

# ■ Maintenance of cable-stayed structures



**FREYSSINET**



# FREYSSINET, IN CABLE-STAYED STRUCTURE

## 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 on 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.

*Cover photos:  
Rion Antirion Bridge (Greece)/Penang Bridge (Malaysia)*

**Representing 5 to 8% of the investment in a structure, the cables are critical and vulnerable elements that require regular monitoring owing to the forces to which they are subjected and their exposure. Backed by its experience in cable-stayed and suspension bridges, Freyssinet has developed a comprehensive range of technical solutions and services for all stages in the maintenance of stay cable systems.**

### Inspection

Structural cables (cable-stayed bridges, suspension bridges, suspended roofs, etc.) are complex civil engineering structures in which the stay cable system is a vital structural element. To achieve their design service life, stay cables and anchors require regular monitoring and detailed inspections must therefore be carried out following extreme events: exposure to vehicle fires, blast waves, lightning strikes, strong winds, earthquakes, etc.

### Instrumentation

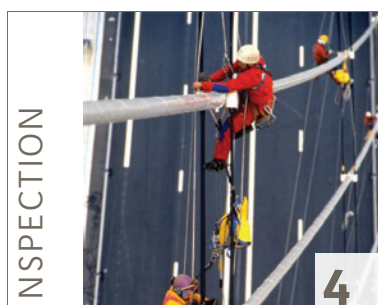
For old structures with stay cable systems that are difficult to inspect, maintain and modernise, such as cables injected with cement grout, Freyssinet provides instrumentation solutions for real-time monitoring of stay cable ageing.

### Specialist maintenance

Through regular operations on the secondary components with the shortest service life, Freyssinet maintains essential durability functions, thereby guaranteeing optimum service life.

### Modernisation

Stay cable technology changes rapidly, and significant progress has been made over the last decade in terms of functionality, strength and durability. Freyssinet has therefore developed exclusive techniques that enable customers to modernise existing stay cable systems by adding new functions: increased corrosion protection, installation of fire protection, improved aerodynamic performance, etc.



# YOUR PARTNER PRESERVATION

## Replacement

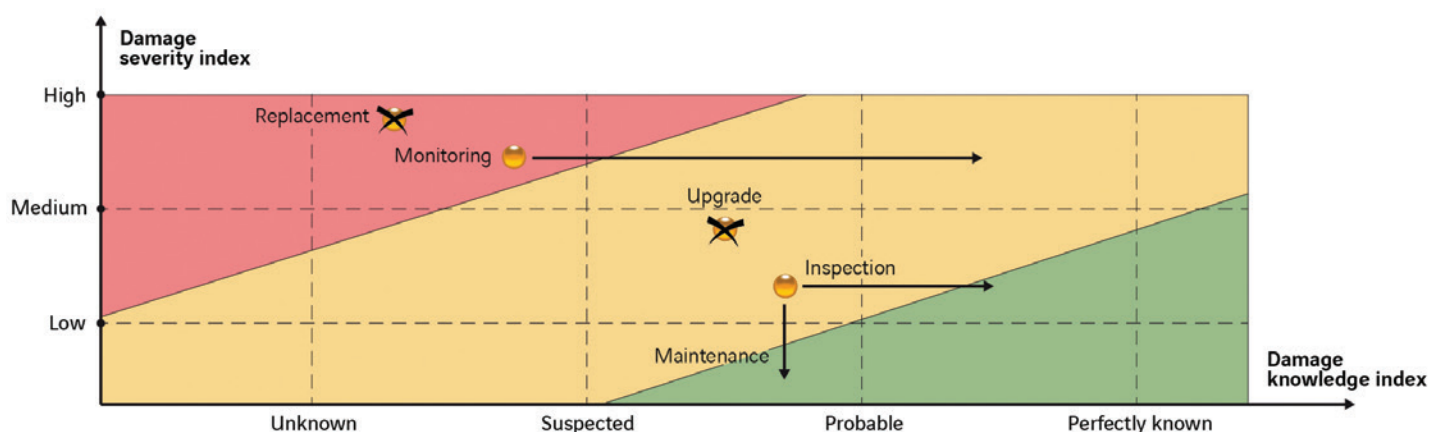
When a cable reaches the end of its service life or when its integrity is compromised as a result of an extreme event, Freyssinet is able to rapidly replace it with a hanger, a carrier tendon or a modern stay cable.

## Maintaining operation during work

To reduce the inconvenience caused to the operator in terms of traffic and protect user safety, Freyssinet has developed special access equipment used by specialist personnel operating under very strict work procedures.

