



WORK GUIDELINE No. 7

Cracks repair

CONTENTS

- 1 Purpose**
- 2 Scope**
- 3 Reference documents**
- 4 Definition**
- 5 Preliminary conditions**
- 6 Safety precautions**
- 7 Personnel**
- 8 Materials for crack repair**
- 9 Procedure for crack repair**
- 10 Quality assurance**
- 11 Special requirement**

1 Purpose

The purpose of the present WG No. 7 is to unify the approach to repairing cracks in concrete.

Conditions to be fulfilled prior to commencement of crack repair, and general instructions for the execution are provided.

2 Scope

In the present WG No. 7 cracks repair in reinforced concrete structural members such as piers, abutments, beams, carriageway slabs, walkways, etc. is proposed.

3 Reference documents

For crack and void repair in dry and damp conditions refer to SINIT Technical Data Sheets: Adh/4 for INJECTION 1 and Adh/1 for P.A. 103.

For crack and void repair in wet area and underwater refer to SINIT Technical Data Sheets: Sub/1 for SUBCOM T.260 and Sub/2 for SUBCOM 150.

4 Definition

A concrete crack is any discontinuity in the concrete. It occurs when admissible concrete tensile or compressive stresses are exceeded.

4.1 Crack types

4.1.1 Crack types and causes of their occurrence.

Depending on their occurrence cracks can be divided into:

- Technological cracks occurring as a result of concrete creep and shrinkage;
- Cracks that have occurred due to a single, a transient or a persistent concrete overstress (mechanical, thermal, chemical, or combined actions).

4.1.2 Crack types and their width.

Considering their width, cracks can be divided into:

- Micro-cracks, which are not visible by naked eye;
- Hair-cracks measuring up to 0.1 mm in width, which are visible by naked eye;
- Macro-cracks exceeding 0.1 mm in width.

Cracks are emphasized, i.e. they are better visible, when a moist concrete commences to dry: while concrete is already dry, cracks still remain damp.

4.1.3 Crack types by depth.

Considering their depth cracks can be divided in:

- Superficial cracks (reticular or “alligator” cracks, and hair-cracks, depth of which generally reaches some millimetres) not reaching the reinforcement;
- Deep cracks reaching the reinforcement or even deeper;
- Cracks extending through the entire cross-section.

4.1.4 Crack types by their activity.

Considering their activity cracks can be divided into:

- Cracks at rest (passive cracks);
- Active cracks when width varies due to thermal action and/or traffic loading.

4.1.5 Crack types depending on their moisture condition.

Depending on their moisture condition cracks can be divided into:

- Dry cracks;
- Damp cracks;
- Cracks with water seeping through at zero pressure;
- Cracks with water seeping through under pressure.

5 Preliminary conditions

The following preliminary conditions shall be fulfilled prior to commencement of crack repair works:

5.1 Identification of cracks

5.1.1 Both supervising Engineer and structural design Engineer shall be informed of the occurrence of cracks on the concrete surfaces immediately.

5.1.2 A crack cadastre shall be prepared. It shall include the following information:

- Name of project/structure or structural member, date of completion;
- Design concrete grade, current control results of concrete grade testing;
- Structural designer’s name;
- Date of noticing cracks (if a new member is in question);
- Crack width, length and course (the maximum crack width shall be recorded) and temperature upon measurement;
- Crack condition (dry, damp, seeping water, calcareous, etc.);
- Crack depth*;
- Crack at rest (passive crack) or active crack**;
- Special information, if any, of premature loading, damage, etc.;
- Photos;
- The structural designer shall decide whether a monolithic bond is required upon filling-up and sealing a crack.

Notes:

- * The crack depth is determined by means of a core 25 or 50 mm in diameter cut out by means of adequate diamond tools, or by ultrasonic examination.
- **To establish the crack activity (crack at rest, active crack), benchmarks shall be stuck on each crack side or a 2 mm thick glass measuring 100 mm in length and 15 mm in width shall be glued with an epoxy adhesive on the crack.

