

Condition assessment of a highly porous limestone fortress: damage categories and structural integrity

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An emblematic monument the Citadella fortress of Budapest has been studied in details to assess the condition of stone structure. The fortress is a large stone structure of 220 m in length and 60 m in width. The height of the porous limestone walls are in between 12-16 metres. The fortress was completed in 1854 but has been partly rebuilt due to changes in function and war related structural damages. The present paper provides an overview of the lithology, weathering forms and structural condition of the fortress related to a forthcoming restoration-reconstruction project. To assess the condition of stone both on site and laboratory analyses were performed. Lithological varieties were documented. Major identified lithotypes are porous oolitic limestone, less porous bioclastic limestone and fine grained highly porous limestone. To identify wet zones portable moisture meter was applied. Surface strength and weathering grade were also assessed using Schmidt hammer and Duroscop. Decay features were diagnosed and mapped. The most common forms are white weathering crusts, scaling and blistering of crusts as well as granular disintegration. Black weathering crusts were also recognized. Laboratory tests were focused on mechanical properties of stones and on mineralogical and chemical compositional analyses. Small samples of stone were collected and tested by optical microscopy, SEM-EDX, XRD and Thermogravimetric analyses. Laboratory analyses proved that the major salt responsible for the damage of external walls is gypsum, although significant amount of halite and hygroscopic salts were found both on the external walls and in the interior parts of the fortress. During structural analyses displacement of walls, tilting and major amount of cracks were recognized. Loss of material and subsidence also caused problems and at some places unstable wall sections were recognized.