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SHAKING TABLE TESTING ON SEISMIC POUNDING OF A RC BUILDING STRUCTURE

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Abstract. This paper describes unidirectional shaking table tests on seismic pounding of a 3-D RC building structure. Two inputs were considered: a seismic accelerogram and a harmonic wave. The tested specimen is a one-and-a-half-story 2/5 scaled portion of a RC building structure consisting of waffle slabs and columns. The instrumentation consisted of strain gauges, displacement transducers, acoustic emission receivers, accelerometers and video recording cameras. The experiments are simulated with SeismoStruct by using linear elements with concentrated plasticity; pounding is described with a concentrated Kelvin-Voigt model. The initial after-test observations showed some damage in the columns.

Key words: Shaking-Table Test; Seismic Pounding; RC Building Structure; Test Simulation.

1 INTRODUCTION

Impact between contiguous buildings under strong seismic events is a relevant issue since the huge forces that are generated during the collision significantly affect the dynamic behavior of the pounding buildings. On some occasions, the effect of impact might be beneficial, mainly in terms of inter-story drift; conversely, in many other situations, pounding is detrimental, particularly in terms of absolute acceleration. Collapses and structural and nonstructural damage of buildings due to seismic pounding have been reported. Although such collision can be avoided by adequately separating the involved buildings, and this gap is routinely required by the design codes, impact can anyway occur because of several reasons: sometimes code prescriptions are not fulfilled, some past codes did not oblige any such separation, and the seismicity can be underestimated. Therefore, seismic pounding of buildings is something to be taken into consideration.

Collision between adjoining buildings can be classified into two categories: slab-to-slab and slab-to-column (or slab-to-wall) impact; they correspond to aligned and unaligned slabs, respectively. The second type is by far more dangerous, since the impact of a rigid and massive slab on a column (or even on a wall) is most likely to lead to collapse. On the other hand, the first type is not free of danger, and is considerably more frequent, since adjoining buildings with unaligned slabs are regularly avoided. Moreover, the numerical simulation of slab-to-slab impact is highly challenging. Thus, this study focuses on seismic pounding of adjoining buildings with aligned slabs.

As outlined in the previous paragraph, collision between two building slabs is a complex phenomenon, because it involves stress traveling waves, high-frequency behavior, and significant local effects [1]. Although a number of pounding tests have been reported, they provide only limited information. Therefore, there is a strong need for additional testing. This research is oriented to fulfil this necessity.

2 EXPERIMENTS DESCRIPTION

This section describes the conducted tests. They consist in exciting the specimen in a single horizontal direction with a shaking table; as a result, the tested structure collides against a rigid steel structure.

Next four subsections deal with the laboratory, the RC structure, the sensors, and the shaking accelerograms, respectively.

2.1 Testing facility

The experiments were carried out on 26 January 2018 at the Structural Dynamics laboratory, University of Granada. These facilities are equipped with an uniaxial MTS shaking table; the table size is 3 m × 3 m.

2.2 Tested specimen

The tested specimen [2] corresponds to a portion of a RC building structure with waffle slabs; this structure is scaled with a factor 2/5. The structure was first designed to support only gravity loads; the live load is 2 kN/m^2 for the floors and 1 kN/m^2 for the roof. The characteristic value of the concrete compressive strength is f_{ck} = 25 MPa and steel yield point is f_{yk} =500 MPa. The waffle flat plates have a constant depth of 0.35 m, and the bottom part consists of a regular pattern of voids forming an orthogonal grid of 7 cm wide ribs separated 83 cm, and a solid zone around the columns. The cross section of the columns is 30 cm × 30 cm.

The tested portion consists of a rectangular fraction of the first floor slab (3.65 m × 3.02 m) together with three columns of the first floor (1.4 m high) and a segment (0.49 m high) of the second floor three ones. The aforementioned first story columns are clamped to the table, and the second story ones are hinged to a rigid steel external substructure. Steel blocks are attached at the top of the slab and at the top of half-columns of the second story to represent the gravity loads and to satisfy similitude requirements between prototype and test model. The weight of the test specimen (including the additional masses but excluding the foundation) was 109.1 kN. The slab pounded against a rigid steel buffer stop, being connected to a highly stiff steel structure; the initial separation (gap) was 20 mm.

