Honshu-Shikoku Bridges

Greetings

The Honshu-Shikoku Bridges were constructed to facilitate transportation between Honshu and Shikoku with expressways and railways, thus contribute to the balanced development of the nation's land and the economic development.

At present, the regions of Kinki and Chugoku in Honshu and Shikoku are connected by 3 routes including 17 long-span bridges, and form one economic and cultural living area, over Seto Inland Sea, with a population of 35 million and the GDP of 130 trillion yen.

The Seto Inland Sea region suffers from very severe natural conditions such as typhoon and earthquake; therefore various technologies were developed when the Honshu-Shikoku Bridges were constructed. In addition, the environmental assessment was implemented to protect the well-known beautiful natural environment of Seto Inland Sea National Park where is blessed with different fantastic sceneries. In doing so, we gave special consideration to the Bridges so that they are in harmony with the surrounding environment.

Currently, utilization of Honshu-Shikoku Bridges allows the time required between Honshu and Shikoku to reduce by one third compared to that of conventional ferries. As the punctuality is secured, reliability of physical distribution has been significantly improved, and the distribution of goods and exchange of people between Honshu and Shikoku have increased. Therefore, the roles played by the Bridges for the activities in terms of economy, industry, everyday living and culture have become increasingly important.

We at Honshu-Shikoku Bridge Expressway Company Limited are committed to making utmost efforts to provide satisfactory services so that the customers can use the Bridge Expressways safely and comfortably. And we still work hard to maintain and manage them in order that the Bridges will be used for a long period of more than 200 years.

We hope that our construction and maintenance engineering for the long-span bridges accumulated in the past will contribute to Japanese and overseas long-span bridge projects.

Shuji Mihara
President
Honshu-Shikoku Bridge
Expressway Company Limited

Contents

Business Policies

Business Policies

Bridge: Communication & Technology

Honshu-Shikoku Bridge Expressway Company Limited (HSBE) will promote the communications for persons or goods and strengthen the connections between the related areas. HSBE will also contribute to the development of national economic activity and the improvement of human livings, by maintaining the world-class long-span bridges between Honshu and Shikoku.
In addition, HSBE will widely contribute to the society by making use of the construction and maintenance technologies for long-span bridges.

1. We will make efforts to provide better services for customers to use the expressways safely, securely and comfortably.
2. We will operate and maintain the expressways to aim for being used more than 200 years.
3. We will advance and succeed our own bridge technologies as a front runner of bridge engineering.
4. We will preserve the beautiful landscape of Seto Inland Sea.
5. We will aim at stabilizing and developing our businesses by managing the businesses fairly and efficiently.

