Seismic isolation devices

How to use and combination
Performance evaluation method of devices

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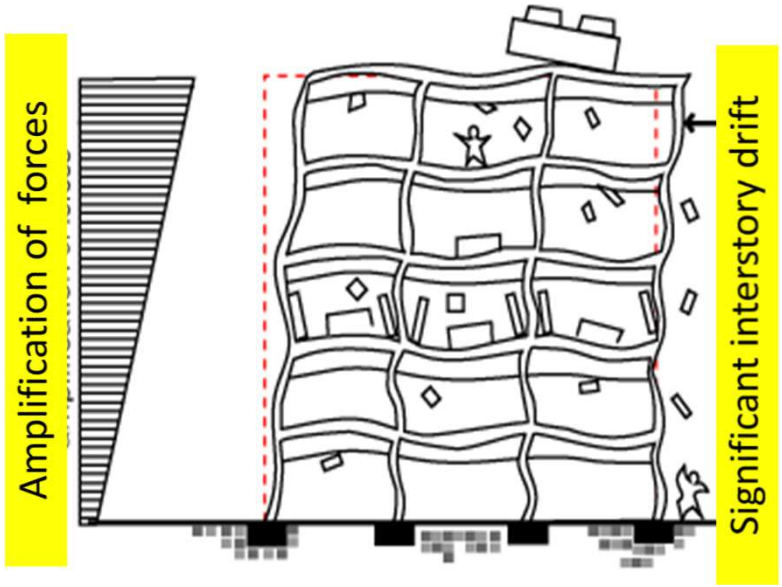
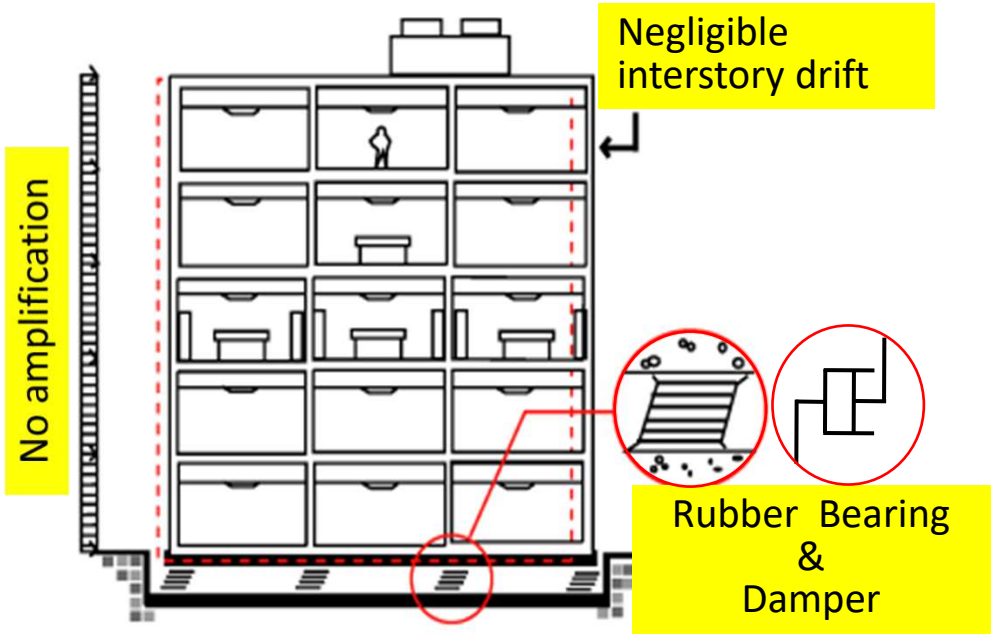
Salient Features of Seismic Isolation System

What's the Seismic Isolated Building?



Non Seismic Isolated Building

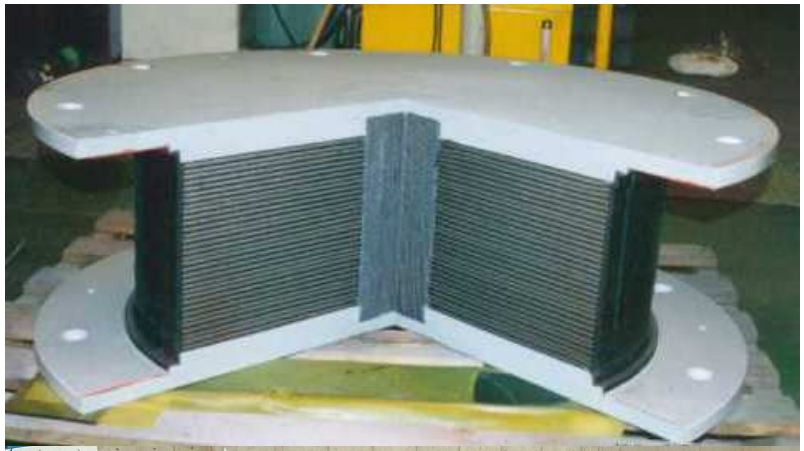


Seismic Isolated Building

Features of Seismic Isolation System

1. Damage control of the structural frame
2. Improvement of design flexibility
3. Prevention of damage to non-structural members
4. Preventing furniture from falling over and maintaining building function

Seismic isolation system needs
the functions of
isolator and damper



Various Types of Isolator

➡ Laminated Rubber Bearing

Natural Rubber Bearing
Lead Rubber Bearing
High Damping Rubber Bearing

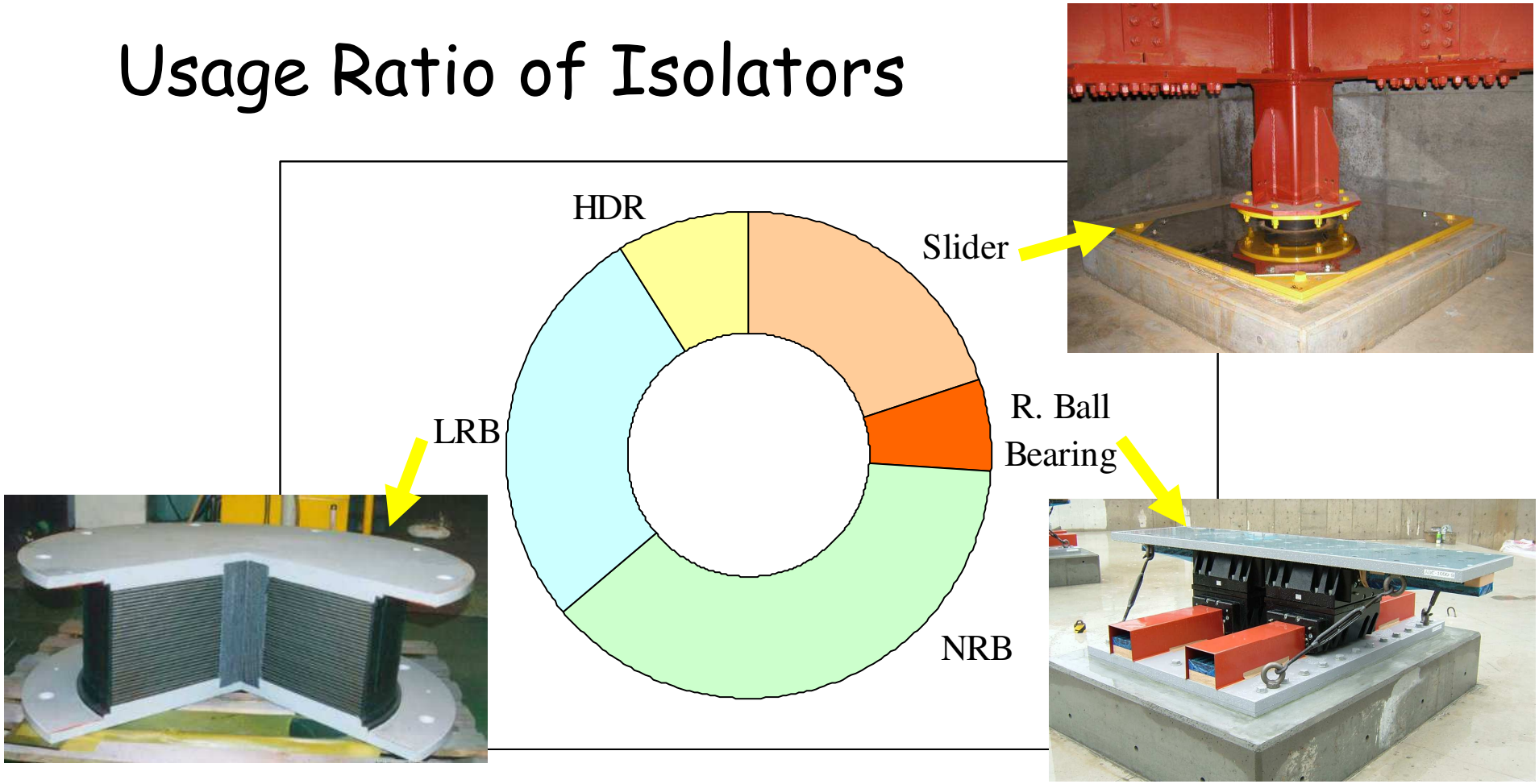
➡ Roller Bearing

Friction Coefficient :
Less than 0.004

➡ Slide Bearing

Friction Coefficient
High Friction Type : 0.1
Low Friction Type : 0.01

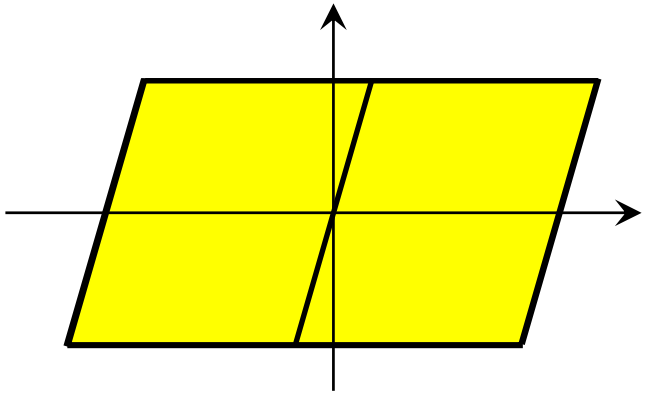
Usage Ratio of Isolators



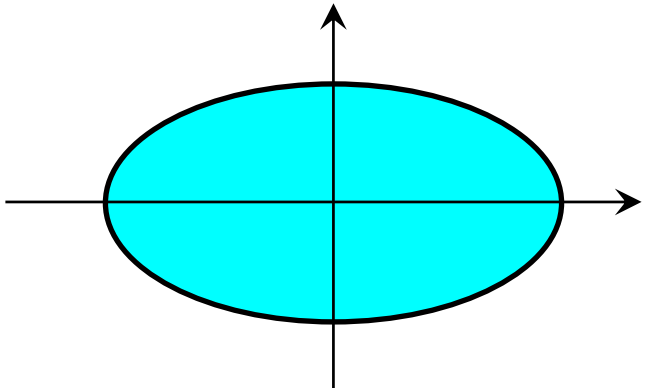
NRB: Natural Rubber Bearing
LRB: Lead Rubber Bearing
HDR: High Damping Rubber Bearing
RBB: Rotating Ball Bearing