Figure 1 displays an image and a sketch of the tested specimen.

2.3 Instrumentation

The test specimen was instrumented with strain gauges, displacement transducers (LVDTs and laser), acoustic emission receivers, accelerometers and video recording cameras. The strain gauges were connected to the longitudinal reinforcement bars of the slab and of the segments of the columns that are right under the slab. The displacement and acceleration transducers gaged the slab horizontal longitudinal motion. The acoustic sensors measured the concrete damage. Data were acquired continuously with a scan frequency of 200 Hz.

2.4 Seismic inputs

Two inputs were considered: (i) the SW

component of the Calitri record of the Irpinia earthquake (23 November 1980), and (ii) a harmonic wave with 1 Hz period. Both inputs were scaled with different factors to generate pounding, while limiting the damage on the specimen. Figure 2 displays the Calitri accelerogram.

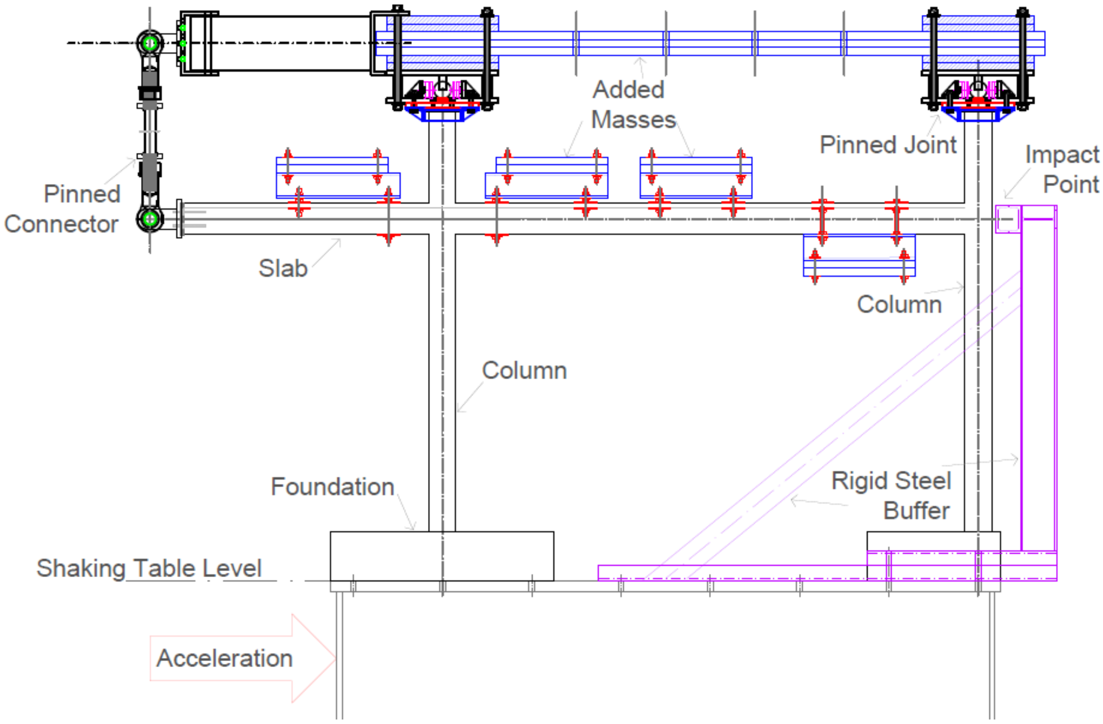


Figure 1: Tested RC building structure

