Subcommittee on Research of the Old Movable Weir in the Ohkouzu Diversion Channel

(Subcommittee 272)

The JSCE-272 subcommittee was organized in January 2012. The subcommittee is chaired by Professor Kyuichi Maruyama from the Nagaoka University of Technology. The purpose of the subcommittee is to carry out scientific and technical investigations of the old movable weir and pass down the results to posterity.

The subcommittee has five working groups: the Historical Studies in Civil Engineering Group, River Engineering Group, Geotechnical Engineering Group, Structural Engineering Group, and Concrete Engineering Group. These groups have conducted the following activities.

The old movable weir

Historical Studies in Civil Engineering Group

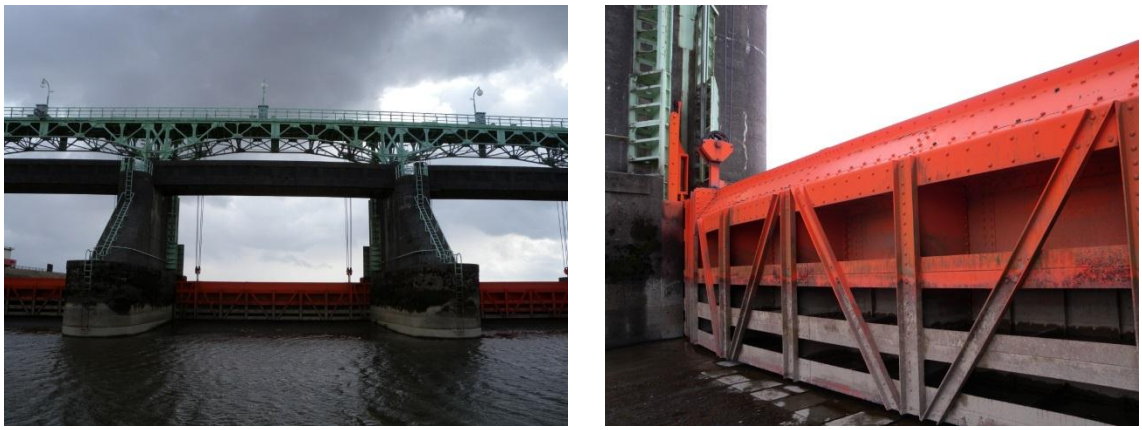
In order to identify the importance of the Ohkouzu movable weir in the history of modern large-scale river diversion structures in Japan, the following surveys were conducted from the viewpoint of civil engineering history.

- The importance of the Ohkouzu movable weir in the history of the design of modern large-scale river diversion structures was examined based on an analysis of the gate type.

- An analysis of the writings of Takenosuke Miyamoto, particularly his diary, formed the basis of discussions about the philosophy behind his design of the Ohkouzu movable weir.

Through these examinations, the following points were clarified.

- From the viewpoint of the structural design, or the design concept, the importance of the Ohkouzu movable weir in the history of modern large-scale river diversion structures in Japan is difficult to accurately determine.
- The Stoney-gate of the Ohkouzu movable weir may be a perfect example of the type of long-span Stoney-gate weir used in the period before the roller-gate weir became popular.



The Stoney-gate of the Ohkouzu movable weir

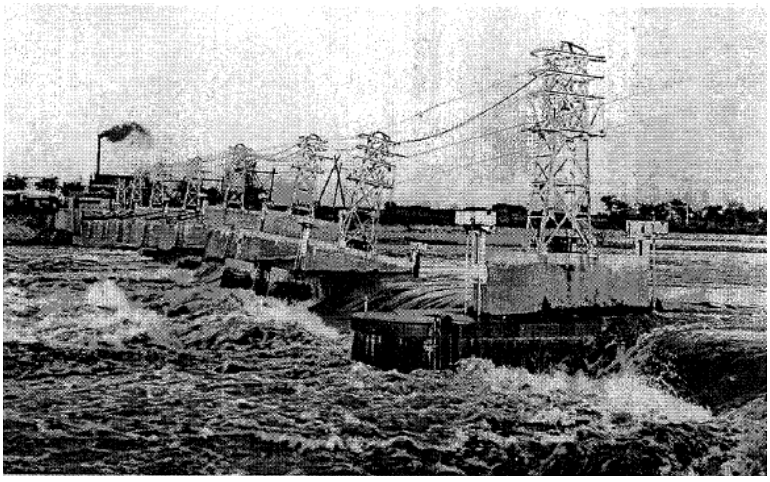
River Engineering Group

The Ohkouzu Diversion Channel protects the Echigo Plain from flooding by the Shinano River. Many researchers in hydraulic engineering and hydrology are interested in the channel because of its age and scale of construction. The river channel is man-made and very long (10 km), so it represents a long-term and large-scale alteration of nature. One of the technical difficulties in managing the channel is to maintain the height of the riverbed. The channel of the riverbed has been degrading since construction ended in 1922. The previous diversion weir was destroyed when the supporting ground deformed in 1927.

The River Engineering Group is studying the following topics.

- Hydrological significance of the Ohkouzu Diversion Channel
- Cause of the collapse of the previous diversion weir in 1927
- Long-term retention of the diversion channel's shape

So far, we have reviewed the literature, analyzed the data, and developed a numerical model of the river flow, sediment transportation, and changes in the riverbed's topography. The longitudinal distribution of the riverbed's height is quite different from its natural and equilibrium conditions. Erosion occurs in the upstream area and sedimentation occurs near the downstream end of the analysis domain. Next year, we will improve the numerical model and conduct a more sophisticated data analysis.



