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Editorial

Some Recent Developments in the Vibration Control and Structure Health Monitoring

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Vibration is a common phenomenon when a structure is exposed to mechanical or environmental actions. It may inflict great cost to lives and to the economy. In order to reduce this, and to monitor resulting damages, vibration control and structural health monitoring have become increasingly important. In particular, the past decade has witnessed emerging thoughts, perspectives, ideas, and methods in vibration control and structural health monitoring, inspired by big data, supercomputing, and AI, as well as from new advances in mechanics, mathematics, materials, and related multi-disciplinary fusions. Significant contributions have been made, such as that of Xu [1], who established a spectral energy theory of frequency response function in the distribution area and proposed a series of methods to accurately describe different structural damages and collapse processes, for instance the perturbation distribution area energy method, the energy catastrophe collapse analysis method, and the regional energy flow density method. For the first time ever, he carried out a 3D shaking table test on a long-span reticulated structure with multi-dimensional earthquake isolation and mitigation devices [2]. He was also the pioneer [2–6] of conducting large-scale shaking table tests on a variety of structures with isolation and mitigation devices, and relevant research results have been applied to several representative construction projects, such as the Haikou Meilan International Airport of China in 2017. However, there are still key challenges. These are due to, on the one hand, the increasing frequency and intensity of natural and man-made disasters in recent years, such as earthquakes, tropical cyclones, floods, and industrial accidents, and on the other hand, the increasing size, complexity, multi-field and intra-and-between-system coupling effects, and the enhanced performance demands of structures and infrastructure systems. These factors have motivated frontier research topics in the field of vibration control and structural health monitoring, including: theories and computational methods of, and materials and devices for, vibration control; the application of vibration mitigation or isolation techniques; the development of structural health monitoring equipment and methods of damage detection and localization for structures; data sensing and processing in structural health monitoring; safety diagnosis and assessment of structures; and interdisciplinary approaches and applications for structural health monitoring, vibration analysis, tests and applications in relative fields.

The Special Issue "vibration control and structural health monitoring", is an opportunity to share knowledge, experience, and information in the field of vibration control and structural health monitoring. In this Special Issue, nine original research papers and one review paper have been included. These papers concerned the vibration control and structural health monitoring in areas of theory and computational methods of vibration control materials and devices for vibration control, tests and applications of vibration mitigation or isolation techniques, vibration analysis, and tests and applications in relative fields.

Zhang and Mou et al. [7] proposed, by investigating a five-story reinforced concrete frame structure, a multi-dimensional elastic–plastic calculation model for frame structures with a magnetorheological damper. The results show that the proposed calculation model can effectively simulate the multi-dimensional seismic response of the structure with and without the magnetorheological damper.

Torsional vibration of eccentric structures would result in and accelerate seismic damage to structures. Yang and Guo [8] established numerical models of spatial eccentric structures with multiple MR dampers and conducted a time–history analysis. Numerical results demonstrate that the control system with multiple MR dampers can significantly attenuate the torsional vibrations of eccentric structures, and thus possess significant application prospects. This study used a mixed ferromagnetic particle coated with carbon nanotubes and graphene, overcoming the technical bottleneck of easy sedimentation and poor re-dispersibility of magnetorheological fluid, which was developed for the first time by Xu [9]. Xu [2] also developed magnetorheological dampers with the world's largest damping force 47.2 t, with integrated magnetorheological control systems, and carried out dynamic tests on building structures and long-span bridges with this intelligent control system.

In order to solve the problem of slow response, poor precision, and weak anti-interference ability in hydraulic servo position controls, Guo and Zha et al. [10] designed a Kalman genetic optimization PID controller. Compared with traditional PID control algorithms, the PID algorithm optimized by generic algorithm improves the system's response speed and control accuracy; the Kalman filter solves the problem of amplitude fluctuations and reduces the influence of external disturbances on the hydraulic servo system. This study is based on the real-time online control algorithm for earthquake catastrophes, solving the problems of time delay and nonlinear time-varying of magnetorheological control, proposed for the first time by Xu [9].

Terrains with inclination, settlements, displacements, and other phenomena lead transmission towers to collapse. Wang and Liu et al. [11] designed a device to monitor the settlement of a transmission tower. The experimental results show that the third to fifth natural frequencies decreased significantly, especially when the tower legs are adjacent to the excitation position.

Machine tool ram affects the ability of the machine to achieve stable cutting conditions. There are various solutions for increasing its stiffness and damping. Novotny and Cervenka et al. [12] proposed an innovative two-axial electromagnetic actuator for controlled vibration dampers with high dynamic force values. This position measurement concept will enable possible use in the field of vibration suppression of vertical rams of large machine tools.

Ying and Ni [13] proposed a method to study vibration response and amplitude frequency characteristics of a controlled nonlinear meso-scale beam under periodic loading. The proposed method includes a general analytical expression of harmonic balance solution to periodic vibration, and an updated cycle iteration algorithm for amplitude frequency relation of periodic response. Numerical results demonstrate a good convergency and accuracy of the proposed method.

Shen and Huang [14] conducted a sensitivity experiment to study the dependence of the shear strain on the seismic properties of bearings (lead rubber bearing and super-high damping rubber bearing). Test results showed that temperature is the most dominant factor, whilst the shear modulus is the least contributing factor.

Road roughness plays an important role in road maintenance and ride quality. Zhang and Hou at al. [15] proposed a road-roughness estimation method based on the frequency response function of a vehicle, which can be estimated directly using the measured response. The results show that road roughness can be estimated using the proposed method with acceptable accuracy and robustness.

Ge and Huang et al. [16] developed a cylindrical viscoelastic damper and investigated its mechanical and damping performance. The experimental results demonstrate that the cylindrical viscoelastic damper presents a full hysteretic curve in a wide frequency range.

This kind of cylindrical viscoelastic damper can be simulated by a multi-molecular-chain model of viscoelastic materials and dampers with eight parameters proposed by Xu [17], which can easily calculate the effect of temperature, frequency, and displacement amplitude. Among the existing mathematical models worldwide, only the finite element model can reflect the influence of these three factors at the same time; however, this model is very complex and involves the determination of nearly 20 parameters.

Aabid and Parveez et al. [18] conduced a review on piezoelectric-material-based structural control and health monitoring techniques. They reported fundamental modeling and applications in engineering fields, explored new approaches and hypotheses and discussed the challenges and opportunities for future work.

Although only ten papers are included in this Special Issue, new advances and developments in vibration control and structural health monitoring have been presented as much as possible. They stimulate frontier research topics in various fields, including civil engineering, mechanical engineering, hydraulic engineering, offshore and marine engineering, and aeronautics and aerospace engineering, amongst others. Given that it is still a challenging topic, new thoughts, perspectives, ideas, and methods, as well as new advances in materials and devices, are still sought to promote research on vibration control and structural health monitoring.

We are striving to enhance the influence of the journal *Actuator* and maintain its leading position in the field of vibration control and structural health monitoring. We are grateful for the contributions from authors who make this Special Issue successful.

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