Japan Society of Dam Engineers

1. Establishment of the Japan Society of Dam Engineers

Dam structures involve many fields of engineering. In recent years, all fields of engineering have advanced remarkably, but as a result of the broadening of engineering, it is becoming increasingly difficult for dam engineering to fully incorporate the latest research results.

Moreover, In addition to its complex geological structure which causes frequent earthquakes, the land of Japan is located in the Asian monsoon zone and thus subject to heavy rain, typhoons, and other weather phenomena, and so advanced technologies are needed to construct and operate dams.

The Japan Society of Dam Engineers (JSDE) was established in 1990 to meet the needs for dam engineering and progress to improve dam technologies in Japan. The society brings together engineers in many fields and now has about 860 members.

2. Organization of the Japan Society of Dam Engineers

The JSDE consists of the General Assembly as the top decision-making body, the Board of Governors which operates the Society, four committees formed primarily to handle activities of the Society under the leadership of the Board of Directors, and three committees to decide the dam engineering awards (see Fig. 1).

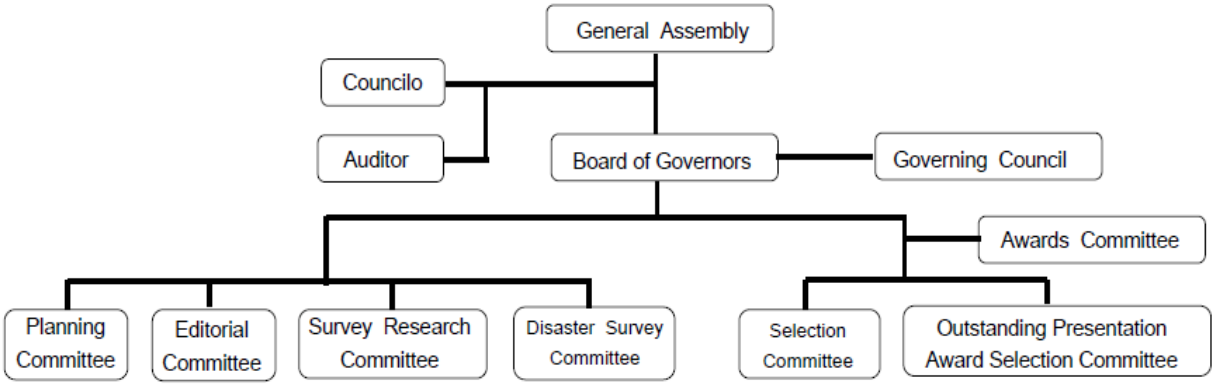


Figure 1. Organization of the Japan Society of Dam Engineers

3. Activities of the Japan Society of Dam Engineers

Activities of the JSDE are as follows.

1. Survey research on dam engineering
2. Holding academic conferences, research seminars, and symposiums, training sessions, and field trips, etc. concerned with dam engineering
3. International exchanges of dam engineering related technologies
4. Publishing an academic journal
5. Collecting and distributing information about domestic and international research activities, and conferences, etc. concerning dam engineering

Figure 2. View of With Dam Night

Figure3. Field Trip and Training Session

Figure 4. View of an All About Dams Consulting Room Training

The 2011 Tohoku Earthquake

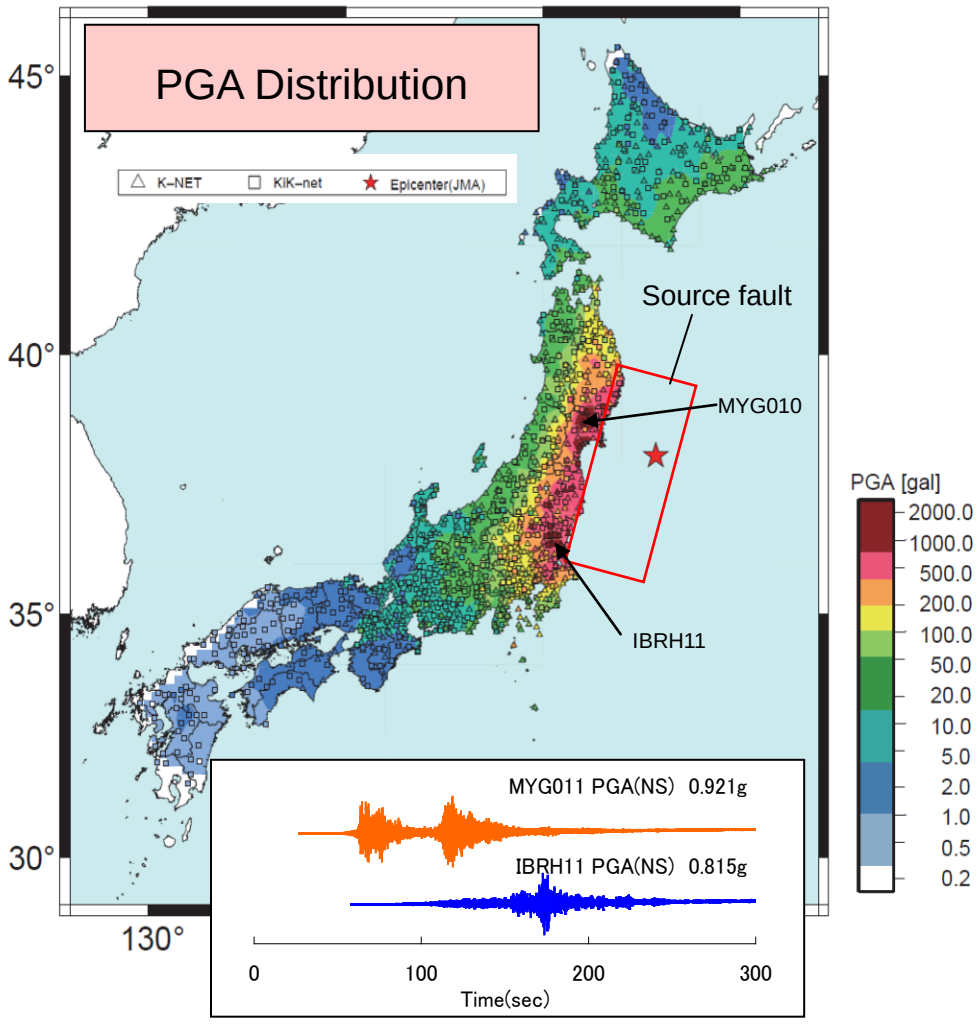
The Tohoku Earthquake of magnitude 9.0 (the greatest in Japan, the 4th largest in the world) occurred at 14:46(Japan Standard Time) on March 11th 2011.

