GeoWatch

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Table of Contents

Local Earthquakes Recorded by Internet Accelerograph

The IA-1 instrumentation in the Schweizerischer Ingenieur- und Architektenverein (SIA, Swiss Engineers and Architects Association) headquarters consisting of 3 IA-1 Internet Accelerographs have captured two recent earthquakes in Switzerland. M_L 3.8 event in Sissach and M_L 4.0 event in Frick, approximately 70 km and 35 km away from the SIA building, Zurich, respectively. The events reported by Schweizerischer Erdbebendienst (SED, Swiss Seismological Service) and as they are recorded in the basement unit of the SIA instrumentation are presented below.

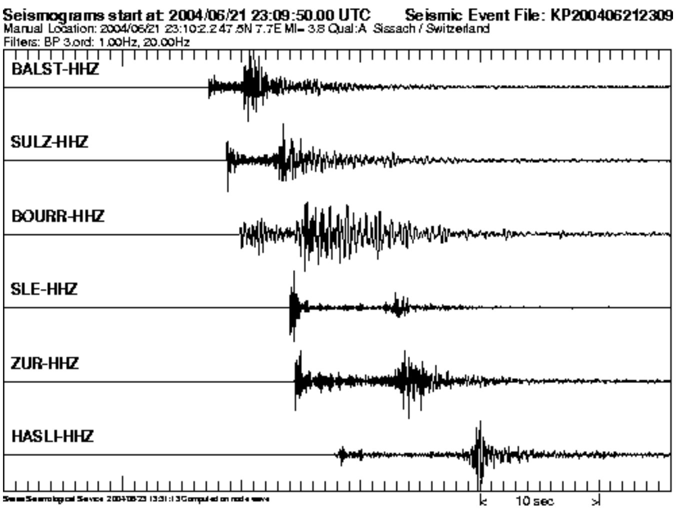

Figure 1. Sissach Event SDSNet Report

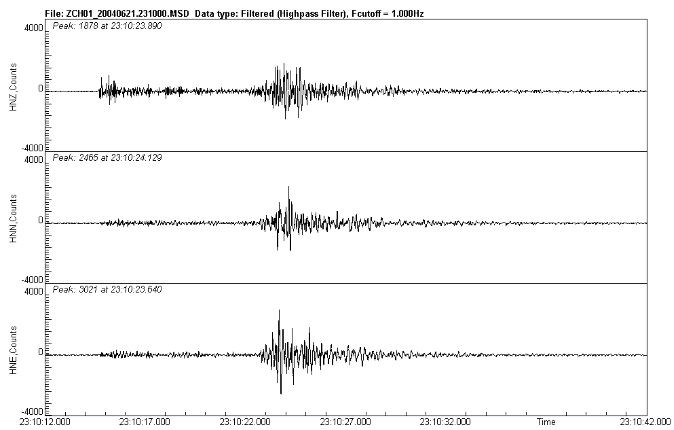

Figure 2. Sissach Event Recorded by SIA Basement Unit

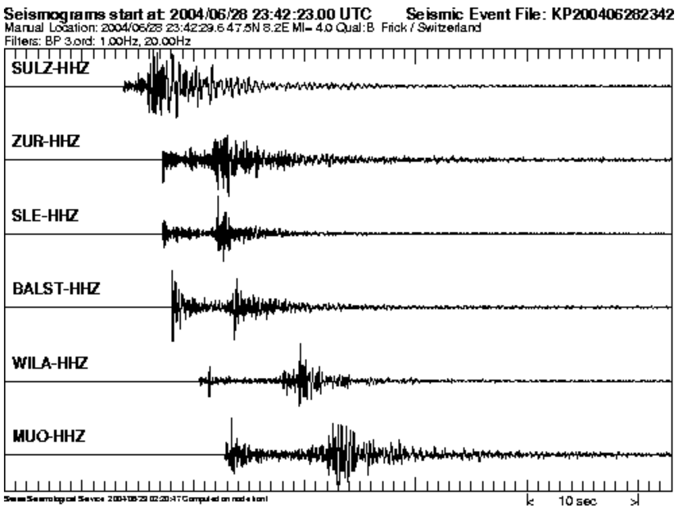

Figure 3. Frick Event SDSNet Report

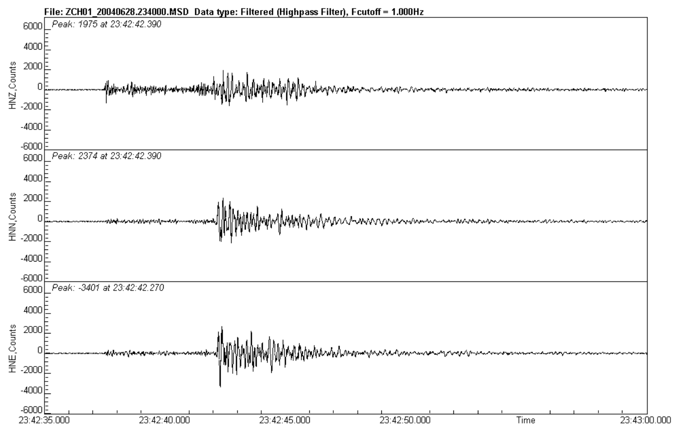

Figure 4. Frick Event Recorded by SIA Basement Unit

The recorded events by the IA-1 at the basement of the SIA building are analysed via GeoDAS by applying 20Hz Lowpass and 1 Hz Highpass filtering. The Vector Sum of the 3 channel data yields the following:

	Sissach	Frick
PGA	8.891×10^{-3} m/s^2 ~0.9 mg	1.061×10^{-2} m/s^2 ~1.1 mg
PGV	2.025×10^{-4} m/s	2.327×10^{-4} m/s
PGD	4.930×10^{-6} m	6.760×10^{-6} m

Technical Note: Istanbul Earthquake Rapid Response and the Early Warning System

GeoSIG would like to thank Prof. Dr. Mustafa Erdik for allowing us to publish their technical note* on Istanbul Earthquake Rapid Response and Early Warning System, which was realized by the Joint Venture Elektrowatt-Ekono AG and GeoSIG Ltd.

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1. Background and Introduction

Potential impact of large earthquakes on urban societies can be reduced by timely and correct action after a disastrous earthquake. The rapid response systems implemented in:

California
USGS, Caltech and CDMG TriNet ShakeMaps
http://www.trinet.org/shake/
Caltech-USGS Broadcast of Earthquakes (CUBE) System
http://www.gps.caltech.edu/~bryant/cube.html
UC Berkeley Seismological Laboratory
and USGS Menlo Park (REDI)
www.seismo.berkeley.edu/seismo/redi
Taiwan
Earth-quake Rapid Reporting System of CWB
http://www.earth.sinica.edu.tw/cdr/IASPEI/data/cwb/rapid.-html
and **Japan**
Real-time Earthquake Assessment Disaster System
in Yokohama – READY –
