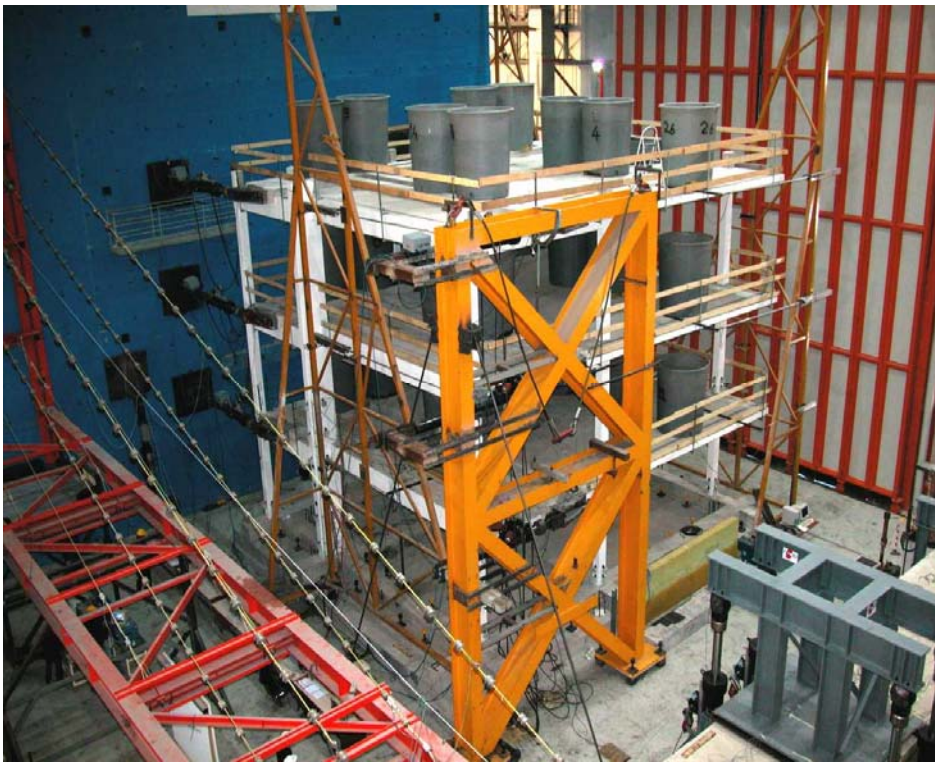
JRC Scientific and Technical Reports

1st EFAST Workshop
Challenges, Needs and Open Questions

EFAST project (Design Study of a European Facility for Advanced Seismic Testing)
Ispra, 2nd and 3rd of March, 2009

Francesco Marazzi and Francisco Javier Molina

European Commission, Joint Research Centre, IPSC, ELSA
Via E. Fermi 2749, TP 480, I-21027 Ispra (VA), Italy



EUR 23822 EN - 2009

JRC EUROPEAN COMMISSION

ipsc Institute for the Protection and Security of the Citizen

The mission of the JRC-IPSC is to provide research results and to support EU policy-makers in their effort towards global security and towards protection of European citizens from accidents, deliberate attacks, fraud and illegal actions against EU policies.

European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen

Contact information
Address: Francesco Marazzi
E-mail: francesco.marazzi@jrc.it
Tel.: +39 0332 783510
Fax: +39 0332 789049

http://ipsc.jrc.ec.europa.eu/
http://www.jrc.ec.europa.eu/

JRC 51632

EUR 23822 EN
ISSN 1018-5593

Luxembourg: Office for Official Publications of the European Communities

Printed in Italy

Table of contents

The EFAST project

EFAST (Design Study of a European Facility for Advanced Seismic Testing) is a joint project financed by the European Commission that foresees the study of all the aspects regarding the design of a major testing facility in Europe that would complement and collaborate with the existing ones. This study aims at identifying the current and future needs in the field, and proposes the concept of a facility using the best available testing technologies. For further information: http://efast.eknowrisk.eu/EFAST/.

Objectives of the workshop

The new infrastructure could consist of a European class new single-site facility integrated with selected existing ones and, possibly, upgraded to meet new network requirements. The aim of the 1st EFAST Workshop was to elaborate design guidelines in the gross for the aforementioned facility. To this end an inventory of the needs of the scientific community and of the industry was needed that would allow the partners of the EFAST project to better determine the characteristics of the facility to meet the expressed needs. During the Workshop more than 30 experts from all around the world made presentations regarding the needs, the technologies, the design and the operation of seismic testing infrastructures. Round tables on these topics have been held in order to stimulate open debate. The conclusions of this workshop will contribute to specify recommended solutions and required performances.

Organisers

The Workshop was jointly organised by the JRC in collaboration with all the partners of EFAST project.

Coordinator:
Francisco Javier Molina
European Commission • JRC-– IPSC – ELSA
Tel. +39 0332 786069 • Fax +39 0332 789049
E-mail: francisco.molina@jrc.it

Scientific secretariat:
Francesco Marazzi
European Commission • JRC-– IPSC – ELSA
Tel. +39 0332 783510 • Fax +39 0332 789049
E-mail: francesco.marazzi@jrc.it

Program and presentations

The detailed program of the workshop is given in the following two pages.

The following link refers to the available slides presented by the invited speakers:
http://efast.eknowrisk.eu/EFAST/index.php/events/workshop1/w1-presentations

A brief summary of each talk and the related questions and answers are reported hereafter for each speaker. The final part of this document refers to the conclusions of the two round tables.

3 March 2009 afternoon

14:00-14:45	Visit to the IPSC ELSA laboratory
15:00-16:30	ROUND TABLE ON TESTING NEEDS *Chairman: Pierre Pegon (JRC – EC)*
16:30-17:00	*Coffee break*
17:00-18:30	ROUND TABLE ON TESTING METHODS AND TECHNOLOGY *Chairman: Georges Magonette (JRC – EC)*
20.30-22.30	*Dinner at Belvedere restaurant*

Contacts

Coordinator:
Francisco Javier Molina
European Commission • JRC— IPSC – ELSA
Tel. +39 0332 786069 • Fax +39 0332 789049
E-mail: francisco.molina@jrc.it

Scientific secretariat:
Francesco Marazzi
European Commission • JRC— IPSC – ELSA
Tel. +39 0332 783510 • Fax +39 0332 789049
E-mail: francesco.marazzi@jrc.it

Administrative secretariat:
Desislava Strezova
European Commission • JRC— IPSC – ELSA
Tel. +39 0332 789366 • Fax +39 0332 789049
E-mail: desislava.strezova@jrc.it

ipsc
Institute for the Protection and Security of the Citizen

European Commission
Joint Research Centre (JRC)
Institute for the Protection and Security of the Citizen

Via E. Fermi
I-21020 Ispra (VA) - Italy

Tel.: +39 0332 78 9947
Fax: +39 0332 78 9923

Web: http://ipsc.jrc.ec.europa.eu/
E-mail: ipsc@jrc.it

JRC
EUROPEAN COMMISSION

Robust science for policy making

OUR MISSION

The mission of the Joint Research Centre is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of European Union policies. As a service of the European Commission, the Joint Research Centre functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

European Commission
Joint Research Centre (JRC)
Internal and External Communications Unit

Brussels:
Tel.: +32 2 295 76 24
Fax: +32 2 299 63 22

Ispra:
Tel.: +39 0332 78 98 89
Fax: +39 0332 78 54 09

Web: http://www.jrc.ec.europa.eu/
E-mail: jrc-info@ec.europa.eu

JRC

1st EFAST Workshop

Challenges, Needs and Open Questions

EFAST

http://efast.eknowrisk.eu/

EFAST: Design Study of a European Facility for Advanced Seismic Testing
FP7, project no. 212109/2007, 2008-2011

Room 3, JRC, Ispra - ITALY

JRC
EUROPEAN COMMISSION

First EFAST Workshop

2 March 2009 morning

09:00-09:15 **Workshop welcome**
Stephan Lechner, *IPSC Director*
Michel Geradin, *IPSC, ELSA Unit Head*

