

Optimal damper placement research

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Abstract. Nowadays increased noise and vibration pollution on technopark and research laboratories territories, which is negatively influencing on production of high-precision measuring instruments. The problem is actual for transport hubs, which experience influence of machines, vehicles, trains and planes. Energy efficiency is one of major functions in modern road transport development. The problem of environmental pollution, lack of energy resources and energy efficiency requires research, production and implementation of energy efficient materials that would be the foundation of environmentally sustainable transport infrastructure in road traffic. Improving the efficiency of energy use is a leading option to gain better energy security, improve industry profitability and competitiveness, and reduce the overall energy sector impacts on climate change. This paper has next indirect goals. Research impact of vibration on constructions, such as bus and train stations, terminals, which are mostly exposed to oscillation. Extend the buildings operation by decreasing the negative influence. Reduce expenses on maintenance and repair works. It is important not to forget about seismic protection, which is actual nowadays, when the safety stands first. Analysis of devastating earthquakes for last few years proves reasonableness of application such systems. The article is dedicated to learning dependence of damper location on natural frequency. As a model for analyze was simulated concrete construction with variable profile. We used program complex Patran for analyzing the model.

1. Introduction

Primary aims on this work were:

1. Influence of finite element's size on analyze results
2. Determine mode shapes of construction (first 3 ones)
3. Damper placement recommendation
4. Construction response on kinematic influence of the ground

By the data of USA geological service (USGS), the amount of human loses because of the earthquake in Japan on 03.11.2011 with magnitude 9.0 was 28050 people, while in Haiti on 01.12.2010 with magnitude 7.0 was 222570 people. In spite of the high magnitude of the earthquake, which caused many human lives, the efficiency of seismic protection system application in Japan has no doubts. Seismic isolation support is the type of so-called passive seismic protection system, which are widely used in the world practice [1-12]. Constructions, influenced by action of forces with constant frequencies, can have harmful vibrations, especially about resonance. In order to remove that, first we can try to get free from the forces, which is usually impossible. In that case, trying to escape resonance conditions, we can change mass or coefficient of elasticity. But it's also usually impractical, and then as a third possibility we can use dampers [13].



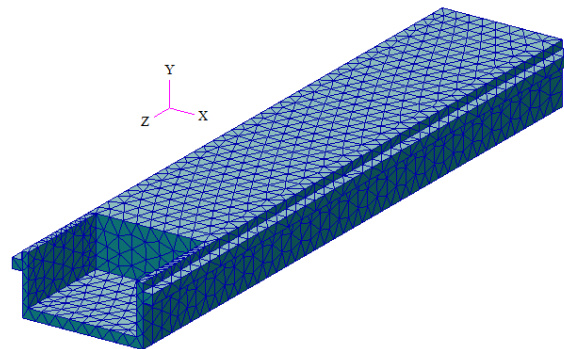


Figure 1. FE model.

Dampers are meant to decrease negative influence on constructions and high-precision measuring instruments from vibrations created by work of aggregates [14].

Before simulating the model on PC Patran we had to find stiffness coefficient, using natural frequency $f_0 = 1,5 \text{ Hz}$ (obtained from field investigation):

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{k}{m}};$$

$$k = 4\pi^2 f^2 m = 4 \cdot \pi^2 \cdot 1,5^2 \cdot 455337,6 = 40446000 \text{ (N/m)},$$

$$\text{where } m = \rho V = 2400 \cdot 189,724 \text{ (kg)};$$

2. Normal modes analysis

Below is shown first 3 modes for mesh=0,21 (the same modes were obtained for mesh=0,7 and mesh=0,93):

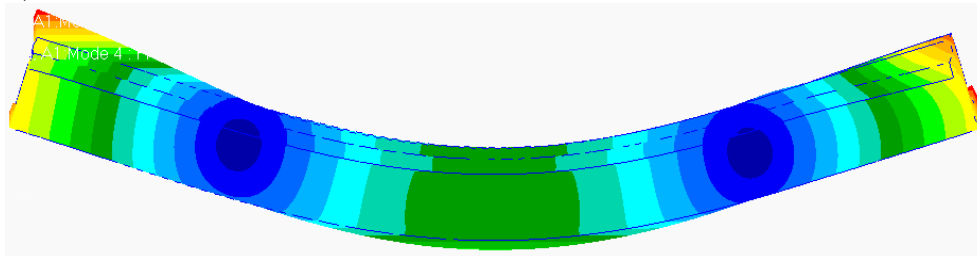


Figure 2. First mode (17,727 Hz).

