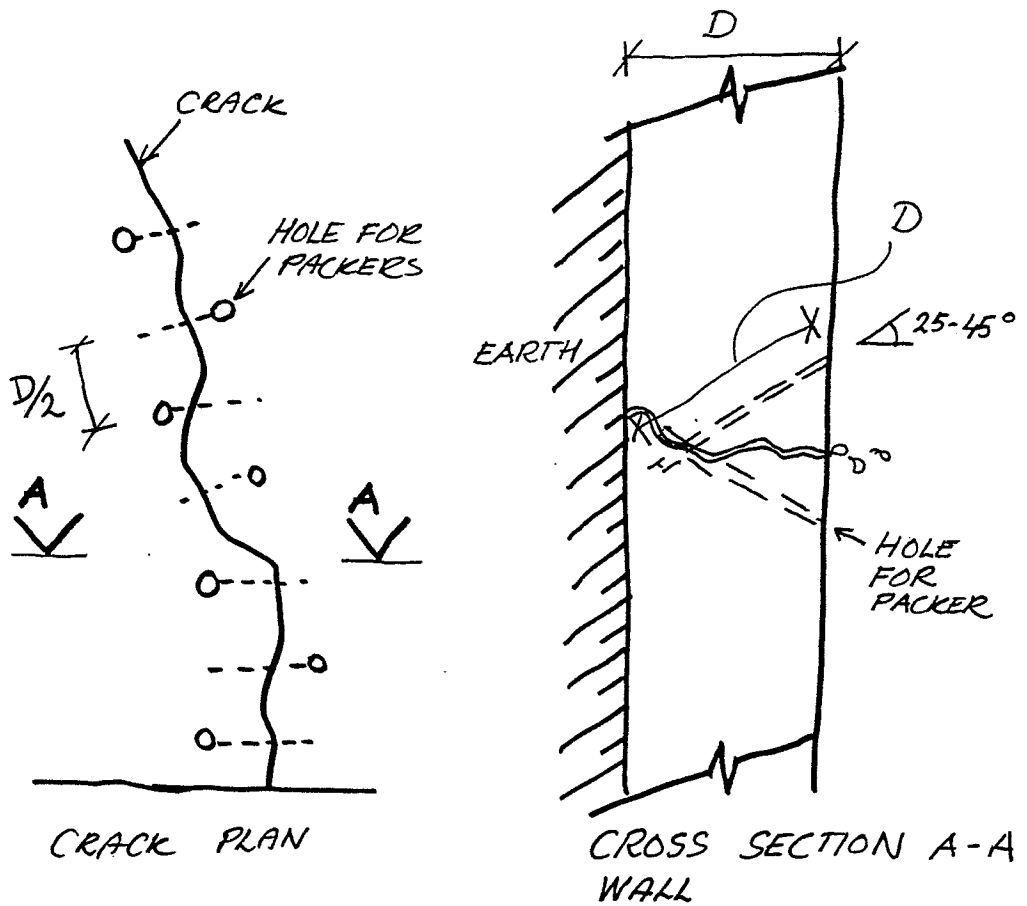


Figure 5: A certain number of packers will be attached on both sides of the crack. The distance between the packers depends on the depth of the crack and the type of packers.

Injection with acrylic

The crack must be cleaned before the injection with acrylic modified materials is carried out.

Injection with polyurethane

When injecting with 2 component polyurethanes sealing must have hardened before injection takes place. The surface around the cracks has to be cleaned, free from dust, grease, oil etc. according to working procedure 4 Preparations of cracks before sealing is done.

When injection with foaming polyurethane the concrete surface near the crack is prewetted before injection. The injection is carried out with the lowest possible pressure. Pumping is continued until polyurethane is flowing out of the crack. After approx. 1 hour the cracks must be re-injected at a higher pressure.

Quality control

1. Climate demands: Air- and concrete-temperatures below +5 °C are not allowed until the injection-fluid has hardened. The min. temperature of the day must be registered. VDPRØV 17. The hardening of the injection must be controlled on samples. Process data is registered on charts as the example in appendix 2.
2. Visual inspections on cores for every 10 repairs. The cracks must be filled.
3. The contractor fills out an injection protocol (appendix 2), with a record of all effected conditions such as concrete temperature, weather conditions, scope of materials, etc.

