EERC
Earthquake Engineering Research Center
MIDDLE EAST TECHNICAL UNIVERSITY

March 08, 2010 Başyurt-Karakoçan (Elazığ) Earthquake

Supplementary Report

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OUTLINE

1. Objective:

Following the initial visit of the METU-EERC team (Bakır et al., 2010), a second team comprising of civil engineers from METU-EERC and a visiting geological engineer from National Disaster Management Authority, India, visited Elazığ region during the period between 17 and 19 March 2010, to study the earthquake-affected area and provide some additional information to the work done by the first team. The basic objective of this field trip was to identify and categorize the damage levels of the different types of buildings with particular focus on the school, hospital and community buildings in the region. In addition, the team attempted to note down the ground failures, if any present, as well as the response and recovery actions being taken by various stakeholders in the affected area. This report is complementary to the findings of the first team from METU-EERC (Bakır et al., 2010).

2. Introduction and Seismotectonics of the Region:

An earthquake of M_L=5.8 occurred in the Elazığ region of Eastern Turkey on March 08, 2010 at 02:32:34 UTC. Earthquake Research Department (ERD) reported the epicenter of the earthquake as 38.7752N - 40.0295E and with a depth of 5 km.

The earthquake was reported to be on the left lateral strike slip East Anatolian Fault (EAF) which is shown to be consistent with the distribution of the aftershocks (Tübitak MAM Report, 2010). The East Anatolian Fault System is one of the most active fault systems in Turkey. Because of the northward movement of Arabian and African plates, the Anatolian Block has a westward extrusion as shown in Figure 1 (Yılmaz et al., 2006). Since EAF serves as a belt between them, the region of East Anatolia is known to be seismically very active (Arpat and Şaroglu, 1972). It has produced several earthquakes within the last century with a spatial distribution as shown in Figure 2. One of the largest of these events, which the region experienced within the last 10 years, was the 2003 Mw=6.4 Bingöl earthquake causing 176 fatalities and 520 injuries (Aydan et al., 2003).

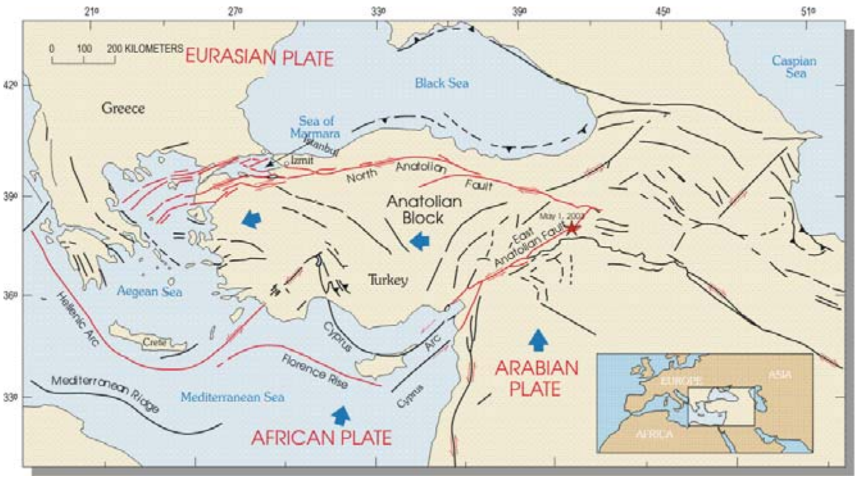

Figure 1. Tectonic Map of Turkey (www.usgs.gov)