Prior to commencement of crack repair works causes of crack occurrence shall be established in detail.

6 Safety precautions

Taking into account of the height above ground of cracks to be repaired, adequate safety requirements shall be met: placing scaffold, protective railing, protection from falling pieces during cutting-out the concrete, personal protective means, etc.

7 Personnel

Skilled workers only, who have already been engaged in repair works of same or similar kind, may carry out crack repair works. Prior to commencement of the works all personnel shall be instructed in all particularities related to both repair works and quality requirements.

8 Materials for crack repair

- 8.1 In view of the crack type and characteristics (dry, damp, at rest, active cracks, underwater cracks and voids) as well as of the requirements of the structural design Engineer the following materials are foreseen for crack repair:
 - INJECTION 1 low viscosity epoxy injection resins (non-elastic);
 - SUBCOM 150 fluid underwater curing epoxy compound (non-elastic);
- 8.2 For crack injection on dry or damp conditions surface plastic tees (Sinit patent) shall be applied with P.A. 103 Epoxy Adhesive used as well to seal the entire crack, to ensure that the resin cannot flow from the crack during the injection.
- 8.3 For crack and void injection in wet area and underwater metallic tees shall be inserted into the fissure with SUBCOM T.260 Underwater Epoxy Paste used as well to seal the entire crack, to ensure that the resin cannot flow from the crack during the injection.

The abovementioned material may only be applied when both substrate and air temperature are not less than +5°C and not more than 35°C

9 Procedure of crack repair

With regard to the crack characteristics (surface, depth, at rest, active, dry, damp cracks, underwater cracks and voids), as well as to their importance to structural member reliability, cracks can be repaired according to the procedures indicated below:

9.1 Superficial (technological) cracks on horizontal surfaces (e.g. carriageway slabs) and on vertical and ceiling surfaces of structural Members

As a rule, such cracks do not reach the first reinforcement layer depth, and shall be repaired as follows (on condition that both cracks and concrete are dry):

- Marking the crack course with a colour chalk;
- Cleaning the cracks by clean compressed air or by powerful industrial vacuum cleaner ;
- SINIT, based on many years experience throughout the world, has studied and patented “a low pressure injection system” (patent N. 932151).

The injected resin must exert a certain pressure without exceeding 3 bars against the internal surfaces of the cracks, as a guarantee of a secure adhesion, especially in the presence of humidity. Extreme attention should be paid to the effect of high pressure: a pressure of one bar develops the equivalent thrust of ten tons per square meter.

Special tees are adhered onto the surface of the cracks using Epoxy Paste Adhesive (P.A.103 or PA.103 S.G.): avoid drilling the concrete as this obstructs injection voids.

These special tees of about 17 sq.cm. of area, cover a wide section of the crack with consequent better distribution of the resin and considerable reduction of the time required for injection. They are installed every 30-60 cm. while the entire crack is sealed with Epoxy Paste Adhesive in order to stop the resin from leaking with consequent loss of pressure.

With an "injection pot" the resin is pumped at low pressure into a hose attached to injection tees.

The injection starts from the bottom of the crack proceeding from the lowest tee to the next higher up each time the succeeding tee shows evidence of the resin advancing. Be sure last tee filled is closed before proceeding to the next.

Repeat the process until the entire crack is filled.

After INJECTION 1 has cured and cracks are sealed, the P.A.103 Epoxy Paste Adhesive, used to adhere the injection tees, can be removed with hammer and chisel or with a cutting-off machine.

Sealing of cracks on reinforced concrete carriageway slabs as described above shall be performed after blast cleaning or high-pressure water jet cleaning of the surface (surface preparation prior to placing waterproofing layers).

9.2 Injection of deep cracks, and cracks through the entire cross-section.

- Marking the crack course with a colour chalk;
- Cleaning the cracks by clean compressed air or by powerful industrial vacuum cleaner ;
- SINIT, based on many years experience throughout the world, has studied and patented “a low pressure injection system” (patent N. 932151).

