



Samos-Sığacık Earthquake Highlights the Importance of Multi Hazards and Physics Based Ground Motion Modelling

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The Mw 6.9 earthquake that took place offshore between the Greek island of Samos and Turkey's İzmir province on 30 October 2020 didn't come as a surprise (Figure 1 by F.S. Malcioğlu, BÜ, Animation 1 by Dr. M. Çağlar, BÜ). Due to the extensional tectonic regime of the Aegean and high deformation rates, earthquakes of similar size frequently occur in the Aegean Sea on fault segments close to the shores of Turkey, affecting the settlements on mainland Turkey and on the Greek Islands. Since 2012, five earthquakes of magnitudes 5.7 and above were strongly felt and caused damage (10.6.2021 Fethiye Mw 6.1; 8.1.2013 offshore Çanakkale Mw 5.7; 24.5.2014 off shore Gökçeada Mw 6.9; 12.6.2017 offshore Karaburun Mw 6.2; 21.7.2017 Bodrum Mw 6.6). The Samos-Sigacik earthquake had a normal faulting mechanism, as almost all regional earthquakes do. It was recorded by the strong motion networks in Turkey and Greece (Figure 1). The recorded levels of ground motion were more or less in line with those expected from an earthquake of this size and so was the damage (<https://eqe.boun.edu.tr/en/30-october-2020-1451-aegean-sea-izmir-mw69-ml66-earthquake-preliminary-assessment>).



Figure 1. 30.10.2020 Samos-Sığacık earthquake, strong motion stations in the region and hard-hit localities. (Fatma Sevil Malcioğlu, BÜ)

However, the Samos-Sığacık earthquake was an outstanding and important event for several reasons:

- The structural damage in central İzmir, located 60-70 km to the north of the epicentre and the third largest city of Turkey, was highly localized and significant. It concentrated in the Bayraklı district of İzmir located in the Bornova plain at the tip of the İzmir Bay and well known for its poor soil conditions.

- 117 people lost their lives, 523 buildings either collapsed totally or were heavily damaged (Source: Ministry of Environment and Urbanisation). The majority of these losses were in the Bayraklı district.
- It occurred during the Covid-19 pandemic. The cases in İzmir before the earthquake were already on the rise before the event. On 25/10/2020, five days before the earthquake, the governor of İzmir announced that the number of cases increased 3.5 times as compared to those at the beginning of the month. A second announcement by the governor on 27/11/2020, about one month after the earthquake, stated that the cases in İzmir had peaked and the intensive care units in the city were 76.6% full, directly linking the situation to the earthquake. The Covid-19 statistics for İzmir have not been released officially.
- The earthquake triggered a small-scale tsunami, the waves of which hit the shores of Sığacık, a settlement of the İzmir province, leading to damage to the boats in the harbour, restaurants and cafes on the shores and inundating streets, killing one person.

Here are some findings, observations and reflections about this important event:

- Spectral levels of ground motion during the main shock were below the design spectral levels defined by 1998 and 2018 Turkish seismic design codes. However, in the Bayraklı district, where damage was heavy, and in the Karşıyaka district, they were above the design spectral levels by the 1975 code. The majority of the buildings in the Bayraklı district were constructed in 1990s, while the buildings in Karşıyaka are slightly older. This implies that their structural designs should largely be based on the 1975 code and this could be one explanation of incurring damage.
- The heavily damaged and collapsed buildings were reinforced concrete and mostly 8-10 stories high.
- We carried out a survey on 38 buildings that received varying degrees of damage by laser vibrometry the week following the earthquake. The data are currently under analysis for understanding the relationships between structural properties and damage levels.
- Mainshock records suggest that local site effects, enhanced by basin effects, could be responsible for structural damage in Bayraklı.
- We installed a seven-station network in Bayraklı and Karşıyaka districts of İzmir within three days of the mainshock in search of site and basin effects. Recorded aftershocks are currently under analysis and the aftershock activity is still on.
- A significant variation of ground motion characteristics among stations installed is evident from recordings. Preliminary findings indicate 4-8 times amplification in the frequency band of 0.5-5Hz in EW direction with respect to competent soil. Amplifications in the north-south direction were about 3-5 times in the frequency range of 2.5-6Hz.
- Soil conditions in Bayraklı and Karşıyaka districts are not that different from each other. Amplifications are also not distinctly off, despite some variations among stations. Still, structural damages are considerably different with Karsiyaka being much less affected. The situation deserves a closer look to be able to explain the role basin effects played in resulting damage distribution. Parts of Bayraklı where largest damages are observed are aligned with central parts of the Bornova plain basin, whereas Karşıyaka is located more along the northern boundaries of the larger basin.

- Infrastructure was generally not affected by the earthquake. Mobile communication within Izmir was affected for a few hours. The communication between Izmir and other parts of Turkey remained largely unaffected. There was traffic congestion on the streets soon after the earthquake caused by people trying to reach their families or leave the city. Announcements were made to urge people not use their cars to allow rescue teams, health personnel and equipment to reach effected parts. Hospitals generally remained operational except two cases, which had to be evacuated due to structural safety concerns.
- The fact that the earthquake took place during the Covid-19 pandemic, and especially at a time when the cases were on the rise in İzmir, highlights the importance of multi-hazards and their consequences. Co-occurrence of individual hazards, or one triggering the another, increases direct and indirect effects, damages and losses and makes coping even more challenging. Right after the earthquake we have updated the mobile application that we use to convey earthquake information and to collect information on what the effect of a particular earthquake has been, for the users to provide feedback on the combined effects of earthquake and Covid-19. The responses that we received show that the majority of the users expected adverse effects of the two hazards occurring at the same time and they found protective measures of social distancing, hygiene and wearing masks hard to follow. The Governor of Izmir and the Minister of Health recently announced that Covid-19 cases peaked in Izmir, directly linking it to the earthquake. 76.6% of the intensive care capacity in the city was exhausted as of 27 November 2020.
- It would be wrong to see and evaluate this earthquake as the İzmir earthquake. Central İzmir is surrounded by active faults that are much closer and potentially more hazardous. Assessment of earthquake damages and losses to the built environment and infrastructure is important, given the population (about 4.5 million), issues with structural characteristics as displayed by the recent event, and İzmir's economic importance. Trade, industry, tourism and agriculture are leading sectors. Industrial output in İzmir is second only to that of the Marmara Region. The Ministry of Environment and Urbanisation and the Izmir Metropolitan Municipality started to develop and announce programs for renewing and transforming the buildings soon after the earthquake. Their implementation before the next earthquake would definitely be a very important step for reducing structural risks.
- The earthquake particularly affected small and medium size enterprises in the Bayraklı district. When in depth studies about its effects on İzmir's economy, commercial and industrial activities become available, their findings will be invaluable for other important large cities of Turkey, particularly for Istanbul.
- This earthquake is an event within Turkey's coping capacity, locally and nationally. It is hardly possible, however, to expect the same for the next earthquake expected to hit Istanbul.