Various Types of damper

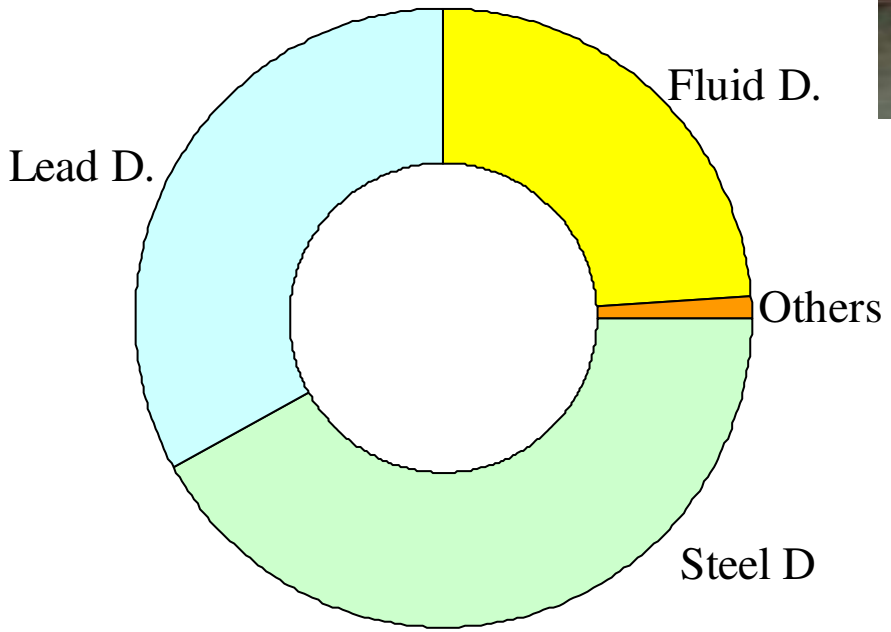
- Hysteresis Damper
  - Elasto-plastic damper
  - Friction damper