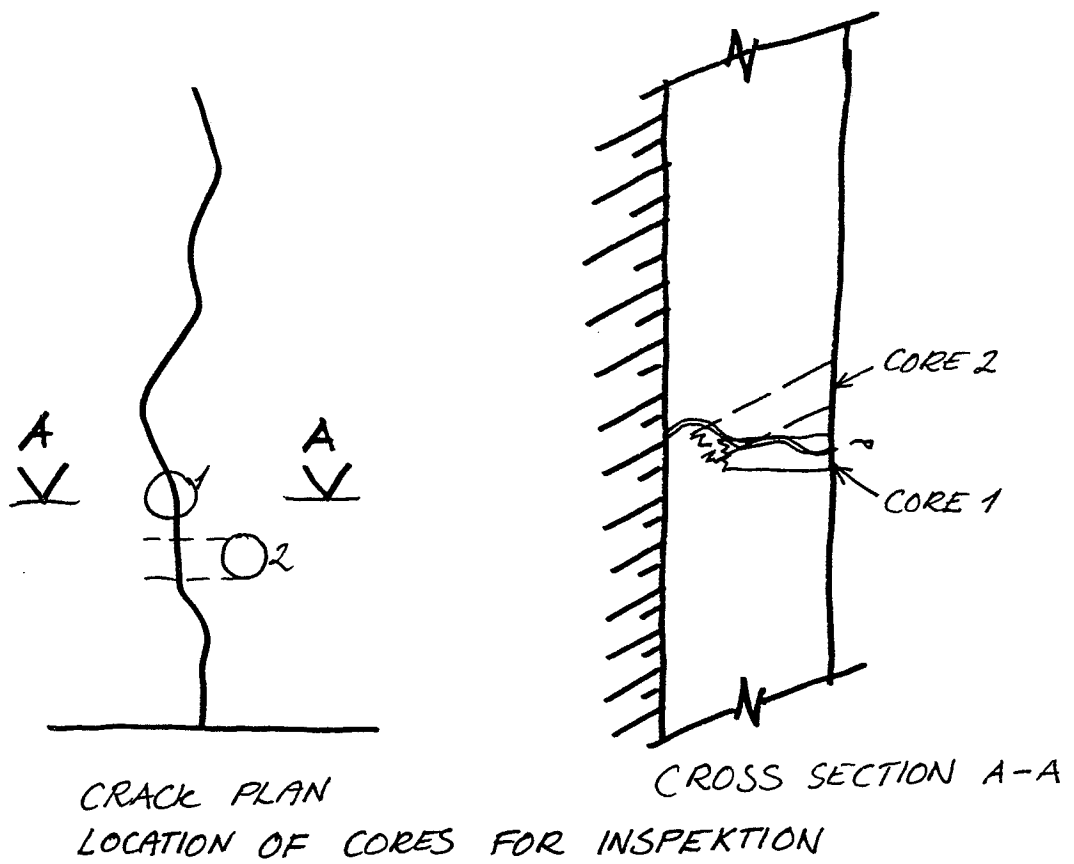


Figure 6: Control by inspection of cores per every 10 repairs. Cores are drilled in the crack.

4.9 Working procedure 9 surface coating

Safety and health

MAL code 0-3, re. 2. for top coat and 1 - 3 for primer:

Health and security precautions are required according to re. 1-21 and the instructions from the suppliers: The repair materials contain organic solvent.

Application instructions

The materials are to be preserved and mixed accordingly to the manufacturer's instructions of mixing ratio and mixing time. The materials must be kept dry and in a frost-free store.

The surface treatment must not be applied before the concrete surface is hardened sufficiently. The concrete surface must be dry, solid, free of loose particles and proper preparations must be made according to the working procedure 2 Cleaning of concrete surfaces and/or repaired according to working procedures 5-7.

The fluid is applied by brush or roller with an amount according to the supplier's specifications. The fluids may be applied in several operations including application of primers.

Quality control

1. Climate demands: Air- and concrete-temperatures below +5 °C are not allowed during the repair. Relative humidity of the air must not be more than 80%. The surface must not be exposed to sun and strong wind. The climate of the day must be registered according to VDPRØV 17/93 and VDPRØV 05/93 3 times a day.
2. Visual inspection of 10 % to detect inhomeginitities in the surfaces.
3. Control of 10 %, no set-offs on a black cotton cloth according to VDPRØV 03/93.
4. Adhesion control according to VDPRØV 04/93 in each control section. Adhesion strength higher than 1,2 MPa.

4.10 Working procedure 10 injection of cooling pipes

Safety and health

MAL code 0 - 4, re. 2.

Health and security precautions are required according to re. 1-21 and the instructions from the suppliers: The repair materials contain cement and the uncured materials are caustic. Use gloves and protective goggles whilst mixing and during application.

Application instruction

All materials shall be mixed accordingly to the manufacturer's instructions or EN 446 Grout for prestressing tendons - Grouting procedures.

Before injection of grout, the pipes and the ducts are prepared according to working, procedure 3 in part 4.3.

