Issue 18 / April 2006

newsletter

supported by the DG Research
of the European Commission

contents

Published by VCE.

SAMCO ASSOCIATION

SAMCO Strategy

European Association on Structural Assessment Monitoring and Control (SAMCO)

The Steering Committee has decided to found a **European Association on Structural Assessment Monitoring and Control (SAMCO)** after the termination of the European funded network. The main motivation is to keep the well functioning network alive and benefit from our joint achievements. This is a call to everyone to become a founding member of this Association. The foundation will happen at the SAMCO workshop at EMPA on 31. March 2006. The motivation to join could be:

- becoming part of a strong European monitoring community (overseas partners are welcome)
- to receive consolidated information on monitoring and assessment
- to get access to the lobbying efforts towards the 7th framework program
- to receive priority in new research proposals
- to participate and benefit from the huge possibilities in international collaboration the network has worldwide
- to benefit from joint activities
- to become a European Centre of Competence

The Association will be organised by the SAMCO coordinator for the 1st working period of 2 years. After that the organiser will be selected on a vote from all members. To carry the costs of organisation it will be necessary to collect membership fees. It has been decided that the individual fee will amount to € 90,-- for 1 person, € 200,-- for companies nominating 3 persons and € 250,-- for companies nominating 5 persons as members. Members will receive full access to the database and benefit from reduced admission fees at the workshops and conferences.

In terms of internationalisation the new Association will join the International Society for Structural Health Monitoring and Intelligent Infrastructure **(ISHMII)** which organises bi-annual events (2007 in Vancouver, 2009 in Switzerland, 2011 in the U.S.A, 2013 in Singapore). You will have the same rights and access to the ISHMII database and information.

More details and a registration form will be sent in case this offer is interesting for you. The Association will start its operation in April 2006.

Please don't hesitate to ask me any details on this proposal.

With best regards

Helmut Wenzel

Contact

VCE Holding GmbH

Dr. Helmut Wenzel

Hadikgasse 60
1140 Wien
Austria

t +43 (0)1-90292 / 1116
f +43 (0)1-8938671
e-mail wenzel@vce.at

SAMCO Results

History of SAMCO Events

Within the framework of SAMCO project 1 Kick-Off Meeting, 12 Workshops and 2 Summer Academies were held in order to bring together top experts in structural assessment, monitoring and control from all over the world and to build connections across the borders.

The **1st SAMCO Workshop** was held in Como / Italy in April 2002, half a year after the **SAMCO Kick-Off Meeting in Assisi**. 22 persons attended this first workshop of which the main subjects were the Progress of the SAMCO activities as well as the 6th Framework Programme. Further the NEES Project was touched on and a prototype of the SAMCO Database was launched.

The **2nd SAMCO Workshop**, held in Brussels dealt mainly with the topics Monitoring and Assessment, Seismic Assessment and Active Control. The basic idea was to disseminate information about the SAMCO network, show recent research work in the field and stimulate a discussion on new projects to be submitted within the 6th framework programme.

The **3rd SAMCO Workshop** took place in Vienna / Austria where the integrated project E-MOI and its sub-projects, in particular the items determination of the final consortium, financial allocation within the project and definition of detailed objectives were discussed.

The 4th SAMCO Workshop was the **1st International Summer Academy** on Structural Assessment, Monitoring and Control. It was a One-Week-Event in July 2003 at the Robinson College of Cambridge University. About 90 persons from 22 countries participated in the event, 37% of them came from industry; the others were researchers and students. The first Summer Academy was a great success for the SAMCO network. The way of dealing with subjects in longer presentations was unique and provided unusual quality of information transfer. The collected contributions were outstanding and provided a very good insight into the current practice in the field.

The main topics of the **5th SAMCO Workshop** taking place in Vienna / Austria were the SAMCO progress, the second call of NMP under the Sixth Framework Programme as well as a range of proposals for projects within the framework of SAMCO, introduced by SAMCO members and partners.

In April 2004 the **6th SAMCO Workshop** was held in Warsaw / Poland. This was the first NAS (Newly Associated States) Workshop in the History of SAMCO. The aim of the Workshop was at first to bring together experts in structural assessment, monitoring and control from Poland and the former EU member states to build connections and to inform each other about the state-of-the-art in bridge monitoring.