This earthquake caused faulting of 500km in length of NS direction generated the strong ground motion from Tohoku to Kanto districts, and the recorded earthquake motions had long duration of 200 seconds or more. There are unique features in the recorded seismic-wave forms, namely two principal motions were observed on MYGH004 in Tohoku district, and one principal motion was observed on IBRH11 in Kanto district.

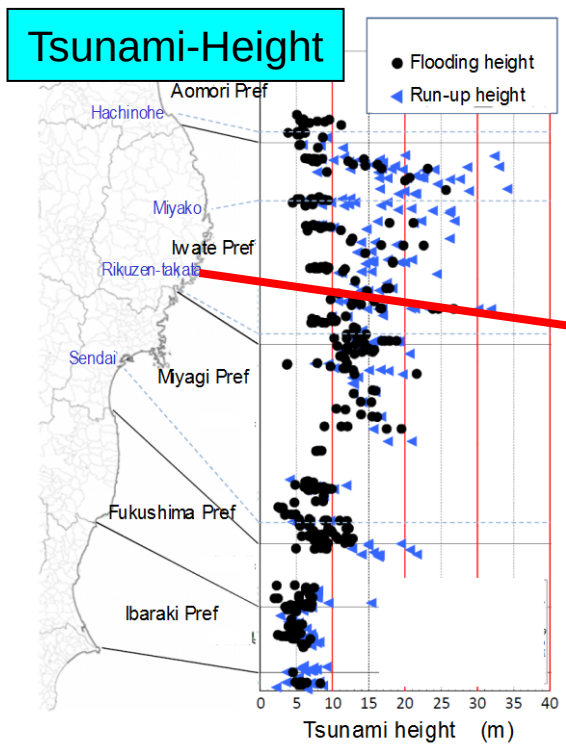
The great tsunami with a height of exceeding 20m caused large disaster including approximately 20,000 deaths and people missing. The earthquake with a long duration caused various disasters, including liquefaction, in a wide area.

The dike of Abukuma River in Miyagi Prefecture was hit by the liquefaction, and large and wide cracks and large settlement arose on the dike.

The liquefaction did damage to the houses in Itako-city in Ibaraki Prefecture, and caused the large damage to lifelines, such as water service and sewer.

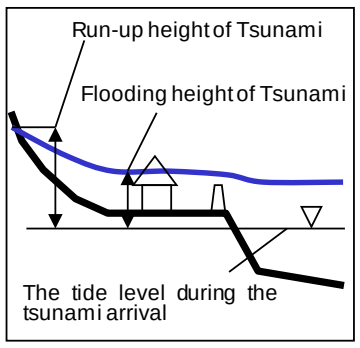


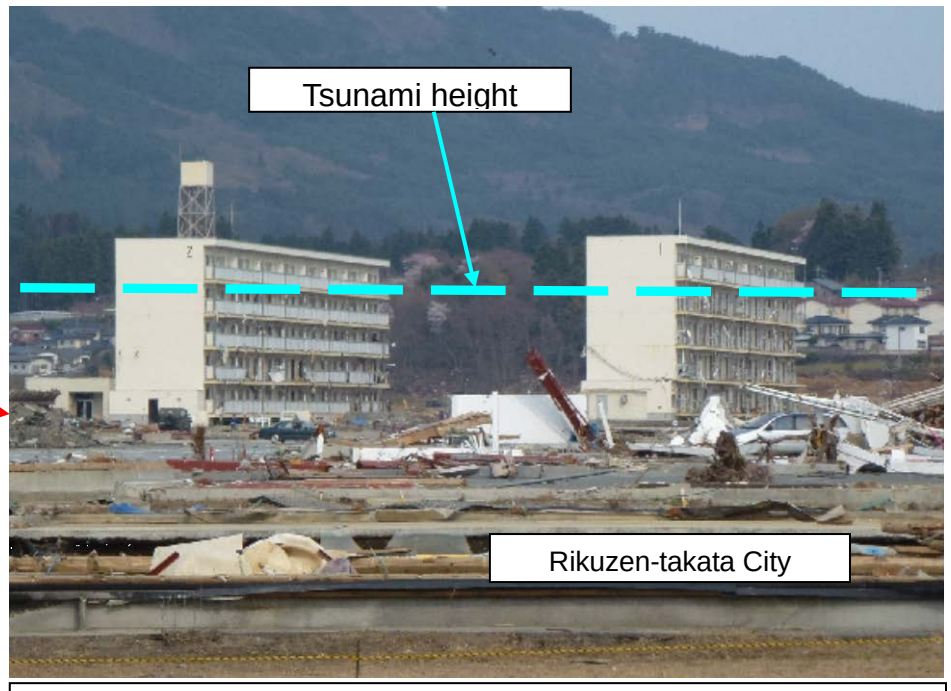
Courtesy of National Research Institute for Earth Science and Disaster Prevention: http://www.kyoshin.bosai.go.jp/kyoshin/topics/html



