Semi-active decentralized mitigation of randomly excited vibrations in 2D frame structures

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ABSTRACT

Semi-active control systems are investigated for more than 40 years [1,2], and despite the great progress in this research area, they are still considered to be a complex topic in both theoretical and technical terms. However, their advantages ensure that these control systems remain an extremely attractive subject of scientific and technological development.

We present a semi-active strategy for mitigation of vibration, which utilizes an energy management approach called Prestress Accumulation–Release [3] and based on controllable activation and removal of selected structural constraints. Here, it is implemented by means of controllable structural nodes of a specific design that allow the transmission of moments between adjacent structural elements to be controlled in an on/off manner. The control strategy turned out to be very effective in damping of free structural vibrations of planar frame structures [4]. Extension of the research to other types of vibrations has shown that the proposed control algorithm is versatile and stays efficient in a range of applications and different configurations of the investigated structures. This work is focused on mitigation of vibrations excited by a randomly generated force load.

Decentralization results in a decisive reduction of the complexity of the data acquisition and control systems, which is crucial for actual implementations in real structures, and which facilitates an ad hoc reconfiguration and expansion of the control system if necessary. It also provides the possibility of considering selected structural elements as separate energy dissipative devices, which in our approach act effectively as vibration dampers. This feature, provided by the decentralization, enables us to take the advantage of two complementary mechanisms of material damping – global dissipation of vibration energy by the PAR and local dissipation in single involved elements.

Numerical analyses using the finite element (FE) method indicate a high degree of effectiveness in alleviation of the amplitude of vibrations induced by a continuous excitation by a random transient force. This confirms that the proposed control strategy can be utilized in the case of momentary impulsive loads that result in predominant free vibrations, as well as in the case of transient random force excitations. It significantly extends the range of possible modes of operation of a structure equipped with the proposed damping system.

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