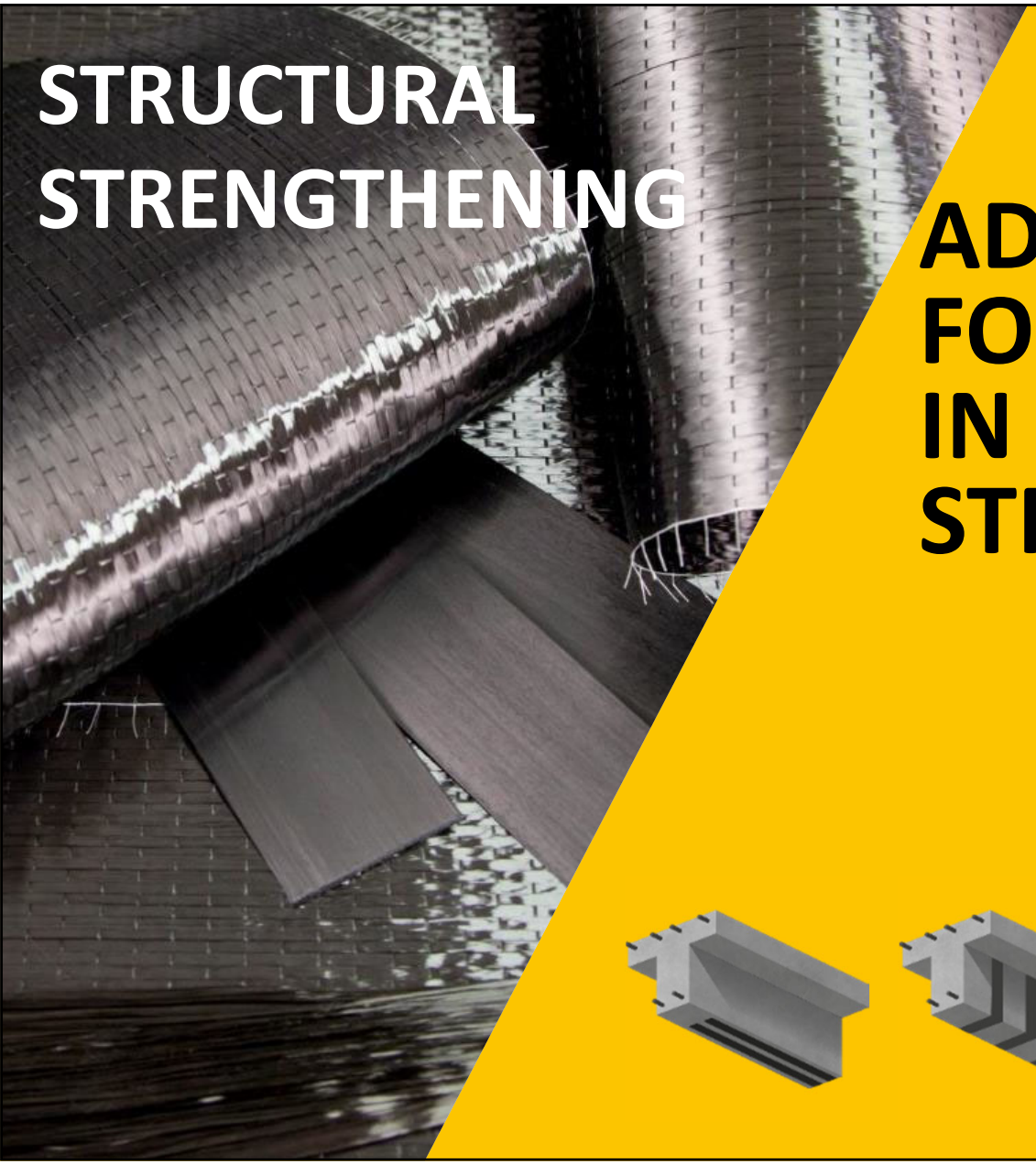
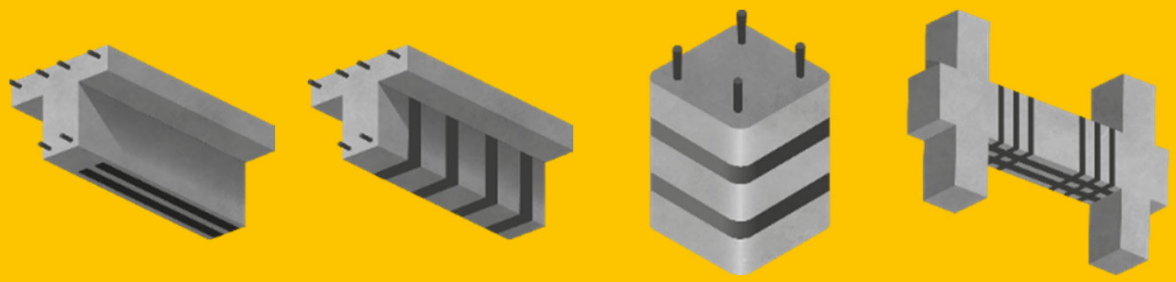


