RINA

Smart Monitoring

RINA provides a wide range of services across the Energy, Marine, Certification, Transport & Infrastructure and Industry sectors through a global network of 170 offices in 65 countries.

RINA is a member of key international organisations and an important contributor to the development of new legislative standards.

RINA consists of the parent company RINA S.p.A., the holding which controls the main sub-holdings RINA Services S.p.A. and RINA Consulting S.p.A. In order to ensure compliance with the applicable recognition, authorization, notification and accreditation rules, including those relevant to the management of impartiality, RINA has adopted a governance and organizational model. According to this model, the sub-holdings are subject to direction and co-ordination by the holding in the finance, administration, strategic, organizational, managerial and business continuity fields, while technical and operational decisions remain under the exclusive responsibility of the sub-holdings and their controlled companies.

The strict separation of duties in the governing bodies and the impartiality risk assessment, which identifies and manages the impartiality and conflict of interest threats coming from the company relations, ensure compliance with the applicable impartiality rules.

Smart Monitoring (SM) is an emerging approach that is proving to be very effective in the integrity management of civil and industrial assets, allowing the development of optimized lifecycle approaches. Asset owners see the benefits of systems able to continuously monitor the state of complex structures and to characterize them during construction, operation, repair or upgrading phases.

OVERVIEW

RINA offers SM services in the civil and industrial engineering fields, providing a wide range of related services.

Why RINA

RINA, thanks to its experience in most industrial sectors and to the multidisciplinary expertise of its staff, is able to:

- Provide independent technology scouting and feasibility analysis during system design
- Support the asset owner offering a "package" of integrated services to improve the decision making process
- Provide turnkey solutions tailored to Clients' needs, offering a complete technical and administrative project management
- Provide a cost-benefit analysis & HSE risk assessment and guarantee adequate operational HSE standards
- Organize a complete system set-up (e.g. training of staff, developing operative procedures, alert simulations and reaction)

Applications

RINA has specific competence and experience in the development of SM solutions for the following asset types:

- Bridges and buildings
- Dams and dikes
- Railways
- Tunnels
- Pipelines
- Geotechnical and metocean assets
- Fixed / Floating offshore structures, berths & ships
- Power plants
- Special assets

KEY SERVICES

- Provision of technology-independent scouting and feasibility analysis
- Monitoring system design, through selection and integration of the most appropriate technologies (open approach)
- Inspections, surveys, Factory Acceptance Tests (FAT), installation, Site Acceptance Tests (SAT) and training, system commissioning & maintenance
- Development, calibration and update of numerical models of the asset
- Assessment of loading conditions, structural response and safety levels under real operational conditions
- Identification of behavioral anomalies and evaluation of their impact on system reliability, availability and durability
- Estimation of the residual life of main/critical structural components
- Investigation of the structural behavior of the system through numerical multi-physics analysis to provide threshold settings
- Remote and on-site data collection, storage, handling, mining, validation and visualization
- Advanced data analysis and processing to provide “operationally relevant information”, including anomalies and damage detection
- Generation and online management of (early) warnings and alarms
- Remote access support via web and integration with Client’s SCADA main frame server

KEY BENEFITS

- Enhanced safety level for people, property and environment, due to early damage detection and early warning systems
- Increased knowledge of the asset structural behavior under operational and exceptional conditions
- Enhancement of confidence levels when introducing new design solutions, materials or construction processes
- Optimization of Inspection, Maintenance and Repair (IMR) programs and support to Condition-Based Maintenance (CBM) approaches
- Validation of structural strengthening phases
- Asset life extension assessment based on monitoring data analysis, which helps assessing the actual asset condition and determine whether repairs are actually needed or not
- Quick access to structure safety information after a major extraordinary event
- Design and construction validation: monitoring helps assessing the correctness of design previsions and construction results, verifying that the structure performance meets design specifications

BRIDGES AND BUILDING MONITORING SERVICES

During the design phase of a structure, RINA assists Clients with the seamless integration of the SM system design. This phase is strategic, for instance in order to shape the best possible offer for a tender or simply to get a resilient and affordable SM system able to optimize the maintenance process during the asset's lifecycle.

The monitoring program also plays a fundamental role throughout the construction phase as it enables the verification of design hypotheses and construction processes, affecting, in some cases, the construction rate of the structure and its overall quality.

