Project References - Monitoring Systems
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Ponte Nanin (Switzerland)

Project description
During refurbishment works to this structure in 2004, over forty years after it was built, modifications to the bridge were carried out to accommodate increased traffic. These changed the bridge’s static system, with several of its pillars newly monolithically connected to its deck, meaning that all movement now occurs at one end.

Some of the bridge’s bearings, which were originally designed to allow sliding movement of the deck, were modified to now act as fixed bearings.

In order to provide ongoing confirmation that the impacts of the changes to the bridge’s structural system are as anticipated, and that the structure continues to function properly and safely, a monitoring regime was instigated.

mageba scope
The main concern following the refurbishment of the bridge related to the flow of forces through the structure.

By measuring the loads in the bearings and observing the force distribution in the bridge structure, these concerns could be immediately allayed based on initial measurements.

The permanently installed system was then adapted to prove the durability of the modified system on an ongoing basis, with particular attention to the structure’s bearings and expansion joints.

For added confidence, the system is equipped with an alarm feature, designed to notify the responsible engineer by email and SMS should any measured value ever exceed its threshold value.

Highlights & facts
mageba products:
Type: RESTON®POT bearings
ROBO®CONTROL automated SHM system
Measures: Displacements, forces, structural temperature
Installation: 2004, still operational

Structure:
City: Mesocco
Country: Switzerland
Completed: 1967
Type: Concrete arch bridge
Length: 192 m
Designer: Christian Menn

The bridge carries Highway A13 / E43 through the Swiss Alps, near the Italian border
A RESTON®POT bearing with a pressure sensor, enabling bridge deck forces to be measured
A solar panel on the bridge meets the system’s energy needs – ideal in remote locations
Dintel Harbour East Bridge (Netherlands)

Project description
The Dintel Harbour East Bridge, which opened in 2001, is located in the port of Rotterdam, one of the world’s busiest ports. Together with the adjacent cable-supported West Bridge, it spans the waterway that leads to Dintel Harbour. It is a pre-stressed reinforced concrete structure, with a main span of 185m and side spans of 86.5m, and thus a total length of 358m.

In 2010, the bridge owner decided to undertake a very detailed assessment of the bridge’s condition, and to closely monitor its condition on an ongoing basis. It was decided that a structural health monitoring (SHM) system should be used, to optimise both processes.

mageba scope
mageba supplied and installed a ROBO®CONTROL SHM system to support the bridge’s short-term assessment and long-term monitoring needs.

A permanent “Advanced” system was designed to monitor the structure’s condition and performance, with a particular focus on weather conditions, traffic loading and the bridge’s structural response to these influences.

In doing this it uses a range of sensors to measure displacement, inclination, strain, acceleration, traffic loading, solar radiation and structural temperature.

After installation, the system was calibrated by measuring the structure’s response to loading, both static and dynamic, from a heavy truck of known weight.

Highlights & facts
mageba products:
Product: ROBO®CONTROL SHM system
Type: Permanent “Advanced”
Installation: 2005

Structure:
City: Rotterdam
Country: the Netherlands
Completed: 2001
Type: Reinforced concrete road bridge
Length: 358 m
Owner: Rijkswaterstaat

The bridge is located in Europoort, part of the port of the city of Rotterdam.

Installation and calibration of the ROBO®CONTROL SHM system

A solar radiation sensor, as installed on the bridge.
Steinbach Viaduct (Germany)

Project description
The Steinbach Viaduct in central Germany carries the A38 autobahn across the Steinbach Valley. It has a length of 372 m, with spans of between 54 m and 78 m, and a maximum height of 35 m. Its construction was completed in 2002, with expansion joints installed at both ends.

However, the bridge was not opened to traffic until several years later, in its first years carrying only the construction traffic involved in the construction of the motorway at either side. Due to the potential effects of the heavy construction traffic on the structure’s slim deck, it was decided to install an automated SHM system to monitor the traffic and its effects.

mageba scope
At the time of the bridge’s construction, TENSA®MODULAR expansion joints were installed in its deck – a 5-gap (LR5) joint at one abutment and a 6-gap (LR6) joint at the other. Several years later, a temporary ROBO®CONTROL monitoring system was installed, to monitor autobahn construction traffic. In addition to displacements, inclinations and strains, the high-tech system was designed to measure structure vibrations at frequencies of 100 Hz. This enabled vehicle weights and speeds to be deduced by comparing the resulting vibrations with those of vehicles of known weight and speed as recorded during system calibration. As a result, overloading of the bridge could be ruled out, enabling the owner to have full confidence in the bridge’s long-term performance.

Highlights & facts
mageba products:
Type: TENSA®MODULAR expansion joints, ROBO®CONTROL monitoring system
Installation: 2002 (expansion joints), 2005 (SHM system)

Structure:
Country: Germany
Completed: 2002
Type: Box girder bridge
Length: 372 m
Designer: Leonhardt, Andrä & Partner

The viaduct is located in central Germany, near the city of Kassel
Installation of a TENSA®MODULAR expansion joint on the bridge in 2002
The central computer of the ROBO®CONTROL monitoring system, installed in 2005


**Structural monitoring**

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## Danube Bridge Sinzing (Germany)

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### Project description

The deck support bearings of the Danube Bridge in Sinzing were observed to suffer unusually fast abrasion of their PTFE sliding discs, requiring disc replacement after just five years of service.

