



Virtual Earthquake Reconnaissance Team (VERT): Phase 1 Response to M7.0 Izmir, Turkey October 30, 2020

By: Yolanda Alberto, Jaskanwal Chhabra, Erica C. Fisher, Manny Hakhamaneshi, Brisid Isufi, Amory Martin, Tonatiuh Rodriguez-Nikl, Sissy Nikolaou, Deniz Ay, Elmon Toraman, Mehmet Unal, Kai Wu

for questions contact VERT report leads:
Erica Fischer (erica.fischer@oregonstate.edu)
Manny Hakhamaneshi (manny.hakhamaneshi@dot.ca.gov)
Mehmet Unal (umehmetu@gmail.com)

Please Note: This report is based on publicly available data on the events. The assessment provided in the report is performed by the judgment of the authors with limited access to ground-truthing.



Topic: Earthquake and Tsunami Characteristics

VERT Phase 2 Response for:
Izmir, Turkey M7.0 Earthquake



Earthquake Characteristics

Date: October 30, 2020 11:51:27 (UTC)

Magnitude: Mw 7.0 (USGS)

Location:

- Epicenter located 15km NNE of Neon Karlovasion, Island of Samos, Greece
- 37.918°N 26.790°E

Depth: 21.0 km ^{1,2}



M7.0 Izmir Earthquake Epicenter ³

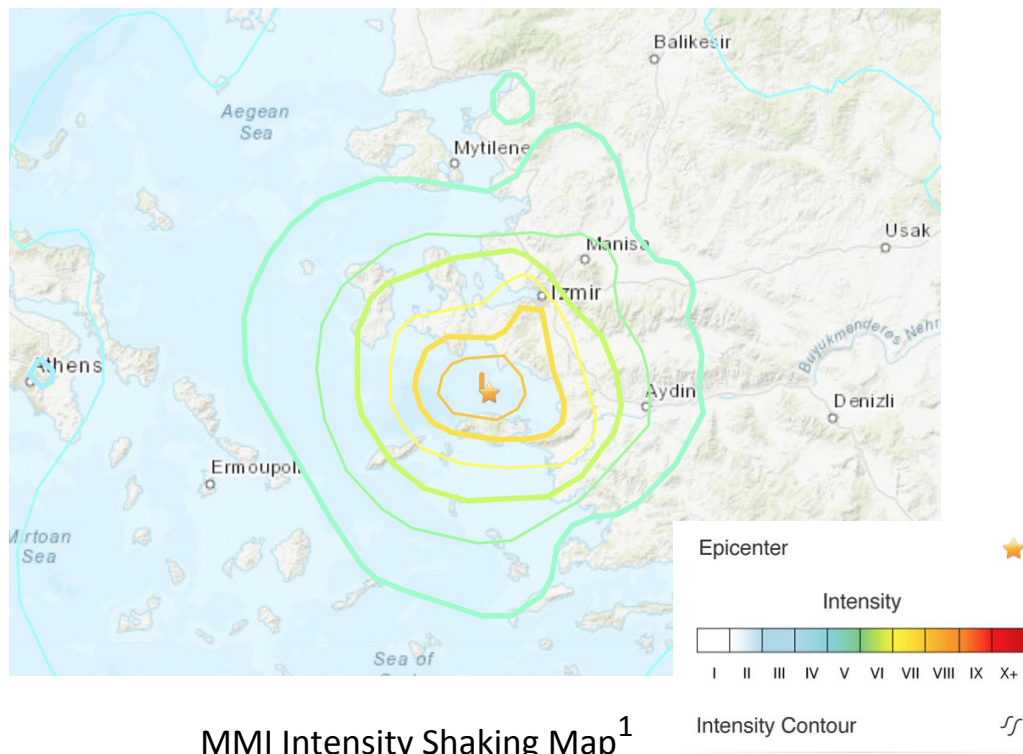
Seismological and Statistical Data, Ground Motions

Fault Mechanism:

- The earthquake resulted from normal faulting at a shallow crustal depth within the Eurasia tectonic plate in the eastern Aegean Sea ¹.
- Maximum Slip: 5m ¹

Max Intensity:

- Severe (MMI: VIII) shaking
- Moderate to Heavy damage

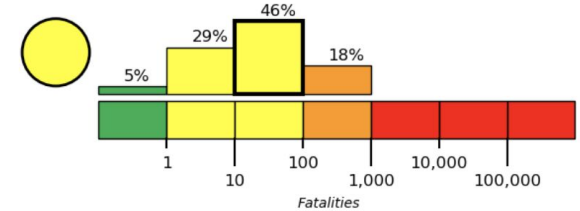


MMI Intensity Shaking Map¹

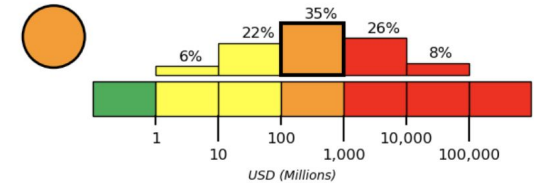
Seismological and Statistical Data, Ground Motions



Estimated Fatalities



Estimated Economic Losses



PAGER Estimations (USGS)¹

Residents and rescue workers search for survivors after a building collapse in Izmir^{4,5}

Seismological and Statistical Data, Ground Motions

Peak Ground Acceleration

- Recorded PGA at epicenter us 0.5g.
- Maximum PGA: 0.97 g recorded at Gumuldur (GMLD) station: 21.2 km distance from epicenter

