Current Dam Technology in Japan

Tsuruda Dam Under Upgrading

Photo by the Joint Venture of Kajima and Nishimatsu

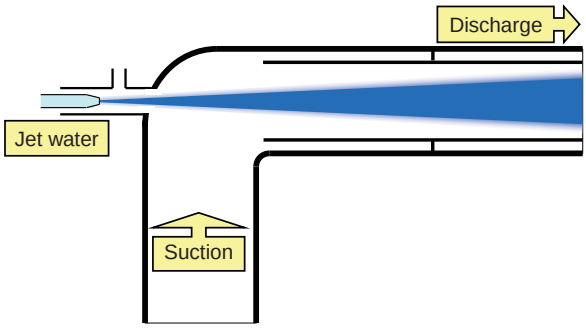
JCOLD

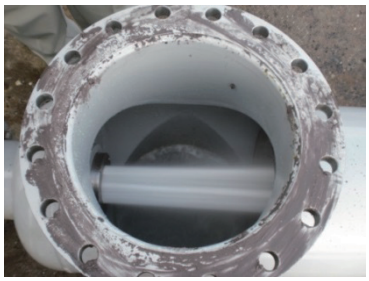
JAPAN COMMISSION ON LARGE DAMS

Sediments and debris on reservoir are no longer a problem by using Special Ejector Pump System <REKIZO> !!

What is “Special Ejector Pump System <REKIZO>”?

The long-term loss of reservoir capacity caused by dam sedimentation is a worldwide serious issue and it is said that more than 30% of the world reservoir capacity will disappear by the middle of 21 centuries. Reservoir sedimentation causes not only the decrease of reservoir capacity but also the rise in the upstream riverbed, decline of the downstream riverbed, recession of the coastline and affects the natural environment and so on. Therefore, with the view of sustainable reservoir operation and integrated sediment management, it is vital to consider necessary countermeasures on sedimentation issues. In this stand, Hazama Ando Corp. developed “Special Ejector Pump System (REKIZO)” to achieve comprehensive dam reservoir sedimentation management.



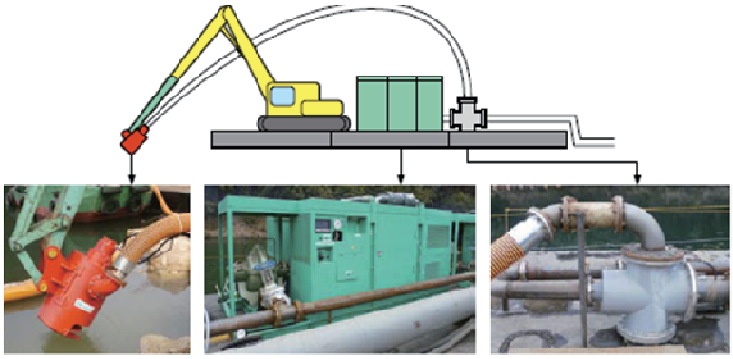


System configuration

■ Suction System

The suction system consists of screw crusher, high pressured pump and special ejector. Screw crusher is installed at the entrance of suction inlet to grind sediment into a proper size, around 150mm, before suction. The sediment of sand and gravel can be suctioned at approximately 35 m3 /hr with the transportation distance of 400m.

“Rekizo”system



Screw crusher　High pressured pump　Special ejector

Material suctioned from the reservoir bottom

■ Transportation System

Transportation system is able to transport sediment by feeding it into a hopper. Compressed air injected into the transportation pipeline enables long distance transportation efficiently. Air injection causes the fluctuation of flow in the pipeline and it creates the special pattern of flow named “Slug flow”. Measured transport rate of direct feeding for maximum 150mm dia. gravel is approximately 50m3/h in case of 600 m transportation length. Maximum transportation length is approximately 1 km.

Feeding system (Hopper station)

Transportation in the reservoir (Pipeline)

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Automatic verification system for dam concrete vibrating work by using “Vi-back”

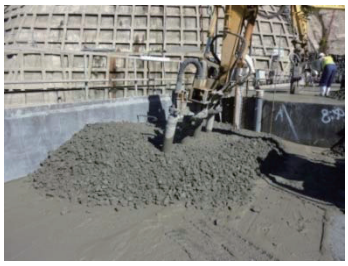
Vibrating Dam Concrete

Vibration of concrete is a critical operation for the construction of dams. What we call a “Vi-back”, and regularly has three or four vibrators on the machine is used during the dam concrete casting. Vibration work is managed by operators to set a proper quality and it is based on observation of the concrete surface. Human error might lead to excessive or inadequate vibration. In order to resolve this issue we have developed an automatic verification system for vibration works: “Shimarisu”.

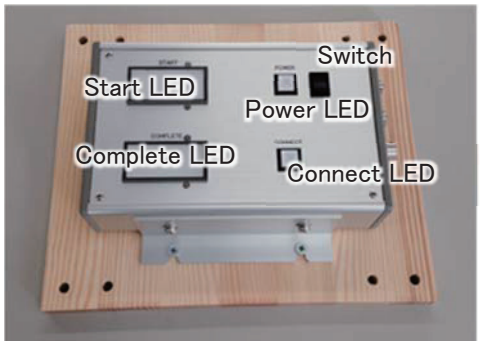
Automatic Verification System for Dam Concrete

The hydraulic pressure load in a vibrator of the Vi-back increases in the beginning because of the rheological changing of the cement-paste and relocation of the aggregate. After that, as proceeding of the liquefaction of the concrete, the friction between concrete and vibrator decrease, and then the pressure decrease as well. The automatic verification system has been developed based on the properties of vibrating concrete mentioned above.

The system collects and analyzes the data from attached pressure sensor in a hydraulic circuit of vibrators in which the decision criteria has been implemented. During the operation a red LED will indicate the required vibration level has not been achieved yet. Once the system determines the criterion has been fulfilled, the LED will turn into blue. The operator can support the status of the quality of the dam concrete not only by the observation but also by an objective standpoint.

Before operation <no light>	During operation <Red>	After operation <Blue>
		
		

System configuration



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Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

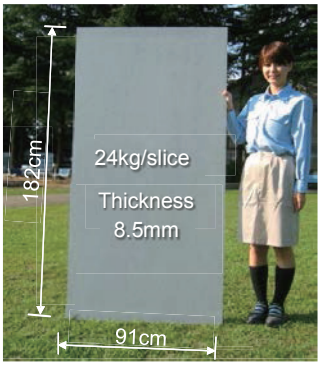
The Smooth Board Method

OBAYASHI

Concrete surface protection method using a high toughness cement board

Summary

The Smooth Board Method is a special formwork construction method using high toughness cement board that has been reinforced with short fibers ,and which is remained after placing concrete (smooth board) .
Smooth board is high toughness and durability despite the thin and light weight. By using smooth board as a surface protection of new structures and existing structures, concrete structures will be improved with its durability.

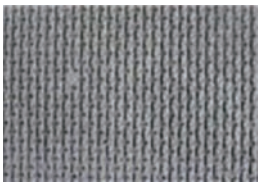


Size of the Smooth Boards

Characteristics

High surface protection performance

- Bending strength is about 8 times the concrete.
- Compressive strength is about 4 times the concrete.
- By applying a water modifier to the back board of the mesh, high adhesion strength between the filled concrete / mortar can be maintained for a long time.
- This board exerts a sealing effect in concrete initial curing, after the concrete has hardened, the harmful substances such as carbon dioxide, salt, will be blocked by this board.
- In addition, this board protects the concrete surface from frost damage in cold climates.



Reverse side detail
(mesh structure)

Physical properties

Item	Test method	Board direction of measurement	Test results
Bending strength	JIS A 1408	Long side direction	32N/mm^2 more※1
		Short side direction	19N/mm^2 more
Bending modulus of elasticity	JIS A 1401	Long side direction	16×10^{3}N/mm^2
		Short side direction	13×10^{3}N/mm^2
Compressive strength	JIS K 6811		107N/mm^2
Coefficient of thermal expansion	JIS K 1325	Long side direction	7.9×10^{-6}/℃※2
		Short side direction	9.7×10^{-6}/ ℃※2
Thermal conductivity	JIS A 1412		0.17W/m℃※3
Bond strength	Adherence test		1.5N/mm^2 more

Note : *1 : 8 times the bending strength of concrete (σ=21N/mm2)
*2 : Almost the same value as the concrete (10×10-6/℃)
*3 : 1/15 of the value of the concrete (2.6W/m℃)

The concrete surface protection performance by the board

Item	Test method	Test results
Freezing and thawing	JIS A 1148 A method	Relative dynamic modulus of elasticity : 96%. No scarring.
Carbonation	JIS A 1153	Carbonation depth in terms of outdoor exposure of 28 years is 1mm.
alt permeability	JSCE G574	Chlorine ion diffusion coefficient : 0.024cm^2/y ※4

Note : *4 : Less than one-tenth of value compared to the concrete

The sales price reduction due to mass production

☐Since this board is mass produced using a papermaking method, we can offer more economical homogeneous product compared to the conventional thick formwork method.

Easy manual installation

☐The thickness of the board is 8.5mm
☐The weight of one board is 24kg.
☐Dimensions: length 1820mm × width 910mm
☐You can handle this board alone.
☐This thin board can easily be cut and drilled in the construction site.

Application

This method can be applied to permanent surface protection of a variety of concrete structures regardless of the new and existing.

Reinforcement of existing tunnel lining concrete	Refurbishment of railway viaduct existing parapets
	
Yokosuka City Enokido tunnel Performed area : 712m^2 Construction period : February 2014	Hokuso Railway Company Performed area : 16,370m^2 Construction period : December 2009

Industrial property rights

・Patents granted

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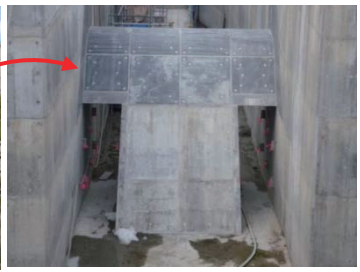
Slim-Crete

Ultra high strength fiber reinforced concrete

Summary

Slim-Crete is a high-ductility and high-strength mortar, and its strength is more than 180N/mm^2 in compression and more than 8.8N/mm^2 in tension. It is one of the material called Ultra high strength Fiber reinforced Concrete (UFC). UFC must be generally kept in a high temperature environment for a certain period of time after casting at a plant, thus its application is limited. On the contrary, Slim-Crete can be kept at normal temperature because its unique mixing ratio, so it can be used at a much wider range of construction site. Since Slim-Crete can be cast even in an actual construction site, cost reduce can be expected.

Applications



Production of the pre-cast material

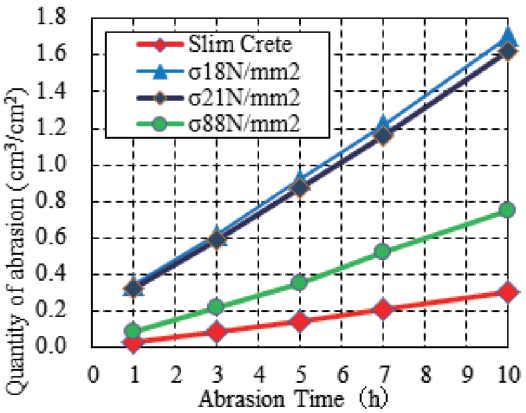
Pre-cast material

Installation

Properties

Abrasion-resistant

- Slim-Crete has a higher abrasion resistance than ordinary concrete.
- Abrasion quantity of Slim-Crete is less than 15% of ordinary concrete.



Industrial property rights

- Patent pending
- Trademark registration
  No. 53442990/Slim-Crete

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Current Dam Technology in Japan

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Automated dam concrete delivery system

OBAYASHI

Full automation of dam concrete placing

Summary

A computer centrally controls the process of concrete delivery operations from batching plant to the placement at the correct coordinates.
(Utilized at the Tomisato Dam, Yomasari Dam, etc.)

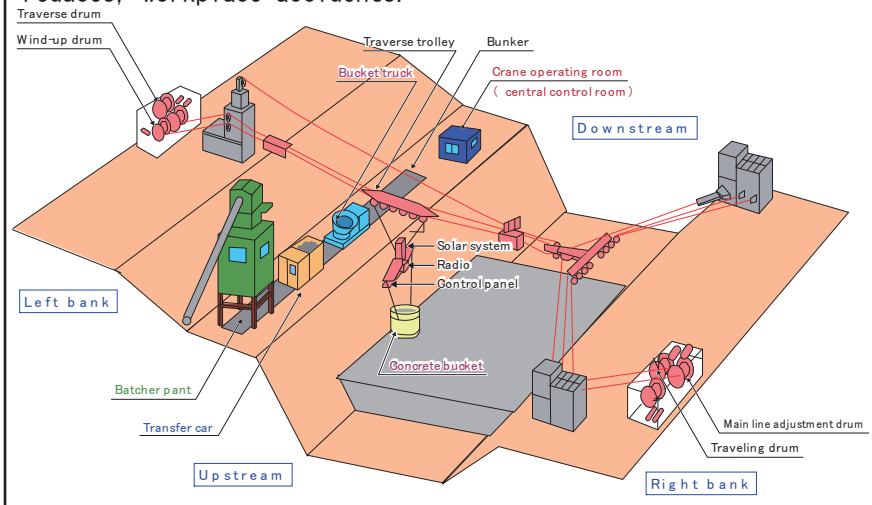
Shortens the concrete placing duration

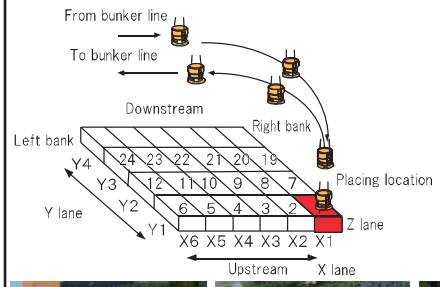
・Computer control can prevent incorrect operations and/or incorrect placement, thereby increasing the production.

・Even when visibility is poor, this system allows normal operations to continue.

Ensuring safety of workers

・Performing unmanned concrete transportation in conjunction with safety shutdown sensors reduces, workplace accidents.





Industrial property rights

・Patents granted

Bunker line (batcher plant)

Placing location

Site constructed : Yomasari Dam

Simply by entering the target coordinates, widths and lengths of lanes to the computer, automatically transports the concrete

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Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

CSG technology using a new high volume continuous mixer (DKP-VI mixer)

OBAYASHI

Rapidly producing large quantities of embanking materials

Summary

This is a continuous mixer capable of quickly producing large quantities of CSG, which is the material used to build the body of a trapezoidal CSG dam. This CSG mixer equipment has been approved by the Japan Dam Foundation. (Utilized at the Asakawa Dam)

Merits

Uniform quality

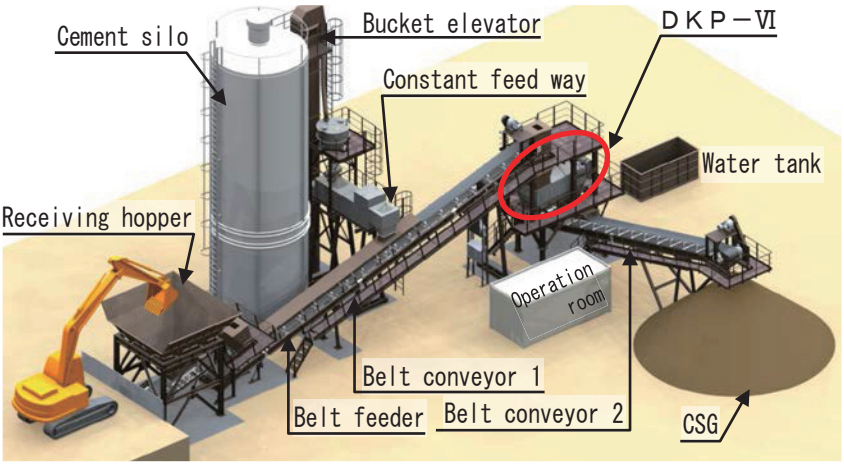
・It provides a mixing process and performance identical to those of a 2-shaft forced mixer, and is capable of providing uniform CSG quality in a short mixing time.

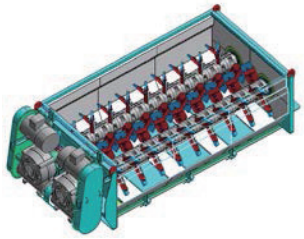
Compact equipment installation area

To reduce the area required to install the plant, the height of the overall equipment is lowered and the belt conveyor is shortened. The weighing device, which was installed on the top in conventional concrete production equipment, is now installed above the belt conveyor.

・It is also suitable for emergency restoration work or road work, and with installation area reduced by approx. 50% it can easily be installed on small temporary site.

