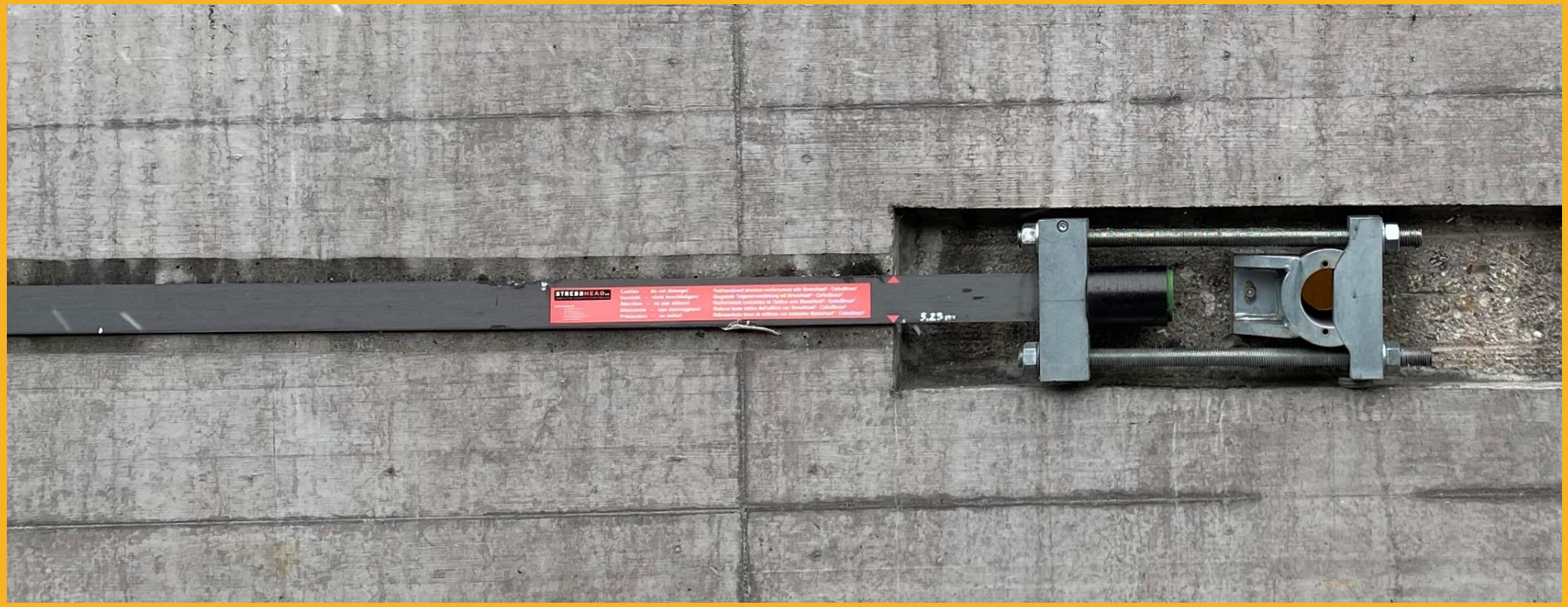


ACTIVE STRENGTHENING WITH POST-TENSIONED CFRP TENDONES

PRESENTED BY:

ERI VOKSHI, P.E.

SIKA CORPORATION, LYNDHURST, NJ

BUILDING TRUST

KEY LEARNING OBJECTIVES

01 **DETERMINE WHY STRUCTURES NEED TO BE STRENGTHENED**

02 **BASICS OF THE ACTIVE POST-TENSIONING CFRP SYSTEM AND INSTALLATION PROCESS**

03 **CASE STUDIES: APPLICATIONS IN THE FIELDS OF BRIDGE REINFORCEMENT, SEISMIC REINFORCEMENT AND APPLICATION OF REINFORCEMENT FOR CIRCULAR STRUCTURES**

DETERMINE WHY STRUCTURES NEED TO BE STRENGTHENED

WHY DO STRUCTURES NEED STRENGTHENING?

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

HOW ARE STRUCTURES STRENGTHENED

EXTERNALLY BONDED FRP OR STEEL

Traditionally done with steel, most bonded strengthening is nowdays done with FRP

SECTION ENLARGEMENT

Used frequently, this method is intrusive to the structure, adds a lot of weight, and takes longer to implement

EXTERNAL POST-TENSIONING

For cases where high-capacity contribution is required, external PT is great solution. Traditionally done with steel, PT strengthening can also be done with FRP

SUPPLEMENTAL SUPPORTS

Supplemental supports are a great solution, though they take headspace and can be tricky to install.

REVIEW OF EXTERNALLY BONDED FRP SYSTEMS


Wet Lay-up Systems


Pultruded Plates


NSM Rods


Post-tensioned FRP Plates


FRCM System

EXTERNAL POST TENSIONING WITH CFRP

Externally FRP systems

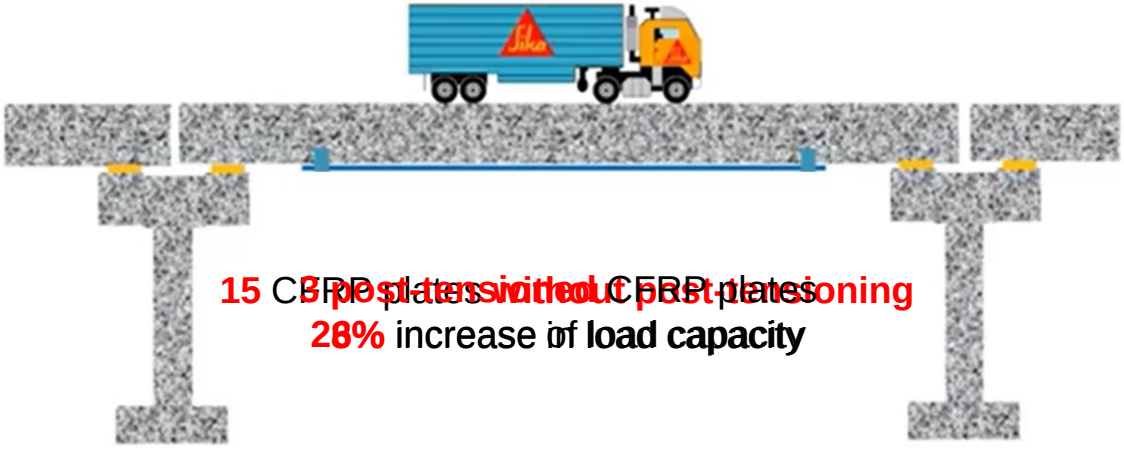
- **Passive Strengthening**

External PT FRP system

- **Active Strengthening**

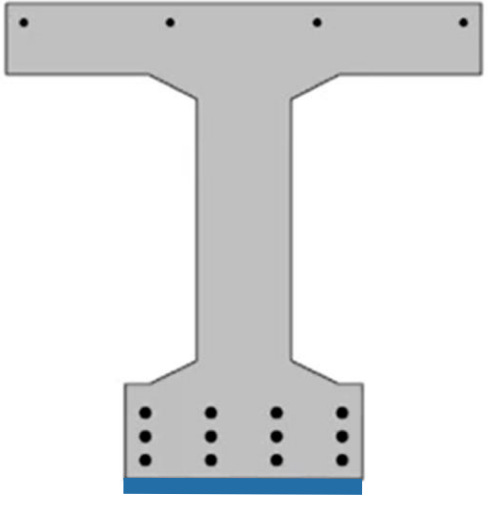
PT SYSTEM ADDRESSES DEFLECTION AND PROVIDES MUCH HIGHER CAPACITY, COMPARED TO EXTERNAL FRP

