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BRIMOS® References
Concrete Bridges

ISO 9001 certified

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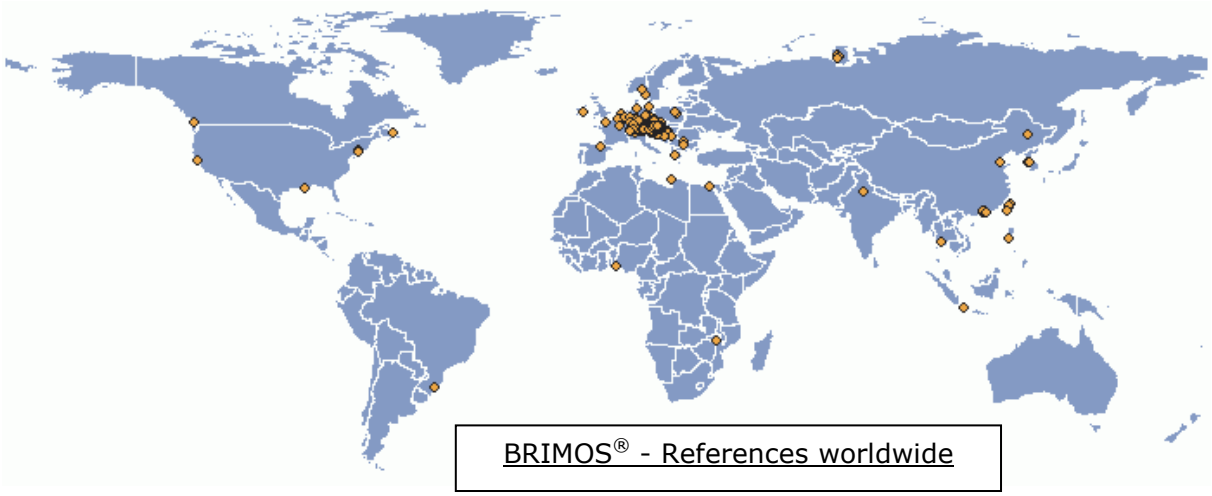
Assessment at Concrete Bridges with BRIMOS®

Selected Reference Projects:

- Railway Bridge Crossing Eislingen (Germany)
- A2.81 Valley Crossing Edlitz (Austria)
- Eko Bridge (Nigeria)
- Lagos Ring Road – Marina Bridge (Nigeria)
- Traun Bridge W4 Steyrermühl (Austria)
- Bezka Danube Bridge (Serbia)
- Estakáda Masaryk (Czech Republic)
- St. Michael Bridge (Austria)
- Colle Isarco Viaduct (Italy)
- Road Bridge Komořany (Czech Republic)
- Estakáda Sluncová (Czech Republic)
- Nibelungen Bridge (Germany)
- Sinich River Bridge (Italy)
- Tete Suspension Bridge (Mozambique)
- Giuliana Bridge (Libya)
- Luegbrücke (Austria)
- Ponte Nanin (Switzerland)
- Seidewitztal-Bridge (Germany)
- Praha Vršovice (Czech Republic)
- Le Pont sur l'Elorn (France)
- Arch Bridge Svinesund (Norway/Sweden)
- Votonosi Bridge (Greece)
- Obernberg Viaduct (Austria)
- Inn Bridge Zams (Austria)
- Confederation Bridge (Canada)



BRIMOS® - References worldwide

BRIMOS® is a development based on 20 years of constant synergy between research and Real-Word-Application Consulting. The experience gained in the course of the assessment of more than 1000 structures worldwide has been incorporated into the assessment procedure. Expertise for bridges as well as for industrial facilities can be provided.

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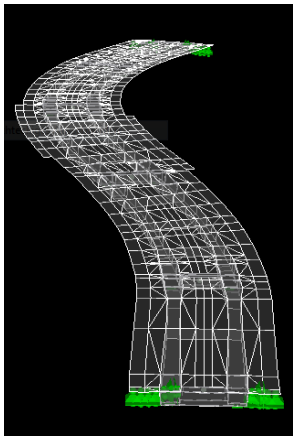
Railway Bridge Crossing Eislingen

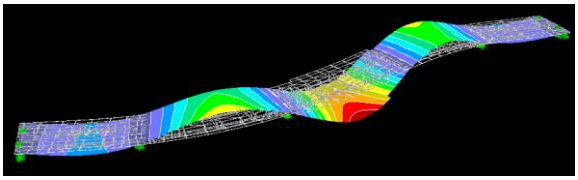
The Railway Bridge Crossing Eislingen leads across the Fils River and a multitrack connection of the German Railways. The four-lane bridge was built in 1966/67. The pre-stressed concrete structure consists of 5 spans, has a total length of 183.35 m (31m/39m/42m/39m/31m) and a curved geometry. The bridge's cross section is designed as a double-webbed T-beam with integrated cylindrical hollow parts in the main girders (construction height 1.65m) The bridge is prestressed in transversal direction (deck slab), the beams in longitudinal direction (main girder) and in vertical direction (pier area) as well.

In the course of the prevailing investigation a dynamic monitoring campaign was undertaken in order to determine the global condition of maintenance (performance assessment) as well as the load bearing capacity by means of BRIMOS®. Along with the conventional bridge assessment this investigation supports the determination and localisation of potential problem zones based on the measured structure's vibration behaviour. Due to the fact that the undamaged reference condition was not stated by means of a dynamic measurement at the beginning of the bridge's service life a finite element model was developed. The calculated parameters serve as expected values based on the undamaged condition. The comparison of the numerical results with those of the measurements supports the assessment of the structural performance concerning reserves of load-bearing capacity compared to the design.

