# Assessment of the Seismic Retrofitting of a Historical Masonry Mosque by Means of Nonlinear Dynamic Analysis

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## ABSTRACT

Seismic actions have been a great challenge for structures in the structural engineering community, and the need for further developments has been approved by catastrophic seismic events at each time. Reproducing the dynamic behaviour of structures with an acceptable level of accuracy is a complex task due to uncertainties related with the geometrical, material and physical structural system, more particularly, in case of existing historical masonry structures. The use of dynamic analysis is a better choice than the use of static or quasi-static approaches since it is a better representation of the dynamic response of a structure by taking account of its energy dissipation capacity. The scope of the present paper is focused on a seismic assessment of a historical masonry structure, Kütahya Kurşunlu Mosque located in Turkey, before and after it has been retrofitted. The historical mosque is located in a seismic prone zone where it is crucial to ensure seismic safety of structures and the local community. Based on the condition of the structure reported from the site inspections, a seismic retrofitting by using steel girder elements was implemented on the structural load-bearing walls. The effectiveness of the seismic retrofitting to the seismic response of the mosque was investigated by means of the finite element method. Three bi-directional nonlinear dynamic analyses were performed by using real ground motion records aiming at validation of the nonlinear dynamic response of the numerical model in terms of damage patterns, and demonstration of the contribution of the seismic retrofitting by comparing the representative model with its retrofitted counterpart. The comparison has been carried out in terms of peak displacement, absolute accelerations and damage patterns. It is found that the contribution of the seismic retrofitting is considerable for the out-of-plane displacements of the load bearing walls. Furthermore, a good correlation between existing damage and the numerical damage is achieved, and, therefore, the validation of the nonlinear response of the representative model is attained. Yet, the variation of the absolute acceleration response before and after retrofitting showed that the seismic assessment and retrofitting should take into account the influence of the acceleration increment which may result in detrimental effects on the movable heritage contents present in the historical structures.