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EXPERIMENTAL VALIDATION OF VIBRATION CONTROL PERFORMANCE AND SENSOR PLACEMENT IN A FRAME STRUCTURE WITH SEMI-ACTIVE JOINTS

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1. Scope

This contribution presents a study dedicated to performance assessment of a vibration mitigation system designed for a frame structure equipped with semi-active joints. The joints allow for a controllable transfer of bending moments between the frame members. The control approach belongs to the class of Prestress-Accumulation Release algorithms [1]. The investigation is based on an experimental approach and is carried out on a laboratory demonstrator. The rendered issues discussed in the study comprise topics related to the optimal control signal synchronisation, sensor placement and performance assessment of the system.

2. Semi-active joint

An important part of the described approach is a semi-active joint concept [2] dedicated for slender frame structures (Fig. 1). The design of the device allows for connecting three neighbouring beams of a frame. One of the connectors allows for a short-lasting controllable limitation of the transferred moments, while the remaining two transfer them continuously in a passive manner. It is assumed that the joints are activated with a time delay short enough to allow for synchronisation of the control system with the dynamic response of the structure. In practice, the effect could have been achieved by utilization of piezoelectric stacks as actuators.

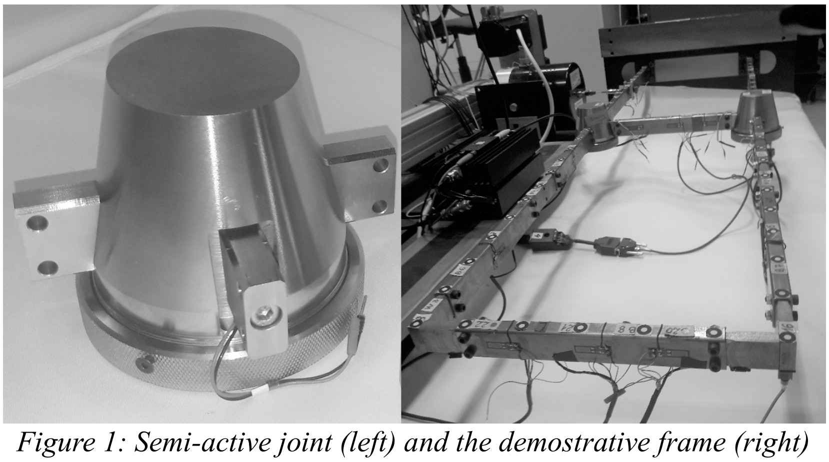

Figure 1: Semi-active joint (left) and the demostrative frame (right)

3. Control approach

A synchronous application of structural reconfiguration is the aim of the presented control approach. The control algorithm assumes synchronisation between the control signal application and the dynamic response of an object [3]. The objective of the strategy is to minimise the strain energy level in the structure and obtain an effect of transferring the vibration energy towards the higher frequency range. The high frequency structural eigenmodes are effectively mitigated with passive means of damping (e.g., material damping, polymer layers). Therefore, the aim here is to mitigate the low frequency dynamic responses of the structures, which are recognised as the most challenging in reduction. The application of a short lasting decrease of the bending moment transmission in the joints results in decreasing the level of the accumulated internal energy related to deformation. A conducted optimisation procedure has shown that the optimal time instant for the reconfiguration takes place at the maximum of the internal energy.

4. Methodology

The study is based on an experimental investigation conducted on a laboratory demonstrator in the form of a cantilever frame (Fig. 1). The demonstrator is equipped with a pair of the described semi-active joints and a feedback controller allowing for application of the procedure in real-time. The study consists of a modal identification of the object and its spectral testing in a variety of conditions. The obtained frequency response functions have been calculated from the data acquired under free and forced excitations as well as in passive and in semi-active modes of operation.

5. Results

The conducted investigation validates the theoretically derived control strategy, reveals a significant effectiveness of the system in mitigation of vibrations and verifies the methods for sensor placement dedicated to the considered case.

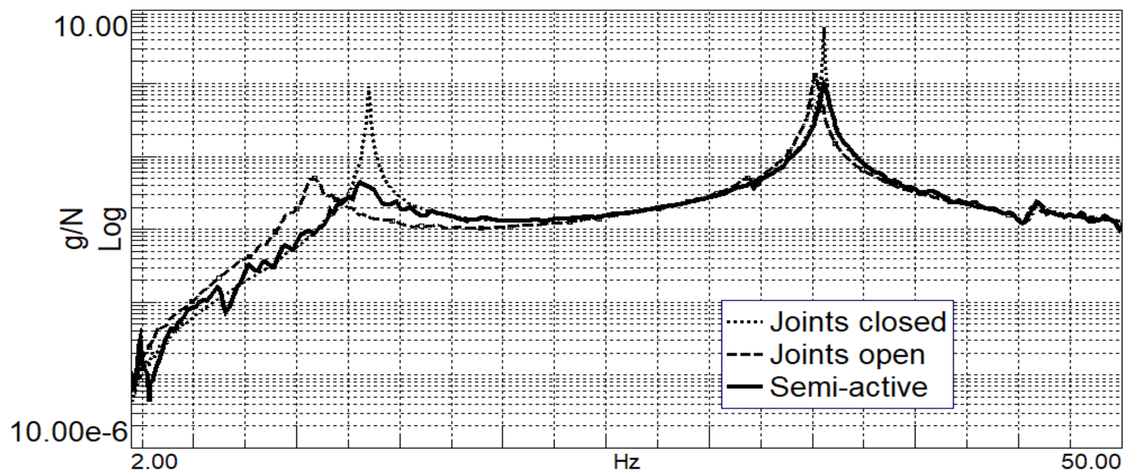

Figure 2: Dynamic responses of the demonstrator under random forced excitation in three modes of operation: joints closed, joints open, semi-active.

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