06th April
ICRI 2022 Spring Convention

Strengthening with CFRP external posttensioning

Eri Vokshi
Sika Corporate
Philippe von Holzen
StressHead Ltd

ICRI CONCRETE REPAIR
Restore | Repurpose | Renew

Presentation outline

- Sika and StressHead
- Determine why structures need to be strengthened and typical strengthening methods
- Discuss how external post-tensioning systems work, including advantages and disadvantages of them
- Design considerations and anchoring methods of FRP post-tensioned systems
- Typical field installation methods

Why do structures need strengthening?

ICRI
CONCRETE REPAIR

Why do structures need strengthening?

- Corrosion damage
- Change in use
- Structural damage
- Insufficient reinforcement
- Excessive deflection
- Seismic upgrade
- Fire




Typical strengthening methods

- Externally bonded FRP or Steel

- Section enlargement

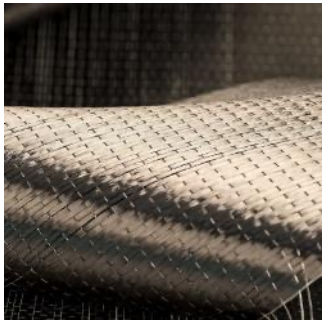
- External Post-Tensioning Systems

- Supplemental supports

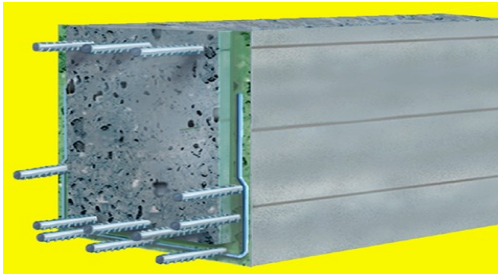
What are FRP materials?

- 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)



ICRI CONCRETE REPAIR

Available FRP systems

ICRI
CONCRETE REPAIR

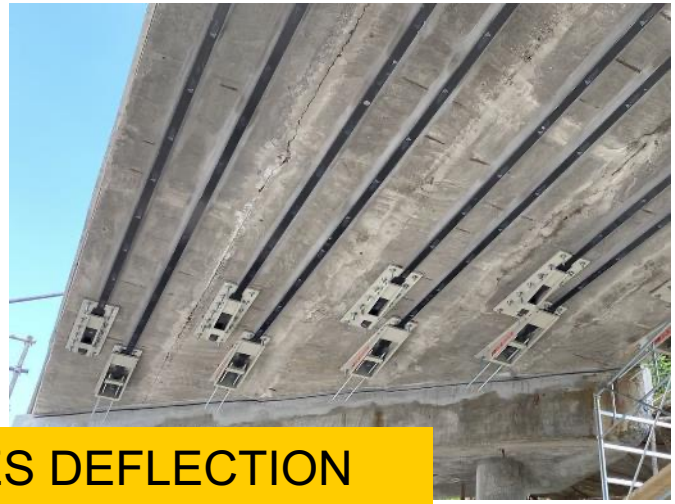
External Post Tensioning with CFRP

Externally FRP systems

- **Passive Strengthening**

External PT FRP system

- **Active Strengthening**



PT SYSTEM ADDRESSES DEFLECTION AND PROVIDES MUCH HIGHER CAPACITY, COMPARED TO EXTERNAL FRP

ICRI CONCRETE REPAIR

External post-tensioning

Steel **vs.** **FRP**

- Corrosive
- Heavy
- Fabrication required
- High maintenance

- Non-corrosive and chemical resistant
- Lightweight
- No creep and slip behavior
- Easy to install
- Unlimited length
- Ultimate strength of CFRP is 5 times higher than steel for the same cross-sectional area

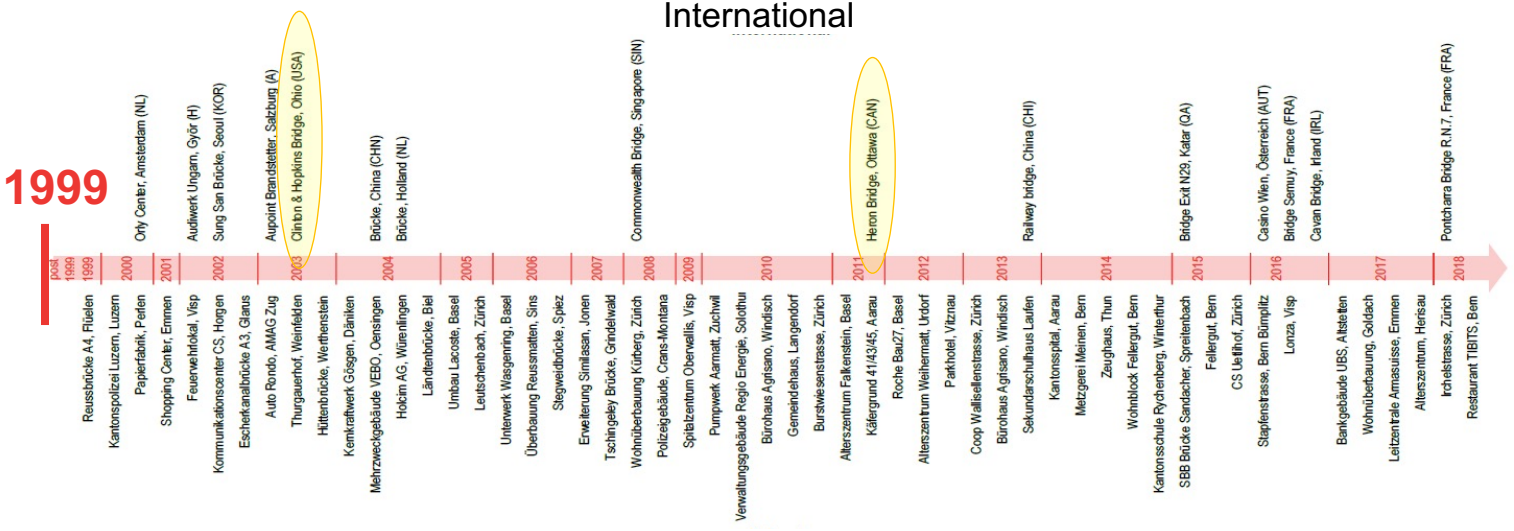
CarboStress PT System

Experience

USA: Ohio (2003)
Clinton & Hopkins Bridge

Canada: Ottawa (2012)
Heron Bridge

International



Switzerland

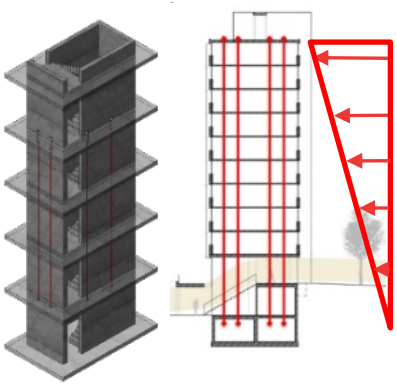
Experience since 20+ years!

