



## The October 23, 2011 Van, Turkey Earthquake ( $M_w=7.2$ )

### EARTHQUAKE DAMAGE

The information about the earthquake damage to buildings and utilities, as well as about casualties is becoming more clear with time.

In this document we summarize what is available to date and give general information on the building stock in the province. We also include a summary of damage reports and their links from national institutions and from local media.

According to the distribution of the instrumental earthquake intensities associated with the mainshock of the Van earthquake, presented in Figure 1, the expected epicentral earthquake intensity is VIII.

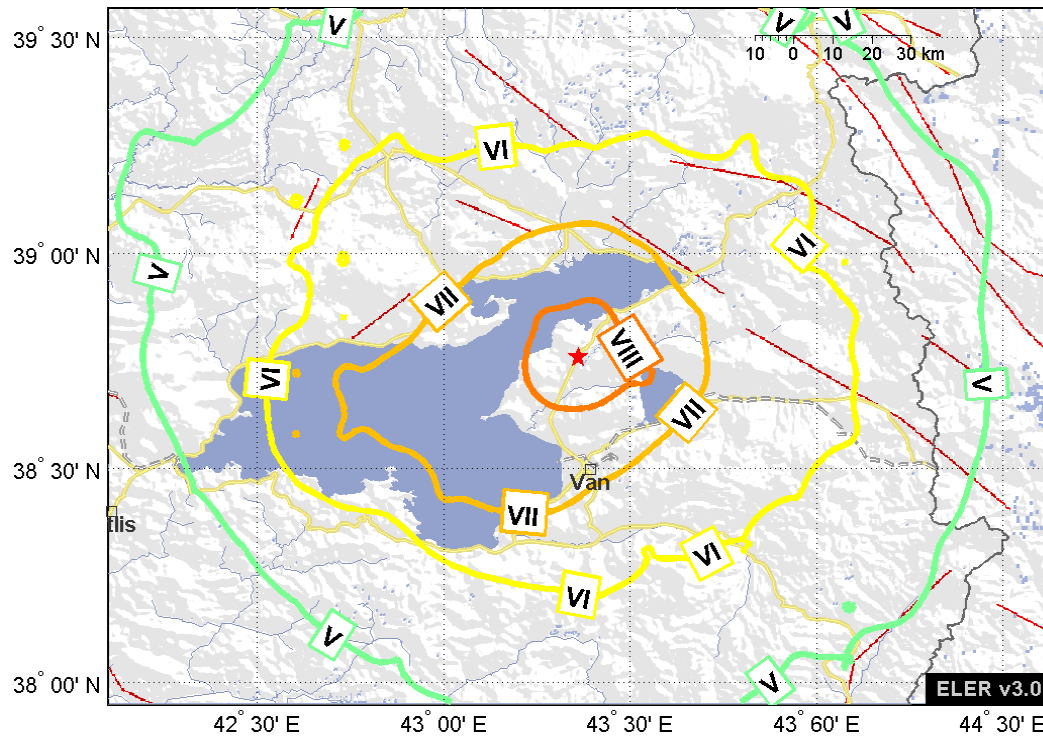


Figure 1. Instrumental earthquake intensities associated with the Van earthquake.

In the region, the province primarily affected by the earthquake is Van. In Figure 2 the administrative units in Van are presented. The provincial population of Van is 1,035,418 as of 2010 according to the Turkish Statistical Institute. 539,619 people live in Van, the center of the province, and in the subprovincial centers. 495,799 people reside in villages.

The building stock in the region can be classified in four groups: reinforced concrete; unreinforced masonry, adobe and rubble stone. Unreinforced masonry type buildings have the largest share in the building stock. The majority of the damage must have occurred in the four subprovinces of Erciş, Merkez and Muradiye based on a comparison of Figures 1 and 2. In Figure 3 the villages in the province of Van that were damaged are shown. The current numbers of damaged units in the villages marked in Figure 3 vary between 1 and 150.

