Numerical Simulation on Damping Characteristics of Lead Devices

Background

Application of lead damper and rubber bearing with a lead plug to seismic isolation and vibration control systems for electric power plants has been investigated. Until now, examinations for mechanical properties of lead under cyclic large deformation have been insufficient. Loading tests of prototypes were required to propose a new shape of lead damper and isolation rubber bearing with a lead plug. Evaluation of mechanical characteristics of lead and development of numerical simulation based on it were efficient to predict the mechanical properties and damping characteristics of lead devices.

Objectives

To develop a numerical model of lead based on material testing and a numerical simulation method to evaluate damping characteristics of lead devises.

Principal Results

1. Proposition of a numerical model for cyclic loading of lead and numerical simulation of lead devices

A numerical model was proposed using results of shear cyclic loading tests and uniaxial tensile loading test to predict the mechanical characteristics of lead from small strain to large cyclic deformation. The proposed material model was implemented into a finite element program, and it was applied to numerical simulation of mechanical properties of lead dampers and rubber bearings with a lead plug. The numerical simulations and the corresponding loading tests showed good agreement.

2. Proposition of a numerical model considering strain rate and temperature dependency

Strain rate and temperature dependency on mechanical characteristics of lead were investigated from uniaxial tensile loading tests conducted under various strain rates and temperatures. An elastoplastic constitutive equation was proposed with a hardening function including strain rates and temperatures. To introduce the proposed constitutive equation to numerical simulation, a finite element analysis method was formulated. Uniaxial loading tests for lead were simulated numerically and our proposed method showed good agreement with tensile loading tests.

Future Developments

Developed numerical model and finite element analysis method will be applied to evaluation of mechanical characteristics of lead devices under dynamic motion.

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References

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A. Matsuda, et al, 2004, “Thermodynamic finite element analysis for lead material used in seismic isolation and vibration control devices”, Technical Report N04040 (in Japanese)

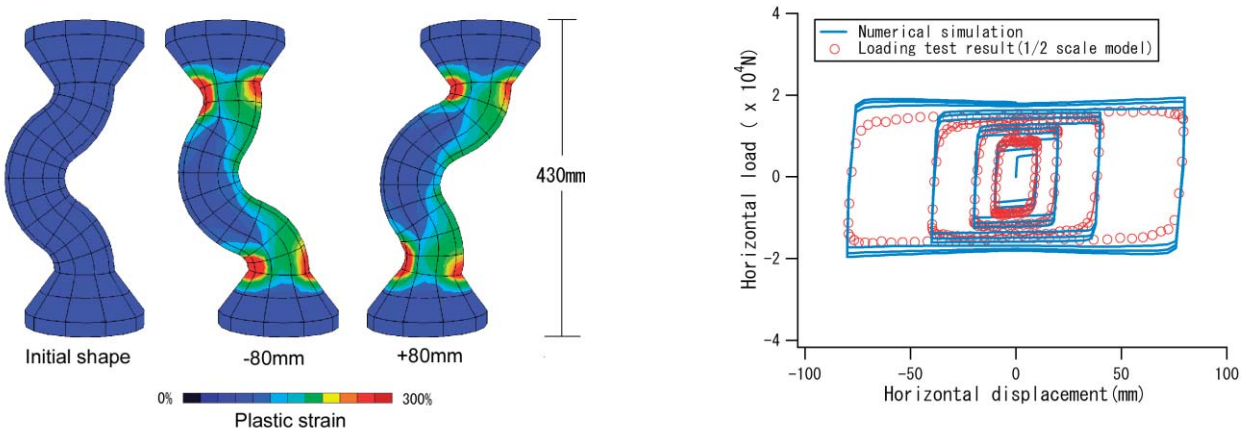

Fig.1 Results of numerical simulation and loading test of lead damper for seismic isolation

Numerical simulation based on the proposed numerical model of lead is possible to predict mechanical behavior of lead damper under cyclic large strain.

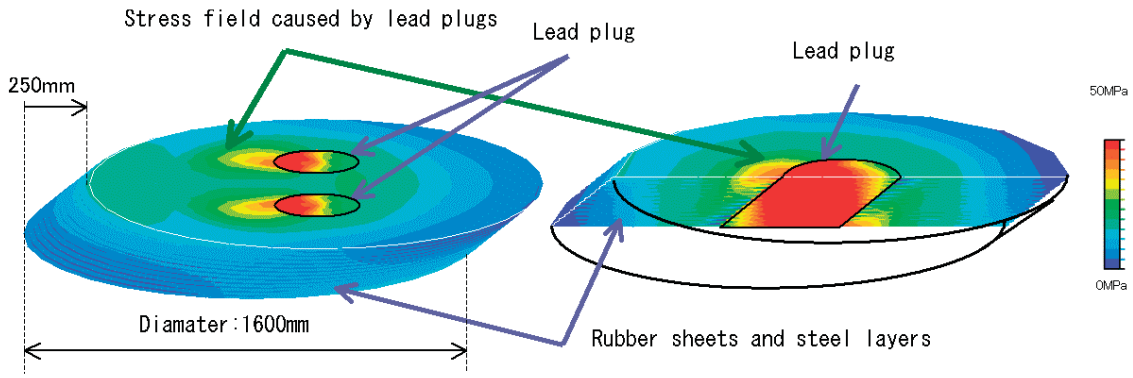

Fig.2 Stress configuration of rubber bearing with lead plug

Numerical simulation method for isolated rubber bearing with lead plugs was developed. It is possible to evaluate the inner stress and deformation of rubber bearings.

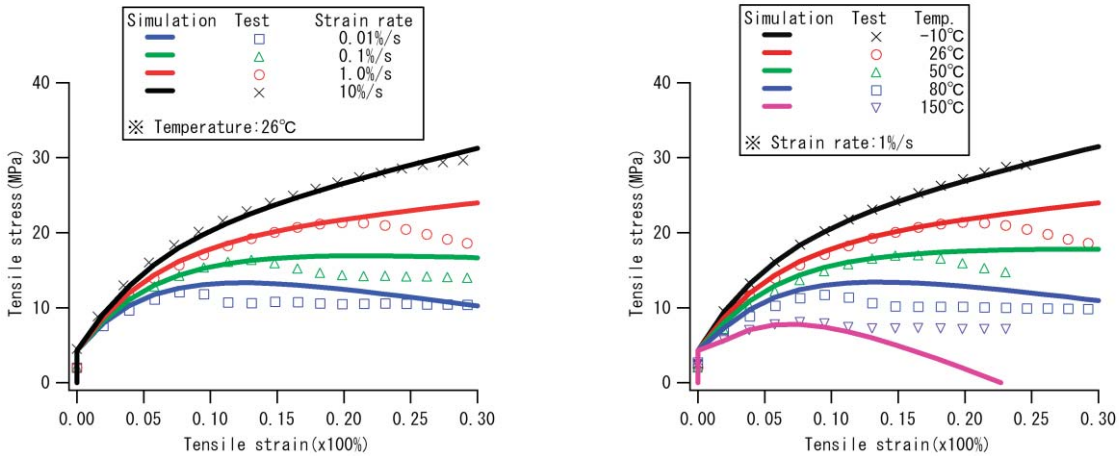

Fig.3 Numerical model of lead considering strain rate and temperature dependency

Strain rate and temperature dependency of lead were investigated by uniaxial tensile test. A numerical model of lead was modified and a thermodynamic simulation method for the numerical model was formulated. Numerical simulation results using the proposed method show good agreement with loading test results.