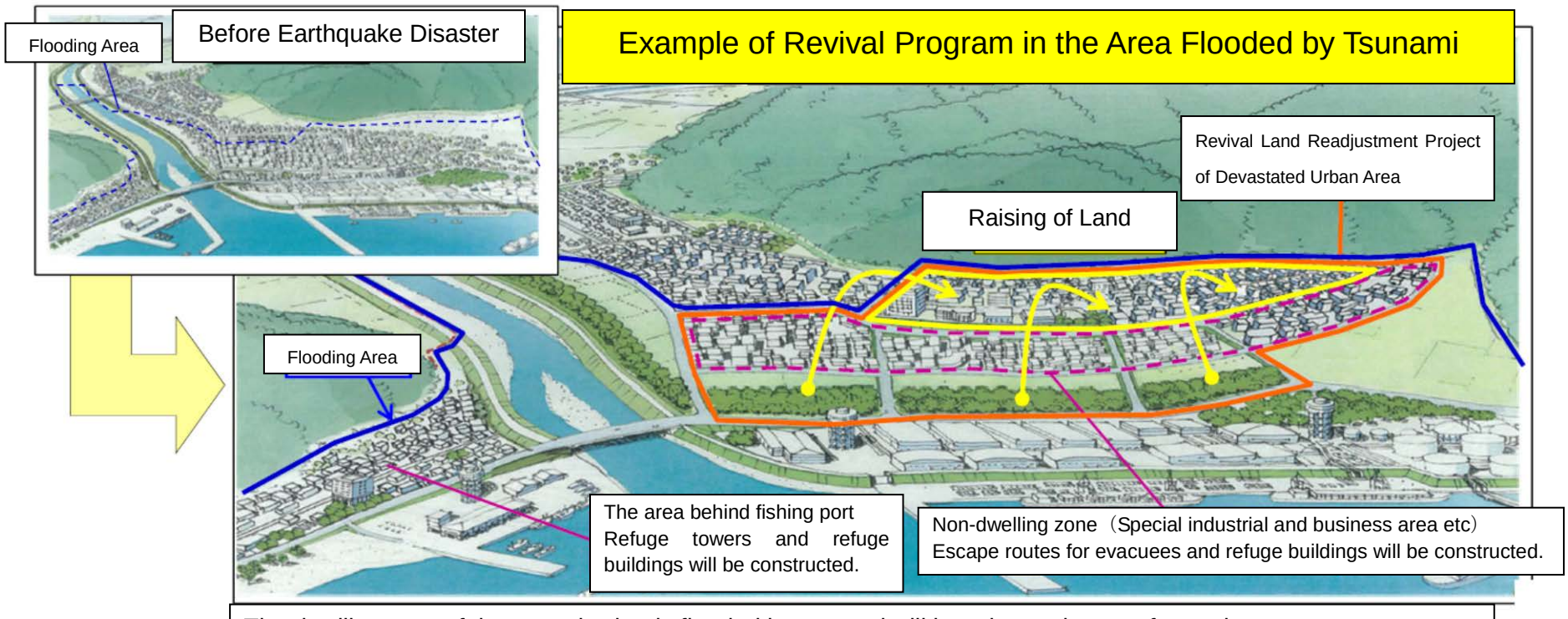
Courtesy of Central Disaster Management Council: http://www.bousai.go.jp/jishin/chubou/higashinihon/sankou.pdf

The tsunami with a height of exceeding 10m was recorded from Iwate to Fukushima Prefectures, and damaged many buildings, and killed and injured many people.
In particular, the tsunami with a height of exceeding 20m was recorded in Iwate Prefecture.





The building 300m away from the seashore was flooded to the fourth floor by the tsunami.



The dwelling area of the coast lowlands flooded by tsunami will be relocated to a safe perch.

Courtesy of The Reconstruction Design Council in Response to the Great East Japan Earthquake: http://www.cas.go.jp/jp/fukkou/pdf/kousou13/shiryou1-1.pdf

Damages of Dams due to The 2011 Tohoku Earthquake

Results of Special Safety Inspection of Dams

Special Safety Inspection of Dams by Site Officers

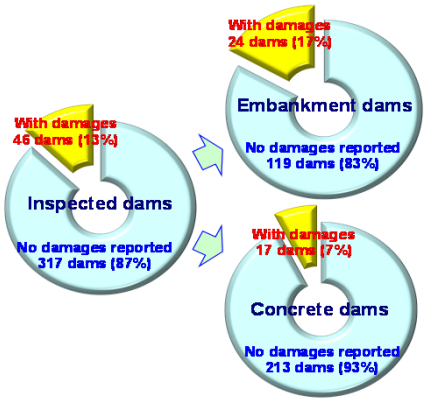
should be conducted immediately after the earthquake
"at dams in river areas managed under the River Law in Japan, when they generate earthquake motion with maximum acceleration of 25 gal or more observed at the dam foundation or earthquake with Japan Meteorological Agency seismic intensity of 4 or higher."

Primary Inspection (Visual Inspection) : **363** dams

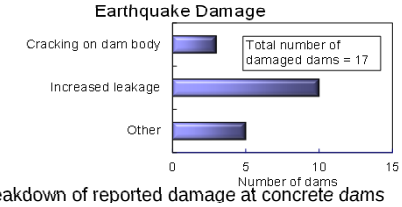
Secondary Inspection (Detailed Visual Inspection & Safety Check Based on Measured Behavior) : **298** dams

Results of Special Safety Inspection

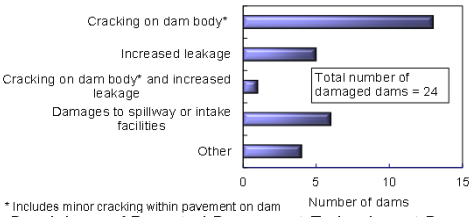
- No severe damage which affects the safety of dams was reported.
- Cracks generated at dam crest and/or spillway, and increase in leakage/seepage through dam bodies and/or their foundation were reported at several dams.
- Dam owners continued careful monitoring of dam behavior, and made detailed investigation and repair of their damage.