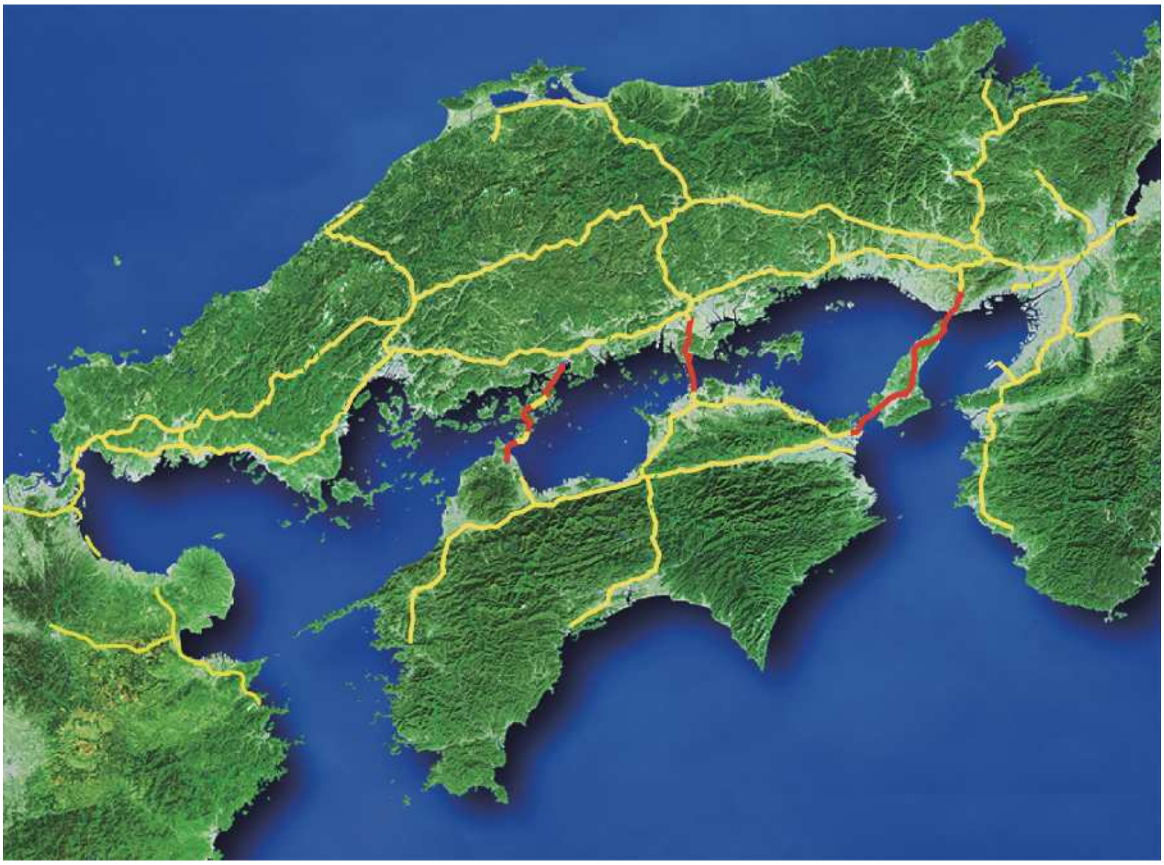
Code of Conducts

1. We will challenge our businesses with pride and confidence to realize the business policies.
2. We will make efforts to communicate with customers by always standing from the viewpoint of customers.
3. We will certainly solve any problems by making points of the sites and taking prompt actions.
4. We will face our businesses with independence and autonomy spirits, and try to be self-improving and our own initiative.
5. We will trust and understand each other in deep for making cheerful and well-communicated work places.
6. We will always keep our spirits for supporting our company with the wish of the company's development and building our own happiness.

Corporate Profile

Corporate Name	Honshu-Shikoku Bridge Expressway Company Limited
Representative	President; Shuji Mihara
Employees	387 employees (As of April 1, 2012)
Head Office Address	4-1-22 Onoe-dori, Chuo-ku, Kobe City
Capital	JPY 4 billion
Date of Establishment	July 1, 1970 Establishment of Honshu-Shikoku Bridge Authority October 1, 2005 Inauguration of Honshu-Shikoku Bridge Expressway Company Limited
Mission	The mission of HSBE is to enhance smooth traffic flow by conducting new construction, upgrading, maintenance, repair and other related management for the expressways efficiently, and furthermore to contribute to the sound development of national economic activity and to the improvement of social lives.

Honshu-Shikoku Bridge Expressway Network



(C) Product/VGL/Geoscience Agency/ARTBANK

Expressway Profile

Contents	Kobe-Awaji-Naruto Expressway	Seto-Chuo Expressway	Nishi-Seto Expressway	Total
Length	89.0 km	37.3 km	46.6 km	172.9 km
Design Speed	100 km/hr	100 km/hr	80 km/hr	—
Lane Number	6 or 4	4	4 or 2	—
Number of Long-span Bridges	2	6	9	17
Open to Traffic	April, 1998	April, 1988	May, 1999	—
Project Cost	JPY 1,470 billion	JPY 670 billion	JPY 730 billion	JPY 2.87 trillion

Akashi Kaikyo Bridge
(Kobe-Awaji-Naruto Expwy.)

Seto Ohashi Bridges
(Seto-Chuo Expwy.)

Kurushima Kaikyo Bridges
(Nishi-Seto Expwy.)

Steps toward Bridging the Sea

Seto Inland Sea

The Seto Inland Sea, which only recently has been spanned by the Honshu-Shikoku Bridges, is one of unusual archipelagos in the world.
Formed some 10,000 years ago, the Inland Sea resulted from the increase in melted glacial ice: the heightened level of the water changed hills to islands and ridges to peninsulas.
Since the Inland Sea is normally gentle owing to its being surrounded by large islands, it has offered calm sea routes and easy passage from ancient times. Nevertheless, when it is rough, sailors find themselves helpless.

