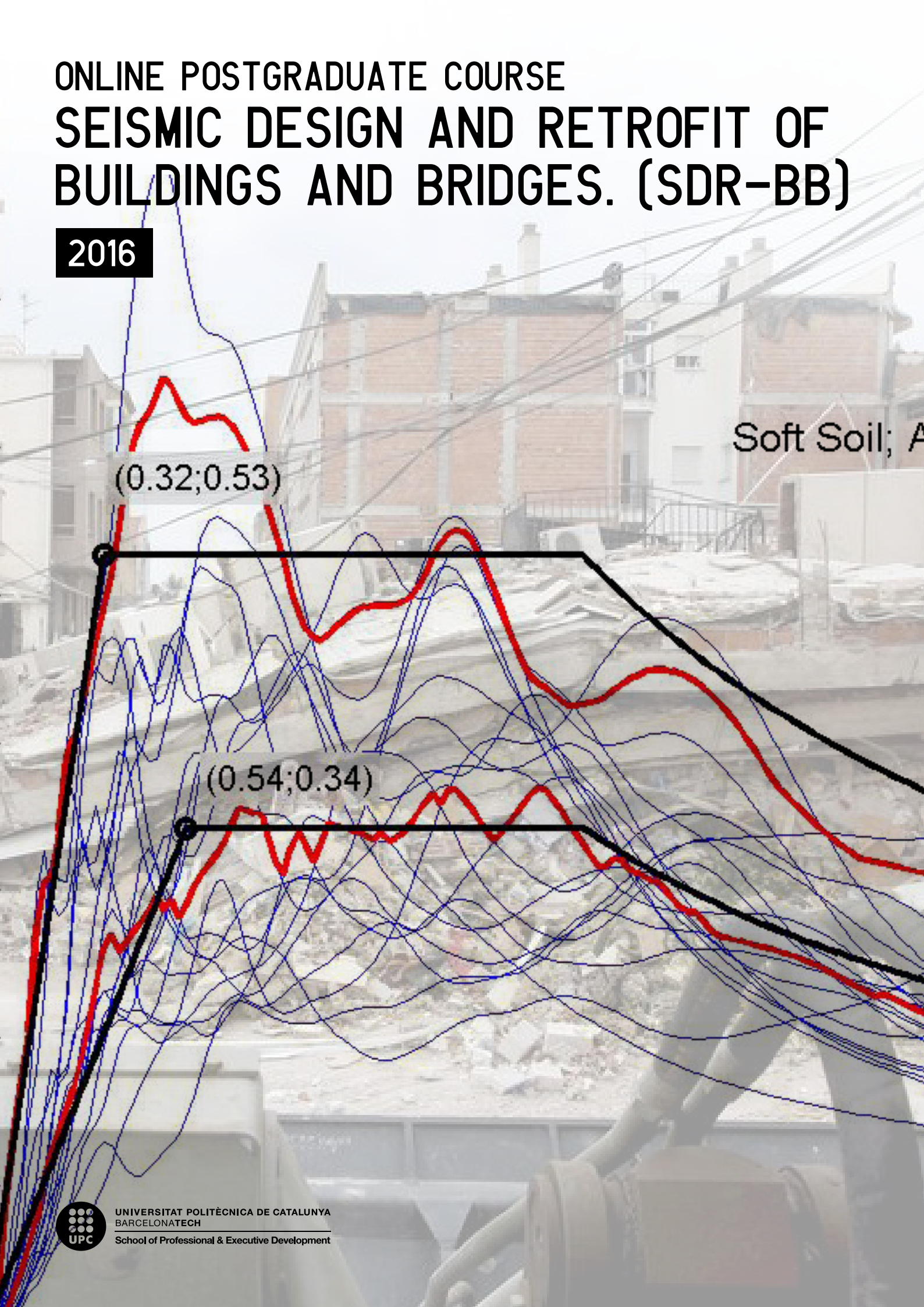
ONLINE POSTGRADUATE COURSE

SEISMIC DESIGN AND RETROFIT OF BUILDINGS AND BRIDGES. (SDR-BB)

2016



UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
School of Professional & Executive Development

