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Dynamic behavior of a Warren truss beam upon loosening of a bolt in a truss node

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Abstract. *The present work aims to show our practical achievements made in the laboratory of the UBB Resita faculty, where on Warren truss hinged at both ends, we studied the negative impact of loosening a bolt in a truss node that has them on natural frequency. Based on the bolt tightening, the specimen had three different states: healthy state, damage state I, and damage state II.*

Keywords: *Warren truss, mode shape, natural frequency*

1. Introduction

Warren truss are popularly used in various engineering fields [1, 2, 3, 4], through experimental tests in the laboratory of Babes-Bolyai University we tested the dynamic behavior of a truss Figure 1, by gradually tightening a screw from the node .and among them, steel tubular trusses have been widely applied in large engineering structures, such as the International Space Station, bridges, concert halls and electricity poles, thanks to their architecturally attractive and favorable forms structural properties [5]. The geometry of the truss elements and the properties of the material are modified, and with them, the modal parameters of the structure are also changed [6]

With the help of LabVIEW data acquisition mode, which receives the signal from the 2 accelerometers [7], and transmits it to the compact NI cDAQ-9172[8] chassis, we export the extracted data in the PyFEST program, developed in the research center of UBB Resita [9].

The elements in truss were numbered with numbers and the nodes were assigned letters. The fastening of the truss was done with screws M6.

I extracted the natural frequencies on a warren truss, articulated at both ends, where each element is 500 mm long. The free length of the truss are L=1000 mm. The cross-section area is 30 mm and the thickness is 5 mm.

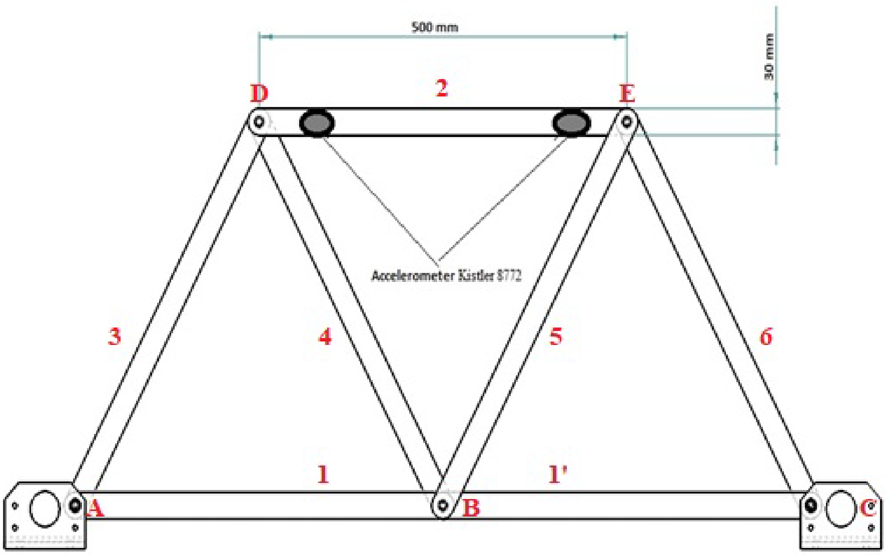

Figure 1. Seven-bar truss

Table 1. The physical-mechanical properties

Mass density ρ [kg/m^3]	Young modulus E [N/m^2]	Poisson ratio [-]	Tensile strength [MPa]	Yield strength [MPa]	Min. elongation [%]
7850	$2\cdot10^{11}$	0.3	470-630	355	20

2. Steps taken in the laboratory

We fix the beam with the truss on the support then on the number two bar we fix two accelerometers. With the help of the Program implemented in LabVIEW Figure 2, we acquire the signal after which the extracted signal is imported into PyFEST Figure 3, which was developed at UBB Resita.

The data reported from LabVIEW were exported in PyFEST and the resulting data were extracted and presented in the Tables 2 and 4.

