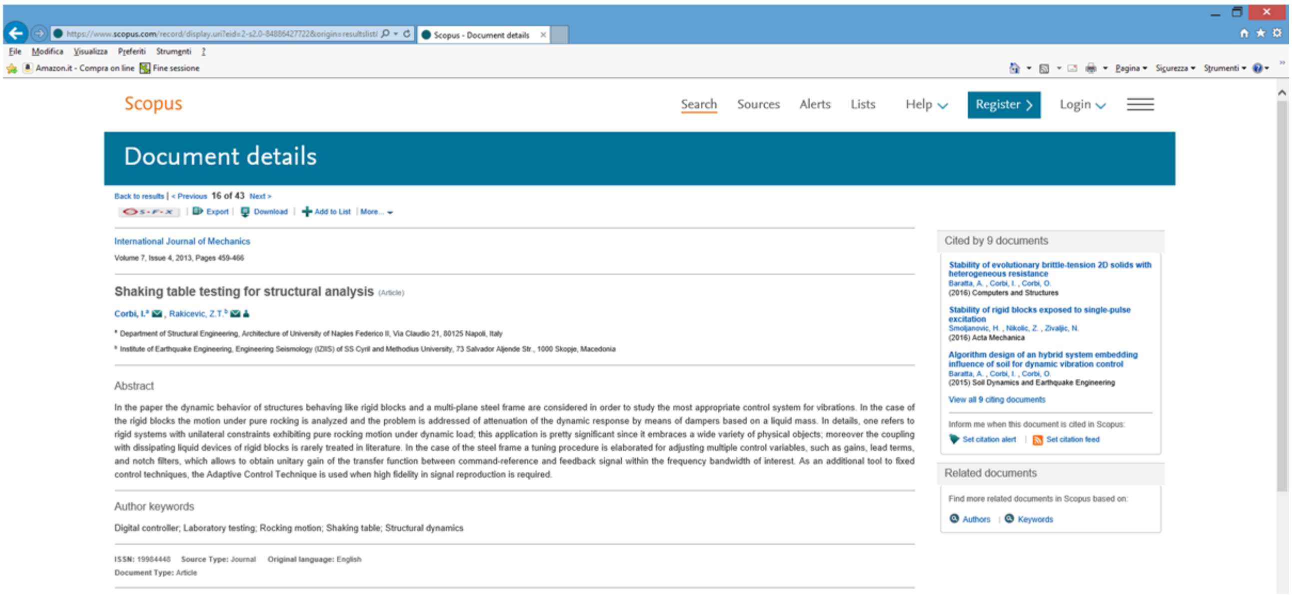

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Shaking table testing for structural analysis (Article)

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Abstract

In the paper the dynamic behavior of structures behaving like rigid blocks and a multi-plane steel frame are considered in order to study the most appropriate control system for vibrations. In the case of the rigid blocks the motion under pure rocking is analyzed and the problem is addressed of attenuation of the dynamic response by means of dampers based on a liquid mass. In details, one refers to rigid systems with unilateral constraints exhibiting pure rocking motion under dynamic load; this application is pretty significant since it embraces a wide variety of physical objects; moreover the coupling with dissipating liquid devices of rigid blocks is rarely treated in literature. In the case of the steel frame a tuning procedure is elaborated for adjusting multiple control variables, such as gains, lead terms, and notch filters, which allows to obtain unitary gain of the transfer function between command-reference and feedback signal within the frequency bandwidth of interest. As an additional tool to fixed control techniques, the Adaptive Control Technique is used when high fidelity in signal reproduction is required.

Author keywords

Digital controller; Laboratory testing; Rocking motion; Shaking table; Structural dynamics

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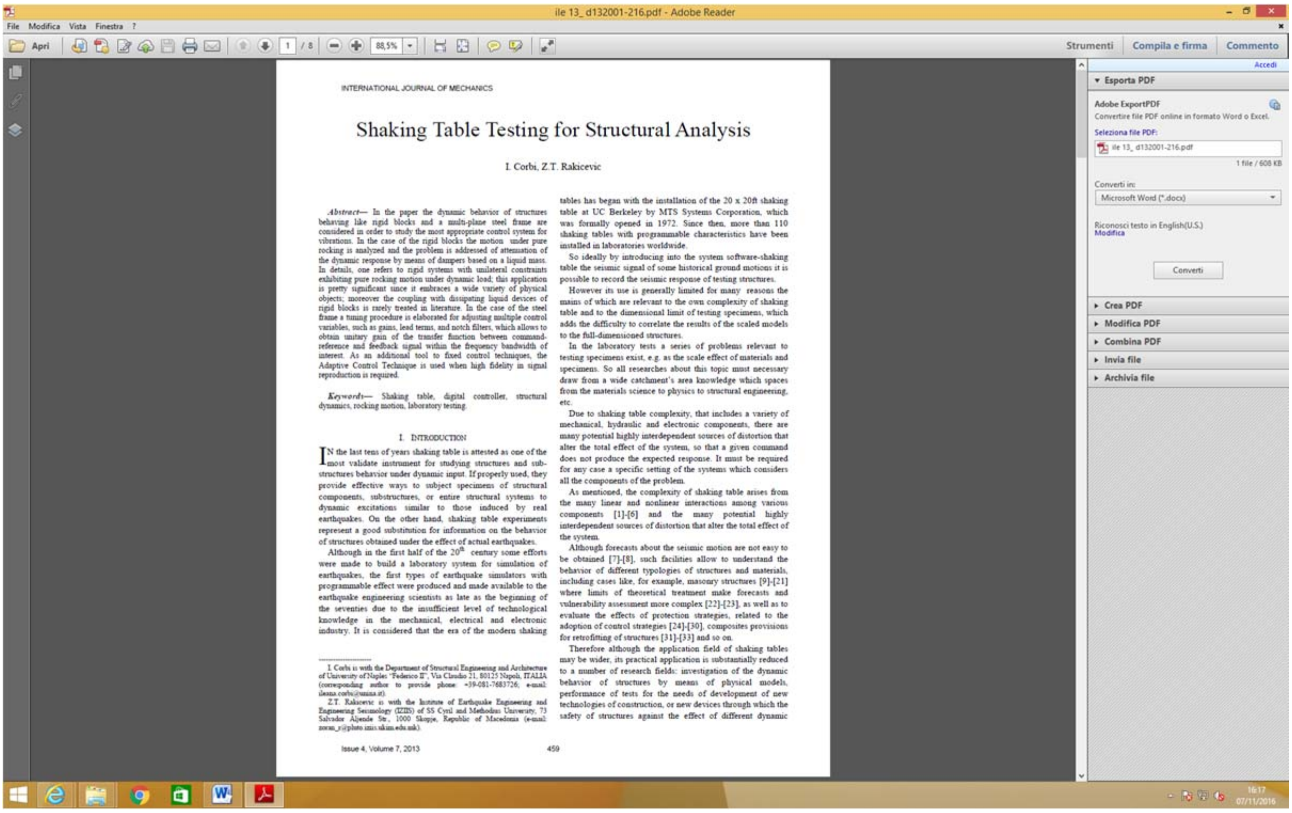