Number of Inspected Dams with/without Earthquake Damage



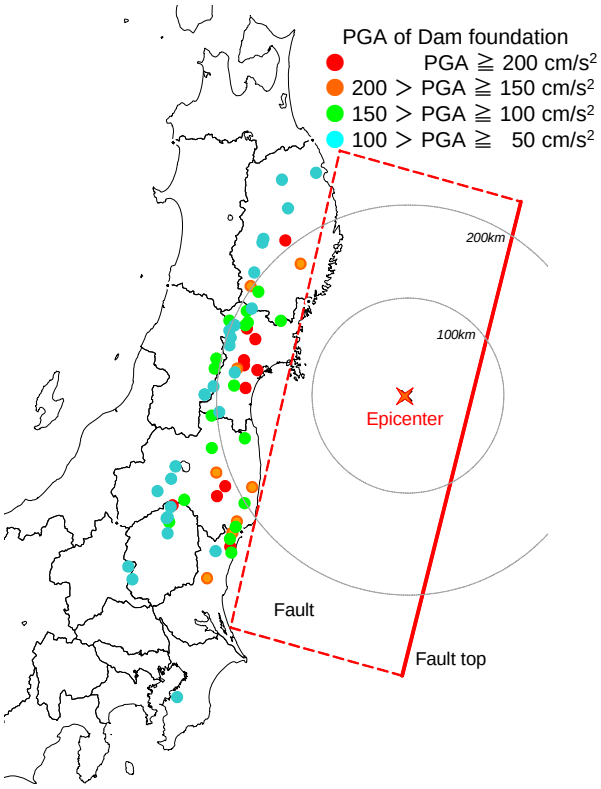
Breakdown of reported damage at concrete dams



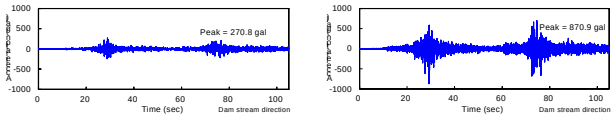
* Includes minor cracking within pavement on dam

Breakdown of Reported Damage at Embankment Dams

Observed Earthquake Motions at Dams



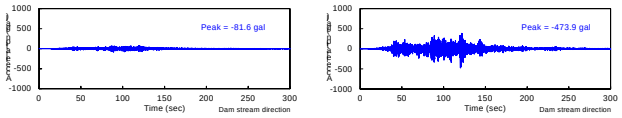
Distribution of Dams which Record EQ Motion with a Max. Accel. a Peak Ground Acceleration of 100 Gal or Larger at Dam Foundation



(a) Dam Foundation (b) Dam Crest

Minamikawa Dam	
Type of Dam	Concrete dam
Height of Dam	46.0m
Year of Completion	1976

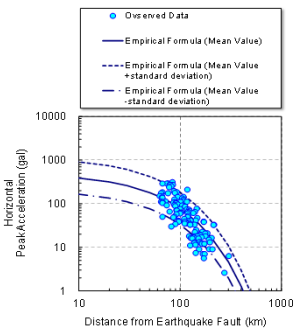
Example of Observed Acceleration Waveform at the Concrete Dam



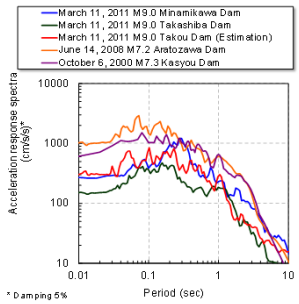
(a) Dam Foundation (b) Dam Crest

Surikamigawa Dam	
Type of Dam	Earth core rockfill dam
Height of Dam	52.5m
Year of Completion	2006

Example of Observed Acceleration Waveform at the Rockfill Dam



Peak Horizontal Acceleration at Dam Foundation



Acceleration Response Spectra Calculated from Earthquake Motion Observed at Dam Foundation (Horizontal direction)

Damages of Dams due to The 2011 Tohoku Earthquake

Results of Detailed Inspection at Several Damaged Dams

Kejyonuma Dam

Profile of Dam

Type of Dam	Earthfill dam
Height of Dam	24.0m
Year of Completion	1995

Peak Acceleration

Crest	Transversal direction	714.0 gal
	longitudinal direction	523.0 gal
	Vertical Direction	316.0 gal
Foundation	Transversal direction	262.0 gal
	longitudinal direction	269.0 gal
	Vertical Direction	173.0 gal

Crack in the stream direction on the crest
(Courtesy of Public Works Research

Open the curbstone and asphalt
(Courtesy of Public Works Research Institute)

Koromogawa No.1 Dam

Profile of Dam

Type of Dam	Earthfill dam
Height of Dam	35.5m
Year of Completion	1963

※The *Koromogawa No.1 Dam* has not been installed seismograph. The *Koromogawa No.4 Dam* is located on the 5km downstream of the *Koromogawa No.1 Dam*. The *Koromogawa No.4 Dam* has been installed seismograph. Maximum acceleration of the *Koromogawa No.4 Dam* is 106gal at foundation and 376gal at crest.

