



METHOD STATEMENT

Sika CarboShear L System

09.09.2015 / VERSION 2.1 / SIKA SERVICES AG / ANNIKA BAIER

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1 SCOPE

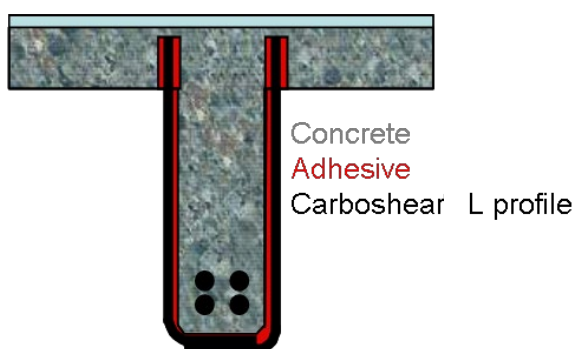
This Method Statement is written as a guideline for the use of the Sika CarboShear L system. This document must be used and referred to, in combination with all other relevant Product Data Sheets (PDS), Material Safety Data Sheets (MSDS) and the specific Project Specifications.

Structural strengthening must only be carried out by trained and experienced specialists, if additional clarification or advice is needed, please contact your local Sika® Technical Service Department.

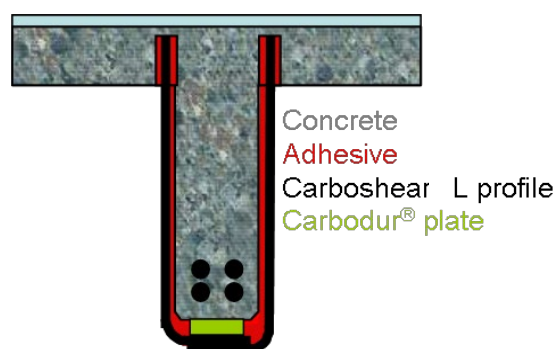
2 SYSTEM DESCRIPTION

The Sika CarboShear L system is a high-performance structural strengthening system, consisting of Sika CarboShear L profiles, Sikadur®-30, Sikadur®-30 LP, or Sikadur®-330 and Sika AnchorFix® 3+ adhesives. It is designed for the post construction reinforcement of concrete structures in shear and to anchor Sika CarboDur® plates. Two CarboShear L profiles made of pre-cured carbon fibre composite are anchored in a top slab and applied around a concrete beam so the bottom horizontal parts overlap, as illustrated below.

The Sika CarboShear L system is part of the Sika CarboDur® CFRP Strengthening System.



CarboShear for shear strengthening



CarboShear for shear strengthening and improved end anchorage of CarboDur® plates

2.1 REFERENCES

This Method Statement has been written in accordance with the recommendations contained in **fib technical report bulletin 14**, especially chapter 5.1 and 8, as well as with the advice contained in **ACI 440.2R-08**.

Pull-off tests for Quality Control purposes should be performed according to **EN 1542**.

2.2 LIMITATIONS

- The products must only be used in accordance with their intended applications.
- Local differences in some products may result in performance variations. The most recent and relevant local Product Data Sheets (PDS) and Material Safety Data Sheets (MSDS) shall apply and must be referred to.
- For any other specific construction / build information refer to the Architect's, Engineer's or Specialist Contractor's details, drawings, specifications and risk assessments.
- All of the works must be carried out as directed by a qualified engineer as the Supervising Officer.

3 PRODUCTS

| Sika Brand | Description |
|--------------------|---|
| Sika CarboShear L | Carbon fibre shear links, designed for strengthening concrete structures in shear and to anchor Sika CarboDur® plates at their end. Part of the Sika CarboDur® CFRP Strengthening System. |
| Sikadur®-30 | Thixotropic, structural two-part adhesive, based on a combination of epoxy resins and special filler, designed for use at normal temperatures between +8°C and +35°C. |
| Sikadur®-30LP | Thixotropic, structural two-part adhesive, based on a combination of epoxy resins and special fillers. Especially designed for use at higher temperatures between +25°C and +55°C. |
| Sikadur®-330 | Two-part, thixotropic epoxy based impregnating resin / adhesive |
| Sika AnchorFix®-3+ | Solvent-free, thixotropic, two-part, epoxy resin-based, high performance anchoring adhesive. |

3.1 MATERIAL STORAGE



Materials must be stored properly in undamaged original sealed packaging, in dry and cooled conditions. Refer to specific information contained in the Product Data Sheet regarding minimum and maximum storage temperatures and times. Protect the products from direct sunlight.