The injection shall ensure that the pipes are completely filled. Pipes and ducts shall be grouted from the lowest inlet. Grouting shall continue until the fluidity of the grout flowing from the outlets is the same as the grout being injected to within the limits specified in part 3.10. Pipes shall be grouted at a continuous and steady rate which shall be slow enough to prevent the segregation of the water from the grout at points where flow is restricted.

The grout shall be used within the appropriate time limit according to the manufacturers or EN 446.

After completion of grouting the unintended loss of grout from the pipes shall be prevented.

Quality control

Climate demands: Air- and concrete-temperatures below +5 °C are not allowed until the grout has hardened. The min. temperature of the day must be registered. Max temperature may be considered according to the manufacturer or EN 446.

Testing of equipment and grout shall comply to the requirements in EN 446.

5. Budget cost estimate prices

Budget cost estimates are listed below based on experiences from maintenance of bridges as described in "Eftersyn af bygværker, Vejdirektoratet, november 1994".

Price index Januar 1997		
Subject	DDK (min)	DDK (max)
End support		
Shotcrete (ex reinforcement)	2.200	3.300
Middle support		
Shotcrete (with reinforcement)	3.300	5.400
Castein	1.100	2.200
Mortar repairs	330	500
Cleaning	30	50
Injections of cracks	4.300	6.500
Thin coating	110	220
Thick coating	400	700
Repair of dilatation joints	330	540
Repair of soft joints	330	540

The table can be used for estimates and budgets. The prices include costs such as:

- traffic regulations
- disturbances and abruptions due to traffic
- difficult access to the work site

When using the price lists for estimates of the repair costs in the construction phase a reduction of approximately 30-40 % is realistic.

To demonstrate the price estimates of the working procedures the following situations are estimated:

- Repairs of honeycombs with mortar - working procedures 1. 2 and 5
- Repairs of honeycombs with shotcrete - working procedures 1.2 and 6
- Injections of cracks - working procedures 4 and 8

The repairs concern routine repairs made on high quality concrete. The repairs are made in the fall and no special precautions concerning the weather have to be considered. The repairs are made while the construction works are continued. The repairs are executed with handcrafts with special experience in repairs either from the casting crew or from another party (external support).

The examples include price estimates of preparations, applications and quality control. The price estimate is prepared as for a situation with a minimum of 10 repairs.

The price also includes a test repair where the skill of the handcraft are demonstrated and a test of the repairs are made according to the working procedures.

5.1 Repairs of honeycombs with mortar

The honeycomb is approximately 1.0 m wide and 0.5 m high and 40 mm deep. The honeycomb is located on a bridge column approximately 1 m above ground level.

The repair is prepared according to working procedure 1: Removal of concrete with defects.

The repair is made with mortar as RENEDEROC HB40 according to working procedure 5: Repairs with mortar.

Designation	Quantity	Unit	Unity price	DDK	Total amount in DDK
1. REPAIRS OF HONEYCOMBS WITH MORTAR					
a. Mobilization					
Mob/demob		ls		300	
Transportation of equipment		ls		240	
Transportation of personnel	20,0	km	3	60	600
Transportation of personnel	1	km	300	300	900
b Repairs					
Cutting with diamondsaw	3,0	m	60	180	
Blasting with compressor	0,5	m2	180	90	
Special mortar	0,5	m2	400	200	
Finish	0,5	m2	80	40	510
c QA Core drilling and inspection					2000
Sub-total					3.410
d Contingencies	app. 10,0	%			340
e Total repair (5 - 10 nos)				1each	3.750

Numbers of repairs between 1 and 5 - the above price shall be increased by 30%
 Numbers of repairs more than 10 - the above price shall be decreased by 20%.

5.2 Repairs of honeycombs with shotcrete

The honeycomb is approximately 2.0 m wide and 0.5m high and 0.2 m deep. The honeycomb is located at the underside of a bridgedeck approximately 7 m above ground level.

The repair is prepared according to working procedure 1: Removal of concrete with defects.

The repair is made with shotcrete according to working procedure 6: Repairs with shotcrete.

Designation	Quantity	Unit	Unity price	DDK	Total amount in DDK
2. REPAIRS OF HONEYCOMBS WITH SHOTCRETE					
a. Mobilization					
Mob/demob		ls		650	
Scaffold up to 6 m		ls		450	
Transportation of equipment		ls		360	
Transportation of personnel	20,0	km	3	60	1.820
Transportation of personnel	1	km	300	300	
b Repairs					
Cutting with diamondsaw	5,0	m	60	300	
Blasting with compressor	1,0	m2	180	140	
Shotcrete	0,2	m2	3.600	720	
Finish	1,0	m2	400	400	1.600
c QA Coredrilling and inspection					2000
Sub-total					5.420
d Contingencies	app. 10,0	%			540
e Total repair				1 each	5.960

Numbers of repairs between 1 and 5 - the above price shall be increased by 30%.
 Numbers of repairs more than 10 - the above price shall be decreased by 20%.

