BRIDGE REHABILITATION USING FRP- CASE STUDIES

PEDRAM MOJARRAD
SIKA AUSTRALIA

BUILDING TRUST

BRIDGE STRENGTHENING

SIKA® FRP PRODUCT RANGE

MAIN FRP STRENGTHENING MATERIALS

Prefabricated systems

- CFRP plates
- L-shaped plates
- NSM applications
- Post-tensioned CFRP system
- Structural adhesives

Manual application systems

- Fabrics
- Anchorages tails
- Grid FRP meshes
- Structural adhesives

Prefabricated systems represent ≈80% of the current applications in Europe, as they are usually considered as a safer system (lower safety factors and less restrictions regarding the unevenness of the concrete surface,) and higher efficiency during the installation process.

ANCHORING TAIL

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NSM (NEAR SURFACE MOUNTED)

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INTRODUCTION

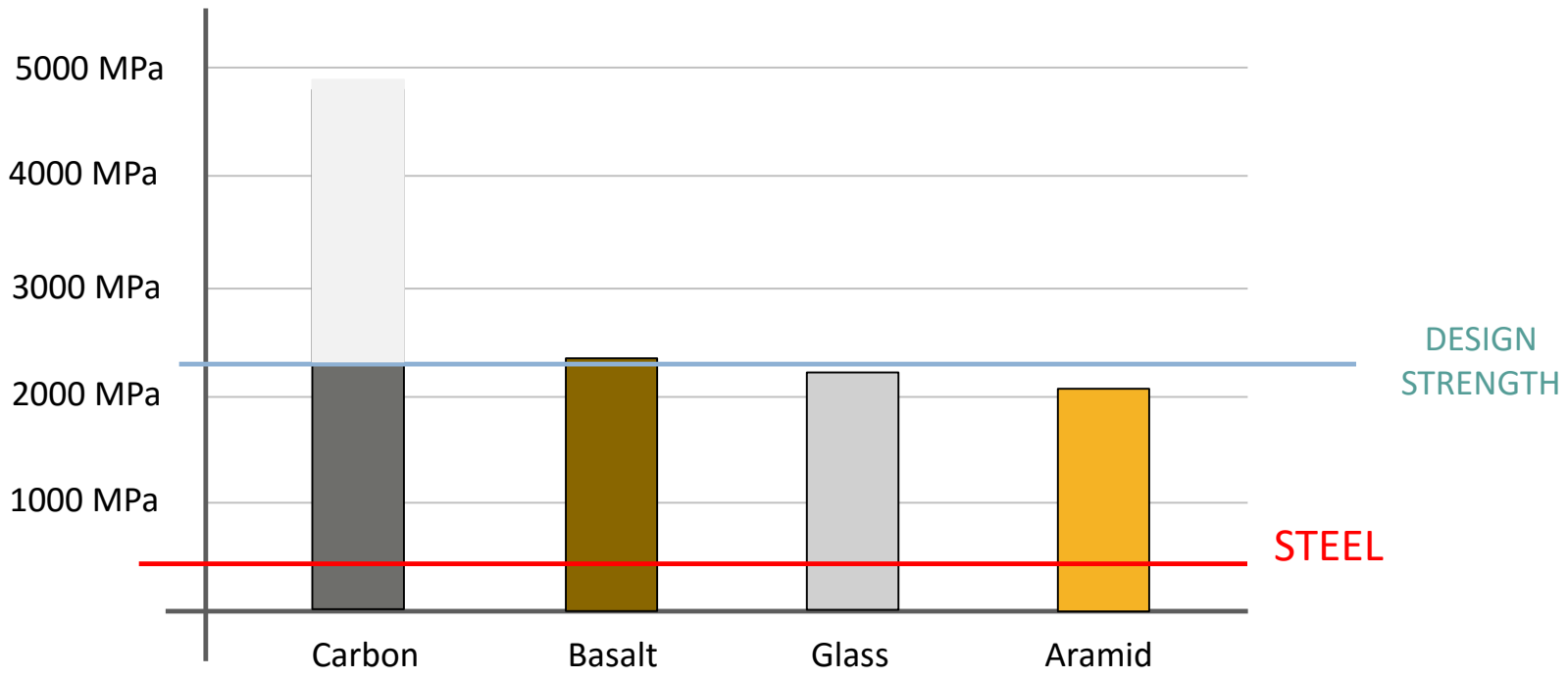
MECHANICAL PERFORMANCE OF FRP SYSTEMS

CARBON FIBER	GLASS FIBER	ARAMID FIBER
STIFFNESS	PRICE	TENACITY
• STRUCTURAL STRENGTHENING • SEISMIC	• MASONRY STRENGTHENING • SEISMIC	• IMPACT • BLAST MITIGATION

