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The use of different modal quantities for identification of damage

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ABSTRACT

Vibration-based damage identification techniques have recently been the subject of much research. The most popular observed quantities are natural frequencies, which have been referred to from pionering papers on the subject until now [1], because as a global property they are easy to be reliably measured and their variation with damage is clearly monotonic. Unfortunately, just due to their being a global characteristic, frequencies offer a modest sensitivity to local damage, mainly when the damage intensity is limited. For these reasons, and with the increasing availability of more affordable experimental techniques, other modal quamtities – modal shapes and modal curvatures – are the focus of increasing attention, also with the aim of detecting early damage. In particular, curvatures became very attractive because they are strictly connected to damage and considerably modify in the neighborood of damage. However, their use is not simple for at least two reasons: first, it is a localized quantity and so its reliable observation requires a large number of sensors; second, their modal variations due to damage is not so directly related to the location of damage, as one could expect, but the variation can even spread over regions not involved by the damage, as shown in [2].

With the aim of making use of all the different measured modal quantities, the first part of the work is devoted to the critical analysis of these quantities, with a special focus on modal curvatures. Making use of a perturbative solution of the equation of motion of a damaged beam, it is possible to obtain a closed form relationship between the modal curvature differences due to damage and the damage distribution itself. This suggests suitably filtering the modal curvature variations in view of obtaining a correct damage localization. This information is added to the contributions of other modal quantities, frequencies and mode shapes, to improve conditioning of the inverse problem of damage identification and to eliminate possible redundant solutions, as already shown in [3].

The validation of the procedure that makes use of the modal quantities measured by an experimental setup, able to record frequencies, modal shapes and modal curvatures, is performed by means of numerical investigation with pseudo-experimental data and of an experimental laboratory campaign. The experiments deal with two beam-like structure configurations, a free-free beam and a continuous beam with an intermediate support.

Several damage cases are considered, both localized and extended, with different intensities; the sensitivity of the procedure to extension and position of damages as well as density and distribution of sensors are investigated with the aim of obtaining a single position and intensity of damage.

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