SECTION 3
MODEL FOR EARTHQUAKE SIMULATOR TESTING

3.1 One-story and Three-story Steel Structures

A series of 66 earthquake simulation tests were performed on a model structure (see Figure 3-1). The structure was a three-story 1:4 scale steel frame which modeled a shear building by the method of artificial mass simulation (Soong 1987). The model does not represent a similitude-scaled replica of a full-scale building. Rather, the test structure was designed as a small structural system. The model has been used in a number of previous earthquake simulation studies. The mass of each floor of the three-story model was 5.46 lb-sec^2/in (958 Kg) for a total mass of 16.38 lb-sec^2/in (2874 Kg). For some of the tests, the structure was modified by rigidly bracing the second and third stories so that the frame would act as a one-story structure. The one-story model had a total mass of 16.7 lb-sec^2/in (2930 Kg).

The model was bolted to the center of a concrete block which was in turn bolted to the shaking table in such a way that the main frames of the model were parallel to the motion of the table. Note that an out-of-plane diagonal bracing system exists perpendicular to the direction of excitation (see Figure 3-1). This out-of-plane bracing was in place during all tests and ensured that there was no motion perpendicular to the direction of table motion and thus the model was effectively reduced to a planar frame.

For the one-story structure, the dampers were placed at the first story and consisted of either two or four damping units (see Figure 3-2). For the three-story structure, the dampers were placed at the first story for the two and four damper cases and at all three stories for the six damper case (see Figure 3-3). The dampers were attached to the structure as shown schematically in Figure 3-4. A close-up view of a damper installed in the first story is shown in