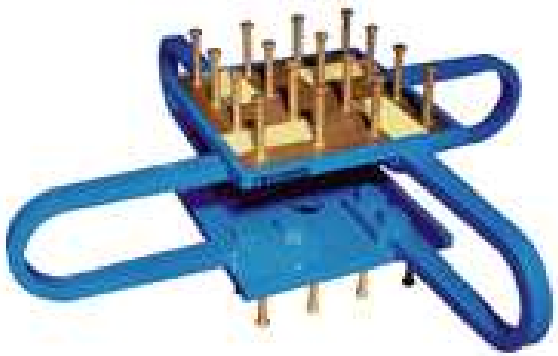


- Fluid Damper
  - Viscoelastic damper
  - Oil damper



Usage Ratio of Dampers



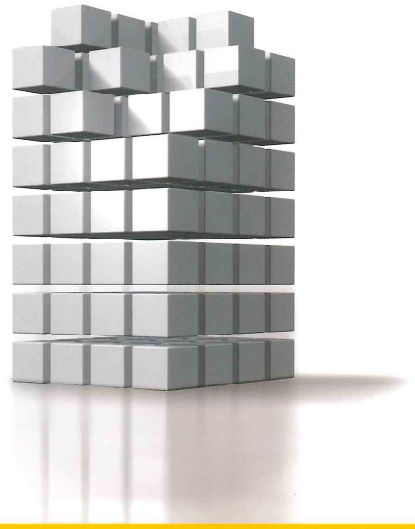


Steel: Steel Damper
Lead: Lead Damper
Fluid: Viscous Damper or Oil Damper

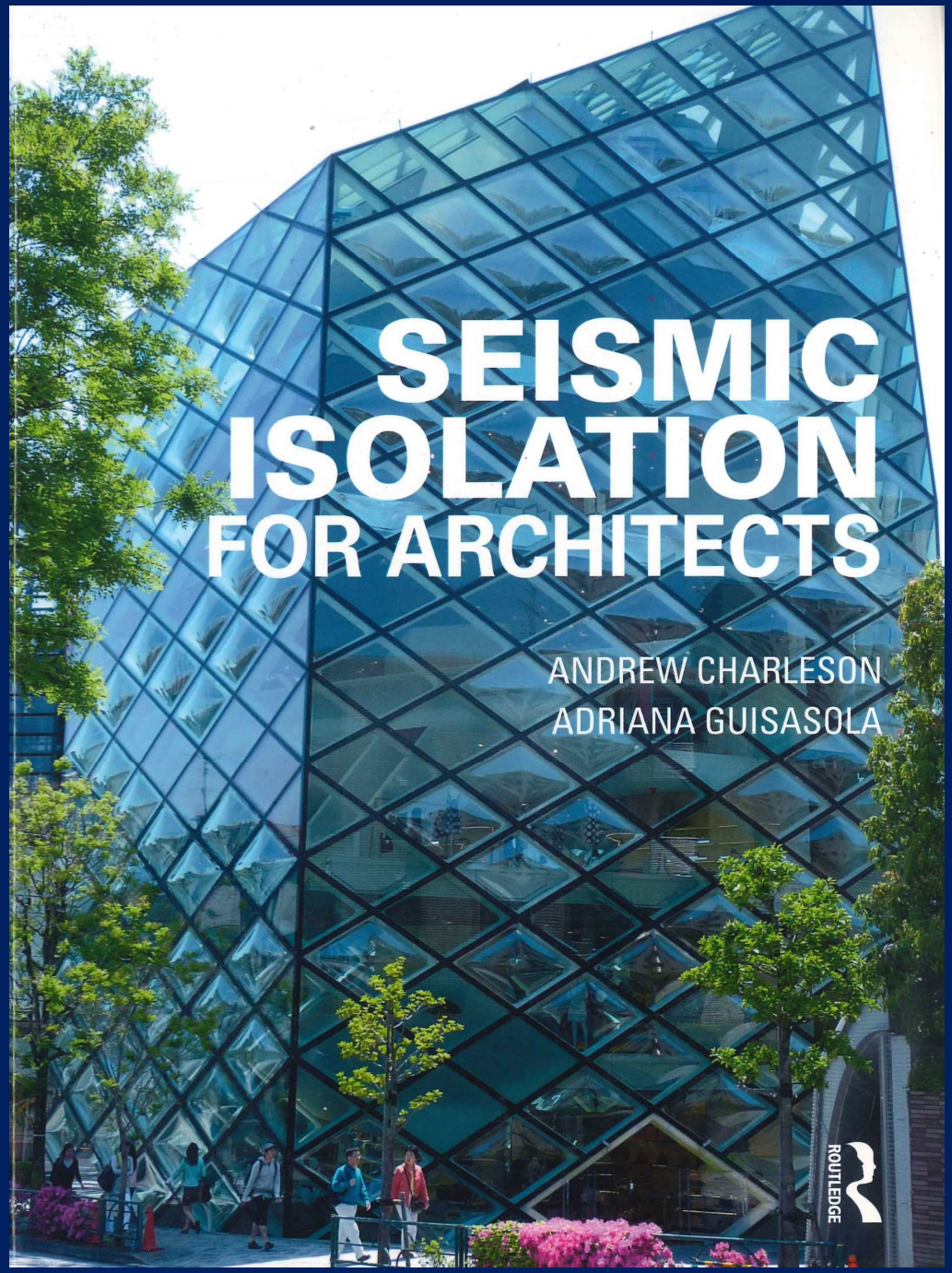
How to Plan and Implement

Seismic Isolation for Buildings

Edited by
The Japan Society of
Seismic Isolation



Ohmsha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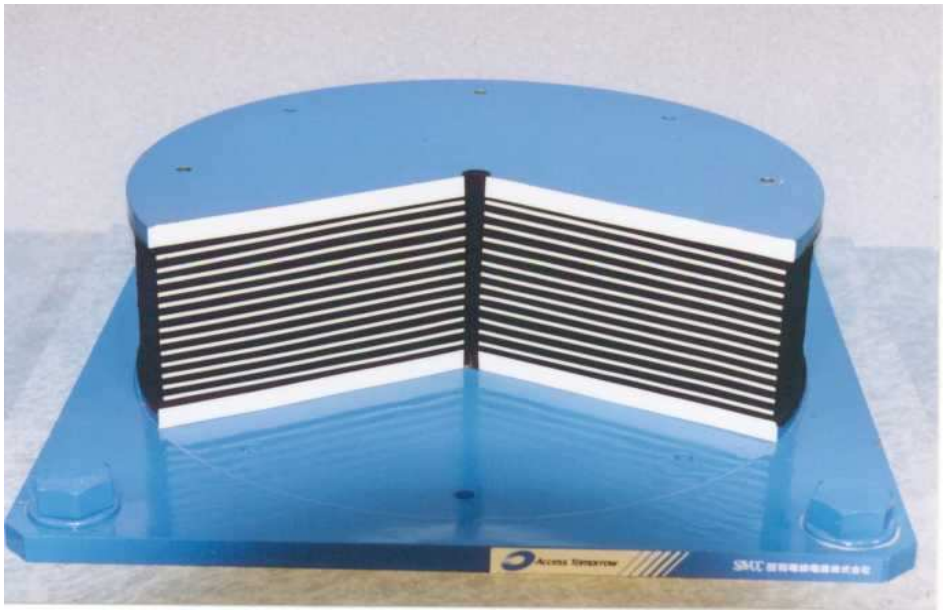
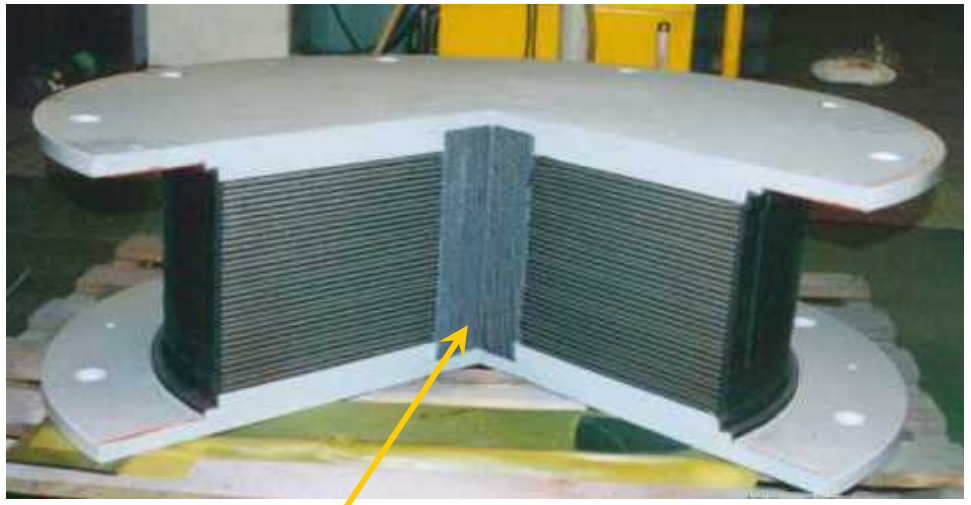
Performance of Isolators

Laminated Rubber Bearing

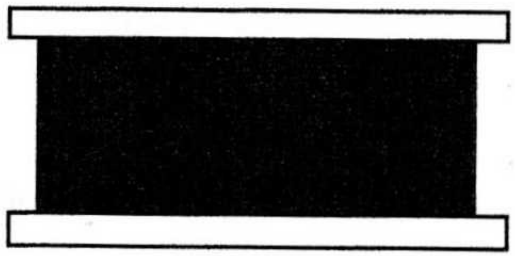


NRB
(Natural Rubber Bearing)
HDR is similar shape
(High Damping Rubber)

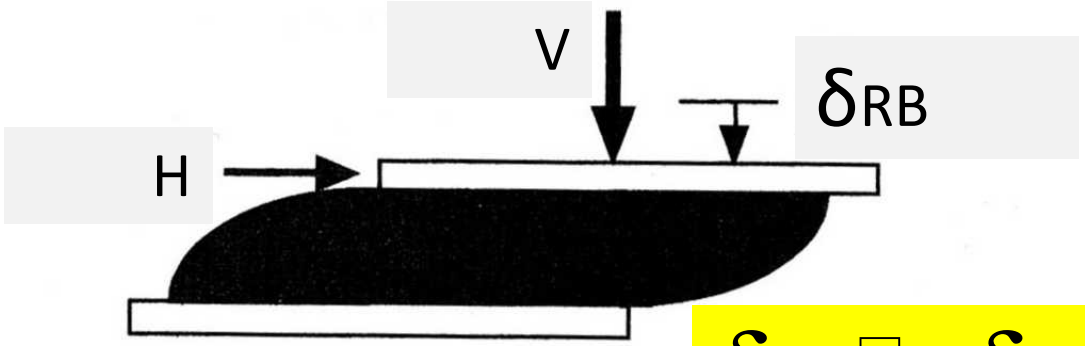


LRB
(Lead Rubber Bearing)

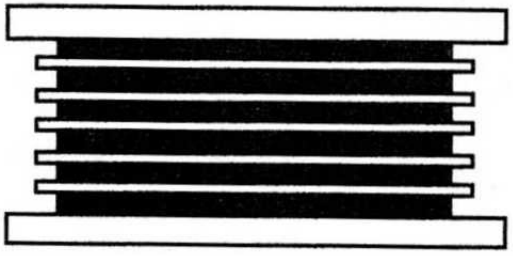
Principle of Laminated Rubber Bearing



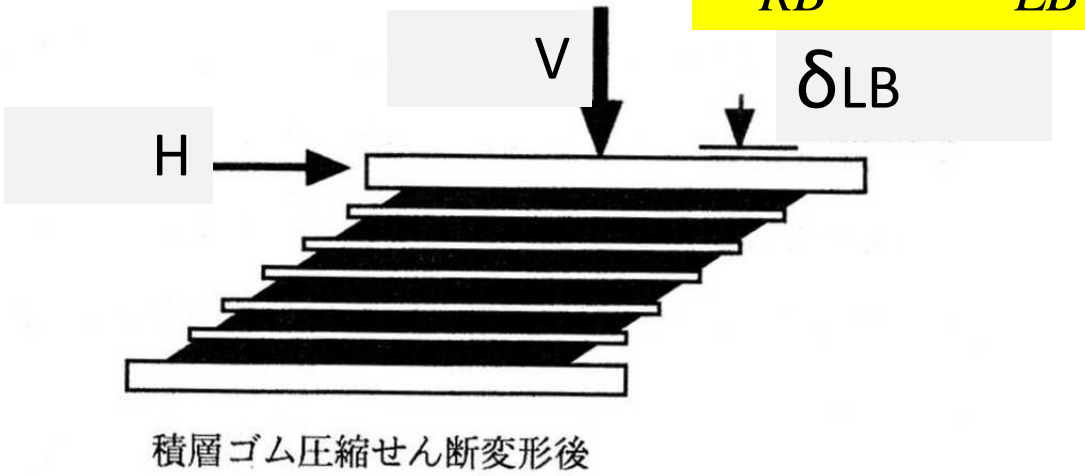
Rubber Block



$\delta_{RB} \square \delta_{LB}$



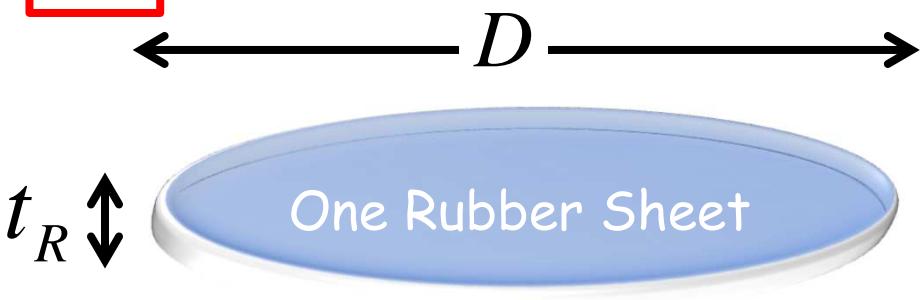
Laminated Rubber



under compressive shear deformation

Shape Factors of Laminated Rubber Bearing

S_1 : Primary Shape Factor



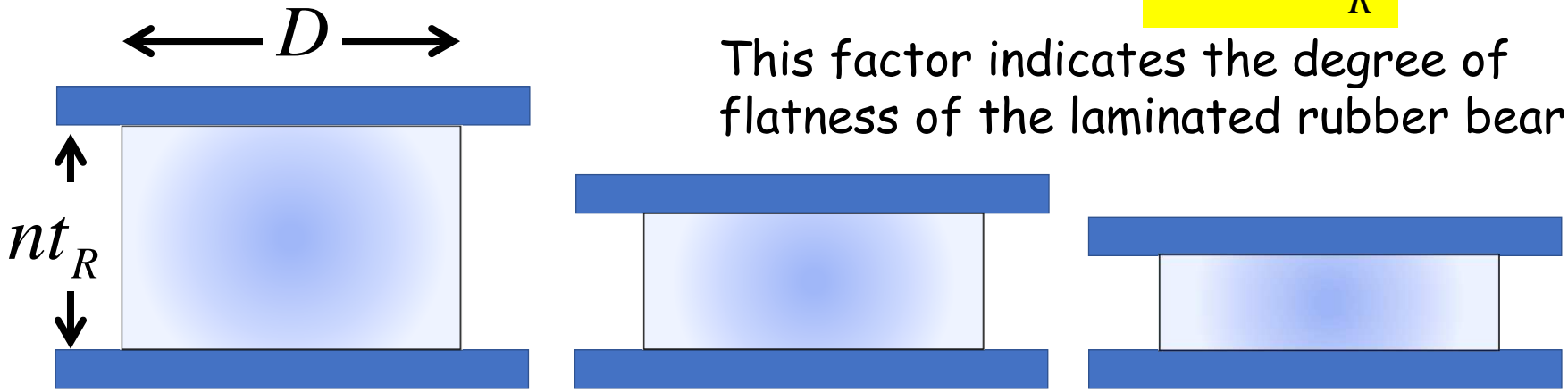
$$S_1 = \frac{\pi \cdot r^2}{2\pi \cdot r \cdot t_R} = \frac{D}{4t_R}$$

This factor increases as the rubber layer is thin.

