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MODERN TRENDS IN EXPERIMENTAL EARTHQUAKE ENGINEERING RESEARCH

BY

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Abstract. The recent advances in experimental procedures in the field of earthquake engineering research are presented. The extensive damages caused by the earthquakes during the last decade led to a gradual change in the general public awareness of this type of natural disaster. The scientific community intensified its efforts to better understand the way different types of structures behave under seismic excitations in order to increase their safety. Shaking table tests have the advantage of well controlled large amplitude, multi-axis input motions and easier experimental measurements. Their use is justified if the purpose of the test was to validate the numerical model or to understand the basic failure mechanisms of either a structure or a structural element. Developments in earthquake geotechnical engineering, including understanding the ground behaviour during seismic shaking, effects of the earthquake on the geotechnical facilities, thorough studies on the site amplification, have also shown tremendous progress. The numerical simulation is a powerful tool especially when the analytical solutions are very complex or can not be found by elementary means. The already existing models have proven to be able to accurately predict the results obtained through classic or innovative experimental techniques.

Key words: shaking table tests; superstructures; numerical simulations.

1. Introduction

The extensive damage caused by earthquakes during the past decades (1994 – Northridge, USA; 1995 – Kobe, Japan; 1999 – Chi-Chi, Taiwan; 2003 – Bam, Iran; 2004 – Niigata, Japan; 2008 – Sichuan, China; 2009 – L'Aquila, Italy), with major influences on urban areas, led to a gradual change in the general public awareness of this type of natural disaster. This resulted in an increased demand for higher structural safety against earthquakes. The scientific community intensified the efforts to better understand the way different types of structures behave under seismic excitation. Their main objectives were to increase structural safety and mitigate the risk of structures being damaged beyond repair or collapse during earthquakes.

The latter is primarily obtained by improvements of the infrastructure, based on increased understanding of the causes and effects of natural hazards and improved methods of engineering and construction to deal with those effects. For earthquake risk assessment in particular, the quantification of the damage a structure may suffer during an earthquake is a crucial parameter of risk assessment. For example, for a given structure and ground-motion, the vulnerability is generally defined, for insurance purposes, as the ratio between the expected loss and the maximum possible loss, sometimes alternatively defined as the ratio of repair cost to the total insured value [1].

Moreover, it is now widely recognized that earthquakes may cause extensive damage not only to load bearing elements in a structure but also to non-structural components, *e.g.* architectural elements, mechanical and electrical equipment, a.s.o. These non-structural components could collapse or be extensively damaged even when the building that houses them performs relatively well. The failure of non-structural components during an earthquake may result in injuries and/or fatalities, hinder rescue operations and produce significant economic losses due to operational failures. Even though keeping the structural integrity during and after the earthquakes has been the primary goal of researchers during the last four decades, significant efforts have been made to understand the behaviour and quantify the seismic response of non-structural components attached to buildings [2].

Another issue that civil engineers have to address is the fact that most of the existing structures have been designed and builted *prior* to the introduction of modern seismic codes. Such buildings have nonconforming design details and often lack the strength and the ductility to withstand major earthquakes [3],…,[6]. Retrofitting all of these buildings is not economically feasible due to the very high costs involved. O t a n i [7] presented damage statistics of RC buildings in four major earthquakes: 1985 – Mexico; 1990 – Luzon (Philippines); 1992 – Erzincan (Turkey); and 1995 – Hyogo-ken Nanbu (Japan). Despite observations of severe damage to RC buildings during these events, the statistics showed that the probability of structural collapse in older-type concrete buildings was relatively low (1.9…6.6%) even in such damaging earthquake events. A plausible conclusion is that if resources can be focused on buildings that are most vulnerable to collapse and inexpensive retrofitting methods are provided accordingly, then seismic risk and fatalities can be significantly reduced at affordable costs.

2. Experimental Investigation Procedures and Research Methodologies

2.1. Shaking Table Tests on Superstructures

Shaking table tests have the advantage of well controlled large amplitude, multi-axis input motions and easier experimental measurements. Their use is justified if the purpose of the test was to validate the numerical model or to understand the basic failure mechanisms of either a structure or a structural element.

