

Abstract

Historic masonry structures are invaluable objects of cultural heritage. Among the countless examples that exist in the world and, specifically, in Italy, one structure stands out: the Garisenda Tower in Bologna. The Garisenda has been one of the defining symbols of the city for roughly 10 centuries, with its characteristic high inclination present since medieval times. The tower has been subject of studies for centuries, and of Structural Health Monitoring (SHM) in more modern times. However, roughly in the last decade, concerns about the tower's structural stability began to arise. The SHM of the tower was enriched with the aid of a plethora of monitoring devices, including in 2019 one that is probably the most suited for direct damage detection: Acoustic Emission (AE). In these last six years, studies from our research group have started to investigate the damage assessment of the Garisenda tower using AE. Because of the then relatively short monitoring time considering AE (and other SHM systems), the understanding of the damage process still had ground to be covered. For example, an integrated analysis of the most current SHM devices in the tower - the internal pendulum, and the Fiber Optical Strings (FOS) - and AE had still not been developed. In addition, the investigation of specific damage mechanisms, such as masonry creep and fatigue, were practically missing from previous works. This thesis addressed these points by leveraging combined studies from *in-situ* SHM field data, structural Finite Element (FE) simulations, and experimental testing campaigns on selenite specimens (the stone from which the inner and outer portions of the tower base, as well as part of the foundation, are made). Results from the thesis indicate that the evolution of damage could be perceived in some different ways. In the period before the closing of the tower to visitors (20/Oct/2023) surges in AE rate were related in general to colder periods, with a stronger coupling between temperature and AE detection, and the damage was primarily concentrated

in the South-East (direction of the leaning). Temperature was also considered for investigations on low-cycle fatigue due to seasonal temperature variations, and an experimental campaign to relate this damage to AE was designed, to be conducted in future works. Overall, this work was able to detect structural stability change and damage with the aid of AE. If there is one thing it aims to highlight is that the continuation of the SHM of the Garisenda tower is, as of now, as important as ever and AE monitoring takes a principal role in it. As such, even though this thesis stands as the first comprehensive work of SHM with AE in the Garisenda, hopefully it will not be the last, and shall be superseded in the years to come.