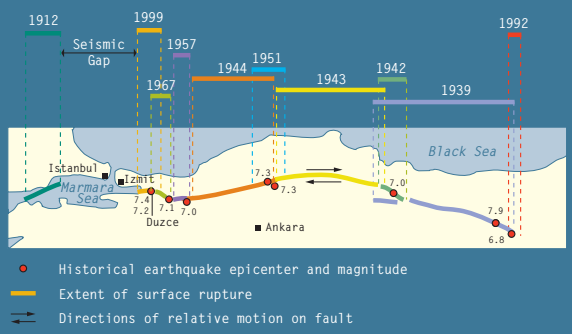
Turkey Earthquake

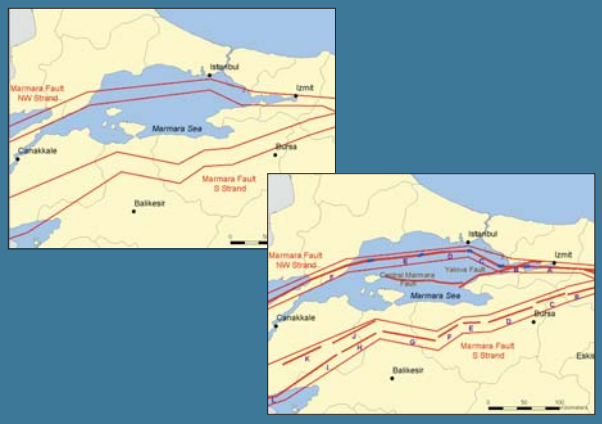
The RMS™ Turkey Earthquake model was developed based on extensive research and consultation with leading U.S. and Turkish experts, and takes advantage of reconnaissance performed by RMS after the 1999 Kocaeli and Duzce earthquakes. The model provides a comprehensive view of earthquake risk in Turkey, including innovative techniques for modeling events and uncertainty in the Istanbul region.

RMS™

Risk Management Solutions



The cluster of earthquakes on the NAFZ in the last century suggests a seismic gap around Istanbul



Alternate sources are considered to account for uncertainty of the seismicity in the Marmara Sea region

Istanbul and the North Anatolian Fault Zone

A significant portion of Turkey is subject to frequent earthquakes, most significantly from the North Anatolian Fault Zone (NAFZ), which stretches across the country and is responsible for many of Turkey's largest historical earthquakes. Though the fault system has been well documented and researched, in the Istanbul region the NAFZ is located beneath the Gulf of Izmit, hiding its structure to geological investigations.

Together with the area around the Marmara Sea, Istanbul accounts for close to 60% of Turkey's insurance exposure. Despite its high exposure, seismic concerns and research were not focused on the Istanbul region until the 1999 Kocaeli and Duzce earthquakes because there had been no significant events in the region since 1874. However, seismic records dating back 2,000 years indicate that large events in the Marmara Sea region occur in clusters of about 300 years. This lack of events suggests a 'seismic gap' that threatens the Istanbul vicinity with a relatively high probability of a large earthquake.

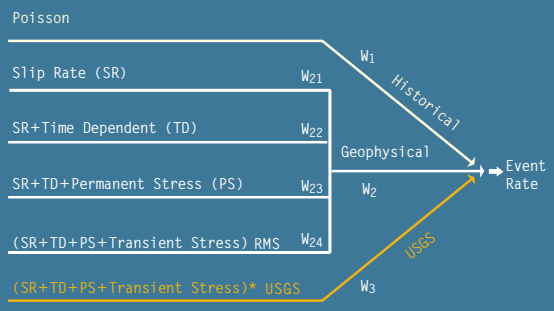
Seismic Source Modeling Across Turkey

The RMS™ Turkey Earthquake model includes area and line sources, as well as a background zone for events occurring outside of the source geometries. Sources are also included that represent earthquakes rupturing multiple segments (cascade events).

Because of the uncertainty in the structure of the NAFZ in the Marmara Sea region, RMS incorporated earthquake sources based on research from the USGS and local experts in Istanbul. The model assumes that the NAFZ splits into two strands when it enters the Gulf of Izmit, and adds two additional faults based on the views of the USGS and other Turkish experts. Rates and maximum magnitudes on specific segments also reflect a balanced view of the different theories of source structure.

