## *Recovery*

# The Reconstruction of Erzincan, Turkey

*This report was contributed by Mehmet Celebi (EERI 1980).*

### Introduction

Recovery, research, and reconstruction efforts following the March 13, 1992, Erzincan, Turkey earthquake were discussed at a conference in Erzincan between October 21–24, 1992. Items of note from the conference, as well as from personal observation of the affected area by the author, are summarized in this report.

The final damage statistics for the building inventory as reported by the Ministry of Public Works and Reconstruction are as follows: total collapse or heavily damaged (irreparable)—7,007 units; medium damage (repairable)—9,227 units; and light damage (repairable)—15,042 units. The definition of a "unit" is a condominium, single-family house, or a business (store or office).

About 40 percent of the population were displaced and all of the population were deprived of essential services such as medical care requiring hospitals, since all three hospitals had collapsed. The goal of the massive reconstruction effort has been to bring the region back to normalcy before the severe winter season.

Approximately $700M in public funds is being spent to rebuild the city of Erzincan and surrounding towns and villages. Approximately a third of this amount is borrowed from the World Bank. About 4,000 new single-family homes and 2,500 new condominium units are under construction and scheduled for completion by December 31, 1992.

Unique repair and strengthening methods are being implemented on those buildings deemed repairable and/or in need of strengthening. Approximately 70 faculty members from three major universities (Istanbul Technical University [ITU], Middle East Technical University-Ankara [METU], and Bosphorus University [BU]) are heavily involved in all phases of planning, development of criteria, review and/or design of new and retrofit or repair construction.

The implementation of the repair and retrofit methods are being monitored by two main groups:

a. ITU Group: responsible for replacement of multiple-family housing constructed with public funds (even though ownership of the original building at the site may have been private before the earthquake). This effort involves 2,000 units of housing.

b. METU Group: responsible for repair and retrofit of 36 public buildings (schools, government buildings, etc.). They have adopted a seismic coefficient of 0.3 for their calculations in retrofitting the buildings.

### Investigations

All three university groups (ITU, METU, and BU) were involved in all aspects of investigations related to defining the geotechnical environment of Erzincan and defining design response spectra for specific site conditions. Furthermore, each group established laboratories for geotechnical investigations. Materials laboratories were established to test samples taken from damaged buildings or from buildings to be retrofitted, and to carry out tests related to quality control of new construction.

Many boreholes have been drilled. The ITU Group drilled approximately 35 boreholes with depths of about 35 meters. Most of these have been cased for conducting cross-hole and related tests during the summer of 1993. The METU group drilled approximately 20 boreholes with greater depths (100–200 meters). They have also carried out specific site characterization efforts in the vicinity of the public buildings earmarked for retrofitting. The BU Group carried out microtremor measurements.

### Temporary Construction (Prefabricated Units)

Two types of prefabricated buildings erected immediately after the

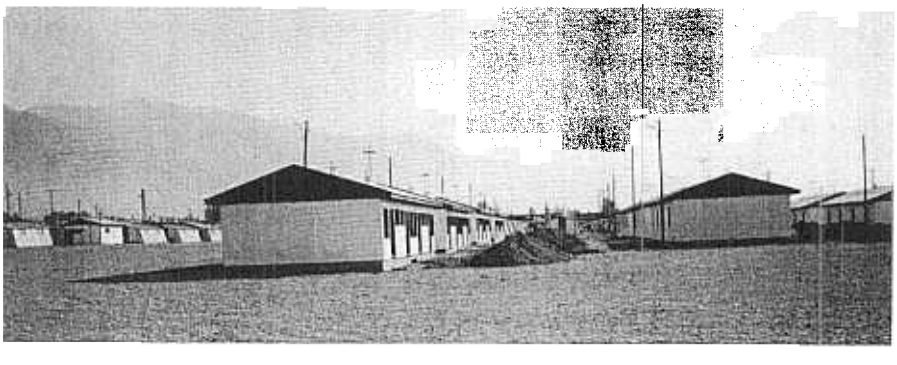

Figure 1 - *Two types of prefabricated temporary housing*

earthquake are still being used by displaced people (Figure 1). The temporary units erected in Erzincan are publicly financed and owned. They were erected within two weeks of the earthquake to provide temporary housing and to replace tents. These units are normally stored in Ankara and are trucked quickly to natural disaster areas. In areas with favorable weather conditions, they are used to provide permanent housing. They are situated with sufficient land for the new owners to enlarge their living spaces.