Nearby Places

Néon Karlovásion, North Aegean, Greece

14.1 km (8.8 mi) SW

Özdere, İzmir, Turkey

32 km (19.9 mi) ENE

Seferihisar, İzmir, Turkey

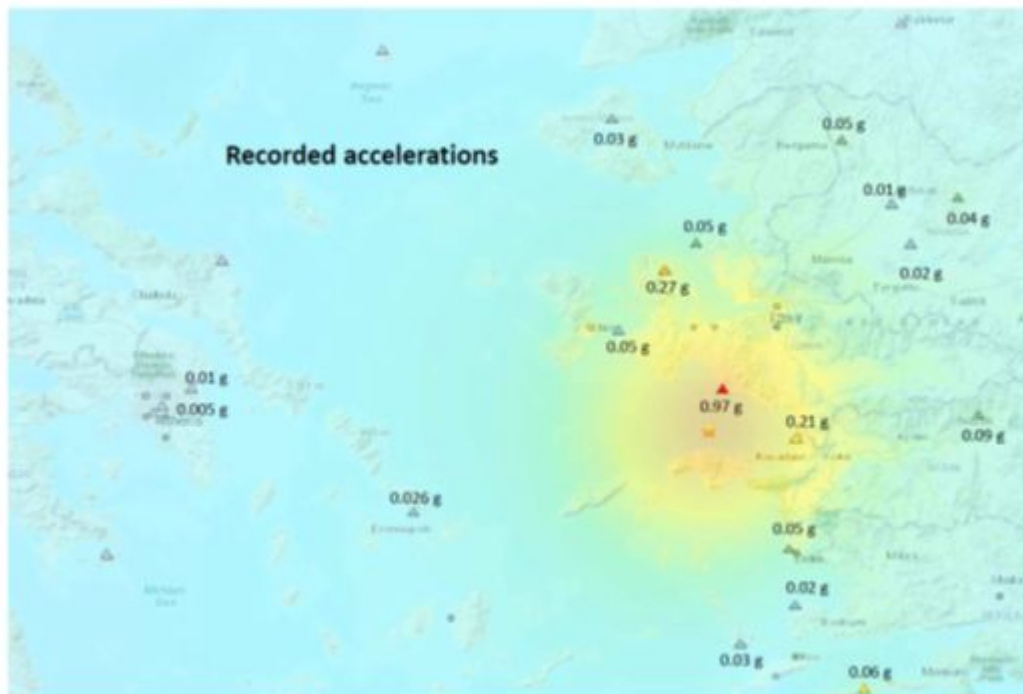
33.6 km (20.9 mi) N

Kuşadası, Aydın, Turkey

40.7 km (25.3 mi) E

İzmir, İzmir, Turkey

64.7 km (40.2 mi) NNE



Recorded Stations¹

Source: USGS

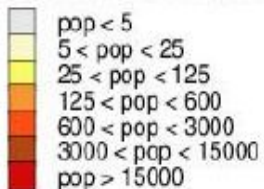
Population of Affected Areas

Sources

- EMSC-CSEM⁷
- NTUA Preliminary Report⁶

★ Earthquake epicentre

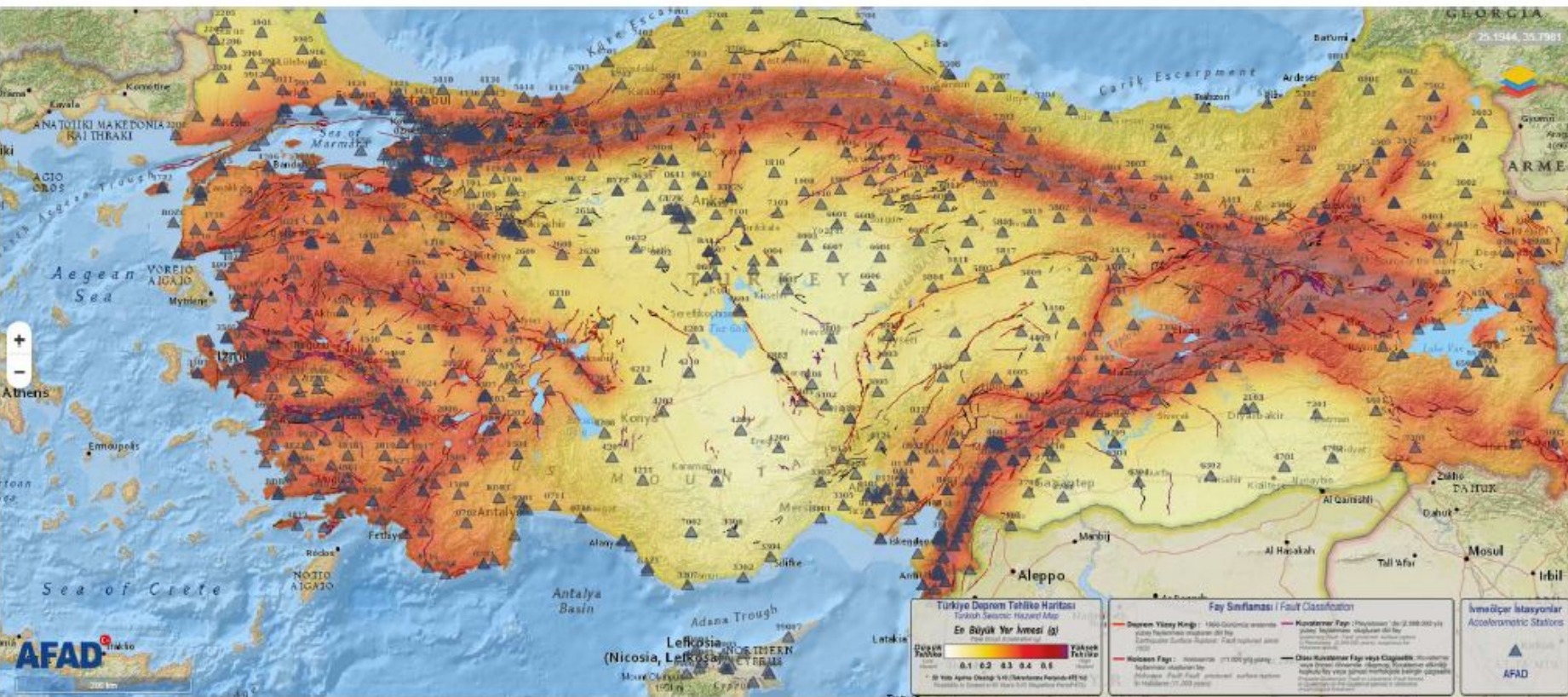
Number of inhabitants per square km





Seismological and Statistical Data, Ground Motions

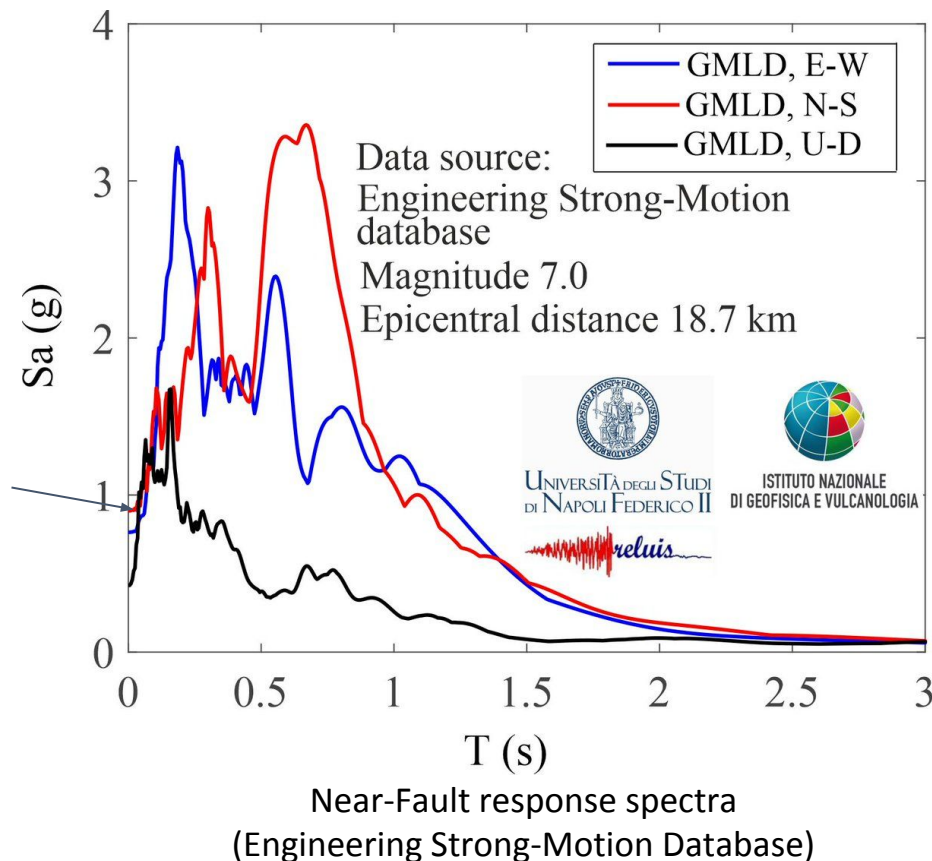
Turkish Accelerometric Station Network



Seismological and Statistical Data, Ground Motions

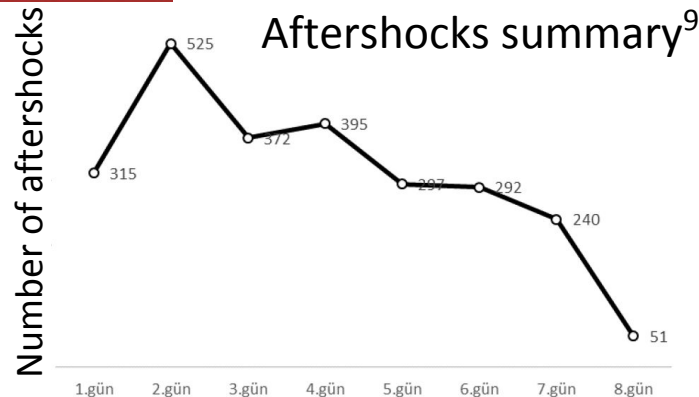
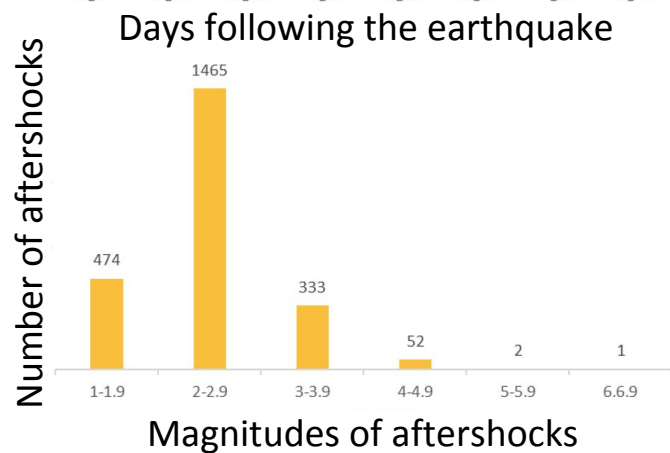
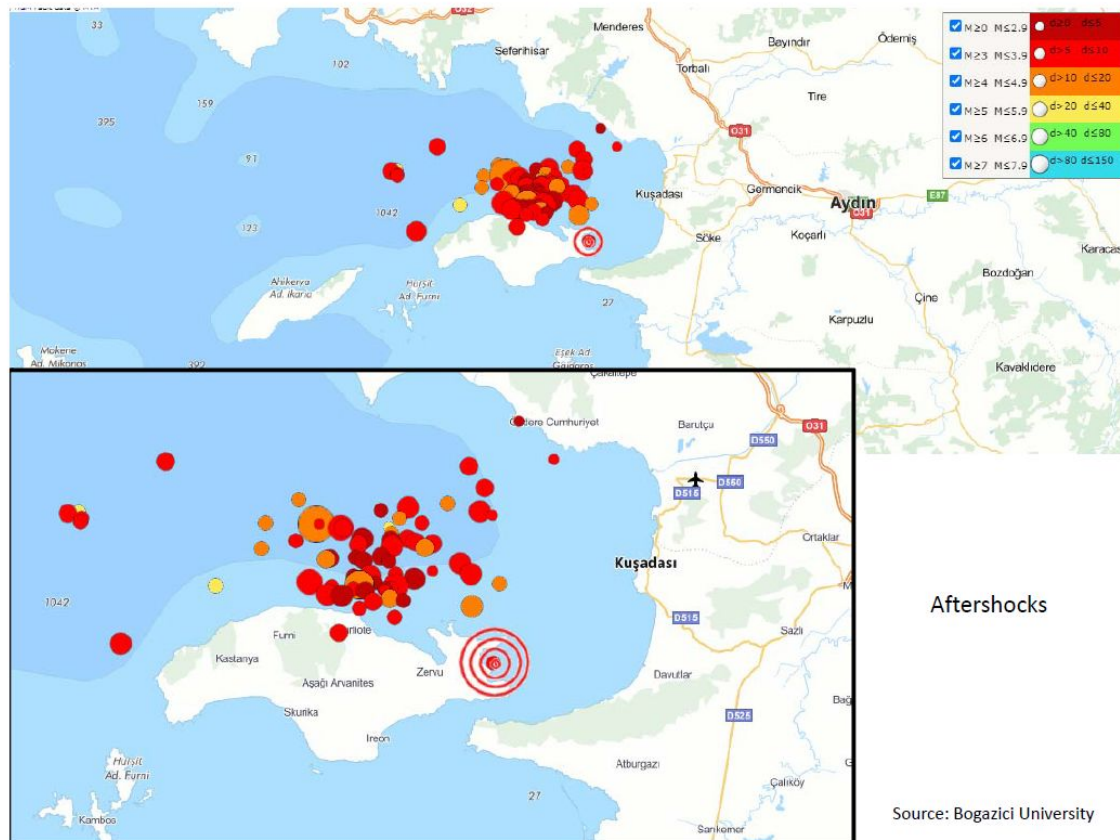
Response Spectra⁶