ONLINE POSTGRADUATE COURSE

SEISMIC DESIGN AND RETROFIT OF BUILDINGS AND BRIDGES. (SDR-BB)

2016

2nd EDITION

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Nowadays, earthquake-resistant design and retrofit of buildings and other constructions is gaining worldwide attention among structural designers and other professionals. Several reasons are behind this tendency:

- Increasing awareness of the enormous damaging potential of earthquakes.
- Highly globalized working environment, where any professional can be involved in design of constructions in seismic-prone regions. Noticeably, almost 25% of the world's population live in seismic areas, many in developing countries; moreover, most of the existing buildings (and many bridges) are highly vulnerable to earthquakes. In other words, today's **globalized world requires "earthquake engineers**".
- Newly developed design and analysis tools, such as PBD (Performance-Based Design), Pushover Analysis and IDA (Incremental Dynamic Analysis), among others. These approaches are becoming more complex, hence, the commercial computer codes are equally turning out to be more complicated.
- Recently-proposed innovative construction and protection technologies, such as Base Isolation, Energy Dissipators, among others.

This teaching activity aims to close this gap by providing attendants with the practical knowledge to perform any intervention (design, planning, analysis, construction, retrofit, strengthening, repair, modification, promotion, etc.) on buildings and bridges located in moderate, mid and high seismicity areas. To reach this goal, most advanced formulations included in major regulations are described, and realistic application examples are fully developed using most spread commercial software codes.

UPC is a highly prestigious teaching and research institution, being currently ranked 22nd in Architecture and Built Environment and 35th in Civil and Structural Engineering (QS Worldwide University Ranking)

This activity is a **professionally-oriented postgraduate program** taught by the UPC School of Professional & Executive Development, the lifelong training at UPC, Universitat Politècnica de Catalunya. **This activity is taught online**, taking profit of the most advanced capabilities of e-learning; among them, the possibility of tailoring the activity to the individual necessities and the option of adjusting the learning path to the time availability of each attendant. The Program is intended for an international audience; the attendants will be able to interact each other, interchanging their professional experiences. The technologies and concepts described in the program are the direct result of the professional, lecturing and research activities of the instructors.

The evaluation will be principally based on a Final Thesis developed by each attendant in a subject of her/his interest.

Francesc López Almansa
Academic Management

+20.000
INTERNATIONAL STUDENTS
HAVE STUDIED AT THE UPC SCHOOL

WHO IS IT FOR?

This Program is oriented to professionals involved with buildings and bridges located in seismic prone regions:

- Structural engineers
- Structural consultants and designers
- Construction managers
- Civil engineers
- Building engineers
- Urban planners
- Architects

This activity will entitle you to lead and coordinate large international groups of engineers and other professionals involved in promotion, design, retrofit or other interventions on singular constructions (tall buildings, long-span bridges and viaducts, subway and railway stations, large tanks, among others) with relevant seismic issues.

OBJECTIVES

The main objective of this program is to familiarize the attendants with up-to-date knowledge on seismic design, analysis and retrofit of buildings and bridges. At the end of the program, the attendants should be able to:

- Understand and apply correctly current major regulations and guidelines of America, Europe and other regions.
- Use the most common software packages for efficient seismic analysis and design of buildings and bridges.
- Plan, coordinate and carry out any intervention (design, analysis, construction, retrofit, etc.) on buildings and bridges situated in seismic regions.
- Promoting, managing and leading large national and international projects involving seismic issues.
- Developing new multi-purpose design, analysis and construction approaches and solutions.

ADMISSION AND ENROLLMENT

To start the enrolment process for this programme you must complete and send the form that you will find at our website.

Next you will receive a welcome email detailing the three steps necessary to formalize the enrolment procedure:

1. Complete and confirm your personal details.

2. Upload your curriculum vitae and attach any additional required documentation, whenever this is necessary for admission.

3. Pay €110 in concept of the registration fee for the programme. This fee will be discounted from the total enrolment fee and will only be returned when a student isn't admitted on a programme.

Once the fee has been paid and we have all your documentation, we will assess your candidacy and, if you are admitted on the course, we will send you a letter of acceptance. This document will provide you with all the necessary information to formalize the enrolment process for the programme.