S_2 : Secondary Shape Factor

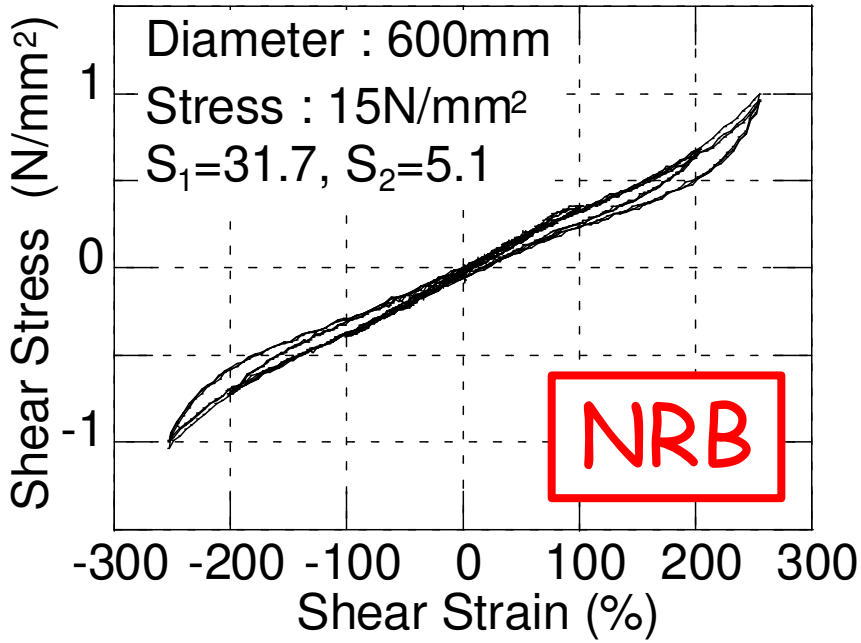
$$S_2 = \frac{D}{nt_R}$$

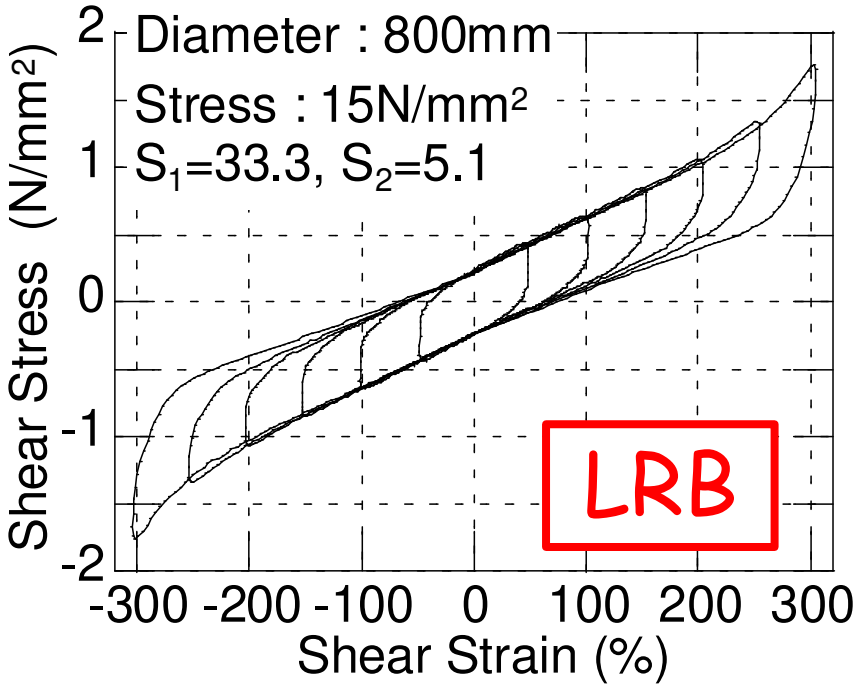
This factor indicates the degree of flatness of the laminated rubber bearing.