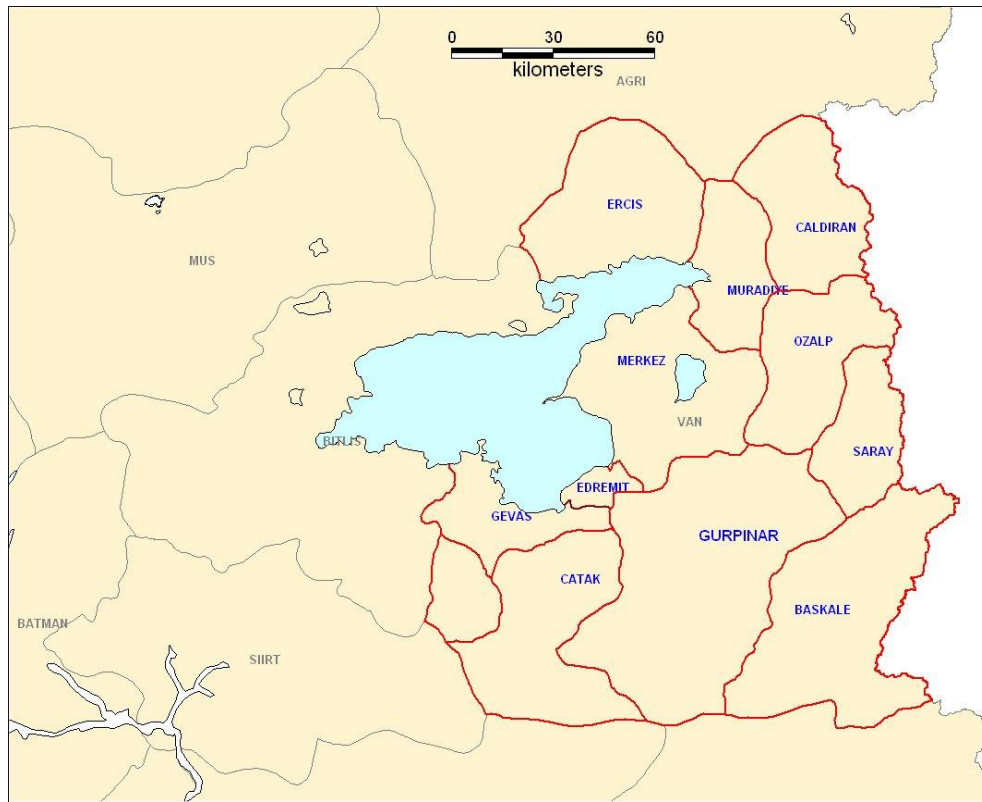


Figure 2. The subprovinces of Van. Merkez is the administrative center of the province.

