

# ► Crack Repair

# WEBAC®



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This brochure deals with the repair of cracks, ranging from structural condition analysis including cause investigations, regulations to be considered and product selection and – last but not least – the execution of crack injections. Additionally, the presentation will cover special applications such as the sealing of structures against highly pressing water using quick-foaming SPUs, the sealing of contaminated cracks and the stabilization and sealing of cracks in masonry.

## NOTE

Please consider all existing regulations and the instructions in the technical data sheets on the respective WEBAC products.

We will be glad to help you find solutions to individual problems.

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# Cracks in Building Structures

- ▶ If cracks affect the stability of building structures, they have to be filled. Various injection resins and injection methods are available for this purpose – depending on the aim of the restoration.

Structural cracks in mineral construction materials such as concrete, screed or mortar occur especially if the low tensile and shear strength of these construction materials

is exceeded. Causes, effects and solutions in crack repair schemes are summarized in the following diagram.

## Reasons for crack repair

### Mechanical overload

- Cracks

### Concreting (faults)

- Construction joints
- Gravel nests
- Cavities/wash-outs

### Environmental impact

- Substances detrimental to concrete



## Restoration

Closing

Flexible bonding

Structural bonding

Sealing

## Regulations

In accordance with CJEU judgment C100/13 on the significance of harmonized European Standards (hES) a new alignment between European product regulations and national usage regulations must be found.

At present, the following regulations are applicable for crack repairs:

- hEN 1504-5:2004 (DIN EN 15045:2005) with CE marking according to BRL\* B, part 1, section 1.1.7.2
- DIN EN 1504-5:2013 (does presently not (yet) entitle to the CE marking)
- DIN V 18028:2006 (supplementary standard) for mark of conformity according to BRL\* A, part 1, section 1.7.6

- ZTVIng ("Riss" in part 5.3) – with BAST list of tested products
- National Test Certificate (abP) according to Rili SIB of German Committee for Reinforced Concrete (DafStb) 2001 Guidelines of Concrete Repair of DafStb
- Special solutions for special requirements beyond any existing regulations

\* German List of Building Regulations of German Institute for Construction Engineering (DIBt), edition 2015/2

# Crack Analysis

▶ A qualified decision on restoration measures cannot be taken without detailed knowledge of the cause of damage. The sustainable restoration of damaged structures requires a comprehensive restoration concept specially developed for the building concerned.

A successful restoration concept can only be prepared after assessing the nature and condition of the structure and analyzing the actual state. To achieve the target state defined in the restoration concept, detailed knowledge of the specific properties of the injection products used for filling cracks is required. If crack repair measures have already been implemented, knowledge of the injection products used and the material's compatibility is required.

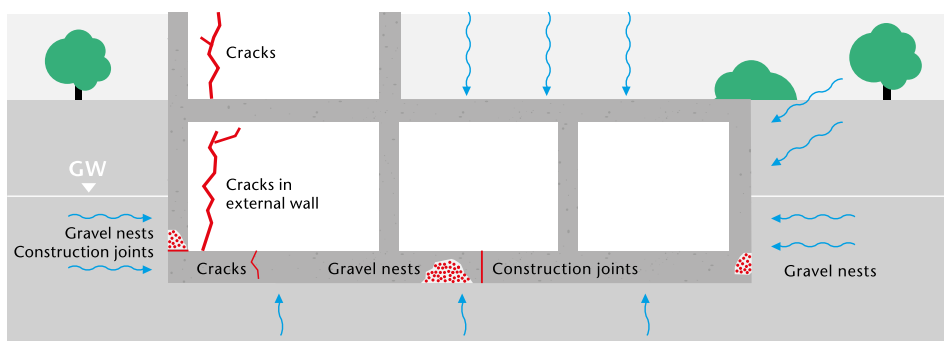
## Crack types and their causes



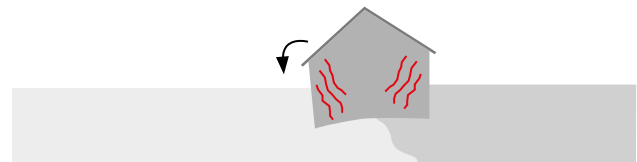
**Superficial hairline cracks** of <math>< 0.1\text{ mm}</math> crack width such as craquelure usually do not affect the component's usability and therefore do not require treatment. They usually run above the reinforcement layers and in most cases occur due to excessive temperature differences in the concrete between the core and the shell.



