Tracking evidence on seismic damage by nonlinear numerical simulations for dating in archaeological

Laura Pecchioli | Germany, Michele, Betti | Italy, Barbara Pintucchi | Italy

One of the purposes of archaeological research is the examination of the evolution of human cultures. Since a fundamental definition of evolution is “change over time,” chronology is a fundamental archaeological parameter. Time has always been critical to archaeologists, from sequence and succession, through the constant search for refined dating techniques, to theoretical issues of scale and change. A well-defined proxy with stylistic, technical, and chemical composition data would be very helpful in complementing scientific dating. A date archaeologically decontextualized is of little value, so it must be stressed that any dating should be included in archaeological hypotheses. Accurate knowledge about the age of artifacts or archaeological remains is one of the major tasks of archaeological investigations.

Non-linear time-history analyses performed with finite element models may be a tool for dating damage due to past earthquake. In the archaeological context of Ostia Antica, we considered an interdisciplinary study to interpret the damage recorded on site with relevant results. Simple numerical simulations and comprehensive non-linear time-history analyses were performed by applying natural ground motion records to validate the damage interpretation. That information can be useful for understanding the mode of collapse, identifying possible time intervals for dating, and thus better defining the historical chronology of a monument. Of course, besides the seismic parameters, the response to an earthquake depends on the structural characteristics of the building, including a defect in design, employed materials, craftsmanship, etc. Furthermore, earthquake dynamic response also depends on the site geology, enhancing ground shaking. The geologic feature of the soil represents an important aspect in the response of a building to seismic shaking. Using incremental nonlinear dynamic analysis, we can consider different scenarios of seismic events, as well as various hypothetical original morphology of structures.

According to the comparison between the numerical results and the observed damage, it is possible to hypothesize that today’s seismic damage is attributable to an earthquake of medium to strong intensity that occurred when the complex was already in a state of abandonment. In this session, the approach and method adopted in the research will be shown as a contribution to the ongoing methodological discussion in archaeoseismology;as tools to complement or confirm interpretations of analysis and reading of written sources.

References

M.A. Rodríguez-Pascua, R. Pèrez Lòpez, J.L. Giner-Robles, P.G. Silva, V.H. Garduno-Monroy, K Reicherter. A comprehensive classification of Earthquake Archaeological Effects (EAE) in archaeoseismology: application to ancient remains of Roman and Mesoamerican cultures. Qua-ternary International 242(1), 20–30 (2011). https://doi.org/10.1016/j.quaint.2011.04.044.

F. Galadini, Klaus-G. Hinzen, S.C. Stiros. Archaeoseismology: Methodological issues and pro-cedure. Journal of Seismology 10(4), 395–414 (2006). https://doi.org/10.1007/s10950-006-9027-x.

Klaus-G. Hinzen, C. Fleischer, S.K. Reamer, S. Schreiber, S. Schütte, B. Yerli. Quantitative methods in archaeoseismology, Quaternary International 242, 31-41 (2011). https://doi.org/10.1016/j.quaint.2010.11.006.

P. Forlin, R. Valente, M. Kázmér. Assessing earthquake effects on archaeological sites using photogrammetry and 3D model analysis. Digital Applications in Archaeology and Cultural Her-itage 9, e00073 (2018). https://doi.org/10.1016/j.daach.2018.e00073.

Klaus-G. Hinzen, L. Cucci, A. Tertulliani. Rotation of Objects during the 2009 L'Aquila Earthquake Analyzed with 3D Laser Scans and Discrete-Element Models. Seismological Research Letters 84(5) (2013). https://doi.org/10.1785/0220130010.

L. Pecchioli, G. Cangi, F. Marra. Evidence of seismic damages on ancient Roman buildings at Ostia: An arch mechanics approach. Journal of Archaeological Science: Reports 21, 117-127 (2018). https://doi.org/10.1016/j.jasrep.2018.07.006.

R. Caputo, Klaus-G. Hinzen, D. Liberatore,·S. Schreiber, B. Helly, A. Tziafalias. Quantitative archaeoseismological investigation of the Great Theatre of Larissa, Greece. Bulletin of Earthquake Engineering 9, 347–366 (2011). https://doi.org/10.1007/s10518-010-9206-6.

F. Marra, G. Milana, L. Pecchioli, P. Roselli, G. Cangi, D. Famiani, A. Mercuri, G. Carlucci. Historical faulting as the possible cause of earthquake damages in the ancient Roman port city of Ostia. Journal of Seismology 24, 833–851 (2020). https://doi.org/10.1007/s10950-019-09844-z.

L. Pecchioli, M. Betti, B. Pintucchi. Archaeoseismological project in Ostia: tracking evidence on seismic damage by nonlinear numerical simulations. Developments in the Built Environment 10, 100073 (2022). https://doi.org/10.1016/j.dibe.2022.100073.