Basic Technology Subjects

Civil Engineering Research Laboratory

Brief Overview

The Civil Engineering Research Laboratory extensively promotes studies into 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 as well as the 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.

- By using an X-ray CT scanner and scanning electron microscope, we developed a new approach in which we examine the fault activity based on whether fine minerals growing along the fault plane moved in the latest event are deformed or not.
- We analyzed displacements of surface faults located in the vicinity of a primary strike-slip fault using dynamic rupture simulation. This simulation enables us to evaluate surface displacements in an earthquake caused on a primary fault near a site (N14007).

Earthquake Engineering

We aim to establish proper countermeasures to control risks on natural disasters, mainly earthquakes, for electric power facilities and equipment. We also develop low-cost solutions to maintain electric power facilities.

- We analyzed the expected JMA (Japan Meteorological Agency) seismic intensity at each substation throughout the country within 100 years in order to assess the validity of the nationally unified seismic force level for substations. The results showed that the JMA seismic intensity is lower than 6-lower at about 90% of the substations and that the seismic intensity of 6-lower indicates the design level of substations. We conducted a statistical analysis of seismic force for seismic intensity of 6-lower based on the recent observation data and showed that the average acceleration response spectrum for the seismic intensity of 6-lower is comparable to the dynamic design seismic force of the existing guidelines.
- We applied the shaking table tests of center-clamp type bushings on transformers at high acceleration input motions. The results showed the non-linear behavior of the bushings and the extrusion of packing from the lower end of the bushings which causes continuous oil leak. In order to replicate the tests, we developed a new analysis method with a fiber model*1, which can evaluate non-linear response of the bushings (N14012).

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 hazard actions such as earthquakes, wind, heavy snow, along with aged deterioration caused by environmental actions such as chloride-induced deterioration, frost damage and temperature changes.

- As a part of the research toward the construction of the seismic damage evaluation method of reinforced concrete (RC) structures based on deformation indices, we conducted static loading tests using RC members under the low margin condition of shear strength and clarified the relationship between the lateral expansion of members after shear failure and the strength reduction[1] (Fig. 1). This means that the damage level of real structures can be derived from the measured lateral expansion after an earthquake.
- For the purpose of expanding the amount of fly ash used in concrete applications, we analyzed previous research focused on phase composition (types and ratio of materials) of the hardened cement paste with fly ash. As a result, we found that the concept of phase composition can be applied to the evaluation of physicochemical performance including strength. However previous research is limited from the viewpoint of variability in the quality of fly ash and various mix proportions. Therefore it is necessary to clarify the relationship of phase composition and performance for various conditions (N14014).

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 for the hydraulic and atmospheric fluid flows relevant to such facilities.

- We developed a method for obtaining appropriate unsteady wind velocity at an inlet boundary in wind simulations. Turbulence properties such as the turbulence length scale (the size of vortices in turbulence) that vary depending on weather conditions are controlled by the input parameters, and the conservation laws of flow dynamics are satisfied in the flows generated by using the method. This approach contributes to an improvement in reproducibility of complex actual wind, and can be applied to unsteady wind simulations for the wind resistant design and the evaluation of ash fall impacts for power facilities (N14011).
- We constructed a numerical simulation method for a natural convection boundary layer along a vertical heated plate. The simulation using this method elucidated the turbulent characteristics inherent in this boundary layer flow. The method enables accurate estimation of the heat transfer rate between the heated plate surface and ambient air, which will contribute to an evaluation for the fire-resistant capability of power plant facilities with precision (N14013).

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 in order to address future introduction of regulations regarding application of CCS, we surveyed trends in technical developments and policies in Japan and around the world (N14005). The world's first CO_2 capture and storage commercial operation of a coal-fired plant began in Canada in 2014. The success of this project depended on establishing CO_2 emission regulations and selling CO_2 to the oil industry.
- We surveyed the present status of technology developments for Enhanced Geothermal System (EGS) which can contribute to the stable operation of geothermal power generation. We summarized the issues relating to these technologies to apply in various sites by dividing these technologies into three types, (i) artificial water injection into the natural reservoir to recharge water volume in the reservoir, (ii) permeability improvement by creating fractures in rocks in and around reservoirs, (iii) artificial reservoir creation (N14017). We will contribute to improving the versatility of EGS technology by solving these issues.

*1 A beam model of the Finite Element Method, which can evaluate non-linear behavior in the section subjected to axial force and bending moment.

[1] Y. Miyagawa et al., JCSE Jour. E2, Vol.70, No.4, pp.402-416 (2014).

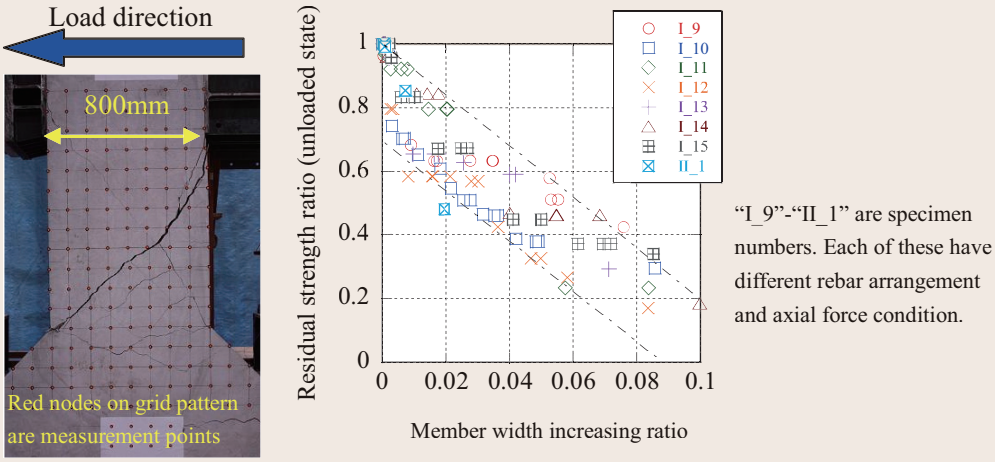

Fig. 1: Relationship between the lateral expansion of RC members and strength reduction

The apparent increase of member width caused by widening of inclined cracks was measured using image measurement (left picture). One plot of the right graph corresponds to a picture in a certain point of time during the loading and the marker was distinguished with the specimen. It was found that both indices were highly correlated.