Erzincan prior to the earthquake:

a. single-story brick masonry with reinforced concrete tie-beams and ceilings;
b. two-story reinforced concrete frame buildings with infill walls;
c. three-story reinforced concrete frames with infill walls and reinforced concrete shear walls; and
d. four-story reinforced concrete tunnel-formed shear wall building.

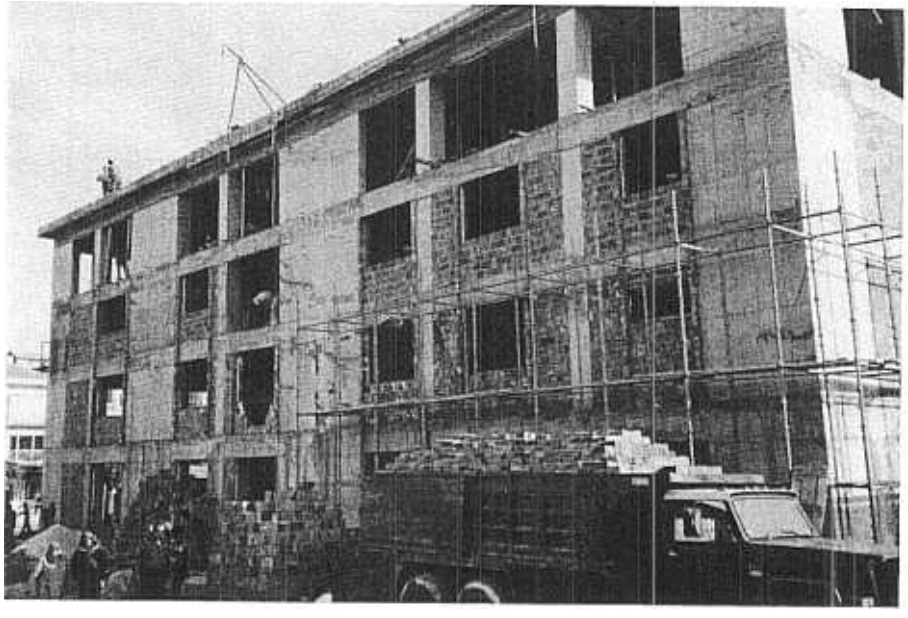

**Figure 2** - *A privately owned four-story new building (note corner and central shear walls)*

There was clear evidence of improved design and construction of new, privately owned buildings. A new private building under construction is shown in Figure 2. The design exhibits better proportioned lateral force resisting elements and construction quality superior to that of typical pre-earthquake buildings.

Several methods and techniques are being used in repairing and retrofitting of structures.

1. lowering the number of floors and altering use plan
2. encasing (capping) of columns
3. addition of shear walls
   a. ITU method
   b. METU method
4. epoxy repair
5. combination of two or more of the above
6. special cases related to industrial structures

These methods are being applied for both public and privately owned buildings.

The approach of reducing the number of floors and altering the

**Rebuilding Efforts**

Rebuilding efforts in Erzincan and vicinity can be classified in two major groups: new construction; and repair and retrofit of the pre-earthquake inventory of buildings.

Several different types of buildings and construction methods are being used for new public housing construction. There are four main types of housing construction, all of types similar to the housing construction that existed in

**Figure 3** - *Unsan Flour Mill during repair and retrofit*

building use, also implemented in Mexico City following the 1985 earthquake, was applied in several cases in Erzincan. The upper two of four floors were removed from one of the two wings of the Kizilay (Red Crescent) Building in the center of Erzincan. Selected columns were strengthened by capping. Before the earthquake, the balconies were closed completely with floor to ceiling walls and used for heavy storage space. In the alteration, the balconies were reconverted to balconies.

Capping reinforced concrete columns is a well known method. In most cases in Erzincan, this method was used in combination with addition of shear walls. Figure 3 shows the repair and strengthening at Unsan Flour Mill. The photograph shows shear walls being added to the corners of the building and columns being capped in the central section of the building.

Repair and retrofit of public housing buildings are being achieved mainly by addition of reinforced concrete shear walls. The shear transfer between the floors and the new walls is being achieved by "Hilti" dowels. This approach has been initiated, designed, and is being implemented under the direction of the ITU Group.