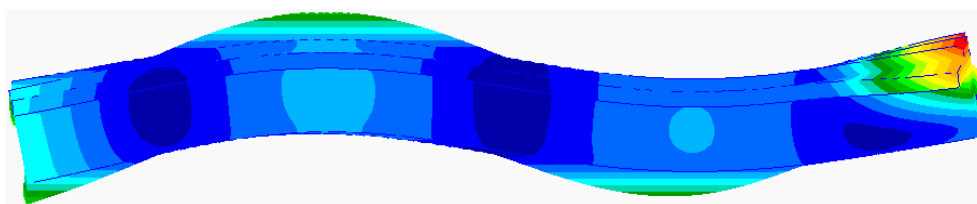


Figure 3. Second mode (28,616 Hz).

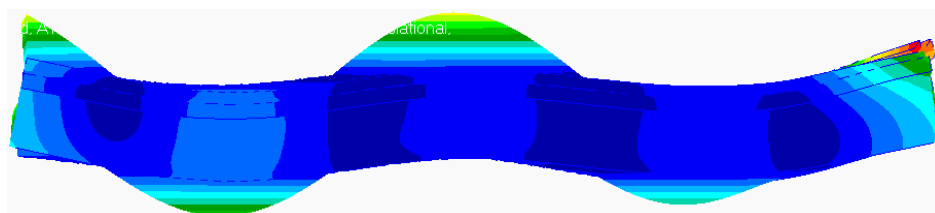


Figure 4. Third mode (38,909 Hz).

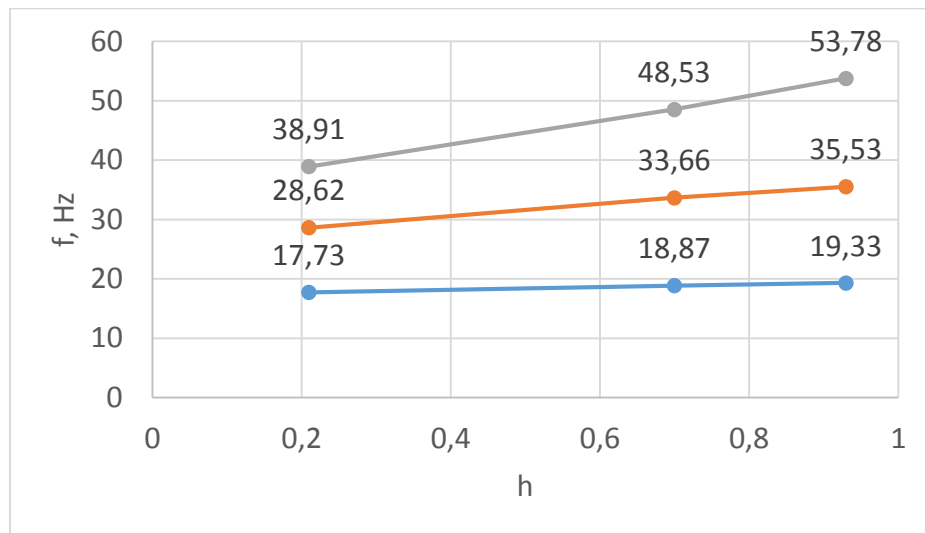


Figure 5. The less size of finite elements make modes to appear earlier.