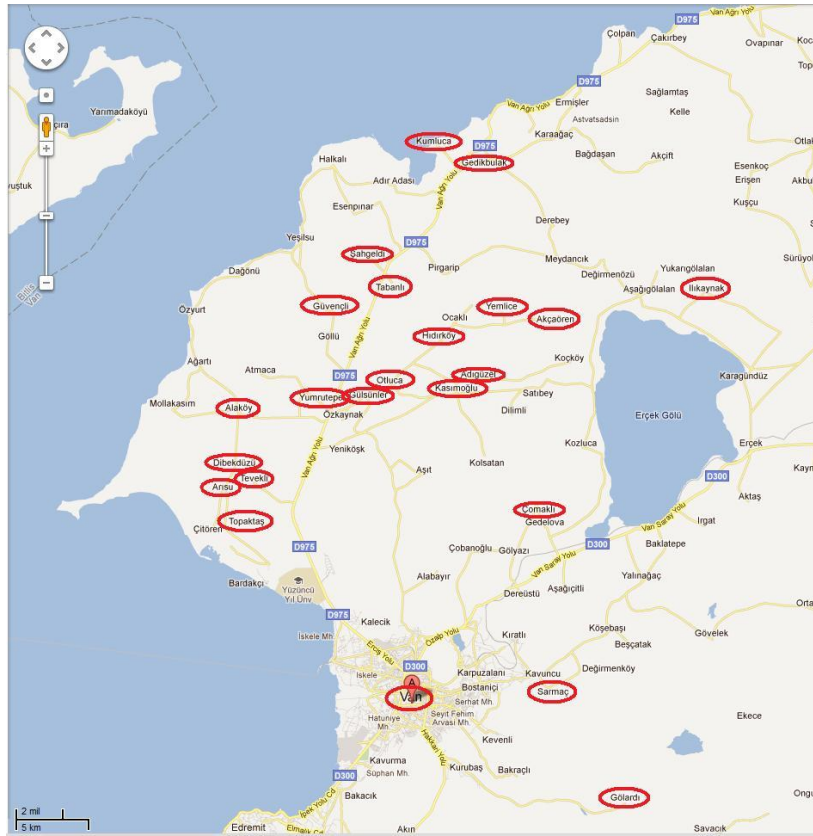


Figure 3. Villages of Van with earthquake damage

## **Buildings**

In Table 1 estimated number of buildings at the provincial and subprovincial level and their percentage breakdown with respect to building types can be found.

In the preliminary damage survey carried out by AFAD in Van, the central town, the villages of the province and central settlements of Erciş Town as of October 28, 2011, 10.00 am. Damage distribution of buildings were as follows:

	Damaged-Nonhabitable	Damaged-Habitable
# Buildings	5739	4882
# Households	8026	7660

We do not know currently the geographical distribution of damaged buildings, nor do we know the structural and damage types of the buildings that were somehow effected by the earthquake. However, the pictures show that the damage patterns are very similar to those of the past earthquakes, namely inadequate reinforcement, lack of confinement at beam-column connections, low quality concrete, and soft first stories. We may assume that 5739 buildings received damage beyond repair. This means, that based on announced numbers, which are subject to change, 12.5% of the buildings in Erciş and Van-Merkez (center) were damaged beyond repair, 10.6% of them received slight, repairable damage.

Table 1. Building Stock Information for Van. These values are obtained by projecting the year 2000 TUIK building census data to the year 2006 based on year 2006 population census data.

	Van( Total)	Erciş	Muradiye	Merkez
<b>Number of Buildings</b>	78,000	10,700	3,600	35,200
<b>Reinforced Concrete</b>	12.7%	27%	5%	5%
<b>Unreinforced Masonry</b>	75%	63%	81%	82%
<b>Adobe</b>	9.5%	8%	12%	9%
<b>Rubble Stone</b>	2.8%	2%	2%	4%

Table 1 suggests that at the provincial level unreinforced masonry buildings, with 75%, constitute the largest group. In the sub-provinces that have experienced significant damage, particularly in Erciş, the reinforced concrete buildings constitute 27% of the total building stock. In Van-Merkez the reinforced concrete structures constitute a relatively small amount of the building stock, only 5%. The rest are unreinforced masonry, adobe, and rubble stone. This may be the reason for the high rate of damage and casualty reports from Erciş.

In Figures 4 and 5, building damages as estimated by software ELER (Earthquake Loss Estimation Routine) are presented. Figure 4 shows grid based, D3+D4+D5 (substantial to heavy damage+very heavy damage+destruction) type damages in the region. It is estimated that 3927 buildings may have received that type of damage (Figure 4, top). The largest damage of this type is estimated in grid cells located in Van city center. In Figure 4 (bottom), percentage of estimated buildings in damage state D3+D4+D5 over the total number of buildings in each grid cell is shown. Figure 5 shows etimated, grid based, D1+D2 (slight damage+moderate damage) type damages in the region. It is estimated that 34537 buildings may have received slight or moderate damage. The distribution of the number of buildings in this damage state is given in Figure 5 (top). The percentage of this number to the total number of buildings in each grid cell is given in Figure 5 (bottom). From these figures it can be concluded that a higher portion of the building stock is expected to be in less critical damage states.