The plethora of research works related to shaking table tests range from tests on structural members only [8],…,[10] to full scale tests on structures [11]. Based on the tests from the structural members it was concluded that the design codes for anti-seismic design produce reasonably close estimates of the result in terms of strength but are very conservative when it comes to displacement [10]. The full scale tests on structures helped researchers to validate different strengthening techniques. It was concluded that the increase in the base-shear capacity led to a more brittle failure in diagonal tension. The recommendations included the use of additional horizontal shear reinforcement for piers in conjunction with vertical unbonded post-tensioning procedures.

Since the latter tests [11] are too expensive and require performant equipment (Fig. 1), and the first type of tests [8],…,[10] do not always yield the best results when it comes to the behaviour of an element in a structure subjected to earthquake excitation, tests on small scale or reduced scale models became more and more popular [12],…,[14] (Figs. 2 and 3).

Fig. 1 – E-Defence full-scale shaking table testing facility in Japan (Photo courtesy of Keizo O h t o m o, Ph.D. [15]).

The research works on the seismic behaviour of reinforced masonry structures [13] are conducted within a European research program aimed at improving the reinforced masonry construction techniques. Laboratory tests are conducted on building materials, structural components and even on scaled models of structures. The results obtained so far are encouraging in terms of increased stiffness of the buildings which are now able to withstand medium earthquake shocks without exhibiting significant damages.

Other investigations on the seismic behaviour of reinforced concrete structures were conducted in laboratories all over the world in order to validate

Fig. 2. – Pseudo-Dynamic testing facility at Joint Research Center
(Photo courtesy of Francisco J. M o l i n a, Ph.D. [16]).

Fig. 3. – Scale model of the LG Beijing tower, shaking table test facility at Tongji University, China (Photo courtesy of Wensheng L u, Ph.D. [17]).

the experimental procedures [14]. The recorded data showed that the damage patterns of reinforced concrete buildings observed in past earthquakes can be reproduced, to a certain degree of reliability, in the laboratories.

Based on the research conducted so far, it can be concluded that the shaking table test results are affected by the size of the specimen, by the similitude design [14], input and excitation control and the precision of the data acquisition system.

Moreover, the results obtained by shaking table tests are used to improve the analytical models [10], [18],…,[20] and provisions included in the design codes.

2.2. Shaking Table Tests on Soils and Substructures

Developments in earthquake geotechnical engineering, including understanding the ground behaviour during seismic shaking, effects of the earthquake on the geotechnical facilities, thorough studies on the site amplification, have also shown tremendous progress [21]. Studies on the behaviour of the soil under seismic excitations could be broadly classified into the following three major categories depending on the applied methodology: a) carrying out model tests to capture the rise in the pore water pressure, ground amplification, a.s.o.; b) development and use of analytical/numerical tools to simulate the ground behaviour and c) the application of the above mentioned concepts to field problems in order to check their validity.

The model tests can be divided into two categories, namely, those performed under gravitational field of earth, generally known as *shaking table tests* [21], [22] and those performed under higher gravitational field such as *centrifuge tests* [23].

Shaking table research has provided valuable insight with respect to liquefaction, post-earthquake settlement, foundation response and lateral earth pressure problems. Extensive research works have been carried out in order to study and understand the failure mechanisms and the behavior of earth structure under seismic excitations using shaking table tests [22], [24], [25]. Despite the advances in shaking table experimental procedures, many researchers reiterate the use of torsional simple tests and *in situ* soil investigations as complementary studies in order to understand and develop the lateral flow mechanism on soil liquefaction during seismic excitations.

These suggestions are closely related to the modern trends in geotechnical earthquake engineering which recognizes the strong influence of the local site effects on the intensity and on the frequency content of the input motions on structures [26]. Consequently, the seismic site response has been studied extensively during the past decade. It has been already established that, from an experimental point of view, centrifuge modeling is quite effective in evaluating the site response of soft soils [27]. The key advantage of centrifuge modeling consists in the fact that during a physical parameter study it allows for the effects of strata thickness, soil properties, earthquake frequency content and the level of shaking to be clearly observed [28].

