BRIDGE REHABILITATION USING FRP - CASE STUDIES

PEDRAM MOJARRAD
SIKA AUSTRALIA
BRIDGE STRENGTHENING
Prefabrciated 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
NSM  (NEAR SURFACE MOUNTED)
INTRODUCTION
MECHANICAL PERFORMANCE OF FRP SYSTEMS

- CARBON FIBER
  - STIFFNESS
  - STRUCTURAL STRENGTHENING
  - SEISMIC

- GLASS FIBER
  - PRICE
  - MASONRY STRENGTHENING
  - SEISMIC

- ARAMID FIBER
  - TENACITY
  - IMPACT
  - BLAST MITIGATION
FRP STRENGTH
FIBERS COMPARISON

ULTIMATE STRENGTH

ULTRA TIGHTNESS

5000 MPa
4000 MPa
3000 MPa
2000 MPa
1000 MPa

DESIGN STRENGTH

STEEL

Carbon
Basalt
Glass
Aramid

FRP STRENGTH
FIBERS COMPARISON

ULTRA TIGHTNESS

5000 MPa
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DESIGN STRENGTH

STEEL

Carbon
Basalt
Glass
Aramid
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.
SIKA FRP PRODUCT RANGE
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)

SIKA FRP PRODUCT RANGE

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:
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...
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.
DESIGN GUIDELINES (in addition to FIB BULLETING 14)
LOCAL EUROPEAN GUIDELINES


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


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

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

**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 reinforcing materials.

**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)
DESIGN SOFTWARE
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**
DESIGN SOFTWARE
CASE STUDIES
INTERNATIONAL AND LOCAL
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
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
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
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
TIMBER BRIDGE, SINS SWITZERLAND
TIMBER BRIDGE, SINS SWITZERLAND
TIMBER BRIDGE, SINS SWITZERLAND
PRE-STRESSED CFRP
CARBOSTRESS® ESCHERKANAL BRIDGE, SWITZERLAND (2002)

SIKA CARBOSTRESS™ (POST TENSIONED CFRP)
SIKA CARBODUR CFRP SOLUTIONS
HERON ROAD BRIDGE, OTTAWA, CANADA

On-site assembly of tendon and prestressing

Strengthened cross beam

SIKA CARBOSTRESS (POST TENSIONED CFRP)

SIKA CARBODUR CFRP SOLUTIONS
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