World Academy of Science, Engineering and Technology
International Journal of Mathematical and Computational Sciences
Vol:14, No:12, 2020

Frequency Domain Decomposition, Stochastic Subspace Identification and Continuous Wavelet Transform for Operational Modal Analysis of Three Story Steel Frame

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Abstract : Recently, Structural Health Monitoring (SHM) based on the vibration of structures has attracted the attention of researchers in different fields such as: civil, aeronautical and mechanical engineering. Operational Modal Analysis (OMA) have been developed to identify modal properties of infrastructure such as bridge, building and so on. Frequency Domain Decomposition (FDD), Stochastic Subspace Identification (SSI) and Continuous Wavelet Transform (CWT) are the three most common methods in output only modal identification. FDD, SSI, and CWT operate based on the frequency domain, time domain, and time-frequency plane respectively. So, FDD and SSI are not able to display time and frequency at the same time. By the way, FDD and SSI have some difficulties in a noisy environment and finding the closed modes. CWT technique which is currently developed works on time-frequency plane and a reasonable performance in such condition. The other advantage of wavelet transform rather than other current techniques is that it can be applied for the non-stationary signal as well. The aim of this paper is to compare three most common modal identification techniques to find modal properties (such as natural frequency, mode shape, and damping ratio) of three story steel frame which was built in Concordia University Lab by use of ambient vibration. The frame has made of Galvanized steel with 60 cm length, 27 cm width and 133 cm height with no brace along the long span and short space. Three uniaxial wired accelerations (MicroStarin with 100mv/g accuracy) have been attached to the middle of each floor and gateway receives the data and send to the PC by use of Node Commander Software. The real-time monitoring has been performed for 20 seconds with 512 Hz sampling rate. The test is repeated for 5 times in each direction by hand shaking and impact hammer. CWT is able to detect instantaneous frequency by used of ridge detection method. In this paper, partial derivative ridge detection technique has been applied to the local maxima of time-frequency plane to detect the instantaneous frequency. The extracted result from all three methods have been compared, and it demonstrated that CWT has the better performance in term of its accuracy in noisy environment. The modal parameters such as natural frequency, damping ratio and mode shapes are identified from all three methods.

Keywords : ambient vibration, frequency domain decomposition, stochastic subspace identification, continuous wavelet transform
Conference Title : ICSRD 2020 : International Conference on Scientific Research and Development
Conference Location : Chicago, United States
Conference Dates : December 12-13, 2020