Crack in the dam axis direction on the crest

Crack on the crest

Takou Dam

Profile of Dam

Type of Dam	Concrete Gravity Dam
Height of Dam	77.0m
Year of Completion	2006

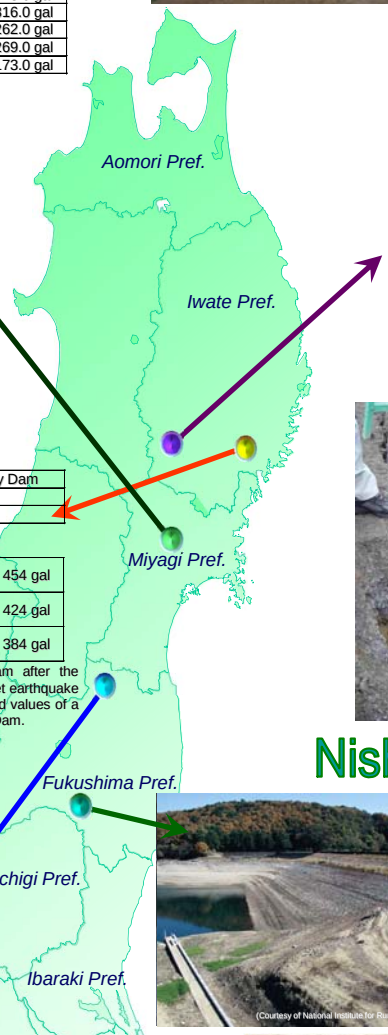
Peak Acceleration

KiK-net MYGH03	Horizontal NW Direction	454 gal
	Horizontal EW Direction	424 gal
	Vertical Direction	384 gal

※The power failure occured at Takou Dam after the earthquake. Therefore, it was impossible to get earthquake records at this dam. The table shows observed values of a Kik-net station (MYGH03) close to the Takou Dam.

Cracking on the Intake tower

Opening of joint



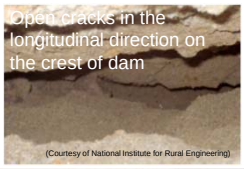
Nishigo Dam

(Courtesy of National Institute for Rural Engineering)

Profile of Dam

Type of Dam	Earthfill Dam
Height of Dam	32.5m
Year of Completion	1955

※The Nishigo Dam has not been installed seismograph.


Open cracks in the longitudinal direction on the crest of dam
(Courtesy of National Institute for Rural Engineering)

Width of open cracks in the longitudinal direction on the crest of dam
(Courtesy of National Institute for Rural Engineering)

Bending of riprap stopper works on upstream slope
(Courtesy of National Institute for Rural Engineering)

Horseshoe-shaped pocket on upstream slope
(Courtesy of National Institute for Rural Engineering)

Surikamigawa Dam

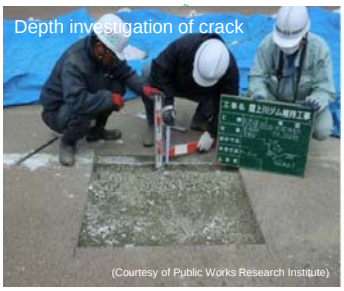
Profile of Dam

Type of Dam	Earth Core Rockfill Dam (ECRD)
Height of Dam	105.0m
Year of Completion	2006

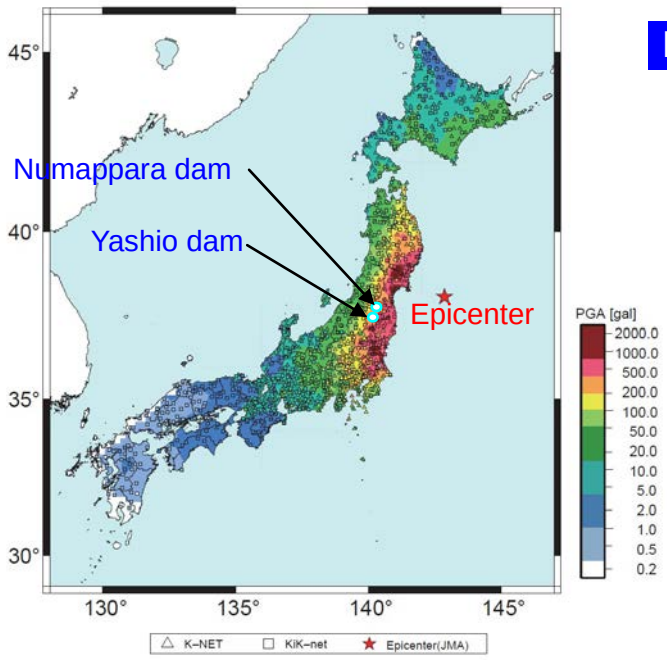
Peak Acceleration

Crest	Transversal direction	473.9 gal
	longitudinal direction	294.0 gal
	Vertical Direction	224.7 gal
Foundation	Transversal direction	81.5 gal
	longitudinal direction	110.2 gal
	Vertical Direction	79.7 gal

2-3mm-wide crack at crest pavement
(Courtesy of Public Works Research Institute)


Depth investigation of crack
(Courtesy of Public Works Research Institute)

