






RESEARCH REPORT

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Injection and sealing compounds of cracks in concrete - SILKO test programme 2015-v3

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Summary	
<p>This is an unofficial translation of the Finnish research report. In case of interpretation disputes the Finnish report.</p> <p>This test programme is an updated version of the test programme VTT-R-05684-14. These SILKO test instructions are used to examine the suitability of injection and sealing compounds of cracks in concrete of outdoor concrete structures owned by the Finnish Transport Agency. The suitable materials are published in SILKO-directions which are available on the web pages of Finnish Transport Agency, http://portal.liikennevirasto.fi/sivu/www/f/urakoitsijat_suunnittelijat/vaylanpidon_ohjeet/sillat/ko_rjausohjeet/SILKO.</p> <p>The test program of injection compounds is based on the European standard EN 1504-5 (2005). In this test program it is shown which tests "for certain intended uses" the Transport Agency requires to be carried out always and which are never required. Also the extra tests the Finnish Transport Agency requires to be carried out are given.</p> <p>EN 1504-5 does not concern sealing compounds.</p> <p>In this publication the test programs for both the sealing compounds for temporary sealing of cracks for injection work and permanent sealing of cracks by filling them by penetrating compounds are given.</p> <p>In addition the acceptance criteria set by the Transport Agency are given.</p>	
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1. Introduction

These instructions are used to examine the suitability of injection and sealing compounds of cracks in concrete of outdoor concrete structures owned by the Finnish Transport Agency. The suitable materials are published in SILKO-directions which are available on the web pages of Finnish Transport Agency http://portal.liikennevirasto.fi/sivu/www/fi/urakoitsijat_suunnittelijat/vaylanpidon_ohjeet/sillat/ko_rjausohjeet/SILKO.

The test program is based on the European standard EN 1504-5 (2013). In this test program it is shown which tests "for certain intended uses" are required to be carried out always and which are never required. In addition the colour of injection compounds is evaluated.

EN 1504-5 does not concern sealing compounds.

Here the test programs for both the sealing compounds for temporary sealing of cracks for injection work and permanent sealing of cracks by filling them by penetrating compounds are given.

Test methods other than those according to European standards are described in sections 5 - 8.

In addition the acceptance criteria set by the Finnish Transport Agency are given.

2. Injection compounds

The SILKO test program and acceptance criteria of injection compounds are according to EN 1504-5 with the following specifications:

- Identification tests of injection agents formulated with reactive polymer binder are:
 - Infrared analysis according to EN 1767. When SILKO approval is applied for the first time the Finnish Transport Agency is informed where the infrared analysis result is stored. When extension for the SILKO approval is applied the positions and relative intensities of the main absorption bands shall match those of the stored spectrum.
- Identification tests of injection agents formulated with hydraulic binder are:
 - Particle size analysis by laser diffraction according to EN 13320-1. When SILKO approval is applied for the first time the Finnish Transport Agency is informed where the analysis results are stored. When extension for the SILKO approval is applied the results of the analyses must correspond to those of the stored analysis results.
- EN 1504-5, Table 1.a:
 - Adhesion by slant shear stress (H, P) Voluntary test
 - Glass transition temperature (P) Not required
 - Chloride content (H) Required
- EN 1504-5, Table 1.b.
 - Watertightness (P) Voluntary test for certain intended uses
 - Glass transition temperature (P) Not required
- EN 1504-5, Table 1.c.
 - Corrosion behaviour (P) Not required
 - (P) Injection compounds formulated with reactive polymer binder
 - (H) Injection compounds formulated with hydraulic binder

The acceptance criteria are according to Tables 3.a, 3.b and 3.c of EN 1505-4 (2005).

In addition the colour of the injection compounds is evaluated.

3. Sealing compounds for permanent crack filling

The obligatory tests of basic characteristics and performance as well as their criteria are given in Tables 1 and 2. There are no voluntary SILKO tests for sealing compounds. Table 1 concerns sealing compounds formulated with reactive polymer binder. Table 2 concerns sealing compounds formulated with hydraulic binder.

Table 1. Tests of basic characteristics and performance and acceptance criteria of crack filling permanent sealing compounds formulated with reactive polymer binder.

Property	Test method	Acceptance criterion
Basic characteristics		
Identification	Infra red analysis, (IR) EN 1767	-
Viscosity	EN ISO 3219 Viscosity shall be measured 5 min after mixing of the product has been completed. The separate of the product shall be maintained at a constant temperature of (21 ± 2) °C before mixing. The temperature of the freshly mixed product shall be measured and recorded before the viscosity is measured. For products that harden in less than 5 min viscosity shall be measured on unmixed components. /1/	-
Pot life	EN ISO 9514 The test shall be performed at three conditioning and test temperatures: 21 °C and the minimum and maximum use temperatures recommended by the manufacturer, with a tolerance of ± 2 °C. /1/	
Performance properties		
Adhesion by slant shear strength	NT BUILD 350 Dry and/or wet crack	Grading scale: + < 50% ++ 50 - 100% +++ > 100% of the strength of the control prism
Colour	Visual estimate	-
Effect on the appearance of concrete	Visual estimate	-
Penetration	Measurement of the filling of the crack	≥ 30% of the crack surface is filled

Table 2. Tests of basic characteristics and performance and acceptance criteria of crack filling permanent sealing compounds formulated with hydraulic binder.

