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Issues on short- and long-term stability of historical and modern man-made cavities in the Cappadocia Region of Turkey

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ABSTRACT

Underground space has long been used through the history for the purposes of human accommodation, religious ceremony, defense, food storage etc. by humankind. There are a number of man-made underground rock structures in different areas all over the world. Today the interest to utilization of underground space is still continuing. The Cappadocia Region of Turkey is one of the seven sites in Turkey included in the World Heritage List in 1985. In this area, there exist significant historical underground settlements such as rock cut dwellings, cities, churches, and semi-underground cliff settlements, and modern man-made cavities used for multi-purposes. Easy carving and thermal isolation properties of the Cappadocian soft tuffs have been the main reasons for the extensive multi-purpose underground use in the region from past to present. In addition to historical and archeological characteristics of the rock structures in the Cappadocia, their short- and long-term behaviors are also important data source in terms of underground rock engineering. The paper attempts to point out some issues including short- and long-term geomechanical properties of the Cappadocian tuffs, in which underground openings are carved, a critical overview on rock mechanical aspects, particularly their stability and implications in rock engineering using some typical structures selected from the region, and possible measures of protection and mitigation based on the authors' collaborative studies with their colleagues both from Japan and Turkey.

KEYWORDS

Man-made cavity, short- and long-term properties, underground city, tuff, stability, Cappadocia

1. INTRODUCTION

From the dawn of civilization, human beings have exploited through the underground space to fulfill different human necessities. Examples of natural or man-made excavated subterranean structures used for the purposes of human accommodation, defense, religious ceremonies or storage can be identified in different areas all over the World (Figure 1). The vernacular underground architecture constitutes a low cost solution and a suitable answer to face up to annual thermal fluctuations. In this century, cities are growing faster than in the past. This urbanization indicates that the population density in cities will reach higher numbers. Thus, the incorporation of underground space beneath existing and future urban areas introduces a new dimension to city

planning. Depending on local conditions, underground space can be integrated with lower levels of subsurface network. Therefore, in addition to historical and archeological characteristics of this kind of rock structures, their short- and long-term behaviors are also important data source in terms of underground rock engineering.

Turkey, a bridge between the Asian and European countries, is richly endowed with a cultural mosaic of various civilizations. One of the seven sites, which are included in the World Heritage List in 1985, is the Cappadocia Region extending over 40000 km². This very famous touristic area forms a high plateau and is covered by soft tuffs and lavas from three old volcanoes namely Erciyes, Hasandağ and Melendiz (Figure 2). Easy carving and thermal properties of