A Novel Approach to Determine the Safety Factor of Suspension Bridge Main Cables

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ABSTRACT

Reliable assessment of the cable's remaining capacity is needed by bridge authorities in order to make important decisions regarding maintenance and rehabilitation or even replacement of main cables in suspension bridges. A new methodology to determine the safety of suspension bridge main cables is proposed and illustrated on a corrosion-deteriorated cable composed of 9061 wires. The approach is the first one incorporating a finite element (FE) model to predict the cable's failure load, accounting for load recovery due to friction in broken wires and simulating the reduced cable's strength as a three dimensional random field. In order to obtain the cable's failure load, the load is increased gradually, having individual wires break according to their residual strength. Because of the load transfer to surrounding wires, the breakage of an individual wire affects the stress state in the surrounding wires. This local damage eventually causes a global reduction in the load carrying capacity of the cable, up to a complete failure. The safety of the cable is determined through a Monte Carlo simulation, in which the reduced strength of the cable is generated for every realization through the Spectral Representation Method (SRM) and is input as a material parameter to the FE model. The speed of the SRM computation is dramatically improved with the application of the Fast Fourier Transform technique. The statistics of the load that will drive a suspension bridge cable to failure under a hypothetical deterioration state and the corresponding safety factor are obtained. Moreover, the proposed formulation is capable of representing the formation of a cluster of broken wires before full collapse of the cable. This result can help us in explaining cable conditions that occur in real life and prevent catastrophic failures.