EFAST PROJECT

09:15-09:30 **EFAST project overview**
Ioannis Politopoulos (CEA – France)

09:30-09:45 **EFAST inquiry**
Francesco Marazzi (JRC – EC)

09:45-10:00 **FAST input to EFAST**
Jean-Claude Queval (CEA – France)

10:00-10:15 **EFAST test program**
Uwe Dorka (Univ. Kassel – Germany)

10:15-10:45 *Coffee break*

TESTING NEEDS

10:45-11:15 **Testing needs from the point of view of ICTP and cultural heritage protection**
Roko Zarnic (Univ. Lubjana – Slovenia)

11:15-11:45 **Needs of large scale testing in developing regions**
Marcial Blondet (Catholic Univ. – Peru)

11:45-12:15 **Nuclear Industry demands regarding a European Facility for Advanced Seismic Testing**
Francois Voldoire (EDF – France)

12:30-14:00 *Lunch*

2 March 2009 afternoon

14:15-14:45 **Problems and certainties in the experimental simulation**
Michele Calvi (Eucentre – Italy)

14:45-15:15 **Testing needs according to IAEA**
Pierre Sollogoub (IAEA – Austria)

15:15-15:45 **Testing needs for soil-structure interaction**
George Gazetas (Univ. Athens – Greece)

15:45-16:15 **Testing needs for Civil Protection**
Mauro Dolce (Civil Protection – Italy)

16:15-16:45 *Coffee break*

16:45-17:15 **Testing needs for civil infrastructures**
Livia Pardi (Autostrade – Italy)

17:15-17:45 **Future of EUROCODE8 and interaction with experimental needs**
Eduardo Carvalho (GAPRES – Portugal)

TESTING DEVICES MANUFACTURERS

17:45-18:00 **MTS**
Allen Clark, Bradford Thoen (U.S.A.)

18:00-18:15 **MOOG**
Fausto Argeri (Italy)

18:15-18:30 **INSTRON**
Glen Wardrop (Germany)

20:30-22:30 *Dinner at Lido di Angera restaurant*

3 March 2009 morning

TESTING METHODS AND TECHNOLOGY

8:30-9:00 **Challenges in distributed and collaborative testing**
Keh-Chyuan Tsai (NCREE – Taiwan)

9:00-9:30 **Open questions on multiple shaking tables and reaction walls**
Andrei Reinhorn (Univ. Buffalo – U.S.A.)

9:30-10:00 **Design and construction issues of a shaking table array**
Wensheng Lu (Univ. Tongji – China)

10:00-10:30 *Coffee break*

10:30-11:00 **IT challenges in EE cyberinfrastructures**
Lelli Van Den Einde (UCSD – U.S.A.)

11:00-11:30 **Questions raised in operating a very large shaking table**
Keizo Ohtomo (CRIEPI – Japan)

11:30-12:00 **Testing of seismic protection devices**
Agostino Marioni (ALGA – Italy)

12:15-13:45 *Lunch*

List of participants

Dr.	Ioannis	Anastasopoulos	National Technical University of Athens
Dr.	Diana	Ancas	Technical University of Iasi
Dr.	Fausto	Argeri	MOOG
Prof.	Gabriela Maria	Atanasiu	Technical University of Iasi
Prof.	Marcial	Blondet	Universitad Catolica Pontificia of Peru
Prof.	Stathis	Bousias	University of Patras
Prof.	Oreste	Bursi	University of Trento
Prof.	Michele	Calvi	EUCENTRE
Dr.	Eduardo	Carvalho	GAPRES - SA
Dr.	Chiara	Casarotti	EUCENTRE
Dr.	Allen	Clark	MTS
Dr.	Ema	Coelho	Laboratório Nacional de Engenharia Civil
Dr.	Filippo	Dacarro	EUCENTRE
Dr.	Roberto	Dalpedri	ALGA S.p.A.
Prof.	Mauro	Dolce	University of Basilicata
Prof.	Uwe	Dorka	University of Kassel
Prof.	Michail	Fardis	University of Patras
Prof.	George	Gazetas	National Technical University of Athens
Prof.	Michel	Geradin	JRC-ELSA
Dr.	Florin	Leon	Technical University of Iasi
Prof.	Wensheng	Lu	Tongji University
Dr.	Georges	Magonette	JRC-ELSA
Dr.	Francesco	Marazzi	JRC-ELSA
Dr.	Agostino	Marioni	ALGA S.p.A.
Dr.	Francisco Javier	Molina	JRC-ELSA
Prof.	Charalampos	Muzakis	University of Athens
Dr.	Paolo	Negro	JRC-ELSA
Dr.	Keizo	Ohtomo	CRIEPI
Dr.	Livia	Pardi	AUTOSTRADE S.p.A.
Prof.	Alberto	Pavese	EUCENTRE
Dr.	Pierre	Pegon	JRC-ELSA
Dr.	Artur	Pinto	JRC-ELSA
Prof.	Paolo	Pinto	University of Rome
Dr.	Ioannis	Politopoulos	CEA
Dr.	Jean-Claude	Queval	CEA
Prof.	Andrei	Reinhorn	State University of New York at Buffalo
Dr.	Vito	Renda	JRC-ELSA
Dr.	Pierre	Sollogoub	IAEA
Prof.	Haluk	Sucuoglu	Middle East Technical University

Prof.	Colin	Taylor	University of Bristol
Dr.	Bradford	Thoen	MTS
Prof.	Keh-Chyuan	Tsai	National Taiwan University
Prof.	Lelli	Van Den Einde	University of California at San Diego
Dr.	Nguyen	Van Thuan	University of Kassel
Dr.	Francois	Voldoire	EDF
Dr.	Glen	Wardrop	INSTRON
Prof.	Mihai H.	Zaharia	Technical University of Iasi
Prof.	Roko	Zarnic	University of Lubjana

Overview of the presentations including questions and answers

2 March 2009 morning

Workshop welcome

Stephan Lechner, IPSC Director

Presentation summary (no slides)

Specialists from all over the word, and particularly from Europe, are present at this workshop. It is important for JRC, and for ELSA in particular, to show and see that there is a strong support from the earthquake engineering community. A wide and real discussion on practical problems related to testing is very important. The presence of a so wide scientific community is also important from both a scientific and a political point of view. It may appear that physical testing activities have been already fully explored, but this field of research has still many unknowns and very advanced techniques and competencies are necessary to make a step further. Physical testing activities in structural mechanic are very important for IPSC. ELSA, with its physical tests, has succeeded in attracting a larger group of experts than other groups working in IT. JRC General Director shares these ideas and Lechner will insist on them to him. The workshop can also act as a catalyst in the implementation of a European dimension of testing and will be contribute to focus the JRC program towards these activities.

Michel Geradin, IPSC, ELSA Unit Head

Presentation summary (no slides)

The workshop is organized in the framework of EFAST project and in close collaboration with EFAST partners. This workshop will be successful if we will be able to meet the needs of all the earthquake community.

PRESENTATIONS ON EFAST PROJECT

EFAST project overview

Ioannis Politopoulos (CEA – France)

Presentation summary

An overview of the EFAST project is presented. A comparison among the budget devoted to seismic testing in the main developed countries clearly shows that, even if the seismic risk in Japan and USA is similar to the European one, our budget is considerably smaller. Important testing installation are working or under construction in Japan, U.S.A., China and Taiwan. New testing techniques are emerging. All this pushes for a new testing facility in Europe. EFAST project will generate a preliminary design of a new testing facility to be inserted into the ESFRI roadmap.

Questions

Magonette: To what extent we are entitled to modify the submitted plan? Can we change it accordingly with the workshop outcomes and guidelines?

Politopoulos: We can modify the program of the demonstration tests, but we cannot modify the deliverables and the milestones because there is a contract with the Commission describing them.