FRP STRENGTH

FIBERS COMPARISON

ULTIMATE STRENGTH



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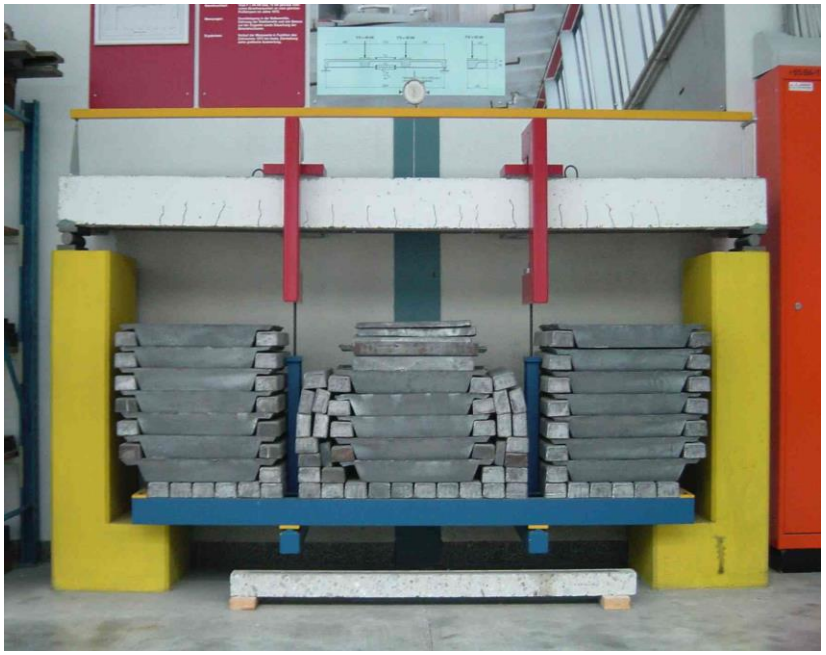
DEVELOPMENT OF THE FRP SYSTEMS

1967: Structural Adhesives initially developed for steel plate bonding for Strengthening



1970 Long Term Test at EMPA (still ongoing)

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

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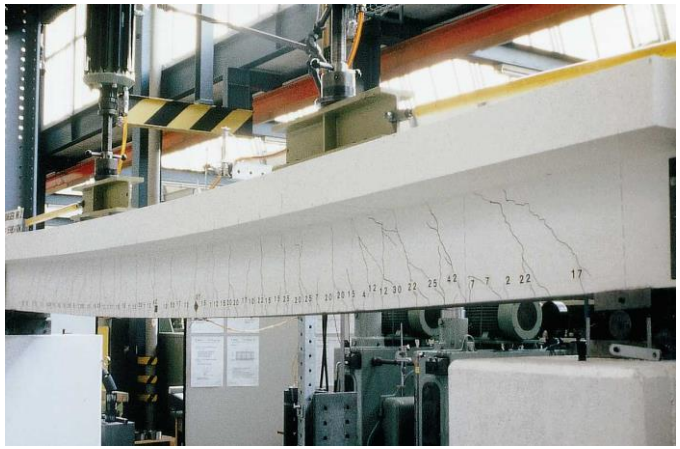
CFRP RANGE DEVELOPMENT

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

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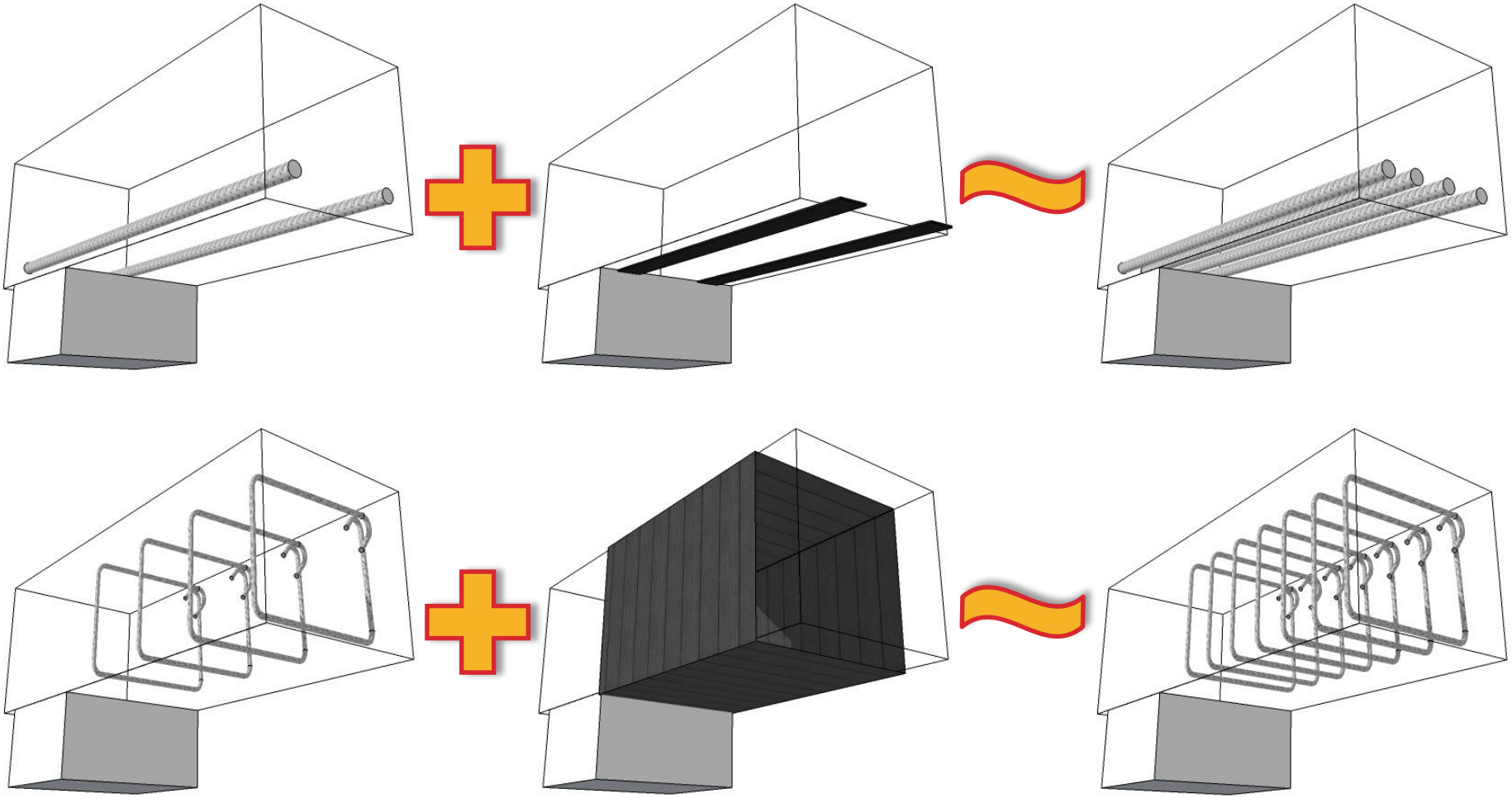
FIRST APPLICATION OF SIKA CFRP PLATES