ADVANCED TECHNIQUES FOR FRP STRENGTHENING IN CONCRETE STRUCTURES

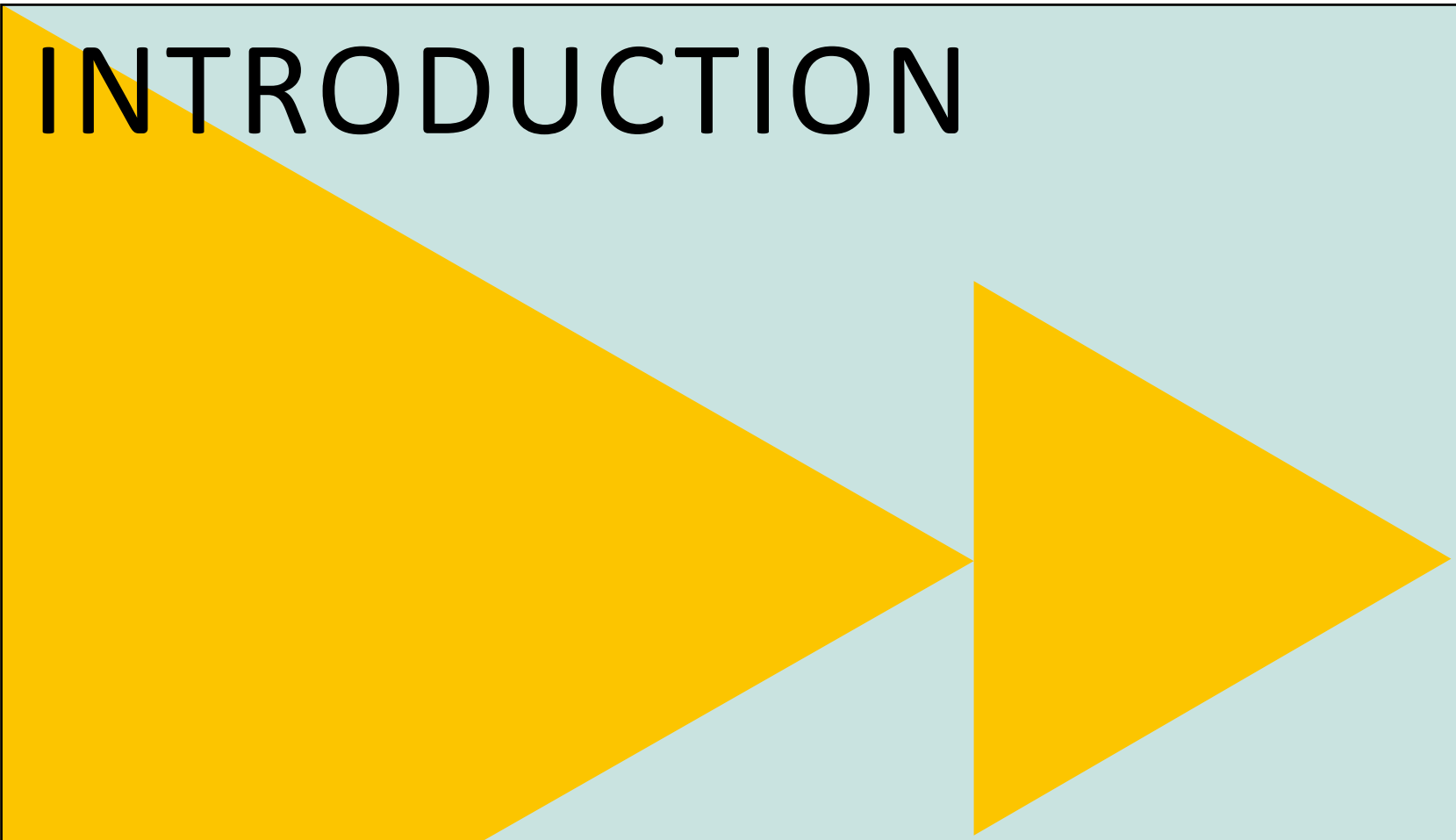
Dec 12th, 2025

ANTONINO MONTALBANO
TM Engineered Refurbishment - Sika Services AG



BUILDING TRUST

INTRODUCTION



STRUCTURAL STRENGTHENING
DEFINITION

FRP SOLUTIONS TO IMPROVE THE **LOAD CARRYING CAPACITY** OF A STRUCTURE

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

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

MILESTONES

1966
Sikadur® resins
First documented application of Sikadur® resins for segmental bridge application in Switzerland

1980-1990
Early studies
Sika studied the possibility of using FRP in construction at EMPA (Zurich)

1991
Sika® CarboDur®
Sika pioneered the introduction of pultruded carbon fiber plates for strengthening

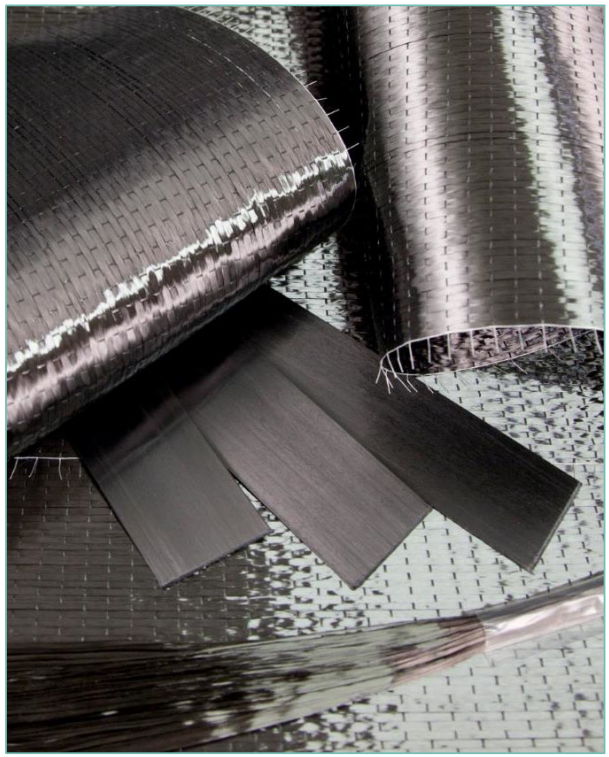
1994
SikaWrap®
Sika introduced the carbon fiber fabrics for confinement and shear strengthening

2000
FRP software
Sika released the first calculation tool for FRP design

Early 2000s
CarboStress and CarboHeater
Sika developed solutions for post tensioned FRP and for special curing conditions

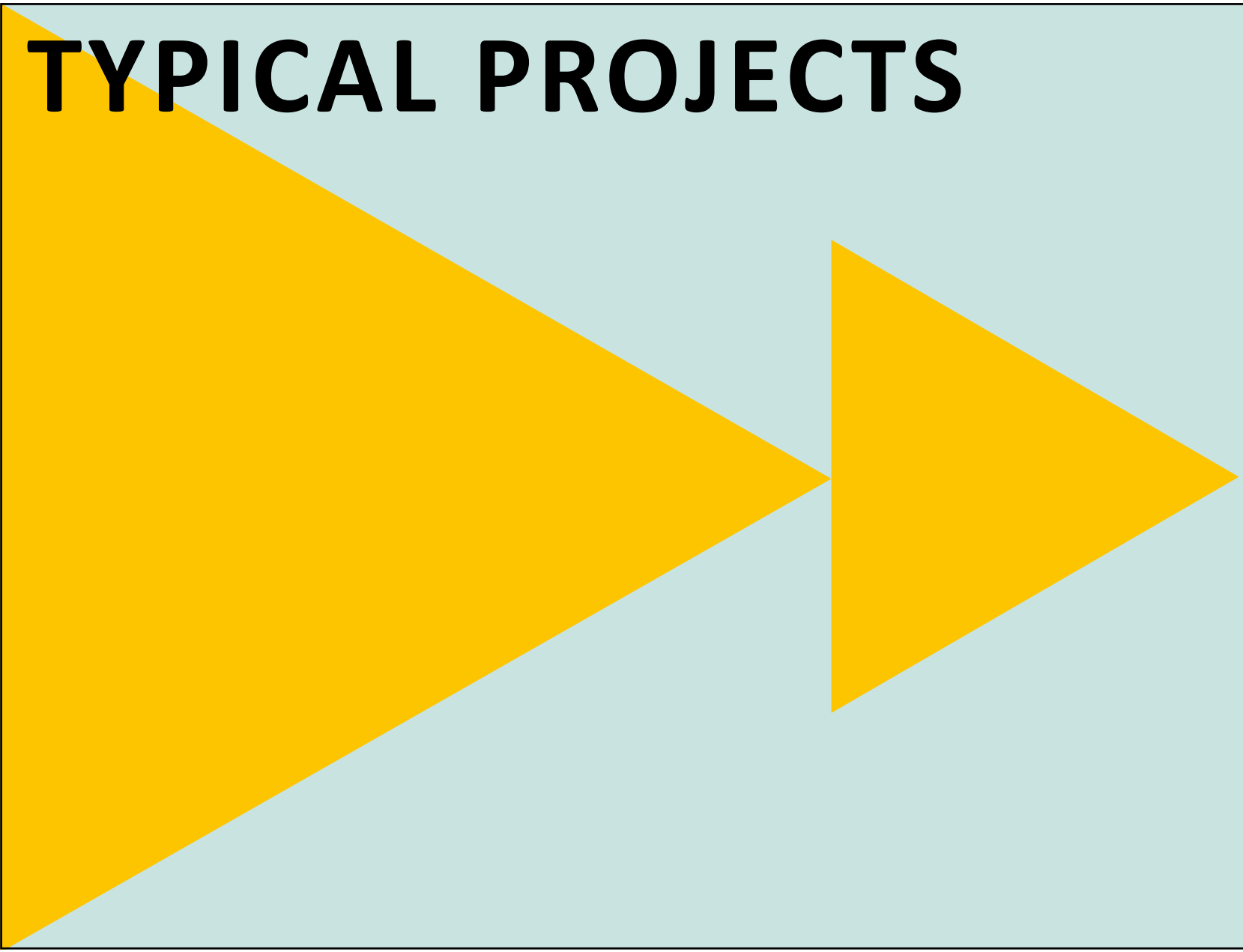
2025
Sika® CarboDur® Software
Sika released the advanced cloud-based calculation software

STRENGTHENING GENERAL PRINCIPLES



- ✓ FRP materials work only in tension.
- ✓ The FRP strengthening system shall be located in areas where tensile stresses occur.
- ✓ The choice and the design of the system are made by an experienced engineer.
- ✓ The installation phase is carried out by experienced and trained contractors
- ✓ Proper surface preparation is the key of a successful application
- ✓ Effectiveness of passive systems is mainly for ULS. For SLS is better to use active systems

TYPICAL PROJECTS



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

*(active systems)