This is the 0.97 g station





Seismological and Statistical Data, Ground Motions



Location of Aftershocks⁶



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Topic: Building Codes

VERT Phase 2 Response for:
Izmir, Turkey M7.0 Earthquake

Suggested Instructions

- Name of building codes used
- How do the building codes compare to IBC/ASCE 7 if these are not used?
- What year of IBC does the region adopt?
 - Additional provisions and amendments for the region
- Are building codes strictly followed?
- Seismic design category (if applicable)
- Design earthquake acceleration



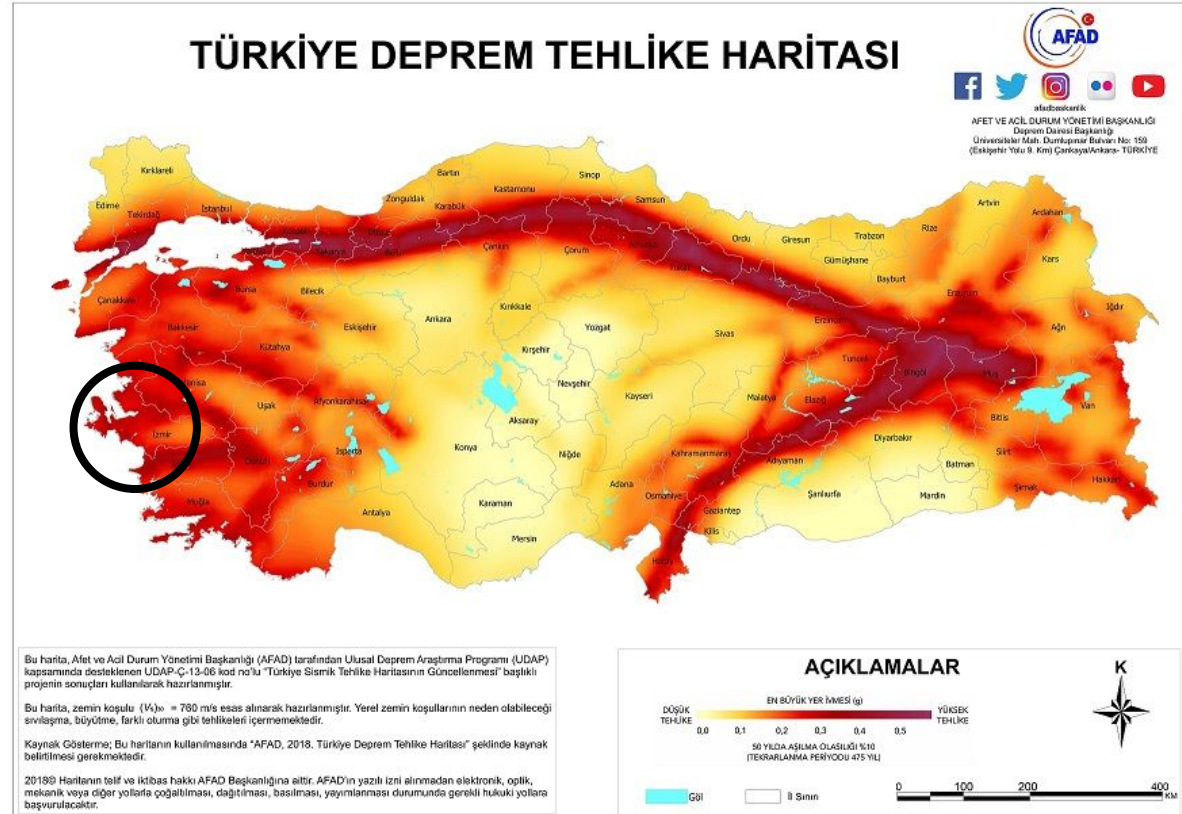
Summary of Building Codes

- *Latest seismic design code* in Turkey was published in 2018.¹
- Provisions for *special detailing for ductility of RC frames* were first published in the 1975 revision of the Turkish design code. However, *non-ductile moment resisting frames* are widespread in Turkey, because the code allowed for the construction of non-ductile buildings.²
- Most of the collapsed buildings were *built before 2000*.³ The latest revision of the design code before 2000 was published in 1997, including a revised zonation map.² *Spectral demands in the 1997 code were comparable to the 1997 Uniform Building Code*.²
- Quality of construction varies significantly from one building to another.² There is a large number of buildings *lacking design documents or a building permit* (illegal construction).⁴

Summary of Building Codes

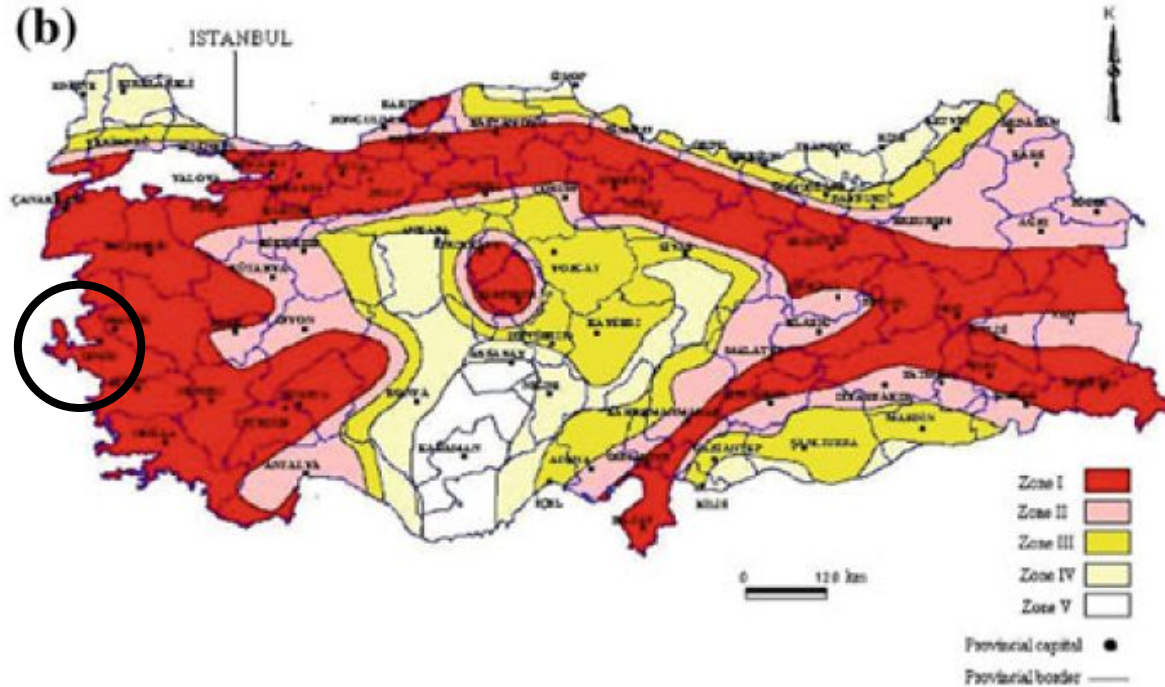
- Latest seismic hazard map was published in 2019:⁴
- The concept of “seismic zones” has been removed in the 2019 revision. Instead, peak ground accelerations are given.⁴
- Izmir: $PGA > 0.3g$.

