Seismic Response Controlled Reinforcement Method "SUMAIRU Damper Frame"

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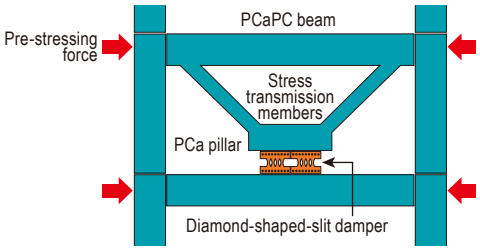
Summary of Method

The SUMAIRU Damper Frame is a seismic response-controlled frame composed of precast columns, beams, stress transmission members such as braces, and damper sections.

Image of SUMAIRU Damper Frame reinforcement

Characteristics of SUMAIRU Damper Frame

1. Damper sections absorb seismic energy and reduce building damage.
2. Comparing with the seismic resistant reinforcement, using a seismic response-controlled frame can reduce the number of reinforcement structures by about 30 to 50% and it is economical.
3. By reducing the number of reinforcement structures, the scale of construction can be reduced. It can also shorten the construction period and reduces environmental impact.
4. Seismic resistance after reinforcement can be evaluated by using the structural seismic resistance index I_s, which considers the energy absorption of damper, without performing advanced time history response analysis.



Composition of SUMAIRU Damper Frame

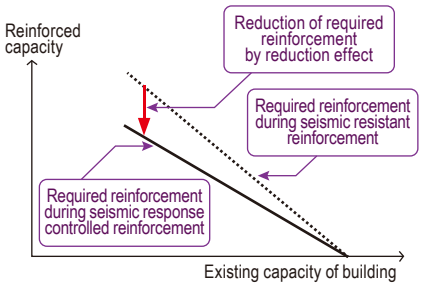
Design concept of seismic response-controlled reinforcement

This method calculates the amount of reinforcement required by using the ratio(F_h/F_{ho})of the response reduction factor due to damping of seismic response controlled reinforcement to that of the seismic resistant reinforcement, and does not require a time history response analysis.

F_{ho} : Response reduction rate during seismic resistant reinforcement $(F_{ho}=1.5/(1+10\cdot h_o))$

F_h : Response reduction rate during seismic response controlled reinforcement $(F_h=1.5/(1+10\cdot h))$

The structural seismic resistance index ${}_dI_s$ is set after damper reinforcement and divided by (F_h/F_{ho}) to confirm that the value satisfies the target structural seismic resistance index I_{so} at the time of seismic reinforcement.

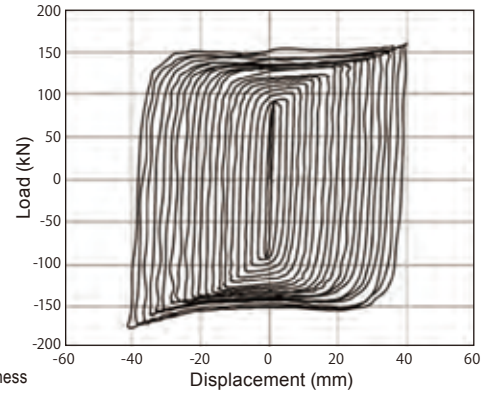


Overview of Diamond-shaped-slit Damper

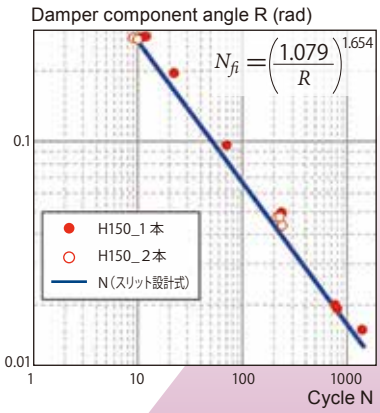
- High toughness steel (LY225) provides excellent deformation performance and energy absorption.
- The type of damper can be selected depending on the deformation and reinforced capacity of the building under seismic load action.

