ABSTRACT

The early detection of structural damage is one of the major challenges in the aerospace, civil, mechanical and marine industries. The early damage assessment helps to reduce the down time, evaluate the safety and prevent the catastrophic events. Also, it plays a major role in real time monitoring and reporting of structures. The damage assessment methods are broadly categorized as visual inspection, local and global non-destructive tests. The visual inspections can only access the external damages, not the hidden damages within the structure. The local non-destructive methods also need the structural area of study to be accessible, which is not always possible. They can give the local condition of the structure, which may not be sufficient to predict the condition of the entire structure. These challenges have led researchers to investigate on vibration based global methods for damage assessment purpose. These methods can easily indicate the health of whole structure, even by measuring the vibration response at a few locations. These vibration methods are mainly based on signal processing or optimization technique. The signal processing is useful when the numerical model of the test structure is not feasible, but they can only locate the damage without its quantification. On the other hand, the optimization based damage assessment methods can locate and quantify the damages with a desired level of accuracy. These methods make use of the measured vibration response of the damaged structure and its numerical model to assess damages. The presence of damage changes the physical properties in the structures such as mass, stiffness, damping, etc. The changes in physical properties alter the dynamic response of the structure such as frequency, mode shapes, damping ratio, frequency response function (FRF), etc. These changes in the vibration responses can be used as damage indicators to assess damages in a structure.

The present study is focused on the development of FRF based numerical algorithm for structural damage assessment. The FRF data includes the information of natural frequencies, mode shapes and modal damping ratios making it a powerful damage indicator. The objective function is defined as the error between the measured FRF data of the damaged structure and simulated FRF data of the updated numerical model with damage parameters. The objective function is minimized through numerical simulations with the help of unified particle swarm optimization (UPSO) to assess the damage locations and their extent. The UPSO is an efficient and robust evolutionary technique since it gives excellent control on the exploration and exploitation capability, leading to global optima. The proposed FRF based structural damage assessment using PSO are applied numerically and experimentally on several skeletal structures. The extensive study of the proposed method shows an improvement in the accuracy of damage prediction and encourages its applicability for structural damage assessment purpose.

Keywords: *Structural damage assessment; Frequency response function; Unified particle swarm optimization; Finite element Analysis; Sub-structuring; Stiffness reduction factor; numerical and experimental study.*