

## TIME TABLE

TIME	Monday May 24	Tuesday May 25	Wednesday May 26	Thursday May 27	Friday May 28
9.00 - 9.45	Registration	Brincker	Aktan	Testa	Testa
9.45 - 10.30	Cunha	Brincker	Aktan	Testa	Morassi
11.00 - 11.45	Cunha	Cunha	Cunha	Gentile	Morassi
11.45 - 12.30	Brincker	Cunha	Cunha	Smyth	Benedettini
14.30 - 15.15	Brincker	Aktan	Brincker	Benedettini	
15.15 - 16.00	Brincker	Aktan	Gentile	Benedettini	
16.30 - 17.15	Aktan	Gentile	Gentile	Smyth	
17.15 - 18.00	Aktan	Gentile	Gentile	Smyth	

## ADMISSION AND ACCOMMODATION

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

A message of confirmation will be sent to accepted participants. If you need assistance for registration please contact our secretariat.

The 700,00 Euro registration fee includes a complimentary bag, four fixed menu buffet lunches (Friday not included), hot beverages, on-line/downloadable lecture notes and wi-fi internet access.

A limited number of participants from universities and research centres who are not supported by their own institutions can be offered board and/or lodging in a reasonably priced hotel. Requests should be sent to CISM Secretariat by **March 24, 2010** along with the applicant's curriculum and a letter of recommendation by the head of the department or a supervisor confirming that the institute cannot provide funding. Preference will be given to applicants from countries that sponsor CISM.

The Deutscher Akademischer Austausch Dienst (DAAD) and the Deutsche Forschungsgemeinschaft (DFG) offer support to German students. Please contact:

DAAD, Kennedyallee 50, 53175 Bonn  
tel. +49 (228) 882-0  
e-mail: [postmaster@daad.de](mailto:postmaster@daad.de)  
web site: <http://www.daad.de/de/kontakt.html>

DFG, Kennedyallee 40, 53175 Bonn  
tel. +49 (228) 885 2655  
e-mail: [ing4@dfg.de](mailto:ing4@dfg.de)  
web site: <http://www.dfg.de>

Information about travel and accommodation is available on our web site, or can be mailed upon request.

*For further information please contact:*

CISM  
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33100 Udine (Italy)  
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## MONITORING, CONTROL AND IDENTIFICATION OF BRIDGES BY DYNAMIC METHODS

Advanced Professional Training  
coordinated by

**Francesco Benedettini**  
Università dell'Aquila  
Italy

**Antonino Morassi**  
Università di Udine  
Italy

**Udine, May 24 - 28, 2010**

## MONITORING, CONTROL AND IDENTIFICATION OF BRIDGES BY DYNAMIC METHODS

Bridge infrastructures are one of the systems on which a large amount of economical resources is reserved in every country, both for new construction and for the programmed maintenance of the existing ones. Due to the fast increase of both ordinary and exceptional traffic loads and because of the harshness of the environmental conditions, bridge structures are deteriorating at an alarming rate. Moreover, since the main European and American highways were built around the 60's-70's, many important bridges have reached the critical age of 30-40 years of service at which rehabilitation and retrofit become essential. In some countries, in addition, the introduction of new national seismic codes requires the assessment of the structural safety of bridges and prediction of their residual operational life under seismic loads that, generally, are higher than the previous ones.

For these reasons, one of the most important and actual challenges in the field of civil engineering infrastructures concerns the development of health monitoring programs able to give real-time knowledge of a critical condition possibly occurring in a bridge system. Bridge condition assessment is usually carried out by visual inspections. However, visual inspections suffer of many disadvantages. They cost significantly and, more important, many experts argued that the limitations and shortcomings associated with the subjective character of this evaluation able, in principle, to cause erroneous destination of economical resources. Non destructive dynamic methods are the ideal candidate for objective/quantitative health monitoring applications on bridges. Traditional applications of Experimental Modal Analysis are mainly based on the measurement of frequency

response functions and, as a consequence, require the closure of the tested structure for its normal use. This circumstance could be too restrictive or even impossible for monitoring programs. In these cases, even if the excitation is not measured (e.g., the input is produced by the ordinary traffic or by ambient noise), modern output-only identification techniques of Operational Modal Analysis represent an effective way of operation for monitoring purposes since they can be used to estimate the dynamic parameters of a bridge without interrupting its service. Full-scale dynamic testing provides very useful information about the structural behaviour of bridges. In fact, the calibration of an analytical model of a bridge, via structural identification techniques, gives a fundamental and quantitative understanding of the critical elements and mechanisms that deserve the most attention in modelling, such

as mechanisms of flexibility, energy dissipation and inertia. The resulting calibrated model can be used to reliably evaluate the serviceability and safety limit states of a bridge or it can be adopted as the starting point of a health monitoring program. The purpose of the course is to present an updated state-of-the-art overview of the dynamic methods for monitoring, control and identification of bridges, including modern experimental techniques, advanced computational methods and analysis of the theoretical aspects which are important in practical applications. Several experimental applications to real life situations concerning full-scale bridges will be treated in the lectures. The course is addressed to PhD students, doctoral and post-doctoral researchers working in the area of civil and mechanic engineering.

## INVITED LECTURERS

**A.Emin Aktan** - Drexel University, Philadelphia, USA  
*6 lectures on:* Introduction to structural health monitoring (SHM) of bridges. Integration and implementation of analytical, experimental and information technologies for SHM purposes. Methods for designing instrumentation and data acquisition set-up for full-scale bridge testing application. Best practice guidelines for analytical modelling of bridges at various levels of detail.