As a bridge bearing specialist, mageba was requested in 2007 to assess the problem and recommend a solution. It was suspected that the deck movements were higher than could be lastingly withstood by PTFE, and that the solution might therefore lie in the use of ROBO®SLIDE, a high-grade alternative to PTFE that offers far higher durability.

To support the approach, it was necessary to understand the deck's movements.

### mageba scope

It was decided to make use of modern structural health monitoring (SHM) technology to evaluate the exact movements of the bridge deck during a two-week period. The short-term nature of the project made a ROBO®CONTROL “Portable” SHM system ideal for this purpose.

A clear correlation between movement and temperature was established, with extrapolation of the recorded data indicating accumulated sliding distances of approximately 2.5 km per year. It could be concluded that these movements were the primary cause of the wear problem, and that the use of ROBO®SLIDE instead of PTFE would significantly prolong the life of the bearings – confirming the proposed solution.

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### Highlights & Facts

**mageba products:**
- **Type:** ROBO®CONTROL SHM system (“Portable”)
- **Measuring:** Displacement, strain, inclination, temperature
- **Installation:** 2008

**Structure:**
- **City:** Sinzing
- **Country:** Germany
- **Type:** Highway bridge with continuous steel deck
- **Length:** 1 km

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Rapid wear of PTFE sliding discs of the bridge deck’s support bearings required explanation

A longitudinal movement measuring sensor as installed at one of the deck’s support bearings

Strain measurement on one of the bridge deck’s steel members
Obermatt Bridge (Switzerland)

Project description
A timber bridge in Obermatt, Switzerland collapsed in 2005 during a flood period, and the cause of collapse could not be precisely determined. When it was rebuilt in 2007, it had a new safety feature: in the case of severe flooding, it can be raised by up to 70 cm to prevent damage from floating debris in the swollen river.

The main theory combined the impact of flood loading with poor timber strength resulting from high dampness. To mitigate the impact on the timber bridge industry, the University of Berne started a research project to demonstrate the durability of timber bridges if properly designed and maintained.

mageba scope
A ROBO®CONTROL automated monitoring system was installed in 2008, to measure the dampness of the bridge’s most critical elements over a period of several years. The system was equipped with an alarm feature, offering immediate notification by email and SMS if a threshold value (25%) of timber humidity was exceeded.

The measurements showed that the moisture content of the bridge’s timber was within an acceptable range, and enabled the client to understand the bridge’s performance and to recognise any changes as they occurred. The project also provided evidence of the durability of properly designed and maintained timber bridges.

Highlights & facts
mageba products:
Type: ROBO®CONTROL automated SHM system
Measuring: Moisture content
Features: Alarm notification in case of exceeding of threshold value
Installation: 2008

Structure:
City: Obermatt
Country: Switzerland
Type: Timber road bridge
Length: 32 m
Collapsed: 2005
Rebuilt: 2007

System
Permanent "Basic"
Services provided
Structural Health Monitoring
Europa Bridge (Switzerland)

Project description
The Europa Bridge in Zurich was built in 1961–1962 to provide a new crossing of the Limmat river and a number of the growing city’s important railway tracks and roads. With its overall length of over one kilometre it is one of Zurich’s most important bridge structures.

In order to aid the planning of renovation works, relating to the bridge’s expansion joints in particular, it was decided to install a structural health monitoring (SHM) system at one abutment in 2009, to survey the bridge’s behaviour – in particular its movements and rotations. Temperature and humidity data was also required in order to calibrate and allow for the impact that changes in these variables might have.

mageba scope
A ROBO®CONTROL SHM system was installed in 2009. In a first phase of operation, high-frequency analysis at 200 Hz was carried out to assess the influence of traffic on the bridge’s behaviour – which was found to be negligible. Rotations were also measured, and found to be very low about all axes - well within the range of sliding finger expansion joints, the type preferred by the owner for the easy maintenance, driver comfort and low noise benefits they offer.

The SHM system was then adapted to measure thermal movements during one complete year. With conditions in all seasons assessed, it was then possible to accurately determine the movement requirements of the new expansion joints.

Highlights & facts
mageba products:
Type: ROBO®CONTROL SHM system
Sensors: Displacements, rotations, structural temperature, humidity
Installation: 2009
Structure:
City: Zurich
Country: Switzerland
Completed: 1963
Renovated: 2010
Length: 1100 m
Incheon Grand Bridge (South Korea)

Project description
At 12.3 km long with a main cable stayed span of 800 m, since 2008 the Incheon Bridge is one of the five longest of its type in the world. Its 33.4 m wide steel/concrete composite deck will carry six lanes of traffic 74 m above the main shipping route in and out of Incheon port and link the new Incheon International Airport on Yongjing Island to the international business district of New Songdo City and the metropolitan districts of South Korea’s capital, Seoul.

