Structural Strengthening with FRP Composites

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Composites
AN INFINITE WORLD OF POSSIBILITIES

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Key Learning Objectives

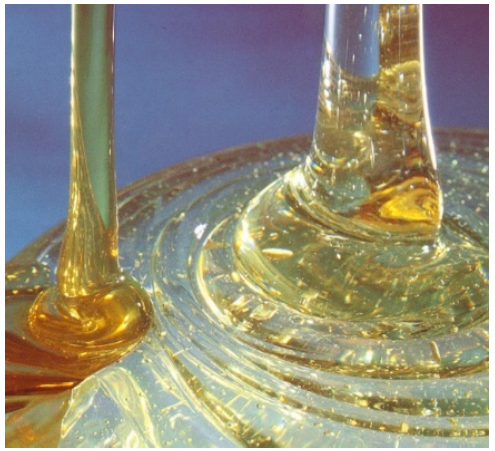
- Determine why structures need to be strengthened
- Highlight materials that can be used for structural strengthening along with their advantages and disadvantages
- Design considerations, along with available industry guidelines, for successful use of materials

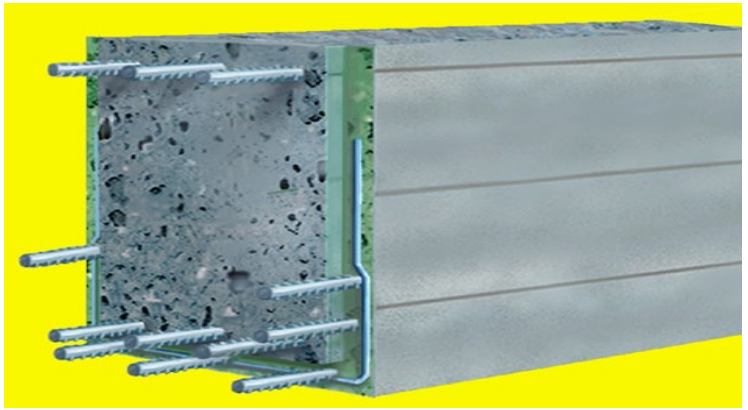
What are FRP Materials?

- Composites are a combination of two or more distinct materials

- Fiber reinforced polymers (FRP)
  - Fibers (carbon or glass)
  - Resins (epoxy matrix)

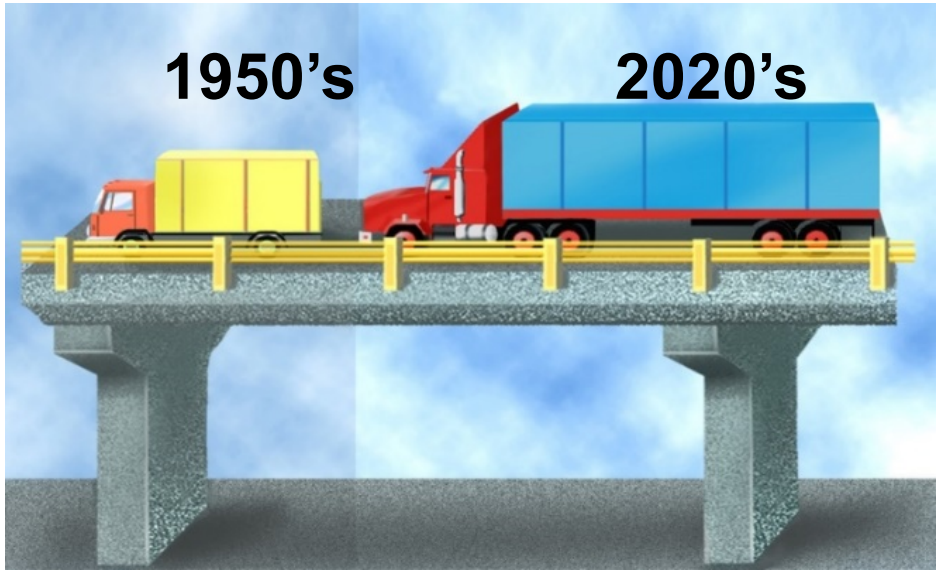
- Reinforced concrete
  - Concrete (matrix)
  - Steel (reinforcement)





Why Do Structures Need Strengthening?

