VCE Vienna Consulting Engineers ZT GmbH

# Monitoring & Assessment

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**VCE Vienna Consulting Engineers ZT GmbH**
**Office Vienna**
Hadikgasse 60, 1140 Wien
T +43 1 897 53 39
F +43 1 893 86 71
vce@vce.at
www.vce.at

**VCE Vienna Consulting Engineers S.R.L.**
**Office Bukarest**
Strada Gheorghe Manu nr. 3, etaj 3
010442 Bucuresti, Romania
T +40 31 437037
office@vce.ro
www.vce.ro
**Office Cluj**
Strada Ciresilor 32-36, Cluj-Napoca
400487 Judetul Cluj, Romania
office@vce.ro

**Î.C.S. VCE Consulting Engineers S.R.L.**
**Office Chişinău**
Bulevardul Moscova 21, ap.(of) 802
2045 Chişinău, Moldova
office@vce.md

**VCE Vienna Consulting Engineers ZT GmbH**
**Office Athen**
Vas, Alexandrou 27
151 22 Amaroussio, Greece
T +30 210 211 19 47
F +30 210 211 65 39
vce-gr@otenet.gr

**Vienna Consulting Engineers d.o.o.**
**Office Zagreb**
Ulica grada Vukovara 284
10000 Zagreb, Croatia
ie@vce-consult.hr

"Always think a step further
and risk the impossible"
H. Wenzel, Director

# About VCE

VCE is an independent, high tech oriented consulting firm with its head office in Austria. The company operates in four principal lines of business:

- **the transportation sector**
  including bridges, tunnels and railways
- **the building and industrial sector**
  general design and management as well as specialized technological expertise
- **the development sector**
  from research and development to feasibility and environmental studies, financial engineering, to development aid
- the structural health assessment (**BRIMOS®**) and **asset management**

The key personnel at VCE consist of experts with great experience in many highly specialized fields. Close cooperation of the company with the big Austrian universities contributes additional know-how if required. Since 1992 intensive research and development activities have been pursued.


Svinesund | Norway/Sweden

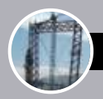

Vladivostok | Russia


Jamal Bridge Siberia | Russia


Zagreb–Macelj | Croatia


A15 motorway | Netherlands


Nanjing Yangtze River | China


Chenab Cable Crane | India


Luling, New Orleans | USA


Sirt–Benghazi | Libya


Steel Plant | Saudi Arabia


Steel Bridges | Sri Lanka


High-Speed-Railway | Taiwan


Tempisque | Costa Rica


Eko Bridge | Nigeria


Pulp Mill | Uruguay


South Pacific Viscose | Indonesia

Russia
Canada
USA
Norway
Sweden
Denmark
Ireland
UK
Netherlands
Poland
Belarus
Belgium
Germany
Slovakia
Czech Rep.
Ukraine
Switzerland
Austria
Hungary
France
Slovenia
Romania
Croatia
Serbia
BiH
Bulgaria
Italy
Spain
Turkey
Greece
Cyprus
Algeria
Israel
Palestine
Libya
Jordan
Egypt
Senegal
Ivory Coast
Nigeria
Kenya
Tanzania
Mozambique
Honduras
Costa Rica
Venezuela
Colombia
Brazil
Uruguay
Kazakhstan
Georgia
Azerbaijan
Armenia
Syria
Iraq
Kuwait
Pakistan
Dubai
India
Saudi Arabia
China
South Korea
Japan
Taiwan
Philippines
Thailand
Sri Lanka
Malaysia
Indonesia

To date over 6000 contracts have been successfully completed in 69 countries world-wide.

# Measurement and Instrumentation

The services of the Measurement and Instrumentation Department range from system identification of structures up to the development of new systems and procedures of measurement and instrumentation in the scope of national and international research projects.

SYSTEM IDENTIFICATION

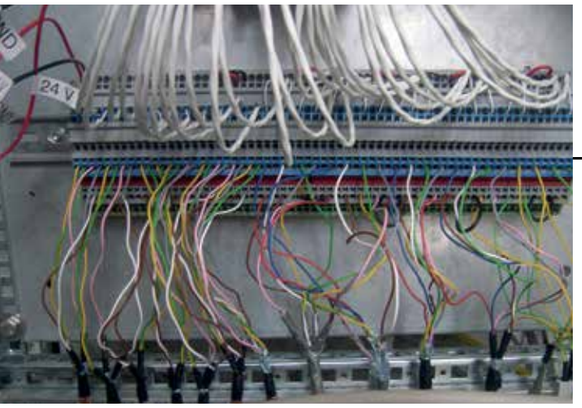
- Measurements and monitoring in the scope of BRIMOS®-analyses
- Permanent instrumentation of structures at risk
- System identification of buildings based on measurements