3. Damper location

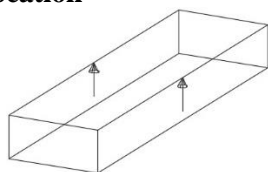


Figure 6. Damper location #1

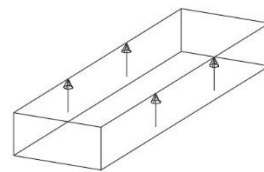


Figure 7. Damper location #2

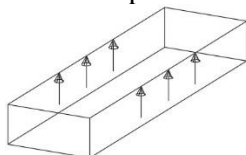


Figure 8. Damper location #3

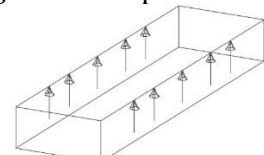


Figure 9. Damper location #4

4. Dynamic analysis

Change of amplitude's extremum due to damper placement

1. Model without any damper

Node ID	Coord 1 Value	Coord 2 Value	Coord 3 Value
2508	-0.5	1.9	15.
1036	-0.5	2.0999999	15.



Figure 10. The location of element with 1036 and 2508 nodes on it.

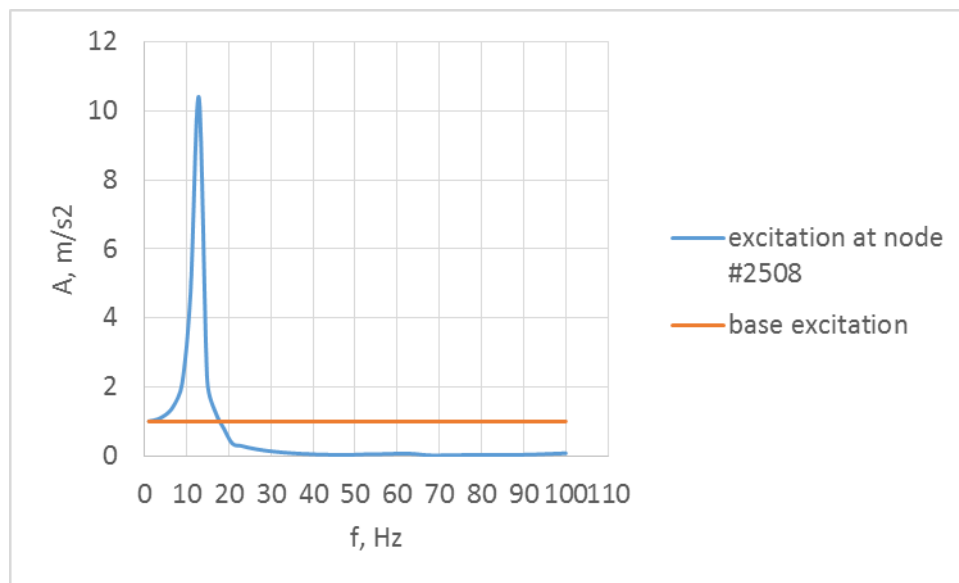


Figure 11. Amplitude of 1036 and 2508 nodes on range 0-100 Hz.

2. Model with one damper on each side, located near nodes where were appeared amplitude's extremum on first mode.

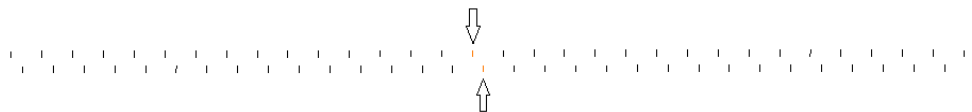


Figure 12. The location of dampers.

