



# REFURBISHMENT STRUCTURAL STRENGTHENING WITH SIKA SYSTEMS

BUILDING AND CIVIL ENGINEERING STRUCTURE CASE STUDIES

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.

Picture/Video: London Underground – Strengthening of cast iron beams with ultra high modulus Sika® Carbodur® CFRP plates



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# EXTENDING FUNCTIONAL SERVICE LIFE

**THE USE OF A BUILDING OR CIVIL ENGINEERING STRUCTURE** may change throughout the course of its service life, as for example its whole function can change, loads can increase and/or higher building standards are required and the structure must be made compliant. Sika provides fully comprehensive solutions with complete systems for all kinds of structural strengthening and improvement. Whether increasing the bending, shear or impact resistance, tested and proven Sika systems are available for use on reinforced concrete, steel, wood and masonry load-bearing structures.

## TYPICAL APPLICATION



**COLUMN STRENGTHENING**



**BEAM STRENGTHENING**



**PRE-STRESSED STRENGTHENING**



**SEISMIC UPGRADING / EARTHQUAKE DAMAGE REPAIR**



**INCREASING IMPACT RESISTANCE**



**CRACK PREVENTION/REDUCTION**

## PROVEN PERFORMANCE AND DURABILITY

Sika Structural Strengthening Systems have been tested extensively internally and externally, under many different conditions to ensure their long-term performance in different environments for:

- Long-term fatigue
- Artificial ageing
- Exposure in alkaline environments
- Installation under dynamic load

Worldwide success with the completion of countless individual large and small projects over the last decades demonstrates the performance, reliability and durability of Sika Strengthening Systems. This is quality you can trust.



## SIKA FOR EXCELLENCE IN STRUCTURAL STRENGTHENING

Sika brings sustained added value to building and civil engineering structure owners, their consultants and contractors. Sika provides technical assistance through every step of the project, from condition survey and developing the initial

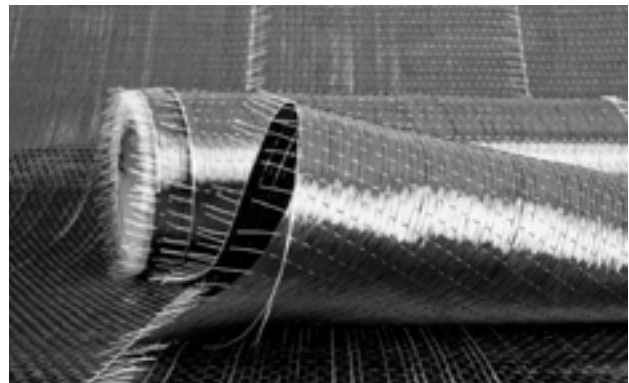
strengthening concept through to the successful completion and handover of your project.

### SIKA – YOUR PARTNER ON SITE



- Global market leader in building and construction chemicals
- Highest technical expertise and practical experience in concrete refurbishment and structural strengthening
- Excellent reputation with leading contractors and authorities

### SIKA VALUE ENGINEERING AND INNOVATIONS



- High performance integrated products and systems that can boost and improve the capacity, efficiency, durability and aesthetics of buildings and other structures – to the benefit of our customers and a more sustainable development
- Sika trained and experienced specialist contractor networks

### UNIQUE SIKA SOLUTIONS FOR SPECIAL CONDITIONS



- Solutions for almost all different application requirements
- Controlled working, curing and hardening times for different climatic conditions
- Special end-anchorage solutions for use in lower strength concrete and other substrates

### PROVEN SIKA SYSTEMS AND APPLICATION TECHNIQUES



- Over 40 years of experience with structural bonding and strengthening systems and techniques
- Products and systems with extensive internal and external testing and assessment
- Highest international standards of production and quality control

# SIKA STRENGTHENING SYSTEMS: COMPREHENSIVE AND YET COMPACT

## The Sika® Carbodur® System

- Sika® Carbodur®: CFRP plates and rods
- Sikadur®-30 structural epoxy resin adhesive
- Sika CarboHeater: Rapid curing and hardening equipment
- Sika® Carbodur® Ultra High Modulus (UHM) plates



Sika® Carbodur® video



The Sika® Carbodur® System is the most widely recognized and established carbon-fiber-reinforced polymer (CFRP) strengthening solution available worldwide. It consists of Sika® Carbodur® CFRP plates and rods, together with the structural epoxy resin based adhesive Sikadur®-30. This simple, tested and well proven, highly durable system has outstanding performance. With the Sika CarboHeater curing times can be accelerated and down time minimized, even at lower temperatures. The use of Sika® Carbodur® Ultra High Modulus (UHM) plates together with Sikadur®-30 adhesive, provides more strengthening options particularly for strengthening iron and steel components.

## The Sika® CarboStress® System

- Unique pre-stressed strengthening system
- Advantages of Sika® CarboDur® CFRP plates
- Advantages of post tensioning
- StressHead anchorage system



Post-tensioning: a force is applied to create permanent stress in a structure, so that it can withstand load more efficiently or with less total deflection. In conventional post-tensioning, the load is put on steel tendons within the concrete structure, however with the Sika® CarboStress® system, the advantages of the Sika® Carbodur® CFRP plates and post-tensioning techniques are combined to form a unique active external strengthening solution.