TYPICAL PROJECTS
STRUCTURAL RECOVERY

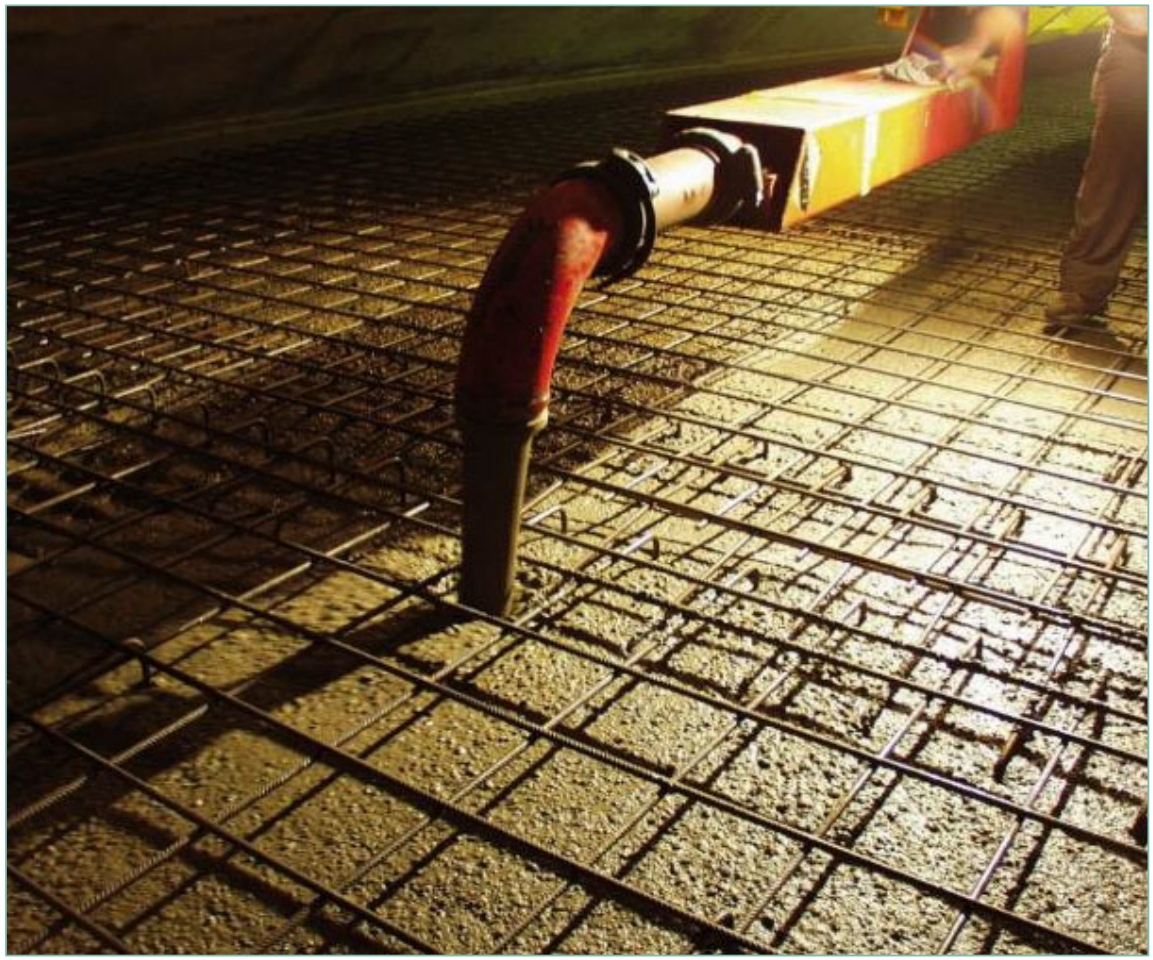
Repair and rehabilitation of a structure after damage due to:

- ✓ Corrosion
- ✓ Mechanical damage
- ✓ Fire
- ✓ Impact
- ✓ Explosion
- ✓ Ageing

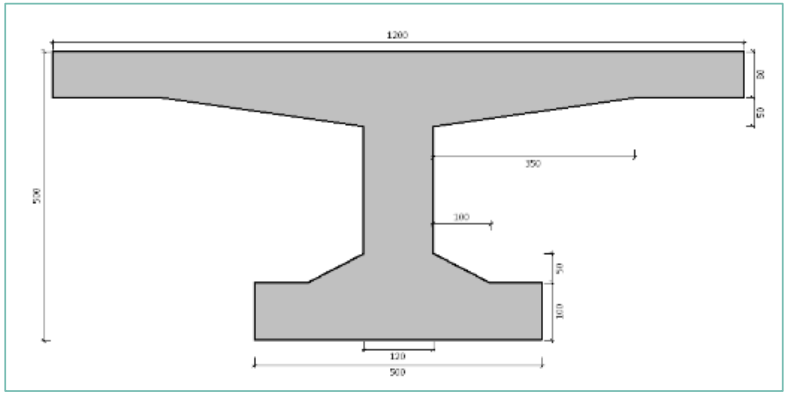
TYPICAL PROJECTS
STRUCTURAL SYSTEM MODIFICATION

- ✓ Slab or wall openings
- ✓ Additional floors
- ✓ Change of use

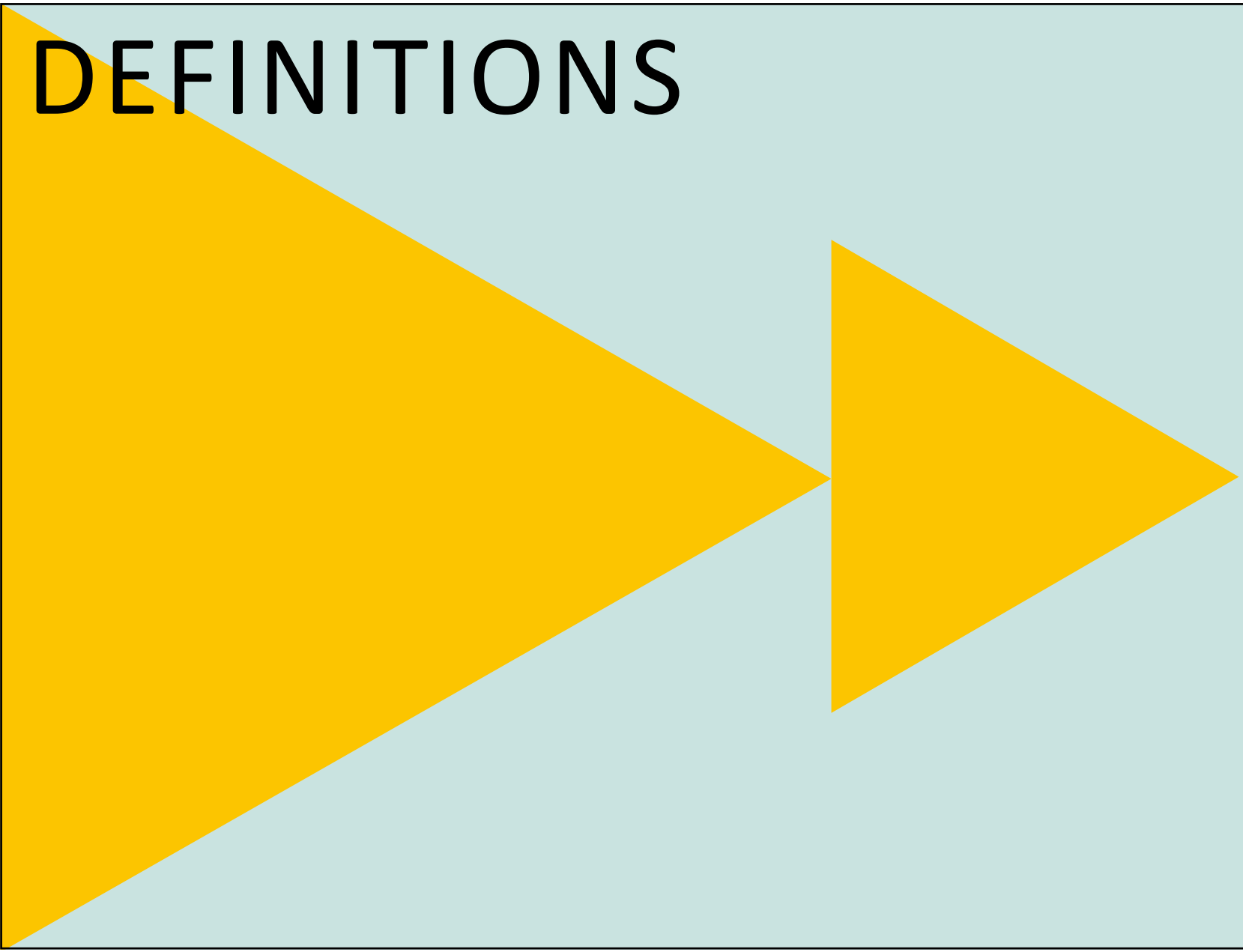
TYPICAL PROJECTS
ERRORS IN DESIGN OR CONSTRUCTION



- ✓ Mistakes in concrete or steel quality
- ✓ Wrong steel quantity or distribution
- ✓ Wrong dimensions
- ✓ Mistakes in design or calculation



