

ARC SHAPED DAMPER RETROFIT TECHNIQUE FOR EXISTING RAIL WAY VIADUCT STRUCTURES

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ABSTRACT

When considering social function of railway viaduct as infrastructure, less damage control is demanded even against significant earthquake. Response control technique with damping device is highly expected as alternative solution. In responding, authors have developed Arc Shaped Dampers. In order to investigate applicability of the proposed damper to moment frame type rail way viaduct structures, seismic retrofit design, nonlinear analysis and experimental loading tests have been conducted to verify present technique. Following results were obtained: the existing structure is failed in post yielding shear, while retrofitted structure assures flexural yielding ductile behavior with higher damping effect.

1. INTRODUCTION

In the current seismic design standard for rail way viaduct structures, less damage is required against intermediate earthquake from less recovery aspect, while collapse prevention required against significant earthquake from life safety aspect. On the other hand, many existing structures designed by old specification are potentially shear failure type or have less ductility with less lateral reinforcement. In the seismic retrofit of these structures, jacketing method has been commonly employed. However, when considering social function of these facility, early recovery and less damage is expected even against significant earthquake.

In these backgrounds, we have developed new seismic retrofit technique with arc shaped steel damper, that prevents brittle failure and assures damage control with appropriately corner arrangement into frame structure as shown in **Fig.1**. Advantageous points of the developed damper are 1) buckling prevention with its arc configuration and 2) wider distribution of plastic region into device. Next, with present dampers into corners of moment frame, followings are assured; 1) strengthening of entire structure, 2) shear force decrease in the column end section, 3) shear capacity increase expected due to deep beam action in the column middle section and 4) seismic response reduction with high damping effect. In addition, 5) corner arrangement of the present arc shaped damper assures open space for public usage.

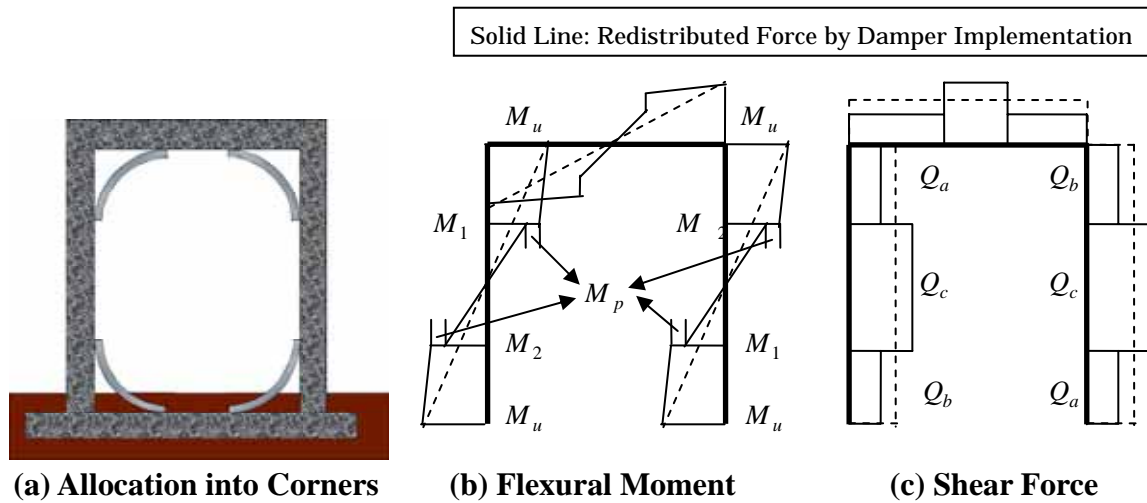


Fig.1- Shear Force Redistribution by Arc Shaped Damper Implementation

The proposed paper will report 1) hysteretic characteristic of the arc shaped damper, 2) seismic retrofit design, 3) nonlinear analysis of the retrofit designed structure and 4) Cyclic loading test of the scale model.

2. HYSTERETIC CHARACTERISTIC OF ARC SHAPED DAMPER

Fig.2 represents hysteretic characteristic obtained in the element test of arc shaped damper with fairly large energy absorption. **Fig.3** also shows obtained equivalent viscous damping ratio. The Arc Shaped Damper has 30 ~ 40% damping in the larger drift angle in the range of $R=0.03 \sim 0.06$.