Renda: USA and Japan has two different approaches: NEES and E-Defence. The first is mainly focused on networking facilities, the second one on having a very big facility. What will be our model and there will be room for networking with the existing installation in the word?

Politopoulos: The collaboration is a general wish. Regarding the type of installation, we are now at the beginning of the project and the things are not yet so clear.

EFAST inquiry

Francesco Marazzi (JRC – EC)

Presentation

A brief summary about the EFAST inquiry has been reported. More than 300 inquiry forms were sent in the past months to contact persons of the leading seismic testing laboratory (reaction walls, shaking tables, centrifuges), of the nuclear and chemical industries and of the construction companies. The feedback was acceptable for testing laboratories (30%) and for nuclear and chemical industries (22%), but low for construction companies (8%). The results will be updated in the next months, so that an increased percentage of returned inquiries is expected. Some provisory conclusions are already pointed out:

- laboratories:
  - wide possibility for multi-axial tests, but only few tests performed with vertical and lateral displacements: multi-axial tests are not a big demand or are avoided when possible
  - asynchronous multiple-support excitation, multidirectional excitation, telepresence and substructuring techniques are not yet common practices.
- nuclear and chemical industries (construction companies?):
  - there is a high demand for tests, but only a few were performed: it is only a problem of high costs or also a lack of accessibility to large facilities?
  - high demand for large-scale tests
  - high demand for both main structures and equipments tests to be used for both research and demonstrative purposes

Questions

Renda: There was an explicit question about the need for networking in Europe?
Marazzi: No, it is surely an interesting question, but a balance between the information requested and the time to complete the inquiry was carefully taken into account.
Molina: This is a very preliminary analysis of the results based on the data received up to a week ago; we will publish a complete report in the following weeks.

FAST input to EFAST

Jean-Claude Queval (CEA – France)

Presentation

A review of current European testing facilities and of the major new projects worldwide was presented as the scenario for the elaboration of the FAST project by CEA before the EFAST project was conceived. The problems and limitations encountered in the past were discussed and gave a preliminary idea of the expected needs with special attention to CEA. For Civil Engineering purposes a 1-DoF shaking table can be adequate, but for qualifications tests a 6-DoF table with high acceleration capacity is required. The FAST project technical solution was described into details.

Questions

Ohtomo: Do you have any idea of how to combine a shaking table with a pseudodynamic test?
Queval: Yes, we can use hybrid testing. In this way we will reduce the costs and avoid the problems related to scaling.
Molina: In the past, CEA transformed his largest shaking table from 3-DoF to 6-Dof. Do you think it is useful to have also the vertical DoFs, what were the advantages and disadvantage to have MDoF in your experience?
Queval: Yes, especially for qualification tests, for equipments and for the aeronautic industry, it is important to have vertical excitation also. It is true that it is not important for all types of tests to have vertical excitation, but if we don't have the capability to do such kind of tests, we will surely never do them.
Molina: Was the quality in the reproduction of the seismogram the same when you increased the DoFs?
Queval: Yes, in principle it is the same, but obviously this depends on the weight of the specimen.

EFAST test program

Uwe Dorka (Univ. Kassel – Germany)

Presentation

Some possibly available specimens for testing in the laboratories of the project partners were described as well as the ideas for multiple shaking tables testing, for substructure testing with shaking tables, for combining shaking tables with other on-site facility and for geographically distributed substructure testing. EFAST being not a research program, the amount of resources for testing is limited.

Questions

Renda: Is there a cross-interaction between the test program and the design of the facility?

Dorka: The testing program will be adjusted accordingly with the real possibility of the testing facility. The described testing program is based on the state-of-the-art review, we also need advises from experts in order to better define it.

TESTING NEEDS

Testing needs from the point of view of ECTP and cultural heritage protection

Roko Zarnic (Univ. Lubjana – Slovenia)

Presentation

The first part of the presentation deals with the Focus Area Cultural Heritage (FACH) of the European Construction Technology Platform (ECTP) (Prof. Zarnic acts as coordinator). There are no Eurocodes on Cultural Heritage (CH) interventions. Such interventions must be low intrusive and based in long term consequences. Regarding the needs, some are related to on-site investigation (long-term monitoring, decay of building fabric, accidental actions, non-destructive, semi-destructive and destructive testing) with the advantage of working with the real materials. Other ones are connected with laboratory investigation (materials, structural elements, models and prototypes). EFAST can help these last ones. Introduction of new materials in repair and structural strengthening is also important. The idea of "low intrusive intervention" needs more research on FRP materials, structural glass behaviour and wood-based composites. Restoration actors ask for demonstration tests. It is very important to involve SMEs into research, so networking is also very important especially for transferring university knowledge into industrial and operational knowhow. A list of the available laboratories should be elaborated.

Questions

Molina: Has CH sector some special needs with respect to other research sectors?

Zarnic: In principle I should say no, but in practice CH deals with sensitive buildings. In this case the multi disciplinary approach is a must.

Dolce: During your presentation you said that in situ tests are very important because of the ageing effects and of the boundary conditions. Could you please comment further about this?

Zarnic: Yes, it is very important to perform in situ tests; if we conduct laboratory tests we must be aware of their limitations.

Needs of large scale testing in developing regions

Marcial Blondet (Catholic Univ. – Peru)

Presentation

In developing countries, most people live in non-engineered low-rise constructions made of poor materials. This implies that most researches performed in developed countries are not directly applicable to developing countries. In developing countries, buildings are highly vulnerable to natural forces. This means that earthquakes usually cause a large amount of destruction and deaths, whereas in developed regions the damage is more related to infrastructures. Research conducted at Catholic University of Peru has significantly improved the knowledge about safer constructions, but they have failed in transmitting this knowhow to people. Large-scale experimental test programs are essential to develop reliable, economical and acceptable solutions for safe housing in developing countries, but testing facilities are expensive. It makes sense to share the facilities with researchers from developing countries through joint research projects aimed to improve the living conditions of millions of people.

Questions

Negro: Is it better for you to improve your laboratory or to have a more easy access to international facilities?
Blondet: We have a 1DoF shaking table. To have a better testing facility is needed.
Taucer: You need new and different facilities and new type of measurement devices or you have already enough?
Blondet: No, we need much more; we have a 1DoF shaking table with only 22 acquisition channels. We need to measure more and also to simulate what happens in the few seconds during the test.
Politopoulos: Of course the measurement techniques are essentials, they raise the quality of tests.
Zapico: Do you think that EFAST should emphasize results dissemination?
Blondet: It is as important as the research itself, we must change the people culture; we must convince people to apply new developments and to change their habits. We need a very multidisciplinary approach.
Dorka: It is important to perform test for developing countries in Europe, U.S.A. and Japan.
Tsai: It is very important to be able to analyse the in-plane and out-of-plane behaviour of brick masonry.
Molina: If you had the money and the possibility to choose between a larger SDoF shaking table and a small MDoF one, what would you choose?
Blondet: If the money is only for installation, I would choose the first one because the maintenance cost would be lower.

Nuclear Industry demands regarding a European Facility for Advanced Seismic Testing

Francois Voldoire (EDF – France)

Presentation

The first part of the presentation deals with the state of the art of the earthquake engineering and research in the nuclear context and summarise what has been done in the structural engineering field. An important point for future is to increase the efficiency of the research by strengthening the analyses combining in silico (simulations), in labo (tests in laboratory) and in situ (on the field) approaches. Another key issue is to better study the soil-structure interaction (SSI). The behaviour of seismic isolation systems and of RC building and the structural behaviour of the equipment must be further analysed. In order to fully exploit the capabilities of the testing techniques, refined measurements methods are needed. Experiments are also needed in order to discover unexpected failure modes. The sharing of expertises among labs, research teams and seismic structural analysts is also a key issue.