ICRI CONCRETE REPAIR

System

Bridge strengthening

Strengthening of industrial and high-rise buildings



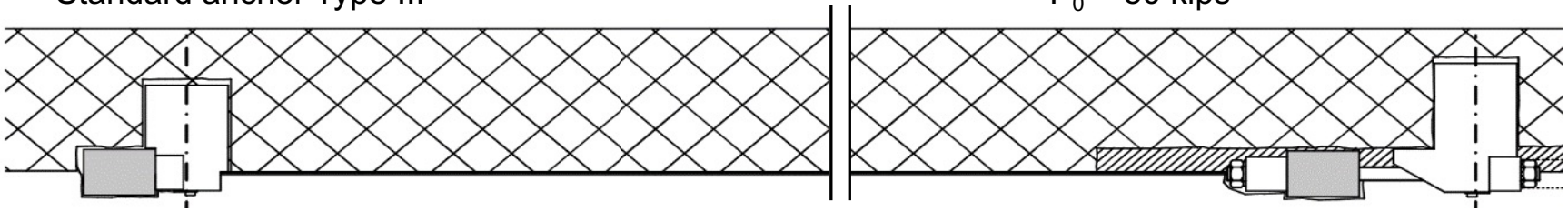
Earthquake strengthening & storm hardening

Reinforcement of silos and water tank (round shape)

System

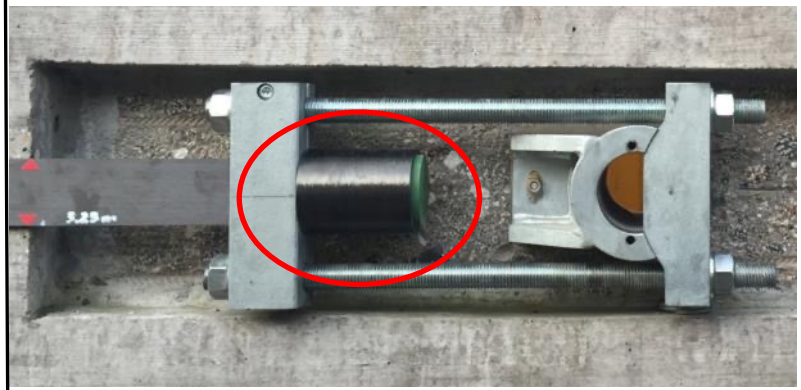
- Standard anchor Type III

P_0 = 50 kips



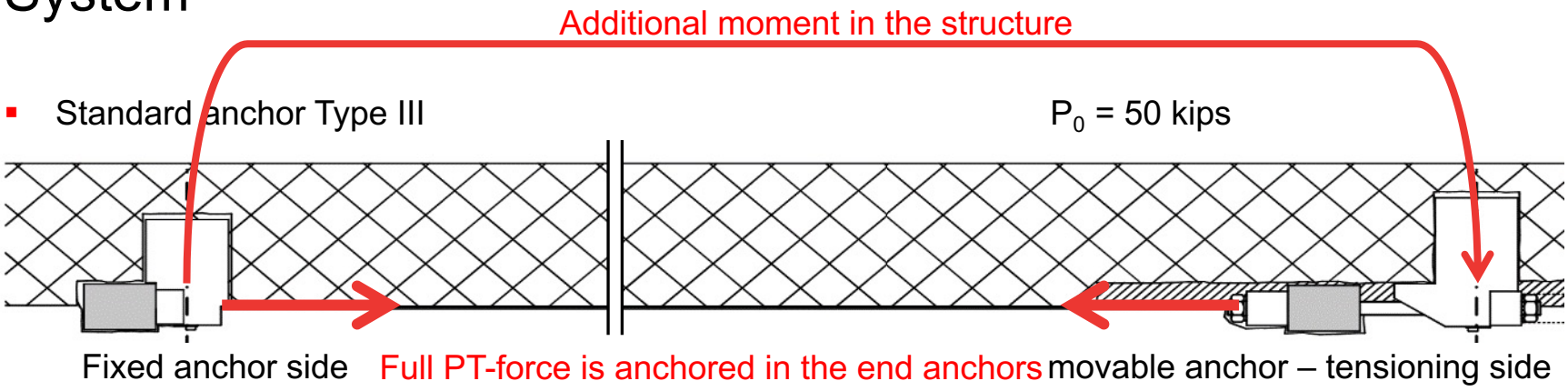
Fixed anchor side

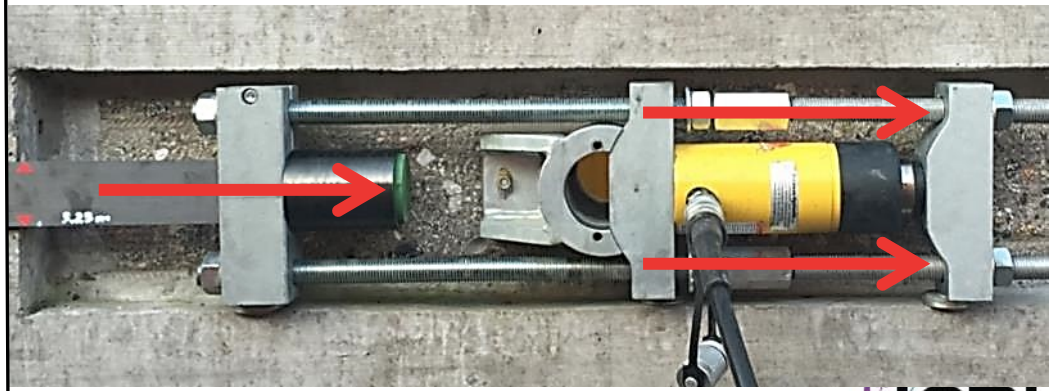
movable anchor – tensioning side



System

- Standard anchor Type III

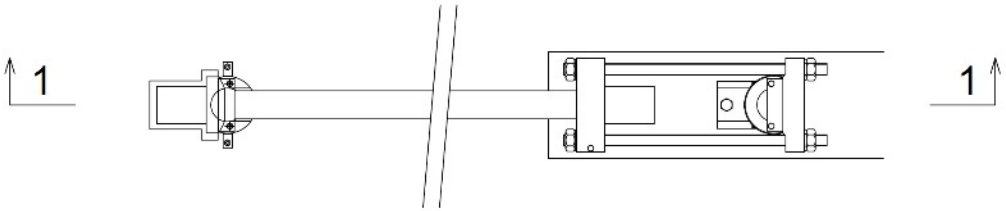




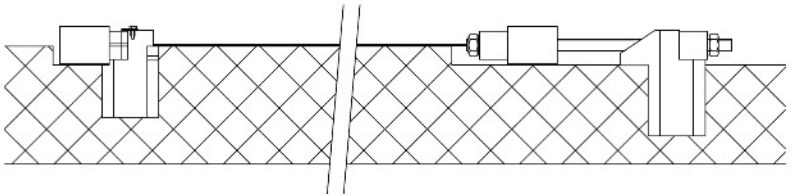
Anchor Types

- Standard anchor (Shear pin)