ECTS European Credit Transfer System

It's the system for measuring work that the students have to maketo acquire the skills and knowledge necessary to overcome differences curriculum materials.

Each ECTS equals 25 hours study, which includes time dedicated to teaching time, to hours of student work, the tutorials, seminars, jobs, practices or projects as well as the time required for the preparation and implementation of examinations

Degree:
Postgraduate diploma issued by the UPC, Universitat Politècnica de Catalunya.

To obtain this degree it is necessary to have an official or recognized university degree equivalent to a bachelor's degree or diploma.

Credits:
20 ECTS (160 teaching hours)

Language of instruction:
English
(a spanish version is also offered)

Modality:
Online

Dates:
Start date: April 2016
End date: November 2016

Registration open until the beginning of the course or until end of vacancies.

Registration fee:
3.900 € (EURO)

The enrolment fee can be paid:
- In a single payment to be paid within the deadline specified in the letter of admission to the programme

- In two instalments:
• 60% of the amount payable, to be paid within the deadline specified in the letter of admission to the programme
• Remaining 40% to be paid up to 90 days at the latest after the starting date of the programme

More information and virtual interactive chat:
Telephone: (34) 93 112 08 65
www.talent.upc.edu

ONLINE POSTGRADUATE COURSE
SEISMIC DESIGN AND RETROFIT OF BUILDINGS AND BRIDGES. (SDR-BB)

Given the professional orientation of the program, teaching will be mainly based on the major **international design codes (FEMA, ACI, AISC, ATC, ASCE, NEHRP, AASHTO, ENs, ISO, Eurocode 8, etc.)**. Since the national regulations of virtually all the countries are based either on the US codes or in the Eurocodes, the participants will be able to perform any intervention in any seismic country.

The course consists of five blocks; some of the blocks are split into a number of subjects:

1. BASIS OF SEISMIC DESIGN

1.1 Dynamics of Structures

- Basic concepts. Displacement, velocity and acceleration. Frequency and period. Excitation (input) and response (output). Mass, damping and stiffness
- Signal analysis. Fourier spectrum
- Single-degree-of-freedom systems. Modeling criteria. Natural frequency and damping ratio. Harmonic input. Free and forced responses. Resonance
- Multi-degree-of-freedom systems. Lumped masses models. Modelling of symmetric and asymmetric buildings. Diaphragm effect. Modal analysis. Natural frequencies and modal shapes. Modal participation factors. Modal masses

1.2 Earthquake Engineering & Seismology

- Earthquakes. Origin and propagation. Intensity. Magnitude. Return period
- Near-source and far-source registers. Impulsivity, directivity and directionality. Influence of the soil type

1.3 Earthquake-Resistant Design

- Effects of seismic inputs on structures. Relative displacement, inter-story drift and absolute acceleration
- Design codes. Eurocode8. American regulations
- Types of building structures: frames, walls, bracings, dual systems. Behavior of building structures under vertical loads and under horizontal forces
- Heuristic seismic design recommendations. Symmetry, uniformity, compactness, lightness, ductility, damping, simplicity, separation. Strong column-weak beam. Short columns
- Types of seismic analyses: static linear, static nonlinear and dynamic nonlinear
- Response spectra. Acceleration, velocity and displacement spectra. Influence of seismicity, damping, soil type, importance and ductility. Response reduction factor
- Multimodal analysis. Number of modes to be considered. Modal combination criteria: SRSS and CQC
- Static nonlinear analysis (push-over). Plastic hinges. Modelling criteria: distributed and concentrated plasticity
- Performance-based design. Performance points (target drifts: IO, LS, CP, DL, SD, NC). American and European (N2) formulations
- Dynamic nonlinear analysis. IDA curves
- Vertical seismic analysis
- Seismic analysis of non-structural components. Floor spectra
- Pounding between adjacent buildings. Required gap

2. SEISMIC DESIGN AND RETROFIT OF BUILDINGS

2.1 Seismic Design of Concrete Buildings

- Types of concrete building structures. Frames, structural walls, dual systems. Primary and secondary members. Critical regions. Ductility classes. Response reduction factor
- Local ductility of critical regions
- Structural elements. Beams. Slabs. Columns. Joints. Walls. Coupled walls. Coupling beams. Failure models and modelling with strut-and-tie models
- Precast concrete structures