During operational phase, SM provides reliable data on the actual condition of the structure, observes its evolution and detects the appearance of new degradations, which can have several causes. A real-time snapshot of the current state and evolution of a building or bridge can be achieved by permanently installing sensors and continuously measuring relevant parameters.

Moreover, data resulting from monitoring programs allow owners to improve operation, maintenance, repair and replacement of structures, based on reliable and objective data. Detection of ongoing damage can be used to identify deviations in design performance values.

Especially for bridges, monitoring can be used as a tool for the "supervised lifetime extension" of the structure approaching its end of life or in need of major repair. It ensures that such bridges are operated safely while allowing the postponement of major investments and traffic disruptions.

Finally, the implementation of monitoring systems with high accuracy, reliability and robustness can add technological credits and prestige to the asset, eventually leading also to a possible decrease in insurance premiums and maintenance costs.

DAMS AND DIKES MONITORING SERVICES

RINA is developing SM programs in order to monitor the structural integrity and safety of dams and dikes operations. Running real-time continuous monitoring allows owners to take immediate decisions and corrective actions regarding a dam's reservoir, body or foundation if problems arise.

Monitoring also plays a fundamental role during construction, potentially enabling the verification of design hypotheses and improving the construction rate of critical components. Monitoring is particularly important during the initial filling of the reservoir, a crucial phase in the life of a dam. Moreover, SM data can help develop technologies that meet current and future standards for dams and dikes, ensuring their compliance with regulations.

The objectives of the employed monitoring approaches depend on the potential risk associated with the structure and on site characteristics, such as:

- Dam / dike type and height
- Extent of potential damage to people and properties located in flood zone
- Reservoir and spillway capacity
- Site seismicity
- Stability of the reservoir slopes
- Foundation weakness zones

The types of measurement to be carried out as well as the instruments location must be selected according to the particular conditions of the foundation and of the structure itself. The following are among the main phenomena to monitor:

- Piezometric level within the dam and the surrounding areas
- Leakage through foundations and dam / dike body
- Dam / dike and foundation stresses and displacements
- Stability (displacements) of slopes affecting the reservoir

RAILWAY MONITORING SERVICES

Focusing on railway systems, RINA monitoring services are twofold.

On the one hand, monitoring can be provided in order to assess the safety of the railway during the execution of potential damaging activities nearby, such as construction works, excavations, etc. In this case, special attention is needed in order to avoid deviations - absolute and relative - of the rail axes. In this context, control systems can be designed to measure:

- Rail-bed moisture
- Vibration on board box cars
- Various points of strain and load
- Clope stability of tracks

On the other hand, monitoring solutions are also provided to assess vibrations and noise levels produced by passing trains. Our interdisciplinary nature allows us to perform fast ad-hoc simulations of wave propagation in order to get preliminary and complementary information useful for the effectiveness of the monitoring system.

RINA also provides bespoke solutions for a wide variety of sensors and communication peripherals, customizing them to be rugged, low power, and reliable even in harsh and remote locations.

Our monitoring activities for railway infrastructures include:

- Dynamic monitoring of rail / sleeper deformation during the transit of trains
- Monitoring of thermal quasi-static rail deformation
- Detecting abnormal train pressure on the rails
- Monitoring of railway switch deformation during transitions
- Structural monitoring of noise barriers
- Monitoring of subsidence events below rails / sleepers

TUNNEL MONITORING SERVICES

Focusing on the safety of tunnels, RINA is developing SM programs in order to detect early damage or anomalies and evaluate their impact on system reliability, availability and durability, estimate the residual lifetime, assess the response of the structure under real operations, optimize maintenance and repair, etc. Monitoring plays an important role at every stage of a tunnel's life:

- At the design stage, when exploration tunnels are used
- During construction, to accurately evaluate the impact of geological conditions, the effect of tunnel excavation on nearby structures and the environment, and to optimize the construction methods themselves. Indeed, modern tunneling methods are substantially based on observational approaches that allow optimizing the supporting structures and speeding up excavation
- Once the tunnel is in service, to enable long-term monitoring thus ensuring the safety of the tunnel over its entire life span, even correlating the structural response with site and environmental conditions