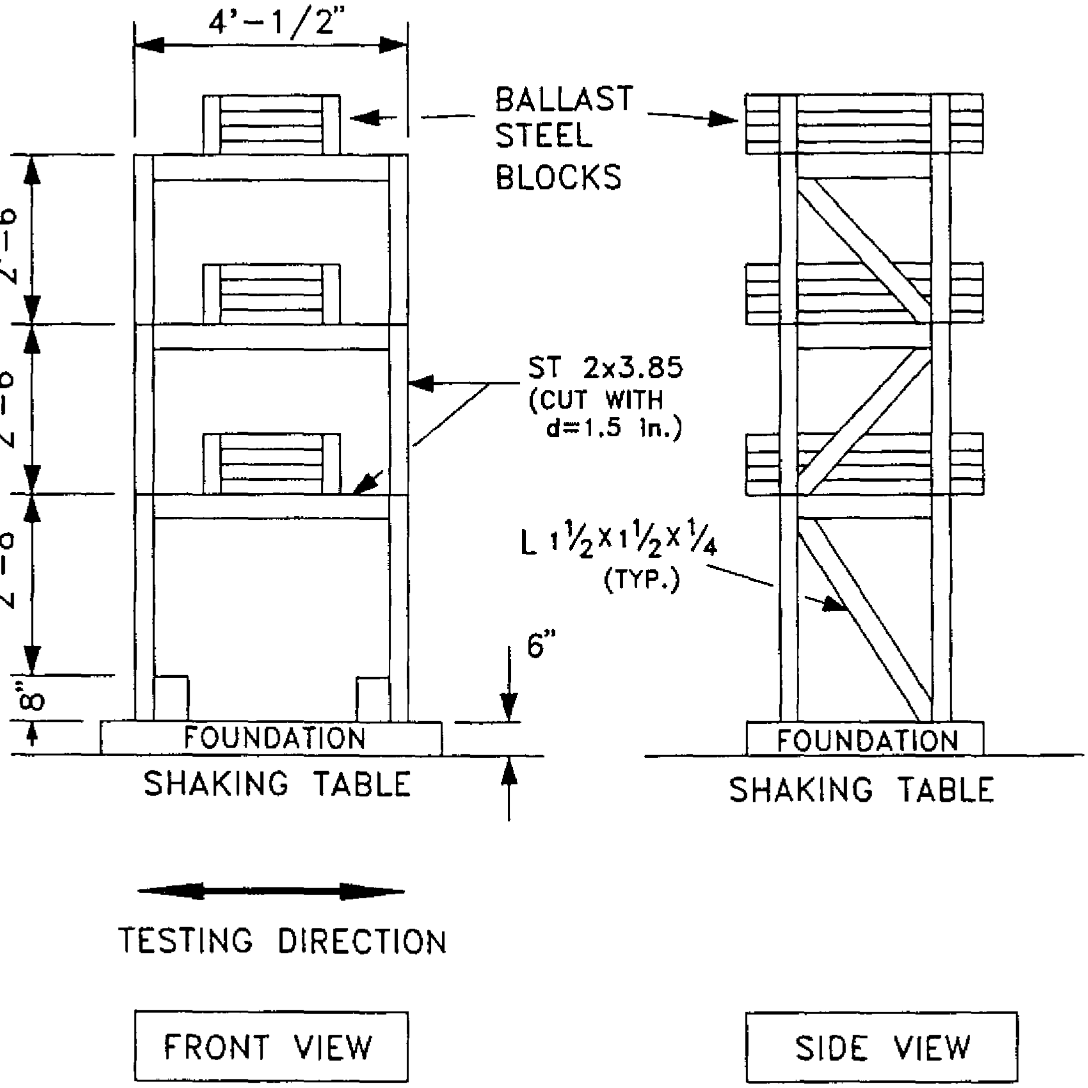

FIGURE 3-1 Schematic of Model Structure
(1 in. = 25.4 mm)