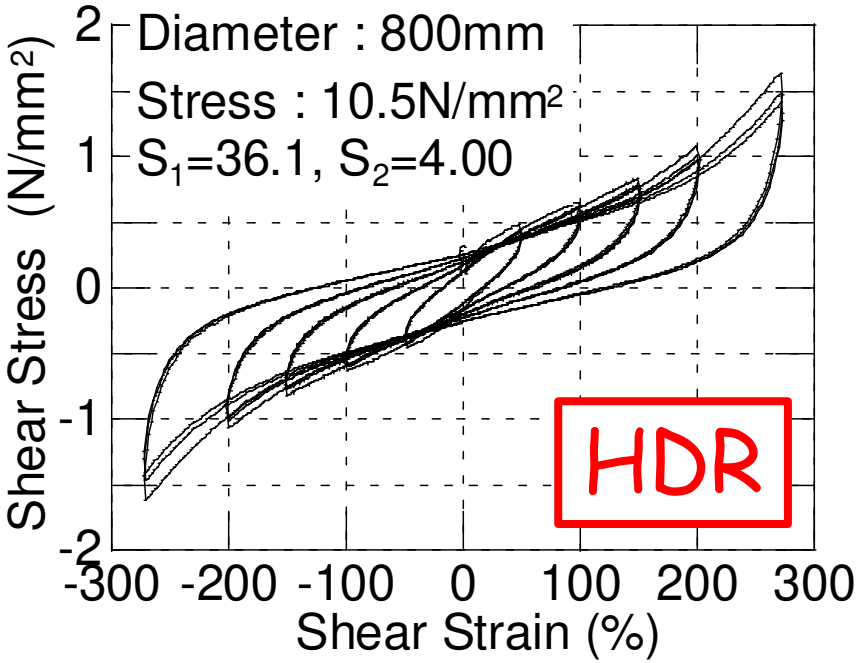


$S_2 = 3$ $S_2 = 5$ $S_2 = 7$

Restoring Force Characteristics of Rubber Bearings



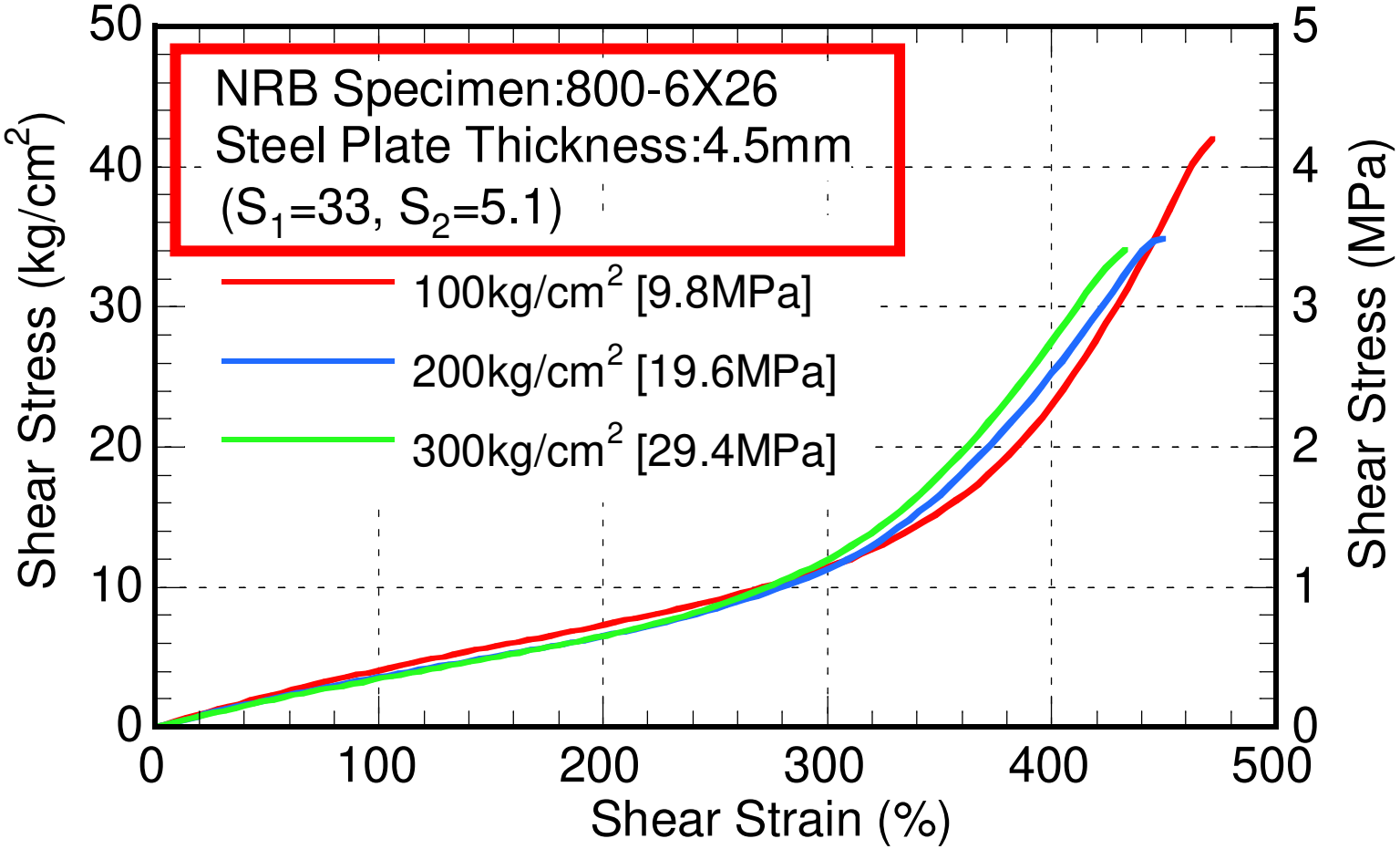




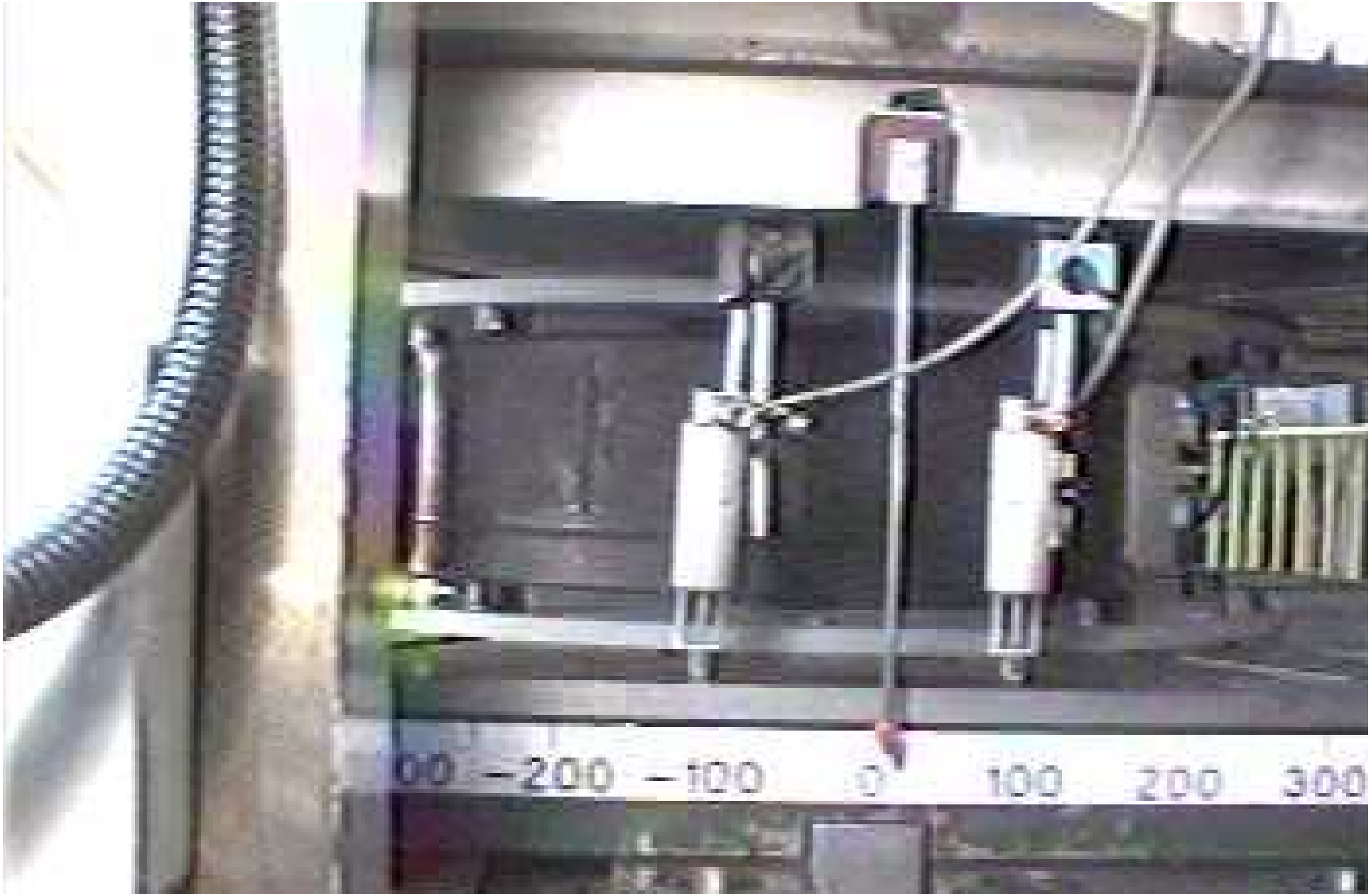
Compressive Shearing Tests

· To confirm the deformation capacity

· Horizontal characteristics was not affected by the compression load.

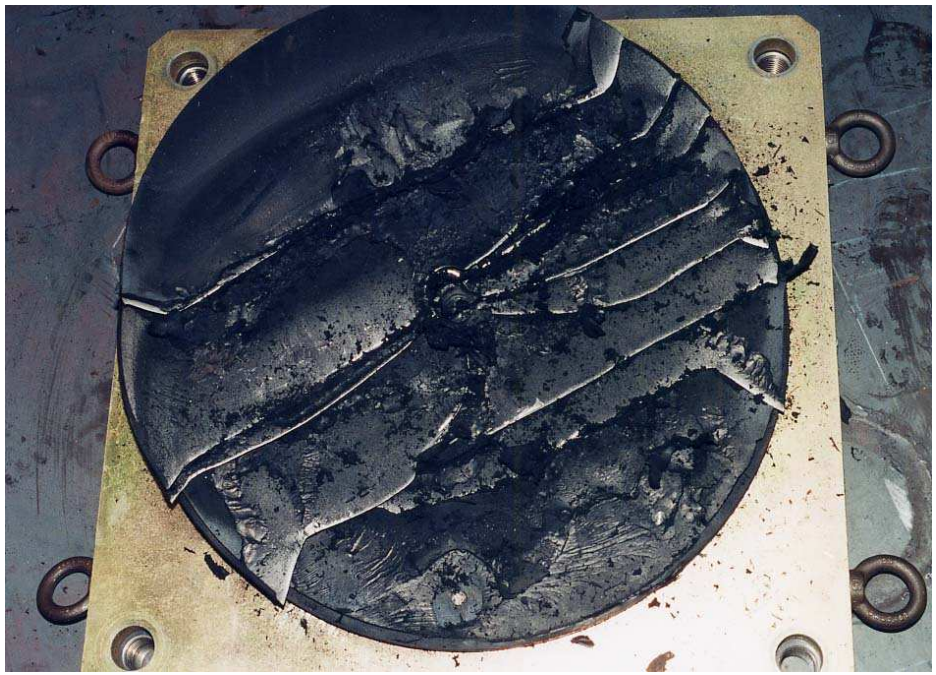


Shear Test under Compression Stress 10MPa

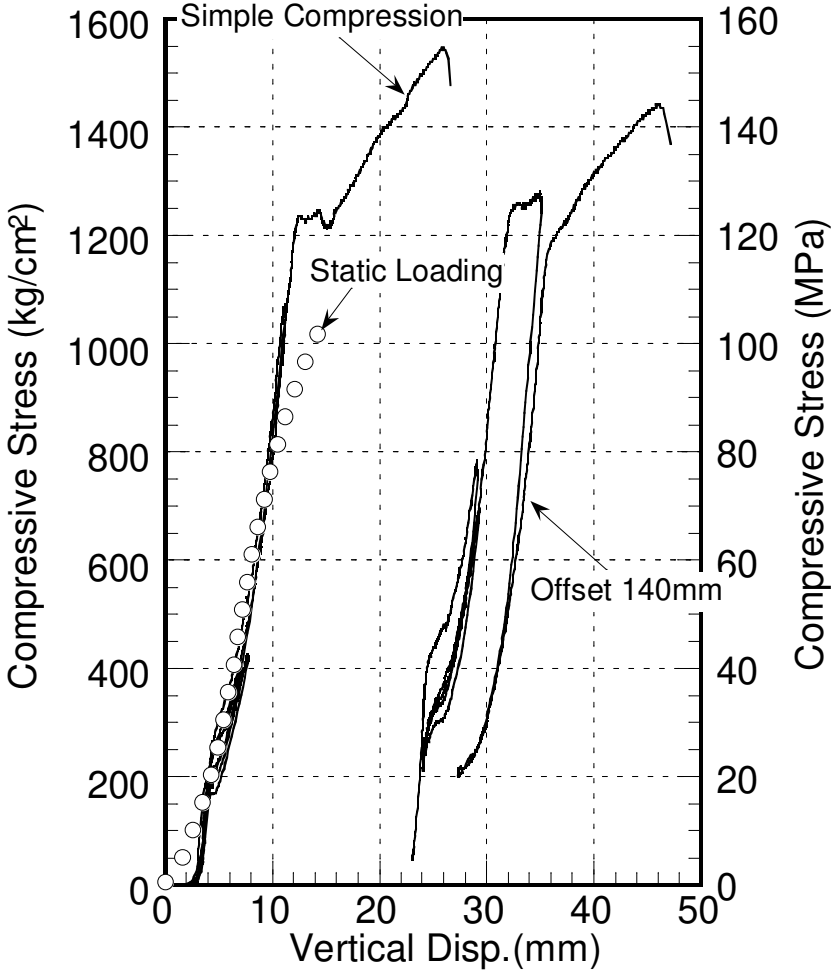


Ultimate Compressive Tests

- To confirm the ultimate compressive strength
- Max. strength depends on the thickness and the tensile strength of the steel shim.