Schematic diagram CSG new mixing equipment





Internal structure of the mixer

Mixing capacity
(100 to 300m³/hour)

DKP mixer

Asakawa Dam

Note: A DKP mixer is Japan Dam Foundation (Damu-Kyokai =DK) approved pipe (P) method mixer, and a DKB mixer is a Japan Dam Foundation ((Damu-Kyokai =DK)) belt conveyor (B) method mixer

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Current Dam Technology in Japan

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2014060

Sediment discharge by the mobile suction method

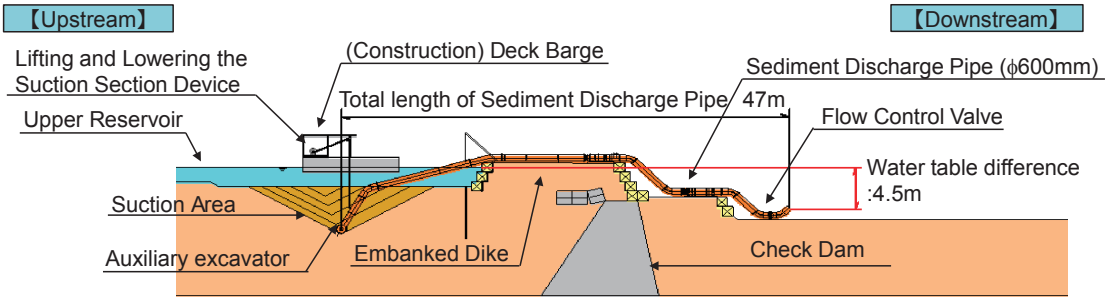
Sediment discharge technology for dam reservoir

OBAYASHI

—Discharging sediments by the suction method utilizing the water head difference—

Summary

Sediment discharge by the mobile suction method using the water head difference is the a system that discharges sediments, suctioned together with water by the of siphon principle using the water head difference, downstream through a discharge pipe.
The mobile type can freely move the suction point with the barge and it can control the sediment discharge capability by vertically moving the suctioning part.



Good point, effect

1. **Low running cost**

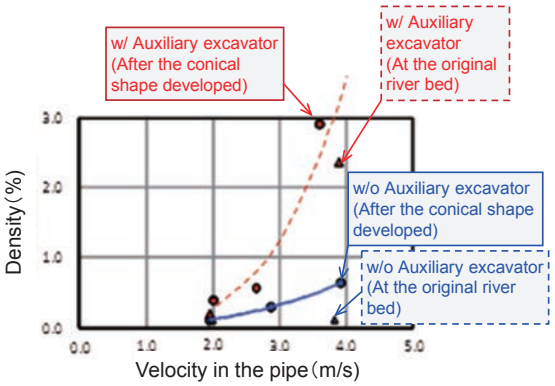
   Almost no fossil fuel is consumed to power the system.

2. **Not take effort for maintenance**

   Structure is simple and not have the machines such as pumps.

3. **Work efficiency improves**

   Work efficiency improves by the use of the auxiliary excavator.



Effect on sediment density of the auxiliary excavator

4. Garbage is hard to be clogged up

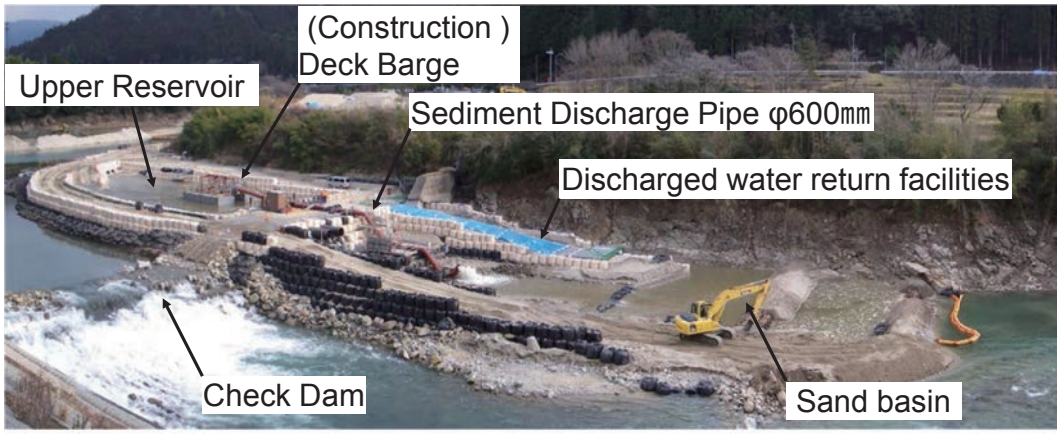
No obstacles in the discharge pipe that prevent discharge of the sediments.

Discharged sediment

Discharged sunken wood

Results, application example

Substantiative experiment at study of discharging sediments by the suction method utilizing the water head difference at the Yahagi dam (The Chubu Regional Department MLIT)



Experiment facilities at Yahagi dam

Main use

The discharging sediments in all dam reservoir applies(But the securing of water level difference is necessary)

Industrial property right

Patent pending.(The mobile suction method developed jointly by Obayashi Corp. and Damdre Corp.)

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GPS compaction control system α(alpha)system

Work area compaction control by monitoring lift thickness,passes and density

Summary

The GPS construction control support system consists of a GPS positioning receiver and angle sensor on the bulldozer or roller compactor. This allows the operator to control the spreading thickness of embankment,traveling tracks,and number of roller compaction passes. The α(alpha)system consists of an acceleration sensor installed on the roller compactor. It judge the ground stiffness or degree of compaction based on the acceleration response during compaction in real time. Both technologies can be applied to RCD method or CSG method or road earthwork.
(Utilized at the Aratozawa Dam, Moriyoshizan Dam)

Merits

GPS compaction control system,allowing more efficient embanking construction

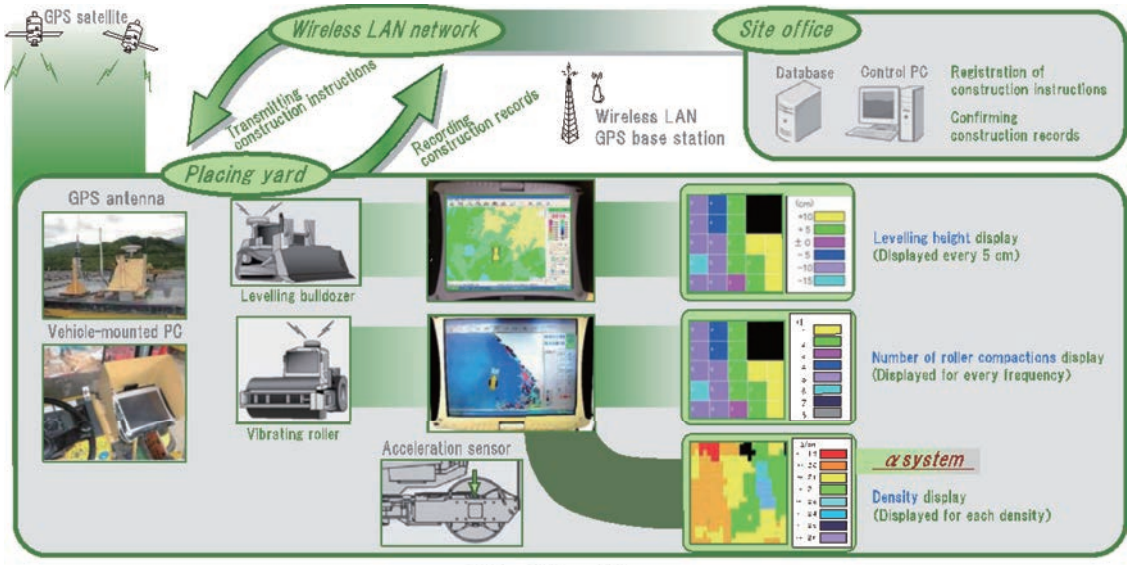
・ It obtains location, track, and elevation data from a GPS satellite. It allows to construct more homogeneous embankments increase the production with better quality control.

αSystem automatically obtains ground stiffness and degree of compaction data

・ During the lift placement,the system automatically obtain ground density for the roller compacted surface,and allows for reports to be quickly submitted to the client.

Can be used with various kinds of roller compactors

・ Because parameters can be set to match the standards and the performance of the roller compactor, it can be applied to various kinds of machines.



System Outline Diagram

Industrial property rights

・Patents granted

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LCC-Navi: LCC Evaluation System for Concrete Structures

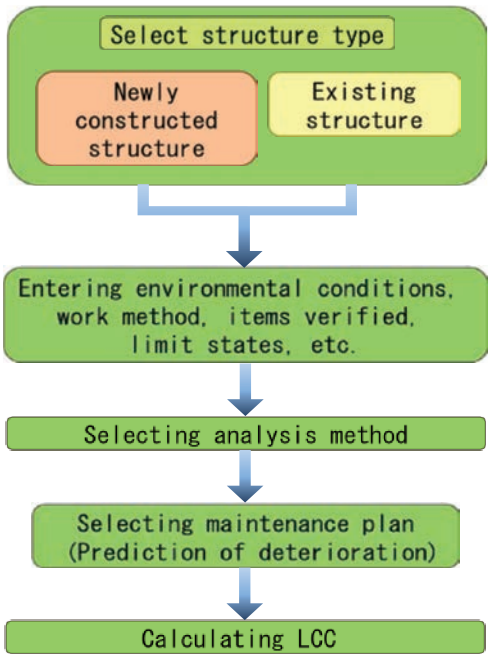
Maintenance Planning System Considering Life Cycle Cost

Summary

Many concrete structures constructed in the high economic growth period have reached the time when they must be renewed. Planning repairs and planning maintenance should be optimized by predicting costs that will be incurred during service period of the structure.

Tt is also becoming increasingly necessary to minimize total costs including initial construction cost and maintenance cost of newly constructed structures.

LCC- Navi is a tool that can predict deterioration of a concrete structure based on the most advanced knowledge, permitting the selection of the most appropriate method from among repair methods in general use and from each company's proprietary methods, making it a tool essential for the preparation of rational maintenance plans.



Merits

Prediction of deterioration based on the most advanced knowledge

・Prediction of chloride induced deterioration (considering the steel corrosion and state of cracks)
・Prediction of carbonation
・Prediction of chemical attack
・Prediction of frost attack
・Prediction of multiple deterioration (chloride induced deterioration , carbonation, frost attack)

Permits selection of a company's proprietary method

・It covers repair methods in general use.
・A contractor can also select one its own proprietary methods (“Smooth board”, “Slim-crete” etc.)

Visualizes results of evaluation

・Users can see prediction of deterioration and life cycle cost results at a glance.
・Users can compare this with the situation if the repair is not done.

Usable as a repair method data base

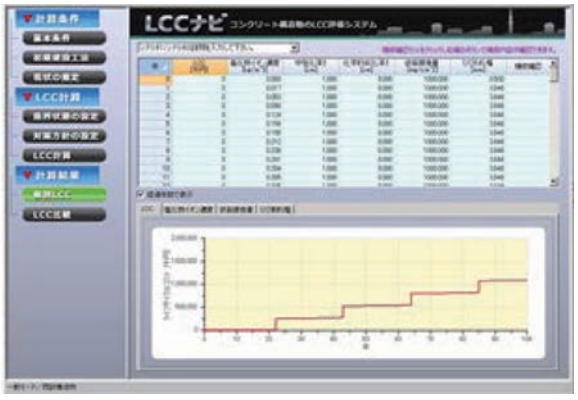
・It can be used as a repair method data base.
・It can always perform evaluations including the newest work methods, because newly developed repair methods can also be added to it as they are completed,

Examples of past use and applications

(Usability of LCC-Navi)

With LCC-Navi, you predict the deterioration of both a newly constructed or existing structure, calculate its life cycle cost, and display the results on a graph simply by entering structure conditions, environmental conditions, repair conditions and other factors on the screen of your PC.

Entry Screen (all conditions entered)



Sample output (Graph of LCC)

Application

(Range of application of LCC- Navi)

・It can be applied to newly constructed or existing structures of various kinds.

・It can deal with chloride induced deterioration, carbonation, chemical attack, frost attack, and multiple deterioration and so on.

Deterioration caused by each deterioration factor is predicted.

[1] Chloride induced deterioration (diffusion equation)

[2] Carbonation (carbonation rate)

[3] Chemical attack (hydrogen sulfide concentration)

[4] Frost attack (water cement ratio)

[5] Multiple deterioration (chloride induced deterioration, carbonation, frost attack)

Bridge (chloride induced deterioration)

Dam (frost attack)

Industrial property rights

Patents granted

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DEHYDRATION SYSTEM

Introduction

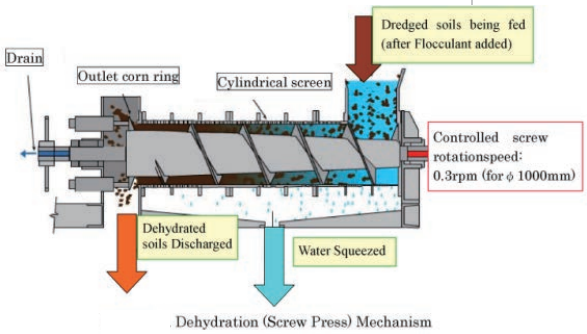
"Solid-liquid separation", "Dehydration" and "Recycling" technologies are required currently in the dredging works in dam lakes due to dam malfunction caused by increase of sediment slurry in the dam lakes. We, OKUMURA CORPORATION have developed low cost and efficient disposal system in difficult conditions such as narrow working site.

System Features

(1) Use of the screw press minimizes an area required for installation, reducing 25% and 90% in comparison with dehydration by filter press and natural drying respectively, which can be used in the very limited working space.
(2) Continuous operation is possible. Cost for dehydration process is saved owing to improvement in mechanical efficiency and manpower saving, comparing with filter press.
(3) The screw press is applicable to a wide variety of soils, when the primary (sand) separation plant is suitably selected.
(4) Structure of the screw press is simple enough to dispense much of routine adjustment or checking, and thus maintenance is very easy.
(5) Adverse impact to the environment due to noise or vibration is utmost mitigated as the rotational speed of the screw is low.
(6) Electrical consumption is reduced by 15% comparing with other dehydrating plants.

Outline of screw press

After the polymer flocculant is added, the slurry containing dredged soils is fed into the mouth of the screw press. The slurry is slowly moved forward corresponding rotation of the screw. As the clearance between the cylindrical screen and the screw shaft of corn shape becomes narrower, the slurry is more pressed, and the water is more squeezed from the slurry and soils. At the outlet of the screw press, a corn ring was fitted. The ring was pneumatically pressed against the dehydrated soils while the dehydrated soils were discharged pushing the ring back. The water was squeezed out through the cylindrical screen.



Dehydration (Screw Press) Mechanism

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Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

Floating T ype T emporary C offerdam M ethod

Innovative Dam Redevelopment – A New Coffering System for Underwater Work–

Feature of technology

With t he f loating t ype t emporary cofferdam method, steel plates (skin plates) are attached to both the inside and outside of the bulkhead, the t emporary c offerdam bar rier t hat i s integrated i nto t he bas e is f loated, and is supported by installing an anti-buoyancy brace on t he t op bar rier of t he dam bod y. T he construction assembles barrier blocks made at the site on the reservoir surface, tows them to the i nstallation p osition, pulls t hem b y winch and secures them. The floating type temporary cofferdam m ethod--assembling an d i nstalling while adjusting the ballast by filling and draining water from a reservoir--is the first of its kind in the world.