1991: First Application of CFRP plates for Structural Strengthening of a bridge

Ibach Bridge, Zurich (Switzerland)

CFRP STRENGTHENING OF BEAMS

AS A SIMPLIFICATION:



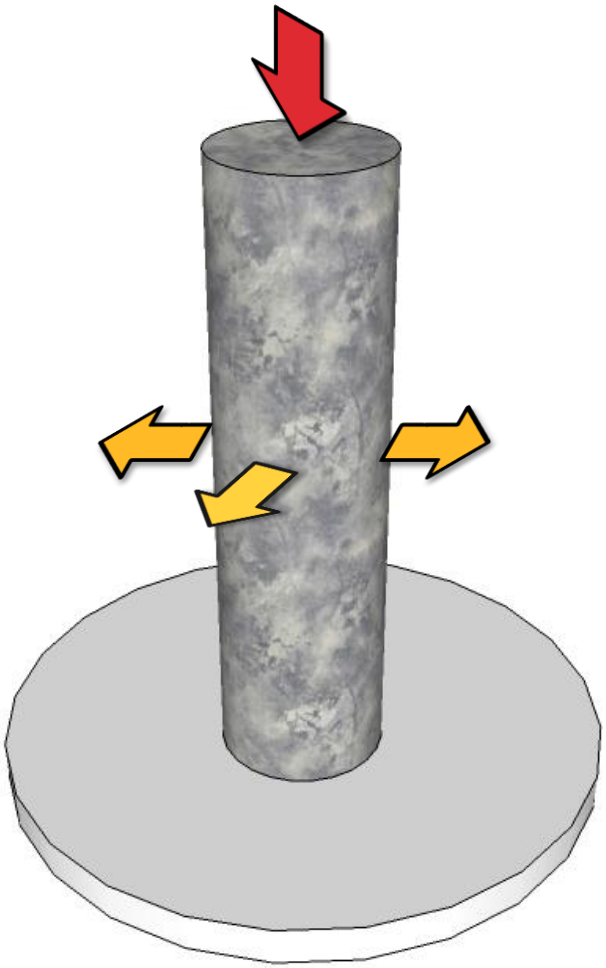
COLUMN CONFINEMENT

POISSON´S EFFECT

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.

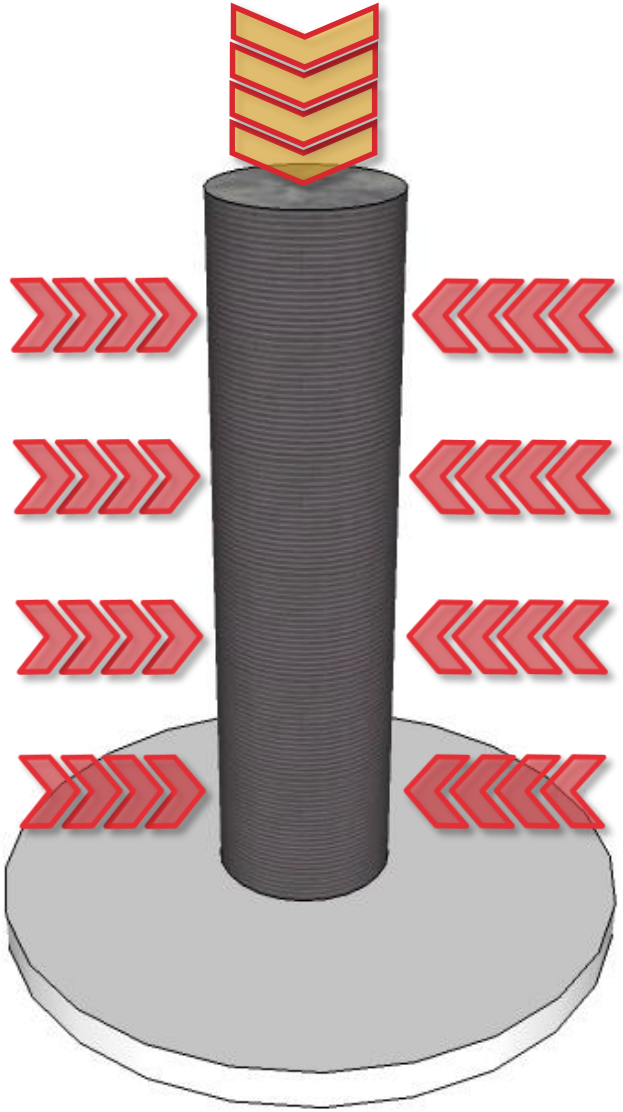
Hence, if the transversal expansion is restricted, the final strength increases…



COLUMN CONFINEMENT

POISSON´S EFFECT

To avoid the lateral expansion, its 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.



DESIGN GUIDELINES (in addition to *FIB* BULLETING 14)

LOCAL EUROPEAN GUIDELINES

Concrete Society TR55 (UK): Design guidance for strengthening concrete structures using fibre composite materials.

CUR-91 (Netherlands): Strengthening of reinforced concrete structures with externally glued CFRP.

