8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

FINITE ELEMENT MODEL UPDATING OF A PRESTRESSED CONCRETE BEAM USING THE OPENSEES.NET SOFTWARE

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Keywords: Finite element model updating, OpenSees.NET, Prestressed concrete beam, Seismic analysis

Seismic analysis of structures is an essential task for safe design of structures especially in earthquake-prone areas. Finite element modeling of structures plays a vital role in this regards. On the other hand, accurate modeling of a structure is still a serious concern since the finite element models always differ from the as-built structures. It comes from the fact that there are lots of structural uncertainties like boundary conditions, connections, structure's geometry, materials properties, etc. Therefore great effort should be devoted to the modeling of such parameters accurately. To create a reliable and accurate finite element model of structures, one can use the model updating algorithms which are popular nowadays particularly in case of complex civil structures. Model updating procedure is normally based on an optimization framework in which the model parameters updated by comparing with the ones of an experimental test in order to make the model simplified assumptions more realistic. In this paper, the new OpenSees.NET software is developed first and it will be shown that this software is a very suitable tool for model updating of structures modeled in OpenSees framework (http://opensees.net). OpenSees (the Open System for Earthquake Engineering Simulation) is a free and well-established software widely used by civil engineering community for simulating the response of structures subjected to earthquakes. The OpenSees.NET software is Microsoft.NET framework assembly as a Wrapper for OpenSees framework. OpenSees.NET developed by using C++/CLI technology for x86 and x64 architectures. By using the developed software, one can perform the structural modeling and post-processing the output data in MATLAB or .NET environment. A prestressed concrete beam is also selected as the case study for finite element model updating using the OpenSees.NET framework.

Lots of model updating methods have been proposed and applied in past years (Friswell & Mottershead, 1995). Model updating approaches are generally classified into time domain and frequency domain algorithms. A time domain model updating method deals with the time history of the structure response while modal parameters are applied in case of frequency domain model updating approaches. In this regard, studying the structural eigenvalues is a common approach where the model updating procedure continues to minimize the difference between the measured and estimated modal frequencies (Zhang et al., 2000). In this paper, a post-tensioned concrete beam model will be updated by tracking the first natural bending mode frequency. The optimization target is the frequency obtained by a laboratory dynamic impact test performed by Noble et al. (2016). The concrete beam is 2.3 m long, 150 mm wide and 200 mm deep. Both ends of the beam are on simple supports with a span length of 2 m. Figure 1 shows the beam geometry and instrumentation of the dynamic test as well.

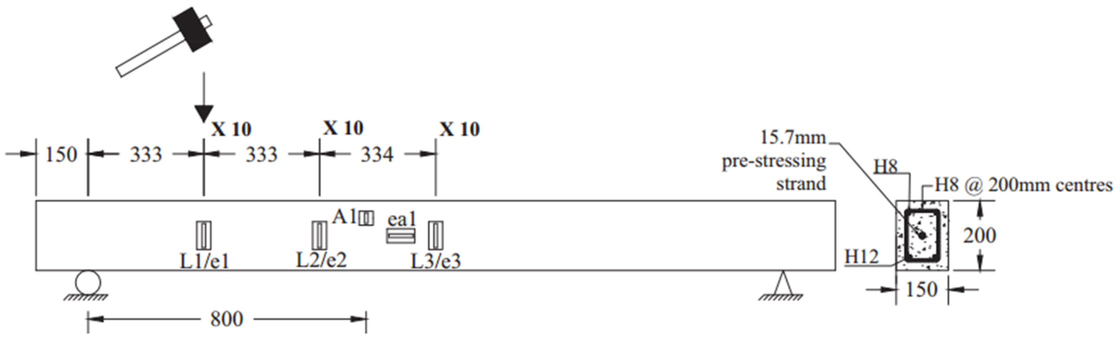

Figure 1. Post-tensioned concrete beam and the instrumentation of the dynamic impact test (Noble et al., 2016).

The acceleration data recorded by an accelerometer (A1 in the Figure 1) is transformed back to the frequency domain using the Fast Fourier Transform (FFT) method and peak picking approach implemented for modal frequency estimation of the beam. The first bending modal frequency of the post-tensioned concrete beam was estimated to be 71.8 Hz. The prestressed force is 70 kN in the experiment. The beam is modeled first in OpenSees and the provided finite element model will be updated by selecting the concrete strength, concrete ultimate strain, prestressed load and prestressing strand modulus of elasticity as optimization variables. The modeling and optimization stages have been implemented using the OpenSees.NET software in MATLAB environment. Each of the selected parameters will be changed in a specific pre-defined interval and new model will be analyzed. The difference between the first bending frequency of the updated model and the experimental one will be .0001 after 125 optimization iterations (Figure 2).

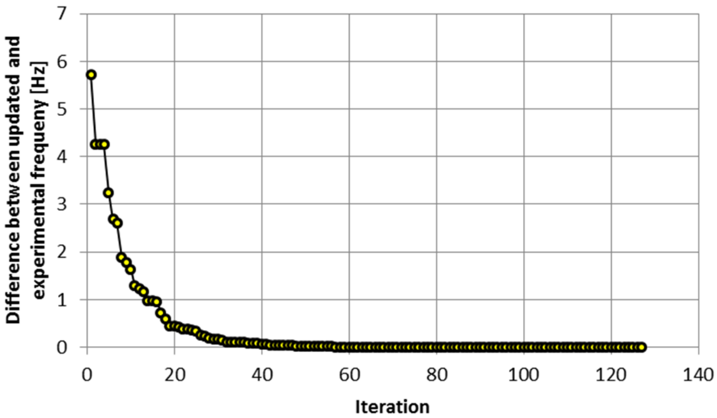

Figure 2. Difference between the first bending frequency of the updated model and the experimental one versus optimization iterations.

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