2.2 Seismic Design of Steel Buildings

- Types of steel and composite building structures. Frames, concentric bracing, eccentric bracing, dual systems
- Critical regions. Ductility classes. Response reduction factor
- Structural elements. Beams. Slabs. Columns. Joints. Pre-qualified connections. Braces: diagonal, chevron
- Special Truss Moment Frames
- Outrigger walls

2.3 Seismic Design of Timber Buildings

- Timber construction. Heavy timber, platform frame, cross-laminated timber
- Earthquake-resistant qualities of timber buildings. Ductility of the connections. Design criteria
- Example of seismic design of a timber building

2.4 Seismic Design of Masonry Buildings

- Masonry construction. Unreinforced, confined and reinforced masonry
- Earthquake-resistant qualities of masonry buildings. Design criteria
- Example of seismic design of a masonry building

2.5 Seismic Retrofit of Buildings

- Use of the Performance-Based Design
- Basic retrofit strategies. Global Structural Stiffening and Strengthening. Bracing. Strengthening of columns. Removal or Lessening of Existing Irregularities. Re-symmetrization. Mass Reduction. Local Modification of Components
- Knowledge levels. Decisions for structural interventions
- FEMA, ATC and ASCE regulations. Eurocode 8 Part 3

2.6 Seismic Design and Retrofit of Foundations

- Basic concepts of soil response to earthquakes
- Liquefaction. Risk of landslides
- Retaining walls. Mononobe-Okabe formulation
- Shallow and deep foundations. Tie-beams and foundation beams. Raft foundations
- Effect of earthquakes on foundations.
- Applications. Liquefaction potential. Seismic design of foundations. Soil-structure interaction

3. SEISMIC DESIGN AND RETROFIT OF BRIDGES

3.1 Seismic Design and Retrofit of Bridges

- Pedestrian, road and railway bridges
- Types of bridges. Decks. Piles. Abutments. Cable-stayed bridges. Suspended bridges
- Design criteria. AASHTO specifications. Eurocode 8 Part 2
- Long-span bridges: spatial variation of the input ground motion

4. NEW TECHNOLOGIES FOR SEISMIC PROTECTION

4.1 Base Isolation

- Concept of base isolation. Degree of isolation. Limitations. Design criteria. Regulations
- Types of isolators. Rubber bearings. RB, LRB, HDRB. Durability.
- Friction devices; flat and curved surfaces. Other isolators. Supplemental damping
- Applications to buildings and bridges. Other applications. 3D isolation
- Observed seismic performance of isolated constructions
- Applications to seismic retrofit
- Design examples

4.2 Energy Dissipators

- Energy dissipators. Design criteria. Efficiency. Regulations. Applications.
- Types of dissipators. Hysteretic devices. Buckling-restrained braces. Steel walls. Friction devices. Viscous and viscoelastic devices. VD walls. Use of SMA. Other dissipators
- Applications to buildings and bridges. Other applications
- Applications to seismic retrofit
- Design examples

4.3 Mass Dampers

- Tuned mass dampers. Design criteria. Efficiency. Regulations. Active and semi-active dampers
- Shock absorbers. Tuned liquid dampers. Tuned sloshing dampers and liquid column dampers
- Applications to tall buildings, communication towers and steel chimneys. Applications to building slabs and pedestrian and road bridges

5. FINAL THESIS

The topic of the Thesis is proposed by each student and is approved by the director of the Program taking into account the feasibility and the practical interest of the proposal. Eligible themes are seismic designs or retrofits of actual building or bridges, or other relevant theoretical or applied studies. It is strongly recommended that the selected subject is closely related to the professional interests of the attendants.

In past edition, some thesis developed by students were:

- *Seismic analysis of a 30 story RC building*
- *Seismic design of a shopping and parking structure*
- *Capacity design of representative multi-span bridges· Simplified racking frame analysis of metro stations*
- *Pushover nalysis to estimate response reduction factor of RC elevated water tanks.*

Noticeably, some of these Theses consisted in developing general design and construction solutions that can be utilized in a wide set of situations.