Various instruments are used to accurately determine the key parameters of structural behavior and to monitor their rate of change. It is possible to observe movement stabilization or, in the case of acceleration, to deduce the likelihood of failure. The comparison of measured values with expected values enables the assessment of tunnel stability and makes it possible to timely implement corrective measures. Moreover, in addition to the general benefits described in the introductory section, monitoring tunnels has the following specific advantages:

Safety Margin Increase

Accurately monitoring tunnels to determine the current condition of the structure allows owners to increase safety margins without any work on the structure

Improved Knowledge of Tunnel Design

Increased knowledge of tunnels structural behavior helps optimize shapes and thickness of metallic frameworks when new construction technologies are used

PIPELINE MONITORING SERVICES

Modern pipeline management needs to assure pipeline integrity, immediate leakage detection and intrusion risk mitigation. Present-day oil & gas and water pipelines thus require real-time and continuous monitoring to optimize their economic and operational performances. In this scenario, RINA offers SM services and customized Pipeline Management and Safety Solutions for the integrity management of pipelines networks.

In addition to the general benefits described in the introductory section, pipeline monitoring has the following specific advantages:

- Increasing environmental awareness and safety
- Increasing security when using a pipeline monitoring system with a twofold role: leakage & anti-intrusion detection
- Reliable detection of even small leakages

The most promising and cost-effective solutions for the safety assessment of pipelines are:

- Distributed solutions: using a fiber optic-based leak detection & anti-intrusion system based on the analysis of temperature or vibrations anomalies along the pipeline network
- Multiple acoustic sensing: using a distributed network of acoustic sensors able to detect leaks by analyzing the induced pressure wave
- Discrete hybrid solutions: using a network of different sensors (pressure, ultrasonic, microwave, thermographic etc.) and/or statistical analysis of pipeline parameters to detect leaks and/or damage

The types of measurement to be carried out, as well as the equipment location, must be selected according to the particular conditions of the pipeline and its layout. RINA know-how allows us to provide monitoring solutions for all the main pipeline threats, such as:

- Soil movements
- Intrusion
- Leakage
- Pipeline corrosion
- Pipeline deformation

GEOTECHNICAL AND METOCEAN MONITORING SERVICES

Geoscience SM services focus on the interaction of structures and infrastructures with soil, water and atmospheric agents. Monitoring actions increase the reliability of engineering assessments and lead to cost-reductions while maintaining high safety-levels. Geoscience-based monitoring services include subsidence monitoring, slope stability monitoring and modeling, and integrated Metocean and Smart Monitoring (MSM).

Subsidence is a key-issue in hydrocarbon extraction because of environmental constraints. There are few reliable technologies for offshore monitoring due to the shading effect of seawater on GPS and interferometry signals. RINA developed an innovative monitoring system based on an array of self-leveling tilt-meters integrated with a GPS platform. The system can reconstruct subsidence bowls over time following seafloor settlements.

Slope Stability Monitoring is strictly related to geotechnical modeling to understand available stability margins under human and environmental loads. RINA has a broad experience in this field, from onshore to offshore applications, providing multifunctional solutions ranging from concept desk-studies to system installation, processing, and results interpretation. The monitoring data can be used for modeling and risk assessment.

Metocean and Smart Monitoring (MSM) systems use sensors to monitor metocean and structural parameters. Typical metocean instrumentation includes wind sensors, pressure sensors and current meters. Structure response is measured by accelerometers, inclinometers and strain gauges. The MSM methodology follows correlated steps: definition of local metocean parameters and structure characteristics; design and installation of ad-hoc equipment; metocean data analysis, statistics and reference load analysis – operational modal analysis; measurement of combined metocean forces on structure; verification of design data vs. local climate; evaluation of extreme and typical metocean conditions.

Our SM services in the geotechnical and metocean field include:

- Design and implementation of bespoke HW/SW solutions for combined metocean/structural/subsidence/slope stability monitoring
- Calibration of metocean and structural models to improve predictions
- Guaranteeing adequate operational HSE standards

FIXED / FLOATING OFFSHORE STRUCTURES AND BERTHS MONITORING

Oil & Gas offshore facilities are subject to continuous loads and excitations due to both the site-specific environmental conditions and the operational conditions. Such stresses play an important role in the definition of the operability windows as well as of the facilities lifetime.

