



STRENGTHENING SikaWrap[®] FX

CARBON FIBER STRINGS FOR STRUCTURAL STRENGTHENING APPLICATIONS

BUILDING TRUST





COMPETENCE YOU CAN TRUST

Sika provides you with a depth of knowledge from our state-of-the-art technical expertise and global practical experience to produce virtually tailor-made solutions for the repair, refurbishment and improvement by strengthening of your existing buildings and civil engineering structures. This includes fully compatible products and integrated systems to suit almost every project and site requirement. Sika customer advice and support is second to none, from concept, through design and detailing, to practical installation and successful completion on site. This is all based on more than 100 years of experience on large and small projects all over the world.

CONTENT

04 SikaWrap® FX - Multiple application possibilities

1. SikaWrap® FX for the anchorage of SikaWrap® fabric systems
 2. SikaWrap® FX as a through-anchor for the Sika Textile Reinforced Mortar System (TRM)
 3. SikaWrap® FX for near surface mounted reinforcement (NSM)
 4. SikaWrap® FX for anchorage of near surface mounted (NSM) cantilevered applications
 5. SikaWrap® FX for closed loop shear strengthening
 6. SikaWrap® FX to strengthen beam-column joints
-

06 SikaWrap® FX - Application areas

08 SikaWrap® FX as anchorage for SikaWrap® Fabrics

Structural retrofitting of the Krousovitis Bridge, Greece

09 SikaWrap® FX as through anchors for the Sika TRM System

Historic House, Amfissa, Greece

10 SikaWrap® FX for near surface mounted reinforcement (NSM)

Apartment building in Rapperswil, Switzerland

11 SikaWrap® FX for cantilever strengthening

Ponte Rialto, Venice, Italy

12 SikaWrap® FX for cantilever strengthening

Apartment building in Leeuwarden, The Netherlands

13 SikaWrap® FX system for closed loop shear strengthening

Extension of a Sports Hall, Biberstein, Switzerland

14 SikaWrap® FX system for complex beam-column joints

Merrion Centre MSCP, Leeds, United Kingdom

SikaWrap® FX - MULTIPLE APPLICATION POSSIBILITIES

SikaWrap® FX PRODUCTS ARE CARBON OR GLASS FIBER STRINGS for structural strengthening applications that are used as stand-alone systems and also as anchoring for SikaWrap® fabric reinforcement and Sika Textile Reinforced Mortar (TRM) strengthening systems.

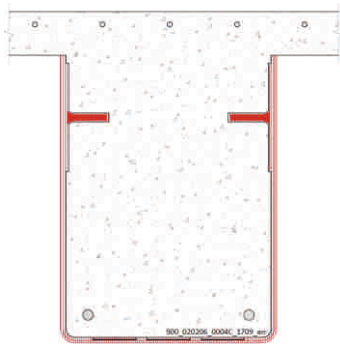
SikaWrap® FX: THE PRODUCTS

SikaWrap® FX products are dry carbon or glass fiber strings, encased in a plastic envelope to protect them from contamination and fraying. Additional numbers are used in the FX product names to indicate the weight of each in grams per linear meter and the letters C or G to denote that the fibers are carbon or glass. All of the SikaWrap® FX products are supplied to site in rolls and then cut as required for their many different applications and structural configurations.

SikaWrap® FX: THE SYSTEMS

SikaWrap® FX carbon fiber strings are impregnated on site with either Sikadur®-300 or Sikadur®-52 epoxy resins, before they are embedded into the prepared predrilled holes, slots cut into the substrate, or concrete surfaces, dependent on the type of application.

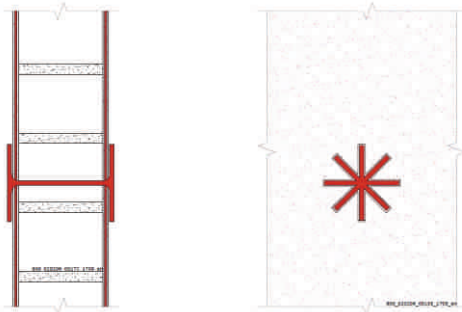
The SikaWrap® FX systems can be used for shear or near surface mounted (NSM) structural strengthening, or in combination with SikaWrap® fabrics as an additional anchorage or connecting option, and also with Sika Textile Reinforced Mortar (TRM) systems to provide additional structural requirements.