Tensile Fracture of Steel Shim

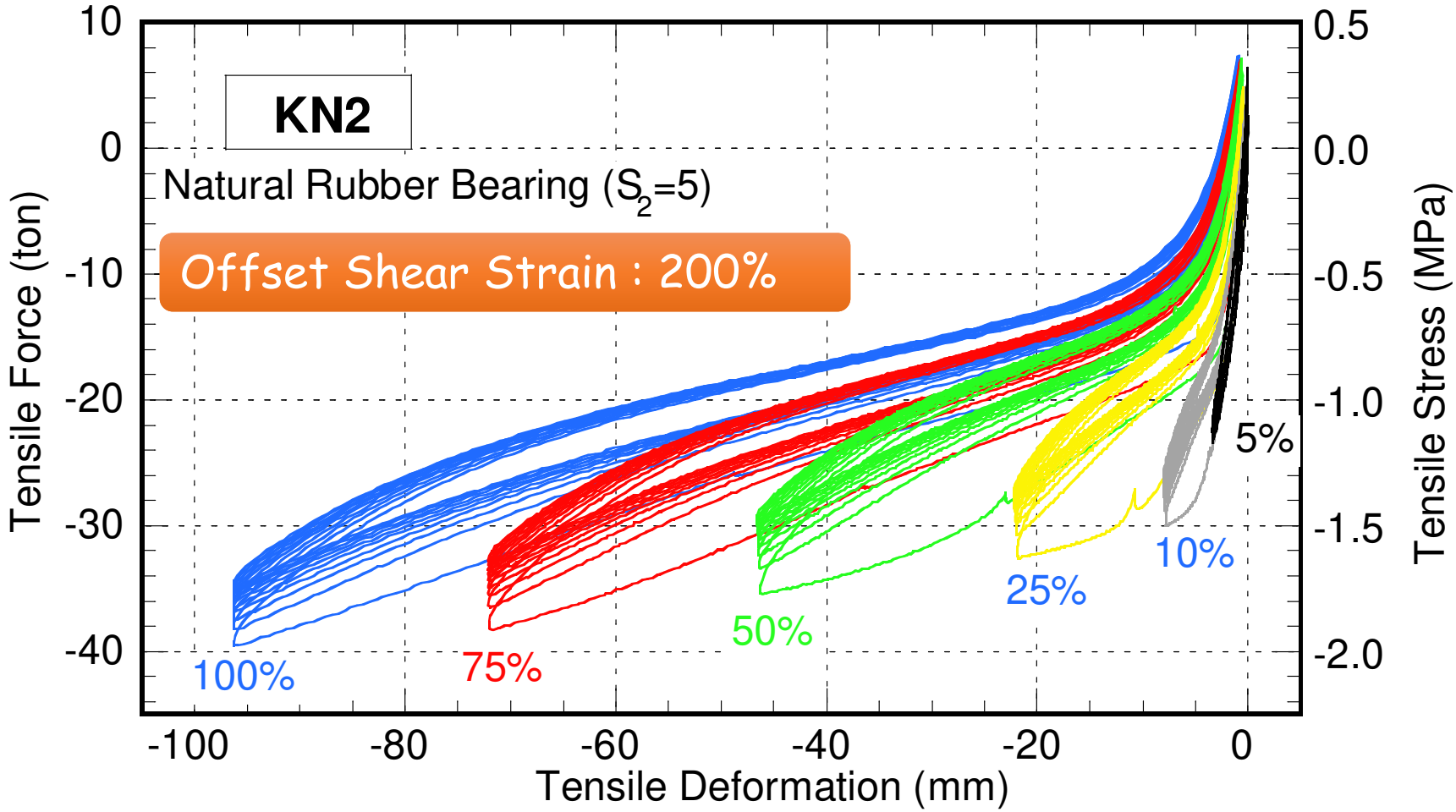


Ultimate Compressive Test

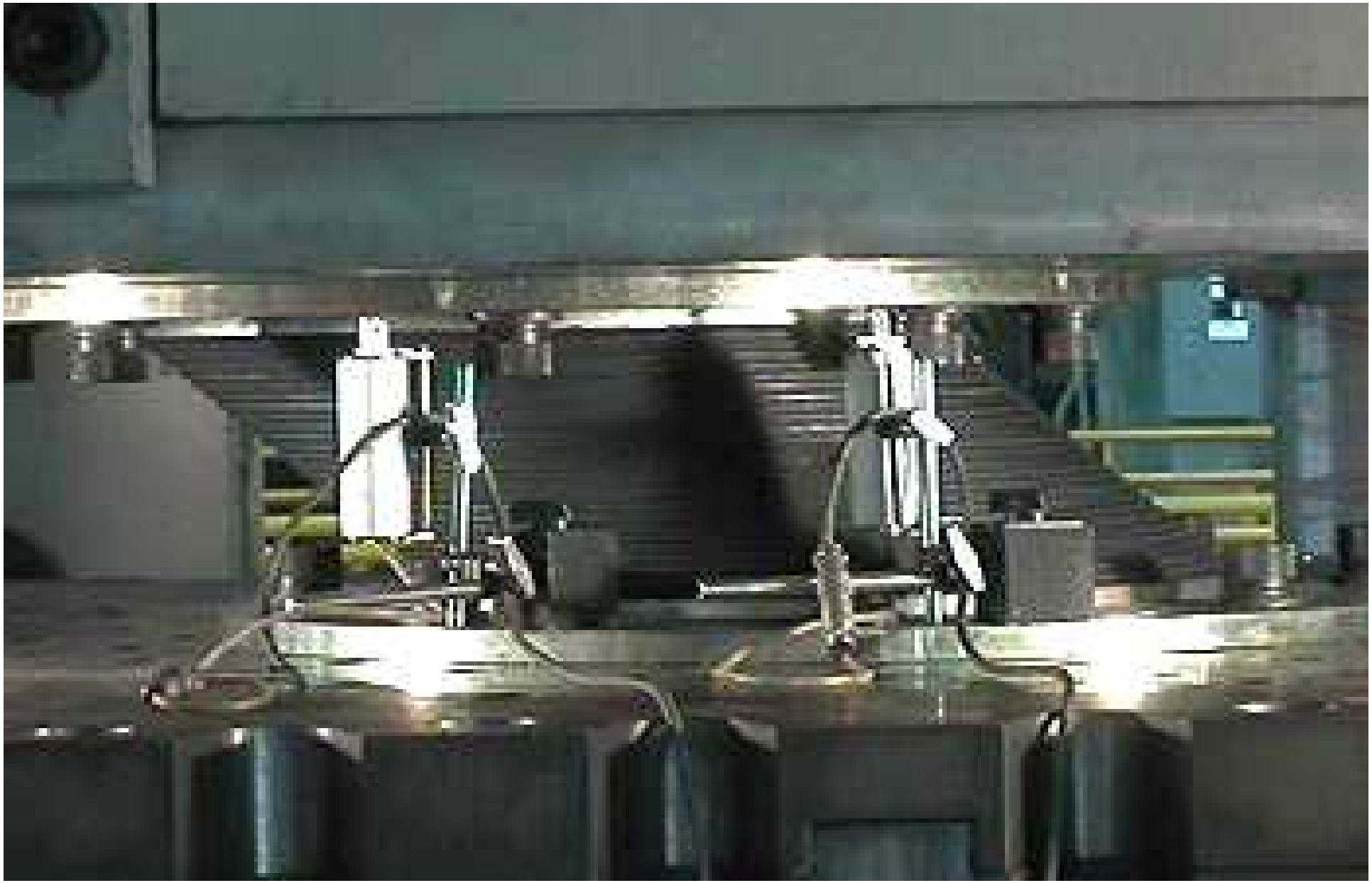
Tensile Tests

- To confirm the tensile deformation capacity
- Tensile strength is equivalent to $3G$

(G : shear modulus of rubber)