Sika CarboShear L profiles may only be transported in their original packaging or otherwise adequately protected against any mechanical damaging.

4 EQUIPMENT

4.1 TOOLS



Concrete Core Drill



Concrete Grinder



Vacuum Cleaner



Brush



Adhesive Gun



Application Trowels



Toothed spatula



Rubber Roller



Mixing Container



Mixing Spindle

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(For a more extensive list of the tools and equipment needed on site, please refer to chapter 9.1)

4.2 CLEANING

Clean all tools and application equipment with *Sika Colma® Cleaner* (or an *Isopropanol based cleaner*), immediately after use. Hardened material can only be removed mechanically.

4.3 ADDITIONAL TOOLS

Concrete slit saw

To drill the hole for anchoring the CarboShear L profile, either several normal holes can be drilled close to each other with a regular concrete core drill, or a special saw (pictured right) can be used to make slits. Information on different concrete saws can be found in chapter 9.1 in the appendix.

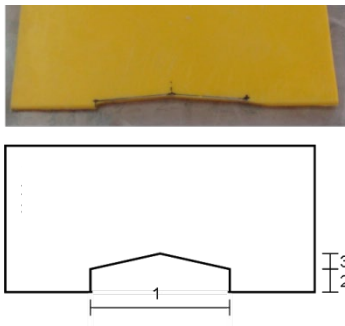


Adhesive applicator

To easily and evenly coat the CarboShear L profiles, it is possible to build a small tool which facilitates application of the adhesive onto the plates. A plastic or metal scraping tool is cut to shape as pictured below, and a simple wooden construction is made where the profiles can be fed through. The tool can be cleaned after use, or simply be discarded and rebuilt on demand. The images below illustrate the construction and application process.

A metal scraping tool can be used multiple times; it should always be cleaned thoroughly after use.

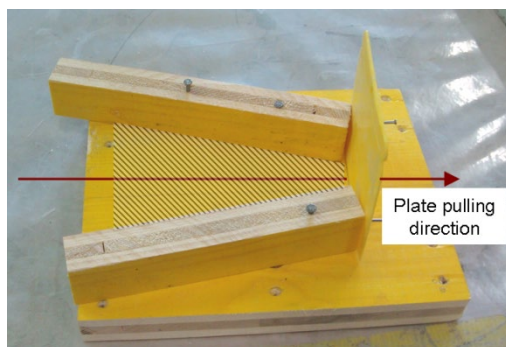
Application Tool Construction and Assembly



Top: Plastic Scraper with the cut-out made in the base

Dimensions:

- 1: 40 mm (width of CarboShear)
- 2: 2 mm (thickness of CarboShear)
- 3: 2-3 mm (thickness of adhesive)



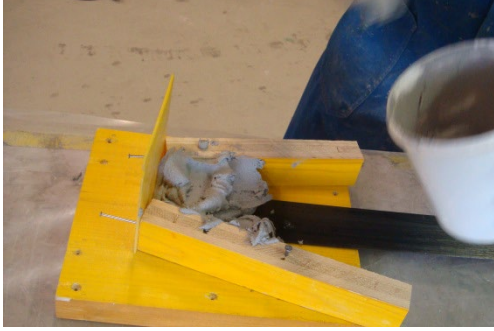
Application tool for applying the Sikadur® adhesive onto the Sika CarboShear profiles

The hatched area shows the adhesive 'feed area'

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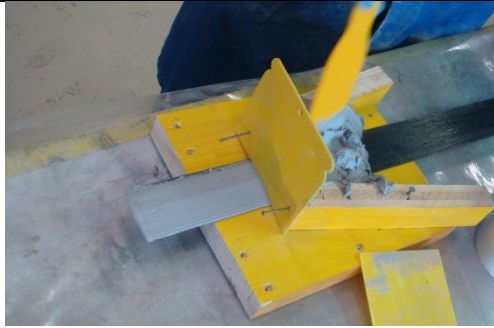
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Application



Adding the Sikadur® adhesive

Tip: Always keep the bulk of the adhesive close to the pre-cut scraper to ensure uniform coverage!



