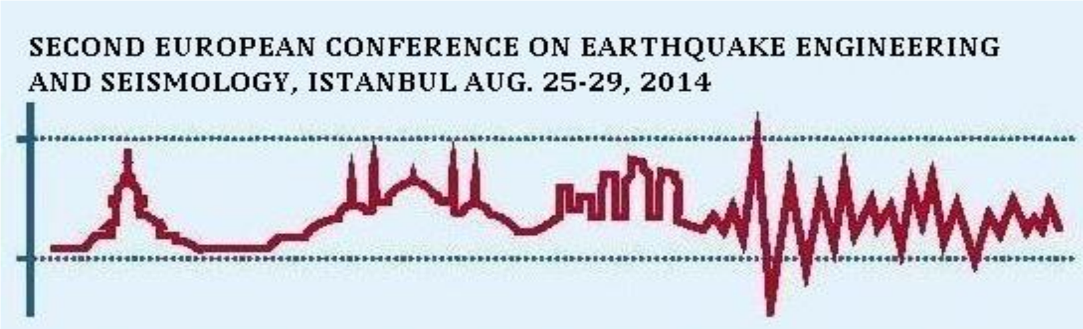

NATIONAL STRONG MOTION NETWORK OF TURKEY

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ABSTRACT

It is clear that destructive earthquakes pose a constant major threat to lives and property throughout Turkey and strong-motion shaking primarily causes earthquake damages. Ground shaking is the most significant hazard in the country because of the resulting potentially widespread destruction. Hence, strong-motion seismology became as a significant application starting from the 1970s. As a result of attempts to understand, predict, and mitigate this hazard, National Strong Motion Network of Turkey (TR-NSMN) was established in 1973. But since 2009, it has been maintained its activities under the Earthquake Department Disaster and Emergency Management Presidency belongs to Prime Ministry. The first strong ground motion had been recorded in 1976 by analog accelerometers. Recently, all analogue, non-communicating instruments have been replaced with new generation digital instruments that provide information in real-time. Over the past 38 years, nearly 11.000 three-component accelerograms have been recorded across Turkey. The collected raw records of all stations are stored in the frame of a national Turkish Earthquake Data Center Project (TDVM-2013) and all data are submitted to researchers, engineers and general public through the Internet under fully open policy. Therefore, users can select specific events or stations to download the waveform data. They can also browse, select, and retrieve various information such as distribution map of PGA, station maps, site information including seismic velocity profiles and soil condition, and so on. Stations are generally abundant on the North Anatolian Fault Zone (NAFZ), East Anatolian Fault Zone (EAFZ), and Aegean Graben System, where destructive earthquakes occurred or bear characteristic of probable seismic gaps. Instruments are installed as free fields in dense urban areas according to standards of international strong-motion stations. The TR-NSMN is composed of 472 strong-motion observation stations. With different regions and arrays, 10 local scale networks, which are yield of different projects or cooperation, around the populated cities, located very close to active faults, have also been operated under the TR-NSMN. The URL of TR-NSMN is http://kyh.deprem.gov.tr.

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INTRODUCTION

The National Strong Motion Network of Turkey (TR-NSMN) was established in 1973 under the Ministry of Republic Works and Settlement General Directorate of Disaster Affairs. But since 2009, it has been maintained its activities under the Prime Ministry, Disaster and Emergency Management Presidency Earthquake Department.

It is well known that destructive earthquakes pose a continuing major threat to lives and property throughout Turkey. One of the most advanced methods for minimize earthquake damages, strong-motion measurements shed light on predicting of site-dependent ground motion resulting from earthquakes. The recordings are fundamental for understanding and characterizing the physics of seismogenic failure, the generation and propagation of damaging ground motions, and the shaking performance of structures. Strong motion records include basic engineering information for earthquake-resistant building design and upgrading of building codes. Thanks to the SM records, by using attenuation relationships; the damage can be estimated at the various distances. Therefore, rapid reporting of shaking levels also helps to focus emergency response efforts in areas where damage is likely to be the greatest.

In this connection, in general, the TR-NSMN seeks to mitigate the impact of future earthquakes by collecting, processing, and disseminating critical earthquake information in a timely way.