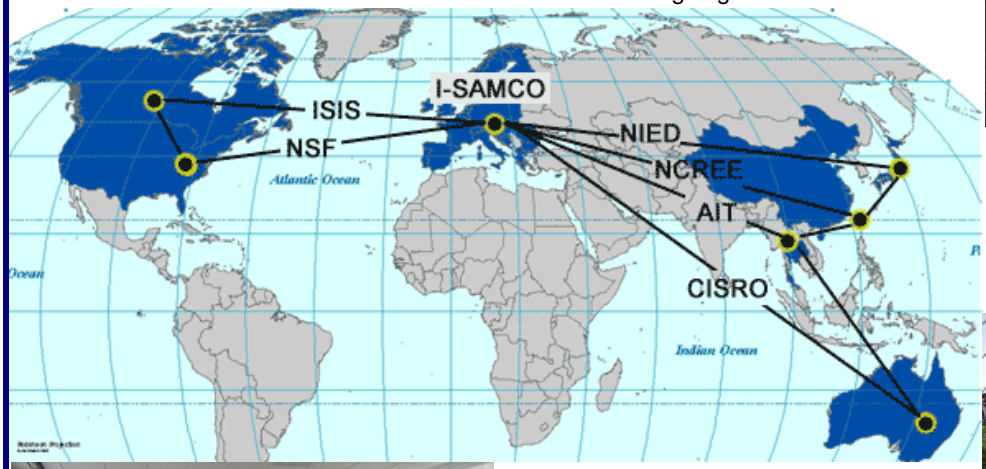
The **7th SAMCO Workshop** took place in June 2004 in Rome / Italy. In the course of the workshop a view on SAMCO covering the entire positive and negative sides of the network as well as suggestions how to improve the cooperation were presented. At this it was mentioned that SAMCO had a good core group, however the role of women might be enhanced to become equal. Further a connection to environmental and social sciences would be desired, items which were briefly discussed with the will to seize those suggestions. Some of the requests have already been covered by I-SAMCO.

The **8th SAMCO Workshop** in September 2004 was the "Harmonization Workshop" in Ispra / Italy with the aim to enable international collaboration, harmonise communication and standardise data and protocols. The intention was to invite researchers from Europe, America and Asia dealing with experimental data to give presentations on the subject explaining the current practice of their regions. Each presentation was followed by an in depth discussion on a probable global format to be proposed and standardised. The workshop ended in a resolution on international collaboration, comprising a roadmap for data format standardisation, a definition of priority areas and programs, international joint calls (NSF-EU-Japan-China) and funding mechanisms.

The first International Workshop, the **NEES and NEESgrid Seminar**, was held in Ispra / Italy from May 23rd to May 24th 2005. The seminar taking place on the premises of JRC Ispra 2005 was organized by NEESit (international Partner NSF) and JRC (project participant.

This international workshop held in the course of the I-SAMCO project had the following objectives:

- Identification of the current practice and state of the art
- Meeting of the International forum
- Integration of SAMCO partners
- Coordination and harmonization of ongoing RTD activities



The I-SAMCO (International SAMCO) Kick-Off Meeting took place in Vienna / Austria in May 2004. As the specific support action I-SAMCO is embedded in SAMCO it was concurrently the **9th SAMCO Workshop**. Large networks and projects have been identified worldwide acting along the same lines as SAMCO to accommodate the international demand for standardization initiatives. I-SAMCO is scheduled to operate until November 2006.

The **10th SAMCO Workshop** took place on April 28th and 29th at BAM (Federal Institute for Materials Research and Testing) in Berlin / Germany and was well attended by 28 participants from all over Europe.

2005 Summer Academy SAMCO

80 persons from 27 nations from all over the world participated in the **SAMCO Summer Academy**, which took place from September 5th to September 9th 2005 in the province of Salzburg in Austria, to be more precise, in Thumersbach, situated at the mountain lake Zeller See opposite the small town Zell am See.