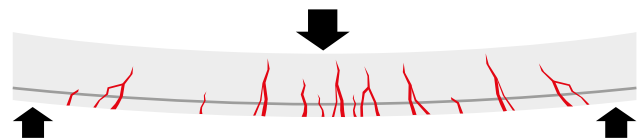
**Separation cracks** are cracks caused by the low tensile strength of concrete. They affect essential parts of the cross section or separate the total cross section. Separation cracks are usually differentiated according to their cause.



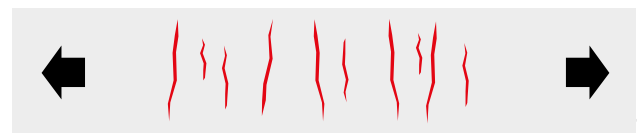
Possible concrete damage on existing buildings



**Settlement cracks** are caused by irregular subsidence and redistribution in the foundation soil.

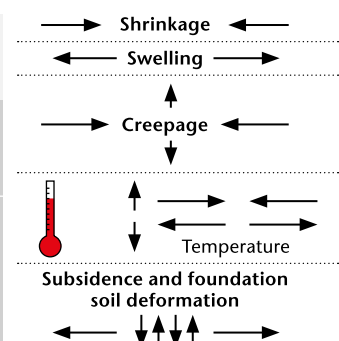


**Bending cracks** are caused by occurring bending moments and perform at approximately right angles to the bending tensile reinforcement, beginning at the tensile edge and ending in the area of the zero line.



**Shear cracks** form from bending cracks, run obliquely to the member axis and most frequently occur near the bearing points of a bending beam.

**Shrinkage cracks** in the component are mainly caused by a decrease in volume and too fast drying. They can run through the entire component, in a directed or disordered manner.



# Crack Analysis

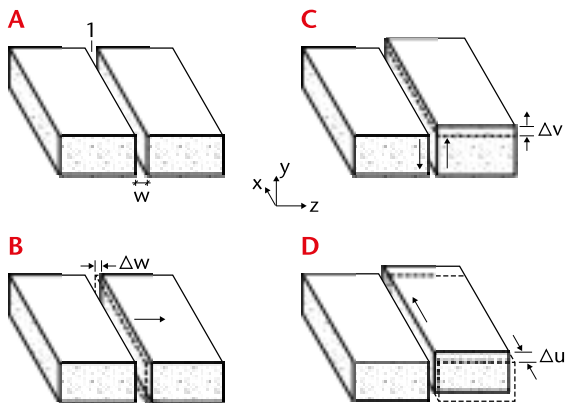
## Crack geometry and dynamic changes

The **crack width** is the distance between the crack edges on the component surface (intersection of the crack flanks). Crack gauges or crack magnifiers can for example be used to determine the crack width.



Measuring the crack width

**Crack width changes** can occur in a unilateral manner due to a steady increase or decrease in crack widths or in a recurring manner. Recurring crack width changes may occur in the short-term (due to traffic loads), daily (due to day/night cycle or solar radiation), or in the long-term (e.g. due to seasons). These impacts frequently overlap with irreversible changes in length such as e.g. contractions due to shrinkage. Knowledge of the crack width change ( $\Delta w$ ) is of particular importance for selecting the suitable flexible injection product and the related success of the restoration measure.



Recurring crack width changes

**Soiling/contamination/efflorescence:** Existing buildings often show crack conditions which are neither described in detail nor specified in the available regulations. Successful crack repair generally depends on the fact that sufficient bonding strength of the interior concrete flanks (bond in the concrete structure) is provided. To do so, the concrete flanks must be free of substances impairing adhesion. Soiling, deposits, contamination and efflorescence such as e.g.

- loose and brittle particles
- soiling such as e.g. oil or grease along the crack edges/flanks within the crack and during the patching process
- deposits and encrustations

impair the flank adhesion of the injection products. This is why the point of time of the crack filling process and the type of injection product used should be selected after analyzing the structural state. It is also possible to fill soiled, contaminated (oily or greasy) cracks with special WEBAC Injection Resins.