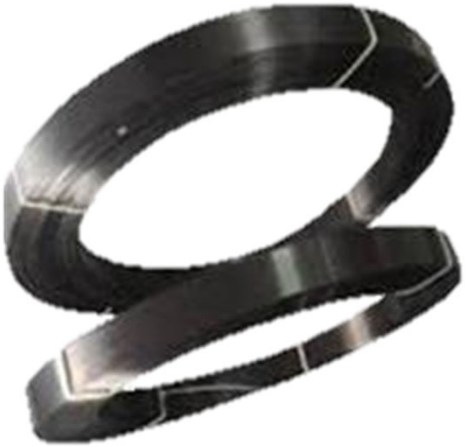
DEFINITIONS



FRP
DEFINITION

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

Composite strengthening systems with organic (mainly epoxy) matrix



FRP
PROS & CONS

PROS

- ✓ Extremely low thickness and high performance;
- ✓ Wide range of product can be adapted to all the needs;
- ✓ Easy to handle and apply;
- ✓ Very high adhesion;
- ✓ Reduced disruption time;
- ✓ Sika® CarboDur® software available for the design;
- ✓ Good chemical resistance.

CONS

- ✓ Require a perfect smooth surface;
- ✓ Substrate must be dry (HR max 4%);
- ✓ Must be protected in humid/wet environment;
- ✓ Not suitable for application on green concrete/repair mortars
- ✓ Higher expertise required for application
- ✓ Use of epoxy in narrow spaces

SIKA SOLUTIONS:

SIKA® CARBODUR®

SIKA® CARBODUR®
CFRP PLATES FOR FLEXURAL STRENGTHENING

Components:

- ✓ CFRP Plate: Sika® CarboDur®
- ✓ Epoxy adhesive: Sikadur®-30

Preformed plates with epoxy matrix

Cut to size and installed on site

Uses:

- ✓ Flexural strengthening of positive or negative moments
- ✓ Active strengthening with post-tensioned plates

SIKA® CARBODUR®
CFRP PLATES FOR FLEXURAL STRENGTHENING

Sikadur®-30 serves as primer, putty and adhesive

- ✓ Plate crossovers possible
- ✓ Layer application possible
- ✓ Protective coating often not necessary
- ✓ Application on concrete, steel, masonry and wood substrates possible
- ✓ 30+ years experience

SIKA SOLUTIONS:

SIKAWRAP®

SIKAWRAP®
CF FABRICS FOR CONFINEMENT AND SHEAR STRENGTHENING

System Components:

✓ Unidirectional carbon or glass fibre fabric: **SikaWrap®**

✓ Epoxy adhesive: **Sikadur®-330** or **Sikadur®-300**

On site laminated fabrics

Used for flexural, shear and confinement strengthening

SIKAWRAP®
CF FABRICS FOR CONFINEMENT AND SHEAR STRENGTHENING

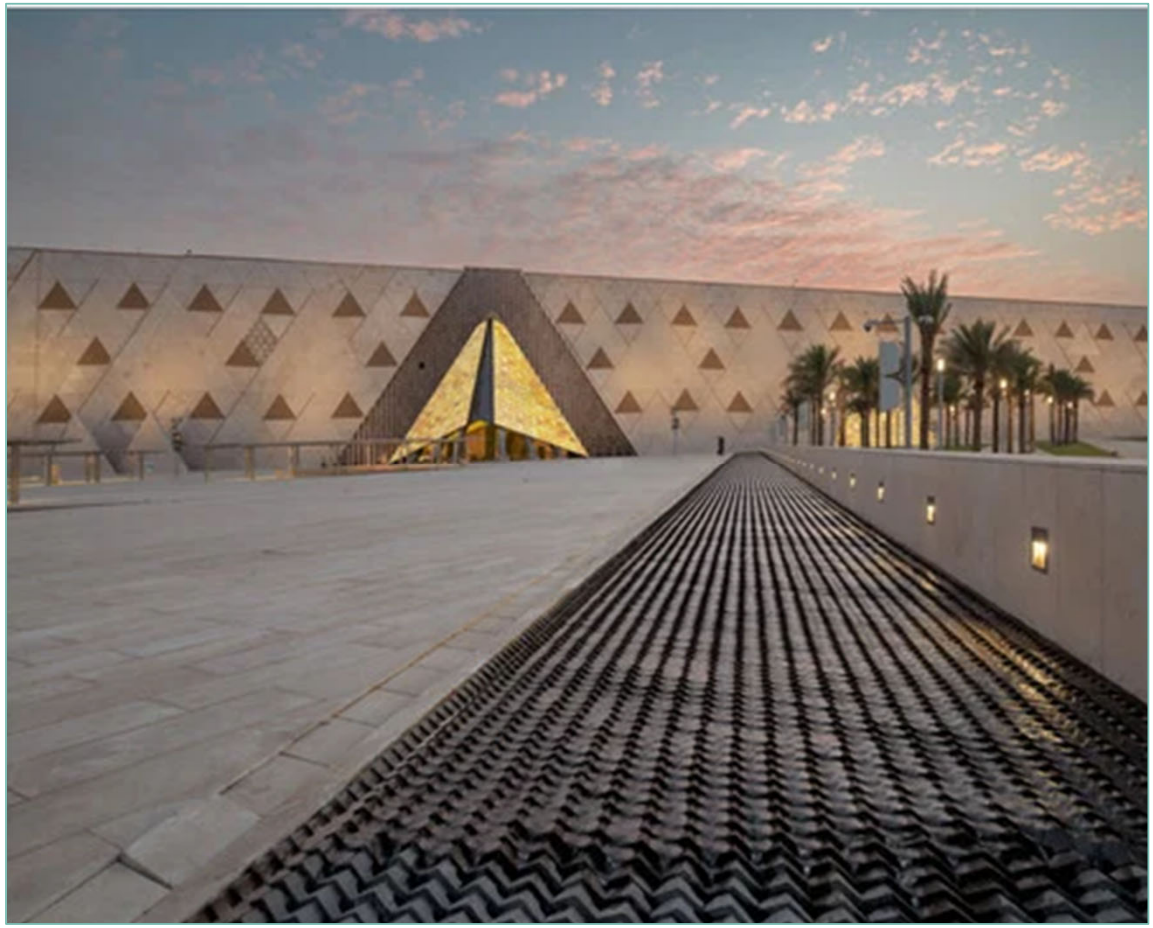
- Shear strengthening

- Confinement strengthening

CASE STUDY

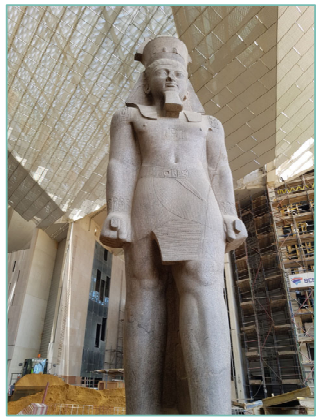
CASE STUDY - GRAND EGYPTIAN MUSEUM

THE LARGEST ARCHAEOLOGICAL MUSEUM IN THE WORLD



Sika solutions used:

- Waterproofing
- Thermal insulation
- Structural strengthening & bonding
- Sealing & Bonding
- Façade solutions