http://www.city.yokohama.jp/me/bousai/dppc/handout-e.-html

are current examples. Earthquake Early Warning in urban and industrial areas allows for clean emergency shutdown of systems susceptible to damage such as power stations, transportation, computer centers and telephone systems. Currently such systems are either implemented on in construction or planning stage in Mexico, Romania, California, Japan, Taiwan, Turkey and Greece. Early Warning Systems, currently in operation in:

Bucharest
http://www.infp.ro/publications/ews.htm
and **Mexico**
http://www.gfz-potsdam.de/ewc98/abstract/espinosa.html

have the capability of issuing an earthquake early warning in advance, by relying on significant distances between the source and the populated urban regions.

2. Istanbul Earthquake Rapid Response and Early Warning System

Istanbul faces a significant earthquake hazard and risk as illustrated by the recently developed earthquake risk scenario for Istanbul: http://www.koeri.boun.edu.tr/de-premmuh/-EXEC_ENG.pdf. The tectonic setting showing the location of the Main Marmara Fault and EMS98 intensity distribution that would result from a moment magnitude Mw=7.5 scenario earthquake is provided in Figure 5. To assist in the reduction of losses in a disastrous earthquake in Istanbul a dense strong motion network is established. One hundred (100) of the strong motion recorders are stationed in dense settlements in the Metropolitan area of Istanbul in dial-up mode for Rapid Response information generation (Figure 6). Ten (10) of the strong motion stations are sited at locations as close as possible to the Great Marmara Fault in on-line data transmission mode to enable Earthquake Early Warning (Figure 7). The remaining 40 strong motion recorder units will be placed on critical engineering structures in addition to the already instrumented structures in Istanbul: http://www.koeri.boun.edu.tr/depremmuh/-stronmotion.htm. All together this network and its functions is called Istanbul Earthquake Rapid Response and Early Warning System (IERREWS). The system is designed and operated by Bogazici University with the logistical support of the Governorate of Istanbul, First Army Headquarters and Istanbul Metropolitan Municipality. The construction of the system is realized by the GeoSIG Ltd. (http://www.geosig.com) and Electrowatt-Ekono (http://www.ewe.ch) consortium. Communications are provided by ARIA GSM (http://www.aria.com.tr) service provider.