NETWORK DESCRIPTION

At the beginning, the network was initiated its activity with 67 analog accelerometers. After 1993, digital accelerometers were integrated into the Network initially. Today, data have been reached to real time and high quality level due to developing technology and increasing number of stations year by year (Fig. 1). As of 2014, old-fashioned instruments have been removed and thus system consists of the instruments that give opportunity for on-line communication. The TR-NSMN has started to record the data as continuous (online) mode and real-time in the frame of a national Turkish Earthquake Data Center Project (TDVM-2013), conducted by AFAD.

At present, the TR-NSMN is equipped with 472 three-component digital accelerometers. It is aimed to have 1000 stations in the network until 2017. In parallel with this aim, approximately, 150 new stations are planned to be added to the existing network for each year.

Accelerometers are mostly deployed around dense cities where suffer from strong earthquakes and broad fault rupture zones such as North Anatolian Fault Zone (NAFZ), East Anatolian Fault Zone (EAFZ) and Aegean Graben Systems on which the big earthquakes occurred or the expected active areas (Fig. 2).

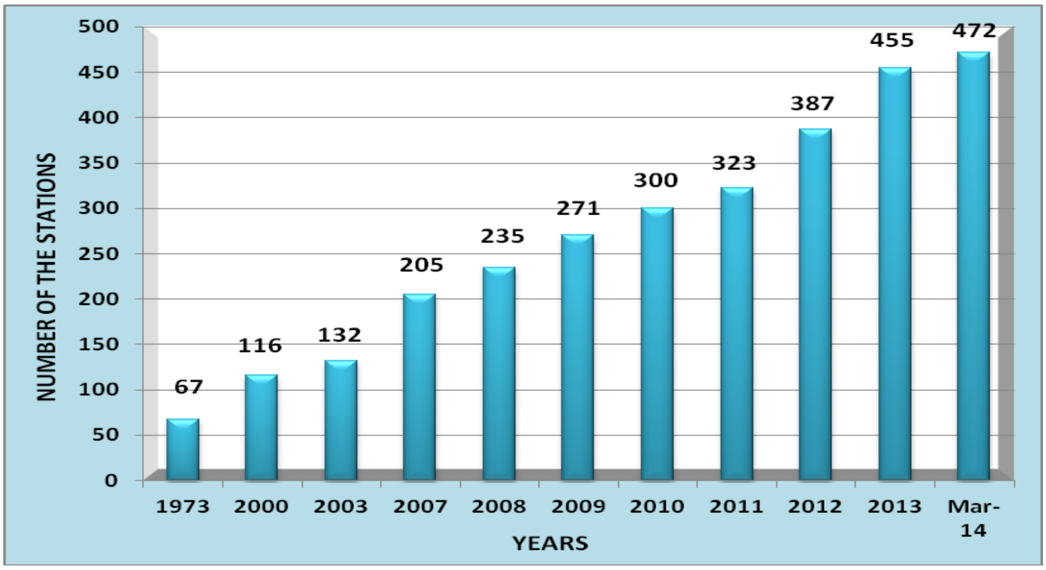

Figure 1. The number of the stations over the years.

