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A Study on Inverse Determination of Impact Force on a Honeycomb Composite Panel

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Abstract : In this study, an inverse method was developed to reconstruct the magnitude and duration of impact forces exerted to a rectangular carbon fibre-epoxy composite honeycomb sandwich panel. The dynamic signals captured by Piezoelectric (PZT) sensors installed on the panel remotely from the impact locations were utilized to reconstruct the impact force generated by an instrumented hammer through an extended deconvolution approach. Two discretized forms of convolution integral are considered; the traditional one with an explicit transfer function and the modified one without an explicit transfer function. Deconvolution, usually applied to reconstruct the time history (e.g. magnitude) of a stochastic force at a defined location, is extended to identify both the location and magnitude of the impact force among a number of potential impact locations. It is assumed that a number of impact forces are simultaneously exerted to all potential locations, but the magnitude of all forces except one is zero, implicating that the impact occurs only at one location. The extended deconvolution is then applied to determine the magnitude as well as location (among the potential ones), incorporating the linear superposition of responses resulted from impact at each potential location. The problem can be categorized into under-determined (the number of sensors is less than that of impact locations), even-determined (the number of sensors equals that of impact locations), or over-determined (the number of sensors is greater than that of impact locations) cases. For an under-determined case, it comprises three potential impact locations and one PZT sensor for the rectangular carbon fibre-epoxy composite honeycomb sandwich panel. Assessments are conducted to evaluate the factors affecting the precision of the reconstructed force. Truncated Singular Value Decomposition (TSVD) and the Tikhonov regularization are independently chosen to regularize the problem to find the most suitable method for this system. The selection of optimal value of the regularization parameter is investigated through L-curve and Generalized Cross Validation (GCV) methods. In addition, the effect of different width of signal windows on the reconstructed force is examined. It is observed that the impact force generated by the instrumented impact hammer is sensitive to the impact locations of the structure, having a shape from a simple half-sine to a complicated one. The accuracy of the reconstructed impact force is evaluated using the correlation co-efficient between the reconstructed force and the actual one. Based on this criterion, it is concluded that the forces reconstructed by using the extended deconvolution without an explicit transfer function together with Tikhonov regularization match well with the actual forces in terms of magnitude and duration.

Keywords : honeycomb composite panel, deconvolution, impact localization, force reconstruction
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