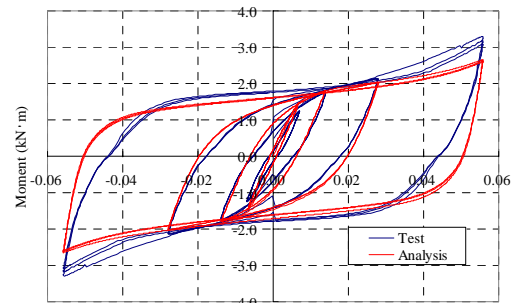


Fig.2 Hysteretic Characteristic of Arc Shaped Damper

3. RETROFIT DESIGN

Fig.4 presents employed model structure with shear reinforcement ratio of 0.15% in which less than 0.2% has been commonly employed in the old design standard. Here, strength increase by retrofit is assumed as 30% that of the existing structure. With reference of horizontal force application illustrated in **Fig.5**, **Fig.6** provides shear force to shear strength relationship with damper section length L_B as a parameter, in which it is found that shear failure is prevented

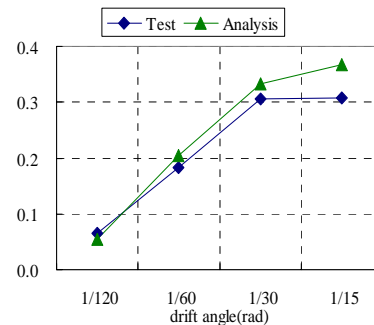


Fig.3 equivalent viscous damping

in the column end section in less than $L_B = 3000\text{mm}$, and also in the middle section in larger than $L_B = 1850\text{mm}$. Based on these results, $L_B = 2100\text{mm}$ is employed as damper section length.

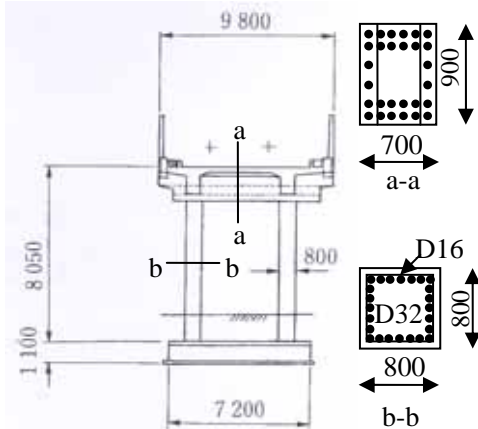


Fig.4 - Model Structure

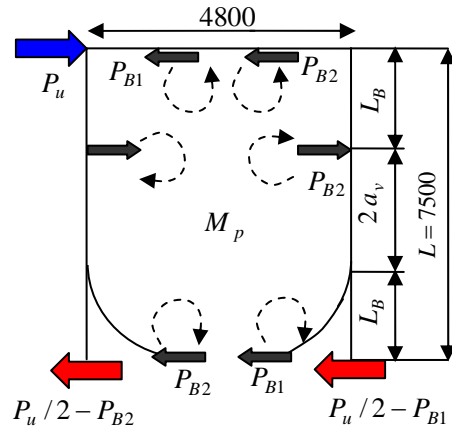


Fig.5- Equilibrium of Horizontal Force

4 . NUMERICAL ANALYSIS

FE nonlinear analyses have been conducted with considering material and geometric nonlinearity. Fig.7 provides obtained load-drift angle hysteresis for variety of damper materials with lower to ordinal yielding strength. In the figure, line (a) shows ultimate drift angle specified in the standard for railway viaduct structures and line (b) in the JSCE standard which covers into lower lateral reinforcement P_{B1} nt. And It is found that existing structure fails in shear but retrofitted others provide stable flexural yielding behaviors.