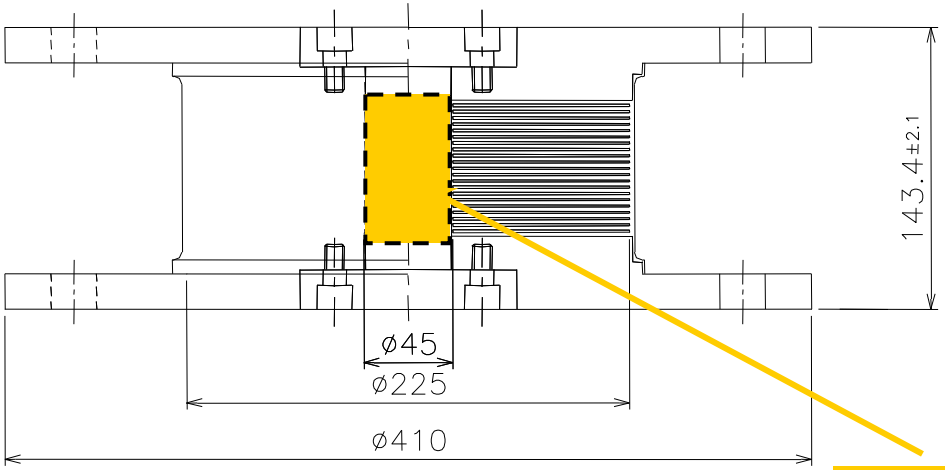


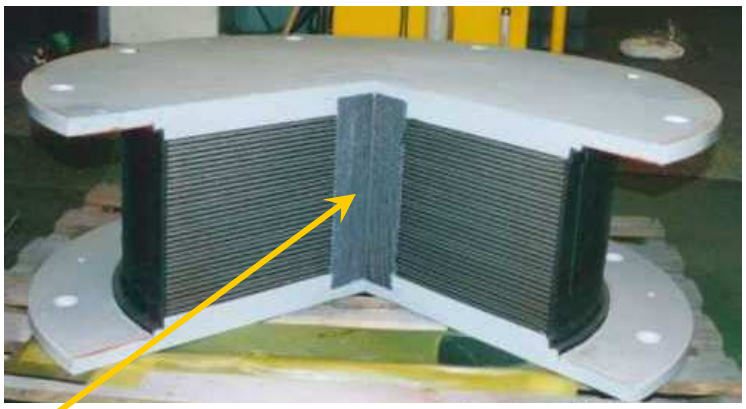
Tensile Test under Shear Strain 200%



Test Specimens of Isolator

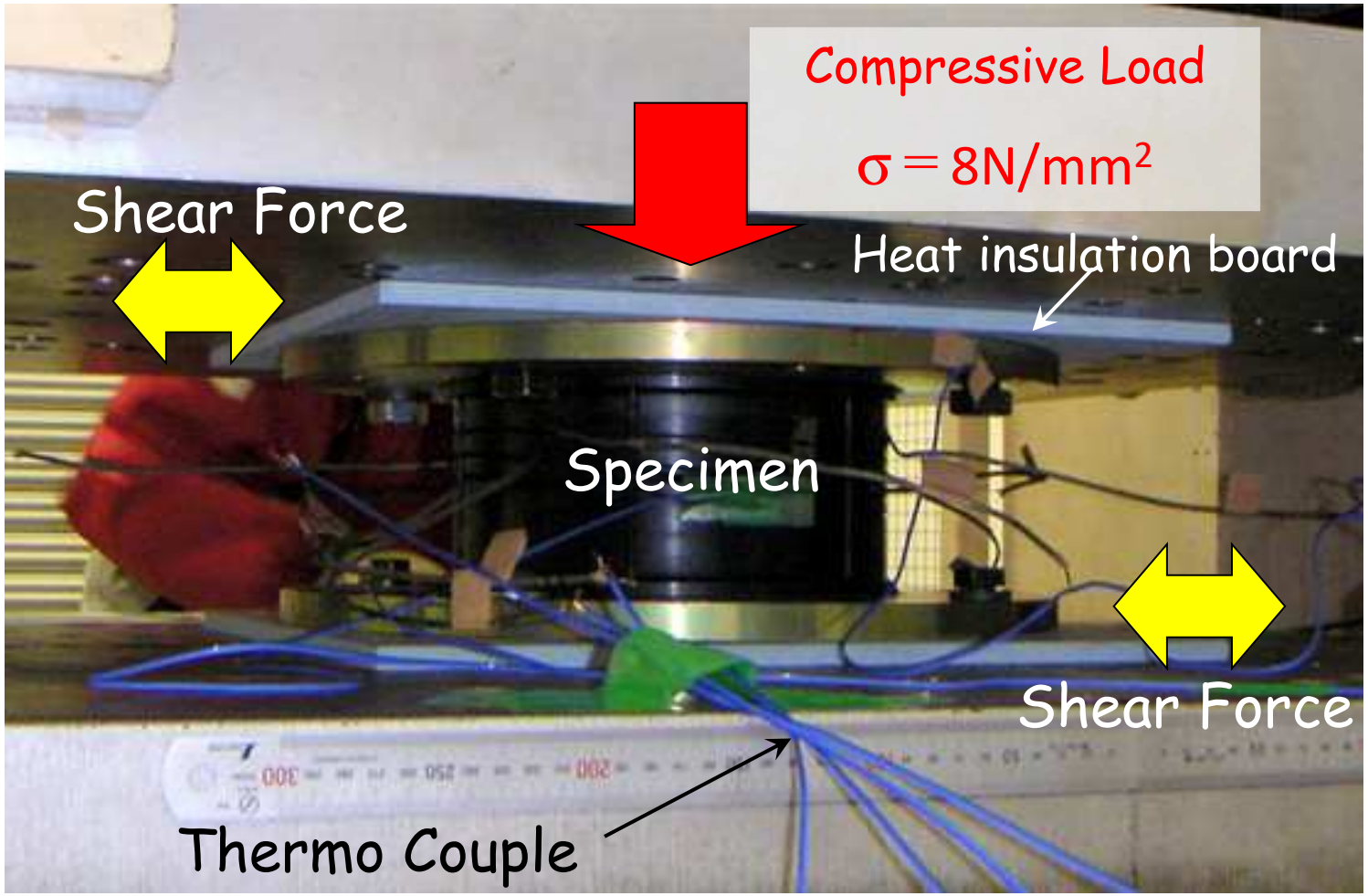
Specimen	LRB	HDR
Rubber Material	Natural Rubber (G=0.39N/mm^2)	High Damping Rubber (G=0.62N/mm^2)
Diameter	225mm	
Diameter of Lead Plug	45mm	—
Rubber Sheet	2.0mm×22 layers=44.0mm	
Steel Plate	1.2mm×21 layers	
Shape Factor	S_1=28.1, S_2=5.11	





Lead Core

Dynamic Test of Rubber Isolator



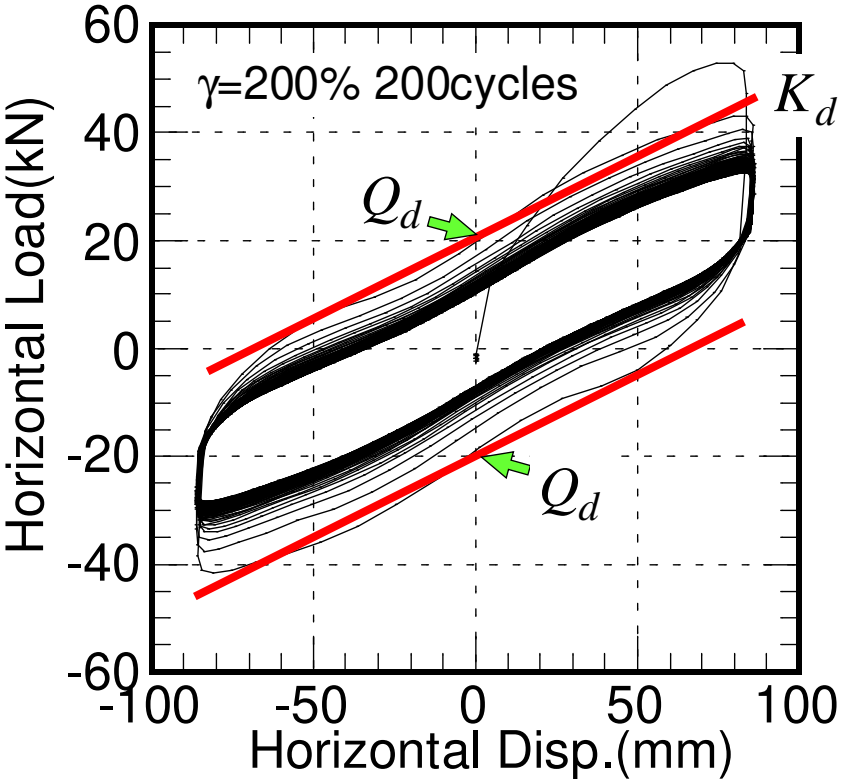
Shear Deformation : γ=200% (88mm) X 200cycles

Frequency : 0.33Hz (Total Deformation : 70m)

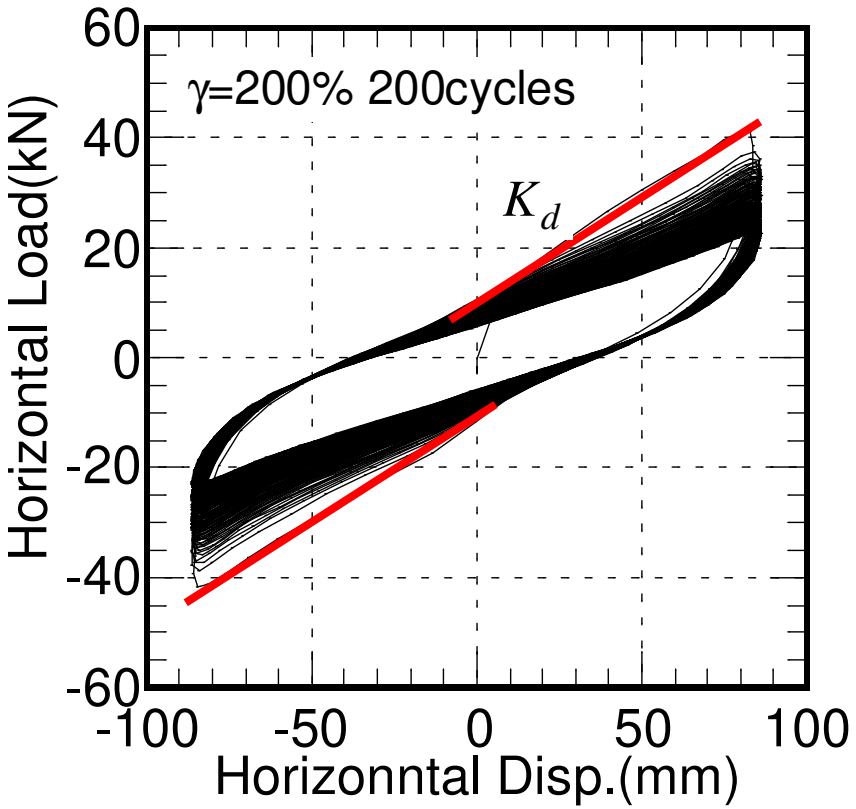
Restoring Force Characteristics by tests