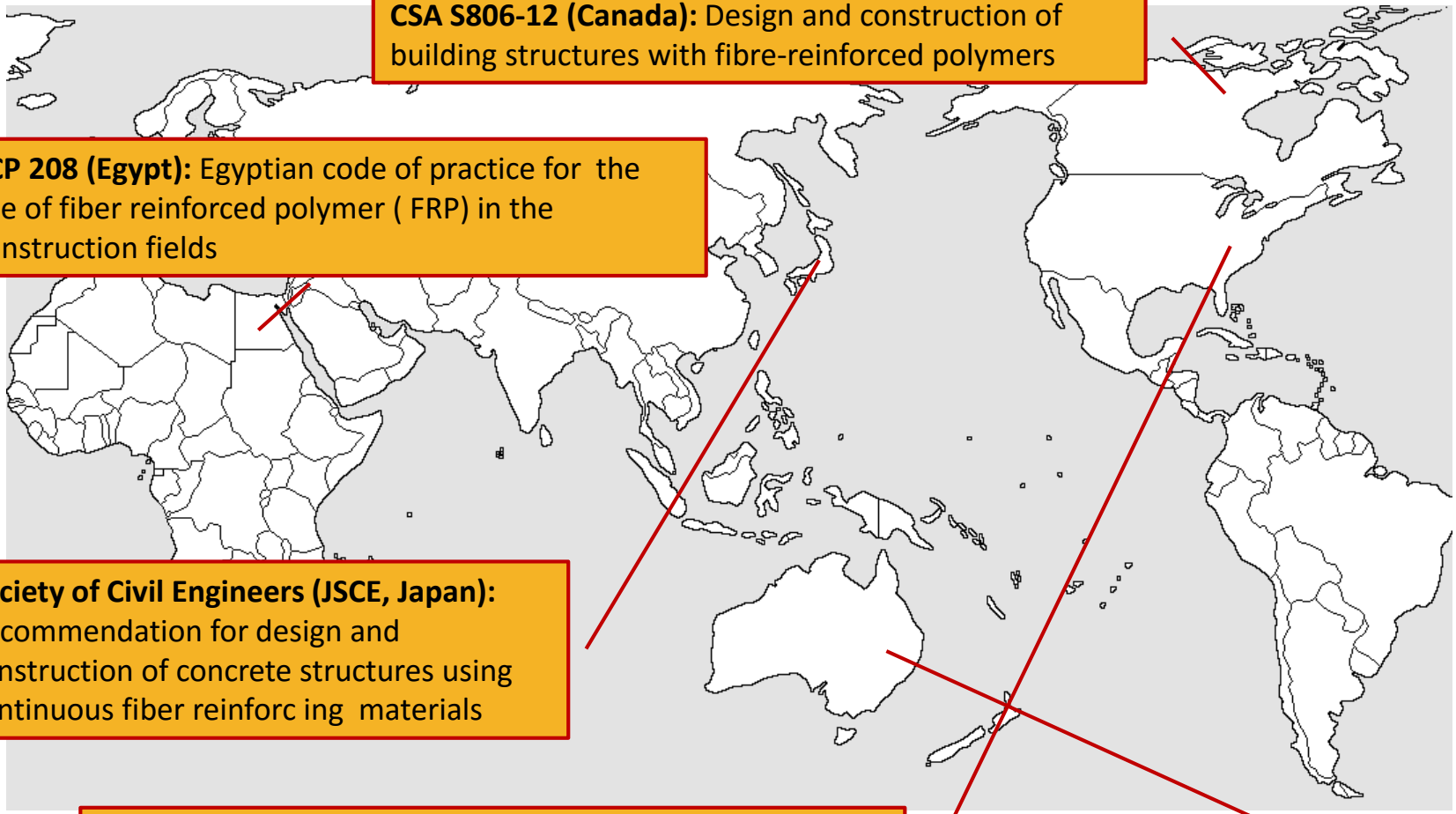
DAfStb Heft 591 (Germany): Strengthening of concrete elements by means of extrenally bonded reinforcements.

SIA 166 (Switzerland): Externally bonded reinforcement.

CNR-DT 200 (Italy): Guide for the design and construction of externally bonded FRP systems for strengthening existing structures.

DESIGN GUIDELINES

OTHER COUNTRIES



CSA S806-12 (Canada): Design and construction of building structures with fibre-reinforced polymers

ECP 208 (Egypt): Egyptian code of practice for the use of fiber reinforced polymer (FRP) in the construction fields

Society of Civil Engineers (JSCE, Japan): Recommendation for design and construction of concrete structures using continuous fiber reinforc ing materials

American Concrete Institute, ACI 440.2R. (USA): Guide for the design and construction of externally bonded FRP systems for strengthening concrete structures.