Repair and retrofit of public buildings (schools and government buildings) are being carried out by a new method initiated, designed, and being implemented under the direction of the METU Group. Application of this method is seen in Figures 4-6. The building is strengthened with shear walls cast within a frame of channel members between two columns which, in turn, is attached to the columns by a standardized jacket comprised of four longitudinal corner angles and plate strips between them. The channel at the top of the frame is anchored by a bolt system to the bottom frame channel of the floor above. This is the basic shear transfer mechanism. Once the new shear wall is cast, the columns are considered as not contributing to the lateral force resisting capability. During casting, a "cement board" is used as a vertical form and left in with the concrete. This board is later painted.

## Conclusions

It is important to document the repair and retrofitting of damaged structures as well as the design and construction of new ones so that their effectiveness can be assessed after future earthquakes. This report serves that purpose on a small scale. What is being accomplished in Erzincan is impressive from not only an engineering point of view, but also from a sociological point of view. A follow-up mission by a social scientist would be very rewarding.

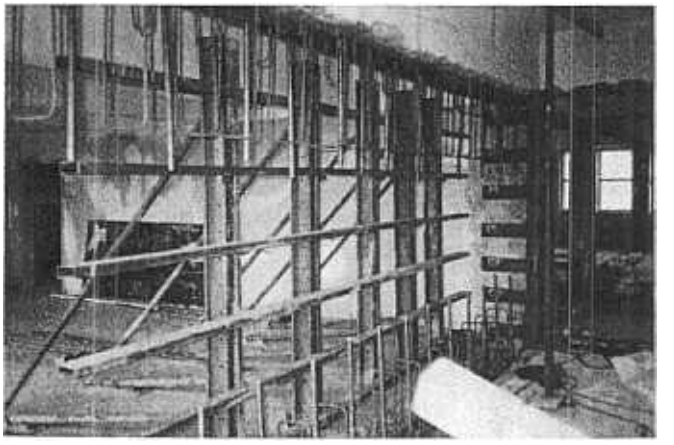

**Figure 4** - *METU method shear wall retrofit*

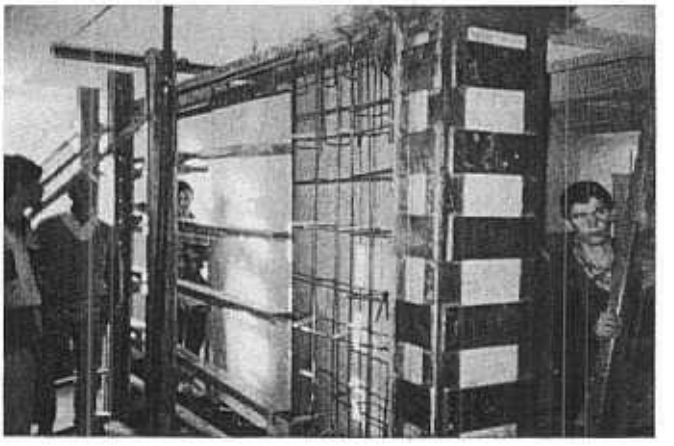

**Figure 5** - *Rebars in place, form being placed*

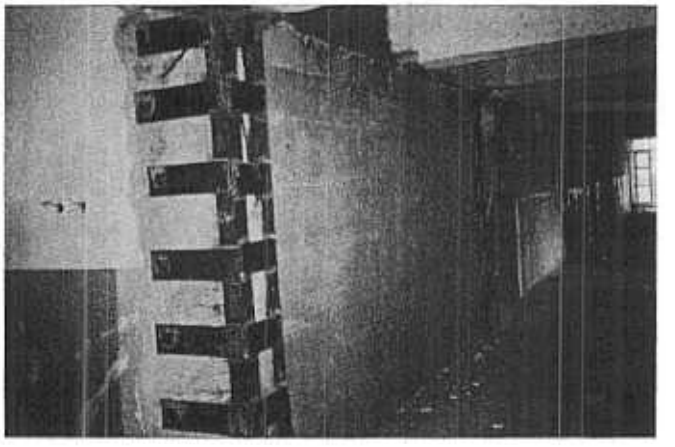

**Figure 6** - *Finished wall - METU method*

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