TEACHING METHODOLOGY

This is an online course, in a full e-learning environment. Online teaching uses the **Adobe Connect Technology**; this software allows listening, viewing, recording, chatting and interacting with the instructors and the other attendants. Attendants will use the **My Tech Space virtual campus**, an effective working and communication platform. This campus provides access to the teaching documentation, allows creating virtual personal spaces, includes forum or e-mail communication tools, facilitates team-working and discussions, among other capabilities.
The major e-learning instruments are:

RECORDED LECTURES
Online non-synchronous teaching consist in two types of sessions: theory and computer applications. Since this program is strongly professionally-oriented, theory sessions are mainly based on practical examples. Both types of sessions are divided in twenty-minute intervals. Each interval finishes with the proposal of an exercise or one question, and next interval begins with its answer and solution. This scheme lets attendants assessing continuously their progression. Computer applications sessions are mainly based in the extensive use of the most spread commercial codes, such as **SAP, ETABS, SAFE, PLAXIS, ROBOT, SHAKE, RISA, STAAD,** among others. In the computer applications sessions, actual examples are worked out from the very beginning to the final design details. These examples are new buildings, retrofitted buildings, high-rise buildings, bridges, base isolation, among others. Attendants are asked to use the same software than the instructor, thus being able to obtain parallel results. Students can ask questions any time, such enquiries will be answered at the earliest availability.

SYNCHRONOUS ONLINE SESSIONS.
A number of synchronous online interactive open sessions will be planned depending on needs of participants. Professors will mainly organize sessions but students can ask also for additional sessions. Professors attend these sessions and students pose questions and address their concerns; as well, relevant issues are discussed. Each synchronous session lasts approximately three hours, being scheduled according geographic location of students.

FORUMS
A number of forums will be created to boost the attendants and to allow for open discussions on case studies, and asking questions, among other learning and evaluation activities.

FAQS
The answers to the *"Frequently Asked Questions"* are included in a database that is continuously updated.

PROVIDED DOCUMENTATION
Wide written and interactive documentation will be delivered to the attendants. This includes teaching notes, scientific and technical papers and reports, books, design codes, worked examples, excel or MatLab files, SAP and ETABS files and other relevant information.

CONTINUOUS EVALUATION
The progression of the attendants will be monitored by frequent quizzes, multi-answer tests, short exercises, computer applications, and other similar activities proposed by professors. This scheme lets attendants assessing continuously their progression.

FINAL THESIS
It is the major output of the program since it allows applying the taught concepts and the described procedures to actual projects. Each student will develop her/his Thesis under tight cooperation with the supervisor (or several) will be assigned. Ordinarily, this process will require extensive use of software codes.

Customary language will be english but, eventually, **questions can be asked and answered in arabic, french, italian and spanish.**

MANAGEMENT & FACULTY

Academic Management

Francesc López Almansa

BEng. MSc. PE. PhD. Forty years' experience as advanced structural consultancy and technology-transfer in buildings. Full Professor at the Universitat Politècnica de Catalunya. Wide lecturing experience in many subjects linked to Structural Analysis and Design. Professor of the Master Programs "Structural Engineering in Architecture", "Technology in Architecture" and "Soil Engineering and Earthquake Engineering" at the UPC. Permanent Visiting Professor of several spanish universities (Girona, Granada and Ramon Llull) and Southern Chile in Latin America. He has supervised 15 Doctoral Theses, most of them related to earthquake engineering. He is the author of more than 200 research papers published in scientific journals and presented at national and international scientific conferences. He has participated in numerous research projects (national and international) financed by public and private funds, having been a promoter and coordinator in many of them.