## CAUSES OF CRACKS

### Related to concrete properties:

- Hydration heat and cooling
- Shrinkage
- Creepage
- Swelling

### Related to stress:

- Load
- Impeded deformations
- Temperature impacts
- Subsidence
- Foundation soil deformations
- Carbonation

## SUSCEPTIBLE TO CRACKS

- Construction joints
- Solid components
- Junctions between solid and less solid components
- Re-entrant corners and cross-section jumps
- Entry areas of strong, concentrated forces
- Bearing points

## Damage Diagnosis

# Crack Analysis

### Moist conditions

Depending on the intensity of the water load, a distinction is made between the following moisture conditions in the existing regulation.

#### DRY



- Crack edges and component's surface visually dry, water access not possible
- Influence of crack/cavity area by water not detectable
- Water access possible but excluded for a sufficiently long time

#### DAMP



- Color change caused by water (capillary water absorption) in crack or cavity area, but no water emergence
- Signs of very recent water emergence
- Crack/cavity visibly damp or matt damp, also on dry cores

#### WET (water-bearing without hydrostatic pressure)



- Stagnant water visible in crack or visible in form of small droplets in crack area
- Water trickling from crack area

#### FLOWING WATER



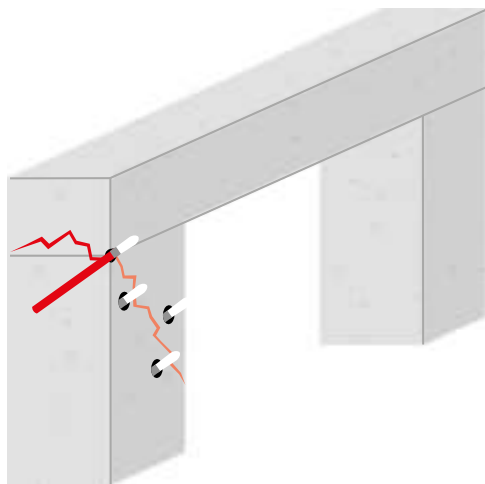
- Water flows through crack or cavity in form of continuous water flow



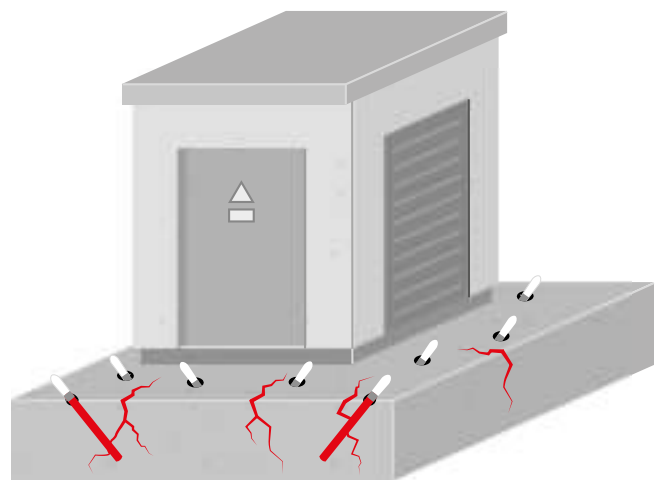
# Objectives

- ▶ Crack repairs are designed to protect structures from detrimental influences and substances and to restore the monolithic behavior of components.

Objective	Explanation
Closing	Prevent penetration of corrosion-promoting substances
Sealing	Eliminate leaks in the component
Swellable filling	Fill cracks with injection products capable of swelling due to reversible water absorption
Flexible bonding	Establish limited-flexibility bond between crack flanks capable of compensating crack width changes
Structural bonding	Establish tension- and compression-proof bond between crack flanks and transfer forces this way



*Structural crack repair*



*Crack sealing in machine foundations*

# Products

► The suitable injection product has to be selected depending on the objective of the restoration and the moisture condition.

The injection products used for crack repairs should have the following properties:


- Viscosity and application adapted to object conditions
- Good workability in a wide temperature range
- Sufficient adhesive strength (on concrete structure)
- High aging resistance
- Non corrosion-promoting
- Compatibility with all materials they are designed to come in contact with

## WEBAC Epoxy Injection Resins (category F)

Mainly solvent-free, mostly low-viscosity 2C epoxy injection resins are used for the **structural filling** of cracks in concrete construction.