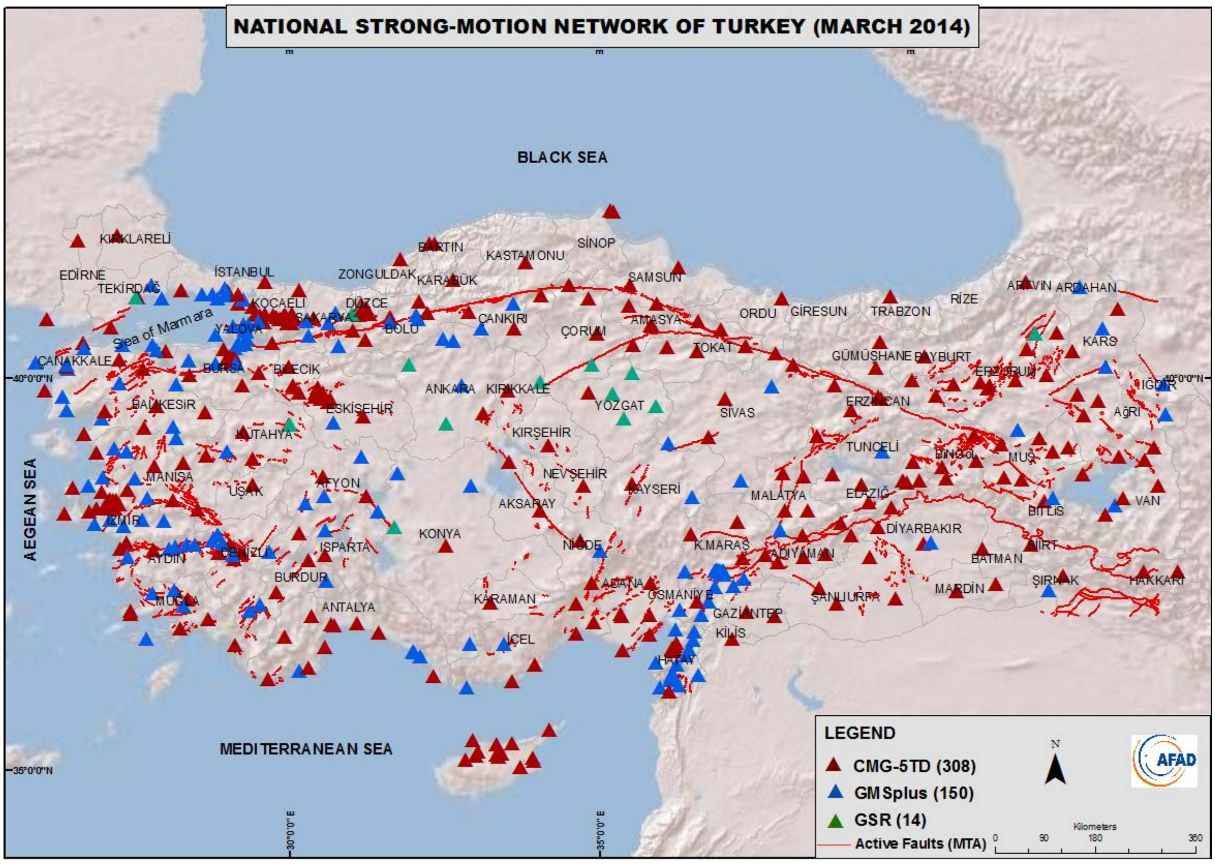

Figure 2. The national strong-motion network of Turkey (TR-NSMN) as of March 2014.

THE CHARACTERISTIC OF THE ACCELEROMETERS AND STATIONS

There are 3 different model digital accelerometers in the network (Fig. 3). These are GSR by GeoSIG (14), CMG-5TD by Guralp (308), GMSplus by GeoSIG (150). GSR 16-18 type accelerometers have 16 and 18 bit digital converter. The CMG-5TD is an integrated DM-24 high resolution digitizer. The full range of flash storage and triggering options is available. GMSplus type accelerometers have been integrated into the network since at the beginning of 2013. It has 24 bit resolution and enables transmission for all records as both continuous and trigger mode at the same time. All accelerographs in the system made up of triaxial force-balance accelerometer.

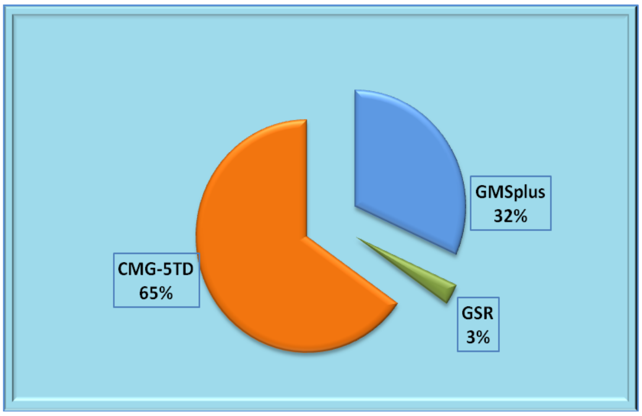

Figure 3. Percentage of the accelerometer types.

Accelerometers are deployed dense urban areas as free fields and mounted in the standardized galvanize hut produced with specific purposes (Fig. 4). Each recorder has been installed by keeping away from buildings to avoid from its effects.

Figure 4. Typical outside and inside view of a strong-motion station.

The instruments are located in governmental building fields owing to ensuring safety and ease of maintenance. While installing, some significant conditions are taken into consideration such as active tectonic lines, population of cities and the dense of buildings, different geological structures, energy lines, communication, security, environmental noise and transportation.