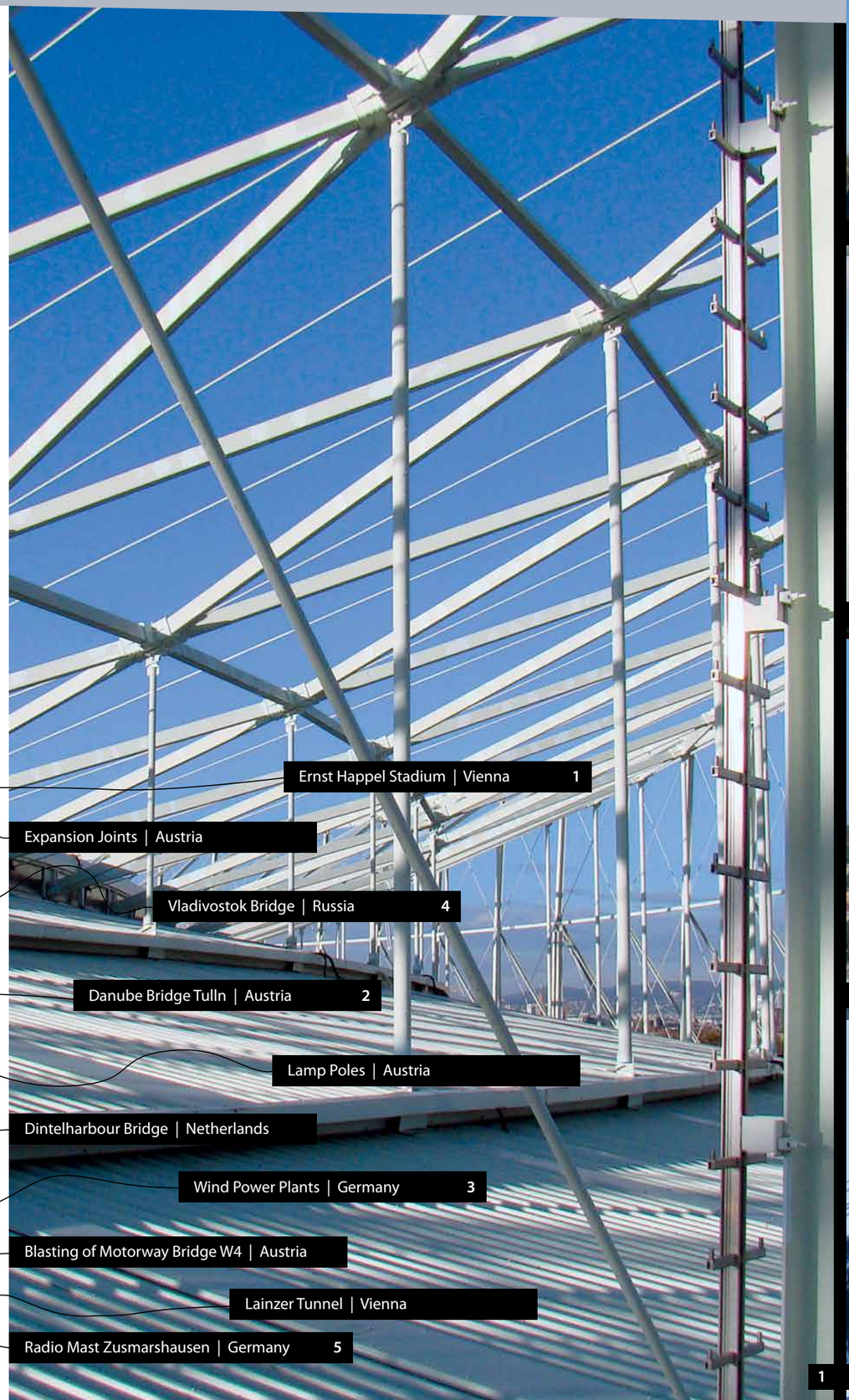
RESEARCH AND DEVELOPMENT

- Development of analytical procedures
- Research on new measurement systems and components
- Further development of measurement methods

SURVEYS

- Assessment according to laws, codes and standards
- Evaluation and interpretation of immission protection measures







# Sound and Vibration Technology and Acoustics

The topic noise and vibration protection becomes increasingly important in metropolitan areas and along big infrastructure projects. This applies in particular to traffic noise but also to sound emissions from trade and industry. Both neighbours and employees are concerned and have to be protected accordingly.