Questions

Renda: What do you think about the re-evaluation of the existing nuclear power plants? Do you think there is a need for specific tests? If yes, do you have an idea about the maximum dimensions, the maximum payload, the characteristics that the shaking table should have?
Voldoire: It is difficult to give a detailed answer. We need two classes of tests: for demonstration and for research purposes.
Renda: We have now in Europe medium size shaking tables. Do you think we need greater ones?
Voldoire: Presently, I don't know.
Reinhorn: Small shaking tables are enough for validation purposes. The testing facility must be integrated with a computational facility to extrapolate results.
Dorka: EC has a network for simulation and computation; EFAST is not a partner of this network.
Taylor: There is a European forum about build & share expertise for the next future.
Tsai: I suggest considering that the nuclear industry could finance the new EFAST facility, funding is always a serious problem.

2 March 2009 afternoon

Problems and certainties in the experimental simulation

Michele Calvi (Eucentre – Italy)

Presentation

The presentation begins with the statement that it is much better to invest a few hours of calculation and theoretical considerations rather then to spend several months of testing in the laboratory. Physical testing faces with the problem of scaling the specimens: the two options are usually to reduce the specimen size for shaking table testing or to keep the original dimensions for pseudodynamic testing (but in this case some problems regarding the velocity of testing arise). The type of testing method affects the choice of the simulation model: quasi static tests are not affected by viscous damping, but for simulating a shaking table tests an equivalent viscous damping must be considered: it should be proportional to initial or tangent stiffness? The observed behaviour of the tested structures is usually better than what is predicted by force-based codes. So, the most important parameter is the strength, not the PGA. There is still a lack of knowledge in non-structural elements, for example in masonry infill in RC frames. They are non-structural, but they can change considerably the structural behaviour and the structural demand. There is nowadays the capability of acquiring a large amount of data, but it is always the brain that filters and interprets them.

Questions

Negro: These tests on infill structures have been already performed about 15 years ago. Uncertainties in the properties of non-structural elements are known. Which kind of research is still needed for infill structures?

Calvi: Non structural elements don't contribute at the Ultimate Limit State (ULS). So, the requested level of damage must be specified, the target performance must be stated in advance. A highest earthquake will surely destroy the infills. The behaviour of structures with not yet destroyed infill walls must be further analysed.

Reinhorn: What about to weaken the structure to reduce demand? For example, what about the idea of placing isolators beneath for reducing the inter-storey displacements?

Calvi: Changes affect both demand and capacity. In fact, if we change the situation, we modify also the capacity demand.

Reinhorn: Was there anybody in charge for modelling and data analysis? What is the role of modelling?

Calvi: Modelling increases considerably the possibility of having good data, but the interpretation of measured data is still a concern. We are lucky if, at the end, we have measures at the right positions.

Reinhorn: We are happy when an experiment doesn't follow exactly the simulation; this means that with that experiment we are learning something new.

Bursi: A special care on the quality of acquired data must be considered for EFAST project. Error propagation analysis in fast testing methods is missing today.

Testing needs according to IAEA

Pierre Sollogoub (IAEA – Austria)

Presentation

There are some open problems in the field of nuclear safety. There are evidences of a seismic hazard at the site higher than the design earthquake due to new or additional data. Sometimes there is a lack or inadequate seismic design, generally due to the age of the facility. Seismic design approaches are in evolution with emphasis on margins evaluation, fragility quantification for structures, systems and components, risk-informed design. In order to prevent the consequences of cases such as the K-K accident in Japan, the safety margins need to be better known. Fragility testing requires high acceleration capacities, control capability until failure and testing methodologies and procedures. There is also a strong need for the development of new approaches (as for example base isolation and damping devices) and for validation of upgrading techniques. Nuclear core components are heavy with large dimensions, so large testing facilities are needed. These needs request a facility that should be large-scale, in real time, with controlled input until failure, with high level of input. It should be used also for qualification of active components.

Questions

Ohtomo: Do you think that vertical displacement is important?

Sollogoub: Yes, it is important for equipment. In any case, even if it will be not relevant for all tests, it is an important feature that the new testing facility should have.

Testing needs for soil-structure interaction

George Gazetas (Univ. Athens – Greece)

Presentation

The presentation deals with old and new needs for understanding better the Soil (Foundation) Structure Interaction (SFSI). It is very important to understand the strong foundation inelastic behaviour: this is especially true for slender structures, soft soils and strong shakings. Taking into account the real behaviour of the soil will allow assuming a more realistic structural behaviour, so making the design cheaper. It is also important to study pile foundations, caisson foundations, deeply embedded foundations with basement walls. Another important aspect is to be able to simulate liquefaction and soil "flow" and their effects on piles, structure, etc. A state-of-the-art large scale facility should be capable of reproducing the SFSI at least at a scale of 1:4. So, large laminar boxes are needed. There are several options for laminar boxes, but no perfect solution exists. Laminar boxes with Plexiglas walls are very useful because they allow to see what is going on and to take optical measurements. Rigid boxes are only useful for calibration of numerical models.

Questions

Pavese: How can you scale the hydrostatic pressure inside the soil?
Gazetas: You can adjust it effectively only with centrifuge facilities, but you can also add some loads on the soil surface.
Pavese: What is the requested minimum dimension of the shaking table for avoiding scaling problems?
Gazetas: Scaling problems in soils are surely greater than for structures.
Pavese: Do you think that it is possible to simulate the boundary effects between the edges of the laminar box and the ideally remaining soil?
Gazetas: In geotechnical engineering we are not so precise, a large laminar box is sufficient.
Taylor: You can also have active controlled walls using actuators.
Politopoulos: These actuators can give damping problems when used for vertical testing.

Testing needs for Civil Protection

Mauro Dolce (Civil Protection – Italy)

Presentation

The presentation gives an overview of the Civil Protection activities. It summarises the experience in the prevention, event and post event phases. An extensive description of the research project conducted in the past years is presented with focus on the development of protecting devices. The main needs for further research in the prevention phase are related to the behaviour of non structural elements, of the inside objects (as for example cultural heritage, high social or economical value instrumentations, dangerous furniture, etc.) and of the infrastructural systems. For the event phase the main need is to be able to properly monitor the soil and the structures (optimisation of the instrumentation and parameter identification and calibration for remote damage assessment). Regarding the post event phase, it is important to evaluate the residual strength of slightly and severely damaged structures, to evaluate the effectiveness of provisional works, to study the safety of temporary shelters and finally to study the possible seismic rehabilitation of damaged structures.

Questions

The presentation was very exhaustive and did not leave room for questions.

Testing needs for civil infrastructures

Livia Pardi (Autostrade – Italy)

Presentation

The first part of the presentation describes the Autostrade S.p.A. group and its activities. Then the needs are specified. First of all there is a strong request for further experimental and theoretical studies on the seismic response of bridges and viaducts with special attention on the three-dimensional character of their response, the constraint devices, the flexibility of their foundations and the actual behaviour of the most critical elements. Soil-structure interactions and non-synchronous ground motions must also be deeply investigated. This is true not only for the new bridges, but also for the existing ones due to degradation and higher demand level (for increased traffic, for increased seismicity etc.). Testing in deteriorated (corroded) specimens is also needed. Finally, anti-seismic devices must be developed and tested. In the final part of the presentation some case studies are described.

Questions

Renda: Regarding the assessment of the residual life, is it important, in your opinion, being able to perform asynchronous tests?

Pardi: Yes, I think so.

Molina: The seismic hazard maps have been changed. How do you assess old structures within the re-evaluated zones? Are you able to do a new assessment without experimental testing?

Pardi: We are trying to assess old bridges and other structures by experimental testing on old components, but it is a difficult task. It is much simpler with new structures.

Future of EUROCODE8 and interaction with experimental needs

Eduardo Carvalho (GAPRES – Portugal)

Presentation

After a brief overview about the Eurocodes and of Eurocode 8 in particular, some open questions are presented. The priority for Eurocodes is now to come into force by 2011, but further improvements are needed is several parts. Regarding specifically Eurocode 8, these aspects require a deeper experimental research activity:

- buildings with flat slabs should be further tested for eventually increase their class of ductility;
- the use of precast RC elements in floor structures needs to be codified;
- national parameters for masonry must be further harmonised, reducing their number to a minimum;
- the out of plane behaviour of masonry structures and rules for "simple buildings" should be assessed;
- the beneficial role of infill in framed structures is still not taken into account;
- some aspects strictly connected with the numerical activity are the improvement of provisions for response in torsion and irregular in-plan structures, soil-structure interaction, displacement-based design for new buildings, non structural elements behaviour.