The good spreading and flow properties of these injection products allow for the injection of cracks with widths of > 0.1 mm and the penetration up into the finest ramifications.

Due to the high inherent and adhesive strength they durably restore the structural bond of the cracked structure and thus the monolithic load-bearing behavior of the component.

Techn. parameters*	WEBAC. 4110	WEBAC. 4120P	WEBAC. 4130	WEBAC. 4170	WEBAC. 4170T
Mixing ratio	2 : 1 parts by vol.	3 : 1 parts by vol.	2 : 1 parts by vol.	3 : 1 parts by vol.	3 : 1 parts by vol.
Viscosity of mixture (23 °C)	360 mPas	200 mPas	700 mPas	95 mPas	110 mPas
Workable life (20 °C)	100 min	50 min	20 min	40 min	20 min
Application temperature	> 8 °C	> 5 °C	> 5 °C	> 8 °C	> 5 °C
Special properties	<ul style="list-style-type: none"> <li>• Excellent edge adhesion</li> <li>• Also cures under dynamic stress</li> <li>• Volume and dimensional stability</li> <li>• Total solid**</li> </ul> 	<ul style="list-style-type: none"> <li>• Low viscosity</li> <li>• Resistant to dynamic stress</li> <li>• Good edge adhesion</li> <li>• Good penetration</li> <li>• Total solid**</li> </ul>	<ul style="list-style-type: none"> <li>• Structural strength; wet</li> <li>• Suitable at low temperatures</li> <li>• Very tough</li> <li>• Suitable for oil-contaminated crack edges</li> <li>• Total solid**</li> </ul>	<ul style="list-style-type: none"> <li>• Very low viscosity</li> <li>• Suitable for damp crack edges</li> <li>• Good adhesion</li> <li>• Total solid**</li> </ul>	<ul style="list-style-type: none"> <li>• Good curing also at low temperatures</li> <li>• Very low viscosity</li> <li>• Suitable for damp and oily crack edges</li> <li>• Good adhesion</li> <li>• Total solid**</li> </ul>
Performance characteristics (acc. to DIN EN 1504-5: 2013)	U(F1) W(2) (1) (R/30) (1)	U(F1) W(2) (1) (20/30) U(F1) W(3) (1) (5/30)	U(F1) W(3) (1) (5/30)	U(F1) W(1) (2) (R/30)	U(F1) W(1) (1) (L/30)

\* The specified data are values determined under laboratory conditions and are subject to certain fluctuations. Deviations are possible in practice depending on the respective object situation.  
\*\* according to test method by Deutsche Bauchemie e.V.

# Restoration Products

## WEBAC PU Injection Resins (category D)

For the **limited flexibility filling** of cracks, structures are required which do not lead to fractures of the injection product even if the entire cracked surface is exposed to expansion and compression movements.

WEBAC PU Resins react with water and form fine blisters. These small blisters are capable of compensating minor changes in volume in large-surface cracks resulting from expansion or compression stress. In combination

with the good adhesion to crack flanks this "limited flexibility" allows to bridge crack width changes resulting from temperature changes or recurring loads, thus preventing the cracks from reopening.

WEBAC PU Injection Foam Resins are pre-injected to quickly and temporarily seal structures or to temporarily reduce the ingress of pressurized in-situ water (► p. 8).



