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Sensitivity of fundamental mode shape and static deflection for damage identification in cantilever beams

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ABSTRACT

Fundamental mode shape and static deflection are typical features frequently used for identification of damage in beams. Regarding these features, an interesting question, still pending, is which one is most sensitive for use in damage identification. The present study addresses the key sensitivity of these features for damage identification in cantilever beams, wherein these features are extremely similar in configurations. The intrinsic relation between the fundamental mode shape and static deflection is discussed, and in particular, an explicit generic sensitivity rule describing the sensitivity of these features to damage in cantilever beams is proposed. The efficiency of this rule in identifying damage is investigated using Euler–Bernoulli cantilever beams with a crack. The validity of the approach is supported by three-dimensional elastic finite element simulation, incorporating the potential scatter in actual measurements. The results show that the generic sensitivity rule essentially provides a theoretical basis for optimal use of these features for damage identification in cantilever beams.

1. Introduction

Damage identification in beam-like structures has been a basic research topic in structural health monitoring for the late decades [1]. Various algorithms have been derived for damage diagnosis in a cantilever beam [2,3]. In studies of damage identification in cantilever beams, fundamental mode shape is the most typical dynamic property [3,4–9] employed for damage localization and quantification. The extensive use of fundamental mode shape in damage identification is, to a large extent, attributed to its good sensitivity, reliability and relative convenience in experimental acquisition using a standard modal testing method. Although the higher mode shapes may theoretically be more sensitive to small damage, difficulties in acquisition considerably decrease their practicability in damage diagnosis. Parallel to fundamental mode shape, static deflections including deflection under tip-concentrated loading and deflection under uniformly distributed loading are alternative simple properties [10–14] for damage identification in cantilever beams. Hereafter, for conciseness in statement, fundamental mode shape, deflection under tip-concentrated loading and deflection under uniformly distributed loading are symbolized as FMS, d_{tcl} and d_{udl}, respectively.

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