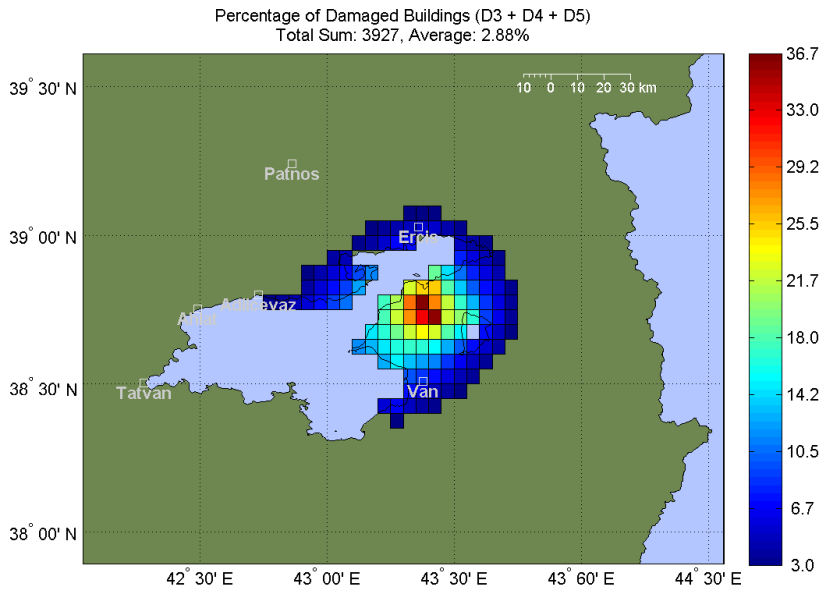
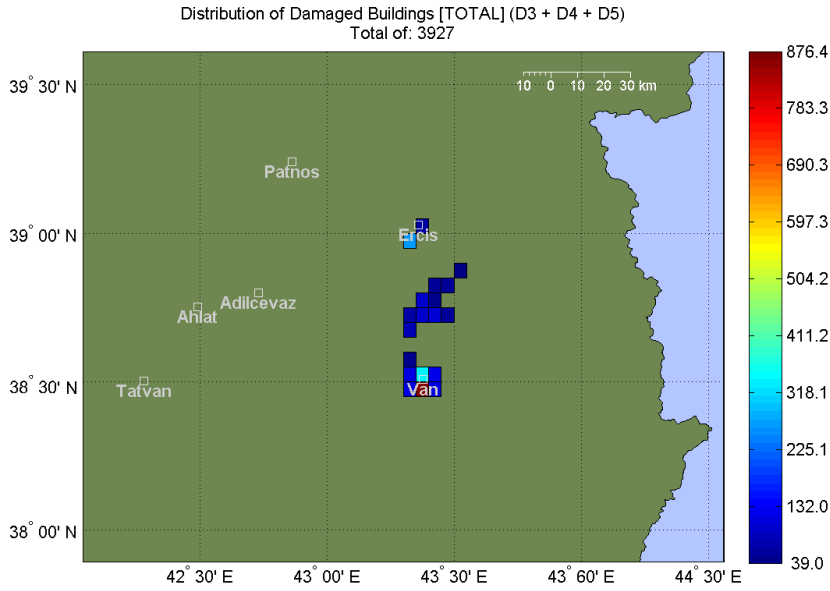


Figure 4. Building damages estimated by ELER, damage type D3+D4+D5. The number of damaged buildings in each grid is shown in the top figure. In the bottom figure grid based percentages of damaged buildings are presented.