31 persons mostly from Slovenia participated in the **13th SAMCO Workshop** dedicated to the newly associated states (**NAS**) of the European Union and which took therefore place in Ljubljana / Slovenia from October 10th to October 11th 2005.

The 14th SAMCO (NAS) Workshop was planned to be held in Hungary, however it was cancelled.

The **Final Workshop** took place from March 30th to 31st at EMPA / Switzerland. It was very well attended with around 50 persons. Amongst other items the history and achievements of the SAMCO project, the future of SAMCO as well as project ideas for FP 7 were outlined. Further the European Association for SAMCO was founded in the course of the workshop.

Damage Detection after Condition Compensation in Frequency Analyses

ABSTRACT

Recent publications raised doubts that damage in structures can be detected by the application of frequency analyses. In fact temperature changes very often show larger reactions in spectra than any smaller damage. Beside temperature, other environmental influences, such as a radiation from sunshine, create changes in the structural systems which have to be considered.

The present paper demonstrates the capabilities of new compensation methods in frequency analyses. When the environmental conditions are monitored together with the structural response a proper reaction can be predicted. The described compensation process in general deals with the following sources of input:

- Temperature (daily and annual cycles)
- Compensation of live load (moving vehicles etc.)
- Influence of wind loads
- Bearing friction
- Restoring forces
- Change of boundary conditions
- Impact energy
- Instrumentation

After elimination of all operational and environmental factors, stable frequencies are achieved.

$$f_{total} = f_0 + \sum_{i=factors} f_i \qquad (1)$$

where

f_{total} … vector of total (measured-like) frequencies

f_0 … vector of structural (own-like) frequencies

f_i … vector of influenced (measured) frequencies

i … considered operational and environmental factors

Any deviation therefrom can be interpreted as damage or extraordinary event. This procedure opens new possibilities for structural management and lifetime prediction. The present paper demonstrates some investigation on two sources, which are assumed to be the major ones.

COMPENSATION OF TEMPERATURE

The following analysis is based on investigations on the Europabrücke – a well known Austrian steel bridge near Innsbruck, opened in 1963 – which is 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 Europabrücke (since 1997) led to the installation of a permanent measuring system in 2003 [1].

The bridge's reference sensor (3D-forced balance accelerometer) is installed within the main span, at a distance of 0,4 times of the span's length from pier II. At this base point, global stiffness and its dependence to several environmental influences are assessed (sampling rate = 100 Hz, file length = 330sec).

By evaluating results (frequency spectra) of several measurements, telescoping them together and viewing them from above (so called trend cards), the following visuals are obtained, which exemplarily show the main span's relevant vertical stiffness-patterns of a particular day with a distinct progression of temperature.

For the sake of completeness, the corresponding frequency spectra themselves are shown in Figure 2, again over a period of this day. An individual procedure has been developed in [2], which contains some measurement preconditioning (offset elimination & bandpass-filtering). To enable a more stabilized automatically performed peak picking in different ranges of frequency, the response spectra are smoothed in the course of frequency assessment.

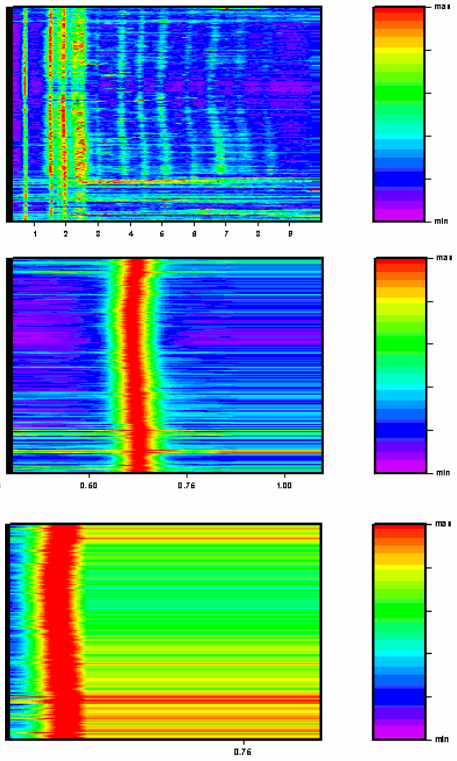


Fig. 1: Trend of stiffness during one day; 0,30-10 Hz / 0,30-1,10 Hz / 0,60-0,80 Hz