2019 Turkey's hazard map⁵



Summary of Building Codes

- Before 2019, the concept of “seismic zones” was used.⁶
- Izmir: zone I (highest seismicity)



Turkey's seismic zonation map before 2019⁶

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Topic: Tsunami/Early Warning

VERT Phase 2 Response for:
Izmir, Turkey M7.0 Earthquake

Suggested Topics

- Does an early warning system exist?
- What is the mechanism of delivering the early warning (sirens, text message, application alert)
- Did the early warning activate?
 - If so, what regions received the warning?
 - Did areas not receive a warning that should have?
- Did the early warning work, or were there technological difficulties?
 - If the warning did not go off, or did not work, why not?



Summary of Tsunami Warning System, Location of Impact

- Within **8-11 minutes** after the detection of the earthquake, tsunami bulletins were issued to national focal points by the Tsunami Service Providers (TSPs) accredited by UNESCO's IOC Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (**ICG/NEAMTWS**)*.
- **Greece and Turkey were put on "Tsunami Watch"** (highest level of alert), while other countries either on "Tsunami Advisory" and/or "Tsunami Information" levels.¹
- An **"extreme alert" tsunami warning was issued to island residents**, sending panicked people running into the streets to get away from the shoreline and large buildings.²
- 'İzmir is Not Ready for Earthquake' Warning from İMO İzmir Branch - There was **no early warning system in İzmir**³

Tsunami Warning System, Location of Impact



Tsunami damage in Seferihisar, Izmir⁴



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Topic: Soft story buildings

VERT Phase 2 Response for:
Izmir, Turkey M7.0 Earthquake

Summary of Soft Story Buildings

- At least **20 buildings collapsed** or were severely damaged in Izmir, Turkey.¹
- Most of the affected buildings are **RC frame buildings with 8 - 9 stories**.² Most of the collapsed buildings were **built before year 2000**.³
- Preliminary observations indicate that causes of collapse include **soft story mechanisms, irregularities, quality of materials and detailing of reinforcement**.^[2,3]



Collapsed building²

Summary of Soft Story Buildings

- Most of the collapsed buildings were concentrated in the Bayraklı District.³

Map of collapsed buildings in the Bayraklı district³



Soft Story Buildings



Failure of lower stories, ten story building ³



Failure of lower stories in an 8 story building ³

Soft Story Buildings



Failure of first 3 floors of a building in Demirkent Site in Bayraklı district⁴



Collapse of two floors on the ground floor of the 8-storey Peace Site in Balled support Bayraklı^{5,6}

Collapsed buildings



Pancake type collapse⁷



Partial collapse, pancake type, 8 story building³



Collapsed eight story building³

Other damage patterns in buildings in Turkey



Damage to infills ²

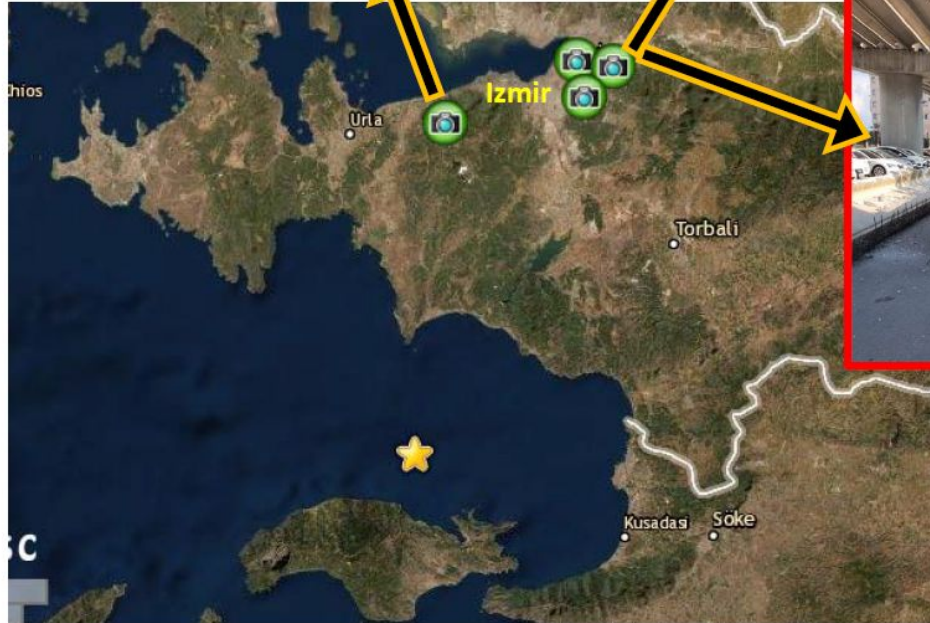


Pounding related damage ²



RC Column shear cracks ³

Other damage patterns in Turkey



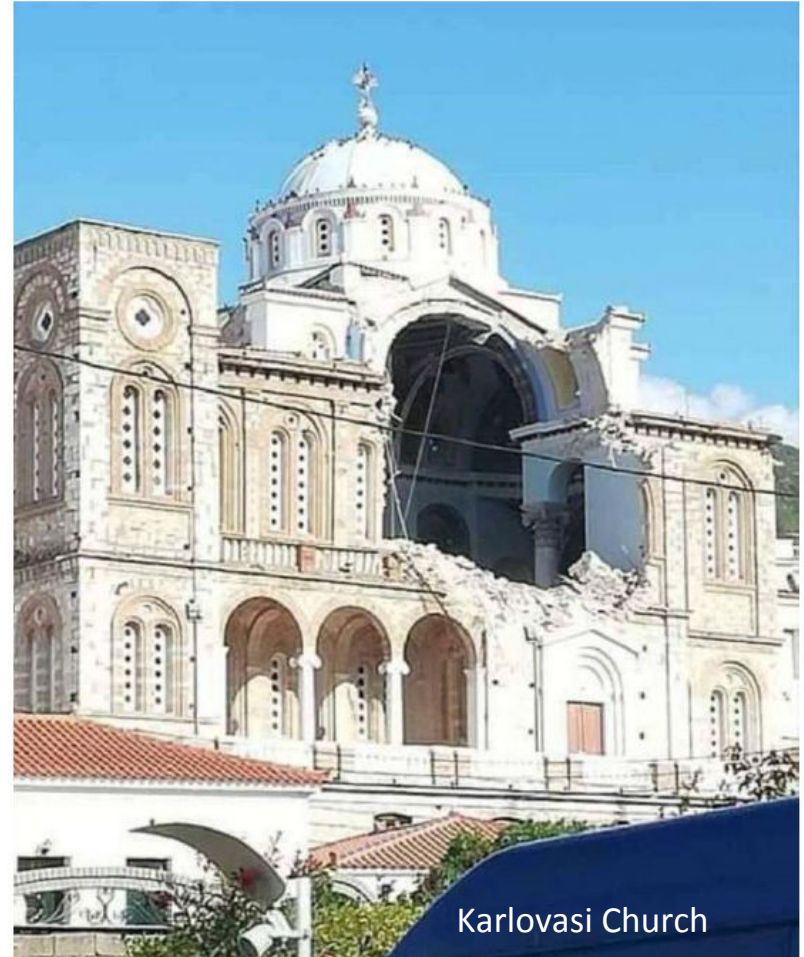
Other damage patterns and locations⁸

Damage in Samos, Greece

- Structural damage mostly of old buildings in Pythagorio, Karlovasi and Vathy ^{1, 9, 10};
- A church in Karlovasi partially collapsed ^{8,9,11}.
- Port damage and tsunami-induced floor



Collapsed old building in Samos (Greece)⁹



Karlovasi Church

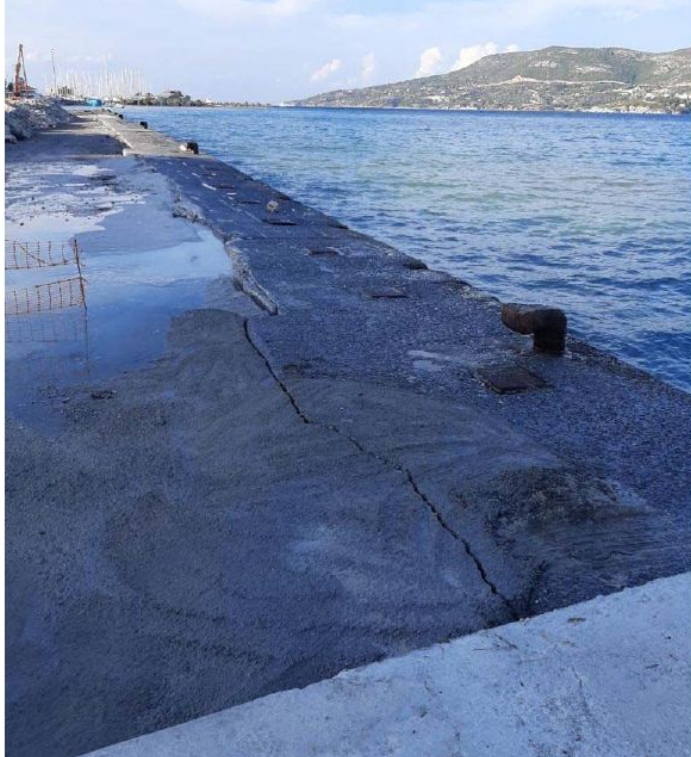
Damage in Samos, Greece

- Port of Vathi:
Flood ⁸



Damage in Samos, Greece

- Port of Vathi: Lateral Movement, Potential Liquefaction-Induced Spread ⁸



Images Source: TO VIMA
[tovima.gr]