Academic Coordination

Bashar Al Farah

BEng. MSc. PE. PhD candidate, at the Universitat Politècnica de Catalunya, Thesis on advanced numerical simulation of dynamic structural behavior of buildings heavily damaged by earthquakes. Eight years' experience in analysis, design, construction and supervision of civil engineering structures (high rise buildings, industrial facilities, residential and defense projects, etc.) located in seismic regions, mainly Arab and South American countries. Relevant experience on nonlinear seismic analysis for practical and scientific purposes. Expertise in structural analysis software: ABAQUS, ETABS, OpenSees, PLAXIS, PROKON, REVIT, RISA, ROBOT, SeismoSoft, SAFE, SAP, among others. Partner and developer at SESPID, specialized in developing engineering software for automated detailing and optimization. Teaching experience in professional courses for civil engineers and architects. Presently working as a structural consultant in Barcelona. Research activities on inflatable structures.

Teaching Staff

Ramón Álvarez Cabal

BEng. MSc. PE. PhD. Professor at the Universidad Politécnica de Madrid since 1982. He has participated in 10 research projects, most of them international, taught courses and lectures at universities and research centers in Europe (Lisbon, London, Utrecht, Wroclaw) and Latin America (Caracas, Mexico, Santiago de Chile) among others. Appointed as an expert by international organizations like NATO (North Atlantic Treaty Organization) and UIC (Union Internationale des Chemins de Fer). He has written 6 books, over 15 scientific papers, monographs, and other documents. Member of committee elaborating Spanish Seismic Design Code and National Application Document of Eurocode 8. Senior Engineer in INTEMAC (company devoted to Quality Control and Pathology studies in Construction) since 1989; responsible of quality control of major singular buildings. Coordinator of technical assistance team after Lorca earthquake (Spain).

Alfredo Arnedo Pena

BEng. MSc. PE. PhD. Professor at the Universitat Politècnica de Catalunya. Wide teaching experience in many subjects linked to Steel Structures. Professor of the Masters Programs "Structural Engineering in Architecture" and "Earthquake Engineering and Structural Dynamics". Wide professional experience in earthquake-resistant design (INYPSA 1984-1999), especially in nuclear power plants. Professional experience in seismic design, protection against impact and explosions (SENER 2003 - present). Spanish delegate to the committee of Eurocode 3 Part 1.3. Spanish delegate to the CEN / TC 135 Committee on Execution. Spanish delegate on the ISO/TC98/SC3/WG9, and WG4, working on the revision of the ISO 3010 "Seismic actions on structures". Author of a book on steel structures and more than 20 scientific papers. Participation in eight research projects funded by private and public institutions; currently participates in project "Seismic design of light-gauge steel framed buildings".

Amadeo Benavent Climent

BArch. MSc. PE. PhD. (1998, Tokyo University, Japan). Full Professor at the Universidad de Granada (2000-2012) and at the Universidad Politécnica de Madrid (2012-present). His research activity has focused on energy-based seismic design and on development of energy dissipators for seismic protection of buildings; this activity involves extensive testing, advanced numerical simulation and development of new design criteria. Technology transfer has generated practical applications consisting of implementing energy dissipators in two buildings in Spain. Over 120 publications, most of them papers published in highly-ranked international peer-reviewed Journals. Has supervised 9 Doctoral Theses and 16 Master Theses, all of them related to earthquake engineering. He has participated in 12 research projects, national and international, financed by public and private funds, being promoter and leader in 8 of them.

Luís M. Bozzo

BEng. MSc. PE. PhD. (1992, University of California, Berkeley). Assistant professor at the University of California (1989-1992) and associate professor at the Universitat de Girona, (1993-2000). More than 100 research papers published in scientific journals and conferences. Principal Engineer at DIRAC-SA, Lima (1983-1998). Founder and Principal Eng. at LUIS BOZZO ESTRUCTURAS Y PROYECTOS, Barcelona (2003-present). His research activity has focused on development a new finite element (CI8m) for accurate modelling of long-span roofs and, mainly, on energy dissipators for seismic protection of building structures ("Shear Link Bozzo"). Most remarkable designs: base isolated hospital building at Barcelona, JVC curved cable-stayed bridge in México, domes of Santuario de los Mártires in México (biggest church under construction worldwide), Cube I and Cube II towers in Zapopan Mexico, 60-story Paradox tower in Santafé, Mexico, among others.