CASE STUDY - GRAND EGYPTIAN MUSEUM
STRUCTURAL STRENGTHENING & BONDING

Sika solutions used:

- SikaWrap®-530 C
- Sikadur®-300
- Sikadur®-41

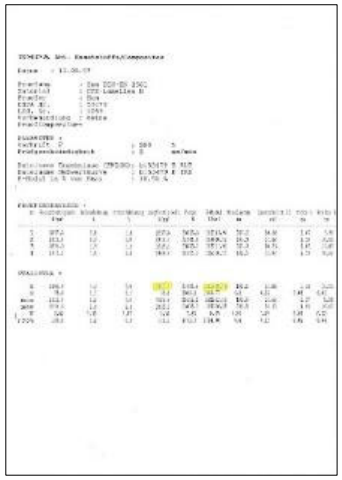
Main contractor: besix orascom
Specialized contractor: Contra
Specialized consultant: AACE (PROF. DR. AMR ABDEL-RAHMAN)
Main consultant: Hill – Ehaf

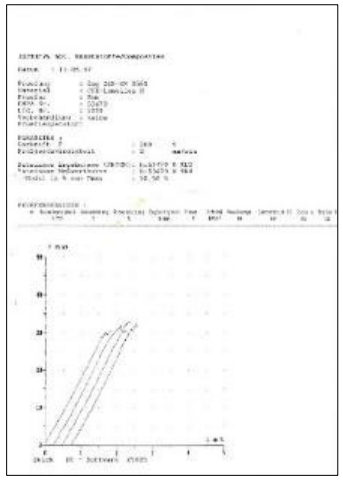
CASE STUDY - GRAND EGYPTIAN MUSEUM
STRUCTURAL STRENGTHENING

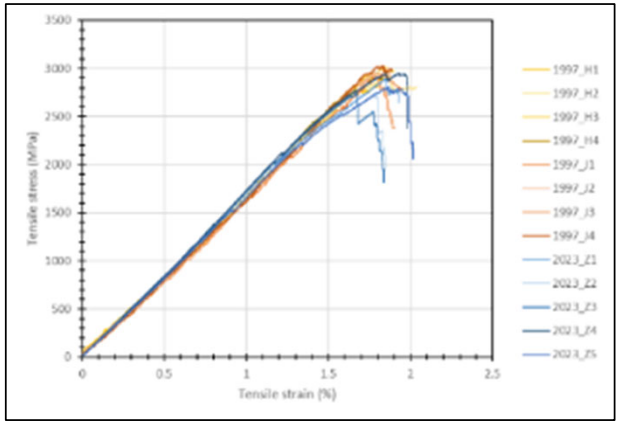
A STORY OF PERFORMANCE AND DURABILITY

TESTING 27-YEAR-OLD SIKA® CARBODUR® PLATES

- Sika® CarboDur® plates produced in March 1996







- Tests performed on May 1997 and Oct 2023

Year	1997	2023
No. of samples	8	5
Tensile strength	2975 MPa	2825 MPa **(-5.0%)**
Elastic Modulus	164 GPa	162 GPa **(-1.3%)**
Max strain	1.88%	1.82% **(-3.6%)**

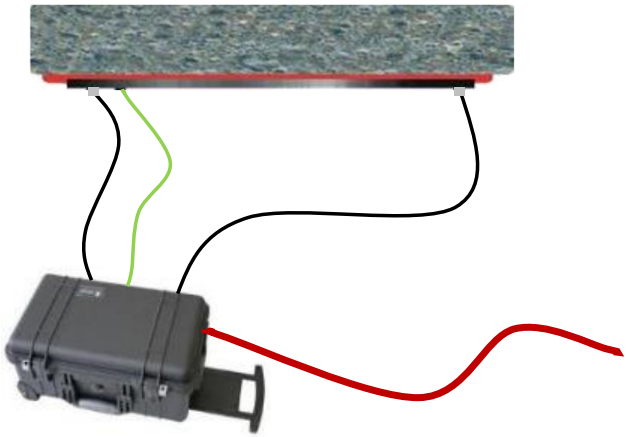
SIKA SPECIAL SOLUTIONS:

- SIKA® CARBOHEATER
- SIKA® CARBOSTRESS
- SIKADUR®-370

SIKA® CARBOHEATER
FASTER CURING, LESS DOWNTIME

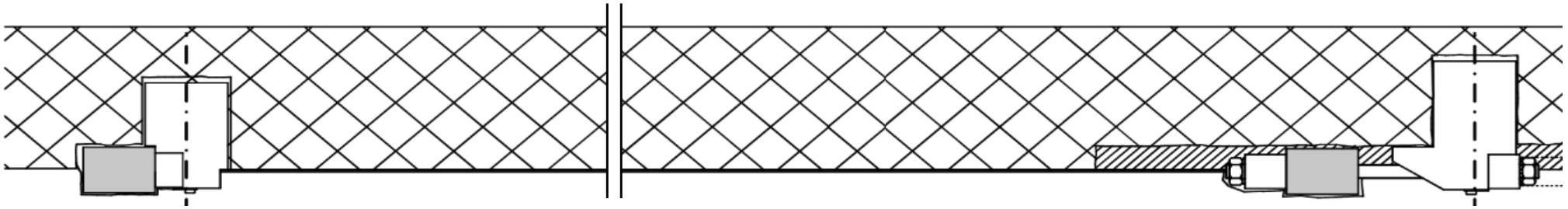
Sika® Carboheater is a device that uses electricity and the conductivity of carbon fibers, heating, the Sika® CarboDur® plate and the resin.
The current flow generates heat dispersion (Joule effect). Controlling and monitoring this effect we are able:

- ✓ Application at low temperatures
- ✓ To complete the curing of the resin in 2 hours
- ✓ To increase the Tg of the resin due to high temperature curing



