Fiber Reinforced Polymer Hydraulic Gates

FRP Hydraulic Gates

Lightweight, sturdy, and maintenance-free

Ministry of Land, Infrastructure, Transport and Tourism, New Technology Information System (NETIS) Registration No. CB-050025-V
Gifu Prefecture New Technology・New Construction Methods Certification No. 03-17

株式会社ヒビ
Hibi Corporation

FRP Hydraulic Gate Types

Slide gate Model: FS

A lift type gate with a structure that uses an opening/closing apparatus to slide the gate leaves up and down. The simple structure allows the operation of the gate to be triggered by a small difference in water levels or by the water pressure balance, in both large and small-scale settings. This type of gate is broadly applicable for rivers, agricultural use, harbors, and electrical generation.

Example of installation in harsh environment that is subject to the effects of salt damage and the like (See pp. 8-9 for details.)

■ Effective width: 2.00 meters ■ Effective height: 0.96 meters ■ Water seal system: Rubber water seal on 3 sides of front face
■ Opening/closing apparatus: Manual rack type opening/closing apparatus
Completed in 2007 Ogasawara Municipality, Chichijima Island,Tokyo

■ Effective width: 5.00 meters
■ Effective height: 1.30 meters
■ Water seal system: Rubber water seal on 3 sides of front face
■ Opening/closing apparatus: Manual rack type opening/closing apparatus (2 units)
Completed in 2004 Ampachi-gun, Gifu Prefecture

Roller gate Model: FR

A lift type gate with rollers affixed to the edges of the gate leaves for the purpose of reducing the weight of the opening/closing apparatus. Broadly applicable to a wide range of uses.

- Effective width: 2.00 meters
- Effective height: 1.50 meters
- Water seal system: Rubber water seal on 4 sides of front face
- Opening/closing apparatus: Manual rack type opening/closing apparatus

Completed in 2003 Ogaki, Gifu Prefecture

Main roller portion

- Effective width: 1.60 meters
- Effective height: 2.00 meters
- Water seal system: Rubber water seal on 4 sides of front face
- Opening/closing apparatus: Electric rack type opening/closing apparatus

Completed in 2004 Kakamigahara, Gifu Prefecture

FRP Hydraulic Gate Types

Swing gate Model: FSW

Opens and closes by rotating on hinges on the edges of the gate leaves. Used for the purpose of preventing backflow into the water channel.

- Effective width: 3.00 meters
- Effective height: 3.50 meters
- Water seal system: Rubber water seal on 4 sides of rear face
- Opening/closing apparatus: Hinge type (natural water pressure)

Completed in 2006 Ogaki, Gifu Prefecture

Miter gate Model: FM

Opens and closes by rotating on hinges on the edges of the gate leaves. When closed, the gate leaves form an angle pointing upstream. Used for the purpose of preventing backflow into the water channel.

- Effective width: 5.10 meters
- Effective height: 2.80 meters
- Water seal system: Rubber water seal on 4 sides of rear face
- Opening/closing apparatus: Hinge type (natural water pressure)

Completed in 1975 Suzuka, Mie Prefecture

FRP Hydraulic Gate Types

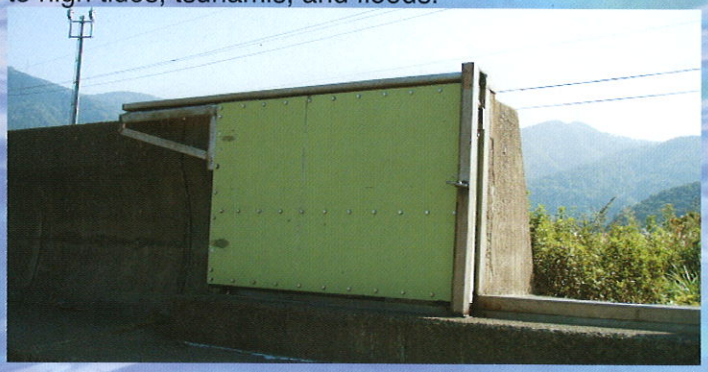
Flap gate Model: FF

Opens and closes by rotating on hinges on the tops of the gate leaves. Used for the purpose of preventing backflow into the water channel, in the same manner as the swing gate.