5.3 Injection of cracks

The crack is located in the tunnel wall from 0.5 to 2 m above ground level. Seawater is penetrating through. The crackwidth is varying up to 0.25 mm. The tunnel wall is 0.4 m thick.

The 6 packers are placed with a distance of 300 mm. The injection is made with acrylic gel. The injection is made according to working procedure 8 Injection of cracks and after the injection is the packers removed and the holes repaired according to working procedure 5 Repair with mortar.

Designation	Quantity	Unit	Unity price	DDK	Total amount in DDK.
3. INJECTIONS OF CRACKS					
a. Mobilization					
Mob/demob		ls		800	
Scaffold up to 6 m		ls		650	
Transportation of equipment		ls		400	
Transportation of personnel	20,0	km	3	60	2.210
Transportation of personnel	1	km	300	300	
b Repairs					
Water jetting	1,5	m	100	150	
Blasting with compressor	1,5	m	80	120	
Packers	6,0	each	220	1.320	
Injection	1,5	m	1.600	2.400	
Remove packers	6,0	each	170	1.020	
Finish, mortar	1,5	m	110	165	5.175
c QA		ls			2.000
Sub-total					7.175
d Contingencies	app. 10,0	%			715
e Total repair				1 each	5.260

Meters of repairs between 1 and 5 - the above price shall be increased by 30%
Meters of repairs more than 10 - the above price shall be decreased by 20%.

6. References

- [1] *Arbejdsministeriets bekendtgørelse nr 801 af 4. oktober 1993 om Støjgrænser på arbejdspladsen.*
- [2] *Miljøministeriets bekendtgørelse nr. 829 af 15. oktober 1993 om Klassificering, emballering, mærkning, salg og opbevaring af stoffer og produkter.*
- [3] *Arbejdsministeriets bekendtgørelse nr 867 af 13. oktober 1994 om Arbejdets udførelse.*
- [4] *Arbejdsministeriets bekendtgørelse nr. 1017 af 15. december 1993 om Indretning af byggepladser og lignende arbejdssteder.*
- [5] *Arbejdsministeriets bekendtgørelse nr. 1109 af 15. december 1992 om Anvendelse af tekniske hjælpemidler.*
- [6] *Arbejdsministeriets bekendtgørelse nr. 1996 af 26. marts 1985 om Epoxyharpikser og isocyanater mv.*
- [7] *At meddelelse nr. 1.01.8 september 1995. Ventilation.*
- [8] *At meddelelse nr. 3.01.3 1988 om Epoxyharpikser og isocyanater.*
- [9] *At meddelelse nr. 3.02.1 juni 1989. Stoffer og materialer.*
- [10] *At meddelelse nr.3.02.2 juni 1989. Brugsanvisning for stoffer og materialer.*
- [11] *At meddelelse nr. 3.02.3 januar 1989. Anmeldelse af stoffer og materialer.*
- [12] *At meddelelse nr. 3.02.5 april 1989. Arbejde med stoffer og materialer.*
- [13] *At meddelelse nr. 4.04.18 oktober 1990. Arbejde med højtryk renseanlæg.*
- [14] *At meddelelse nr. 4.05.02. 1995. Vurdering af løft.*

- [15] *At meddelelse nr. 4.06.1. 1995. Støj på arbejdspladsen.*
- [16] *At meddelelse nr. 4.06.5. 1995. Høreværn.*
- [17] *At meddelelse nr. 4.09.1 april 1990. Åndedrætsværn.*
- [18] *At meddelelse nr. 4.09.2 oktober 1985. Faldsikring.*
- [19] *At meddelelse nr. 4.09.3 oktober 1985. Øjenværn.*
- [20] *At meddelelse nr. 4.09.4 marts 1990. Beskyttelseshjelme*
- [21] *At meddelelse nr. 14.06.2 1985. Hånd-arm vibrator*
- [22] *Overfladebehandling af betonoverflader. Vejdirektoratet. Feb. 1997*
- [23] *BPS Typiske beskrivelsesafsnit. Betonrenovering 3. Høring Januar 1997.*
- [24] *HETEK. Repairs during the Construction Phase. Field studies. Report No. 68. Road Directorate. January 1996.*
- [25] *HETEK. Repairs during the Construction Phase. State of the Art. Road Directorate. September 1996.*
- [26] *HETEK. Repairs during the Construction Phase. Billedmateriale. Road Directorate. Maj 1996.*
- [27] *ZTV - SIB 90: Der Bundesminister für Verkehr. Bon. November 1990.*
- [28] *European Standards prEN1504-1, -3 and -9. Products and systems for the protection and repair of concrete structures. Drafts. Sep. 1995 Bruxelles.*
- [29] *Overfladebeskyttelse af betonbroer. Kontrol metode. Vejdirektoratet. April 1993.*
- [30] *HETEK. Repairs during the Construction Phase. Illustrations. March 1997.*

Appendix 1: Registration of defects and non-conformities.

