

Estimation of the Seismic History of the City of Thessaloniki through back analysis of its Byzantine Land Walls

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ABSTRACT: This paper aims at developing the tools and strategy for assessing the dynamic and seismic performance of the Byzantine Walls of the city of Thessaloniki in order to evaluate the seismic history of the city as a whole. The particular Walls have been constructed at the end of the 4th century A.D. in the reign of Theodosius the Great and as such, their structural integrity and record of damage reflects to a certain degree the level of seismic forces that has developed during the centuries. Moreover, the fact that they are extending in kilometers within the civil grid of the modern city allows the study of the role played by the local soil conditions for a given earthquake scenario. It is worth noting that despite their relatively simple structural system, their foreseen seismic behavior as a 3D body has not been thoroughly studied so far, primarily due to the lack of efficient numerical tools and the high computational cost related, especially towards the study of their response in the time domain. Along these lines, a refined dynamic analysis approach is proposed and the structural performance of particular parts of the Walls complex is examined for a number of realistic earthquake scenarios, accounting for the site specific soil conditions, the spatially variable nature of the incident seismic waves, as well as the overall geotechnical/geotectonic environment of the area. Through this advanced simulation scheme, an upper bound of the historical level of seismic forces for the city of Thessaloniki is traced (through back analysis), while the overall refined approach can be also used as a guide for the direct assessment of the existing seismic capacity of monuments as a whole.

1 INTRODUCTION

1.1 *Scope*

The impact of earthquakes on monumental heritage is a critical issue that has attracted growing scientific interest during the last decades. Monuments however, are most often complex structures, whose preservation and/or seismic strengthening heavily relies on the clear understanding of all factors affecting their vulnerability as well as on the accurate study of the effects of past earthquakes. Until recently, the investigation of the seismic performance of important and extended monuments was restricted by the inherent limitations of numerical analysis thus preventing the engineers from the study of their dynamic response in the time domain under realistic (recorded or artificial) ground motion scenarios. This problem was further stressed in the case of (Classical, Roman, Byzantine or Medieval) city (Sea or Land) Walls whose dimensions were normally significantly large, hence the complexity of the analytical or numerical procedures to be followed, (as well as the subsequent computational cost) were considerably high. Along these lines, it was deemed interesting to focus on the city Walls of Thessaloniki, utilizing state-of-the-art numerical tools and the experience gained from the seismic study of other histor-

ical structures of the Byzantine Era throughout the city, in order to attempt to shed some light not only on the structural history of the Walls through the centuries, but if possible, to back analyze and evaluate the reliability of the seismic scenarios developed for the Metropolitan City of Thessaloniki as a whole.

The Walls, still surrounding partially the old town of Thessaloniki were initially built in 315 B.C. by the king Kassandros and were completed at the time of Great Theodosius (379-395 A.D.). Nowadays, the Walls extend in kilometres within the civil grid of the modern city but their continuity has been disrupted due to partial or complete collapse at numerous locations. Historically, due to their dynamic nature, in the sense that they could be adapted in accordance with civilian needs, thus being repaired after sieges and following rules of economy and functionality where the art of war was concerned, the Walls of Thessaloniki (as those of Constantinople, Nicaea and others), did in fact changed considerably over the centuries (Bouras, 2002) following the heavy fortification requirements that arose. From the overall Byzantine Walls complex which extends in kilometres within the city, two sections (Figure 1) were chosen to be studied, particularly: (a) a simple relatively small, essentially stand-alone part of the Walls located approximately in