DESIGN OF A QUASI-ZERO-STIFFNESS ISOLATOR WITH CAM-ROLLER-SPRING MECHANISM AND EXPERIMENTAL TESTS

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ABSTRACT
A compact quasi-zero-stiffness (QZS) isolator with cam-roller-spring mechanism (CRSM) was proposed for the low-frequency vibration isolation. Firstly, parameters of quasi-zero-stiffness were obtained by static analysis, and then the prototype of the QZS isolator was fabricated. Furthermore, the isolation performances were evaluated by experimental tests in terms of force transmissibility, which revealed that negative stiffness resulting from CRSM significantly reduces the total vertical stiffness of the system, and hence can obviously reduce the starting vibration isolation frequency, leading to an excellent low-frequency vibration isolation performance.

Keywords: vibration isolation, quasi-zero-stiffness, low-frequency, force transmissibility.

INTRODUCTION
The linear vibration isolation system (VIS) can be only effective when the excitation frequency is larger than $\sqrt{2}$ times the natural frequency of the system, which limits a linear VIS to attenuate vibration in low-frequency band. To extend bandwidth of vibration isolation, usually the stiffness of VIS is reduced to lower the natural frequency, but this leads to large static deflection. Therefore, a VIS with the characteristic of high-static and low-dynamic stiffness (HSLDS) is ideal. Recently the VIS with quasi-zero stiffness [1-2] have been developed which integrate elements with negative and positive stiffness to achieve the characteristic of high-static and low-dynamic stiffness. This type of VIS can provide sufficiently large static stiffness to reduce static deflection, meanwhile offer very small dynamic stiffness for vibration isolation at low frequency when the equipment oscillates about the static equilibrium position.

RESULTS AND CONCLUSIONS
In this paper, a QZS isolator with cam-roller-spring mechanism is proposed, and the compact prototype is designed and manufactured, as shown in Fig. 1. The static analysis is carried out to find out the so-called zero stiffness condition. That is, in order to achieve QZS characteristic at the static equilibrium position, the negative stiffness of the cam-roller-spring mechanism should be designed to be equal to the positive stiffness of the metallic coil spring. Note that in CRSM, the spring is a flexible beam. The stiffness of QZS isolator is sensitive to the pre-compression of the flexible beam $\delta$, which depicted in Fig. 2. It can be seen that a pre-compression up to 1 is perfect to achieve small stiffness in as large displacement range as possible.
Furthermore, the experiment tests of isolation vibration performance are carried out, as shown in Fig. 3. The force transmissibility is depicted in Fig. 4, which is defined by the ratio of the root mean square (RMS) of transmitted force to the base to that of excitation force. In this case, the supporting mass is 100 kg, and the stiffness of the coil spring is 193N/mm. Thus, the natural frequency of the linear counterpart is about 7Hz, and the beginning frequency of vibration isolation is about 10Hz. However, as seen from Fig. 4, the starting frequency of QZS system is about 6Hz. Therefore, the adding cam-roller-spring mechanism lowers the natural frequency of VIS, and hence extends bandwidth of vibration isolation.

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REFERENCES