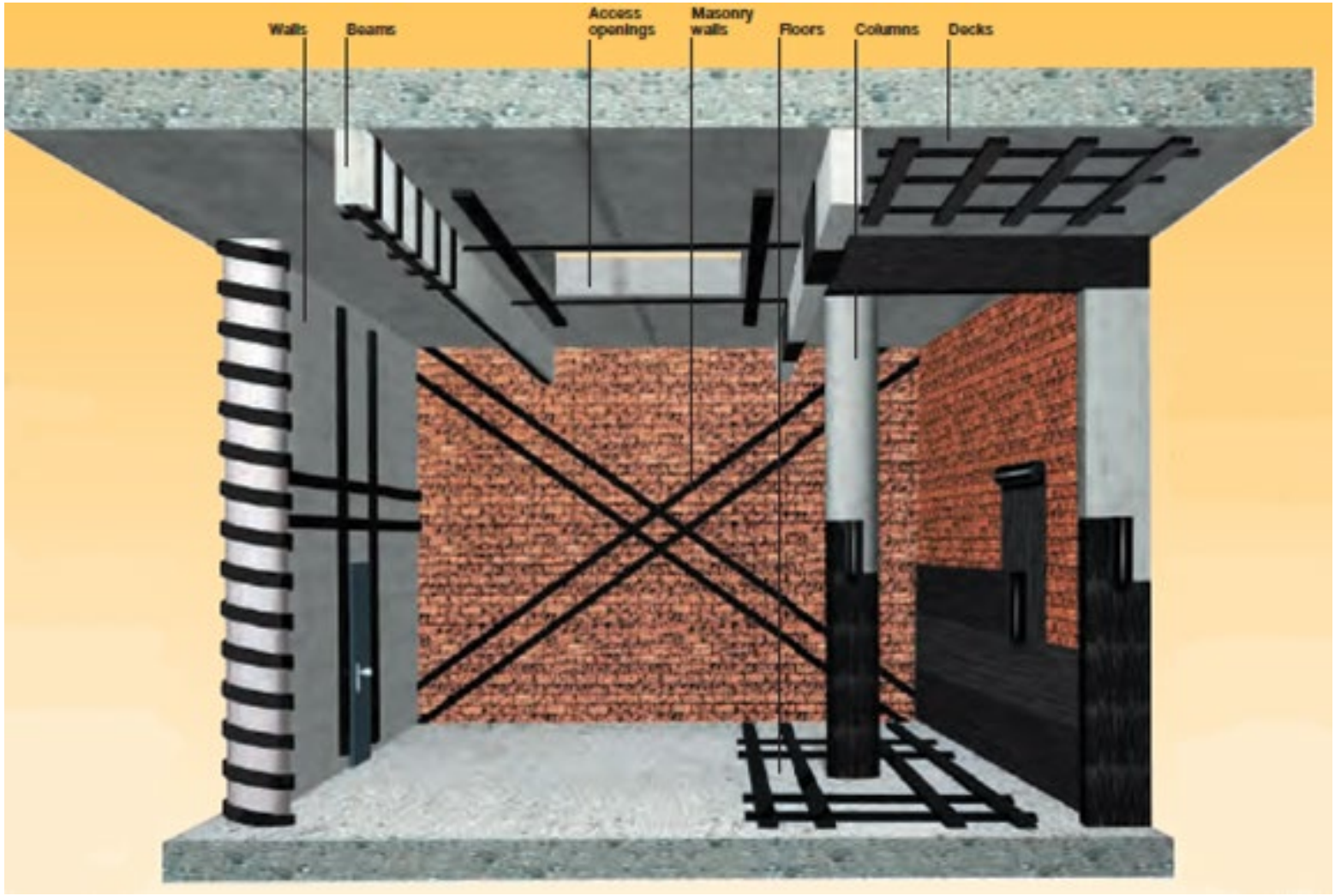
- Insufficient reinforcement
- Corrosion damage
- Change in use
- Structural damage
- Seismic upgrade
- Blast hardening



