Combination of Multiple Non-Linearities in Structural Modelling, Simulation and Assessment Work

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Summary

System identification methodologies have reached a mature state. Damage detection has been the key topic of recent research work in this field. Learning from evolution of dynamic characteristic throughout the damage process, one can validate damage detection methods or set benchmark studies for typical aging processes of a structure. When dynamics gain a guiding role in the behaviour of a structure our conventional approaches fail. The influence of the various non-linearities can not be neglected anymore. This paper is determined to describe a number of these non-linearities and their embedment into the system identification procedure. The results show that changes of natural frequencies are clearly visible, but not a reliable identification approach. Identifying the non-linearities helps to identify damage at an early stage and enables even damage quantification, location and most important remaining lifetime prediction.

Keywords: Non-linear dynamic behaviour, system identification, damage detection, health monitoring

1. Introduction

Structural Health Monitoring (SHM) is a subject that has received considerable attention in recent years. Incidents such as the collapse of the I-35 Bridge in the U.S. give a clear indication of the importance of SHM. In practice, bridge assessment includes several measures, such as inspection, data interpretation, risk assessment and development of engineering recommendation.

For global structural assessment in particular, vibration monitoring (Wenzel 2005) has been widely used. The authors have been involved at the frontline of development of SHM in civil engineering and particular SHM of bridges (Wenzel 2009). Vibration characteristics captured from vibration monitoring provide global information on structural behaviours such as stiffness, connectivity, boundary conditions, mass distribution and energy dissipation. The basic principle of vibration based structural assessment is that structural performance changes from defects will create changes in the dynamic response that can be detected from the changes in the vibration characteristics. In other words changes in energy distribution, frequencies, mode shapes, vibration intensities and system damping can be used as indicators of the changes of physical properties of structures such as mass distribution, vibration energy contribution, stiffness, connectivity, boundary conditions and energy dissipation. Extensive works have been done on developing methods and algorithms for damage detection using vibration characteristics. Döbling et al (1996) present a comprehensive list of literature in damage detection, divided the detection algorithms into 4 levels of increasing complexity. They are:

- level 1 determination that damage is present in a structure,
- level 2 determination of the geometric location of the damage,
- level 3 quantification of the verity of damage, and
- level 4 prediction of the remaining service life of a structure.

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