Simple and uniform application of the Sikadur® adhesive onto a Sika CarboShear profile in the desired domed shape, by simply pulling the plate through the tool

5 HEALTH AND SAFETY

5.1 RISK ASSESSMENT



The risks to health and safety from everything including any defects in the structure, working procedures and all of the chemicals used during the materials installation must be properly assessed and safely accommodated.

Any working areas on platforms and temporary structures must also provide a stable and safe area to work. All work and working procedures must be carried out fully in accordance with the relevant local health and safety legislation.

5.2 PERSONAL PROTECTION

Work Safely!

Safety shoes, gloves and other appropriate skin protection should be worn at all times. The use of disposable or new / clean protective clothing during the materials preparation and application is strongly recommended.

Always wear nitrile based protective gloves when handling epoxy adhesives as they can cause skin irritation.

Apply barrier cream to hands and any unprotected skin before starting work.

Appropriate eye protection should be worn at all times whilst handling, mixing and installing the products. Carrying an eye wash with you at all times is recommended.

Always wash hands with suitable soap and clean water after handling the products and before food consumption, smoking, visiting the toilet and after finishing work.

The work area needs to be well ventilated, and operatives should take frequent breaks in fresh air to avoid any other health issues.

Silica dust produced by the grinding or blast cleaning of concrete can be hazardous. Protect yourself and others by using a vacuum grinder or vacuum blast cleaning equipment with dust extraction and abrasive recycling attachments respectively. Always wear a dust mask/respirator when grinding concrete. Do not inhale the concrete dust.



For more detailed health and safety information, please refer to the relevant Material Safety Data Sheet (MSDS)

5.3 FIRST AID



If the epoxy resin based adhesive products come into contact with eyes or mucous membranes, remove any glasses or contact lenses and rinse with clean warm water for 10 to 15 minutes then seek medical attention.

Any chemical spillages on skin must be cleaned immediately and rinsed thoroughly with clean warm water.

For more detailed health and safety information, please refer to the relevant Material Safety Data Sheet (MSDS).

5.4 WASTE DISPOSAL



Do not empty any surplus material into drainage or water systems; dispose of all waste materials and packaging responsibly through licensed waste disposal facilities or contractors, fully in accordance with local legislation and the authorities' requirements. Also avoid any chemical materials run-off into soil or into waterways, drains or sewers.

Any uncured adhesive waste or spillages must be disposed of as hazardous waste. Waste and / or leftover *Sika Colma® cleaner* must be disposed of according to local regulations. Cured adhesive waste can be disposed of safely as normal building materials waste according to the relevant local regulations.

For more detailed health and safety information, please refer to the relevant Material Safety Data Sheet (MSDS)

6 SUBSTRATE PREPARATION

6.1 DAMAGED SUBSTRATES



Before preparing the substrate for the application of the Sika CarboShear L profiles, the substrate must be thoroughly inspected and any unsound material (such as areas of damaged concrete, pieces of the original wooden formwork or tie-wires etc.) must be removed.

If inadequate concrete thickness or weak concrete cover has to be removed, or prior leveling of uneven surfaces is needed, then the following Sika repair materials / systems can be applied: (For full details on these materials and their application / limitations, please refer to the relevant Product Data Sheets)

- For the protection of prepared, exposed or corroded steel reinforcement: SikaTop® Armatec® 110 EpoCem®
- As structural concrete repair / replacement materials: Epoxy resin-based materials for fast repairs in small areas: Sikadur®-41 mortar, Sikadur®-30 adhesive; Alternatively for larger areas or volumes use cement-based materials / systems: Sika MonoTop®-4012 (multipurpose for horizontal, vertical, overhead applications).

If there are large blowholes or honeycombing in the concrete surface, these must first be filled with a suitable repair mortar. As repair mortar use Sikadur®-41 epoxy mortar or Sikadur®-30 adhesive, filled to a maximum of 1:1 by weight with Sikadur®-501 quartz sand, to get the ideal consistency and thixotropic nature for the application. Sikadur®-30 adhesive must be used as a bonding bridge layer for both of these options to ensure a good bond with the concrete substrate and no voids in the repairs.