## The Sika® CarboShear System

- Unique L-shaped CFRP plates/brackets



The shear capacity of concrete beams can be increased by the external applied Sika® CarboShear® L-shaped profiles. Installation is fast and easy, excellent anchorage is assured and no drilling through the top slab is required.

## The SikaWrap® Fabric Strengthening System

- SikaWrap® Fabrics
- SikaWrap® FX fabric anchors
- Sikadur®-330 epoxy based 4in1 product (primer, filler, impregnating resin and adhesive)
- Sikadur®-300 epoxy based impregnation resin and adhesive
- Saturator Machine



SikaWrap® video



The SikaWrap® fabric strengthening system consists of woven or stitched, unidirectional, carbon and glass fibre fabrics and Sikadur® impregnating resins. This system provides a wide range of solutions to meet different demands on many different types of projects. The installation is extremely flexible and accommodating of different surface planes and geometry, making this a very multifunctional material for many applications including confinement, shear, seismic upgrading and weak substrate strengthening.

## Near Surface Mounted (NSM) Application

The embedding of Sika® Carbodur® pultruded rods or plates into concrete, timber or masonry substrates has many advantages:

- Superior end anchorage
- No extra protection necessary as embedded
- No aesthetic impact
- Installation in weak or cracked substrates is possible
- Application is possible on flat and curved substrates
- Available as different profiles (rectangular or round) and dimensions to suit



## SikaWrap® FX Fibre Connectors

Used for:

- Shear strengthening
- End anchorage of SikaWrap® fabrics
- Near Surface Mounted reinforcement (NSM)



The carbon fibres are uni directional and encased in a plastic sleeve to form a continuous cord. The flexibility of the cord allows strengthening in difficult access locations and of any substrate geometry. Once installed the connector is impregnated with Sikadur®-300 laminating resin.