AS5100-8: Bridge Rehabilitation

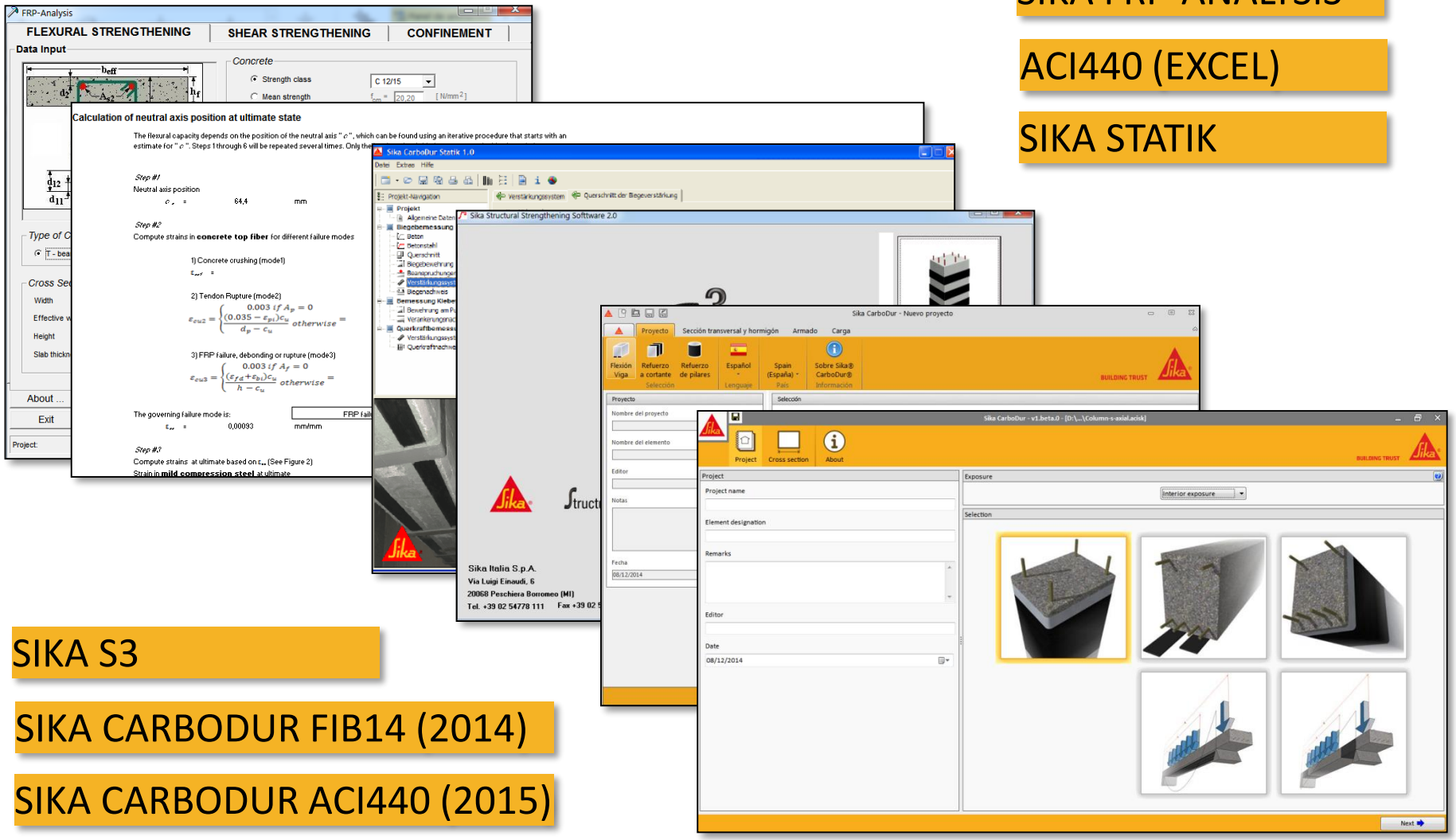
INTRODUCTION

SIKA FRP DESIGN SOFTWARES

SIKA FRP-ANALYSIS

ACI440 (EXCEL)

SIKA STATIK



SIKA S3

SIKA CARBODUR FIB14 (2014)

SIKA CARBODUR ACI440 (2015)

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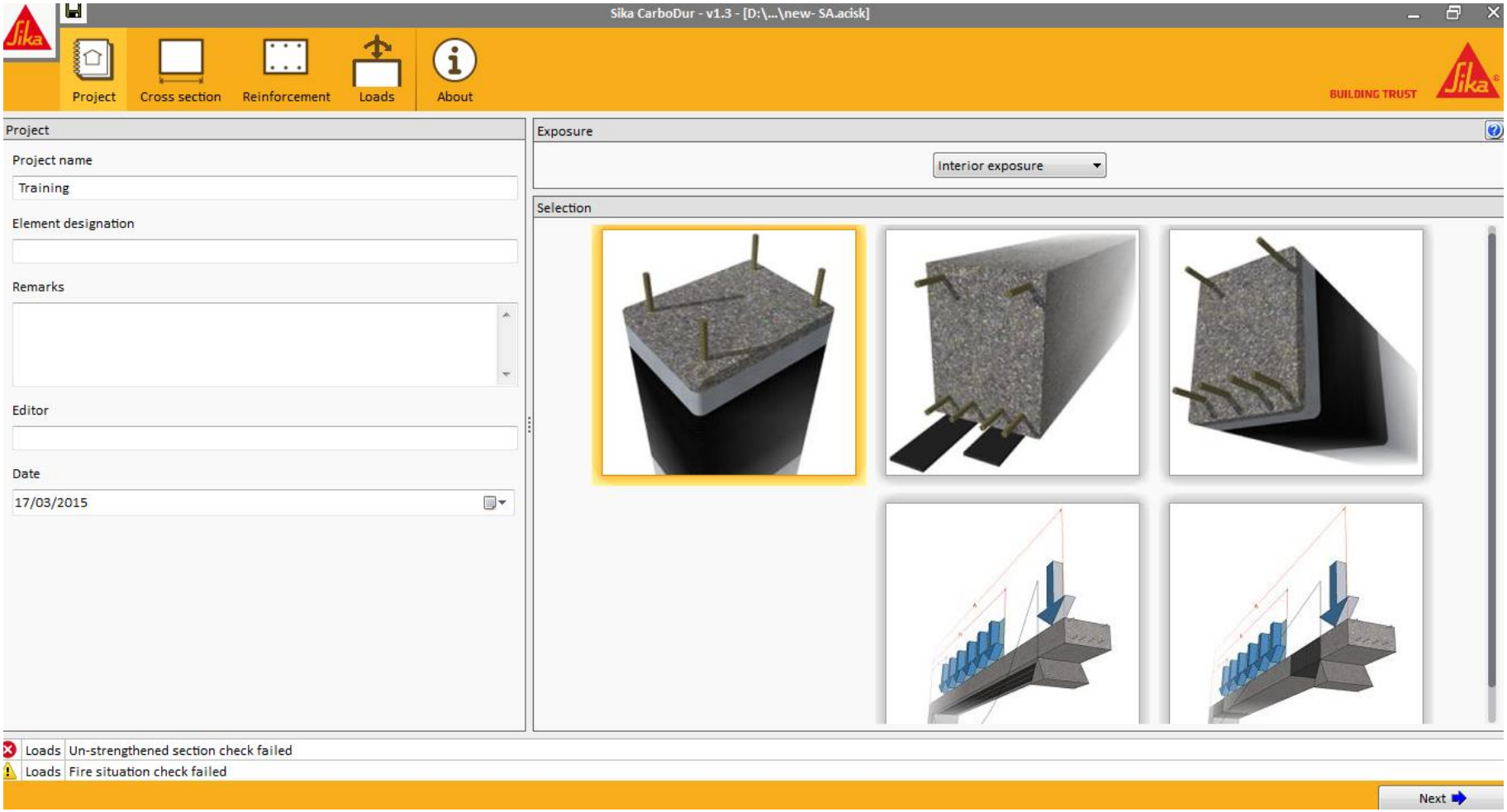
DESIGN SOFTWARE