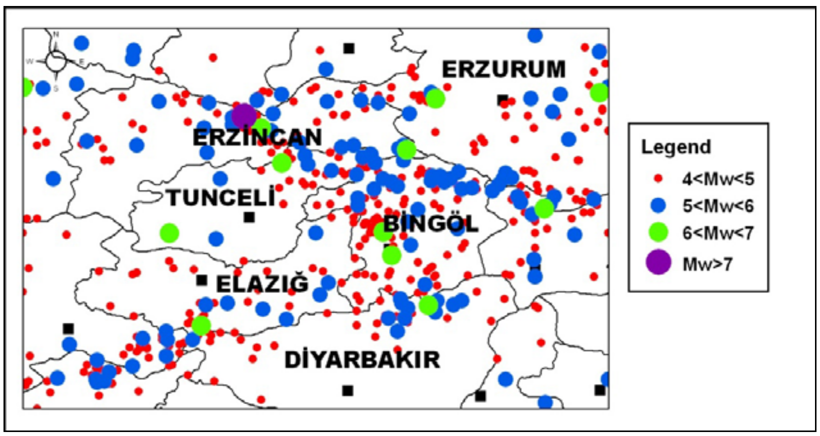

Figure 2. Seismicity map of the region

For further information on the seismotectonics of the region and analyses of the strong ground motions recorded during 8 March 2010 Başyurt-Karakoçan earthquake, readers are referred to METU-EERC reports by Bakır et al. (2010) and Sandıkkaya et al. (2010), respectively.

3. Field Observations:

3.1 Building Damage

The earthquake has caused major structural damage in villages of Okçular, Göçmezler, Yukarı Kanatlı, Yukarı Demirci and Tabanözü (Figure 3). The type of construction and materials of construction in these villages are very similar. The main types of construction material in the region are stone and adobe: adobe blocks are used as brick elements in the walls, mud with thatch is used for plastering, mud with small stones and twigs of trees are used in roof slabs supported by round wooden logs as cross beam structure. In addition, irregular sized uncoursed stones are used very frequently with or without mud/clay mortar in the walls. In stone masonry buildings, roof is made of earthen material, corrugated metal sheets or made with concrete slabs (particularly in school and hospital buildings). Some of the buildings had clay brick masonry walls as well. But reinforced concrete (R/C) structures are rarely found.

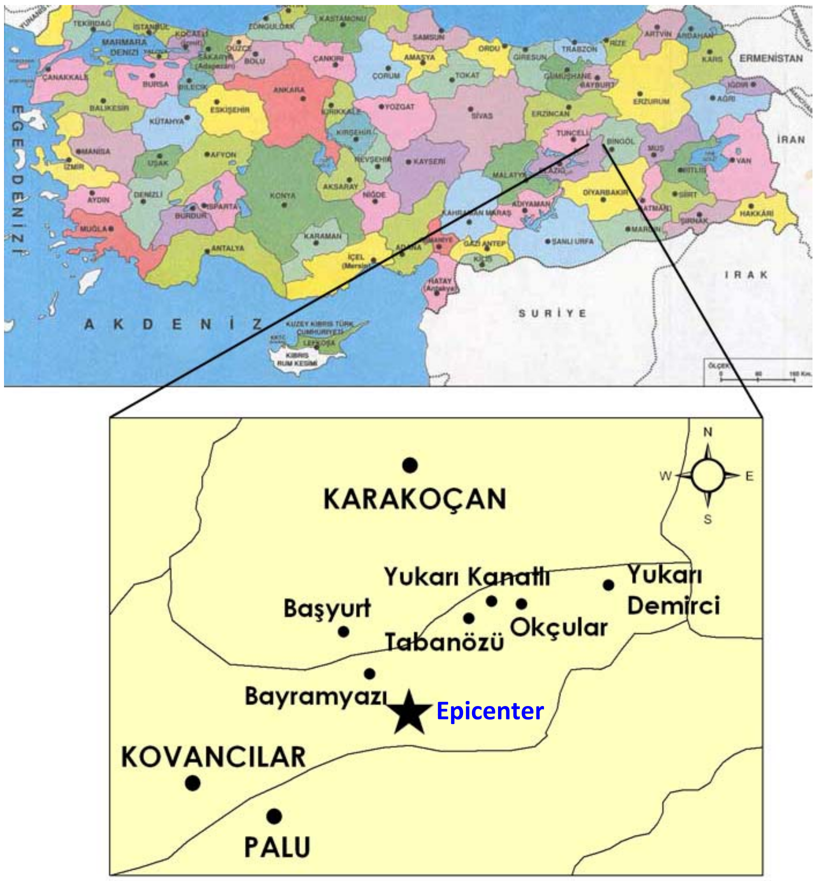

Figure 3. Political map of Turkey (Top). Map showing the villages in Elazığ region visited by the team (Bottom)

