

Delphi archaeological site

Engineering geological conditions and problem:

The development of the sanctuary and the oracle of Delphi began in the 8th century B.C. with the establishment of the cult of Apollo. After the First Sacred War the sanctuary increased its pan Hellenic religious and political influence.

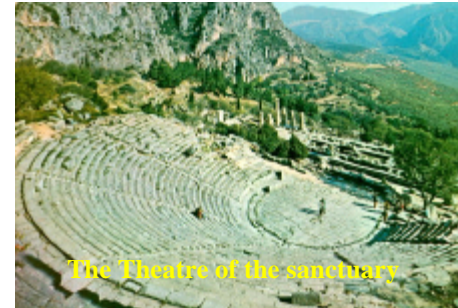
The archaeological site is built under a vertical steep slope consisted of limestone. In the rock mass almost vertical discontinuities are developed which are intersected by joints, fractures and open cracks. This pattern of fracturing results in a progressive loosening of rock mass which is then subjected to weathering and erosion processes. Zones of weakness have been developed on the rock cliff where favorable conditions have been created for limestone blocks to be detached causing extensive rock falls.

The most destructive earthquakes were the following:

- 600 BC: complete destruction of the sanctuary
- 373 BC: extensive damage of the archaic temple of Apollo, mainly by rockfalls (devastation of Helice town in Corinth Gulf).
- 1870 AD: significant damage to the monuments (reactivation of the Arachova-Delphi fault zone)

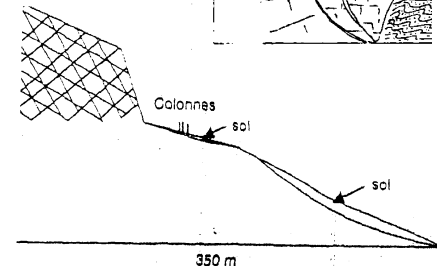
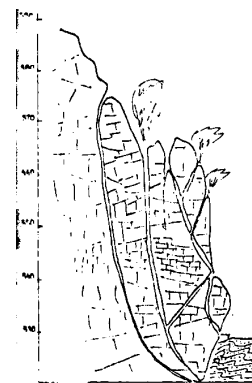
Major causes of instability:

- Rockfalls,
- Ground creep
- Foundation subsidence and deformation

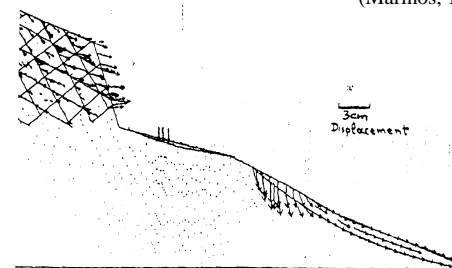


The Theatre of the sanctuary

Schematic cross section of the rock slope (rockfalls)



Discrete element model of the slope above the archaeological site (Marinos, 1999)



Max. displacement profiles during the seismic excitation, (Marinos, 1999)

Protective measures already performed:

Stability modeling (including slope stability analysis for seismic excitation) performed by the Geotechnical Dept. of the National Technical University of Athens and the Lab. de Mechanique des Terrains de l' Ecole des Mines de Nancy.

Proposed protection measures:

- Systematic rock bolting
- Cement injections
- Removing of small rocks

References on studies already done:

- C.V. Constantinidis, J.Christodoulis, A.I. Sofianos, (1988). Weathering processes leading to rockfalls at Delphi archaeological site, Proceedings of the international symposium of IAEG on The engineering geology of ancient works, monuments and historical sites, Balkema, Rotterdam, Brookfield, pp. 201-205.
- K. S. Koroniotis, A.A. Collios, A. Basdekis, (1988). Stabilization of the rock slopes at the region of Kastlia spring at Delphi, Proceedings of the international symposium of IAEG on The engineering geology of ancient works, monuments and historical sites, Balkema, Rotterdam, Brookfield, pp. 207-211.
- Marinos, P., (1997). Engineering Geology and Geotechnical Engineering of the Archaeological Site of Delphi, Greece. IAEG Int. Symp. Engineering Geology and the Environment, Athens.
- Marinos, P. (1999). The archaeological site of Delphi, Greece. A site vulnerable to earthquake and landslides. UNESCO-IGCP 425 Int. Meet. Landslide Hazard Assessment and Mitigation for Cultural Heritage Sites and Other Locations of High Society Value, Paris, pp. 83-90.