Evolving Bridge Concept

Out of a longing to be able to cross the sea easily, a concept of a bridge across the Seto Inland Sea was evolved in the late 1880's, when modern civil engineering practices were established. In May, 1889, a local assemblyman, Jinnojo Ohkubo, first advocated the idea of a bridge across the Inland Sea.

From Dream to Reality

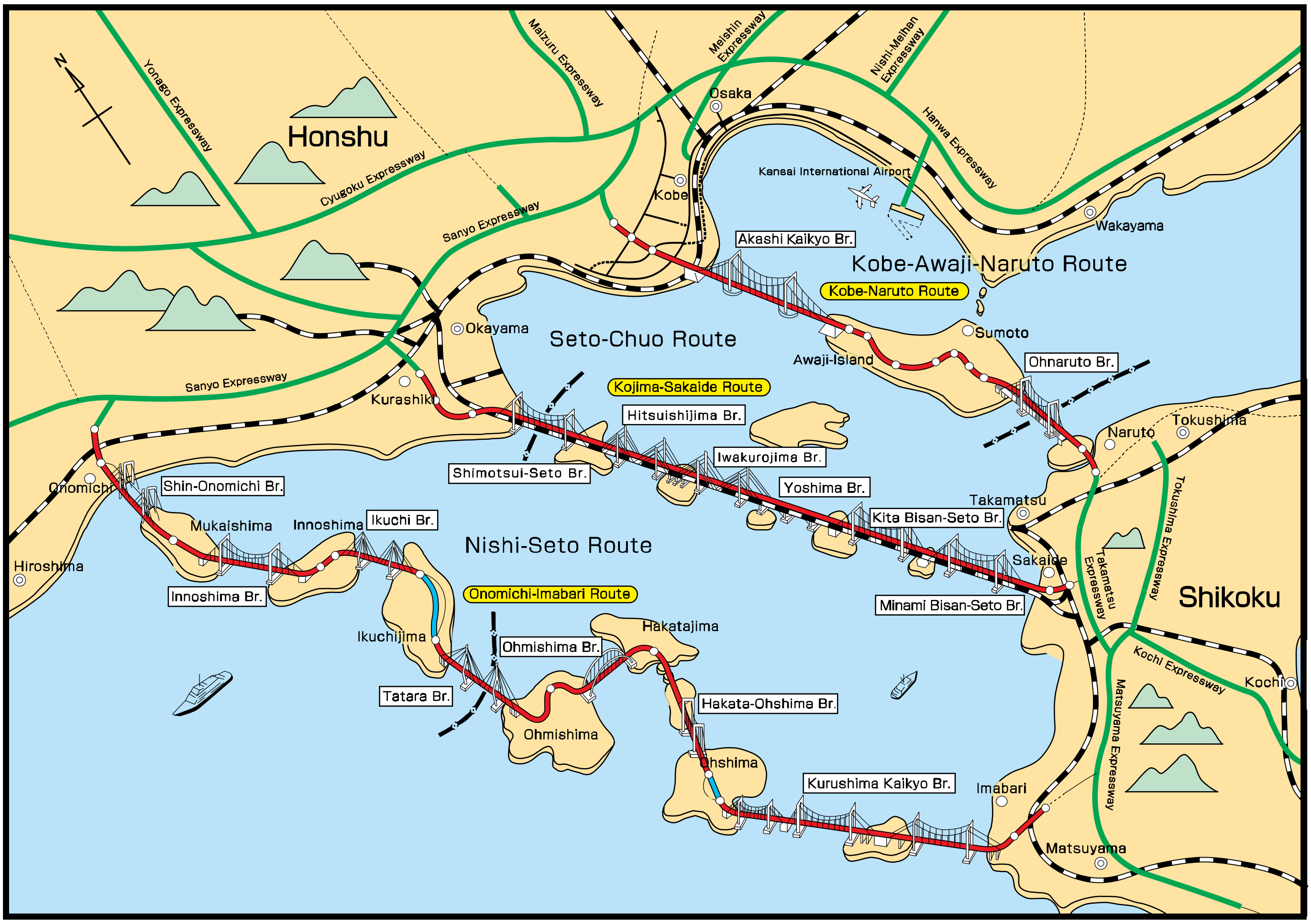
In 1950, the Comprehensive National Land Development Law was passed—a boon for local development which accelerated the movement to link Honshu and Shikoku.
A tragic accident occurred in May of 1955 that probably identified the need for a bridge as nothing else could: two ferries connecting Honshu and Shikoku collided and sank. Many of the 168 precious lives were lost including young boys and girls. In November of the same year, the former Japan National Railway (JNR) initiated a field investigation on the bridge route; at the same time, related local governments also started earnest researches.
The then Ministry of Construction (MOC) initiated another earnest investigation in 1959. Since that time, JNR and MOC, which were simultaneously conducting ongoing feasibility studies, jointly entrusted their research results to the Japan Soceity of Civil Engineers (JSCE).
JSCE thereupon established a technical committee to conduct extensive experiments and studies. In 1967, JSCE issued a final report and submitted it to both JNR and MOC. After evaluating the report, the then Ministry of Transport (MOT) and MOC jointly announced their official backing of the Honshu-Shikoku Bridge Project.

