I-680 ACTIVE CONTROL OF TEFLON MOUNTED SLIDING STRUCTURES

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INTRODUCTION: It is the objective of this study to find the dynamic characteristics of a hybrid system so that stable performance results near its natural frequency, especially for low mass-ratio structures. Such experiments were conducted on a combined active and passive device controlled two degree of freedom system. A single story rigid frame model was constructed and tested for a fixed base response and Teflon mounted sliding bearing base response to the harmonic base excitation as well as its control through the active mass exciter. This study is the second part of the passive isolation characteristics of Teflon under rigid mass vibrating system[1)] and its main purpose is to examine the effect on, and of the inertia on the response acceleration of the flexibly mounted sliding mass. Experiments on the active mass controlled fixed base structure were for comparison and an evaluation of the structural parameters only.

EXPERIMENTAL TESTS, RESULTS AND DISCUSSION: The model is a steel frame 424 *mm* wide and 167 *mm* high. The mass exciter is fixed on to the top. The top mass is 15.2 *kgf* (inclusive of 2.0 *kgf* active mass) and the foundation mass is 26.7 *kgf*. Four Teflon bearings were attached to the bottom as shown in Fig. 1. A Teflon bearing area of 4 cm^2 producing a pressure of 10 kgf/cm^2 was used. Before an attempt could be made to test the single story frame, it was necessary to evaluate the characteristics of the active mass exciter. The experimental sequence was divided into four cases, (1) response of the fixed frame to base excitation, (2) response of the fixed frame to base excitation and active mass control force, (3) response of Teflon mounted frame to base excitation, (4) response of Teflon mounted frame to base excitation and active mass control force. Accelerations were recorded at the shaking table level, the top of the frame and at the top of the active mass exciter. An extra channel was added for the Teflon mounted frame to measure the accelerations above the Teflon mountings and feedback acceleration from the top of the frame. Tests were carried out at a base excitation amplitude of 30, 50, 100 and 150 *gal* and at frequencies between 3 $\sim$ 12 *Hz* so as to generate the frequency response data. Free vibration tests were also conducted to find the value of the actual structural damping ratio. Recordings were also made to ascertain the experimental phase changes at each frequency. The exciter was adjusted to produce an opposite inertial force relative to the first story except near sudden phase changes of the frame.

The case 1 and case 2 results shown in Fig. 2 indicate a resonant frequency of 7.3 and 7.8 *Hz* respectively, and a maximum response acceleration of 1300 *gal* for 30 *gal* input excitation. This in comparison to the case 2 peak is more than 4 times. A further insight is the fact that a large control force is needed to supress the vibrations of the fixed base frame and becomes impracticable for large structures. The results for the 50 and 100 *gal* input for the fixed base frame show a similar trend and highlights the need to attenuate the amplified accelerations of about 2000 *gal*. The shift in the resonance peak to 7.8 *Hz* is due a reduction in the top mass inertia when active mass is acting. The active mass though reduced the peak acceleration significantly from one-half to one-third of the fixed base response, the observed values still warranted a modification in thought. This necessitated the implementation of Teflon sliding bearings and the active mass control for two main reasons, (1) to attenuate the response accelerations, and (2) to practically control the response by application of weak control forces in the neighborhood of the resonance condition. Fig. 3 shows the Teflon mounted structures's frequency response characteristics. The 30 *gal* input do not shift the natural frequency, but attenuates the peak acceleration. This could be explained by the sliding initiated close to the resonant frequency, isolating it, but not altering its structural parameters. Whereas the 100 and 150 *gal* input produces a continuous slip state between 5.0 and 8.0 *Hz*, taking advantage of the Teflon's isolation characteristics[1]. The peak response is reduced to less than one-half of the fixed base frame with active mass and shifts the natural frequency to 7.8 Hz, because of the mass-ratio effect. Fig. 4 shows the frequency response curves for case 4 with the application of active mass. The response is quite similar except a reduction in the natural frequency in the vacinity of 6.0 Hz for the sliding structure with active mass. Significant effect of the control force on the peak response acceleration is observed for large input accelerations and its ability to slide. No sliding was observed for the 30 gal input with the active mass and this confirms the above proposition.

CONCLUSIONS:

1. A hybrid system of the type proposed is necessary to reduce the response at the natural frequency of the sliding structure, especially for simple systems and hence the proposition for a closed-loop feedback active mass control structure.
2. A comparison of the fixed base and the sliding structure show significant reduction in response due to the friction damping characteristics of Teflon.
3. When isolated, the relative displacement of the top mass decreases and as such a small active mass could further reduce the response acceleration near the resonance condition. A reduction of up to 40% in response is obtained for the feedback controlled active mass. The residual sliding displacement is also reduced near the natural frequency.

REFERENCES:

[1] Qureshi, S.M., Miyahara, S., Tsutsumi, H. and Uno, K., ' Rigid Mass on Teflon Interfaces Under Dynamic Excitation ' Eighth Japan Earthquake Engineering Symposium, 1851-1856, (1990).

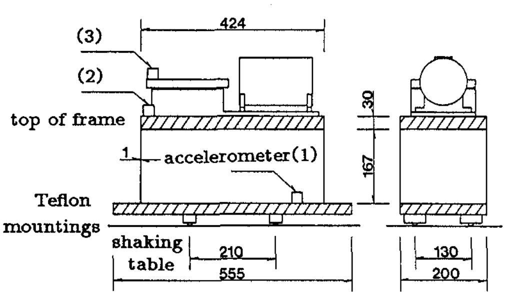

Fig. 1: Experimental Model (all dimensions in mm)

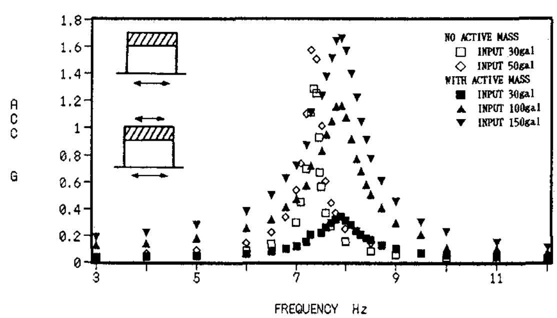

Fig. 2: Top of Frame Frequency-Response Curves for Fixed Base Structure (case 1 & 2)

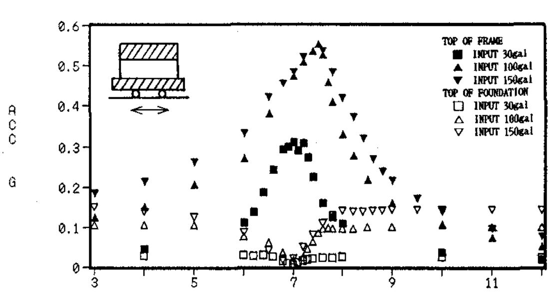

Fig. 3: Frequency Response Curves for Sliding Structure (case 3) (no active mass)

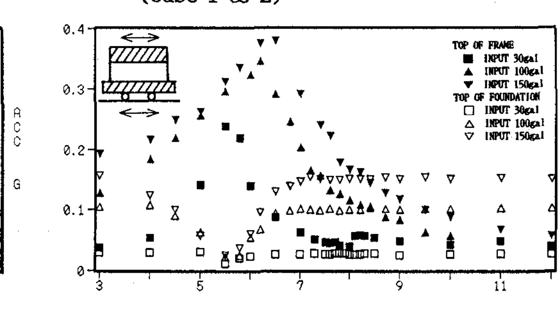

Fig. 4: Frequency Response Curves for Sliding Structure With Active Mass (case 4)