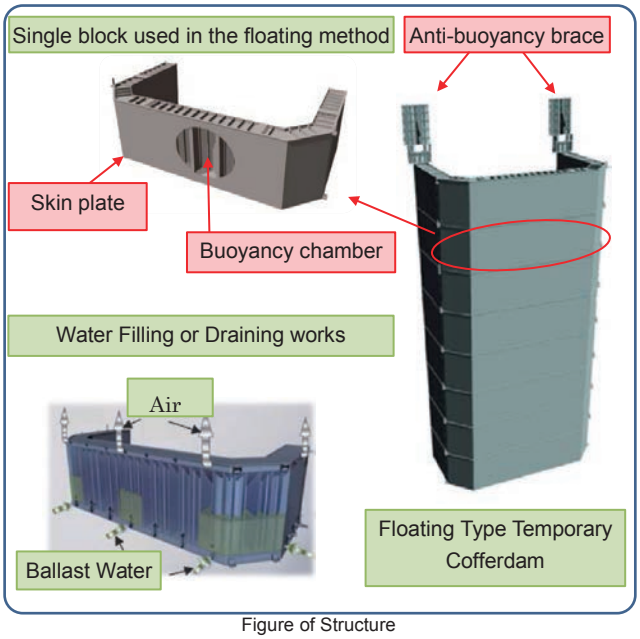
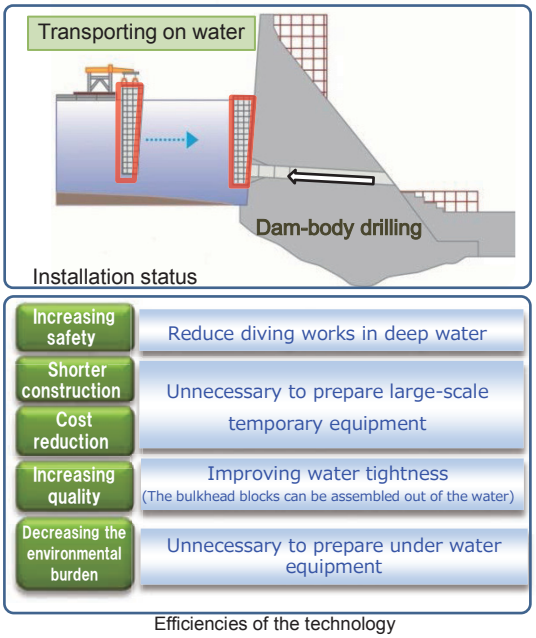


Figure of Structure



Efficiencies of the technology

Technology developers:
Kajima Corporation; Hitachi Zosen Corporation
Joint developers:
Ministry o f Land, I nfrastructure, Transport and Tourism Kyushu Regional Bureau; Japan Dam Engineering Center

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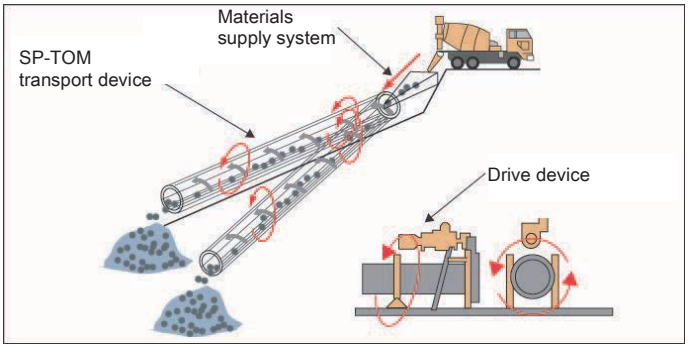
Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

New Construction Technologies

SP-TOM (Special Pipe Transportation Method)

This method can transport large quantities of concrete, soil and stone stably and continuously, by rotating a steel-pipe which several hard rubber blades are installed in a spiral pattern inside. The pipeline is installed on the slope.



SP mixer (Special Pipe mixer)

This mixer was developed to mix CSG materials. This method is to mix materials passing through the interior by rotating a mixing tube equipped with blades inside the mixer.

The mixing tube is installed to incline. The self-weight of the CSG materials cause them to flow through the mixer. This mixer has two mixing effects inside its mixing tube; forced agitation by drive power and falling

Patent:
Incorporated Administrative Agency Japan Water Agency; KAJIMA CORPORATION; OBAYASHI CORPORATION; TOBISHIMA COPORATION; Kumagai Gumi Co., Ltd.; The Zenitaka Corporation; Osakasaiseki Engineering Corporation

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Sediment Bypass System at Asahi Dam

1. Introduction

At the Asahi Dam of Kansai Electric Power Co., Inc., a sediment bypass system was built to take a fundamental measure to control prolonged water turbidity and the progress of rapid sedimentation ascribable to the collapse of mountain slopes caused by a great flood of 1990 and has been operated since 1998. The effectiveness of the bypass system was verified after the commencement of system operation for controlling prolonged water turbidity and the progress of sedimentation in the reservoir.

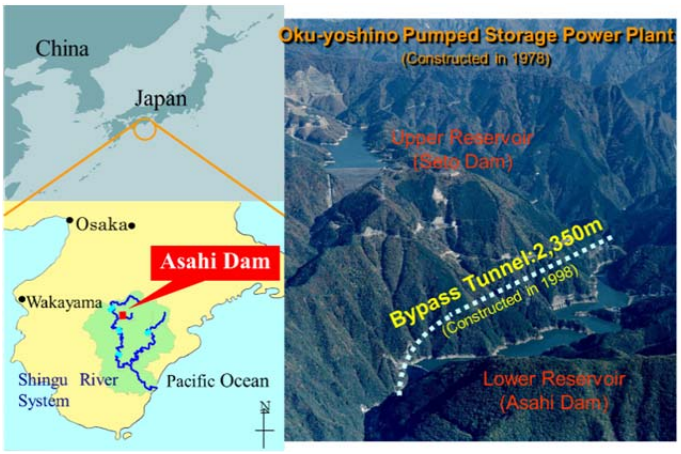

Fig. 1 Location

2. Technical Topic

The bypass system was adopted through the solutions for some technical challenges in the design stage.

(1) Tunnel capacity to mitigate both prolonged turbidity and reservoir sedimentation

The sediment bypass system was designed to treat bed load and suspended load besides wash load from the purposes of mitigating both prolonged turbidity and sedimentation. There were two requirements for the bypass system. One was to eliminate most of the prolonged turbidity when the peak inflow was 200m^3/s, which is the 1-year return period inflow. The other was to flush all of bed load from the upstream when the peak inflow was 1,200m^3/s (100-year flood) which is the dam design flood. The capacity of the bypass system was determined as 140m^3/s by performing simulations.

(2) Function of flushing bed load

The entrance of the tunnel was composed of a diversion weir and an orifice intake, which would be desirable for flushing bed load. With these structures, the volume of water and sediment into the tunnel could be naturally regulated.

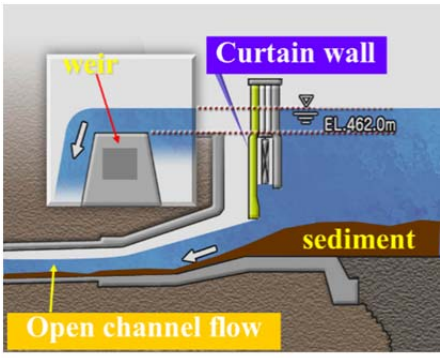

Fig. 2 Intake cross section

3. Monitoring

(1) Effect of prolonged turbidity and reservoir sedimentation

Water was turbid for 50 to 130 days during the year on the average before. The average number of days of prolonged turbidity was reduced to about ten after the start of operation. In the meantime, it was estimated that 80% of the total sediment at the Asahi Dam that would have deposited without the bypass system was bypassed downstream.

4. Maintenance

(1) Actual abrasion

Abrasion was observed nearly throughout the invert in the tunnel section. Repair was made periodically using high-strength concrete (design strength: 70 N/mm^2). Therefore how to increase the efficiency of periodical repair is an issue. The distribution of cumulative abrasion was confirmed to have a certain planar tendency. The depth of abrasion is locally larger near the tunnel outlet than near the tunnel intake. In the transverse direction, abrasion was predominant on the right bank side at the intake and on the left bank side at the outlet. The maximum cumulative abrasion depth on the left bank side at the outlet was largest at 1272 mm.

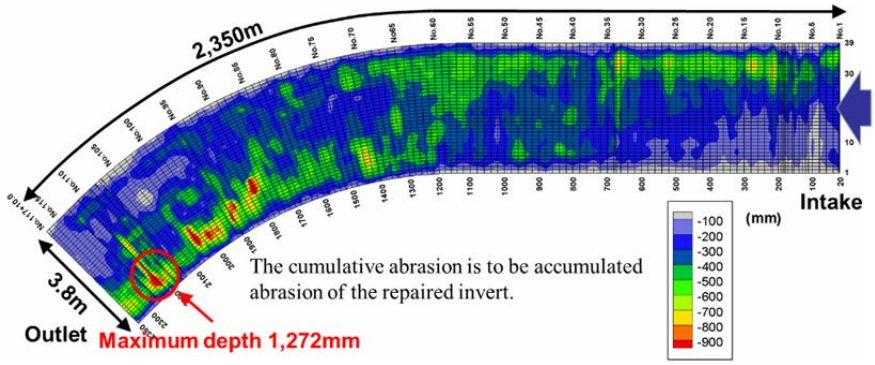

Fig. 3 Cumulative abrasion in the tunnel invert

(2) Abrasion control measures

The abrasion control methods are selected from the reinforcing material of high-strength concrete, steel plates, stones and resins proven to be useful in preventing abrasion. These methods shall be compared with one another in terms of life-cycle cost. Combinations of repair methods that are fit for the location shall be examined considering the distribution and volume of abrasion at areas currently subjected to abrasion, using the ease of construction, cost and the frequency of repair as parameters.

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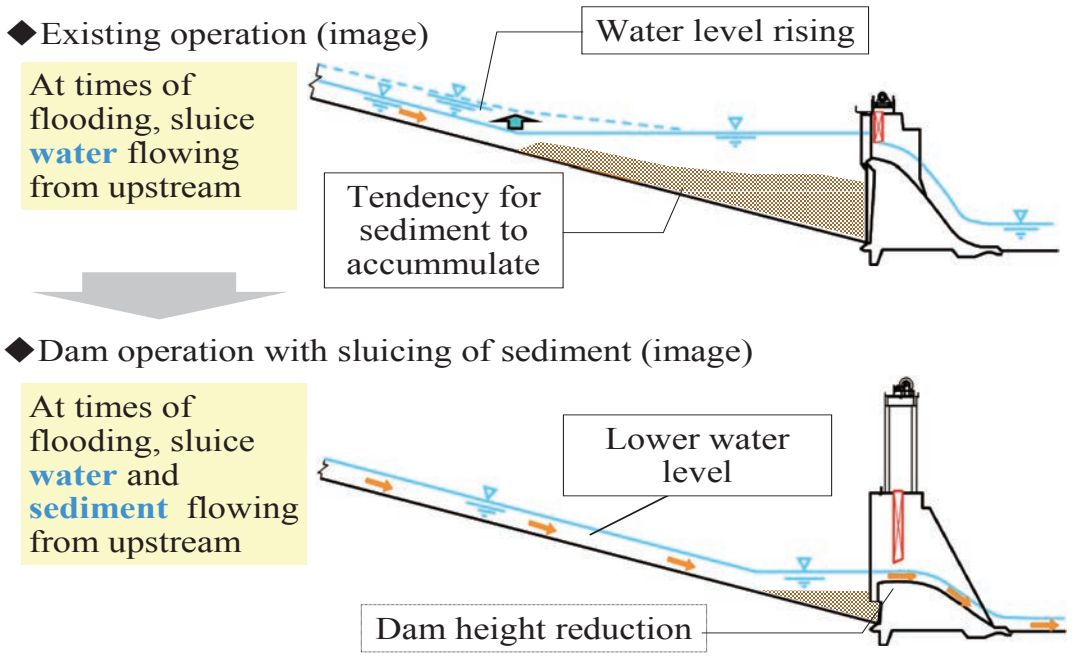
Dam retrofitting work and advanced retrofitting techniques to prepare damsfor sediment sluicing in the Mimikawa River Basin, Japan

Sediment s luicing i s pl anned f or Yamasubaru, S aigou a nd Oouchibaru Dams on t he Mimikawa River, which are administered by Kyushu Electric Power Company. In order that water level can b e l owered s ufficiently at times o f r iver flooding, cr est g ate r etrofitting w ork o n Yamasubaru and Saigou Dams is currently being carried out.

While work is being carried out, a temporary cofferdam is installed upstream of each dam, and the river diverted through a headrace to allow power generation to continue. In addition, there is the issue that while retrofitting work is in progress, it is necessary to discharge water from dams safely during flooding, in the same way as up unt il now. As shown in Fig. 3, to resolve this, a 4m high steel-rubber gate (SR gate) has been installed in the upper part of the temporary cofferdam, the first instance of such a measure being taken in Japan.

(1) Sluicing of Sediment – Overview



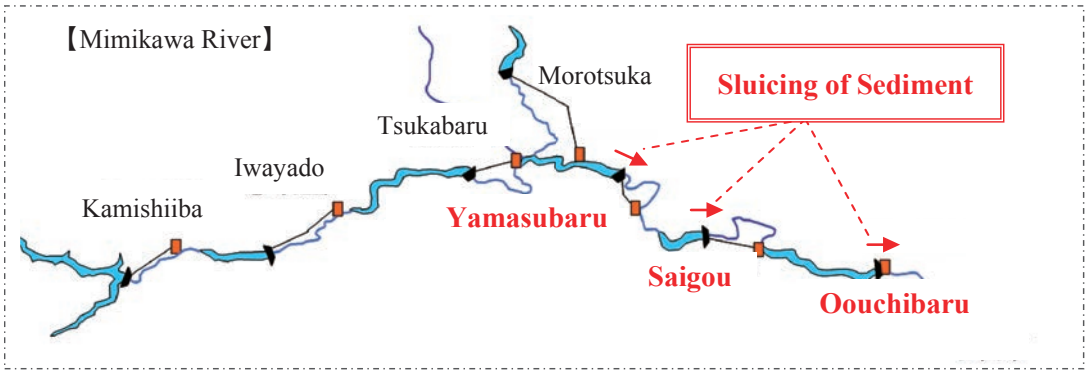


Fig1. Sluicing of Sediment - Image

(2) Dam Retrofitting

Fig2. Dam Retrofitting - Image (Yamasubaru and Saigou Dams)

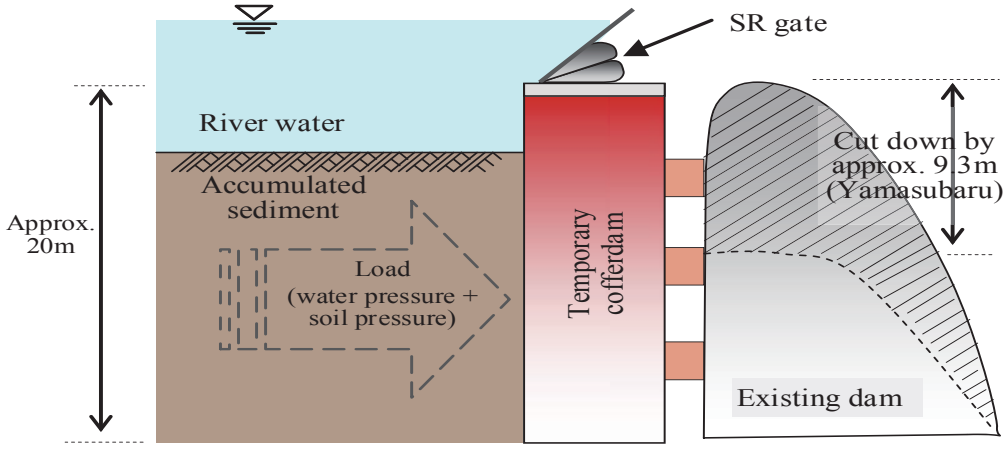


Fig3. Schema of Temporary Cofferdam Installed Upstream for Period of Dam Retrofitting Work

Fig4.SR gate (Saigou Dam)

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Forecast of Large-scale Sedimentation by Using the Distributed Runoff and Sediment Runoff Model

Abstract

- It is important to forecast large-scale sedimentation for sustainable dam reservoir management (reservoir risk management).
- "The Distributed Rainfall and Sediment Runoff Model (DRSR Model)" was developed to forecast the sediment yield into reservoirs during calamity such as heavy rainfall disaster.

Slope Failure and Sediment Runoff Model

- Slope failure model
  - ✓ Physically-based slope stability (the infinite slope stability model)
  - ✓ Rainfall index (Total amount of rainfall and rainfall intensity)
- Sediment runoff model
  - ✓ Bed material load : Equation of Ashida and Michiue
  - ✓ Suspended load : Non-equilibrium suspended load
  - ✓ Grain size : Mixed grain size

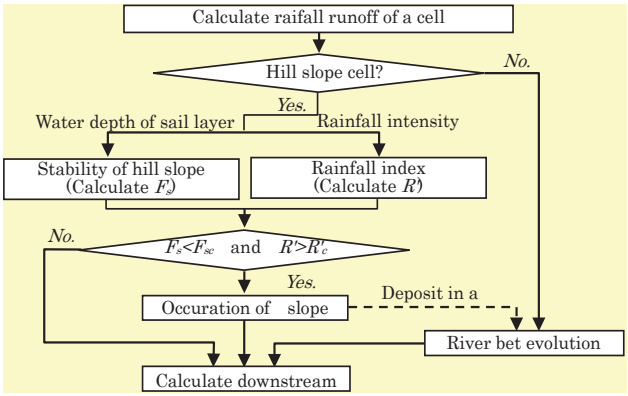

Fig. Calculation Flow of Slope Failure Model.

Slope Failure Simulation (Application to Yahagi-Dam Basin during Tokai Heavy Rains)

- ✓ The DRSR model shows very good prediction result of slope failures, which is in good agreement with the locations of actual slope failures recognized by detailed aerial photo interpretation.

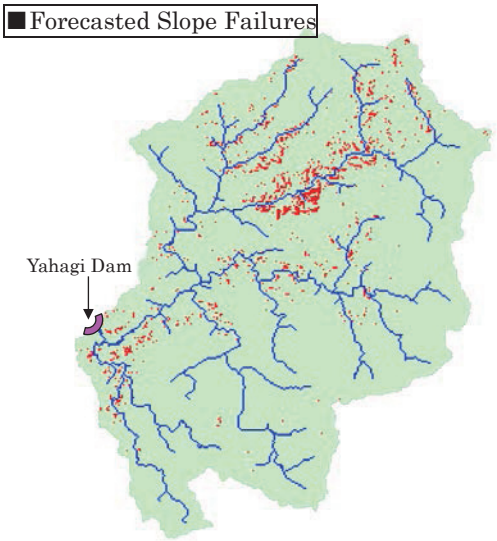

Fig. Distribution of Failed Slopes (■:failed slope).

