Biomechanically Excited SMD Model of a Walking Pedestrian

Through their biomechanical properties, pedestrians interact with the structures they occupy. Although this interaction has been recognized by researchers, pedestrians' biomechanical properties have not been fully addressed. In this paper, a spring-mass-damper (SMD) system, with a pair of biomechanical forces, was used to model a pedestrian for application in vertical human-structure interaction (HSI). Tests were undertaken in a gait laboratory, where a three-dimensional motion-capture system was used to record a pedestrian's walking motions at various frequencies. The motion-capture system produced the pedestrian's center of mass (COM) trajectories from the captured motion markers. The vertical COM trajectory was approximated to be the pedestrian SMD dynamic responses under the excitation of biomechanical forces. SMD model parameters of a pedestrian for a specific walking frequency were estimated from a known walking frequency and the pedestrian's weight, assuming that pedestrians always walk in displacement resonance and retain a constant damping ratio of 0.3. Thus, biomechanical forces were extracted using the measured SMD dynamic responses and the estimated SMD parameters. Extracted biomechanical forces from all test trials were expressed with third-order Fourier series. It was found that the amplitude of the first-order biomechanical forces changed with the pacing frequency and that it fit a linear model. Amplitudes of the second- and third-order biomechanical forces were found to be scattered and not closely related to walking frequency. A generalized extreme value distribution was fit to each of the amplitudes. Phases in the model for biomechanical forces were not related to pacing frequency, and a mean value of the phases is proposed.

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