Questions

Blondet: Which type of masonry does the Eurocode refer to: reinforced or confined?

Carvalho: Three types of masonry are present on the Eurocode 6: reinforced (with vertical or horizontal reinforcements), not reinforced and confined (with vertical parts or precast). Materials can by stones, bricks or blocks. For low seismicity zones non reinforced masonry is allowed.

Blondet: What are you wishing to test?

Carvalho: There are a lot of national determined parameters, such as the number of stones, or the selection of shear or compression for the design, that must be harmonized. It will be useful to try to make the parameters converge to a much smaller number. It would be important also to consider and validate the different national design methodologies. The focus now is to put the Eurocodes in force and, afterwards, try to improve them with experimental verifications.

Zapico: Soil-structure interaction and response in torsion are handled in an analytical or numerical way. May the experimental approach be interesting also?

Carvalho: It might be interesting but the problem must be treated first in an analytical way because it is very complex. It is the case of the "accidental" torsion, for example, that appears in some structures that are meant to be symmetric when they are not. Often, the strength eccentricity is different from the stiffness one.

Molina: What are the technologies that may have some advantages and disadvantages in earthquake engineering testing? Can you give us some advice based on your experience as a laboratory manager?

Carvalho: Shaking table and PsD tests have their own merits and applications. The best think would be to do not scale the specimen, so use a 1:1 scale factor. But the shaking table has the problem of the limitation on the weight and mass and running a test of a big specimen at a high velocity may result really expensive. Since it is not possible to change the specimen construction material, we must use scaled specimens. This implies further limitations. On the other hand, using the PsD method, the problem with the mass disappears. The need of power is smaller as the test is carried out much slower. In any case there are advantages and drawback in both methods.

TESTING DEVICES MANUFACTURERS

MTS

Allen Clark, *Bradford Thoen* (U.S.A.)

Presentation

The presentation begins with a presentation of MTS activities, then some examples of realisation in the field of earthquake and civil engineering testing are presented. The main focus is on shaking table testing facilities. The second half of the speech deals in details with the current technology of MTS systems. This technology was developed during a long time with some of the most prestigious university in the word. A SCRAM Net (Distributed Shared Memory) Network is used to connect controllers, acquisition nodes, simulation nodes and MATLAB workstations in real time.

Questions

The presentation was very exhaustive and did not leave room for questions.

MOOG

Fausto Argeri (Italy)

Presentation

The presentation shows some examples of realisation in the field of earthquake engineering with special focus on the pseudodynamic testing method. The actual technology of MOOG systems is described. The MOOG actuators are driven by a digital controller connected with the pseudodynamic algorithm. An agreement between JRC and MOOG was signed in 2006 to promote pseudo-dynamic testing in several research centres (currently they are 4).

Questions

The presentation was very exhaustive and did not leave room for questions.

INSTRON

Glen Wardrop (Germany)

Presentation

The INSTRON activities in the field of earthquake engineering testing are briefly presented with some examples of realised testing facilities. The related technology is described. The final part of the presentation describes the developed software for testing and for acquisition and treatment of the measured data.

Questions

Molina: Do you have experience in the combination of several shaking tables?
Wardrop: No.
Molina: Do you have experience in the control of shaking tables with more than one DoF?
Wardrop: Yes, we have that experience and it works very well in the automotive sector. However, it takes a lot of time to tune everything to make it work properly.

3 March 2009 morning

TESTING METHODS AND TECHNOLOGY

Challenges in distributed and collaborative testing

Keh-Chyuan Tsai (NCREE – Taiwan)

Presentation

The first part of the presentations contains an overview of the NCREE experimental and numerical activities on collaborative hybrid tests, numerical simulation platform, substructure and distributed tests, field tests. The second part deals with the open challenges and problems in seismic testing, in particular the necessity to impose proper boundary conditions, the requirements for performing real-time or fast hybrid simulations and the need to take into account the possibility of expansion of the existing facility. Experimental techniques should be coupled with proper computational and visualisation tools that can provide simultaneous 3D display in platform for networked structural experiments. A detailed description of the extension of the existing testing facility is given. The MATS (Multi-Axial Testing System) testing facility concept is illustrated as an example of hybrid testing. A discussion about the existing problems in hybrid testing and fast hybrid testing techniques concludes the presentation.

Questions

Renda: You raised the advantage of sub-structuring and hybrid testing developed in house. According to your experience, is distributed testing important when performed in many laboratories? Are you able to run hybrid testing in your laboratory? And, once one is able to run hybrid testing, is it difficult to pass from hybrid to distributed testing?

Tsai: Distributed testing and hybrid testing are important when it is too expensive to test the full structures. In that case the structure is cut in two parts. The biggest problem is how to impose the boundary conditions. The advantage of distributed testing is collaboration, working together, exchange of ideas between partners. You need also a good structural model to justify distributed testing. Is not difficult to move from hybrid testing to distributed testing, as long as there is an Internet connection. The main improvement is that test data will be automatically recorded. This will revolutionize the test: all data are available in real time.

Bursi: Does the assumption of damping affect the results of test? Why was the issue raised?

Tsai: The assumption on damping depends on the quality of the experimental set up. Each design will vary in its quality. Low cost designs may introduce friction, resulting in data recorded from the test being contaminated. It is important to identify the sources of friction because this will determine the assumptions on damping.

Molina: My question concerns real-time hybrid testing on aspects regarding hardware. In general hybrid testing is not very appropriate (with current technology) to study degradation. Most hybrid testing studies have been performed on simple systems that do not change (remain almost linear). Then, having this limitation in mind, what could be the real application of real-time hybrid testing with current technologies?

Tsai: We do no have a lot of experience on real-time testing. When there is sudden failure of a connection there is a sudden drop of the restoring force, which a fast hybrid algorithm may not be able to handle. A sudden degradation may be difficult to handle.

Open questions on multiple shaking tables and reaction walls

Andrei Reinhorn (Univ. Buffalo – U.S.A.)

Presentation

The presentation starts from classical hybrid simulations testing techniques and arrives to more advanced real time dynamic hybrid simulation schemes. Reasons for the need of real-time simulation include the appropriate representation of strain-rate effects, inertial effects and the behaviour of non structural elements. This technique is evolving and refining, but some challenges are still present: actuators providing forces at the boundaries must move as dictated by the base motion, but must provide small relative drifts (difficult to control accurately). Implementation of displacement or force commands requires accurate models of hydraulic (nonlinear equipment). Complex interface forces, moments and torques increase the number of necessary actuators and synchronization issues. Computational substructures must be solved in "real-time" at rate of excitation or faster – particularly challenging are large structures and nonlinear structures; synchronization is possible but requires compensation for inherent time delays in physical implementations. Computing acceleration at base boundaries must include the effects of earthquake excitations and of the mass system above. Explorative approaches divide into physical (through hardware) and computational ones and have been studied at SUNY in recent years. Another important discussed issue is the synchronisation of two shaking tables. They can operate separately or can be connected and driven together for large experiments.

Questions

The presentation was very exhaustive and did not leave room for questions.

Design and construction issues of a shaking table array

Wensheng Lu (Univ. Tongji – China)

Presentation

After a short overview of Tongji University activities, the existing shaking table facility is described. This facility is now insufficient for the current needs in China, for instance to have a multi earthquake excitation for testing great-span bridges, lifeline engineering and other great-span structures in civil engineering. These reasons push for the conception and realisation of a new shaking table array facility (3Dof tables). The main characteristics of the new installations are then described and discussed. For example, they expect to have a phase lag of some 5 to 10 degrees between the responses of two shaking tables.

