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Prediction of bolt clamping forces using MS similarity maps calculated from a reduced-order model based on a CNN approach

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ABSTRACT

This paper presents a comparison between the experimental and finite element analysis results, based on changes in the size and location of the bolt clamping force in a bolted structure, with respect to the frequency response and the MS similarity function. When the severity and location of bolt loosening change, the dynamic characteristics of the structure change as well. In particular, it has been confirmed that the tendency for the MS similarity function to relatively change significantly in the frequency range around each natural frequency can be used to predict bolt loosening in the system.
For the finite element model of the bolted structure, the frequency response is efficiently calculated using a reduced-order model (ROM) generated by the Krylov subspace-based model order reduction (MOR) method, and the MS similarity function is calculated. Subsequently, a method has been presented for generating and utilizing an MS similarity map in the form of a heat map image for deep learning. Finally, a convolutional neural network (CNN) was trained using numerous MS similarity maps as training data, demonstrating its capability to predict the clamping force of bolted structures.

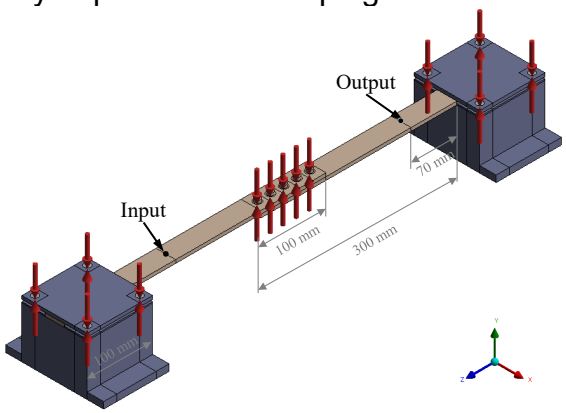

Fig. 1 Bolt-connected structure for prediction of bolt clamping forces

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REFERENCES

Kim, D.H. and Han, J.S. (2022), "Frequency response similarity-based bolt clamping force prediction method using convolutional neural networks," *J. Mech. Sci. Technol.*, **36**, 3801-3813.

Han, J.S. (2012), "Efficient Frequency Response and Its Direct Sensitivity Analyses for Large-Size Finite Element Systems Using Krylov Subspace-Based Model Order Reduction," *J. Mech. Sci. Technol.*, **26**(4), 1115-1126.

Kim, J.H. and Sin, K.H. (2022), "Application of the MS Similarity Function to the Selection of Impact Hammer Test Data for Frequency Response Function Estimation," *Trans. Korean Soc. Noise Vib. Eng.*, **32**(4), 329-336.

Woo, C.Y., Shin, K.H. and Han, J.S. (2023), "A Study on the Generation and Utilization of the MS Similarity Map to Detect the Bolt Clamping Force in Bolted Structures," *Trans. Korean Soc. Mech. Eng. A*, **47**(7), To appear.