Damage in Samos, Greece

- Typical Non-Structural Damage in Samos supermarket ⁸

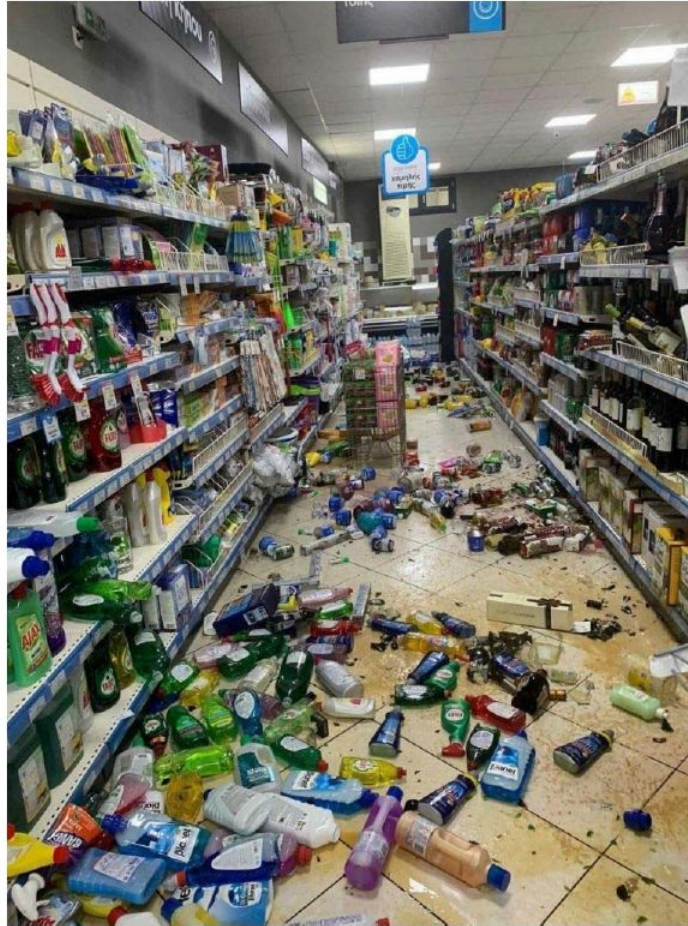


Image Source: in.gr¹²

Damage in Ikaria, Greece

- Rockfalls in the island of Ikaria⁸



Image Source: TO
VIMA¹³



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Topic: Earthquakes and the Pandemic

VERT Phase 1 Response for:
Izmir, Turkey M7.0 Earthquake

Suggested Topics

- Overview of how the government managed post-earthquake emergency management in the midst of the pandemic
- Stresses on health care services
- Management of shelters
- Management of building inspections

Summary of Earthquakes and the Pandemic

- In the shelters and meal lines, use of face coverings were widespread; however,
 - Masks sometimes were not worn properly.
 - Social distancing recommendations were not followed oftentimes.¹
- Five members of a government rescue team formed by 25 people tested positive after the rescue efforts ended.²
- The number of cases doubled after the earthquake.^{3,4}



Summary of Earthquakes and the Pandemic

- Shelters/encampments are cleaned and disinfected daily ⁵
- The entering and exit areas are controlled with digital cards.
- The temperature of the people entering the shelter areas are measured ⁶
- The face covering reminders are not widespread, only in a few locations ⁷
- The Turkish Nurses Association reported many cases of social distancing and hygiene problems in encampments ⁸



One of the four major encampments ⁷



Daily disinfections of tents ⁵



Summary of Earthquakes and the Pandemic

Dünya Doktorları (Doctors of the World) is on the ground providing health service such as psychological support services and COVID-19 kits. Based on staff observations, and needs assessments, the following gaps in services are highlighted ⁹:

- Aid and services in the larger encampments are being provided to the detriment of the small camps, which are reporting more needs.
- More hygiene kits including COVID – 19 PPEs (masks and child-masks) and disinfections are needed.
- More mobile lavatories and showers.
- Psychosocial support, for residents of all ages as well as refugee communities.
- Mobile psychosocial support to reach those staying in smaller encampments or suburbs.
- Awareness raising on available support mechanisms in response to the earthquake, particularly targeting isolated groups such as refugees.

Summary of Tsunami Warning System, Location of Impact



Rescue teams look for survivors and victims in the city of Izmir on November 2, 2020, after a powerful earthquake struck Turkey's western coast and parts of Greece. (AFP)¹⁰



Rescuers from public have pulled more than 100 earthquake survivors from the rubble of Izmir without taking care of COVID-19 health recommendations¹¹



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Topic: Changes since 1999

VERT Phase 1 Response for:
Izmir, Turkey M7.0 Earthquake



Suggested Topics

- Retrofit measures implemented
- Mitigation measures
- How did policy changes perform



Summary of changes since 1999

Background

- A large proportion of the building stock does not comply with the structural/seismic codes in effect at the time of their construction.¹
- Half to three quarters of existing buildings in Turkey lack the required design documents and permits ("illegal construction"). These buildings are generally characterized poor materials and workmanship.¹
- Studies based on scenario earthquakes close to Istanbul estimate 30,000–40,000 heavily damaged buildings (5% of the building stock) with 5000–6000 collapses, 30,000–50,000 casualties and \$11 billion in direct losses due to damage to buildings (citing Erdik et al., 2003; Strasser et al., 2008).¹



Summary of changes since 1999

Timeline

- During the years immediately after the Kocaeli Earthquake in 1999, the priority was restoration of housing and economic activity.¹
- Seismic mitigation efforts attracted relatively modest attention and budget for more than ten years; related research skewed toward seismic risk assessment more than development and implementation of retrofit/renewal strategies.¹
- A notable effort: The Istanbul Seismic Risk Mitigation and Emergency Preparedness (ISMEP) Project started as a World Bank project in 2005 with a €310 million budget which rose to €1.5 2014². The World Bank's involvement with the ISMEP project officially ended in December 2015, after a third and final extension.³ ISMEP is still ongoing under the Governorship of Istanbul with a recently updated closing date of 2021⁴ and the budget has reached \$2.3 billion.^{5,6} The main components of the project are (a) enhancing emergency preparedness; (b) mitigating seismic risk for priority public facilities; (c) enforcing the building code.¹



Summary of changes since 1999

Timeline

- The Van Earthquake of 2011 speeded action on the seismic vulnerability of the building stock; six months after the earthquake, Parliament approved Law No 6306 “Transformation of areas under disaster risk,” (Disaster Law).¹
- The law is implemented by the Ministry of Environment and Urbanization and regulates the identification and renewal of high risk buildings and high risk areas (the cabinet is in charge of the latter).¹
- To facilitate rapid voluntary implementation, renewal projects require the agreement of at least two thirds of the occupants. Objections are reviewed by local technical commissions formed by ministry employees and university professors. Once a building is deemed high risk, the administration has the authority to order a evacuation and demolition. Rent and other assistance to property owners is granted by law, however there are problems in allocations of the funds in practice.^{1,7}

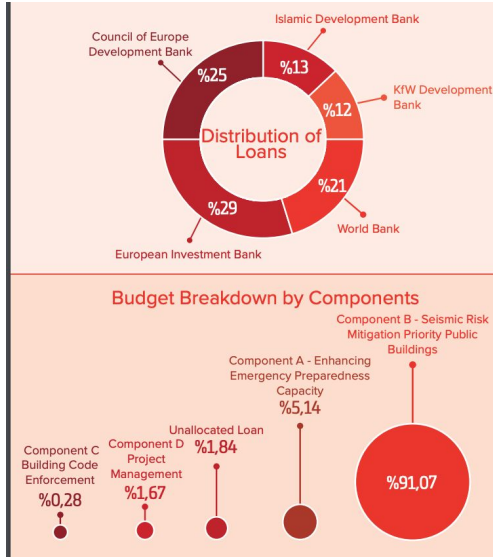
Summary of changes since 1999

- Bayrakli District Municipality established the Earthquake Study Center (BAY-DEM) in 2009 to provide earthquake risk evaluation service for buildings upon residents' request.
- More than 10,000 buildings were evaluated in 10 years, only 5% is found risk-free and 57% is found "very risky".⁸
- Two of the buildings collapsed after the earthquake were analyzed by BAY-DEM (Rıza Bey in 2012 and Doğanlar in 2018) and were found highly risky and further analysis were recommended.⁹



Bayraklı District
Municipality's Earthquake
Study Center⁸

Summary of changes since 1999



2005- Ongoing: ISMEP
Megaproject for Earthquake Risk
Mitigation in Istanbul ⁵



2012: Central Government
enacted Law No. 6306: Law on
Transformation of Areas under
Disaster Risk ¹⁰

T.C. Resmî Gazete

Başbakanlık Mevzuatı Geliştirme ve Yayın Genel Müdürlüğüne Yayımlanır	
18 Mart 2018 PAZAR	Sayı : 30364 Mükerrer

YÜRÜTME VE İDARE BÖLÜMÜ

BAKANLAR KURULU KARARI

Karar Sayısı : 2018/11275

Türkiye Deprem Tehlike Haritası ve parametre değerleri hakkındaki Kararın yürürlüğe konulması; Başbakan Yardımcılığı (Afet ve Acil Durum Yönetimi Başkanlığı)'nın 12/1/2018 tarihli ve 6925 sayılı yazısı üzerine, 15/5/1959 tarihli ve 7269 sayılı Kanunun 2 nci maddesine göre, Bakanlar Kurulu'na 22/1/2018 tarihinde kararlaştırılmıştır.