# OVERVIEW OF SIKA STRUCTURAL STRENGTHENING SYSTEMS



**1**

Sika® Carbodur®  
System

**2**

Sika® CarboStress®  
System

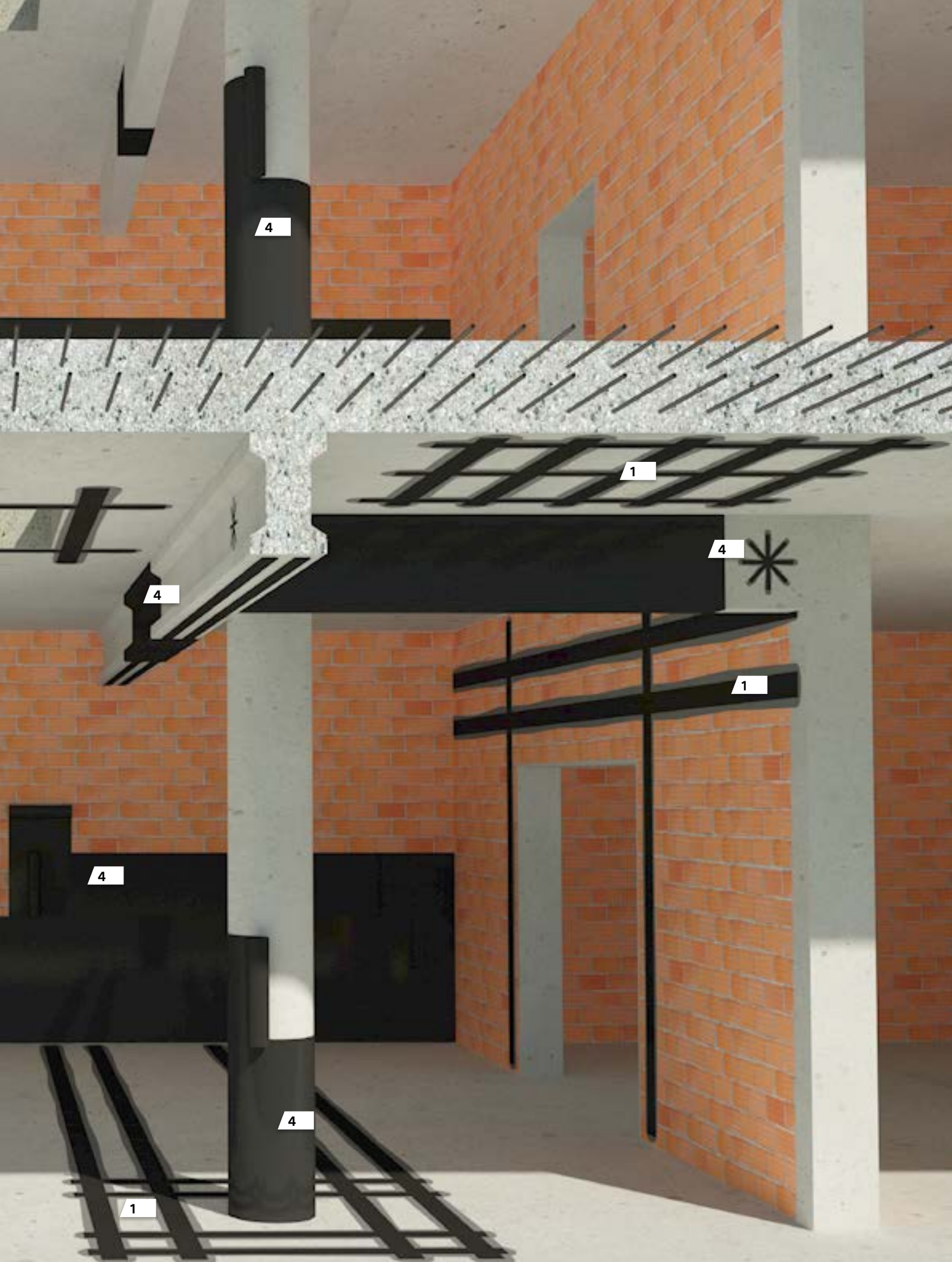
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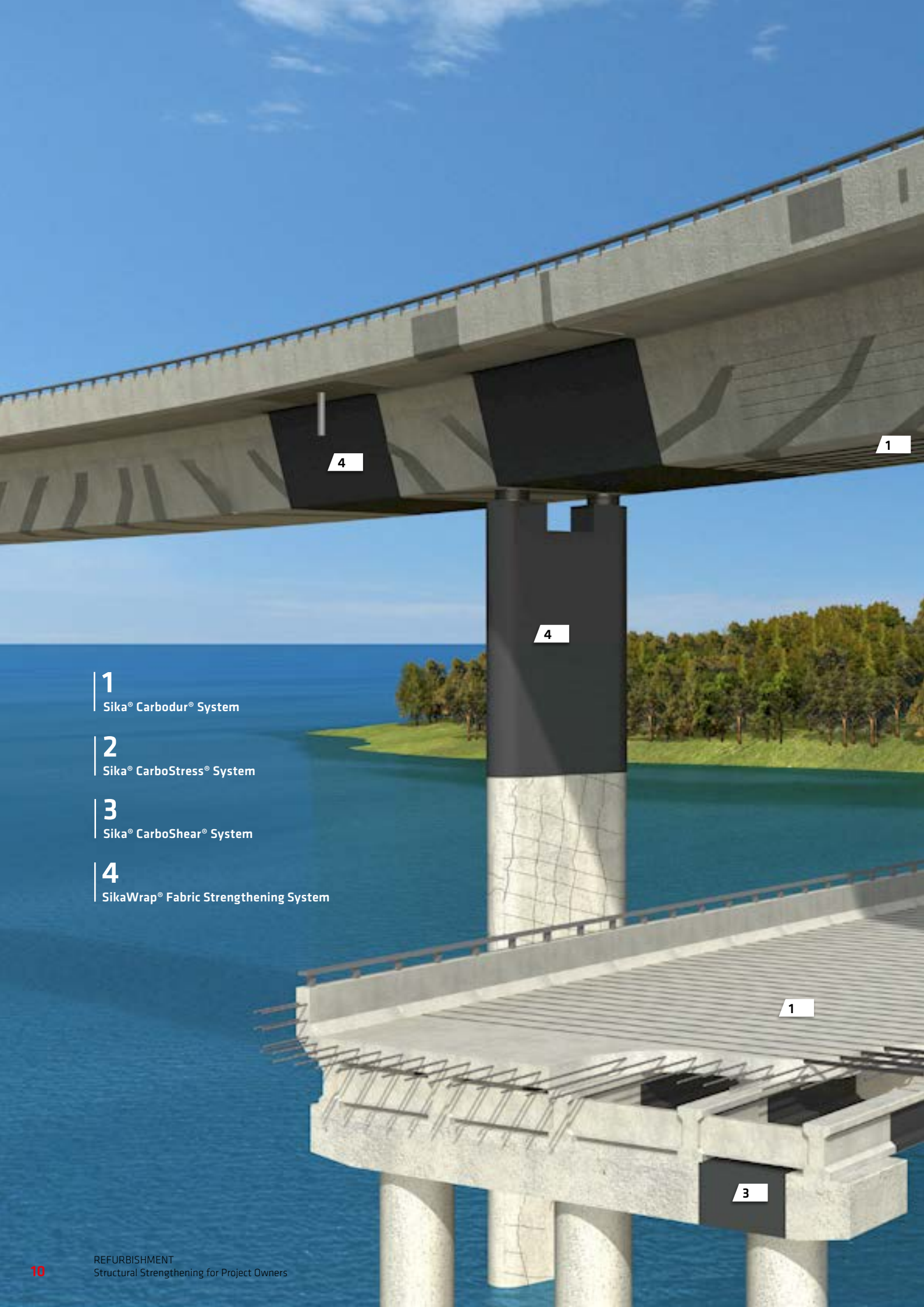
Sika® CarboShear®  
System

**4**

SikaWrap® Fabric Strengthening  
System







1

Sika® Carbodur® System

2

Sika® CarboStress® System

3

Sika® CarboShear® System

4

SikaWrap® Fabric Strengthening System

1

3

4

4

1







# BRIDGE STRUCTURES

Grafton Bridge, Auckland, New Zealand

**AUCKLAND'S ICONIC GRAFTON BRIDGE**, was the world's largest single span reinforced concrete arch bridge when originally built in 1910. Today it is recognized as one of the 100 most significant concrete structures in the world.

It has continued its history of innovation, by using Sika® CarboShear® technology for structural strengthening works that were required in 2010.

Sika® Carbodur® CFRP plates were installed on the underside of the reinforced concrete beams to provide additional mid-span movement resistance. The Sika® CarboShear® L shaped CFRP profiles were then installed, in pairs, around the beams and up into the deck slab to improve the shear performance.