IERREWS consists of the following components:

- Monitoring system composed of various sensors,
- Communication link (off-line for the rapid response and on-line for the early warning) that transmits data from the sensors to computers,
- Data processing facilities that converts data to information, and
- System that issues and communicates the rapid response information and early warning.

3. Rapid Response System

The Rapid Response part of the IERREWS has the objective of providing:

- Reliable information for accurate, effective characterization of the shaking and damage by other rapid post-earthquake maps (Shake, Damage and Casualty maps) for rapid response;
- Recorded motion for post-earthquake performance analysis of structures;
- Empirical basis for long-term improvements in seismic microzonation, seismic provisions of building codes and construction guidelines; and
- Seismological data to improve the understanding of earthquake generation at the source and seismic wave propagation.

The Rapid Response System satisfies the COSMOS (The Consortium of Organizations for Strong-Motion Observation Systems) Urban Strong-Motion Reference Station Guidelines (www.cosmos-eq.org) for the location of instruments, instrument specifications and housing specifications. The relative instrument spacing is about 2–3 km which corresponds to about 3 wavelengths in firm ground conditions and more than 10 wavelengths for soft soils for horizontally propagating 1s shear waves. Strong-motion instruments are generally located at grade level in small and medium-sized buildings, such that the motion recorded corresponds to that on the ground in the surrounding area. Site geology at stations has been characterized in general terms. Certain stations have bore hole data. New bore hole surveys for other stations are being planned. For communication of data from the rapid response stations to the data processing center and for instrument monitoring a reliable and redundant GSM communication system (backed up by dedicated landlines and a microwave system) is used, on the basis of a protocol agreement with the ARIA GSM Service provider. In normal times the rapid response stations are be interrogated (for health monitoring and instrument monitoring) on regular basis. After triggered by an earthquake, each station will process the streaming three-channel strong motion data to yield the spectral accelerations at specific periods, 12 Hz filtered peak ground acceleration and peak ground velocity and will send these parameters in the form of SMS messages at every 20s directly to the main data center through the GSM communication system. The main data processing center is located at the Department of Earthquake Engineering, Kandilli Observatory and Earthquake Research Institute of Bogazici University (KOERI-BU). A secondary center located at the Seismological Laboratory of the same Institute serves as a redundant secondary center that can function in case of failure in the main center. Shake, damage and casualty distribution maps will be automatically generated at the data centers after the earthquake and communicated to the end users within 5min. Full-recorded waveforms at each station can be retrieved using GSM and GPRS modems subsequent to an earthquake.

For the generation of Rapid Response information two methodologies based on spectral displacements and instrumental intensities are used. These methodologies are coded into specific computer programs similar to HAZUS (http://www.fema.gov/hazus/). Both of the methodologies essentially rely on the building inventory database, fragility curves and the methodology developments in the Istanbul Earthquake Risk Assessment Study conducted by the Department of Earthquake Engineering of Bogazici University (http://www.koeri.boun.edu.tr/depremmuh/-EXEC_ENG.pdf).

For the computation of input ground motion parameters, spectral displacements obtained from the SMS messages sent from stations will are interpolated to determine the spectral displacement values at the center of each geo-cell using two-dimensional splines. The earthquake demand at the center of each geo-cell is computed using these spectral displacements. The instrumental intensity at each the center of each geo-cell is computed as a function of short-period spectral acceleration. Using the response spectra and the instrumental intensities the building damage and the casualties are computed separately by using the spectral-displacement based and intensity based fragility curves. The computations are conducted at the centers of a 0.01° x 0.01° grid system comprised of geo-cells (1120 m × 830 m) size. The building inventories (in 24 groups) for each geo-cell together with their spectral displacement and intensity based fragility curves are in-corporated in the software. The casualties are estimated on the basis of the number of collapsed buildings and degree of damage. Example of building damage map that results from a randomly simulated strong motion data is provided in Figure 8. For transmission of the Rapid Response information to the concerned agencies (Istanbul Governorate, Istanbul Municipality and First Army Headquarters) digital radio modem and GPRS communication systems are used. The data will also be made available on the Internet.