The permanent monitoring system exhibits the remarkable loading impact, as the bridge is currently stressed by more than 30000 motor vehicles per day (approximately 20% of them are freight traffic). By applying the previously described method to the reference sensor's measurement data for the whole day, a progression of stiffness, which consist of 281 single peaks is obtained

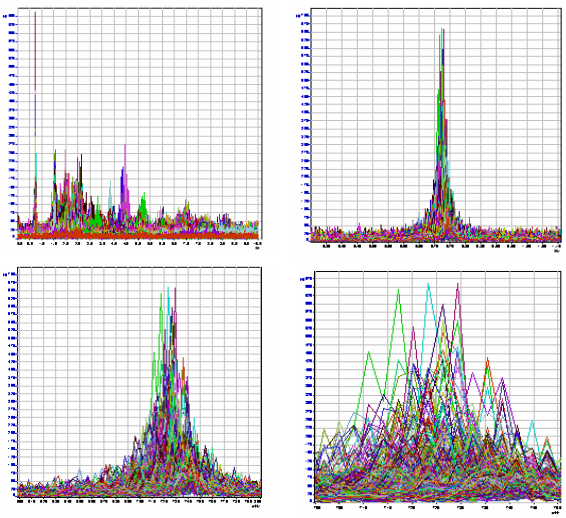


Fig. 2: The trendcard's front views for one day; 0,30-10 / 0,30-1,10 / 0,60-0,80 / 0,68-0,74 Hz

(Figure 3-left) and represents randomly occurring ambient and forced vibration conditions (=> scatter).

Due to this relation, temperature sensitive asphalt layer is implemented into the cross sections of the global structural analysis model, which leads to a distinctive progression of the mid span's flexural rigidity (Figure 4- right).

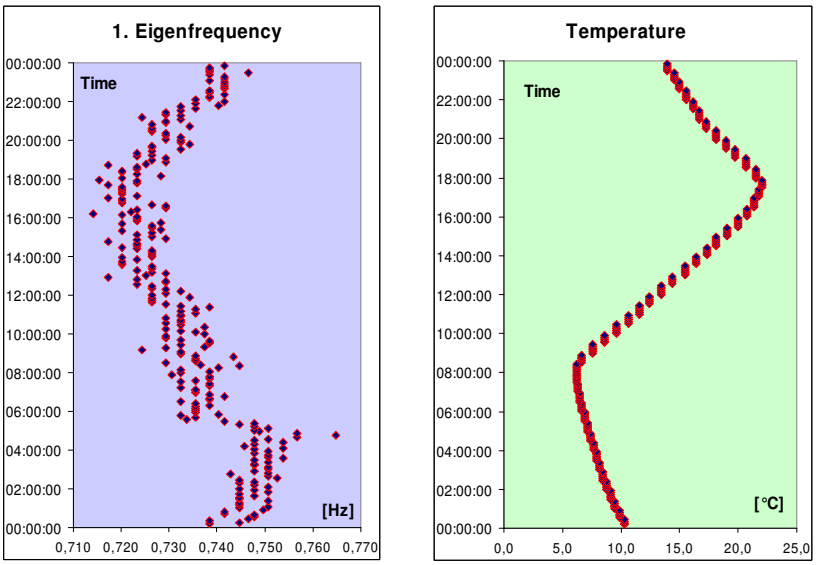


Fig. 3: Pattern of 1st Eigenfrequency and its obvious dependency on temperature

The complementary relation between stiffness and the air temperature itself (registered at the bridge's base point directly above the pier II) is obvious and can be interpreted as a long sinusoidal wave of the main span in the vertical direction. In the course of the described procedure it should be considered, to omit the described bandpass filtering and replace it by a further optimized smoothing of the frequency spectra for reasons of stabilizing the accuracy of peak picking.