To that end, continuous monitoring of the main parameters that induce loads and excitations is a remarkable tool for oil companies and ship - owners to predict the necessary maintenance activities, resources allocation and, ultimately, the residual lifetime of a structure. It can also contribute to a best estimate approach in the assessment of day-to-day operating windows.

In this context, RINA offers various SM services, of both the campaign inspections and real-time monitoring type, for the integrity management of Fixed / Floating Offshore Structures and Ship Shaped Floaters (FPSO, FSO, FSRU etc.).

Systems implemented by RINA are based on the most innovative and cost-effective approaches and technologies, able to continuously operate under the most severe environmental conditions for the whole floater/ship lifetime.

Our services include:

- Structural integrity monitoring and assessment of loading conditions and safety level of topside structures
- Ship hull stress monitoring
- Health assessment of the main structures subject to stresses affecting lifetime
- Assessment of particular parts of special floaters such as the stinger for pipe-lay vessels, the derrick for drilling ships/floating platforms, and the jack-ups legs
- Identification of anomalies and evaluation of their consequences for system reliability, availability and durability
- Monitoring fatigue life consumption
- Providing real-time information on stresses and acceleration levels affecting the main structures, with warning signals when preset threshold values are exceeded
- FEM model calibration by considering the actual load on the structures directly measured during their operating service and subsequent updating of the fatigue assessment

POWER PLANT MONITORING SOLUTIONS

RINA offers SM services, of both the campaign inspection and real-time monitoring type, for the integrity management of power plants components. Rotating machines (turbines, fans, large pumps) and items subject to fouling & wear (coal storage, distribution, pulverization mill) have a major impact on plant availability and efficiency, so real-time monitoring is highly recommended for these critical components. On the other hand, a periodical monitoring approach can be adopted for equipment provided with redundancy and/or not critical. SM output data will facilitate decision making and an efficient and cost-effective planning of operation & maintenance, at both equipment and plant level. Our SM services will help our Clients to:

- Monitor equipment condition, detecting faults early on, minimizing fouling, leakage and wearing and reducing downtime for maintenance
- Optimize preventive maintenance programs
- Optimize plant performance/efficiency
- Optimize plant assets
- Analyze residual life, reducing warehouse stocks of expensive spare parts / items
- Perform what - if analyses (operating scenarios, revamping works, etc.)

Taking a wind farm as example, the implementation of a real-time monitoring system focused on critical and essential equipment allows optimizing maintenance and reducing direct costs of mechanical and electrical repairs. In particular, a monitoring system based on CBM (Condition Based Monitoring) technology can predict the onset of a problem, identify it and avoid downtime and secondary damage. A SM system based on a network of accelerometer sensors can support the wind farm operator by means of:

- Operational modal analysis and fatigue life evaluation
- Extraction of modal parameters (e.g. modal frequencies, modal shapes and damping coefficients)
- Data spectrum analysis and identification of anomalies / damages

The above mentioned approach can also be used for power lines monitoring, for example:

- Power cable tunnels
- Underground power cables
- Submarine power cables
- Substation equipment
- Overhead lines

Distributed temperature technologies can provide continuous monitoring of high power cable temperatures, detecting hot spots, delivering operational status, condition assessment and power circuit rating data, helping operators optimize the transmission and distribution networks.

SPECIAL ASSET MONITORING SOLUTIONS

RINA's competence in the SM field is illustrated by our capability of applying SM services to special assets. The creation and implementation of a Smart Monitoring system for the VEGA launcher ground segment, as described below, is an excellent example of our experience with special assets. RINA has contributed to the success of the maiden flight of the new European launcher VEGA, which lifted-off from the spaceport of Kourou, in French Guiana on February 13th, 2012. We installed a structural monitoring system on the VEGA launcher "Ground Segment" in September 2011.

