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Structural health monitoring techniques for historical buildings

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Abstract

The knowledge of the health conditions of its historical buildings is a great concern for many towns in Italy, where churches and palaces are known all around the world. The monitoring of the structural integrity of historical buildings is also needed to preserve the precious cultural inheritance from the past, see Figure 1(a). Churches, masonry towers and bell towers are among the structures subjected to the higher risk, due to their age, elevation and low base area on height ratio. This paper discuss the structural integrity monitoring of buildings by the technique of identifying their dynamic characteristics with non-destructive analysis. Each body has its own shapes, frequencies of vibration and dumping properties (the modal parameters), that are a function of its mechanical characteristics: a damaged structure shows a frequency autospectrum which differs from that of the integral one, [1]. The detection of the dynamic characteristics of a buildings can then identify the presence of damaged zones, cracks and structural degradation during the time, as illustrated for example in [2-4].

(a)

(b)

Figure 1. (a) Deformation of the inner vaults of the Duomo of Parma, Italy; (b) the Polytec laser Doppler vibrometer at the laboratory of the University of Parma.

The methodology of measurement here proposed makes use of a laser Doppler vibrometer (LDV technique), see Figure 1(b); it is a relatively new non-contact detection technique that provides measures of displacement with great accuracy and reliability, [5-7]. The results of measures are elaborated via computational programs to identify the modal response of the structure and detect the evolution of any damaged zone by calculating mass and stiffness changes in reverse based on changes in mode shapes. The assessment procedure includes i) full-scale ambient vibration testing of the historical building, being ; ii) the modal identification from ambient vibration responses; iii) the finite element modelling and dynamic-based identification of the uncertain structural parameters of the model. The validity of the proposed method is firstly experimentally demonstrated through vibration measurement for a steel plate before and after damage, as schematically illustrated in Figure 2.

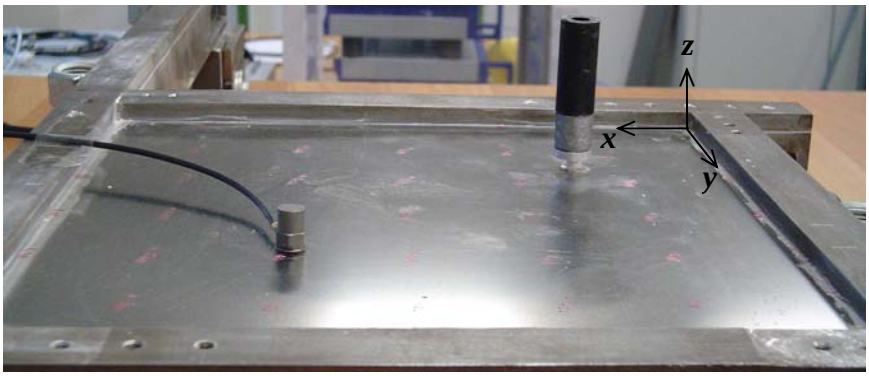

Figure 2. The 4-side constrained steel plate for the validation of the laser Doppler measurement method.

Keywords: Laser Doppler Vibrometer, structural integrity, modal analysis, vibration-based damage detection

Essential references

1. OS Salawu, 'Detection of structural damage through changes in frequency: a review', Engineering Structures 1997;19(9):718-723.
2. JW Lee, *et al.*, 'Health-monitoring method for bridges under ordinary traffic loadings', Journal of Sound and Vibration, 2002;257(2):247-264.
3. L Majumder, CS Manohar, 'A time-domain approach for damage detection in beam structures using vibration data with a moving oscillator as an excitation source', Journal of Sound and Vibration, 2003;268:699-716.
4. C Gentile, A Saisi, 'Ambient vibration testing of historic masonry towers for structural identification and damage assessment', Construction and Building Materials 2007;21:1311-1321
5. DM Siringoringo, Y Fujino, 'Experimental study of laser Doppler vibrometer and ambient vibration for vibration-based damage detection', Engineering Structures 2006;28:1803-1815.
6. AJ Bougard, BR Ellis, 'Laser measurement of building vibration and displacement', Shock and Vibration, 2000;7(5):287-298.
7. HH Nassif, *et al.*, 'Comparison of laser Doppler vibrometer with contact sensors for monitoring bridge deflection and vibration', NDT&E International, 2005;38:213-218.