The present investigation (measurement 2011) is to be understood as an initial measurement. Upcoming measurements are to be referred to this initial one in order to quantify possible changes of the structure's operational condition.

- Client: BBV Systems
- Location: Eislingen, Germany
- Checking Period: 2011
- Services: Dynamic Measurement
  Finite Element Simulation
  BRIMOS® Performance Assessment and Rating





BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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A2.81 – Valley Crossing Edlitz

The valley crossing Edlitz is part of the Austrian Highway A2 and is located between Grimmenstein and Friedberg. The 8-span pre-stressed structure – built in 1984 – has a total length of 350 m (41.50+45.80 +45.80+45.80+45.80+45.80+42.50+37.00) and a curved geometry. The bridge's cross-section has a width of 25 m and consists of a three-cellular box girder. To support the cantilevers pre-fabricated slabs were included, representing the cross-section's outer edge.

In the course of the present project a periodic bridge inspection following the Austrian regulation RVS 13.03.11 was carried out. This has been the third follow-up inspection since the structure went into operation. The inspection comprised all accessibly surfaces of the bridge. To reach most of the structural members and to enable a close inspection a under bridge inspection unit was used.

Additional to the visual inspection - acting on our own initiative - dynamic measurements at the bridge deck (superstructure) were performed by means of BRIMOS® Structural Health Monitoring. To capture the bridge's vibration behavior under regular operation measurements were taken on every span at one representative reference point (HOT SPOT).

- Client: ASFINAG Autobahn Service GmbH Ost
- Location: Thomasberg, Austria
- Checking Period: 2010
- Services: Bridge Inspection
  Dynamic Measurement
  Analysis and Evaluation of the structural condition
  Maintenance Concept and Cost Estimate

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☒ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Eko Bridge (Main Bridge East) in Ijora, Lagos

The Eko Bridge is located in Ijora, Lagos and connects Lagos Mainland with Lagos Island. The prestressed structure consists of two separate load-bearing structures – one for each driving direction. The Main Bridge East which was part of the BRIMOS® investigation has a total length of 190 m and was opened to traffic in the early 1970ies. The cross-section of the superstructures comprises of a three cellular box girder and has a width of 14m.

On the 11th of July in 2008 a fire caused extensive damage to the underside of the superstructure and the piers of the Eko Bridge. Because of the fire the concrete cover at the superstructure's underside failed and the exposed reinforcement bars were partly buckled. Furthermore at several piers concrete has broken off up to a depth of the first reinforcement layers. In those areas where fire caused the most excessive damage, additional temporary supports were erected – surrounding certain piers. The Site Inspection Report stated that without immediate investigations of the structure the safety and stability of the bridges could not be reviewed.

The dynamic monitoring campaign at the Bridge object Eko Bridge, Main Bridge East was undertaken in order to determine the structure's global condition (the structure's integrity) as well as the load bearing capacity by means of BRIMOS® Structural Health Monitoring. Along with the conventional bridge assessment this investigation supports the determination and localization of problem zones based on the measured vibration behaviour of the structure.

Particularly judgements and evaluations, to what extent the fire has caused serious damage and tailored recommendations regarding possible retrofit and maintenance interventions are needed to support the decision process of the bridge owner.

The present investigation is to be understood as an initial measurement. Possible upcoming measurements are to be referred to this initial one – a possible change of the structure's operational integrity can be quantified with this approach.

- Client: BBV Systems
- Location: Lagos, Nigeria
- Checking Period: 2010
- Services: Dynamic measurement
  BRIMOS Assessment and rating

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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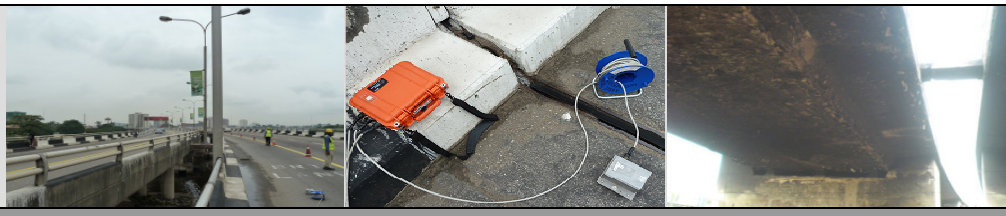

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Lagos Ring Road Marina Section at King George V Road

The bridge object is part of the Lagos Ring Road, in particular the Marina Section at King George V Road, Lagos Island and was built between 1975 and 1979. The six-span bridge has a total length of 168 m consisting of two 24 m long outer spans and four 30 m long inner spans. The bridge's geometry follows a curved ground view. The prestressed concrete bridge consists of two separate load-bearing structures – one for each driving direction. Each of them has a width of 11.75 m.

On the 19th of March in 2010 a fire caused extensive damage to the underside of the superstructure and the piers of Lagos Ring Road, Marina Section at King George V Road. Because of the fire the concrete cover at the superstructure's underside, at the abutment walls and at some columns shows severe damage. The 1st Site Inspection Report stated that without immediate investigations of the structure the safety and stability of the bridges could not be reviewed.

The dynamic monitoring campaign at the Bridge object Lagos Ring Road, Marina Section was undertaken in order to determine the structure's global condition (structural integrity) as well as the load bearing capacity by means of BRIMOS® Structural Health Monitoring. Along with the conventional bridge assessment this investigation supports the determination and localization of problem zones based on the measured vibration behaviour of the structure.