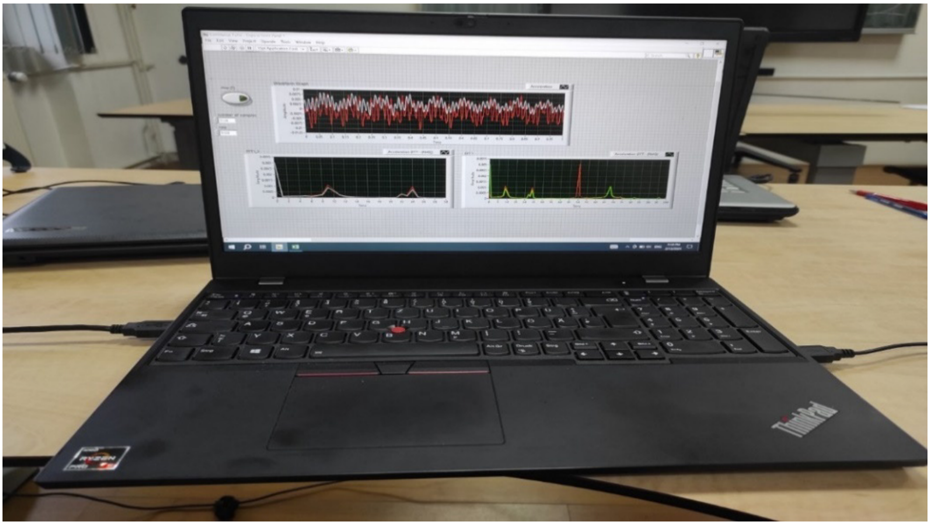

Figure 2. Signal extracted using LabVIEW

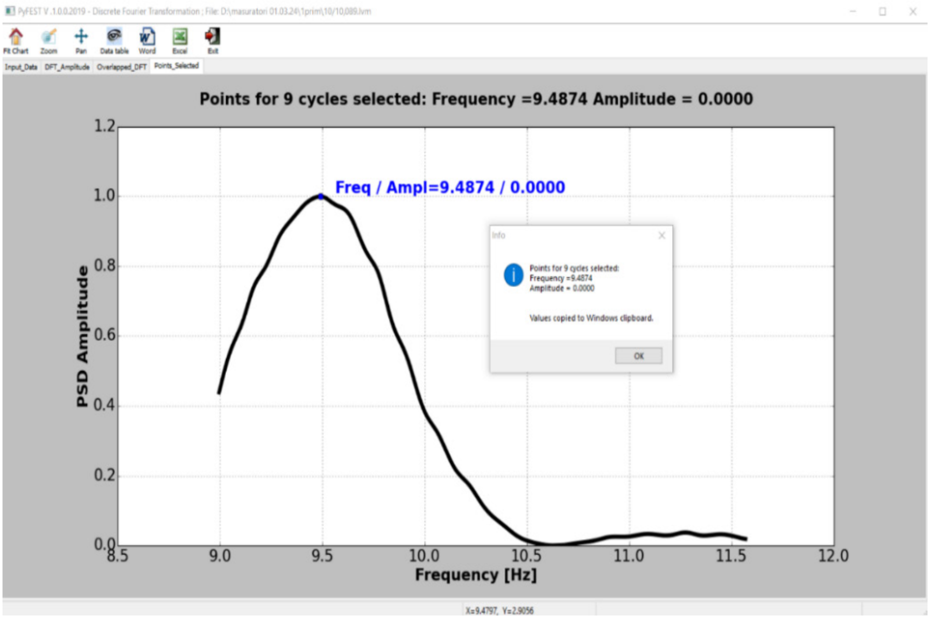

Figure 3. Frequency found with PyFEST

F - Excited frequency in LabVIEW
Fpy- Frequency measured in PyFEST

Table 2. Analyzed cases healthy state 20 Nm

Case	Mode 1		Mode 2		Mode 3		Mode 4	
	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]
1	10,089	9,377	22,197	21,790	25,003	25,3992	70	73,401
2	10,160	9,379	23,297	21,556	25,103	24,0618	72,003	73,904
3	10,200	9,358	23,397	22,086	25,597	24,1394	72,203	74,706
4	10,321	9,388	23,497	21,766	25,603	25,4479	72,300	73,981