1. SikaWrap® FX FOR THE ANCHORAGE OF SikaWrap® FABRIC SYSTEMS

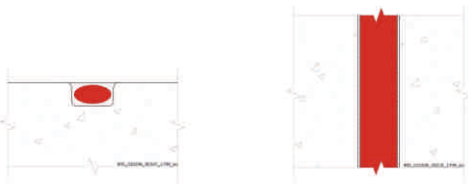


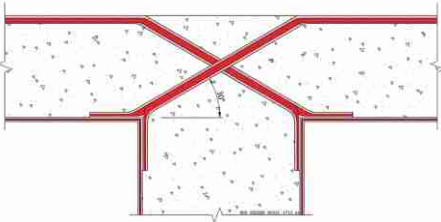
With SikaWrap® carbon fiber fabric applied for shear strengthening, the weakest points are always the fabric ends. During any overload, these ends of the fabric may start to peel and thereby reduce the overall strength of the member significantly.

In order to avoid this, SikaWrap® FX strings can be used to create an embedded end-anchor, with one part bonded into holes predrilled in the substrate and the other part spread out into slots cut in the concrete surface. In this way the substrate and the structural connection are both strengthened, whilst also significantly increasing the peel-resistance of the system.

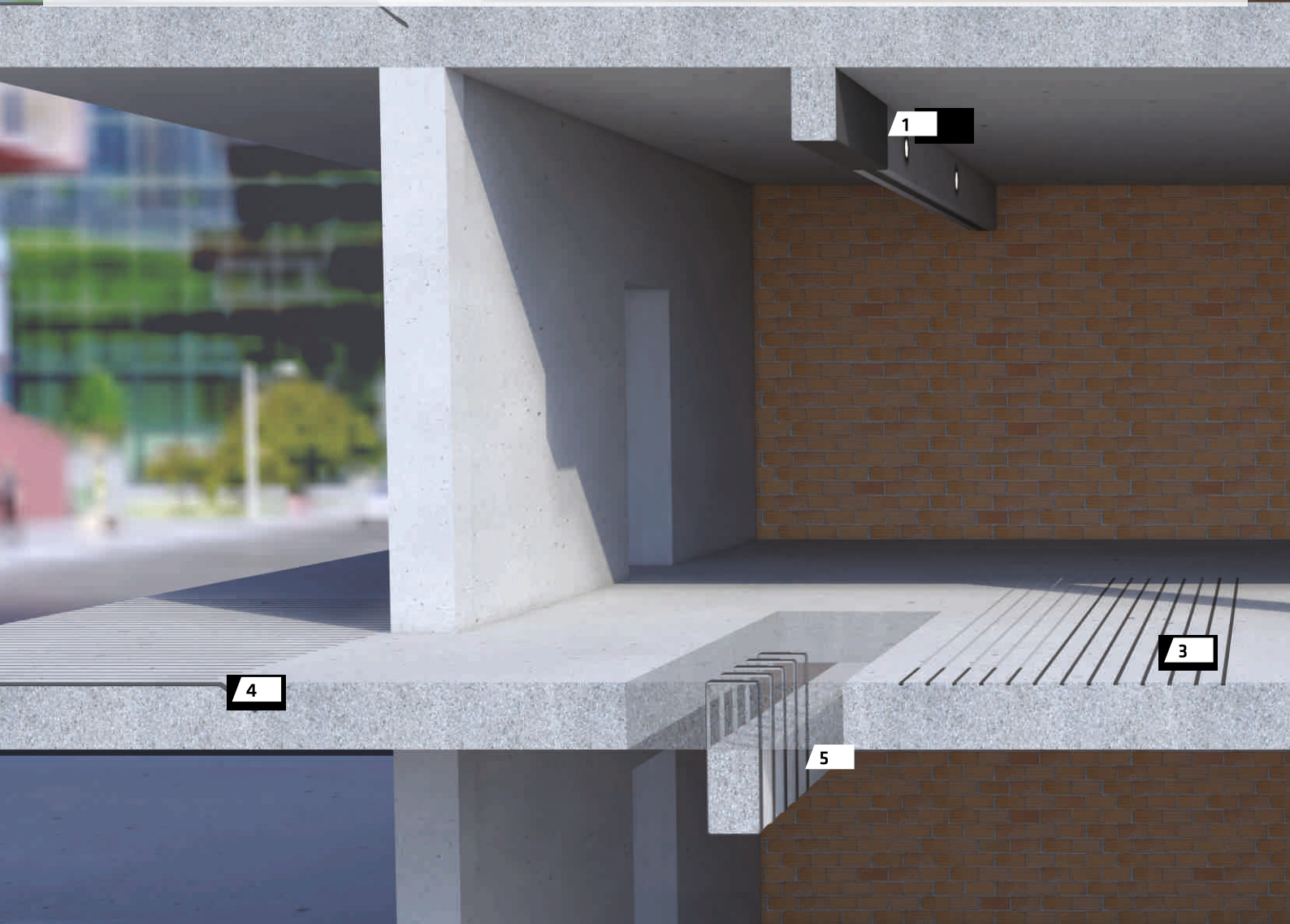


2. SikaWrap® FX AS A THROUGH-ANCHOR FOR THE SIKATEXILE REINFORCED MORTAR SYSTEM (TRM)

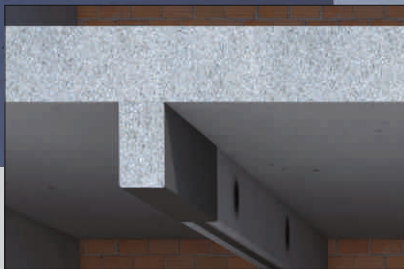
The Sika TRM system is based on cementitious mortar and bonds well to both hollow and solid masonry structures. In some cases, additional anchorage of this system is required and SikaWrap® FX can easily be installed through masonry walls and spread out on both sides, then bonded into or onto the mortar system as required. The Sika TRM system is then even more securely bonded to the substrate and an integral part of the masonry walls, meaning that any potential danger of de-bonding is significantly reduced.

	<p>3. SikaWrap® FX FOR NEAR SURFACE MOUNTED REINFORCEMENT (NSM)</p> <p>Flexural strengthening for both negative and positive moments is usually done with Sika® CarboDur® CFRP plates, either applied externally, or as so-called NSM systems, installed in slots cut into the surface. As an alternative to these rigid plate profiles, SikaWrap® FX carbon fiber string system can also be used for such applications, and since they are impregnated with resin on-site, they have the additional advantages that they can be installed in any length and in any layout including being curved, wrapped around any corners, or even in spirals, for example to strengthen reinforced concrete or masonry domes.</p>