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Shaking Table Testing for Structural Analysis

I. Corbi, Z.T. Rakicevic

Abstract— In the paper the dynamic behavior of structures behaving like rigid blocks and a multi-plane steel frame are considered in order to study the most appropriate control system for vibrations. In the case of the rigid blocks the motion under pure rocking is analyzed and the problem is addressed of attenuation of the dynamic response by means of dampers based on a liquid mass. In details, one refers to rigid systems with unilateral constraints exhibiting pure rocking motion under dynamic load; this application is pretty significant since it embraces a wide variety of physical objects; moreover the coupling with dissipating liquid devices of rigid blocks is rarely treated in literature. In the case of the steel frame a tuning procedure is elaborated for adjusting multiple control variables, such as gains, lead terms, and notch filters, which allows to obtain unitary gain of the transfer function between command-reference and feedback signal within the frequency bandwidth of interest. As an additional tool to fixed control techniques, the Adaptive Control Technique is used when high fidelity in signal reproduction is required.

Keywords— Shaking table, digital controller, structural dynamics, rocking motion, laboratory testing.

I. INTRODUCTION

IN the last tens of years shaking table is attested as one of the most validate instrument for studying structures and sub-structures behavior under dynamic input. If properly used, they provide effective ways to subject specimens of structural components, substructures, or entire structural systems to dynamic excitations similar to those induced by real earthquakes. On the other hand, shaking table experiments represent a good substitution for information on the behavior of structures obtained under the effect of actual earthquakes.

Although in the first half of the 20th century some efforts were made to build a laboratory system for simulation of earthquakes, the first types of earthquake simulators with programmable effect were produced and made available to the earthquake engineering scientists as late as the beginning of the seventies due to the insufficient level of technological knowledge in the mechanical, electrical and electronic industry. It is considered that the era of the modern shaking tables has began with the installation of the 20 x 20ft shaking table at UC Berkeley by MTS Systems Corporation, which was formally opened in 1972. Since then, more than 110 shaking tables with programmable characteristics have been installed in laboratories worldwide.

So ideally by introducing into the system software-shaking table the seismic signal of some historical ground motions it is possible to record the seismic response of testing structures.

However its use is generally limited for many reasons the mains of which are relevant to the own complexity of shaking table and to the dimensional limit of testing specimens, which adds the difficulty to correlate the results of the scaled models to the full-dimensioned structures.

In the laboratory tests a series of problems relevant to testing specimens exist, e.g. as the scale effect of materials and specimens. So all researches about this topic must necessary draw from a wide catchment's area knowledge which spaces from the materials science to physics to structural engineering, etc.

Due to shaking table complexity, that includes a variety of mechanical, hydraulic and electronic components, there are many potential highly interdependent sources of distortion that alter the total effect of the system, so that a given command does not produce the expected response. It must be required for any case a specific setting of the systems which considers all the components of the problem.

As mentioned, the complexity of shaking table arises from the many linear and nonlinear interactions among various components [1]-[6] and the many potential highly interdependent sources of distortion that alter the total effect of the system.

Although forecasts about the seismic motion are not easy to be obtained [7]-[8], such facilities allow to understand the behavior of different typologies of structures and materials, including cases like, for example, masonry structures [9]-[21] where limits of theoretical treatment make forecasts and vulnerability assessment more complex [22]-[23], as well as to evaluate the effects of protection strategies, related to the adoption of control strategies [24]-[30], composites provisions for retrofitting of structures [31]-[33] and so on.

Therefore although the application field of shaking tables may be wider, its practical application is substantially reduced to a number of research fields: investigation of the dynamic behavior of structures by means of physical models, performance of tests for the needs of development of new technologies of construction, or new devices through which the safety of structures against the effect of different dynamic

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