Layout / Elevation



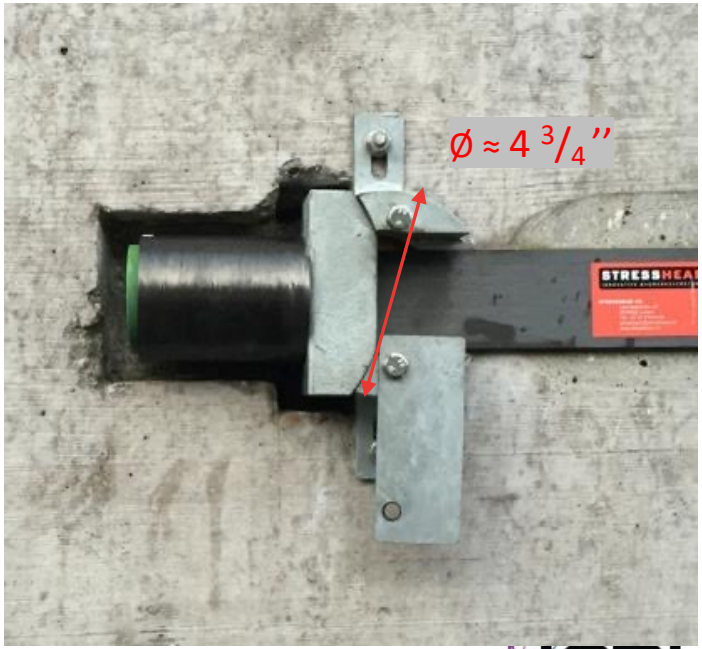
Section 1-1



<u>Standard anchors:</u>

Geometry: t = approx. 8”

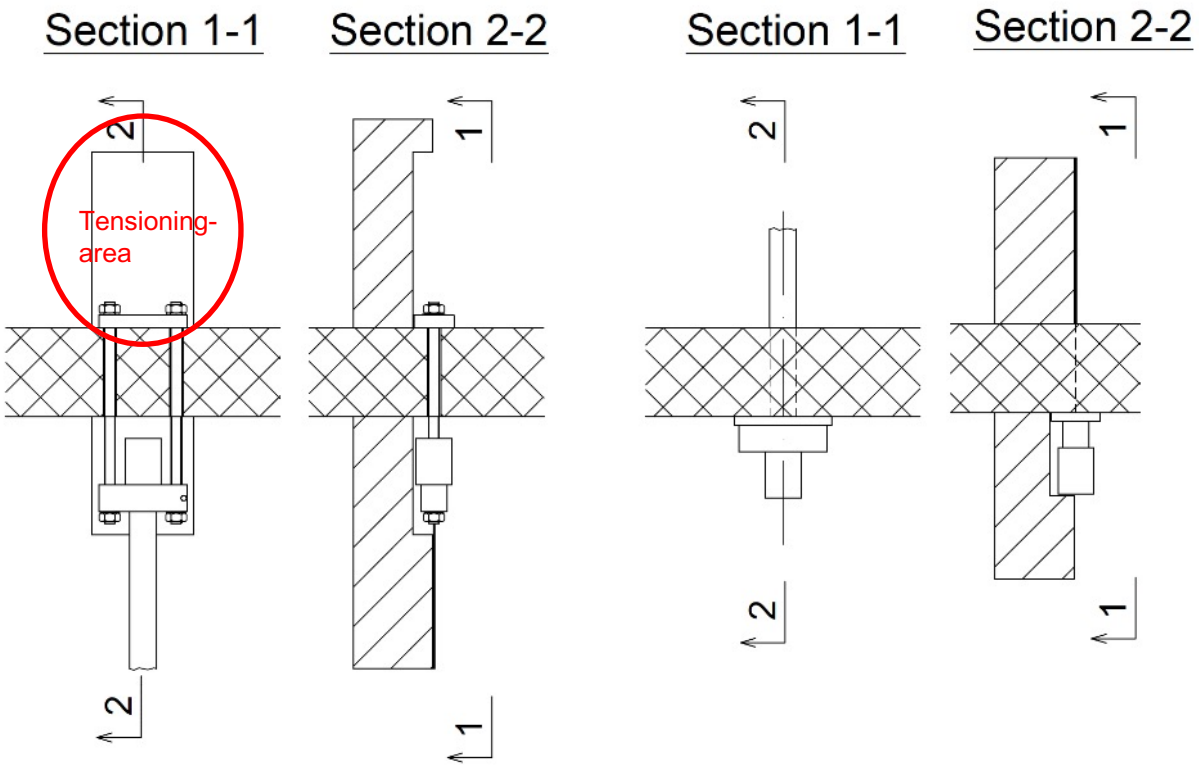
Concrete: f_{cd} = approx. 3’000 psi



ICRI CONCRETE REPAIR

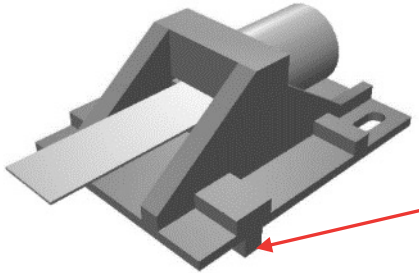
Anchor Types

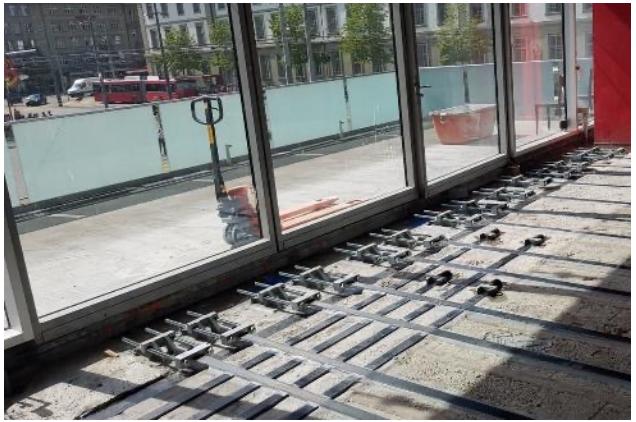
- Standard anchor through ceiling or wall