The ZLV launch area includes a permanent civil structure (the Bunker) and a mobile building (Mobile Gantry). RINA was involved in the following project phases:

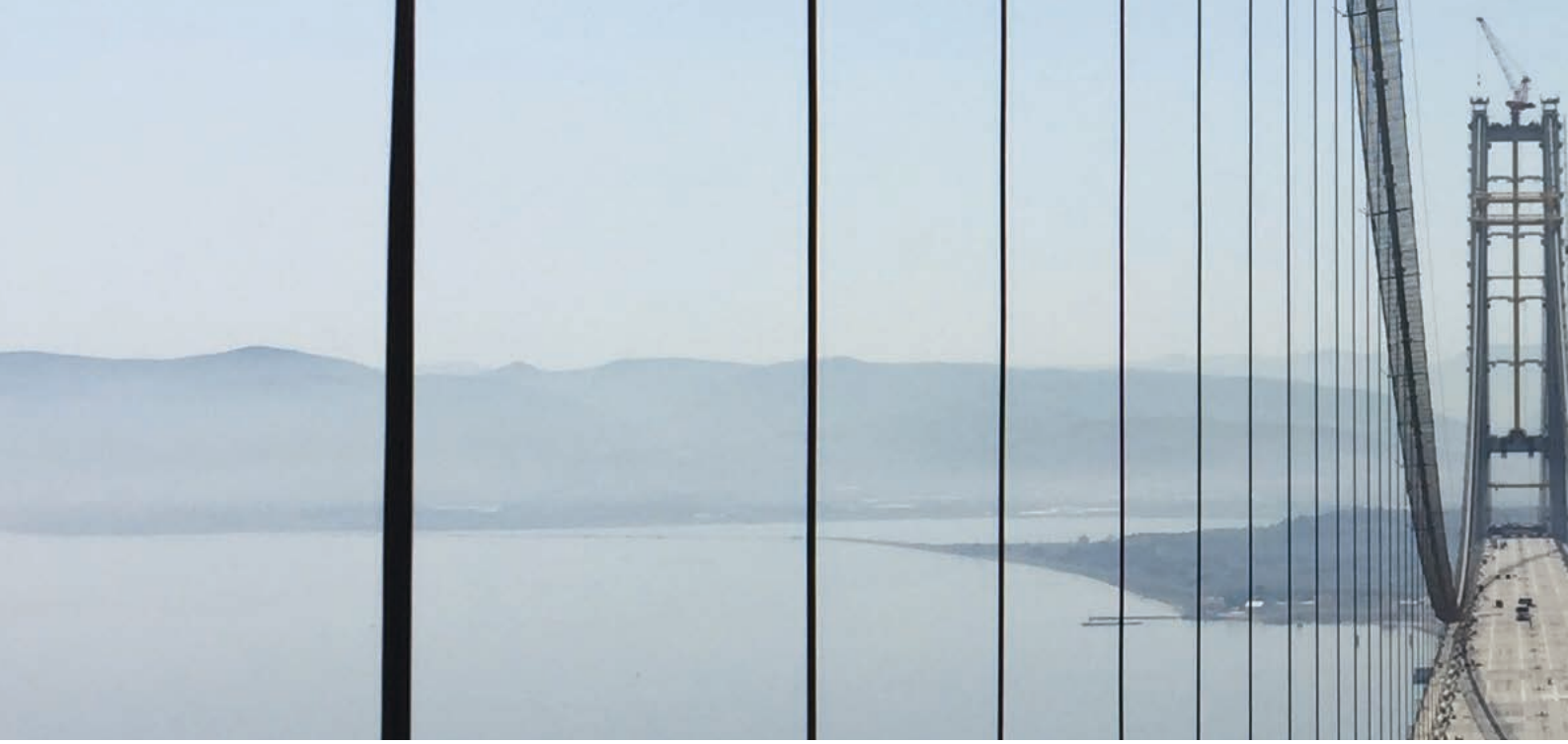
- SM system installation and setup for work activities
- Test plan, procedures and test results
- Data post-processing and final reports

The SM system was installed to provide an accurate assessment of the health status of the Vega launcher infrastructures, which are subject to environmental, vibrational, thermal and acoustic stresses both during the launcher assembly and lift-off phases. The innovative system, mainly based on optical fiber sensors, has been designed, integrated, validated and employed during the first VEGA launch from Kourou (French Guiana) on February 13th, 2012. In particular, the sensors network has been installed on the Mobile Gantry, Mast, Bunker and Launch Table. The scope and the output of this project is the continuous monitoring of the structure, through the real-time acquisition of the dynamic and quasi-static deformation induced by environmental stress and launch phase. The correct integration of these sensors has allowed us to identify and extract the deformation, pressure, and vibration values and the acoustic profile both in the preliminary phase and during the lift-off phase. The successful measurements allowed us to validate the design hypothesis and models in terms of:

- Strain
- Sound pressure
- Temperature
- Vibrations

The system will also provide a useful support for estimating the infrastructure life-cycle, thus allowing a better planning of maintenance operations.