	<p>4. SikaWrap® FX FOR ANCHORAGE OF NEAR SURFACE MOUNTED (NSM) CANTILEVERED APPLICATIONS</p> <p>Combinations of the anchorage and the NSM applications of SikaWrap® FX result in a useful cantilever strengthening system. This was originally developed to strengthen balcony decks, but it can also be used for many other different cantilever situations. With part of the SikaWrap® FX anchored into the main structure and the rest embedded in a slot on the balcony surface, these structures can take significantly more load.</p>
	<p>5. SikaWrap® FX FOR CLOSED LOOP SHEAR STRENGTHENING</p> <p>SikaWrap® FX can also be used as an alternative for the shear strengthening of beams instead of fully wrapping them with SikaWrap® carbon fiber fabrics. When using SikaWrap® FX systems this type of installation does not require the same extensive removal of damaged concrete, or the mechanical preparation of large surface areas, but only a few holes need to be drilled/cut to feed the SikaWrap® FX strings through. Where it is suitable this application is therefore cleaner, faster and easier for the same overall strengthening result.</p>
	<p>6. SikaWrap® FX TO STRENGTHEN BEAM-COLUMN JOINTS</p> <p>To strengthen a beam-column joint, many layers of a CFRP fabric usually need to be applied and in a specific order and direction. As an alternative, SikaWrap® FX strings can be used in a similar way to steel dowel bars, so that the concrete elements are effectively tied together and the SikaWrap® FX system is always under tension to accommodate the required structural loading.</p>

SikaWrap® FX - APPLICATION AREAS

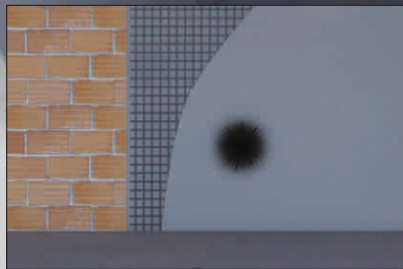


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SikaWrap® FX for the anchorage of SikaWrap® fabric systems

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SikaWrap® FX as a through-anchor for the Sika Textile Reinforced Mortar System (TRM)

