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ARE  
SIKA**

**BUILDING TRUST**





## CONCRETE REPAIR AND STRUCTURAN STRENGTHENING WITH **CFRP**

LUIS ALMELA, TM REFURBISHMENT

SEPTEMBER 2023, SIKA EUROPE MANAGEMENT

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## Luis Almela

RBDM TM Refurbishment EMEA  
**Sika Europe Management AG**

- Building engineer.
- Postgraduate in special building materials.
- 13 years in Sika.
- 7 years experience in business development activities mainly in EMEA.
- Specialized in concrete repair and strengthening with CFRP.

# WHAT WE DO

## BUILDING TRUST



### SIKA AT A GLANCE

33,000	EMPLOYEES
101+	COUNTRIES
400+	FACTORIES WORLDWIDE
5	NEW/EXPANDED FACTORIES IN 2022
104	NEW PATENTS IN 2022
2+	ACQUISITION IN 2022
10.49 BN	NET SALES IN 2022 (IN CHF)

Sika is a specialty chemicals company with a leading position in the development and production of systems and products for sealing, bonding, damping, reinforcing, and protecting in the building sector and motor vehicle industry.



# THE CONCEPT



## TOTAL CONCRETE REFURBISHMENT MANAGEMENT

*Sika has the most innovative products to prolong the life of a structure, improve the concrete condition, reducing the need to demolish and rebuild structures that could otherwise be saved.*

*Sika to supply a fully comprehensive range of integrated products and systems for **Total Concrete Refurbishment Management**, ensuring that the right solution is selected for each specific project.*

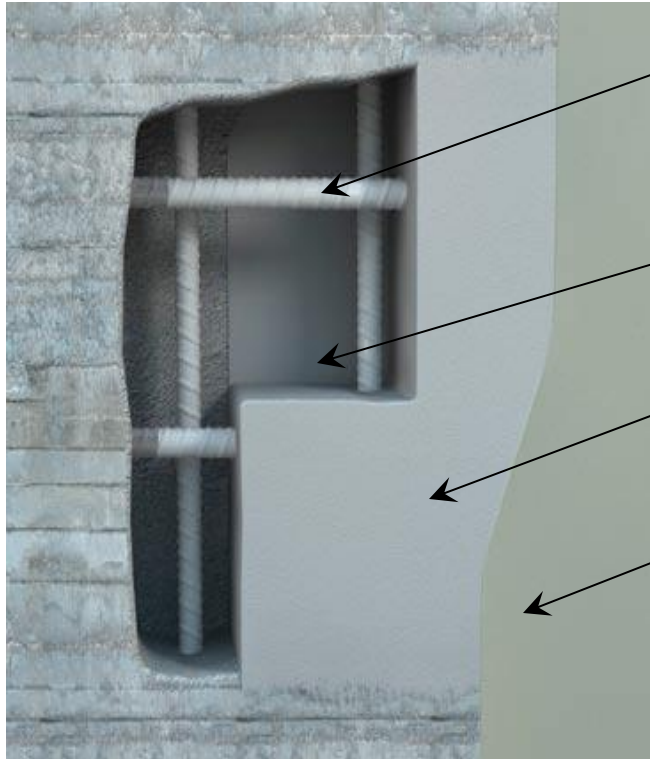


## REPAIR MANAGEMENT

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# CONCRETE REPAIR SYSTEM



Step 1: Reinforcement Corrosion Protection

Step 2: Bonding Primer

Step 3: Repair Mortar

Step 4: Smoothing / Levelling Mortar

Step 5: Protection system



# CONCRETE REPAIR SYSTEM



# THE CONCEPT

## TOTAL CONCRETE REFURBISHMENT MANAGEMENT



### PROTECTION MANAGEMENT

Once the appropriate renovation and corrosion management works have been carried out, protecting the concrete against penetration of deleterious elements will help to prolong the design life of the structure. Protection Management from Sika provides all types of concrete protection solution from invisible protection to crack bridging system.

- Hydrophobic Impregnation
- Protective Coating



### CORROSION MANAGEMENT

All reinforced concrete structures can suffer from damage and deterioration at some stages during their life span. Total Corrosion Management Systems from Sika encompasses an effective range of complete corrosion protection solutions.

- Cathodic Protection
- Resistivity Increase
- Corrosion Inhibitor



### REPAIR MANAGEMENT

When reinforced concrete is affected by corrosion, some intense repair work shall be undertaken. Repair Management concept from Sika encompasses a full range of material for concrete restoration.

- Steel Bar Protection
- Structural Repair Mortars
- Resurfacing Mortars



### STRENGTHENING MGMT

When reinforced has corroded to such an extent that affect the structural capacity of the structure, strengthening shall be carried out to reinstate it. Strengthening Management concept from Sika provides solution for all types of strengthening requirements.