The cable stayed section of the crossing is 1,480 m long, made up of five spans measuring 80 m, 260 m, 800 m, 260 m and 80 m respectively: height of the inverted Y main towers is 230.5 m. A 1.8 km approach span and 8.7 km viaduct complete the crossing, both constructed with precast prestressed concrete box girder decks. Foundations are drilled piles 3 m in diameter. Total cost is more than $1.4 bn, which is funded through a Private Partnership in Investment (PPI), the first in South Korea to involve an outside strategic investor.

mageba scope
The Incheon bridge is equipped with 76 mageba TENSA®MODULAR expansion joints. Largest expansion joint type LR24 (movement: 1,920 mm) equipped with ROBO®GRIP anti-skid surface, ROBO®SLIDE high grade sliding material and a ROBO®CONTROL remote monitoring system. Dimensions of each modular joint type LR24 (L×W×H): 16 m × 4.9 m × 0.8 m. The large dimensions and the weight of nearly 50 tons per joint, required special measures for the transport from Europe to Korea.

Highlights & Facts
mageba Products:
Type: 76 TENSA®MODULAR expansion joints (up to type LR24), ROBO®GRIP, ROBO®SLIDE, ROBO®CONTROL
Permanent monitoring system
Features: max. movement 1,920 mm
Installation: 2009
Structure:
City: Incheon
Country: South Korea
Type: Cable-stayed bridge
Length: 12.3 km

Incheon bridge: Link between Incheon Int. Airport and metropolitan districts Seoul
A mageba modular expansion joint in service
TENSA®MODULAR expansion joint type LR24 ready for installation
Run Yang Bridges (China)

Project description
The Run Yang – Nan Cha Bridge, opened in 2005, crosses the Yangtze River near the Chinese city of Zhenjiang. The cable supported structure, with a 1.49 km main span, total length of 2.5 km and 210 m high towers, is one of the longest suspension bridges in the world.

The exceptional structure required exceptional expansion joints to facilitate its enormous absolute deck movements, and these were supplied by mageba at the time of the bridge’s construction.

Several years later, mageba was also requested to assess the bridge’s larger-than-expected accumulated deck movements, in support of ongoing maintenance work and optimised long-term performance.

mageba scope
TENSA®MODULAR expansion joints with 27 individual movement gaps (a world record) were installed in 2005, each joint facilitating 2160 mm of movement.

During the bridge’s first years in service, its expansion joints and bearings were found to be suffering from accelerated wear, and the cause of this wear was believed to be very large accumulated deck movements (the total distance moved by a point on the deck during a period of time).

A ROBO®CONTROL “Portable” system was used to evaluate the movements during a two-week period. This concluded that the movements greatly exceeded expected values, and enabled the bridge engineer to optimise planning of remedial works.

Highlights & facts
mageba Products:
Type: TENSA®MODULAR expansion joints of type LR27,
ROBO®CONTROL SHM Portable monitoring system
Features: max. movement 2,160 mm
Installed: 2003–2009

Structure:
City: Zhenjiang
Country: China
Built: 2005
Type: Suspension bridge
Length: 2,500 m
Owner: Jiangsu Provincial Yangtze River Highway Bridge Construction Commanding

System
Portable “Basic”
Services provided
Inspection & Measurements
River Suir Bridge (Ireland)

Project description
The River Suir Bridge is part of the N25 Waterford Bypass route near the bend in the river at Granny. The cable-stayed bridge with 230 m main span is the longest span bridge in Ireland. With its 112 m tall tower, it is a landmark structure for Waterford City and surrounding areas. The main structure consists of its tall tower with a series of stay cables which fan out from the top of the tower to support the main span at intervals of about 10 m. Corresponding cables fan to the back spans using the weight of the back span and anchor piles to balance the forces. The cable-stayed design removes the need for intermediate supports or piers in the river and permits a longer deck and a reduced deck thickness which means that there will be a great clearance for boats and craft to pass under the bridge.

mageba scope
Mageba delivered 2 TENSA®MODULAR expansion joints of type LR7 with a total length of 27.80 m, which permit movements in all three directions and rotations about all three axis. The expansion joints were designed with shear studs for concrete connection.

Before opening to traffic, measurements on all 76 stay cables using a portable structural health monitoring system, providing data on actual cable forces and cable damping. Afterwards, a permanent health monitoring system was installed. The system includes 62 measurement channels in total. The data is automatically analysed on site and presented via the web interface, with an overview of the current situation and graphical representation of the overall performance to date.

Highlights & facts
Mageba products:
Type: TENSA®MODULAR expansion joints type LR7 Structural health monitoring system
Features: with max. movement 560 mm
Installation: 2009

Structure:
City: Waterford
Country: Ireland
Built: 2006–2009
Type: Cable-stayed bridge
Length: 465 m
Constructor: Waterford JV (Dragados)
Owner: National Roads Authority
**Project description**

The Weyermannshaus Viaduct, which opened to traffic in 1977, forms part of a bypass motorway of Switzerland’s capital city, Berne.

During a detailed visual inspection of the underside of the bridge after 40 years of service, considerable cracking was discovered at several coupling joints of the post-tensioned concrete deck.

Uncertainty about the time of crack appearance raised concerns about structural safety, with alternative theories suggesting that the cracking might have occurred many years previously due to concrete shrinkage etc. or more recently due to increased traffic loading. An assessment was required to ensure the structure’s safety and identify any remedial work required.