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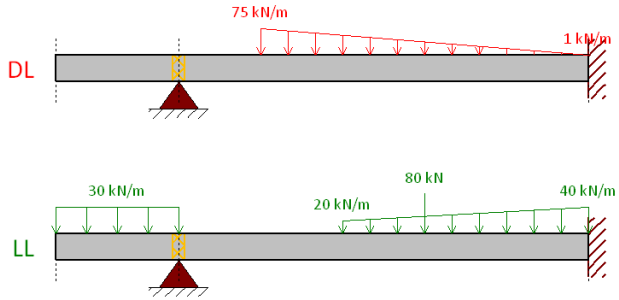
SIKA CARBODUR® SOFTWARE: KEY ADVANTAGES

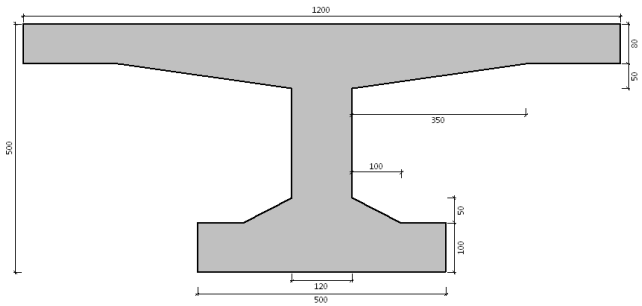
PROFESSIONAL

Unlike simplistic excel sheets or calculation tools, the Sika CarboDur® software comprises high-performance calculation possibilities for real situations, for example:

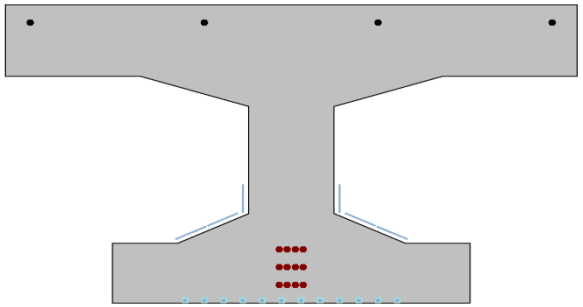
Strengthening of full structural members according to its loads distribution. The design is not based on a single section



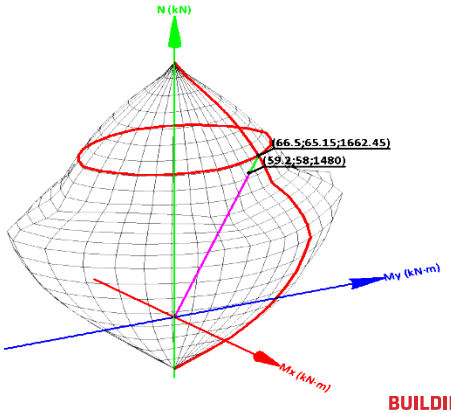
Calculation of complex geometries both for reinforced or prestressed concrete members.