Questions

Geradin: What is the budget of the project?
Lu: 80 million dollar for design, construction and devices.
Bursi: Was there a competition for the choice of the shaking table provider? Or was the choice direct?
Lu: 3 years ago there was a bidding process in the world: 5 suppliers responded and only 2 were technically feasible, offering support and financial quotations. MTS got the job.
Pavese: Was the reaction mass determined by the total mass of tables? If the total reaction mass is of 30 thousand tonnes, the associated cost is 21 million euro, which is a large sum. Why did not you consider a lighter mass with a different system of isolation? Or was the mass determined by geometric constraints?
Lu: The old shaking table was 4x4 m. The new tables for bridge testing are 4x6 m occupying a total area of 30x70 m: for performance reasons this geometry required a mass of concrete much larger than that strictly necessary.

IT challenges in EE cyberinfrastructures

Lelli Van Den Einde (UCSD – U.S.A.)

Presentation

The presentation focused on the technical characteristics of NEESit and on the implementation problem that the project has encountered up to now. The analysis of these drawbacks stimulates several recommendations. It is necessary to get the community to shift culture to more collaborative, multi-disciplinary, highly distributed teams. In order to stimulate the use of the data repository, it is better to offers "carrots and sticks" to encourage usage and participation. The database should be targeted to a heterogeneous earthquake engineering community, with different levels of sophistication and requirements. A balance between academic IT development and production quality software development must be achieved. In the final part of the presentation, a detailed list of available IT resources for software and resources is presented. Most of them are based on an open source philosophy, so they can be downloaded and used by all the users.

Questions

Reinhorn: To deal with requirements and solutions separately is a mistake, they are strictly interlaced and must be jointly analysed.

Molina: Do you have any recommendation for Europe?

Van Den Einde: You should develop open source tools and to be ready to collaboration, to share. Deal with every user case by case and do not try to arrive at a consensus. Database should be centralised if they are not supported locally or should be decentralised if they are supported locally.

Sollogoub: How are available IT resources used?

Van Den Einde: The data are usually inserted into the database with some delay, it takes time before people put their data into the database. The data utilisation is also usually difficult. Every NEES partner should put their data on the database, but this does not always happen easily. So, the actual strategy is to adopt a founding mechanism related to the fulfilment of this request. Data repository can be accessible at different levels to different users with different rights (for example access restricted to project partners). About telepresence: it is especially useful after the experiment for observing the test.

Questions raised in operating a very large shaking table

Keizo Ohtomo (CRIEPI – Japan)

Presentation

A brief overview of the E-Defense shaking table facility is presented. The main expectations from such a large facility are to be able to characterise the structures up to the complete collapse and to eliminate the scale effects. Some problems still persist as, for example, those related to the boundary conditions (of buried structures, of soil and shallow foundation interaction, of soil and deep foundation interaction etc.). Another point is that a collapse test usually needs a support frame as well as a structure being tested. If the support frame is designed rigid enough so that it prevents the spread or the tilting of a target structure, the support frame may occupy a large part of the test set up and contribute significantly to the payload. Sometimes it can be difficult to simulate the desired ground motion if the specimen mass is huge and if its response is highly nonlinear. The development in the field of substructure hybrid testing for underground structures concludes the presentation.

Questions

Bursi: The shaking table runs in feedforward or feedback mode? Is there a parallel hybrid calculation?
Ohtomo: The shaking table works in feedback.
Reinhorn: Are there a reaction force measurements?
Ohtomo: Yes, we obtain them from the shaking actuators measuring acceleration, velocity and displacement.
Sollogoub: Was there any interesting outcome by studying non scaled structures, i.e. with scale 1:1?
Ohtomo: The soils-structure interaction tests are always influenced by the boundary conditions.
Pavese: Could you please quantify the costs of a test on the E-Defence shaking table?
Ohtomo: The public authority pays for tests.

Testing of seismic protection devices

Agostino Marioni (ALGA – Italy)

Presentation

The main standards for anti-seismic devices are commented at the beginning of the presentation. Two types of classification are described: the first is related to the performance of the devices, the second one on their type. According to these classifications, standards require specific tests. ALGA has an experimental laboratory for the most common production tests. For non common products or for research purposes the tests are performed at Eucentre, where a dedicated testing facility is operative for these devices. For exceptional products, however, only one U.S.A. laboratory is suitable. Moreover, the demand of tests on anti-seismic devices will tend to increase with entering in force of the European Standard EN 15129 and the increase of the number of structures incorporating such devices. The need for a facility that can perform such kind of tests is evident.

Questions

Reinhorn: What happens if the quality control tests give negative results? You will do additional tests?
Marioni: If the quality control tests fail, the number of tests is increased; if it is still negative, the whole lot is eliminated. This procedure is codified in ISO standard rules.
Reinhorn: Do you perform tests during the life-time of your devices?
Marioni: Ageing simulation tests are foreseen only for rubber materials. Fatigue and wear tests are requested for the seals of hydraulic systems.

3 March 2009 afternoon

Visit to the IPSC ELSA laboratory

The visit includes a presentation given by Javier Molina about the main historic achievements of the laboratory. Then, the ELSA researchers give explanations about the devices and specimens in place.

ROUND TABLE ON TESTING NEEDS

Chairman: *Pierre Pegon* (JRC – EC)

The elaborated text of the agreed document of the first round table is given in the conclusions. Some of the personal comments expressed during the discussion were the following:

Carvalho: Masonry structures on real scale have been already tested with the Pseudodynamic method at JRC. Tests with shaking table have been realised on scaled model or limited portions of the real structures. A large shaking table facility could sensibly improve our knowledge on these type of structures because it will allows to test up to 2 or 3 storeys masonry building in both directions. Large scale tests are especially required for validation. Masonry and infills should be tested in shaking table because of gravity forces and out-of-plane effects. European techniques and materials are very different, so many tests are foreseen. This kind of tests could be very expensive, we should have cost-effective tests. Soil structure interaction it is also a very important subject. Scaling problem in this field are even more important than with masonry structures.

Zarnic: Tests on new materials are necessary. Full scale tests can be very useful to evaluate the global behaviour of a part of a monumental structure retrofitted with new materials: it is important to know how they work together.

Pegon: You said yesterday that it is very difficult to reproduce a cultural heritage structure into laboratory. So, why do you think a new testing facility will be important for that sector?

Zarnic: We must convince the restaurateurs that new techniques and materials can be effective. Architects want to insert new materials, restaurateurs don't want, as engineer we have to demonstrate that these new materials and techniques are good.

Taylor: Tests on piles conducted on 1:20 scaled specimens: the general results were quite good. Probably is more important to study the mechanism of the soil with a bigger box facility.

Blondet: There should be promoted collaboration with poor countries for testing their houses. Access should be given to the facility. Collaboration is important. Remember the cost of maintenance of a big platform.

Pavese: PsD and Shaking Table capabilities should be included, but this is the last step, before is necessary to make any preliminary study for proper evaluation of the correctness of the experimental conception (numerical simulations, preparatory tests etc.).

Negro: A unique facility cannot solve all the problems. European laboratories have always collaborated, so probably is not necessary to have a big facility where all tests can be performed, but it is more important to develop telepresence, distributed tools and so on, all that is collaboration between laboratories.

Pegon: EFAST will not cancel what is already present in Europe.

Reinhorn: We are strong sustainers of the open-source philosophy for gradually improve our knowledge. We developed OpenSees for this purpose. A close interaction with the numerical capabilities should be guaranteed. The more sophisticated will be the platform, the simpler will be the structure that you can really test without being involved in errors.

Taylor: Numerical capabilities will sensibly increase in the future. Flexibility is also very important.

Tsai: Think at expandability as well.

Van den Einde: The foundation of the facility must be larger than required in order to accept future amendments.