Infrastructure of the stations is built according to a specific plan as seen in the Figure 5. Containers are mounted on the base-concrete, the dimension of which is 220cmx220cmx30cm. The middle-concrete, on which accelerometers are installed, is 40cmx40cm x60cm. While half of middle-concrete is on the ground, the other half is under the ground. There is 20cm space between base and the middle- concrete. Space between them is full of mixture of sand-grovel.

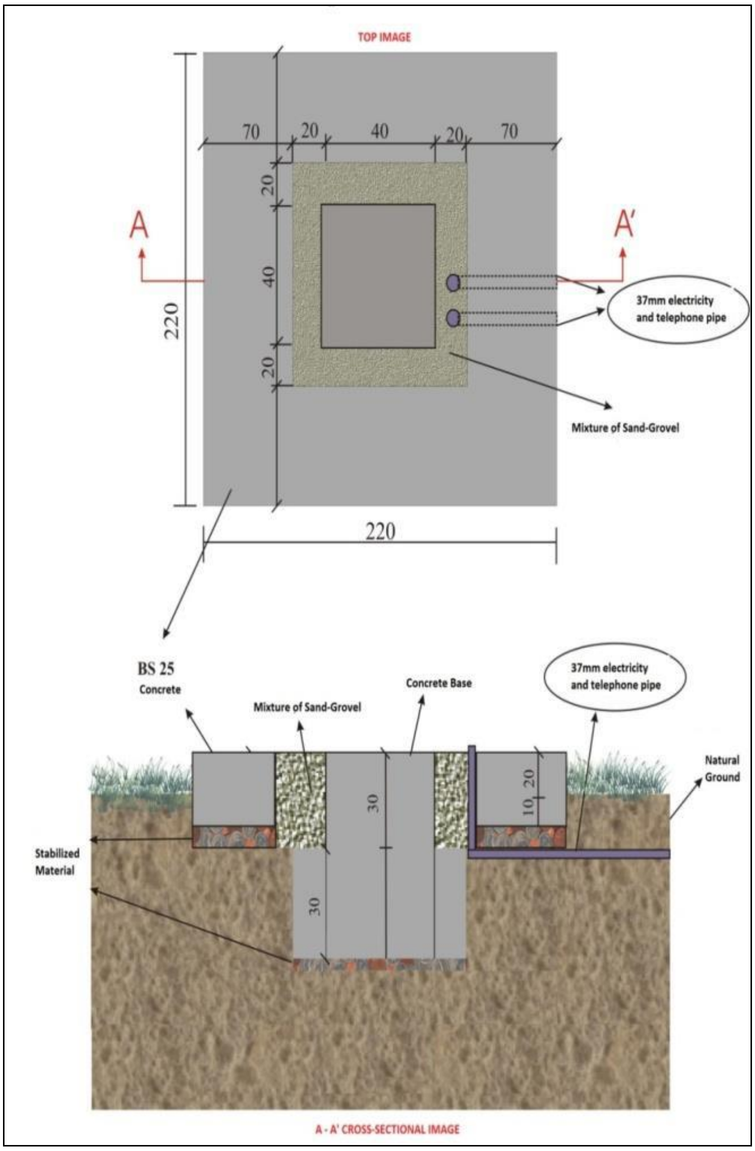

Figure 5. The cross sectional image of infrastructure of the stations.

The data coming from field are transmitted to the data center by means of Dial-Up, ADSL, GPRS and Satellite. Data transferring is mostly provided via GPRS (EDGE) as seen in the Figure 6.