Almost 100 years after the bridge was built, this bridge strengthening was part of the 'Auckland Central Connector' project. This has provided the landmark structure with essential seismic resistance to modern standards, enabling it to withstand a one-in-1000-year earthquake, as well as increased capacity to carry higher volumes of bus traffic and to accommodate a possible future light rail transport system – all without altering the bridge's appearance or changing its heritage status.

The overall refurbishment work included:

- Strengthening the bridge columns using additional steel reinforcement
- Strengthening the bridge beams with Sika® Carbodur® CFRP plates and Sika® CarboShear® L profiles
- Installing new, reinforced-concrete shear keys and deck links to resist horizontal seismic forces
- Removing green growth and repairing cracks in the original concrete
- Replacing the deck joints and bridge bearings



Sika® Carbodur® strips and CarboShear L plates bonded to the concrete structure.



# BRIDGE STRUCTURES

M3 Hawley Lane Bridge, Farnborough, Hampshire, UK

## SIKA HELPS COMPLETE EUROPE'S LARGEST COMPOSITE REINFORCEMENT BRIDGE STRENGTHENING PROJECT

When the M3 Hawley Lane Bridge started to show signs of excessive deflection under heavy traffic, engineers at Enterprise Mouchel devised a repair solution that included the installation of a new central bridge pier to support two existing outer piers. To counteract changes to the deck's dynamics and reinforce the bridge between the three structural piers, Sika® Carbodur® rods and Sika® Carbodur® plates were used – marking one of Europe's largest applications of composite reinforcement systems.



Sika Solutions for Flooring Adhesives forces of constant and heavy traffic, a third pier proved the most suitable reinforcement solution to meet the increasing capacity demands.

Sika worked closely with the consulting engineers to advise material selection and properties required for a performance based specification –in-line with Highways Agency best practice. To achieve the required performance, carbon fibre plates and rods were specified as part of a complex repair and concrete protection solution. The use of carbon fibre offered an accelerated application process and enhanced performance properties when compared to traditional steel reinforcement. The £5 million project will see a total of 1,000 m of Sika® Carbodur® Rods and 5,000mtr of Sika® Carbodur® Plates installed.

Using the company's extensive experience of structural strengthening –including in 2011 the UK's largest application of ultra-high modulus composite reinforcement at Embankment Tube Station –Sika will be closely involved at Hawley Bridge from initial specification to project completion. The company's full range of structural strengthening systems are suitable for increased loading, change of use, column wrapping, as well as applications in the nuclear industry for protection against seismic activity.

On track to be delivered within a two month period, the project will be successfully finished to the highest standard thanks to a well organised, detailed application process and with minimal effect on the road's users –above and below the M3 Hawley Lane Bridge.

# BRIDGE STRUCTURES

Quinton Bridges, Birmingham, UK

**SIKA CFRP PLATES SPECIFIED TO RESTRENGTHEN UK'S FIRST MAJOR EXTERNALLY BONDED REINFORCED BRIDGE.** At the M5 junction 3 Quinton Interchange near Birmingham, a structural inspection showed de-bonding to one of the bridge's 192 steel plates – installed in 1975 as the UK's first ever major application of bonded external reinforcement.

Appointed to replace all the steel plates to improve the bridge's resilience and prevent potential future weight restrictions, AME Y –consultants for the Highways Agency – turned to Sika for technical assistance and the possible use of Sika's prefabricated Carbon Fibre Reinforced Polymer (CFRP) plates

Specified at major strengthening projects throughout the UK transport structures – including the UK's largest ever application of carbon reinforcing at Embankment Underground Station in London – 725m<sup>2</sup> of Sika CFRP plates were specified and applied onto the two bridges that form the interchange over a six week timeframe.

Re-strengthening the in-situ bridge deck proved ideal as it provided Amey with a repair solution that minimised disruption to road users, an easy application process and ensured long term reinforcement with proven results. Designed to deliver high performance structural stability in demanding environments, the Sika CFRP plates were manufactured to meet the project's specific dimensional requirements.

To minimise disruption to the M5, specialist contractor Concrete Repairs Limited (CRL) completed the entire application process when traffic flows were at their lowest and with minimal lane closures. The project was carried out in a series of carefully planned shifts between 8pm and 6am from Monday to Thursday, and 24 hours a day at weekends from 8.30pm on Fridays through to 6am on Monday mornings.

To ensure structural bond of the plates, Sikadur® structural epoxy adhesive was applied to the underside of the substrate and the plate itself. Suitable for use in vertical and overhead configurations, the high-modulus, high-strength, structural epoxy adhesive offers exceptional tolerance to moisture to provide a reliable, durable and long term solution.

When positioning the plate, full contact of the adhesive to the two surfaces guaranteed a long-term bond before temporary supports were put in place whilst the adhesive cured. The excellent adhesive performance allowed installation to carry on throughout winter, with the skilled applicators adapting their processes to suit the low temperatures and prevent water condensation on the surfaces. To speed up the application, CRL covered each plate in a thermal blanket to enhance the curing process further and minimise delays.

As well as guaranteeing exceptional quality, the plates' bespoke Pre-Preg (pre-impregnated) manufacturing process also maximises efficiency with delivery of exact design dimensions in terms of length, width and thickness. Delivered to site ready for installation, the careful collaboration between Sika and CRL helped to simplify the application and meet the tight deadline.