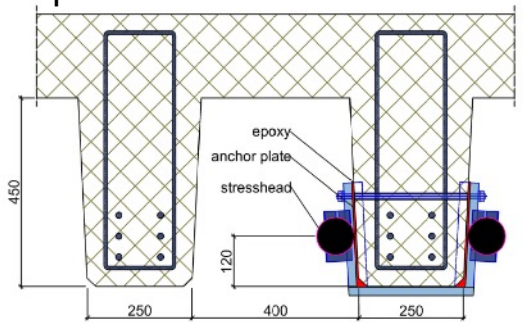
Anchor Types

- Various anchorages (Shear bar)





-> precast concrete elements



Anchor Design Process

Given on site

- Required PT force
- Material strength
- Geometry

Support

- Various anchorages
  > 20a experience
- Classic construction steel
  Easy to adapt

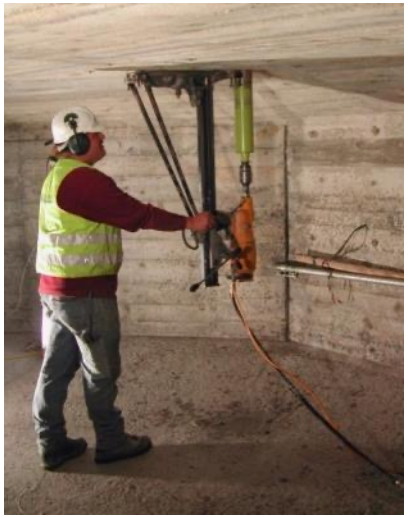
Standard anchor

Customized solution

ICRI
CONCRETE REPAIR

Application (e.g. Typ III) – 1. step preparation

Define location



Drilling

Chipping

Installation & injection

For standard anchors: chipping- and assembling scheme from StressHead

2. Step Installation

Bonding:

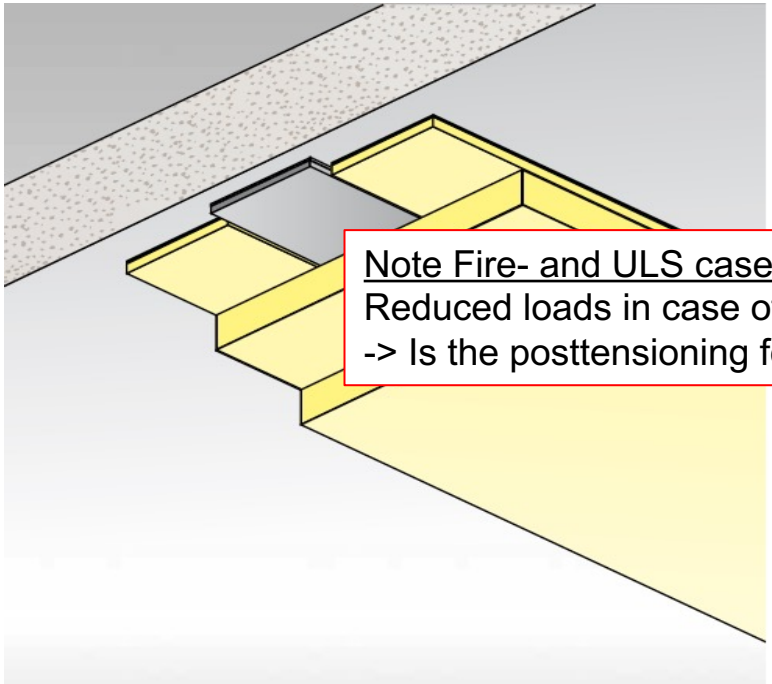
- Additional strengthening and stiffness
- Mechanical protection

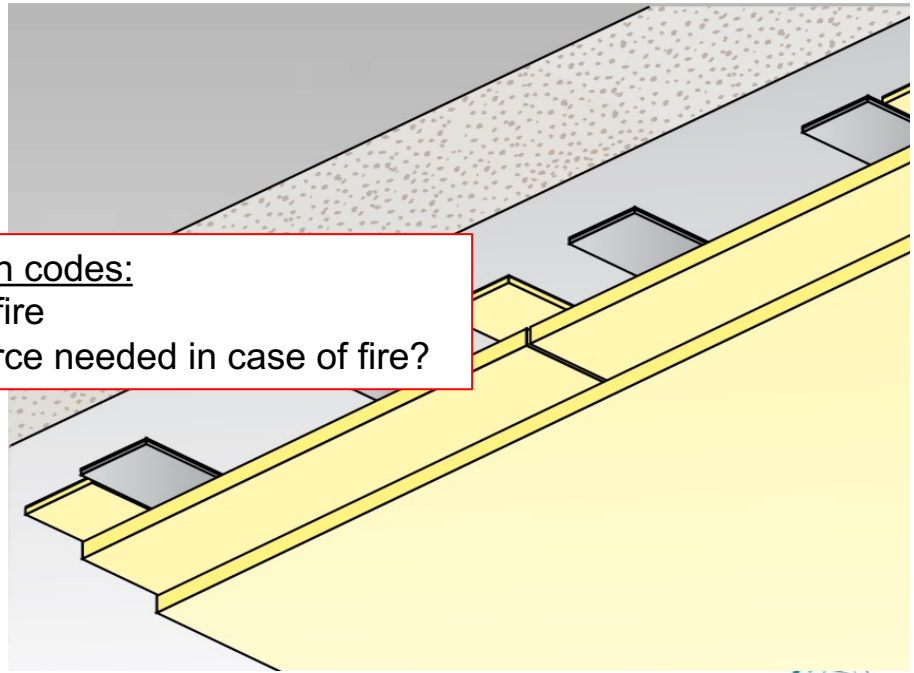
3. Step Installation and tensioning

3. Step Installation and tensioning movable anchor

Protection (optional)

