INCREMENTALLY DAMAGED STATES OF A BEAM STRUCTURE

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Abstract: As part of an initial investigation of structural health evaluation, laboratory experiments are used to determine potential parameters for damage detection. A structural change due to damage may be identifiable by examining vibratory characteristics including natural frequency and damping shifts. The aim of this work is to experimentally relate motions of undamaged and cumulatively damaged structures. For a cantilever beam, time histories and frequency responses were experimentally obtained for the undamaged and two incrementally damage states. The stainless steel beam was cumulatively damaged by mechanical drilling and routing at both modal maximum and node locations. Modal analysis was then performed using impact hammer and accelerometer, and the data was captured and analyzed with National Instruments LabVIEW.

Theoretically, natural frequencies will decrease as a structure's stiffness decreased due to damage. However, the extent of damage and thus quantitative frequency shift are not yet predictable. The experimentally measured natural frequencies reveal that the first mode's frequency did not decrease under damage state one but decreased 3.23% under damage state two. The second mode natural frequency reduced 1.47% and 2.45% under damage state one and two, respectively. The third mode natural frequency diminished 2.04% and 3.23% under damage state one and two, respectively. The peaks in frequency response are also broader when damage has occurred, showing that damping has increased. Using the half-power bandwidth method, the measured damping ratios for the first mode are 1.58%, 1.54%, and 2.17% for three different damage states (undamaged, damage state one, and damage state two), respectively. Damping ratios for the second mode are 0.85%, 0.47%, and 0.62% while the ratios for the third mode are 0.07%, 0.08%, and 0.18% for three different damage states.

These experimental results confirm that the natural frequency incrementally drops with incremental structural damage. However, the trend rate is not yet predictable as more data points are required. The trend behavior is even more uncertain for damping effects, where often damping will increase with damage but may decrease. In future work, the trend behaviors will be further studied for the damaged behavior of a laboratory-constructed tower. Here, mode shape shifts will also be used to identify damage location.

Keywords: damage, health, response, frequency.

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