ABSTRACT

Traditional art of building in Bosnia and Herzegovina comprises brick or stone masonry structures. Most historical buildings belonging to national cultural heritage were made of stone-masonry. The country is situated in seismic active region of South-East Europe. In the case of strong earthquake motion such buildings could suffer heavy damages. Some structural elements of historical buildings, as domes and arches, cracked already by moderate earthquake but without the loss of stability. Substantial damages were caused by recent war disaster. Damages could be accumulated through the history as well. Generally, stone-masonry buildings in Bosnia and Herzegovina can be classified in vulnerability classes between A and C according to European Macroseismic Scale. Design and construction procedures for rehabilitation are presented here with examples of repair and strengthening of mosques, which present historical stone masonry structures dating from the Ottoman period in Bosnia and Herzegovina. Traditional and contemporary materials were used for their rehabilitation. It is important to preserve original forms, especially those of damaged elements. The challenge for structural engineers and architects was to find equilibrium between aesthetical and structural demands.
INTRODUCTION

Masonry structures represent traditional way of building in Bosnia and Herzegovina. Most of the historical buildings are masonry structures as well. In spite of the fact that reinforced concrete structures prevail by the new erected buildings, masonry structures are further built, even with application of the new building materials. Regarding damage assessment, the existing masonry building are more vulnerable to the earthquake loading compared to the buildings constructed according to modern technical codes. Structural assessment of the existing building becomes every day task for the structural engineers and architects especially in dense populated urban areas. Depending on the historical period and building tradition in some specific regions, brick or stone masonry was applied. A lot of historical buildings belong to national cultural heritage of the specific country or even to the world heritage. So, they merit special care and protection. Historical buildings, especially those belonging to cultural heritage in Bosnia and Herzegovina are mostly built of stone masonry. Generally they have robust and enduring structure and in the case of stronger earthquakes could suffer substantial or heavy damages, even collapse of the structure. (Hrasnica, 2008, 2012; Asteris et al., 2014)

Very impressive and challenging parts of the historical and cultural building heritage represent towers of sacral buildings, church and mosque towers. The latter ones are known as minarets. The towers of the sacral buildings are of special interest, from the aesthetical and structural point of view, not to forget their practical every day functions. The elegance and the beauty are two epithets (although not technical), which are commonly connected to them. Sacral buildings towers are very often the main bench marks of urban complex, which dominate over the other building structures and form recognizable image of the city. A lot of the cities are known by their church towers or minarets. Their structural behavior differs significantly from the main sacral buildings. Generally, they can be described as tall slender masonry structures. Due to their traditional building materials, masonry, and relatively slender structural system, they are very interesting and in the same time challenging topic for structural engineers and architects, as well.

Evaluation of the structural safety of historical masonry towers in accordance with principles of heritage preservation is one of the central issues in the maintenance of the national and worldwide architectural heritage. The structural engineers are requested to expertly balance between safety and required duration of a facility, respecting original conceptions and following the philosophy of minimal intervention. (Čaušević, 2009; Čaušević, Kuljuh, & Rustempašić, 2011; Čaušević & Kudumović, 2011; Asteris et al., 2014)

The chosen examples of sacral building towers are situated in Mediterranean area, which is known as very active seismic region, as well. The famous fault where Eurasians and African plates touch each other is situated in the heart of this area. This is confirmed through the significant number of strong earthquakes, which hit area in the last decades. (Roca et al., 2010)
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