2.3. Shaking Table Tests on Rehabilitated Structures

The seismic rehabilitation of a damaged structure aims at ensuring an adequate behaviour and response of the respective structure to any future earthquakes. The seismic performance of various structural elements has been extensively studied [29],…,[31] and the findings helped improving the seismic design standards and specifications [18].

During recent years, several studies related to the dynamic behaviour of rehabilitated structures under seismic excitation have been conducted using shaking table tests [10], [14]. New procedures of strengthening the damaged structures were proposed and then validated using shaking table tests [32].

The effectiveness of newly developed strengthening techniques was rendered evident during a series of recent shaking table tests conducted at the ELSA Laboratory of the Joint Research Centre of the European Commission [33]. The tests were conducted both on undamaged concrete structures as well as on retrofitted reinforced concrete structures using glass fibre reinforced polymers. The strengthening using the new composite materials was applied to the concrete structures that exhibited different extents of damages after the first series of shaking table tests. After the data processing it was concluded that the retrofitted structures behaved in a similar way, if not better in certain cases, to the initial undamaged RC structures [33], [34]. The laboratory work showed that the use of composites could represent a sound alternative to traditional methods, as it allows improving considerably the seismic performance of an existing RC structure by increasing its deformation capacity without significantly affecting its stiffness. Consequently, the seismic retrofit design is mainly governed by the displacement demand.

3. Numerical Simulations and Computer Models

Computer modelling and numerical simulations play an important role in the design process of modern structures. The numerical simulation is a powerful tool especially when the analytical solutions are very complex or can not be found by elementary means.

The nonlinear behaviour of structural materials and even structures can expressed in terms of differential equations. A numerical simulation is the process by which the differential equations are numerically solved. Furthermore, the numerical formulation of the differential equations forms the computer model, which contains all the premises or the characteristics that govern the behaviour of the computer simulation.

Modern building materials require new constitutive laws or models in order to be used in numerical simulations. Such constitutive laws are also known as material behaviour laws and are, more often than not, expressed in the form of stress–strain curves [35]. Researchers have to walk a thin line when in-comes to numerical modelling: a too complex model may yield very good results but it may require a lot of computer time to reach them while a simpler model may save computer time but yield only adequate results. All constitutive laws should be confirmed and validated through experimental works. For example, K o n s t a n t i n i d i s *et al.* [35] conducted many experimental investigations including monotonic, repeated and reversed cyclic loadings before they were confident that the proposed model provides a good fit to a wide range of experimental envelope curves and hysteresis loops.

Once the constitutive laws were proven to be correct they are further embedded in F.E. computer programs. Such programs are used by the researchers to study the behaviour of structures under different types of loadings [36],…,[38]. Because of the thorough investigations in the nonlinear material behaviour, the today F.E. software packages can provide accurate results compared to the experimentally obtained ones [36].

The continuous improvements in numerical simulations techniques lead to an increased confidence of the researchers in such powerful tools of analysis [38]. Consequently, new improved models have been developed for use in the practical applications for building evaluation and design verification [39]. Such models, even though under verification and validation, have shown promising results in assessing the nonlinear behaviour of structures, especially RC buildings, to seismic excitations. Despite the novelty such numerical simulations bring to the field of civil engineering, the already existing models have proven to be able to accurately predict the results obtained through classic or innovative experimental techniques. Moreover, the computer models help in improving the design codes [40] to assure better predictions using nonlinear dynamic analyses.

4. Modern Tendencies in Earthquake Engineering Research

Every disaster leaves critical clues in its wake not only of its cause but also how to protect lives in future emergencies. The information gained from these disasters, coupled with the knowledge obtained from numerous seismic tests, has help civil engineers to design better structures.

Until recently, seismic engineering research all over the globe suffered from tremendous fragmentation of research infrastructures, access and sharing of the results between researchers. In a world where information and knowledge are the backbone of every decision making, new strategies emerged to connect the research laboratories in the field of earthquake engineering.

