Basic Technology Subjects

Civil Engineering Research Laboratory

Brief Overview

The Civil Engineering Research Laboratory extensively promotes studies regarding geology and geotechnical engineering, earthquake engineering, structural engineering, and fluid dynamics, which are essential for maintenance work and natural disaster mitigation at electric power civil engineering facilities, as well as for backend management in nuclear fuel cycle.

Achievements by Research Theme

Geosphere Science

To solve issues associated with the siting and construction of electric power facilities and with maintenance and asset management for aging facilities, we quantify the evaluation methods for earthquake faults, the estimation methods for the explosive magnitude of volcanic eruptions, the assessment methods for the stability of underground facilities, and the methodology for groundwater solute transport modeling.

- Based on a worldwide compilation of the magmatic properties of erupted magma, we showed an evidence-based estimation of the upper-limit viscosity of eruptible magma, which can contribute to the hazard assessment of large-scale pyroclastic eruptions (N11020).
- Many unexpected earthquakes with normal faulting were triggered in the southern Abukuma region by the 2011 Great East Japan Earthquake (Mw9.0). We analyzed the subsurface geometry of the ruptured faults and the P-wave velocity structure around the source area by a campaign aftershock observation (Fig. 1). Their spatial relations with the geological structure, active faults, and stress field were also estimated to recognize the common properties of such triggered earthquakes (N11048).

Earthquake Engineering

We aim to develop strong-motion evaluation and seismic-resistant and seismic isolation design technology for the seismic assessment of electric power plants and equipment, as well as to lay a foundation for disaster risk assessment technology regarding the strategic maintenance management plans for the electricity industry.

- A fast algorithm was developed for analyzing ambient vibration records in health monitoring for large structures. Its main advantage is to stably obtain accurate results with a quarter length of data, compared with conventional algorithms. To illustrate the effectiveness of the developed scheme, we applied it to an actual-size experimental structure and validated the identified characteristic mode (N11039).
- The source rupture process of the 2011 Great East Japan Earthquake was inferred from strong-motion data by using a waveform inversion technique. The results showed the complex rupture process to interpret two distinctive strong-motion packets at a time interval of about 50 seconds observed on the acceleration records in and around Miyagi Prefecture (N11058).

Structural Engineering

To secure the safety and reliability of steel and concrete structures and to extend the lifespan of such structures, we develop structural performance evaluation methods considering natural hazard actions such as earthquakes, wind, heavy snow, and others, along with aged deterioration caused by environmental actions such as chloride-induced deterioration, frost damage, and temperature changes.

- For underground reinforced concrete structures, we developed methods that estimate the maximum deformation response of members during earthquakes by using the width of residual flexural cracks and the corrosion progress of reinforcing steel. In addition, we clarified the durability performance recovery effects by looking at epoxy resin repairs for cracked members. These results can be applied to the soundness evaluation of the underground reinforced concrete structures of thermal and nuclear power plants that experience earthquakes. (This is part of a cooperative contract study by Japanese electric power companies.) (N11005) (N11006) (N11010) (N11013) (N11045)
- We have launched a field observation system on an ultra-high-voltage steel transmission tower with 142 m in height to investigate responses under natural environments, and we clarified the redundant member vibration caused by Karman vortex excitation, which develops under the limited low-wind velocity of around 4 to 5 m/s.

Achievements by Research Theme

Fluid Dynamics

We aim to evaluate the impacts of natural disasters such as strong winds, heavy snow, tsunamis, and volcanic eruptions on electric power facilities, as well as to establish mitigation measures. We also strive for flow-related technologies applicable to hydraulic, solar, and wind power generation.

- We have developed a numerical model for snow accretion on overhead transmission lines subject to wind and snow from an arbitrary direction and implemented it as a simulation code, named SNOVAL. This tool can be used to help more accurately predict galloping phenomena and heavy snow accretion, as well as to develop more appropriate countermeasures against the malfunction of transmission lines caused by these snow disasters (N11016).
- Using computational fluid dynamics technology, we have estimated the influence of building arrays on the alteration of wind profiles in urban areas. The results have quantitatively indicated the degree of wind velocity reduction and its spatial extent. This data can be used to determine a reasonable reference wind velocity in designing distribution facilities for electricity in urban areas (N11052).