EXTERNALLY BONDED CFRP VS POST-TENSIONED CFRP



15 CFRP plates without post-tensioning

28% increase of load capacity



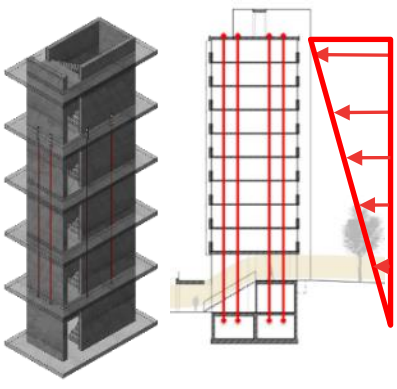
15 CFRP plates

BASICS OF THE ACTIVE POST-TENSIONING SYSTEM WITH EXTERNAL CFRP TENDONS

System

Bridge strengthening

Strengthening of industrial and high-rise buildings



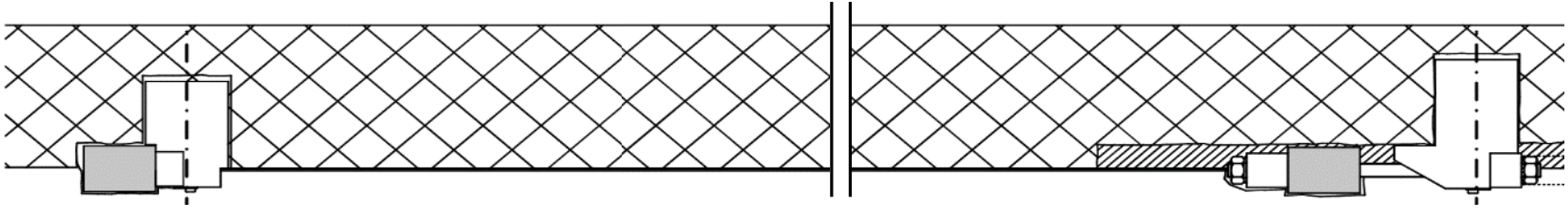
Earthquake strengthening & storm hardening

Reinforcement of silos and water tank (round shape)