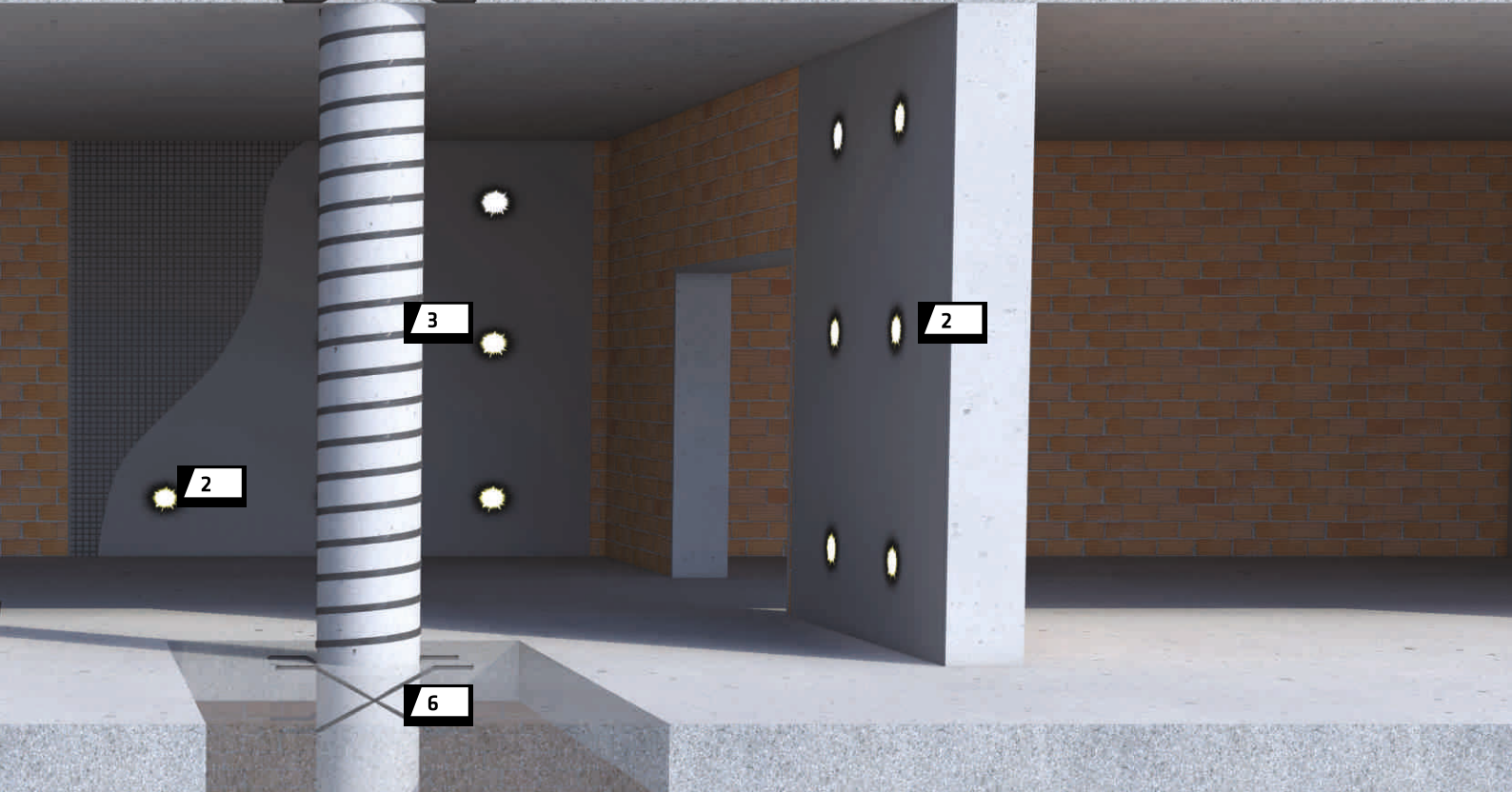
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SikaWrap® FX for near surface mounted reinforcement (NSM)



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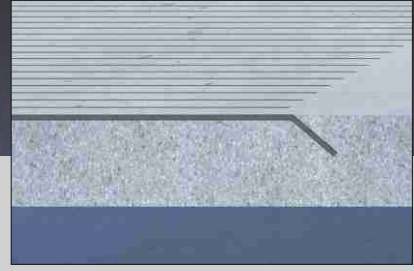
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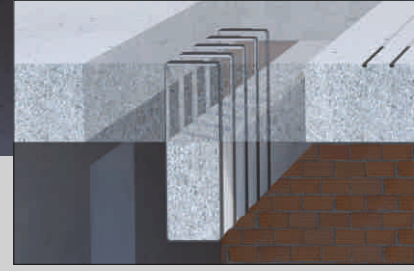
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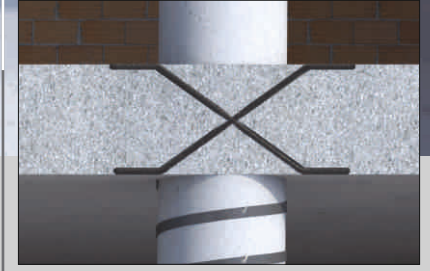
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SikaWrap® FX for anchorage of near surface mounted (NSM) cantilevered applications



