Damage Distribution based Energy-Dissipation Retrofit Method for Multi Story RC Building in Turkey

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Summary

In recent years seismic response control technology with elasto-plastic dampers is widely applied for seismic retrofit of RC buildings in Japan [1]. On this paper, design method for retrofit of Turkish RC buildings with elasto-plastic dampers and elastic steel frame are proposed and the validity of proposed method is confirmed.

Shown in Fig.1, elastic steel frames are introduced around dampers to assure the ductility of RC frame structure and the energy dissipation of dampers. Ratio of elastic frames stiffness K_{sf} and dampers stiffness K_d, $\gamma_s = K_{sf}/K_d$ is defined on this paper. Damper stiffness of each story K_{di} is calculated by Eq. (1) which is proposed on this paper. This equation is obtained by introducing γ_s to equivalent linearization method and equivalent story drift angle method which was proposed by Kasai *et al* [2] where Q_i is shear force based on Ai distribution, h_i is story height, $K^f_{\mu i}$, μ_d and μ are secant stiffness and ductility factor of dampers and retrofit frame for retrofit target displacement.

$$K_{di} = \frac{Q_i}{h_i}\frac{\sum_{i=1}^{N}\left(K^f_{\mu i}h_i^2\right)}{\sum_{i=1}^{N}\left(Q_i h_i\right)}\left(\frac{1}{\gamma_s + 1/\mu_d} + \frac{\mu}{\alpha_y}\cdot r_d\right) - \frac{K^f_{\mu i}}{\gamma_s + 1/\mu_d} \qquad (1)$$

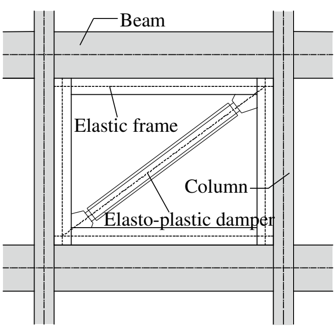


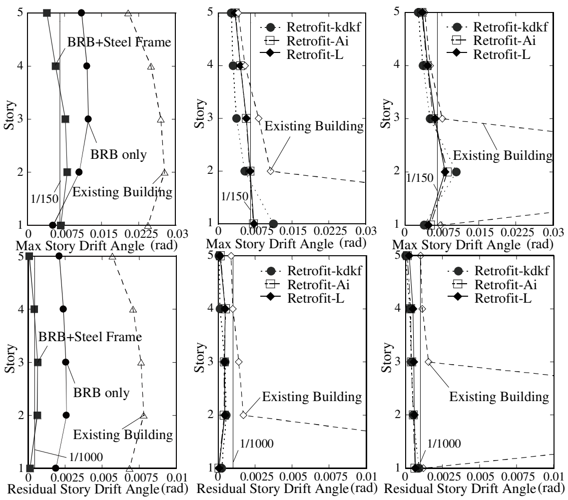
Fig.1: Retrofit Concept

By using Eq. (1), damper distribution of seismic control retrofit on existing buildings can be obtained. The validity is confirmed by time history analysis. Analysis models are standard model and weak story models. Standard model is five story school building constructed in Istanbul (in 1990) that does not satisfy Turkish new Seismic Code which is similar to Japanese design code. Weak story models have low stiffness on each floor (1L～4L model, e.g. 1L stands for the model with weak story on 1st floor.). Target of retrofit is defined as 1/150 story drift angle for design earthquake wave BCJ-L2 of Japanese code.

Time history analysis results for existing building model and retrofit models (kdkf: K_d/K_f constant, Ai: Based on Ai distribution, L: Proposed Method (Eq.(1))) are compared in Fig.2. In these figures, max story drift angle and residual story drift angle of models retrofitted with dampers and elastic frames are around 1/150 and under 1/1000 respectively. The results satisfy retrofit target displacement for immediate occupancy. It can be concluded that damage concentration and residual displacement are prevented as steel frame remains elastic during the input ground motion.

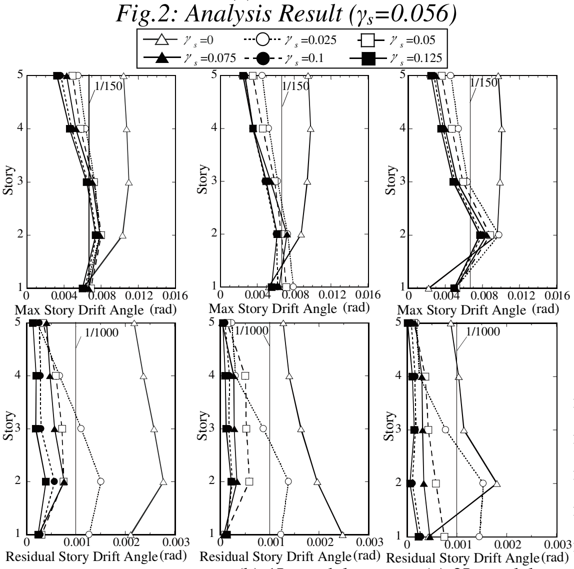
Next, the effect of γ_s on structural response is investigated through a parametric study. Max story drift angle on each story is shown in Fig.3 and displacement hysteresis of 2nd story is shown in Fig.4. As γ_s increase, max and residual story drift angle tends to decrease. Response of retrofit buildings satisfies the immediate occupancy performance level by designing γ_s around 0.05.

Fig.5 shows cumulative plastic energy of damper and ratio of frame plastic energy and total plastic energy of each model. As γ_s increase, the amount of energy dissipation of dampers increases. By using the equation predicting damage distribution of each story, proposed by Akiyama and et al [3], and considering RC frames as soft element on proposed equation, damage concentration for weak stories of each retrofit model can be predicted.



(a) S model (b) 1L model (c) 2L model

Fig.2: Analysis Result (γ_s=0.056)



(a) S model (b) 1L model (c) 2L model

Fig.3: Analysis Result (Varying γ_s)

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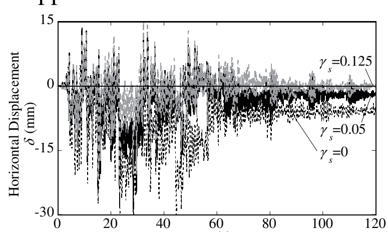
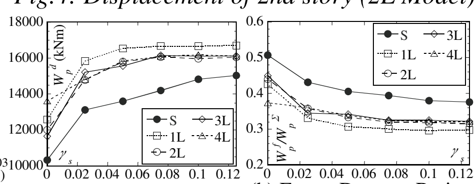


Fig.4: Displacement of 2nd story (2L Model)



(a) Plastic Energy of BRB (b) Frame Damage Ratio

Fig.5: Analysis Result (Various γ_s)