Founding of HSBA

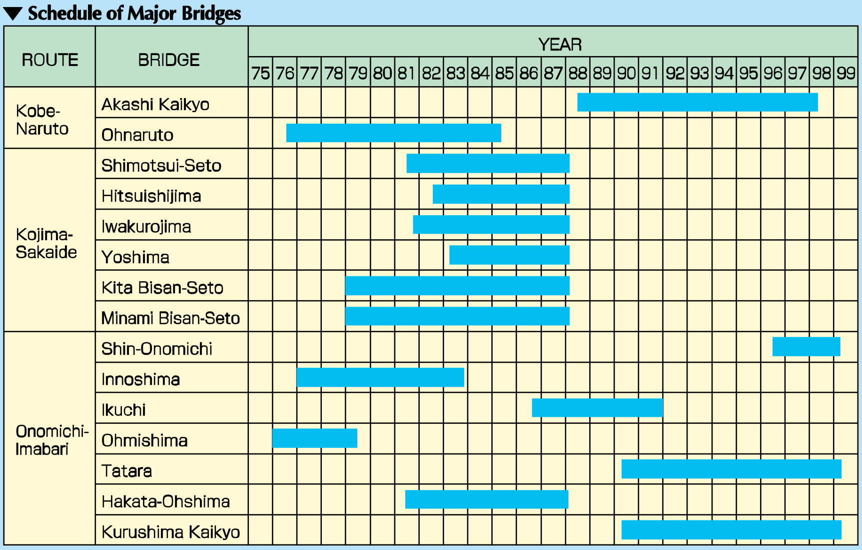
The government officially determined to initiate construction for three routes of the Honshu-Shikoku Bridge Project in 1969 by including them in the New National Land Development Program. The government also intended to establish a new public corporation to implement the project since the bridges were to combine two different modes of transporation, highway and railway, which would require extensive research and development, as well as finance from both local governments and the private sectors.
The Honshu-Shikoku Bridge Authority (HSBA) was founded on July 1, 1970, based on the Honshu-Shikoku Bridge Authority Law. Its primary objective was to oversee, in an integrated and efficient manner, the construction and operation of the toll highways and railways which link Honshu and Shikoku.

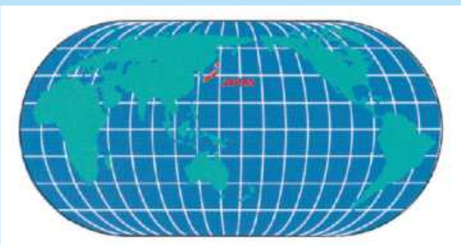
From HSBA to HSBE

On October 1, 2005, Honshu-Shikoku Bridge Expressway Company Limited (HSBE) was founded instead of Honshu-Shikoku Bridge Authority (HSBA) in order to manage not only the operation of the toll highways and railways which link Honshu and Shikoku but also the Service Area business and new business to improve the service level for road users.



