Disposalmethods ofvibrationsin SurroundingEngineering structures

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Abstract

Much of theenergyof vibrationcaused bydynamicresourcespreadin the soil as Rileywaves.That maycauselargedisplacement inthe earth to surroundingstructures, whichtransmitStress resulting fromvibrations and also causedinconveniencetopeopleinresidential buildings. For effectivelyprotectstructuresagainst damagethatis caused bydynamicloads, manymeasurescan betaken. Thus, This paper investigates the control of vibrations of engineering structures due to a dynamic loading.Finally,theintroduction ofthenew method ofcontrollingvibrationsinstructureswill be discussed. So the study employs an identified model of the integrated structural system that is shown to accurately predict the responses of the experimental setup in the Washington University Structural Control and Earthquake Engineering Lab. The application of modern control techniques to mitigate the effects of seismic loads on civil engineering structures offers an appealing alternative to traditional earthquake resistant design approaches. In particular, semi-active control devices appear to present the best opportunity for near-term acceptance by the civil engineering community.

KEYWORDS: Engineering structures, controlmethods, vibrations, dynamicloads

Introduction

The application of modern control techniques to mitigate the effects of seismic loads on civil engineering structures offers an appealing alternative to traditional earthquake resistant design approaches. In particular, semi-active control devices appear to present the best opportunity for near-term acceptance by the civil engineering community. Devices in this class offer the ability to dynamically vary their properties, indicating that they will be effective for a variety of loading conditions. They typically have low power requirements, eliminating the need for a large external power source. Furthermore, semi-active devices are considered to be stable because they do not have the ability to input energy into the structural system (including the control device and the structure).

So, there aredifferent methodsforstructuralvibrationcontrol. Includea variety ofcontrol methodsandcontrolofengineeringstructures. Inthispaper,severalcasestudyisdiscussed, thatinclude thefollowing:

1. Seismic Response Control Using Smart Dampers

A variety of semi-active devices have been considered for seismic applications, including variable orifice dampers, variable friction devices, adjustable tuned liquid dampers, variable stiffness dampers, and controllable fluid dampers bySpencer Jr., B.F. and Sain, M.K. (1997).Magnetorheological(MR) dampers are classified as controllable fluid devices. Dyke, S.J., Spencer Jr., B.F., Sain, M.K. and Carlson, J.D,Yi, F, S.J., Frech(1998)using MR dampers, these devices have demonstrated a great deal of promise for civil engineering applications.Both experimental and analytical studies have demonstrated that the performance of MR dampers is superior to that of comparable passive systems Dyke, S.J., and Spencer Jr., B.F. (1996). Additionally, recent testing of a 20-ton MR damper at the University of Notre Dame havedemonstrated that these devices can provide forces of the magnitude required for full-scale structural control applications Spencer Jr. B.F., Carlson, J.D., Sain, M.K., and Yang, G.
(1997).

This part discusses a recent study that was performed to demonstrate the efficacy of multiple MR devices for seismic response control. The research focuses on an experimental system in theWashington University Structural Control and Earthquake Engineering Laboratory. Four parallel-plate, shear-mode MR dampers are employed to control a six story test structure subjected to uniaxial ground acceleration. Two MR control devices are located between the base and first floor, and two are located between the first and second floors. The procedure used to identify models of the MR damper and of the structure is described herein. Verification of the model is performed by comparing the predicted results with the experimentally obtained results. A clipped optimal controller is designed for the system using acceleration feedback. The performance of the controlled system is then examined. Comparisons of the semi-active system with a variety of passive control configurations indicate that the performance of the semi-active system exceeds that of passive systems.

1.1.Experimental Setup

Experimental investigations are being performed in the WashingtonUniversity Structural Control and Earthquake EngineeringLaboratory. This experimental facility houses a uniaxial seismicsimulator and was established to provide a testbed for experimentalverification of innovative seismic control techniques. The simulatorconsists of a 1.5 ×1.5 m^2 ($5 \times 5 ft^2$) aluminum slidingtable mounted on high-precision, low-friction, linear bearings.
The MR devices employed in this experiment are prototype devices, shown schematically in Fig. 1. The tested devices were obtained from the Lord Corporation for testing and evaluation. The device consists of two steel parallel plates. The dimensions of the device are 4.45× 1.9×2.5 cm^3(1.75× 0.75× 1.0 in^3). The magnetic field produced in the deviceis generated by an electromagnet consisting of a coil at one end of the device. Forces are generated when the moving plate, coated with a thin foam saturated with MR fluid, slides between the two parallel plates.