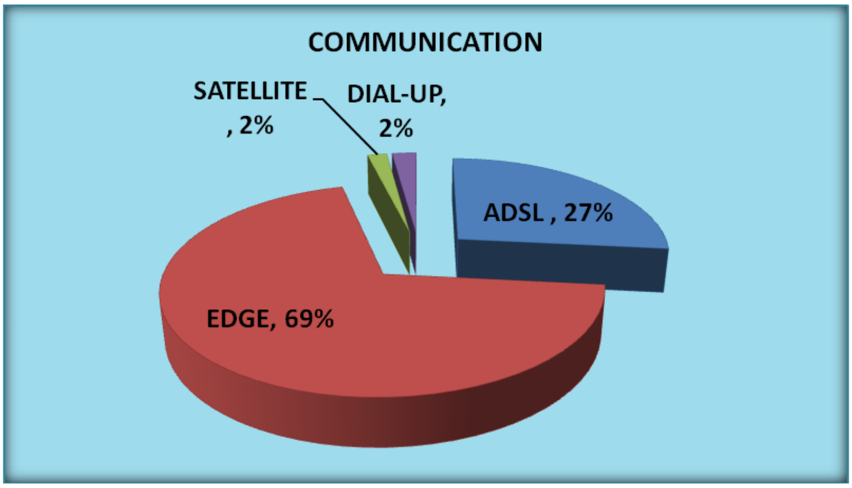

Figure 6. Communication types of SM stations.

Site conditions at the accelerograph sites were investigated through geophysical and geotechnical surveys. The share-wave velocity profiles of the upper 30m were determined with MASW technique, which is used for definition of soil classification. On the web page, V_{S30} values are available in the station information form through which related researchers are able to access to it by using search engine (Fig. 7).

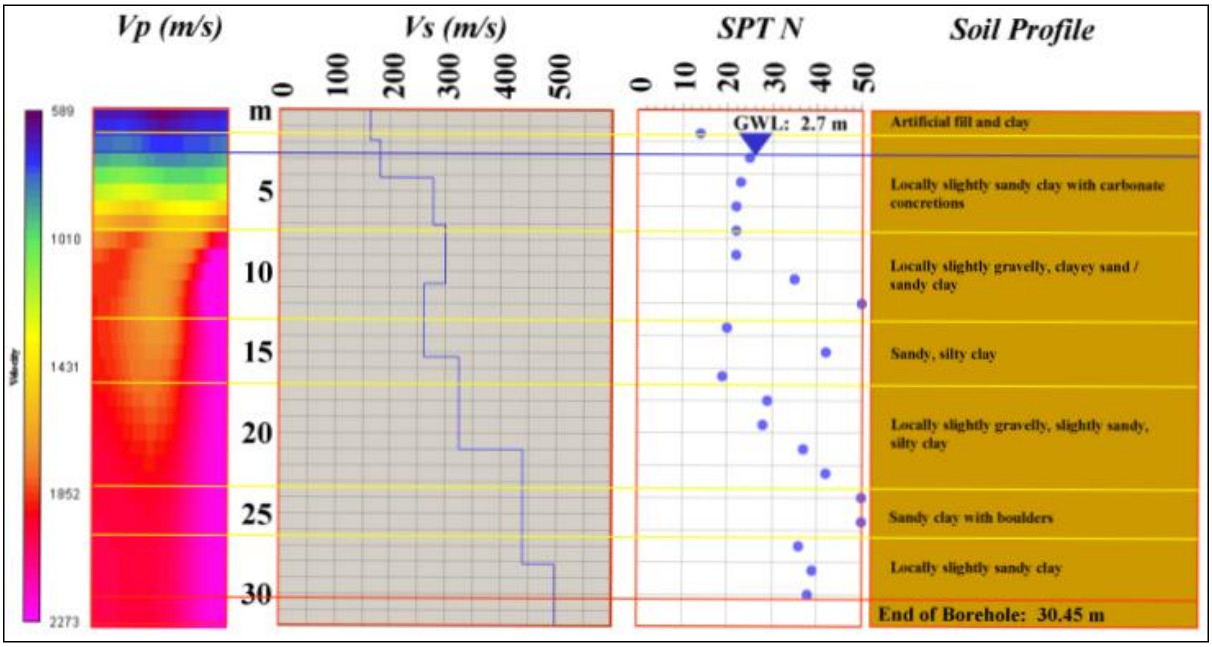

Figure 7. An example of station information form shown on the web site.

LOCAL NETWORKS

Local networks have also been operated within the framework of the different projects or cooperation. These are deployed with specific geometrical arrays on active fault systems in order to observe seismic activity closely.