The renovation of motorway bridges is essential to ensure journeys remain safe and reliable for all road users. For performance, effectiveness and efficiency, Sika's CFRP Composite Plates ensured a high quality restoration that has further strengthened Sika's reputation as a favorite for specifiers and contractors around the world





# BRIDGE STRUCTURES

London Underground Embankment, London, UK

**LONDON UNDERGROUND TUNNEL WAS STRENGTHENED WITH SIKA** as part of a major strengthening programme on the London Underground, an innovative solution was required to provide long term strengthening to over 90 cast iron beams.

The solution to the challenge lay with Sika® Carbodur® UHM and a well planned application procedure. An Ultra High Modulus Carbon Fibre Reinforced Polymer (CFRP) system, Sika® Carbodur® UHM is designed for high performance and demanding reinforcement applications. The plates, measuring 7.3m long, 200mm wide (2 no per beam) and maximum 4.7mm thick and offering exceptional reinforcing capability, proved the ideal solution. With over 1,300 m of Sika® Carbodur® UHM plates applied, it has marked the UK's largest ever project to use ultra high modulus composite.

The specialist contractor carried out the skilled application, having been appointed by LU Framework Contractor, Clancy Docwra. The process began with each beam, measuring 7.5m long and 0.5m wide, cleaned using a powerful grit blasting technique that removed grease, oil, rust and any other contaminants which could reduce adhesion. Once dried, a coat of SikaCor®-EG 1 primer was applied, followed by the

application of a resin to prepare the surface. Ensuring secure, reliable attachment of the Sika® Carbodur® Plates, Sikadur® structural epoxy adhesive was then applied to both the underside of the cast iron and the plate itself. When placing the plate into position, full contact of the adhesive to the two surfaces guaranteed a long-term bond was achieved before a series of temporary supports were put in place whilst the adhesive cured.

The excellent performance of the adhesive allowed installation to carry on throughout the winter months when low temperatures and condensation can cause problems for other adhesives.

Following an extensive design and specification process, the result is the UK's largest ever application of ultra high modulus composite reinforcement.



# BRIDGE STRUCTURES

Penang Bridge, Penang Island, Malaysia

**THERE ARE TWO BRIDGES** connecting the Malaysian mainland with the Penang peninsula.

The original Penang Bridge is a dual carriageway toll bridge that spans 13.5 km and was completed and first opened to traffic in 1985, and by 2010 was used by over 80'000 vehicles a day. Following an accidental fire in 2010, a complete inspection and structural assessment of the bridge was undertaken. In addition to the concrete repairs that were necessary after the fire and 25 years exposure in the aggressive marine environment, the structure was also found to be in need of structural strengthening to replace the damaged steel tendons.

The damaged concrete was removed and the reinforced concrete beams were repaired with a SikaTop® concrete repair System and SikaGrout® poured concrete. The beams were then strengthened to the performance levels required by the

Engineers, using a layered build-up of the Sika® Carbodur® CFRP System. Finally, all of the exposed concrete and CarboDur® plate surfaces were given a protective Sikagard® coating to protect them against UV light and future attack from the aggressive marine environment respectively.

The Second Penang Bridge was completed in 2014 and at 24 km, is the longest bridge in South-East Asia and designed to last for 120 years with minimal maintenance. Sika's involvement started at the very beginning with systems for the concreting and construction work, from curing compounds to Sikadur® structural resins and concrete protection with Sikagard® hydrophobic impregnation, all contributing significantly to the required durability of the structure.



Installation CarboDur®



Coating of CarboDur® plates with Sikagard®







# BUILDINGS

Merrion Centre, Leeds, UK

**THE MERRION CENTRE IS A PRIME LEEDS SHOPPING LOCATION** with over 100 retailers within it.

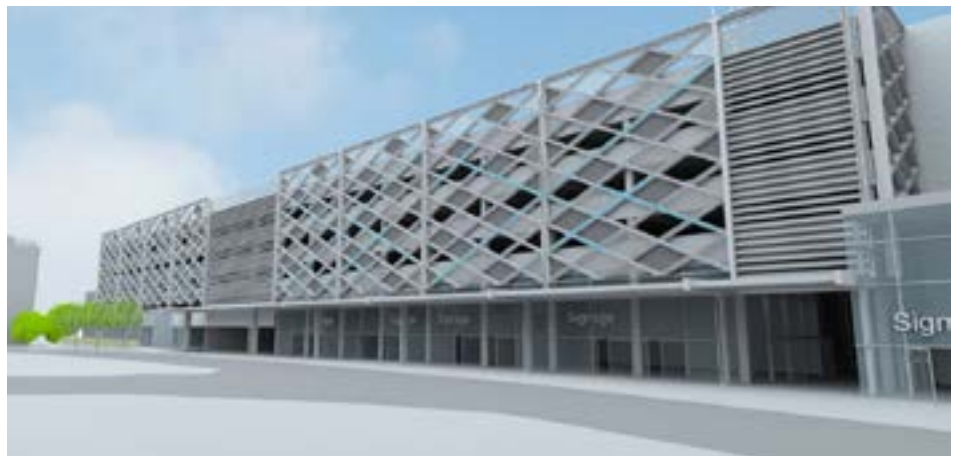
As the structure approached its 50th anniversary, Curtins Consulting was employed to develop and deliver a refurbishment strategy for the multi storey car park at the Merrion Centre. Curtins have been involved in refurbishment projects for over 50 years. They have experience of large and small, straightforward and complex projects which enables them to develop an approach to give the best value to the client and the team.