SikaWrap® FX for closed loop shear strengthening



SikaWrap® FX to strengthen beam-column joints

SikaWrap® FX AS ANCHORAGE FOR SikaWrap® FABRICS

Structural retrofitting of the Krousovitis Bridge, Greece

THE OLD BRIDGE OF KROUSOVITIS CREEK in Northern Greece was built around 20 years ago and has four spans of approximately 120 m that each consist of four pre-stressed beams, which are connected by transverse girders to support the reinforced concrete deck slab.

After this period of service the bridge was due to be refurbished and it was decided to also increase the cross-section of the deck with additional reinforced concrete in order to provide longer term durability and an increased service life. As a result of these changes in cross-section and the resulting increased deck loading, it was also necessary to increase the load carrying capability and enhance the shear strength of the existing beams. A SikaWrap® system of structural strengthening with CFRP fabrics was selected in preference to traditional steel or concrete, to avoid adding any significant extra weight to the beams themselves. The fast installation of this strengthening system also meant that further disruption was minimized and the bridge could be re-opened to traffic much sooner.

The additional shear strength was achieved by external wrapping of the beams with SikaWrap® carbon fiber fabrics that were impregnated and bonded on site with Sikadur® epoxy adhesives. The geometry of the different cross-sections required additional anchorages for the SikaWrap® fabrics and these were provided using the SikaWrap® FX system.

A full range of integrated Sika solutions was used on this project including Sika concrete repair materials, Sikadur® epoxy adhesive mortars and structural resin injection products, plus Sika® FerroGard® 903 Plus impregnating corrosion inhibitor and Sikagard® protective coatings for long-term anti-corrosion and concrete protection.



**INCREASING SHEAR STRENGTH
FAST AND EFFICIENT INTEGRATED SOLUTION
MINIMIZING TRAFFIC DISRUPTION**



SikaWrap® FX AS THROUGH ANCHORS FOR THE SIKA TRM SYSTEM

Historic House, Amfissa, Greece

THIS GREEK WAR OF INDEPENDENCE HERO PANOURGIAS HOUSE in Amfissa dates back to the end of the 18th century and was built in the traditional local materials and architectural style. It consists of a main two-story building with a ground floor extension, making a total area of 287 m².

Due to its historic connections the authorities had decided to convert the property into a Historical Information Center, but due to its deteriorated condition, significant restoration works were required that would also bring the property up to meet modern building regulations including the latest seismic standards, for its new role and public use. These works were organized with the National Council for Quality Development program (NCQD) in order to make the structure suitable for this new purpose, whilst maintaining the primary elements and appearance of the historic building as far as possible, with its place in the local environment.

The building had several local peculiarities, one was the use of rubble infill masonry for some of the walls, which also had to be stabilized so that the building structure could be strengthened. The restoration works had to be designed to preserve and highlight all of the historic areas of the building and effectively to leave the appearance as-is. Therefore the modifications for its change of use also had to be made with the same constraints, without altering the buildings character, as well as ensuring that it would meet all of the latest building regulations and the requirements for static and seismic loading. Natural materials from the same area were used to help the harmonization of the building in the environment and blend with its original construction. The Sika Textile Reinforced Mortar System (TRM) was used to improve the masonry and give new life to the building structure, by allowing all of these new requirements to be met and integrated in the traditional shell of the structure.

This Sika system comprises Sika MonoTop® repair mortar and render in accordance with EN998-1 (GP) and EN 998-2 (M20) for masonry applications; and a SikaWrap® glass fabric mesh reinforcement, with high tensile strength in both directions. The mesh is then fully embedded in the mortar, and SikaWrap® FX carbon fiber strings are used to anchor this reinforced mortar system fully into the substrate. This was achieved by installing the SikaWrap® FX through the walls which were already strengthened with the Sika TRM system on one or both sides, and then spreading and bonding the strings directly on the fully hardened mortar surfaces.

Note: The engineers specification made provisions for a double layer of the Sika TRM system on the ground floor walls and a single layer for the first floor walls. There were also many other Sika products used on this project, including Sikadur® injection resins for structural crack sealing, and Sika AnchorFix® resin for bonding structural steel dowel bars.