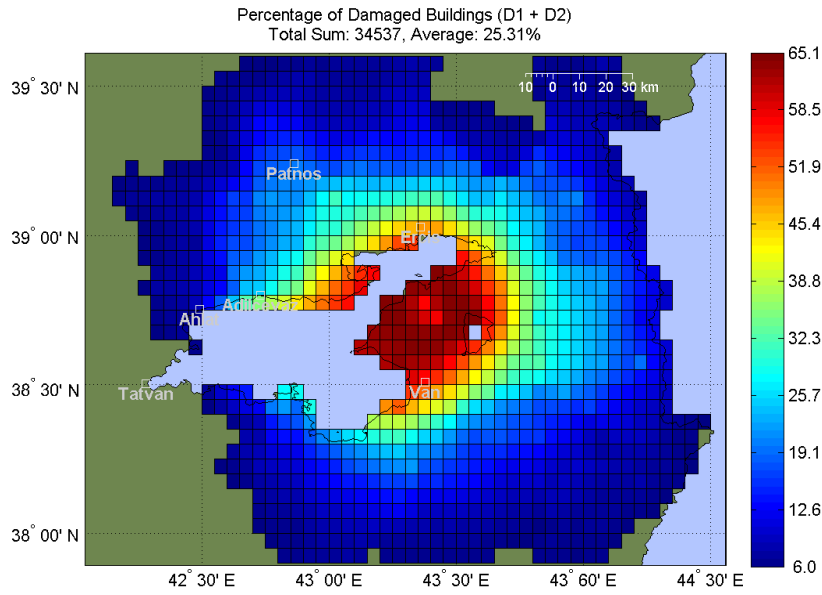
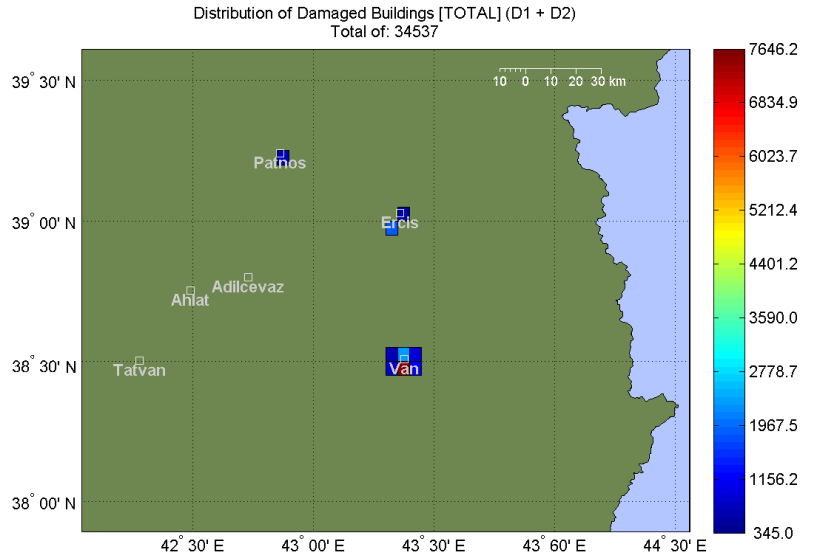


Figure 5. Building damages estimated by ELER, damage type D1+D2. The number of damaged buildings in each grid is shown in the top figure. In the bottom figure grid based percentages of damaged buildings are presented.

### **Casualties**

The numbers of deaths and injuries are still changing. Death toll is expected to increase in the following days. According to the Disaster and Emergency Management Agency of Turkey (AFAD, [http://www.afetacil.gov.tr/Ingilizce\\_Site/index.html#](http://www.afetacil.gov.tr/Ingilizce_Site/index.html#)) 604 people died (as of November 5, 2011) and 2.608 people were injured in the earthquake (as of October 31, 2011)

### **Historical and Cultural Heritage**

The museum of Van received damage as a result of the earthquake. The museum building, a modern structure, and the collections were affected by the earthquake. The extent of damage is currently unclear.

Two minarets in Van, two minarets in Muş and two minarets in Erciş collapsed. There is also minaret damage in the villages.

### **Hospitals**

There are governmental and private hospitals in the region. Although the incoming patients are being treated in open spaces, this appears to be due to their large numbers, rather than structural damage. The governmental hospitals in Van and surrounding provinces appear to have received no or very light damage.

### **Industry**

The industrial enterprises in Van can be classified as small and medium. The industry is clustered in three zones. The old and new automotive mechanic shops are in zones 1 and 2 respectively. The third zone is the main industrial zone of Van where most of the production and storage units are located.

Most of the building damage in zone 1 was limited to damage of the partition walls (Figure 6) . No significant damage was observed in the new section (zone 2). Most of the damage concentrated in the main industrial zone (3) where most of the critical facilities and storage units are located. The main cause of damage was ground shaking. No damage was observed due to geotechnical effects such as liquefaction or soil failure. Most of the small size facilities were not insured.