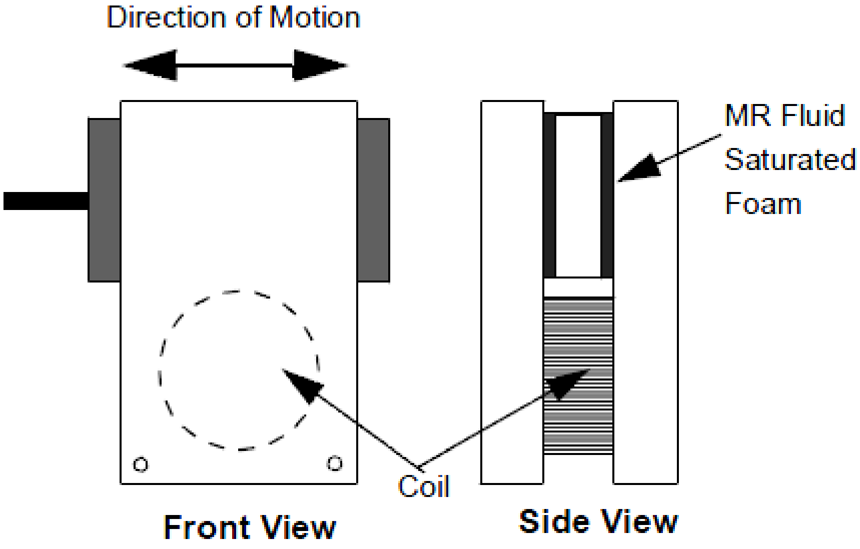
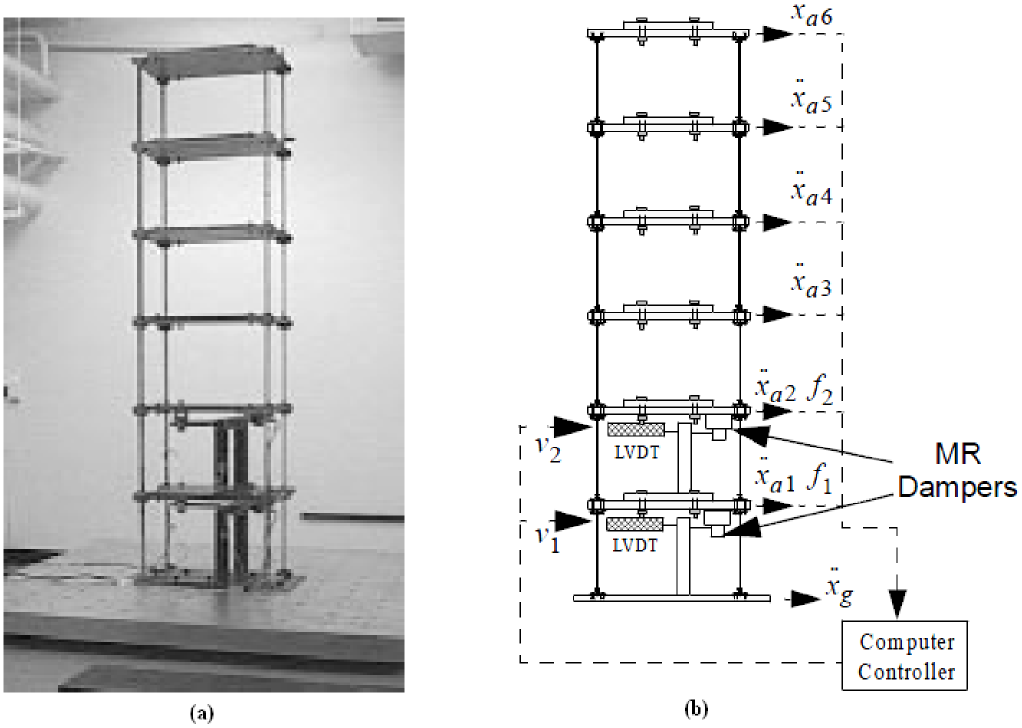