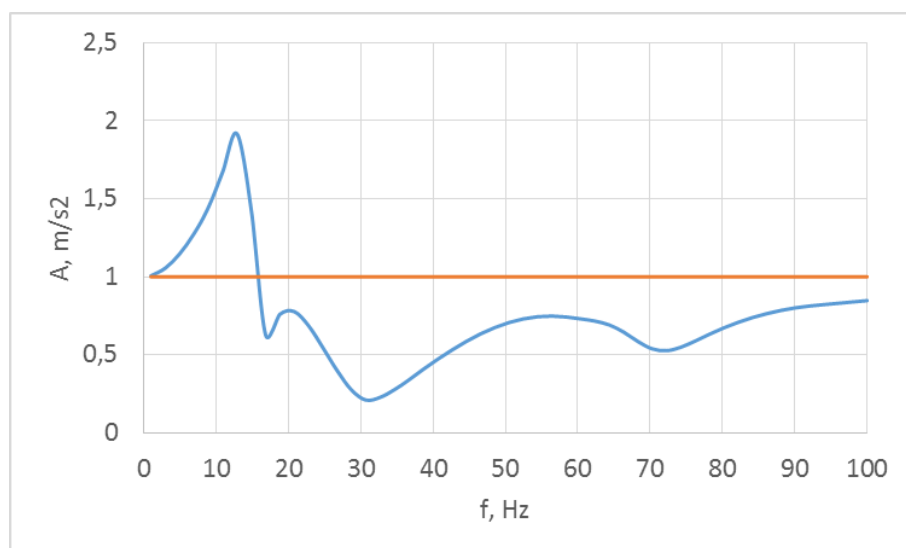


Figure 13. Amplitude of 1036 and 2508 nodes on range 0-100 Hz.

3. Model with 2 dampers on each side, located near nodes where were appeared amplitude's extremum on second mode.



Figure 14. The dampers location.

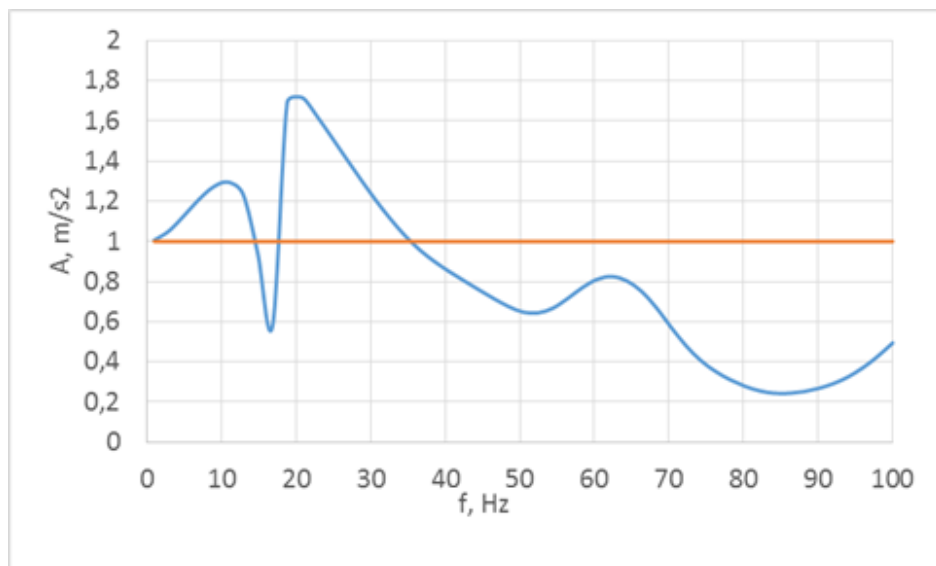


Figure 15. Amplitudes on range 0-100 Hz.