- Protection against fire

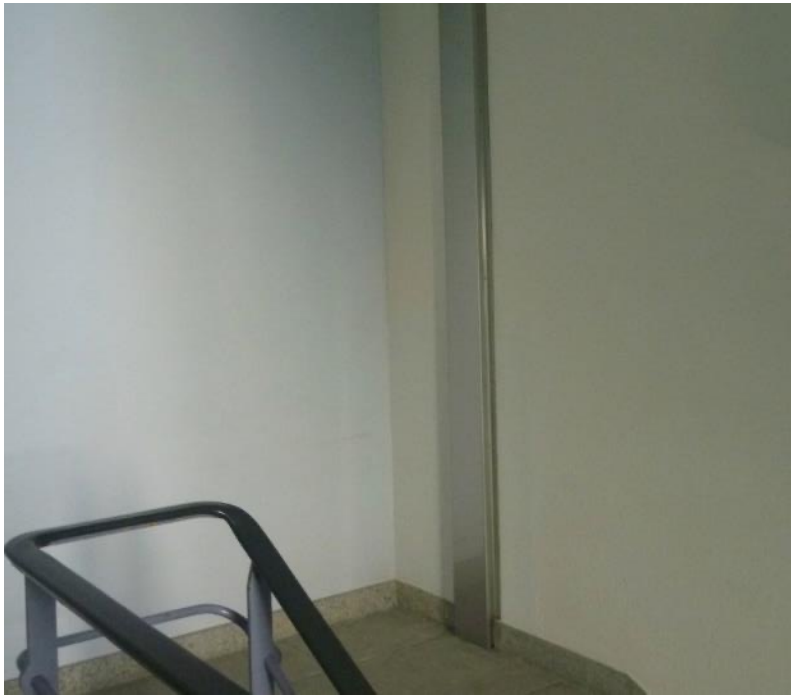




Note Fire- and ULS case in codes:
Reduced loads in case of fire
-> Is the posttensioning force needed in case of fire?

Protection (optional)

- Protection of plates against mechanical impact

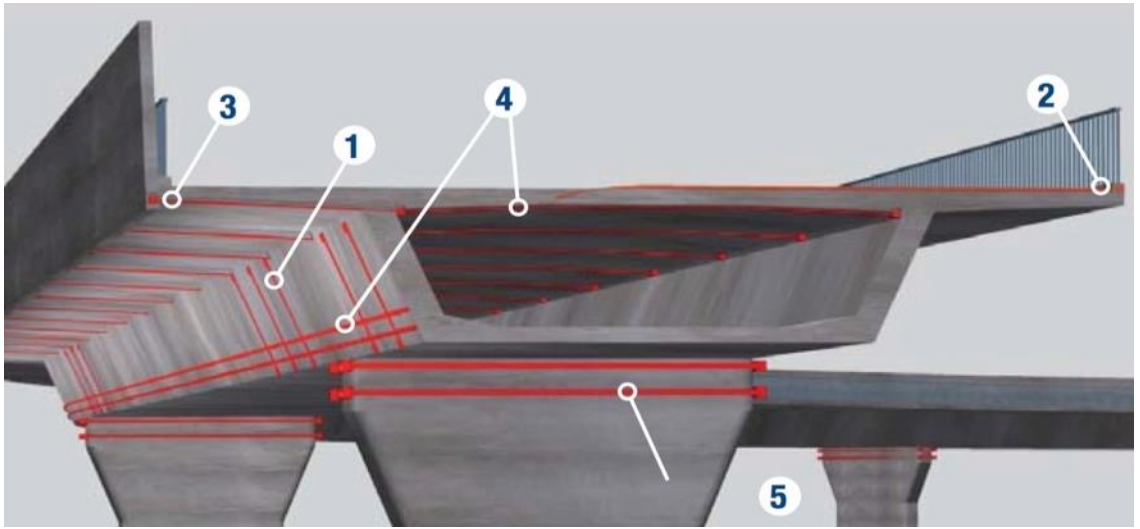


Case studies

Strengthening of Bridges

Strengthening of bridges:

1. Shear
2. Widening of the super structure
3. Wind / noise barrier walls
4. Longitudinal and transverse
5. Pier heads



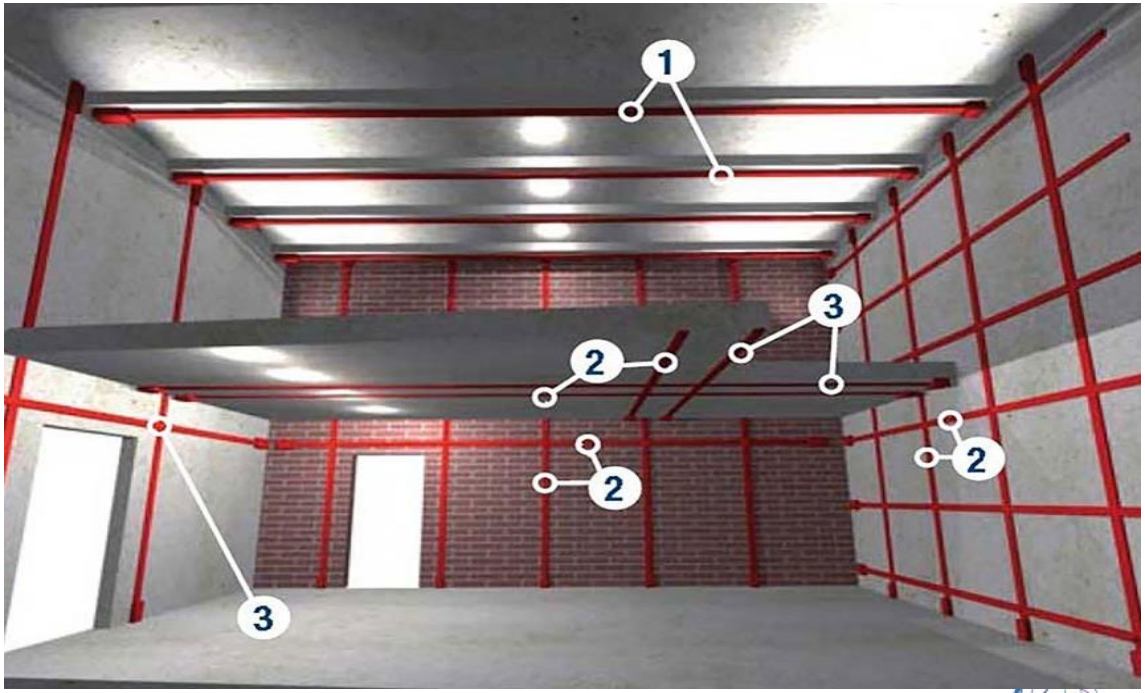
Strengthening of Industrial and High-rise buildings

Industrial and high-rise buildings:

1. Slab and beam strengthening
2. Earthquake strengthening
3. Strengthening due to changes

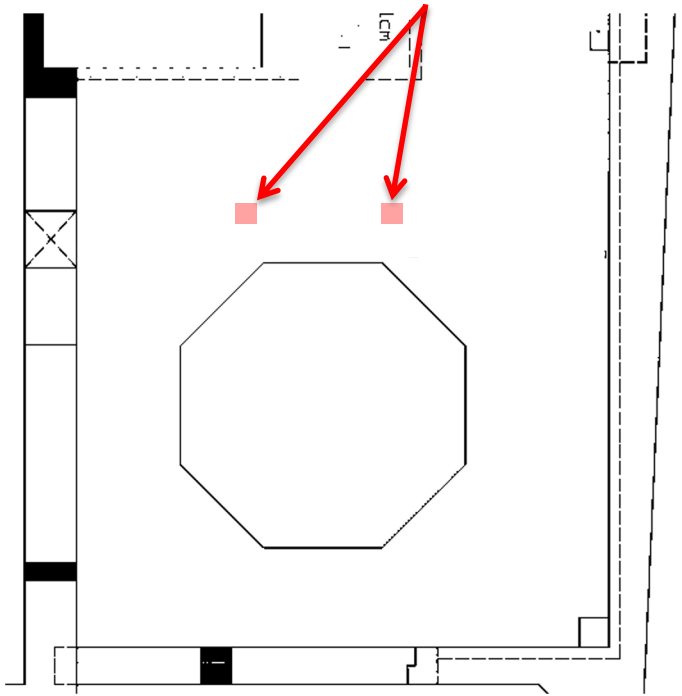
Ideal application criteria:

- High strengthening degree
- Serviceability problems
- Strengthening of prestressed structures
- Cracked concrete



Vienna (AT) – Serviceability problem

- Casino – Romoval of existing pillars



Lucerne (CH) – Extend span of beam

- Paper plant Perlen, new columns

Lucerne (CH) – Extend span of beam

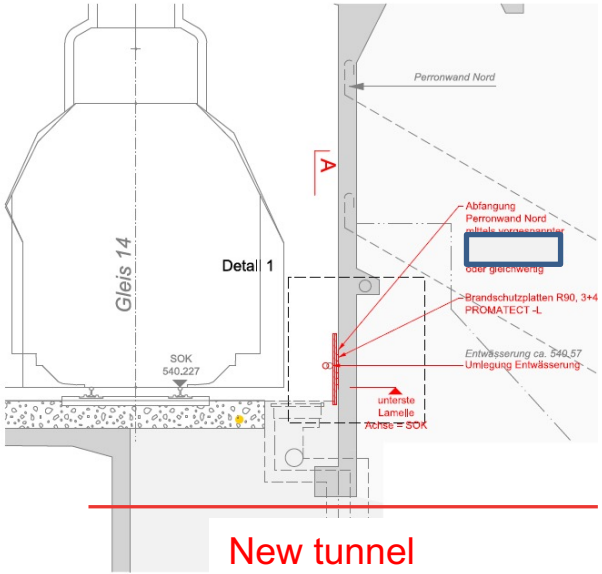
- Paper plant Perlen, new columns

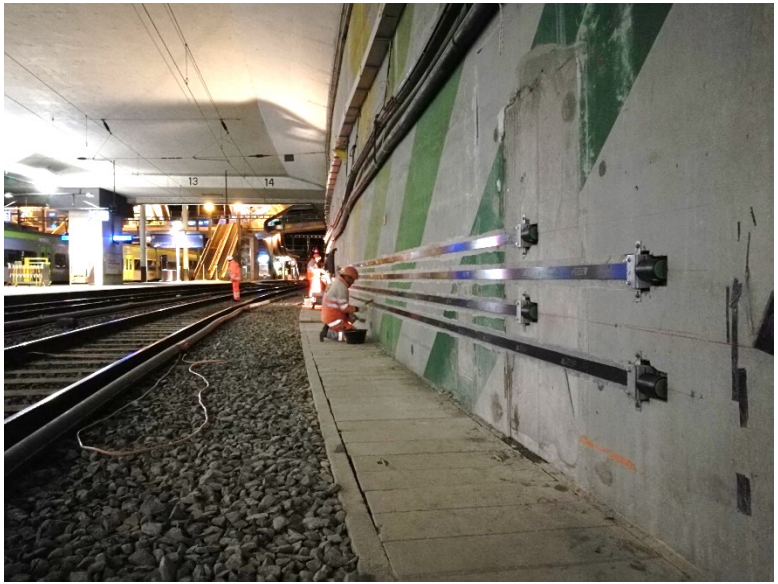
Lucerne (CH) – Extend span of beam

- New situation with displaced columns new columns

Bern (CH) – Structural change

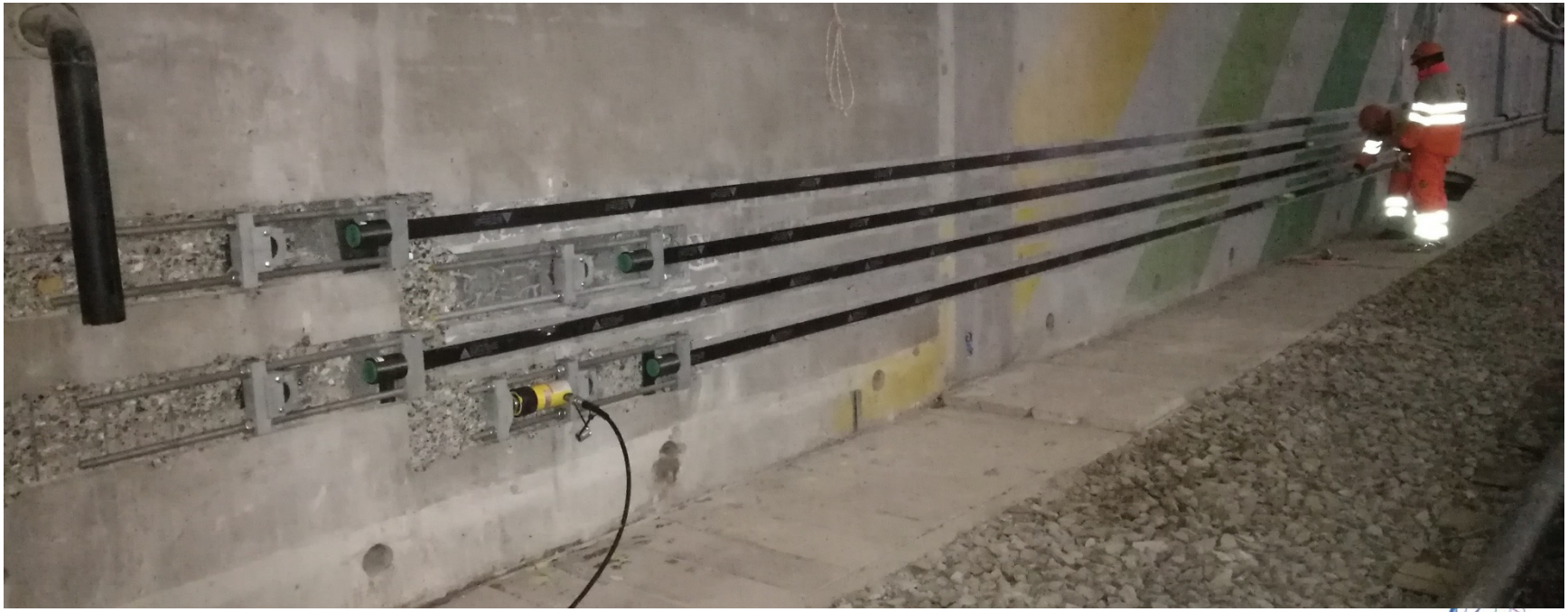
- Trainstation. New pedestrian tunnel





Bern (CH) – Structural change

- Trainstation. New pedestrian tunnel

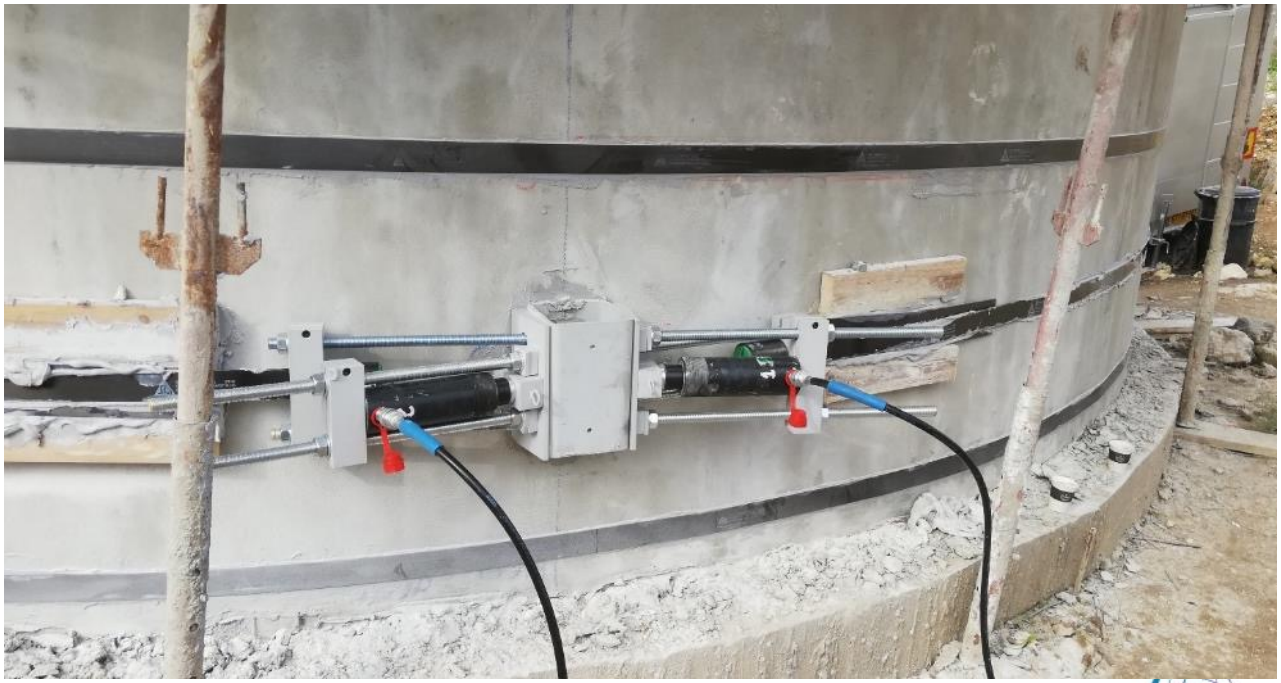


Würenlingen (CH) / Tel Aviv (IL) – Silo strengthening

- Silo strengthening / water tanks, etc.