Figure 1. Schematic Diagram of a Shear Mode MR Damper

The outer plates of the MR device are 0.635 cm (0.25 in) apart, and the force capacity of the device is dependent on the strength of the fluid and on the size of the gap between the side plates and the center plate. In this experiment, a center plate with a thickness of 0.495 cm (0.195 in) is selected resulting in a gap of 0.071 cm (0.028 in). Each of the control devices can generate a maximum force of 29 N, which is approximately 1.4% the weight of the structure.
Power is supplied to the device by a regulated voltage power supply driving a DC to pulse-width modulator (PWM). The PWM supplies voltage pulses to the MR damper at a frequency greater than 20 kHz, and the command voltage to the circuit controls the duty cycle of the individual pulses. The circuit has been calibrated such that a 5V command signal corresponds to 100% duty cycle.
The test structure used in this experiment is a six-story, single bay, steel frame (Fig. 2(a)). The structure is 180 cm (74 in) tall and has a mass of 147 kg (325 lb) which is distributed uniformly among the floors. Parallel-plate MR dampers are placed between the ground and

first floor, and between the first and second floors of the structure. Two dampers are used in each location.



(a) (b)

Figure 2.(a) Photograph of Test Structure, (b) Schematic Diagram of Test Setup

Sensors are installed in the model building for use in determining the control action. PCB Piezotronics capacitive accelerometers on all six floors of the structure provide measurements of the absolute accelerations, and a force transducer placed in series with one MR damper on each floor measures the control force$f$ being applied to the structure. Note that only these eight measurements are used in the control algorithm. Additionally, two LVDT's are located in the structure to measure the displacements of the lower two floors and the MR dampers. A schematic diagram of the experimental setup is shown in Fig. 2(b). A multi-channel data acquisition system made by DSP Technology is used for data acquisition and system evaluation.

1.2. SYSTEM IDENTIFICATION

A modification of the approach used by Spencer and Dyke [13] was used to identify a nonlinear model of the system. The steps in this process include:

i) identifying a model of the MR device,
ii) identifying a model of the test specimen,
iii) developing an integrated model of the system,
iv) verification of the integrated model.

2. Seismic response control of smart sliding isolated buildings using variable stiffness systems

Effectiveness of a new semiactive independently variable stiffness (SAIVS) device in reducing seismic response of sliding base isolated buildings is evaluated analytically and experimentally.S.Nagarajaiahand S.Sahasrabudhe(2006). Through analytical and experimental study of force-displacement behavior of the SAIVS device, it is shown that the device can vary stiffness continuously and smoothly between minimum and maximum stiffness. Passive sliding base isolation systems reduce interstorey drifts and superstructure accelerations, but with increased base displacements, which is undesirable, under large velocity near fault pulse type earthquakes. It is a common practice to incorporate non-linear passive dampers into the isolation system to reduce bearing displacements. Incorporation of passive dampers, however, may result in increased superstructure accelerations and drifts; while, properly designed passive dampers can be beneficial. A viable alternative is to use semiactive variable stiffness systems, which can vary the period of the sliding base isolated buildings in real time, to simultaneously reduce bearing displacements and superstructureresponses further than the passive systems, which deserves investigation. This study investigates the performance of a 1:5 scaled smart sliding base isolated building model equipped with the SAIVS device analytically and experimentally, under near fault earthquakes, by developing a new moving average non-linear tangential stiffness control algorithm for control of the SAIVS device. The SAIVS device reduces bearing displacements further than the passive cases, while maintaining isolation level forces and superstructure responses at the same level as the passive minimum stiffness case, indicating the significant potential of the SAIVS system.