The Structural Engineering design brief for the project was to carry out refurbishment of the existing multistorey car park, including construction of new vertical circulation cores and change of use for retail units where necessary with a proposed design life of 20 years.

Construction trials and investigations carried out in 2011 witnessed severe pitting corrosion to steel reinforcement in

the insitu concrete section of the existing floor slab. Transverse steel bars, composite shear studs and reinforcement links projecting from precast, pre-stressed bridge beams were all observed to be suffering from severe corrosion where de-icing salts had penetrated the concrete matrix from the surface and through surface cracks. Delamination between the precast pre-stressed planks and the insitu topping had been recorded prior to these construction trials. Curtins assessment was that the original structure had been designed such that the down stand bridge beams were acting compositely with the floor slab; the floor slab was spanning between the bridge beams and gaining the benefit of fixity by the provision of projecting dowel bars and shear links and inclusion of transverse steel reinforcement.

Prior to the refurbishment the car park, floor slabs acted more as a series of simply supported elements which were not positively tied together. The bridge beams were receiving benefit from the projecting dowel bars and shear links but not the full benefit that appeared to have been designed from the drawn details. Cracks had developed in the insitu concrete topping and corrosion of steel reinforcement has taken place. It was concluded that corrosion and deterioration will continue to take place unless remedial action was taken. The corrosion had led to the bridge beams no longer acting compositely over their length. This did not appear to be affecting their strength, which would be evidenced by vertical stress cracks forming in the middle of them. Corrosion has led to fixity of the slab support being reduced; this in turn increased the mid span bending moment and hence the potential of overstressing in the pre-stressed tendons in the slabs. Exposure of the slab support during the construction trials showed that support of



the slabs was less than 50mm to some planks, in some places less than 10mm. Originally, the transverse steel reinforcement would also have provided support; this benefit has been reduced or removed following corrosion of those bars. Delamination between the pre-stressed planks and in-situ topping has led to reduction of bending and shear capacity of both the floor slab and bridge beams due to the reduction in overall

The refurbishment proposed that:

1. Delaminated insitu concrete topping shall be removed from the existing concrete floor slabs.
2. Where exposed, corroded transverse reinforcing bars (10mm dia) shall be replaced along their full length (1200mm) or lapped minimum 400mm with existing uncorroded bars.
3. Remaining mild steel reinforcement should be protected by either the use of a corrosion inhibitor or galvanic anodes; the concentration or frequency depending upon chloride content of the original remaining concrete substrate shall be determined by a concrete repair specialist.
4. Migrating Corrosion Inhibitor (MCI) or Galvanic anodes should be used to provide corrosion control to the entire intact (sound) concrete deck surface including top and soffits, surfaces and downstand bridge beams. A decorative protective anticarbonation paint should also be spray applied onto the downstand bridge beams.
5. Areas where concrete had been removed should be replaced with new pre-bagged concrete repair mortar of equal or higher compressive strength and all concrete repairs should be allowed to reach their design strength.
6. Carbon fibre anchorage points should be drilled into the existing or repaired concrete slab above the pre-stressed bridge beams.
7. Carbon fibre wrap should be installed using the dry method to the entire soffit of the existing car park planks and vertically down the vertical face of the downstand bridge beams, a minimum length of 200mm.
8. Carbon fibre anchors should be installed into the existing or repaired concrete slab or perimeter edge beams, to a suitable depth depending on installation. The existing



slab was approximately 110mm thick, or 220mm at an inclination of 30 degrees above the horizontal.

9. Carbon fibre plate bonding to strengthen long span traditionally reinforced beams.
10. Elastomeric waterproof decking should be applied to the entire top surface of each car park deck.

Prior to finalisation of the scheme a full scale trial installation and load test was carried out to confirm that the proposed strengthening works would satisfy the requirement of the design and identify any practical installation issues. This trial was carried out on an area of good condition slab, and any areas with structurally damaged concrete due to spalling were avoided, for the purposes of the trial. The installation included application of the required thickness of fabric to the soffit of the slab, including the anchoring and lap details onto the down stand inverted T beams. A 20mm radius fillet was cast in the angle between beam and slab along with holes drilled to allow the installation of the composite spike anchors, prior to the installation of the fabric. Following the full cure of the strengthening system the slab was then loaded and monitored, to demonstrate its performance.

The project was tendered at the end of 2012 and the specialist car park refurbishment contractor was awarded the project and started on site in autumn 2013. They started with an initial external façade phase, which was designed to increase the level of occupation of the retail units by improving the aesthetics of the centre and resolve some water penetration issues to the retail units from the car park above.

The full range of technical specialist refurbishment materials were supplied by Sika Limited, which included strengthening, repair and protection, corrosion control and car park deck waterproofing systems. The contractor continued onto the main phase of the works, pulling off site only during the Christmas periods to maximise parking spaces available during the busy period for the centre.



# BUILDINGS

## Maypo Office and Laboratory Building in Mexico City, Mexico

**THE FOUR-STORY OFFICE AND LABORATORY BUILDING** was originally built in the early 1980s.

Since then, more extensive research on soil characteristics and the seismic activity in the region have led to new design standards and construction methods that have greatly improved the seismic resistance of new buildings. However, existing buildings built to the earlier, less stringent standards present a challenge. Worried about the safety of their building, Maypo initiated a detailed structural assessment and seismic upgrade for the property.