System

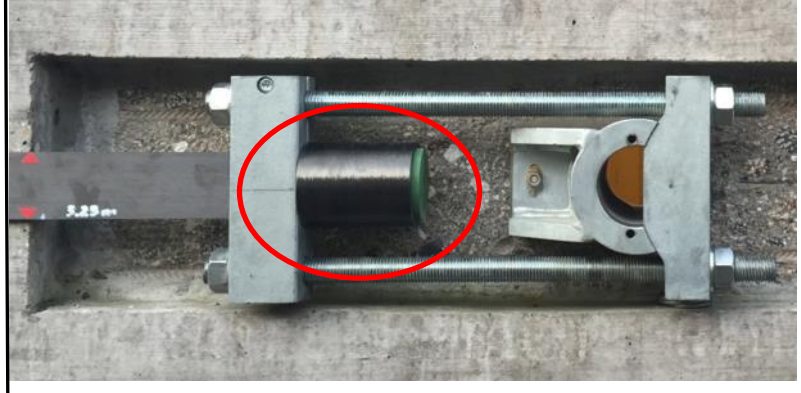
- Standard anchor Type III

P_0 = 50 kip



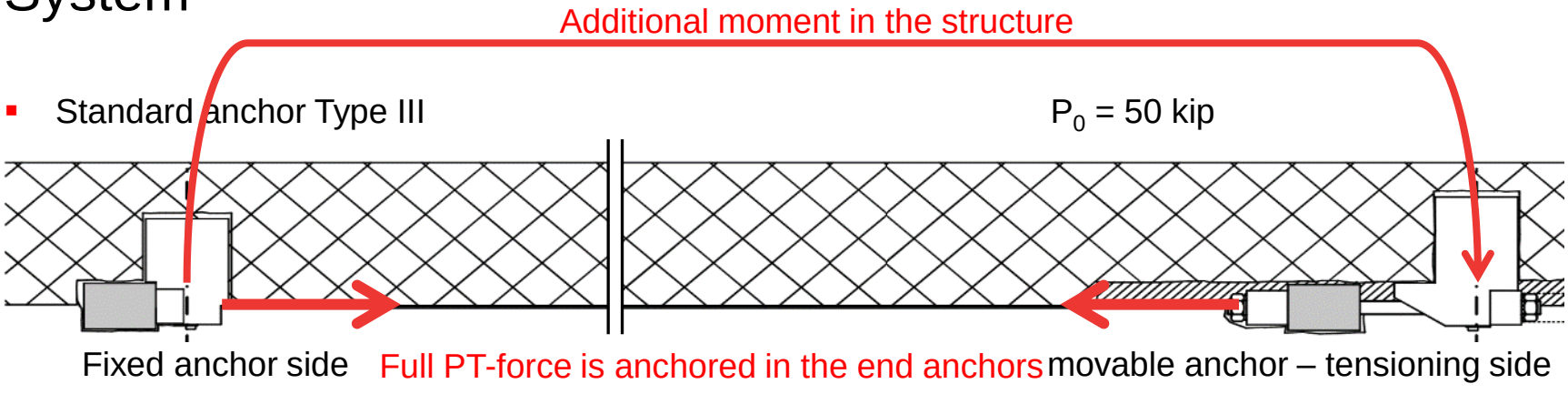
Fixed anchor side

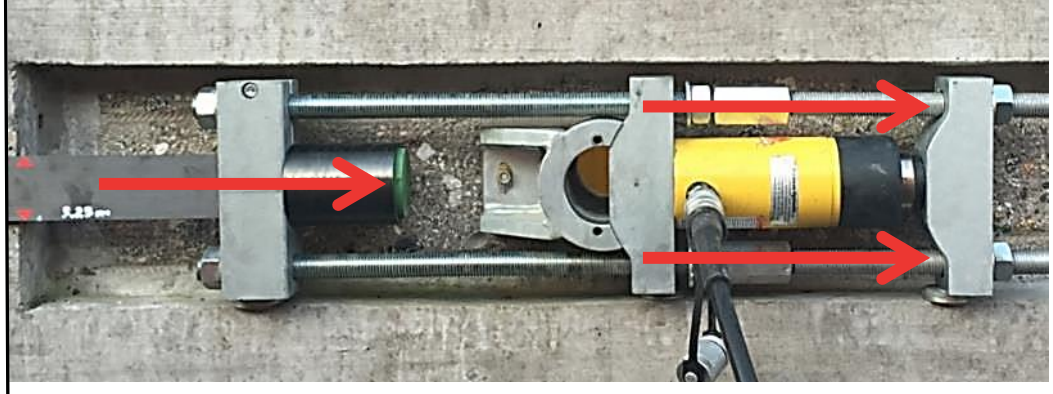
movable anchor – tensioning side



System

- Standard anchor Type III





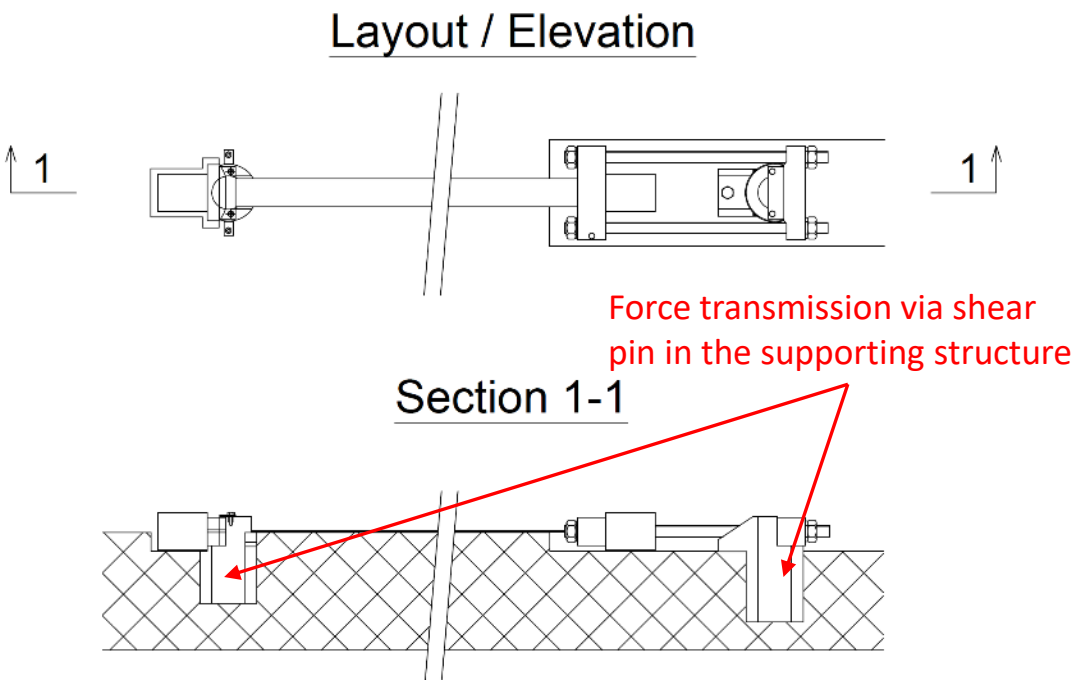
Anchor Types

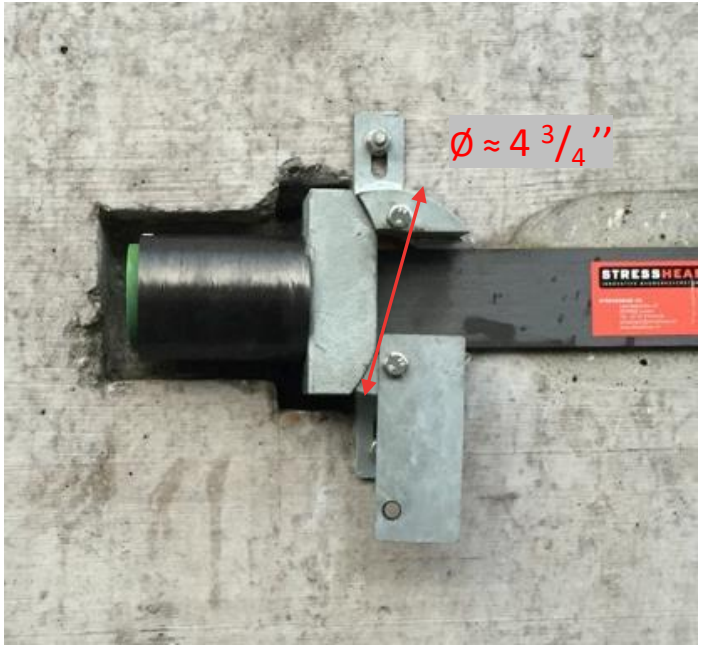
- Standard anchor (Shear pin)

<u>Standard anchors:</u>

Geometry: t = approx. 8”

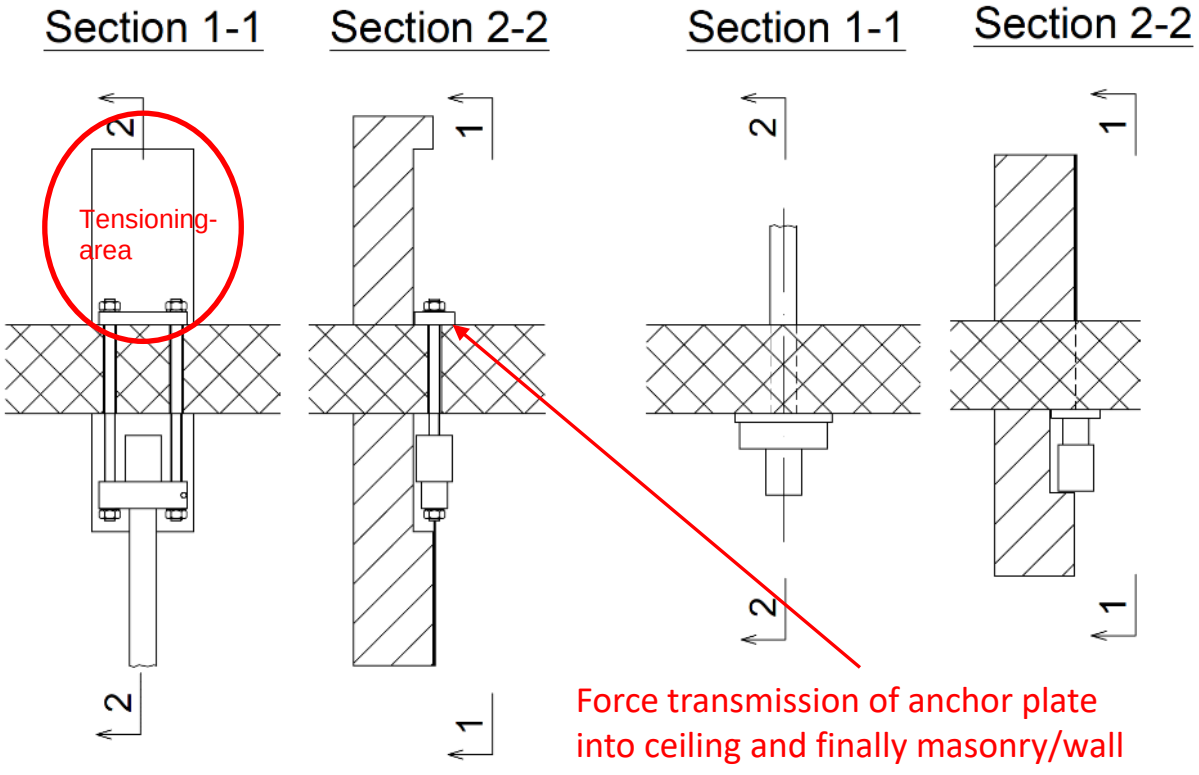
Concrete: f_{cd} = approx. 3,000 psi





Anchor Types

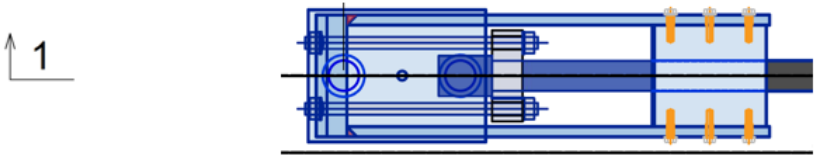
- Standard anchor through ceiling or wall



Anchor Types

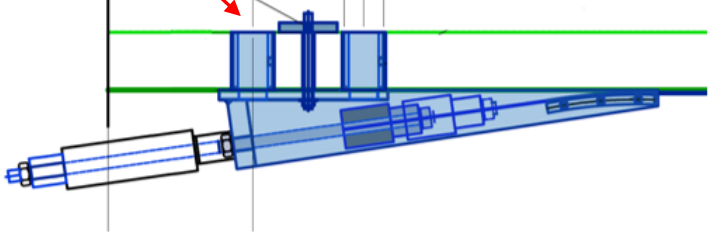
- Individual anchor types (designed project specific)

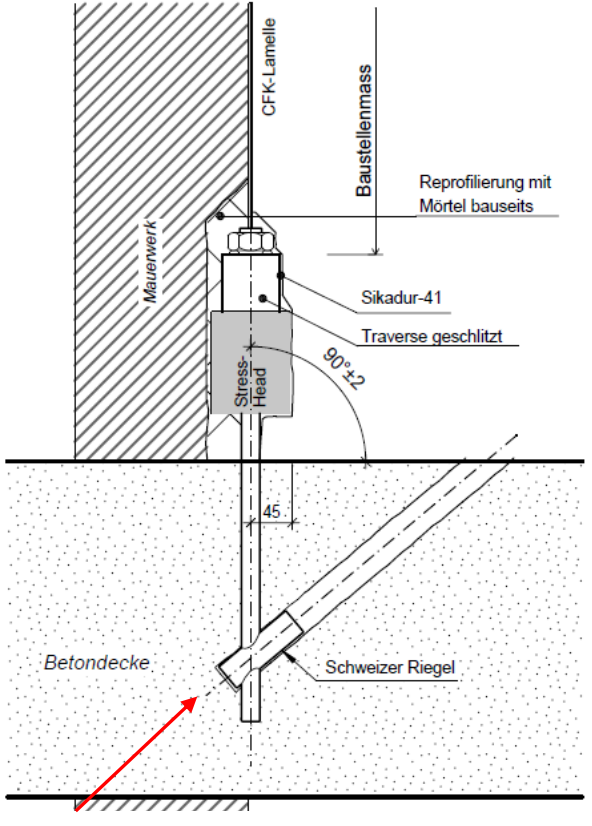
Layout / Elevation



Force transmission via two shear pins
(modification of standard anchor)