2.1.SEMI-ACTIVE INDEPENDENTLY VARIABLE STIFFNESS (SAIVS) DEVICE

The SAIVS device consists of four springs (each 15:24 cm long) arranged in a rhombus configuration as shown in Figure 3(a). Each spring is located at an angle θ to the horizontal.
Each of the four springs is supported on the inside by two telescoping tubes, which allow extension and compression of the springs and prevent them from buckling. The telescoping tubes contribute to the frictional forces in the device, which adds energy dissipation characteristics. As shown in Figure 3(a), an electromechanical actuator controlled with a computer is connected to joint 1. Joint 1 is fixed in the X direction and can be positioned in any desired position in the Y direction by the attached actuator and controller, thus changing _. Joint 2 is free to move in the X and Y directions. Joints 3 and 4 are free to move in the X direction only. The guide rail, on which joint 2 moves, is attached to the shake table. The guide rails, on which joints 3 and 4 move, are attached to the base. The electromechanical actuator is fixed to the base and can move joint 1 to the any position in the Y direction, as desired. Thus, the electromechanical actuator can switch the configuration the SAIVS device to any desired position continuously and smoothly by positioning joint 1. Depending on its current position, the device generates connection force at joint 1 in the X direction, due to the relative displacement between joints 1 and 2. The device in the passive open and passive closed positions is shown in Figures 3(b) and (c), respectively. In the open position (Figure 3(b)), the device offers minimum resistance and has minimum stiffness. In the closed position (Figure 3(c)), the device offers maximum resistance and has maximum stiffness. Using the electromechanical actuator, the device can also be switched to any configuration in between open and closed positions. Hence, the device is capable of varying the stiffness continuouslyand smoothly between the minimum and maximum stiffness. The actuator requires 104W peak power, and voltage supply in the range of 0–4 V to change the configuration of the device from open to closed position. The device does not move in the Z direction.

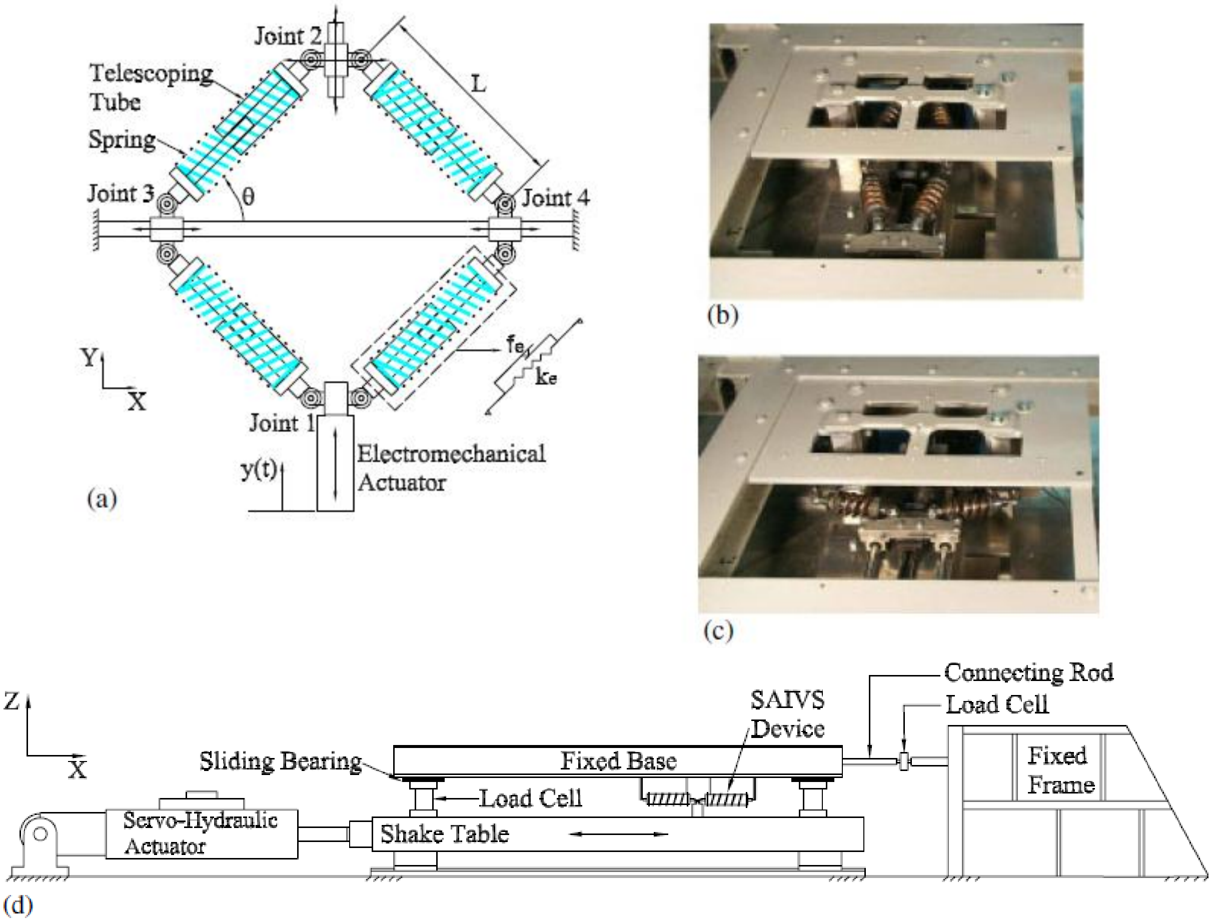


Figure 3. Semi-active independently variable stiffness (SAIVS) device: (a) analytical model; (b) device in open position; (c) device in closed position; and (d) calibration setup.

