

# Disaster Prevention and Maintenance for Hydropower Facilities

## Background and Objective

Proper maintenance, renewal and operation of hydropower facilities are important in terms of provision for global warming and stable electric power supply while the number of such facilities constructed more than 50-60 years ago is increasing. In recent years, aging of the facilities and changes which appear in environments surrounding rivers and forests along them are remarkable, and increase in the number and scale of disaster affects hydropower operations.

In this project, evaluation and analysis methods for existing dam and spillway gate structures will be established to secure safety against strong earthquakes considering damaged state of the structures. Also, total management of watershed-sedimentation techniques which estimate points/places of sediment yield in dam basin and observe behavior of sedimentation and turbidity in rivers and reservoirs, and the simple analysis model which predicts sediment level and turbidity will be developed.

## Main results

### 1. Seismic performance evaluation for aged dam structures

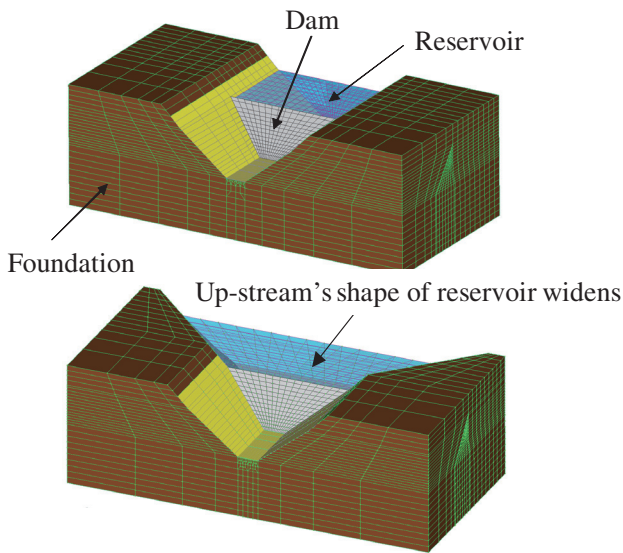
To obtain the basic information of seismic performance using FEM analysis, an experiment and numerical analysis of concrete gravity dam during earthquake were conducted. In the experiment, fracture propagation and local deformation of dam were studied to construct the numerical model of fracture at contact zone between dam and foundation, followed from 2009. In numerical analysis, dam's shape (Fig. 1) and several analysis models and methods were studied at the point of the effects on calculated results.

Static loading tests of vertical lift gate models (Fig. 2) focusing on the damage under strong earthquake were carried out to obtain experimental data to verify the stimulation results of the gates with consideration of plasticity and buckling of primary members. Each model was a part of the vertical lift gate including two main girders, and was statically subjected to hydrostatic and earthquake loads. The results of loading tests were utilized for investigating failure modes and ultimate strength of the gates.

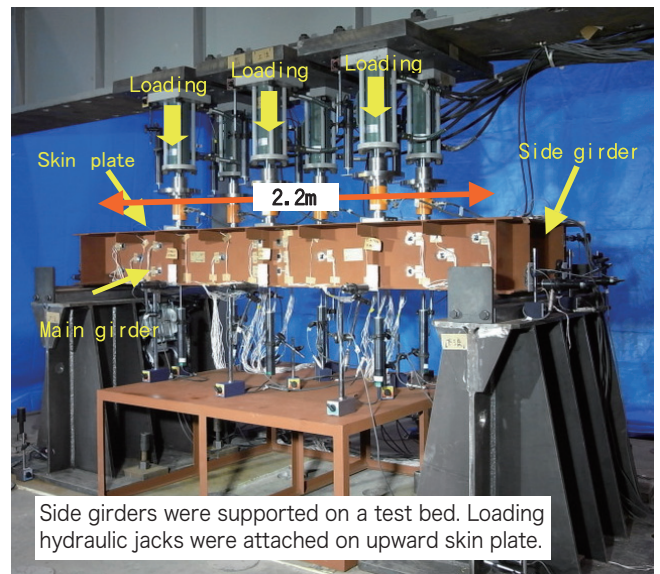
### 2. Development of total management of watershed-sedimentation techniques

Discriminatory models of vegetation were constructed by using satellite image and aerial photograph to monitor sediment source areas on upstream of hydropower dam. We applied the models for the river basin where mountain slopes were devastated by deforestation and landslide (Fig. 3). In addition, we installed the monitoring equipment of water transfer to make it easy to evaluate the hazard of slope failure that was main factor for sediment production. The water transfer in heavy rainfall was observed by using this equipment and the three dimensional seepage model of slope was developed to simulate the water transfer phenomenon.