Particularly judgements and evaluations, to what extent the fire has caused serious damage and tailored recommendations regarding possible retrofit and maintenance interventions are needed to support the decision process of the bridge owner.

The present investigation is to be understood as an initial measurement. Possible upcoming measurements are to be referred to this initial one – a possible change of the structure's operational integrity can be quantified with this approach.

- Client: BBV Systems
- Location: Lagos, Nigeria
- Checking Period: 2010
- Services: Dynamic measurement
  BRIMOS Assessment and rating

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Traun Bridge W4 Steyrermühl

The bridge object is part of the A1 highway and was constructed in 1959. It is composed of 18-spans (reinforced concrete) and has a total length of 240.45 m. A comprehensive dynamic analysis on the present bridge object was conducted by means of BRIMOS® Structural Health Monitoring.
While the bridge structure – related with the driving direction Salzburg – was removed (blown) in August 2010, the remaining structure (driving direction Vienna) was monitored in order to evaluate the impact of the blasting with regard to its structural safety and operability. The investigation was focused on the primary load-bearing structure (arch).

In 2005 referential dynamic BRIMOS® measurements at both load-bearing structures were performed by VCE. Based on these measurements the structural behaviour was analysed in detail. Along with the simultaneously conducted conventional bridge inspection (according to RVS 13.71) this investigation supported the determination and localization of problem zones based on the measured dynamic behaviour of the structure.
In the course of these initial investigations an additional study (consisting of preliminary design, numerical simulation & cost estimation) was elaborated and evaluated concerning different possibilities of structural adaptation due to an aspired enlargement of the bridge's deck width.

Time series for the purpose of comparison:

- Regular traffic 2005
- Regular traffic 2010 (saturday evening & night)
- Closed bridge immediately before and after the blasting (sunday morning)
- Regular traffic 2010 (sunday morning)

■ Client:	ASFINAG Bau Management GmbH
■ Location:	Steyrermühl, Upper Austria
■ Checking Period:	2005 - 2010
■ Services:	Visual Inspection
	Dynamic Measurements (under heavy freight traffic and bridge blasting)
	Static Recalculation and cost estimation for different enlargement alternatives
	Integral Life Cycle Analysis

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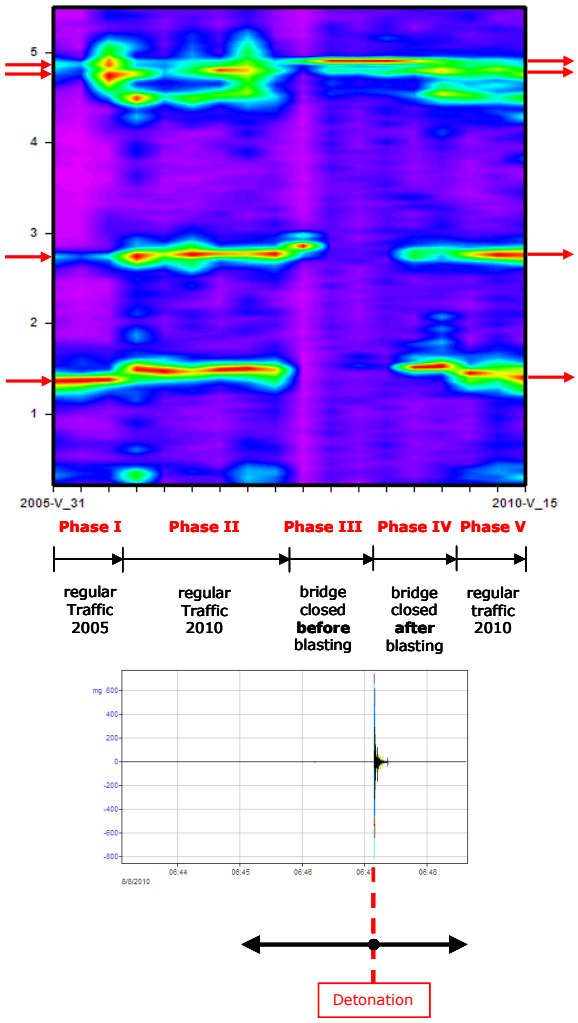
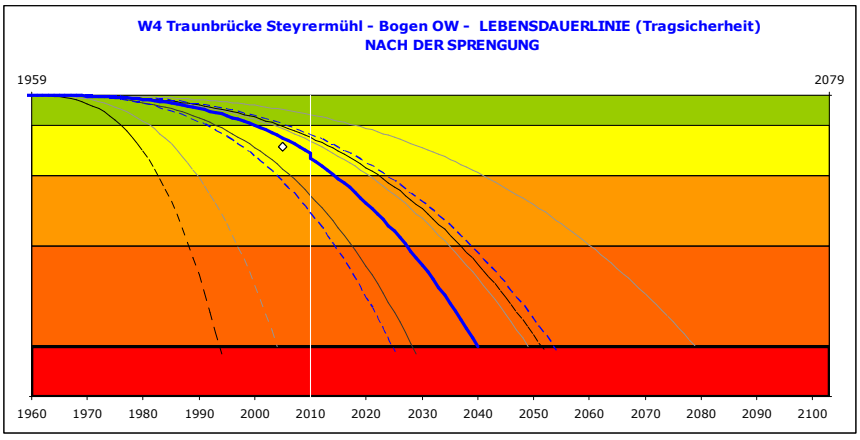


Progression of **measured structural stiffness patterns 2005-2010** (0.2-5.5 Hz) including exposure to bridge blasting and response to heavy freight traffic before and after this exceptional loading case – driving direction Vienna

The prevailing investigation (measurement 2010) was the first follow-up measurement after the initial dynamic measurement with BRIMOS® in 2005.
Measurements at selected single bridge locations (HOT SPOTS) enabled a comprehensive documentation and quantification of the bridge's decisive structural behaviour and possible changes respectively.
A direct comparison after 5 years of structural service life shows the progression of the calculated life cycle curve (bridge deck under the influence of traffic load and the bridge blasting) from 1959.



