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Progressive Collapse Analysis Of Prestressed Bridges Using Improved Applied Element Method

By

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ABSTRACT

Bridges are necessary for transporting cars, trucks, and trains across bodies of water, mountain gorges, and other roads. Protecting the entire structure against catastrophic collapse is essential. As a result, modelling the collapse process of each structural part is required to acquire a thorough knowledge of the overall performance of bridges under excessive loading conditions. The current study intends to provide a suitable numerical tool based on the Improved Applied Element Method (IAEM) for two-dimensional modelling of the progressive collapse process of prestressed bridges under extreme loading conditions. For that purpose, a new methodology of an improved numerical technique based on the IAEM has been developed to facilitate the simulation of large scale bonded and unbonded prestressed structures and cable-stayed-bridges. Three major extensions have been implemented: the first is adding a new layer to represent the behavior of the prestressing bonded tendon and the transfer of the stresses between the tendon and concrete. The second one is modeling the unbonded tendon as an assemblage of straight normal springs that connect the anchorage points with dummy elements generated between each two successive multi-layered elements. The third one is modeling the cable-stayed bridges, in which the pylons and the deck are modeled using the advantage of the multi-layered element, while the stay cable is modeled as a single straight chord (straight normal spring) with an equivalent modulus of elasticity. For the three extensions, an initial load step has been developed to consider the effect of prestressing. During this load step, an initial strain is produced in the tendon and the cable to represent the effective prestressing. In addition, the mass matrix has been modified to account for the mass of the cable-stay that is needed to apply at certain DOFs. Material and geometric nonlinearities are considered in the proposed model for the multi-layered element, the tendon, and the stay-cable. Several verification examples are presented to examine the capability of the models. The reliability of the model is investigated by comparing its results with existing experimental and numerical results. Furthermore, the developed features of the IAEM are used to perform progressive

collapse analysis of various bridges under extreme loading conditions. A typical prestressed concrete girder bridge is also analyzed under blast load and column removal scenarios. Furthermore, a cable-stayed bridge is also examined under a cable-loss scenario. Finally, a probabilistic analysis of the blast load as a random variable using the Monte-Carlo method is carried out to investigate its effect on the response of the prestressed bridges.