This means that disruption to the operation of the structure is generally kept to a minimum.

### Inspection, monitoring, maintenance and replacement strategy



The natural ageing of technology eventually leads to certain failures (faults) which in turn accelerate the ageing of the system: a faulty seal in an anchor or poor fatigue resistance of an element, for example.

The criticality of a fault is associated with its severity, weighted by the knowledge we have about it. The more serious a fault and the less is known about it, the greater its potential for harm (orange and red zone). Conversely, a fault of little consequence in terms of strength and durability of the system, and which is also well known and monitored, will be considered as minor (green zone).

All types of maintenance are designed to eliminate (through modernisation or replacement) or reduce (through maintenance) the severity and improve the level of understanding of these defects (through inspection and monitoring), in order to optimise the system's service life.



# INSPECTION



Visual inspection of stay cables

**Regular inspection and instrumentation of the cable-staying system provide better knowledge about its performance over time and mean that defects can be detected and maintenance action taken as soon as necessary, before the wear has any negative impact on the system's performance and functions.**

## Visual inspections

- Inspection of visible parts by human or robotic means: corrosion of metal parts, ageing of sealing materials;
- Opening of anchor covers and outer sheaths on the main run of the stay cable;
- Opening of deviators and dampers and inspection of internal mechanisms;
- Fibre-optic inspection inside anchors.

## Stay cable tension and vibration behaviour measurement

- Anchor tension adjustment using annular jacks;
- Force measurement using the vibrating wire method;
- Permanent tension monitoring by means of force sensors installed in anchors.

## Detection of the effects of corrosion and fatigue

- Ultrasound detection of weakened cables in anchor zones.

## Spotlight on an exclusive process:

### UScan, ultrasound fault detection in wires and bars

The UScan ultrasound inspection system is used to detect and locate faults such as breakages, cracks or reductions in transverse cross-section, in steel prestressing wires. It applies to all types of prestressing tendon or stay cable, provided that the end of the wire is accessible.

#### Advantages

- Very sensitive and highly reliable
- Long detection range
- Quick
- Measurements performed from the end of the strand
- Enables early detection of faults and maintenance





# INSTRUMENTATION



*Stay cable fitted with an accelerometer*

**Freyssinet and Advitam provide instrumentation solutions for real-time monitoring of stay cable ageing. These solutions are particularly well suited to old structures with systems that are difficult to inspect, maintain and modernise.**

### Stay cable vibration behaviour monitoring

- Cable vibration monitoring by accelerometer.

### Detection of the effects of corrosion and fatigue

- Acoustic monitoring of highest-risk stay cables and installation of alarms triggered by the breakage of the wires that make up the cables.

### Geometric monitoring

- 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) and detect any defects (reduction in Young's Modulus, strand slippage, etc.).

### Structural design

The measurements provided by the instrumentation can be cross-referenced with a structural analysis in order 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 and fatigue, therefore enabling action at the right time, in the right place. By providing a better understanding of changes in the condition of stay cables, it allows for optimum management of cable replacement operations. The process has been instrumental in saving numerous structures over the last decade.



# SPECIALIST MAINTENANCE



Opening of anchor covers for inspection

Through regular operations on components with the shortest service life, specialist maintenance is used to maintain essential functions and guarantee optimum service life of the entire stay cable system.

## Overhaul of corrosion protection devices

- Cleaning from tube drains to allow water drainage at the low point of the cable stays;
- Retouching protective paint or coatings on metal parts;
- Retightening of stuffing boxes.

## Stay cable tension adjustment

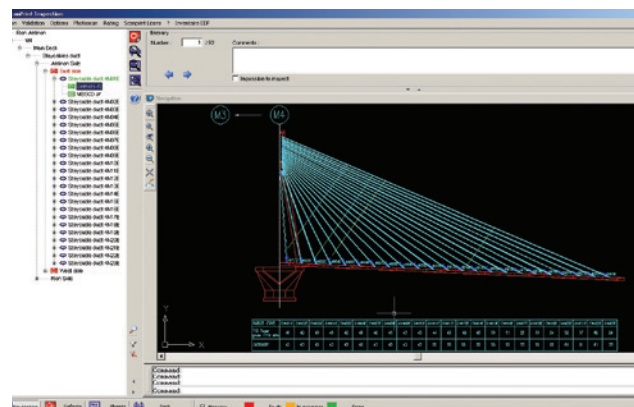
- Partial detensioning or retensioning of stay cables using an annular jack;
- Retensioning using the Isotension® system.