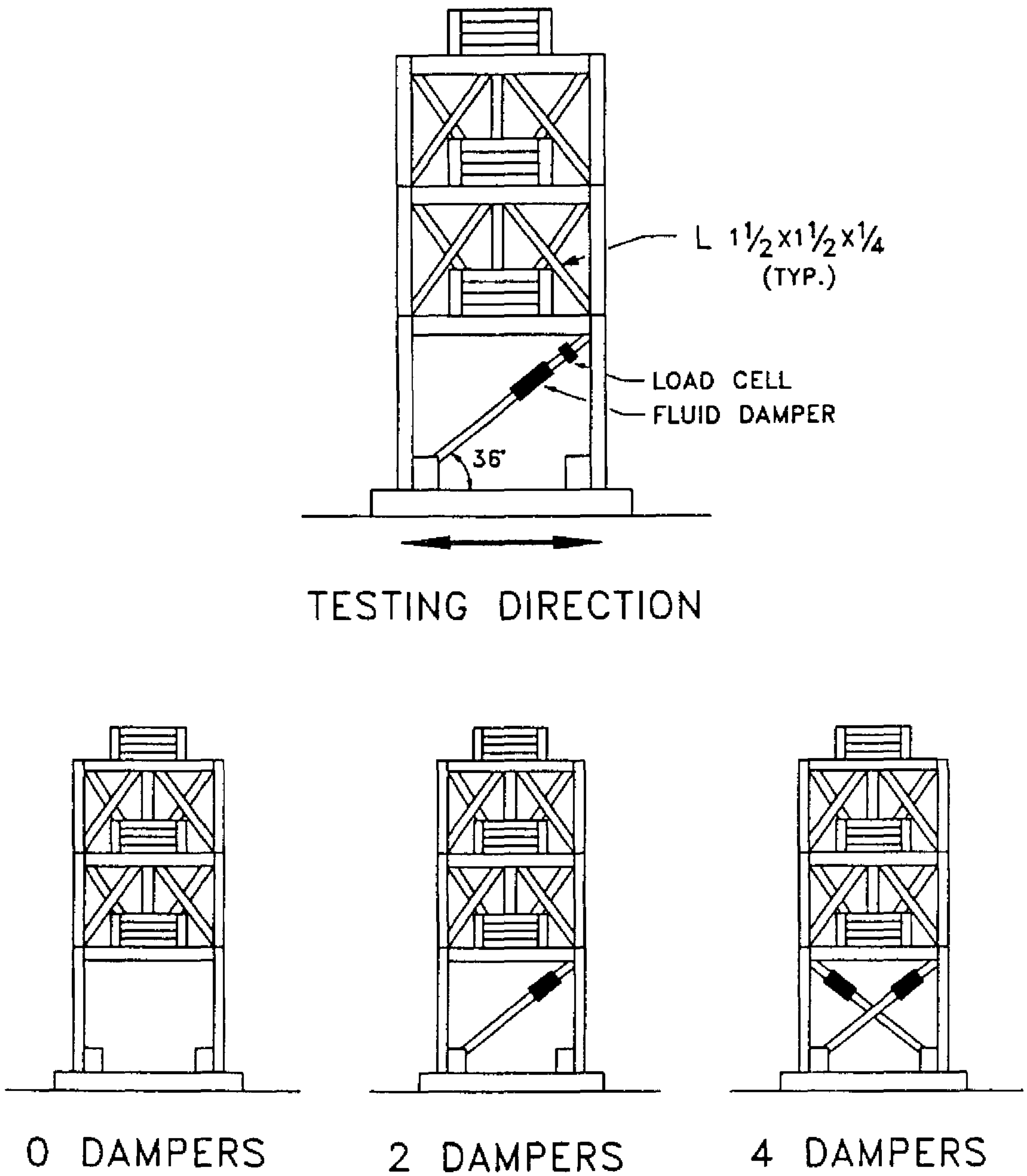

FIGURE 3-2 Damper Configurations for One-story Structure (1 in. = 25.4 mm)

