SEMI-ACTIVE MITIGATION OF STRUCTURAL VIBRATIONS IN 2D FRAMES BY ON/OFF NODAL RECONFIGURATION

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1. Introduction

An important part of the research in structural control is devoted to mitigation of structural vibrations. The basic strategy is to properly design the structure, but such a passive approach might be insufficient in many applications. An example is constituted by space structures: due to their low weight and high slenderness, they are inadequately damped by the natural mechanisms of material damping and susceptible to prolonged free vibrations and excessive forced vibrations.

When passive structural optimization is not sufficient, an active or semi-active system might be applied. Active systems are based on the paradigm of active counteraction: actuators are employed to generate control forces that counteract structural motion. Such systems are well-researched and extremely efficient [1]. However, these advantages often come at the cost of a 1) large power consumption required by the external actuators, and 2) danger of instabilities, especially in case of a control system failure, which is related to the relatively large forces generated by the actuators.

In contrast to the active counteraction employed in the active control systems, there is a class of systems that employ the Nature-inspired paradigm of self-adaptation to variable external conditions. Such systems are called semi-active [2,3], and they exert control through online modification of selected structural parameters rather than large counteracting forces. Such an approach is clearly advantageous in terms of the power consumption (power is required to change the structural or material characteristics only rather than to generate large forces) and significantly decreased danger of instabilities. The cost is a slightly reduced effectiveness and an often larger design complexity.

2. Structural reconfiguration

One of the approaches in the area of semi-active control can be identified as controllable structural constraints or dynamic structural reconfiguration. It can be traced back to the switchablestiffness truss elements proposed in 1990s [3], and includes controllable delamination [4], jammed granular material [5] and nodes with a controllable ability to transfer moments [6,7]. In all these reports, the structural control has been enforced by means of a controllable structural constraints.

An example is the temporary decoupling of rotational degrees of freedom in a frame node, which has been first studied numerically in [7] and then experimentally in [8], in an application to damping of free vibrations. Such a decoupling turns an originally frame node (with full transmission of moments between the adjacent beams) into a hinge, which no longer transmits the bending moments. In practice, such nodes can be friction-based and controlled by an actuator that exerts a normal force of a controllable level.

3. Experimental results

This contribution discusses a semi-active vibration damping system for slender 2D frame structures and proves its effectiveness in various loading conditions. Significant mitigation of vibration amplitudes have been achieved in free vibrations, as well as in harmonic and random forced vibrations. The actuators have the form of frame nodes with a controllable ability to transfer moments.

In all tested cases the laboratory experimental results have been confirmed with numerical simulations. Exemplary results in damping of harmonic vibrations are shown in Fig. 1.

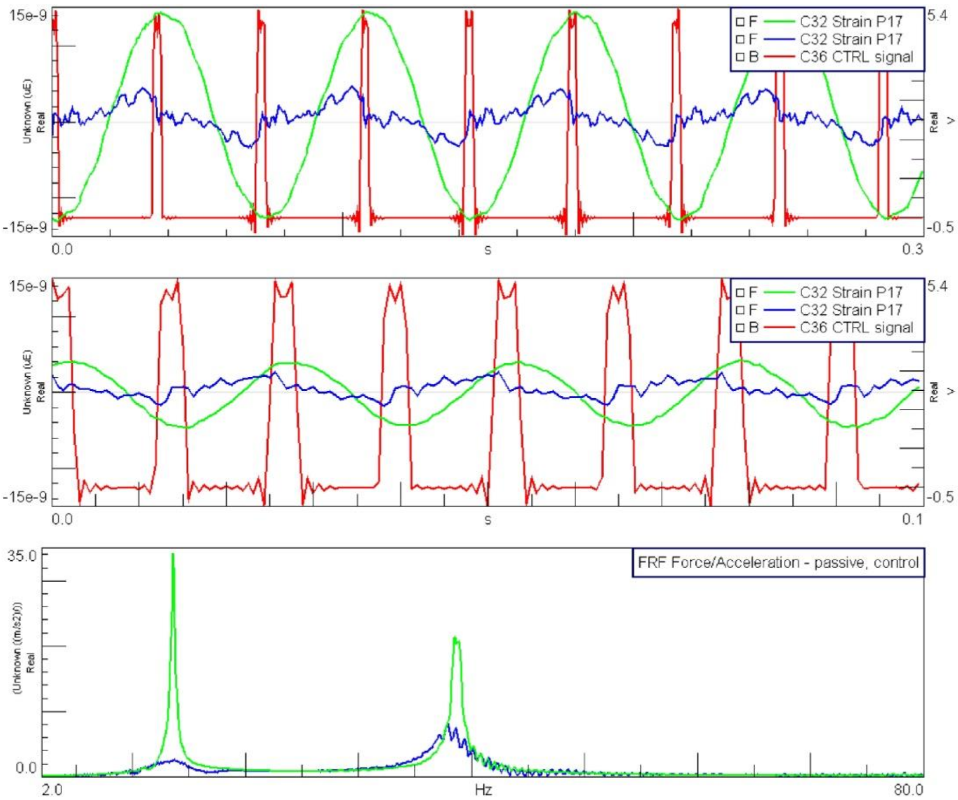

Fig. 1. Strains at a selected sensor location in a passive and semi-actively controlled structure and the control signal (top, middle); the corresponding accelerances of the frame tip (bottom)

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5. References

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