Stiffness vs. Temperature

To describe the verified phenomenon mechanically, it has to be focused on temperature dependence of the roadbed's asphalt layer, as the change of steel characteristics under varying climate conditions is negligible. In the first step, a characteristic relationship of the dynamic Young's modulus in dependence of temperature is used [3].

$$f_i = \frac{\lambda_i^2}{2 \cdot \pi \cdot L^2} \left(\frac{EI}{m} \right)^{1/2} \qquad (2)$$

According to the widely known eq. 2, frequency of vibration is proportional to the square-root of the moment of inertia [4]. For that reason, a curve in terms of frequency needs to be generated (Figure 5- middle) for the next step, when a temperature-based stiffness path is eliminated from the overall trend (from Fig. 5 left to Fig. 5 right).

The obtained trend shows very clearly the remaining impact of freight traffic itself, which strongly affects the timeframe between 5 a.m and 10 p.m, when trucks are allowed to pass the bridge and cause two characteristic offsets during the course of the day.

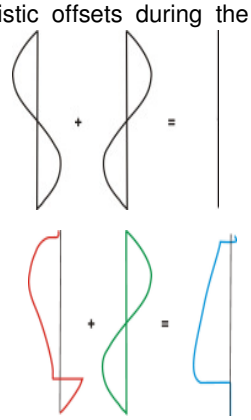


Fig. 6: Comparison of expected (above) and actual (below) consequences of temperature-compensated natural frequency patterns

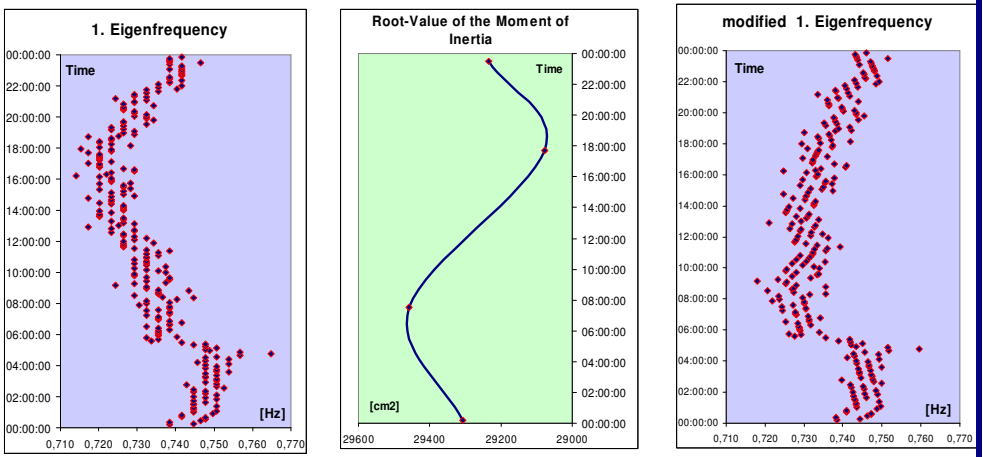


Fig. 3: Pattern of 1st Eigenfrequency before and after compensation of temperature

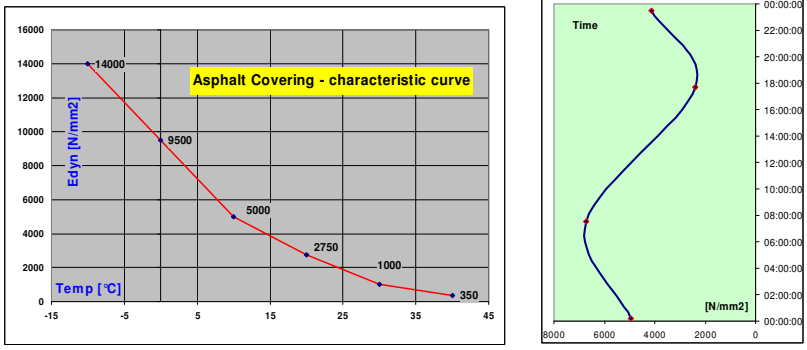


Fig. 4: Progression of the asphalt layer's flexural rigidity in dependence of its temperature

COMPENSATION OF ADDITIONAL (MOVING) MASSES

The modified trend of the main span's stiffness already includes lots of characteristics of the prevailing freight traffic progression. Unfortunately traffic data from the competent authorities are available only per hour. For some introductive exploration on approximate additional mass compensation steps need to be undertaken.

