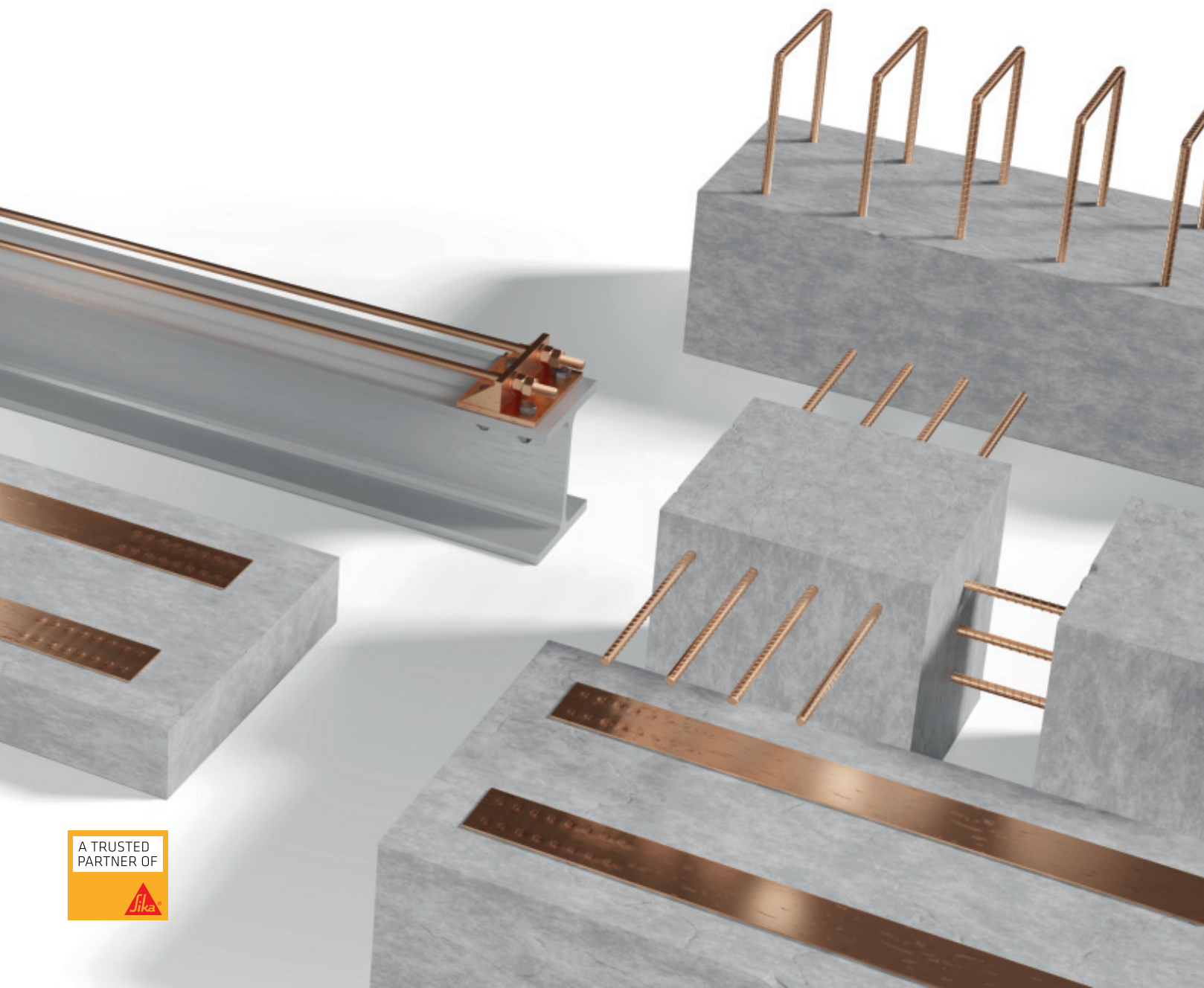


# Structural reinforcement with memory<sup>®</sup>-steel

**Intelligent prestressing**  
when/why/how

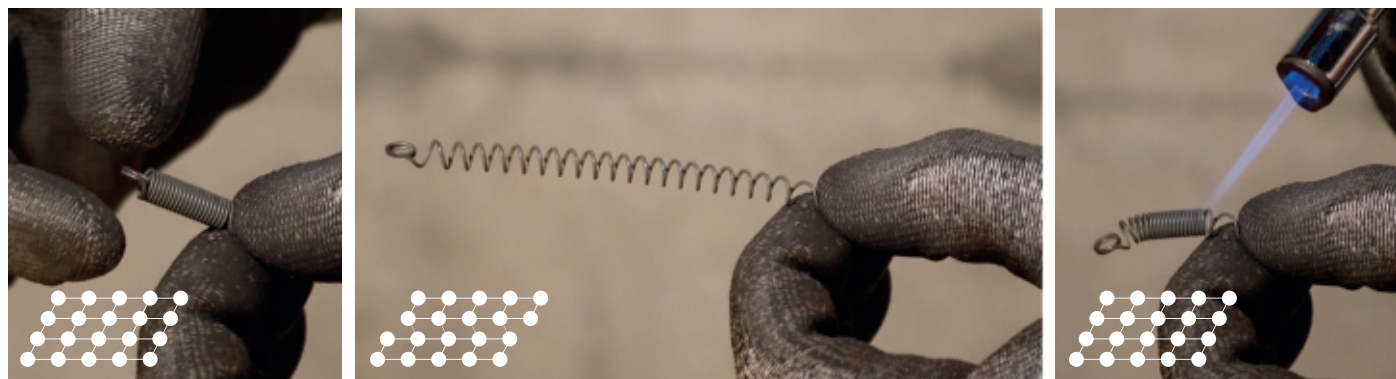




# Intelligent prestressing

## Robust, sustainable solutions for structural engineering

The innovative memory®-steel technology was specially developed for the structural reinforcement in building and bridge construction. In the following, possible applications of memory®-steel in combination with Sika cementitious mortars, Sika fire protection and fiber composites are shown. Thanks to the various possibilities, robust, economical, and sustainable reinforcements for reinforced concrete and steel components are possible. As a result of the active prestressing of memory®-steel in the Sika concrete replacement mortar, the service life of a structure can be increased.



### What is memory®-steel?

The shape memory alloy (SMA) remembers its original shape and changes the atomic crystal structure when prestrained in longitudinal direction. During the activation (heating process on construction site), a deformation back into the original and more stable crystal lattice structure takes place. If this deformation is prevented by anchoring against the concrete structure, prestressing takes place without friction loss in the memory®-steel.



[www.re-fer.eu/memoryen/](http://www.re-fer.eu/memoryen/)



Wrapping with SikaWrap®



Combination Sika® CarboDur® with memory®-steel re-plate



memory®-steel re-bar in Sika concrete replacement mortar

Like other industries, also the building sector will have to meet new sustainability requirements in future. Population growth, urbanization, water shortages and thus increased demand for resources and energy are leading to new regulations. Buildable space is becoming scarcer and more expensive. Compared to new buildings, renovation measures have an excellent carbon footprint thanks to the low material consumption. Compared to demolition and new construction, only short-term traffic diversions are necessary for the retrofitting of civil engineering structures, and thus manpower is not tied up in traffic jams.

Together with our partner Sika, re-fer takes responsibility and supports future-oriented research in construction. We are pleased to introduce the new memory®-steel technology to the construction industry alongside traditional reinforcements with carbon fibers.

### Proven strengthening systems

Over the past twenty years, Sika has successfully strengthened thousands of structures with fiber-reinforced composites in over 100 countries worldwide. Sika systems made of carbon fiber reinforced polymers (CFRP) enjoy wide acceptance on the market and are typically used as slack, and thus passive, post-strengthening of concrete structures. The existing internal reinforcement is not relieved in the case of passive reinforcement. Sika® CarboDur® CFRP strips are bonded to the concrete surface or in the slot. SikaWrap® carbon fiber mesh is suitable for wrapping around reinforced concrete columns or nodes.