**INCREASING STATIC AND SEISMIC LOAD BEARING CAPABILITY
HARMONIZATION WITH LOCAL ENVIRONMENT AND HISTORIC ELEMENTS
COMBINATION OF SIKA STRUCTURAL SYSTEM SOLUTIONS**

SikaWrap® FX FOR NEAR SURFACE MOUNTED REINFORCEMENT (NSM)

Apartment building in Rapperswil, Switzerland

A ROUTINE INSPECTION OF THIS MULTI-STORY APARTMENT BUILDING

in Rapperswil, Switzerland showed that the structure no longer met current building standard that has been updated with increased requirements for seismic resistance in this region.

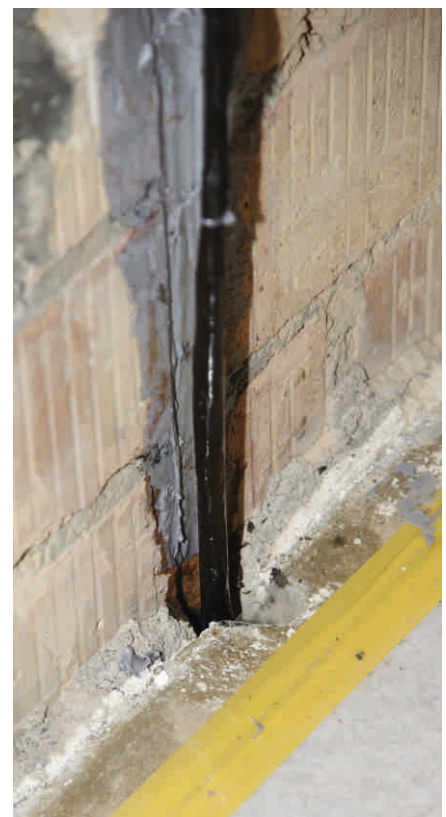
To be fully compliant with all of today's standards and building regulations the structure had to be strengthened to the increased levels of seismic resistance required to be able to withstand the potential levels of earthquakes in the area.

Sika® CarboDur® plates were installed to strengthen the ceiling slabs and SikaWrap® FX was selected as the best option to strengthen the walls as near surface mounted reinforcement (NSM), which was used through all floor levels from the basement to the roof and in one continuous run. The SikaWrap® FX strings were impregnated with Sikadur® epoxy resin adhesive and transported on a roll with ca. 20 cm diameter, and then installed into pre-cut slots in the walls. They were covered again with Sikadur® epoxy resin adhesive and the surface was broadcast with kiln dried sand. Later test cores confirmed an excellent bond to the substrate. The Sikadur® adhesive had also penetrated approximately 2 mm into the masonry substrate. The two free ends of the SikaWrap® FX strings were fixed into the substrate as the end-anchors.

In addition, the masonry walls were also reinforced at the same time, using the Sika Textile Reinforcement Mortar System (TRM). The first layer of Sika MonoTop® was applied on the surfaces and then a SikaWrap® glass fabric reinforcing grid was embedded and covered with a second layer of the mortar to complete the strengthening system.

All of these different Sika systems can be used independently as stand-alone solutions, or they can be combined for more complex projects to provide complete bespoke and integrated structural strengthening solutions.

INCREASING SEISMIC RESISTANCE NO SPECIAL PRE-TREATMENT INTEGRATED BESPOKE SIKA STRENGTHENING SYSTEMS



SikaWrap® FX FOR CANTILEVER STRENGTHENING

Ponte Rialto, Venice, Italy

THE RIALTO BRIDGE IN VENICE IS ONE of the most well-known bridges in the world. Almost every day of the year, thousands of tourists take pictures, walk over it or sail under it by Gondola. The Ponte Rialto is one of the four bridges that span the Canal Grande.

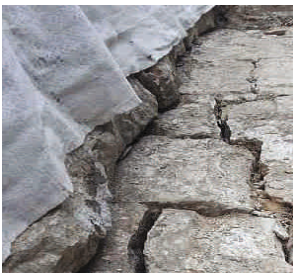
It was designed by Antonio da Ponte, took three years to build and was completed in 1591. The bridge is 48 meters long with a single 22 meter span arch made of natural stone masonry, on either side of the central portico, the covered ramps carry rows of shops. During the original construction of the bridge, many people believed and expressed concern that the project was too audacious from an engineering point of view, yet the bridge is still standing today and is an architectural icon in the City of Venice.

However because of the importance of the bridge and its strong historic and architectural heritage as a landmark in the city, a restoration project was planned in order to conserve the bridge for future generations. The careful design and planning of this work had to take three main requirements into consideration: maintaining the architectural design and nature, preservation of the historic materials and protection of the structure. Due to the nature of the structure and the need to maintain its visual appearance, non-invasive systems were to be used wherever possible.