Because the original building design details and calculations no longer existed, a series of diagnostic studies were performed, including research on soil mechanics in the area, steel reinforcement location and assessment, concrete condition survey, and an overall visual inspection; followed by 3-dimensional computer modeling with the results for dynamic structural analysis. These revealed that in the event of a seismic event the concrete floor slabs exhibited deflection and excessive vibration resulting in cracking, the supporting beams exhibited shear cracking at their ends and the non-structural masonry walls interfered with the free deformation of the main structure. Furthermore, the computer modelling also revealed that the main support columns were overloaded.

A number of steps were then taken to refurbish and upgrade the whole building, including additional steel bracing and casting additional concrete, sealing existing cracks by injection and then overall structural strengthening. The beams were strengthened in flexure and shear using the SikaWrap® fabric strengthening system, the columns had continuous Sika® Carbodur® CFRP plates installed along their axis over several storeys, then the columns were also wrapped with SikaWrap® fabric to increase their strength and ductility. The complete refurbishment project was easily completed on time due to the lightweight nature and rapid installation procedure for these Sika systems. The weight of the structure was only slightly increased, and no useable area was lost.



International Concrete Repair Institute (ICRI):  
Sika won the ICRI Award of Merit in the Low-Rise Category in 2013.  
Click on the QR Code to learn more about Sika's ICRI Award-Winning Projects



Beams and columns strengthened with SikaWrap®



# BUILDINGS

Audi Automotive Plant in Győr, Hungary

**A FORMER LOGISTICS AREA NEEDED STRENGTHENING** as it was to be converted into a Production Hall and had to accommodate much heavier loads.

In the course of internal re-organization, a hall which had been used as a logistics area was to be fitted with fabrication machinery. The existing reinforced concrete base plate which is divided by contraction joints into several sections was not compliant with the required layout. Displacement and consequential forces onto the base plate, caused by temperature change would exceed the production tolerances. Several base sections were joined using the Sika CarboStress

System. Three tendons, consisting of CarboDur® plates and special end anchorage heads were installed to produce a united base without joints. The CFRP plates were then encapsulated into the concrete base to protect the system and to make the area ready for use.

With 29 m this is the one of the longest post-tensioned CFRP plates ever installed in the world.



The longest post-tensioned CFRP-plates ever installed



Plate and end-anchorage



Base channel with post-tensioned CFRP plates

# HISTORIC STRUCTURES

## Wooden Bridge in Sins, Switzerland

**THE FAMOUS WOODEN BRIDGE OVER THE RIVER REUSS IN SINS** in Switzerland is more than 200 years old and was built in 1807 with an original design capacity of 12 tons.

Today, the bridge also serves as a back-up route for heavy vehicles, and the required loading is 20 tons. The residents opposed an option to replace the historic bridge with a new structure, so overall refurbishment and strengthening to upgrade the whole structure was carried out in 1991. The structural strengthening of this timber bridge was also part of a long-term study and it was one of the first Sika® Carbodur® strengthening projects on wooden structures. The system was selected for its excellent mechanical properties and minimal visual impact, as retaining the visual appearance of the bridge was also a key decision factor.

To refurbish the bridge the deck was removed and rebuilt, and Sika® Carbodur® CFRP plates were bonded to the bottom of the crossbeams to reduce deflection. The installed plates were left exposed and uncoated to facilitate inspection and assessment, but to date the installation remains maintenance free.



CarboDur® strengthened crossbeam



Bottom view of strengthening system

# HISTORIC STRUCTURES

St. Nicolas Church, Krakow, Poland

**ST. NICHOLAS CHURCH IS ONE OF THE OLDEST BUILDINGS** and a monument in Krakow, Poland. The church dates back to at least 1229 and it was designated as a parish church in 1327.

The building has seen much redesign and rebuilding over the centuries and the current structure was built on the foundations of earlier structures destroyed in the past. The church is now officially classified as a baroque and neo-baroque three-bay nave basilica.

Over the centuries, the foundations and the limestone rock on which they stand have been subjected to washout and the 'karst phenomenon' (wash-out accelerated by carbonic acid from atmospheric CO<sub>2</sub> in the rain), causing severe degradation. Vibrations caused by increasing traffic, especially from the rail tracks located just behind the church, also contributed to the deterioration. This all led to the front facade deviating from vertical and moving away from the structural supporting walls. On inspection, cracking was also observed throughout the structure, including within the main nave and the aisles.

The original timber frame was inadequate to stabilize the structure, so a new steel frame and braces was carefully retro-fitted internally and through the attic of the church, hidden to normal visitors. After confirming the substrate was otherwise sound, the cracks were injected with cementitious grout and then the walls, window frames and vaulted areas were strengthened with the Sika® Carbodur® system. After completion of the refurbishment the building was reopened to the public in 2012.



International Concrete Repair Institute (ICRI):  
Sika won the ICRI Award of Excellence in the Historic Category in 2013.  
Click on the QR Code to learn more about Sika's ICRI Award-Winning Projects.





# COOLING TOWERS AND CHIMNEYS

Water Tower, Bengeo, Hertfordshire, UK

**Sika® CarboDur® CARBON FIBRE STRUCTURAL STRENGTHENING SYSTEM WAS CHOSEN AS THE IDEAL SOLUTIONS** to re-establish an ailing roof slab on Bengeo Water Tower, which is owned by Three Valleys Water and is located on the outskirts of Hertford.