Currently, such strategies are already implemented in the form of NIED (National Research Institute for Earth Science and Disaster Prevention) in Japan, NEES (Network for Earthquake Engineering Simulation) and PEER (Pacific Earthquake Engineering Research Centre) in the U.S.

In Europe, two major research project are undergoing: E-FAST (Design Study of an European Facility for Advanced Seismic Testing) and SERIES (Seismic Engineering Research Infrastructures for European Synergies) with the purpose of creating an advanced large scale testing facility interconnected with the already existing research laboratories in the filed of earthquake engineering.

Even though having a large scale testing facility helps running full-scale seismic tests on structures, the costs and the complexity of the recorded data related to such experiments are overwhelming. Therefore, new distributed testing methods with state of the art control, data acquisition and communication systems are desired to be implemented [41].

The main goal of all these projects (Fig. 4) is to bring together universities, research laboratories, industry partners and local or governmental authorities in unifying their efforts for designing newer, better and safer structures.

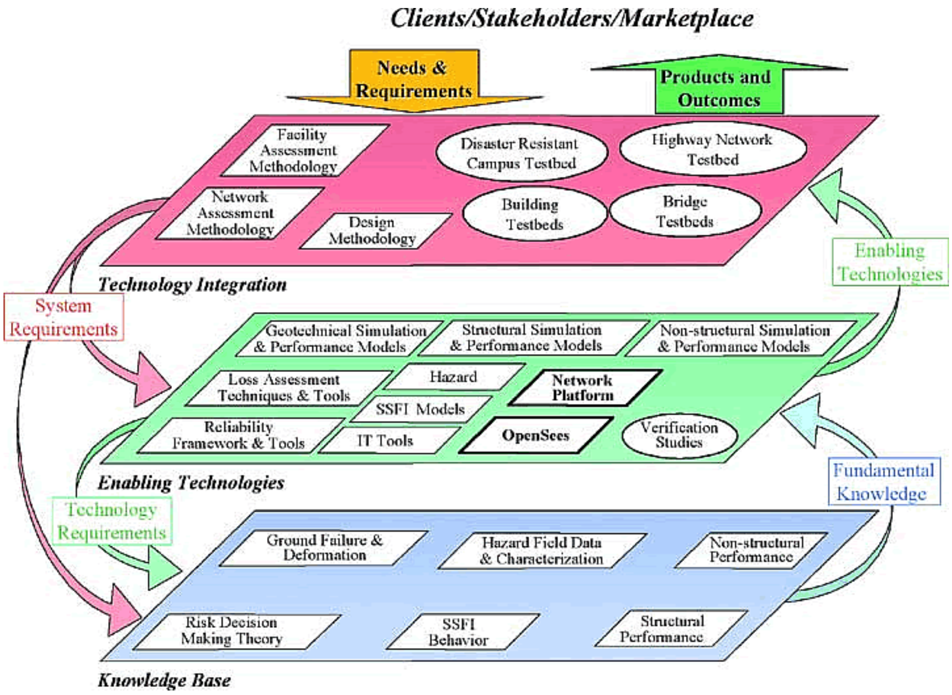

Fig. 4 – Levels of decision-making , served by enhanced technologies for performance-based earthquake engineering research (picture available at http://peer.berkeley.edu/about/mission_goals.html , May 1st, 2010).

5. Conclusions

The present paper presents the recent advances in experimental procedures in the field of earthquake engineering research. This resulted in an increased demand for higher structural safety against earthquakes. The scientific community intensified the efforts to better understand the way different types of structures behave under seismic excitation. Their main objectives are to increase structural safety and mitigate the risk of structures being damaged beyond repair or collapse during earthquakes.

Shaking table tests have the advantage of well controlled large amplitude, multi-axis input motions and easier experimental measurements. Their use is justified if the purpose of the test was to validate the numerical model or to understand the basic failure mechanisms of either a structure or a structural element. Based on the research conducted so far, it can be concluded that the shaking table test results are affected by the size of the specimen, by the similitude design, input and excitation control and the precision of the data acquisition system.