Figure 6. Damaged walls of a mechanic shops in zone 1 (top). Similar damage to a facility in zone 3 (bottom).

### ***Silos and tanks***

Storage units in Erciş and Van received extensive damage. Many cement and wheat silos which were full at the time of the earthquake, either fully collapsed or were seriously damaged. Some suffered from rupture at their base due to bending or due to insufficient seating width of the supporting concrete. Local buckling or anchorage failures were also observed. Eye witnesses claimed that nearly all of the tall twin silos collided with each other.

The heavy and slender, elevated steel cement silos collapsed due to improper detailing/dimensioning or suffered from inadequate seating width of the supporting concrete (Figures 7-9.)





A number of wheat silos in Van Industrail Zone, collapsed due to inadequate dimensioning (Figures 10 and 11).

Tank damage was minimal. Some amount of deformation was observed at the weak supports of a small elevated fuel oil tanks in Ercis. Small amount of liquid overflow due to insufficient free board was observed. Similar problems occurred in some larger size other tanks in the surroundings of Erciş (Figure 12 and 13).



Figure 7. Collapsed cement silo in the Van Industrial Zone



Figure 8. Damaged cement silo in Van Industrial Zone due to concrete crashing



Figure 9. Collapsed silo on the Ercis-Patnos highway due to failure of the supporting concrete



Figure 10. Collapse of the elevated wheat silos (Facility 1) due to inadequate dimensioning, Van



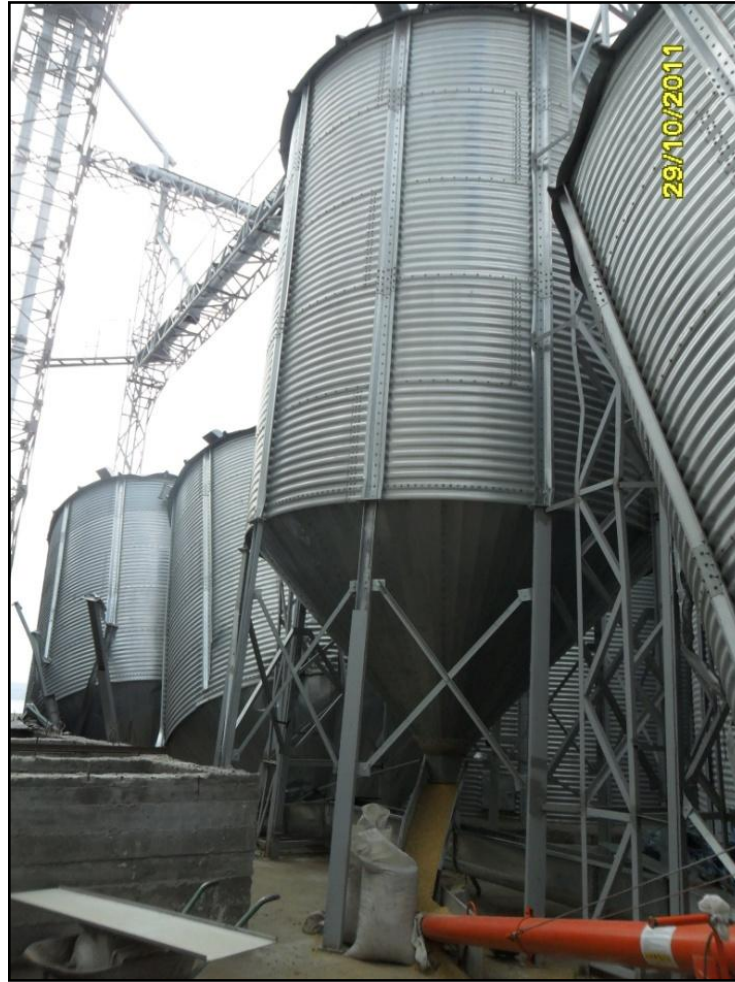


Figure 11. Collapse of the elevated wheat silos (Facility 2) , Van



Figure 12. Overflow of liquid at elevated fuel oil tank (Ercis)