■ The Transportation Process of Failure-Generated Sediments

✓ The DRSR model enables separate tracing of sediments from different sources, bed sediments and failure-generated sediments.

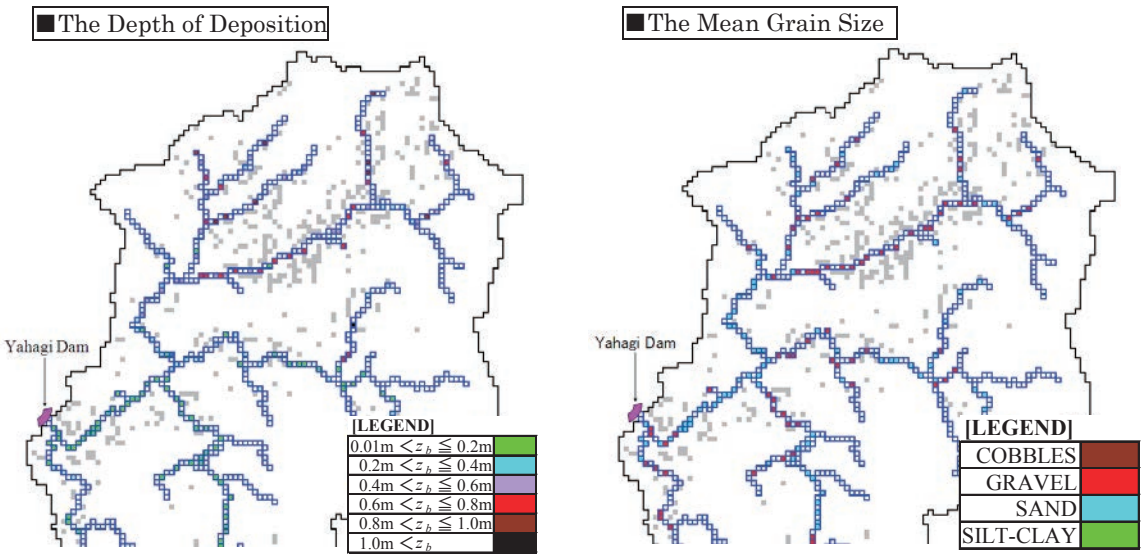

Fig. Distribution of failure-generated sediments at 24 hours after the slope failure occurred (□:river channel ■,■:depth or grain size).

■ Estimation of Sediment Inflow into Dam Reservoirs

✓ The DRSR model can estimate the sediment inflow into dam reservoirs during a torrential rainfall, for each grain size and per sources.

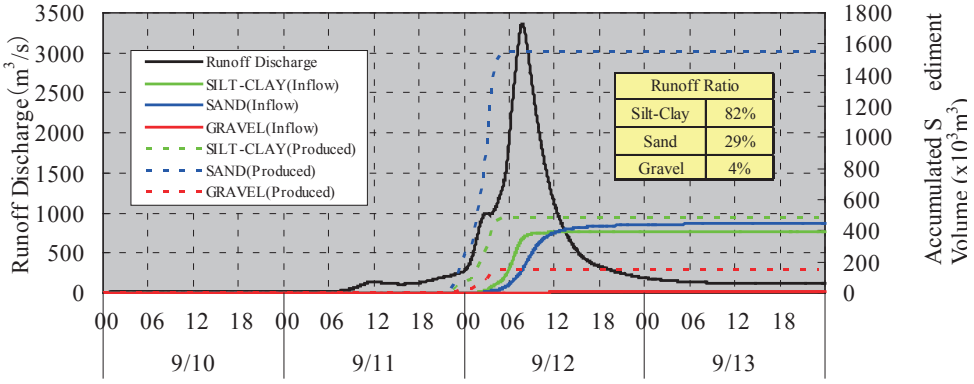

Fig. Accumulated Sediment Production and Inflow by Grain Size.

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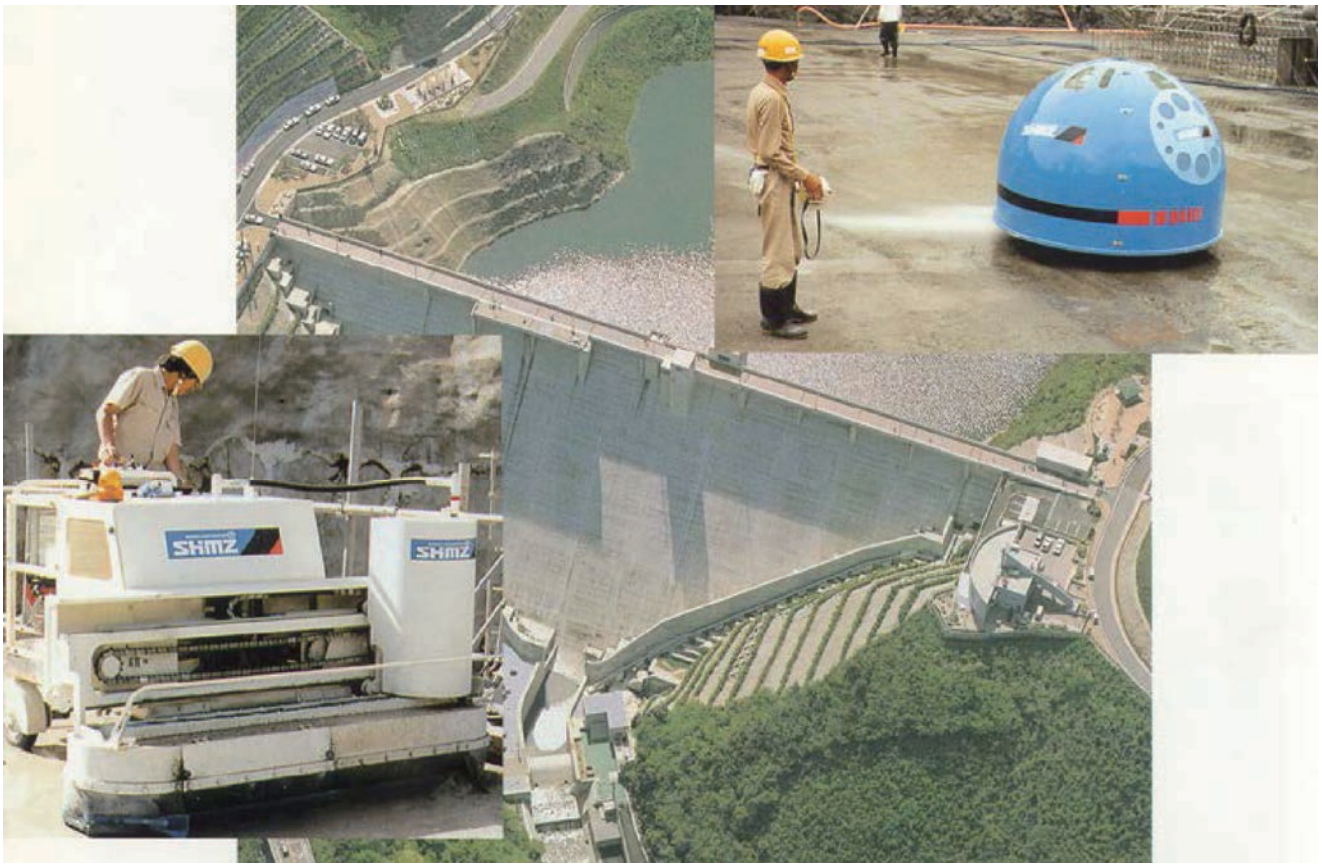

Compact and maneuverable robot makes it possible to efficiently cut away laitance !

Green cutting robot for dam concrete

Shimizu' s green cutting robot for concrete can cut away laitance, which is a concrete scale on the joint surface while placing concrete at the dam sites and its remote control enables the efficient cutting works. It is applicable to a narrow area of construction sites because of its high mobility due to the light weight and the compact size compared to the conventional cutting machines. Applying the robots considerably enhance the productivity of the working area per hour. Two types of robots are available, brushing type and water-jetting type, depending on the different construction methods.

Conventional methods using high-pressure washers or wire brushes possess problems such as requirement of a lot of skilled workers, the workers easily getting wet, and necessity to handle the machine for a long time. The green cutting robot solves these problems at once by improving the work environment, saving labor, and increasing the work efficiency during the placing concrete at dam sites.

■ Features

- -It ensures the process of cutting away the laitance and guarantees a higher quality of concrete bonding surface.
- -It can be remote-controlled, which enables the cutting area per hour approximately three to five times larger than that achieved in the conventional manual work.
- -The robot size has been reduced to one-third of the conventional cutting machines. It can travel freely in all directions and therefore efficiently handle laitance even throughout a narrow area.

Brushing type

- –Three rotating wire brushes are pressed on the concrete surface with a certain force to efficiently cut away the laitance on the joints.
- –Cutters themselves rotate 360 degrees, which enables the even cutting and removal of laitance.
- –The force for pressing the brushes and the travelling speed can be adjusted according to the concrete strength.
- –This type of robot is best suited when the RCD method is applied, which uses concrete with extremely stiff consistency.

Brushes

■Basic specifications

Type of vehicle	Tired mobile vehicle
Size and weight	Outer diameter: 1,800 mm. Total height: 1,300 mm. Cutting width: 1,600 mm. Weight: 700 kg.
Traveling performance	Traveling speed during installation: Maximum speed: 10 m/min
	Traveling speed in service: Maximum speed: 6.8 m/min
Brushes	Three brushes of outer diameter of 350 mm
Safety devices	Touch sensors, bar sensors and rotating lights equipped with a buzzer
Operation method	Wireless remote control

Water-jetting type

- –High-pressure injection nozzles both rotates and slides from side to side in order to cut away and remove the laitance.
- –90-degree turn is possible with a single touch of a button.
- –Water pressure, jetting distance, and traveling speed can be adjusted freely. The cutting and removal work can therefore be performed according to the concrete strength.
- –This type of robot is best suited when the extended layer construction method or the columnar concrete placement method is applied, which uses conventional dam concrete with a high fluidity.

Cutting by wireless remote control

Rotating part of the Nozzles

■Basic specifications

Type of vehicle	Tired mobile vehicle
Size and weight	Total length: 1,700 mm. Total width: 2,000 mm. Total height: 1,200 mm Cutting width: 1,700 mm. Weight: 1,000 kg.
Traveling performance	Traveling speed during installation: Maximum speed: 15 m/min
	Minimum turning radius: 4.2 m
Head	Maximum: 200 kgf/cm^2 x 100 l/min x 400 rpm
Nozzle	Uniform fan-shaped nozzle
Safety devices	Touch sensors and rotating lights equipped with a buzzer
Operation method	Wireless remote control and on-board operation

*For construction, jet pumps are required separately.

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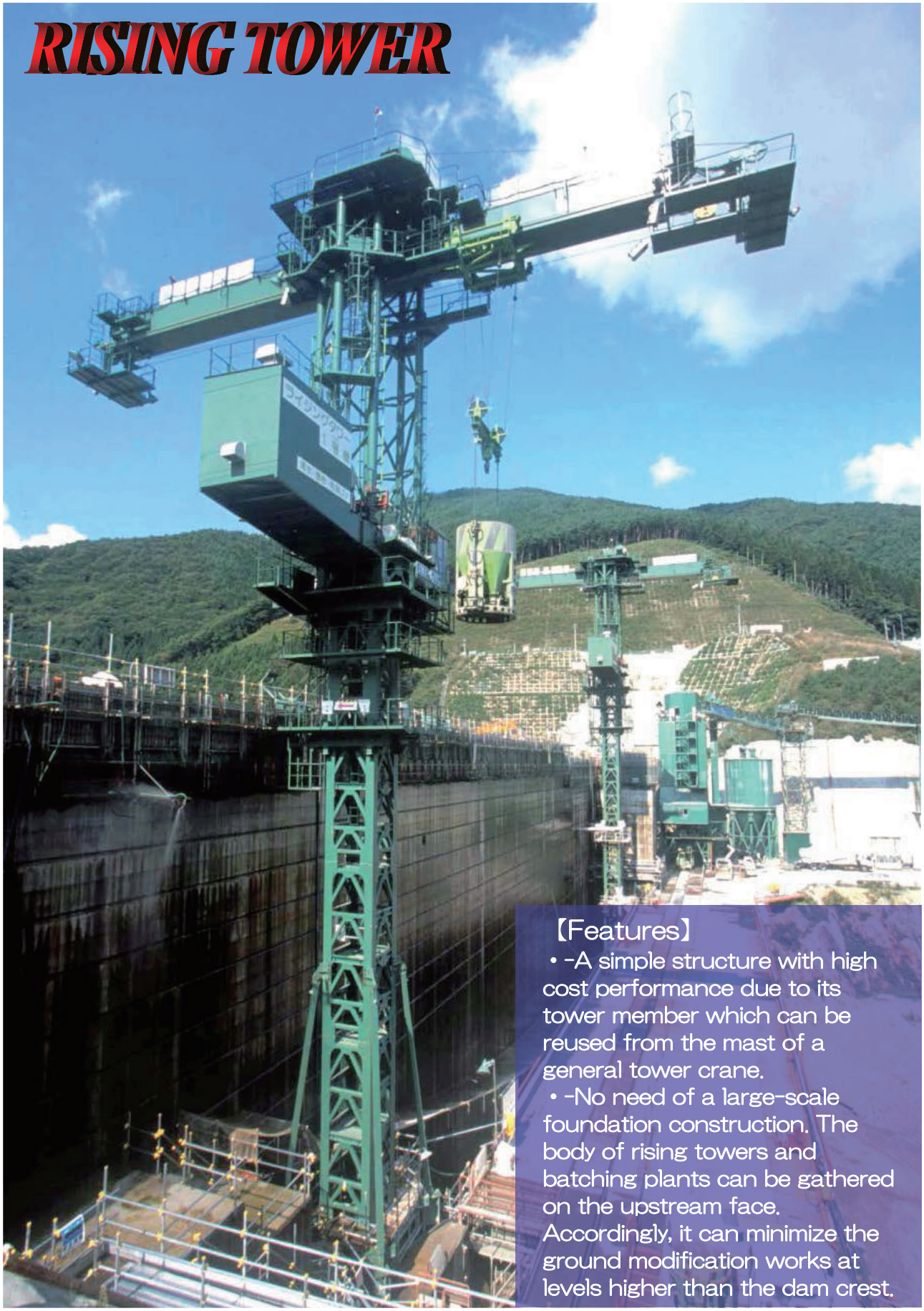
Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

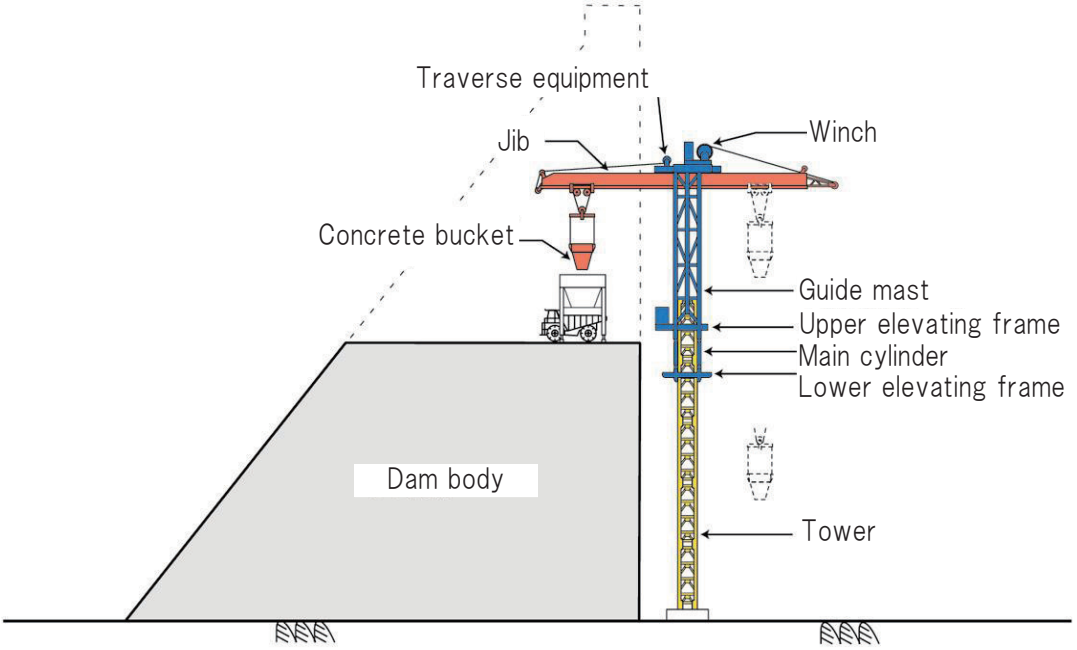
RISING TOWER



【Features】

• -A simple structure with high cost performance due to its tower member which can be reused from the mast of a general tower crane.