Life - Cycle Analysis including the influence of the exceptional loading case of bridge blasting

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☒ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☒ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☒ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☒ Deflection Measurements	☐ Seismics

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Bezka Danube Bridge

Description

In the course of the completion of the E75 (part of the European Corridor 10) on 4 lanes the construction of a new bridge over the Danube is required between Novi Sad and Belgrade near Bezka. This bridge will be erected as a so-called "twin"- bridge parallel to the existing bridge, which currently accommodates two lanes in both directions and is to have the same appearance. The Danube is bridged with spans of 60m+105m+210m+105m+60m (without foreland structures).

The old bridge, built as prestressed concrete bridge in 1975, is to be maintained and continued to use. In November 2008 a BRIMOS® measurement for the assessment of the condition was carried out at this "old" structure. In addition the effects of the existing sliding slope on the structure were analyzed.

In January 2009 a monitoring system for permanent supervision of the bridge pier movements was installed additionally in order to be able to identify negative effects of the foundation works for the new construction on the old structure on time. Furthermore movements of the sliding slope are to be detected by means of the measuring system. The measuring system includes a tachymeter for continuous monitoring of the pier movements as well as acceleration sensors for vibration supervision during sheet pile and bored pile works. The measuring results are continuously transferred into the VCE database and are available in the Internet via the BRIMOS® web interface.

- Client: Alpine
- Location: Serbia
- Checking Period: 2008, 2009

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☒ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☒ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☒ Deflection Measurements	☐ Seismics

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Estakáda Masaryk

The Estakáda Masaryk in the centre of Prague is part of the new railway connection between Prague's main station and Prague Holešovice station. The bridge deck carries four tracks and even five tracks in the western side span. The structure is predominantly composed of prefabricated compound units and is pre-stressed in longitudinal and transversal direction. The load carrying structure is divided into of twelve spans with different span length (l = 39.9 / 34.9 / 9 x 37.0 / 31.5 m) and a total length of 439.3 m. The bridge follows a strongly curved ground view and its deck's width varies between 29 and 22 m (3 – 5 cellular box girders). The construction height of the bridge deck – without the roadbed – varies between 3.20 m and 3.70 m. The railway bridge was finished in summer 2008 and was assigned as bridge construction of the year by the Czech association of civil engineering.

In the course of the prevailing investigation an extensive dynamic monitoring campaign was undertaken in order to examine the Estakáda Masaryk's initial condition. The dynamic assessment with BRIMOS was widely performed according to the Czech code ČSN 736209 but in addition to that the measurement provided several supplementary information. Part of the Czech assessment procedure is the comparison of the measurement with a finite element model. Within the scope of the present assessment the live loads' dynamic effect on the load bearing capacity and on the operability was evaluated and recommendations for the further service life were made. Special attention was paid to the analyses of the internal prestressing of the primary load bearing structure (main girders in the longitudinal direction) and of the secondary load bearing structure (track slab and ground plate – in transversal direction).

The present investigation (measurement 2009) is to be understood as an initial measurement. Possible upcoming measurements are to be referred to this initial one - possible changes of the structure's operational integrity can be quantified with this approach.

- Client: EURAVIA CS a.s
  závod Řevnice
- Location: Prague, Czech Republic
- Checking Period: 2008 – 2009
- Services: Dynamic measurement
  BRIMOS® - Assessment and rating
  According to Czech Standard CSN 736209
  Finite Element Simulation

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☒ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☒ Deflection Measurements	☐ Seismics

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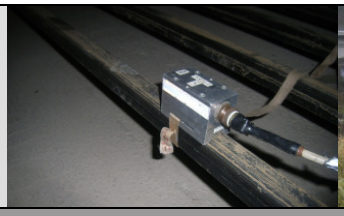


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St. Michael Bridge

The St. Michael Bridge across the Mur River is part of the A9 Pyhrn Motorway and was finished in 1975. The five-span bridge is made of pre-stressed concrete and consists of individual load bearing structures for each driving direction. The bridge's total length is 329 m. Each structure has a width of 17.25 m and is constructed as a continuous, two-cell box girder. Due to the occurrence of excessive deflections at the main span lifting and rehabilitation by means of external tendons was realised at the main span and in the area of pier 2 and 3 (1987/88). To ensure the admissible tensile stress within the cross section and the structural safety at the outer spans they were also strengthened with external tendons in 1994/1995.
In the course of the prevailing investigation a dynamic monitoring campaign was undertaken in order to determine the global condition of maintenance (the structure's integrity) as well as the load bearing capacity by means of BRIMOS®. For that purpose the effecitve cable forces of the external prestressing were determined and compared with the expected forces from structural analysis and with the maximum permissibel tensile force.
Furthermore a dynamic analysis of the bridge deck was made. The comparison of the initial measurement from 1998 with the follow-up measurement in 2009 is to be understood as a measured life cycle curve (bridge deck affected by the strengthening with external tendons).
Within the scope of the follow-up measurement 2009 a vertical deformation measurement was done at the main span of every load bearing structure regarding heavy freigth traffic (operation condition during day- and nighttime). The measurmentes carried out at the St.Michael Bridge serve as supporting measures to provide the bridge's structural safety and operability.