Section 1-1

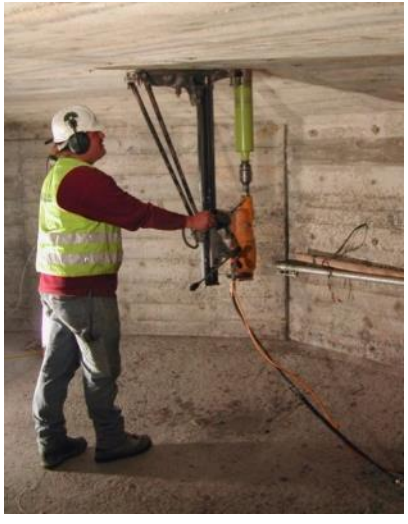




Access other side not necessary
(anchoring in foundation)

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:

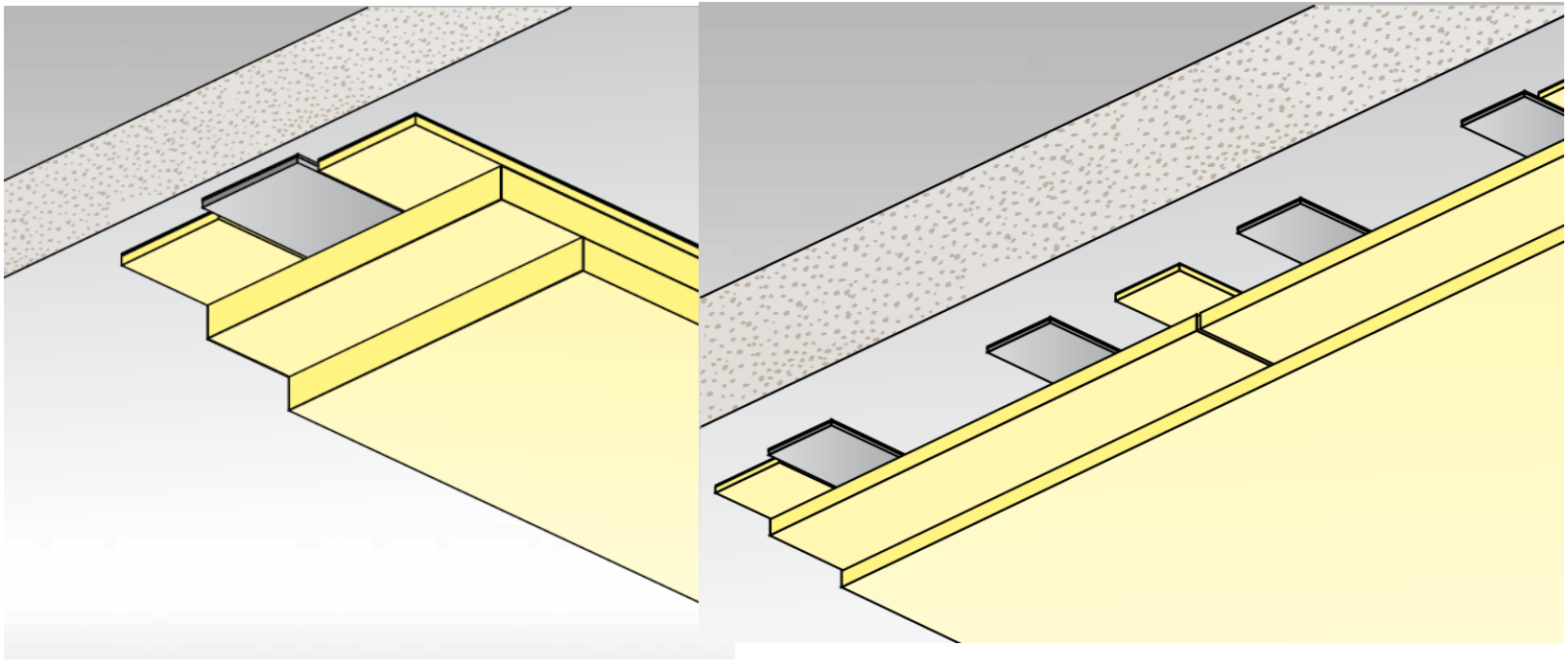
- Additional strengthening and stiffness
- Mechanical protection

3. Step Installation and tensioning

3. Step Installation and tensioning movable anchor

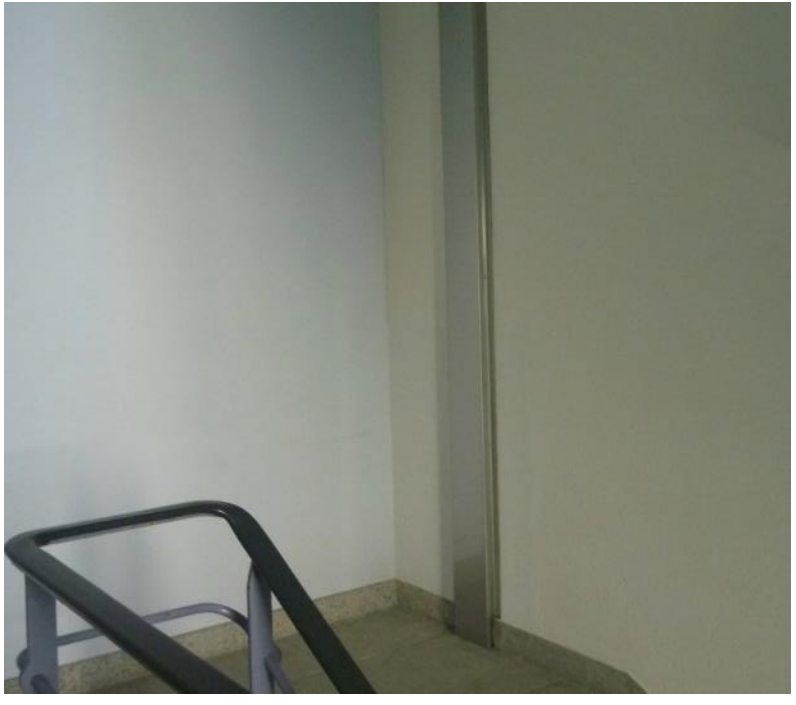
PROTECTION (OPTIONAL)

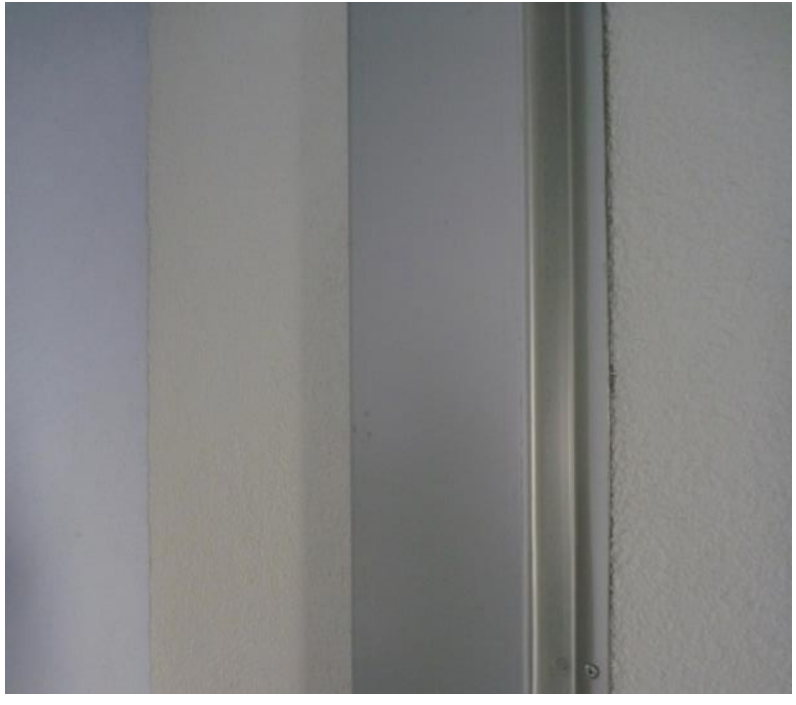
- Protection against fire



PROTECTION (OPTIONAL)