• -No need of a large-scale foundation construction. The body of rising towers and batching plants can be gathered on the upstream face. Accordingly, it can minimize the ground modification works at levels higher than the dam crest.



・Lifting force		17.1 t
・Rated load		16.5 t
・Maximum capacity of bucket		4.5 m^3
・Length of horizontal jib		19.0 m
・Lifting velocity	full load	71 m/min
	empty load	76 m/min
・Lowering velocity	full load	71 m/min
	empty load	142 m/min
・Traverse velocity		40 m/min
・Maximum lifting power		250 kW
・Maximum power of traverse equipment		7.5 kW

Example: Takoh Dam.
Height = 77m. Volume = 310,000 m^3

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SFWD Automatic Ground Evaluation System
Super FWD

is an advanced ground evaluation system applicable to any type of ground by using state-of-the-art precise ICT (information and communications technology).

Features

The multi-stage loading and accumulated displacement method enables to identify the modulus of deformation and yield bearing capacity of the ground quickly and conveniently with highly accuracy. This measurement method has the highest correlation with plate loading tests or field California bearing ratio tests among the existing technologies.

1 Multi-stage loading and accumulated displacement method

By applying incremental loads continuously with multiple stages, cumulatively increasing displacements are acquired. Based on the load-displacement relationship, a stiffness module and a load bearing capacity of the ground are estimated.

2 Loading plates of 450- and 300-mm diameters

A loading plate of 450-mm diameter is applicable. It enables to evaluate the underground to a depth of 120 cm*. The stiffness of the compacted ground composed of gravelly soils of large grain size can be identified accurately.

*Measureable depth from the surface is approximately 2.5 times the diameter of the loading plate.

3 Fully automatic control using computers

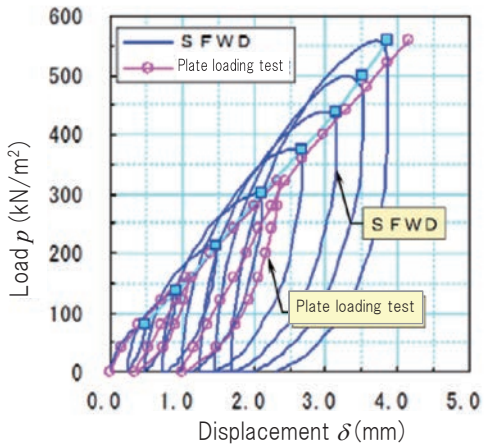
All the operations, starting from the installation of loading plates to the measurement and retraction of loading plates, can be fully and easily controlled automatically by using computers.

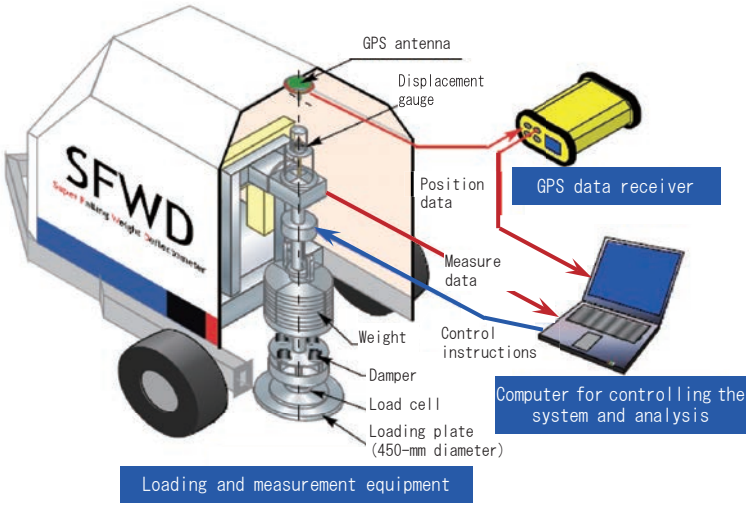
4 Multifunctional software

The SFWD software has various functions such as the full automatic control of the system itself, navigating to the measuring point by acquiring GPS positional information, outputting the management ledgers, and outputting distributions of the modulus of deformation.

Comparison between loading behavior of plate loading tests and that of SFWD

SFWD enables the measurement of accumulated displacements during the multi-stage loading and provides the behavior equivalent to that acquired in plate loading tests.

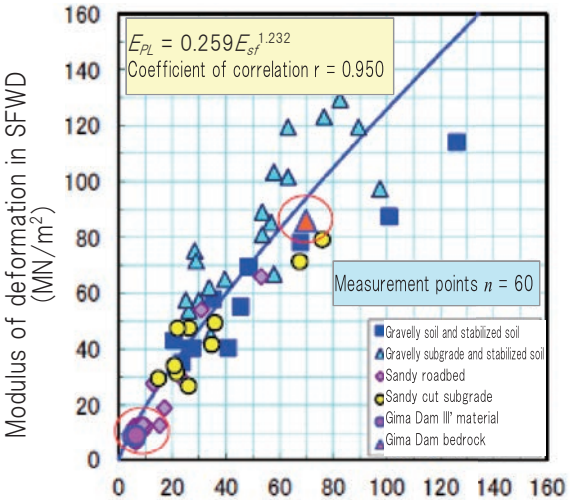




Correlation between SFWD and plate loading tests

Obtained modulus of deformation in SFWD has a high correlation with that in plate loading tests, E_{pl}. The correlation equation is applicable to the various types of soils. It has been also applied at dam sites.

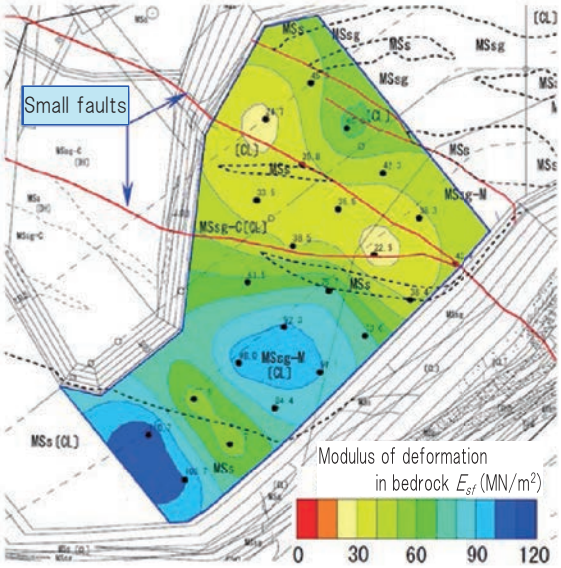
Testing material of No. III in the Gima dam zone

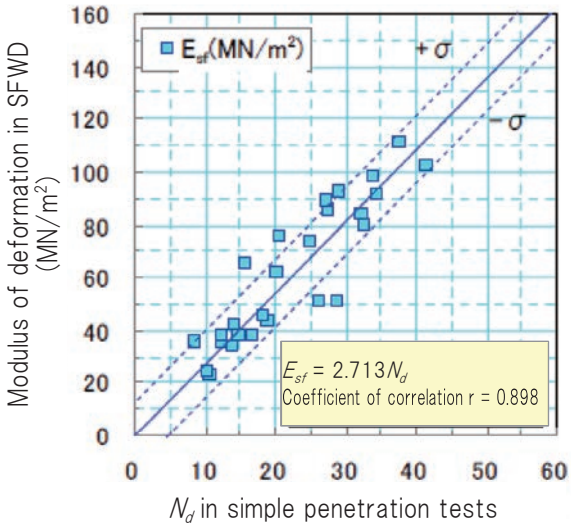


Application to the dam foundation ground

Obtained modulus of deformation in SFWD has a high correlation with N_d value acquired in simple cone penetration tests. Measuring at multiple points enables the visualization of the distribution of ground stiffness and the ease to grasp the deformation strength properties.

Testing at Gima Dam foundation ground





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Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

Introduction of WEC model

～ A water quality simulation model which requires low computational load ～

1. Overview

The dam reservoir may have effects on the environment around it. When we focus on the water environment, there are water quality problems caused by long term turbid water discharge after floods, and eutrophication that occur in dam reservoir within and downstream rivers. When performing the prediction, and the analysis of probable cause, and the countermeasures of these problems, it is useful to use numerical simulation in addition to the analysis of observed data.

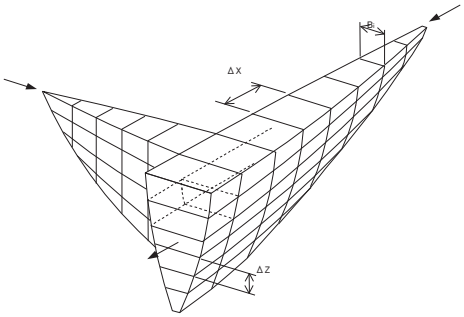

Figure1: Conceptual diagram of mesh division on WEC model

WEC (Water Resources Environment Center, Japan) model is a water quality simulation model which requires low computational load.

2. Characteristic

- This model use spatially **two-dimensional grids** and consists of codes to solve the combination of equations of mass balance, momentum that is Boussinesq approximation.
- Diffusivity terms of momentum and material by turbulence are represented by turbulence energy and energy dissipation rate.
- Therefore water temperature and suspended solids (SS) can be accurately simulated in the reservoir fluid.
- Ecological model employed Droop type model in which nutrient concentration in the cells (cell quota value is considered), it is possible to simulate the growth of motile phytoplankton.
- Flow changes due to water quality control devices such as flow control fence and air diffusing type circulator can be simulated **by adding sub-models**.
- This model can be executed by normal PC and has been applied to **more than 70 dam reservoirs in Japan**.

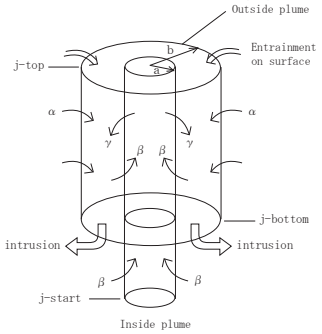

Figure3: Structural drawing of air diffusing type circulator model (Bubble plume model)

1) Equations of mass balance

$$\frac{\partial}{\partial x}(uB)+\frac{\partial}{\partial z}(wB)=0$$

2) Momentum equation in the horizontal direction

$$\frac{D(Bu)}{Dt}-\frac{\partial}{\partial x}\left(\nu_L B\frac{\partial u}{\partial x}\right)-\frac{\partial}{\partial z}\left(\nu_{eff} B\frac{\partial u}{\partial z}\right)=-\frac{B}{\rho}\frac{\partial p}{\partial x}+\frac{\tau_x}{(n_s\cdot n_y)}$$

3) Momentum equation in the vertical direction

$$\frac{D(Bw)}{Dt}-\frac{\partial}{\partial x}\left(\nu_L B\frac{\partial w}{\partial x}\right)-\frac{\partial}{\partial z}\left(\nu_{eff} B\frac{\partial w}{\partial z}\right)=-\frac{B}{\rho}\frac{\partial p}{\partial z}+Bg\delta+\frac{\tau_z}{(n_s\cdot n_y)}$$

4) Transport equation by turbulence energy

$$\frac{D(Bk)}{Dt}-\frac{\partial}{\partial x}\left(\frac{\nu_L}{\sigma_k}B\frac{\partial k}{\partial x}\right)-\frac{\partial}{\partial z}\left(\frac{\nu_{eff}}{\sigma_k}B\frac{\partial k}{\partial z}\right)=BP_r-Bg\frac{\nu_{eff}}{\sigma_t}\frac{\partial\delta}{\partial z}-B\varepsilon+\frac{F_k}{(n_s\cdot n_y)}$$

5) Transport equation by energy dissipation rate

$$\frac{D\varepsilon}{Dt}-\frac{\partial}{\partial x}\left(\frac{\nu_L}{\sigma_\varepsilon}B\frac{\partial\varepsilon}{\partial x}\right)-\frac{\partial}{\partial z}\left(\frac{\nu_{eff}}{\sigma_\varepsilon}B\frac{\partial\varepsilon}{\partial z}\right)=C_1B\frac{\varepsilon}{k}P_r-C_2B\frac{\varepsilon^2}{k}+\frac{F_\varepsilon}{(n_s\cdot n_y)}$$

6) Transport equation by temperature

$$\frac{D(BT)}{Dt}-\frac{\partial}{\partial x}\left(\frac{\nu_L}{\sigma_\delta}B\frac{\partial T}{\partial x}\right)-\frac{\partial}{\partial z}\left(\frac{\nu_{eff}}{\sigma_t}B\frac{\partial T}{\partial z}\right)=\frac{F_T}{(n_s\cdot n_y)}$$

7) Transport equation by suspended solids (SS)

$$\frac{\partial(BC)}{\partial t}+\frac{\partial(BuC)}{\partial x}+\frac{\partial(B(w-w_s)C)}{\partial z}-\frac{\partial}{\partial x}\left(\frac{\nu_L}{\sigma_C}B\frac{\partial C}{\partial x}\right)-\frac{\partial}{\partial z}\left(\frac{\nu_{eff}}{\sigma_C}B\frac{\partial C}{\partial z}\right)=\frac{F_C}{(n_s\cdot n_y)}$$

Figure2: Basic equations of hydraulic analysis model

3. Case study

(1) Comparing the vertical distribution of water temperature

- In conventional models, it is not possible to predict the situation in the case of measures. But WEC model can predict the effect of measures such as the aeration water circulator by adding sub-models (Bubble plume model).
- On the condition stopped aeration, high water temperature layer is formed in the epilimnion. But when the aeration is operating, the epilimnion thickens and surface temperature is decrease.

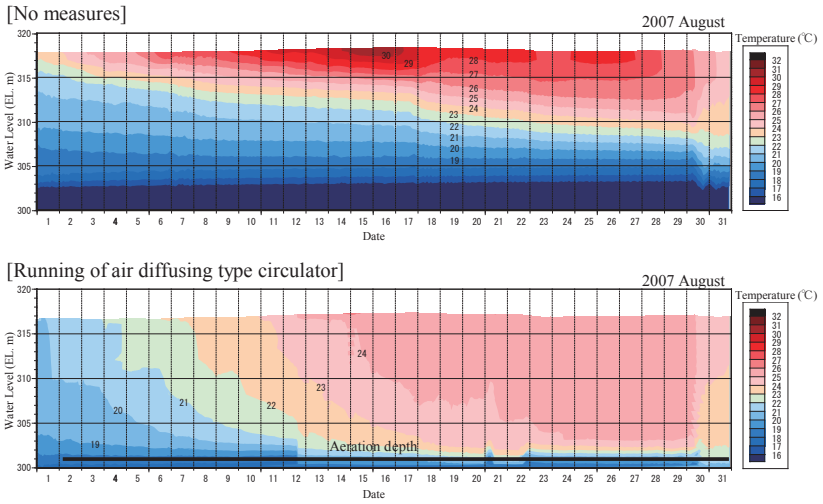

Figure4: Comparing the temperature vertical distribution

(2) Change in the behavior of turbid water

- WEC Model can predict for changes of the reservoir flow by installing the flow control fences for coping with the turbid water.
- The turbid water is intruded into an intermediate layer of the reservoir, and turbidity of surface layer in dam site is decreased.

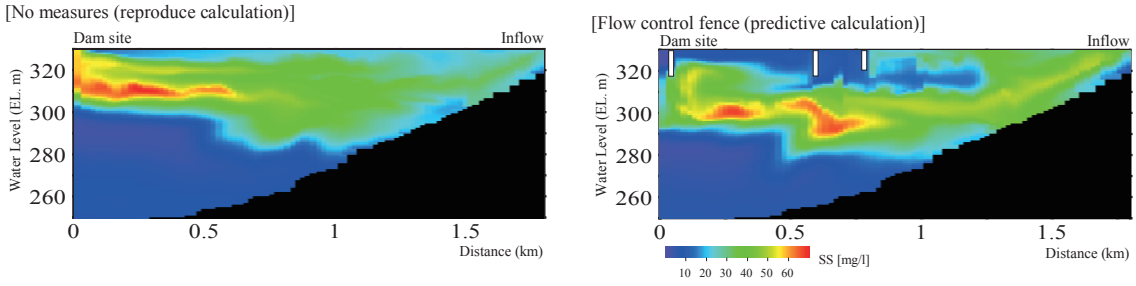

Figure5: Comparing the longitudinal change of suspended solids

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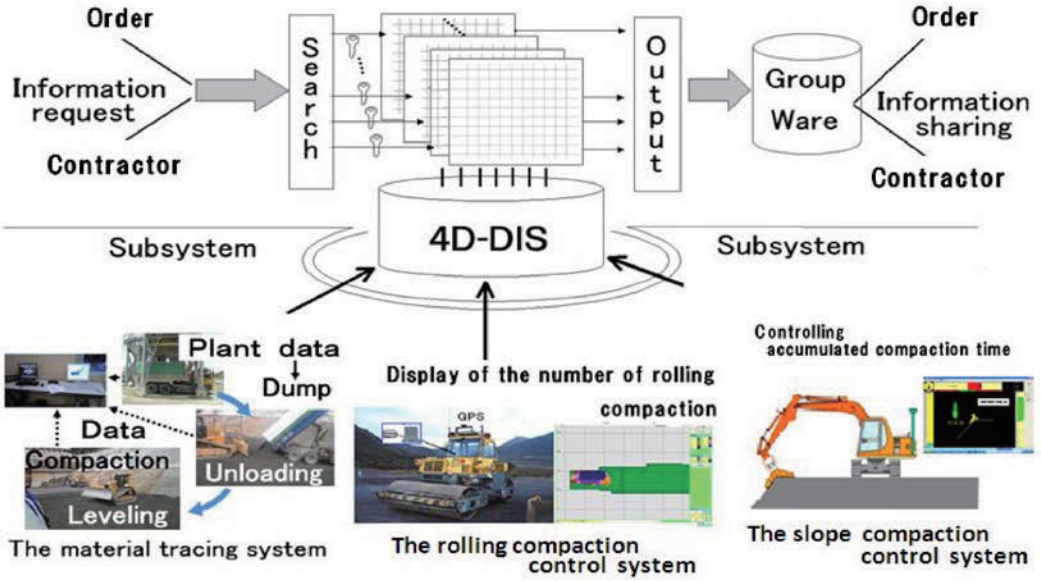
The Development and Management of the ICT System for Dam Construction

Summary of the Whole System

This system centers on the 4 Dimensions-Dam Information Service and consists of individual subsystems such as the rolling compaction control system, material tracing system and the slope compaction control system. These subsystems enable improvements in efficiency and assurance of the quality of construction.