■ Effective width: 1.30 meters ■ Effective height: 1.00 meters ■ Water seal system: Rubber water seal on 4 sides of rear face
■ Opening/closing apparatus: Hinge type (natural water pressure)
Completed in 2003 Ogaki, Gifu Prefecture

Tide barrier / flood barrier gates Model: FL

A gate that is installed in a levee or breast wall to prevent inundation and associated destruction of land areas due to high tides, tsunamis, and floods.



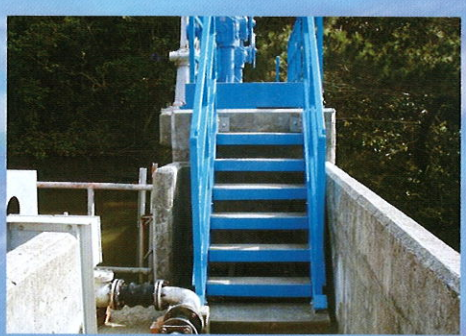
Tide barrier gate (horizontal sliding type)

Flood barrier gate (swing type)

Accessory structures

Operator walkways installed in pumping stations and the like at dams and waterways. Surfaces that are provided for controlling hydraulic gates and the like are treated to prevent slipping.

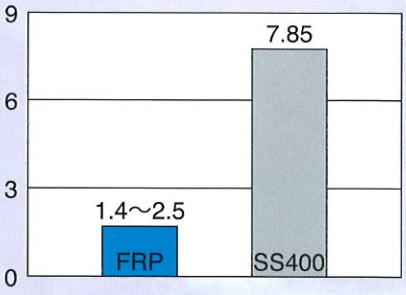
Operation bridge



Stairway

Light weight

The use of FRP has a variety of advantages, including a more compact opening/closing apparatus, better moving efficiency, lower power consumption during installation, expanded use of human labor during installation, and improved safety.



FRP specific gravity

FRP has a low specific gravity in the range of 1.4 to 2.5, approximately one-fifth that of ordinary steel.

Compact opening/closing apparatus

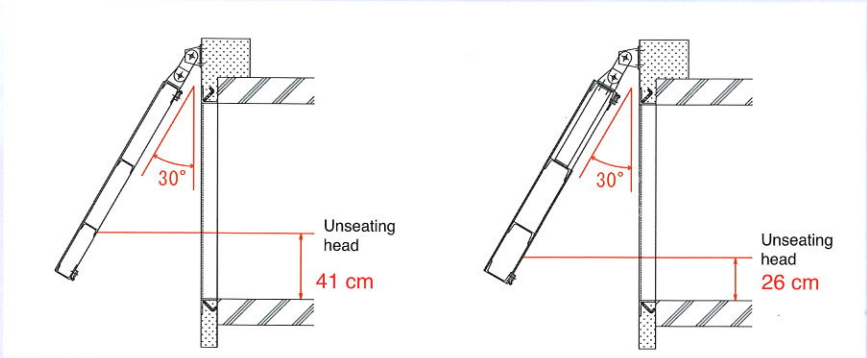
Reducing the weight of the gate leaves reduces the load on the opening/closing apparatus, making it feasible to use a more compact apparatus. The gross weight of the gate leaf in the FRP hydraulic gate shown in the photograph is less than half the weight of a steel hydraulic gate, so an opening/closing apparatus with less capacity can be used. This contributes to a lower product cost and lower energy consumption during opening and closing operations.

Example of more compact opening/closing apparatus

	Gate leaf gross weight	Opening/closing apparatus
Steel hydraulic gate	1528.0 kg	Manual rack type opening/closing apparatus for 40 kN
FRP hydraulic gate	705.6 kg	Manual rack type opening/closing apparatus for 30 kN

Better moving efficiency

With the flap gate and the swing gate, which are opened and closed by the natural flowing and non-flowing of water, reducing the weight of the gate leaves allows them to move in response to lower water levels, thereby reducing the rate at which flow of water is blocked. FRP and steel flap gates with the same dimensions and the same design head were compared to see what water levels would be required to open the gates to a 30-degree angle. The FRP gate was shown to move at a water level about half of that required to move the steel gate.