Frequency of vibration, based on eq. 2 again, is inversely proportional to the square root of the mass. This means, that live loads cause increase in effective mass, which leads to hourly calculated factors to modify the fluctuating frequency. Due to

that relation the scattered trend of frequency is straightened in dependence of modal contribution of trucks per hour (Figure 8)

CONCLUSIONS

The discussed approach – benefited by permanent monitoring – allows to reach the conducted goals, even if already gained experience with the applied methods is still of some approximation in character. The results are very promising, although using air-temperature instead of that of structural elements. The shown approach represents an innovation in stiffness assessment appropriate for long-term application. The goal of generating frequency progressions over time without major environmental and operational impact has come into reach.

The procedure will be optimized in progressive stages, as soon as the already introduced cantilever-sensor based approach is implemented.

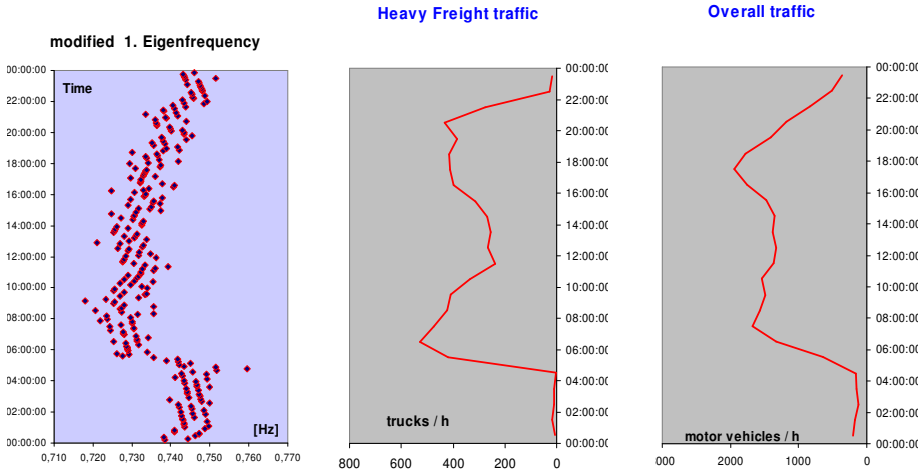


Fig. 4: Modified pattern of stiffness being strongly affected by traffic loading (moving additional masses)

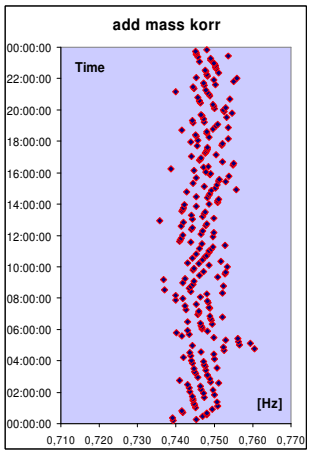


Fig. 5: Stiffness pattern after approximate compensation of additional masses)

In fact the permanent monitoring system's present configuration would provide the possibility to develop a more sophisticated and more reliable, strictly measurement data-based method. Parts of a certain pattern recognition procedure output (introduced in [5]) - based on smoothing of the measurement signals, could be utilized.

Forced Balance Accelerometers located in a defined distance along the cantilever's outer edges - in both directions of traffic – enable the verification of recurring truck passages and their related velocity and tonnage without any disturbance of traffic.

By this way the moving loads within each measurement file - passing the main span simultaneously - could be identified and would lead to a shifting of the single peak in the frequency response spectrum, which represents the registered time history in each measurement file.

