Interdisciplinary investigation of stone heritage sites for conservation purposes; a case study of the Székesfehérvár Ruin Garden in Hungary.

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Székesfehérvár is a historic town in Hungary, Central Europe, located 65 km southwest of Budapest, the current capital. The Ruin Garden of Székesfehérvár is a unique monument, which served as the coronation and burial church for the Kings of the Hungarian Christian Kingdom. The site is considered a "National Monument" due its importance in the Middle Ages, therefore its protection is deemed necessary. Several expansions and/or reconstructions took place between the 11th and 15th centuries. The Basilica and other associated buildings were severely damaged by the Turks (16th to 17th century). Further deterioration was followed; the site was used for storage and many of its building and decorative stones were removed and reused in new constructions in the area. The first archaeological excavations began in the 19th century.

Several lithotypes could be found among the remaining stones on site. The interdisciplinary characterisation of the identified materials was crucial not only for the conservation of the Székesfehérvár Ruin Garden but also for other historic structures in Central Europe. The different lithologies were described and depicted on coloured maps, which were also used for the different construction phases of the monument and the weathering phenomena observed on the materials. Moreover, non- or micro-destructive tests were implemented for the in-situ characterisation of the studied building materials (e.g. Schmidt Hammer, moisture content measurement, micro-drilling). Further testing and analysis took place under laboratory conditions, using analogous stones obtained from active quarries and it included petrographic analysis, X-Ray Diffractometry, determination of real density by means of helium pycnometer and bulk density by means of mercury pycnometer, pore size distribution by mercury intrusion porosimetry and by nitrogen adsorption, water absorption, determination of open porosity, micro-drilling, frost resistance, ultrasonic pulse velocity test, uniaxial compressive strength test and dynamic modulus of elasticity.

The most common lithotypes were limestones (>80%). Porous Miocene limestone prevailed, while cemented Mesozoic limestone and travertine were less common. Rhyolite, siliceous sandstone and white marble were sparse. The stones showed moderate to high grade of weathering. The main identified weathering form was black crust on the porous limestones. White crusts, scaling and flaking were also common. Biological growth was also identified on several parts of the ruin.

The laboratory results showed that strength was not necessarily a clear indicator of the stone durability. Bedding and other lithological heterogeneities could influence the strength and durability of the specimens. In addition, long-term behaviour was influenced by the exposure conditions, the fabric and the pore size distribution of each sample. Porosimetry showed high porosities for the oolitic limestones, with their main pore volumes found in the range of larger pores. On the contrary, cemented Mesozoic limestone showed very low porosities. Wide ranges in water absorption and strength values were recorded suggesting significant physical differences among the lithotypes. The interdisciplinary study confirmed that the monumental stones suffered from deterioration in terms of mineralogy, fabric and physical properties, when compared to the freshly quarried stones. Compatibility between the freshly quarried and historical stones was proven, which would be crucial in case of future interventions demanding new materials of similar properties and composition. The strong correlation observed between the micro-destructive techniques and the laboratory test indicated the possibility of minimizing sampling from

cultural heritage sites. The interdisciplinary investigation of the stone material properties and long-term behavior can contribute to the preservation of the site and allow the selection of appropriate interventions and conservation measures.

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