Optimum Design of Resilient Friction Bearings for Seismic Isolation of Equipment

Kyoto University Student Member ○ Touraj Taghikhany
Kyoto University Fellow Hirokazu Iemura
Kyoto University Member Yoshikazu Takahashi

Introduction

This paper proposes a method for optimum design of seismic isolated raised floor to protect equipments. By using this method optimum parameters of isolation system with resilient friction bearings (RFBI, Slider & Rubber bearing, …) is determined for different level of allowable acceleration. The accuracy of numerical response analysis is confirmed by result of experimental tests of real model.

Methodology

Past seismic casualties demonstrate when the elastic energy is small, the total input energy is deemed to concentrate in weakest level and if this level has not enough capacity to dissipate input energy, system will be collapsed. In this regard seismic isolated equipments with rigid body response and low stiffness of isolators has same behaviour and for this reason, design of seismic isolated equipments with energy concept has advantages over to other methods. This paper tries to determine optimum parameters of seismic isolation system for the prescribed allowable acceleration level of equipments *with maximum energy dissipation and less displacement.* Allowable level of acceleration is the maximum horizontal acceleration that equipments can resist against their inertial force without any failure. Seismic isolation system should be design to control absolute acceleration response under the allowable level. Fig.1 clearly depicts procedure of optimum parameter recognition in resilient friction model for specific allowable acceleration. In this method, equipment and raised floor are considered as a solid mass (Fig.2) that they are installed on isolation system and make a nonlinear SDOF model. Then response spectrum of earthquake is computed for various friction coefficient (μ) of assumed SDOF model. Now, for specific level of allowable acceleration different pairs of friction coefficient and period (μ , T) that their acceleration are under this level are eligible to use as design parameters of isolation system of equipment. But it is easy to understand just those pairs, which are in conjunction point of allowable acceleration has minimum displacement (they have minimum period among eligible points). Between these pairs with minimum displacement, any one has maximum energy dissipation is considered as an optimum friction coefficient and optimum period of specified allowable acceleration.

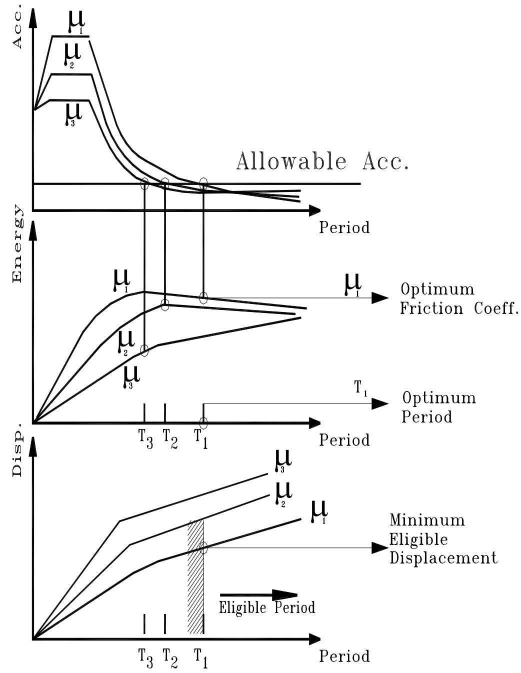


Fig.1- Procedure of optimum parameter recognition

Numerical Analysis and Optimum Parameters

Response and energy spectra of Elcentro Earthquake (NS 1940) are computed for range of friction coefficient that it is shown in Fig.2. For specific level of allowable acceleration like 0.14 PGA (0.05g), after

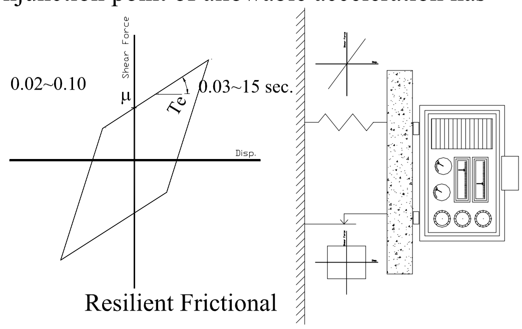


Fig.2- SDOF Resilient Friction Model

Seismic Isolation, Resilient Friction model, Experiment, Optimum Design

〒606-8501 京都市左京区吉田本町京都大学土木システム工学構造ダイナミクス研究室 TEL.075-753-5089

determination of intersection points of computed spectrums and straight line of allowable acceleration, dissipated energy of each point is calculated. From two graphs in Fig.3, with the specific allowable level is equal to 0.14 PGA it is found the system with friction coefficient 0.03 and period 4.02 second dissipates the maximum input energy. Now, Optimum values of main parameters of resilient friction models can be determined for range of allowable accelerations. Fig4 clearly depicts optimum friction coefficient and period of resilient friction model for different level of allowable acceleration (0.06PGA(0.02g)~0.29PGA(0.1g)) under Elcentro earthquake. This graph shows that optimum friction varies between 0.01 and 0.045 but optimum period is reduced by increasing of allowable level of acceleration.