- Flexural Strengthening
- Confinement
- Shear Strengthening
- Active Strengthening



## STRENGTHENING MANAGEMENT

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# STRUCTURAL STRENGTHENING- DEFINITION

SOLUTIONS TO IMPROVE THE **LOAD BEARING CAPACITY** OF AN EXISTING STRUCTURE



DIFFERENT SYSTEMS FOR  
**FLEXURAL, SHEAR  
AND CONFINEMENT**  
STRENGTHENING

**ADVANTAGEUS  
ALTERNATIVE** TO TRADITIONAL  
SOLUTIONS IN MOST OF THE CASES.



STRENGTHENING SYSTEMS ARE BASED ON  
COMPOSITE TECHNOLOGY, MOSTLY WITH  
**CARBON FIBRE** REINFORCED PLASTICS  
(CFRP)



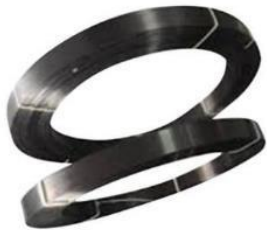
# STRENGTHENING TRADITIONAL SOLUTIONS



# FRP - DEFINITION

- F -> FIBER
- R -> REINFORCED
- P -> POLYMER

Composite strengthening systems with organic (mainly epoxy) matrix



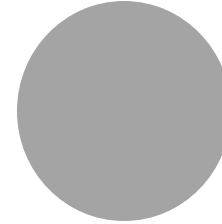
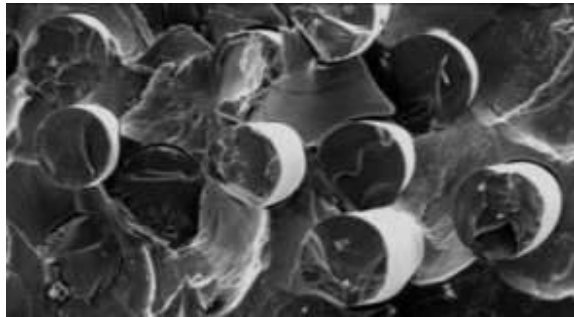
# CARBON FIBRE REINFORCED POLYMER (CFRP)



**STRENGTHENING  
FIBERS**



**EPOXY RESIN**



Human hair (dia 0,08 mm)



Carbon fibre (dia 0,007 mm)

## Approx number of fibres

Sika® CarboDur® S1.030	500.000
Sika® CarboDur® S512	1.000.000
Sika® CarboDur® S812	1.600.000
Sika® CarboDur® S1214	2.900.000

# DEVELOPMENT OF THE SIKA FRP SYSTEMS - SIKADUR®30

1967: Sikadur® range developed as steel plate bonding for Structural Strengthening



1970 Long Term Test at EMPA  
Sikadur® -30 (not finished yet)

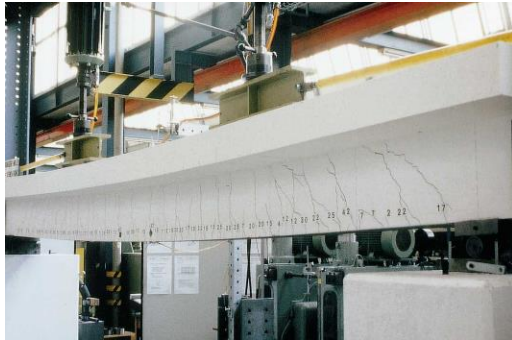


Steel: long-term durability is critical as resulting of the risk of corrosion. From 90s, steel plates were progressively substituted by CFRP systems.



# DEVELOPMENT OF THE SIKA FRP SYSTEMS – SIKA® CARBODUR®

1982: Tests of Carbon Fiber Reinforced Polymer (CFRP) Plates for Structural Strengthening of Reinforced Concrete



Cyclic Load Test



>50 test beams



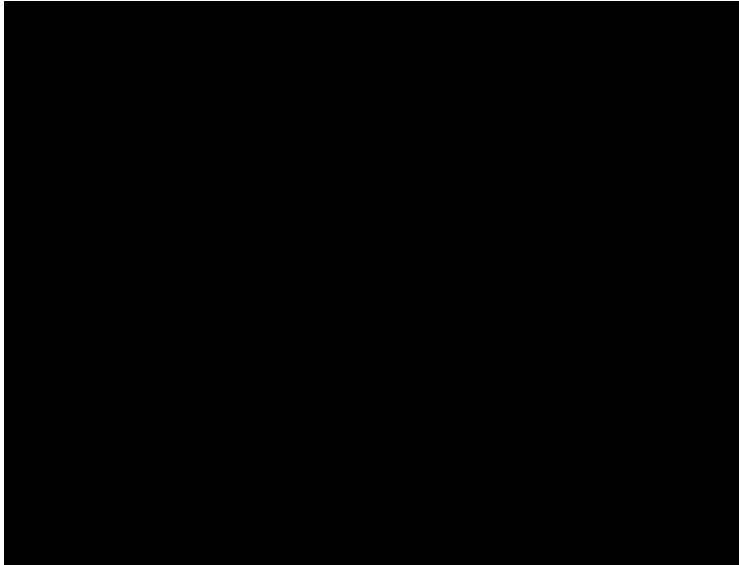
Climatic Test (heat+humidity)