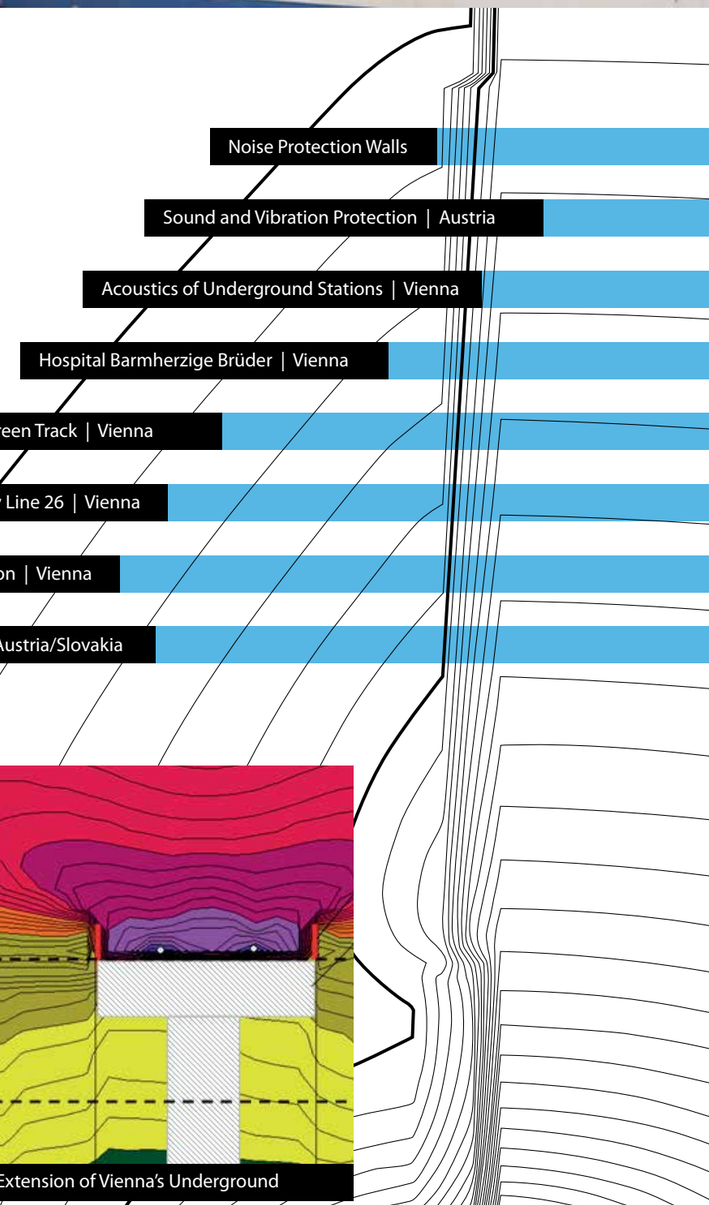
MEASUREMENTS
- Free-field acoustics (ambient, traffic and industrial noise)
- Room acoustics (reverberation period, absorption, workplace)
- Secondary airborne noise

PREDICTIONS/SURVEYS
- Attendant acoustic analyses and calculations for planned infrastructure projects including industrial safety and model calculations on vibration engineering

EVALUATIONS
- Evaluations according to the legal and normative bases

DESIGN
- Protective measures
- Optimization

Acoustic Emission Measurements for the Austrian Federal Railways





Trams in Vienna: Immission Protection


Acoustic Assessment of Expansion Joints


Measurement in an Operating Room

Measurements and Analyses of Tram Line 60


Extension of Vienna's Underground

# Asset Management – Life Cycle Engineering

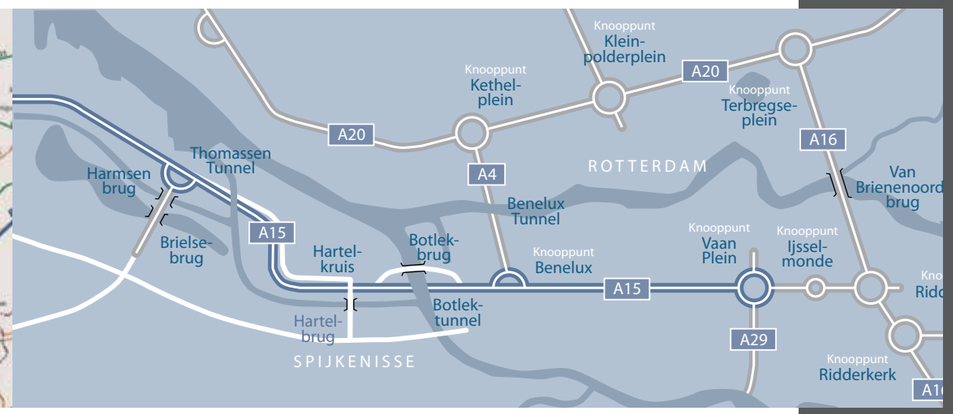
To enable proper and long-term maintenance planning for a huge and heterogeneous set of engineering structures VCE developed an integrated life cycle management tool that offers tailored solutions with regard to the given location, involved materials, fabricates and the underlying design code at the time of construction.

The core of this tool is formed by a probabilistic ageing model and a comprehensive cost model. Each structural member is represented by a generic ageing function, which is derived from the major sources of information reflecting impact on structural ageing (visual inspection/ numerical simulation/structural monitoring and freight traffic progression). Furthermore the model incorporates VCE's 50 years of experience in the field of bridge inspections and structural health monitoring. Due to defined treatment-trigger-criteria a huge set of maintenance strategies is generated leading to an extensive optimization exercise. The final project output is composed by tailored maintenance plans for every structure.