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



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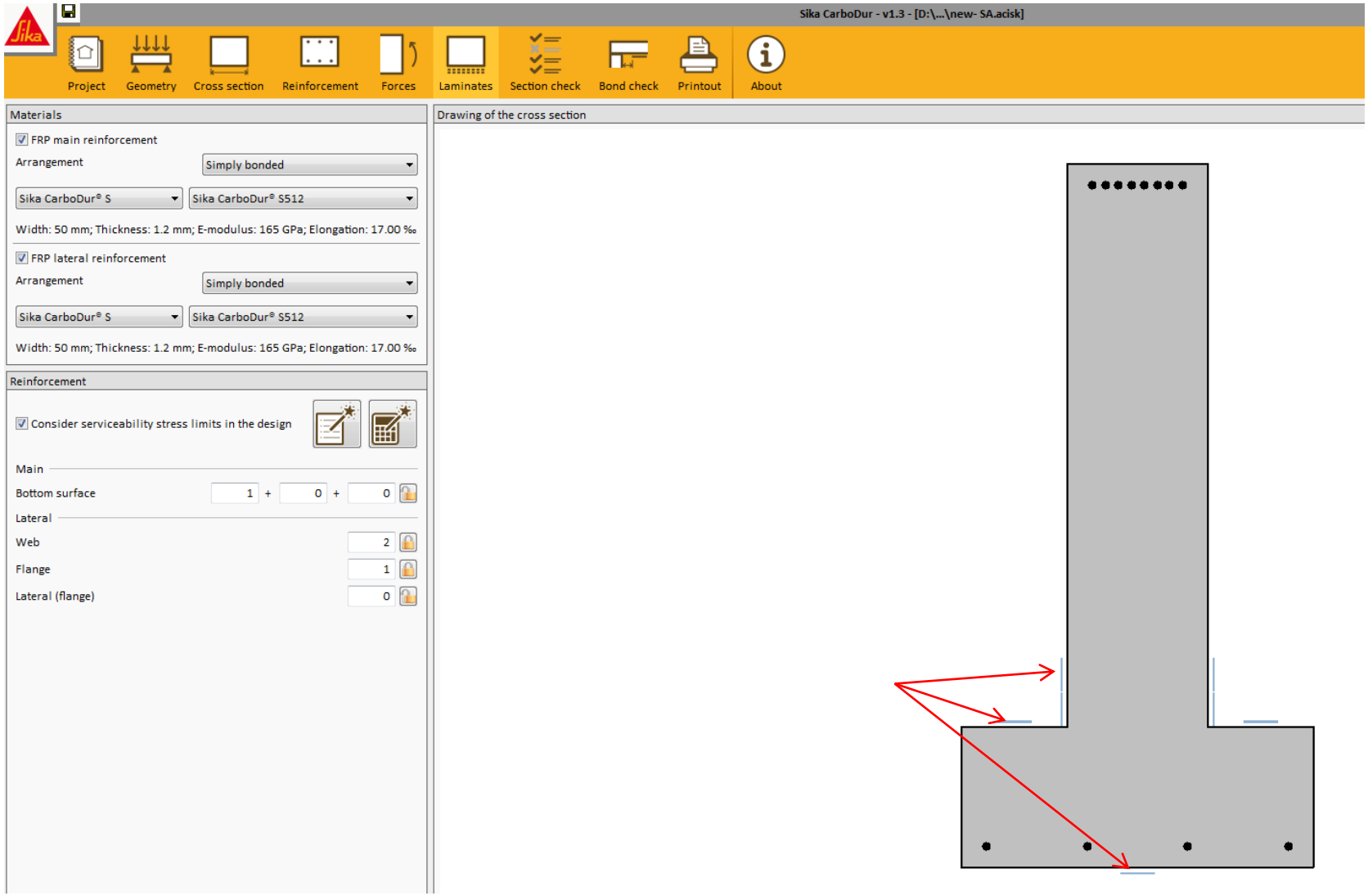
DESIGN SOFTWARE



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CASE STUDIES

INTERNATIONAL AND LOCAL

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GRAFTON BRIDGE- AUCKLAND NZ

SUNSHINE SKYWAY BRIDGE- FLORIDA USA

FULL SCALE LOAD TESTING

TRESTLE SPAN REPAIRS

PONT DU DANCOURT, DONCHÉRY (ARDENNES), FRANCE

BUNBURY BRIDGE

BUNBURY BRIDGES

DARBY RIVER- VIC

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DARBY RIVER- VIC

- Solution: The site had to be completely encased to ensure there was no contamination of the river waterway or surrounding native bushland.
- The result is a successful rehabilitation and strengthening of the Darby River Bridge that achieved the result with minimal disruption to traffic flow allowing full access to one of Australia's most spectacular national parks.

- Date: April, 2013

DARBY RIVER

NARROWS BRIDGE

WA

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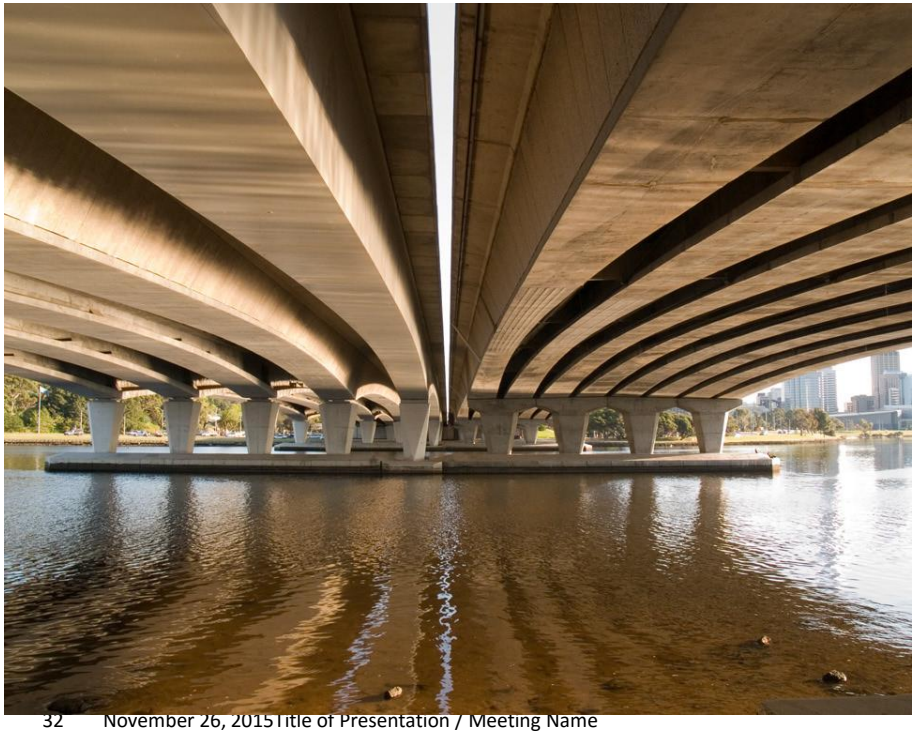
NARROWS BRIDGE

- Carbon Fibre laminate was used to strengthen the structure. Application to the deck soffit was efficient, particularly with the long lengths involved (up to 55 metres).
- Date: April 2001
- Location: Perth, WA
- Contractor: Structural Systems, WA