**mageba scope**

It was decided to use a ROBO®CONTROL “Permanent” structural health monitoring (SHM) system to assess the bridge’s response to traffic loading and temperature changes, enabling different theories/models to be assessed.

Following installation and calibration of the system, high-frequency (200 Hz) measurements were conducted during a period of one week in each season of a year. The system was then modified to assess long-term impacts.

As a result, a model based on the belief that the concrete could be considered “uncracked” could be confirmed, with fatigue analysis supporting a remaining life of at least several decades without the need for any major renovation work.

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**Highlights & Facts**

**mageba products:**

- **Type:** ROBO®CONTROL SHM system (“Permanent”)
- **Measuring:** Crack widths, accelerations, temperatures
- **Installation:** 2010

**Structure:**

- **City:** Berne
- **Country:** Switzerland
- **Type:** Post-tensioned concrete bridge
- **Completed:** 1977
- **Length:** 1 km

**System**

Permanent „Advanced“

**Services provided**

Consulting

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Cracking of concrete section at a coupling joint of the deck’s prestressing cables

One of the ROBO®CONTROL SHM system’s sensors, measuring crack width at one location

Comparison of actual and predicted influence lines confirmed “uncracked” theoretical model
Rhine Waterfalls (Switzerland)

Project description
The Rhine Falls in Schaffhausen, Switzerland is one of the region's most important tourist attractions and visitors marvel at the spectacle from a terrace at the castle of Laufen and several platforms on the cliff beneath it.

Rock anchors previously installed to stabilise the cliff showed unexpected force changes, leading to concerns that some sliding surfaces had developed.

To ensure the ongoing safety of the terrace, it was decided to install 11 additional rock anchors, together with a structural health monitoring (SHM) system to monitor anchor force changes and thus provide early warning of any future rock movements.

mageba scope
A ROBO®CONTROL “Permanent” SHM system was installed in 2010 to monitor the forces in the newly installed rock anchors. The system transmits all data to a central server, enabling the responsible engineers to monitor all anchor forces from their offices via a web interface.

The engineer set limitations for the anchor forces, which are implemented in the system’s alarm notification feature. Should any limitation value be exceeded, immediate notification will be sent by email and SMS to the engineer and the owner. This enables the owner to have confidence in the structure’s condition at all times, avoiding the need for much more extensive and invasive strengthening work.

Highlights & Facts
mageba products:
- Type: ROBO®CONTROL permanent “Advanced”
- Features: Crack sensors, inclination sensors, accelerometers, and structural temperature
- Installed: 2012

Structure:
- Country: Taiwan
- Built: 2007
- Type: Concrete box girder bridge
- Length: Each span 35 m

Scaffolding on the cliff face during installation of the SHM system, showing equipment locations
The sensors are discretely positioned and barely visible from the waterfall viewing platforms
Example of data presentation on the ROBO®CONTROL system’s web interface.
Project description
The Älvsborg Bridge, built in 1966, is a suspension bridge in Gothenburg, Sweden, connecting the north and south parts of the city across the Göta Älv river. The bridge has a total length of 933 m and a main span of 417 m.

To support the planning of bridge renovation works, including the replacement of critical components such as the large sliding finger joints at each abutment, the use of a structural health monitoring system was proposed – in particular, to quantify the structure’s actual movements and rotations, enabling the selection and design of new expansion joints to be optimised.

mageba scope
A ROBO®CONTROL “Permanent” SHM system was installed in 2011, with a network of sensors providing precise records of all movements and giving a detailed understanding of the bridge’s structural behaviour.

The data was used to conclude that bridge movements are less than had been expected. Such information was of great value to the bridge engineer in optimising the planning of the bridge renovation works, particularly in relation to the selection and design of the new expansion joints.

The recorded data will also serve as a reference for future analysis and modification work.

Highlights & facts

mageba products:
Type: ROBO®CONTROL permanent “Advanced” SHM system
Installation: 2011

Structure:
Country: Sweden
Completed: 1966
Type: Suspension bridge
Length: 933 m

Movements correlated with temperatures give a detailed understanding of bridge’s behaviour
Project description
This elegant foot and cycle bridge was erected to connect pedestrian zones either side of a busy traffic artery, and consists primarily of an arch-supported deck with 42 m span. Intensive construction activity is planned to take place in this area in the coming decade, including several high rise buildings. This will lead to uncontrollable ground settlements in the whole area, including in the immediate vicinity of this newly built structure.

mageba scope
A number of specialised components and services were required to ensure the correct construction of the bridge, with even load distribution, especially among its hanger cables, and to allow for adaptation in the future should ground settlements occur. Injectable lifting pot bearings were installed under the structure, to allow any future ground settlements to be countered. An automated monitoring system helped to ensure the even distribution of loading among the bridge’s hanger cables. And spring disc dampers were installed at the bottom of each hanger cable to prevent vibrations of the deck.