- Client: ASFINAG Autobahn Service GmbH SÜD
- Location: Styria, Austria
- Checking Period: 1998 - 2009
- Services: Dynamic measurement (Bridge deck and tendons)
  Deformation measurement (bridge decks)
  Finite Element Simulation
  BRIMOS® - Assessment and rating
  Serviceability test under heavy freight traffic

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☒ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☒ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☒ Deflection Measurements	☐ Seismics

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Colle Isarco Viaduct (Gossensass)

The Gossensass Viaduct is part of the Brenner highway in the north of Italy. The bridge with a total length of 1028.80 meters consists of 13 spans and was built in 1969. The deck of the post-tensioned box-girder bridge is represented by two box-girder superstructures with a total width of 22.10 m which are linked by the same piers. The bridge was designed fully isostatic. The box-girders consist of cast-in-place balanced cantilever beams with varying girder depth. The height of the box girder varies from 10.80 m over the middle support to 2.85 m in the mid-span. In the main span (length = 163 m) as well as in six more spans suspended t-beams – all of them 45 m long - are inserted via Gerber joints. The construction type of the viaduct – particularly the Gerber joints – results in a high sensitivity for dynamic vibrations.

The dynamic monitoring campaign was undertaken in order to determine the global condition of maintenance of the load-bearing structure (the structure's integrity) as well as the load bearing capacity by means of BRIMOS®. Along with the conventional bridge assessment this investigation supports the determination and localisation of potential problem zones based on the measured structure's vibration behaviour and the decision process of the bridge owner in the course of cost planning for maintenance and possible rehabilitation measures.

The assessment at the Colle Isarco Viaduct consists of a detailed initial measurement campaign performed in March 2007 and a follow-up measurement one year after the first one. Additionally a permanent monitoring system for condition and traffic monitoring was installed at every carriageway.

- Client: Autostrada del Brennero
- Location: Gossensass, Italy
- Checking Period: 2007 – 2008

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☒ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☒ Environmental Influences	☒ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Road Bridge Komořany

The prestressed concrete road bridge Komořany is a 2-lane crossing of a multi-track connection of the Czech Federal Railways. The main structure consists of two spans with the lengths of 16.72 m and 46.43 m and therefore a total length of approx. 63 m, with a total width of the bridge deck of approx. 13 m. In the main span a suspended beam made of 9 prestressed concrete prefabricated elements (I-beams) is inserted into the bridge structure via 2 Gerber joints. Both the suspended beam and the monolithic parts of the bridge are reinforced with partial prestressing in the longitudinal direction. The bridge was completed in 1961 and represented one of the first prestressed concrete applications in the former Czechoslovakia.

Subject of the present check is a dynamic test at the road bridge Komořany with BRIMOS® to analyze the global maintenance state of the structure. This test serves to use results from the vibration behaviour of the structure for the determination and localization of problem zones parallel to conventional structural checks. On the basis of the available check in particular the load-bearing capacity of the bearing structure is to be defined and therefore recommendations for the further operation duration are to be given. The main focus is on the suspended beam where both the embedding into the bridge bearing structure (Gerber joints) and the condition of the cross prestressing requires special attention.

- Client: Motorway and Expressway Management of the Czech Republic
  Administrative Authority Chomutov
- Location: Komořany,
  Czech Republic
- Checking Period: 2007, 2008

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☒ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☒ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Estakáda Sluncová

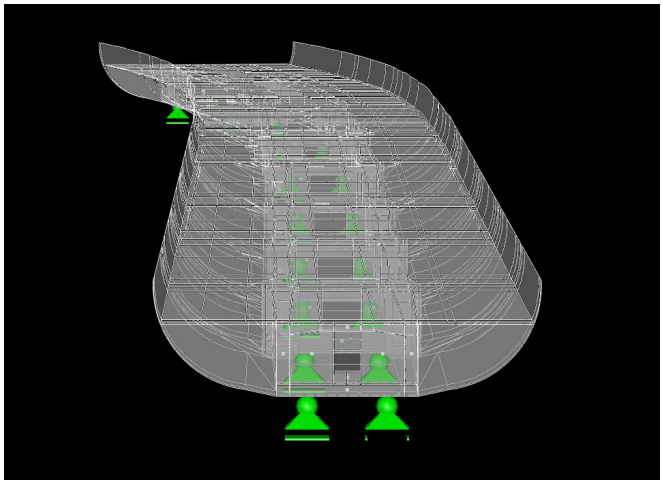
The railway bridge Estakáda Sluncová in Prague is part of the new railway connection between Prague's main station and Prague Holešovice station. The structure - finished in summer 2008 – is a continuous beam with total length of 323.8 m, consists of eight spans which are 26.0 + 2x36.7 + 4x47.6 + 34.0 long and follows a strongly curved ground view. The bridge has an internal and an external pre-stressing in the longitudinal direction. Its cross section is composed of a three cellular box girder. The middle cell is rectangle shaped whereas the two outer cells have the shape of a quarter ellipse.

In the course of the prevailing investigation an extensive dynamic monitoring campaign was undertaken in order to examine the Estakáda Sluncová's initial condition. The dynamic assessment with BRIMOS® was widely performed according to the Czech code ČSN 736209 but in addition to that the measurement provided supplementary information. Part of the Czech assessment procedure is the comparison of the measurement with a finite element model.