▼ **Schedule of Major Bridges**





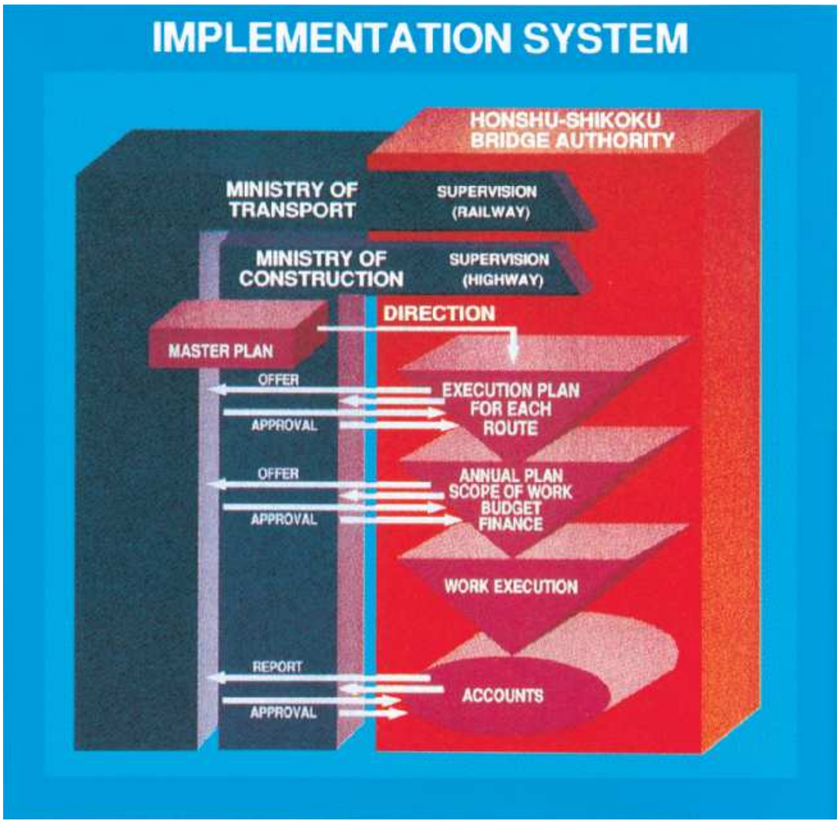
The land of Japan consists of four main islands: from North to South, Hokkaido, Honshu, Shikoku, and Kyushu.Transportation by ships and airplanes between those islands had been often interrupted by bad weathers such as winds, waves, and fogs. To eliminate such inconvenience and promote balanced development of the country, construction of fixed crossings to link those islands was carried out

Construction System

Government Supervision

HSBA was a public corporation founded in law and supervised by both MOT and MOC. HSBA had to present execution plans to both ministries before implementing those plans for each route. In addition, HSBA had to offer an annual plan each fiscal year that explicitly outlines the scope of all proposed projects, budget, and finance based on execution plans approved and ongoing.

In November, 1972, HSBA submitted a final research report to both MOT and MOC.
After evaluating the report, both ministries issued guidelines in September, 1973, for a master plan for construction. Execution plans for construction outlined by HSBA were officially approved by the government in October. This approval was the official "go" for construction to begin the three routes.



Connectiong Honshu with Shikoku by three routes means more than easy access and convenience for local residents. As trunk roads in the nationwide transportation network, these routes play a vital role in promoting a united and balanced development of the national land and economy.