1989

PhD Thesis H.-P. Kaiser, EMPA, Switzerland

# DEVELOPMENT OF THE SIKA FRP SYSTEMS – SIKA® CARBODUR®

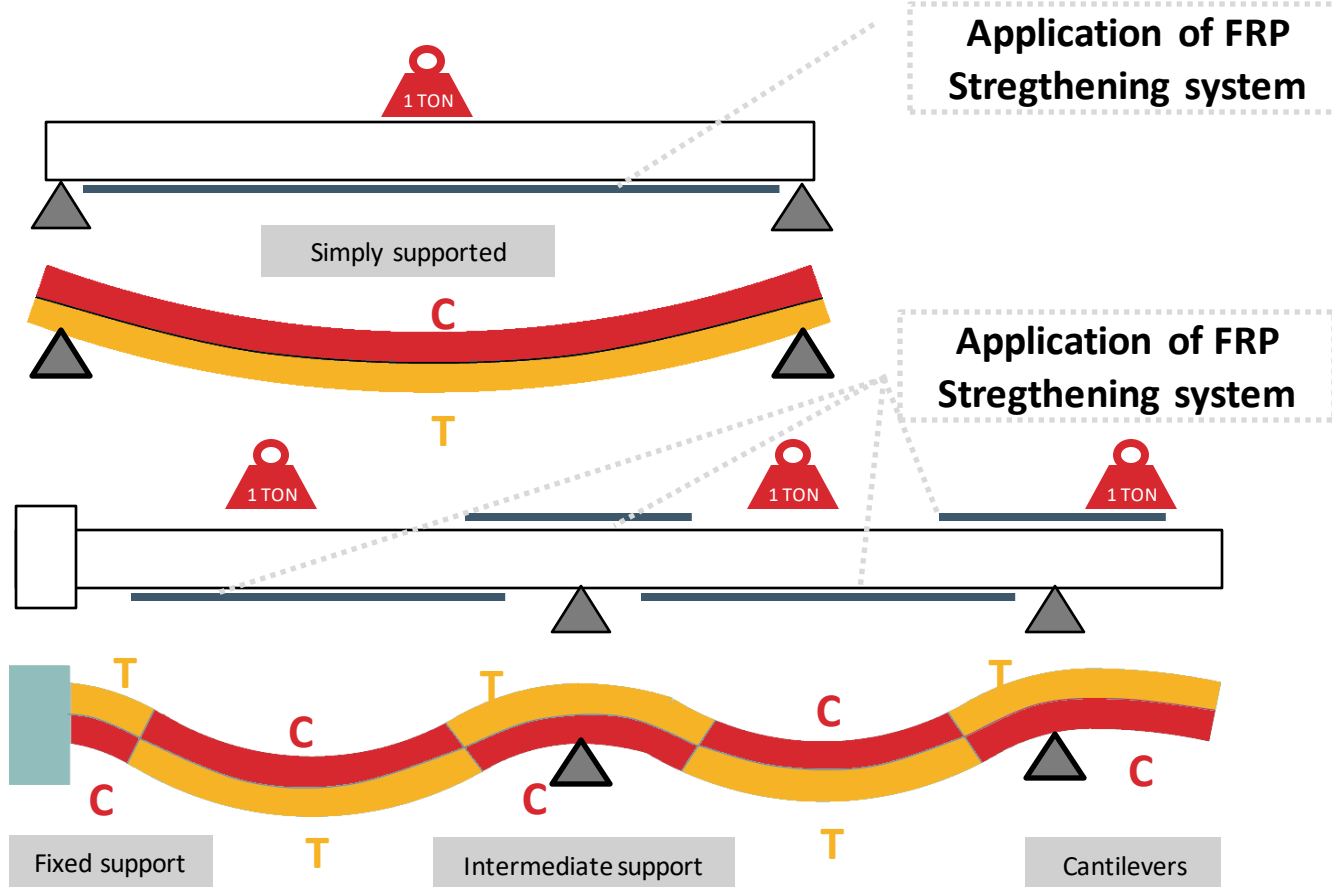
1991: First Application of Sika CFRP systems for Structural Strengthening of a bridge



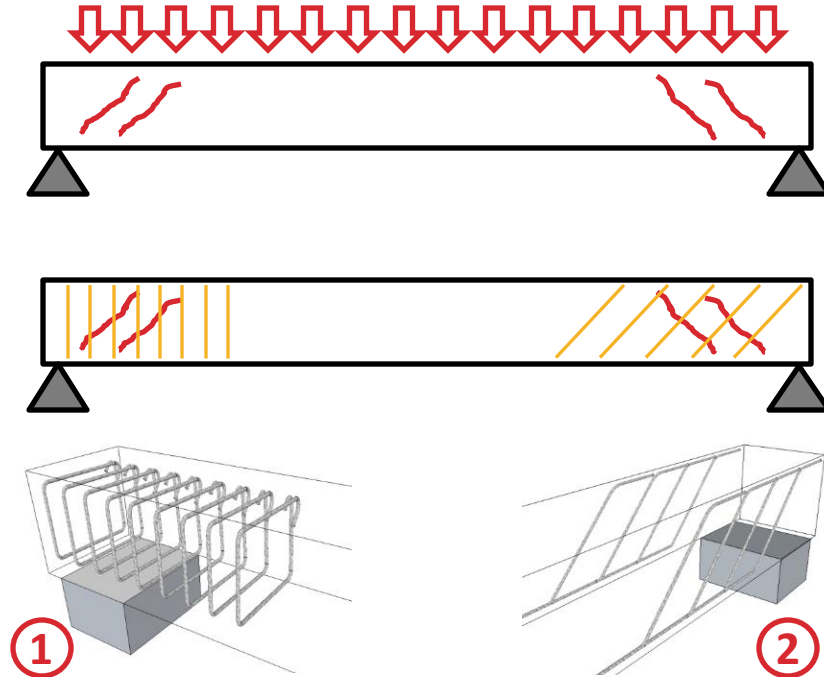
Ibach Bridge, Zurich (Switzerland)



# MAIN TYPES OF STRENGTHENING - FLEXURAL



# MAIN TYPES OF STRENGTHENING - SHEAR



The collapse of a beam as a consequence of shear forces is related to the development of inclined cracks, usually next to the supports.