Currently, with different regions and arrays, 10 local- scale networks around the populated cities located very close to active faults have been operated under the TR-NSMN. The first one is, supported by the NATO Science for Peace Program (SFP977484) in 2001, procured with 20 instruments around two arrays (Gülkan et al. 2007). One of these array has already been positioned between Yalova and Bursa (BYT-NET: 27) region in north-western and the other one is between Aydin and Denizli (DAT-NET: 18) region in western of Turkey. In addition to these, between Hatay and K.Maras region (MAT-NET: 55), in Eskişehir (ANA-NET: 15), in Kocaeli (KOC-NET: 25), in Antalya (ANT-NET: 14) and in Düzce (DUZ-NET: 8) provinces are the others. Another important local array, İZMİR-NET, which consist of 32 stations installed in İzmir province with TUBİTAK support (Polat et al. 2009). The last of these arrays, KKTC-NET (13) and Iskenderun (ISK-NET: 10) have been connected to the national network in 2012. Locations of the local networks are shown in Figure 8. In time, all local networks have been enhanced in terms of both number and instrument quality.

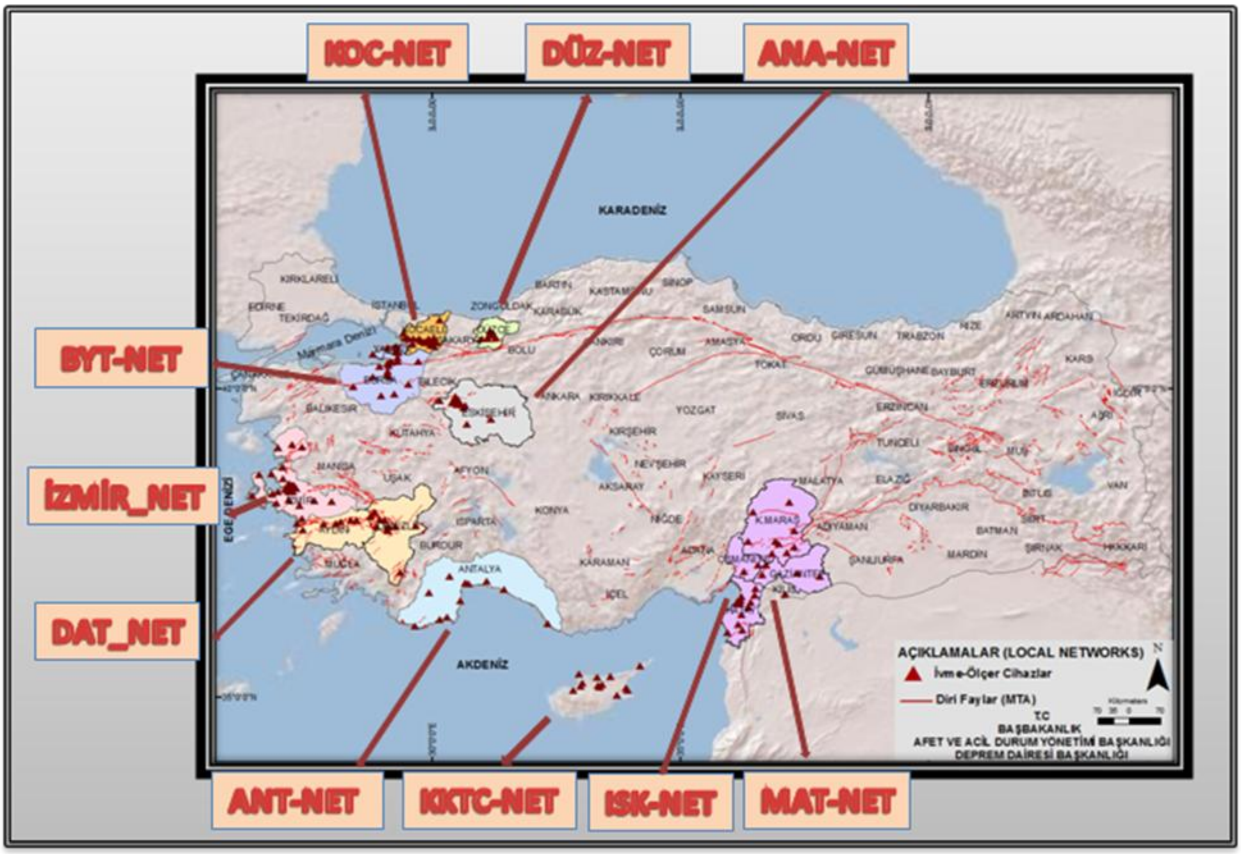

Figure 8. General appearance of local networks.