4. Early Warning System

The Early Warning part of the IERREWS ten strong motion stations were located as close as possible to the Great Marmara Fault in 'on-line' mode. Continuous telemetry of data between these stations and the main data center is realized with digital spread spectrum radio modem system involving repeater stations selected in the region (Figure 7). Considering the complexity of fault rupture and the short fault distances involved, a simple and robust Early Warning algorithm, based on the exceedance of specified threshold time domain amplitude levels is implemented. The band-pass filtered accelerations and the cumulative absolute velocity (CAV-time integral of the absolute acceleration) are compared with specified threshold levels. When any acceleration or CAV (on any channel) in a given station exceeds specific selectable threshold values it is considered a vote. Whenever we have 2 or 3 (selectable) station votes within selectable time interval, after the first vote, the first alarm is declared. The early warning information (consisting three alarm levels) will be communicated to the appropriate servo shut-down systems of the recipient facilities, which will automatically decide proper action based on the alarm level. Depending on the location of the earthquake (initiation of fault rupture) and the recipient facility the alarm time can be as high as about 8s.

Acknowledgements

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Mr. Lukas Gaetzi (GeoSIG Ltd.), Mr. Talhan Biro (GeoSIG Ltd.), Mr Oleg Razinkov (GeoSIG Ltd.), Mr. Mohammad Hakimi (Yaran Ltd.), Mr. Emre Budak (Sentez Ltd.) and Mr Cagatay Cakan (Aria Inc.).

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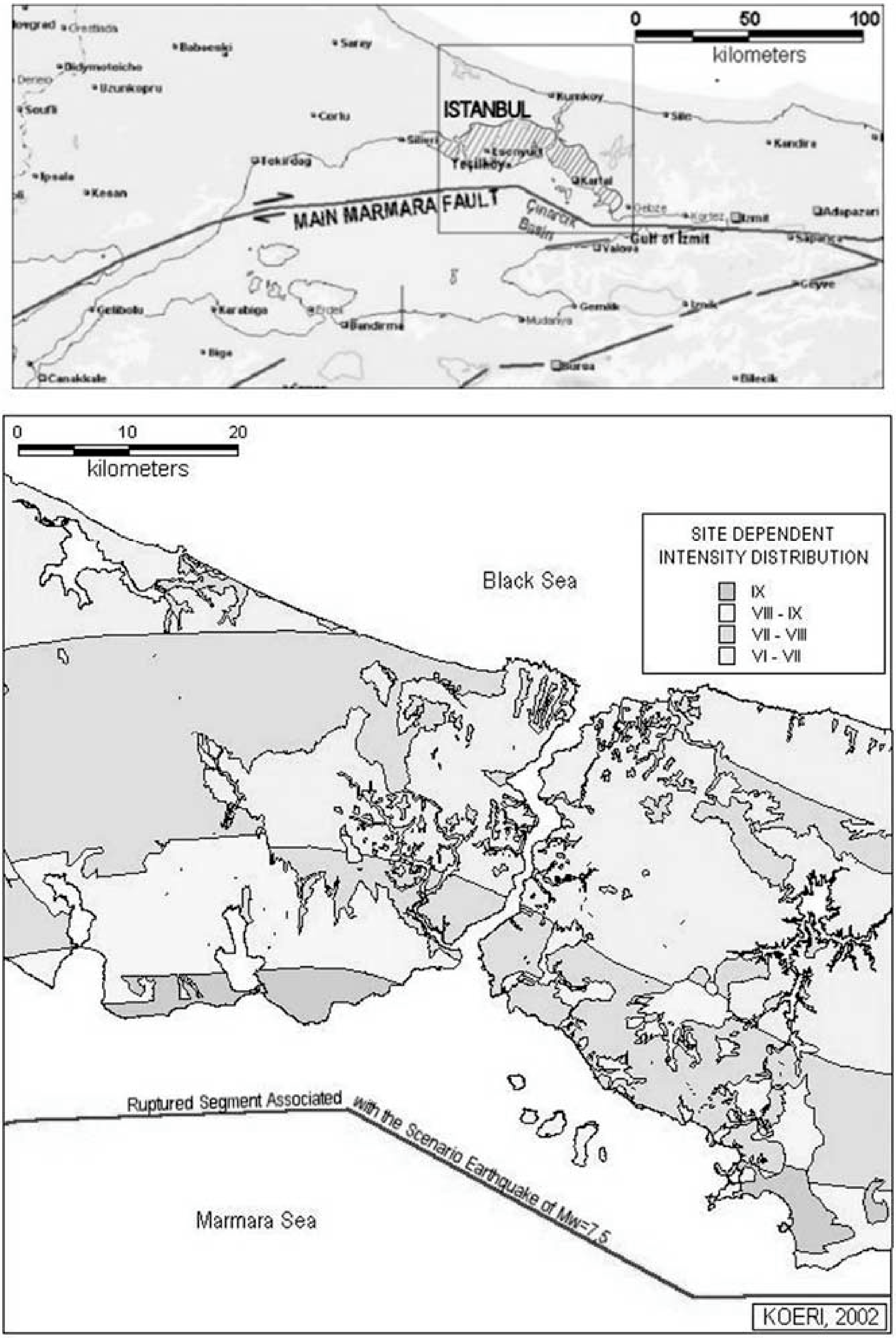

