Interferometric synthetic aperture radar and numerical collapse simulation for residual service life prediction of bridges affected by slow deformation phenomena

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The authors present an innovative approach for structural assessment of bridges undergoing slow deformation phenomena induced by hazard sources such as landslides, ground consolidation, subsidence or foundation scouring. The methodology is multidisciplinary in nature and is based on the combination of displacement measurements derived from Synthetic Aperture Radar Interferometry (InSAR), applied to satellite images, with structural and collapse analyses performed through advanced numerical modelling with Applied Element Method (AEM). InSAR allows to follow the temporal evolution of slow deformations affecting the structure and, exploiting observations from two different viewing geometries of the satellite radar antenna, it is possible reconstructing the two-dimensional movements of a bridge over time, with proper defined error bounds on the estimated displacements. AEM instead is capable of reproducing with a high degree of accuracy the structural behavior from the elastic stage to crack initiation and propagation, steel yielding, up to element separation and collision, therefore is particularly suitable for collapse simulations, allowing to improve the comprehension of the structural behavior and identify the most critical structural elements. The combination of these two powerful tools is aimed at detecting anomalies in the deformation trends, identifying potential critical conditions and evaluating the time to failure of the bridge in the event that the slow movements progress with a trend consistent with the measurements in the monitored period. The application of the methodology to the case study of the Albiano-Magra Bridge, in Italy, which collapsed on April 8th, 2020, is discussed. The integration of InSAR displacement measurement and collapse simulations with AEM has allowed identifying the most probable triggering cause of the collapse and estimating the residual service life of the bridge, whose reliability increases with the extent of the available satellite monitoring period.