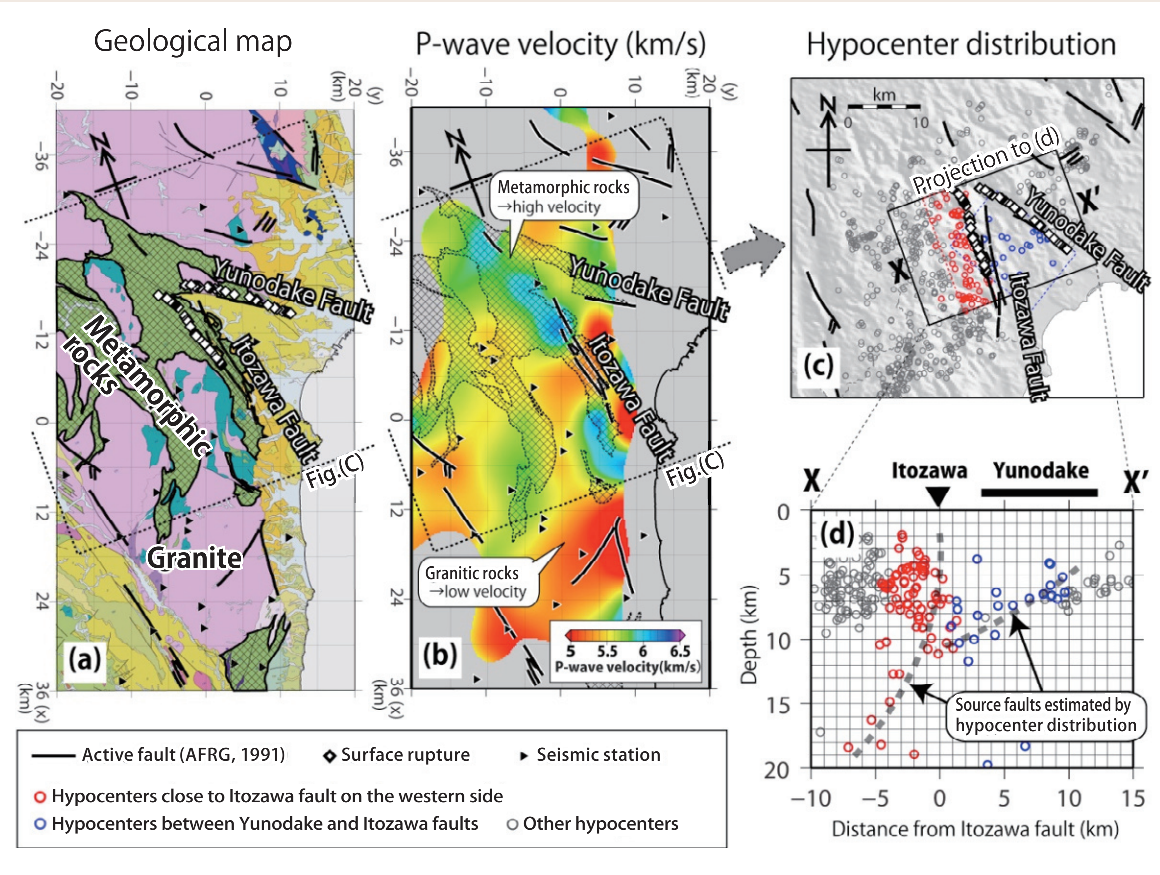

Fig. 1: Geological properties in the southern Abukuma region as estimated by a campaign aftershock observation

(a) Geological map (b) P-wave velocity on the surface (c) epicenter distribution (d) depth section of the hypocenter distribution; high and low P-wave velocity anomalies correspond well with the surface distribution of metamorphic rocks and granitic rocks, respectively. Since the hypocenters are located mainly in a relatively low velocity zone, the occurrence of the triggered earthquakes may be controlled by the geological structure. The hypocenter distribution indicates that the deeper parts of the Itozawa and Yunodake faults, which were ruptured by the largest triggered earthquake (M7.0), can become convergent.