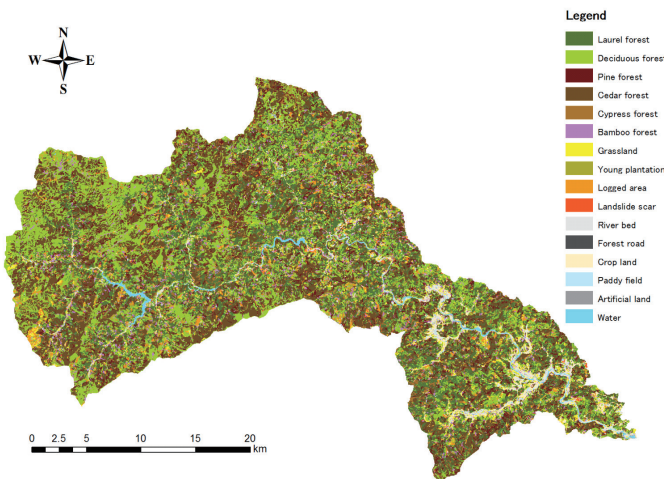
C-HYDRO 2D, which can calculate two-dimensional horizontal flow and river-bed fluctuation, was developed in order to evaluate processes of sedimentation and turbidity flow in reservoirs and rivers. This code contains the Calculation Engine and the Graphical User Interface (GUI, Fig. 4) which is the setting part of the initial condition, the executing part of the calculation and the display part of the calculated results. Also, field observation in a reservoir using a movable current measuring system, equipped with the Global Positioning System (GPS) and the Acoustic Doppler Current Profiler (ADCP), occurred to confirm the validation of C-HYDRO 2D.



**Fig. 1 3D finite element method analysis models**  
The seismic response of dam and seismic water pressure on upstream surface of dam are different, because of the effects of analysis model and analysis assumption. To estimate the effects of these factors, 3D finite element method analysis was studied.

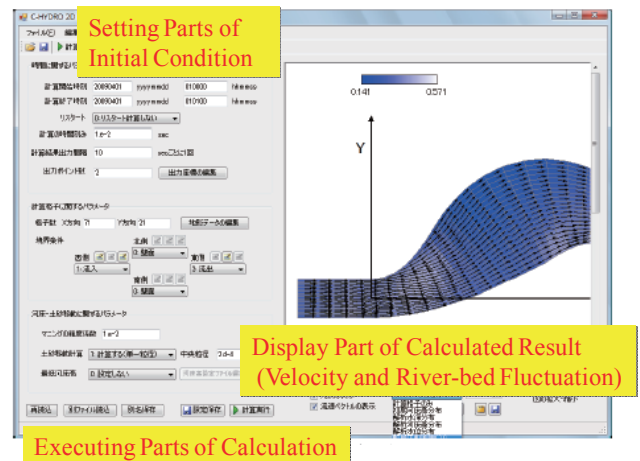


**Fig. 2 Loading test of vertical lift gate model**  
Test parameters of partial models of vertical lift gate were gate width and distance between main girders. The loading test assumed the failure of main girders and skin plate under hydrostatic and hydrodynamic loads resulting from strong earthquake.



**Fig. 3 Vegetation classification map reflecting erosion process**

Forest dominant species such as cedar, cypress, pin and broad leaved tree which have different erosion function were discriminated from satellite image and aerial photograph. This map is useful for monitoring logged area and vegetation recovery after logging.



**Fig. 4 GUI of C-HYDRO 2D**

The Graphical User Interface has three functions: Input of initial conditions; Execution of calculations; Display of calculated results which are velocity and river-bed fluctuation.