Apart from local networks, within the framework of the AFAD RED Project (Rapid Loss Estimation Project) 20 accelerometers have been installed both K.Maraş and Hatay provinces in 2013. While installing it, conditions such as density of buildings and population, different sites and geological units etc. were primarily taken into consideration. Initiated for a specific purpose, scope of this project will be extended and will be implemented at the various regions in 2014 as well.

DATA TYPE and FORMAT

The first strong ground motion was recorded in 1976. Since the establishment of TR-NSMN data center (1973), it is possible to access to all accelerograms on the web site.

File names are generated and saved as in this example:

Date (yyyymmdd)+time(hhmmss)+abbreviation of the station (1201)(ex.20030501002704_1201).

All records are created as ASCII format as seen in Figure 9. Beneath the header information there are three components of acceleration data like; N-S (North-South), E-W (East-West) and U-D (Up-Down). Besides, sample interval value for each record can be found in the header information.

There isn’t any process implemented on acceleration data, except for base-line correction, in the other words, records on the web page are entirely raw data and unit of PGA values is cm/sn^2 (gal).

```
STRONG GROUND MOTION RECORDS OF TURKIYE
PLACE                      : DENIZLI MERKEZ METEOROLOJI MUDURLUGU
EARTHQUAKE DATE            : 19/08/1976 01:12:39 (GMT)
EPICENTER COORDINATES      : 37.71000N-29.00000E
EARTHQUAKE DEPTH (km)      : 20
EARTHQUAKE MAGNITUDE       : 5.0ML
STATION ID                 : 2001
STATION COORDINATES        : 37.76219N-29.09222E
STATION ALTITUDE (m)       : 427
RECORDER TYPE              : SMA-1
RECORDER SERIAL NO         : 986
RECORD TIME                : 19/08/1976 01:12:40 (GMT)
NUMBER OF DATA             : 1601
SAMPLING INTERVAL (sec)    : 0.01000000
RAW PGA VALUES (gal)       : (N-S) 348.5268 (E-W) 290.3560 (U-D) 173.2901
Copyright EARTHQUAKE RESEARCH DEPARTMENT
GENERAL DIRECTORATE OF DISASTER AFFAIRS
       N-S           E-W           U-D
   -13.107400    -47.950600    -18.514590
   -13.104980    -47.952520    -27.176980
   -12.865700    -46.140580    -22.777830
   -11.157570    -41.740460      6.933893
        ...           ...           ...
        ...           ...           ...
```

Figure 9. The ASCII data format of TR-NSMN in data base.

In accordance with increasing number of the stations, records have also considerably soared as seen in the Figure 10. To date, much high-quality strong ground motion data has been recorded. Such data are crucial for designing earthquake-resistant structures and understanding the source mechanism of earthquakes and the propagation of seismic waves from source to site, including local site effects.

As of March 2014, totally, 10.984 records, belonging to 4405 earthquake, are submitted to the users via (http://kyh.deprem.gov.tr).

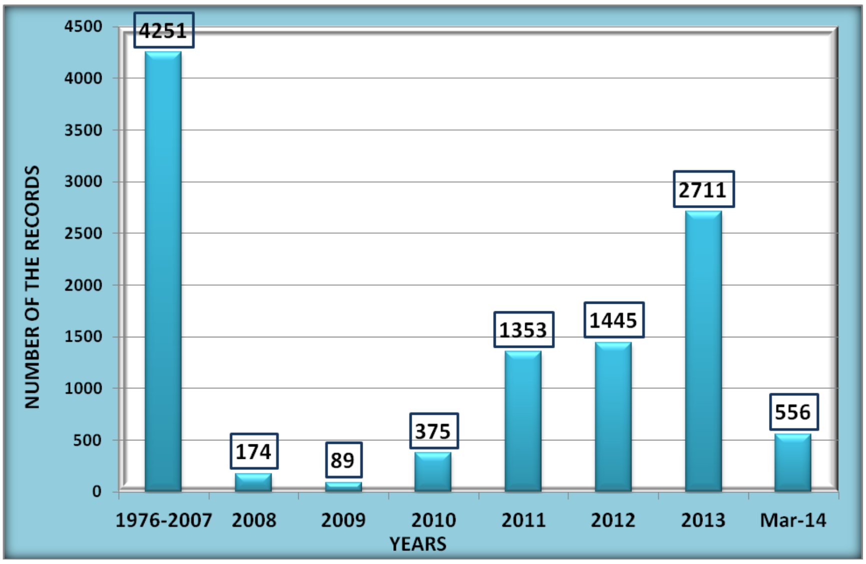

Figure 10. The number of the records over the years.