Where concrete repairs are necessary to a structure prior to bonding the Sika CarboShear L profiles, it is important that the repair materials are fully compatible with the adhesive and suitable for use in a structural situation (i.e., low shrinkage, compatible modulus of elasticity, good interface bond and adequate strengths). If the repair materials are not suitable, the effect will be detrimental to the long-term performance of the bonded plates.

Further advice on all aspects of concrete repairs can be obtained from your local Sika Technical Service Department.

6.2 TESTING

The actual strength of the concrete substrate must be verified on all projects. If the necessary values (mentioned in section 8 of this document) can't be achieved, then strengthening may still be possible by use of the SikaWrap®

Fabric system. Please refer to the SikaWrap® Fabric Product Data Sheets and Method Statements for this alternative Sika solution.

If the concrete is considered too weak for use and must be repaired as outlined in 6.1 above, then another test shall be performed after the repairs are completed and adequately cured. Please refer to Section 8 of this Method Statement for information on these testing procedures and the necessary concrete strength.

Concrete must normally be older than 28 days (dependent on the environmental situation, the mix design and effective strength requirements).

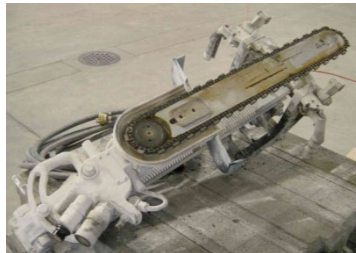
6.3 SUBSTRATE PREPARATION

To prepare the substrate for installation, an anchoring slit must be made, the concrete surface must be leveled, and the edges rounded (either by grinding or building up with Sikadur®-30 adhesive).

To make the anchoring slit, two different procedures (A&B, see table below) are possible. The L profile must be able to enter the slit to the desired depth and lie flat against the concrete beam. Anchorage lengths from 100 mm to 200 mm are usually chosen, depending on the project requirements and specifications.



A)
Drill several holes into the top slab to form a slit for the anchoring part of the CarboShear L-profile
Even out edges and irregularities



B)
Directly fabricate the slit (left) with the use of a diamond coated chain saw (right)

(for more information, see chapter 9.1)

The drilled hole must be cleaned from all dust and loose particles, using a vacuum cleaner and a brush. Do not blow into the hole with pressurized air, as this may press dust particles to the concrete surface which can prevent good adhesion.

The surface where the two legs of the CarboShear L profile will lie must be ground to remove the laitance layer of the concrete as well as may any variations and formwork marks greater than 0.5 mm. During concrete grinding, either a tool with integrated vacuum cleaner must be used or a dust mask must be worn to prevent the inhalation of concrete dust. After grinding, the surface should look like in the picture on the bottom, left, with the laitance layer removed and the grains showing. The plane and level of the substrate is to be checked with a wood or metal batten. The tolerance required depends on the specified standard to be achieved. Sika generally recommends tolerance testing according to the fib bulletin 14, but the tolerance measurement and testing can be according to any local guidelines. Obviously testing must only be carried out in relation to one standard or another.



| Standard | Fib bulletin 14 |
|----------------------------|-----------------|
| Tolerance for 0.3 m length | 4 mm |

After preparing the substrate surface, it has to be cleaned from oil, grease and standing water as well as all loose particles. The loose material is to be removed with a brush and a vacuum cleaner, as illustrated in the pictures on the right. After grinding and cleaning, the concrete should have a laitance and contaminant free, open textured surface. The substrate moisture content must lie below 4%.

The levelling / grinding and cleaning of the concrete surface should be performed shortly before the installation of the profiles. Otherwise, it is possible that the surface will get contaminated / dirty again, then additional cleaning would be required so as not to impair the quality of the adhesive bond.

The edges of the beam need to be rounded to a minimum radius of 25 mm. If the beam edge is not exactly rectangular, it can be re-profiled with Sikadur®-41 epoxy mortar or Sikadur®-30 adhesive, filled with Quartz sand Sikadur® 501 to max. 1:1 ratio to guarantee a good fit of the whole surface of the CarboShear L profile. After reprofiling, the flatness of the surface should be checked again, as mentioned above.

If the angle between the beam sides varies from 90° by more than a few degrees, the CarboShear L profiles cannot be installed. In this case, SikaWrap® fabrics should be considered for shear strengthening.



