DESIGN OF A SHAKING TABLE TEST FOR A REINFORCED CONCRETE FRAME STRUCTURE

by

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SYNOPSIS

This paper presents the design of a test for a two-story reinforced concrete structure to be subjected to progressively increasing simulated earthquake motions. The test is being conducted using a 20ft. square shaking table facility located at the Earthquake Simulator Laboratory at the University of California, Berkeley, and will provide information about the performance of the complete structure as well as the behavior of some critical sections under forces produced by ground accelerations transmitted to the foundation. The results of the shaking table test will be used in analytical investigations into the behavior of reinforced concrete structures subjected to ground motions strong enough to cause inelastic deformations.

INTRODUCTION

A series of tests on reinforced concrete structures is being planned for a 20ft. square shaking table located at the University of California, Berkeley, California. The objectives of the tests are to obtain information on the behavior of such structures vibrating at amplitudes large enough to cause inelastic deformations. The results of the tests will be used in complementary analytical studies. The design of the first of these tests is described below.

TEST STRUCTURE

The test structure was derived by considering a typical two-story office building with the dimensions shown in Fig. 1. A preliminary design of the building was made to meet the requirements of the 1970 Uniform Building Code and the ACI 318-71 Building Code. The building resists the lateral loads by a moment resisting action with typical shear and axial force conditions that will be present in a small building structure during an earthquake. Since the building is too large for the shaking table, a section of the building that includes two frames was considered (Fig. 1).

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The structure for the test is shown in Fig. 2 and was obtained by reducing the size of the original structure by 30%. The distance between the frames was made as short as possible without affecting the T-beam action in the floor diaphragm. The amount of reduction in the length dimensions was selected in order to retain the mechanical characteristics of the original structure while providing greater convenience and economy than a full scale test. As a result of this the test structure had 12ft. span in the main direction and 3ft. span in the transverse direction, both centerline to centerline dimensions. The clear height from floor to bottom of girder was 5ft. $7\frac{3}{4}$in. at both stories. Column sections were all $8\frac{1}{2}$in. x $5\frac{3}{4}$in. at both stories. The depth of the slab was $2\frac{7}{8}$in. The reinforcing steel is shown in Fig. 2. The vertical loads acting on the structure during the test were taken to be the total design dead load plus 25% of the design live load prescribed by the 1970 Uniform Building Code. Because of the extra reduction in the transverse span and the fact that the test structure did not have all the non-structural elements that contribute to the dead load, mass was added at each story to simulate the actual conditions of the original structure (20 kips at the first story and 12 kips at the second story).

Two types of analyses were performed to predict the structural response as well as to decide where to locate the instrumentation. Both of them considered an artificial earthquake having a maximum acceleration of $\frac{1}{3}$g and a duration of 9 seconds. An elastic analysis assuming uncracked sections gave a fundamental period of 0.21 seconds and indicated that ductility factors of 3.4 and 2.9 were required at the bottom and top of the first story columns, while the end sections of the first story girder required 2.5. An inelastic analysis based on a cracked section and elasto-plastic behavior showed three cycles of vibration during the first two seconds with incursions into the plastic range of behavior at the bottom of the first story columns and the ends of both first and second story girders.

INSTRUMENTATION

The instrumentation was designed to obtain some overall properties of the structure such as acceleration histories and story drifts as well as to record average curvatures at sections which would develop inelastic behavior. Accelerometers will be placed on the floor slabs and potentiometers that will measure absolute story displacements will be attached to a reference frame located off the shaking table. The distribution of the internal forces throughout the structure will be obtained by means of force transducers inserted at the column mid-heights. These transducers, each consisting of a narrow, 4in. long, steel I section, were designed to remain in the elastic range under the worst loading conditions. Strain gages applied to these transducers will permit the recording of the three internal forces acting at the mid-height of the columns. The average curvature at critical sections will be obtained by attaching aluminum frames at 4in. between centers along these sections and measuring the relative displacements between the frames with LVDT's. Finally, strain gages will be epoxied to all the reinforcing bars at the bottom section of the first story columns.

TEST PROCEDURES

The 20 foot square shaking table (1) located at the University of California, Berkeley, California will be used to subject the base of the test structure to the El Centro accelerogram and artificial earthquake motions. A mini-computer based data acquisition system (2) will record the signals from the various transducers installed on the structure, and the mini-computer will also be used for processing the data after the test has been completed.