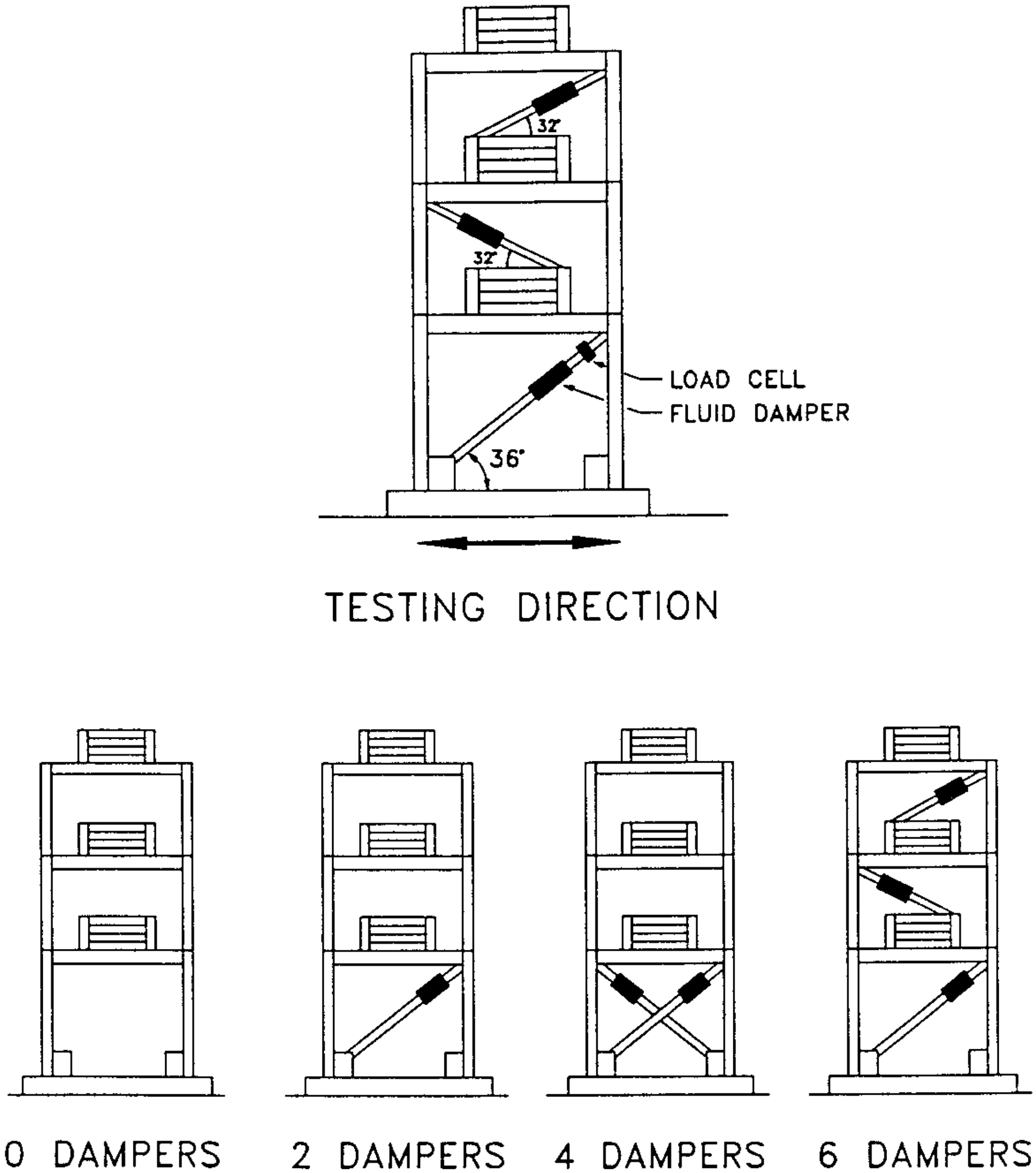

FIGURE 3-3 Damper Configurations for 3-story Structure

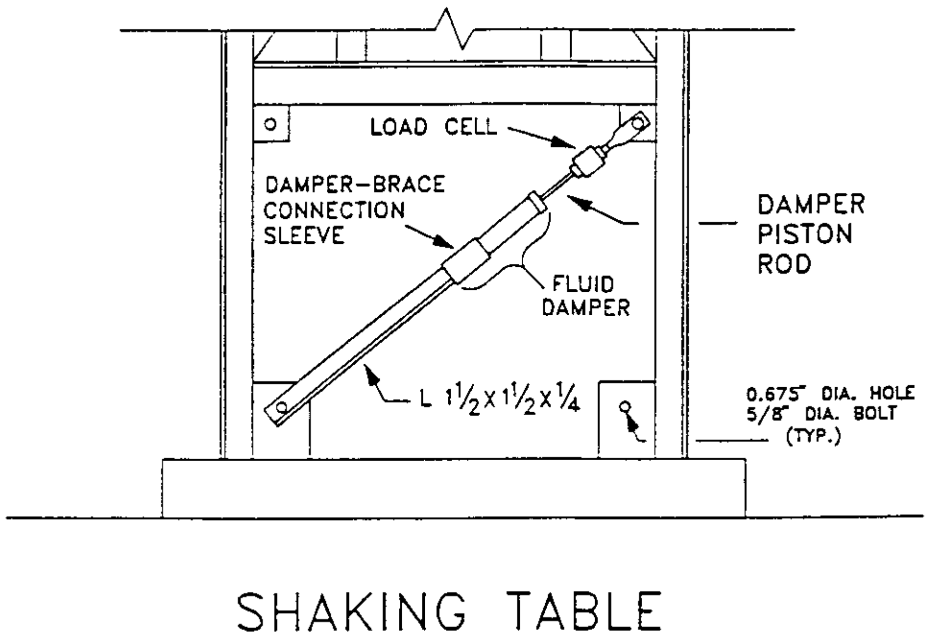

FIGURE 3-4 **Schematic of Damper Connection Details (1 in. = 25.4 mm)**

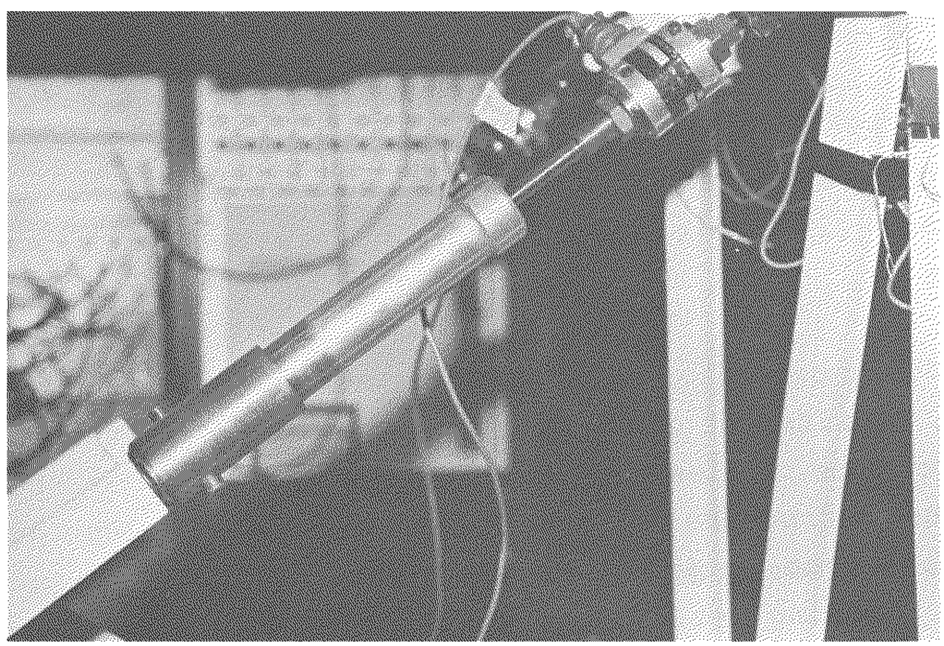

FIGURE 3-5 **Close-up View of Two Dampers in the Model Structure at the First Story**

Figure 3-5. A view of the one-story structure with four dampers and a close-up view of the structure with two dampers in the first story is presented in Figures 3-6 and 3-7, respectively.