Multiple Recurrence Models

For events outside of the Marmara Sea region, a Poissonian recurrence relationship is used. For the NAFZ and the Marmara Sea Source Zone, time-dependency is incorporated to account for stress



A logic tree approach was used to model uncertainty between recurrence models in the Marmara Sea region

RMS collected data on more than 70 major industrial facilities after the 1999 Kocaeli and Duzce earthquakes

build-up along these fault zones. Additionally, for the Northwest strand of the Marmara Sea Source Zone, the effect of stress migration, or the transfer of stress between adjacent segments, is taken into consideration when calculating the probability of stochastic events.

For the Marmara Sea region, the model accounts for uncertainty between the different recurrence approaches using a logic tree method that was applied by weighting the factors and combining them to create a rate for each stochastic event.

Detailed Ground Motion Modeling

For a given event, the model analyzes the attenuation of seismic energy in order to determine the level of ground shaking at a particular site. Attenuation relationships used in the model were calibrated against 25 historical events in Turkey dating back 180 years. To determine how ground shaking at a site will be amplified, RMS developed high-resolution soil and liquefaction data for Istanbul at the Mahalle (district) level, and Ilce (sub-province) level for the rest of the country.

Building Vulnerability

The RMS™ Turkey Earthquake model differentiates vulnerability functions for buildings in large urban areas with high seismicity such as Istanbul, as compared to other regions. Each Ilce (sub-province) in Turkey has been classified into one of these two categories. In addition, vulnerability functions differ by construction type, occupancy class, year built, and building height. The vulnerability model was validated and calibrated using insurance claims and damage data collected from experts and RMS engineers in reconnaissance following the 1999 Kocaeli and Duzce earthquakes.

Industrial Facilities

The Turkey Earthquake model also supports additional vulnerability functions using the RMS™ Industrial Facilities model (IFM). Calibrated against the 1999 Turkey earthquakes and other events, the IFM includes 26 industrial facility types and a full range of construction classes found in Turkey.

Turkey Earthquake Model History

- Released 2002
- Available in RiskLink®-ALM and RiskLink®-DLM

Geographic Scope

All of Turkey

Exposure Data Resolution

Latitude/Longitude, Mahalle (district) for Istanbul, City, Ilce (sub-province), Il (province), or CRESTA Zone

Probabilistic Event Set

- 9,540 stochastic events from 116 seismic sources
- Multiple-segment ruptures included to account for cascade events
- Alternate source models to account for uncertainty of fault structure in Marmara Sea region
- Time-dependency for the North Anatolian and Marmara Sea Source Zones
- Stress migration for the Northwest strand of the Marmara Sea Source Zone
- Recurrence based on Poisson models for the rest of Turkey

Hazard Modeling

- 2 attenuation relationships specific to fault type, reviewed in consultation with local experts
- Soil and liquefaction data at Mahalle resolution for Istanbul, and Ilce for the rest of Turkey
- Calibrated against 25 historical events in Turkey

Vulnerability Modeling

- Building, contents, and business interruption
- Turkey-specific vulnerability functions
- Damage curves accounting for variation in building vulnerability for 2 seismic zones
- 17 distinct building classes and 4 height ranges
- Vulnerability functions for pre-1975, 1975-1998, and post-1998 construction to reflect code revisions
- Building inventory databases reflect building stock mix by areas of urban and non-urban development, occupancy, height, and year built
- Secondary modifiers include shape configuration, soft story, torsion, short column, structural upgrade, construction quality, pounding, and mechanical/electrical equipment

Special Features

- Additional vulnerability curves available for license with the RMS™ Industrial Facilities model

ALM® Profiles

- Resolution: CRESTA Zone and State
- Lines of Business: TCIP (DASK), Residential Excess, Commercial, Industrial, and Commercial/Industrial

Risk Management Solutions, Inc.

7015 Gateway Blvd.
Newark, CA 94560
USA

Tel 1.510.505.2500
Fax 1.510.505.2501
Tel 44.20.7256.3800 (Europe)

Worldwide Web
http://www.rms.com

E-mail
info@rms.com