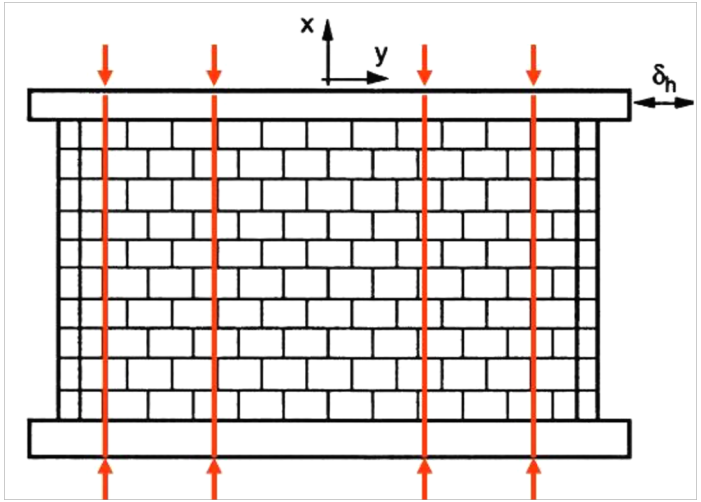
Tel Aviv (IL) – Fresh water tank

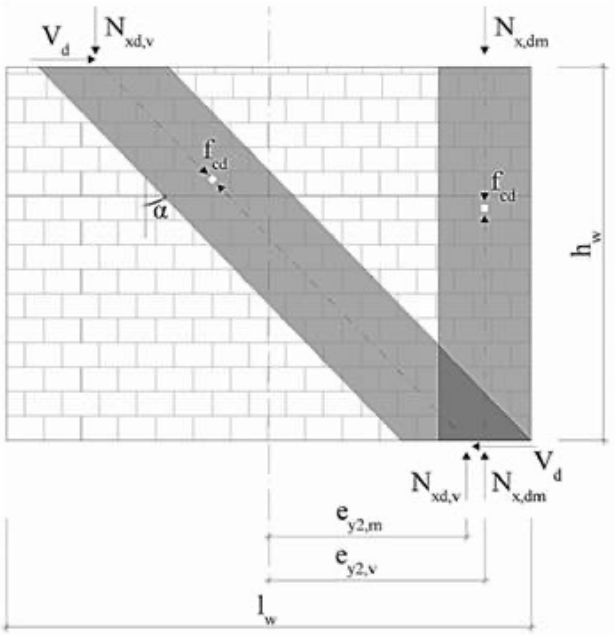
- Circular strengthening



Earthquake Strengthening / Storm hardening

- Strengthening of masonry walls



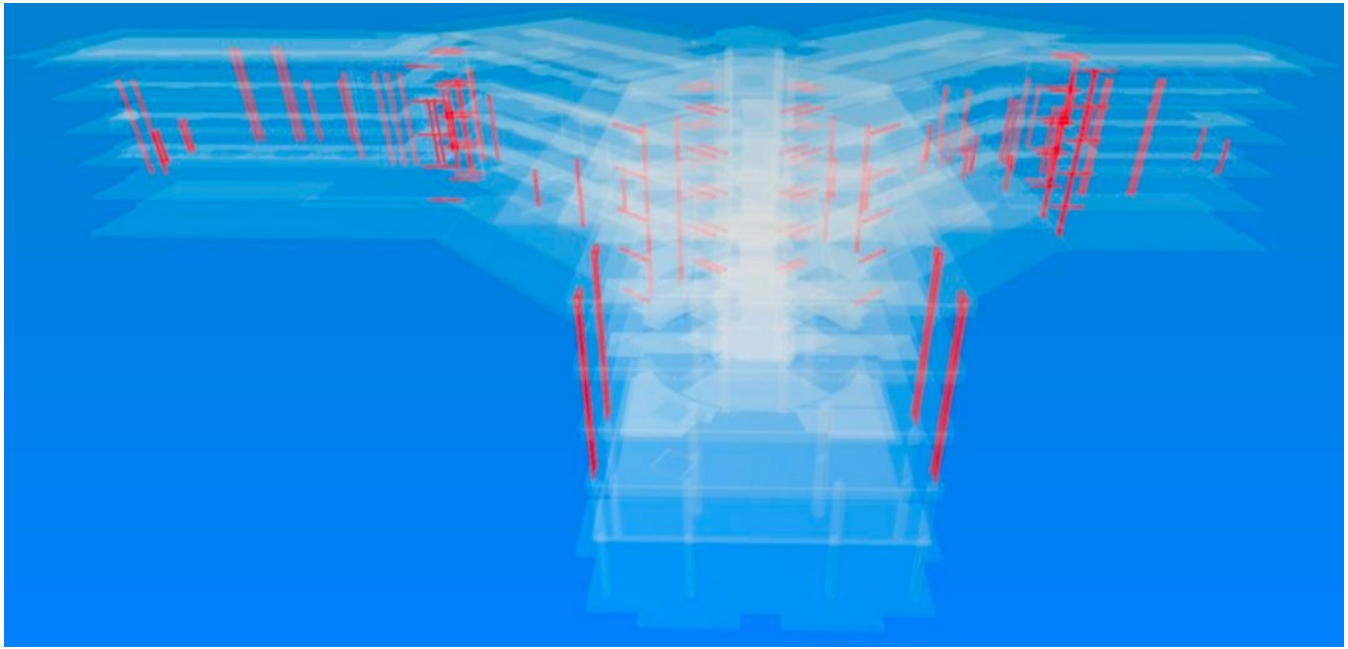


Davos (CH) – High Mountain Clinic

- Earthquake strengthening

Davos (CH) – High Mountain Clinic

- Earthquake strengthening – 160 systems

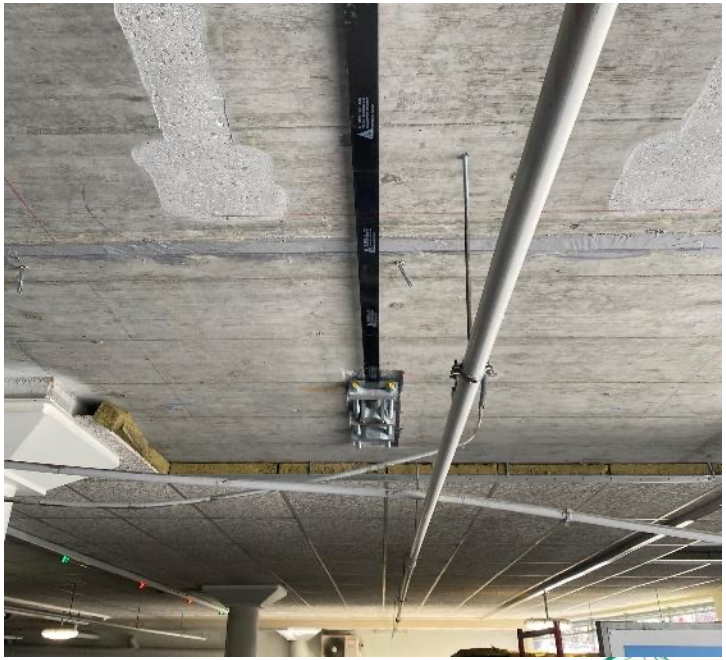


Davos (CH) – High Mountain Clinic

- Earthquake strengthening – 160 systems

Mels (CH) - Earthquake Strengthening

- Shopping mall in Switzerland



Tests & Design

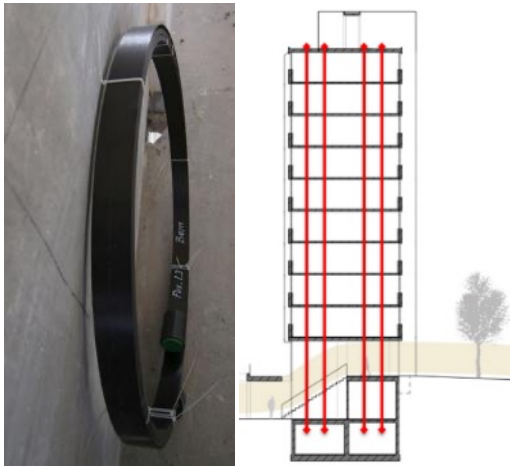
Tests

- University of Lucerne (CH) — Different anchors, strengthened slab
- Politecnico di Milano, Italy (I) — Under fatigue (2 Mio cycles)