## Maintenance after extreme events such as earthquakes, storms and lightning strikes

- Checking fastenings between sheaths and anchors;
- Replacement of faulty or damaged parts.

## Spotlight on an exclusive process: ScanPrint®

ScanPrint® is a software package for the long-term management and monitoring of infrastructures, particularly cable-stayed structures. It can be used to organise all of the parameters and documents relating to structures and store monitoring information year after year: inspection, diagnostics, instrumentation. The tool's functions include analysis, engineering, automated reports, scheduling and expert planning of maintenance operations.





### Wear part replacement

- Replacing elastomer cover seals;
- Replacing dynamic damper components.

### ScanPrint® inspection and maintenance work management system

- Mobile inspection result storage unit;
- Database records information by date and position on the structure;
- Maintenance work management and scheduling module.



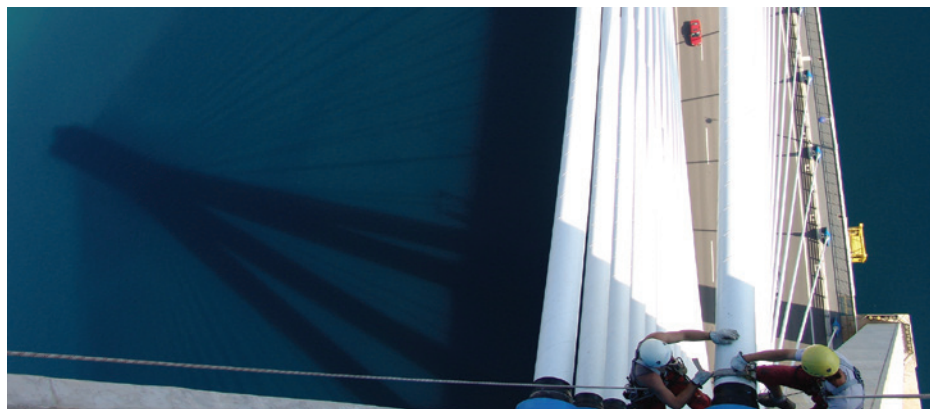
1 - Repainting of locked-coil cables

2 - Maintenance of dampers

### Find out more:

## Maintenance contracts

Specialist Freyssinet teams regularly inspect the stay cable systems on several major structures in accordance with the maintenance plan established at the time of commissioning. In addition to an external visual inspection carried out once a year, these operations include the less frequent sample opening of certain critical elements of the system such as the anchors and dampers to check that they are performing correctly over time.



# MODERNISATION



Installation of aerodynamic sheaths on existing stay cables

There have been significant developments in the state of the art of stay cable technology over the last decade. These include widespread implementation of system performance tests, in relation to sealing for example, improved knowledge of cable vibration phenomena and how to prevent them, and greater understanding of structure operating risks.

## Improved anchor drainage and sealing

- Drilling of drains in form tubes and bearing plates;
- Drainage and wax reinjection of anchor zones: Freyssinet has developed a special technique used to drain the filler from anchors, including from inaccessible parts. The drained anchor can then be reinjected using the latest techniques to obtain complete filling of the anchor;
- Stuffing box sealing can be supplemented using sealing products with proven fatigue resistance and performance over time.

## Improvements in relation to the effects of ageing

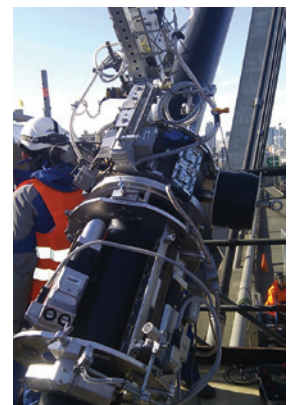
- Installation of UV-stable sheaths;
- Reapplication of corrosion protection coatings;
- Specific corrosion protection treatment for metal form tubes.

## Reduction in vibrations and their dynamic effects

- Installation of aerodynamic sheaths on cables without them.

## Spotlight on an exclusive process: Freyssilix Robot

The helical ribs placed on a stay cable sheath are known to effectively reduce vibrations caused by the rain and wind. Today, they are commonly used in state-of-the-art stay cable technologies. For systems not originally equipped with this technology, Freyssinet provides exclusive robotic technology that can be used to fit HDPE sheaths with this type of rib. The shape and pitch of the rib are adapted to the specific method of installation. Climatic wind tunnel tests have demonstrated the efficiency of the system in terms of vibration reduction. The robotic installation ensures proven and consistent welding quality, eliminating the need for major operations performed by workers at height.