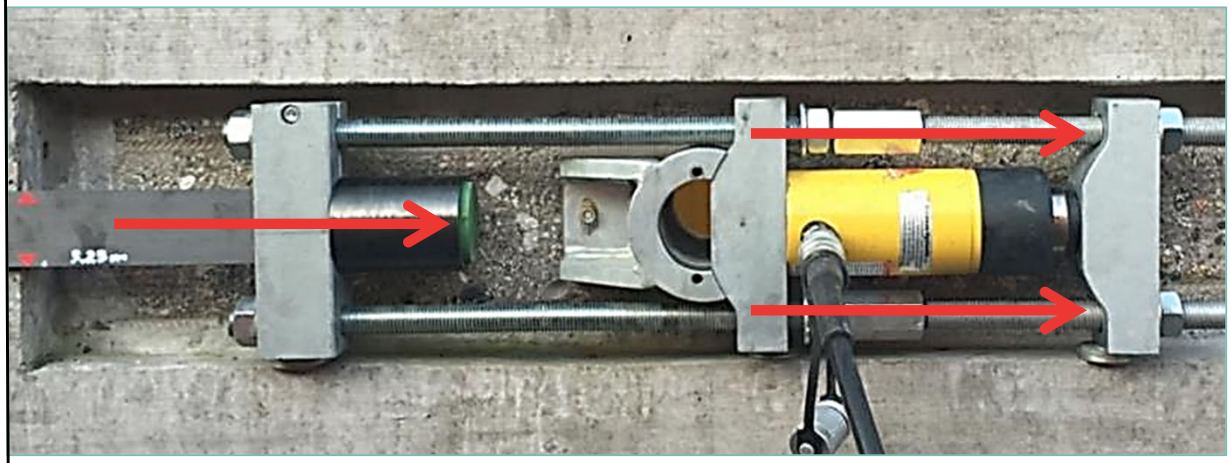
SIKA® CARBOSTRESS
THE SYSTEM

P_0 = 220kN



Fixed anchor side

movable anchor – tensioning side



SIKA® CARBOSTRESS
PROPERTIES

Sika® CarboStress System characteristics

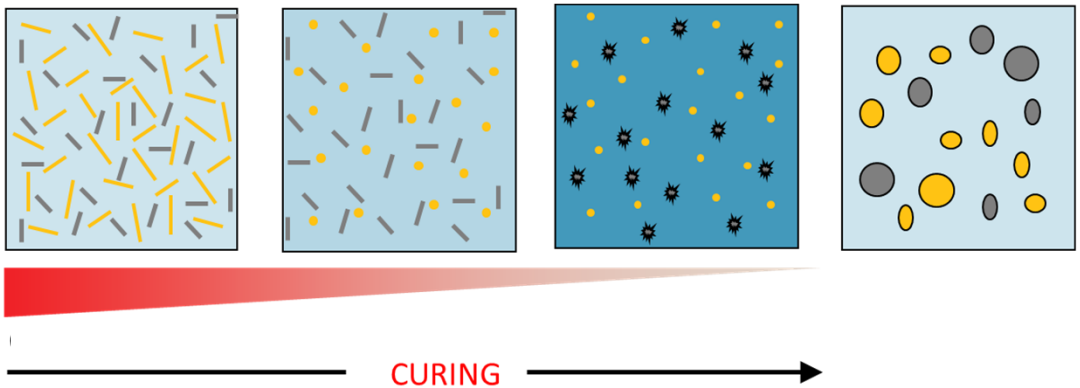
- ✓ Post-tensioning force F_{P0} = 220 kN
- ✓ Guarantied anchored force $F_{Psk,min}$ = 300 kN

Characteristics of Plate (Sika® CarboDur® S626)

- ✓ Post-tension at F_{P0} = 220 kN σ_{P0} = 1‘410 N/mm2
- ✓ Tensile strength σ_u = 2'800 N/mm2
- ✓ Post-strain at F_{P0} = 220 kN ε_{P0} = 0.85 %
- ✓ Modulus of elasticity E_{min} = 165 GPa

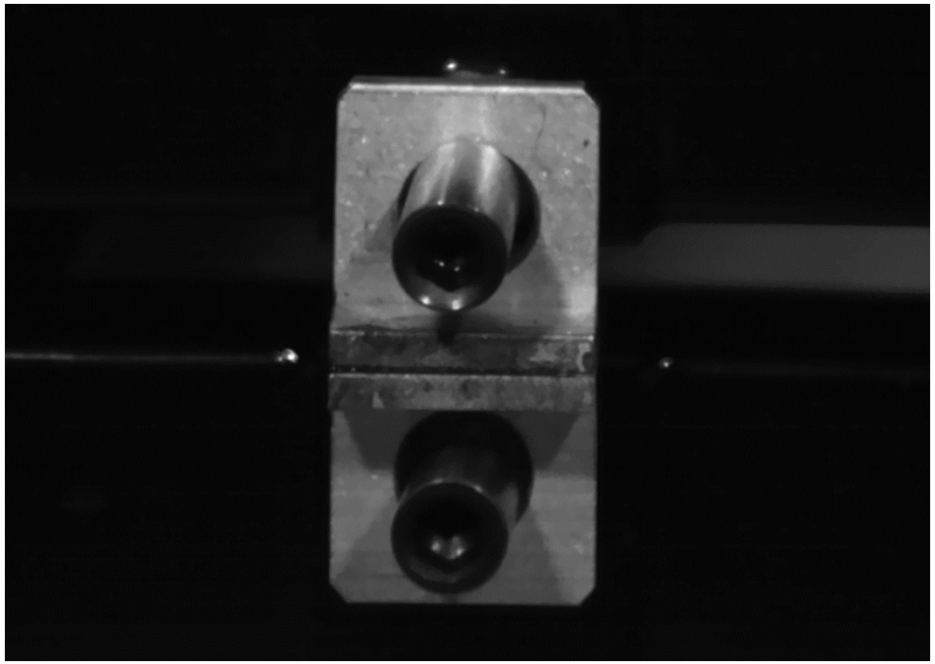
NEW TECHNOLOGIES
TOUGHENED EPOXY TECHNOLOGY

- **SmartCore** is the toughening technology patented by Sika, which enables 2C-epoxy adhesives to reach elevated resistance to both static and dynamic loads in combination with high stiffness.
- The innovative toughening agent is mixed in the epoxy matrix. During the curing process, tough domains arise at micro/nano scale, finely distributed and chemically linked to the matrix, allowing a unique high level of toughness.

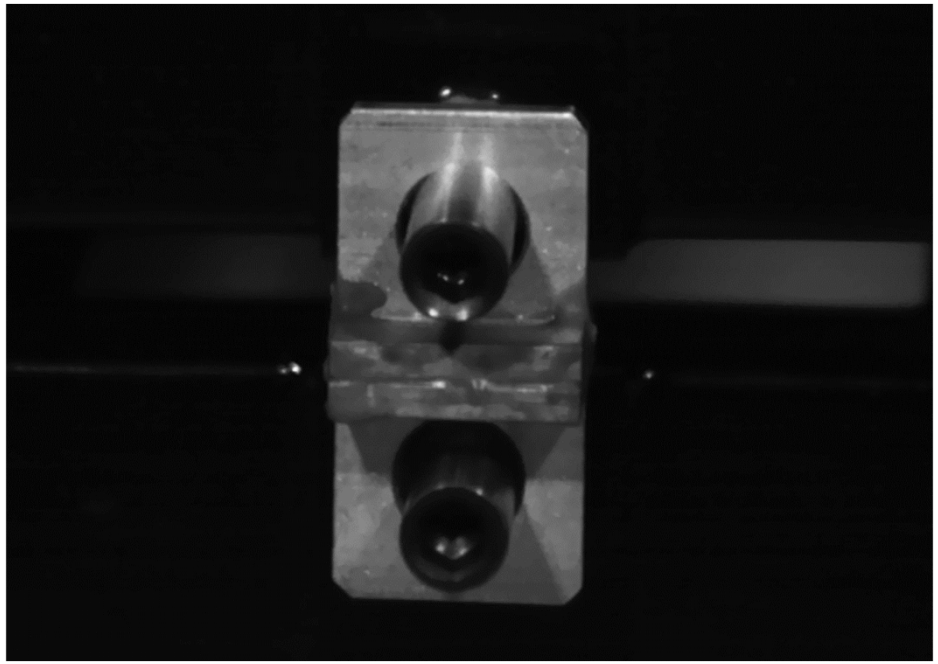


TOUGHENED EPOXY RESINS

IMPULSIVE LOAD - HIGH-SPEED CAMERA RECORDINGS



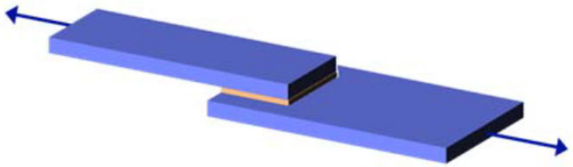
- Std. 2C-Epoxy
- (Impact Strength: 11N/mm)