Figure 5. Location of the IRREW System in Marmara Region and Scenario. Earthquake-Based Hazard in Istanbul

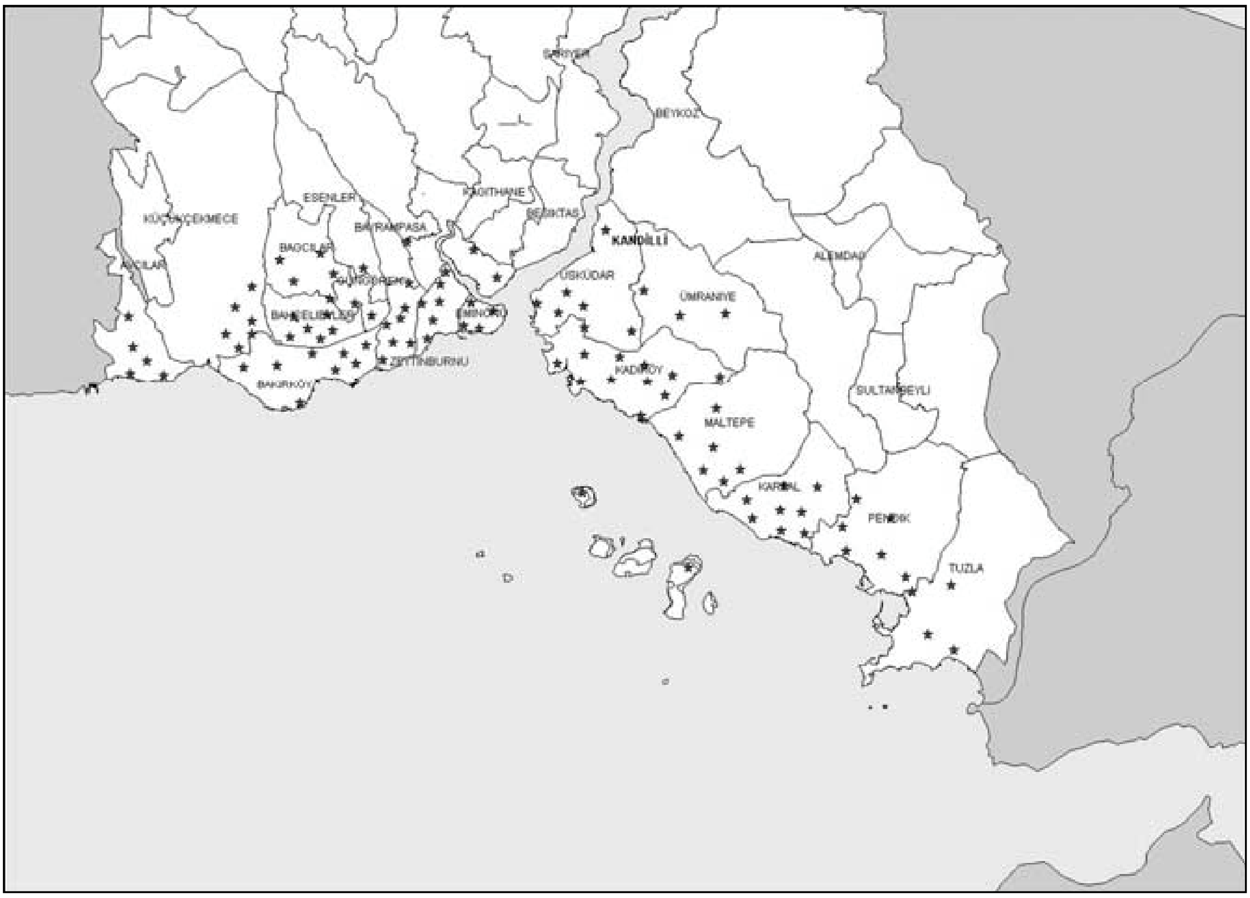