Jorge L. Cabanillas

BEng. MSc. PE. PhD candidate, at the Universitat Politècnica de Catalunya. Sixteen years experience in analysis, design, construction and supervision of civil engineering structures (buildings, industrial facilities, long span roofs, bridges, etc.) located in seismic regions, mainly in South America. Expertise in structural analysis software: SAP2000, ETABS, SAFE, CSiBridge, Perform 3D, CSiCol, among others. Founder and Principal Engineer at DISEÑO DE PROYECTOS EN INGENIERÍA (Perú). Representative of CSI (Computers & Structures, Inc.) for South America and Caribe. Wide teaching experience in professional courses for civil engineers and architects. Most remarkable designs: 520 m long railway cable-stayed bridge in Santo Domingo (Dominican Republic), arch bridges in Puyo (Ecuador) and Moquegua (Perú), among others.

Alberto Ledesma Villalba

BEng. MSc. PE. PhD. Full Professor of Soil Mechanics and Geotechnical Engineering at the Universitat Politècnica de Catalunya. Thirty years of teaching and research experience on that field, including numerical models in Geomechanics, back-analysis,

unsaturated soils, landslides and soil dynamics. Supervisor of 12 Doctoral Theses. Participation and coordination in a number of Research Projects funded by the European Commission. Over 150 publications, most of them papers published in international peer reviewed Journals. Geotechnical advisor of several companies and administrations, in Spain and other European and American countries, involving large excavations, urban tunnels and embankment dams. Active member of the International Committee controlling the construction of the high speed train tunnel crossing Barcelona next to World's Heritage buildings.

Pere Roca Fabregat
BEng. MSc. PE. PhD. Professor of Construction Engineering at the Universitat Politècnica de Catalunya. Teaching, research and technology-transfer activity focused in structural analysis and retrofit of masonry and historical constructions, including advanced numerical modelling and extensive testing. A number of innovative retrofit solutions have been developed; practical applications have been promoted and supervised, some of them in World heritage constructions. 20 Doctoral Theses supervised, some in earthquake engineering. More than 250 research papers published in scientific journals and presented at scientific conferences. He has participated in research projects, national and international financed by public and private funds, having been promoter and coordinator in many of them. Member of the ISCARSAH committee on the Analysis and Restoration of Structures of Architectural Heritage of the International Council for Monuments and Sites (ICOMOS) since 2001.

José Romo Martín
BEng. MSc. PE. PhD. Professor at the Universidad Nacional de Educación a Distancia, European University of Madrid and of the Universidad Politécnica de Madrid. Author of more than 100 papers and scientific and technical journals. President of ACHE (Spanish Concrete Association) since 2014 and of Spanish group of IABSE during 2003-2009. Member of FIB TG1.6 "Tall Buildings". Awarded with medal of ACHE, 2008. Professional experience in road and foot bridges and buildings; PROSER junior engineer (1983-1985), GIBBs & Hill senior engineer (1985-1986) and CEO and partner at FHECOR (1987-present). Principal designer of an important number of bridges and buildings, many of them singulars (long-span bridges, high rise buildings and long-span roofs) and located in seismic-prone regions. His most relevant designs are the proposal for bridge over the Chacao Channel (Chile) and a 7-km long crossing of the Tagus River (Portugal), including a main cable-stayed bridge, among others.

LIFELONG TRAINING AT UPC

UPC School of Professional & Executive Development offers a wide selection of lifelong training courses with over 200 yearly master's degrees, postgraduate courses and specialization courses with a professional outreach, adapted to the current economic and social, business and professional needs.

UPC's lifelong training at postgraduate level has been designed to broaden competencies of professionals in the fields of architecture, construction and urbanizations, civil and industrial engineering, business management and administration; sustainability and communication and information technologies.

The courses are top quality, supported by research and knowledge transfer at the UPC and by the collaboration with over 300 companies that participate in the training courses. Since 1994, over 80,000 professionals have found a boost to their careers with these programmes.

Offered programs make it possible to expand technical learning in each technological area and make available necessary tools and knowledge to learn new personal skills in the spheres of project management, administration and leadership. Our goal is to help future managers in fields of engineering, innovation and technology to achieve ideal knowledge and to develop necessary skills and capacities to take on responsibility for new required competencies in job market.

INSPIRING INNOVATION. EMPOWERING TALENT.

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