Summary of the Whole System



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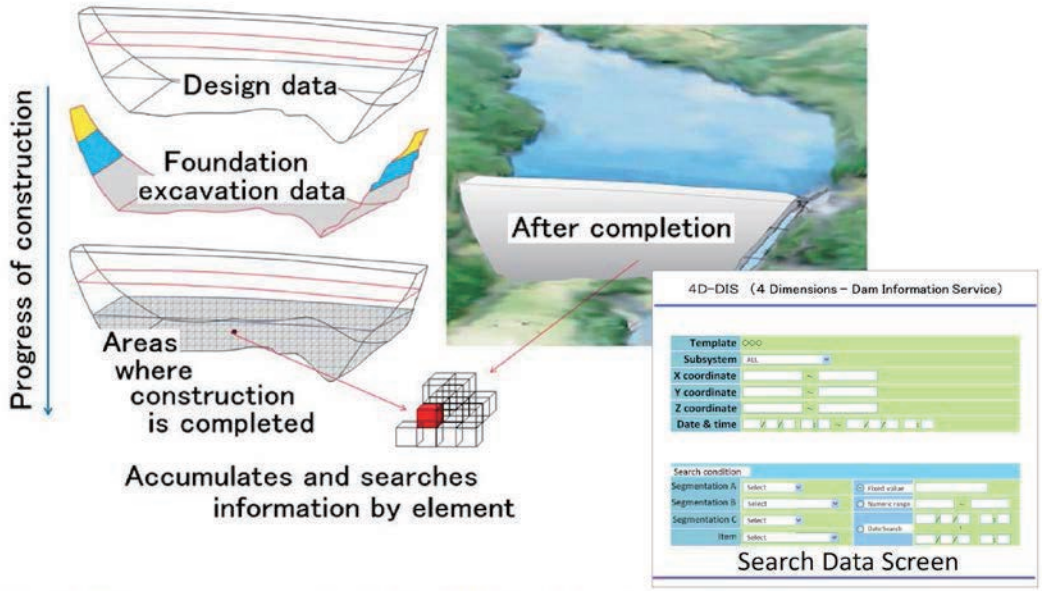
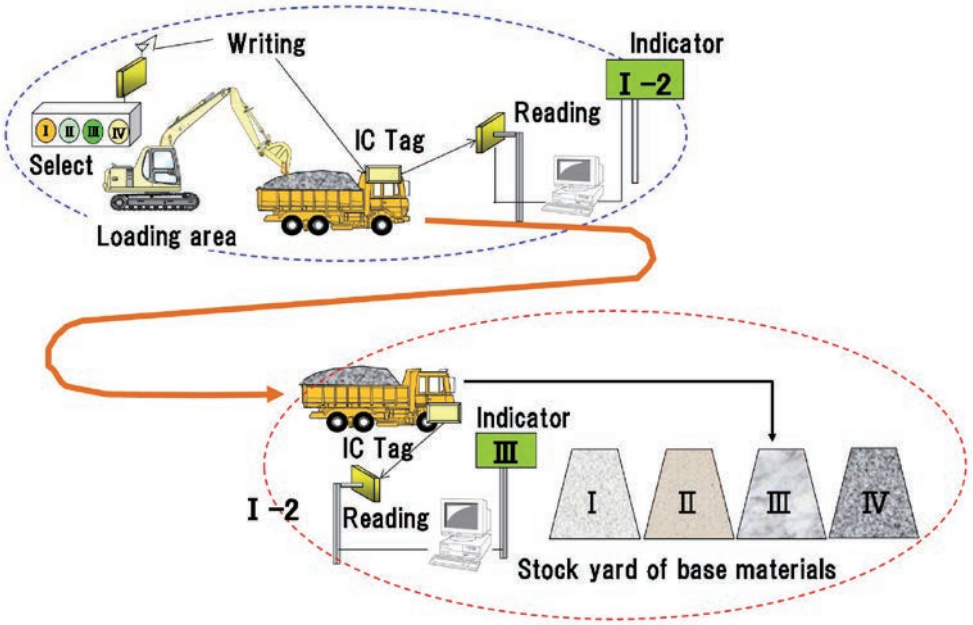
Data Concept



For the 4D-DIS core, we have adopted the Relational Database Management System.
The characteristics of the core exist in that it manages accumulated data four-dimensionally with use of a coordinate and time .

Image of Base Material Management

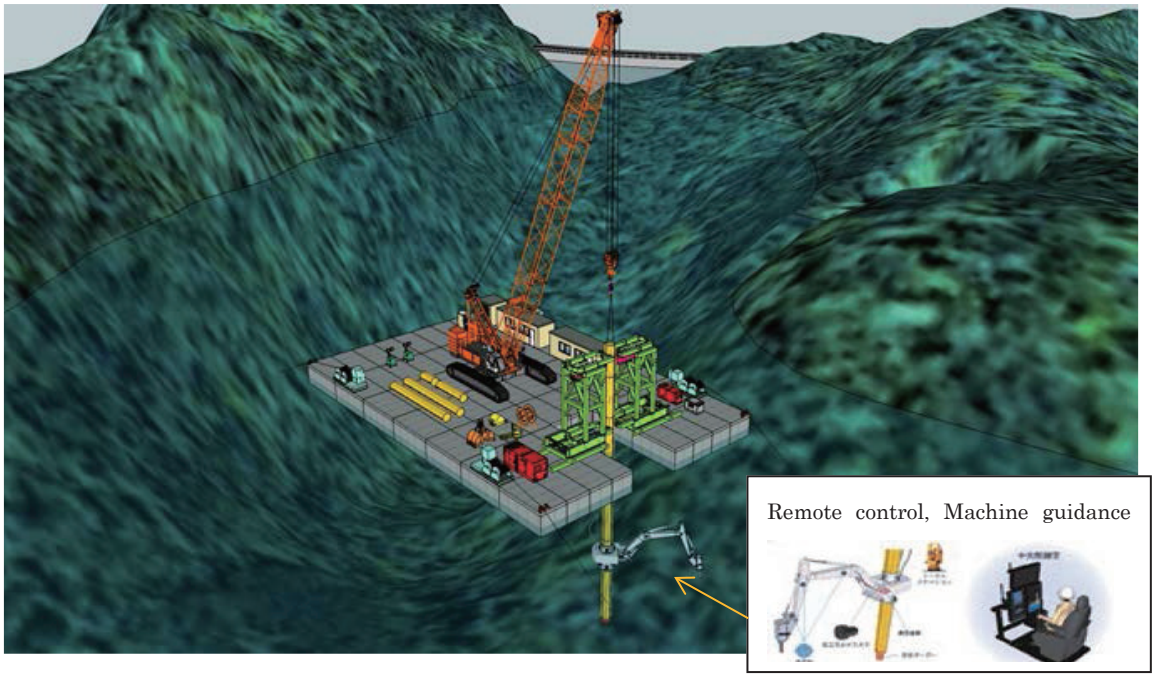


By utilizing Integrated Circuit tags in the management of extraction, transportation and temporary placement of base materials, the system prevents human errors, assures classification in temporary placement and grasps quantities .

Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

Remote Controlled Multifunctional Underwater Equipment
Underwater Operation Using an Equipment with Apparatus (T-iROBO UW)



Summary

This equipment enables a series of underwater operations such as rock crushing, excavation, debris disposal, precise sounding, photography, etc. in a safe and reliable condition through remote controlling. These are carried out by various apparatuses on a machine attached to a shaft which is lowered from a barge. The machine moves up and down along the shaft.

The equipment has been developed to conduct various underwater works without divers. It is especially advantageous for works in deep, steep and limited visibility areas such as dam reservoirs. Significant improvements of safety and operational efficiency are observed through remote controlled visualization technology and computerized technology.

Specific Features

a. Enables deep underwater works without divers
b. Applicable for all types of reservoirs
c. Applicable for very steep areas via an equipped casing auger
d. Enables a series of works to be carried out by various apparatuses
e. Equipped with I.T, machine guidance

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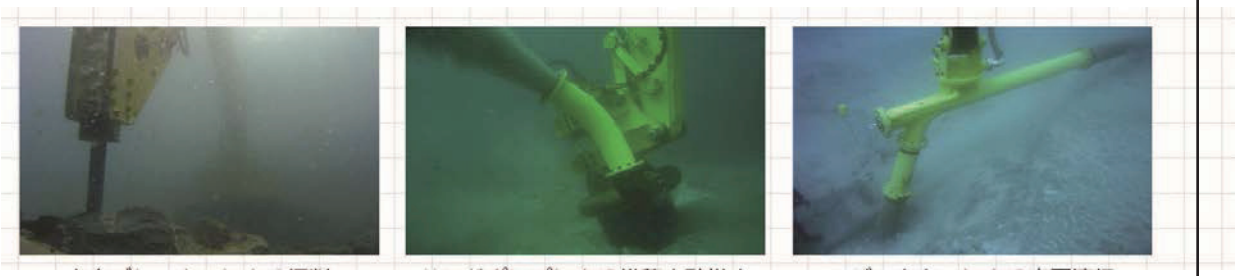
f. Applicable for deep and dark reservoir bases via equipped ultrasonic camera

g. Enables precise execution via equipped sounders

Various Apparatuses

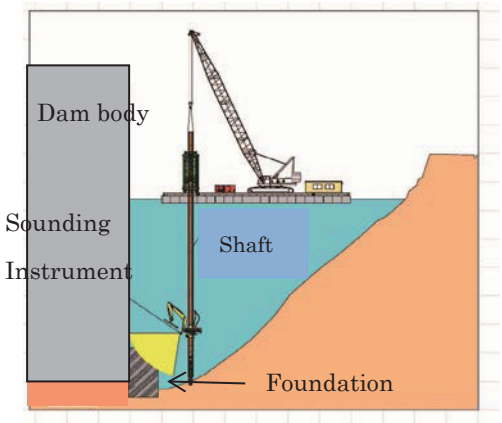
Applicable for a series of works via various apparatuses attached to a machine



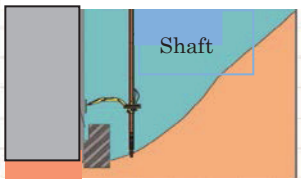
Rock crushing with a breaker | Sand pump suctioning | Cleaning by an ejector

Examples of applicable works

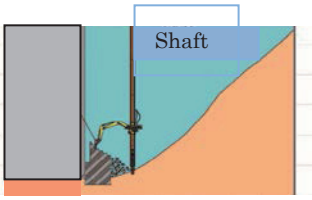
Precise sounding



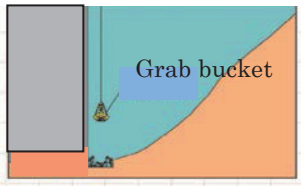
Edge cutting



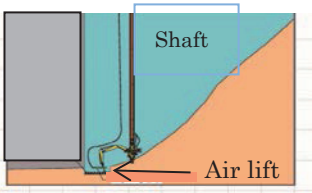
Crushing concrete



Grab dredging



S urface treatment



Other applications

a. Drilling by an air drifter
b. Surface cleaning by a rotary brush
c. Rock & concrete cutting by wire-saw
d. Steel beam & pipe and reinforced concrete cutting by nibbler

Environmental analysis of water quality
Technology for environmental evaluation in a closed water area

Summary

- The deterioration of water quality in a closed water area such as a dam reservoir is a matter of social concern affecting infrastructural projects.
- Technologies for water quality conservation and improvement are required to maintain the sustainability of infrastructural projects and ecological systems.
- Reliable numerical analysis, linking water flow, water quality and the ecological system, is a powerful method to estimate the present and future environmental situation in closed water areas.

Flow model

Flow and water exchange of closed water area

Advection and diffusion of turbidity

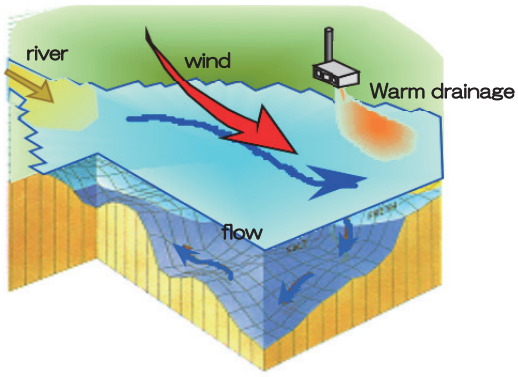
Diffusion and flow of cool and warm water

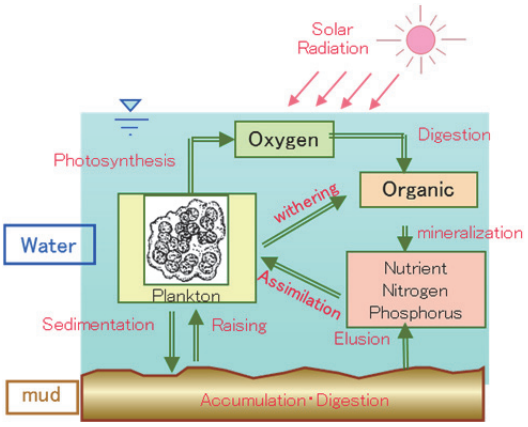
Water quality, ecosystem model

Eutrophication ,poor oxygenation

Red tide , Algae

Organic grime, siltation





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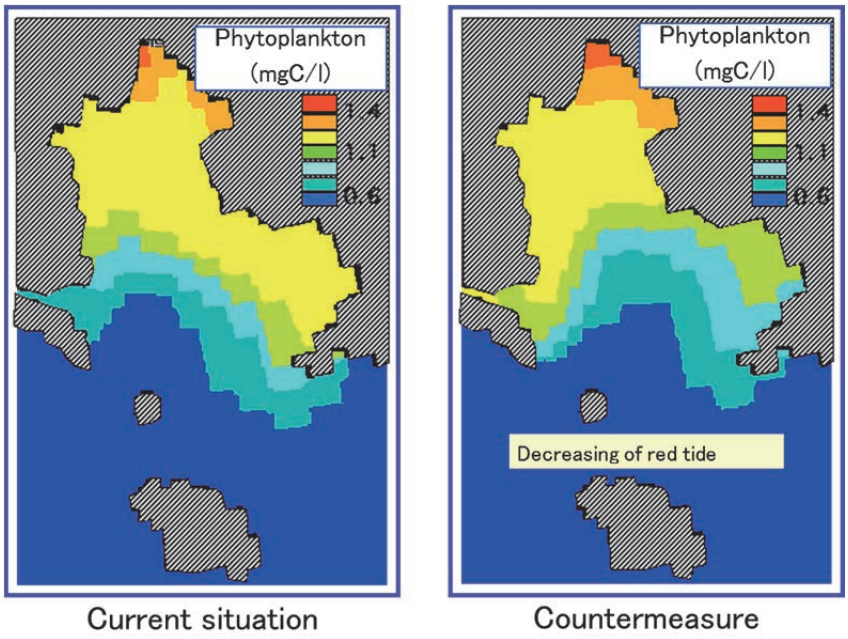
Technical summary, characteristics

- A three-dimensional water environment simulation system is applicable to practical subjects. This system, which consists of physical water flow and ecosystem modules, can provide precise results regarding the environment of a water area.
- This system analyzes not only physical phenomena such as water flow, water temperature and turbidity, but also chemical and biological reactions such as the inflow and elution of nutrient salts and the decline/withering of plankton etc.
- By taking into account the bottom bathymetry, the weather and/or river inflow conditions etc. using this analysis, the system has a high applicability to practical environmental assessment and ecological planning.