Highlights & facts

mageba products:
Types: ROBO®CONTROL
“Portable”monitoring system
RESTON®POT Lift bearings
RESTON®SDD Spring Disc Dampers
Notable: Support in achieving and confirming optimal construction for maximum durability of the structure
Installation: 2011

Structure:
City: Zurich
Country: Switzerland
Type: Arch bridge
Length: 230 m

The bridge is located close to Zurich city centre
An inclined lifting pot bearing at one end of the bridge
Acceleration sensors - used to determine the load distribution in the steel structure
Project description
The Hunter Expressway was originally proposed in 1988 but the construction started in 2010 after 22 years. It provides a much needed east west link in the Hunter Valley, connecting Newcastle and the lower Hunter, hence reducing travel time by almost half an hour. The Eastern Section from F3 to Kurri Kurri comprises three viaducts through the Sugarloaf Range. The viaducts have a total length of 787 m and are up to 47 m in height above the ground.

mageba scope
mageba supplied not only the spherical bearings, shear keys and modular expansion joints for the viaducts, but also a structural health monitoring system. The installed RESTON®SPHERICAL bearings are all equipped with the mageba high-grade sliding material called ROBO®SLIDE and have a load carrying capacity of 30,000 kN. The RESTON®FORCE shear keys transmit a total horizontal force of 8,500 kN. The supplied Tensa®MODULAR expansion joints have a total length of 142 m and allow for a total displacement of 680 mm. In 2013 a hydrostatic tube balance monitoring system has been installed on all viaducts.

Highlights & facts
mageba Products:
Type: 60 RESTON®SPHERICAL bearings
12 RESTON®FORCE shear keys
12 Tensa®MODULAR expansion joints
ROBO®CONTROL structural health monitoring system
Installation: 2011–2013
Structure:
Location: Hunter, New South Wales
Country: Australia
Built: 2010–2013
Type: Viaduct
Length: 40 km
Builder: Thiess
Macdonald & MacKay Bridges (Canada)

Project description
The Angus L. Macdonald and A. Murray MacKay bridges are critically important structures for the city of Halifax, capital of the Canadian province of Nova Scotia. They were opened to traffic in 1955 and 1970 respectively, and several decades later, it was determined that both structures were in need of significant reconstruction / maintenance work in order to meet the demands of modern traffic for decades to come.

The Angus L. Macdonald Bridge, in fact, is receiving an entire new deck, and computer modelling of the deck, verified by measured data, is playing a key role in the design process.

The A. Murray MacKay Bridge, on the other hand, is retaining its existing deck, but is being subjected to significant renovation work.

mageba scope
Early in the project, it was determined that a fully automated ROBO®CONTROL structural health monitoring (SHM) system should be used to measure and record the movements and rotations of the bridge decks. The installed system has provided the data needed by the computer modelling of the new deck of one bridge, and assisted in the planning of remedial works of the existing deck of the other, enabling the bridge’s engineers to optimize their designs and minimize the life-cycle costs of the bridges.

In 2015, it was decided to install new TENSA®MODULAR expansion joints with up to seven gaps each (type LR7) at four axes of the Angus L. Macdonald Bridge, replacing the existing joints. These joints were designed for steel connection, and feature noise-reducing “sinus plates” surfacing.

Highlights & Facts
mageba products:
Type: ROBO®CONTROL automated SHM system
TENSA®MODULAR expansion joints of type LR3 & LR7 LS
Installed: 2012 (SHM), 2015 (joints)

Structure:
City: Halifax
Country: Canada
Type: Suspension bridges

Angus L. MacDonald Bridge
Built: 1955
Length: 4,265 ft (1,300 m)
Main span 1,447 ft (441 m)

A. Murray MacKay Bridge
Built: 1970
Length: 3,937 ft (1,200 m)
Main span 1,398 ft (426 m)

Location of the bridges in Halifax, Nova Scotia, Canada
Presentation of measured data (in graphic form) from the applied SHM system
Temporary plates at the point of future installation of the expansion joints
Project description
The Taizhou Yangtze River Bridge links the cities of Taizhou, Zhenjiang, and Changzhou across Asia’s longest river. At the point where the bridge is located, the river has a width of approximately 2.1 km. In order to minimize impacts on river flow and navigation, a three-pylon (two main span) suspension bridge with spans of 390 m, 1,080 m, 1,080 m and 390 m was proposed.

The ambitious construction project represented the first attempt to create a long-span multi-tower suspension bridge, and the bridge won the 2013 Institution of Structural Engineers Supreme Award for structural engineering.

mageba scope
mageba supplied TENSA®MODULAR expansion joints for each end, each with 18 individual gaps and facilitating movements of up to 1,440 mm.

A ROBO®CONTROL permanent “Advanced” SHM system was also supplied and installed, to measure deck movements at the expansion joints.

Measurements to date enabled it to be concluded that the movements and rotations of the extraordinary bridge’s deck are as expected, and that the exceptional expansion joints continue to perform very well.

A new feature, currently being developed, will also support remote expansion joint inspections.