Skema for registrering af afvigelser, eksempel

Entreprise:	Afvigelsesrapport nr.:
Entreprenør:	Dato:
Aktivitet:	
Lokalitet:	

Afv. nr.	Afv. type	Tegn. nr.	Vurdering af afvigelsens betydning: ingen/lille/stor	Kontrol sign.	Bemærkninger

Beskrivelse/skitse af afvigelse:

DEFECT REGISTRATION SLIP

ID./DATE.	ID./DATE.	ID./DATE.	ID./DATE.
01	11	21	31

DEFECT NO.	DESCRIPTION OF DEFECT		DEFECT LOCATION			DRAWING NO.	PREPARED DIMENSIONS				NCR. NO. OR ROUTINE REPAIR	REPAIR METHOD ACC. TO DOC. NO. 342.00100	REPAIR DATE	SIGN. FOR REPAIR FINISHED	COMMENTS	
			BD	TD	WI		W2	W	L	D						A
							MM	MM	MM	MM						

DOC. PREP. BY: _____
 WORK INSTRUK. NO.1 _____
 DOC.no: 342.00100.
 BELONGS TO NCR NO.1 _____
 ENCLOSURE NO.1 _____

LEGEND:

<p> C = CRACK D = DIRT A = AIRHOLES F = FINS/LUMPS S = SPACER M = MECHANICAL DEFECT </p>	<p> MC = MORE COVER BC = BAD COMPACTION HC = HONEY COMB LC = LESS COVER US = UNEVEN SURFACE </p>
---	--

<p> BD = BOTTOMDECK TD = TOP DECK WI = WALL 1 W2 = WALL 2 </p>	<p> O = OUTSIDE I = INSIDE T = TOP B = BOTTOM </p>
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Appendix 2: Registration charts for injection procedures.

Registrering og injicering af revner i tunnelvægge

SKEM4098b3.DOC

Etape nr. _____

Kontrolafsnit nr.: _____

Højre / Venstre

Registrering	Injicering	Dato dokument: _____
Indmåling	Dato: _____	Sign.: _____ Side: _____

Skitse:

Bundplade. OK. kote

Revne
 X Borehul
 O Diagonalt hul
 Vand

Foto:

Kontrol				Sign.
Besigtigelse	Tørt	Fugt	Vand	
Kompl. injicering:	Ja/ Nej			
		Godkendt tilsyn		Sign.
		Dato: _____		Sign.

Injicering af betonkonstruktioner

SKEM4098.DOC, Rev.: C

Etape: _____ Kontrolafsnit: _____ Dato: _____ Registrering: _____ Side: _____

Vægttykkelse: _____ Borediameter: _____ Ansvarlig for injicering: _____ Side: _____

Revne nr.	Revne inden injicering		Revnetype		Temp. luft/beton	Borehul		Injic. bolt Dim	Injic. bolt stk	Forbrug injicering		Efterinjicering		Revne efter injicering		
	OK (mm)	UK (mm)	Bredde (mm)	Temp. ratur		Bevægelses	Antal			Dybde	Hældning	Tryk (bar)	Tryk (kg)	Tryk (bar)	Tryk (kg)	OK (mm)

Bemærkninger

Appendix 3: Approval tests of coatings.

Systemoplysninger			
Leverandør	Materialetypebetegnelse	Produktnavn	Init
	Silikatmalebehandling		

Egenskaber for materialer i leveringstilstand					
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init
Miljøvenlighed	ATs bekendtgørelser skal overholdes	Arbejdshygienisk brugsanvisning	2	Ja / Nej	

Almene egenskaber for den behandlede overflade					
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init
Tilsmudsning	Ringe smudssamlings-tendens	Dokumenteres ved referencer	3	Ja / Nej	
Alkalibestandighed	Den behandlede overflade (på sydvendt lodret beton) skal være intakt efter 5 år	Dokumenteres ved referencer	3	Ja / Nej	
Vedligeholdsmulighed	Enkel og sikker genbehandling skal være mulig	Skriftlig genbehandlingsmetode skal foreligge	4	Ja / Nej	
Holdbarhed over for vejrlig	Mindst 3 år på lodrette sydvendte flader	Dokumenteres ved referencer (se V. B.1 s.4)	3	Ja / Nej	
Kulørbestandighed (Anvendes hvor væsentligt kulørt udseende ønskes)	Oplysning fra pigmentlev: Kulørægthed: »8« evt »7« Vejrbestandighed: »4-5« Alkaliegthed: »+«	Henholdsvis: DIN 54003 DIN 54001 DIN 16 624, blatt 2	5	Ja / Nej	

