STRONG GROUND MOTION SIMULATION IN CEPHALONIA ISL. (IONIAN SEA) AND COMPARISON WITH OBSERVED CONSEQUENCES OF THE 2014 EARTHQUAKES

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The effects of the 2014 Cephalonia dual earthquakes are investigated by exploiting a large amount of data obtained after these events. The scope of this effort is to examine the contribution of parameters such as ground motion characteristics, site effects and the structures’ vulnerability to the damage distribution. The Cephalonia Island is the most hazardous region of eastern Mediterranean, capable of producing earthquakes with M>7, as in 1953, when the whole island and surrounding regions were devastated by a cascade of three strong earthquakes. In the aftermath of the huge catastrophe and lessons learned, Cephalonia was rebuilt with new constructions to efficiently bear the large regional seismic hazard. The most recent earthquakes occurred on 26.1.2014 (Mw=6.1) and on 3.2.2014 (Mw=5.9) in the vicinity of Lixouri and produced extremely high PGA values, largely exceeding the provisions of the National Seismic Code, which, however, did not severely impact the built environment, with a proportion of damage mainly related to secondary effects such as liquefaction.

The used data are constituted of ground motion recordings, buildings inventory, registered damage, geotechnical/geophysical seismic soil characterization, and ambient noise measurements. The two main-shocks and their aftershocks were recorded by a local seismological network of four broadband stations installed by NOA situated within the broad epicentral areas. The structural exposure model was based on the 2011 buildings census data. Real damage was obtained by the local sector of earthquake rehabilitation regarding the usability characterization of the affected buildings (green, yellow and red tags) based on their structural safety. Geotechnical/geophysical data available from the literature as well as data from borings conducted after the 2014 earthquakes for the scope of roads’s rehabilitation were employed. Free-field ambient noise was measured at 80 positions in the epicentral area obtained through a campaign conducted after the occurrence of the two earthquakes and HVSRs were computed. The reliability of the HVSR measurements was examined by comparing them with borehole data and seismic velocities from field measurements.

Analysis of buildings’s inventory was performed on a building-by-building level for the towns of Argostoli (capital of Cephalonia) and Lixouri, and on aggregated-basis per municipal district for the rest of the island. Structural vulnerability was assessed using the RiskUE-LM1 method (Milutinovic and Trendafilloski, 2003), which applies EMS-98 (GrĂłnthal, 1998) vulnerability classes and respective behavior indices. Damage data was analyzed to estimate EMS-98 macroseismic intensities on the island. We note that due to the short time between the two earthquakes, it was possible to assess only the cumulative consequences of the two events upon the buildings.

Damage was concentrated in the western part of the island. Old stone masonry constructions were worst affected. Several reinforced concrete buildings were also heavily damaged. Damage in Lixouri was more severe relative to Argostoli due to the town’s epicentral location. This fact, apart from the stronger ground motion recorded in Lixouri, may also be due to larger vulnerability, given that 20% of its buildings were attributed to high vulnerability class as opposed to 4% in Argostoli. EMS-98 macroseismic intensities (I) were assessed from the
structural damage data. The western part of Cephalonia (Paliki peninsula) exhibits I=VI-VIII while in the Argostoli peninsula I=VII was assessed. The northeastern, central and southern parts of the island experienced lower intensities (I=IV-V).

In order to shed light on the effects of the 2014 earthquakes in the natural and urban environment, deterministic ground motions were obtained using the stochastic simulation approach implemented in the EXSIM algorithm (Boore, 2009). Synthetic PGA and EMS-98 equivalent Seismic Intensity were derived for the selected earthquake scenario taking into account HVSR as site response proxies (Nakamura, 1989). The derived intensity measures were found consistent with the observed environmental and macroseismic intensities. Scenario damage grades derived from the RiskUE-LM1 approach were then compared to the accumulated damage of the dual 2014 earthquakes, manifesting a satisfactory overall behavior of the constructions throughout the island.

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