DAMAGE DETECTION METHOD USING POWER SPECTRAL DENSITY FUNCTION

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Structures undergo different types of loading during their lifetime. As these loads cause the performance of the structures to decay gradually, the urge of damage detection using nondestructive methods has been felt during the past two decades (Esfandiari et al., 2020). In this study, a structural damage detection method is presented using measured power spectral density data. It uses the power spectral density function and the decomposed form of frequency response function to evaluate response sensitivity with respect to the change of stiffness parameters for finite element model updating (Kammer and Nimityongskul, 2009). Damage is considered to be a reduction in structural stiffness parameters (Bakhtiari-Nezhad et al., 2005). For frequency domains introduced here, updated stiffness parameters are captured with high accuracy through solving the sensitivity equations by the least square approach. MATLAB software is used for the numerical analyses. The performance of this method is investigated through identifying the damage of a bridge truss structure as shown in Figure 1.

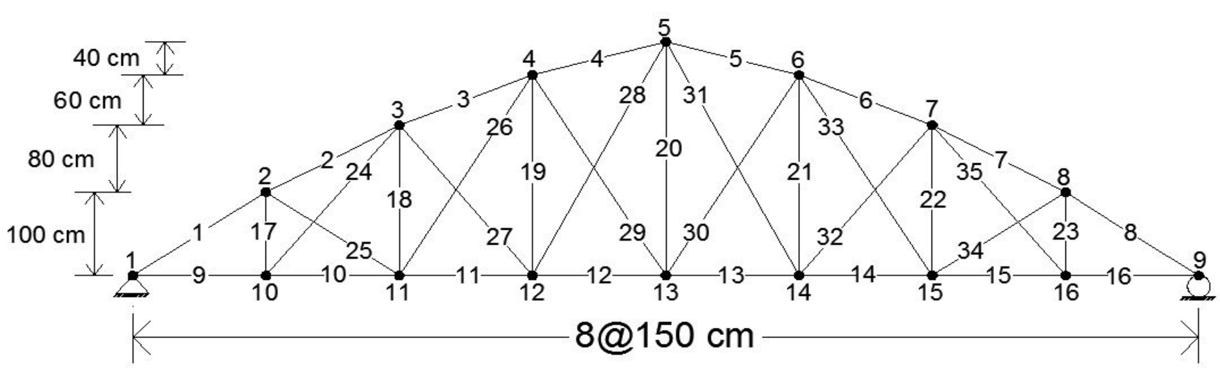

Figure 1. Geometry of truss model

The truss is modeled numerically using the finite element model of the structure consisting of 35 elements and 16 DOFs. The elements are made from steel with Young's modulus of 20 Mpa and cross sectional areas are given in Table 1. Also, the kinematic DOFs are of the truss model are shown in Figure 2. Several different damage scenarios are applied to this model at various locations and damage severity from 30% to 70% as shown in Table 2. Also, in order to account for the measurement errors 50 sets of 5% random noise have been applied to the model. The excitation are applied at the DOFs 9, 13, 15, 17 and 19 and the measurement points are assumed to be in DOFs 7, 9, 11, 14, 17, 18, 27 and 28.

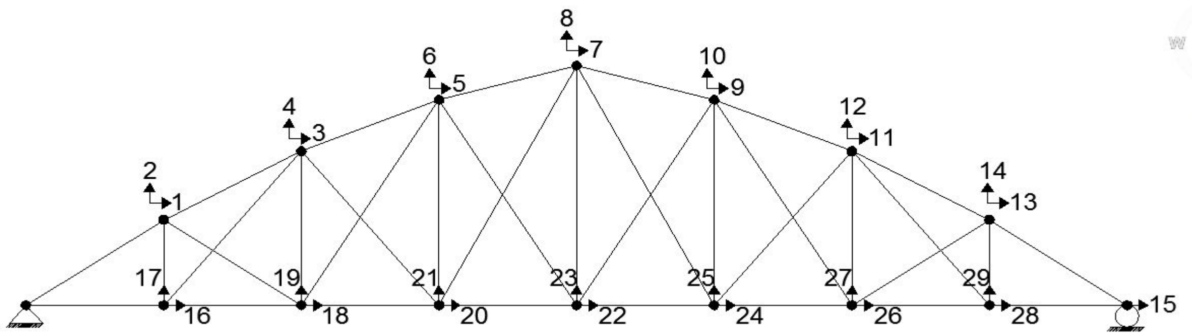

Figure 2. The degrees of freedom of the truss

Table 1. Cross sectional areas of the truss elements

Element Number	Area (cm^2)
1-8	1.8
9-16	1.5
17-23	1
24-35	1.2

Table 2. Damage scenarios

Scenario number		Element number and damage percentage				
1	Element no.	5	14			
	Damage percentage	30	50			
2	Element no.	4	16	23		
	Damage percentage	40	50	60		
3	Element no.	3	11	32	35	
	Damage percentage	30	30	30	30	
4	Element no.	7	19	27		
	Damage percentage	30	40	30		
5	Element no.	2	9	13	29	33
	Damage percentage	30	40	50	40	30
6	Element no.	6	20			
	Damage percentage	40	70			

Comparing the numerical results of all damage scenarios with the assumed damages demonstrate that this method is able to accurately detect the damage locations and their amplitudes.

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