Damage of Dams for Hydropower Generation due to The 2011 Tohoku Earthquake



The 2011 Tohoku Earthquake on11th.March
Epicentre of EQ and Location of Dams

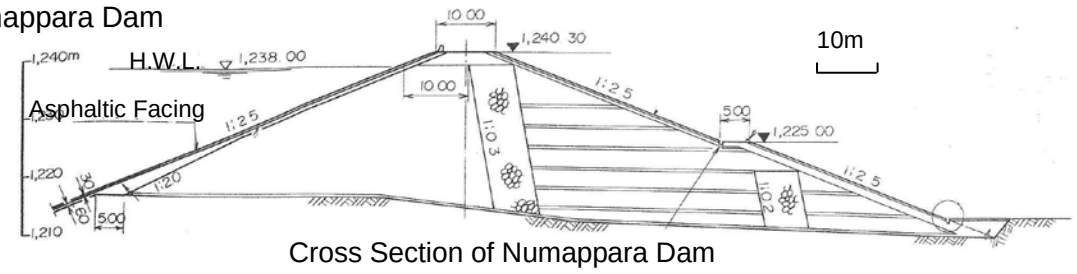
Damage and Repair of Numappara Dam

Overview of Numappara Dam

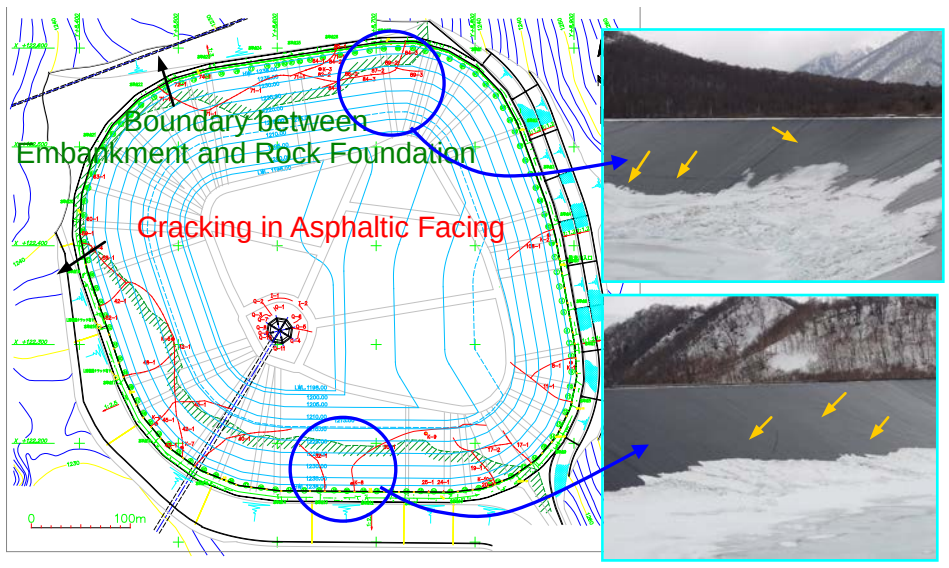
General Features

Purpose	Power Generation (Pumped Storage-type; Upp.Res.)
Type	AFRD (Asphalt Faced Rockfill Dam)
Dam Height & Length of Crest	1,597m & 38m
Completion	June 1973

Numappara Dam on 12th.March, 2011
（Dam and Reservoir were covered with Ice and snow）



Cross Section of Numappara Dam



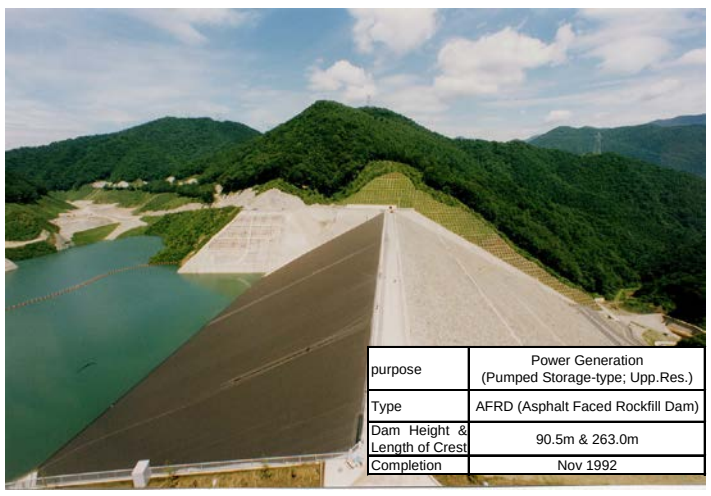
Cracks Generated in Asphaltic Facing due to the Earthquake
（Cracks are generated nearby boundary between embankment and rock foundation.）

Maximum Acceleration Recorded during the Earthquake

Crest of Dam	382gal
Fundation of Dam	210gal

Completion of Crack Repairment by Overlay at the end of June 2011
（Total length1,500m of cracks were repaired without heavy machinery.）

Damage and Repair of Yashio Dam

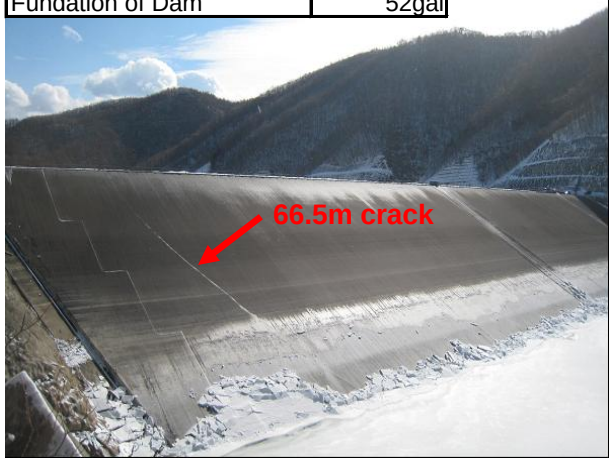


purpose	Power Generation (Pumped Storage-type; Upp.Res.)
Type	AFRD (Asphalt Faced Rockfill Dam)
Dam Height & Length of Crest	90.5m & 263.0m
Completion	Nov 1992

Overview of Yashio Dam (Asphaltic facing)