### Innovation memory®-steel

memory®-steel is an iron-based shape memory alloy «corrosion resistance class 1». The re-plate lamellas, which are prestrained in the factory, are mechanically anchored to the concrete substrate and afterwards heated. This procedure actively introduces a prestressing force into the concrete. Cracks are closed and the deflection of the component can be reduced. re-bar (ribbed steel) is end-anchored on both sides in the Sika concrete replacement mortar. After curing of the end sections, activation is carried out by applying heat. The middle section can then also be filled with mortar. The prestressed bars thus reduce the stress in the existing internal reinforcement. Crack opening and deflections are also reduced.

The following short excursus provide an insight into the basics of structural design.



### Structural retrofitting in a nutshell

Whether for the static inspection of a new building or for a conversion, certain boundary conditions must be respected.

- Available space
- Planned use (loads)
- Required life span

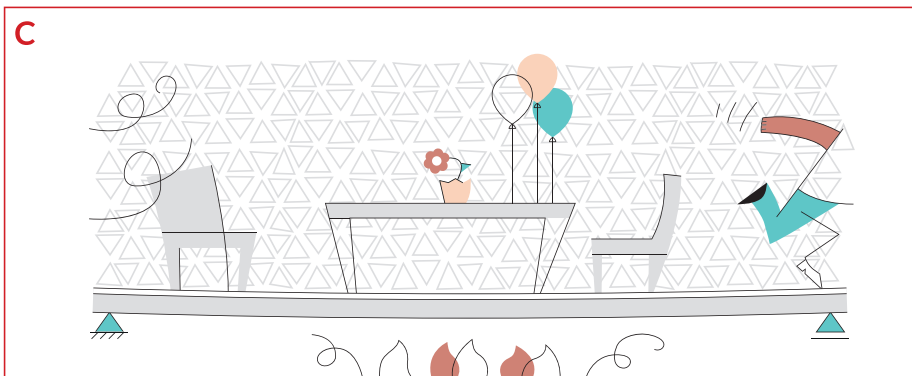
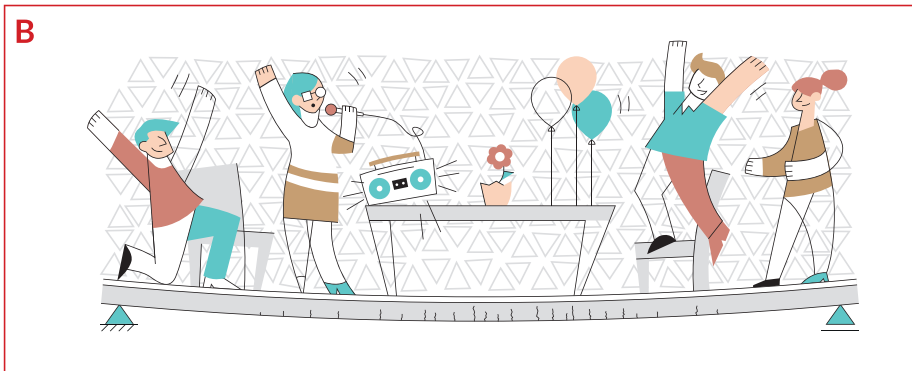
These lay the foundation for the structural design and determine the loads to be included. The local design codes serve as support and must be complied with.

### Example building constructions

Larissa and her boyfriend Ronnie were able to buy an apartment at an auction. They want to partially rebuild and modernize the apartment. Load-bearing walls are to be torn down and an intermediate support by the window front is also to be removed. This would massively change the use and the static system of the building.

Ronnie is a civil engineer and wants to manage the conversion himself. He calculates the modified structure. According to the local standard, the first thing to be checked is the **service condition (A)**. The reinforced concrete ceiling must be able to bear all permanent loads such as its own weight and the new marble floor. In addition, there is a share of variable loads such as furniture and people. In the state of use, concrete cracks as well as deflection must comply with the standard.

