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ENHANCED SEISMIC LATERAL LOAD DISTRIBUTION IN BRIDGES FITTED WITH A NEW VISCOELASTIC DEVICE

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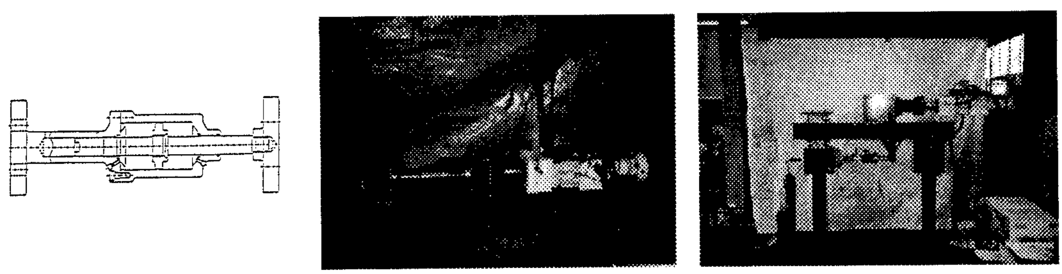
1. Introduction Many bridges suffered damages during strong earthquakes due to the concentration of large forces on just a few load-resisting elements, whereas piers supporting movable supports remained undamaged. Distributing the lateral forces among the piers would enhance seismic safety. A new viscoelastic device is developed to enable lateral loads to be transmitted to piers supporting movable bearings of a bridge during earthquakes. Test results are reported in this paper.

2. A New Viscoelastic Device for Lateral Load Distribution Offering several advantages primarily in performance and maintenance, a new viscoelastic device is constructed of a mechanically simple piston-cylinder assembly filled with silicone putty compound. Silicone putty is a polymer material that readily deforms under slowly applied pressure, but becomes rigid when subjected to shock or impact loads. The device is similar to the so-called Shock Transmission Units (STU) that have been used to relieve increasing traction and braking loads in the London Docklands Light Railway.



(a) Device Construction (b) Test of Device (c) Test of Bridge w/ Device

Fig. 1 Viscoelastic Device for Lateral Load Distribution

Under applied loads, the putty compound is squeezed from one side of the piston to the other side through openings around the piston. The device is attached to the girder near a movable support and to the top of the pier. The arrangement allows movement of the movable support during ambient temperature changes, but will fix the girder-pier connection during earthquakes and thereby transmitting a share of the lateral load to the piers with movable supports.

3. Cyclic Mechanical Behavior First, mechanical cyclic behavior of the device is investigated. It can be observed that the silicone putty readily allows movement of the piston under low frequencies. Hystereses in Fig. 2 plotted with bold lines is for a device with a relatively bigger piston (smaller orifice) and relatively harder putty. Putty stiffening is exhibited at about 0.1 Hz. Beyond 0.1 Hz, the silicone putty has become almost rigid and stiffness is provided by the the end rod of the cylinder and the piston.

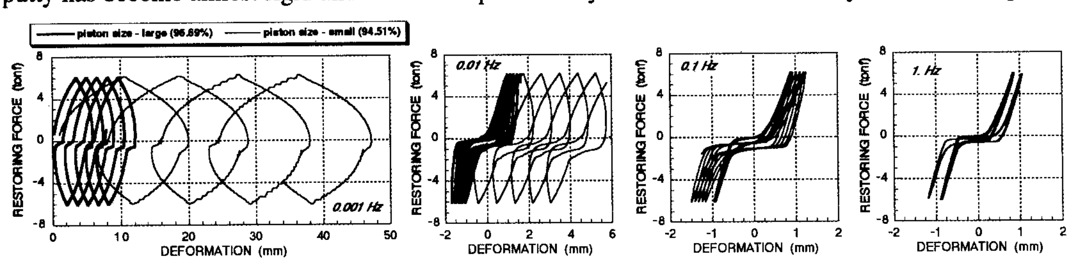


Fig. 2 Comparison of Load-Deformation Behavior of Device with Different Piston Sizes

The same device was then fitted with a smaller piston which would permit easier passage of the putty when squeezed. Results are shown in the hystereses plotted witth the thinner lines in Fig. 2. It can be observed that the piston was easier displaced inside the putty-filled cylinder and stiffening was initiated at a much higher frequency of about 1. Hz.

