Documentation of the failures triggered by the July 20, 2017 Bodrum-Kos, Aegean Sea Mw=6.6 earthquake

G. Papathanassiou[1] S. Valkaniotiss[2], Sp. Pavlides[3]

(1) Democritus University of Thrace, Dept. Civil Engineering, Xanthi, Greece gpapatha@civil.duth.gr
(2) Trikala, Greece
(3) Aristotle University of Thessaloniki

Extended abstract

On July 20, 2017 at 22:31 UTC (01:31 local time) a shallow earthquake of Mw6.6 magnitude occurred in Gökova Bay at a depth of ≈10Km (Fig. 1). The epicenter of the earthquake, located between Bodrum, Turkey and the island of Kos, Greece, SE Aegean Sea. In particular, according to Kandilli Observatory and Earthquake Research Institute (KOERI) the epicenter was at 36.9620ºN 27.4053ºE, while according to the National Observatory of Athens (NOA) at 36.9643ºN 27.4332ºE. The fault plane strikes N280°E and dips to the north with an angle of about 40 degrees in a nearly E-W direction with surface deformation that reached about 20cm onshore islet Karaada (Ganas et al. 2017, Karasözen et al. 2018). Preliminary inversion results of geodetic data, as constrained by InSAR observations, suggest that the upper edge of the fault (14km length and 12km width) is offshore (near the Gökova ridge bathymetric feature) at a shallow depth (2±0.5km - Ganas et al. 2017, Karasözen et al. 2018).

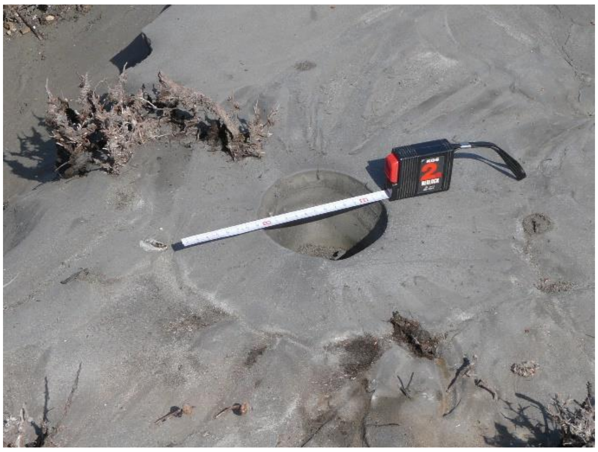
The recorded acceleration at the city of Bodrum, which is located at an epicentral distance of 12 km was 158.76 cm/sec^2. Based on the preliminary distribution of peak ground acceleration (PGA), provided by ITSAK, 2017, the PGA values at the city of Kos and cape Louros were estimated as 0.2 g and 0.25 g, respectively (ITSAK, 2017).

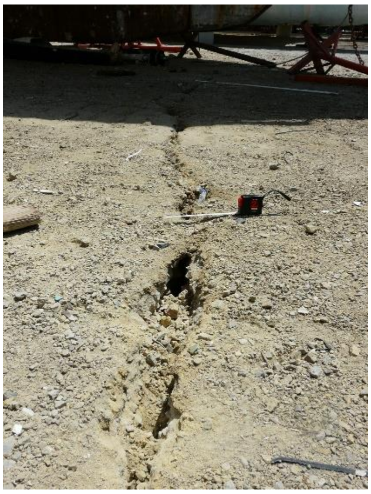
The primary goal of this study was to document the earthquake-induced secondary effects and to provide quantitative data regarding the characteristics of the liquefaction related phenomena at the island of Kos. In order to achieve this, a post-earthquake field survey conducted on 13-14 August, 2017.

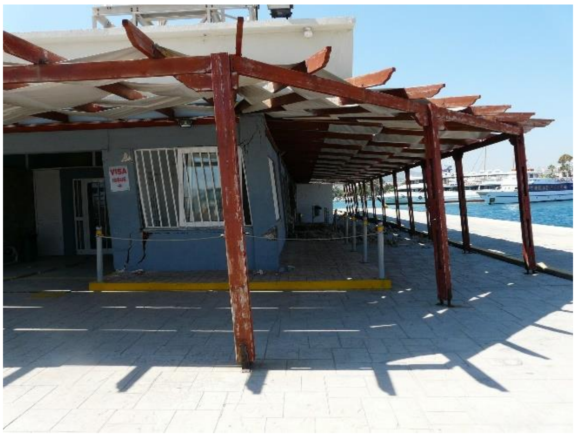
Based on the field observations, it can be summarized that the earthquake caused damages to the building stock of the town of Kos, mainly to Ottoman and Venetian-era constructions, including partial collapses that killed two people and seriously injured several others (Papathanassiou et al., 2019). Damages were also reported in the city of Bodrum. Focusing on the island of Kos, the most remarkable type of environmental effects is the liquefaction related phenomena that induced severe damages to the port facilities and to the custom building at the new port of Kos, and at the old harbor of the city. Moderate liquefaction-induced structural failures were induced at the marina of Kos, while at cape Louros ejected material due to liquefaction covered more than 450m^2 (Papathanassiou et al., 2019). Furthermore, a tsunami wave was reported indicating that the generation of tsunami-related phenomena e.g. flooding and structural damages is likely in the Aegean Sea. In particular, the tsunami effects were observed at the south coast of Bodrum peninsula and at the northeast coast of Kos Island, with a maximum run-up measured at 1.9 m at Bodrum area (Yalçıner et al., 2017). Small-scale size rockfalls were reported in the southern part of the island of Kos.