Within the scope of the present assessment the live loads' dynamic effect on the load bearing capacity and on the operability was evaluated and recommendations for the further service life were made. Special attention was paid to the analyses of the internal pre-stressing of the primary load bearing structure (main girders in the longitudinal direction).

The present investigation (measurement 2008) is to be understood as an initial measurement. Possible upcoming measurements are to be referred to this initial one - possible changes of the structure's operational integrity can be quantified with this approach.

- Client: SKANSKA, DS a.s
  Dopravní stavitelství Brno
- Location: Prague, Czech Republic
- Checking Period: 2008
- Services: Dynamic measurement
  BRIMOS® - Assessment and rating
  According to Czech Standard CSN 736209
  Finite Element Simulation



BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☒ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☒ Deflection Measurements	☐ Seismics

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Nibelungen Bridge in Worms

Description

The Nibelungen bridge in Worms with a total length of 334.62 m crosses the Rhine river in 3 spans. The bridge openings amount to 99.70 m, 114.80 m and 97.50 m. The bridge cross section consists of a deck prestressed in cross direction with two haunched bars as box girders. The structure was built from 1950 to 1953.

The cross structural conditions and the conditions of the cross tendons were assessed by the BRIMOS® tests at the Nibelungen bridge. In particular statements on possible local damage areas were made. The tests carried out were a first check.

- Client: BBV – Vorspanntechnik GmbH
- Location: Worms, Germany
- Checking Period: 2006

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☒ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Ponte sul Rio Sinigo – Sinich River Bridge

Description

The bridge built in the period from March 1980 to May 1982 crosses the valley of the Rio Sinigo in form of a three-hinged arch with a clear span of 125 metres. The cross section is designed in form of a box. The deck is prestressed in longitudinal direction.

Immediately after completion a visible decrease in pitch (> 50 cm) took place, the values varying by up to 60 cm according to seasonal temperature fluctuations. The requirements of the admissible rolling loads and the planned traffic route are currently not met. The current rehabilitation concept provides for a trussing and lifting of the bridge vertex. This requires the knowledge of the state of maintenance.

The following tasks were dealt with by means of the dynamic examination of the structure with BRIMOS® :

- assessment of the current state of maintenance
- assessment of the load-bearing safety
- assessment of dynamic stress (geometry, influence of cambering in the centre of the deck)

The results of the check served as a basis for the rehabilitation and repair measures.

- Client: Bilfinger Berger AG
- Location: Hafling/Merano, Italy
- Checking period: 2006

Measurement & Evaluation

By means of three-dimensional acceleration sensors the dynamic characteristic of structures can be clearly

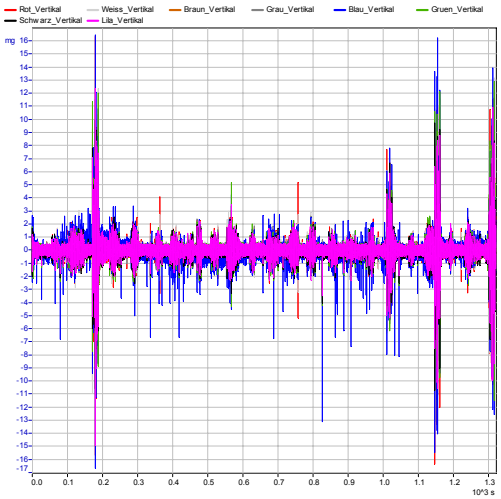
BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

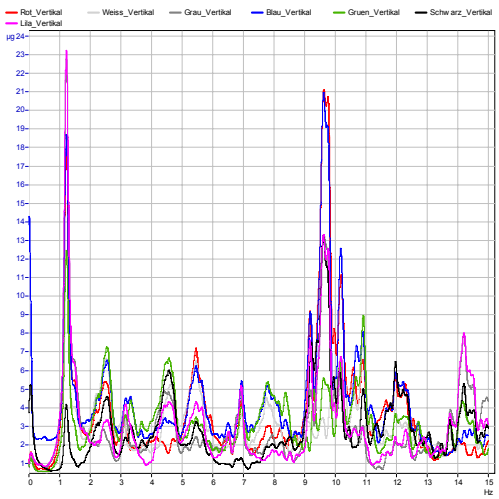


determined in longitudinal, transversal and vertical direction. The influence of varying traffic intensity on the measurement data and therefore on the results can be considered by using a reference sensor during evaluation.