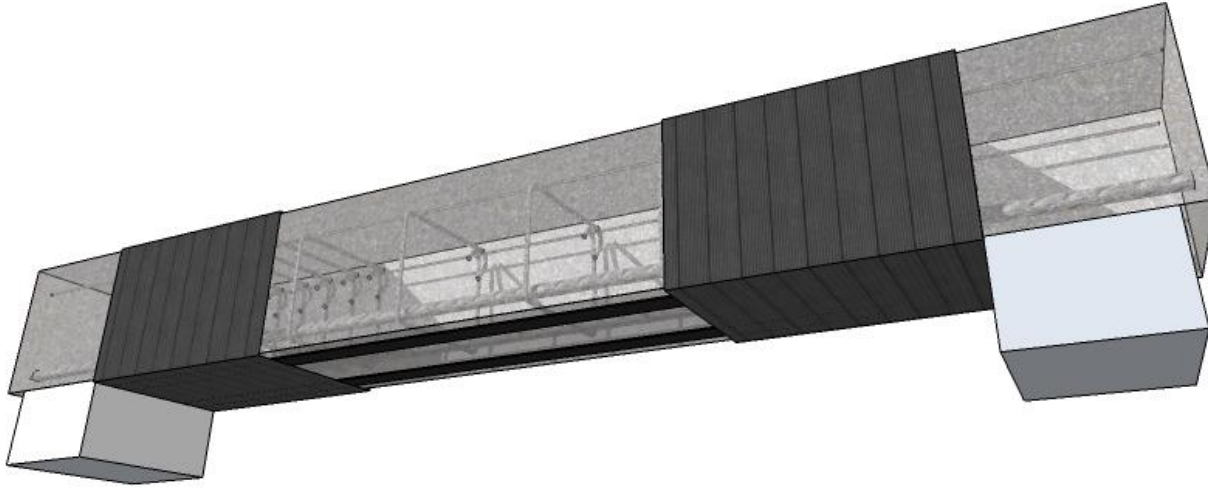
The internal steel bars are positioned so as to intercept any inclined crack, preventing its development. 2 alternatives are possible:

1-Vertical stirrups are the most common solution.

2-Inclined bars are quite efficient, but their installation is usually more complex.



# MAIN TYPES OF CFRP STRENGTHENING



A complete strengthening comprises the shear and flexural reinforcement of the member.

## Bending

Carbon fiber laminates only work under tension. Hence, it's necessary to determine the position of the tensile stresses along the element.

## Shear

External CFRP stirrups are displayed at the beam's ends. The wrapping scheme can be either complete (full wrapping) or partial (U-wrapping or lateral display).

# SIKA® CARBODUR® PLATES FOR FLEXURAL STRENGTHENING



Sika CarboDur®  
FLEXURAL STRENGTHENING

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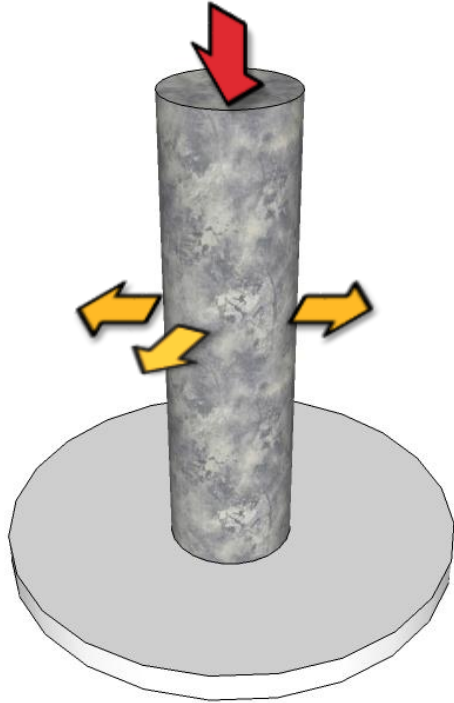
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# MAIN TYPES OF STRENGTHENING - CONFINEMENT



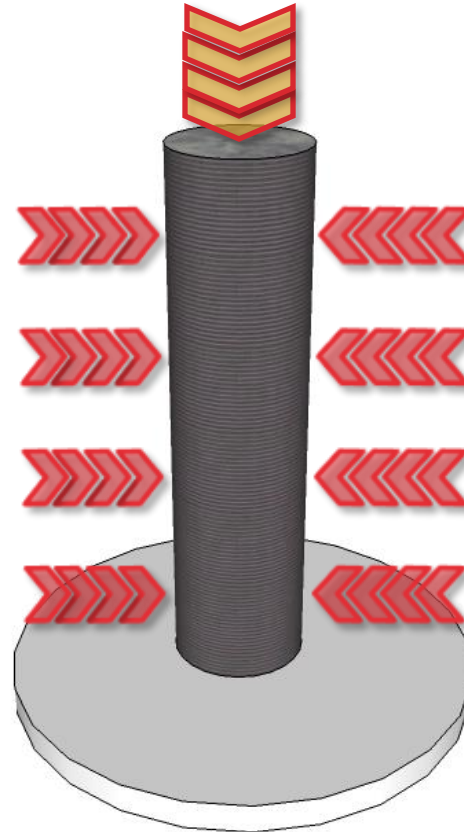
Due to the Poisson's effect, the concrete is transversally expanded when compressed.