The previous diversion weir collapsed in 1927

Geotechnical Engineering Group

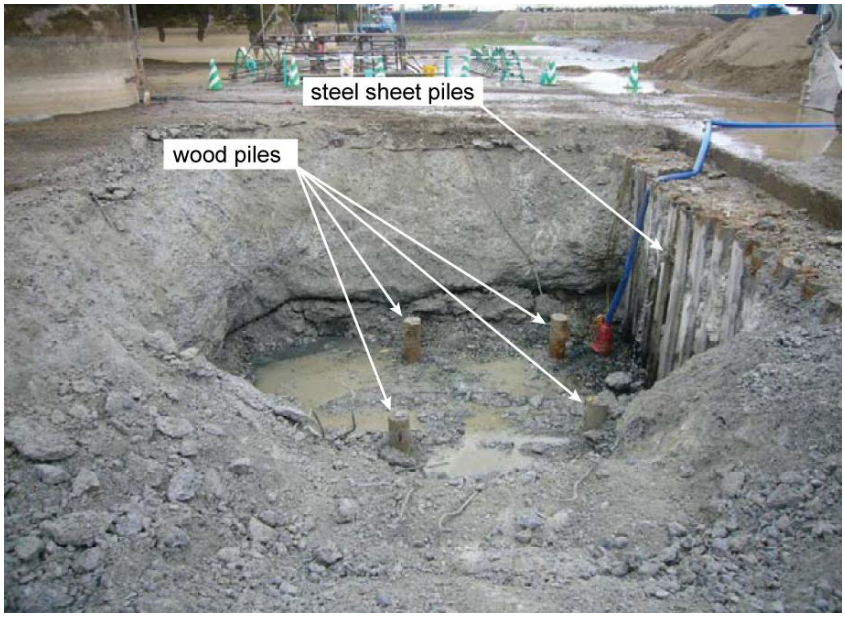
The cavities under the base of the old movable weir and the corrosion of the steel sheet piles and wooden piles were examined, and a statnamic test of the wooden piles' bearing capacity, was carried out to clarify the present conditions. No cavities were found under the apron between the old movable weir and the first groundsill, but there are extensive cavities under the first groundsill, or under the old movable weir. The steel sheet piles were not corroded, and wooden piles were in good condition.

The old movable weir was built to restore the function of the previous diversion weir which had sagged in as few as five years after starting operation. One of our aims is to

understand how design concept for the foundation was affected by the problems with the diversion weir. Four new borehole investigations were carried out to determine the caved-in areas and soil profiles under the foundation of the old movable weir.

The literature was reviewed to determine how the bearing capacity had been designed. An investigation of the main river structure at that time indicated that the ground was a stiff clayey layer. Therefore, the end bearing capacity was designed for a pile-end placed on this stiff clayey layer. The actual bed layer, however, is a firm sand layer with an *N*-value of over 40, which meant that the end-bearing capacity had been underestimated. The total bearing capacity, however, is sufficient under present criteria, if the wooden piles are assumed to be friction piles.

The reason for the sagging of the previous diversion weir remains unknown. A series of laboratory tests, including physical properties, strength, and liquefaction resistance, have been performed to supplement the analyses of the River Engineering Group.



The steel sheet piles and the wooden piles

Structural Engineering Group

Our group is investigating from a structural engineering point of view the steel frame structure that supports flood gates. The frame structure consists of truss beams and trestles. Every second truss beam is supported by Gerber-type hinges on their upper chords. Currently, few steel structures have trestles. Therefore, the design concept,

structural characteristics, and maintenance work up to the present time are worthy of investigation.

The Structural Engineering Group is studying the following topics.

- Literature review on the design and the history of repair/reinforcement
- Investigation of corrosion of the steel frame structure
- Analysis of mechanical and material characteristics of steel samples
- Safety evaluation of the steel frame structure
- Influence of temperature on the structure

So far, we have carried out a tensile test, a Charpy impact test, and a material component analysis for steel samples extracted from the frame structure. The test results show that the steel grade is equivalent to 400N/mm^2 class steel, although the absorbed energy values from the Charpy impact test do not satisfy current Japanese industrial standards. For the safety evaluation, a 3D finite element model was created based on design drawings and an on-site investigation. The model was validated through vibration measurements using wireless accelerometers. The temperature stress and thermal expansion coefficient also were measured and compared with the results of a numerical analysis. Through these studies, we examined the influence of different types of the structure on the temperature stress.

Concrete Engineering Group

This group is investigating the deterioration of the concrete structures of the Ohkouzu Diversion Channel and the fundamental properties of the concrete, including its mechanical properties and durability.

1. The state of the damage/deterioration
   The group examined the exterior of the 80-year-old Ohkouzu movablel weir to assess the general level of deterioration. The crack patterns in each concrete member of the bridge of the weir were examined and compared with the results of past investigations of degradation.
2. Basic properties of the concrete
   The mix proportions of the concrete, compressive strength, Young's modulus, and mass transfer resistance in each structural member were investigated and the quality of the concrete at the time of construction was evaluated.

3. Arrangement of reinforcement bars

   The steel reinforcement bars in the control bridge were subjected to a load-carrying test to assess their mechanical performance. The safety of the bridge also was investigated.

4. Durability of the concrete

   The neutralization depth and the levels of chloride and Ca leaching in each structural member were investigated. In addition, the effects of the concrete mix proportions and environmental factors on the progress of deterioration in the concrete members were evaluated.

To learn more about the Ohkouzu Diversion Channel, please visit the following web site:
http://www.hrr.mlit.go.jp/shinano/english/weir/history.html