- Protection of plates against mechanical impact





CASE STUDIES

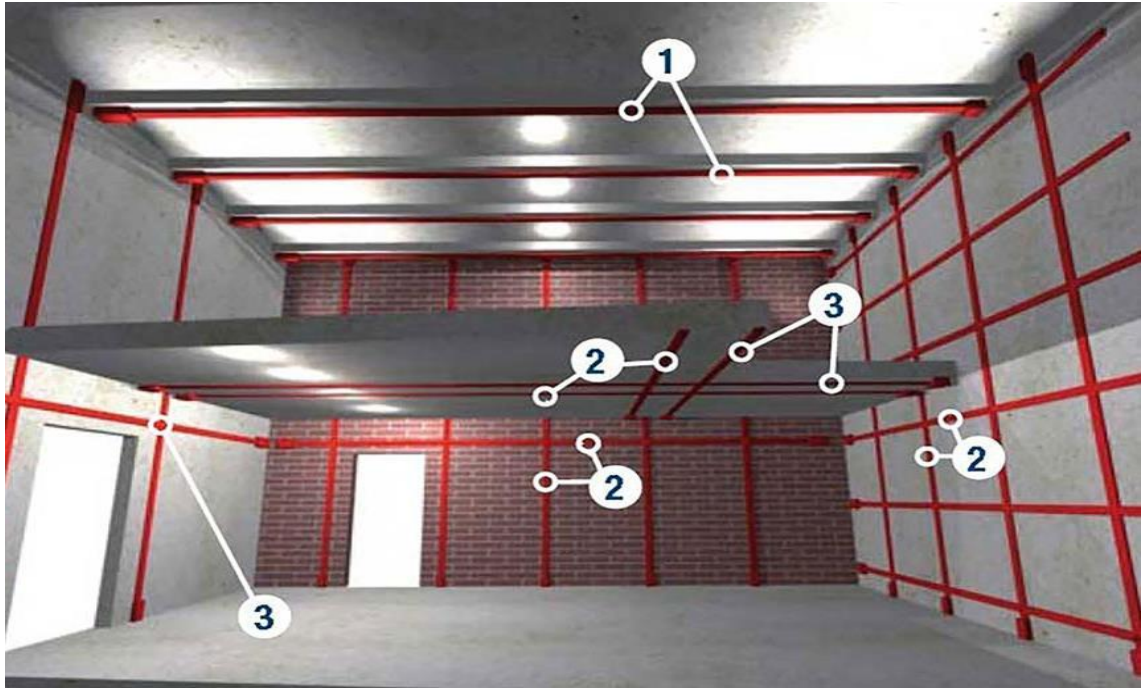
Strengthening of Industrial and High-rise buildings