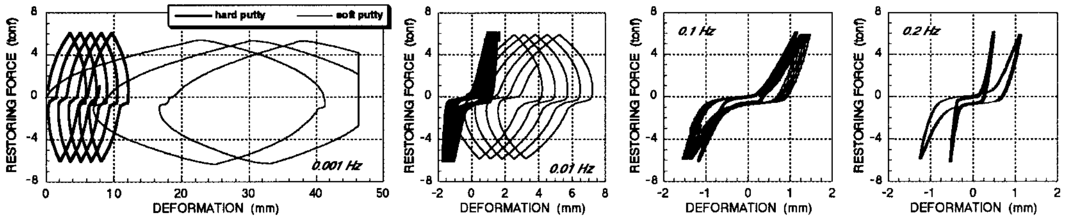


Fig. 3 Comparison of Load-Deformation Behavior of Device with Different Putty Properties

A 'softer' putty was packed into the device with the larger piston and its load-deformation hystereses (plotted with thinner lines in Fig. 3) are compared with the previous case of a 'harder' putty. It can be observed that the piston was easier displaced inside the putty-filled cylinder and stiffening was initiated at about 0.2 Hz.

4. Lateral Load Distribution in Bridge Model Test A simple-span bridge model fitted with the viscoelastic device (Fig. 1c) was next tested. Without the device, the pier supporting the fixed bearing would have to resist almost all of the lateral loads.

For slowly applied loads, the device barely offered any resistance and moved along with the girder and the pier with the fixed bearing as can be seen in the displacement time history in Fig. 4, whereas it can also be observed that the pier supporting the movable bearing was only displaced slightly except for a small amount transferred through friction and also due to rotational restraint of the device joints.

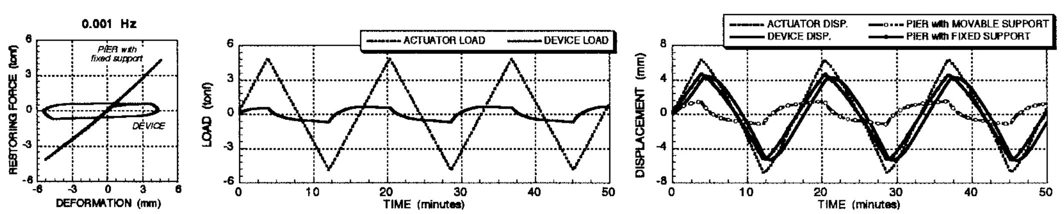


Fig. 4 Simple Span Bridge Prototype Subjected to Slowly Applied Loads (0.001 Hz)

When the bridge model is subjected to higher-frequency loads (the case of 1. Hz presented) or earthquake-like loads, the device would act to transmit loads to the pier with the movable bearing. It can be observed from the displacement time history in Fig. 5 that both piers are displaced equally and thereby shared in resisting the total lateral load from the girder. The device had acted to transfer about half of the load acting on the pier with the rest transferred through friction of tthe roller bearing.

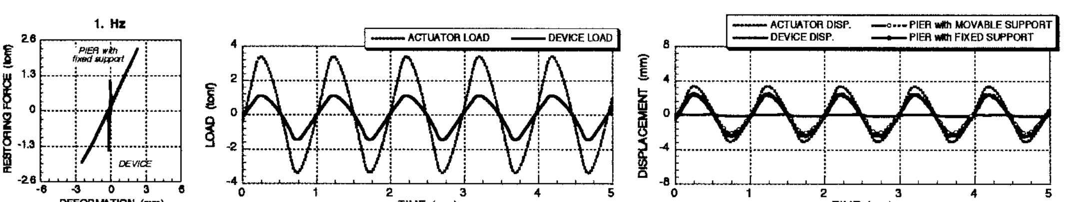


Fig. 5 Simple Span Bridge Prototype Subjected to Higher-frequency Loads (1. Hz)

5. Conclusions A new viscoelastic device, made up of a simple piston-cylinder assembly and packed with silicone putty, is developed to enable transmission of loads to piers with movable bearings during earthquakes. Test were conducted to obtain basic load-deformation behavior of the viscoelastic load-transmission device under cyclic loadings and the effect of piston sizes and putty flow properties were investigated. A bridge model fitted with the viscoelastic device was tested and the effectiveness of the device in distributing lateral loads has been shown.