2.2.Experimental test setup of SAIVS device

The experimental setup to test the force–displacement characteristics of the SAIVS device isshown in Figure 3(d). The SAIVS device is connected between the shake table and a fixed base. The base is fixed by connecting a rod in between a fixed frame and the base. A load cell is connected in series between the connecting rod and the base. The fixed base is supported by four Teflon®-stainless steel sliding bearings. The sliding bearings are supported by four tri-axial load cells, which independently measure friction forces in the bearings. Joints 1; 3and 4 are connected to carriages which slide on rails. The rails are connected to a plate, which is connected to the fixed base. A linear electromechanical actuator is connected to joint 1 and plate. To measure displacement y(t) of the device, a LVDT is connected to joint 1. Joint 2 is connected to another carriage/rail assembly, which is connected to the shaketable. A servo-hydraulic actuator displaces the shake table based on a prescribed displacement time history of a given test, thus applying a relative displacement between joints 1 and 2 of the device. The SAIVS device acts as a connection between the shake table and the fixed base. The load cell, which is connected between the base and connecting rod, measures the force generated by the SAIVS device and the total friction force in sliding bearings. The force generated by the SAIVS device is obtained by subtracting the friction force, which is measured independently by four tri-axial load cells, from the force measured by the load cell that is connected between the base and connecting rod. The relative displacement, u(t), between joints 1 and 2, is measured by connecting a LVDT between the shake table and the fixed frame.

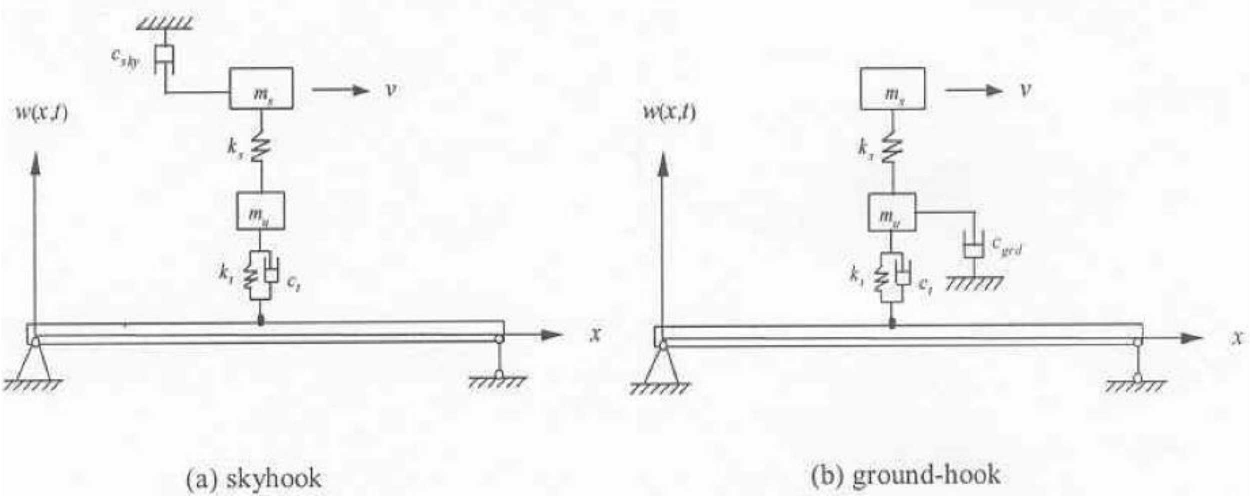
3. VIBRATION CONTROL OF BRIDGES UNDER MOVING LOADS

This division describes the effect of a bridge-friendly truck on a road and bridge structure and proves that the concept of road-friendliness can be extended to bridges. A semi-active optimized damper, when compared to a passive one, reduces the local contact force in all cases and shifts the contact force peaks after the unevenness crossing. An obvious disadvantage of thisbridge control strategy is the reduction of the permitted height of vehicles passing under a bridge.