Type	Plate thickness	Height of plastic deformation parts	Homothetic ratio
H150	22mm	150mm	$\alpha=1$
H200	30mm	200mm	$\alpha=20/15$
H250	37mm	250mm	$\alpha=25/15$

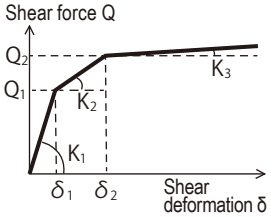
Types of damper



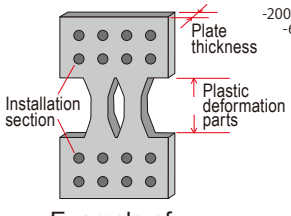
Example of hysteretic response



Example of fatigue characteristics



Resilience characteristics



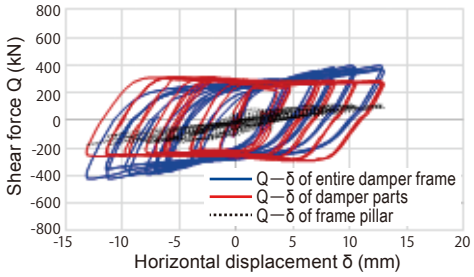
Example of damper shape

Performance Experiments

The specimen was a 1/2.5 scale model, and the applied force was R = 1/250, 1/150, 1/125, and 1/82 for 3 times alternating load.

- The hysteretic response of the entire damper frame indicates stable behavior and sufficient deformation performance.
- At each story drift angle, the experimental and analyzed values of the shear force are well consistent.
- Reinforcement frames have sufficient deformation performance to provide energy absorption for steel plate dampers.

Status of experiment

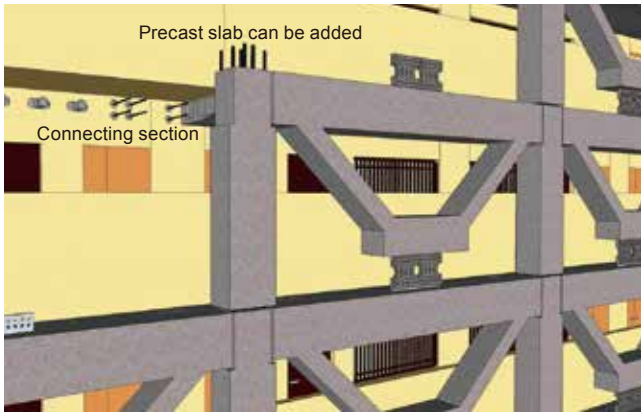


hysteretic response

SUMAIRU Damper Frame Installation Image

- Frame is connected to the beam at the horizontal section.
- For connect to existing structures, steel pipe cotter, post-installed anchor and prestressed bonding can be possible.
- In the case of steel pipe cotter connection, it is possible to connect the frame while leaving the finished material in place.

Installation image using pipe cotter (Balcony type) ▶

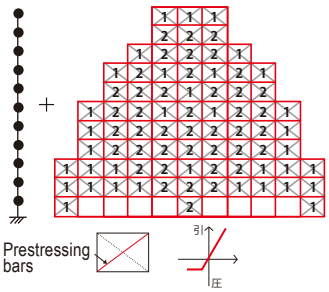


Verification Example of Seismic Response Controlled Reinforcement Design

The response reduction factor ratio (F_h/F_{ho}) was evaluated and verified the validity of the seismic response-controlled design method from the response analysis results based on the seismic response-controlled model and seismic resistance model.

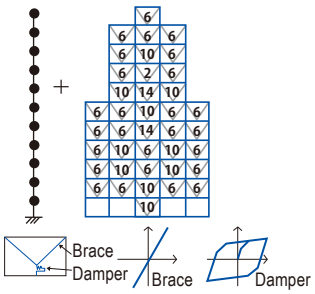
As a result, the maximum story drift angle of seismic response-controlled model and seismic resistance model were almost equivalent, and the design method of the seismic response control reinforcement using the response reduction ratio was evaluated as appropriate.

Seismic resistance model
(Prestressing bars)



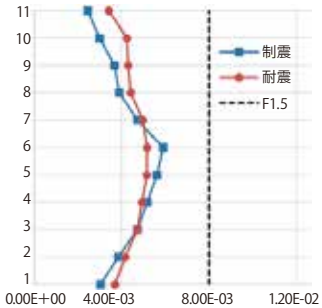
Diagonal parts:
Nonlinear elasticity member
(Bilinear type)

Seismic response controlled model
(Damper)

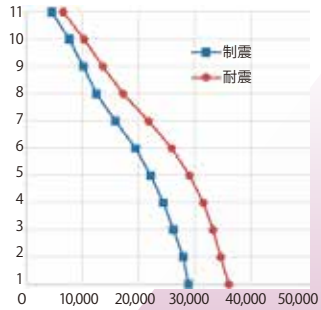


Damper parts:
Horizontal spring members
(Trilinear type)

Brace parts:
Axis member
(Elastic behavior)



Maximum story drift angle (rad)



Story share force (kN)