Figure 13. Overflow of asphalt in storage tanks (Ercis-Adil Cevaz highway)

### ***Prefabricated structures***

The heavy precast-concrete frames with precast roof beams suffered from connection problems. Noticable movements were observed at the beam- column connections (Figure 14) of the structures located around the Van-Ercis highway. More severe cases were observed at the Industrial zone of Van. The beams slipped-off from their seats because of inadequate steel-concrete bondage (Figures 15-17). Precast-concrete beams collapsed because of inadequate anchorage at the column –beam connections (Figure 17), at the top. Also column bending cracks occurred at the bottom of columns (Figure 18).



Figure 14. Joint separation in prefabricated structures



Figure 15. Collapsed prefabricated structure in Van Industrial zone (Facility 1)





Figure 16. Failure of precast beams due to weak connection and lack of steel bondage



Figure 17. Collapsed prefabricated structure in new construction in Van



Figure 18. Cantilever column bending cracks at the base

## **Utilities**

### ***Electric distribution system***

In Van, the electricity was shut down immediately after the earthquake for safety purposes. Two hours later, it was provided gradually in order not to cause any harm to people. In the second day, 70% of the city started receiving electricity. In the third day temporary housing units received electricity. Elevated transformers located at the balconies of flexible towers were particularly vulnerable to ground shaking. Brittle bushings were crashed because of the fall of building elements on to the interconnected cables between the transformers and buildings. A total of seven transformers (6x400kW and 1x600 kW) were damaged, burned or broken. Images of damage are provided in Figures 19 and 20).





Figure 19. Burned/damaged 400 kW and 600 kW transformers due to fall from elevated locations



Figure 20. Damage to brittle bushings due to fall of building elements onto the interconnecting cables

### ***Water system***

No damage to water supply and sewage systems was reported in Van. The water supply was uninterrupted. However, pipe breaks occurred outside the city. The water transmission line of 100. Yıl University had pipe breaks at many locations due to soil liquefaction and settlement/land slide (Figure 21). There was a number of pipe breaks in the transmission line from the source to the city. Many pipes had to be repaired in order to provide water to the surrounding villages and to temporary accommodations.

In Ercis, water distribution interrupted for a couple of days due to pipe breaks in the main system. This created a problem due to negative pressure in the system. There were also some

localized damages in Celebibağ region (Figure 22). However after minor repairs and reconfigurations all services were fully functional.



Figure 21. Pipe breaks and repaired sections in Topakca village due to liquefaction induced lateral spreading



Figure 22. Pipe crash and pullouts and repaired pipes in Celebibağ , Ercis

### ***Transportation infrastructure***

Damage to transport infrastructure was minimal. There were cracks on the Van-Ercis highway which were immediately repaired.





### **Geotechnical damage:**

In this section examples of soil failures are presented.

In Çelebibag (Western Ercis near the Erciş-Patnos highway), land slide induced lateral spreading and settlement was observed in weak soils. Permanent ground deformations reached 50 cm in the horizontal and vertical directions. Water transmission/distribution in the vicinity of tension zones were damaged. The damage was repaired immediately after the earthquake (Figure 23).

In Van, extensive liquefaction induced lateral spreading, settlement and rock falls took place near the village Topakca, next to the river in Northern Van, 6 km's to the northwest of the 100. Yıl University (Figures 24- 28).



Figure 23. Soil cracks due to land slide in Celebibag, Ercis



Figure 24. Liquefaction and settlement zone near Topakca village, Northern Van



Figure 25. Sand boils due to liquefaction in Topakca (Mermit) village, Van





Figure 26. Overall basin settlement (upto 50cm) in the village Topakca



Figure 27. Overall basin settlement nearby the Topaktas village



Figure 28. Rockfall in Topaktas (Mermit) village behind the damaged house





## IMPORTANT LINKS FROM THE PRESS ABOUT 10/23 /2011 (13:41:21,VAN EARTHQUAKE ( $M_W=7.2$ , $M_L=6.6$ ))

<http://www.hurriyetdailynews.com/n.php?n=217-dead-more-than-700-wounded-in-eastern-turkey-interior-minister-2011-10-24>