REFERENCES

1. Wenzel, H., and D. Pichler. 2005. "Ambient Vibration Monitoring," *J. Wiley and Sons Ltd.,* Chichester - England, ISBN 0470024305
2. IMC: *FAMOS Version 3.2, Reference Manual*. Berlin – Germany. 2001
3. Willberg, U. 2001. "Asphaltschichten auf hydraulisch gebundenen Tragschichten – Untersuchungen zum Tragverhalten," *Doctoral Thesis.,* Munich - Germany, pp. 10-11.
4. Blevins, R.D.1979. „Formulas for natural frequency and mode shape," Van Regional Company, New York
5. Veit R., H. Wenzel and J. Fink. 2005. "Measurement data based lifetime-estimation of the Europabrücke due to traffic loading - a three level approach", In International Conference of the International Institute of Welding. Prague.

Contact

VCE Holding GmbH

Helmut Wenzel and
Robert Veit

Hadikgasse 60
A - 1140 Wien

Tel: (+43) 1 - 90292 – 1116 or 1420
Fax: (+43) 1 - 8938671
Email: wenzel@vce.at
veit@vce.at

University of Ottawa / Department of Civil Engineering

Hiroshi Tanaka

161 Louis Pasteur
Ottawa, Ontario
Canada, K1N 6N5

Tel: (613) 562-5800 ext. 6144
Fax: (613) 562-5173
Email: htanaka@uottawa.ca

Company Profile

KINEMETRICS INC.

About Kinemetrics Inc.

Kinemetrics Inc. is a leader in the earthquake instrumentation industry. For over thirty five years, the company has been creating products for monitoring bridges, dams, structures, seismic arrays and networks, as well as systems for the nuclear power industry. With a reputation for high-quality products and superior reliability Kinemetrics pays careful attention to customer service and satisfaction.

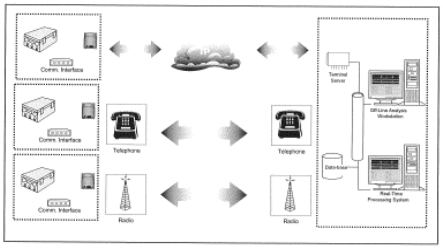
Kinemetrics, with its corporate office in California and its additional sales, services and repair office in Switzerland, has a solid reputation for producing unique, high quality instruments. Over 45 reliable representatives and a full-service department dedicated to fulfilling maintenance contracts, installations, training and support serve customers throughout the world.

Since the transfer of ownership to Oyo Corporation of Japan in 1991, Kinemetrics also has developed into the undisputed world leader for cutting-edge seismic instrumentation. With the 1999 acquisition of Quanterra Inc. of Harvard, Massachusetts, the company continues with its strategic plan of creating a new generation of very broadband seismic instrumentation and network solutions.

Through cooperative efforts with each other and with other strategic partnerships, the two organizations successfully designed, delivered, installed and now maintain national seismic networks and observatories in such diverse areas as the Middle East, South America and Asia.

KINEMETRICS **Sierra**

Seismic Monitoring System



Kinemetrics' importance in the world market is often a source of surprise for those who live in or visit Pasadena in Southern California. Few people are aware that this company produces many of the instruments that provide seismological data to scientists and supply engineers with valuable information enabling them to make buildings, dams and bridges safer. Even fewer people know that Kinemetrics' instruments are used to monitor the seismic safety of many of the world's most famous structures, including New York's Statue of Liberty, San Francisco's Golden Gate Bridge, Egypt's Sphinx, Athens' Parthenon and India's Taj Mahal.

Kinemetrics' manufacturing and design facilities in Southern California enable the company to take advantage of the unique opportunities of the region. Partnerships with leading higher education and scientific research institutions ensure that the company will remain in the forefront of technological innovation.

In addition to the acquisition of Quanterra in 1999, Kinemetrics became certified that same year with the International Standards Organization's ISO9001 quality management system. The company has since upgraded its certification to ISO9001:2000.

Kinemetrics continues to be known and respected around the world for producing reliable, high-quality products. The company values, present since Kinemetrics' inception in 1969, are still reflected in their Quality Statement:

Solutions

Aspen:
Environmental Monitoring
is a distributed open-architecture system designed to provide a comprehensive set of environmental monitoring data and processed information.

VDAS:
Nuclear Treaty Verification
The Verification Data Acquisition System VDAS is a commercial-off-the-shelf distributed, open-architecture system addressing the special needs of the nuclear treaty verification community.