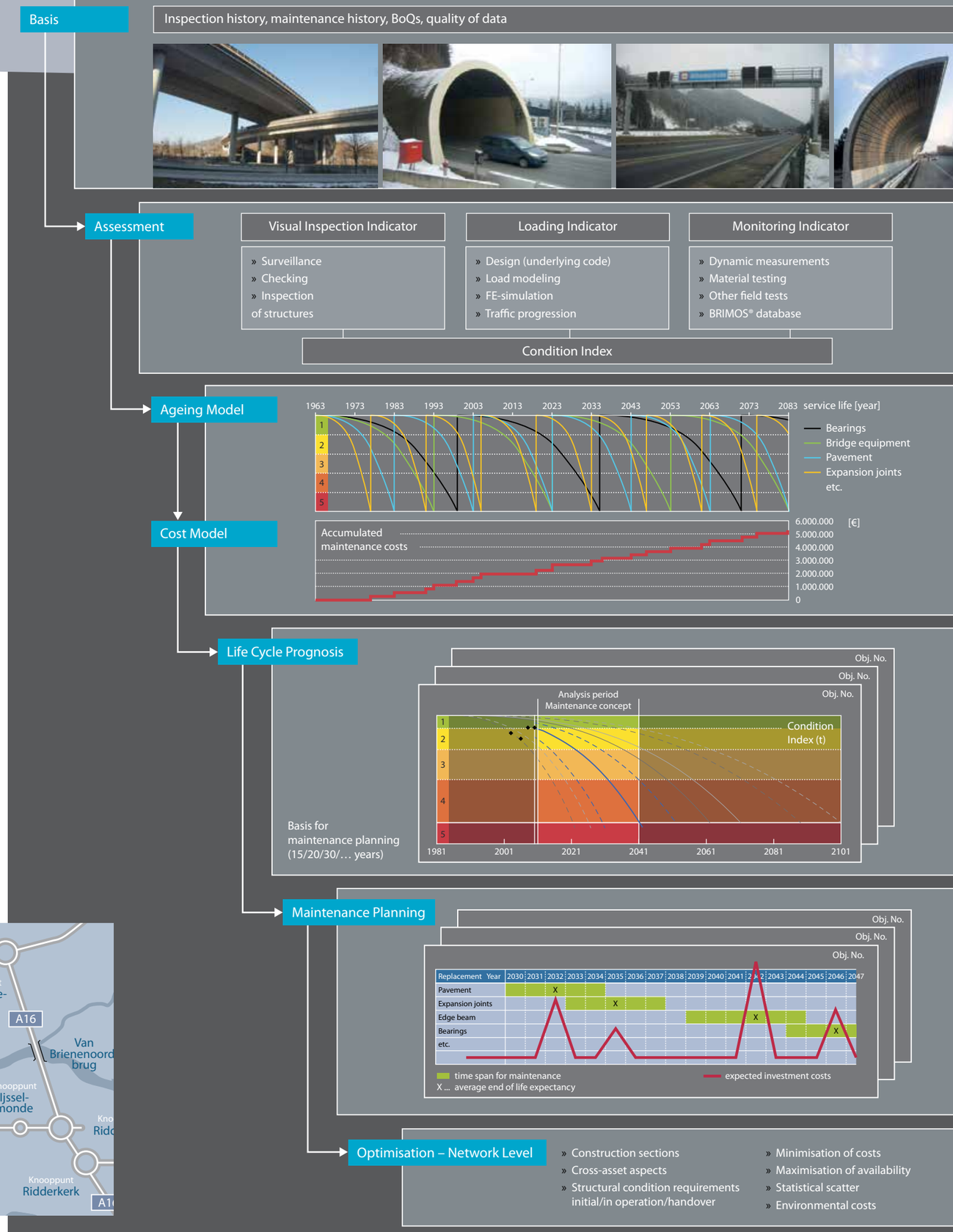
REFERENCES

- A-Lanes A15 Maasvlakte – Vaanplein, Netherlands
- BAB A9 AS Lederhose – Border Thuringia Bavaria, Germany
- S6 Semmering expressway, Austria
- Bridge object 1618-150, New Jersey, USA
- Jamal railroad bridges, Russia
- Ponte della Scafa, Italy
- Silkeborg Spuns North, Denmark
- PPP A5 Nordautobahn Schrick–Poysbrunn, Austria
- Network-arch railway bridge, Vienna Central Station


BAB A9, Germany




A15 Maasvlakte – Vaanplein, Netherlands



# BRIMOS® Structural Health Monitoring

„From Vibration to Information“

The BRIMOS® Technology – successfully applied at numerous structures worldwide – is based on ambient vibration monitoring and offers a broad set of solutions in the field of Structural Health Monitoring.