This expansion leads to the collapse of the column, as concrete has a very limited capacity for elongation.

Hence, if the transversal expansion is restricted, the final strength increases...

# MAIN TYPES OF STRENGTHENING - CONFINEMENT

To avoid the lateral expansion, it's necessary to ensure a confinement around the element, by using a rigid material with a high strength. This material must keep the geometry of the member when it tries to expand.





# MAIN TYPES OF STRENGTHENING - CONFINEMENT



SikaWrap®  
STRUCTURAL STRENGTHENING

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# TYPICAL PROJECTS

## STRUCTURAL IMPROVEMENT

- Increased traffic or machine load
- Reduction of Vibration
- Reduction of deflection
- Increase of seismic resistance
- Increase of impact or blast resistance
- Upgrade due to change in standards or regulations

## STRUCTURAL RECOVERY

- Repair and rehabilitation of a structure after damage due to corrosion, mechanical damage, fire, impact, explosion, ageing, etc.



# SIKA AT WORK - BRIDGES





# SIKA AT WORK - NARROWS BRIDGE, PERTH, AUSTRALIA

- Carbon fiber laminate. Application to the deck soffit was efficient, particularly with the long lengths involved (up to 55 meters).
- Date: April 2001
- Location: Perth, wa
- Contractor: structural systems, wa





# SIKA AT WORK - BRIDGES ON THE BR 101/SC HIGHWAY, BRAZIL



## LOCATION

- South of Brasil - Tijucas / Santa Catarina

## CUSTOMER

- Arteris Concessionaria

## PROJECT

- Several bridges involved.  
To extend service life and align the design loads with current guidelines

# SIKA AT WORK - BRIDGES ON THE BR 101/SC HIGHWAY, BRAZIL



## SIKA SOLUTIONS

- **Sika MonoTop®** Concrete repairs mortar
- **Sika® CarboDur®** CF plates (~35 000m)
- **SikaWrap®** CF fabrics (~5000 sqm)
- **Sikadur®** Epoxy resins (~12 tons)



# URBANIZATION & SUSTAINABILITY

ADDRESSING SUSTAINABILITY BY GIVING A 2<sup>ND</sup> LIFE TO STRUCTURES



# SIKA AT WORK: LOKVERKSTADEN-MOTALA, SWEDEN





# SIKA AT WORK: LOKVERKSTADEN-MOTALA, SWEDEN



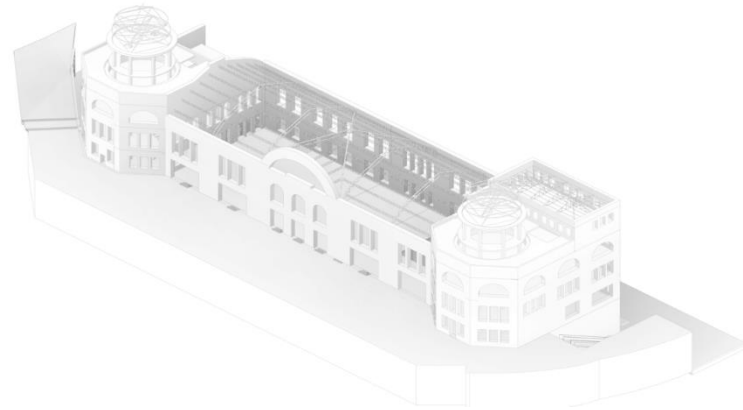
# SIKA AT WORK: LOKVERKSTADEN-MOTALA, SWEDEN



**Project Description:** Concrete repair & strength of roof structure for additional snow loads.

- Sika® Carbodur S 1214/ 1514.
- Sika wrap C 231.
- Sikadur®-330.
- Sika Monotop-4012/ -3012.

# SIKA AT WORK - PRINCIPE PÍO STATION, MADRID, SPAIN



- Built between 1926-1934, the building operated as Madrid's North train station. It was operating until 1976, when it was totally closed due to the loss of traffic compared with the new Chamartín station.
- In 2015 the project to reconvert it into a theatre/music hall was approved, and in 2019 it becoming one of the relevant cultural spaces in Madrid.
- The building is protected "Level 1" classified monument.