Advantages of FRP Repairs

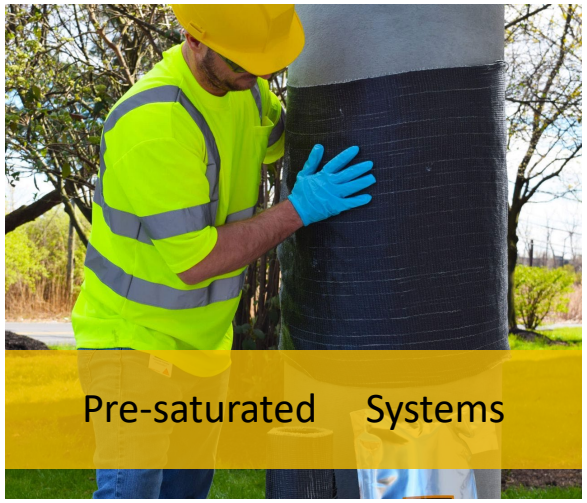
- Cost/scheduling benefits
- “Get in, Get out, Stay out!”
  - FHWA Mantra for accelerated construction
- Reduced maintenance costs
- Light weight materials puts less strain on infrastructure
- Non-corrosive, designed for long-term performance
- Less expensive repairs allow for more structures to be repaired with fixed budget

FRP Systems at a Glance



Available FRP Systems

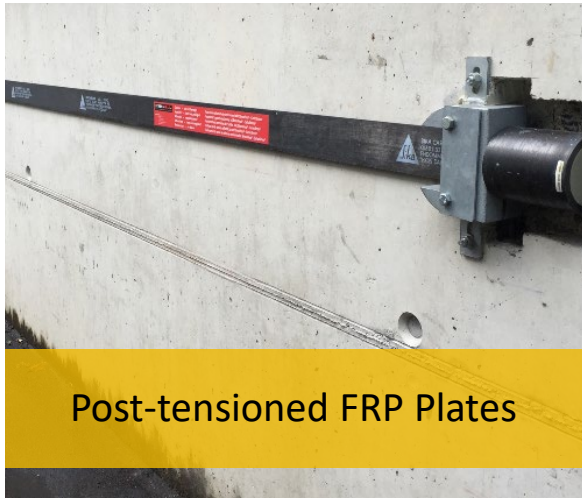
Epoxy Wet Lay-up Systems



Pre-saturated Systems

Pultruded Plates

NSM Plates



Post-tensioned FRP Plates

Composites

Surface Prep
Testing Substrate

- Concrete prepared by sandblasting
- Concrete smoothed out using grinders
- All defects repaired using epoxy mortar
- Minimum tensile strength = 200 psi

