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Seismic response of the Circuit Wall of the Acropolis of Athens: Recordings versus numerical simulations

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ABSTRACT

The Acropolis of Athens is one of the most prestigious ancient citadels in the world, and therefore, the structural integrity of its monuments and structures is of paramount importance. Since Greece is characterized by high seismicity, a seismic array of accelerographs has been installed on the Acropolis hill over the last decade in order to monitor the dynamic response and distress of monuments and structures in real time. One of the monuments is the Circuit Wall, which is actually an old perimeter masonry retaining structure. Undoubtedly, monitoring its seismic response comprises a very interesting and useful "real-scale experiment". Furthermore, records and analyses in the literature have shown that the seismic behaviour of any retaining structure is a complicated problem of dynamic soil-structure interaction, where many parameters seem to have a substantial impact on the overall dynamic response and distress. Based on the aforementioned, the current study aims to shed light on the seismic response and distress of the Acropolis' Circuit Wall. After a short description of the prevailing geological and geotechnical conditions of the Acropolis' hill and the available geometrical and mechanical properties of the Wall, an evaluation of the available seismic records is conducted. Subsequently, preliminary two-dimensional dynamic numerical simulations are being performed utilizing the finite-element method in order to estimate the seismic response of the Wall in terms of acceleration. Despite the various uncertainties of the numerical simulations (i.e. the input parameters), the results are in a good agreement with the available records.

1. Introduction

The Acropolis of Athens is one of the most important Archaeological Sites in the world and attracts annually a great number of visitors. As shown in Fig. 1, it includes the remains of several ancient structures of great architectural and historical significance, the most famous being the Parthenon. Therefore, the structural integrity of all monuments founded on the Acropolis' hill is of paramount importance. One of these monuments is the masonry Circuit Wall, which actually retains the backfill materials that form the plateau around the Parthenon. It is worth mentioning that the integrity of the Circuit Wall is a crucial issue for the Acropolis Restoration Service (YSMA) of the Hellenic Ministry of Culture, since, apart from its great significance, the Wall is directly related to the safety of millions of visitors [3].

As shown in Fig. 2, Acropolis is located on an extremely rocky hill above the city of Athens. According to Koukis et al. [10] and Trikkalinos [17], the prevailing geological conditions are unusual since a rather hard rock (i.e. limestone) is overlying a relatively softer geomaterial (i.e. Athenian schist). As shown in Figs. 1–3, the Circuit Wall is a masonry structure, which has been founded on inclined limestone, and retains soft soil materials (i.e. backfill). The geometrical properties of the Wall (i.e. wall height and width) vary substantially around the Acropolis' hill. In the past, the southern part of the Wall has exhibited some serious structural damages (i.e. significant detachments), while few notable cracks have currently been observed at the south-east corner of the Wall (see Fig. 4(a) and (b)).

Furthermore, records and analyses in the literature have shown that an earthquake may increase substantially the horizontal earth pressures on a retaining wall, causing thus a substantial additional distress. According to Kramer [12], the seismic response and distress of any retaining structure is a complicated problem of dynamic soil-structure interaction, as the dynamic earth pressures developed on the wall depend on the structural response (i.e. deformation and/or displacement) of the wall, and vice versa. In parallel, apart from the characteristics of

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Fig. 1. View of the Acropolis of Athens, where the Parthenon and the Circuit Wall are shown.

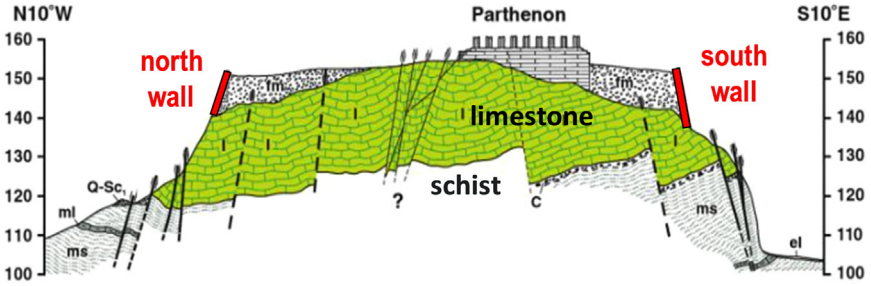
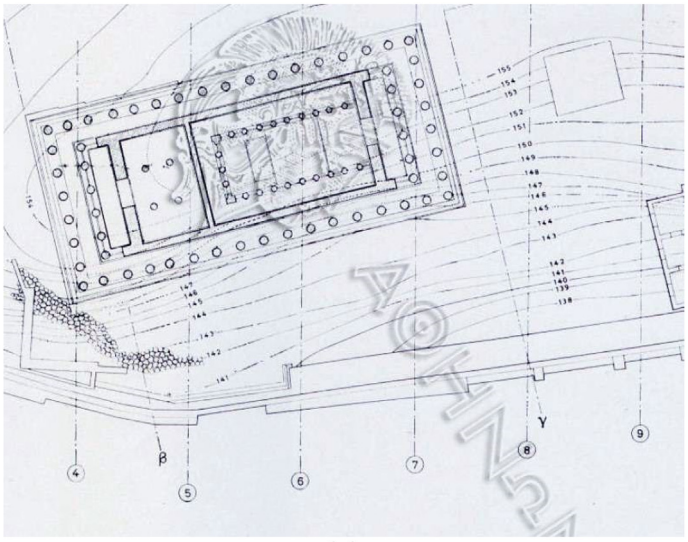
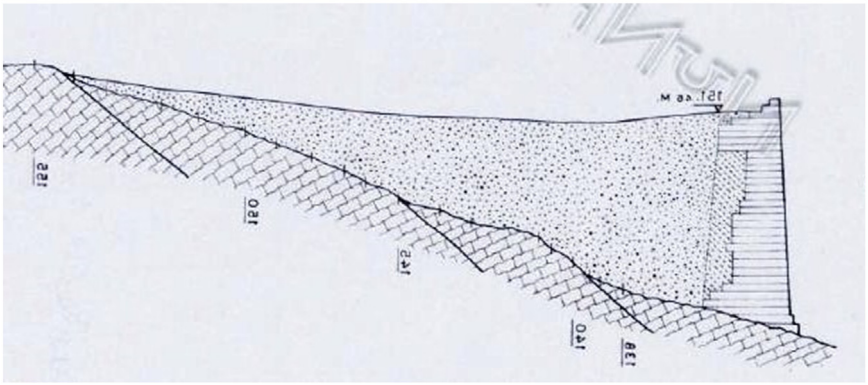


Fig. 2. A sketch showing the prevailing geological conditions and the Circuit Wall (in red) (after [10]).



(a)



(b)

Fig. 3. (a) Plan view of the area under examination, and (b) representative cross section of the southern wall (after [16,17]). The Circuit Wall is masonry and retains backfill materials lying on inclined limestone.

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