## In-Depth Monitoring

The structure is covered by a dense measurement grid to determine the three-dimensional dynamic structural behaviour. This enables comprehensive assessment of the structural condition with regard to identification, localisation and quantification of damage.

## Hot-Spot Monitoring

Based on only few sensor positions a report concerning the general current condition of a structure is provided – with regard to a possible detailed follow-up measurement.

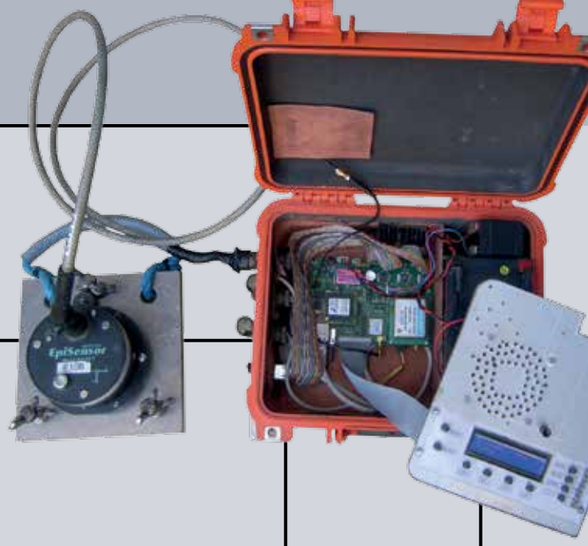
## Permanent Monitoring

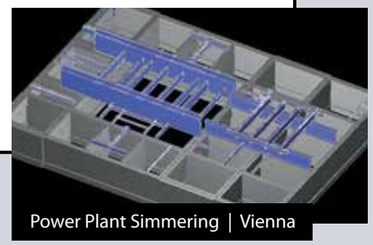
According to the given requirements and problems tailored measurement systems are developed and installed to provide information on the progress of the relevant structural key performance indicators over time. All measurement data and the results of the automated data analysis are available on the BRIMOS® Web-Interface.

## Cable Monitoring

The BRIMOS® method enables a rapid and non-destructive determination of cable forces. In addition the cable stiffness, the damping and the vibration sensitivity of each single cable can be derived based on the measured dynamic characteristics.


Estakáda Masaryk | Czech Republic




Power Plant Simmering | Vienna


Suspended Roof | Airport Vienna


Smokestack | Czech Republic


Donaustadt Bridge | Vienna


W4 Steyrermühl | Austria


Pentele Bridge | Hungary


Waterford Bridge | Ireland


Incheon Bridge | South Korea


Europa Bridge | Austria


Svinesund | Norway/Sweden


Tete Bridge | Mozambique

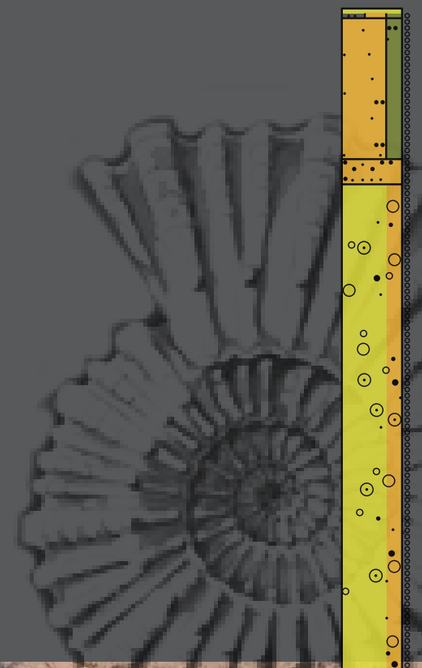
# Geotechnical Engineering

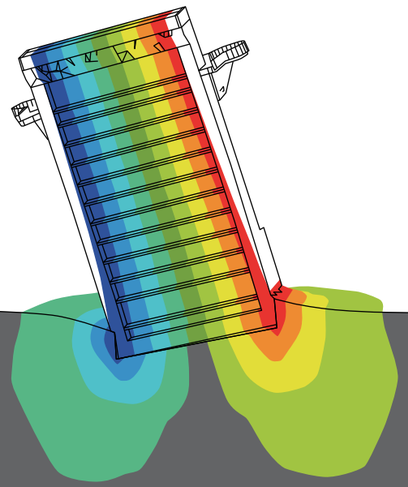
The foundation is an integral part of every structure, however, its impact has to be evaluated differently in every individual case. In contrast to artificial materials (steel, concrete, bricks ...), whose properties are usually clearly defined and can be adjusted to the application case, the subsoil is given and its properties can only be determined at random and incompletely in the course of surveys. Due to this problem and considering safety-relevant and economic aspects, geotechnical engineering is always a challenge both for big and small construction projects.

Geotechnical engineering in construction focuses on the interaction between structure and subsoil (stability, subsidence, differential deformations, dynamic behaviour, hydrogeology), the handling with the foundation during the construction progress (excavation, temporary building pit supporting system, drainage) and the impacts of the operation of a structure on the environment (groundwater, vibrations, secondary airborne sound).