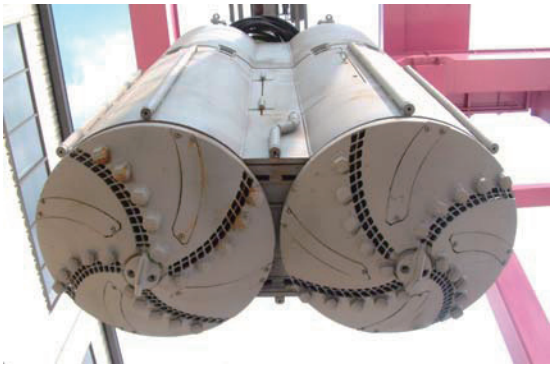


Examination example of red tide measures

Application items

- Three-dimensional simulation of the flow and water quality of a water area.
- Planning of environmental measures, such as water exchange improvement in a closed water area, and water purification.
- Diffusion analysis of cold/warm and contaminated water from industrial facilities into water bodies.

Clean & Effective Dredger for Sedimentation Sand in Dam Reservoir



Prototype Dredger-4 inch type

Purpose

Sediment at the mid-area of dam reservoirs mainly consists of sand with particle sizes between 0.01mm and 1.0mm, with water content between 50% and 60% and in a relatively stiff condition. This sedimentation sand is not ef fectively dredged by ordinary submer ged pumps. Moreover , stoppage of the pump occurs frequently due to existing obstacles such as wooden debris.

This dredger has been developed for the purpose of ef fective dredging of deep sedimentation sand at mid to downstream areas of dam reservoirs, while dam operation is carried out.

Capacity of the dredger

a. Enables dredging under water 30m to 50m deep
b. Enables dredging even for stiff sediments by using cutter bits equipped on the cutter face
c. Improves dredging efficiency via water jets which can loosen the stiff sediment
d. Reduces the volume of turbid water to be treated by re-circulating the top clear layer of the turbid water
e. Enables automatic operation through density control of the dischar ging sand to avoid stoppage of the pump
f. Sucked-up material such as twigs are crushed into small pieces by the cutter and discharged out

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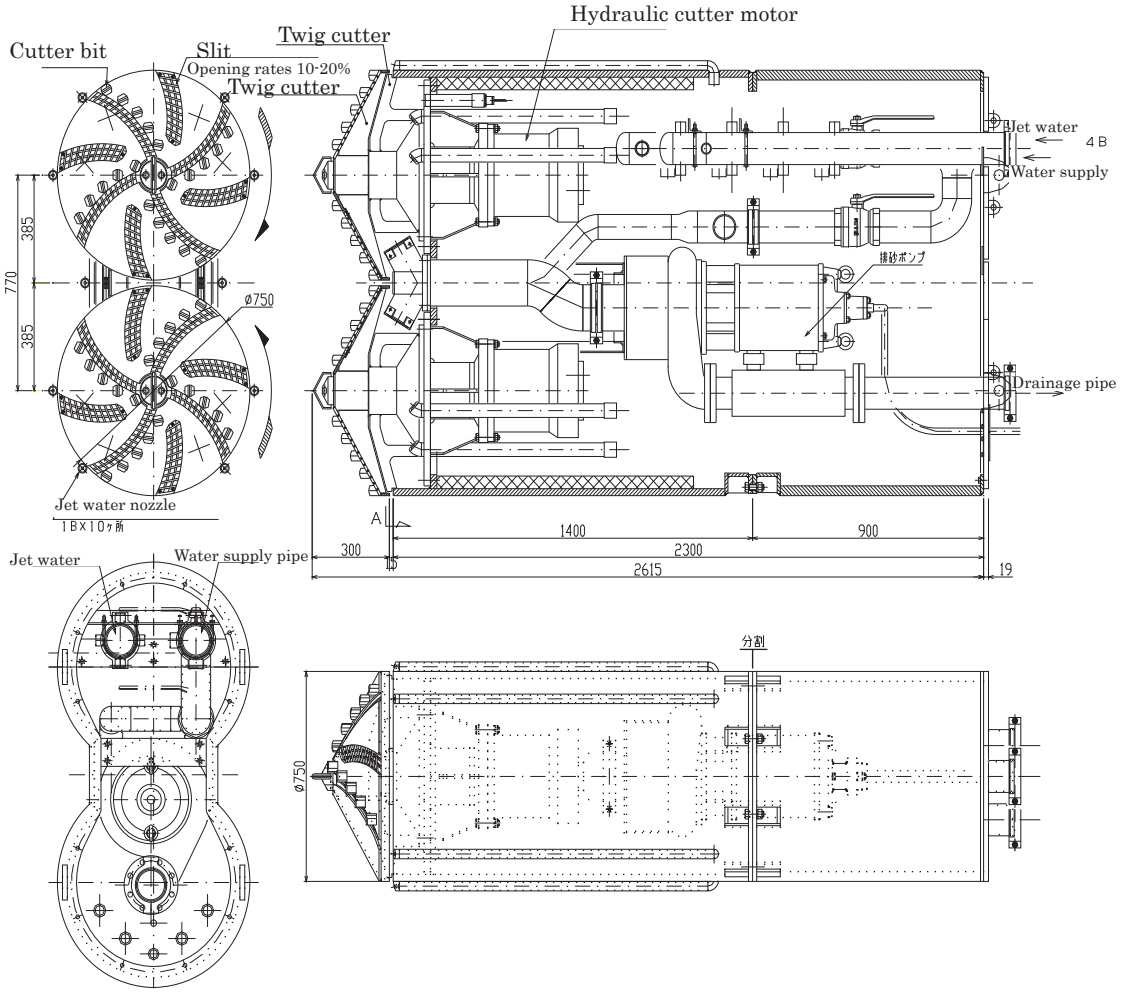
Figures of cutter face and main body



Cutting face **Main body**

Specific Features

a. Cutters are arranged in a spiral so that large debris is flipped away

b. The slit width is 16mm. Thus, any debris with its smallest dimension lar ger than 16mm is flipped away, not sucked in.

c. The opening ratio of the slit is adjustable between 10% to 20%. Thus, the suction amount can be adjusted

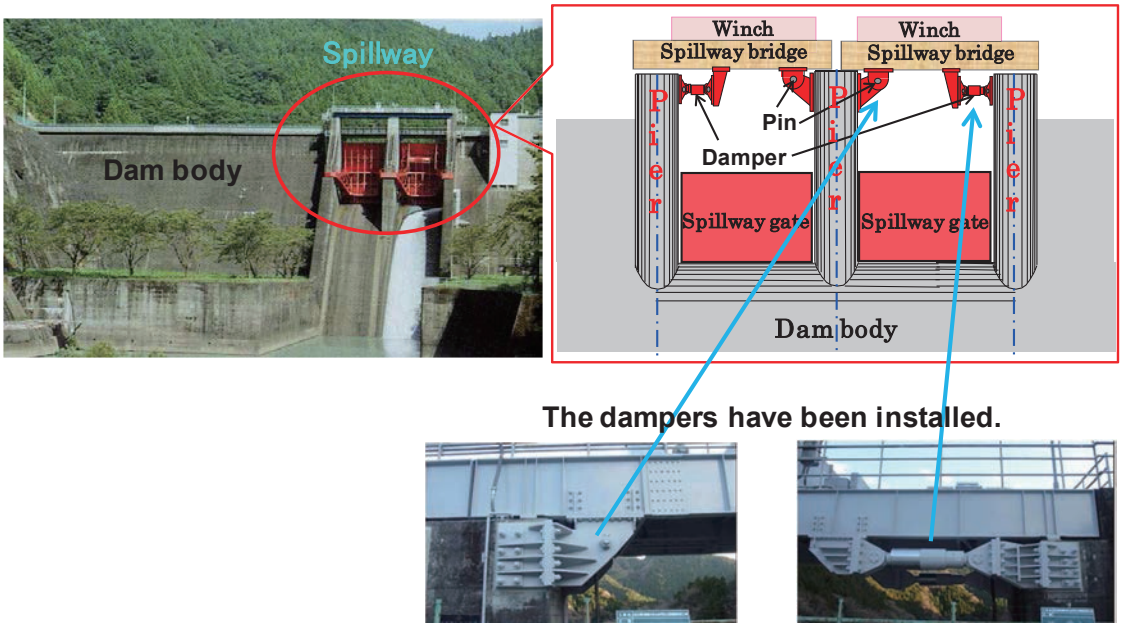
d. Cutters are fixed inside the cutting face so that sucked twigs are cut and discharged

e. Two hydraulic cutter motors prevent rotation of the dredger

f. Dredged sludge is directly transported to a designated position through the discharge pipe

SEISMIC UPGRADING METHOD OF SPILLWAY PIERS

~Improves safety of spillway piers against large earthquakes~



Background and purpose

■ Spillway piers on dams are the important structures for the open-close control of spillway gates, and required to hold seismic performance that can maintain the function for the flood control against large earthquakes. Because of this, the upgrading of spillway piers for seismic safety is significant in order for preparation against the maximum class strong earthquake motions that could occur at present or in the future. Then, we propose a seismic upgrading method of spillway piers on existing dams to ensuring public safety.

Features

■ We propose a seismic upgrading method of spillway piers on dams based on the utilization of existing spillway bridges and a particular application method of the damper with high hysteresis damping coefficient.

■ First, at the bridge's movable support, the displacement is allowed toward the extremely slow expansion and contraction velocity caused by the thermal change, and thermal load is released. Secondly, the displacement is simultaneously restricted when earthquakes happen.In this seismic upgrading structure, the existing spillway bridge is utilized as the seismic response controlled member along with the damper of the high hysteresis damping coefficient.

■ The proposed method is economical, since it does not require drawdown of the reservoir water level, and only requires some improvements of the bridge supports at the junction between the spillway piers and the bridges above the maximum water level, thus causing no loss of hydropower generation, which can even be continued during the construction work.

Applications

■ The proposed seismic upgrading method of piers was actually adopted to the spillway piers of 5 dams which are located in the Ohi River of Shizuoka prefecture in Japan.

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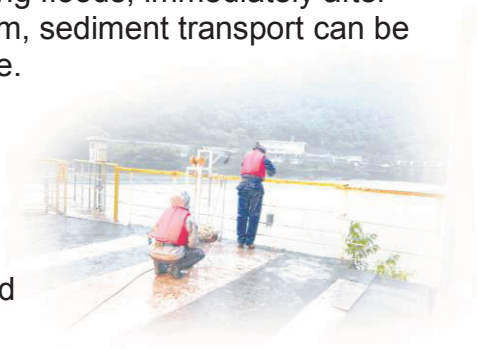
Ultrasonic Attenuation Measuring System for Suspended Sediments

Alpha-Lambda

New measuring system for monitoring sediment transport

Alpha–Lambda is a measuring system for the field investigation of suspended sediments in rivers. It can efficiently and effectively monitor the quantity and quality of sediments and is expected as a new measuring system for comprehensive sediment control in sediment transport systems. This system enables quick and easy investigation of the entire sediment transport system from mountain watersheds to the seashore during floods, immediately after floods, and during normal flow. Using this system, sediment transport can be understood in terms of quantity, quality, and time.



Features

New measuring system developed for the field investigation of suspended sediments

- Adoption of ultrasonic attenuation spectroscopy
- Non-necessity of water sampling
- Measurement of high-concentration sediment volume (max. $50\ \mathrm{kgm^{-3}}$)
- Measurement of grain-size distribution of sediments with a maximum grain size of 2 mm
- Automatic measurement for flooded dangerous fields
- Measurement at the sediment transport system (rivers, dams, brackish water, and sea areas)

Advantage

- The cost of investigation and analysis of sediment volume can be reduced
- Dangerous water sampling work in flooded rivers during typhoons, storms or at night is not required
- The volume (concentration) of high-concentration sediment from dams such as sediment flushing can be measured directly
- Sediment volume can be measured according to grain size (clay, silt, fine sand, medium sand, and coarse sand)

Products

The ultrasonic attenuation spectrometer has been developed in collaboration with the College of Engineering of Nihon University, Electric Power Development Co., Ltd. and Hokuto Riken Co., Ltd.

- Name Ultrasonic attenuation spectrometer
- Measuring frequency 3.0–9.0 MHz
- Method Pulse reflection method
- Sensor Plano-concave ultrasonic transducer
- Auxiliaries Thermistor probe/water gauge and electrical conductivity meter
- Measurement interval 10, 20, 30, and 60 min (options), manual
- Water temperature conditions 0–30 °C
- Power AC100 V 50/60 Hz
- Weight 28 kg
- Option Nephelometer, dissolved oxygen meter, pH meter
- Manufactured and sold by Hokuto Riken Co., Ltd.

Software

The software "**Alpha-Lambda**" is a program for measuring suspended sediment concentration and grain-size distribution using ultrasonic attenuation spectroscopy and has been developed by Electric Power Development Co., Ltd.

- Measuring time Max. 1 min
- Measuring range for grain size 0.1–2,000 μm (100 grain size class)
- Grain-size distribution Unimodal and bimodal log-normal distribution
- Measuring range for concentration Max. 50 $\mathrm{kgm^{-3}}$ (varies with grain size)
- Water temperature conditions 0–30 °C
- Developed and sold by JP Business Service Co., Ltd.

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Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

Introduction, Renewal of Existing Dam and Hydropower

For many countries, hydropower remains the dominant source of renewables-based electricity. It's one of the oldest and most important renewable resources. But the scope to add further hydropower capacity in OECD countries is, by contrast, limited, as the best resources have already been developed. Under the circumstance, OKUTADAMI hydropower station unit-4(200MW) was expanded.

Project Summary of Okutadami Unit-4 Expansion Project

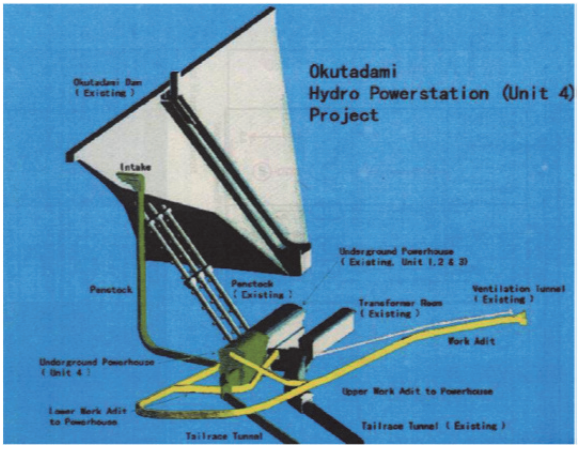
J-POWER's OKUTADAMI hydropower station is located in most upstream of Tadami-river running a boundary between Niigata and Fukushima-prefecture. The project site is also the area with heaviest snow in Japan and often experiences more than 6m. It's the largest scale of renewal project of existing dam/hydropower station.

Location of OKUTADAMI-dam

Outline Photo in spring

	Existing(Unit1~3)	Expansion(Unit4)
Power Generation Type	Dam and Waterway	
Catchment Area	591.1km^2	
Total Storage Capacity	601x10^6(m^3)	
Effective Storage Capacity	458 x10^6(m^3)	
Dam Type	Concrete Gravity	
Volume of Dam	1,636 x103(m^3)	
Crest Length x Dam Height	480(m) x 157(m)	
Penstock	185.9~189.5(m) x3	285(m) x1
Tailrace	3,048(m) x1	3,353(m) x1
Rated Head	170(m)	164.2(m)
Maximum Water Consumption	249(m^3/s)	138(m^3/s)
Generating Capacity	360(MW)	200(MW)
COD	1960, Dec.	2003, Jun.