Both sides of the Rialto Bridge are rimmed by a balustrade made of Istria stone, which protrudes beyond the external edge of the masonry arch and rests on stone cantilevers anchored underneath the deck. Upon close inspection and removal of the stone deck, many of these cantilevers supporting the balustrade turned out to be cracked and the balustrade had also rotated slightly outward. Therefore these needed their structural integrity to be restored and strengthened to ensure they could accommodate the loading for the long term.

Sika provided a complete integrated solution for all of the structural strengthening requirements using SikaWrap® fabrics to reinforce the stone cantilevers and increase the safety and support of the balustrades, thereby blocking any further rotation. This was achieved using SikaWrap® unidirectional carbon fiber fabric, impregnated with Sikadur® epoxy resin adhesive by careful manual dry application techniques. The connecting end-anchorage into the structure at each end, were formed with SikaWrap® FX carbon fiber strings, also impregnated onsite with Sikadur® epoxy resin and bonded into the stone supports with Sika AnchorFix®. The entire strengthening solution is also invisible as it is hidden under the restored deck.

**MAINTAINING THE ARCHITECTURAL DESIGN
NON-INVASIVE AND INVISIBLE
PROTECTION OF THE STRUCTURE**



SikaWrap® FX FOR CANTILEVER STRENGTHENING

Apartment building in Leeuwarden, The Netherlands

CANTILEVERED BALCONIES HAD COLLAPSED DRAMATICALLY due to reinforcement corrosion. This had originally been caused by steel reinforcement corrosion that in turn caused cracks to develop in the concrete decks, allowing the unrestricted ingress of water and chloride ions. This had increased and accelerated the rate corrosion, including pitting corrosion, which seriously weakened the structure, eventually causing the collapse

After this incident and to avoid any repeat, the Dutch government decided to demand mandatory investigations and reports on the condition of all residential buildings with cantilevered balconies of this type dating from the sixties and seventies. In this apartment building structure there was no immediate risk of any further collapse identified, however it was determined that all of the cantilevered balcony decks in all of the apartments in the structure had to be strengthened, with additional measures taken to prevent any such problems in the future.

As a result all of these decks were structurally strengthened using SikaWrap® FX carbon fiber strings as Near Surface Mounted (NSM) reinforcement. This Sika system was applied by cutting slots approximately 30 mm deep in the concrete surface, which could be done relatively easily and without any heavy equipment. The ends of these SikaWrap® FX strings were then anchored using Sika AnchorFix® epoxy adhesive, into additional holes drilled into the main structure. The load bearing capacity was therefore increased ensuring future stability and safety.

Once the SikaWrap® FX strings had been installed, the slots were re-filled using a fast-hardening Sika cementitious flooring system. The balcony decks were then sealed and made waterproof to prevent future water and chloride ingress, using a fast-drying Sikafloor® Pronto (acrylate resin based) deck coating system that also provides a range of decorative finishes.

**EASY AND FAST APPLICATION
DISTURBANCE KEPT TO A MINIMUM
SIKA SYSTEM SOLUTIONS FOR BALCONIES**



SikaWrap® FX SYSTEM FOR CLOSED LOOP SHEAR STRENGTHENING

Extension of a Sports Hall, Biberstein, Switzerland

AN EXTENSION TO THIS SPORTS HALL meant that electrical wiring and other services needed to be installed through a single-span beam.

In order to install these as planned, several holes had to be drilled through a load-carrying beam causing some of the steel reinforcement bars to be cut and/or section lost in this process. Therefore in order to keep the beam at its designed load carrying capacity, a method of structurally shear strengthening the beam was required and the different options were considered.

Using steel links or strengthening by completely wrapping the beam with a composite fabric strengthening system was not possible because the concrete floor slab is supported directly on the top of the beam. The engineers therefore selected to use the SikaWrap® FX system as the best alternative option, which consisted of the carbon fiber strings bonded directly onto the prepared sides and bottom of the beam, and through the core holes drilled at the top of the beam. Once the strings had hardened the holes were filled and sealed with Sika AnchorFix® epoxy resin. In this way the engineers were able to fulfill the same strengthening requirements as complete CFRP fabric wrapping, but with a system that was also practical to install.

Additional note: Before applying the SikaWrap® FX system for shear strengthening, the beam was also laterally strengthened using Sika® CarboDur® plates on each side, to ensure the required flexural strength and load bearing properties were maintained. The core drilling works for the end-anchorage of the shear strengthening loops was executed after these plates were installed and had cured sufficiently.