Field Saturated FRP Systems

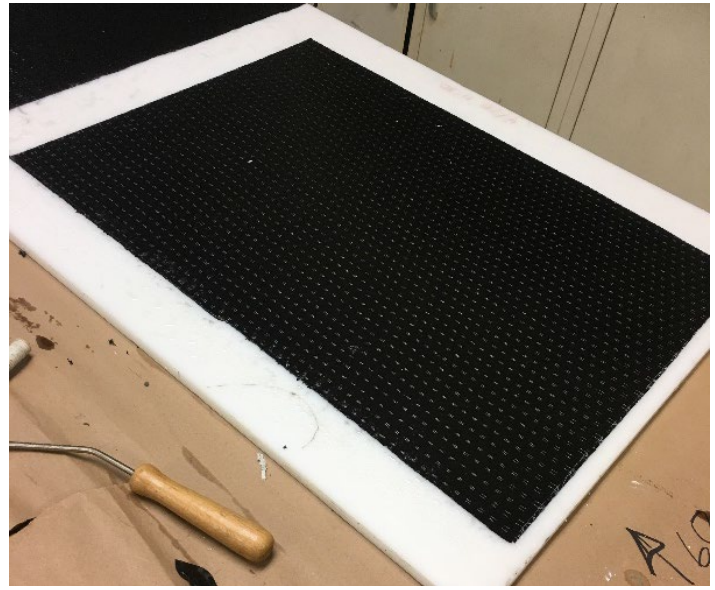
Field Saturated FRP Systems

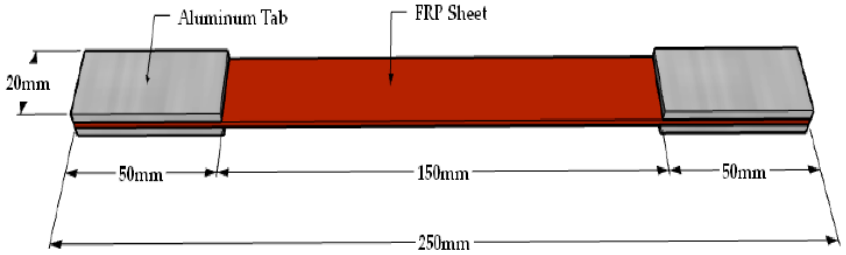
Wet Lay-Up

Field Saturated FRP Systems

QA Acceptance Criteria

1. Delamination
   - Limits of delaminated FRP area to ensure adequate performance
2. Material Testing
   - Tensile tests of laminate from field (ASTM D3039/D7565)
3. Tensile Bond
   - Pull off tests to determine bond strength to concrete
   - Minimum 200 psi (1.4 MPa)





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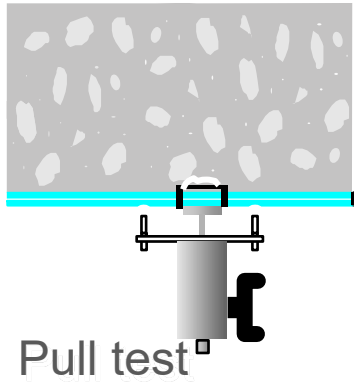


Pre-Saturated FRP Systems

Pre-Saturated FRP Systems

- Pre-saturated (“Prepreg”) systems have been used in aerospace industry since the 1950’s
- Fabric impregnated with resin during manufacturing process
- Consistent resin to fabric ratio
- Reduction in Labor
- Application efficiency

Pre-Saturated System

FRP Plates and NSM Systems

Near Surface Mounted

FRP Plates and NSM Systems

- Designed for strengthening concrete, timber and masonry structures
- Higher stiffness than wet lay-up systems
- Lightweight
- Non-corrosive