Sollogoub: The future testing facility should be flexible and multi-input. 3D excitation capabilities are important for qualification tests. For example, it is very important to be able to study the control loop system that stops the nuclear reactor. This system is complicated and probably will be changed on the new nuclear power plants so the new platform must be flexible. It is important to have high accelerations, high velocities and high displacements; testing frequencies must be higher than 20 Hz (i.e. those possible till now).

Reinhorn: 30-50 Hz is what is requested in American standard.

Voldoire: Full scale testing is important for reproducing local effects, boundary conditions must be well considered.

Politopoulos: Vertical excitation is important? How much? When?

Sollogoub: The fact that we are not sure whether vertical excitation is important, pushes towards a deeper research about it. Independently to nuclear power plants, in the past there were some important failures that can be explained only by considering also the vertical acceleration. Consider also the case of slabs, where some important instrumentation (as the electrical ones) is placed: it is important to consider the effects of the vertical acceleration. In transportation structures it is important to be able to perform 3D shaking table tests in order to account of everything.

Lu: Qualification tests require accelerations of up to 4g and working with relatively low payload. Frequencies should be between 0.1 and 50 Hz. In general is not important to have simultaneously high velocities and high accelerations. Heating and ageing effects should also be considered.

Marioni: There is a lack in the laboratories regarding the possibility to have high testing speeds. There are no labs capable for testing high performance devices at 2.2 m/s as requested by European standard and reduced-scale models are not valid because of the heat phenomena. Factories cannot perform exceptional tests.

Pavese: Eucentre has 1.7 m/s velocity. Lack is in velocity and acceleration. Even if standards have specifically requirements for some specific tests, if the will be performed only 1 or 2 times a year, there is no interest to spend money to perform such a reduced number of tests.

Marioni: This is true, but in this way there is not solution because scaling is not possible.

Pinto: Non-structural elements must also be mentioned. Do we need something more, i.e. a new platform, or must we use better the existing facilities to test these elements? Probably it is more important to make the results of our tests available to all the community, not only at the university level. We should give a relevant educational role to the facility, we must think well about the impact of our research.

Geradin: Testing of new construction techniques and materials should be included, as for example structural glass.

Voldoire: We need more to identify the boundary conditions between the shaking table and the structure. We must control better the motion of the shaking table. It is important to control the reliability of the tests. Special tests are needed for this.

Reinhorn: We should improve the application of the image technology learning from the medicine diagnosis applications. Real-time data viewer is very important: the role of real-time must be a very important task. From the safety point of view, the collapse of the structure must always be foreseen and a catch system must be implemented.

Tsai: We also are developing instrumentation and techniques for optical measurements.

Pegon: An important point is also to foreseen a protection system for the shaking table when tests arrive to the structural collapse.

Ohtomo: Numerical analysis is important before the tests.

Taylor: We must also pay attention to the generational overturning of the researcher.

Pegon: A team should conduct the new testing facility.

Renda: The facility should offer full-scale testing for developing countries. It must be integrated with the existing ones but going beyond.

Taucer: The databases should be complementary among themselves.

Taylor: Each test reveals the known unknown but also the unknown unknown.

Ohtomo: Scaling problems are very important, but also detailing aspects should be considered carefully.

ROUND TABLE ON TESTING METHODS AND TECHNOLOGY

Chairman: *Georges Magonette* (JRC – EC)

The elaborated text of the agreed document of the second round table is given in the conclusions. Some of the personal comments expressed during the discussion were the following:

Magonette: We need your comments. Not all technical aspects can be defined now, but we need to have some ideas from you. There are many possible solutions and possibilities are very broad. For example are there some advices concerning the working space?

Sollogoub: You need to be able to construct the specimens not so close to the testing space and to transport them on the shaking table.

Queval: It is important to have working space around the facility to be able to fix actuators and equipments.

Negro: The transportation system for the specimens in the lab must be a part of the design. The actuation system must be flexible.

Magonette: It also very important to have a dedicated area for demolition.

Dorka: The facility must be as large as a football court and part of it without any roof. We should have some green spaces around the laboratory to be able to extend it.

Politopoulos: For soil-structure interaction it is very important to have a very big shaking table and very stiff. A low deformation is necessary to perform accurate tests.

Magonette: There is the need for a strong coupling between the experimental and the numerical activities. Not only the staff, but also the computers much be coupled.

Zarnic: The ECTP can give support to the EFAST facility promotion and financing within the 8th FWP. The facility should be extended to research in protection against other types of disasters.

Magonette: We must discuss about the general structure of the testing facility. For example, we need one large 1D shaking table or a 6 DoF for nuclear purposes?

Reinhorn: Real-time (dynamic) substructuring has added value even when it cannot be applied to specimens submitted to degradation. It is worth to have at least the hardware capabilities for this kind of tests.

Molina: We should first clarify which technology we want to apply. We may agree that, regarding the Pseudodynamic testing, we have already in Europe what we need. The ELSA laboratory is at the highest level in the word. So the proposal of CEA of a shaking table is the most suitable.

Geradin: The most versatile tool would be an installation with multi-axial excitation and strongly coupled with numerical simulation. It is a problem that each team develops software in its own environment and this might create problems. On the other hand the new testing facility should provide something that does not exist in Europe.

Dorka: There are nice shaking tables around the world and they should cooperate. It is a mistake to double something that already exists. With good software we can simulate successfully ground motions and environments. We have to see how to connect the system to high power software.

Politopoulos: I must remember that EFAST is a design study. There is no much room for research; we must use the state-of-the-art in this field.

Clark: The proposal of CEA comes from a feasibility study, so it is based on the state-of-the-art. If we want to test a real building which should be shaken at the foundation, may be the SDOF system is interesting.

Reinhorn: The versatility is the best approach, for example using some 20 small shaking tables that can be eventually linked with space trusses. Further studies are needed to fully synchronise the shaking tables. At this preliminary stage it is important at least to estimate how much to extend the testing facility. The foundations should reflect it. Several solutions can also be considered.

Sollogoub: Flexibility is important. The nuclear sector asks for a rigid shaking table with 6 DoF. The rigid requirement is especially needed for qualification tests.

Magonette: A good balance between what is actually requested by our costumers and the adaptability to new testing techniques available in the future must be searched.

Reinhorn: We have a facility for quality testing. In the meantime we are developing the hardware to be ready for new developments.

Tsai: We recently decide to upgrade the controllers, we are investing on them. Technology is now ready for using shaking tables in hybrid testing.

Molina: Does people operating shaking tables know what instrumentation is needed to assure the quality of the tests, for example in order to measure the amount of pitching?

Reinhorn: We should distinguish between qualification (demonstrative) and research (exploration) tests. For the latter we should measure all the motions of the table and all the responses of the specimen. All the possible inputs produced by the shaking table should be measured. Image techniques should complement the measurements. For qualification tests the weight of the specimen must be smaller in order to guarantee better accuracy in the input, these tests are usually the most critical and difficult.

Taylor: Adaptable control improves the situation but non-linearity is difficult to compensate with a fast adaptation. The quality of the piston bearings is very important.

Reinhorn: We have reference traceable load cells that we use to calibrate our cells. Our load cells are constructed by ourselves. The possibility of having load cells embedded in the system must be studied.

Lu: It is important to consider also the possibility of testing real structure outside the laboratory. We should improve our devices which can be used for in-situ testing.

Carvalho: The design study must consider the constructions costs as well as the operational costs.

Conclusions

The discussed matters during the two round tables were summarised during the post-workshop meeting held on the 4th of March 2009 at ELSA laboratory. This meeting was attended by all the partners and the three members of the Scientific Committee. The draft document prepared by the chairmen of the two round tables held the day before during the 1st EFAST workshop was analysed and discussed. Participants suggested amendments and improvements of the proposed text. What follows is a more elaborated version of those documents.