The 30 metre high tower, which has a capacity of 900 cubic metres, dates back to the early 1930's and was built with a 75mm thick reinforced concrete roof slab with minimum steel reinforcement.

Penetration of the concrete by the elements had lead to corrosion of the reinforcing steel and consequently the slab had become structurally unsound. Because of the nature of the project, it was important that any repair materials used on this project met all criteria required for contact with potable water.

Veritas, carried out a structural analysis of the structure and decided upon a solution to reinstate and in fact improve upon the original strength of the slab by using the Sika® CarboDur® structural strengthening system. After removing and reinstalling the failing concrete, specialist contractors Stonbury Limited bonded 500 metres of Sika® CarboDur® pultruded carbon fibre plates in a radial pattern to the underside of the roof slab using Sikadur® 31 Rapid, a specially formulated, cold cure epoxy adhesive. This is a fast and

efficient system, with a tried and tested track record, offering high performance with good technical support. In addition Carbon Fibre will have no problems with corrosion caused by the moist atmosphere. From a practical point of view, carbon fibre is much lighter than steel and can be hoisted and placed in a water tower with no need for specialist hoisting and clamping equipment, so saving considerably on return to service times.

Other works undertaken was the removal of original asphalt liner and replacement with DWI approved polyurethane membrane also sealing of roof slab against rainwater ingress. Formation of new access openings and security upgrades to current codes. Replacement of access ladders and valves. Coating of pipework and installation of new handrailing to the access shaft. Sika believe that this is the first project of its kind where carbon fibre strengthening has been utilised within a potable water tank. Its benefits could change the way structures are refurbished for years to come.



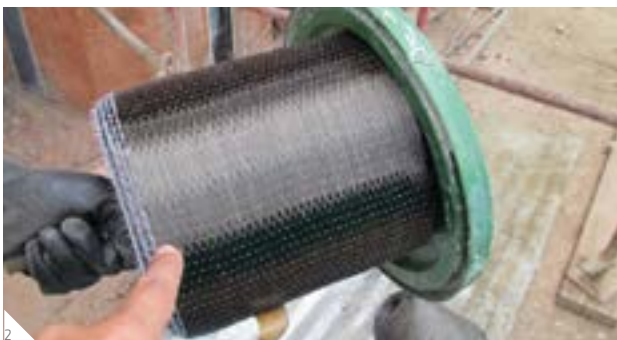
# COOLING TOWERS AND CHIMNEYS

Heritage Masonry Chimney, Bogotá, Colombia

**THE MASONRY CHIMNEY WAS BUILT BETWEEN 1925 AND 1929** and was part of a large abattoir complex supplying meat for the City of Bogotá.

After some years the complex declined and eventually was abandoned for several decades until the University Distrital bought the buildings in 2010 with the objective of developing and converting them into a cultural center. The masonry chimney was considered to be a heritage structure and had to be retained. Whilst built in good quality unreinforced masonry (URM) originally, it now needed upgrading and strengthening to be in-line with the current Colombian Seismic Construction Code. A structural strengthening system was therefore required, and one that would also preserve the aesthetics and appearance of the structure.

A complete Sika solution was selected. After cleaning the structure thoroughly, Sikadur® epoxy mortar was applied to level the surfaces and prepare them for application of the SikaWrap® fabric strengthening system. SikaWrap® fabric strips were then cut to size and applied symmetrically, both diagonally and vertically, to improve the strength of the whole chimney structure with a uniform appearance. Finally the whole masonry chimney surfaces were overcoated with an acrylic protective coating.



- 1 Substrate levelling
- 2 SikaWrap® roll
- 3 Installation of SikaWrap®
- 4 Coated strengthening system

# SIKA FULL RANGE SOLUTIONS FOR CONSTRUCTION:



**WATERPROOFING**



**CONCRETE**



**REFURBISHMENT**



**MERCHANT**



**SEALING AND BONDING**



**FLOORING**



**ROOFING**



**INDUSTRY**

## FOR MORE INFORMATION:



### WHO WE ARE

Sika Limited and Sika Ireland Limited are part of the global Sika Group, specialising in the manufacture and supply of chemical based products. Sika have a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing, and protecting in the building sector and the motor vehicle industry. Sika has subsidiaries in 93 countries around the world and manufactures in over 170 factories. With approximately 17,000 employees Sika generates annual sales of CHF 5.49 billion (£3.98bn). We are also committed to providing quality, service, safety and environmental care.

In the UK and Ireland, we provide market-leading solutions for concrete, waterproofing, roofing, flooring, refurbishment, sealing & bonding, and industry, and have manufacturing sites in Welwyn Garden City, Preston, Leeds and Dublin with more than 700 employees and a turnover of more than £130 million.

The information, and, in particular, the recommendations relating to the application and end use of Sika® products, are given in good faith based on Sika's current knowledge and experience of the products when properly stored, handled and applied under normal conditions. In practice, the differences in materials, substrates and actual site conditions are such that no warranty in respect of merchantability or of fitness for a particular purpose, nor any liability arising out of any legal relationship whatsoever, can be inferred either from this information, or from any written recommendations, or from any other advice offered. The proprietary rights of third parties must be observed. Please refer to our homepage [www.sika.co.uk](http://www.sika.co.uk) for our current standard terms & conditions applicable to all orders. Users should always refer to the most recent issue of the Product Data Sheet for the product concerned, copies of which will be supplied on request.



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