Injection of PU resins



Techn. parameters*	WEBAC. 1403P	WEBAC. 1405	WEBAC. 1420P	WEBAC. 1500
Mixing ratio	1 : 1 parts by volume	2 : 1 parts by volume	1 : 1 parts by volume	1 : 1 parts by volume
Viscosity of mixture (23 °C)	105 mPa·s	150 mPa·s	400 mPa·s	250 mPa·s
Workable life (23 °C)	120 min	50 min	> 60 min	> 25 min
Application temperature	> 5 °C	> 5 °C	> 5 °C	> 5 °C
Special properties	<ul style="list-style-type: none"> <li>• Low viscosity</li> <li>• Good elasticity</li> <li>• Adjustable reaction time (accelerator: <b>WEBAC. B14</b>)</li> <li>• Total solid**</li> </ul> <b>CE</b>	<ul style="list-style-type: none"> <li>• Very high flexibility</li> <li>• Low foam formation</li> <li>• Good adhesive power, high edge adhesion on concrete, steel, polymer</li> <li>• High shear strength</li> <li>• Resistant to bitumen, coal-tar pitch, existing sealings</li> <li>• Adjustable reaction time (accelerator: <b>WEBAC. B14</b>)</li> <li>• Environmentally safe</li> <li>• Total solid**</li> </ul> <b>CE U</b>	<ul style="list-style-type: none"> <li>• High chemical resistance also to biogenic sulfuric acid</li> <li>• Very flexible</li> <li>• Fast-sealing foam upon water contact</li> <li>• Compatible with bitumen</li> <li>• Tested for microbiological purity (W 270 test according to regulations by German Technical and Scientific Association for Gas and Water (DVGW))</li> <li>• Total solid**</li> </ul> <b>CE</b>	<ul style="list-style-type: none"> <li>• Fast-sealing foam structure upon water contact</li> <li>• Low viscosity</li> <li>• Elastic foam structure</li> <li>• Fast curing – permanent sealing</li> </ul> <b>CE</b>
CE classification (EN 1504-5)	U(D1) W(2) (1/2/3) (9/30)	U(D1) W(2) (1/2/3) (5/30)	U(D1) W(3) (1/2/3) (10/30)	U(D1) W(3) (1/2/3) (9/30)

PU/SPU Combi

\*The specified data are values determined under laboratory conditions and are subject to certain fluctuations. Deviations are possible in practice depending on the respective object situation.  
\*\*following test method by Deutsche Bauchemie e.V.


# Restoration Products

## Water stop with PU injection foam resins

It is usually impossible to fill cracks in case of (highly) pressing water. To do so, the water flow must first be stopped locally. Quick-foaming SPU resins are the ideal solution for this task and temporarily seal the cracks.


The cracks can then be filled with the permanently sealing resins according to the moisture condition until structural or flexible bonding of the elements is obtained.

### Technical parameters\*

	WEBAC. 150	WEBAC. 151	WEBAC. 157
Mixing ratio	1 : 1 parts by volume	1 : 1 to 1 : 10 parts by volume	1 : 1 parts by volume
Viscosity of mixture (23 °C)	600 mPa·s	240 – 1.200 mPa·s	400 mPa·s
Workable life (23 °C)	120 min	120 min	120 min
Special properties	<ul style="list-style-type: none"> <li>• Fast and highly expanding foam</li> <li>• Foam structure not too rigid</li> <li>• Universally applicable, high reliability</li> <li>• Adjustable reaction time (accelerator: <b>WEBAC. B15</b>)</li> <li>• Good reactivity and extraordinary resistance to alkaline water up to pH 13</li> </ul> 	<ul style="list-style-type: none"> <li>• Consistency: Soft, Flexible, Solid</li> <li>• Variable reaction time</li> <li>• Universally applicable</li> </ul>	<ul style="list-style-type: none"> <li>• Elastic foam structure</li> <li>• Low expansion pressure</li> <li>• Reliable sealing</li> <li>• Adjustable reaction time (accelerator: <b>WEBAC. B15</b>)</li> </ul>

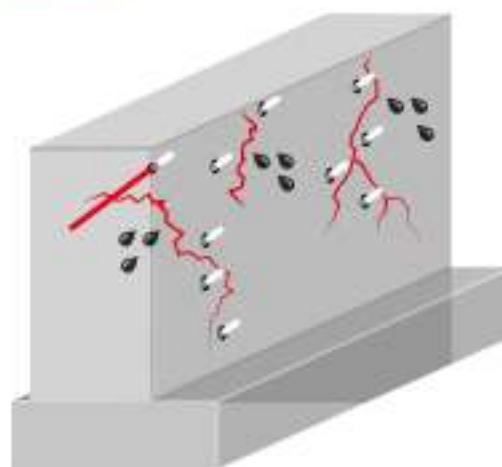
\*The specified data are values determined under laboratory conditions and are subject to certain fluctuations. Deviations are possible in practice depending on the respective object situation.