Recep Tayyip ERDOĞAN
CUMHURBAŞKANI

2007 and 2018: New Building
Codes for Earthquake Resilience
^{11,12}

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Topic: Soil amplification/Geotechnical impacts

VERT Phase 1 Response for:
Izmir, Turkey M7.0 Earthquake

Suggested Topics

- Impact of soil amplification on building damage and locations
- Comparison of recorded ground accelerations to code-prescribed numbers
- Summary of geotechnical damage including locations

Summary of other soil amplification

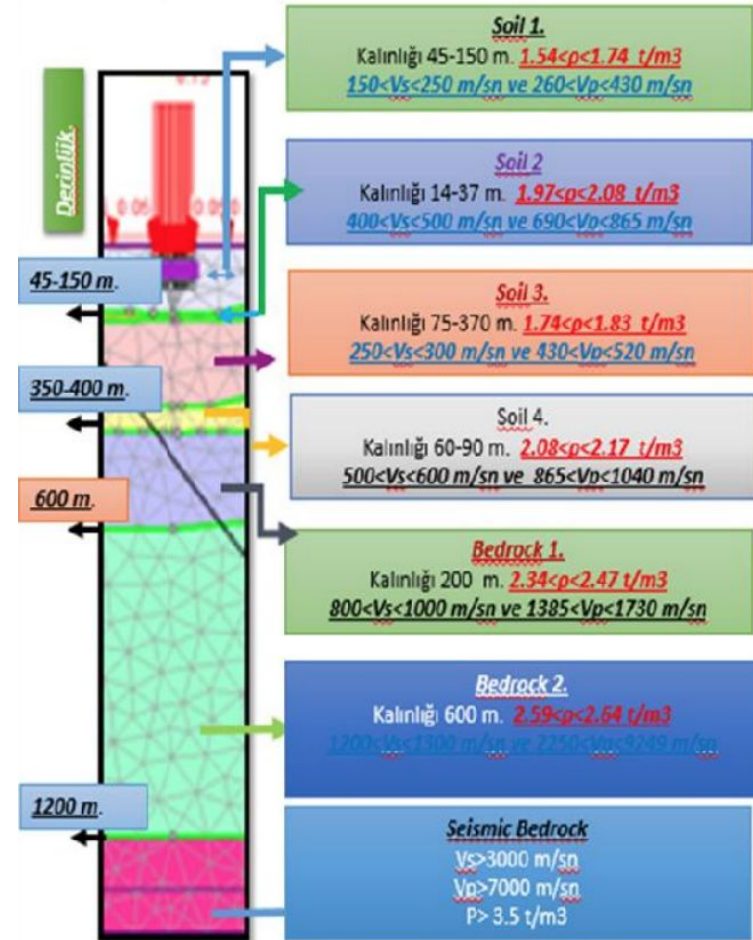
- The İzmir's Bayraklı Municipality Earthquake Research Center prepared *two reports of collapsed buildings, the Rızabey Building and the Doğanlar Building*, where they observed liquefaction, deflections and deformation in the ground.¹
- A report by the Izmir municipality² pointed out that *deformation and door jams at the Doganlar Apartment Building* were observed at ground level due to liquefaction. Further soil studies were requested. This conclusion was similar to the one reported at the Riza Bey Apartment Building.³
- In the Bayraklı region, ground accelerations are reported to be amplified by 2-3 times due to alluvial ground.⁴

Geotechnical evaluation of the earthquake

Although the closest residential area to the epicenter is Seferihisar, the concentration of damage is at Bayrakli district of Izmir which requires close examination of Bayrakli region⁵.

Based on site observations and reports published on the area, it can be understood that Bayrakli is sitting on a thick alluvial layer⁶ (see Figure). **The bedrock depth is very deep and the groundwater level is high with the potential of liquefaction.** The existence of alluvium layers led to the potential of liquefaction and bearing capacity loss due liquefaction and ground deformation due to lateral spreading.

Soil Layers in Bayrakli region⁶

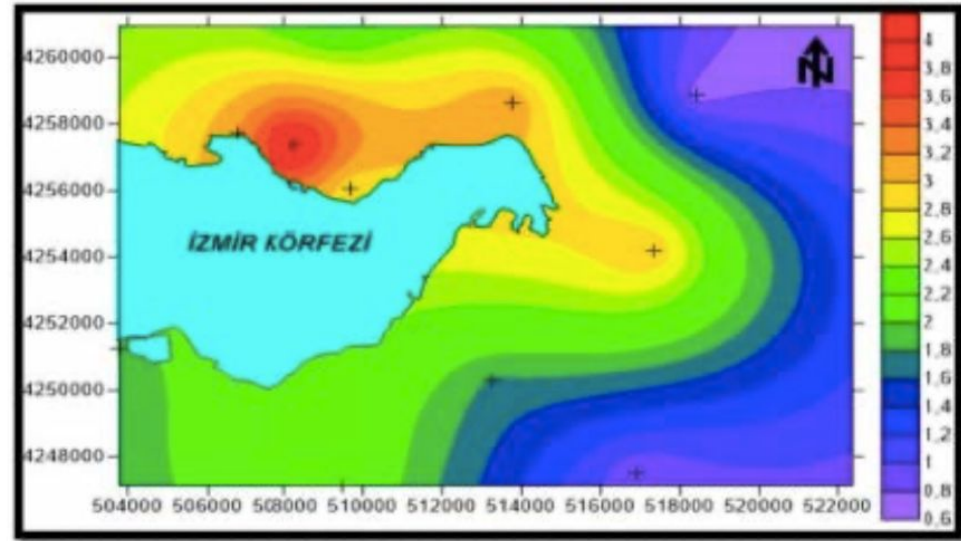


Geotechnical evaluation of the earthquake

Closer look to the ground amplification should be given for this or similar regions sitting on alluvium layers (see Figure).

When checking ground motion distribution from the epicenter:

- The closest residential area is Seferihisar, 35 km away with PGA of 0.050 g,
- Menderes is 51 km away from the epicenter with PGA 0.075 g,
- Bayraklı is 69 km away from the epicenter with PGA 0.108 g.



Summary of soil amplification⁶



Geotechnical evaluation of the earthquake

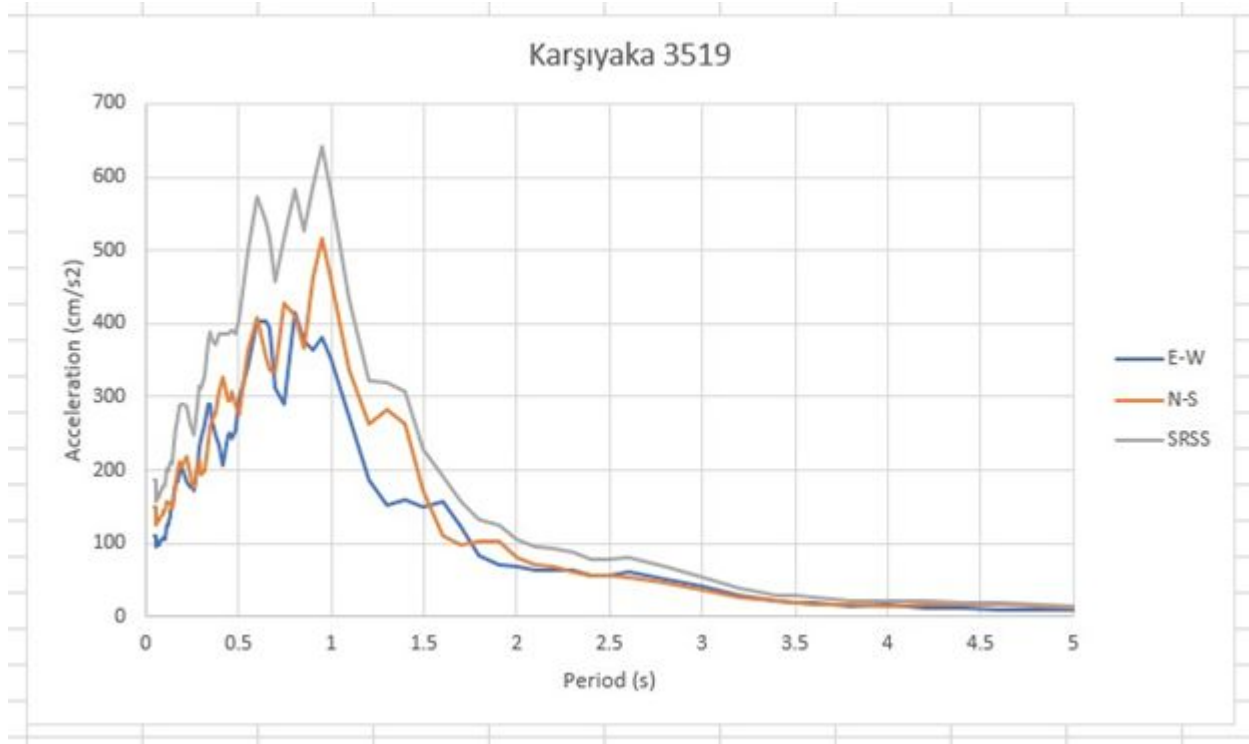
- When the acceleration records based on epicenter and distance are interpreted, *existence of an amplification can be concluded for Bayrakli district* which is known to have thick soft deposits ⁹.
- The AFADs (Disaster & Emergency Management Authority Presidential of Earthquake Department) Turkey Earthquake Risk Map indicates the highest ground acceleration is around 0.450g in for the region.
 - Based on this data, it can be seen that amplification effect for Bayrakli region of Izmir is much lower than the predicted design acceleration.
- Damaged building inspection in the area shows that *spread foundations are mostly preferred whereas basement floor is uncommon*. Ground settlement is not observed in the examined buildings.
- Although numerically amplification effects exist in the area, as the measured ground acceleration is much lower than highest predicted design acceleration *we cannot conclude that the damage is associated to this effect*.



