TIME TABLE

(Registration on Monday at 8:30)

TIME	Monday	Tuesday	Wednesday	Thursday	Friday
	May 23	May 24	May 25	May 26	May 27
9.00 - 9.45	Opening Lecture	Chiorino	Sassone	Carreira	Carreira
9.45 - 10.30	Chiorino	Chiorino	El Badry	Carreira	Sassone
11.00 - 11.45	Chiorino	Chiorino	El Badry	Carreira	Sassone
11.45 - 12.30	Chiorino	Chiorino	El Badry	Carreira	Sassone
14.30 - 15.15	Videla	Sassone	El Badry	El Badry	
15.15 - 16.00	Videla	Sassone	El Badry	El Badry	
16.30 - 17.15	Videla	Sassone	Robertson	Robertson	
17.15 - 18.00	Videla	Sassone	Robertson	Robertson	

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 23, 2011** 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
web site: http://www.daad.de/de/kontakt.html

DFG, Kennedyallee 40, 53175 Bonn
tel. +49 (228) 885 2655
e-mail: 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:

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33100 Udine (Italy)
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ACADEMIC YEAR 2011 **The Germain Session**

Centre International des Sciences Mécaniques
International Centre for Mechanical Sciences

ANALYSIS OF CREEP AND SHRINKAGE EFFECTS IN CONCRETE STRUCTURES

Advanced Professional Training
coordinated by

Mario A. Chiorino
Politecnico di Torino
Italy

Domingo J. Carreira
Illinois Institute of Technology
Chicago, IL
USA

Udine, *May 23 - 27,* 2011

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Advancing concrete knowledge

ANALYSIS OF CREEP AND SHRINKAGE EFFECTS IN CONCRETE STRUCTURES

Modern concrete structures are becoming more and more complex as a result of elaborate conceptual design and intricate construction techniques combining cast-in-place and prefabricated elements, structural steel components, prestressing and segmental erection, tensioning of stays and ties, jacking, and so on. Typical examples are large span cantilever and cable-stayed bridges, cast-on-form or cantilever built arches prestressed by jacking, composite steel-concrete structures, concrete or steel-concrete high-rise and supertall buildings. Some of these examples represent extreme recent applications of structural concrete. In general, we may speak of structures characterized by sequential applications of external actions (loads and imposed deformations) and by progressive variation in the restraint conditions during construction and early life. For these reasons, these structures are very sensitive, from the construction stage until the end of their service life, to time-dependent effects caused by delayed deformations of concrete (creep and shrinkage). If proper attention is not devoted to these effects, structural reliability in terms of serviceability and, in some instances, of ultimate safety may be adversely affected.
An appropriate evaluation of such effects for designing durable and safe structures requires the establishment of reliable methods for predicting creep and shrinkage strains (a material properties problem), and for determining the consequent time-dependent structural response with an adequate degree of accuracy (a structural analysis problem).
The first part of the course briefly addresses the problem of selecting realistic prediction models, focusing on factors affecting rheology of hardened concrete, criteria for construction of a comprehensive database of creep and shrinkage tests and validation/calibration of prediction models with respect to it, comparison and statistical evaluation of different models, with a discussion on adequate statistical indicators.
The second and main part of course deals with analysis of structural effects. Fundaments of the theory of aging linear viscoelasticity are reviewed and basic theorems and general solutions illustrated for the cases of effective homogeneous structures with rigid or elastic (steel) restraints and of heterogeneous structures and sections. Numerical methods for the solution of hereditary integral equations in terms of incremental forms based on a sum or on conversion to rate-type laws with internal variables are illustrated, as well as algebraic simplifications like the age-adjusted-effective-modulus method. Guidelines are indicated for selecting the appropriate computational approaches, with attention to the design stages and sensitivity of the structure.
Advanced problem like hygrothermal effects and cracking, interaction of creep with shear-lag and with flexible shear-connections in composite beams, effects of creep and shrinkage in complex structures such as tied arches, cable-stayed bridges and high-rise buildings are discussed in the last part of the course, together with techniques for long-term structural monitoring and interpretation of results.
The course is modeled after the harmonized formats of the following technical guidance documents: the CEB Manual on the same subject (1984), the corresponding sections of *CEB-FIP Model Code 1990* and of *fib Textbook on Structural Concrete* (2010), and, especially, the recent advanced ACI Guide *"Analysis of Creep and Shrinkage Effects in Concrete Structures"* (2010, under final approval) and the proposed new section on the same subject for the *fib* New Model Code 2010 under final editing. The whole set of these documents was edited by the first coordinator with the cooperation of other experts and in particular, for the last two, of the second coordinator and most of other lecturers.
Emphasis will be given within the course to this favorable scenario of internationally harmonized, although progressively evolving, fundaments and basic rules of application for codes and technical guidance documents on a subject of significant relevance for the long-term reliability assessment of modern concrete structures, highlighting areas of well established consensus and open problems.
The course is addressed to doctoral and postdoctoral researchers, teaching and research assistants in structural mechanics, civil and structural engineering, specialists and practicing engineers in the field of advanced structural analysis and design.