Figure 6. Rapid Response Stations

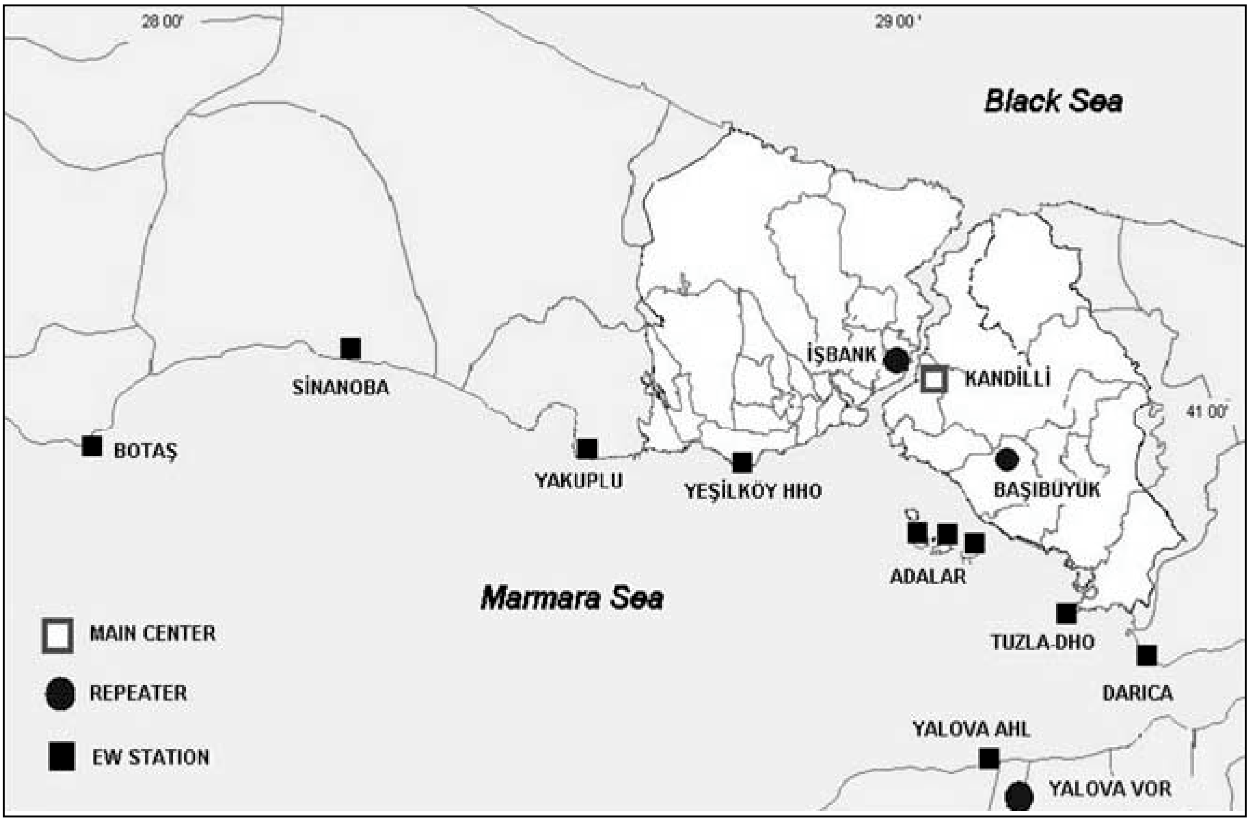

Figure 7. Early Warning Stations