(1)Yield load of LRB decreased, No change in Stiffness

(2) HDR's stiffness gradually decreased



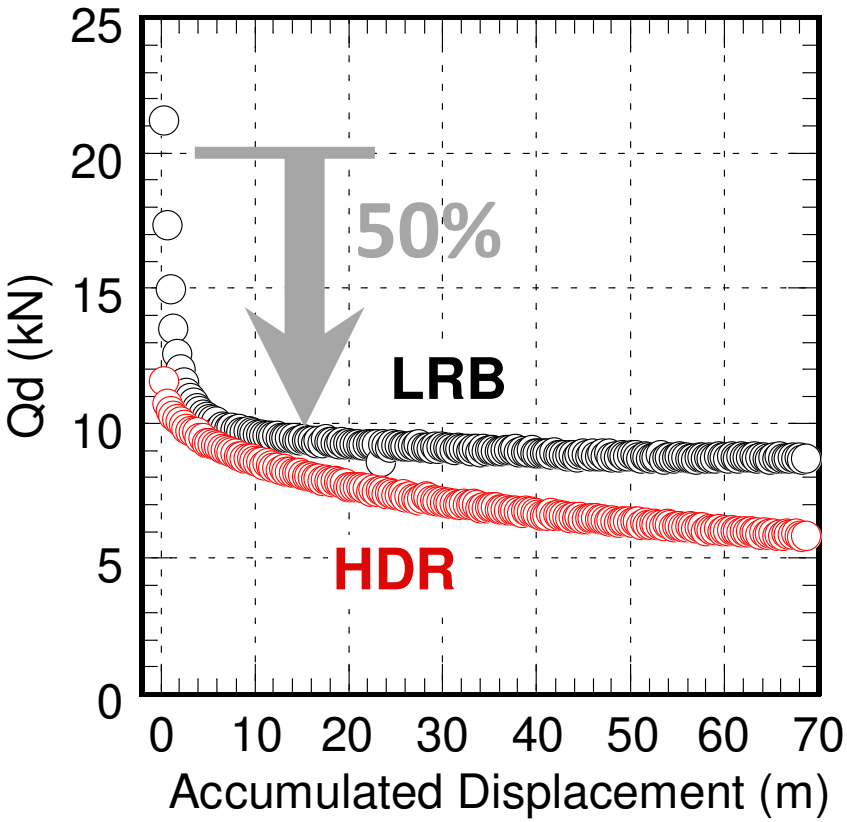
LRB



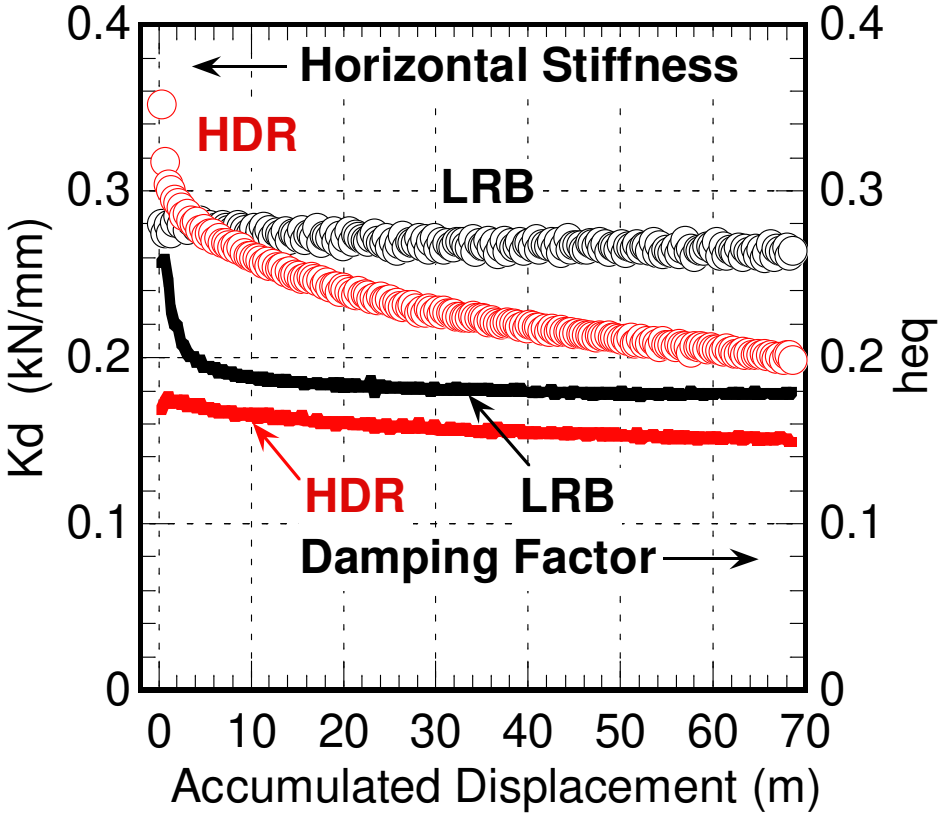
HDR

Yield Load and Horizontal Stiffness

Yield Load



Stiffness and Equivalent Damping Factor



Shearing Tests for Lead Rubber Bearing

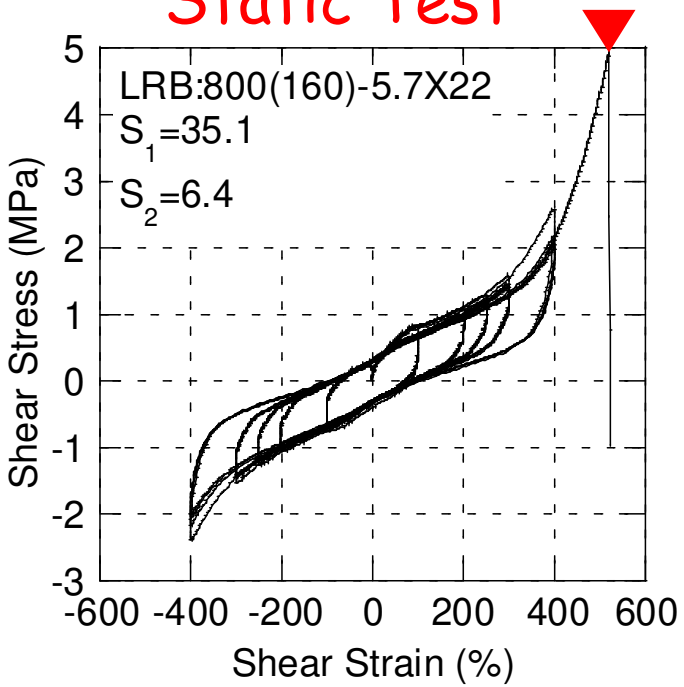
Compressive Stress
5MPa

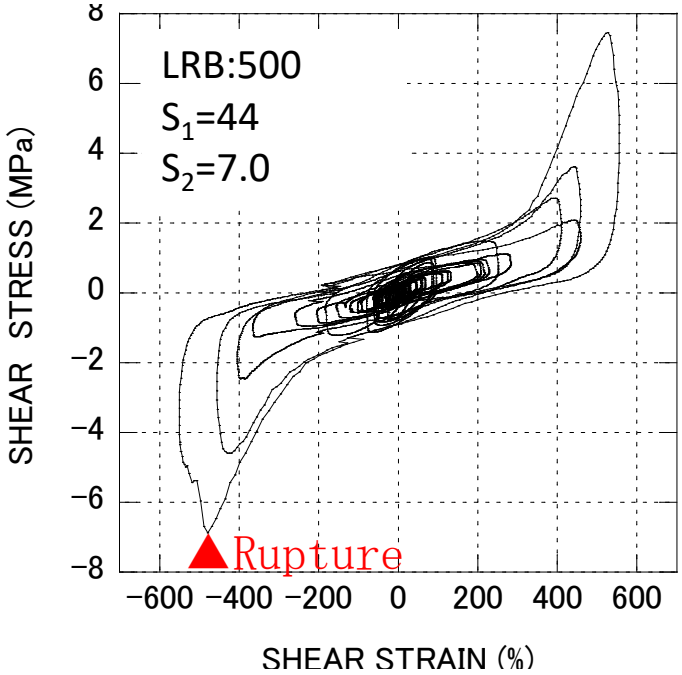
Dynamic Test by E-Defense

Lead Core

Ruptured

Static Test





Conclusions

Required Performance of Isolation Devices

- Bearing performance for vertical load
- Horizontal deformation performance
- Energy absorption performance
- Dependence of compressive load, velocity, displacement, temperature etc.
- Variation in stiffness etc.
- Durability
  (Manufacturer Warranty : 60years or more)

The design value should be within these respective allowable performance.

Conclusions

- It is important to know the performance of isolators and dampers
- When evaluating performance, it is necessary to consider ageing
- It is important for us to know them correctly and inform them properly

An extra topic

3D seismic isolation system

Chisui-kan (Tokyo)

3-D Isolation

Natural Period (sec) :

X : 2.98

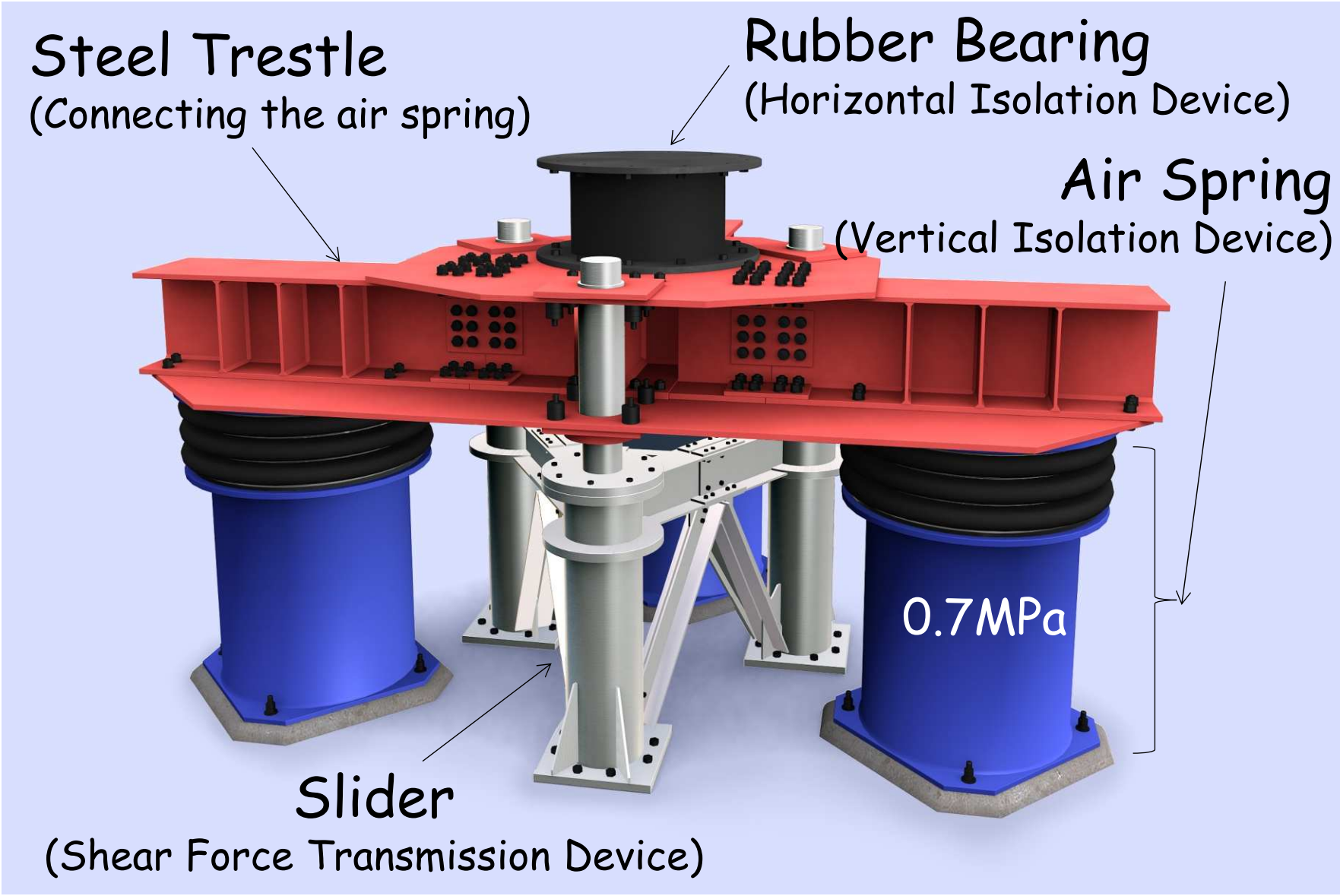
Y : 2.95

Up and down : 1.28

Apartment Building
RC / 3 Stories
Isolation System:

NRB + Oil Damper for Horizontal
Air Spring for Vertical
Rocking Restraint System

3-D Seismic Isolation Device



Isolation Layer