PRELIMINARY SUGGESTED READINGS

BOOKS
- Gross B., Mathematical Structure of the Theories of Viscoelasticity. Hermann, 1953.
- Lovitt W., Linear Integral Equations. Dover, 1950.
- Salençon, J., Viscoélasticité pour le Calcul des Structures. Éditions École Polytechnique, 2009.
- Ghali A., Favre R., Elbadry M., Concrete Structures - Stresses and Deformations. Spon, 2002.
- Jirásek M., Bazant Z.P., Inelastic Analysis of Structures. Wiley, 2002.
- Chiorino M.A., Gardner J. (Eds), Structural Implications of Shrinkage and Creep of Concrete, ACI SP-246, 2007.

GUIDES, MANUALS AND PRE-STANDARD DOCUMENTS:
- ACI 209.1R-05. ACI 209.2R-08.
- ACI 209.3R-XX: Analysis of Creep and Shrinkage Effects in Concrete Structures, M. A. Chiorino (Ed), 2010, final draft from Editor.
- Chiorino M.A., Sassone M., Further considerations and updates on time dependent analysis of concrete structures, in "Structural Concrete, Textbook", V. 2, *fib* Bull. 52, 2010, p. 43-69.

PAPERS
- Chiorino M.A., An Internationally Harmonized Format for Time Dependent Analysis of Concrete Structures, IABSE-*fib* Conf., Dubrovnik, 2010, pp. 473-480.
- Casalegno C., et al., Time dependent effects in cable-stayed bridges built by segmental construction, *fib* Congress, Washington, 2010.
- Robertson I. N., Prediction of vertical deflections for a long-span prestressed concrete bridge structure, Eng. Structures, V. 27, 2005, p. 1820- 1827.

WEB SITES
- Creep Analysis Research Group: www.polito.it/creepanalysis
- Papers by Z.P. Bazant may be downloaded from: www.civil.northwestern.edu/people/bazant.html

INVITED LECTURERS

Mario A. Chiorino - Politecnico di Torino, Italy
7 lectures on: Fundaments of aging linear viscoelasticity. Effective homogeneous concrete structures with rigid or plastic yielding restraints. Basic theorems: imposed loads and deformations; single and multiple changes of structural system. Effective homogeneous concrete structures with elastic restraints. Heterogeneous structures. Computational methods for the numerical solution of hereditary integral equations. Algebraic simplifications: AAEM method. Guidelines for time dependent analysis of structures.

Carlos C. Videla - Pontificia Universidad Católica de Chile, Santiago
4 lectures on: Creep and shrinkage prediction models and related uncertainty aspects. Factors affecting creep and shrinkage of hardened concrete. Comprehensive database on creep and shrinkage. Guide for modeling and calculating shrinkage and creep in hardened concrete. Statistical evaluation of available prediction models. Discussion of statistical indicators. Influence on the reliability assessment of structures: random scatter, uncertainty of prediction and confidence limits.

Mario Sassone - Politecnico di Torino, Italy
8 lectures on: General numerical incremental solutions for heterogeneous and sequential structures in the aging linear viscoelastic domain. Solutions by AAEM method. Solutions for effective homogeneous concrete structures with elastic restraints. Discussion of case studies: segmental concrete bridges and constructions, tied concrete arches, cable-stayed bridges, high-rise concrete or steel concrete buildings. Analysis of beams and framed structures with account for cross section heterogeneities.

Mamdouh M. El-Badry - University of Calgary, Canada
7 lectures on: Cross section analysis. Prestress losses in members with one layer of prestressing steel. Time dependent analysis of prestressed concrete members with multiple layers of prestressing and reinforcing steel using creep-transformed section method. Time dependent analysis of composite members: influence of different thickness of concrete; steel-concrete composite members. Members subjected to sustained temperature gradient.

Domingo J. Carreira - Illinois Institute of Technology, Chicago, USA
5 lectures on: Advanced problems. Hygrothermal effects and cracking. Interaction of creep with shear lag effects in box girders and in wide flanged concrete or steel-concrete composite beams and additional influence of flexible shear connections. Effects of creep and shrinkage in high-rise concrete or steel-concrete buildings.

Ian N. Robertson - University of Hawaii, Manoa, USA
4 lectures on: Monitoring of time dependent effects in large structures. Design of instrumentation system for long-term structural monitoring. Instrument installation and monitoring challenges. Short-term loading and thermal effects. Long-term shrinkage and creep effects. Comparison with shrinkage and creep prediction models.

LECTURES

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

ANALYSIS OF CREEP AND SHRINKAGE EFFECTS IN CONCRETE STRUCTURES

Udine, May 23 - 27, 2011
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 05035 - SWIFT/BIC VEBHIT2M - IBAN CODE IT46 N 05035 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 _____

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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.

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

Date _____ Signature _____