Sierra:
Seismic Monitoring
Sierra provides rapid information for earthquake mitigation by monitoring seismic events from local, regional and national networks and arrays.

Condor:
Power Plants
The most comprehensive earthquake monitoring solution for nuclear power plants (NPPs) -- including seismic-event data recording, retrieval, analysis and notification via.

Oasis:
On-line Alerting/Civil Structure Health monitoring
OASIS is a hardware and software system for real-time, on-line monitoring of structures for continuous evaluation of structural integrity.

Contact

Corporate Headquarters:

Kinemetrics Inc.

222 Vista Avenue
Pasadena, CA 91107

USA

Tel: (626) 795-2220
Fax: (626) 795-0868
Web Site: www.kinemetrics.com
Email: sales@kmi.com

European Office:

Kinemetrics SA

ZI Le Trési 3
CH-1028 Préverenges

Switzerland

Tel: ++4121 803 2829
Fax: ++4121 803 2895
Email: kmi_sa@bluewin.ch

Announcements

2006

JUNE

■ **12th – 16th**

Advances in Modeling and Control of Flexible Mechanical Systems

Udine / Italy

ADMISSION

The registration fee is € 450 for students and participants on the regular staff of universities and research centres, or € 650 for other participants.

Applicants must apply at least one month before the beginning of the course. Application forms can be sent by post or on-line through our web site: http://www.cism.it

A letter of confirmation will be sent to accepted participants.

Contact

CISM

André Preumont

Palazzo del Torso - Piazza Garibaldi 18
33100 Udine
Italy

t +39 0432 248511 (6 lines)
f +39 0432 248550
e-mail: cism@cism.it

JULY

■ **5th to 7th**

3rd European Workshop on Structural Health Monitoring

Granada / Spain

More information:

www.shm-europe.net

Contact

Universidad Politecnica de Madrid, Aerospace Materials Department

Alfredo Güemes

28040 Madrid
Spain

t +34 91 3366327
f +34 91 3366334
e-mail aguemes@dmpa.upm.es

AUGUST

■ **23rd to 26th**

ICDVC-2006 - The Second International Conference on Dynamics, Vibration and Control

Beijing / China

SEPTEMBER

■ **13th to 15th**

IABSE Symposium - 'Responding to Tomorrow's Challenges in Structural Engineering'

Budapest / Hungary

Early Bird Registration for reduced fees is by May 15 2006!

Symposium Topics

new functional demands, new expectations, new working practices, new opportunities.

Attractive Subject Areas

high performance materials, glass, fibre reinforced polymers, challenging structures.

More Information:

http://www.iabse.org/conferences/budapest2006/index.php

Contact

IABSE / AIPC / IVBH

Sissel Niggeler

ETH Hönggerberg
CH-8093 Zürich,
Switzerland

t +41-44-633 3150
f +41-44-633 1241
e-mail niggeler@iabse.org

■ **18th to 19th**

I-SAMCO Workshop "Advances in Structural Monitoring of Historical and Modern Structures"

Prague / Czech Republic

LOCATION

Institute of Theoretical and Applied Mechanics, Czech Academy of Science

OBJECTIVES

The workshop should bring together scientists and practicing experts in the field who will present their work and should attract also young entrants.

It will be focused on the different aspects and problems faced during the monitoring of structures with regards to their character.

More information and download of registration form from this site:

Contact

Institute of Theoretical and Applied Mechanics

Stanislav Pospisil

Prosecká 76
190 00 Prague 9
Czech Republic

t +420283880854
f +420286884634 or +420605766729
e-mail pospisil@itam.cas.cz

http://www.itam.cas.cz/samco

■ **21st to 22nd**

Course on Structural Health Monitoring in Civil Engineering

Leuven, Belgium

More information and download of registration form:

Programme
Registration Form

Contact

KUL, Dept. Burgerlijke Bouwkunde

Guido De Roeck

Kasteelpark Arenberg 40
BE-3001 Heverlee

t +32 16 321666 or +32 16 321665
f +32 16 321988
e-mail guido.deroeck@bwk.kuleuven.be