After the successful completion of the work, the two are eager to celebrate a housewarming party. This is quite a punishment for the building structure (as well as for the participants). The concrete ceiling is overloaded during the party, which endangers the **structural safety (B)**. The full live load must be added to the loads already mentioned. In addition, safety factors have to be increased. For this condition, structural engineers must ensure that there is sufficient load-bearing resistance.



People dance until the early hours in the morning. The jukeboxes are blaring, and the power distributor in the basement is glowing. The last guests say goodbye and then it happens - Larissa follows a strange smell coming from the cellar. There is a fire! The exceptional **fire case (C)** must also be proven according to the local

standard. The building structure must not collapse even under full fire. Fire safety must be guaranteed for a certain period of time so that all people can leave the endangered building structure safely. For this rare event, structural engineers can apply reduced safety factors.

- memory®-steel re-plate or re-bar are applied specifically to reduce crack opening and deflection under the new **service load**.
- Sika® CarboDur® lamellas are applied to ensure the remaining **structural safety** of the newly reinforced component.
- **Fire safety** is ideally covered by memory®-steel. The steel loses strength at 400-500 °C, but the epoxy adhesive of the CFRP lamellas already loses strength at temperatures of approx. 50 °C.



SikaCem® Pyrocoat over the complete strengthening



SikaCem® Pyrocoat only locally over re-plate

### Simple fire protection

The SikaCem® Pyrocoat sprayed plaster is applied locally in strips over the complete re-plate length or over the entire surface strengthened with the lamellas. A layer thickness of 15 mm already corresponds to a fire resistance of R60. The cementitious plaster is also used as fire protection for concrete ceilings or beams and is listed in several fire protection registers. Thanks to its low  $\lambda$ -value, SikaCem® Pyrocoat is also suitable as an insulating plaster.

The combination of Sika® CarboDur® CFRP lamellas with re-plate and SikaCem® Pyrocoat is very interesting in terms of price. Thanks to the low layer thickness of the fire protection, more room height is also available.

If re-bar is inserted into the Sika concrete replacement mortar, no additional fire protection measure is necessary. The mortar cover guarantees fire protection at the same time. When re-bar is laid in the cut-out area of a reinforced concrete ceiling, the entire use of the room is retained.



Combination of Sika® CarboDur® with re-plate



re-bar applied in Sika MonoTop® (fire protection due to mortar cover)





60 years old reinforced concrete bridge



Damaged concrete and corroded internal reinforcement



Hydromechanical removal of damaged concrete and roughening



Shear reinforcement/anchoring with re-bar U-profiles



Grouting of the central area with Sika MonoTop®



Surface finish and completion

### Strengthening of old bridges

Exterior structures are exposed to freeze/thaw cycles and other environmental factors such as de-icing salts or exhaust gases. Pollutants penetrate the concrete especially on the tension side and in the shear area where cracks occur and can lead to premature corrosion of the internal reinforcement. During the construction of a reinforced concrete bridge, the steel reinforcement is subjected to a normalized stress level under service load (point 1 in the figure below).

Due to corrosion, relaxation and fatigue of the building materials, the stress in the structural steel also increases and the load-bearing resistance of the building structure is reduced (point 2). If the bridge structure falls below the load-bearing capacity according to requirements in the local design code, a replacement structure must be built, or a strengthening measure initiated.