Property	Test method	Acceptance criterion
Basic tests		
Identification	Thermo-gravimetric determination according to EN ISO 11358	-
Time of efflux	EN 14117 Viscosity shall be measured 5 min after mixing of the product has been completed. /1/	-
Setting time	EN 196-3	-
Performance properties		
Adhesion by slant shear strength	NT BUILD 350 Dry and/or wet crack	Grading scale: + < 50% ++ 50 - 100% +++ > 100% of the strength of the control prism
Colour	Visual estimate	-
Effect on the appearance of concrete	Visual estimate	-
Penetration	Measurement of the filling of the crack	≥ 30% of the crack surface is filled

4. Sealing compounds for temporary sealing of cracks for injection

The obligatory tests of basic characteristics and performance as well as their criteria are given in Tables 3 and 4. Table 3 concerns sealing compounds formulated with reactive polymer binder. Table 4 concerns sealing compounds formulated with hydraulic binder. There are no voluntary tests for sealing compounds.

Table 3. Tests of basic characteristics and performance and acceptance criteria of temporary sealing compounds formulated with reactive polymer binder.

Property	Test method	Acceptance criterion
Basic tests		
Identification	Infra red analysis, (IR) EN 1767	-
Viscosity	EN ISO 3219 Viscosity shall be measured 5 min after mixing of the product has been completed. The separate components of the product shall be maintained at a constant temperature of (21 ± 2) °C before mixing. The temperature of the freshly mixed product shall be measured and recorded before the viscosity is measured. For products that harden in less than 5 min viscosity shall be measured on unmixed components. /1/	-
Pot life	EN ISO 9514 The test shall be performed at three conditioning and test temperatures: 21 °C and the minimum and maximum use temperatures recommended by the manufacturer, with a tolerance of ± 2 °C. /1/	
Performance properties		
Adhesion	EN 1542	≥ 0.4 N/mm ²
Colour	Visual estimate	-
Effect on the appearance of concrete	Visual estimate	-
Spreadability	Evaluation	Must not be too difficult to spread
Removability	Evaluation	-

Table 4. Tests of basic characteristics and performance and acceptance criteria of temporary sealing compounds formulated with hydraulic binder.

Property	Test method	Acceptance criterion
Basic tests		
Identification	Thermo-gravimetric determination according to EN ISO 11358)	-
Time of efflux	EN 14117 Viscosity shall be measured 5 min after mixing of the product has been completed. /1/	-
Setting time	EN 196-3	-
Performance properties		
Adhesion	EN 1542	≥ 0.4 N/mm ²
Colour	Visual estimate	-
Effect on the appearance of concrete	Visual estimate	-
Spreadability	Evaluation	Must not be too difficult to spread
Removability	Evaluation	-

5. Colour and effect on the appearance of concrete

The colour of hardened injection compound placed in a transparent cup is evaluated visually.

The effect of a permanent crack filling sealing compound on the appearance of concrete is evaluated visually on concrete specimens with the compound applied on their surface.

The effect of a temporary sealing compound used for sealing cracks during injection on the appearance of concrete is evaluated visually on concrete specimens with the compound applied on their surface and removed after hardening.

Photographs and verbal visual evaluation are given as test results.

6. Penetration depth

6.1 Principle

The penetration depth of a permanent crack filling sealing compound into a concrete crack with known width is measured.

6.2 Test specimens and their pre treatment

The test specimens are two concrete beams, 100 x 100 x 500 mm³.

For 7 days after casting the beams are stored in water after which they are stored at 95...100% relative humidity at $+20 \pm 2$ °C for 21 days. At the age of 28 days the beams are bended to failure. One of the broken beams is removed into $65 \pm 5\%$ relative humidity and one into tap water at $+20 \pm 2$ °C for 14 days.

6.3 Test procedure

Free water is removed from the fracture surface. The ends of the beams are placed in horizontal position with their fracture surfaces against each other in such a way that a crack with a width of 0.2 mm is formed. The crack is sealed with the crack filling sealing compound from the upper surface of the beam by tapping with a brush.

After the hardening of the sealing compound it is observed visually whether the compound seals the whole crack or not. The beams are again bended into failure. The penetration depth of a continuous layer of the sealing compound and the area the compound covers of the crack surface are measured.

6.4 Test results

Whether the sealing compound seals the whole crack or not, the average penetration depth and the minimum and the maximum of it and the relative portion of the crack area that is filled with the crack filling sealing compound at both humidity conditions are given as test results.

7. Spreadability

The spreadability of the temporary sealing compound is evaluated in connection with the preparation of the test specimens for other tests.

8. Removability

8.1 Principle

The effort needed to remove the temporary sealing compound from the concrete surface, the damaging of the concrete substrate when the sealing compound is being removed and the effect of the application and removal of the sealing compound on the outlooks of the concrete surface are evaluated.

8.2 Test specimens and their pre treatment

Two concrete paving slabs are used as test specimens. One slab is stored for 14 days at $65 \pm 5\%$ relative humidity and one in water at $+20 \pm 2$ °C.

8.3 Test procedure

Free water is removed from the surface of the slab stored in water. Approximately 40 mm wide and 250 mm long stripe of the temporary sealing compound is applied on both slabs. The thickness of the applied layer is according to the directions of the product. The slab stored at $65 \pm 5\%$ relative humidity is returned there and the slab stored in water is removed into 95...100% relative humidity at +20 °C.

After 3 days the colour of the sealing compound is evaluated and the slabs are photographed. The sealing compound is removed from the slab surfaces using applicable tools. The removability is evaluated. In the end the effect of the removed sealing compound on the appearance of the concrete substrate is evaluated and the slabs are photographed.

8.4 Test results

The evaluation of the removability of the sealing compound and the effect of the removed sealing compound on the appearance of the concrete substrate are given as test results. In addition photographs taken of the slabs before and after the removal of the sealing compound are presented.

References

1. EN 1504-5. Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity. Part 5: Concrete injection. 2005. 36 p.