Region with extensive damage and fatalities ⁷

Strong Motion Records

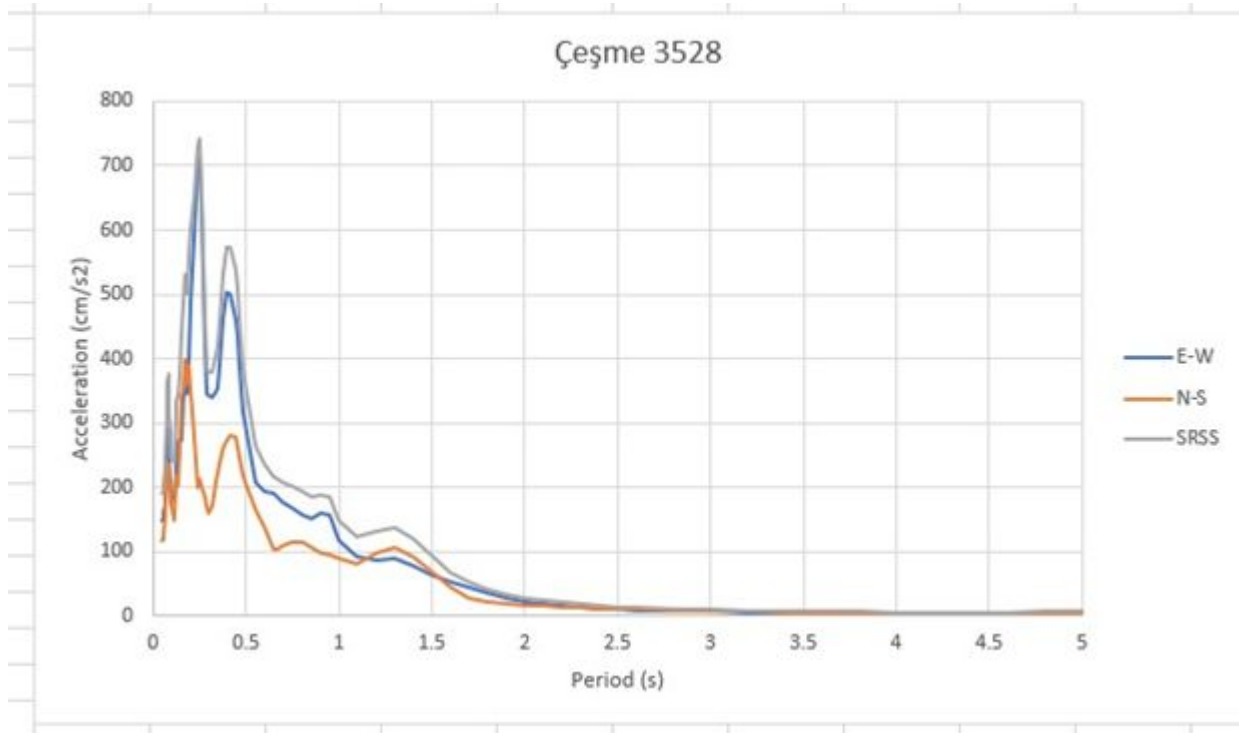
Karsiyaka



Source: F. Çinicioğlu, Özyeğin University, Turkey through G. Gazetas, NTUA, Greece⁹

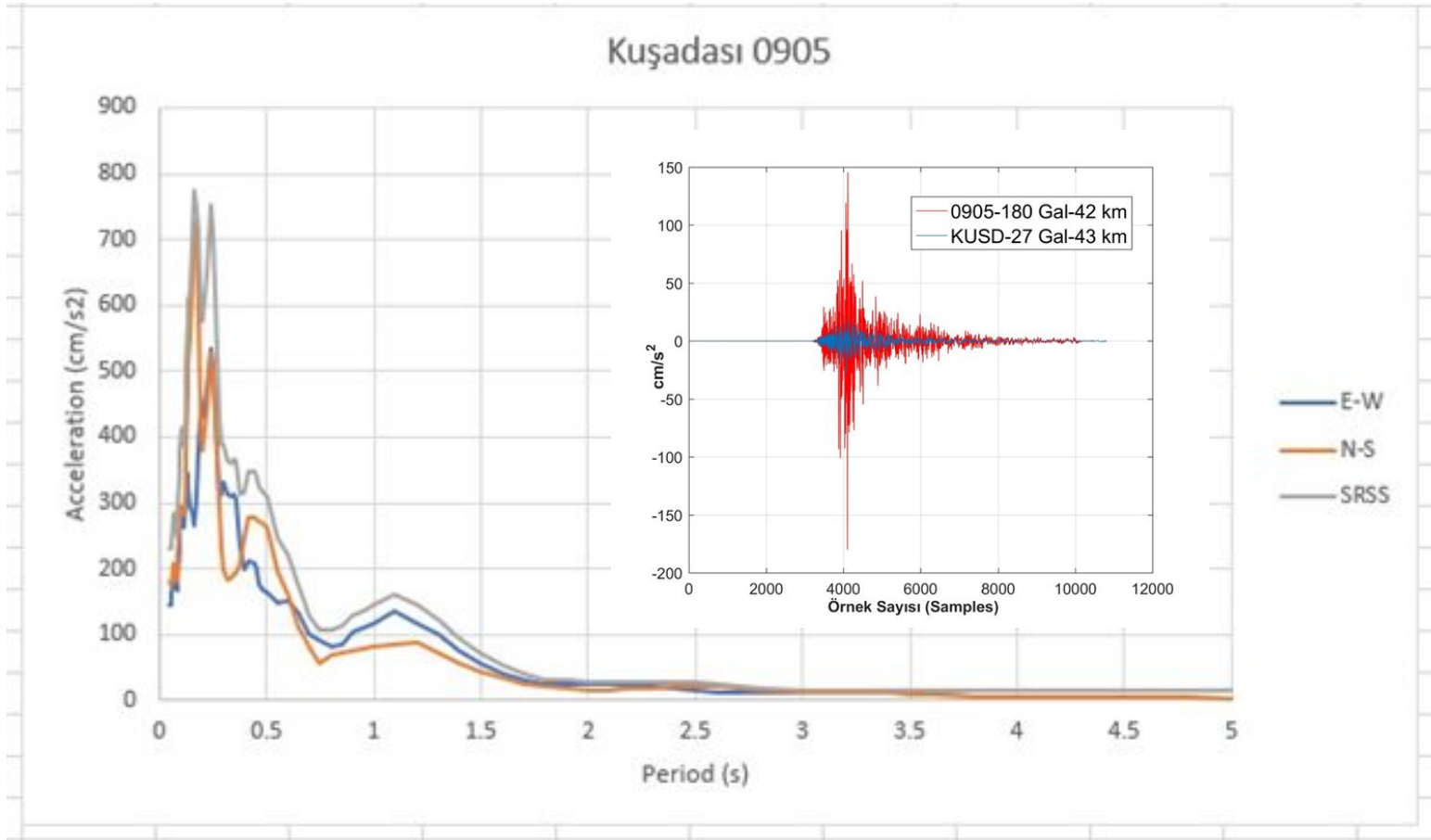
Strong Motion Records - Cesme

Cesme



Source: F. Çinicioğlu, Özyeğin University, Turkey through G. Gazetas, NTUA, Greece⁹

