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 back-end management in nuclear fuel cycle and underground energy utilization technologies.

Achievements by Research Theme

Geosphere Science

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

■To develop a new method for evaluation of fault activity relating to those faults without sedimentary covers, we examined the spatial distribution of various types of microfractures within the damage zone surrounding a Quaternary-active fault which is located east of the epicenter of the 1943 Tottori earthquake, and compared them with previously reported results for a Quaternary-inactive fault. We showed that the Quaternary-active fault has a damage zone characterized by a fracture density that decays exponentially with distance from the fault for open microfractures that represent an opening between opposing fracture walls and lack cementation. Here, we developed a new approach in which we examine the history of fault activity based on whether or not open microfracture density increases with proximity to the fault.

■To characterize upward movement phenomenon of carbon dioxide (CO_2) for geologic storage of CO_2, a conceptual diagram of upward gas migration in shallow ground and a hydrogeological structure model coupled two phase flow model of groundwater and gas were constructed using results of surveys and tests performed at natural gas emission parts along the fault and its fractured zone. A numerical simulation of the natural gas upward movement in the ground was conducted by using the abovementioned models and results showed that consideration of capillary pressure, initial saturation of underground gas, fault fracture zone, and trap structure caused by fault displacement could reproduce the behavior of the upward movement.

Earthquake Engineering

We aim to establish proper countermeasures to control risks associated with natural disasters, mainly earthquakes, for electric power facilities and equipment. We also develop low-cost solutions for the maintenance of electric power facilities.

■We conducted a geophysical exploration at K-NET Minatomachi station (HKD020) where a large acceleration record was obtained during the 2004 Rumoi earthquake (M6.1). The results of this exploration showed that the depth of the basement rock, which is corresponding to the base stratum where the standard seismic motion is formulated for the design of nuclear power plants, is deeper than that derived from previous investigations. We also estimated the basement earthquake motion using the new subsurface model and dynamic property of soils (Fig. 1). (N13007) This result was utilized as a reference of the “seismic motion formulated without a hypocenter” in the Review Meeting on Conformity to the New Regulatory Requirements for Nuclear Power Plants by Nuclear Regulation Authority, Japan.

■We developed a high-precision borehole inclinometer using FBG optical sensors to investigate the mechanisms of slope behavior around dam reservoirs and foundations of transmission towers. The new inclinometer detected a very slow slope-movement of a few mm a year, which cannot be detected by the conventional methods. It was revealed through a detailed investigation by boring that the concentrated displacement in the ground detected by the device corresponded to the preliminary step toward a primary slip of the slope. (N13006)

Structural Engineering

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

■We established “Seismic Analysis and Performance Evaluation Manuals” for concrete gravity dams and spillway gates, and described a framework of seismic performance evaluation using Finite Element Method Analysis, characteristics of evaluation, analysis models and examples. These manuals are practical

guidebooks covered with various techniques for performance evaluation, equivalent to "Guideline for the Seismic Performance Evaluation of Dams against Large Earthquakes (draft)" published in March 2005 by the Ministry of Land, Infrastructure and Transport, and are expected to be used in soundness evaluation of large-scale earthquakes. (N21) (N22)

■We developed an estimation method of chloride ion effective diffusion coefficient in concrete using volume resistivity which is an important physical property in order to assess the chloride induced deterioration of reinforced concrete structures. Volume resistivity is easily measurable for in-situ, thus this method is expected to be utilized for an efficient implementation of the inspections and investigations of reinforced concrete structures located in seaside areas, such as thermal power plants. (N13002)

Fluid Dynamics

In order to evaluate the impact of volcanic eruption and fires on the safety of nuclear power plants and also to improve construction, operation, maintenance, and natural disaster mitigation technologies for hydro, solar and wind power plants, we strive to develop basic evaluation technologies of hydraulic and atmospheric fluid flows relevant to such facilities.

■In order to find a rational design basis for wind force acting on electricity distribution facilities, wind tunnel experiments were conducted for a scaled-model of airy residential area where 2-story houses are regularly arranged with 25% plane area density. The results clarified the extent of location where wind force is at least halved and C-class wind load is applicable. The scientific data will be utilized to evaluate applicability of C-class wind load to actual distribution facilities. (V13016)

■Numerical simulations were conducted for wind around photovoltaic (PV) panels arranged in array to identify panel location where wind force on each panel decreases by more than 50% in comparison with that of single PV panel. The results can be used to design panel support structures based on a reasonable wind force condition, leading to reduction of the construction expenditures. (N13012)

Underground Energy Utilization Technologies

We aim to develop exploration and evaluation technologies for utilizing underground space and developing underground energy such as CO_2 geological storage, large scale electric power storage and geothermal power generation.

■To support electric power utilities to address future introduction of regulations about applying CCS to coal-fired power plants in Japan, we investigated trends in technical developments and policies related to CCS in countries around the world. In Europe, collaboration between enterprises with large CO_2 emissions is progressing, while progress of CCS deployment is falling short of governmental expectations due to economic recession. On the other hand, under the U.S. governmental visions related to retaining energy security by developing energy sources in the country, CO_2 captured from CCS-equipped plants is being utilized to EOR (Enhanced Oil Recovery).

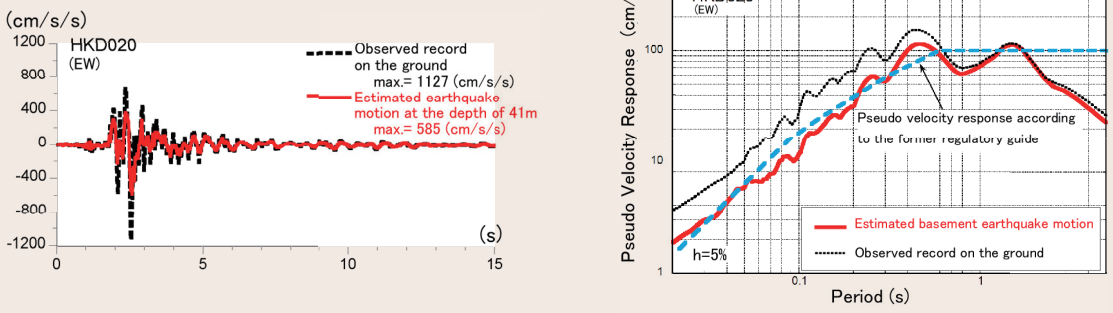

Fig. 1: Comparisons of the observed record during the 2004 Rumoi earthquake and the estimated basement earthquake motion

An earthquake ground motion with a peak ground acceleration of 1127 cm/s/s was recorded at K-NET Minatomachi station (HKD020). The results of geophysical exploration showed that the depth of the basement rock top was GL-41m, which is deeper than the depth derived from previous investigations. We estimated the peak acceleration of the basement earthquake motion to be 585 cm/s/s through equivalent linear analysis considering the non-linear soil response of the surface layer with a thickness of 6 m (left). It is revealed that the pseudo velocity spectrum of the estimated basement earthquake motion was almost the same level as that of the "earthquake ground motion without the site specific epicenter" by the former regulatory guide of the Nuclear Safety Commission of Japan.