7 APPLICATION

Before starting the works on site, Sika always recommends that you prepare a checklist (an example is given in Section 9.3) to ensure that all of the necessary tools and materials are available on site when installing the plates. Review and record the ambient conditions and confirm that the most appropriate type of Sikadur® adhesive is available for the conditions on site, the specified program and the desired performance and exposure in service.

7.1 ADHESIVE

The Sikadur®-30 epoxy adhesive is used for the preparation of the anchoring part (see chapter 7.2 below). Depending on the project requirements and the application temperature, either Sikadur®-30, Sikadur®-30 LP, Sikadur®-330 or Sika AnchorFix® 3+ can be used to fill the anchorage slits, and either Sikadur®-30 or Sikadur®-30 LP is used as adhesive between the concrete and the CarboShear L profile.

The different adhesives should be mixed and used according to the respective Product Data Sheets. The adhesives can either be mixed in pre-batched units, or from bulk packing, according to the volumes required and the practical situation on site.

Pre-batched packs:

Add component B to component A and stir with a mixing spindle fitted to an electric low speed mixer (max. 500 rpm) to avoid entrapping of air. Mix thoroughly for about 3 minutes to a homogeneous mix with a uniform grey color and appearance. Then, pour the whole mix into a clean container and stir again for approx. one more minute, again at low speed to keep air entrapment at a minimum.

Bulk packaging, not pre-batched:

Stir the material components well in their individual containers. Measure and add the components together in the correct proportions to a suitable mixing container, then stir using an electric low speed mixer and continue as stated above for the pre-batched packs. For larger quantities use a mixing paddle instead of a mixing spindle.

The adhesive pot life begins when the resin and hardener are mixed. It is shorter at high temperatures and longer at low temperatures. Additionally, the greater the quantity / volume of material mixed together at one time, the shorter the pot life. To obtain longer workability at high temperatures, the mixed adhesive may subsequently be divided into portions; alternatively, another method is to chill the components A and B before mixing them.

Excess adhesive extruded from under the profiles during application should be scraped neatly away before curing. Do not reuse this material for bonding additional profiles.

The sequence of operations should be planned to ensure that the adhesive can be applied, the profiles bonded, and installation completed within one hour of mixing the adhesive or within 80% of the pot life, whichever comes first.

Adhesive Consumption

When using Sikadur®-30 for bonding of the profiles as well as for filling the anchor hole, the values in the middle column of the table below apply. When using Sikadur®-30 for bonding of the links and Sikadur®-330/Sika AnchorFix®-3+ for filling the anchor hole, the values in the right column apply.

| Type of CarboShear link | Sikadur®-30 | Sikadur®-30 & Sikadur®-330 Sikadur®-30 & Sika AnchorFix® 3+ |
|----------------------------|-------------|--|
| Sika CarboShear L 4/20/50 | 0.5 kg | 0.25 kg & 0.25 kg |
| Sika CarboShear L 4/30/70 | 0.6 kg | 0.35 kg & 0.25 kg |
| Sika CarboShear L 4/50/100 | 0.7 kg | 0.45 kg & 0.25 kg |
| Sika CarboShear L 4/80/150 | 1.0 kg | 0.75 kg & 0.25 kg |

Dependent on the size of anchorage hole, plane- and roughness of the substrate as well as loss or wastage, the actual consumption of adhesive may be higher (anchor hole: assumption 150mm depth).

If the anchor holes are cut with a concrete chainsaw instead of a core drill, the consumption will be considerably lower.

7.2 CARBOSHEAR L PROFILE PREPARATION

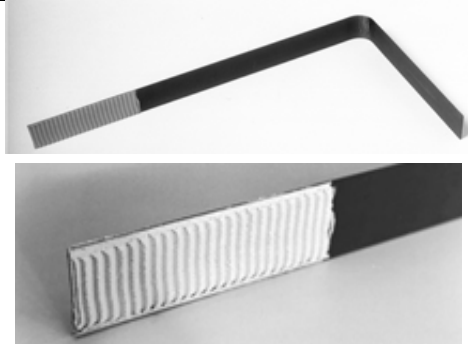
After cutting the two legs of the L profile to the desired length, the profile needs to be cleaned with Sika Colma® Cleaner (or an Isopropanol based cleaner) and a white cloth to remove oil, grease and dust particles. After cleaning, the anchoring area needs to be prepared with Sikadur®-30 as illustrated below.