**Francesco Benedettini** - Università di L'Aquila, Italy  
*3 lectures on:* Development and application of a maintenance program for a cluster of bridges of a Public Local Territorial Authority based on synergetic use of visual inspections and dynamical tests. Special application: crossover and veering phenomena in concrete twin-arches.

**Rune Brincker** - University of Southern Denmark, Aalborg, Denmark  
*6 lectures on:* Ideas and concepts of Operational Modal Analysis (OMA). Testing procedures. OMA signal processing. Frequency domain methods. Time Domain methods. Automated identification and other future aspects.

**Álvaro Cunha** - FEUP, University of Porto, Portugal  
*6 lectures on:* Basic concepts of signal processing and of Input-Output Experimental Modal Analysis (EMA). OMA testing of bridges and special structures. Finite element model correlation and updating. Applications to large suspension bridges and to lively footbridges. Continuous dynamic monitoring for alert and damage detection.

**Carmelo Gentile** - Politecnico di Milano, Italy  
*6 lectures on:* Monitoring techniques based on non-contact measurement of displacement time-histories by microwave interferometry. Correlation between EMA/OMA and FEA, sensitivity analysis, manual and semi-manual model tuning, model updating. Examples of dynamical characterisation and structural identification of bridges.

**Rene Testa** - Columbia University, New York, USA  
*3 lectures on:* Dynamic system monitoring of long-span bridges. Application of modal analysis to fatigue and/or crack propagation in steel bridges.

## SEMINARS

**Antonino Morassi** - Università di Udine, Italy  
*2 seminars on:* Dynamic methods for damage detection in structures: general aspects and applications to bridges.

**Andrew Smyth** - Columbia University, New York, USA  
*3 seminars on:* Monitoring techniques based on modal analysis supplemented with GPS measurements. Structural identification techniques using GPS data in fusion with accelerometer data.

## LECTURES

All lectures will be given in English. Lecture notes can be downloaded from CISM web site, instructions will be sent to accepted participants.

## PRELIMINARY SUGGESTED READINGS

Aktan, A.E.; Farhey, D.N.; Helmicki, A.J.; Brown, D.L.; Hunt, V.J.; Lee, K.-L.; Levi, A. 1997. Structural identification for condition assessment: experimental arts. *J. Struct. Eng.-ASCE* 123(12), 1674-1684.

Catbas, F.N.; Ciloglu, S.K.; Hasancebi, O.; Grimmelsman, K.; Aktan, A.E. 2007. Limitations in structural identification of large constructed structures. *J. Struct. Eng.-ASCE* 133(8), 1051-1066

Morassi, A.; Vestroni, F. (Eds.) 2008. *Dynamic Methods for Damage Detection in Structures*, CISM Courses and Lectures, Vol. 499, Springer, Wien.

Cunha, A.; Caetano, E. 2006. *Experimental Modal Analysis of Civil Engineering Structures*. *J. Sound Vib.* 6(40), 12-20.

Testa, R.B.; Yanev, B.S. 2002. Bridge maintenance level assessment. *Comput.-Aided Civ. Inf.* 17(5), 358-367.

Gentile, C.; Bernardini, G. 2008. Output-only modal identification of a reinforced concrete bridge from radar-based measurements. *NDT & E. International* 41(7), 544-553.

Smyth, A.; Wu, M.L. 2007. Multi-rate Kalman filtering for the data fusion of displacement and acceleration response measurements in dynamic system monitoring. *Mech. Syst. Signal Pr.* 21(2), 706-723.

Zulli, D.; Alaggio, R.; Benedettini, F. 2009. Frequency-avoiding in arch bridges: a possible structural health monitoring approach. *Proc. XIX Conference AIMETA, Ancona (Italy)*.

Brincker, R.; Zhang, L.M.; Andersen, P. 2001. Modal identification of output-only systems using frequency domain decomposition. *Smart Mater. Struct.* 10(3), 441-445.

**MONITORING, CONTROL  
AND IDENTIFICATION OF BRIDGES  
BY DYNAMIC METHODS**

**Udine, May 24 - 28, 2010**

**Application Form**

(Please print or type)

Surname \_\_\_\_\_

Name \_\_\_\_\_

Affiliation \_\_\_\_\_

Address \_\_\_\_\_

E-mail \_\_\_\_\_

Phone \_\_\_\_\_ Fax \_\_\_\_\_

**Method of payment upon receipt of confirmation (Please check the box)**

*The fee of Euro 700,00 includes IVA/VAT tax and excludes bank charges*

*I shall send a check of Euro \_\_\_\_\_*

*Payment will be made to CISM - Bank Account N° 094570210900,  
VENETO BANCA - Udine (CAB 12300 - ABI 05418 - SWIFT AMBPIT2M - IBAN  
CODE IT83Z 05418 12300 09457 0210900).  
Copy of the receipt should be sent to the secretariat*

*I shall pay at the registration counter with check, cash or VISA  
Credit Card (Mastercard/Eurocard, Visa, CartaSi)*

**IMPORTANT: CISM is obliged to present an invoice for the above sum. Please indicate to whom the invoice should be addressed.**

Name \_\_\_\_\_

Address \_\_\_\_\_

C.F.\* \_\_\_\_\_

VAT/IVA\* No \_\_\_\_\_

(\* Only for EU residents or foreigners with a permanent business activity in Italy.

**Only for Italian Public Companies**

*I ask for IVA exemption (ex law n. 537/1993 - art. 14 comma 10).*

**Privacy policy:** I understand that data received via this form will be used only to provide information about CISM and its activities, within the limits set by the Italian legislative decree no. 196/2003 and subsequent amendments.

Complete information on CISM's privacy policy is available at [www.cism.it](http://www.cism.it).

I have read the "Admission and Accommodation" terms and conditions and agree.

Date \_\_\_\_\_ Signature \_\_\_\_\_