Specielle egenskaber for overfladebehandlingsystemet						
Den samlede planlagte behandling og lagtykkelse (incl. udfyldning) skal opfylde følgende krav:						
Egenskab	Krav	Metode	Målt værdi	Faneblad nr	Krav opfyldt?	Init
Vedhæftning og sammenhæng	Ingen enkeltværdier under 0,8 MPa	ISO 4624 og VDPRØV.04/93		6	Ja / Nej	
Vanddampdiffusionsmodstand	Z _{H₂O} højst 2,5 GPa·s·m ² /kg	ASTM E 96-80		8	Ja / Nej	

Identifikationsprøvning					
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init
Densitet	Skal foreligge	ISO 2811 - 1976	10	Ja / Nej	
Tørstofindhold	Skal foreligge	ISO 1515 - 1973	10	Ja / Nej	
Sammensætning af bindemiddel	Skal foreligge	Infrarød spektroskopi	10	Ja / Nej	
Bemærkninger:			Firmastempel, dato og underskrift		

Forkortelser: V. = Vejledning i overfladebehandling af betonoverflader. B.= Bilag. s.= side.

Systemoplysninger			
Leverandør	Materialetypebetegnelse	Produkt navn	Init
	Acrylplastmalebehandling		

Egenskaber for materialer i leveringstilstand					
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init
Miljøvenlighed	ATs bekendtgørelser skal overholdes	Arbejdshygiejnisk brugsanvisning	2	Ja / Nej	

Almene egenskaber for den behandlede overflade					
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init
Tilsmudsning	Ringe smudssamlings-tendens	Dokumenteres ved referencer	3	Ja / Nej	
Alkalibestandighed	Den behandlede overflade (på sydvendt lodret beton) skal være intakt efter 5 år	Dokumenteres ved referencer	3	Ja / Nej	
Vedligeholdsmulighed	Enkel og sikker genbehandling skal være mulig	Skriftlig genbehandlingsmetode skal foreligge	4	Ja / Nej	
Rengøringsmulighed	Skal tåle højtryksspuling	Se V. B.1 s.8	3	Ja / Nej	
Holdbarhed over for vejrlig	Mindst 3 år på lodrette sydvendte flader	Dokumenteres ved referencer (se V. B.1 s.7)	3	Ja / Nej	
Kulørbestandighed (Anvendes hvor væsentligt kulørt udseende ønskes)	Oplysning fra pigmentlev: Kulørægthed: »8« evt »7« Vejrbestandighed: »4-5« Alkalægthed: »+«	Henholdsvis: DIN 54003 DIN 54001 DIN 16 624, blatt 2	5	Ja / Nej	

Specielle egenskaber for overfladebehandlingssystemet						
Den samlede planlagte behandling og lagtykkelse (incl. svumning) skal opfylde følgende krav:						
Egenskab	Krav	Metode	Målt værdi	Faneblad nr	Krav opfyldt?	Init
Vedhæftning og sammenhæng	Ingen enkeltværdier under 1,2 MPa	ISO 4624 og VDPØV.04/93		6	Ja / Nej	
Porefri overflade	Ingen gennemgående porer og revner	Visuel bedømmelse		3	Ja / Nej	
Vandafvisende evne	Tydelig vandafvisende overflade på betonunderlag (se V. B.1 s.8)	NT BUILD 342. Klasse 2 efter neddykning i 1 døgn		6	Ja / Nej	
Evne til at modvirke kloridindtrængning	Den ækvivalente beton-tykkelse skal svare til 10 mm af referencebetonen	APM 402		7	Ja / Nej	
Behandling bestående alene af den planlagte grundning og slutbehandling skal opfylde følgende krav:						
Egenskab	Krav	Metode	Målt værdi	Faneblad nr	Krav opfyldt?	Init
Vanddampdiffusionsmodstand	Z _{H₂O} højst 2,5 GPa·s·m ² /kg	ASTM E 96-80		8	Ja / Nej	
Kuldioxiddiffusionsmodstand	Z _{CO₂} mindst 3000 GPa·s·m ² /kg	NT-BUILD 300		8	Ja / Nej	

Identifikationsprøvning					
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init
Densitet	Skal foreligge	ISO 2811 - 1976	10	Ja / Nej	
Tørstofindhold	Skal foreligge	ISO 1515 - 1973	10	Ja / Nej	
Sammensætning af bindemiddel	Skal foreligge	Infrarød spektroskopi	10	Ja / Nej	

Forkortelser: V. = Vejledning i overfladebehandling af betonoverflader. B.= Bilag. s.= side.