# SIKA AT WORK - PRINCIPE PÍO STATION, MADRID, SPAIN



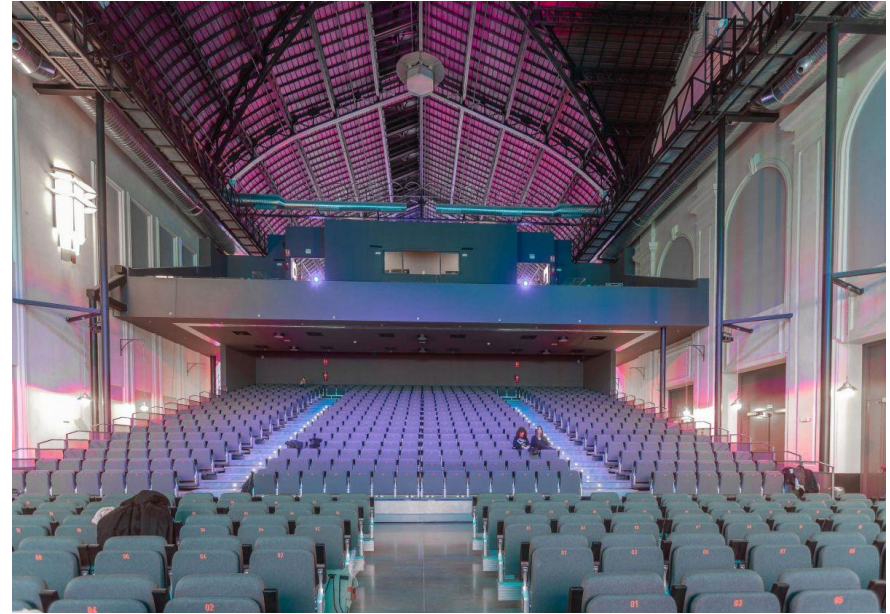
SIKA CARBOHEATER II  
APLICACIÓN EN "ESTACIÓN NORTE" (MADRID)

Sika España, 2018

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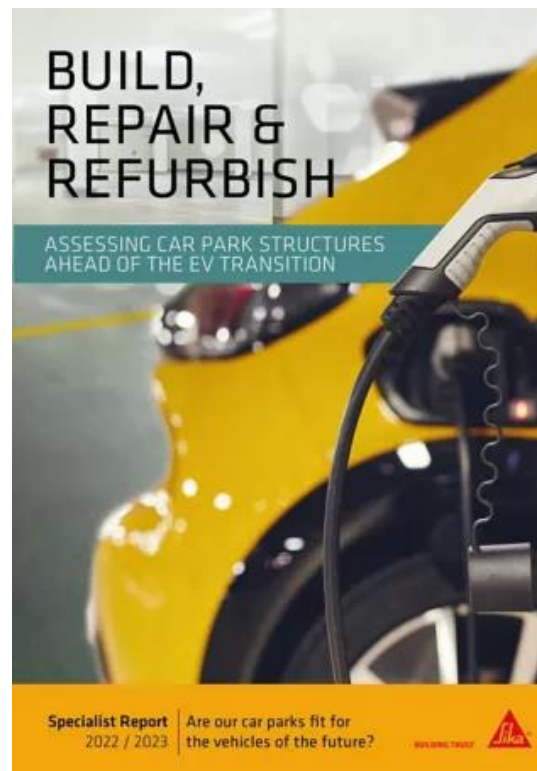
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# SIKA AT WORK - PRINCIPE PÍO STATION, MADRID, SPAIN





# SIKA AT WORK – CARPARKS

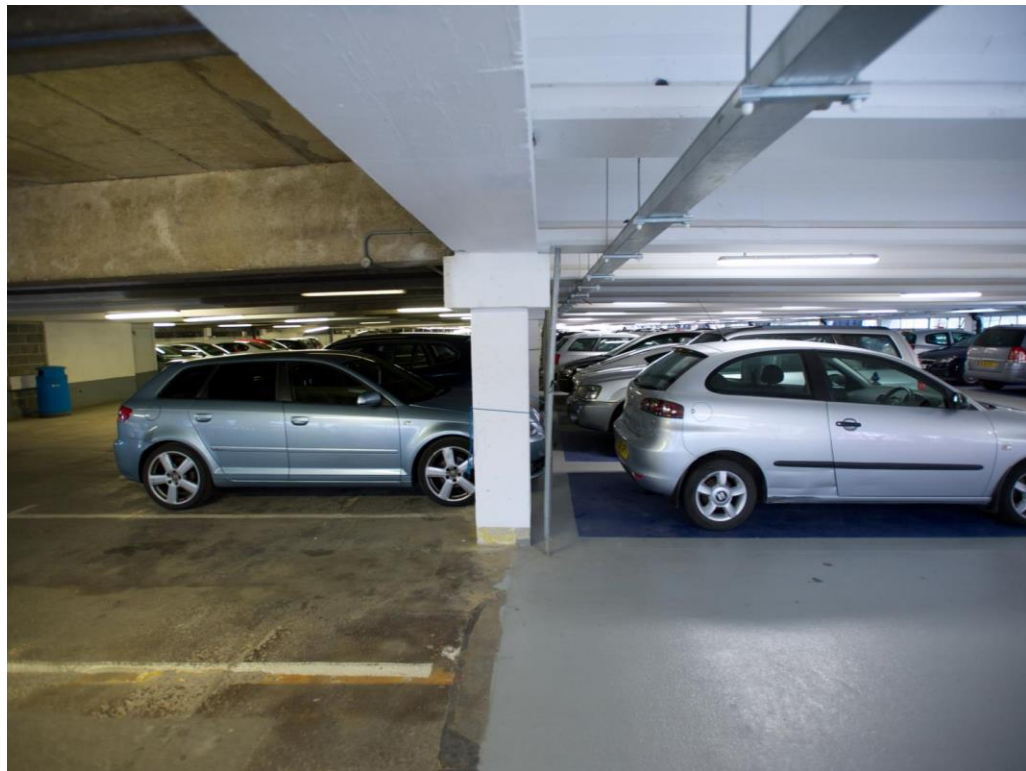


# SIKA AT WORK - MERRION CENTRE, LEEDS, UK

- 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.
- Maintaining the concrete structure of the building while the car park could still be used (70%) was a must → the owner still has the income of the car park.