Shaking table research provides valuable insight into liquefaction, post-earthquake settlement, foundation response and lateral earth pressure problems. Hence, they are closely related to the modern trends in geotechnical earthquake engineering which recognize the strong influence of the local site effects on the intensity and on the frequency content of the input motions on structures.

Computer modelling and numerical simulations play an important role in the design process of modern structures. The continuous improvements in numerical simulations techniques lead to an increased confidence of the researchers in such powerful tools of analysis. Consequently, new improved models are developed for use in the practical applications for building evaluation and design verification.

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R E F E R E N C E S

1. Spence R., So E., Jenny S., Castella H., Ewald M., Booth E., *The Global Earthquake Vulnerability Estimation System (GEVES): An Approach for Earthquake Risk Assessment for Insurance Applications*. Bull. of Earthquake Engng., *6*, 463-483 (2008).
2. Chaudhuri S.R., Villaverde P.E., *Effect of Building Non-Linearity on Seismic Response of Non-Structural Components: A Parametric Study*. ASCE J. of Struct. Engng., **134**, *4*, 661-670 (2008).
3. Bracci J.M., Kunnath S.K., Reinhorn A.M., *Seismic Performance and Retrofit Evaluation of Reinforced Concrete Structures*. ASCE J. of Struct. Engng., **123**, *1*, 3-10 (1997).

4. Abrams D., Smith T., Lynch J., Franklin S., *Effectiveness of Rehabilitation on Seismic Behaviour of Masonry Piers*. ASCE J. of Struct. Engng., **133**, *1*, 32-43 (2007).
5. Villaverde R., *Methods to Assess the Seismic Collapse Capacity of Building Structures: State of the Art*. ASCE J. of Struct. Engng., **133**, *1*, 57-66 (2007).
6. Kim T., Stojadinovic B., Whittaker A.S., *Seismic Performance of Pre-Northridge Welded Steel Moment Connections to Built-up Box Columns*. ASCE J. of Struct. Engng., **134**, *2*, 289-299 (2008).
7. Otani S., *RC Building Damage Statistics and SDF Response with Design Seismic Forces*. Earthquake Spectra, **15**, *3*, 485-501 (1999).
8. Wight G.D., Kowalsky M.J., Ingham J.M., *Shake Table Testing of Post-Tensioned Concrete Masonry Walls with Openings*. ASCE J. of Struct. Engng., **133**, *11*, 1551-1559 (2007).
9. Wang J.-C., Ou Y.-C., Chang K.-C., Lee G.C., *Large Scale Seismic Tests of Tall Concrete Bridge Columns with Precast Segmental Construction*. Earthquake Engng. a. Struct. Dyn., **37**, 1449-1465 (2008).
10. Wu K.I., Kuo W.-W., Yang Y.-S., Hwang S.-J., Elwood K. J., Loh C.-H., Moehle J.P., *Collapse of a Non-Ductile Concrete Frame: Shaking Table Tests*, Earthquake Engng. a. Struct. Dyn., **38**, 205-224 (2009).
11. Moon F.L., Yi T., Leon R.T., Kahn L.F., *Testing of a Full Scale Unreinforced Masonry Building Following Seismic Strengthening*, ASCE J. of Struct. Engng., **133**, *9*, 1215-1226 (2007).
12. Benedetti D., Carydis P.G., Pezzoli P., *Shaking Table Tests on 24 Simple Masonry Buildings*. Earthquake Engng. a. Struct. Dyn., **27**, 67-90 (1998).
13. Zonta D., Zanardo G., Modena C., *Experimental Evaluation of the Ductility of a Reduced-Scale Reinforced Masonry Building*. Mater. a. Struct., **34**, 636-644 (2001).
14. Xianguo Y., Jiaru Q., Kangning L., *Shaking Table Test and Dynamic Response Prediction on an Earthquake Damaged RC Building*. Earthquake Engng. a. Engng. Vibr., **3**, *2*, 205-214 (2004).
15. Ohtomo K., *Questions Raised in Operating a Very Large Shaking Table*. 1st EFAST Internat. Workshop, Ispra, Italy, March 2009.
16. Molina F. J., *ELSA Laboratory and its Implementation of the PsD Method*. 1st EFAST Internat. Workshop, Ispra, Italy, March 2009.
17. Lu W., Fhang Z., Lu X., *Design and Construction Issues of Shaking Table Array*. 1st EFAST Internat. Workshop, Ispra, Italy, March 2009.
18. * * * *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*. FEMA Publication No. *356*, prepared by the American Society of Civil Engineers for the Federal Emergency Management Agency, Washington, DC, 2000.
19. * * * *Seismic Rehabilitation of Existing Buildings*. Amer. Soc. of Civil Eng., ASCE/SEI 41-06, Reston, VA, USA, 2007.
20. Elwood K.J., Matamoros A.B., Wallace J.W., Lehman D.E., Heintz J.A., Mitchell A.D., Moore M.A., Valley M.T., Lowes L.N., Comartin C.D., Moehle J. P., *Update to ASCE/SEI 41 Concrete Provisions*. Earthquake Spectra, **23**, *3*, 493-523 (2007).
21. Prassad S.K., Towhata I., Chandradhara G.P., Nanjundaswamy P., *Shaking Table Tests in Earthquake Geotechnical Engineering*. Current Sci. Spec. Section: Geotechn. a. Earthquake Hazards, **87**, *10*, 1398-1404 (2004).