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



LUCERNE (CH) – EXTEND SPAN OF BEAM

- Paper plant Perlen, new columns

LUCERNE (CH) – EXTEND SPAN OF BEAM

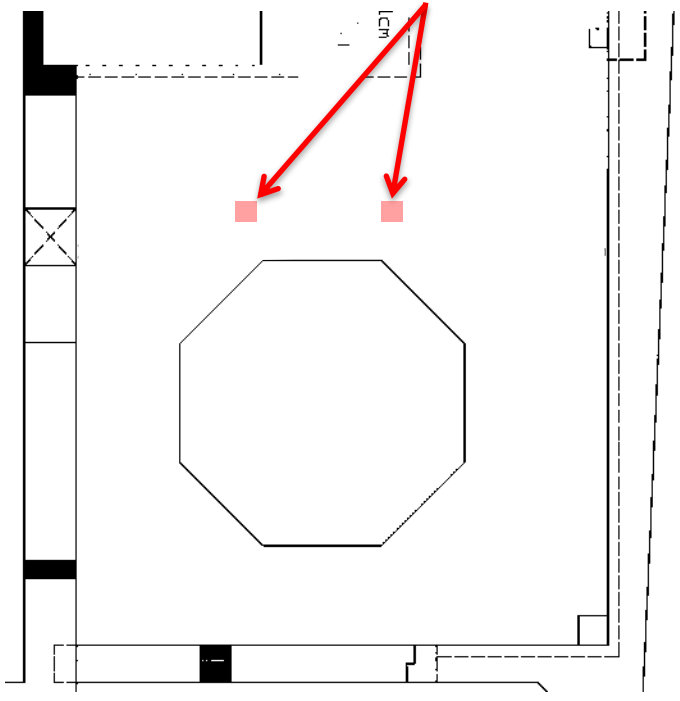
- Paper plant Perlen, new columns

LUCERNE (CH) – EXTEND SPAN OF BEAM

- New situation with displaced columnsnew columns

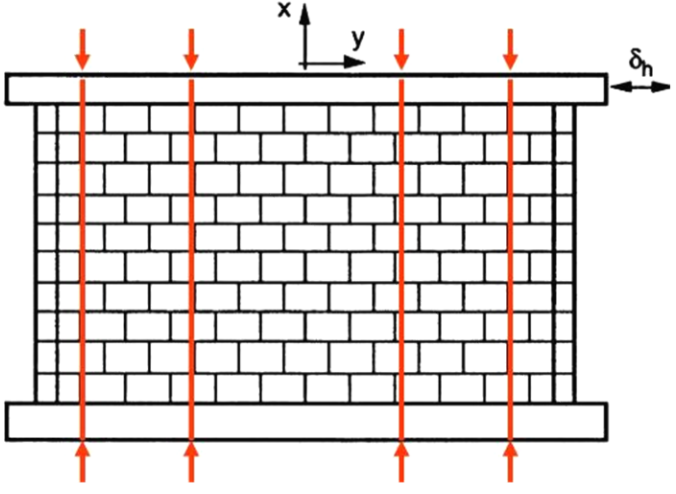
Vienna (AT) – Serviceability problem

- Casino – Romoval of existing pillars

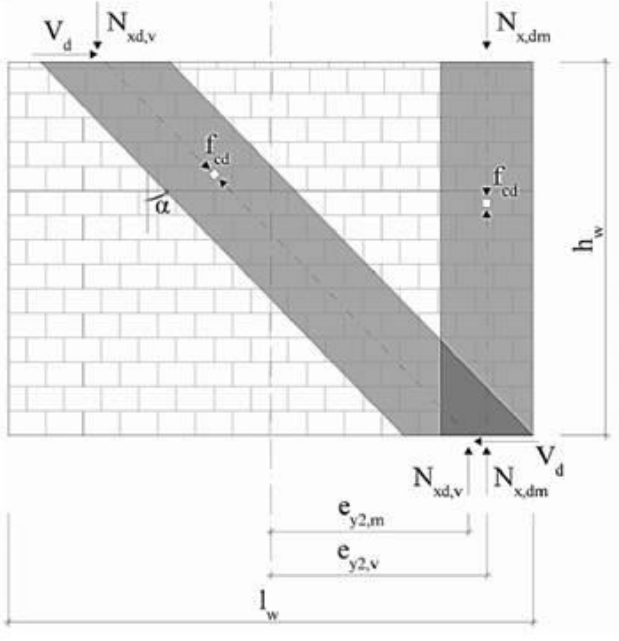


Earthquake Strengthening / Storm hardening

- Strengthening of masonry walls

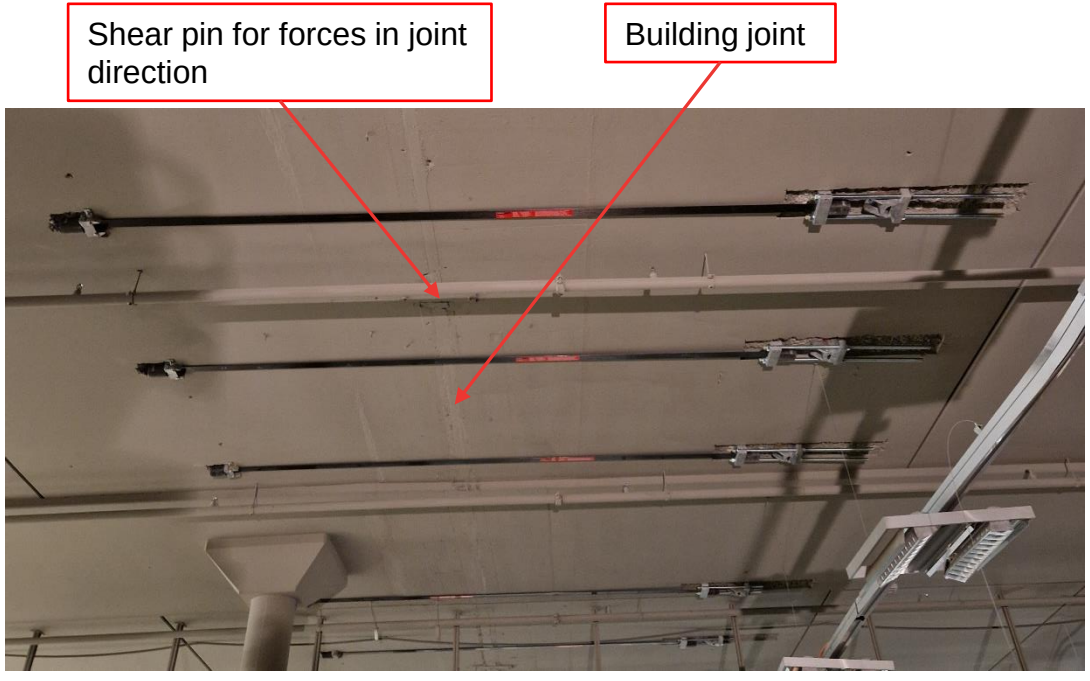


Additional vertical force to result a greater lateral strength



Earthquake Strengthening

- Earthquake strengthening of a shopping mall

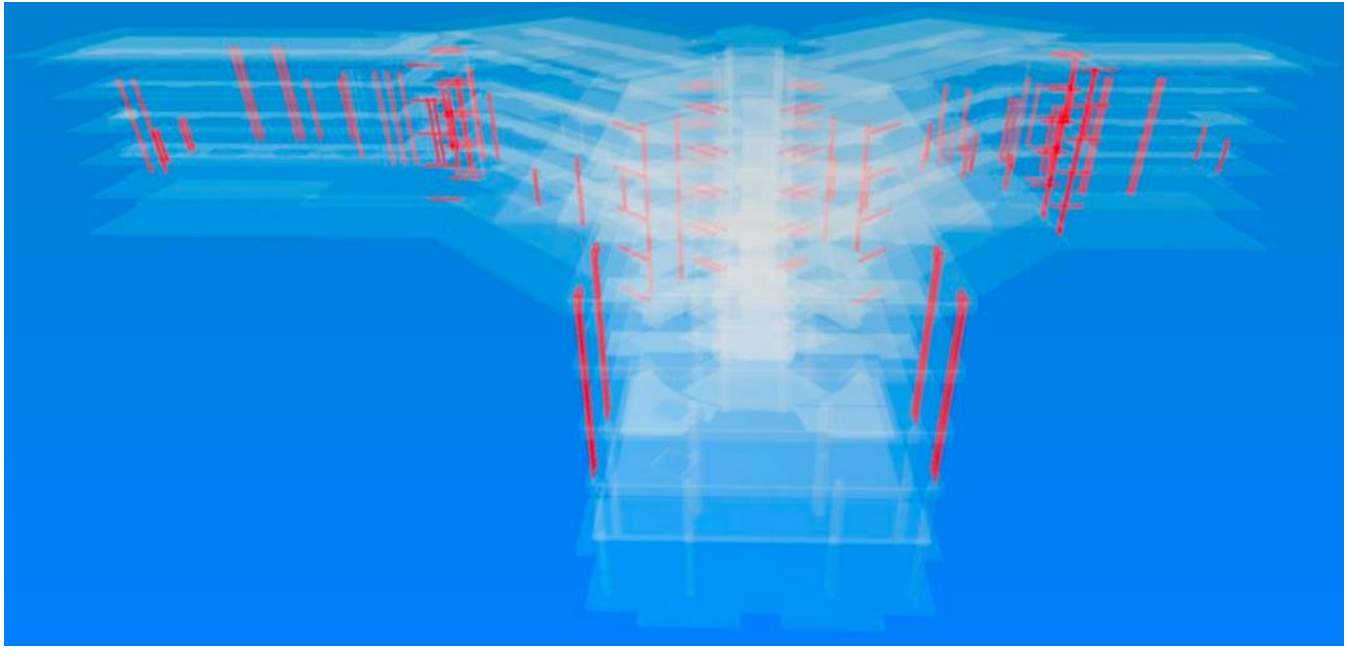


Davos (CH) – High Mountain Clinic

- Earthquake strengthening

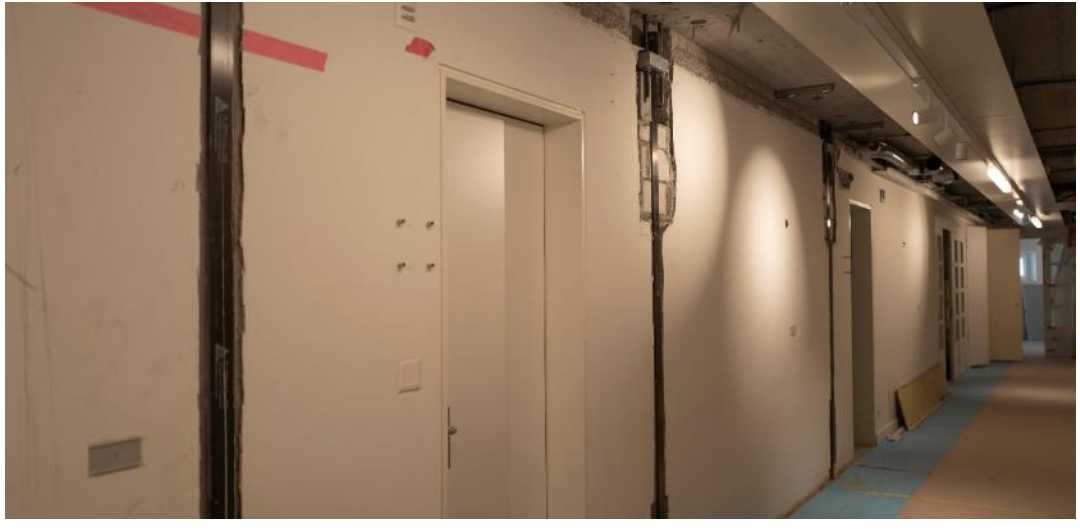
Davos (CH) – High Mountain Clinic

- Earthquake strengthening – 160 systems



Davos (CH) – High Mountain Clinic

- Earthquake strengthening – 160 systems

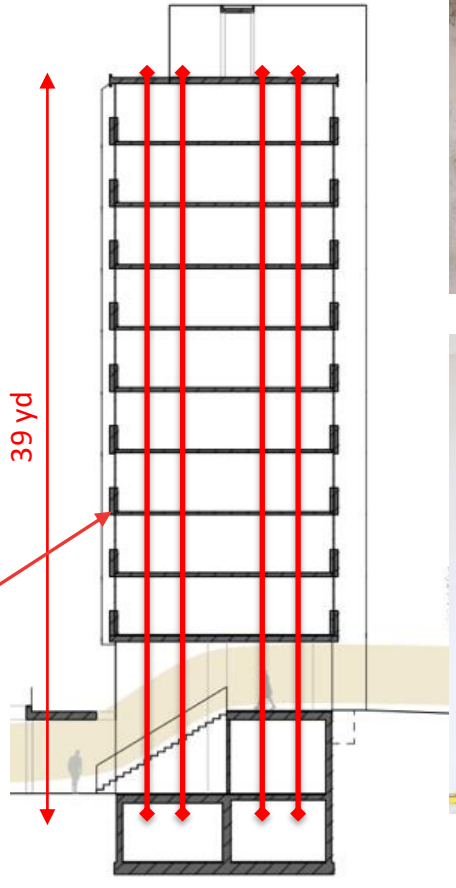


- horizontal and vertical strengthening with different lengths
- Over several floors
- Embedded in the wall to be invisible