REFERENCES

1. Rea, D. and Penzien, J., "Dynamic Performance of a 20ft x 20ft Shaking Table", Proc. 5WCEE, Rome, 1973.

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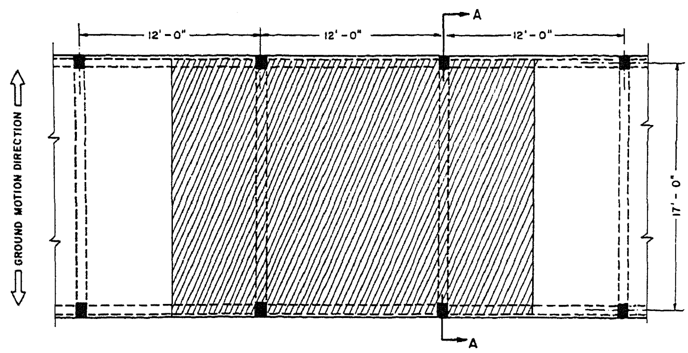
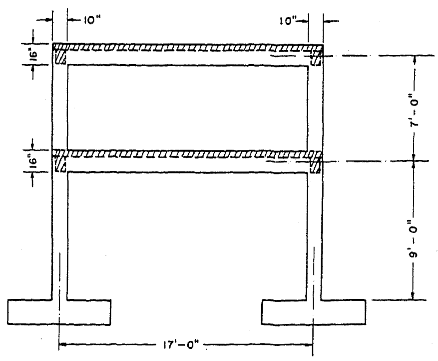


PLAN VIEW



SECTION A-A

FIG. I OFFICE BUILDING DIMENSIONS

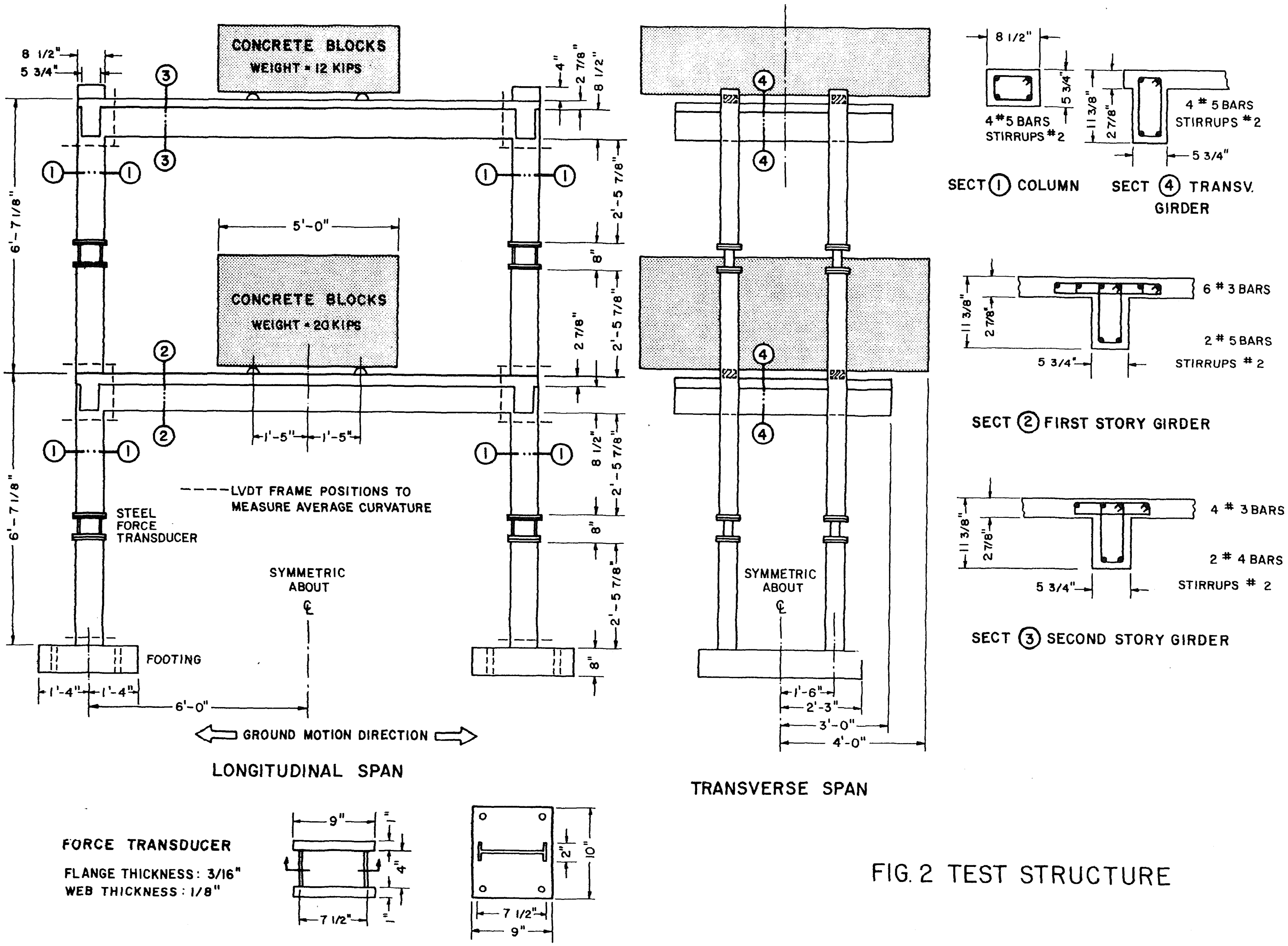


FIG. 2 TEST STRUCTURE