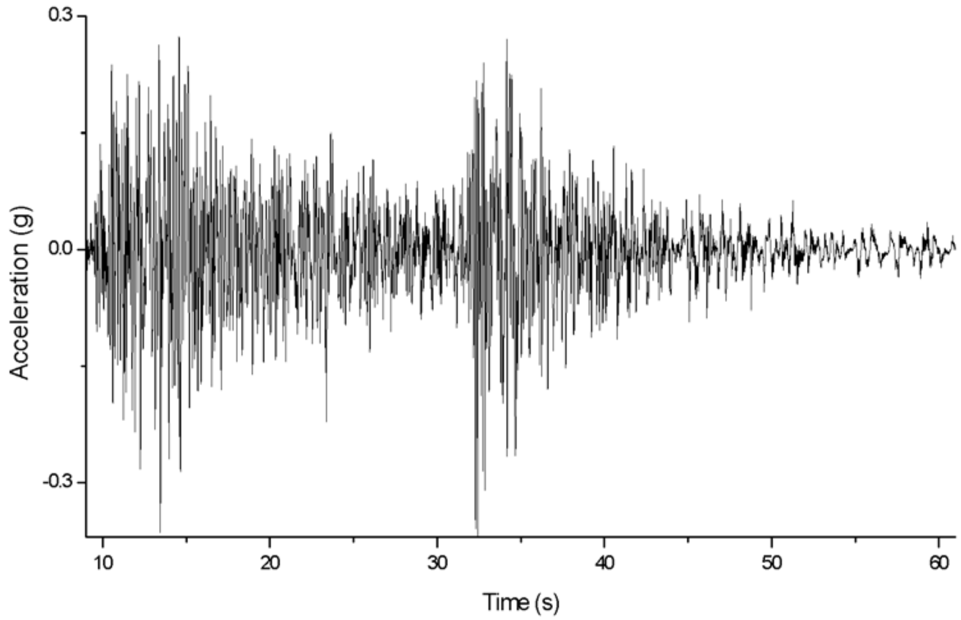
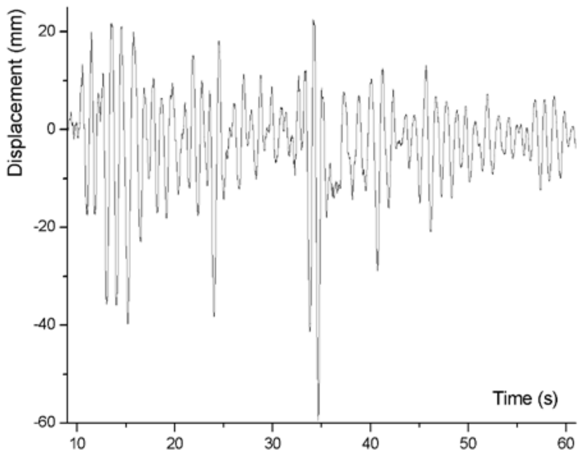
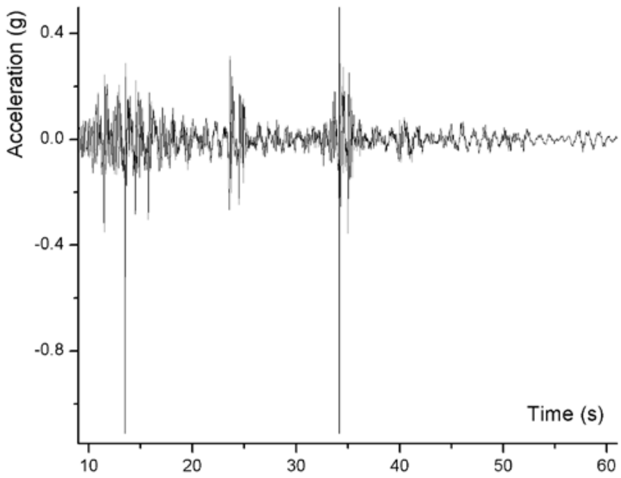


Figure 2: Scaled seismic accelerogram





(a) Displacement (b) Acceleration

Figure 3: Preliminary experimental results of the slab time-history

3 EXPERIMENTAL RESULTS

Figure 3 displays preliminary experimental results; Figures 3.a and 3.b correspond to the slab displacement and the acceleration, respectively. Noticeably, the huge peaks in the acceleration correspond to the impact instants.

4 NUMERICAL SIMULATION

The experiments are simulated with SeismoStruct [3] by using concentrated plasticity. Pounding is described with a Kelvin-Voigt model [4].

5 CONCLUSIONS

This paper describes seismic pounding tests on a laboratory RC building structure with waffle slabs. Experiments are simulated with SeismoStruct and pounding is described with a Kelvin-Voigt model. Initial after test observations showed damage in the columns.

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