Applying Epoxy to Substrate

Strip Installation

- Set strip by hand
- Work from one end to the other
- Moderate pressure

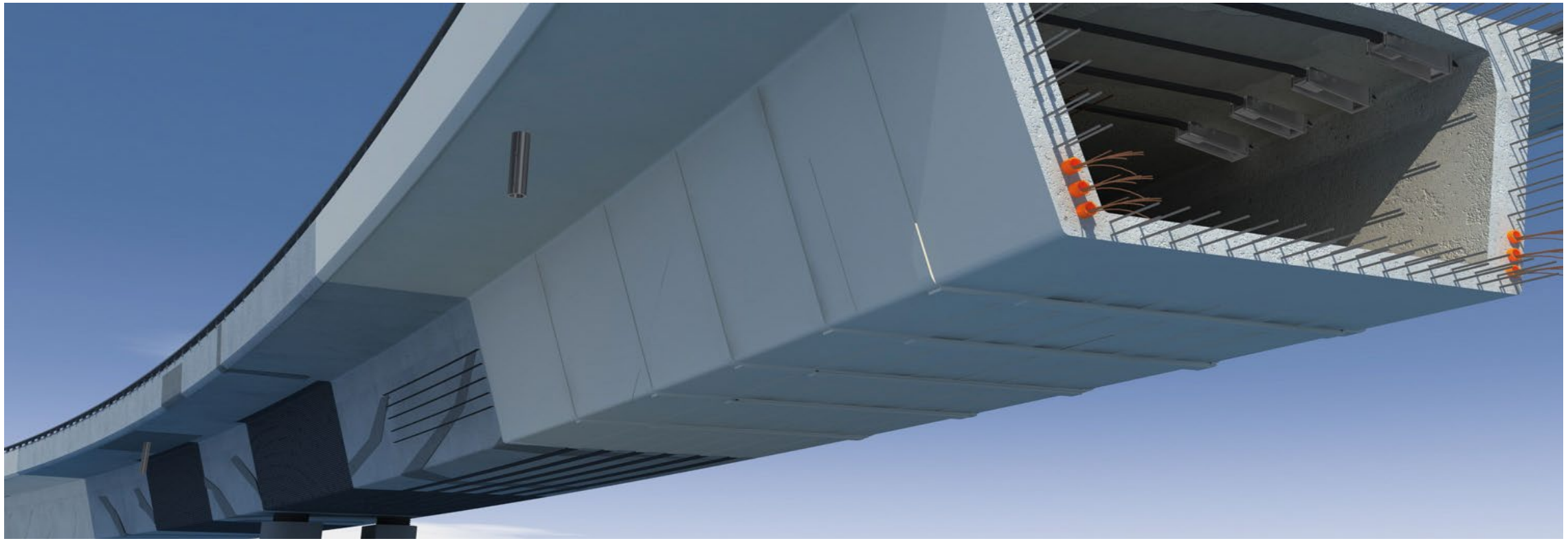
NSM Reinforcement
Near Surface Mounted

Place rods in epoxy filled grooves

Post-Tensioned FRP Plates

Post-Tensioning FRP System

- Active external post-tensioning
- Structure safety and serviceability problems
- Application under operational conditions
- Less labor than conventional PT installations
- Non-corrosive FRP materials