Taking into account the quantitative characteristics of the earthquake-induced secondary effects e.g. liquefaction phenomena and tsunami, the macroseismic intensity was evaluated by applying the Environmental Seismic Intensity (ESI-07), a scale based only on environmental effects introduced by Michetti et al. (2007). Thus, according to Papathanassiou et al. (2019), the macroseismic intensities at the coastal area of cape Louros and the at waterfront area of the city of Kos were assessed as VIII taking into account i) the dimensions of liquefaction manifestations in the former case, ii) the lateral spreading and subsidence at the port and at the old harbour of the city of Kos, and iii) the characteristics of the generated tsunami documented by Yalciner et al. [4]. Details regarding the liquefaction related phenomena are presented in sections 5.1 and 5.2 in this article.

The secondary goal of this study is to investigate in detail a lateral spreading site, located at the old harbor of the city of Kos. This was achieved by performing traditional ground measurements as well as an image-based survey following the Structure from Motion (SfM) technique in order to virtually measure the deformation. The novelty of this study is related to the fact that the applied SfM technique for measuring the lateral spreading displacement was based on a simple handheld digital camera instead of a UAV. Comparing the obtained measurements by these two methods, it is resulted that the deviation of the measurements on horizontal axis e.g. width of cracks, between the virtual (SfM-based) and the manually field observations is less than 1%. Thus, it can be concluded that the SfM-based technique provide reliable data regarding the lateral displacement and accordingly, could be used for the purposes of a rapid post-earthquake field survey (Papathanassiou et al., 2019).







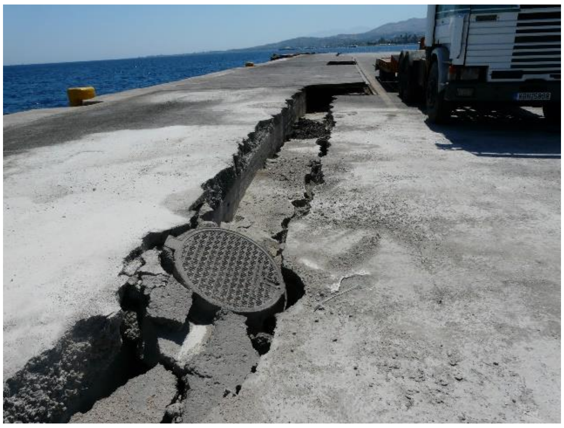


Figure 1. (upper left) Earthquake-induced ground failures at the cape Louros (photo taken by G. Papathanassiou on August 13, 2017), upper right) liquefaction manifestations at the area of marina that is used as a dry dock and for the maintenance and repairs of sailboats and yachts Louros (photo taken by G. Papathanassiou on August 13, 2017), lower left)) lateral spreading phenomena induced damages to custom building (photo taken by G. Papathanassiou on August 14, 2017), lower right)) failure at the new port of Kos (photo taken by G. Papathanassiou on August 14, 2017).

References

Ganas A, Elias P, Valkaniotis S, Briole P, Kapetanidis V, Kassaras I, Barberopoulou A, Argyrakis P, Chouliaras G, Moshou A.2017. Co-seismic deformation and preliminary fault model of the July 20, 2017 M6.6 Kos earthquake, Aegean Sea; 2017. https://www.emsc-csem.org/Files/event/606346/Kos_report_30-7-2017.pdf

ITSAK, 2017. Earthquake Mw6.6 July 21, 2017, Preliminary report, ITSAK, OASP; 2017. Thessaloniki, 20 pages (in Greek) - http://www.itsak.gr/uploads/news/earthquake_reports/EQ_COS_20170721_M6.6.pdf

Karasözen, E., Nissen, E., Büyükakpınar, P., Cambaz, M.D., Kahraman, M., Ertan, E.K., Abgarmi, B., Bergman, E., Ghods, A., Özacar, A.A., 2018. The 2017 July 20 Mw 6.6 Bodrum–Kos earthquake illuminates active faulting in the Gulf of Gökova, SW Turkey. Geophys. J. Int., 214 (1), 185-199 https://doi.org/10.1093/gji/ggy114

Michetti AM, Esposito E, Guerrieri L, Porfido S, Serva L, Tatevossian R, Vittori E, Audemard F, Azuma T, Clague J, Comerci V, Gurpinar A, McCalpin J, Mohammadioun B, Mörner NA, Ota Y, Roghozin, E. 2007. Intensity Scale ESI 2007. Mem. Descr. Carta Geol d'Italia. 74, Rome; 2007

Papathanassiou G., Valkaniotis S., Pavlides S. 2019. The July 20, 2017 Bodrum-Kos, Aegean Sea Mw=6.6 earthquake; preliminary field observations and image-based survey on a lateral spreading site, Soil Dynamics and Earthquake Engineering, 116, 668-680, https://doi.org/10.1016/j.soildyn.2018.10.038

Yasuda S, Morimoto I, Kiku H, Tanaka T. 2004. Reconnaissance report on the damage caused by the three Japanese earthquakes in 2003. In proceedings of the 11th ICSDEE and 3rd ICEGE. Berkeley CA USA;1:14-21.

Yalçıner A, Annunziato A, Papadopoulos G, Dogan G, Guler H, Cakir T, Sozdinler C, Ulutas E, Arikawa T, Suzen L, Kanoglu I, Guler I, Probst P, Synolakis C. 2017. The 20th July 2017 (22:31UTC) Bodrum/Kos earthquake and Tsunami; Post Tsunami Field Survey Report. 2017; http://users.metu.edu.tr/yalciner/july-21-2017-tsunami-report/Report-Field-Survey-of-July-20-2017-Bodrum-Kos-Tsunami.pdf