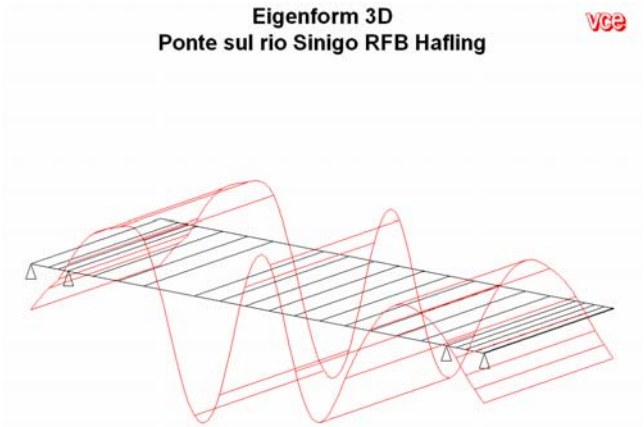
Signal

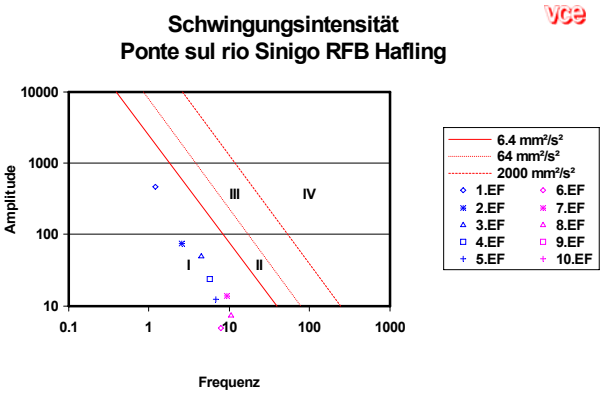


Frequency



Mode Shapes and Vibration Intensity





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Tete Suspension Bridge

Description

PONTE DE TETE located in Tete Mocambique was built as a road bridge over the Zambezi River in the sixties of the last century. It is a five span suspension bridge with a total length of 720 meters. The span lengths are 70-180-180-180-70 meters. The flexible bridge deck is supported by 284 hangers and 4 steel struts.

Due to the age of the bridge, the heavy traffic and the partly very bad condition of the bridge rehabilitation measures are necessary. The rehabilitation scheme is designed by GRID, a Portuguese consultant company.

VCE's task was to assess the condition of all 284 hangers and to measure the hanger forces due to self weight with BRIMOS®. The measurements were carried out by a VCE engineer in the period from September 29th to October 9th 2006 using the BRIMOS-Recorder®.

- Client: GRID/ANE
- Location: Tete, Mozambique
- Checking Period: 2006

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☒ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Giuliana Bridge

Description

The Giuliana bridge in Benghazi / Libya consists of 4 single-span foreshore bridges per lane and a three-span main structure. The foreshore bridges have a total span of 35 metres. The cross-section has the form of a double box girder with continuous deck, prestressed in longitudinal direction in the footbridges and floor slabs.

The two main structures with spans of 80-120-80 metres are haunched box girders. The main structures are prestressed in longitudinal and cross direction (deck pavement). The object was erected in the 1970s.

The structure was generally rehabilitated by Bilfinger Berger. In the course of the works great corrosion was detected at the longitudinal and cross tendons. First investigations have shown defective pressure grouting of the tendons.

The global maintenance state of the structure was analysed by the dynamic investigations with BRIMOS® . In addition statements on the condition of prestressing and recommendations for the further procedure during rehabilitation were made.

After the rehabilitation has been concluded a check with BRIMOS® is scheduled.

- Client: Bilfinger Berger AG
- Location: Bengasi, Libya
- Checking Period: 2005

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☒ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Highway Bridge – Luegbrücke

Description

The LUEGBRÜCKE – a well known Austrian steel concrete composite bridge, opened in 1963 - is part of one of the main alpine north-south routes for urban and freight traffic. A long-term preoccupation of VCE with BRIMOS® (BRIdge MOnitoring System) on the LUEGBRÜCKE (since 2005) and the assessed prevailing vibration intensities with regard to fatigue problems and possible damage led to the installation of a permanent monitoring system in 2006.

High-precision sensor data of accelerations, displacements, as well as separately registered meteorological data are implemented into analytical calculations, which provide the possibility to realize lifetime considerations, which are of eminent importance for bridge operators.

Previous measurements at the LUEGBRÜCKE matched very well with the comparative analytical calculations, but they also exhibited the remarkable loading impact. Currently the bridge is stressed by more than 30000 motor vehicles per day (approximately 20% freight traffic). The bridge deck is represented by a steel-concrete composite superstructure (width = 21.5m; variable height along the bridge-length 2.20 – 5.0 m). This motorway bridge with 44 spans differing in their length (longest span 72.5m, shortest span 27.6 m supported by piers with an elevation of up to 60m) and a total length of 1837 m comprises five lanes - distributed on a width of almost 22 meters.

- Client**:** ASFINAG ASG
- Location: Steinach am Brenner (Brenner Highway - Austria)
- Checking Period: since 2005

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☒ Condition Monitoring	☒ Rehabilitation Planning	☐ Quality Control
	☒ Lifetime Assessment	☒ Traffic Analysis	☒ Environmental Influences	☒ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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brimos® BRIDGE MONITORING SYSTEM



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Ponte Nanin – Switzerland
Permanent Monitoring

The two arch bridges Ponte Nanin and Ponte Cascella are located on the E43 near Mesocco in Switzerland. They were constructed in 1967 using the same temporary works for both bridges. This was only made possible because of their close proximity two each other and because the bridges, which run parallel to each other (one slightly further down the valley), have almost identical spans.

The bridge structure Ponte Nanin has a total length of 192.0 m with a main span of 112.0 m. The bridge consists of an arch made of reinforced concrete and a pre-stressed concrete bridge deck (width = 10.2 m).

Between 1995 and 1997 the Ponte Nanin underwent refurbishment during which the arch and the abutments were rehabilitated. This involved the transferal of loads to different sections of the bridge and thus VCE in partnership with Mageba SA was asked to measure the load transfer through the bearings in the abutments and the movement of the expansion joints at the moveable end of the bridge.

- Client: Mageba SA
- Location: Nanin, Switzerland
- Monitoring Period : Start - March 2005
- Services: Permanent Monitoring
  Measurement of load transfer in the bearings of the bridge abutments.
  Measurement of the expansion joints.

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☒ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Seidewitztal-Bridge

Description

The construction of the new Seidewitztal-Bridge near Dresden is carried out by temporary use of accessory pylons growing along with the construction.