22. Koga Y., Matsuo O., *Shaking Table Tests of Embankments Resting on Liquefiable Sandy Ground*. Soil Found., **30**, 162-174 (1990).
23. Hushmand B., Scott R.F., Crouse C.B., *Centrifuge Liquefaction Tests in a Laminar Box*. Geotechnique, **38**, 253-262 (1988).
24. Kokusho T., *Current State of Research on Flow Failure Considering Void Redistribution in Liquefied Deposits*. Soil Dyn. a. Earthquake Engng., **23**, 585-603 (2003).
25. Orense R.P., Morimoto I., Yamamoto Y., Yumiyama T., Yamamoto H., Sugawara K., *Study on Wall-Type Gravel Drains as Liquefaction Counter Measure for Underground Structures*. Soil Dyn. a. Earthquake Engng., **23**, 19-39 (2003).
26. Rayhani M.H.T.. El Nagar M.H., *Centrifuge Modelling of Seismic Response of Layered Soft Clay*. Bull. of Earthquake Engng., **5**, 571-589 (2007).
27. Elgamal A., Yang Z., Lai T., Kutter B., Wilson D.W., *Dynamic Response of Saturated Dense Sand in Laminated Centrifuge Container*. ASCE J. of Geotechn. a. Geo-Environm. Engng., **131**, *5*, 598-609 (2005).
28. Brennan A.J., Thusyanthan N.I., Madabhushi S.P.J., *Evaluation of the Shear Modulus and Damping in Dynamic Centrifuge Tests*. ASCE J. of Geotechn. a. Geo-Environm. Engng., **131**, *12*, 1488-1497 (2005).
29. Franklin S., Lynch J., Abrams D.P., *Performance of Rehabilitated URM Shear Walls: Flexural Behavior of Piers*. Mid-America Earthquake Res. Center Report, Univ. of Illinois, Urbana, U.S.A., 2003.
30. Abrams D., Smith T., Lynch J., Franklin S., *Effectiveness of Rehabilitation of Seismic Behavior of Masonry Piers*. ASCE J. of Struct. Engng., **133**, *1*, 32-43 (2007).
31. Zhu L., Elwood K.J., Haukaas T., *Classification and Seismic Safety Evaluation of Existing Reinforced Concrete Columns*. ASCE J. of Struct. Engng., **133**, *9*, 1316-1330 (2007).
32. Rai D.C., Goel S.C., *Seismic Strengthening of Rocking-Critical Masonry Piers*. ASCE J. of Struct. Engng., **133**, *10*, 1445-1452 (2007).
33. Di Ludovico M., Manfredi G., Mola E., Negro P., Prota A., *Seismic Behavior of a Full Scale RC Structure Retrofitted Using GFRP Laminates*. ASCE J. of Struct. Engng., **134**, *5*, 810-821 (2008).
34. Mola E., Negro P., *Full Scale PsD Testing of the Torsionally Unbalanced SPEAR Structure in the "As-Built" and Retrofitted Configurations*. Proc. of SPEAR (Seismic Perform. Assess. a. Rehabil.) Internat. Workshop, Ispra, Italy, 2005.
35. Konstantinidis D.K., Kappos A.J., Izzuddin A., *Analytical Stress–Strain Model for High-Strength Concrete Members under Cyclic Loading*. ASCE J. of Struct. Engng., **133**, *4*, 484-494 (2007).
36. Paolucci R., Shirato M., Tolga Yilmaz M., *Seismic Behaviour of Shallow Foundations: Shaking Table Experiments vs. Numerical Modeling*. Earthquake Engng. a. Struct. Dyn., **37**, 577-595 (2007).
37. Lu X., Zhou Y., Yan F., *Shaking Table Test and Numerical Analysis of RC Frames with Viscous Wall Dampers*. ASCE J. of Struct. Engng., **134**, *1*, 64-76 (2008).
38. Grange S., Kotronis P., Mazars J., *Numerical Modeling of the Seismic Behaviour of a 7-Story Building: NEES Benchmark*. RILEM Mater. a. Struct., DOI 10.1317/s11527-008-9462-y, 2008.
39. Poursha M., Khoshnoudian F., Moghadam A.S., *A Consecutive Modal Pushover Procedure for Estimating the Seismic Demands of Tall Buildings*. Engng. Struct., **31**, 591-599 (2009).