Table 3. Analyzed cases damage state 10 Nm

Case	Mode 1		Mode 2		Mode 3		Mode 4	
	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]
1	10,089	9,3849	22,197	21,8112	25,003	21,7628	70	74,099
2	10,160	9,4172	23,297	21,8001	25,103	21,7486	72,003	72,489
3	10,200	9,291	23,397	21,4163	25,597	21,8065	72,203	74,056
4	10,321	9,4051	23,497	21,4605	25,603	23,3408	72,300	72,568

Table 4. Analyzed cases damage state 0 Nm

Case	Mode 1		Mode 2		Mode 3		Mode 4	
	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]	F [Hz]	Fpy [Hz]
1	10,089	10,7096	22,197	22,5186	25,003	24,3441	70	69,033
2	10,160	9,0154	23,297	21,1198	25,103	24,3843	72,003	69,041
3	10,200	9,0164	23,397	23,3739	25,597	25,3486	72,203	69,022
4	10,321	9,0559	23,497	23,9939	25,603	25.3658	72,300	69,025

Table 5. The average of the analyzed cases

Case	Mode 1	Mode 2	Mode 3	Mode 4
20 Nm	9,368	21,79988	24,76208	73,998425
10 Nm	9,37455	21,81203	24,85065	73,2694
0 Nm	9,449325	22,75155	22,16468	69,03063