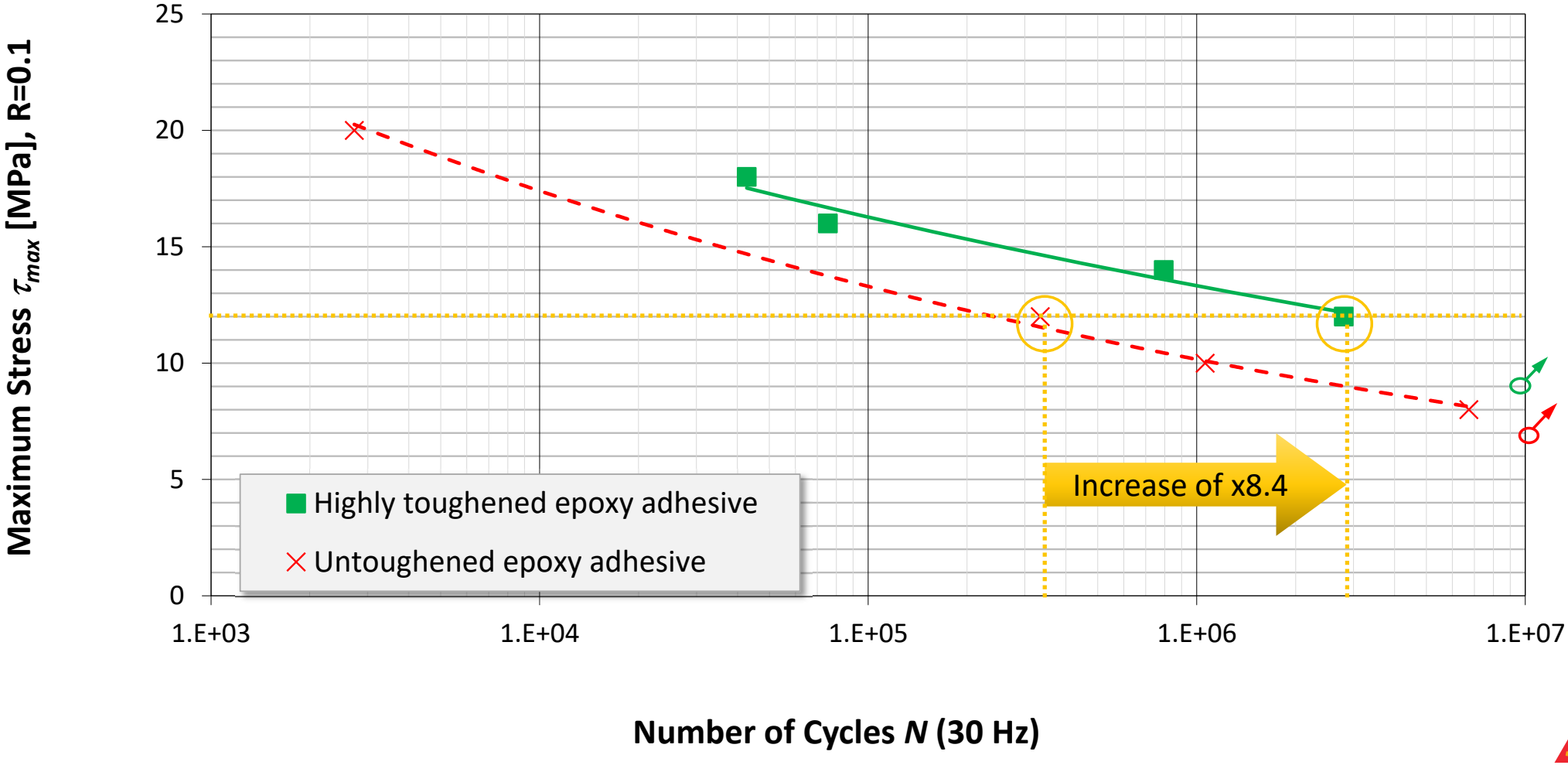


- High toughened 2C Epoxy
- (Impact Strength: 30N/mm)

TOUGHENED EPOXY TECHNOLOGY

FATIGUE TEST ON FRP TEST SPECIMEN





SIKADUR®-370
TOUGHENED EPOXY RESIN

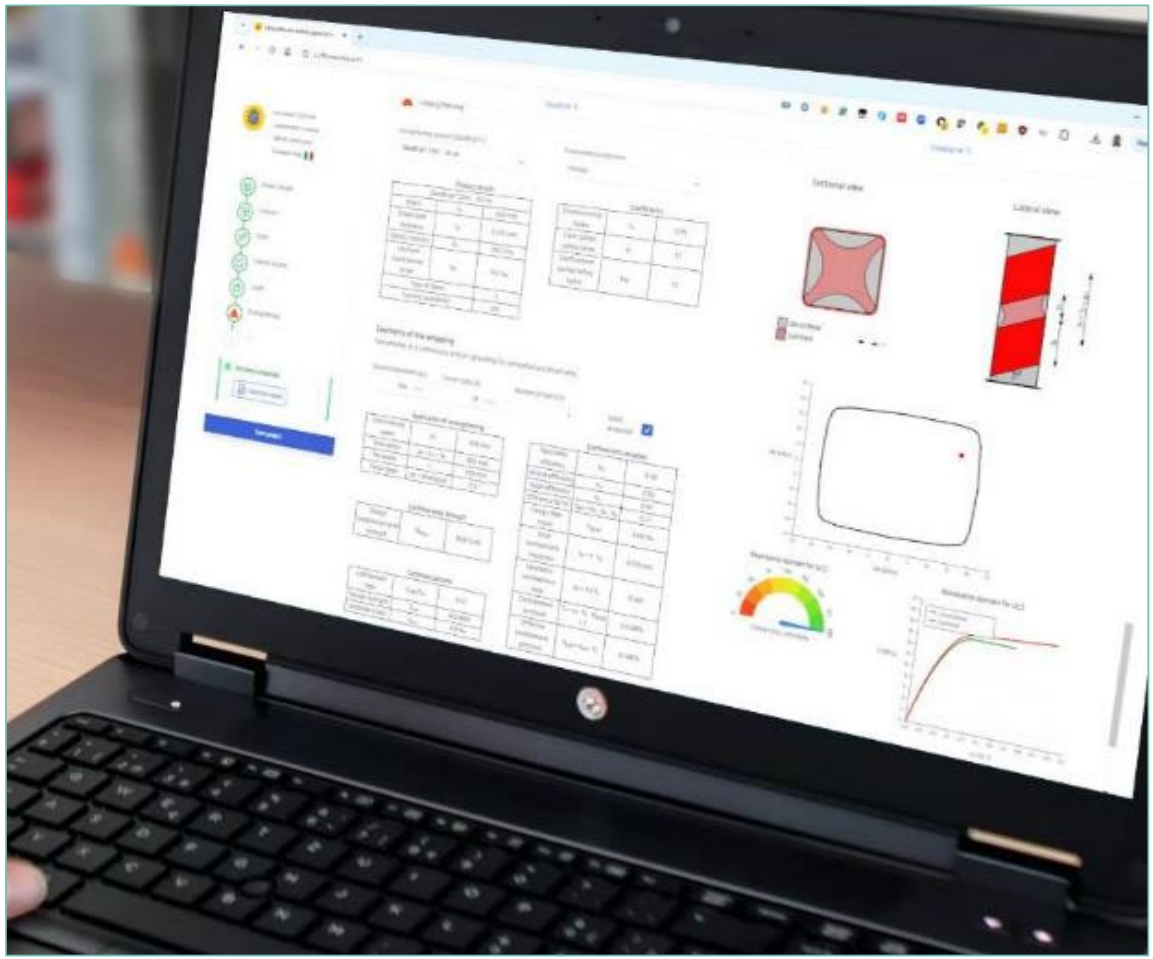
- Toughened 2C Epoxy-PU resin, Thixotropic consistency
- It bonds to concrete, masonry, steel, stonework, cast iron, alluminum and other construction materials
- Anti-corrosion inhibitors inside

FIELDS OF USE

- Sika® CarboDur® to steel bonding
- Steel-to-steel bonding
- Sika® CarboDur® to Sika® CarboDur® splice overlapping
- Steel bridges repair
- Steel structures reinforcement (industrial & civil buildings, lattice & telecommunication towers)
- Friction joints improvements
- Fatigue induced cracks repair