Maximam Acceleration Recorded during the Earthquake

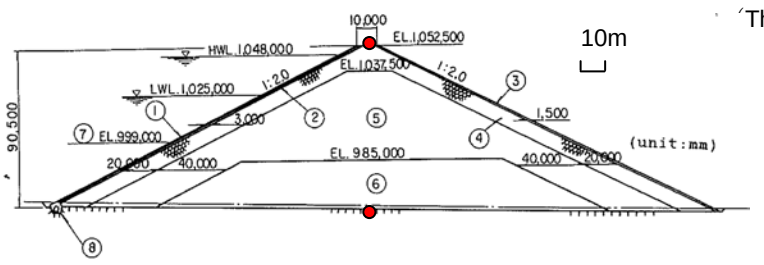
Crest of Dam	253gal
Fundation of Dam	52gal



Cracks Generated in Asphaltic Facing at Left Bank (2011.3.12)

Cracks Generated in Asphaltic Facing at Right Bank (2011.3.12)

（The cracks were generated at the left bank and the right bank along the boundary between the facing and rock foundation.）



● accelerometer

① Impermeable facing
② Transition
③ Riprap
④ Rock-Zone R_3
⑤ Rock-Zone R_2
⑥ Rock-Zone R_1
⑦ Presumed sediment surface
⑧ Cut off

Cross Section of Yashio Dam

Repairing at Left Bank Asphaltic Facing. Cutting of Asphaltic Concrete around a Crack.(2011.4～)

Completion of Repair Work, and Filling Water without Water Leakage from Asphaltic Facing. （2011.5.26）

Due to the 2011 Tohoku Earthquake, 2 AFRDs for hydropower generation, which are Numappara Dam and Yashio Dam, were damaged in their Asphaltic Facings. The Cracks were repaired in short period, 2 or 3 months. Two dams were repaired before the heavy load season for electricity in summer.

Damage to the Fujinuma Pond due to the 2011 Tohoku Earthquake

1. Outline

Fujinuma pond secures the water storage by water conveyance form the adjoining indirect catchment basin, not regulated to river management system by Japanese River Law. The construction started in 1937 and completed in 1949 after the suspension by the World War II. Improvement of the spillway and breakwater protection work from 1977 to 1979 and seepage control work by grouting and improvement of intake facilities from 1984 to 1992 were executed.

Table 1 Specifications

Commissioning Entity	Fukushima Prefecture
Location	Sukagawa City, Fukushima Prefecture
Purpose	Irrigation
Type	Main：Earth Dam Auxiliary：Earth Dam
Height	Main：18.5m Auxiliary：10.5m
Crest Lenghe	Main：133.2m Auxiliary：72.5m
Volume	Main：99,000m^3
Total Storage Capacity	1,500,000m^3
Effective Storage Capacity	1,480,000m^3
Completed	1949

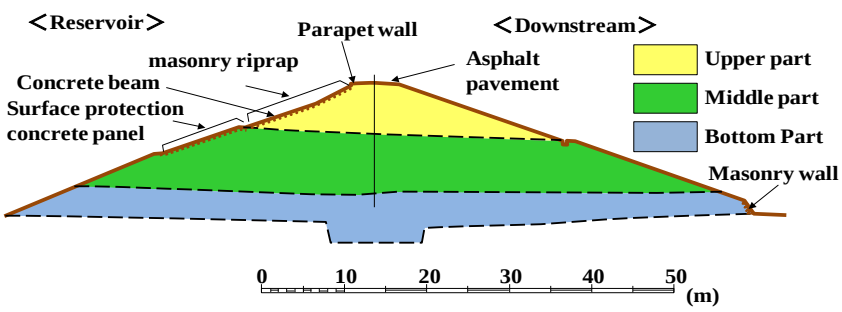


Figure 1. Cross Section of the Main Embankment
(Courtesy of Fukushima Prefecture)

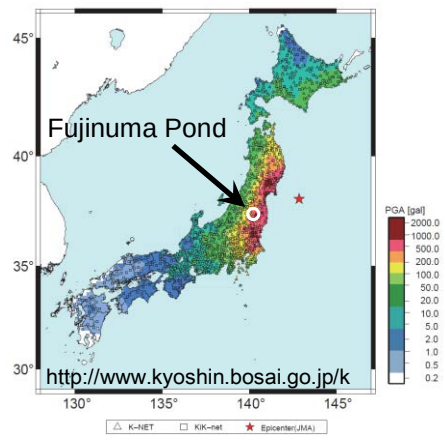


Figure 2. Location of Fujinuma Pond and PGA Distribution

2. Damages to the Embankments

【Main Embankment】

- Seven-phase slidings shown in Figure 4.
- Being washed away of almost all the upper part and large part of the middle part and the bottom party.
- Collapse of masonry on the upper part down to the reservoir side.
- Large displacement of the surface protection concrete frame to the reservoir side at the central area a little to the right abutment
- Slidings both at reservoir side and at downstream side.

【Auxiliary embankment】

- Primary sliding to the reservoir side with 55m width, 25m length and 3m depth.
- Secondary sliding at the forward edge of the primary one.

