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Dynamic High-Rise Moment Resisting Frame Dissipation Performances Adopting Glazed Curtain Walls with Superelastic Shape Memory Alloy Joints

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Abstract : This paper summarizes the results of a survey on smart non-structural element dynamic dissipation when installed in modern high-rise mega-frame prototypes. An innovative glazed curtain wall was designed using Shape Memory Alloy (SMA) joints in order to increase the energy dissipation and enhance the seismic/wind response of the structures. The studied buildings consisted of thirty- and sixty-storey planar frames, extracted from reference three-dimensional steel Moment Resisting Frame (MRF) with outriggers and belt trusses. The internal core was composed of a CBF system, whilst outriggers were placed every fifteen stories to limit second order effects and inter-storey drifts. These structural systems were designed in accordance with European rules and numerical FE models were developed with an open-source code, able to account for geometric and material nonlinearities. With regard to the characterization of non-structural building components, full-scale crescendo tests were performed on aluminium/glass curtain wall units at the laboratory of the Construction Technologies Institute (ITC) of the Italian National Research Council (CNR), deriving force-displacement curves. Three-dimensional brick-based inelastic FE models were calibrated according to experimental results, simulating the fac¸ade response. Since recent seismic events and extreme dynamic wind loads have generated the large occurrence of non-structural components failure, which causes sensitive economic losses and represents a hazard for pedestrians safety, a more dissipative glazed curtain wall was studied. Taking advantage of the mechanical properties of SMA, advanced smart joints were designed with the aim to enhance both the dynamic performance of the single non-structural unit and the global behavior. Thus, three-dimensional brick-based plastic FE models were produced, based on the innovated non-structural system, simulating the evolution of mechanical degradation in aluminium-to-glass and SMA-to-glass connections when high deformations occurred. Consequently, equivalent nonlinear links were calibrated to reproduce the behavior of both tested and smart designed units, and implemented on the thirty- and sixty-storey structural planar frame FE models. Nonlinear time history analyses (NLTHAs) were performed to quantify the potential of the new system, when considered in the lateral resisting frame system (LRFS) of modern high-rise MRFs. Sensitivity to the structure height was explored comparing the responses of the two prototypes. Trends in global and local performance were discussed to show that, if accurately designed, advanced materials in non-structural elements provide new sources of energy dissipation.

Keywords : advanced technologies, glazed curtain walls, non-structural elements, seismic-action reduction, shape memory alloy
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