DAMAGE AND ENGINEERING IMPLICATIONS

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INTRODUCTION

In this report, we discuss the damage done by the February 4 earthquake and the engineering implications in greater detail. We report on the damage to selected structures in the capital city and on a few structures in the rest of the affected area but do not attempt to include all the important failures.

EARTHQUAKE-RESISTANT DESIGN PRACTICE IN GUATEMALA

When the February 4 earthquake occurred, no earthquake-resistant-design code had been enacted into law in Guatemala, and therefore it was not mandatory to design structures to withstand seismic forces. Each engineer or architect selected a foreign code and designed accordingly (J. Asturias, oral commun., 1976). The same professional was usually in charge of supervising the construction process. Review of design and construction by specialized structural engineers, independent of the original designer, was not required, as it is in Chile, Mexico, and the United States.

According to two local structural engineers, J. Arias and R. Zepeda (oral commun., 1976), many professionals used elements of a version (not necessarily the latest) of the Structural Engineers Association of California code. Thus, the structures in Guatemala City were not designed according to common standards. In the short time available for the study, it was difficult to assess, from the condition of the buildings, whether the various standards employed are suitable for the local soil conditions, quality of construction materials, dynamic characteristics of the structures, and other important factors. It is noteworthy to mention that the material characteristics, such as the strength of steel reinforcing bars, are frequently assumed by the engineer without any supporting technical evidence.

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TYPES OF STRUCTURES

Guatemala City has many modern buildings; most are reinforced concrete, but a few are high-rise steel structures. The predominant type of modern construction appears to be the reinforced-concrete frame structure having flat beams in one or two directions and masonry (reinforced or unreinforced) filler walls. It is common to find filler walls made of poorly reinforced hollow brick or hollow tile.

One of the most common forms of construction is adobe, which is used for the majority of houses, churches, and small structures throughout the country. Roofs are generally tile on wood-pole rafters.

Reinforced mud or bajareque construction is also used extensively in Guatemala. It consists of a wood frame covered with lath, the wall space being filled with mud and plastered. Bajareque is similar to quincha, which is frequently used for building houses in the coastal region of Peru. Quincha construction sustained extensive damage in the 1970 Peruvian earthquake (Husid and Gajardo, 1970; Berg and Husid, 1971, 1973).

Wooden construction was common in Puerto Barrios and in the port of Santo Tomás. Corrugated-steel and reinforced-concrete grain silos were used in the area affected by the earthquake. Water tanks were predominantly elevated and built of reinforced concrete or steel.

DAMAGE SURVEY

Although the capital city was not damaged as severely as towns along the Motagua River Valley and some towns in the highlands west of Guatemala City, there was extensive damage in several zones, and some reinforced-concrete and steel structures completely collapsed.

The types of construction found outside Guatemala City are adobe, bajareque, and wood. Adobe construction in many towns sustained the same

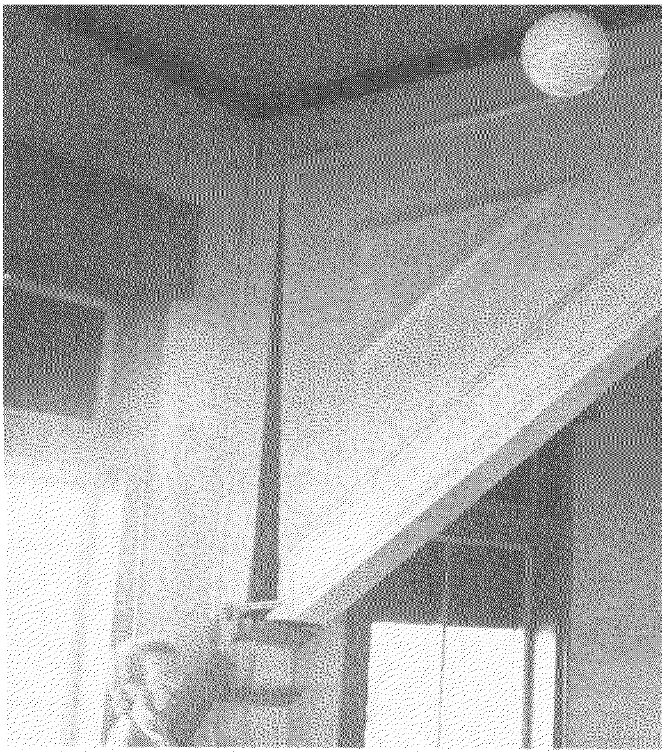

FIGURE 51.—Damage to a wooden structure in Puerto Barrios, caused in part by ground compaction. Note the large offset of 11 cm shown in the photograph.