### Technical parameters\*

	WEBAC. 155
Viscosity	255 mPa·s
Special properties	<ul style="list-style-type: none"> <li>• 1C PU injection foam resin which reacts with humidity, permanent sealing effect with waterproof resin layer</li> <li>• Water contact required for foam reaction and curing</li> <li>• Very high elasticity and adhesion</li> </ul> 
CE classification (EN 1504-5)	U(D1) W(3) (2/3/4) (8/30)

\*The specified data are values determined under laboratory conditions and are subject to certain fluctuations. Deviations are possible in practice depending on the respective object situation.

Permanent sealing 1C SPU with CE



Crack repair in concrete

# Technical Items

## WEBAC 1C Injection Pumps

When applying WEBAC PU/EP Injection Resin using single-component pumps, both components are mixed first and then filled into the pump's hopper.



WEBAC. IP EasyPro



WEBAC. HP 100

## WEBAC 2C Injection Pumps

When using 2C pumps, both components are introduced to the mixing head separately and mixed there. This pump technology is especially recommended when applying very quick-reacting injection materials (SPU) and large quantities of material.



WEBAC. IP 2K-F2



WEBAC. HP 250



WEBAC. HEP 1001

## WEBAC Injection Packers

Injection packers are filler necks which connect the structural element to the injection pump during the injection process. Depending on the type of connection to the construction element one distinguishes between drill-hole packers and surface packers.

### Drill-hole packers

- Drill-hole packers are cylinder-shaped injection packers which are installed and tightened in drill holes made for this purpose.
- Depending on the type of installation a distinction is made between mechanical packers and hammer-in packers.
- **WEBAC. Mechanical Packers** are anchored in the drill holes by screwing.
- **WEBAC. Hammer-in Packers** are installed into the drill holes (providing sufficient strength of the structural element).

### Surface packers

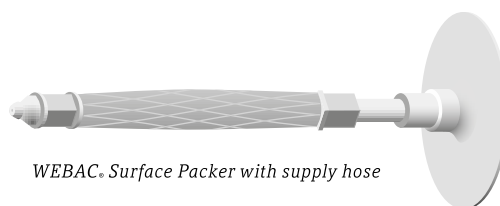
- **WEBAC. Surface Packers** are glued directly onto the crack at the structural element's surface.
- No drilling is required (non-destructive injection).



WEBAC. Mechanical Packer



WEBAC. Hammer-in Packer



WEBAC. Surface Packer with supply hose



WEBAC. Surface Packer

# Application of WEBAC Injection Resins

- ▶ Good organization and preparation facilitate the application and assure the required high quality of crack repairs.

## Preparatory work

The drill holes are usually made alternately on both sides of the crack, at a 45° angle so that they cross the crack course in the middle of the structural component and all cracking in the elements are covered (Ill. 1).

The distance between the drill holes depends on the crack width, the thickness of the structural element, the temperature-related workable life and the viscosity of the material (reference value: thickness of the structural element/2).

All drill dust is removed from the drill-hole walls by means of a round wire brush, and compressed air is blown through the drill holes or a vacuum cleaner is used (Ill. 2).

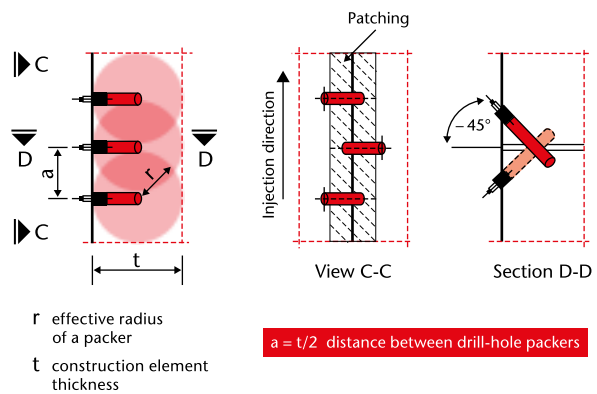
The drill-hole packers (**WEBAC® Mechanical Packers**) are inserted into the drill channels, so that the complete rubber disappears in the structure and firmly tightened in the structural element (Ill. 3).

If no drill holes can be made into the structure (e.g. prestressed concrete, load-bearing reinforcements, listed buildings), surface packers must be used. These are placed, installed and glued directly onto the crack at the structural component's surface and tightly integrated in a patching (▶ p. 11). In so doing, the distance between the surface packers usually corresponds to the thickness of the structural element.