SS400
gate leaf weight = 318.0 kg

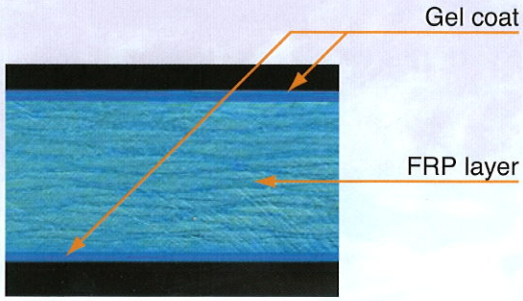
FRP
gate leaf weight = 137.7 kg

Expanded use of human labor during installation, lower power consumption during installation, and improved safety

The expanded use of human labor during installation is expected to reduce the installation expense. It is also anticipated that transport vehicles and heavy construction equipment can be made more compact, and that installation tools can be simplified.

Durability

Existing products have been in continuous maintenance-free use for approximately 50 years.



Weather resistance

FRP generally deteriorates from exposure to ultraviolet light. Accordingly, as an anti-ultraviolet light measure for all of the FRP materials that are molded by Hibi, all surfaces that are exposed to direct sunlight are treated with a highly weather-resistant gel coat (a surface protective layer).

Corrosion resistance

FRP materials are not corroded by rust in the way that steel materials are. The materials exhibit superior durability even in severely briny and watery environments such as sewers, factory waste water treatment facilities, and the like. The steel (SS400) hydraulic gate and the FRP hydraulic gate shown in the photographs were installed in the same water channel at the same time, prior to 1969. The steel hydraulic gate has been painted approximately once every 5 to 8 years as a maintenance measure, and the gate leaf has been replaced once, after about 40 years. In contrast, the FRP hydraulic gate still remains in its initial state without any maintenance at all.

FRP hydraulic gate

Steel hydraulic gate

FRP hydraulic gate
(enlarged view of gate leaf)

Steel hydraulic gate
(enlarged view of gate leaf)

Durability

In order to quantitatively evaluate the state of deterioration of an actual FRP hydraulic gate over time, we recovered an FRP gate leaf that had been used in an agricultural water channel for at least 35 years, disassembled it, and measured its tensile properties. The recovered gate leaf had not been repaired for the entire 35 years, but even so, no deterioration had occurred that would lead to a loss of strength.

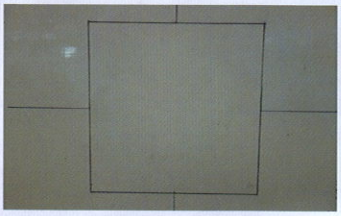
Laminated plate taken from gate leaf after at least 35 years		Newly made laminated plate	
Tensile strength (MPa)	Tensile elasticity (GPa)	Tensile strength (MPa)	Tensile elasticity (GPa)
201.0	27.3	204.4	25.2

Reference document: JSCE Committee on Hybrid Structures: Hybrid Structures Series 06
Guidelines for Design and Construction of FRP Hydraulic Gates (Draft), pp. 82-83,Japan Society of Civil Engineers, February, 2014

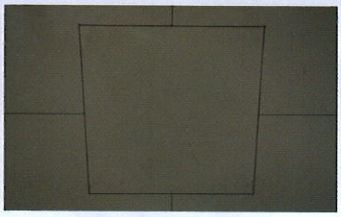
Impact resistance

The soundness of an FRP gate leaf for a hydraulic gate has been confirmed in impact experiments in which it was assumed that the gate leaf was struck by drifting timber.

The gate leaf was struck directly, as it would be during a flood, and no abnormalities were observed, indicating that the gate leaf retains adequate function as a hydraulic gate.