3.1.SUSPENSION CONTROL

When the direct reduction of bridge deflections was found to be too complicated, new trends in the development of vehicle suspensions follow the concept of tuning the vehicles to minimize the tyre-road contact forces – such vehicles are called bridge-friendly vehicles. In the development of road-friendly truck suspensions, passive, active and semi-active control systems have been considered.

The control force in a passive control is developed as a result of the motion of the structure itself and does not require external power. It is inexpensive, simple and reliable, but it has a performance limitation. An active control system can provide better performance, but is more costly and less reliable and requires electrohydraulic or electromechanical actuators to generate the control force. Semi-active suspensions are a good compromise between performance and cost. The term ”semi-active control system” can be used to refer to any policy in which the damping can be adjusted between a minimum and a maximum level. The control system can be based on a skyhook or groundhook scheme that shown in figure4.



(a) skyhook

(b) ground-hook

Figure 4. Skyhook and groundhook control systems

The control policy is designed to modulate the damping force by using a passive device to approximate the force that would be generated by a damper fixed to an inertial reference. The device can only absorb vibration energy by a actuator with a low power operation. It has the flexibility of active systems and the reliability of passive systems. A modification by combining a ground-hook with passive control was introduced to reduce road damage as well as riding comfort. A mechatronic solution combined with a controlled damper provides a tool for its optimization and the reduction of dynamic contact force. The concept of road-friendliness has been extended to bridge-friendliness by means of the optimization of the damper parameters on bridges, e.g. Valášek, M. - Kejval, J. - Máca, J. (2002).Extended Ground Hook control systemshown in fig 5. The aim of this work is to explore the benefits of bridge-friendly trucks on ordinary, simply supported bridges.

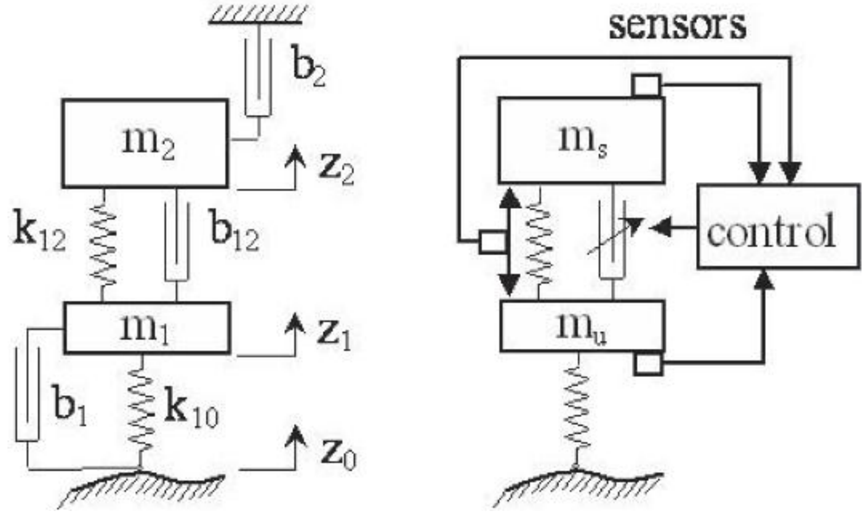


Figure 5.*Extended Ground Hook control system*

The results from previous studies with a quarter-car model were so promising that a more accurate model with a half-car and a slab bridge were brought together, e.g. Máca J. - Šmilauer V. - Valášek M. (2005). A similar model was re-solved for a simply supported bridge with a specific road profile, traversed by a quarter-car model with a passive sky-hook and ground-hook control configuration. The effect of a semi-controlled damper is significant on the bridge response for close natural frequencies of the vehicle and the bridge Chen Y., et al., (2002).

Conclusions

The analytical and experimental study presented clearly indicates that the semiactivesti_ness variation using the SAIVS device in sliding base isolation systems in buildings reduces the base displacements further than the passive open and passive closed cases, While the results shown herein demonstrate the potential of the variable sti_ness system in fault parallel components of chosen earthquakes, better controlalgorithms need to be developed for achieving reductions in response in the case of fault normal components. The analytical and experimental study demonstrates the signi_cant potential of the SAIVS system.Also

Theresults of the numerical study indicate that the semi-active system using the clipped-optimal control algorithm achieved excellent performance. Furthermore, using only a very small amount of power, the semi-active systems is superior to a number of optimal passive systems.

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