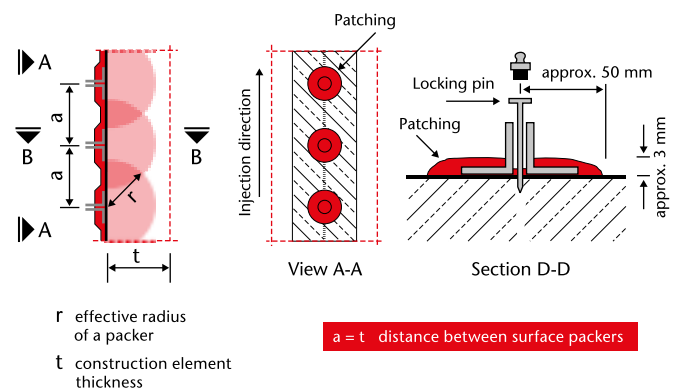
After mounting the packers, they are checked for connectivity by means of compressed air. When using limited-flexibility injection products this test must be performed with water.

If the crack course is not continuous, additional drill holes have to be made.

## Distances between injection packers in case of drill-hole packers



## Distances between injection packers in case of surface packers



## Performance

# Application of WEBAC Injection Resins

## Gluing and patching

**WEBAC Epoxy Putties** are used for installing surface packers and for patching cracks.

Especially when filling cracks where structural strength is required, the cracks must be patched prior to the injection in order to ensure a high filling level in the cracks and to prevent the injection product from being washed out of the cracks.

**WEBAC Surface Packers** are glued onto the crack at the component's surface using EP putty (distance between

drill holes = thickness of structural element). In order to prevent clogging of the injection channel when gluing the packer onto the element surface, a steel nail (locking pin) is driven into the crack onto which the packer is then fitted. As soon as the putty has cured the nail is removed. The cracks are patched on all sides with an even layer of WEBAC Epoxy Putty at least 10 cm wide and 3 mm thick. A vent must be provided at the highest points of the cracks.

Techn. parameters*	WEBAC® 4510	WEBAC® 4515	WEBAC® 4520	WEBAC® 4525	WEBAC® 4525P
Workable life (21 °C)	30 min	10 min	30 min	25 min	25 min
Curing (21 °C)					
5 mm film thickness	8 h	100 min	15 h	8 h	8 h
8 mm film thickness	4.5 h	45 min	> 8 h	4.5 h	4.5 h

\* The specified data are values determined under laboratory conditions and are subject to certain fluctuations. Deviations are possible in practice depending on the respective object situation.

## Injection

The injection pressure depends on the nature and condition of the building structure. The cracks are injected against gravity from bottom to top until injection material can be seen emerging from the adjacent packers and the element surface (Ill. 4).

A secondary injection is necessary to completely fill the cracks.

## Impregnation/grouting of cracks and surfaces

Cracks near the surface can be closed and surfaces affected by craquelure can be filled without pressure using injection products with a good wetting effect. The impregnation of cracks is suitable for horizontal or slightly inclined surfaces. The permanent crack-closing effect depends on the penetration depth. It is mainly affected by the viscosity development, the wetting effect of the injection products and the width of the cracks.

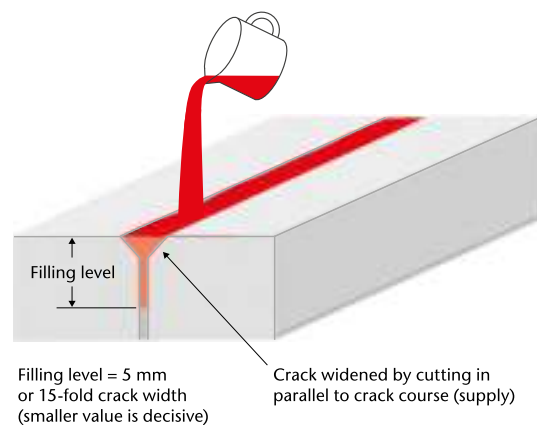
### INJECTION PRESSURE

The injection pressure is the nominal value of the delivery pressure at which the injection product is delivered to the filler neck (packer).

$$\text{max. pressure} = \frac{\text{Concrete strength} \cdot \text{d}^3}{3} \times 10 \text{ bar}$$