Before testing

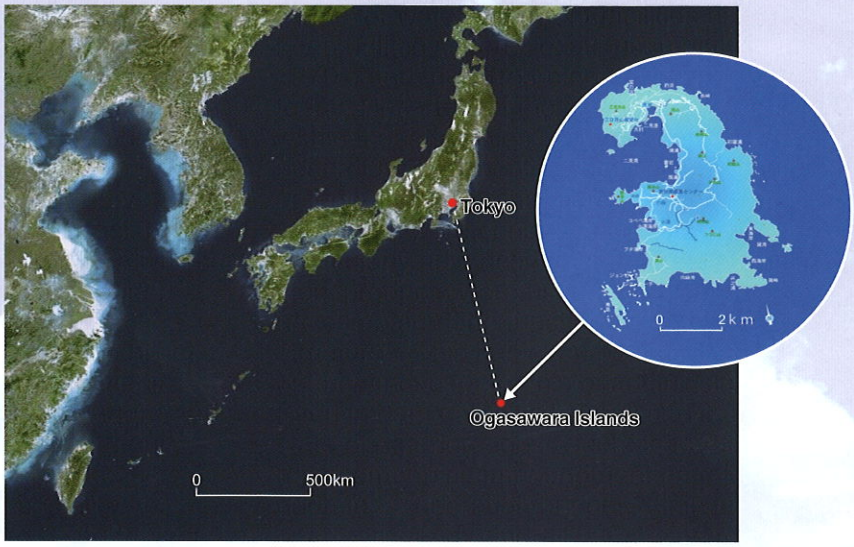


After testing

Why use FRP?

Example of installation in a harsh environment that is subject to the effects of salt damage and the like

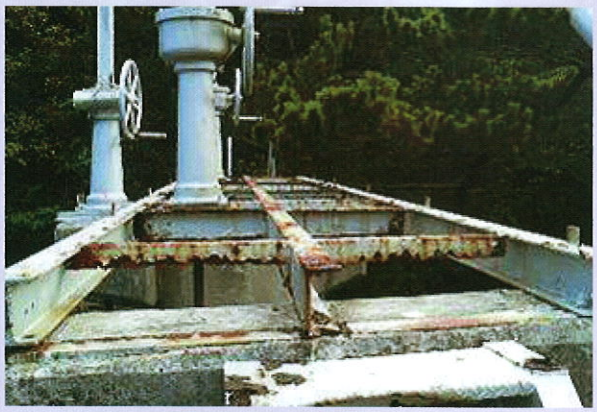
Ogasawara Municipality on Chichijima Island is located approximately 1,000 kilometers south of Tokyo Bay. The island is in the middle of the ocean, making it a harsh environment for civil engineering structures that are installed outdoors, where they are subject to the effects of salt damage.



Dams for water treatment facilities have been built in several locations, mostly in the 1970s, and they are being maintained even today. Not a few of the existing structures within these facilities are thought to be in need of replacement or repair due to their deterioration over the more than 35 years since they were constructed. Corrosion is particularly advanced in structures in which steel products were used, and it appears to have impaired the functioning of the structures. This has even become a blight on the landscape of this beautiful island. Even in dam gates with small curvature, the state of deterioration is such as to require replacement, so impoundment gate leaves, doorstops, operation bridges, stairways, guardrails, and handrails are being replaced.

Year constructed	2007	
Gate type	Slide gate	
Gate leaf structure	Plate girder type	
Gate leaf molding method	Hand lay-up method	
Gate leaf effective dimensions	2.00 meters (B) × 0.96 meters (H)	
Design head	Front face	0.96 meters
	Rear face	0.00 meters
Opening/closing system	Automatic lowering type	
Installed units	2	
Other FRP products	Doorstop, operation bridge, stairway	