Systemoplysninger						
Leverandør	Materialetypebetegnelse	Produkt navn		Init		
	Acrylplasttykfilmmalebehandling					
Egenskaber for materialer i leveringstilstand (omfatter også eventuel nødvendig grunder)						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Miljøvenlighed	ATs bekendtgørelser skal overholdes	Arbejdshygiejnisk brugsanvisning	2	Ja / Nej		
Almene egenskaber for den behandlede overflade						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Tilsmudsning	Ringe smudssamlings-tendens	Dokumenteres ved referencer	3	Ja / Nej		
Alkalibestandighed	Den behandlede overflade (på sydvendt lodret beton) skal være intakt efter 5 år	Dokumenteres ved referencer	3	Ja / Nej		
Vedligeholdsmulighed	Enkel og sikker genbehandling skal være mulig	Skriftlig genbehandlingsmetode skal foreligge	4	Ja / Nej		
Rengøringsmulighed	Skal tåle højtryksspuling	Se V. B.1 s.12	3	Ja / Nej		
Holdbarhed over for vejrlig	Mindst 3 år på lodrette sydvendte flader	Dokumenteres ved referencer (se V. B.1 s.11)	3	Ja / Nej		
Kulørbestandighed (Anvendes hvor væsentligt kulørt udseende ønskes)	Oplysning fra pigmentlev: Kulørægthed: »8« evt »7« Vejrbestandighed: »4-5« Alkaliægthed: »+«	Henholdsvis: DIN 54003 DIN 54001 DIN 16 624, blatt 2	5	Ja / Nej		
Specielle egenskaber for overfladebehandlingssystemet						
Den samlede planlagte behandling og lagtykkelse (incl. svumning) skal opfylde følgende krav:						
Egenskab	Krav	Metode	Målt værdi	Faneblad nr	Krav opfyldt?	Init
Vedhæftning og sammenhæng	Ingen enkeltværdi under 1,2 MPa	ISO 4624 og V DPRØV.04/93		6	Ja / Nej	
Porefri overflade	Ingen gennemgående porer og revner	Visuel bedømmelse		3	Ja / Nej	
Vandafvisende evne	Ekstra kraftig vandafvisende overflade på betonunderlag (se V. B.1 s.13)	NT BUILD 342. Klasse 1 efter neddykning i 1 døgn		6	Ja / Nej	
Evne til at modvirke kloridindtrængning	Den ækvivalente betontykkelse skal svare til 20 mm af referencebetonen	APM 402		7	Ja / Nej	
Behandling bestående alene af den planlagte grundning og slutbehandling skal opfylde følgende krav:						
Egenskab	Krav	Metode	Målt værdi	Faneblad nr	Krav opfyldt?	Init
Vanddampdiffusionsmodstand	Z _{H₂O} højst 5 GPa·s·m ² /kg	ASTM E 96-80		8	Ja / Nej	
Kuldioxiddiffusionsmodstand	Z _{CO₂} mindst 3000 GPa·s·m ² /kg	NT-BUILD 300		8	Ja / Nej	
Revneoverbygnings-evne	Revneoverbygning på beton ved 0°C og ved en lagtykkelse på 500 ± 50 µm mindst 0,8 mm	Se V. B.1 s.14		9	Ja / Nej	
Identifikationsprøvnings						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Densitet	Skal foreligge	ISO 2811 - 1976	10	Ja / Nej		
Tørstofindhold	Skal foreligge	ISO 1515 - 1973	10	Ja / Nej		
Sammensætning af bindemiddel	Skal foreligge	Infrarød spektroskopi	10	Ja / Nej		

Forkortelser: V. = Vejledning i overfladebehandling af betonoverflader. B.= Bilag. s.= side.