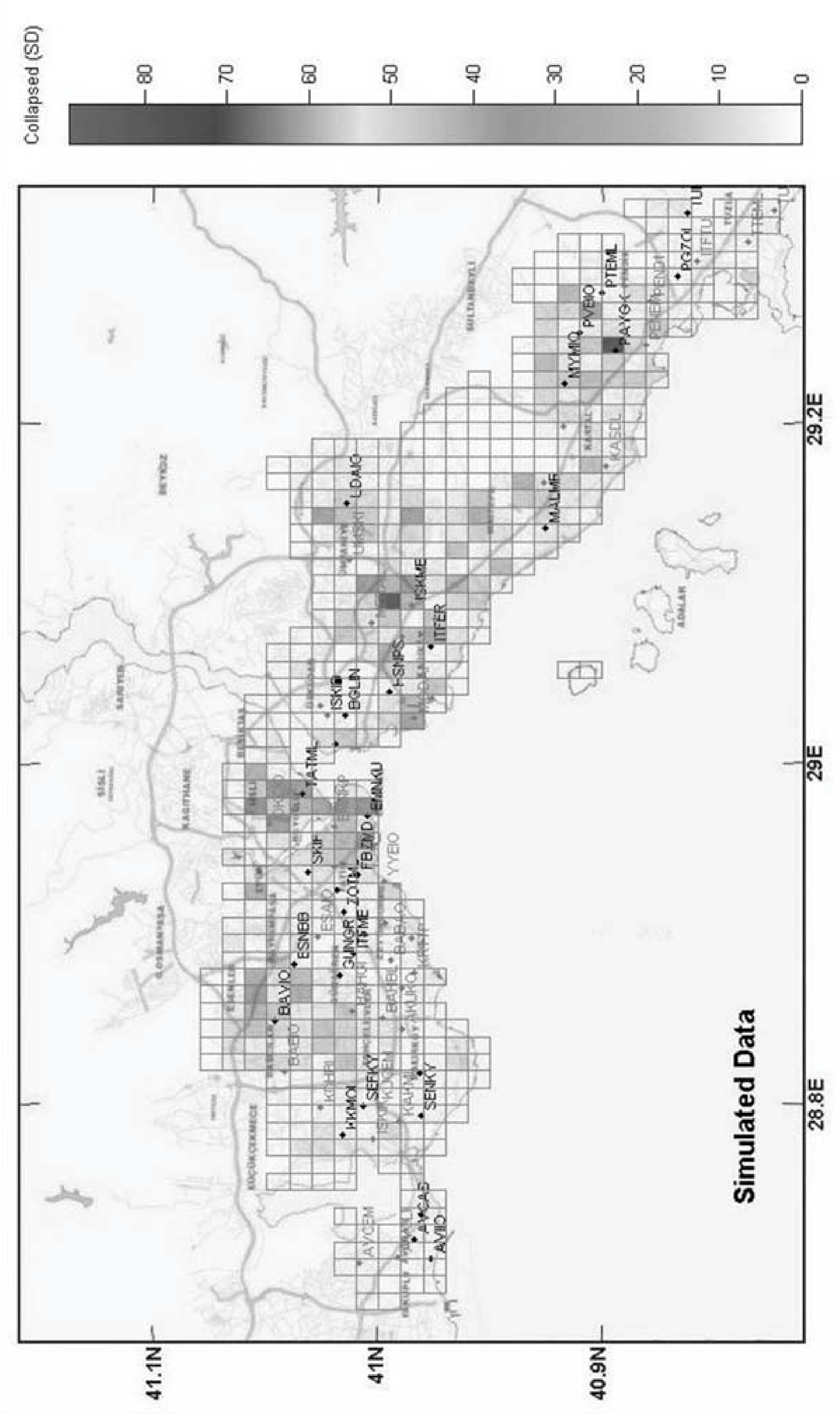

Figure 8. Example of building damage map that results from a randomly simulated strong motion data