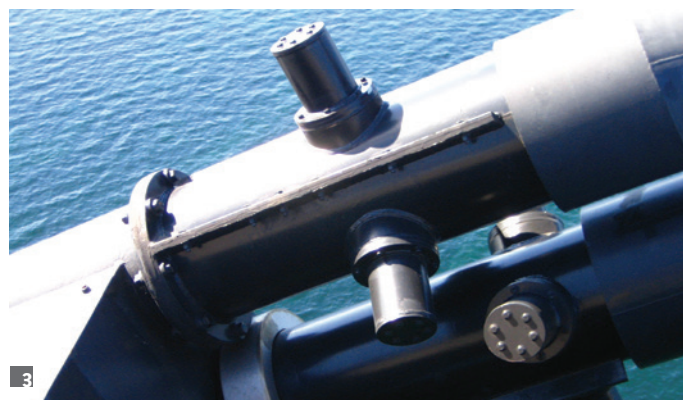
- Freyssilix: automated welding of helical ribs onto smooth plastic sheaths, reducing instabilities caused by a combination of wind and rain;
- Stay cable vibration control and reduction through the addition of dynamic dampers;
- Filtering of bending moments in anchors through the installation of deviators or overhaul of original deviators;
- Securing of wedges in their anchor blocks.

### Increased bearing capacity

- Addition of strands to unsaturated anchor blocks;
- Replacement of strands by new strands made of higher quality steel.

### Protection against new risks

- Improved stay cable fire-resistance through application of special heat protection on lower runs;
- Improved lightning protection;
- Blast resistance.



1 - Draining the filler  
2 - Maintenance of upper anchor guide  
3 - Installation of dampers on an existing structure

## Find out more: Fire protection

In areas at risk of exposure to hydrocarbon fires lasting several hours, Freyssinet provides an exclusive fire protection solution consisting of a factory-moulded casing that ensures a thermal barrier that preserves the stay cable's bearing capacity during the fire. In transition areas where factory moulding is difficult, the insulating material is applied manually or sprayed on. The surface is then smoothed to the desired finish. A coloured coating can be applied upon request.



# REPLACEMENT



H1000 cables on the Las Americas Bridge in Panama

**When damage to the stay cable system is severe and irreversible due to ageing or an accident, complete or partial replacement using modern technology must be envisaged. Freyssinet has unrivalled experience in these complex operations, in which the capacity of the structure, the specific installation methods and operating constraints must all be taken into account to find the solution that causes the least disruption to the structure and its operation.**

Freyssinet performs the work with the structure still in service and implements a stringent safety plan to ensure the safety of users and workers.

Following an exceptional event such as an accident, Freyssinet is able to set up specific logistics for replacement with a temporary stay cable in just a few days, and replacement with a permanent stay cable in a few weeks.

## *Spotlight on a project:*

### **Penang Bridge (Malaysia)**

An evaluation of the structure, built between 1996 and 1999, showed a high degree of overload in the shortest stay cables anchored near the towers. Two broken bars were then detected in other elements, which led to their replacement and the installation of an acoustic monitoring system on all the other stay cables. This allowed us to detect other breaks and to identify fatigue vulnerability in the couplers of the bar system comprising the stay cables, leading to the complete replacement of all 144 stay cables. Freyssinet conducted this operation, without interrupting traffic, within the scope of a design and construction service. Auxiliary cables, temporarily secured to the bridge deck and towers, enabled the dismantling of the stay cables one by one, the coring of concrete structures and the installation of modern technology based on parallel strand stay cables.





Freyssinet's technical and operational teams provide integrated management of issues raised by replacement operations.

### Structural analysis

- Establishment of the cable-by-cable replacement diagram and checking of each construction phase;
- Establishment of possible traffic restrictions during performance of the work.

### Installation of temporary stay cables

- Connection of anchor components to towers and deck;
- Hoisting and anchoring of temporary stay cables;
- Load transfer from defective stay cable to temporary stay cables.

### Stay cable detensioning and dismantling

- Cutting/dismantling of stay cable;
- Disconnection of anchor heads from structures;
- Removal of parts with minimal disruption to the operator.

### Installation of a new stay cable

- Use of modern installation techniques;
- Load transfer from temporary stay cables to the new stay cable;
- Detensioning and dismantling of temporary stay cables;
- Tension adjustment in all stay cables, if necessary.

1 - Stay cables damaged by a vehicle fire  
2 - Temporary replacement cable  
3 - Device for lowering cable to be replaced



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Peru  
El Salvador  
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Venezuela

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