REFERENCES

- Pulp mill in Punta Pereira, Uruguay
- Elementary school Vösendorf, Austria
- Cathedral workshop St. Stephan, Vienna
- Railway route Campina–Predeal, Romania
- Piaristen Krems, Austria
- Pafos–Polis motorway, Cyprus
- Cardinal König House, Vienna
- Hospital St. Pölten, Austria
- Irish Rail, Ireland





The Montes del Plata project is a pulp mill which is being erected and operated according to the most novel and modern principles. After completion this plant will set the technological and ecological standard for such facilities.

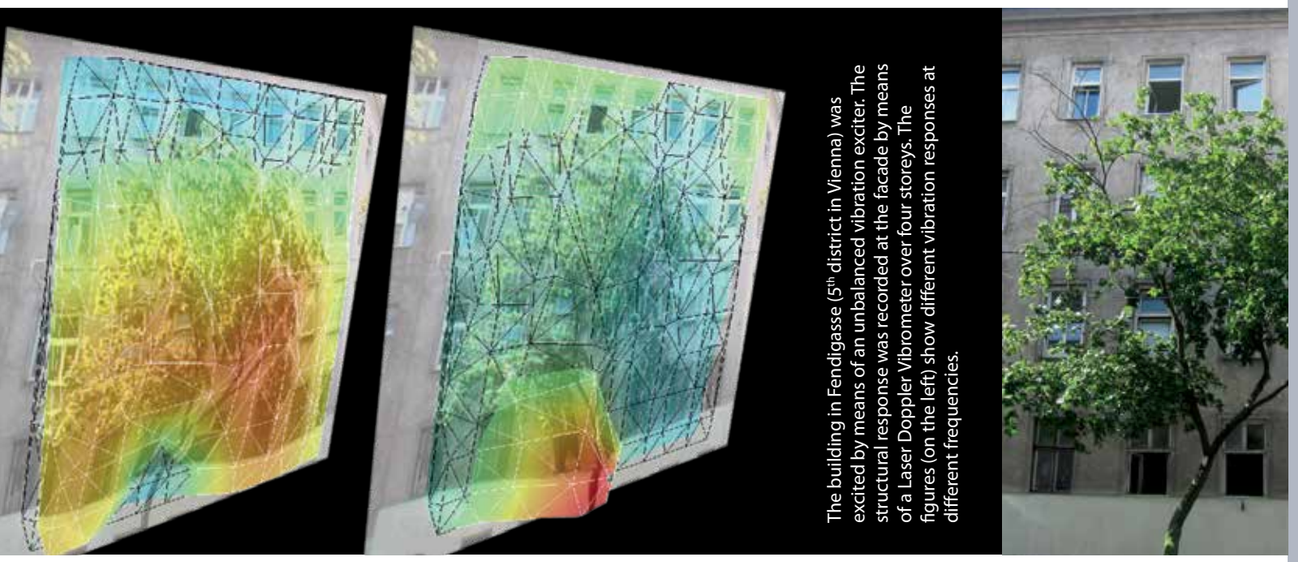
## What is concealed beneath the visible?

# Earthquake Engineering & Seismic System Identification

In the last few years the awareness with regard to earthquake risks and the structural safety of buildings under seismic loads has been rapidly changed in the Viennese area.

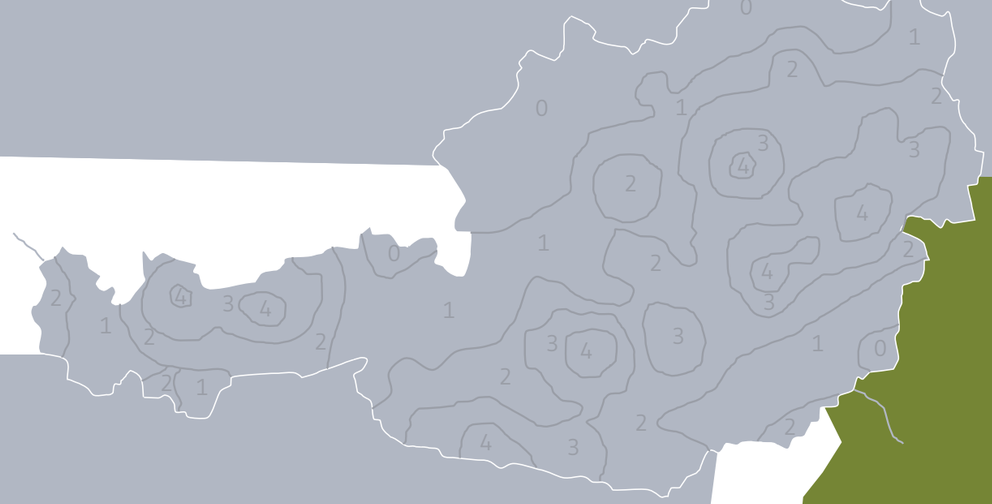
In particular the dominant existing buildings in Vienna (historic residential brick-masonry buildings) represent an enormous challenge for science and the engineering community.