Bern (CH) – Precast concrete elements

- Fellergut – Lack of reinforcement in the joints

Source Pläne: W2H Architekten AG

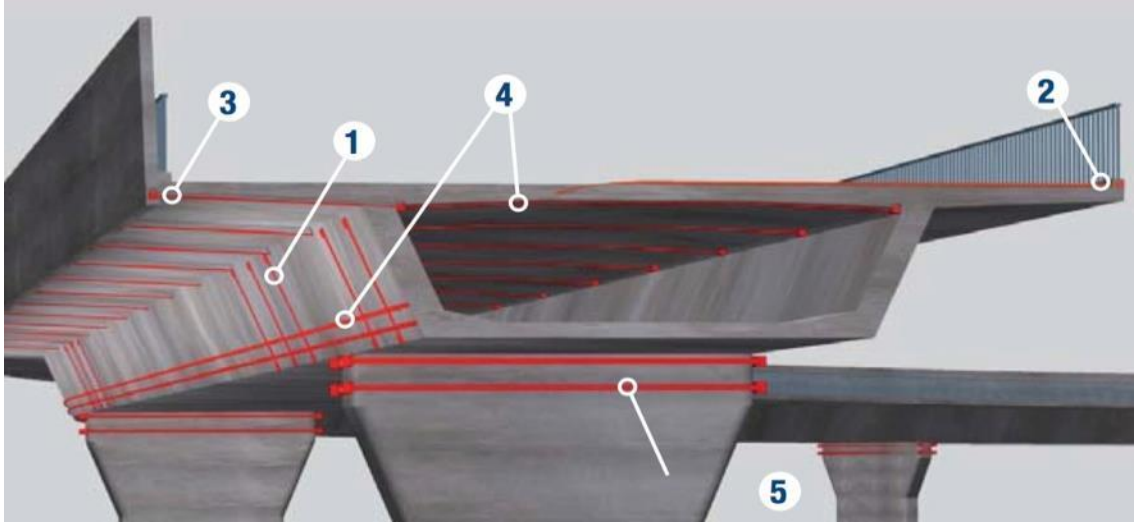


Insufficient reinforcement in the coupling joints for seismic laods

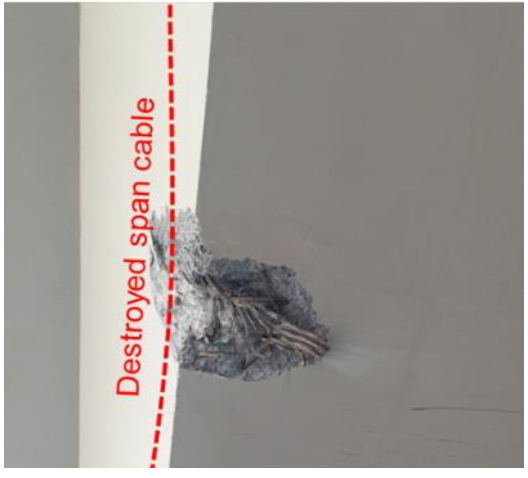
Strengthening of Bridges

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 Bridges



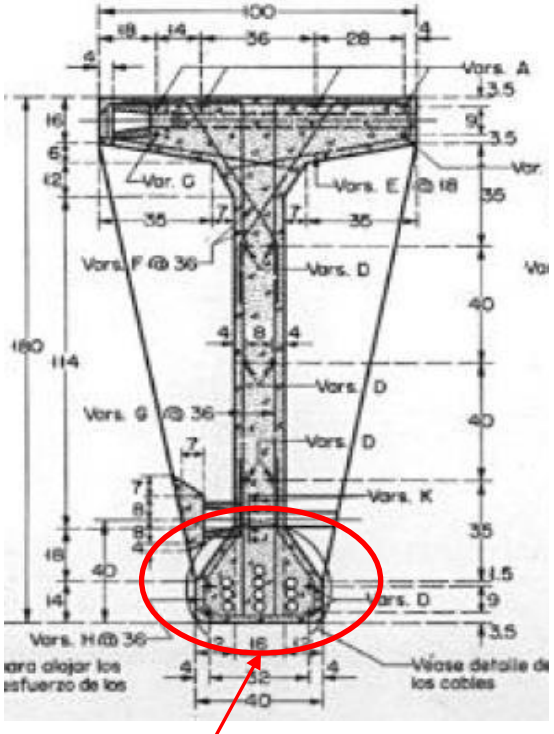
Damage of the existing structure

Higher loads

Corrosion problems

Ensenada (MX) – Prestressed beams

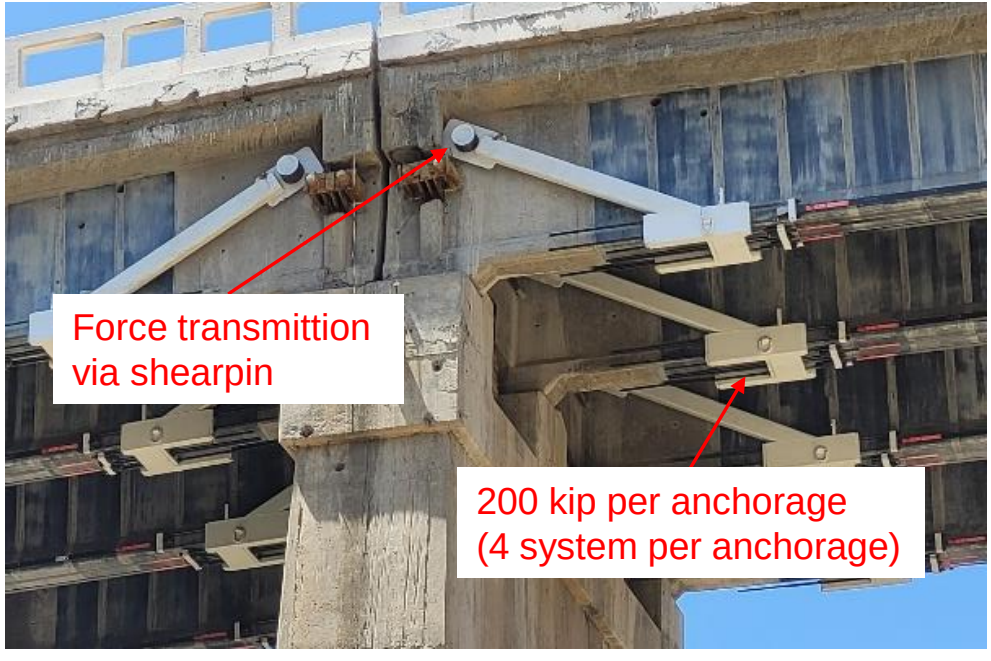
- Strengthening due to heavy haulage (1 bridge / 48 systems)



prestressing cables

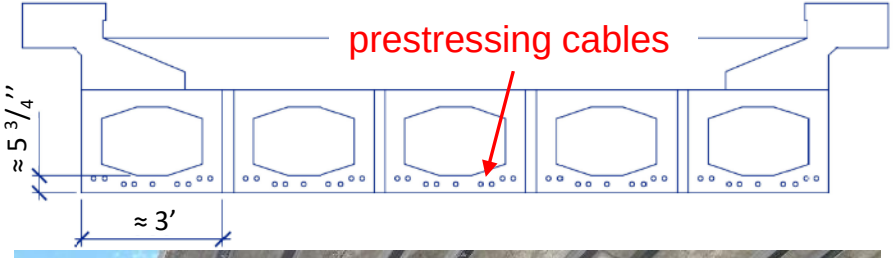
Ensenada (MX) – Prestressed beams

- Strengthening due to heavy haulage (1 bridge / 48 systems)



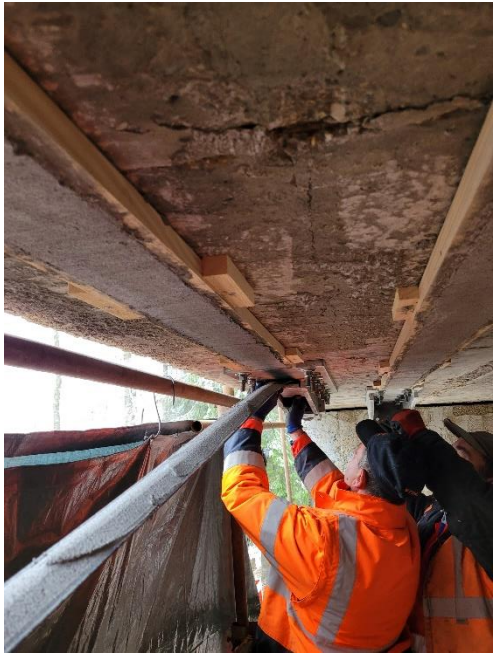
High Tatras (SK) – Precast box girders (2 bridges)

- Strengthening due to higher loads (3 bridges / 90 systems / 3 weeks)



Precast box girders (2 bridges)

- Strengthening due to higher loads (1 bridge / 60 systems / 2.5 weeks)



Israel (IL) / Tel Aviv (IL) – Circular strengthening

- Silo strengthening / water tanks, etc.