Existing steel gate leaf



Existing operation bridge

Existing stairway

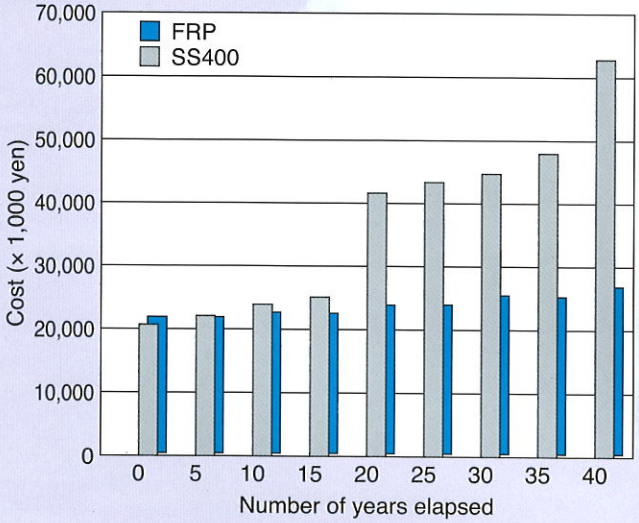
In this particular case, the cost of the FRP hydraulic gate leaves was approximately twice the cost of the SS400 hydraulic gate leaves. However, the FRP gate leaves are only about one-third the weight of the SS400 gate leaves, so they could be transported and installed by human labor, without the use of heavy equipment. The resulting reduction in the heavy equipment transport and installation expenses meant that the total project cost was about the same. As for maintenance costs, the harsh environment, with its associated salt damage, means that the SS400 gate leaves need to be repainted every 5 years. Furthermore, the gate leaves were replaced twice in a period of 40 years, meaning they were replaced once every 20 years. Consumable supplies such as rubber water seals and the like are replaced once every 10 years in both types of the hydraulic gate leaves. That includes the presumed expenses for repainting and the replacement of the rubber water seals. It is assumed that the SS400 gate leaves are repainted at the same time that the rubber water seals are replaced every tenth year. The expenditures that are required for each of these procedures are shown in the following table.

Comparison of initial costs and maintenance costs (× 1,000 yen)

Material	Weight of gate leaves for 2 gates (kg)	Initial costs			Maintenance costs		
		Cost of hydraulic gate leaves	Installation cost	Total	Repainting cost (once per 5 years)	Rubber water seal replacement + Repainting cost (once per 10 years)	Gate leaf replacement (after 20 years)
FRP	248	18,024	2,612	20,636	0	1,300	0
SS400	720	9,561	10,714	20,275	1,700	2,000	15,839

Gate leaf replacement (after 20 years)

Installation in progress using only simple installation tools



A life cycle cost comparison of the FRP hydraulic gate leaves and the SS400 hydraulic gate leaves indicates that the initial cost of the FRP gate leaves is slightly higher than that of the SS400 gate leaves. However, with the first repainting of the SS400 gate leaves, the cost of the SS400 gate leaves becomes higher than that of the FRP gate leaves, and when the SS400 gate leaves are replaced, the expenses for the FRP gate leaves become approximately 45% less than for the SS400 gate leaves. After 40 years, when the SS400 gate leaves are expected to be replaced a second time, the cost of the FRP gate leaves is projected to become 60% less than that of the SS400 gate leaves.

In a case such as this, the higher construction expenses for the SS400 gate leaves mean that there is almost no difference in the initial cost of the SS400 gate leaves and the FRP gate leaves. Because of the severely corrosive environment, the difference in maintenance costs is considerable, which makes the choice of FRP gate leaves particularly advantageous. Even if there were no difference in the construction expenses and the installation expenses were equal, the FRP gate leaves would become approximately 30% less costly as soon as the SS400 gate leaves were repainted for the first time.

Entire gate

Gate leaf

Operation bridge

Stairway

In addition to cases like the present example, where the installation conditions are harsh and the gates are used in a salty environment, FRP hydraulic gates can demonstrate major advantages under severely watery conditions, such as in sewage treatment facilities and factory waste water treatment facilities. Moreover, in cases where the opening/closing apparatus is powered by a motor or an engine, costs can be lowered further, because the rate at which electric power or fuel is consumed can be reduced.