Most of the buildings do not have foundation systems, if any the ground is carpeted with 10 - 15 cm of mud mortar mixed with thatch. Some buildings have stone masonry foundations and very few buildings have reinforced concrete foundations.

The walls are either adobe or stones with mud blocks of thicknesses around 60-80 cm. The roof material is a mixture of wooden logs overlain with stones and mud with a thickness of 40 to 50 cm. The average dimension of typical residential buildings in the region is about 6 m by 8 m long, with up to 3 rooms and a verandah. A typical room has a size of about 2 m by 4 m. The buildings are either single or double storey mostly with basement floors used as barns. It was noted that around 95% of the building population in the region are non-engineered structures. (For further details on building types and observed damage, please see Bakır et al., 2010).

The major failure mode of buildings is out-of-plane failure of walls resulting in total collapse of the heavy roofs, which is also the main reason of the fatalities. According to the local residents, most of the deaths are caused by either chocking under soil or due to falling stones.

Most of the structures have wooden logs in the place of columns and beams as shown in Figure 4. Mostly due to weak connection of these primitive elements, these could not function well during the shaking. The major cause of deaths and injuries was falling of the buildings' components on the people living there and / or getting trapped under the debris due to failures of the wall as well as the roof.

Figure 4. Wooden logs being used as columns and beams (Okçular village)

To identify and classify the damage level to each structure, the team defined certain criteria in the field based on the variability of damages observed. The damages are categorized into five main levels: Collapse (C), Severe (S), Moderate (M), Light (L) and None (N) levels. The criteria used for classifying the category of damage are defined broadly as below:

Collapse (C): Failure of all structural (main load carrying) elements.

Severe (S): Severe damage in most of the main structural elements is observed and cannot be repaired fully.

Moderate (M): Open cracks are observed within the plane of the wall, wall-to-wall connections and wall-to-roof connections. The observed damage can be repaired with proper retrofitting measures.

Light (L): Small size cracks and plaster failure are observed and the observed damage can be repaired easily.

None (N): No visible damage.

This report provides a summary of the field observations made in villages visited by the team along with some points for discussions and suggestions.

Yukarı Demirci:

Yukarı Demirci village is located at 38° 52’N and 40°10’E with an altitude of 1735m. According to local residents, out of a population of 320, 14 of them have lost lives and 23 are injured. Almost 100% of the residential buildings in Yukarı Demirci are either collapsed or severely damaged. Major mode of failure in these buildings is the total collapse of the structure (Figures 5 & 6).

The team has inspected the collapsed Yukarı Demirci Primary School which has a R/C main beam on stone masonry walls that have failed completely (Figures 7 and 8). It was fortunate that the earthquake did not happen during the school hours; otherwise it would have been difficult for the students and teachers to escape from such collapsed buildings.

It is noted that there is no medical-care building in the village.

Figure 5. Yukarı Demirci Village (An overview)

Figure 6. Yukarı Demirci village: several collapsed buildings next to each other

Figure 7. Yukarı Demirci Primary School (An exterior view)

Figure 8. Yukarı Demirci Primary School (An interior view)

Tabanözü:

This village is located at 38° 50’N and 40°04’E with an altitude of 1303m. There are approximately 50 severely damaged buildings in Tabanözü but no deaths or injuries are reported. The type of failure of the adobe buildings is similar to the ones observed in Yukarı Demirci. One of the severely-damaged adobe buildings is shown in Figure 9. There are several R/C residential buildings in this village, of which a few has light damage. Figure 10 shows the exterior view of a 2 storey R/C building with diagonal shear cracks on the brick walls. Figure 11 displays transverse (out of plane shear) displacement of the parapet of a 3 storey R/C building.