Specifications

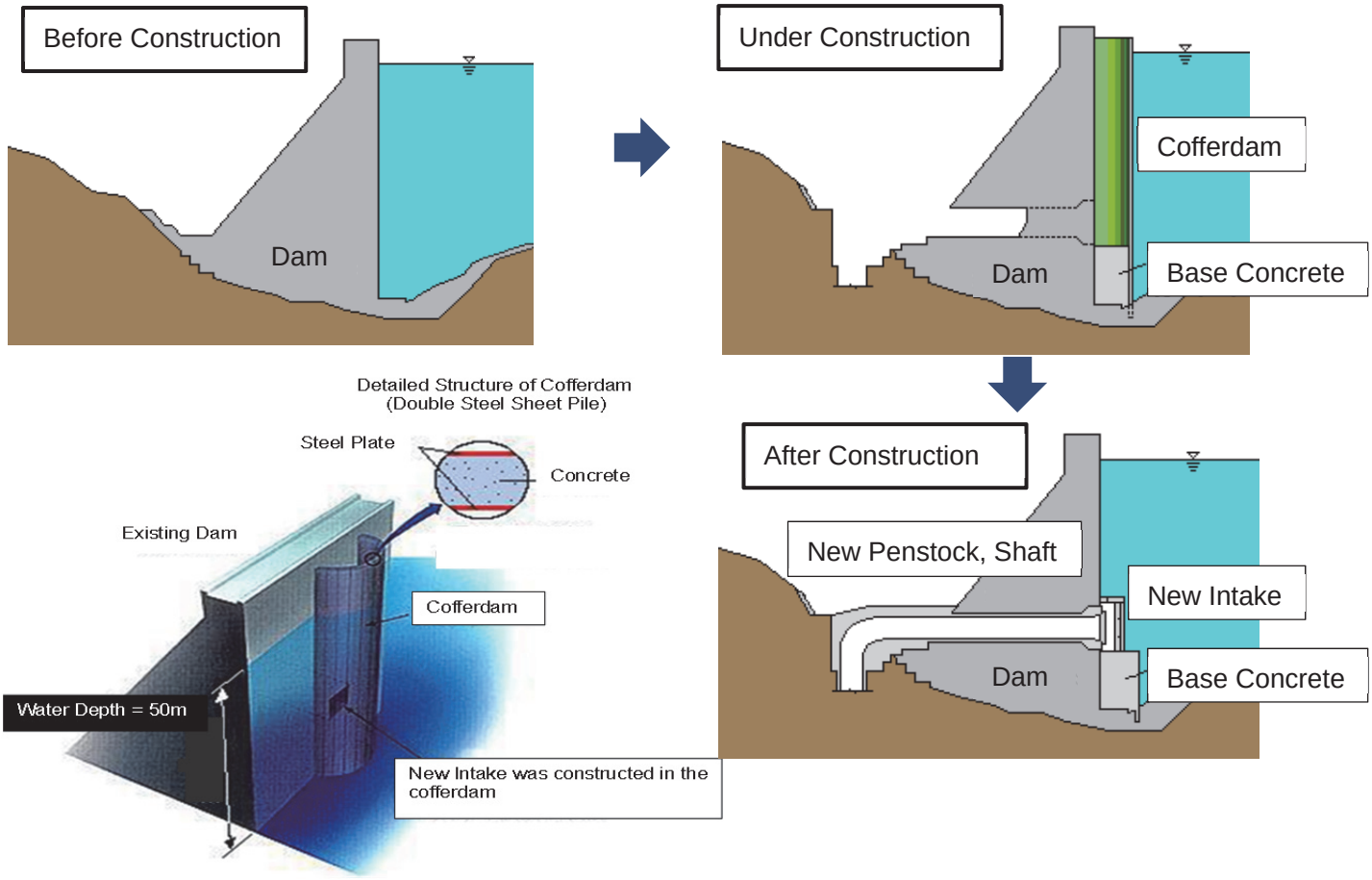


3D View of the Project

Characteristics of Project

- Construction period was only 4 months, July to October, every year in consideration of breeding season of golden eagle family (endangered bird) that was nesting near the dam.
- OKUTADAMI reservoir has highest water level during the above 4 months in the year and huge amount of total capacity, approximately 6millon m^3. So it was difficult to drawdown the reservoir.
- Cofferdam (half cylinder shape,16m diameter & 57m height) was adopted to keep the dry condition around the new intake during a construction period without drawdown.
- Unique technology, double steel sheet pile filled concrete, was adapted to the cofferdam to resist 50m hydraulic pressure.(see attached drawing; "Detailed Structure of Cofferdam")
- New penstock was installed after excavation of the existing dam.
- Slot Drilling and Giant Breaker was used from downstream for excavation of existing dam.
- Rectangular shape having round corner was adopted for excavation of existing dam to minimize the concentration of stress.

Procedure of Construction



Actual Site Photos during a Construction, Installation of Cofferdam, Excavation of Dam

Installation of Guide Frame

Installation of Sheet Pile

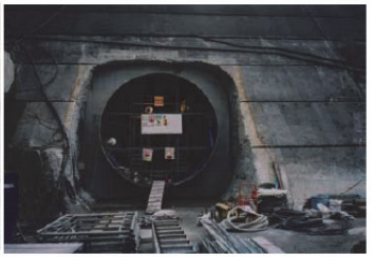
Filling Concrete

Dry-up in Cofferdam

Slot Drilling

Excavation by Giant Breaker

Treatment of Excavation Surface



Installation Penstock & Filling Concrete

Adoption for Future Potential Project

- This unique method was verified in this project and will be adopted for future potential project.

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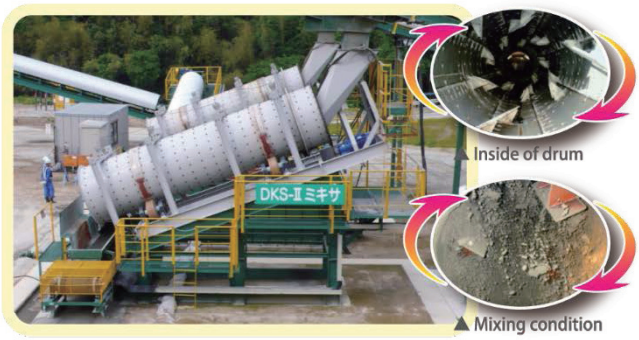
Current Dam Technology in Japan

JAPAN COMMISSION ON LARGE DAMS

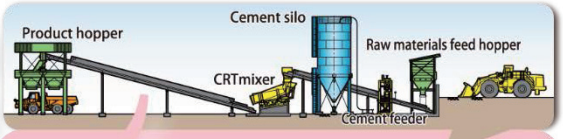
CRT(The Continuous Rotary Tube)Mixer System

The Continuous Rotary Tube (CRT) Mixer System provides using the Cemented Sand and Gravel (CSG) Method. By attaching agitating blades inside the steel drum and maintaining specified rotation speeds and angles, the mixer is capable of producing mixtures of consistent and stable quality.



Features of Mixer

1. Continuous rotary mixer
2. Stable supply of high-quality CSG
3. High production capacity (200m^3/hour)
4. Automation of CRT Mixer System
5. An energy saving machine & Low cost



Mixing Plant Description

Name of Plant System	DKS- II Mixing Plant
Name of Mixing Element	CRT Mixer
Type of Mixing Element	Forced Type in the shape of Pipe
Dimension	φ1,500mm × L6,000mm
Productivity	200m^3/hour
Rotational Speed	5～20 rpm
Capacity of Motor	30kW 200V

Nishimatsu Construction Co., Ltd.

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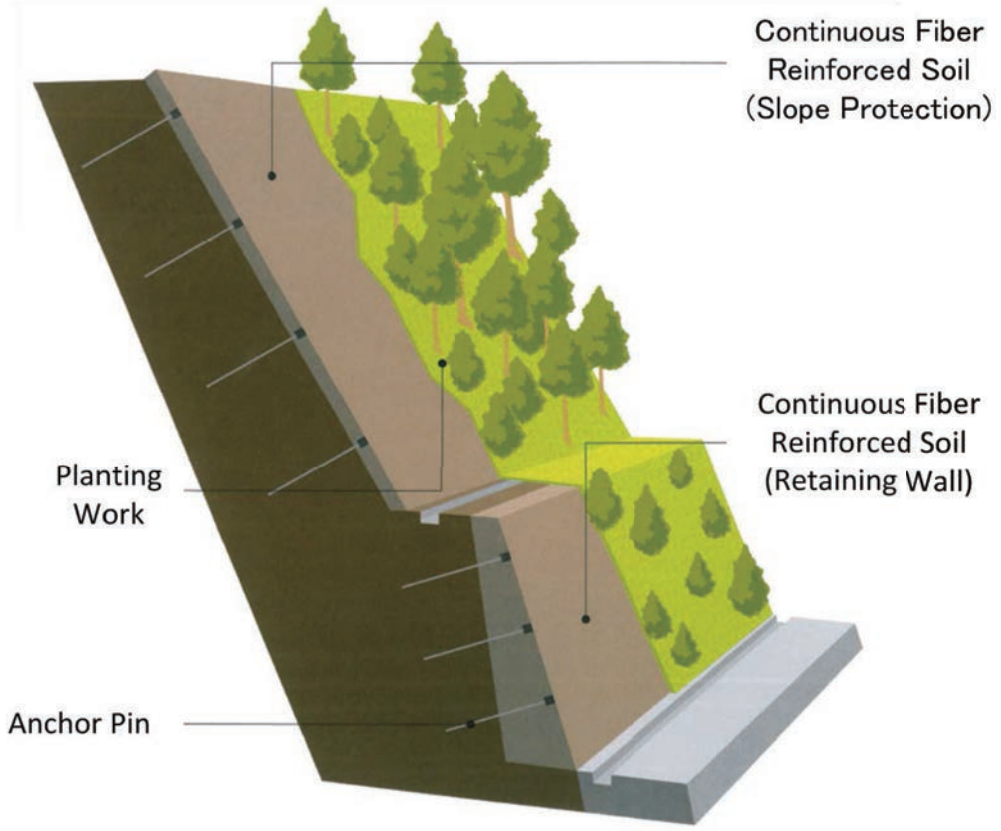
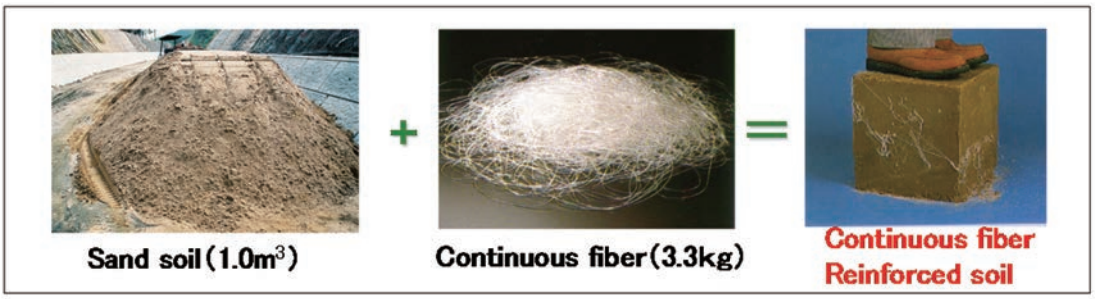
JAPAN COMMISSION ON LARGE DAMS

Greening method for rock slope, GEOFIBER

～ Continuous Fiber Soil Reinforcement Technology ～

1.Outline





Geofiber, the continuous fiber reinforced soil, has pseudo cohesion, high erosion resistance, good permeability and gives increases residual strain to the sandy material with multi filament fiber. Executing soil nailing and surface vegetation, Geofiber can complete a perfect protection on the rock face by plant bases.

Geofiber method has more than 3000 construction results.

2. Applications

■Application on Huge Excavation Slope at the Dam

The trees are healthy growing and continue to harmonize with the surrounding forest.

■Restoration of the collapsed slope in Kiyomizudera

The landscape of the slope collapsed by the heavy rain is under restoration.

NITTOC CONSTRUCTION CO., LTD	
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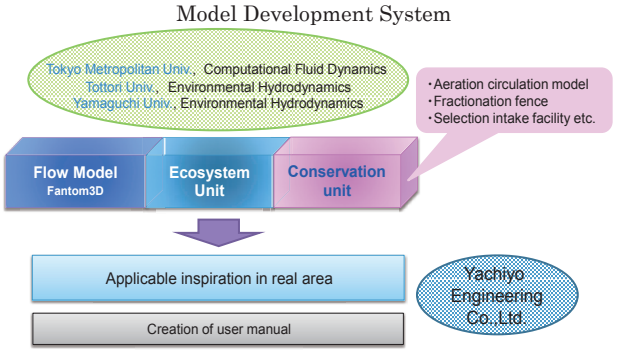
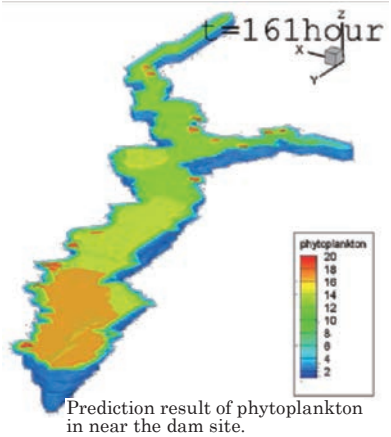
3D Water Quality Prediction Model (Fantom3D) Development

The three-dimensional numerical model (Fantom3D) that can dynamics predictable the flow and water quality in reservoirs and lakes has been jointly developed by Yachiyo Engineering Co,. Ltd. and the Univer sities (Tokyo Metropolitan University, Tottori University, Yamaguchi Univer sity). Fantom3D model can predict the complex flow (stratified flow, wind drift current, circulation flow, seiche etc.) and accompany the mass transport that occur in closed waters.

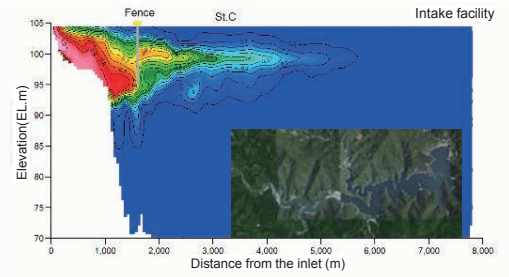


Fantom3D model offers various tools to response the facilities for water quality conservation by which to resolve the water pollution problems such as prolonged turbidity, abnormal growth of phytoplankton as well as low oxygen water etc.



Prediction result of phytoplankton in near the dam site.

Fantom3D model is an object-oriented one. It is possible to perform parallel calculations on multiple CPU by dividing the study water area and to reduce greatly the computation time. In the near future, global climate change is a pressing global concern; bring about a wide range adverse effect, such as deterioration of water quality and shortage of safe water resources in various regions. We provide the tools and methods to inquire into the cause of abnormal growth of phytoplankton (Bloom) and to determine the generating source in reservoirs by applying Fantom3D, and further to examine the installation position, scale and operation of efficient and effective measures facilities.



Prediction of controlling the inflow turbid water by fence

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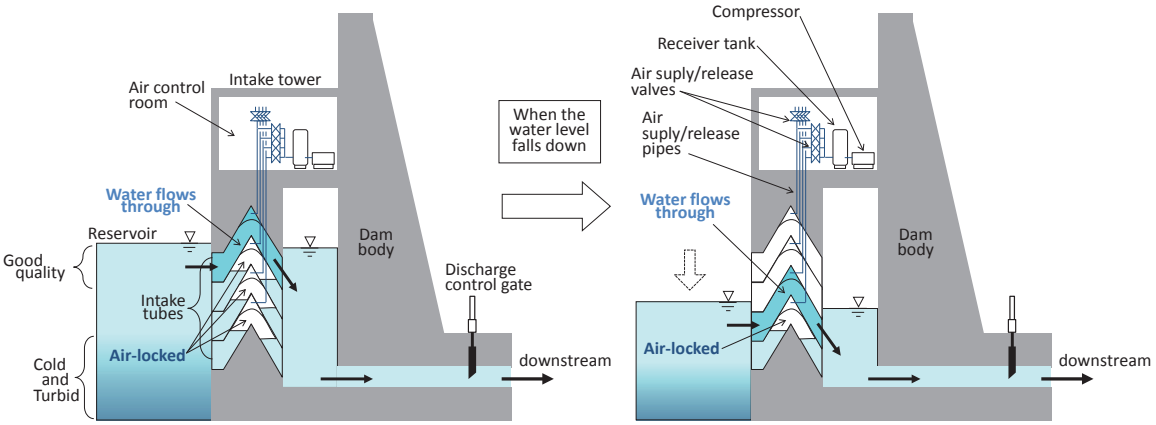
Air-lock Selective Intake

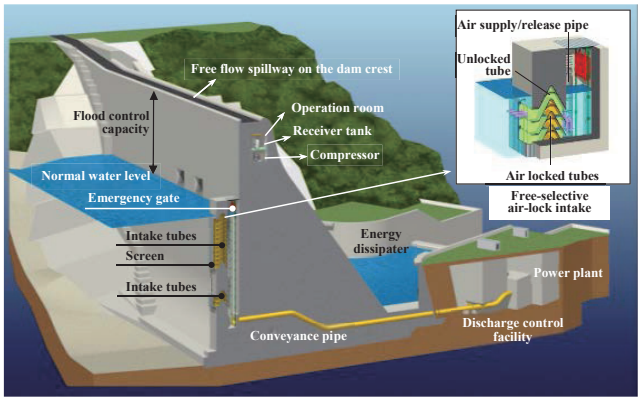
PATTENT; Japan Dam Engineering Center, Yachiyo Engineering Co., Ltd.



Selecting the intake depth of the reservoir is beneficial for quality management of the water supply for downstream.

Air-Lock Selective Intake is the brand-new system which can be the alternative to conventional selective intake systems such as multistage gates.

Air-lock Selective Intake system uses steel reverse V-shaped intake tube and air control unit. It makes intake possible from any water level as a result of air-locked condition created by passing water through intake tube at any water level and filling other intake tubes with compressed air. Pneumatic control system consists of compressor, receiver tank, air supply/release valves. Opening the air-supply valves sends compressed air into intake tubes to perform Air-lock.



Opening the air-release valves releases the air inside intake tube into atmosphere to pass the water.

This system have the high economic performance by no use of multistage metal gates which include parts to be frequently maintained such as rubber sealants and wire ropes, no use of heavy steel structures and hoist equipment.

This system is under operation on 7 dams, and under construction on 2 more dams in Japan.

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