Making things for a more abundant planet

Hibi's motto is "Making things for a more abundant planet," and we are devoted to the task of developing products of great value to the Earth by researching and refining our technologies on a day-to-day basis.

Hibi manufactures fiber reinforced polymer (FRP) hydraulic gates by focusing on lighter weight, lower maintenance expenses, and greater durability, which is particularly required of products that are used for outdoor public works structures. The highly rated performance of these products in FRP structures that are currently in use under severe environmental conditions such as salt water and the like has earned them considerable praise from all sides.

Striving every day to improve our knowledge and technology, we seek to meet our customers' demands in everything from sales and design to installation and after-service.

We have established the FRP manufacturing methods that are best suited to outdoor public works structures. Building on the experience we have accumulated and the abundance of products we have installed in the half-century since we built our first machine, we continue to meet the challenge of developing even better technologies.

Starting with the installation of equipment such as hydraulic gates and debris collectors, we have accumulated an abundance of experience in a wide range of fields, including bridge construction. All employees work as a team to increase workplace efficiency, address safety issues, and pursue improvements in technology and quality.

Products

FRP Footbridge

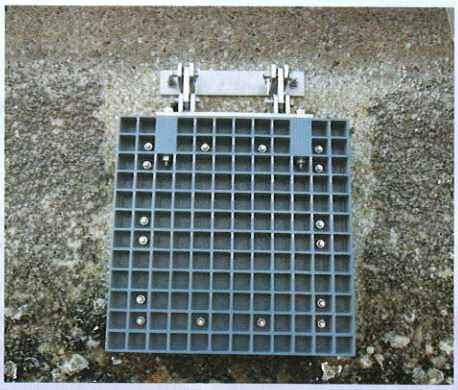
The use of lightweight and highly durable FRP as the structural material can reduce the life cycle cost, lower construction expenses, and improve construction efficiency.

FRP Footbridge Stairway

The use of highly durable FRP as the structural material can reduce the life cycle cost by eliminating the need for maintenance work such as repainting and the like.

FRP Lift Gate

This simple lift gate is highly resistant to corrosion, and because it is fixed in place by driven anchors, it can be installed as a retrofit.

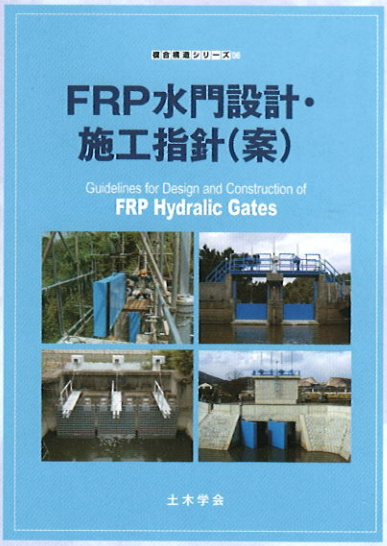


FRP Flap Gate Model GM

A comparatively inexpensive grid-molded backflow-prevention gate. Its light weight gives it excellent water cutoff and drainage performance.

FRP Lining

Applying an FRP coating to a steel surface prevents corrosion more effectively than does repainting.



FRP Hydraulic Gate Design and Construction Guidelines (Draft)

Japan Society of Civil Engineers
Committee on Hybrid Structures
Subcommittee on Guidelines for Design and Construction of
FRP Hydraulic Gate (Editing)

Published February, 2014

We pledge that bridges made in accordance with these guidelines will be highly reliable in design, manufacture, and installation.

Inquiries about “Guidelines for Design and Construction of FRP Hydraulic Gates (Draft)”:

FRP Hydraulic Gates Engineering Association
613-1 Naoe, Yoro-cho, Yoro-gun, Gifu Prefecture

Phone: +81 (0) 584-32-1226
E-mail: frp.hg@hibi-frp.co.jp

株式会社ヒビ

Hibi Corporation

613-1 Naoe, Yoro-cho, Yoro-gun, Gifu Prefecture 503-1337
Phone +81 (0) 584-32-1222　Fax +81 (0) 584-32-0308
URL: http://www.hibi-frp.co.jp