In this web page, daily strong motion records, earthquake reports (M≥4), station information, including station characteristics and photographs from external and internal, and maps are available and also always up to date. By using search engine users can easily provide the station or earthquake information and also download the Raw Data and its wave form (Fig 11). Detailed Special Reports including significant strong motion parameters are also published after the destructive earthquake.

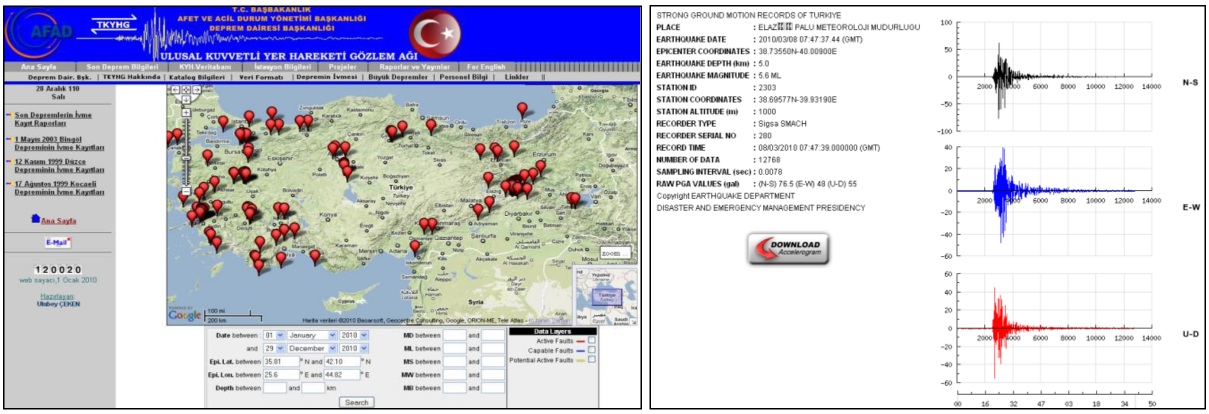

Figure 11. Views from the web page.

TARGETS

In the near future, it was planned to study the following aspects:

- At the end of 2014, it is aimed to have 550 stations in the network. Furthermore, total station number will be 1000 until 2017 according to Disaster and Emergency Management Presidency Strategy Plan.
- Local geology and V_{S30} profile of all stations will be completed.
- The number of local or regional array will be enhanced,
- Shake and intensity maps will be implemented,
- Strong-motion indexes such as real-time intensity, acceleration, velocity, displacement, and response spectra will be calculated continuously and automatically in order to utilize seismic hazard analysis
- Attenuation relationships will be developed at the regional and country scale,
- For the purpose of preparing comprehensive database, which could be beneficial for engineering applications and scientific studies, data will be stored and categorized.

CONCLUSIONS

With 472 accelerometers, the National Strong Motion Network of Turkey (TR-NSMN) is not only one of the greatest regional acceleration networks in the Europe and Middle East, but also one of the greatest in the world. Recently, all analogue and old-fashioned instruments have been replaced with new generation digital instruments that provide information in real-time. Today, the TR-NSMN has recorded almost 11000 recordings started from its first established time in 1976. To realize national data-base, all these events are stored in AFAD ASCII formats together with other earthquake parameters. Users and scientists are able to transfer the ASCII data by selecting some criteria and by using the map or digital graphical interface. Earthquake data and fast-track reports for events above M≥4 have been updating regularly and serving the users, scientist to facilitate their jobs abs scientific studies. Data of TR-NSMN are open to scientific community and can be downloaded via internet web site (http://kyh.deprem.gov.tr).

With the national responsibility the TR-NSMN will also keep on its activity uninterruptedly in the coming years by providing high quality, reliable and rapid strong motion data both nationally and internationally areas with sustainable use of modern technology and innovation.

ACKNOWLEDGEMENTS

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