Figure 9. A severely damaged three-bay, two-storey adobe building in Tabanözü

Figure 10. Shear cracks in a R/C building in Tabanözü

Figure 11. Transverse displacement of the parapet of a R/C building in Tabanözü

Yukarı Kanatlı:

Located at 38° 51’N and 40°05’E, this village has more than 50 severely-damaged and collapsed buildings with 3 fatalities and few injuries. Type of construction and typical modes of failure are very similar to those observed in the other villages. In Figure 12, a severely damaged stone masonry building is shown where a cupboard worked like a column and saved lives of the household.

The mosque in the village has a R/C frame with stone masonry infill and exterior walls. The stone minaret collapsed during the earthquake as shown in Figure 13. The exterior view of the mosque does not display the damage entirely but as observed in Figure 14, the stone walls have partially collapsed inside.

The primary school building in Yukarı Kanatlı village is a stone masonry building and it has severe damage with partially failed stone walls as shown in Figure 15 & 16.

Figure 12. A stone masonry house

Figure 13. Mosque and collapsed minaret in Yukarı Kanatlı village (An exterior view)

Figure 14. Mosque in Yukarı Kanatlı village (An interior view)

Figure 15. Yukarı Kanatlı Primary School (An exterior view)

Figure 16. Yukarı Kanatlı Primary School (An interior view)

Başyurt:

Başyurt village is located at 38° 50’N and 39°58’E with an altitude of 947m. Located relatively distant from the epicenter, only light damage in a few buildings with no deaths or injuries are reported in this village. Most of the buildings are either adobe or stone masonry buildings with very few R/C frame structures. Figure 17 shows one of the lightly-damaged R/C frame buildings and Figure 18 shows a stone building with moderate damage.

The R/C building of Başyurt Primary School is also slightly damaged with visible shear cracks on the interior masonry walls.

Figure 17. Fine shear cracks in a R/C frame building in Başyurt

Figure 18. A moderately damaged stone masonry building in Başyurt

Okçular:

The village is located at 38° 51’N and 40°06’E and is the most adversely affected village during the 8 March 2010 Elazığ Başyurt-Karakoçan earthquake. Among more than 1000 residents of this village, 19 have lost their lives and 34 have been injured. Approximately, out of a total of 120 houses occupied, 105 are severely damaged or totally collapsed. At the time of the mainshock, 30 houses that were not occupied collapsed completely, which most probably avoided additional deaths and injuries. An overview of the village is shown in Figure 19.

Most of the collapsed houses are either adobe or stone masonry with out of plane failures of the walls and total collapse of heavy roofs (Figures 20, 21 and 22).

Figure 19. An overview of Okçular village

Figure 20. A collapsed adobe house in Okçular

Figure 21. A collapsed stone masonry-adobe house in Okçular

Figure 22. A collapsed house in Okçular with a roof failure

The stone masonry primary school building in Okçular village (Figure 23) is classified as moderately-damaged by the team because of the severe cracks in the exterior wall connections (Figure 24).

Figure 23. Okçular Primary School (An exterior view)

Figure 24. Okçular Primary School (Exterior wall connections)

The R/C frame medical-care building in Okçular does not have any damage as observed in Figure 25, except a fine crack in one of the walls.

Figure 25. Okçular Village Medical-care building

Bayramyazı:

Bayramyazı village is located at 38° 48’N and 39° 59’E. Although it is located fairly close to the epicenter, the team did not observe any collapsed buildings. Severe damage is observed especially in adobe masonry houses (Figure 26 and 27). The team did not observe any damage in the R/C mosque and minaret shown in Figure 28 whereas the adobe masonry house next to it, is moderately damaged.