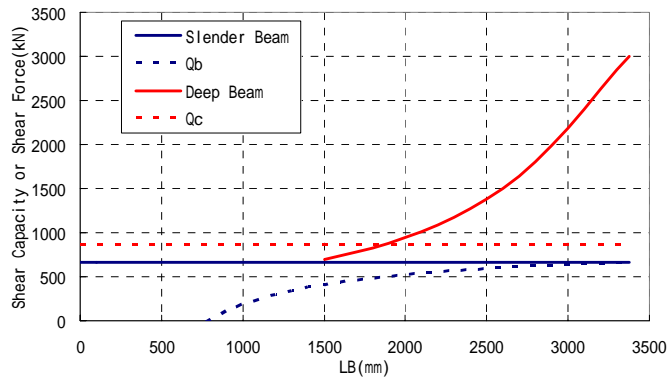


Fig.6-Shear Force to Shear strength relationship

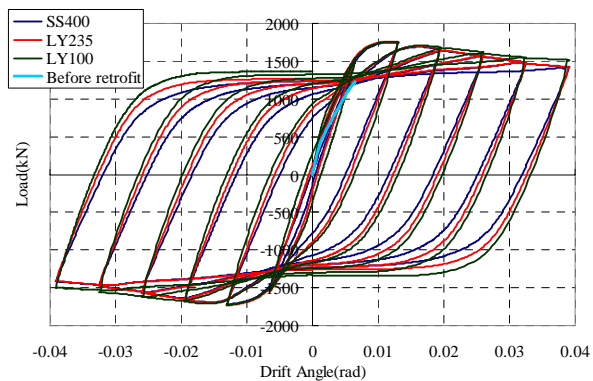


Fig.7 Load-Drift Angle Hysteresis

5 . EXPERIMENTAL LOADING TEST

The purpose of the test is to verify

proposed retrofit technique. Cyclic loading tests have been conducted with 1/5 scale model. Test parameters are lateral reinforcement ratio, i.e. 0.05, 0.15 and 0.25% and with and without retrofit. **Fig.8** represents comparison of load displacement histories between existing and retrofitted model both with 0.15% lateral reinforcement. 40% strength increase, more than 80% ductility increase and 80% energy absorption increase are observed with the proposed damper retrofit.

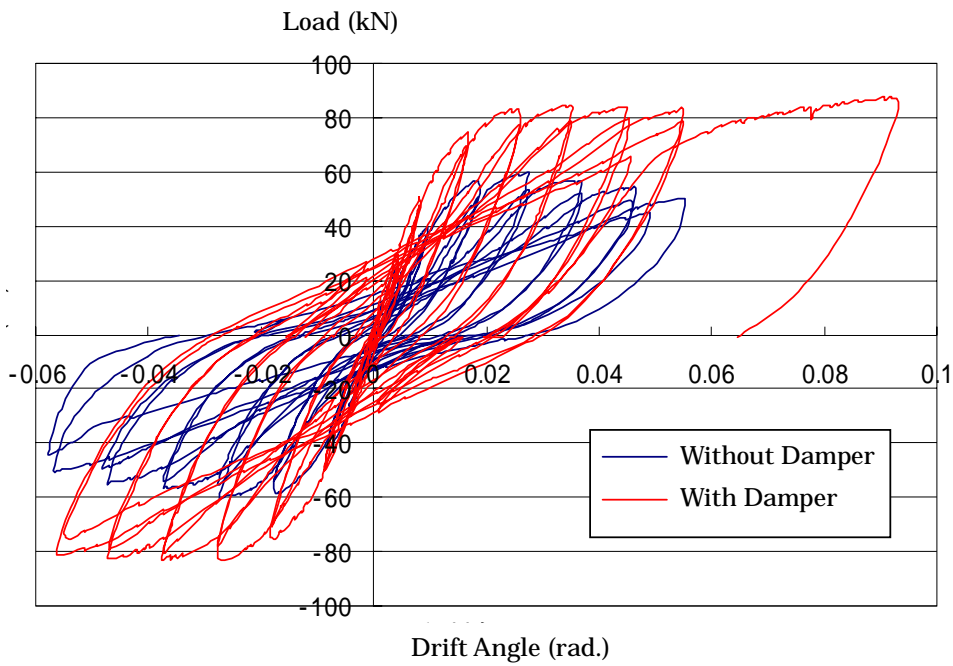


Fig.8 Comparison of Load-Displacement Histories between Existing and Retrofitted Model Specimens