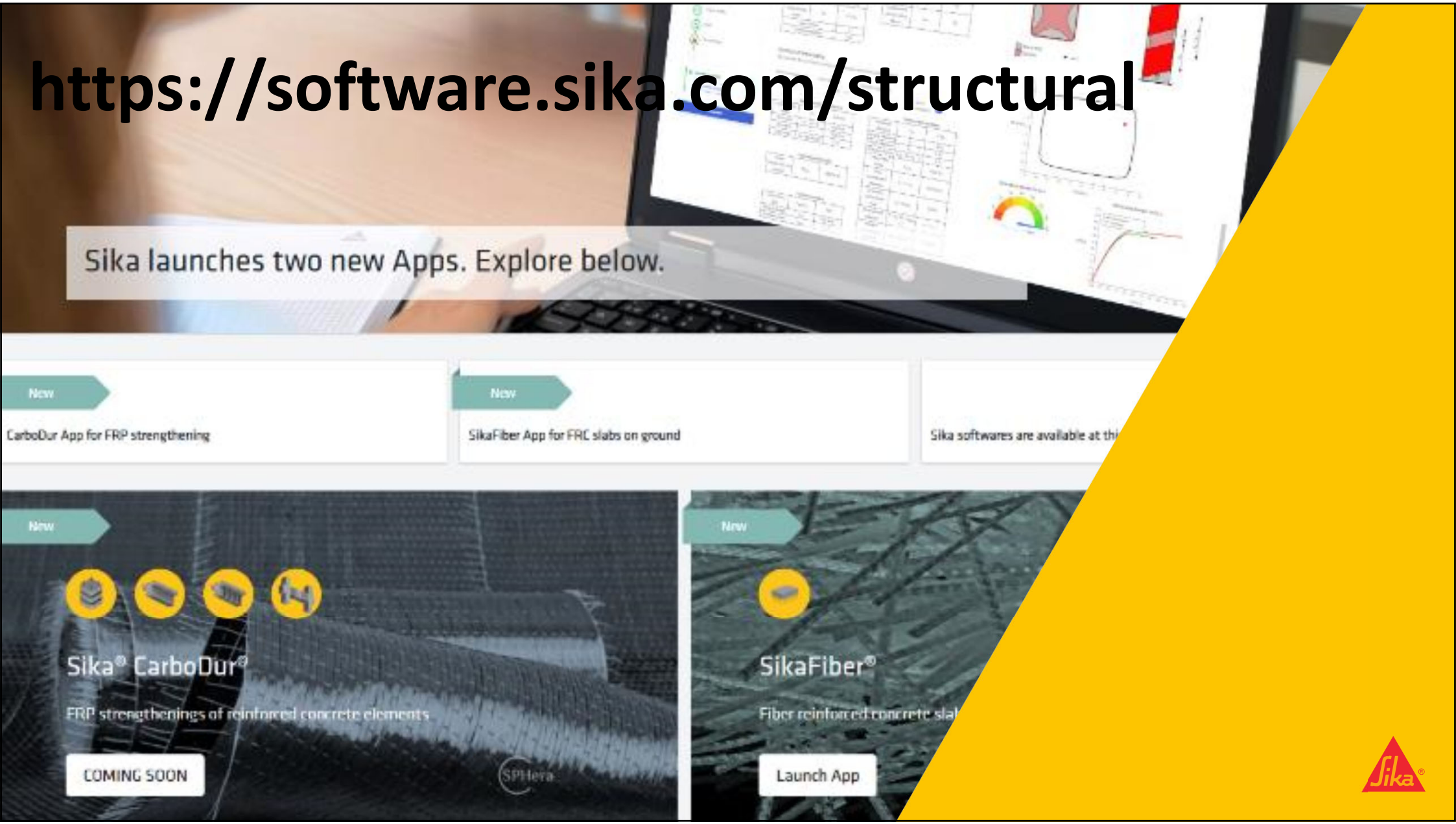
SIKA® CARBODUR® SOFTWARE

ADVANCED STRUCTURAL DESIGN MADE SIMPLE

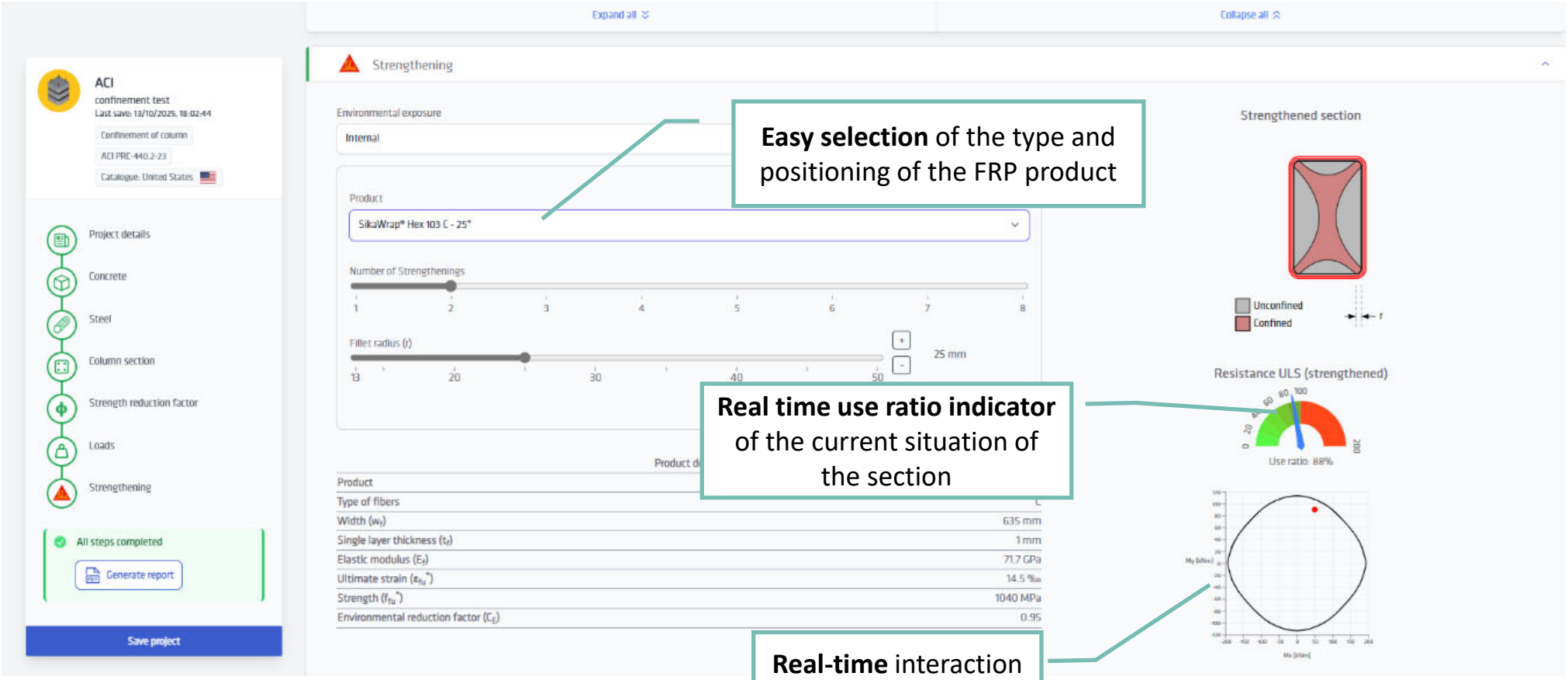


BENEFITS

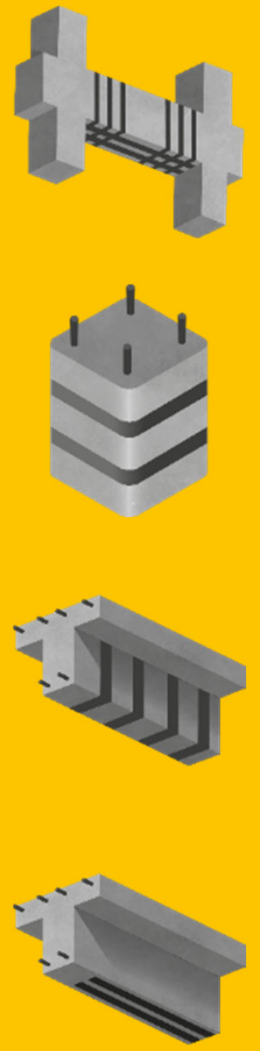
- ✓ **Cloud based. No installation**
- ✓ **Fully Browser-Compatible**
- ✓ Free license
- ✓ Always Up-to-Date
- ✓ Excellent user interface
- ✓ **Real-time calculations**
- ✓ Multi language
- ✓ Multi design standard


https://software.sika.com/structural
Sika launches two new Apps. Explore below.
New
CarboDur App for FRP strengthening
New
SikaFiber App for FRC slabs on ground
Sika softwares are available at th
New
Sika® CarboDur®
FRP strengthenings of reinforced concrete elements
COMING SOON
New
SikaFiber®
Launch App

NEW SIKA® CARBODUR® SOFTWARE
ADVANCED STRUCTURAL DESIGN MADE SIMPLE



THANK YOU



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