Highlights & facts
mageba Products:
Type: TENSA®MODULAR expansion joints (LR18), ROBO®CONTROL monitoring system
Installation: 2012

Structure:
City: Taizhou
Country: China
Completed: 2012
Type: Suspension (3-tower)
Length: 2,940 m
Owner: Jiangsu Taizhou Bridge co., Ltd
Contractor: CCCC SECOND HARBOUR ENGINEERING COMPANY LTD., CCCC Second Highway Engineering Co., Ltd, China Zhongtie Major Bridge Engineering Group Co., LTD

Installation of the bridge’s ROBO®CONTROL monitoring system beneath an expansion joint
The Sernigerbaach Viaduct in eastern Luxembourg carries the local A1 highway (European route E44) across the valley that shares its name. It consists of twin continuous-deck structures, each with eight spans. The total length of the bridge is 650 m.

While planning renovation works in 2012, the responsible engineers decided to make use of modern technology to facilitate measurement and evaluation work and thus optimise the planning. A structural health monitoring (SHM) system would be used to record and assess the bridge’s condition and performance during a one-year period.

**mageba scope**
The SHM system was used to record deck movements and rotations at both abutments, over a period of one year in order to obtain data for all seasons. The measured values were collected, classified and evaluated in the ROBO®CONTROL master station. Thereafter, relevant data was sent via GSM/GPRS to be viewed on the mageba web interface.

All movement and rotation data was correlated with temperature, which was also measured. This enabled the responsible bridge engineer to evaluate the structure’s behaviour, and verify its safe performance, avoiding the need for more extensive renovation works.

**Highlights & facts**

**mageba products:**
- **Type:** ROBO®CONTROL monitoring system
- **Sensors:** Displacement, inclination, temperature
- **Installation:** 2012

**Structure:**
- **Country:** Luxembourg
- **Built:** 1987
- **Renovated:** 2012
- **Length:** 650 m
- **Client:** Administration des Ponts et Chaussées

*System Permanent „Advanced“ Services provided Structural Health Monitoring*
Pan Asia Bridge (Taiwan)

**Project description**

This structural health monitoring system is installed on one concrete box girder. The girder is part of the High Speed Railway in Taiwan. It is a single span concrete box girder with a total length of 35 meters. There are two train tracks on top of the girder.

The main purpose of the system was achieved by providing the client with valuable data of vibrations and crack opening for a period of 2 years.

The correlation of such parameters with types of trains and temperature could determine the current state of the structure and foresee the eventual structural retrofitting procedure.

**mageba scope**

The goal of the monitoring project is the measurement and monitoring of the crack movements and crack behavior under traffic and environmental loads for one year.

The system measures at 100 Hz and 200 Hz interval different parameters on the structure using different measuring principles and presents the data online.

The system is assigned to fulfill 4 major tasks such as monitoring of environmental loads (temperature, humidity), monitoring of the crack behavior, monitoring of structure’s temperature and monitoring of the vibrations of the cantilever section and the girder.

**Highlights & Facts**

**mageba products:**

- **Type:** ROBO®CONTROL permanent “Advanced”
- **Features:** Crack sensors, inclination sensors, accelerometers, and structural temperature
- **Installed:** 2012

**Structure:**

- **Country:** Taiwan
- **Built:** 2007
- **Type:** Concrete box girder bridge
- **Length:** Each span 35 m
Taohuayu Yellow River Bridge (China)

Project description
The Taohuayu Yellow River Bridge is the fourth bridge of the Xixia Wuzhi Highway over the Yellow River in the city of Zhengzhou. The bridge has an overall length of 7,691.5 m, including approaches.

The main structure is a two-tower, three-span self-anchored suspension bridge with a main span of 406 m and side spans of 160 m.

The stiffening girder was erected by the one-way, multi-point and synchronous incremental launching method, computer controlled.

The bridge opened to traffic in October 2013.

mageba scope
mageba supplied expansion joints and a structural health monitoring (SHM) system for the bridge when constructed. TENSA®MODULAR joints with up to 16 gaps (type LR16) each allow up to 1,280 mm of movement.

The SHM system enables the condition and performance of the newly constructed structure to be continually assessed, for the purposes of initial construction quality control and ongoing inspection and maintenance.

It also maximizes the bridge engineer’s understanding of the structure’s response to environmental and other influences.

Highlights & facts
mageba Products:
Type: TENSA®MODULAR expansion joints (LR16), ROBO®CONTROL monitoring system
Installation: 2013
Structure:
City: Zhengzhou
Country: China
Completed: 2013
Type: Suspension bridge
Length: 7,691 m
Owner: Henan Taohuayu Yellow River Bridge Investments Co., Ltd.
Contractor: China Railway Mayor Bridge Engineering Group CO., LTD
Designer: Shandong Provincial Communications Planning and Design Institute

The ROBO®CONTROL SHM system enables movements to be quantified and understood.

mageba scope
A 13-gap TENSA®MODULAR expansion joint at one end of the cable suspended structure

The bridge crosses the Yellow River in the city of Zhengzhou in eastern China

A 13-gap TENSA®MODULAR expansion joint at one end of the cable suspended structure
Wazirabad Signature Bridge (India)

Project description
A new cable stayed bridge is currently under construction across the Yamuna River in Wazirabad, Delhi. Its dramatic inclined steel pylon, at 154 m high, and elegant stay cable design, will make it a particularly attractive addition to the Wazirabad skyline.