The VEGA SM system is now fully operative and a dedicated data post-processing report is issued after each VEGA Launch Campaign. A further improvement of the SM system for the next campaigns is the implementation of a real-time SW platform for the SM system management. Moreover an upgrade of the SM system is envisaged for the next program VEGA-C.



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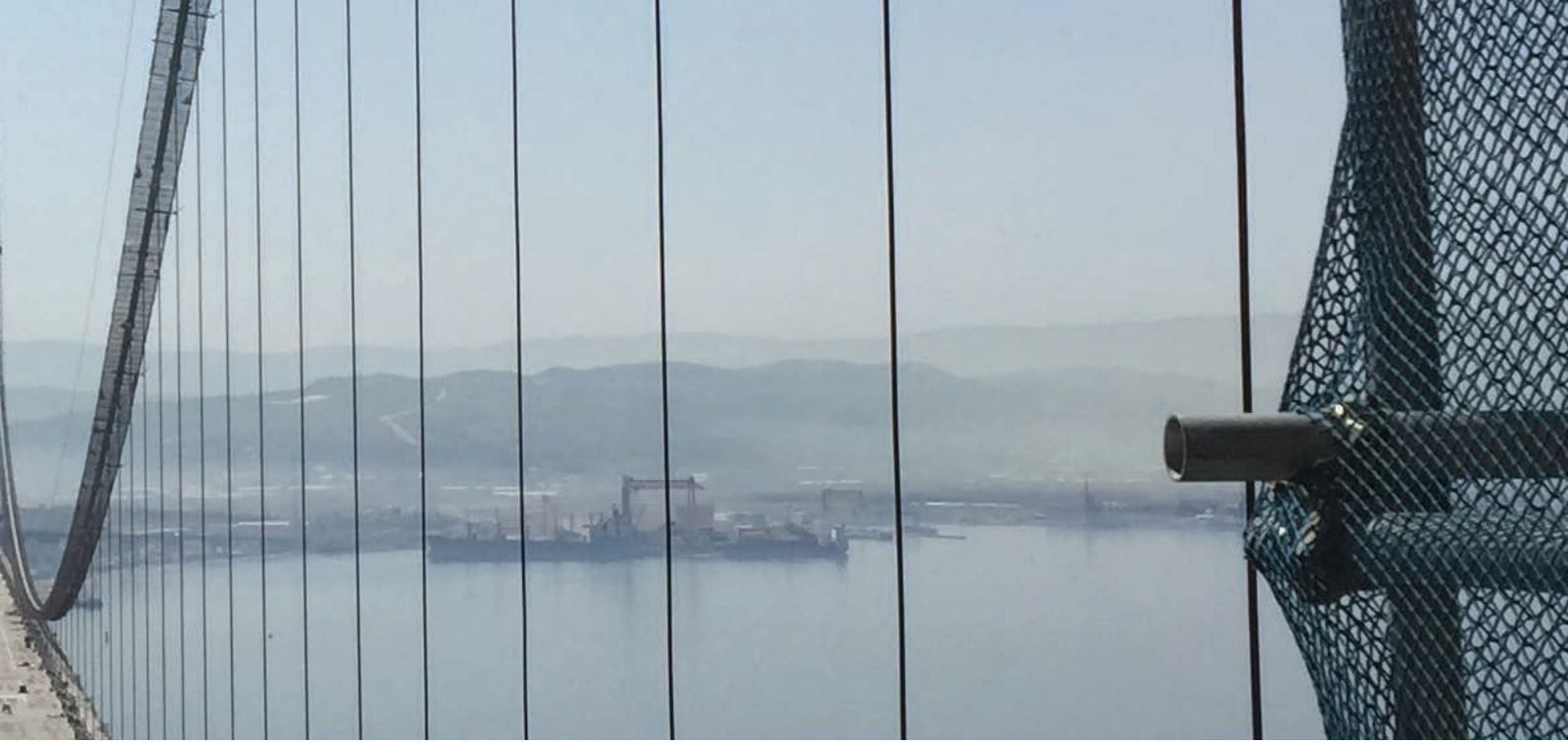

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