# SIKA AT WORK - MERRION CENTRE, LEEDS, UK





# CALCULATION GUIDELINES



# FRP DESIGN EUROPEAN GUIDELINES



**SP164.1325800.2014 (Russia)**

**Concrete Society TR55 (UK)**

**CUR-91 (Netherlands)**

**DAfStb Heft 591 (Germany)**

**SIA 166 (Switzerland)**

**CNR-DT 200 R1/2013 (Italy)**

# SIKA CARBODUR® CALCULATION SOFTWARE

INTRODUCTION

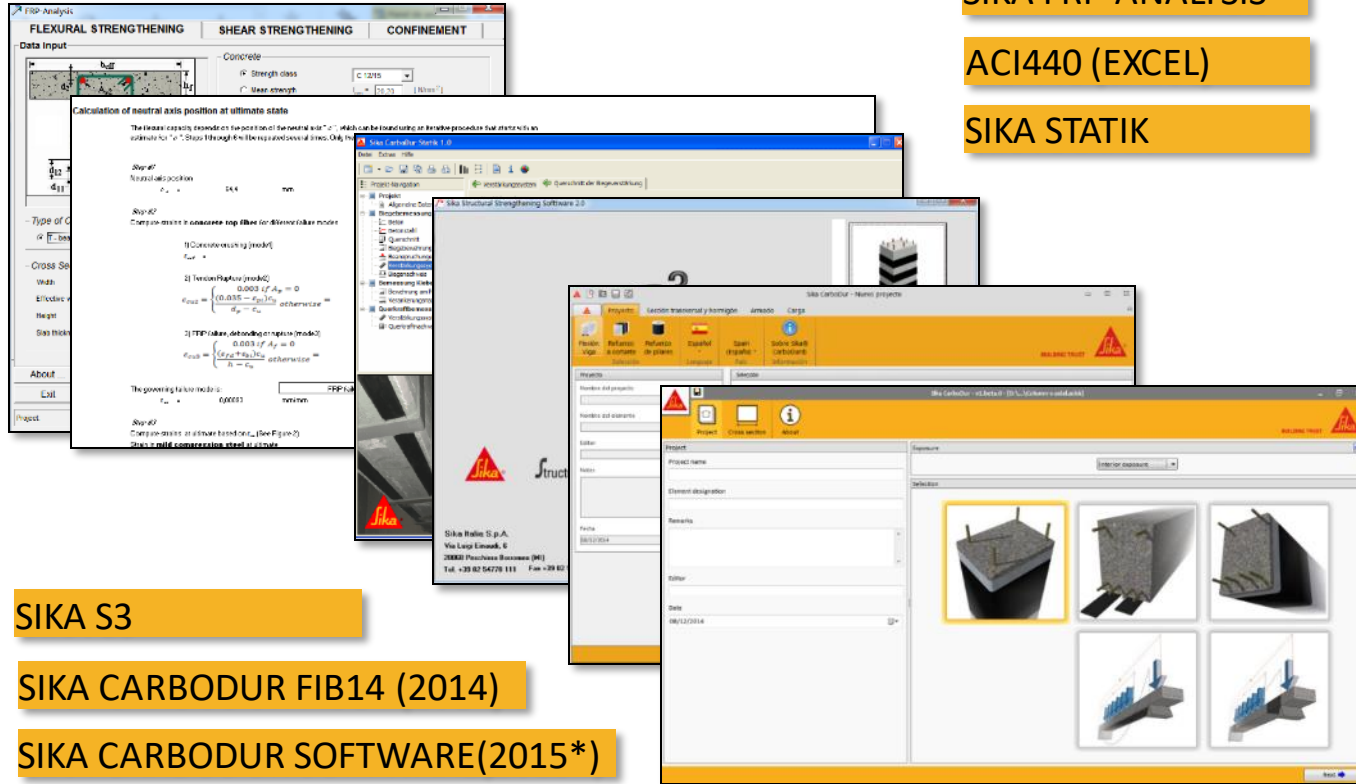
# INTRODUCTION

## SIKA FRP DESIGN SOFTWARES

SIKA FRP-ANALYSIS

ACI440 (EXCEL)