Typical Applications

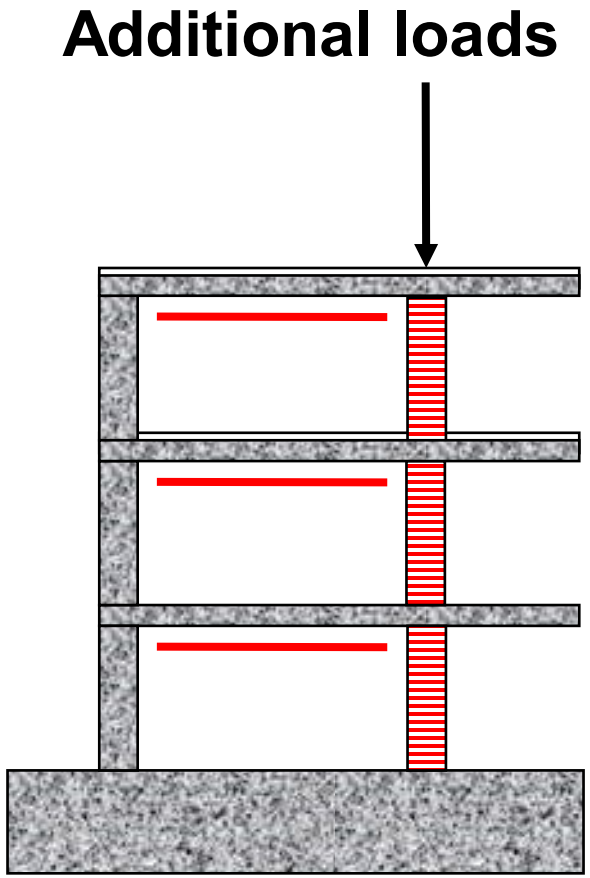
Flexural Strengthening

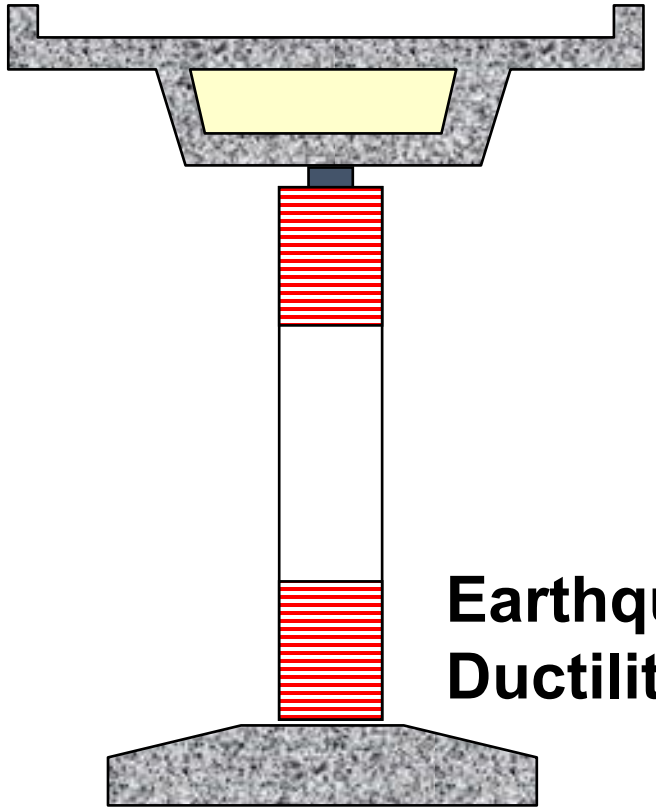
Shear Strengthening

Combined Strengthening
Anchorage

Confinement

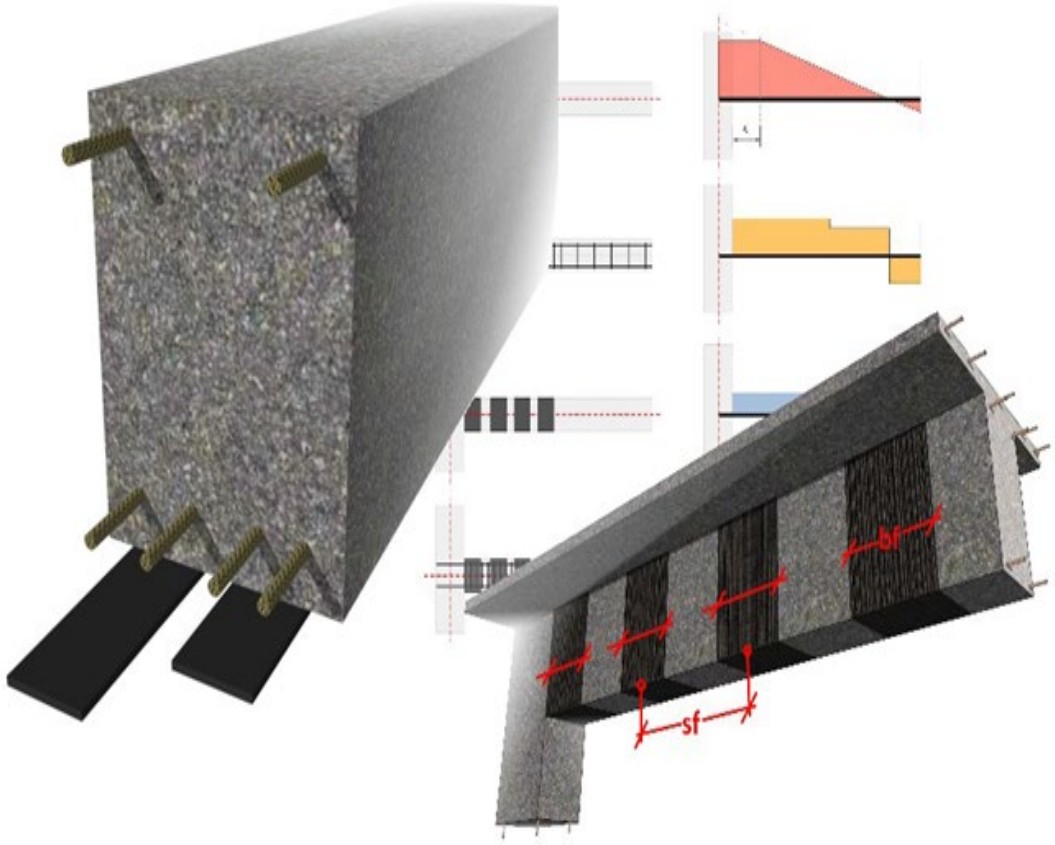
Seismic Strengthening

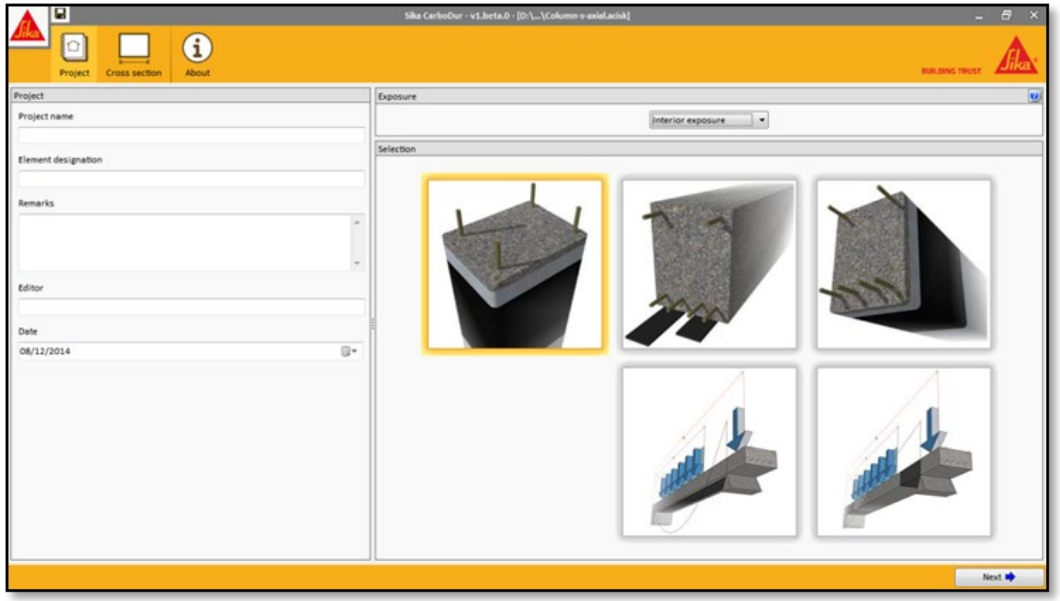




Earthquake Ductility

FRP Design Software





- Ensures compliance with industry guidelines and building codes
- Limitations imposed to account for fire, over strengthening, vandalism and damage

Conclusions

- Composites are considered a viable means of strengthening existing structures
- Thousands of projects have been successfully strengthened with FRP materials around the world
- Typical FRP strengthening applications include flexural, shear, confinement and seismic upgrades
- Codes and standards are available to assist engineers in proper strengthening applications

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