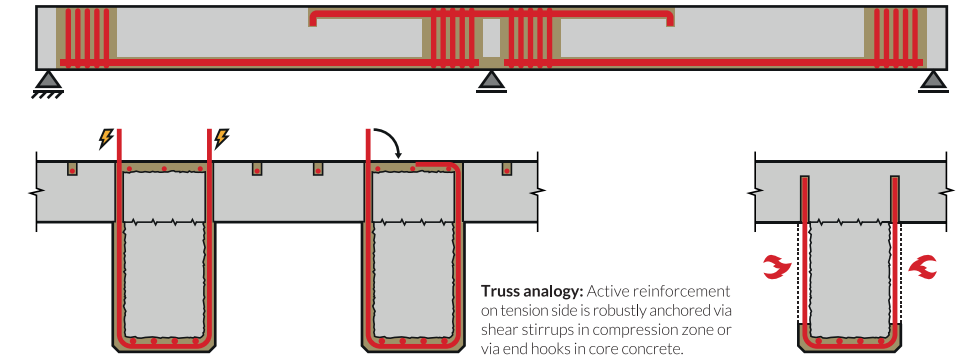
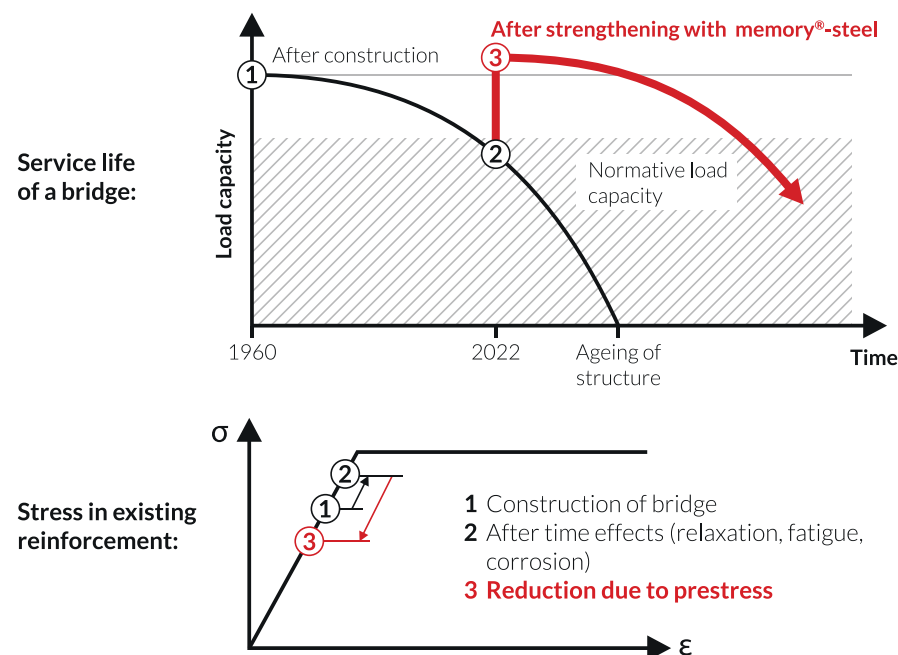
### New construction or repair

Active reinforcement with re-bar in the

Sika concrete replacement mortar relieves the load on the load-bearing structure and specifically reduces the stress in the steel reinforcement (point 3). Deflection and crack opening are reduced.

The contaminated concrete in the critical area (tension as well as shear) is removed during a rehabilitation measure and replaced with a high-quality Sika concrete replacement mortar. With little additional effort, re-bars are inserted. The healthy concrete in the compression zone or in the core is left in place. The reinforcement measure is anchored in the intact concrete, either via the pure mortar bond or by means of end hooks on re-bar. For bridge girders, shear stirrups can alternatively be used in the anchorage area. By enclosing the tension rods, forces are transferred into the healthy concrete in the upper compression zone (truss analogy).

The refurbishment measure is obvious thanks to the advantages of this innovative strengthening system.



- Cementitious/vapor-open Sika mortar layer protects re-bar and reinforcement against corrosion
- 100% recyclable and low carbon footprint
- Controlled prestressing force without friction loss
- Tensile forces are introduced over a large area via concrete replacement mortar
- Prestressed re-bar U-stirrups for shear reinforcement and improvement of the anchorage zone
- Robust anchorage independent of the concrete substrate

When repairing with the intelligent memory®-steel in the Sika concrete replacement mortar, a new replacement construction can be avoided. re-bar is inserted into the Sika repair mortar, which provides a protective layer thanks to its new alkaline depot. This prevents corrosion of memory®-steel in the long term. The

reinforcement measure is durable, robust, and sustainable. Resources are used in a targeted manner and another life cycle is initiated for the supporting structure. Success in terms of safety and economy often lies in the clever combination of the various reinforcement systems.





strengthening solutions

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## Reinforced concrete structures:



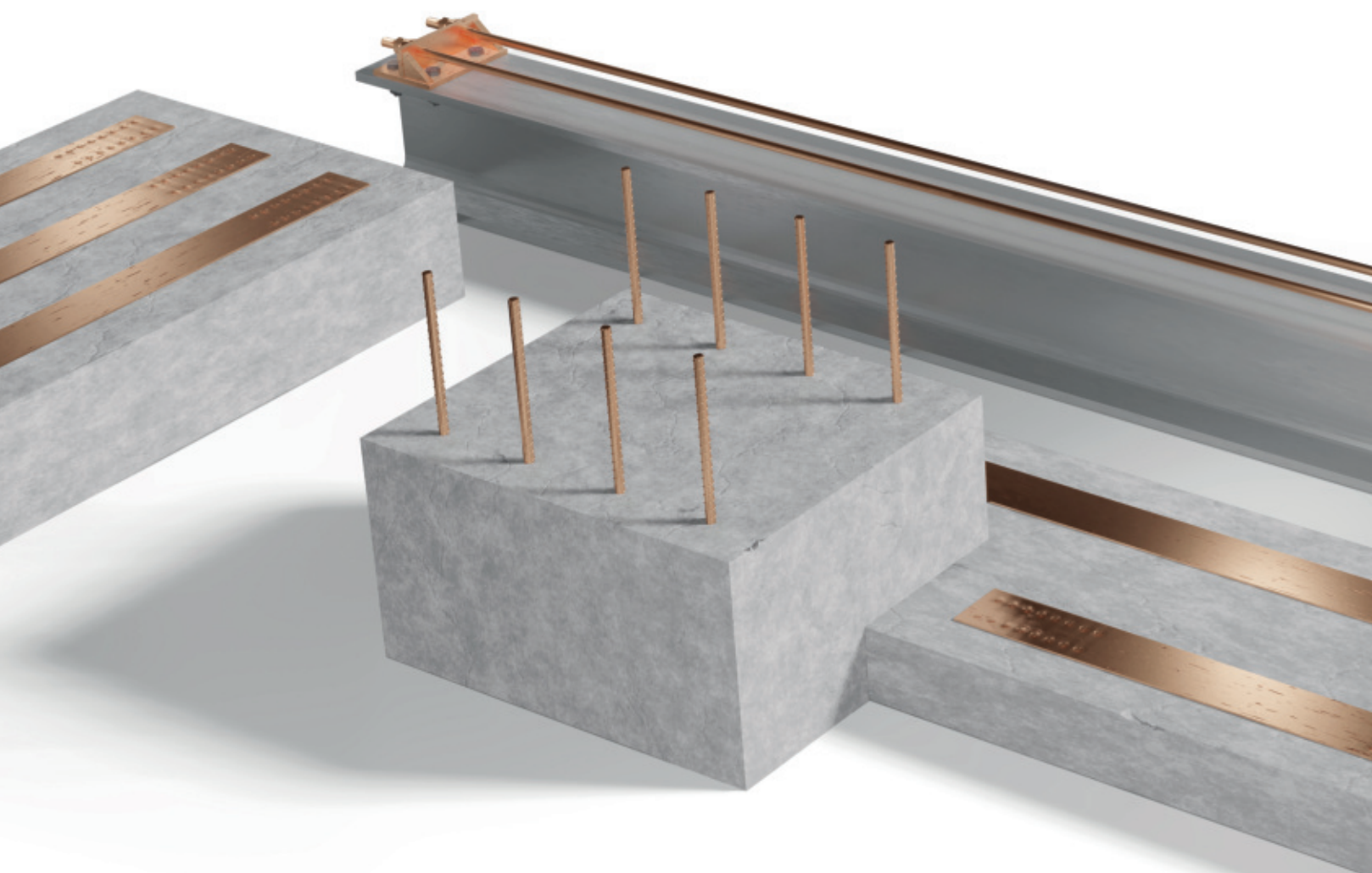
re-plate 120/1.5



re-bar 10/16



re-bar R18



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