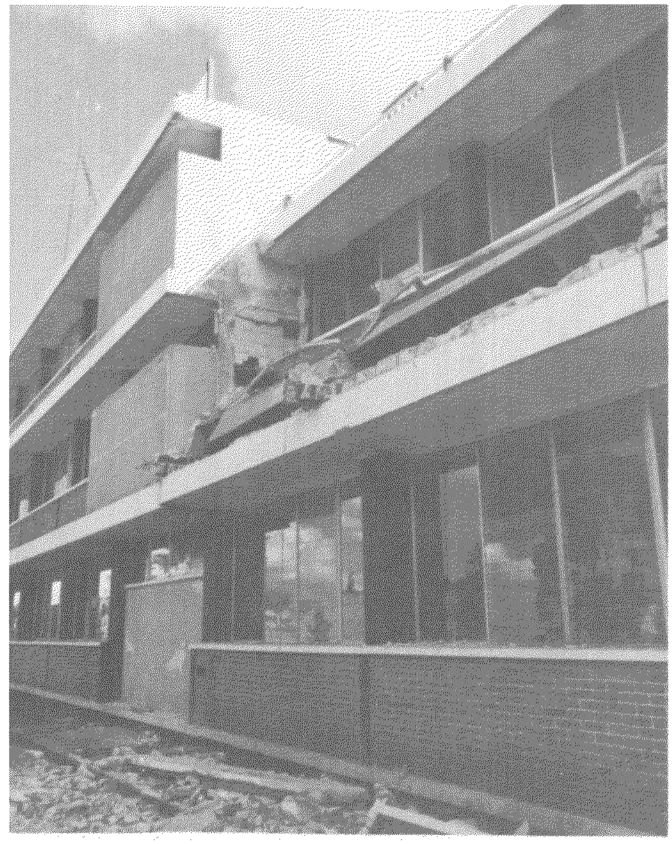

FIGURE 52.—Collapse of the second story of a building at the Colegio San Javier (Zone 12), Guatemala City.

heavy damage that has been observed after many previous earthquakes in other countries (Husid and Gajardo, 1970; Eisenberg and others, 1972; Husid and Espinosa, 1975; Espinosa and others, 1975). Wooden construction withstood damage well even when extensive damage was caused by ground compaction (Ray Wilson, oral commun., 1976) beneath the building (fig. 51).

Many school buildings were severely damaged by this earthquake, and, if the earthquake had occurred during class time, the death toll would have been larger. The second story of a three-story reinforced-concrete frame structure with masonry walls at the Colegio San Javier collapsed (fig. 52). In the same school complex, a second building, next to the one that partially collapsed, was extensively damaged. There was no available information about the lateral loads used in the design of the school structures.

The Instituto Guatemalteco Americano, a five-story reinforced-concrete frame structure with poorly reinforced hollow brick walls sustained extensive damage. This structure has rather large cantilevered slabs in its perimeter supporting very heavy concentrated loads (reinforced-concrete ornaments and hollow brick walls) at their free end. Most of the walls were on the verge of collapse, and the slabs showed severe cracks in the cantilevered area. A slab on the penthouse partially collapsed, and reinforced-concrete columns and beams showed severe damage at the same level. It is important to note that this school building, which sometimes houses more than 2,000 students, has only one stairway. If the earthquake had occurred when 2,000 students were attending classes, many could have been injured as a result of panic and lack of adequate exits.

A three-story framed reinforced-concrete structure (fig. 53) was partially collapsed (Zone 12) when columns on its second floor failed.

Severe damage to several hospitals in Guatemala City created a serious problem because of the large number of injured people therein. Included were the Hospital Neuro-Psiquiátrico (Zone 7), Sanatorio San Vicente (Zone 7), Hospital Roosevelt (Zone 11), and the Nursery School of Casa del Niño No. 1 (Zone 1).

The Cathedral of Guatemala City, which was partially destroyed during the 1917–18 earthquakes