VCE has developed a procedure to determine the actual seismic hazards of a building by measurements, to eliminate any weaknesses and therefore ensure future unrestricted usability.



The building in Fendigasse (5th district in Vienna) was excited by means of an unbalanced vibration exciter. The structural response was recorded at the facade by means of a Laser Doppler Vibrometer over four storeys. The figures (on the left) show different vibration responses at different frequencies.





## Test Methods

### 1. Assessment

- Visual assessment on site and inspection of the plans and historic maps
- Evaluation according to the developed classification method
- Division into risk classes as further decision support

### 2. Detailed Analyses of Existing Structures

- Determination of structurally dynamic behaviour (excitation by unbalanced vibration exciters)
- Identification of weaknesses (e. g. floor stiffness, facade elements)
- Categorization and interpretation

### 3. Verification, Analysis

- Modelling of the structure (numeric or simplified)
- Update, influence of the measurement results (e. g. dynamic parameters, coupling and shear behaviour of the wooden beam ceilings, impact of partition walls etc.)
- Parameter studies (e. g. variation of additional mass in attic conversions)
- Verification of the deflection of seismic forces

The main results and findings from the various research projects were recently published in a book. The authors hope to provide an essential contribution to the discussion on seismic hazards and seismic resistance in the Viennese area.

The book "*Erdbeben im Wiener Becken – Beurteilung, Gefährdung und Standortrisiko*" (Earthquake in the Vienna Basin – Assessment, Hazards and Site Risks, only available in German) can be ordered free of charge. Please contact Ms. Margit Klocker, klocker@vce.at.

**Erdbeben im Wiener Becken**

Beurteilung
Gefährdung
Standortrisiko


Günther Achs
Christoph Adam
Adrian Bekó
Walter Brusatti
Martin Fritz
Thomas Furtmüller
Fritz Kopf
Michael Pietsch
David Schäfer
Alfred Strauss
Barbara Theilen-Willige
Helmut Wenzel
Thomas Zimmermann

# Research

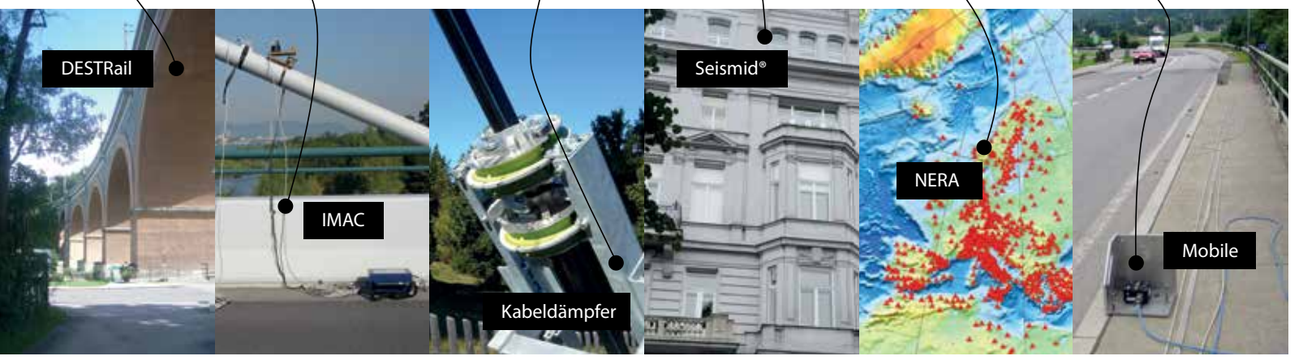
VCE has been successfully engaged in intensive research activities on national and European level for many years. Some of our research projects are listed below:

NATIONAL RESEARCH PROJECTS:

- **SEISMID®.** Development of Methods for Recording the Resistance of Existing Buildings in Vienna against Seismic Forces
- **MIMOSA.** Multi Non-Linear Structural Condition Modelling and Assessment
- **DESTRail.** Preventive Measures for Catastrophes by Real-time Damage Detection
- **Cable Damper.** Development of a New, Effective, Low-cost and Low-maintenance Cable Damper
- **DyGes.** Dynamic Weight Registration System

EU-RESEARCH PROJECTS:

- **NERA.** Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation
- **SYNER-G.** Systemic Seismic Vulnerability and Risk Analysis for Buildings, Lifeline Networks and Infrastructures Safety Gain
- **Mobile.** Moveable Bearings Innovation Launch in enlarged Europe
- **IRIS.** Integrated European Industrial Risk Reduction System
- **IMAC.** Integrated Monitoring and Assessment of Cables