- Client: BBV Vorspanntechnik GmbH
- Location: Dresden, Germany
- Checking Period: 2005

BRIMOS® Services conducted:

Lifecycle Management:	☐ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☒ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

ISO Certificate 9001

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Praha Vršovice

Description

The cable stayed bridge Praha Vršovice is an important part of the city highway system of Prague and has a total length of 400,4 meters.

The superior goal of the prevailing monitoring campaign was an analysis of the vibration behaviour of all 56 cables in order to determine the effective cable forces. The obtained values were compared to the expected, theoretical values based on permanent loading and live loading. Additionally the load bearing capacity of the cables as well as their bending stiffness were determined.

These investigations strongly support the decision process of bridge owners in the course of cost planning for maintenance and possible rehabilitation measures.

- Client: TSK Praha
- Location: Prague, Czech Republic
- Checking Period: 2005

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Le Pont sur l'Elorn

Description

The dynamic assessment of Pont sur l'Elorn carried out by VCE in 2003 was a demonstration measurement for introduction of our ambient vibration testing system BRIMOS®. In addition to this global investigation of the whole structure – except the two pylons – we got dynamic data of all stay cables for determination of the cable forces by means of our mobile data acquisition system BRIMOS®-Recorder.

In general a dynamic assessment of the vibration behaviour serves for the determination of the load-bearing safety and capacity of a structure. In order to achieve an overall picture on the load-bearing behaviour an initial measurement of the whole box girder was carried out. The investigations basically referred to all stay cables as well as the interaction between cable and box girder.

The dynamic characteristic of a structure is a function of the modal parameters eigenfrequencies, mode shapes and damping values as well as vibration intensities which can be determined by BRIMOS®.

- Client: Republic of France
- Location: Brest, Bretagne, France
- Checking Period: 2003

BRIMOS® Services carried out:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Arch Bridge Svinesund

Description

The construction of the new Svinesund Bridge (arched bridge with 250 m main span) between Norway and Sweden is carried out by means of temporary guying of auxiliary pylons, which grow according to the construction progress. The latter are anchored with prestressing cables whose forces were regularly checked by measurements with the BRIMOS-Recorder® with external sensor during the construction phase. The measurements were carried out by the construction company.

The same method for the determination of the cable forces was also brought in constructing the Seidewitztal-Bridge near Dresden.

- Client: BBV Vorspanntechnik GmbH
- Location: Svinesund, Norway / Sweden
- Checking Period: 2003

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☒ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Votonosi Bridge

Description

The workmanship of pier M1 of the Votonosi bridge was checked by means of BRIMOS® measurements during the construction phase. The measured dynamic characteristic was used for the updating of an FE-model with which the defective condition could be verified and quantified. Based on this a rehabilitation concept was elaborated and implemented. The success of rehabilitation was checked by means of BRIMOS® measurements again.

- Client: Egnatia Odos
- Location: Thermi, Greece
- Checking Period: 2002

BRIMOS® Services conducted:

Lifecycle Management:	☐ Condition Assessment	☐ Condition Monitoring	☒ Rehabilitation Planning	☒ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Obernberg Viaduct

Description

The task of the BRIMOS® investigation was the assessment of the structural condition.

The maintenance state of the abutments and the foundation elements was not examined in the scope of this commission – statements on that can therefore be only made to the extent of an interaction between the vibration behaviour of the structures and of the substructures.

- Client: Alpenstrassen AG
- Location: Obernberg, Austria
- Checking period: 1998

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Inn Bridge Zams

Description

The determination of the vibration behaviour of the arched structure of the Inn bridge Zams served for the assessment of the load-bearing safety and capacity. The objective of this examination was to carry out a condition assessment and a basic measurement for further tests.

This examination was carried out with the measurement system BRIMOS®, developed by VCE. By means of this method the vibration behaviour, which is a function of the eigenfrequency, the mode shape and the damping, is measured and analysed.

- Client: Government of Tyrol
- Location: Zams, Austria
- Checking period: 1998

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☐ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics

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Confederation Bridge

Description

The Confederation Bridge is one of the largest bridges in Canada. It is the access between New Brunswick and the Prince Edward Island. We made series of dynamic measurements to determine the level of effective vibration. In order to obtain the dynamic characteristics of a structure we identify the modal parameters natural frequencies, mode shapes and damping with our BRIMOS® Recorder. After this we compare the results with the analytically determined values. Because of the ambient acceleration measurements and their evaluation with the system BRIMOS®, the system behaviour can be well-defined. To assess the current condition of maintenance of the load-bearing structure, conclusions can be drawn from the current load-bearing behaviour (=system identification), detected by interpretation of the measurements and comparison with computer simulation.

The service for the Confederation Bridge included:

- Structural condition evaluation, visual, acoustic and radiograph inspection
- Vibration based condition assessment, continuous monitoring, vibration characteristics, changes in physical conditions ⇒ changes in vibration characteristics
- Research using Confederation Bridge field
- Monitoring data, verification of design assumptions, variability of extracted dynamic properties, monitoring information in decision support for operations and maintenance
- Advance towards the use of monitoring data for health monitoring

- Location: Canada
- Checking Period: 1995

BRIMOS® Services conducted:

Lifecycle Management:	☒ Condition Assessment	☒ Condition Monitoring	☐ Rehabilitation Planning	☐ Quality Control
	☐ Lifetime Assessment	☐ Traffic Analysis	☐ Environmental Influences	☐ Risk Assessment
Special Measurements:	☐ Attendant Monitoring	☐ Noise and Vibrancy	☐ Deflection Measurements	☐ Seismics