ROUND TABLE ON TESTING NEEDS

The elaborated text of the agreed document of the first round table contains the following points:

- A better knowledge of the behaviour of flat-slab buildings, pre-stressed framed structures, masonry structures, structures with masonry infills, cultural heritage buildings and bridges is needed. In particular:
    - **For Eurocode8** a very important issue are masonry & masonry infill structures with more than 2 storeys. These structures can be tested with the pseudodynamic method, but, because of their distributed masses, the best choice is probably to test them on a shaking table if it can be done in real size. Several tests should be conducted because of the variability of construction techniques and materials.
    - **For cultural heritage** a main need is to test structures retrofitted with innovative techniques.
- A stronger validation and closer harmonization for **Eurocodes** national parameters. This is a short term need in the sense that it should be fulfilled in the following years, so probably with the existing testing facilities. Nevertheless, to achieve these goals, further studies regarding assessment and retrofitting of buildings are needed. Full scale and multiple-support test are also requested. Most of the tests on large-scale specimens are needed for demonstrative purposes and are more feasible pseudo-dynamically because of the difficulties and cost of dynamic tests on huge specimens.
- Access to the facility by **emerging countries, with low cost,** must be facilitated (for testing, for example, one storey stone houses in real scale).
- **Soil-(Foundation)-Structure Interaction** (S(F)SI) must be deeply studied. Tests must be as close as possible to real scale in order to avoid scaling effects; this means using large boxes (for example: height 4 m, length 8 m, depth to be specified) + the specimen. Even with such large bows, it is unlikely that pile tests will be feasible on a shaking table. In same cases the pseudo-dynamic method can be used or tests can be done, with a dynamic shaker or outdoor, on a real soil to provide suitable results for calibration of numerical models. However this type of tests cannot deal with the full interaction problem since the input is imposed to the structure thus disregarding the kinematic interaction.
- Some requests are specific for **nuclear industry**: there is a need to test structural components & equipment & processes (both for demonstrative full scale aspects and for a better understanding of the behaviour in the non-linear range). Vertical acceleration and floor amplification are very important. Due to floor amplification, components must be tested with high acceleration (4g) in the frequency range form 0.1 Hz to 50 Hz. Vertical excitation must often be taken into consideration (3D tests). The behaviour of tanks, vessels with fluids, complex connected slender structures as well as S(F)SI are some key points for nuclear industry.
- Some important aspects related to **secondary structures** (sensitive equipments “integrated engineering systems”, high value equipment) must be addressed. These complex structures are

characterised by having multiple supports, this fact affects the overturning moment and payload.

- It is important to be ready for the **qualification** of protection devices. There are only a few high capacity demanding tests required by codes. The remaining, less demanding tests, are carried out either by the manufacturers themselves or in the existing facilities. However Europe should get the capacity for doing also these large scale tests in the future.
- Jointly with the experimental activities, it is important to assign importance to pre-test, post-test and between tests **computation** in order to better conduct the test (design of the specimen and the set-up, analyse final but also intermediate results, asses the quality of measurement and detect probable improper function of a sensors etc.). This work may be done in the experimental facility itself (if there is sufficient computational capability) or by networking in cooperation with specific computational facilities or other laboratories. This stresses the importance of networking & complementarity.
- It is very important to have a proper acquisition system and a proper network of sensors. New measurement technologies should be also considered that allow **field measurements** (optical measurements, but not only).
- To conduct a meaningful probability risk assessment available actual margins of the structures have to be estimated. To this end tests with high excitation level up to collapse or resulting in a relevant significant damage level must be carried out. This implies that the new facility should have the capability to reproduce high intensity excitations (high acceleration, velocity and displacement).
- The research community asks for more exhaustive and reliable results and needs to maximize the **impact of research**. To easily share the data, new "Informatics Technologies" (IT) should be adopted.
- Last but not least, a better use of **existing facilities** and **integration** with EFAST should be foreseen. Once more, the importance of networking and cooperation is pointed out.

ROUND TABLE ON TESTING METHODS AND TECHNOLOGY

The elaborated text of the agreed document of the second round table contains the following points:

- A key feature of the future testing facility must be its **versatility**: wide working space, adequate room for construction, an outside demolition area, possibility to extend the laboratory accordingly to future needs, capability for applying **multi-axial loading** and for **substructuring** testing. The possibility of some outdoor tests should also be investigated.
- The initial design of the facility must enable future extensions and improvements (for example: only 1 DoF is realised at the beginning, but basement is already prepared for 6 DoF, so the facility can be upgraded in a following time).
- It is important to have a strong coupling between the experimental and the **numerical** aspects. Software **harmonization** should be promoted.
- Information, **dissemination** and **collaboration** must be stressed.
- The reaction wall could be conceived as composed by **modular** and **light** elements so that to enable modification of its configuration depending on the requirements for different tests.
- Uni-axial, bi-axial, tri-axial and **6DoF** shaking table facilities are needed for different kind of tests, but for Nuclear Industry qualification tests a rigid 6DoF is compulsory.
- Even if fast and real-time **substructuring** (hybrid) techniques are still under development and yet impossible in practice for degrading specimens, the new testing facility must be designed taking them into account, so having the required hardware capacity to do it.
- Besides the main testing facility, some **dedicated Testing Facilities** (MATS - Multi-Axial Testing System, testing of non structural components) should be considered. If the

aforementioned machines are not constructed from the beginning, the design of the facility must be thought so that they could been integrated in a second phase.

- During the design phase of the new testing facility, **networking** should be considered.
- The **spurious pitching** (and other input errors) of the shaking tables must be minimized at the best today attainable level for qualification tests. It must be bounded between reasonable values for other tests and in any case it should be always measured and reported.
- **Instrumentation** issues should be studied jointly with the design of the testing part of the facility in order to have a proper calibration hardware and software: some certified elements, some partially certificated elements, optical hardware and methods for field measurements.
- A special care must be devoted on the estimation and quantification of the **construction costs** and of the **maintenance costs** (all aspects must be considered: infrastructures, operation costs, the numerical and IT tools and teams etc.)

Acknowledgments

The Authors thank the project partners and the colleagues of the ELSA unit for their help in organising and conducting the workshop. The secretary Desislava Strezova made an enormous logistic and administrative work. Particularly useful for this report were the detailed notes taken during the sessions by our colleagues: Silvia Dimova, Fabio Taucer, Georgios Tsionis, Pinar Ozdemir Caglayan, Beatriz Zapico, Armelle Anthoine and Anna Bosi. Pierre Pegon and Ioannis Politopoulos also revised this document constructively.

European Commission

EUR 23822 EN **– Joint Research Centre – Institute for the Protection and Security of the Citizen**
Title: 1st EFAST Workshop - Challenges, Needs and Open Questions
Authors: Francesco Marazzi, Francisco Javier Molina Ruiz
Luxembourg: Office for Official Publications of the European Communities
2009 – 36 pp. – 21 x 29.7 cm
EUR – Scientific and Technical Research series – ISSN 1018-5593

Abstract
During the 2nd and the 3rd of March, some of the main experts in earthquake engineering, seismic protection and testing methods from all around the world were invited to attend the 1st EFAST Workshop hosted at JRC in Ispra.
EFAST (Design Study of a European Facility for Advanced Seismic Testing) is a joint project financed by the European Commission that foresees the study of all the aspects regarding the design of a major testing facility in Europe that would complement and collaborate with the existing ones. This study aims at identifying the current and future needs in the field, and proposes the concept of a facility using the best available testing technologies.
During the Workshop the experts made presentations regarding the needs, the technologies, the design and the operation of seismic testing infrastructures. Round tables on these topics were held in order to stimulate open debate. The recommended solutions and required performances served as input for the development of the design of the new research infrastructure.
This report describes into detail what was said during the Workshop. A summary for each presentation with the main questions and answers is given. The detailed discussion held during the final round tables is also reported. The obtained conclusions close the document.

How to obtain EU publications

Our priced publications are available from EU Bookshop (http://bookshop.europa.eu), where you can place an order with the sales agent of your choice.

The Publications Office has a worldwide network of sales agents. You can obtain their contact details by sending a fax to (352) 29 29-42758.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

JRC
EUROPEAN COMMISSION

Publications Office
Publications.europa.eu