Testing proceeded in the following sequence. First the one-story configuration without and with fluid dampers was tested. The structure suffered damage in previous testing and exhibited both low stiffness and strength. Cracks existed on the webs of the structural tees forming the first story columns. Propagation of the cracks was prevented by drilling small holes at the tip of each crack. In this condition, the one-story structure was identified to have, at small amplitudes of vibration, a frequency of 2 Hz and damping ratio of 0.55 percent of critical. In seismic excitation, damping was estimated to be about 2 percent of critical.

Subsequently, the one-story structure was tested in a stiffer configuration. Steel plate stiffeners were welded at the top and bottom of each first story column. The properties of the structure at small amplitude of vibration were identified to have a frequency of 3.13 Hz and damping ratio of 2 percent of critical. Under seismic excitation, damping was estimated at about 3 percent of critical. Tests were conducted in this one-story configuration without and with fluid dampers.

Recognizing that damping in the structure without fluid dampers may be low, a different configuration was created and tested. A system of wire rope cables and pulleys was attached to the one-story stiffened structure as shown in Figure 3-8. The pulleys were locked so that during deformation the cables slid on the pulley guides. During motion, the cables did not change length so that they introduced frictional damping without increasing the stiffness. In seismic excitation, this damping was estimated to be about 5 percent of critical. In this configuration, tests were conducted without fluid dampers.

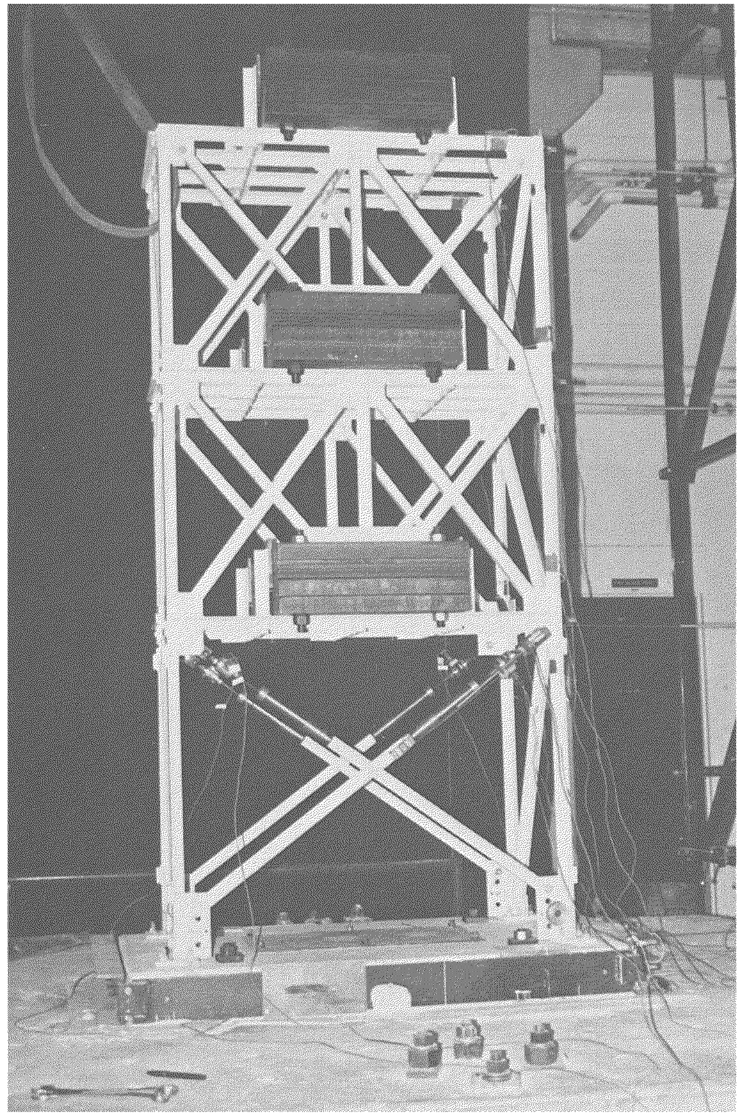

FIGURE 3-6 **View of One-story Model Structure with Four Dampers**