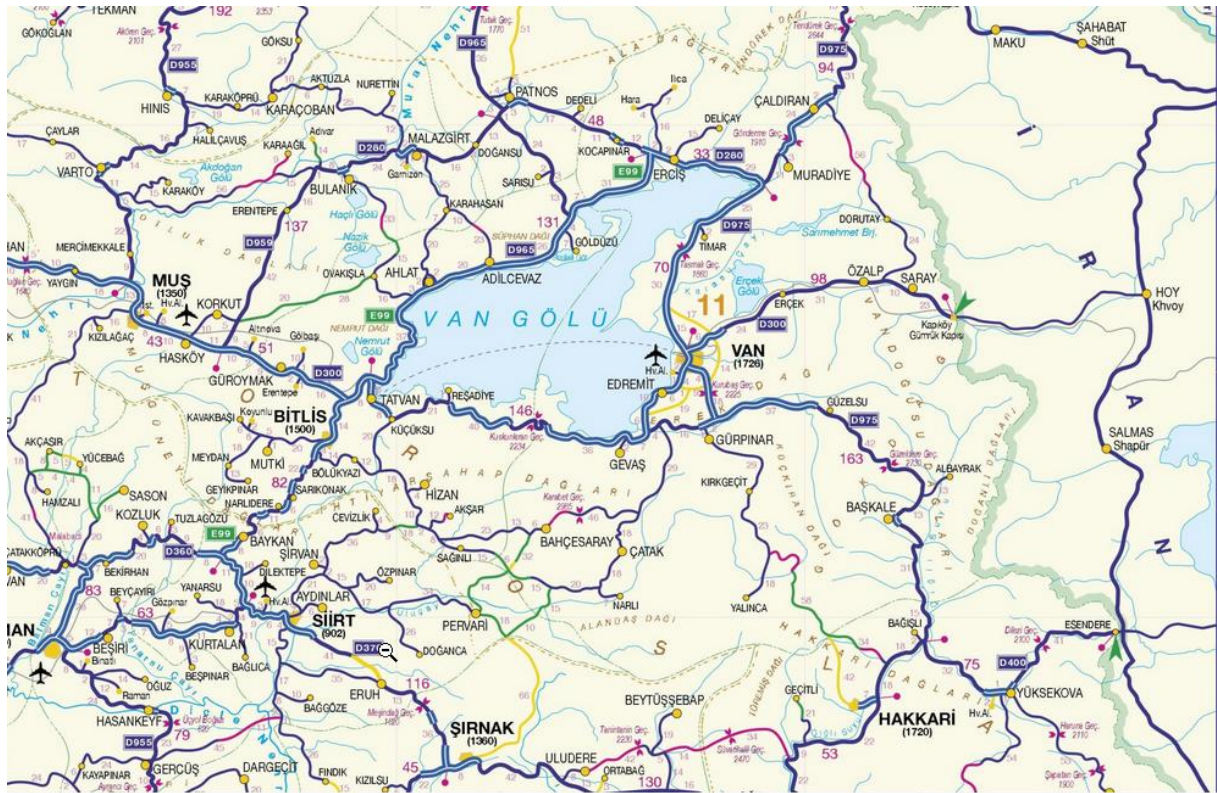
<http://english.sabah.com.tr/National/2011/10/23/72-earthquake-hits-van>

<http://gundem.milliyet.com.tr/olu-tahmini-1000-/gundem/gundemdetay/24.10.2011/1454348/default.htm>

<http://www.bbc.co.uk/news/world-europe-15425268>

[http://edition.cnn.com/2011/10/24/world/europe/turkey-quake/index.html?hpt=hp\\_t1](http://edition.cnn.com/2011/10/24/world/europe/turkey-quake/index.html?hpt=hp_t1)

Airports and highways in close proximity to city of Van are illustrated below



<http://www.kgm.gov.tr/SiteCollectionImages/KGMimages/Haritalar/Turkiye.jpg>

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