VERIFICATION OF ASSUMPTIONS IN DYNAMICS OF LATTICE STRUCTURES

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1. Introduction

Monitoring of structures and the ability to detect damage at the earliest possible stage is very important in many engineering structures. Health-monitoring techniques have been developed and employed as a means for an overall, continuous condition for assessment of complex structures. These complex systems are subject to faults, coming, among others, from assumed models, which should be, as close as possible to real structural behavior.

Many structures, among them, electricity transmission towers, windmills, radio and TV masts, bridges and parabolic dishes, concentrating solar energy, are built as trusses. All of them are subjected to dynamic loadings coming, mostly from winds, water waves and sun.

In last two decades, a lot of attention has been paid to the detection of damages in structures, among them in trusses. Many works devoted to structural assessment are based on the assumption that trusses are structures with pin joints.

The paper is revising this assumption. In real engineering design, there are no structures composed of rods connected with hinges. All, above-mentioned structures are made with rigid or flexible joints. The “pin joint” assumption is valid only for static analyses. It states that if joint displacements caused by rod bending can be neglected, comparing with displacements caused by rod elongations, the structural system can be considered as pin joint. As it is commonly known, such cases occur when some necessary conditions joining numbers of joints and hinges are fulfilled.

The “pin joint”, static assumptions has been, without any formal justification, taken for granted in dynamics. Simple examples presented in the paper show that “pin joint” assumption can lead to considerable errors.

The paper is illustrated with numerical examples of two bar and 25 bar tower structures. Results of different assumptions, applied to the structural elements connections are discussed.

2. Modal analysis of a 25-bar, 3d transmission tower

The 25 bar truss, shown in Figure 1, is build with pipes of 159 mm diameter and 8 mm wall thickness. The material is steel, with Young modulus 205 GPa.

Two structures of the same geometry are discussed. The first one (a) is considered to be a truss. The second one (b) is seen as a frame. Both structures are solved for eigenfrequencies and eigenmodes.

In Fig.2a and 2c, two eigenmodes, together with their eigenfrequecies are presented, for the truss. In Fig.2b and 2d, also first two eigenmodes and egenfrequencies are shown for the same structure, however treated as a frame.

It is interesting to note, that not only values of eigenfrequencies in both cases differ significantly, but also eigenmodes are completely different. In case of the truss, the first eigenmode is showing larger displacement of the upper part of the structure. This in the contrary to the first eigenmode for frame, which is demonstrated by a kind of “local vibration” of lower structural members. The similar observation can be made concerning second mode.