Clean CarboShear L profile with Sika Colma® Cleaner (or an Isopropanol based cleaner)



Application of Sikadur®-30 and profiling with toothed spatula (both sides)
Let adhesive cure for min. 12 hours



L profile with finished anchor part

7.3 INSTALLATION

If the substrate is prepared as described above and the anchor profile has cured fully, the CarboShear L profile can be installed as illustrated step-by-step in the table below.

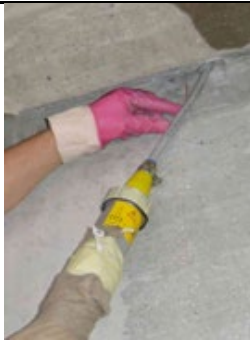
During installation, be careful to avoid water condensation on the surfaces (dew point conditions). Avoid any vibration to the structure for 2 days after application.



The area where the CarboShear L profile will be installed should be taped, as a guide to install the profiles straight and to avoid adhesive wastage. A layer of adhesive is applied and scraped very thin.



The profiles are coated either by hand with a spatula or with the applicator described in chapter 4.3. The adhesive should cover the whole surface and be dome shaped, being thicker in the middle. Ensure that the area around the bend of the L profile is coated well.



The slit in the top slab is filled with adhesive (Sikadur®-30, Sikadur®-330 or Sika AnchorFix® 3+) from the bottom of the hole so no air pockets form, and the anchoring end of the profile is inserted. The excess adhesive shall be removed.

If the hole goes all the way through the concrete slab, make sure to remove any adhesive that may be squeezed out on top.



The profile surfaces are pressed to the concrete with a plastic roller. Excess adhesive that is squeezed out from under the profile is removed.



Before installation of the second profile on the other side of the beam, the bottom is leveled with adhesive to guarantee a smooth surface without kinks.

The second CarboShear L profile is installed the same way as the first on the other side of the beam, overlapping in the horizontal area underneath the beam.

7.4 COATING AND PROTECTION

In general, additional coatings to protect the CarboShear L profiles should not be necessary. If the material is exposed to direct sunlight, it can be painted with a coating material such as Sikagard®-550W Elastic or Sikagard®-675 ElastoColor W for UV protection. If improvement of reaction to fire is necessary, coating with Sikacrete®-213F is possible. For an application where the product is immersed in water, a coating with Sikagard®-63N can be considered. Please refer to the relevant Product Data Sheets and Method Statements for the product / system details and application requirements. Further advice on these additional protective products and systems can also be obtained from your local Sika Technical Service Department.

8 INSPECTION, SAMPLING, QUALITY CONTROL

8.1 BEFORE APPLICATION

The substrate strength (concrete, masonry, natural stone) must always be checked and verified in all situations by means of a series of pull off tests (as outlined in EN 1542). The mean adhesive tensile strength of the prepared concrete substrate must be 2.0 N/mm², min. 1.5 N/mm² (standard Sika recommendation). If the strengthening work has to be performed according to the fib bulletin 14, then the concrete needs to have a minimum tensile strength of 3 N/mm².

Concrete substrates must be at least 28 days old, (dependent on the environmental situation, the mix design and effective strength requirements).

If the substrate is too weak, then either preliminary repair of the substrate or application of the SikaWrap® fabric strengthening system as an alternative to using Sika CarboShear L profiles could be considered. If the substrate is weak or damaged and needs to be repaired, a repetition of the substrate strength pull-off tests is necessary after the repair work is completed and cured, prior to the installation of the strengthening system.

8.2 QUALITY CONTROL AFTER INSTALLATION

To test the adhesion of the profiles and the quality of the installation, another pull-off test can be made after the strengthening work is completed. Since the test is destructive, an additional CarboShear L profile or alternatively a piece of CarboDur® plate needs to be installed.

Air pocket check

To check the installed profiles for voids in the adhesive layer or at the interfaces, they can be tapped with a metal bar (different sounds for fully bonded plates and plates with air pockets in the adhesive) or tested with ultrasonic methods. If a significant amount of air pockets is found, the CarboShear L profile needs to be replaced.

