Shaking Table Testing of Civil Engineering Structure

Ankur Sharma[1], Bhupendra Sahu[2], Versha Sahu[3]

[1,2] *Students,* [3]*Assistant professor*
Civil Engineering Department RSR Rungta College of Engineering & Technology Bhilai (C.G)

Abstract– *Shaking tables are nowadays a valuable tool for the seismic behaviour assessment of civil engineering structures. The main purpose of this paper is to present some aspects of the recent experience obtained throughout the accomplishment of several series of tests (on different types of structures) which were achieved using the new LNEC 3D earthquake simulator. It should be mentioned that the tests results are not presented, as the emphasis is focussed on the main issues found in order to perform the tests as close as possible both to the nature occurrences and the structural behaviour. Some of the adopted solutions and procedures are described and eventual alternatives are discussed.*

Keyword – *Earthquake, Shaking table, Dynamic.*

I- INTRODUCTION

The use of shaking tables for the assessment of the dynamic and seismic behaviour of civil engineering structures is effective since the sixties. At the beginning, shaking tables had important limitations concerning the power available and they have been used to study the dynamic characteristics (natural frequencies and mode shapes) of small models behaving essentially in the linear range. Meanwhile, bigger and more powerful shaking tables have been put in operation allowing for the adoption of lower scaling factors and therefore involving very important dynamic forces. Nowadays a significant amount of research using shaking tables can be found in the literature. This research has been oriented mainly for the ultimate behavior of steel and rc building structures, structural elements (with a clear emphasis on rc and masonry wall rc frames with infills and dissipating device and global models of structures at smaller scales. Among the most paradigmatic example of the use of shaking tables are the two series of tests performed at the Tsukuba facility on 1:1 scaled models; the first one was performed in the framework of the US-Japan Cooperative Earthquake Research Program on a building model with 7 storey's; more recently (Minowa et al, 1996) two 3-storey building models have also been tested to failure. In what concerns shaking table tests on bridge structures and bridge piers, information is rather scarce and just a few results are found in literature. The tests performed at LNEC (Carvalho et al, 1978), at the University of California (Williams and Godden, 1976) and at ISMES facilities (Casirati et al, 1996) are among the few papers published on the subject. Those tests have been performed on models at 1:100 scale (LNEC), 1:30 (UC) and 1:8 (ISMES). In order to advance its experimental activity in engineering, which started in the late fifties, LNEC decided to study and build a new type of earthquake simulator mainly conceived for the testing of civil engineering structures, such as buildings and bridges, being, however, also useful for the validation of the dynamic behavior of some mechanical and electrical equipment. This very particular simulator has three independent translational degrees of freedom which are driven by hydraulic actuators, whereas its rotational degrees of freedom are minimize by torque tube system, one for each axis (roll, pitch and yaw). Under the horizontal cranks, either passive gas actuators, to cope with the dead weights of the shaking table and of the testing specimen, or rigid blocks, eliminating the vertical motion of the table, can be inserted.

II- LITERATURE REVIEW

Among the most paradigmatic examples of the use of shaking tables are the two series of tests performed at the Tsukuba facility on 1:1 scaled models; the first one was performed in the framework of the US-Japan Cooperative Earthquake Research Program on a building model with 7 storey's; more recently (Minowa et al, 1996) two 3-storey building models have also been tested to failure. In what concerns shaking table tests on bridge structures and bridge piers, information is rather scarce and just a few results are found in literature. The tests performed at LNEC (Carvalho et al, 1978), at the University of California (Williams and Godden, 1976) and at ISMES facilities (Casirati et al, 1996) are among the few papers published on the subject. Those tests have been performed on models at 1:100 scale (LNEC), 1:30 (UC) and 1:8 (ISMES). In order to advance its experimental activity in engineering, which started in the late fifties, LNEC decided to study and build a new type of earthquake simulator mainly conceived for the testing of civil engineering structures, such as buildings and bridges, being, however, also useful for the validation of the dynamic behavior of some mechanical and electrical equipment. This very particular simulator has three independent translational degrees of freedom which are driven by hydraulic actuators, whereas its rotational degrees of freedom are minimized by torque tube systems, one for each axis (roll, pitch and yaw). Under the horizontal cranks, either passive gas actuators, to cope with the dead weights of the shaking table and of the testing specimen, or rigid blocks, eliminate the vertical motion of the table.

III- ADVANTAGES

Best direct way to simulate earthquake ground motion effects.

More realistic consideration of dynamic effects

- Inertia force
- Damping force
- No need to attach loading device that may influence the structural performance

IV- CONLLUSION

In this paper some of the experience gained with the operation of the LNEC 3D Earthquake Simulator was reported. Some specific aspects were referred to, namely:

a) Test setups;

b) Signal acquisition and processing;

c) Establishment of test strategies

In what concerns test setups, some problems arising when high inertia forces are involved were discussed. The advantage of having the mass associated to that inertia forces located out of the simulator seems to be unquestionable from several points of view. Signal acquisition and processing is also an important issue and some examples of the care to be put in the signal processing and interpretation were highlighted. Finally, an analytical procedure, useful to define test strategies, was presented. That procedure allows the optimization of the testing sequence in tests performed by stages with increasing shaking intensities, thus producing the most profitable information to be obtained at the end of each stage.

REFERANCE

[1] *Bairrao, R.; Vaz, C. T.; Kacianauskas, R.; Kliukas, R. - Shaking Table Tests of Reinforced Concrete Columns under Horizontal and Vertical Loading, Proceedings of the 15th International Conference on Structural Mechanics in Reactor Technology (SMIRT), paper H04/3, 1999.*

[2] *Carvalho, E. C.; Ravara, A.; Duarte, R. T. – Seismic Studies for the International Guadiana Bridge, Proceedings of the 6th European Conference on Earthquake Engineering, 1978.*

[3] *Casirati, M.; Franchioni, G; Bousias, S. – Seismic Tests on Three Shaking Tables of a 1:8 Irregular Bridge Model in Support of Design Euro code 8, Paper no. 2047, Proceedings of the 11th World Conference on Earthquake Engineering, 1996.*

[4] *Duarte, R. T. – The Use of Analytical Methods in Structural Design for Earthquake Actions, in Experimental and Numerical Methods in Earthquake Engineering, Ed. J. Donea and P. M. Jones, Kluwer Academic Publishers, 1991;*

[5] *Duque, J.; Bairrao, R. – LNEC Experience and Strategies in Earthquake Simulation. Recent Developments, Paper 2624, accepted for presentation at the 12th World Conference on Earthquake Engineering, 2000.*

[6] *Emílio, F. T.; Duarte, R.T.; Carvalhal, F. J.; Costa, C. O.; Vaz, C. T.; Corrêa, M. R. – The New LNEC Shaking Table for Earthquake Resistance Testing, Memoire LNEC 757, 1989.*

[7] *Minowa, Chikahiro; Hayashida, Toshihiro; Abe, Isamu; Kida, Takeki; Okada, Tumeo – A Shaking Table Damage Test of Actual Size RC Frame, Paper no. 747, Proceedings of the 11th World Conference on Earthquake Engineering, 1996.*

[8] *Williams, D.; Godden, W. G. – Experimental Model Studies on the Seismic Response of High Curved Overcrossings, Report no. FHWA-RD-77-91, EERC, University of California, Berkeley, 1976.*