SIKA STATIK



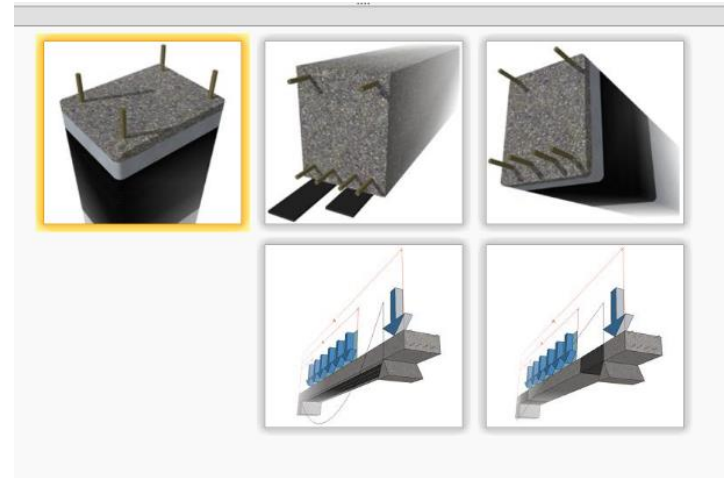
SIKA S3

SIKA CARBODUR FIB14 (2014)

SIKA CARBODUR SOFTWARE(2015\*)

# SIKA® CARBODUR® SOFTWARE

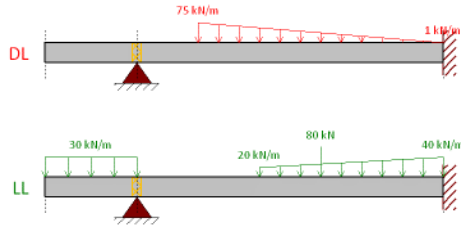
- Sika® CarboDur® Software one of the most complete and powerful FRP strengthening software available.
- Free download from <http://www.sika.com>. Within 15 days from installation is necessary to require the activation of a **FREE** license.
- We have 5 different modules:
  - ✓ RC section FRP confinement design
  - ✓ RC section FRP flexural strengthening design
  - ✓ RC section FRP shear strengthening design
  - ✓ RC beam FRP flexural strengthening design
  - ✓ RC beam FRP shear strengthening design



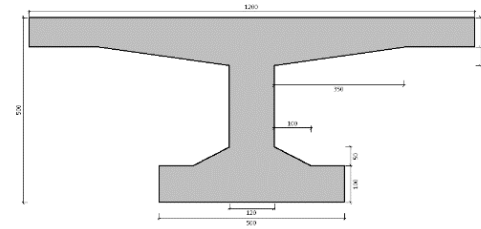


# SIKA® CARBODUR® SOFTWARE

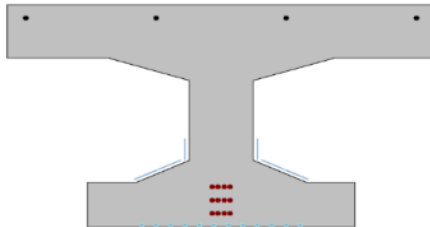
Strengthening of full structural members according its loads distribution. The design is not based on a single section



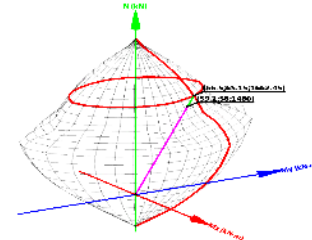
Calculation of complex geometries both for reinforced or prestressed concrete members



Full FRP range of solutions (bonded, NSM, postensioned CFRP) according to the local availability



2D and 3D interaction diagrams for columns, allowing the calculation of elements exposed to axial + bending simultaneously



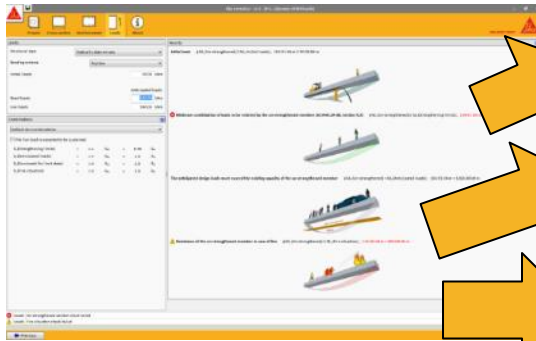
# SIKA® CARBODUR® SOFTWARE: KEY ADVANTAGES

## SAFE

All of the structural calculations strictly follow the latest International Guidelines. No alternative or non-proven design methods are considered.

Additionally, the Sika CarboDur® design software includes the necessary automatic measures, to check the restrictions (geometrical or physical) and logical parameters of the relevant FRP design code.

If some conditions are not met or exceeds any limitations, the software automatically informs the user about this fact and blocks the calculation process.



✘ Minimum combination of loads to be resisted by the un-strengthened member (ACI440.2R-08, Section 9.2)

$$\phi \cdot M_n (\text{Un-strengthened}) \geq M_u (\text{Strengthening limits}); 104.91 \text{ kN-m} < 743.00 \text{ kN-m}$$

⚠ Resistance of the un-strengthened member in case of fire

$$\phi \cdot M_n (\text{Un-strengthened}) \geq M_u (\text{Fire situation}); 116.56 \text{ kN-m} < 860.00 \text{ kN-m}$$

✘ Loads | Un-strengthened section check failed

⚠ Loads | Fire situation check failed

# SOFTWARE DEMONSTRATION

Project

Project name  
Webinar Sika Sweden

Element designation

Remarks

Editor  
Luis Almela

Date  
13/09/2023

Selection

TRSS - EN 1992-1-1  
Switzerland

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Sika

Next



THANK YOU FOR YOUR ATTENTION  
ANY QUESTIONS OR PROJECTS WE CAN  
HELP WITH PLEASE?





THANK YOU FOR YOUR ATTENTION

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