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Structural Health Monitoring of Civil Engineering Structures

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Abstract

Our country is home to many important engineering structures such as bridges, dams, historical structures with different carrier systems. Both touristic and usage-purpose structures are damaged in time-dependent conditions. Considering the important earthquakes that have occurred in our country, which is located in the seismic belt, many structures have been exposed to earthquakes of great intensity. These earthquakes may have caused time-dependent internal stresses and/or damages in the structures. In addition to these, fatigue damage may occur over time in structures exposed to continuous and variable traffic, wind and human loads. Therefore, these structures may face the danger of collapse in the next earthquake. Structures that took many years to build may have been affected by earthquakes and constant traffic, wind and human loads, as well as time-dependent material deformations, temperature changes and blasting in the immediate surroundings. As a result, it is necessary to determine the safety of different structures of great importance by using developing methods as a result of these stresses they are exposed to. Today, with the developing technology, the designs of important engineering structures such as bridges, historical structures and dams can be easily made using computer aided methods. In particular, the safety of these structures against earthquakes or other dynamic effects can be determined with various programs prepared using the Finite Element Method. However, when these damaged or destroyed structures are examined, it is seen that there are many differences between the structures designed with computer programs and the existing structures. Among the reasons for these are some acceptances during the designs and various workmanship errors. Therefore, it is necessary to determine the safety of existing structures under earthquake and permanent loads using experimental methods and to monitor how the changes in the structure affect the remaining life of the structure over time. The structural behavior of engineering structures under dynamic effects is determined by the dynamic characteristics defined as natural frequency, mode shape and damping ratio. Experimental Modal Analysis method is used to determine the dynamic characteristics of structures depending on experimental measurement methods. In this method, sensitive accelerometers are placed on the modal motion points obtained as a result of finite element analysis on the structure. Vibration signals from accelerometers are collected with the help of data acquisition unit and dynamic characteristics are obtained by using up-to-date software. Structural Health Monitoring (SHM) is a method that has been widely used in civil engineering in recent years, based on the principle of continuous monitoring and control of the structural behavior of engineering structures with different types of materials and structural systems, together with experimental methods, and determination of damage by taking into account the changes that may occur. Experimental methods used in Structural Health Monitoring systems are divided into two main parts as destructive/damaged and non-destructive methods. Non-destructive methods are preferred because no damage is desired on the structures after the experimental measurements. Experimental Modal Analysis method is divided into two as Forced Vibration Method and Ambient Vibration Method. In the Forced Vibration Method, the structure is vibrated with a known and measurable effect (shake table, impact hammer, shakers, etc.) and the response of the structure to this effect is measured. In the Ambient Vibration Method, on the other hand, it is assumed that the building vibrates with an ambient effect (such as wind, vehicle load, earthquake, blast or pedestrian movement) and the response of the building to this effect is measured. With Structural Health Monitoring, the current conditions of the structures are determined, the structural behavior characteristics are determined, the building is

monitored 24/7, the damage that will occur in the building due to aging and external factors is determined in advance, and the building is immediately intervened with the early warning system. SHM systems are increasingly being integrated into the structural design phase as a necessary part of structures design. Each SHM system is specifically designed and ordered to specific monitoring purposes. It is of great importance that the structure-specific behaviors are well determined and the most appropriate monitoring systems for the structure (displacement, accelerometer, straingage, pressure gauge, heat meter, etc.) are placed in the determined locations. Classification, processing, and storage of data obtained 24/7 from sensors placed in suitable locations is another important issue. The management of the obtained big data also affects the reliability of the Structural Health Monitoring system. Processing all data and making them meaningful by interpreting constitutes the decision mechanism for the structures in the Structural Health Monitoring System. The allowable limit values of the structural condition are defined as threshold values and compared with the values obtained by processing the raw signals. Thus, the confidence interval of the structure is determined, and the structural status is monitored.