NARROWS BRIDGE

M80 FREEWAY UPGRADE PLENTY RD BRIDGE

VIC

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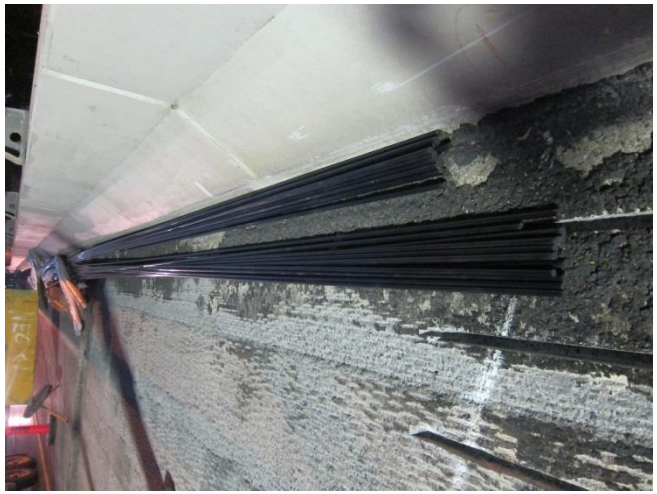
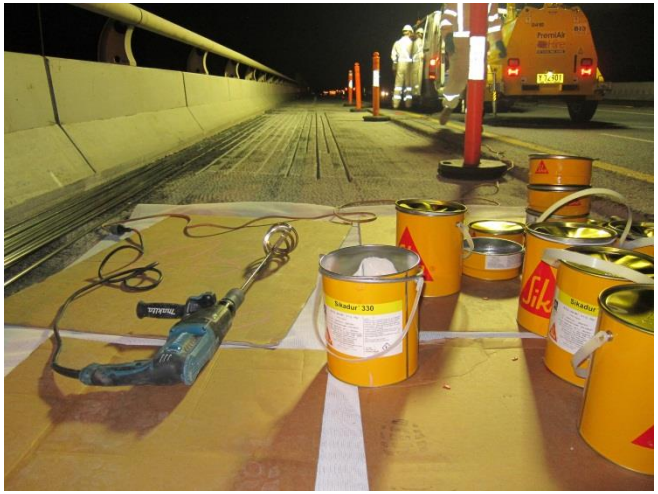
M80 FREEWAY UPGRADE PLENTY RD BRIDGE

- Using NSM (Near Surface Mounting) technology, 12mm diameter were selected, so not to upset any existing steel reinforcement, cutting 20mm into the road deck concrete. These carbon fibre rods are fully encapsulated in Specialised Structural Epoxy Resin paste. providing maximum protection and strengthening effects per light weight unit.
- Date: February 2014
- Contractor: Structural Systems VIC

M80 FREEWAY UPGRADE PLENTY RD BRIDGE





M80 FREEWAY UPGRADE PLENTY RD BRIDGE

TIMBER BRIDGE, SINS SWITZERLAND

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TIMBER BRIDGE, SINS SWITZERLAND

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TIMBER BRIDGE, SINS SWITZERLAND

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PRE-STRESSED CFRP

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CARBOSTRESS® ESCHERKANAL BRIDGE, SWITZERLAND (2002)

Live End

Fix End

SIKA CARBOSTRESS (POST TENSIONED CFRP)

SIKA CARBODUR CFRP SOLUTIONS

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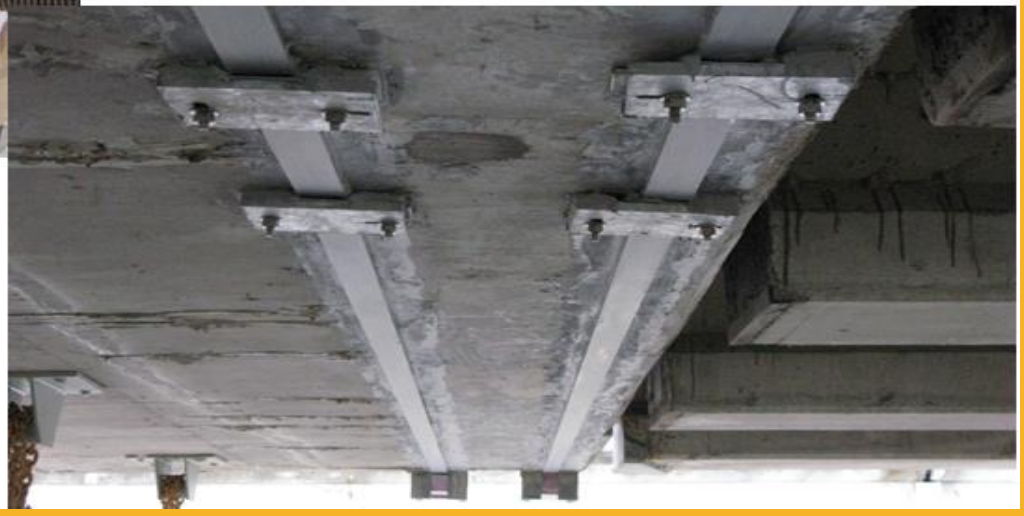
HERON ROAD BRIDGE, OTTAWA, CANADA

On-site assembly of tendon and prestressing



Strengthened cross beam

SIKA CARBOSTRESS (POST TENSIONED CFRP)

SIKA CARBODUR CFRP SOLUTIONS

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SUMMARY

- CFRP application is easy and quick to apply and eliminates all the hassle using steel, etc.
- Bonding is critical, though. So needs decent substrate preparation.
- Being applied on concrete, steel and timber, successfully. Obviously requirements are different.
- Seismic upgrade.
- Durable. Still can be protected against UV, fire, …
- CFRP a good solution for many cases, but not the only one.
- Limitations apply.

THANK YOU FOR YOUR ATTENTION

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