PRACTICAL TO INSTALL
COMBINATION OF SIKA SYSTEMS
EFFICIENT STRUCTURAL STRENGTHENING



SikaWrap® FX SYSTEM FOR COMPLEX BEAM-COLUMN JOINTS

Merrion Centre MSCP, Leeds, UK

AFTER ALMOST 50 YEARS IN SERVICE, the carpark at the Merrion Centre, a major retail and commercial destination in Leeds, UK, was in need of refurbishment and repair.

The initial condition survey and assessment found severe steel reinforcement corrosion in various areas, mainly due to winter de-icing salts penetrating into the concrete decks through cracks in the surface. Due to corrosion related damage and concerns for the structural integrity, substantial concrete repair and protection works were necessary. This included structural strengthening measures, including flexural strengthening of reinforced concrete beams with an increased bending moment.

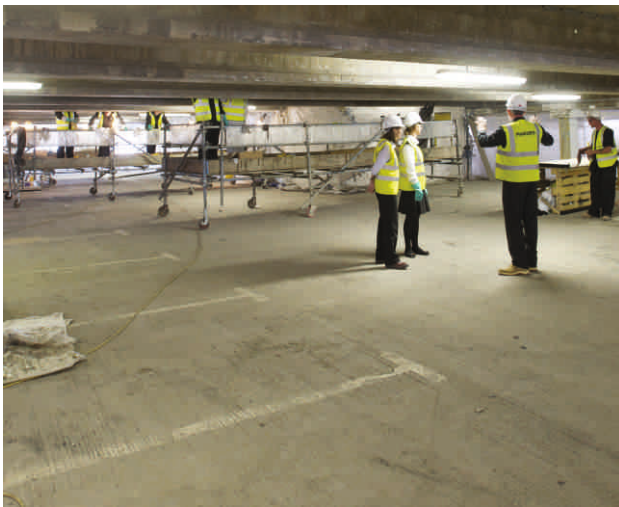
The damaged concrete over the areas of corroding steel reinforcement was carefully removed and replaced with a complete Sika concrete repair system to protect the pre-stressed planks below. Additional measures were taken to provide corrosion protection in exposed areas, including the application of Sika® FerroGard® migrating corrosion inhibitors, Sika galvanic anodes and a Sikgard® anti-carbonation coating system on the facades and other vertical surfaces for future protection and improved aesthetics.

The structural strengthening measures that were required included the flexural strengthening of the beams that had excess deflection, together with overall strengthening of the main parking deck slabs. These decks were also strengthened overall to ensure that despite any loss of section and corrosion damage over the years, the original design load capacity was correct and would be maintained for the future. A single layer of SikaWrap® bi-directional carbon fiber fabric was used to provide the additional moment capacity and meet reduced deflection requirements.

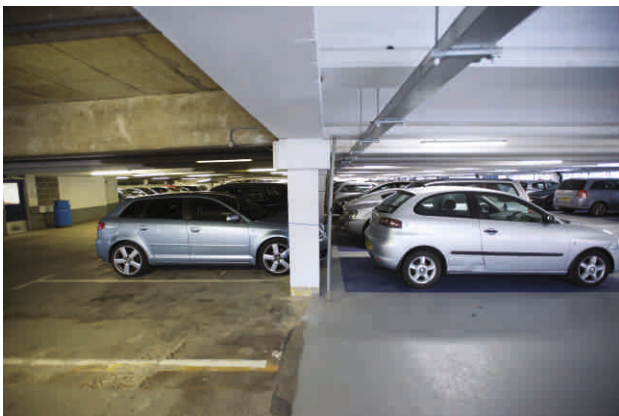


During the carbon fiber design phase, the calculations showed a potential peeling issue with the fabric applied on the soffit of the slabs where they met the supporting beams. However this issue was solved by introducing SikaWrap® FX carbon fiber strings as anchors installed into holes predrilled into the beams at an angle of 30° above horizontal, with the SikaWrap® fabric reinforcement then applied and bonded over them.

The parking structure refurbishment works were completed with the application of a new Sikafloor® waterproof deck coating system, designed to accommodate the future exposure to traffic and weathering, whilst preventing the future ingress of water and de-icing salts into the slabs. This complete integrated Sika systems approach also ensured minimal disruption for the owner, their tenants and their customers as many of the parking areas could still be used during much of the phased works.



MINIMAL DISRUPTION
EXTENDED SERVICE LIFE
INTEGRATED SIKA SYSTEM SOLUTIONS



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