**Example:**

$$C 20/25 = \frac{25}{3} \times 10 \text{ bar} = 83,3 \text{ bar}$$



Performance

# Application of WEBAC Injection Resins

Work sequence using the example of an injection via drill-hole packers



Ill. 1: Making drill holes



Ill. 2: Removing drill dust



Ill. 3: Tightening packers



Ill. 4: Injection



Ill. 5: Dismounting packers



Ill. 6: Closing drill holes

## Final work

Upon conclusion of the injection process and the material's curing process the patching can be removed in a non-destructive manner, e.g. by heating with a hot air gun. The packers can be knocked off or dismantled. The drill holes are then closed with suitable mineral materials and the surface is reprofiled (Ill. 5 and 6).

# Cracks in Masonry

- Masonry is an inhomogeneous structure which can be statically strengthened similar to highly porous concrete elements (compressed concrete) by using special PU injection resins; PU resins used for damp proof courses provide for the sealing effect.

## Injection for static stabilization

There are two competing concepts for restoring the load-bearing capacity of masonry:

- The entire masonry structure is stabilized in the damaged areas by surface injections using injection resins whose strength is lower than that of the masonry itself in order to avoid secondary cracking in the stone structure.
- High strength injection resins are injected into highly confined areas for the formation of structural pillars or beams (stability anchors).

Techn. parameters*	WEBAC® 1610	WEBAC® 1660
Mixing ratio	1 : 1 parts by volume	1 : 1 parts by volume
Viscosity of mixture (23 °C)	285 mPas	450 mPas
Workable life (23 °C)	35 min	25 min
Application temperature	> 5 °C	> 1 °C
Special properties	<ul style="list-style-type: none"> <li>• Sealing, stabilizing</li> <li>• Tough</li> <li>• Very good penetration</li> <li>• Fast curing with or without water</li> <li>• Slight foam formation upon contact with water</li> <li>• Also suitable for use at low temperatures with accelerator (WEBAC® B16)</li> </ul>	<ul style="list-style-type: none"> <li>• Sealing, stabilizing</li> <li>• Very high compressive and bending tensile strength</li> <li>• Fast curing with or without water</li> <li>• Slight foam formation upon contact with water</li> <li>• Also suitable for use at low temperatures with accelerator (WEBAC® B16)</li> </ul>

## PU injection resins for sealing structures

To protect building structures from the penetration of damaging substances, structurally irrelevant cracks in masonry can be sealed with PU injection resins which also form post-construction damp proof courses within

the masonry. The sealing and moderately solidifying effects are obtained by stabilization and mainly blocking of pores and capillary structures within the mortar.

Techn. parameters*	WEBAC® 1401	WEBAC® 1403	WEBAC® 1404	WEBAC® 1420	WEBAC® 1440
Mixing ratio	3 : 1 parts by vol.	1 : 1 parts by vol.	3 : 1 parts by vol.	3 : 1 parts by vol.	3 : 1 parts by vol.
Viscosity of mixture (23 °C)	45 mPas	80 mPas	110 mPas	300 mPas	250 mPas
Workable life (23 °C)	120 min	90 min	60 min	100 min	120 min
Special properties	<ul style="list-style-type: none"> <li>• Extremely low viscosity</li> <li>• Low foam development</li> <li>• Good penetration</li> <li>• Mainly based on renewable raw materials</li> </ul>	<ul style="list-style-type: none"> <li>• Quick seal foam structure upon contact with water</li> <li>• Universally applicable, high reliability</li> </ul>	<ul style="list-style-type: none"> <li>• Very economical use</li> <li>• Mainly based on renewable raw materials</li> </ul>	<ul style="list-style-type: none"> <li>• High chemical resistance also to biogenic sulfuric acid</li> <li>• Very flexible</li> <li>• Quick seal foam structure upon contact with water</li> </ul>	<ul style="list-style-type: none"> <li>• Tear-resistant foam structure</li> <li>• Resistant to mechanical stress</li> <li>• Dynamically stabilizing</li> <li>• Quick-foaming</li> </ul>

\* The specified data are values determined under laboratory conditions and are subject to certain fluctuations. Deviations are possible in practice depending on the respective object situation.

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