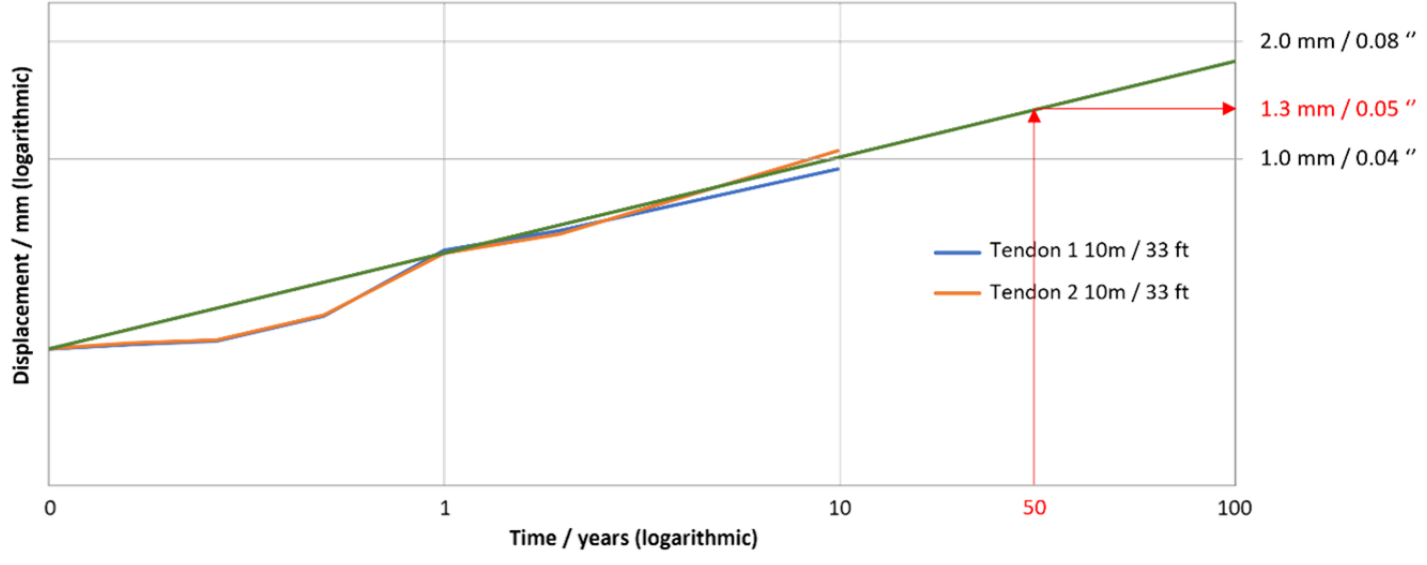
Tel Aviv (IL) – Fresh water tank

- Circular strengthening

DESIGN PROCESS

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 at 240 kN / 55 kip (2009 – 2019)
  -> To extrapolate to 50 years (Creep, relaxation, etc.)
  -> Result: No loss of tensioning force over the years

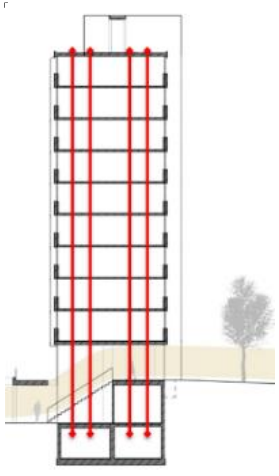


Design

- Design based on classic steel span cabels

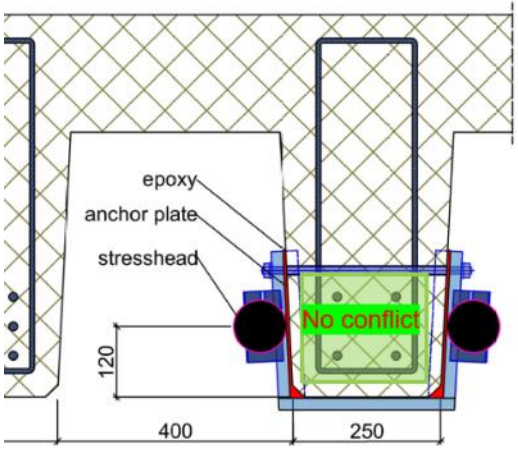
stresshead@stresshead.ch

Take Away!



Lightweight and Fast

Corrosion protected system



Various kind of anchorages
>20a experience

Do not hesitate to contact us for any inquiries!

Eri Vokshi

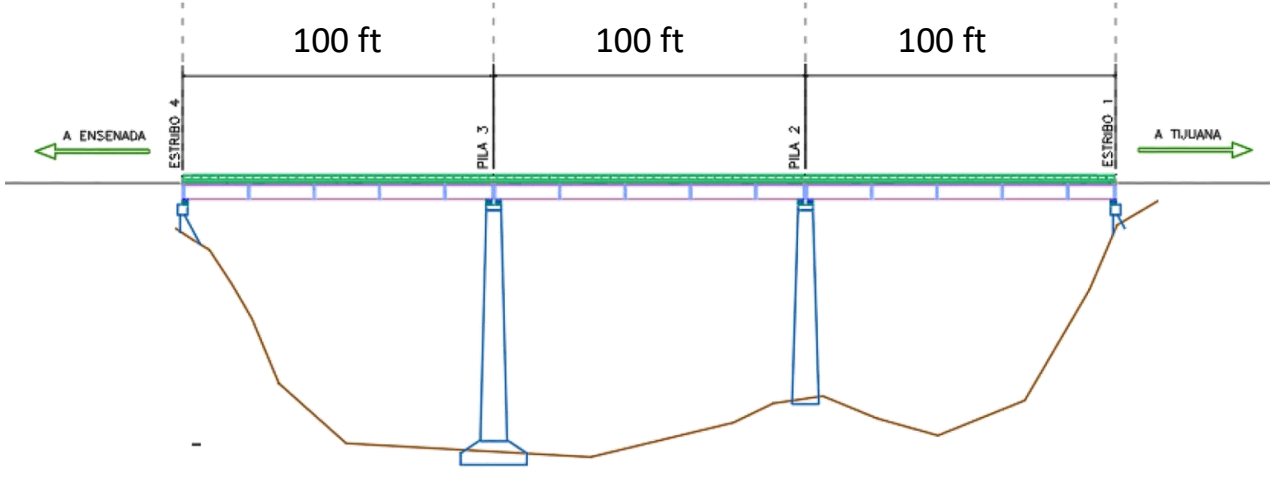
Technical Sales Manager -
CFRP and Corrosion Products

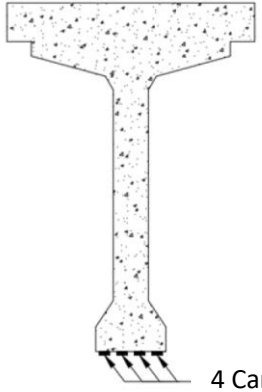
Sika US

vokshi.eri@us.sika.com

Connect with us on LinkedIn

Price Estimation: 3-span bridge, increase load capacity by +15%





4 CarboStress per beam

3-span bridge

4 beams 100 ft long beams per span

4 CarboStress systems per beam

- **Totally 48 CarboStress systems each 100 ft to increase the load capacity by +15%**