As well as its pleasing aesthetic impact, the shape of the pylon enables it to provide, to a substantial extent, the stress balance required to support the deck.

The construction and maintenance of this remarkable structure will be supported by the real-time data provided by a sophisticated structural health monitoring (SHM) system.

mageba scope
The ROBO®CONTROL SHM system was installed to monitor the structure’s condition, behaviour and performance during both the construction and service phases. In particular, it is designed to monitor the effects of weather, earthquakes and other environmental influences, and to detect and report any damage that may occur.

To do this, it uses a wide array of sensors (100 in total). The precisely measured data is made available to the bridge’s engineers in real time, via a user-friendly interface, greatly improving the efficiency of monitoring work compared to manual methods.

Highlights & facts
mageba Products:
Type: ROBO®CONTROL monitoring system
Features: 100 sensors
Installation: 2013

Structure:
City: Delhi
Country: India
Completed: 2014
Type: Cable stayed bridge with composite deck
Main span: 251 m
Length: 675 m
Contractor: Gammon JV
Designer: Schlaich Bergermann JV
Zoo Elephant House (Switzerland)

Project information
Zurich city’s zoo has constructed a new park for its elephants, which opened in 2014. The 10,000 m² park includes a large housing unit consisting primarily of a wooden roof shell – the largest self-supporting wooden roof structure in Switzerland. A hot, humid environment will be maintained inside the structure, as prevailing in the natural habitat of the Indian elephant, whereas the outside shell needs to withstand the seasonally changing weather conditions of Switzerland.

Due to the roof’s unusual design in terms of size, shape, and construction material, and the high humidity of the air underneath, it was decided to install a permanent automated monitoring system to provide continuous monitoring of the roof structure’s anchorages and moisture levels.

mageba scope
mageba developed a monitoring plan for this demanding task. 24 humidity sensors, distributed over the entire roof surface, measure the moisture content of the roof’s timber, and the anchor forces arising in the roof’s foundations are also measured. The effect of humidity is correlated to the structure in terms of stress, creep, shrinkage and other deformations, with possible thrust/traction in the anchorage area.

The measured values are displayed in real time on the system’s web interface. The system also includes an alarm feature, offering automatic notification of exceeding of pre-defined limits in any parameters.

Highlights & facts

mageba products:
Type: ROBO®CONTROL permanent SHM system
Features: Anchorage force sensors, air and structural temperature and humidity sensors
Installed: 2013

Structure:
City: Zurich
Country: Switzerland
Built: 2013
Type: Wooden pavilion
Span: 110 m
Owner: Zurich Zoo
Architect: Markus Schietsch
Engineer: Walt & Galmarini

Zurich Zoo is located near Zurich city center

Layout of sensors on the wooden roof

Humidity sensors installed on the underside of the roof
Project description
The Mumbai Metro construction project began in 2008 and had been executed in order to meet the city’s rapid population growth.

Mumbai is the capital city of Maharashtra, the most economically developed state of India with a population growth rate of around 2% per annum (as per 2011). The main objective of the Mumbai Metro is to provide mass rapid transit services to people within an approach distance of between one and two kilometres, and to serve the areas not connected by the existing Suburban Rail network.

At the WEH junction, trains pass over the highway on a cable-stayed bridge and at the same time traffic on the highway crosses on another concrete bridge, making the junction a very complex intersection.

mageba scope
As shown on the picture above, the cable-stayed bridge is located over the highway bridge hence being built in a critical environment where any damage would cause significant repercussions. Therefore, the bridge had to be equipped with a system that is able to immediately react to any alarming impact.

The installed ROBO®CONTROL structural health monitoring system is mageba’s reliable product development to monitor the structure’s condition, behaviour and performance during operation. In particular, it monitors the pylon’s inclination, the cable’s vibration and tension, the deck’s deflection as well as the concrete’s deformation allowing any critical deviation to be detected and accordingly presented to the engineers in charge.

Highlights & facts
mageba Products:
Type: ROBO®CONTROL permanent monitoring system
Features: Strain gauges, displacement, laser, humidity sensors, accelerators, inclinometers
Installation: 2015

Structure:
City: Mumbai
Country: India
Completed: 2011
Type: Cable-stayed bridge
Length: 175 m
Owner: Mumbai Metropolitan Region Development Authority
Contractor: Mumbai Metro One Private Limited (MMOPL)

The cables have been equipped with accelerometers measuring its vibration and tension (see red circle)
Lavoitobel Bridge (Switzerland)

Project description
The iconic Lavoitobel Bridge, designed by the famous sculptor and architect Max Bill in collaboration with the structural engineer Mirko Robin Roš, is an historic arch bridge in the Swiss Alps and was constructed in 1966 and 1967. It spans the corresponding Lavoitobel valley and counts among Switzerland’s famous representatives for bridge construction.

After a detailed and preventative revision by the region’s Civil Engineering Department, the authority decided that this bridge does not cover today’s traffic requirements. Several maintenance works have hence been planned in order to assure future structural safety.

The entire renovation project comprised, amongst others, new bridge bearings as well improvements for its structural safety.

mageba scope
In order to verify that the adjusted structural design and load distribution operated as planned, the responsible engineers decided to install an automated structural health monitoring (SHM) system to monitor the forces acting on the new bearings.

