Solutions Foreva

Inspection and maintenance of prestressing tendons

IMPROVE, PRESERVE, SECURE

FREYSSINET
SUSTAINABLE TECHNOLOGY

R VII 4

FREYSSINET - THE BENCHMARK FOR PRESTRESSING TENDON MAINTENANCE

The Freyssinet Group

Freyssinet brings together **an unrivalled set of skills in the specialist civil engineering sector**. It implements solutions with high added value in two major fields: construction and repairs.

Freyssinet is involved in numerous projects across five continents, making it the world leader in its specialist areas of:

- Prestressing
- Construction methods
- Cable-stayed structures
- Structural accessories
- Repairs
- Structural reinforcement and maintenance

Freyssinet is highly involved in sustainable development issues, and has set up a number of initiatives, particularly to reduce the environmental impact of its projects and enhance its social responsibility policy.

Freyssinet is a subsidiary of the Soletanche Freyssinet Group, a world leader in the soils, structures and nuclear sectors.

Maintenance of the Pont-à-Mousson viaduct

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Drawing strength from its know-how and expertise in structural prestressing, Freyssinet has masterminded an end-to-end range of prestressing tendon inspection and maintenance services:

-Assessment of the structure's integrity and tendons;

-Monitoring of tendon ageing;

-Conformity-oriented renovation;

-Strengthening and replacement work.

The service life of a prestressed structure is highly dependent on the durability of its prestressing tendons. Their durability determines the structure's bearing capacity and holds in check any cracking to the concrete components or joints opening between the prefabricated segments.

The main risk facing prestressed structures is corrosion to the steel tendons. Corrosion is generally caused by aggressive water-borne agents (de-icing salt, sea spray, etc.) that migrate through defects in the integrity of the structure's extrados.

Internal and external prestressing

The impact of a broken tendon on the durability of a prestressed structure depends on the type of prestressing used, i.e. either bonded or unbonded prestressing. The prestressing force of the broken tendon either reattaches to the structure or not, leading to a loss of resistance on a local level or across the entire tendon.

Controlled work

Work on the tensioned prestressing tendons (whose integrity may be uncertain) of a structure in full or limited operation must be carried out by experts, while guaranteeing the safety of users and maintenance personnel.

Additional prestressing for a viaduct featuring independent spans with prefabricated prestressed concrete beams

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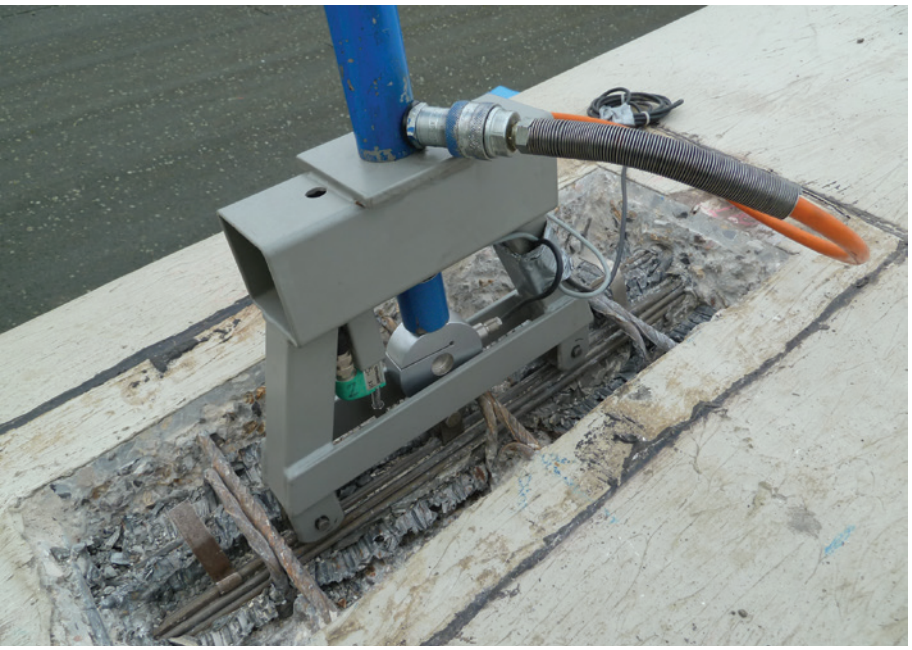
Inspection



Verifying the force in a prestressing tendon using the crossbow technique

Volumetric measurement of injection voids

Freyssinet offers inspection solutions for assessing the integrity of prestressing tendons.

Visual inspections

- Opening of anchorage caps and inspection of visible parts;
- Inspection of sheathes and connections.

Inspection of filled sheathes

- Inspection of sheathes filled with cement grout using:
  - Hammer sounding, electrical testing with the E-Scan process (external prestressing);
  - Photographic inspections of the fill using X or gamma rays (internal prestressing);
  - Opening of windows;
- Endoscopic inspection across the length of the identified injection voids;
- Volumetric measurement of the injection voids.

Inspection of the greased sheathed strands

- Electrical continuity testing.

Material sampling and destructive testing

- Analysis of the cement grout;
- Tensile testing of the prestressing tendon.

Tensile measurement of the tendons

- Tendon force measurement using the vibrating wire method (external prestressing);
- Strand force measurement using the crossbow method (internal prestressing).

Measurement of the structure's concrete deformation and stresses

- Measurement of any cracks or joints opened under working loads;
- Measurement of the compression rate in the concrete elements (Slotstress process).