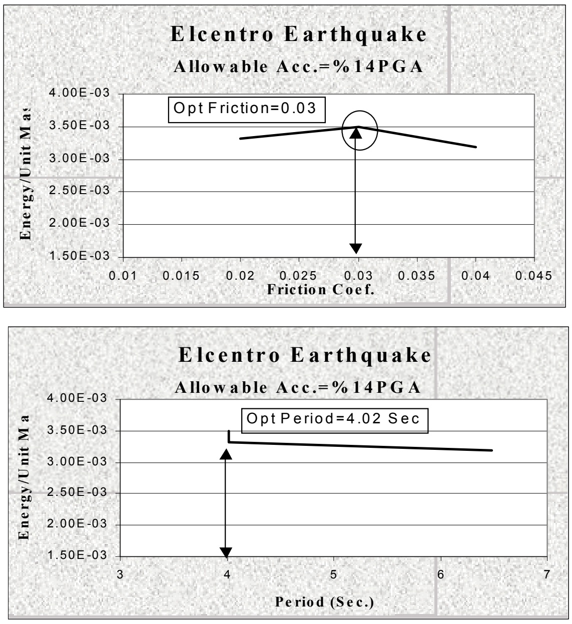


Fig.3- Variation of Dissipated Energy in Resilient Friction Model

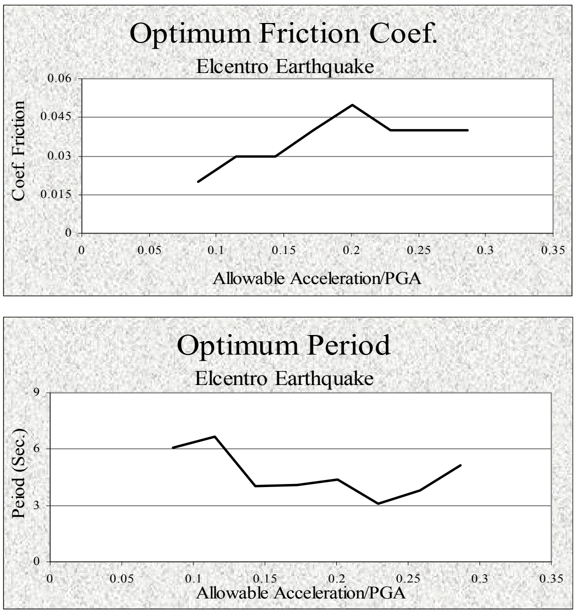
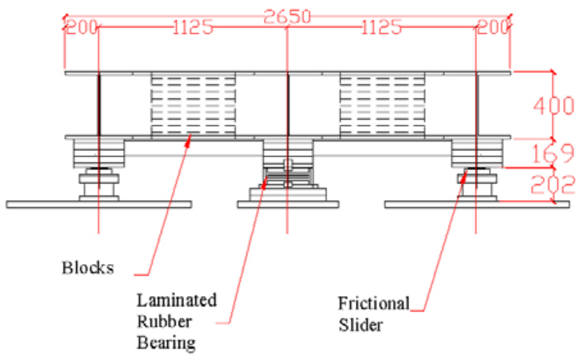


Fig.4- Optimum Parameters for Resilient Friction Model

Experimental Confirmation

Here numerical response analysis is compared with results of experimental tests which was conducted in *Structural Dynamic Department of Kyoto University*. In this test a 4150 x2650 mm raised floor was installed on 4 frictional sliders and 2 laminated rubber bearing. Weight of raised floor and blocks, which can be considered as equipment, totally were 100 KN. Friction coefficient of sliders was 0.10 and stiffness of laminated rubber was equal to 1.731 KN/mm. Fig 5-a) shows section of raised floor and in Fig 5-b) acceleration of numerical analysis and experimental test is compared under Kobe earthquake. This graph shows numerical result can be acceptable to predict real response and optimum parameters of seismic isolated raised floor.

a)



b)

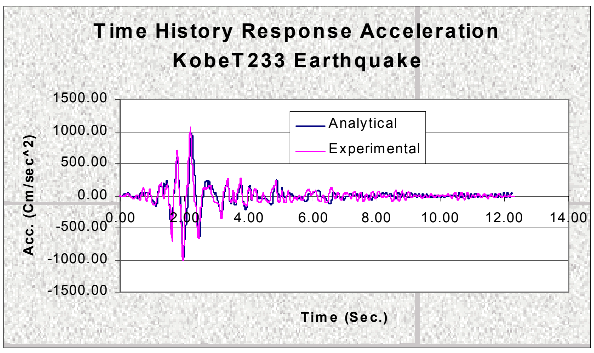


Fig 5- a) Section of Raised Floor
b) Numerical and Experimental Comparison.

Conclusion

In this paper, after proposing a method for optimum design of isolation system in equipment, optimum parameters of Resilient friction model under Elcentro Earthquake were determined for different allowable level of acceleration. Results of analysis show that optimum period decreases by increasing of allowable level of acceleration. Optimum friction coefficient μ varies between 0.01~0.045 but it generally grows up by increasing of allowable level of acceleration.