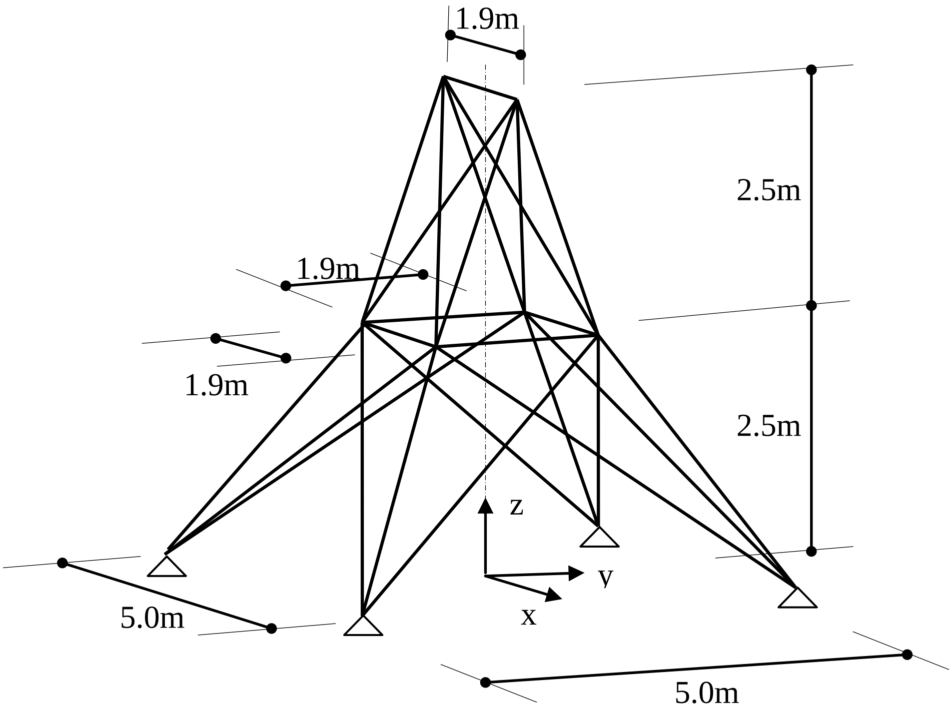
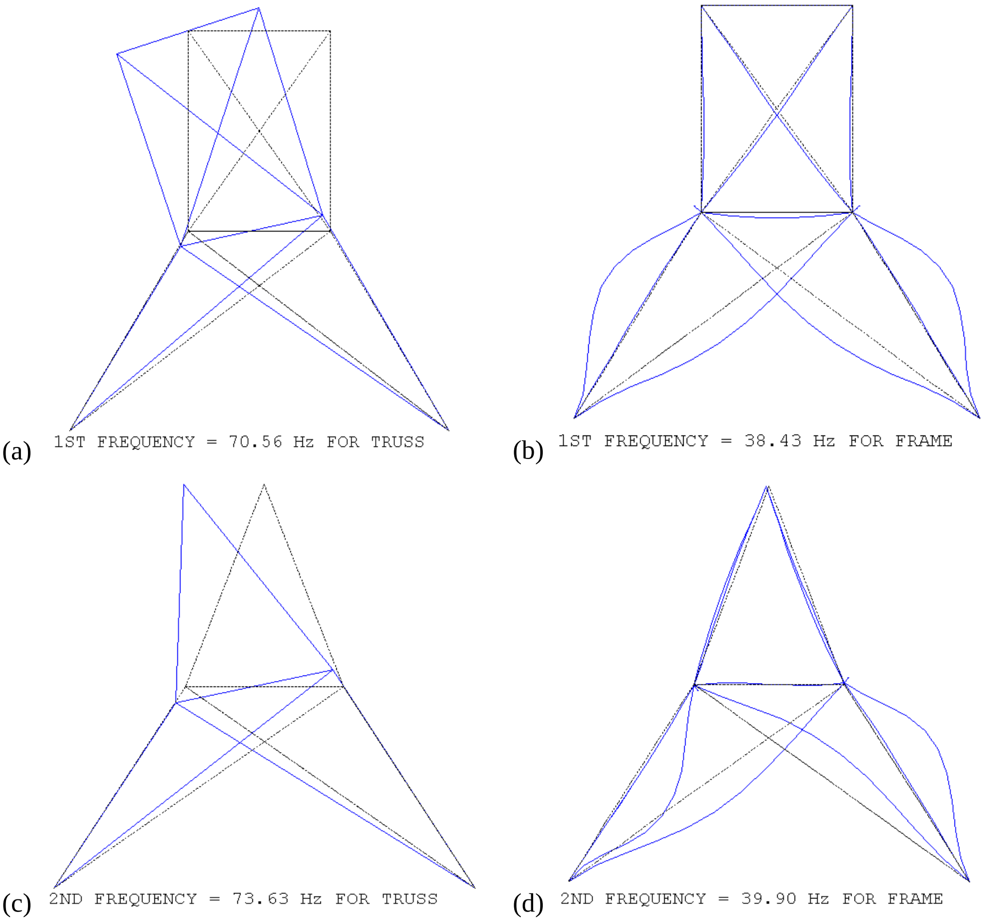


Fig.1. 25 bar transmission tower


(a) 1ST FREQUENCY = 70.56 Hz FOR TRUSS

(b) 1ST FREQUENCY = 38.43 Hz FOR FRAME

(c) 2ND FREQUENCY = 73.63 Hz FOR TRUSS

(d) 2ND FREQUENCY = 39.90 Hz FOR FRAME

Fig.2 Two first eigenfrequencies and eigenmodes; (a) first eigenmode for the truss (view along y direction); (b) first eigenmode for the frame (view from y direction); (c) second eigenmode for the truss (view from x direction); (d) second eigenmode for the frame (view from x direction)