Figure 26. An adobe house in Bayramyazı which has a wide opening in its exterior wall

Figure 27. An adobe house in Bayramyazı where an interior wall has experienced major out-of plane displacement

Figure 28. A moderately- damaged adobe house (Left) and R/C mosque and minaret (Right) with no damage in Bayramyazı

3.2 Ground Failures

In the field, the team could not find any good evidences of ground failures in the form of major ground cracks, differential settlement / displacements, bulging or landslides due to the shaking. However, in Okçular, residents reported that the some of the buildings displaced as a rigid body and the gaps between the buildings changed. As per their statement, this may have happened due to land sliding on the slopes where these buildings were located. The team did not find any clear evidence for slope movements on the surface (may be due to slopes being covered with building debris at the time of observation, landslide features were not clearly evident); however, two big landslides were found on the opposite slopes of the hill (Figure 29). But, no clear escarpment of the landslides on the damage side could be seen.

Figure 29. Landslides in the background

Among the impacts of earthquake on the ground, the team did observe a 30m long running crack with 25-35 cm wide opening along the road edge as indicated in Figure 30. The crack was aligned along N140-N320. Even though the villagers stated that the crack formed at the time of earthquake, it was not fully apparent whether the crack has appeared due to ground shaking or not.

Figure 30. Cracks observed along the road edge

4. Discussions and Suggestions:

Although the region experienced a moderate size earthquake, the damage observed is severe. According to the team, the severity of damage is due to the inferior quality of the building materials used in the region and poor construction practices in non-engineered structures. Further strengthening and rehabilitation of the existing light to moderately damaged buildings and reconstruction for the collapsed and severely damaged buildings are being urgently needed in the region. Furthermore, the team would like to point out the need of guidelines specially designed for non-engineered structures such as adobe in Turkey which can be easily followed by the general public. This can be possibly done through demonstration structures in such areas and generating awareness / preparedness among the affected community.

Eastern Anatolia region is seismically very active and a higher magnitude earthquake may be expected at any time in the region. Since research regarding the seismicity of the region is very limited, it may not be possible to make realistic seismic hazard analyses and assessments. The team suggests further detailed studies in the East Anatolian region to develop better understanding of the seismic risk potential of the region and to investigate methods for risk reduction.

5. Acknowledgements

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6. References:

Sandıkkaya, A., E. Yenier, and Akkar S. (2010). Processed records of the 8 March 2010 Elazığ – Kovancılar, earthquake, *METU EERC (http://eerc.ce.metu.edu.tr/documents/ProcessedRecords_080310Earthquake_v2.pdf)*.

Arpat, E. and F. Şaroglu (1972). The East Anatolian fault system: thoughts on its development, *M.T.A. Bull.*, **78**, 33–39.

Aydan Ö., R. Ulusay, M. Miyajima (2003). The Bingöl Earthquake of May 1, 2003, *Japan Society of Civil Engineers* (*http://www.jsce.or.jp/report/19/report/report200307.pdf*).

Bakır S., E. Canbay, A. Erberik, Z. Gülerce, A. Aldemir, İ. O. Demirel (2010). 8 Mart 2010 Başyurt-Karakoçan (Elazığ) Depremi Ön İnceleme Raporu (in Turkish), *METU EERC (http://eerc.ce.metu.edu.tr/documents/ElazigRapor_300dpi.pdf)*.

TÜBİTAK Marmara Araştırma Merkezi, 8 Mart 2010 Karakoçan Elazığ Deprem Raporu (2010) (in Turkish) (http://www.ydbe.mam.gov.tr/DEPAR/2010_03_08_Elazig/index.html).

Yılmaz, H., S. Over, S. Ozden (2006). Kinematics of the East Anatolian Fault Zone between Türkoğlu (Kahramanmaraş) Çelikhan (Adıyaman), Eastern Turkey, *Earth Planets Space*, **58,** 1463-1473.