4. Model with 3 dampers on each side, located near nodes where were appeared amplitude's extremum on third mode.

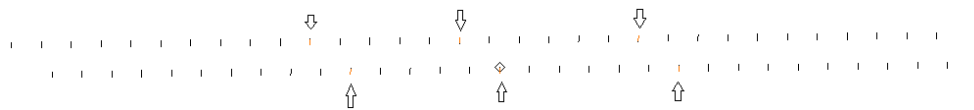


Figure 16. The dampers location

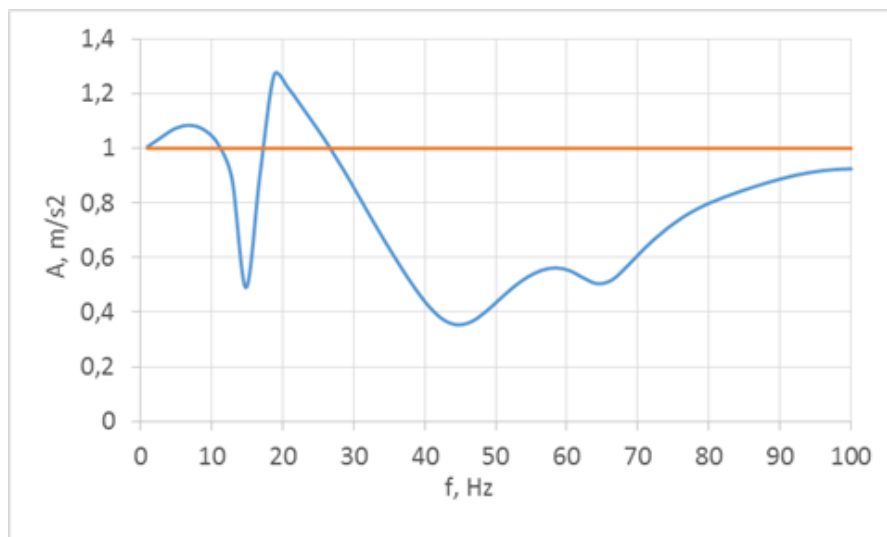


Figure 17. Amplitudes on range 0-100 Hz.

5. Model with 5 dampers on each side, located near nodes where were appeared amplitude's extremum on first three modes.

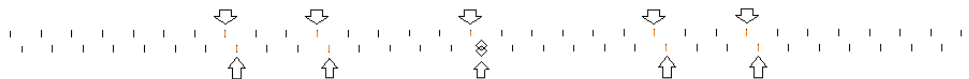


Figure 18. The dampers location.

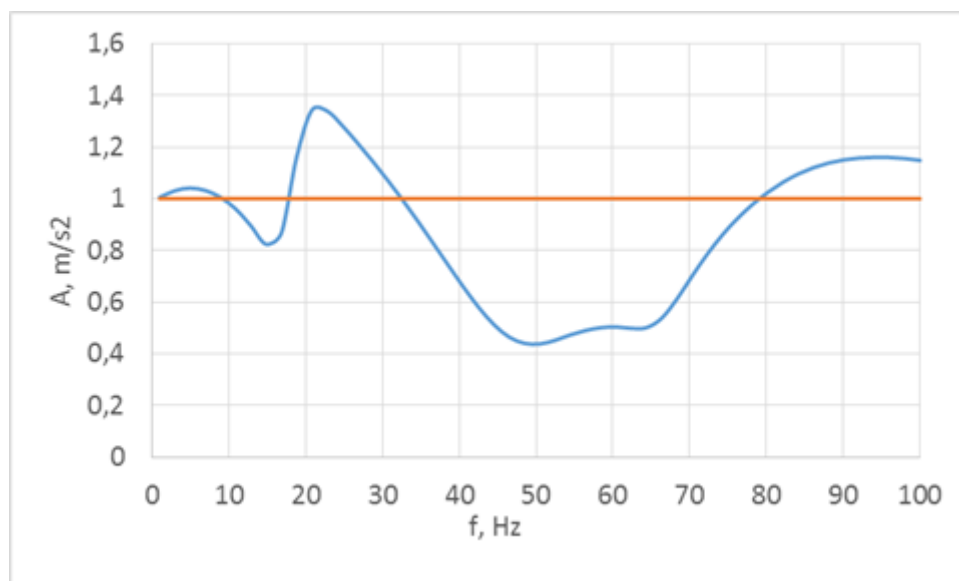


Figure 19. Amplitudes on range 0-100 Hz.

5. Conclusion

- The less size of finite elements make modes to appear earlier
- The less size of finite elements makes modes more expressive
- 3-rd option of damper location is the most optimal (matches with 3-rd mode)
- The number of dampers is not directly influencing factor

Application of dampers reduce the negative influence on constructions, which are mostly exposed to vibration. Consequently, we can reduce cost of the building maintenance with correctly located dampers. Dampers as a seismic isolation of construction reduces forces in supporting structures, dimensions of cross sections, amount of reinforcement [7].

References

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