The injected resin must exert a certain pressure without exceeding 3 bars against the internal surfaces of the cracks, as a guarantee of a secure adhesion, especially in the presence of humidity. Extreme attention should be paid to the effect of high pressure: a pressure of one bar develops the equivalent thrust of ten tons per square meter.

Special tees are adhered onto the surface of the cracks using Epoxy Paste Adhesive (P.A.103 or PA.103 S.G.): avoid drilling the concrete as this obstructs injection voids.

These special tees of about 17 sq.cm. of area, cover a wide section of the crack with consequent better distribution of the resin and considerable reduction of the time required

for injection. They are installed every 30-60 cm. while the entire crack is sealed with Epoxy Paste Adhesive (P.A.103 or P.A. 103 S.G.) in order to stop the resin from leaking with consequent loss of pressure.

Where cracks extend through the entire depth of member and are accessible from below, should be sealed with Epoxy Paste Adhesive (P.A. 103 or P.A. 103 S.G.).

With an "injection pot" the INJECTION 1 resin is pumped at low pressure into a hose attached to injection tees.

The injection starts from the bottom of the crack proceeding from the lowest tee to the next higher up each time the succeeding tee shows evidence of the resin advancing. Be sure last tee filled is closed before proceeding to the next.

Repeat the process until the entire crack is filled.

After INJECTION 1 has cured and cracks are sealed, the Epoxy Paste Adhesive, used to adhere the injection tees, can be removed with hammer and chisel or with a cutting-off machine.

Sealing of cracks on reinforced concrete carriageway slabs as described above shall be performed after blast cleaning or high-pressure water jet cleaning of the surface (surface preparation prior to placing waterproofing layers).

9.3 Injection of cracks and voids in concrete underwater

The same basic technique as above may be used to repair cracks in permanently submerged or wet concrete structures, provided the sealing compounds are specifically intended for underwater use and cure completely even in water.

The procedure remains the same, namely:

- Mark the crack course with a wettable colour chalk or wettable permanent paint.
- Clean the crack by gritblasting or, better, by high pressure water-jetting.
- With a pneumatic or hydraulic drilling machine make holes Ø 12-15 mm, 10-15 cm deep, every 30-60 cm along the fissure, where to insert metallic tees with a diameter of about 10 mm to be used to inject SUBCOM 150 underwater epoxy compound.
- Fix the metallic tees and seal the crack over the whole length with SUBCOM T.260 (Underwater Epoxy Paste).
- Where the cracks extend through the entire depth and be accessible from behind, also that part should be sealed with SUBCOM T.260.
- With an injection pot and a hose inject SUBCOM 150 through the various tees, starting from the lowest tee, proceeding to the next higher up as soon there is evidence of the progressing resin compound.
- Close the injection metallic tees when moving the hose to another one.
- When the resin compound shall be completely cured, the tees may be cut off or removed.

10 Quality assurance

After the crack repair the following activities to prove the quality shall be carried out:

- Taking Ø 100 mm cores in the cracked area. Minimum boring depth shall be equal to the reinforcement depth. The structural design Engineer shall previously approve eventual cutting of reinforcement. The number of cores to be taken after completion of works shall be specified by the supervising Engineer, or cylinders shall be taken simultaneously with the current control;

- Visual inspection to check if a crack has been completely filled up with injection compound;
- Test of crack for water-tightness. This test shall only be executed on cracks exposed to precipitation water;
- Test of monolithic bond shall only be carried out if requested by the structural Designer. In this compression test a core is loaded to failure, where the rupture must occur in the concrete and not in the crack course.

11 Special requirements

Experienced Engineers shall attend sealing of cracks, where water under pressure is seeping through. Such cracks shall be injected in a broader area. As circumstances may require, sealing of cracks can be performed in two stages.