Repairing and strengthening of bridge structures by using composite materials

Two are the main causes of reinforcement corrosion
- Carbonation
- Corrosive contaminants
  - At mixing
  - From external environment
    - Sodium chloride
    - Calcium chloride
    - Other contaminants

The diagnosis of the deterioration causes is essential before repairing

Carbonation

Chlorides

Carbonation

Corrosion penetration

Collapse of the structure

Trigger of corrosion

Detachment of Concrete

Life of the structure

Cracks in the concrete

\[ t_i - t_p \]
**Diagnosis of carbonation and chloride penetration**

**Materials for Concrete Repair**
- Corrosion protection of reinforcement
- Repair with shrinkage compensated mortars
- Strengthening by using composite materials

**Corrosion-inhibiting systems**
- Corrosion-inhibiting cementitious mortar
- Cathodic galvanic protection
  - Example: Movement joints
Materials for Concrete Repair

- Corrosion protection of reinforcement
- Repair with shrinkage compensated mortars
- Strengthening by using composite materials

Substrate preparation

Application of structural shrinkage compensated mortars

O-Ring Test: Crack Resistance

O-Ring Test

Low shrinkage – after 180 days no cracks must be registered
**FRP System**

- Corrosion protection of reinforcement
- Repair with shrinkage compensated mortars
- **Strengthening by using composite materials**

**Fiber Reinforced Polymers**

**Fiber**
- Loads carrying
- Optimum properties
- Deformation decreasing

**Matrix**
- Stress transfer
- Protection
- Anchoring
- Toughness
- Fatigue resistance

**Mapei FRP System**

**Technical reference documents**

**ACI 440**

Guide Test Methods for Fiber-Reinforced Polymer (FRP) Composites for Reinforcing or Strengthening Concrete and Masonry Structures

**FRP Advantages**

- **R**: allations
- **L**: 
- **H**: ivernt
- **A**: 
- **C**: 
- **H**: uality guarantee
**FRP System**

Application field: **Flexural strengthening**

![CFRP laminated strips](image)

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**FRP System**

**Case History: PONTE “Terrassa” Barcellona**

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**FRP System**

**Experimental campaign**

**Objective**

Experimental program conducted on 5 full-scale PC T-beams with a RC slab designed according to ANAS (Italian Transportation Institute)

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**FRP System**

**Experimental campaign**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Cut tendons</th>
<th>% Damaged</th>
<th>CFRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>0</td>
<td>0%</td>
<td>-</td>
</tr>
<tr>
<td>S2</td>
<td>2</td>
<td>17%</td>
<td>-</td>
</tr>
<tr>
<td>S3</td>
<td>4</td>
<td>33%</td>
<td>-</td>
</tr>
<tr>
<td>S4</td>
<td>2</td>
<td>17%</td>
<td>2 layers</td>
</tr>
<tr>
<td>S5</td>
<td>4</td>
<td>33%</td>
<td>3 layers</td>
</tr>
</tbody>
</table>

Sample S1 has 2 tendons cut, Sample S4 has 4 tendons cut, Sample S5 has 4 tendons cut.
The experimental outcomes qualify the application of CFRP as an effective tool to restore the flexural capacity of PC girders.

Buckland & Taylor, Sept 2013
Thank you very much for your kind attention