- StressHead Ltd, Lucerne (CH) — Long Term Tests since 10years with overtensioning
  -> To extrapolate to 50 years (Creep, relaxation, etc.)
  -> Result: No loss of tensioning force over the years
- Applied expierence on site — 20 years

Design

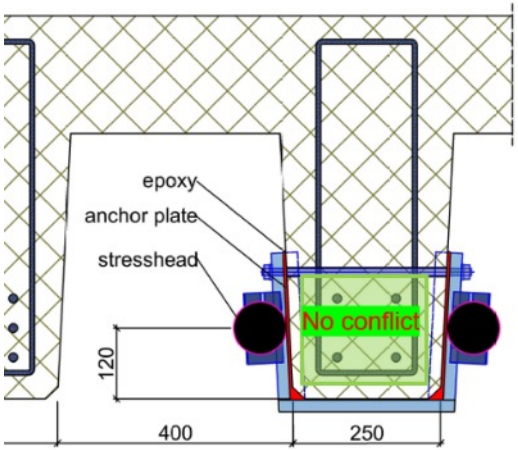
- Design based on classic steel span cabels

Take Away!



Lightweight and Fast

Corrosion protected system



Various kind of anchorages
>20a experience

ICRI
CONCRETE REPAIR

Questions?

Eri Vokshi

Sr. Product Engineer - CFRP and Corrosion Products

Sika US

vokshi.eri@us.sika.com

BUILDING TRUST

Philippe von Holzen

Sales and Business Development Manager

StressHead Ltd

vonholzen@stresshead.ch

STRESSHEAD Ltd
INNOVATIVE STRENGTHENING OF STRUCTURES

ICRI
CONCRETE REPAIR