Systemoplysninger						
Leverandør	Materialetypebetegnelse	Produkt navn	Init			
	Uelastisk svummebehandling					
Egenskaber for materialer i leveringstilstand						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Miljøvenlighed	ATs bekendtgørelser skal overholdes	Arbejdshygiejnisk brugsanvisning	2	Ja / Nej		
Almene egenskaber for den behandlede overflade						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Vedligeholdsmulighed	Enkel og sikker genbehandling skal være mulig	Skriftlig genbehandlingsmetode skal foreligge	4	Ja / Nej		
Rengøringsmulighed	Skal tåle højtryksspuling	Se V. B.1 s.16	3	Ja / Nej		
Holdbarhed over for vejrlig	Mindst 3 år på lodrette sydvendte flader	Dokumenteres ved referencer (se V. B.1 s.16)	3	Ja / Nej		
Specielle egenskaber for overfladebehandlingssystemet						
Den samlede planlagte behandling og lagtykkelse skal opfylde følgende krav:						
Egenskab	Krav	Metode	Målt værdi	Faneblad nr	Krav opfyldt?	Init
Vedhæftning og sammenhæng	Ingen enkeltværdi under 1,2 MPa	ISO 4624 og VDPRØV.04/93		6	Ja / Nej	
Porefri overflade	Ingen gennemgående porer	Visuel bedømmelse		3	Ja / Nej	
Vandafvisende evne	Tydelig vandafvisende overflade på betonunderlag (se V. B.1 s.17)	NT BUILD 342. Klasse 1 efter neddykning i 1 døgn		6	Ja / Nej	
Evne til at modvirke kloridindtrængning	Den ækvivalente betontykkelse skal svare til 10 mm af referencebetonen	APM 402		7	Ja / Nej	
Vanddampdiffusionsmodstand	Z _{H₂O} højst 2,5 GPa·s·m ² /kg	ASTM E 96-80		8	Ja / Nej	
Kuldioxiddiffusionsmodstand	Den planlagte lagtykkelse skal have en ækvivalent betontykkelse på mindst 20 mm	NT-BUILD 372, 1991 med omregning til ækvivalent betontykkelse		8	Ja / Nej	
Identifikationsprøvning						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Densitet	Skal foreligge	ISO 2811 - 1976	10	Ja / Nej		
Tørstofindhold i plastdispersion	Skal foreligge	ISO 1515 - 1973	10	Ja / Nej		
Sammensætning af plastdispersion	Skal foreligge	Infrarød spektroskopi	10	Ja / Nej		
Bemærkninger:	Firmastempel, dato og underskrift					

Forkortelser: V. = Vejledning i overfladebehandling af betonoverflader. B.= Bilag. s.= side.

Systemoplysninger						
Leverandør		Materialetypebetegnelse		Produktnavn		Init
		Elastisk svummebehandling				
Egenskaber for materialer i leveringstilstand						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Miljøvenlighed	ATs bekendtgørelser skal overholdes	Arbejdshygiejnisk brugsanvisning	2	Ja / Nej		
Almene egenskaber for den behandlede overflade						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Alkalibestandighed	Den behandlede overflade (på sydvendt lodret beton) skal være intakt efter 5 år	Dokumenteres ved referencer	3	Ja / Nej		
Vedligeholdsmulighed	Enkel og sikker genbehandling skal være mulig	Skriftlig genbehandlingsmetode skal foreligge	4	Ja / Nej		
Rengøringsmulighed	Skal tåle højtryksspuling	Se V. B.1 s.21	3	Ja / Nej		
Holdbarhed over for vejrlig	Mindst 3 år på lodrette sydvendte flader	Dokumenteres ved referencer (se V. B.1 s.20)	3	Ja / Nej		
Specielle egenskaber for overfladebehandlingssystemet						
Den samlede planlagte behandling og lagtykkelse skal opfylde følgende krav:						
Egenskab	Krav	Metode	Målt værdi	Faneblad nr	Krav opfyldt?	Init
Vedhæftning og sammenhæng	Ingen enkeltværdi under 1,2 MPa	ISO 4624 og VDPRØV.04/93		6	Ja / Nej	
Porefri overflade	Ingen gennemgående porer og revner	Visuel bedømmelse		3	Ja / Nej	
Vandafvisende evne	Kraftig vandafvisende overflade på betonunderlag (se V. B.1 s.21)	NT BUILD 342. Klasse 1 efter neddykning i 1 døgn		6	Ja / Nej	
Evne til at modvirke kloridindtrængning	Den ækvivalente betontykkelse skal svare til 20 mm af referencebetonen	APM 402		7	Ja / Nej	
Vanddampdiffusionsmodstand	Z _{H₂O} højst 10 GPa·s·m ² /kg	ASTM E 96-80		8	Ja / Nej	
Kuldioxiddiffusionsmodstand	Den planlagte lagtykkelse skal have en ækvivalent betontykkelse på mindst 20 mm	NT-BUILD 372, 1991 med omregning til ækvivalent betontykkelse		8	Ja / Nej	
Revneoverbygnings-evne	Lagtykkelse mindst 2000 µm skal kunne godkendes efter klasse I (små bevægelser, temperatur/trafik-revner)	ZTV-SIB 90, TP-OS, afsnit 6.15		9	Ja / Nej	
Identifikationsprøvning						
Egenskab	Krav	Metode	Faneblad nr	Krav opfyldt?	Init	
Densitet	Skal foreligge	ISO 2811 - 1976	10	Ja / Nej		
Tørstofindhold	Skal foreligge	ISO 1515 - 1973	10	Ja / Nej		
Sammensætning af plastdispersion	Skal foreligge	Infrarød spektroskopi	10	Ja / Nej		
Bemærkninger:			Firmastempel, dato og underskrift			