Spotlight on an exclusive process:

Slotstress

This process is used to measure the local compression rate in concrete and provide a greater insight into the stress exerted on the structure (effects of relaxed prestressing tendons, temperature gradient, creep, etc.). Inspection results are checked against the structure's re-design and geometric monitoring data.

Monitoring

Saint-Cloud viaduct, France

EverSense® Acoustics sensors

Freyssinet provides instrumentation solutions for real-time monitoring of tendon ageing.

Detection of the effects of corrosion

- Acoustic monitoring of highest-risk tendons and installation of alarms triggered by the breakage of the wires making up the tendons.

Geometric monitoring of the structure

- Measurement of the structure's profile and monitoring of deformation in service, to assess the effect of the long-term behaviour of the materials (concrete shrinkage and creep, relaxation of prestressing steel, etc.) and detect any defects.

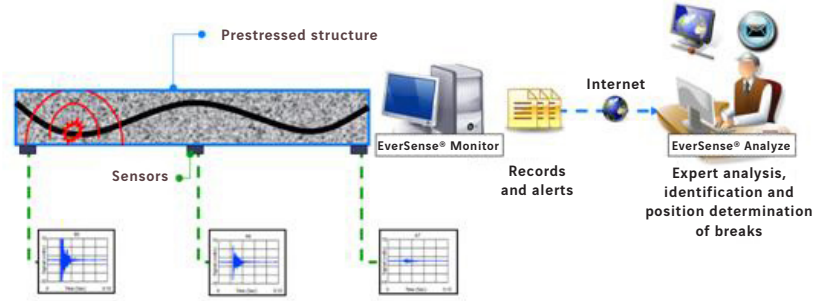
Structural design

- The measurements provided by the instrumentation can be cross-referenced with a structural analysis to determine the structure's residual safety factor, for example, and assist in decision-making regarding operating conditions.

Spotlight on an exclusive process:

EverSense® Acoustics

EverSense® Acoustics allows for real-time detection and location of wire breakages along the entire length of the cable. This permanent instrumentation is used to identify active areas of corrosion, therefore enabling action at the right time, in the right place. By providing a better understanding of changes in the condition of the tendons, reinforcement or replacement work can be deferred.



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MAINTENANCE
External prestressing

Temporary prestressing

Final additional prestressing

New prestressing anchoring

The previous design for external prestressing tendons generally used a bundle of prestressing steel tendons housed in a plastic sheath injected with cement grout.

In case of early-stage corrosion to the tendons, Freyssinet reinjects any voids in the grout.

In case of advanced corrosion to the tendons, the effect of a broken tendon may be sudden due to a lack of attachment points with the structure. Preventive action will then be required by replacing the tendons.

Tendons restored to conformity

Vacuum reinjection of the sheathes with cement grout.

Replacement of prestressing tendons

Installation of provisional additional prestressing:

- Creation of deviation and anchor sheaves;
- Fitting of temporary tendons;
- Installation of temporary tendons after replacing existing tendons.

Dismantling of the existing prestressing:

- Installation of a system to protect against whipping tendons;
- Instrumentation of the structure;
- Remote-controlled tendon cutting according to specific phasing;
- Extraction of the elements.

Installation of new C-system prestressing tendons:

- Adaptation of existing inserts by the anchorings and deviators;
- Installation of prestressing with individual greased sheathed strands housed in a HDPE sheath injected with cement grout;
- Or by uncoated strands housed in a HDPE sheath injected with wax.

MAINTENANCE
bonded internal prestressing

Additional prestressing of a beam

Individual tensioning of greased sheathed strands

Bonded internal prestressing tendons comprise a bundle of strands housed in a corrugated plastic sheath injected with cement grout and placed inside the concrete.

In case of early-stage corrosion to the tendons, Freyssinet reinjects any voids in the grout.

In case of advanced corrosion to the tendons, it is often very difficult to accurately determine the actual resistance of the structure; preventive action will then be required by adding additional prestressing tendons that will gradually replace the deteriorating internal prestressing.

Tendons restored to conformity

Vacuum reinjection of the ducts with cement grout

- Sealing of facings in reinjection areas;
- Vacuum reinjection with volumetric fill control.

Structural reinforcement

Installation of C-system additional prestressing

- Adaptation of the structure to allow tendons to be anchored and deviated;
- Installation of individually greased and sheathed strands, housed in a HDPE sheath injected with cement grout;
- Or fitting of uncoated strands housed in a HDPE sheath injected with wax.

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MAINTENANCE
unbonded internal prestressing

Peeling following a broken greased sheathed strand

Replacement of a greased sheathed strand section

Unbonded internal prestressing tendons generally comprise individually greased and sheathed strands, incorporated into the element during concreting.

When a strand breaks, the prestressing force is completely lost across the entire length of the tendon. The strand must then be replaced or the structure reinforced.

Tendons restored to conformity

Extraction and replacement of all or part of the strand

- Replacement of the defective strand section by opening a window in the concrete element at the site of the defect. The new strand is coupled to the two healthy sections left in place with Freyssinet single-strand extenders;
- Extraction and replacement of a steel strand, while keeping the individual sheath embedded in the concrete.

Structural reinforcement

Installation of C-system additional prestressing

- Adaptation of the structure to allow tendons to be anchored and deviated;
- Installation of individually greased and sheathed strands, housed in a HDPE sheath injected with cement grout;
- Or fitting of uncoated strands housed in a HDPE sheath injected with wax.

Over 60 locations worldwide

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