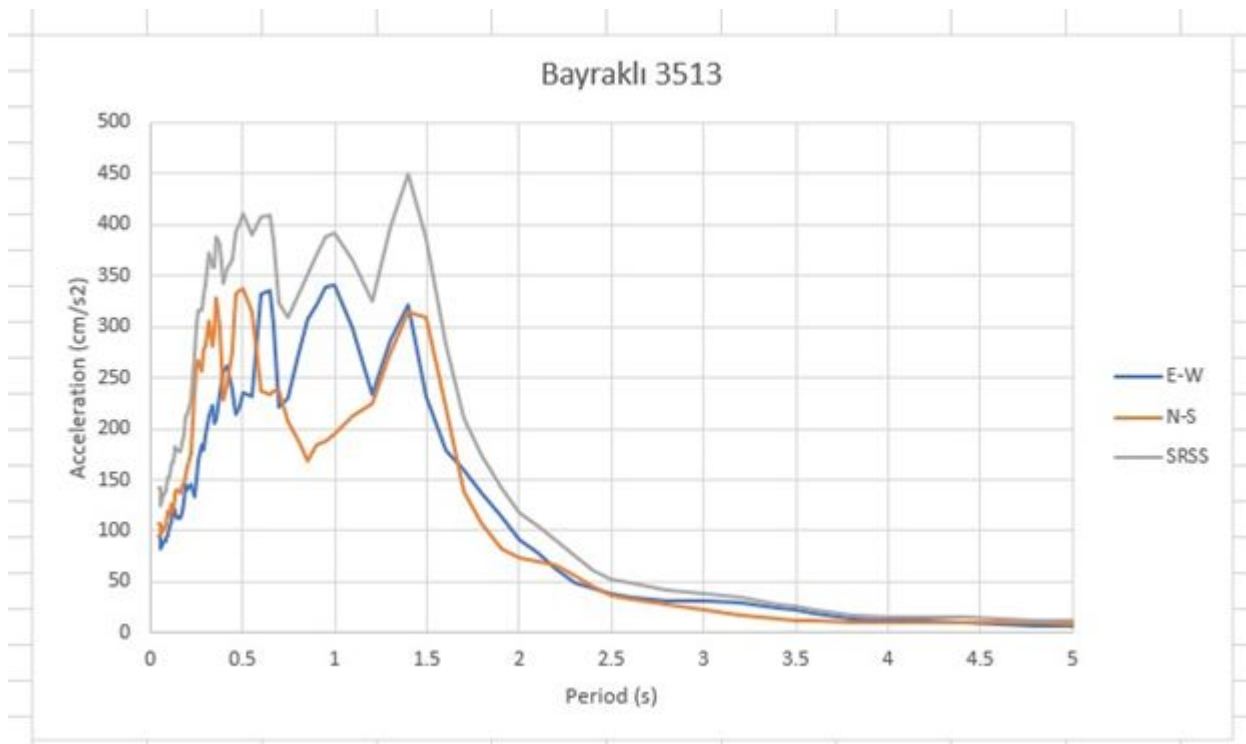
Strong Motion Records - Kusadasi



Source: F. Çinicioğlu, Özyeğin University, Turkey through G. Gazetas, NTUA, Greece

Strong Motion Records - Bayrakli

Bayrakli

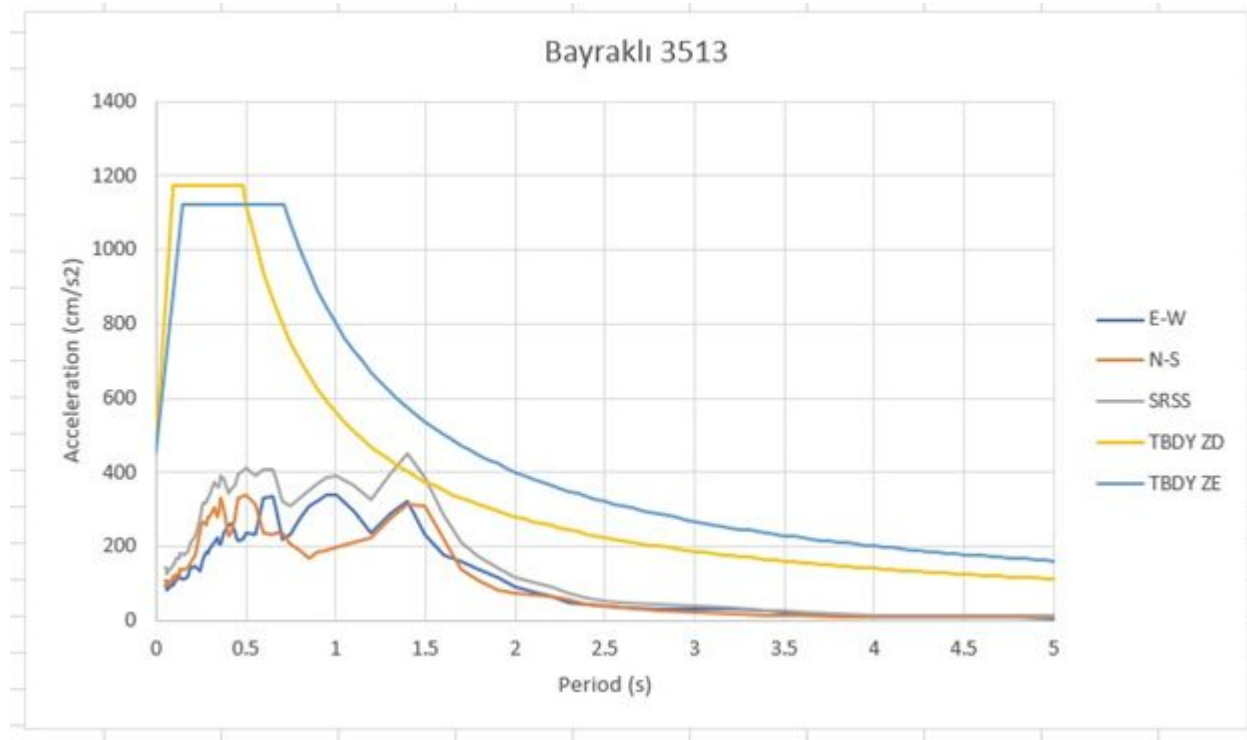


Source: F. Çinicioğlu, Özyeğin University, Turkey through G. Gazetas, NTUA, Greece⁹



Code vs. Records - Bayrakli

Bayrakli



Source: F. Çinicioğlu, Özyeğin University, Turkey through G. Gazetas, NTUA, Greece⁹

Summary of other geotechnical damage



Collapsed buildings in part due to
soil amplifications, Izmir⁸

Potential Soil Effects and Structural Damage

Bayrakli
(location to
be confirmed)



Source: F. Çinicioğlu, Özyeğin University, Turkey through G. Gazetas, NTUA, Greece⁹



Potential Soil Effects and Structural Damage

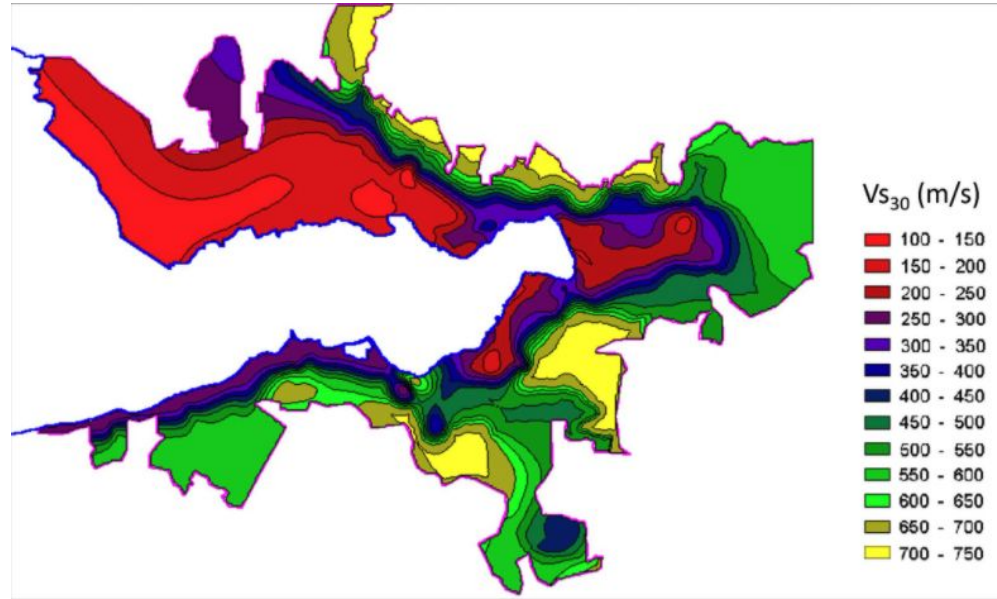
Karsiyaka
(location to
be confirmed)



Source: F. Çinicioğlu, Özyeğin University, Turkey through G. Gazetas, NTUA, Greece⁹

Summary of other geotechnical damage

- The expected amplification of seismic shaking is generally inferred by the average seismic shear wave velocity in the upper 30 m ('Vs30').
- Most of the heavily built areas are located on the soft sediments of the city located in Karşıyaka, Bayraklı, Bornova and Konak districts⁷.



The distribution of Vs30 (average shear wave velocity in the upper 30m) map of the Inner İzmir Bay Basin ⁷



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