## Success by Research

### SYNER-G

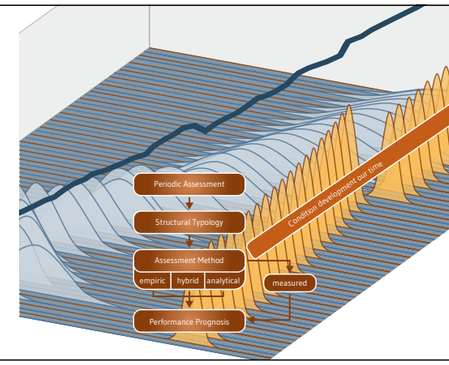
SYNER-G is a research project with a focus on systemic seismic hazards and risk analyses of buildings, lifelines and infrastructures. The major objective of the project is the development of an open-source software, which can deal with the systemic connections of various areas. This management tool links all components of a system under seismic hazard and considers the dependencies within a system as well as interactions between the individual systems.


### IRIS

In the European research project IRIS knowledge and technologies for risk assessment have been developed for various industries. The safety concept comprises technical, human, organizational and cultural aspects and therefore facilitates the assessment of risks and decision support. By means of the cooperation of many industrial sectors on international level the results for the improvement of safety can be implemented and applied in all areas, which increases general safety.

### MIMOSA

The national research project MIMOSA has developed models for the determination of non-linear structural behaviour, which help to define and quantify the reasons for the behaviour of structures by means of comparisons with measurements. This enables accurate predictions regarding further development of the structure and therefore allows optimizing the required maintenance works and the use of resources.

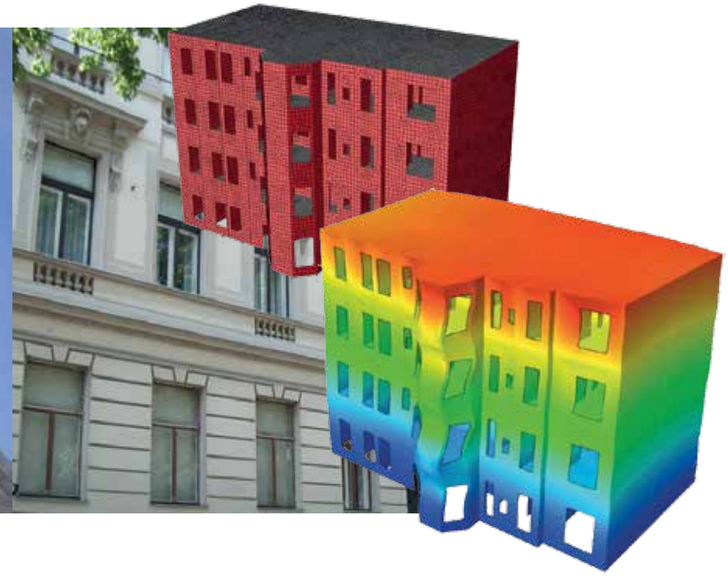


# Awards

VCE obtained the Austrian Award for International Consulting three times, was nominated in this category five times, was nominated for the Austrian Award for Telematics and received an award for the EU research project IRIS as "Austrian Champions in European Research".

AUSTRIAN AWARD FOR INTERNATIONAL CONSULTING 1999
**Kao Ping Hsi Bridge, Taiwan.** The Kao Ping Hsi Bridge in Taiwan is a cable-stayed bridge with a record-breaking cantilever of 330 m. The design of the bridge follows old Chinese principles of harmony considering modern methods and materials. The project represents the gate to the plain of Ping-Tung.

NOMINATION FOR AUSTRIAN AWARD FOR INTERNATIONAL CONSULTING & AUSTRIAN CONSTRUCTION AWARD 2011
**Assessment of Buildings on Earthquake Resistance.** The European rules for building in earthquake areas are continuously tightened so that attic conversions of old buildings in Vienna can hardly be approved anymore, in single cases there are even impending official orders to demolish buildings. VCE has developed a procedure to measure the actual seismic hazards of a building, to eliminate any weaknesses and therefore ensure future unrestricted useability.



1997 Nomination Austrian Award
Bridge Monitoring System

1998 Nomination Austrian Award
Floating Track Slab

1999 Austrian Award
Kao Ping Hsi Bridge, Taiwan

2001 Nomination Austrian Award
CaSCo – Consistent Semi Active System Control

2004 Nomination Austrian Award
IMAC – Integrated Monitoring & Assessment of Cables

2006 Nomination Austrian Award for Telematics
DyGes – Dynamic Weight Registration System

2008 Austrian Champions in European Research
IRIS – Integrated European Industrial Risk Reduction System

2011 Nomination Austrian Award & Austrian Construction Award
Assessment of Buildings on Earthquake Resistance

1993 Austrian Award
Wind Tunnel Test: Kao Ping Hsi, Taiwan

1992 Nomination Austrian Award
Incremental Launched Bridges Taiwan

1990 Austrian Award
Olympic Grand Bridge, South Korea