The RESTON®POT bearings were equipped with pressure sensors on the elastomeric pad, enabling the force acting on each bearing to be readily calculated by the connected SHM system. In the event of any sudden or unexpectedly significant change in the force acting on a bearing, or in the load distribution among the different bearings, the system will provide an immediate alarm notification.

Highlights & facts
mageba products:
Type: ROBO®CONTROL permanent monitoring system
Features: RESTON®POT bearings
Features: Pre-integrated sensors on the bearing’s elastomeric pad
Installation: 2016

Structure:
Region: Tamins (Canton Grisons)
Country: Switzerland
Completed: 1967
Type: Arch bridge
Length: 200 m (main span 105 m)
Owner: Road Authority of Grisons
Contractor: Road Authority of Grisons
Engineer: Mirko Robin Roš
Architect: Max Bill

The bridge is located in canton Grisons, a mountainous region in the south-eastern Swiss Alps.

The SHM system installed externally with integrated solar panel and separate weather sensor.

One of the vertically oriented bearings at one abutment, equipped with load cells.
Johan Sverdrup Field Centre (Norway)

Project description
The discovery of the Johan Sverdrup field has been made in 2010 and counts among one of the largest oil discoveries ever made on the Norwegian continental shelf. Named after the father of Norwegian parliamentarism, the Johan Sverdrup Field Center was discovered in 2010 as a direct result of Edvard Grieg field discovery made in 2007, which had proven the possibility of continuous oil-water contact over the entire southern part of the Utsira High.

The field covers an area of approximately 200 km² on the Utsira High in the central part of the North Sea and and is being developed in multiple phases.

The project of interest is composed of four platforms connected together by three steel bridges. Each bridge is designed to withhold the enormous movements coming from the platforms, driven by extreme waves.

mageba scope
mageba is supplying RESTON®POT bearings to support the platforms’ connecting bridges while accommodating specified movements and rotations. Moreover, four different systems of mageba’s ROBO®CONTROL structural health monitoring technology evaluate the bearings’ performance through:

- Inclination sensors
- Load measuring sensors
- Wire displacement sensors
- Inductive displacement sensors

The 12 ROBO®CONTROL acquisition units are installed at each bearing in the hazardous area of the field’s platforms and collect the data from the different sensors. A central computer server processes the measurements in real time for further analysis and graphical presentation. All data is finally sent to the field’s general control room.

Highlights & facts

mageba products:
Type: RESTON®POT bearings of type TF and TE
ROBO®CONTROL monitoring system „Advanced”
Installation: 2016–2017

Structure:
Area: Utsira High, 140 km west of Stavanger
Country: Norway
Completed: 2017
Type: Offshore platform
Owner: Statoil, Lundin Norway, Maersk Oil, Petoro, Det norske oljeselskap
Contractor: Aker Solutions ASA

System
Permanent “Advanced”
Services provided
Structural Health Monitoring

Location of Johan Sverdrup oil field in the North Sea

Example of data presentation on a computer

Bearing production in Switzerland: the massive sliding plates feature 5.5 t weight and 3.2 m
Samuel De Champlain Bridge (Canada)

Project description
The Samuel De Champlain Bridge is located in Montreal, Canada, and replaced the old Champlain bridge over the St. Lawrence River. This crossing is one of the busiest in Canada with over 60 million vehicles and $20 Billion in international trade passing over it on a yearly basis.

The $4.2 billion project consisted of two main bridges – the New Bridge on the St-Lawrence and the Île-des-Soeurs Bridge – fully opened for the traffic on June 2019.

The bridge, 3.5 km long, is a stayed cable bridge designed for a 125 years long service life. This has been possible by taking into consideration the smartest forethoughts and high quality products and materials for a challenging project of a structure subjected to approx. 160,000 vehicles every day – sometimes in harsh weather conditions.

mageba scope
mageba provided Structural Health Monitoring service and modular joints for this iconic bridge.

In the course of the project duration, more than 50 embedded and 150 surface sensors are being installed on the bridge, allowing the Government of Canada to monitor displacement, corrosion, movements, temperature, stresses, strain and environmental conditions of the bridge over the next 30 years. This will most certainly optimize the maintenance supporting the owner to keep the structure at his best performances. Moreover, the ingenious system provides the ability to react instantly to changes and deterioration.

In parallel, the largest expansion supplied will span over 20 meters and cover upwards of 800 mm in movements (10 gaps).

Highlights & Facts
mageba products:
Type: ROBO®CONTROL permanent Monitoring System
TENSA®MODULAR expansion joints types LR8, LR9 & LR10
Features: approx. 200 sensors
Installation: 2016–2019

Structure:
City: Montreal
Country: Canada
Type: Cable-stayed bridge
Completed: 2019
Owner: Infrastructure Canada
Contractor: SNC Lavalin, Dragados, Flatirom Canada, TY Lin, MMM Group Preliminary Design: Arup

The new bridge is located in Montreal, Canada, and is part of the government’s extensive corridor project.

Erection of the cable stay bridge
Corrosion Sensor installed on the pier starter reinforcement