40. Yavari S., Elwood K.J., Wu C.L., *Collapse of a Non-Ductile Concrete Frame: Evaluation of Analytical Models*, Earthquake Engng. a. Struct. Dyn., **38**, 225-241 (2009).
41. Reinhorn A.M., *Issues in Hybrid Simulations of Dynamic Systems: Combined Physical and Computational Simulations Using Shake Tables and Auxiliary Reactive Systems*. 1st EFAST Internat. Workshop, Ispra, Italy, March 2009.

TENDINȚE MODERNE ÎN CERCETAREA EXPERIMENTALĂ DIN DOMENIUL INGINERIEI SEISMICE

(Rezumat)

Se prezintă noi tendințe avansate în cercetarea experimentală din domeniul ingineriei seismice. Distrugerile importante provocate de cutremurele de pământ din ultima decadă au dus la o creştere graduală a îngrijorării populației față de aceste dezastre naturale. Comunitatea oamenilor de ştiință şi-a intensificate eforturile în a înțelege modul cum diferite tipuri de structuri se comportă la acțiuni dinamice pentru a creşte gradul de siguranță al acestora. Testele experimentale folosind platforme seismice au avantajul unui control foarte bun aupra experimentului chiar şi în cazul deplasărilor foarte mari, a solicitării multi-direcționale a modelelor precum şi o mai mare uşurință în ceeea ce priveşte măsurarea şi înregistrarea datelor referitoare la parametrii de interes. Cu toate acestea, datorită costurilor semnificative pe care le presupune folosirea şi întreținerea acestor platforme seismice, folosirea lor se justifică prin prisma validării modelelor numerice şi a simulării utilizând programe avansate de element finit. De asemenea, se are în vedere şi progrsul semnificativ înregistrat în domeniul nou al ingineriei seismice geotehnice prin înțelegerea comportamentului terenului în timpul unei excitații seismice, efectul vibrațiilor asupra lucrărilor geotehnice şi nu în ultimul rând efectele locale de amplificare a undei seismice datorate profilului stratigrafic al terenului. Simulările numerice reprezintă şi ele unelte importante mai ales atunci când soluțiile analitice ale problemelor inginereşti au un grad mare de complexitate. Modelele dezvoltate în ultimii ani au facut posibilă simularea cu acuratețe a comportamentului structurilor în timpul acțiunilor dinamice, fapt dovedit şi prin numeroase teste experimentale de validare.