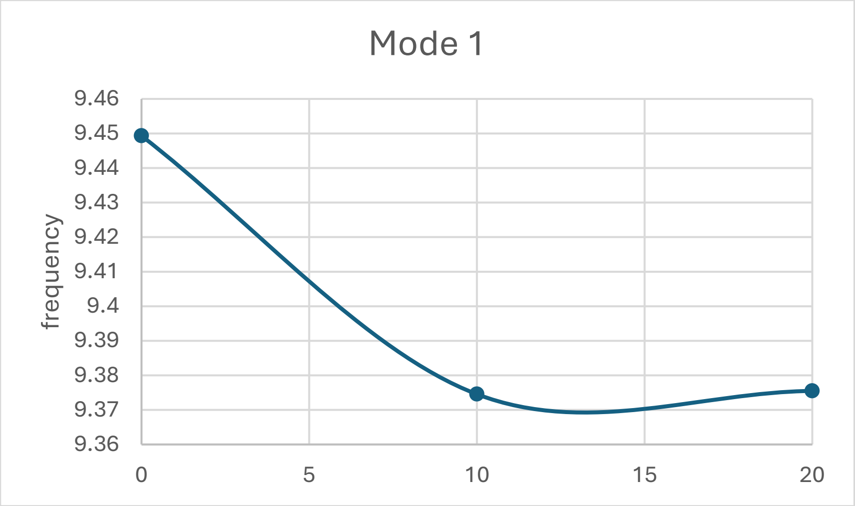

Figure 4. The first mode of vibration

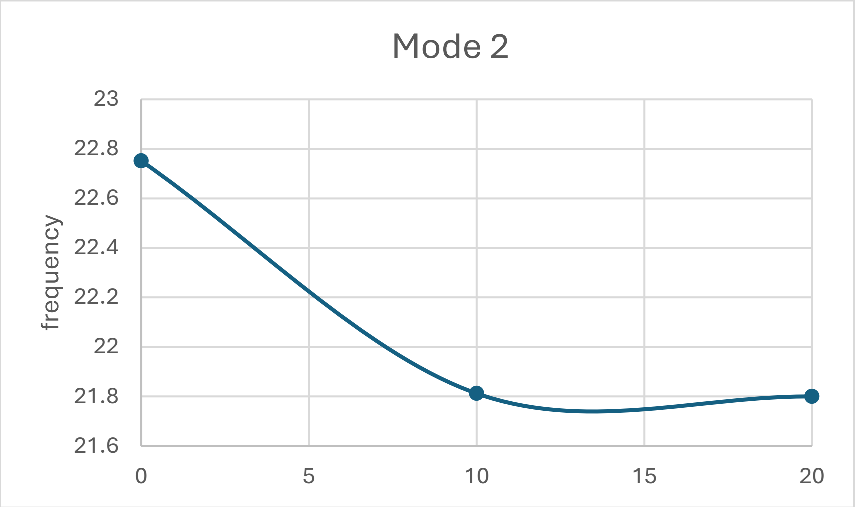

Figure 5. The second mode of vibration

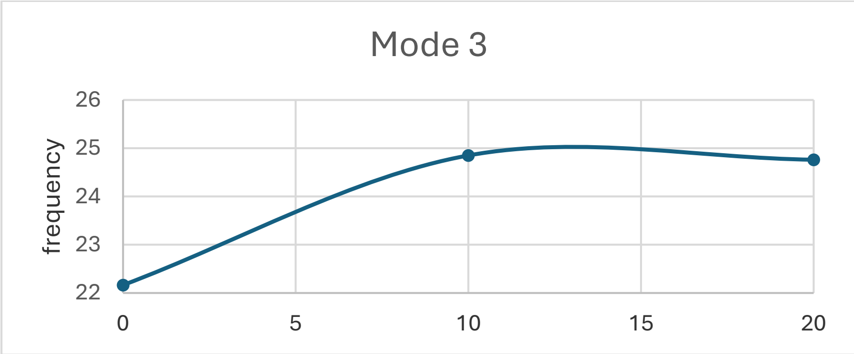

Figure 6. The third mode of vibration

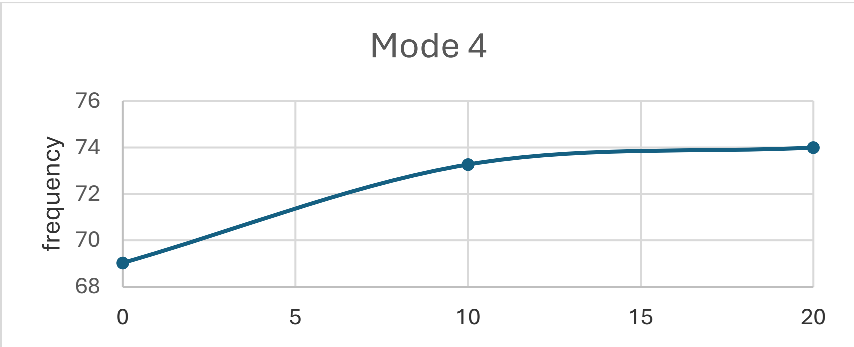

Figure 7. The fourth mode of vibration

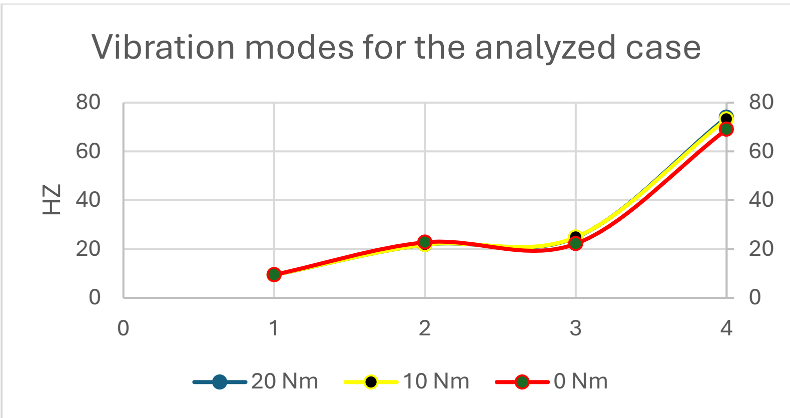

Figure 8. Vibration mode

3. Conclusion

The paper presents the eigenfrequencies measured on a Warren beam for the first four modes of vibration, to which for node E a tightening moment was applied from 0 to 20 Nm.

It was established that the natural frequencies of a structure are directly related to its stiffness. As the stiffness increases, the natural frequencies also increase. This means the truss will resonate at higher frequencies when its screws are tightened.

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