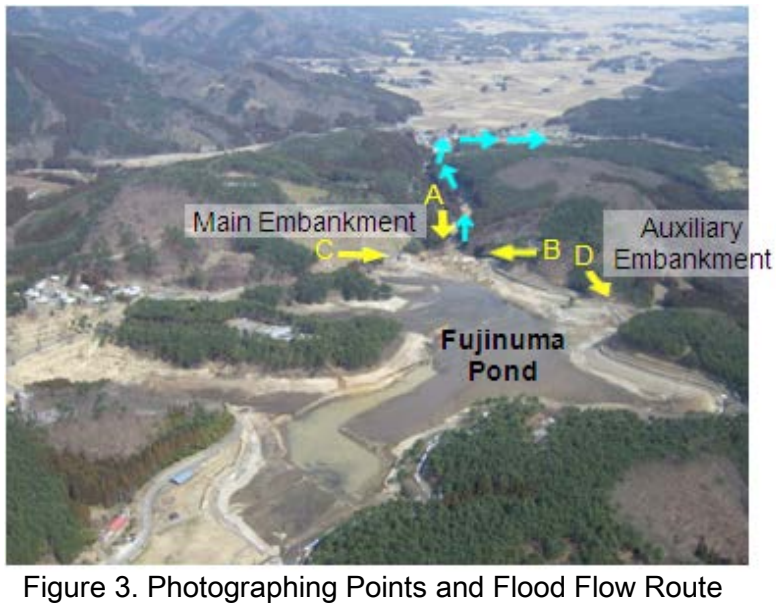


Figure 3. Photographing Points and Flood Flow Route

(B～D: Courtesy of National Institute for Rural Engineering)

3. Causes of Failure

(1) The earthquake response analysis suggested that the peak acceleration at the embankment crest was 442 cm/s^2 and the duration of the motion over 50 cm/s^2 continued for 100 seconds, which was an earthquake motion never had been experienced.

(2) The compaction degree of the embankment was low compared to that with the modern construction method and the strength of the embankment was small in undrained condition during earthquakes. Especially in the upper embankment consisting of sand rich materials there was a saturated portion and it was proved the further strength loss occurred when it was subjected to the earthquake motion such as that of the 2011 Tohoku Earthquake.

(3) One of the failure causes was the nature of the soil of the embankment, rich in sandy materials, considering that slides occurred in the auxiliary embankment consisting of similar material to the upper part of main embankment.

(4) In the slide occurred in the auxiliary embankment sliding surface was restricted to the embankment boundary of the different construction periods, which suggested the possibility that in the main embankment, the difference of the degree of compaction depending on the different construction periods might be attributable to the occurrence of the sliding.

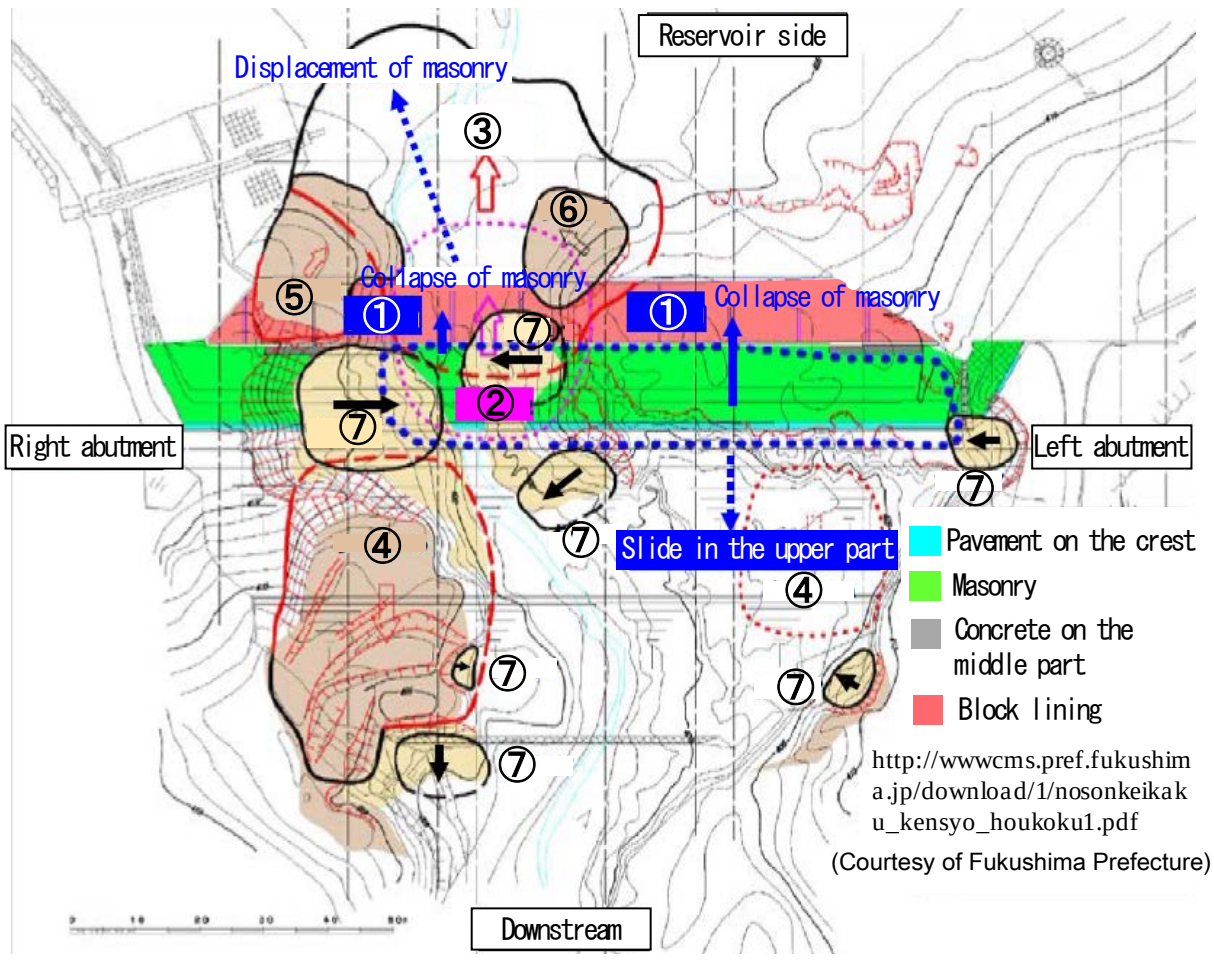


Figure 4. Damages to the Main Embankment