To check the installed profiles for air pockets / voids within the adhesive layer, or at the bond interfaces, they can be tapped with a metal bar (there are distinctly different sounds for fully bonded profile areas and any profile areas with air pockets / voids); alternatively, this can be tested more precisely using ultrasonic methods. If a significant amount of air pockets / voids is found, then the load transfer will not be sufficient, and the Sika CarboShear L profile needs to be replaced.

9 APPENDIX

9.1 CONCRETE SAW FOR ANCHORAGE SLITS

While the anchorage slits can be made by core drilling or regular drilling and concrete removal, cutting slits with a special concrete chainsaw can be faster and simpler. Since these tools operate with the help of water, allow the slits to dry before application of the resin.

Listed below are some tools that can be used for the application of the CarboShear system.

Please note: Sika is not affiliated with any of the companies listed below. Please always follow the manufacturer's instructions and manuals, especially regarding the compatibility of tool and substrate.

STIHL GS 461 RockBoss®: A powerful concrete cutter / chainsaw designed for deep cutting and square corners

<http://www.stihlusa.com/products/concrete-cutters/professional-concrete-cutters/gs461/> (*)

ICS® 695GC: Concrete cutting chainsaw

http://www.icsdiamondtools.eu/wp-content/uploads/2014/06/ICS_2015_ProductCatalog_EU_EN_web_spreads.pdf

(*) English, product catalog

<http://www.nestag.com/nestag/de/produkt/ics-695gc/> (*) German & French

(*) all web pages were accessed on 09/09/2015

9.2 CONSTRUCTION RECORDS

Throughout the project, a record should be written and maintained that details all aspects of the works involved in the preparation, mixing and application, including:

- Surface preparation
- Material delivery/ batch numbers
- Mixing and application of adhesive
- Ambient conditions (ambient temp., substrate temp., humidity, dew point)
- Any possible contamination
- Details of all test samples and results
- Any significant vibration
- Any other points of note or concern on site

9.3 ON SITE CHECKLIST: EQUIPMENT AND MATERIALS

- Grinding equipment
- Rotary cutter or hacksaw
- Concrete drill (or Diamond covered chainsaw)
- Brushes
- Vacuum cleaner
- Trowels / Spatulas
- Roof-shaped spatula
- Adhesive application device
- Adhesive gun
- Rubber roller
- Mixing container
- Mixing spindle
- Mixing paddle
- White wipes
- Tape
- Sika CarboShear L profiles
- Sikadur® -30 /-30 LP
- Sikadur® -330
- Sika AnchorFix® 3+
- Sika Colma cleaner (or an Isopropanol based cleaner)
- Thermometer
- Moisture meter
- Safety goggles
- Safety hard hat
- Skin protection cream
- Protective gloves
- Nitrile gloves
- Clean water
- Eye wash kit

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9.4 ON SITE CHECKLIST: QUALITY CONTROL

| Substrate preparation: | YES | NO |
|---|-----|----|
| Have 3 pull-off tests been carried out? | | |
| Average value measured on 3 locations: [MPa] (avg. should be 2.0 MPa, no value below 1.5 MPa.) | | |
| Are there any cracks above 0.2 mm wide in the concrete? | | |
| Has any damage to the structure been repaired? | | |
| Have any cracks been injected? | | |
| Is the evenness of the concrete surface (see table in section 6.3) fulfilled? | | |
| Environment: | | |
| Does the air and surface temperature exceed 5°C? | | |
| The actual average temperature is: [°C] | | |
| Is the ambient temperature at least 3° above the dew point? | | |
| Is the average relative humidity on the concrete surface below 4%? | | |
| Is there free moisture on the surfaces? | | |
| Are the surfaces to be bonded cleaned? | | |
| Is there any dust or other contaminants present? | | |
| After installation: | | |
| Has the bonding been checked by tapping? | | |
| Has the bond been checked with ultrasound equipment? | | |
| Has the bond been checked with thermography? | | |
| Are there any voids? | | |
| Is there any adhesive with areas of discoloration? | | |
| Have pull-off tests been carried out on test specimens? | | |
| Average pull-off strength x3 specimens [MPa] (avg. should be 2.0 MPa) | | |
| Have there been any deviations or changes from the initial specification and schedule? | | |
| If Yes, please describe them below: | | |
| | | |



10 LEGAL NOTE

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FOR MORE SIKA CARBOSHEAR L INFORMATION:

See the relevant PDS and technical article

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Method Statement
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