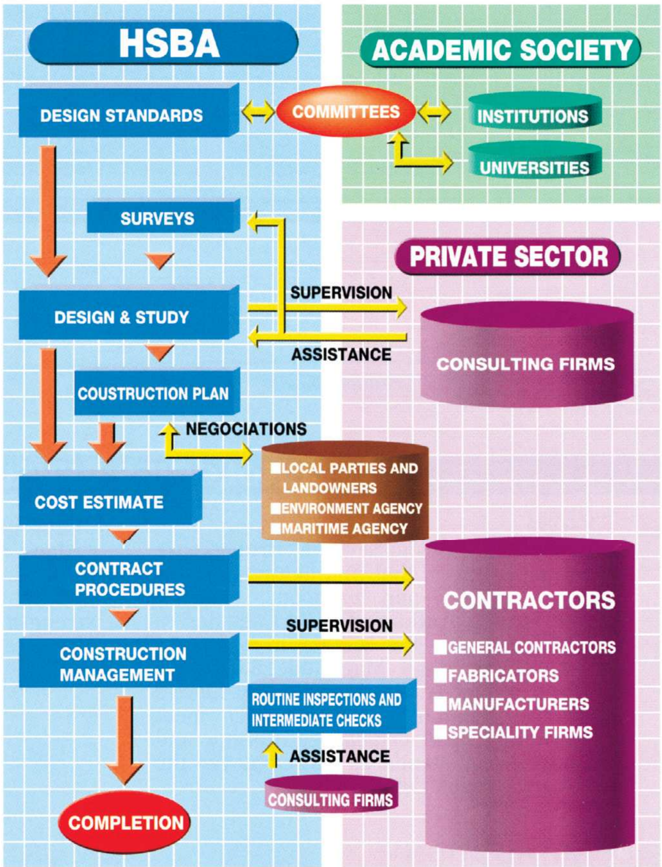
Design & Construction Task

Design of the Honshu-Shikoku Bridges was developed by in-house engineers of HSBA along with some engineering services provided by consulting firms based on the design standerds and codes which were established by HSBA in cooperation with committees conducted by Public Works Research Institute (PWRI), Japan Society of Civil Engineers (JSCE) and Bridge and Offshore Engineering Association (BOEA). At the study and design stage, new materials and construction methods were newly developed through the cooperation of HSBA and industrial firms.

The in-house engineers also negotiated with relevant agencies, interested local parties and landowners. Then the in-house engineers prepared drawing, technical specification, and other documents, as well as official cost estimates for contract procedures.

HSBA contracted a variety of general contractors, manufacturers, fabricators, and other specialty firms. The in-house engineers supervised them by various inspections and intermediate checks so that their works satisfied HSBA's specifications.
For routine inspections, HSBA got some assistance of consulting firms.

GENERAL PROCEDURE TO IMPLEMENT TASKS



Management

HSBA had been responsible for the construction and maintenance of the bridges connecting Honshu and Shikoku, therefore, HSBA had been repaying all funds borrowed or loaned for the construction of highways and railways, including maintenance cost and interest, from such business income as toll revenues. However, as the government had decided that HSBA had been privatized from October 1, 2005, aiming at more efficient management, HSBA had restarted as the Honshu-Shikoku Bridge Expressway Company Limited (HSBE). All debt will be repaid by Japan Expressway Holding and Debt Repayment Agency (JEHDRA) because both asset and debt are inherited by JEHDRA.

HSBE rents the road asset, which HSBA had held, from JEHDRA and pays the rent from the business income. JEHDRA repays the debt caused by the construction of these highways within 45 years after the privatization.

Scope of Activities

HSBE is operating and managing the following three routes in accordance with law.

■Kobe-Awaji-Naruto Expressway
including Akashi-Kaikyo Bridge and Ohnaruto Bridge.

■Seto-Chuo Expressway
including Shimotsui-Seto Bridge, Hitsuishijima Bridge, Iwakurojima Bridge, Yoshima Bridge, Kita Bisan-Seto Bridge, and Minami Bisan-Seto Bridge.

■Nishi-Seto Expressway
including Shin-Onomichi Bridge, Innoshima Bridge, Ikuchi Bridge, Tatara Bridge, Ohmishima Bridge, Hakata-Ohshima Bridge, and 1st～3rd Kurushima Kaikyo Bridges.

HSBE is authorized to conduct the following regarding those routes:

■Renovation, maintenance, disaster restoration projects, and other operational works for the road asset rented from JEHDRA.

■Management of the highway-railway combined parts of bridges based on the commission from JEHDRA.

■Construction, research, surveys, designs, experiments and studies concerning long-span bridges commissioned by the central and local gevernments.

■Operation of rest stops and gas service facilities.

Finance (at Construction Period)

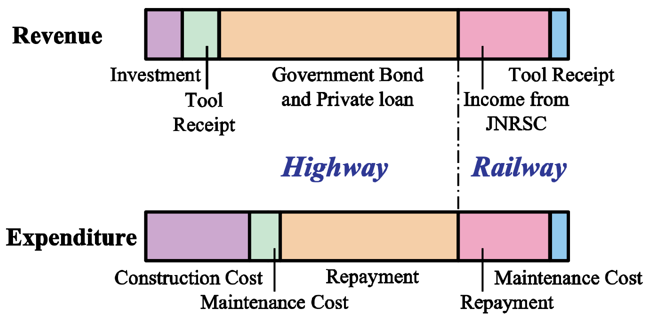
Revenue

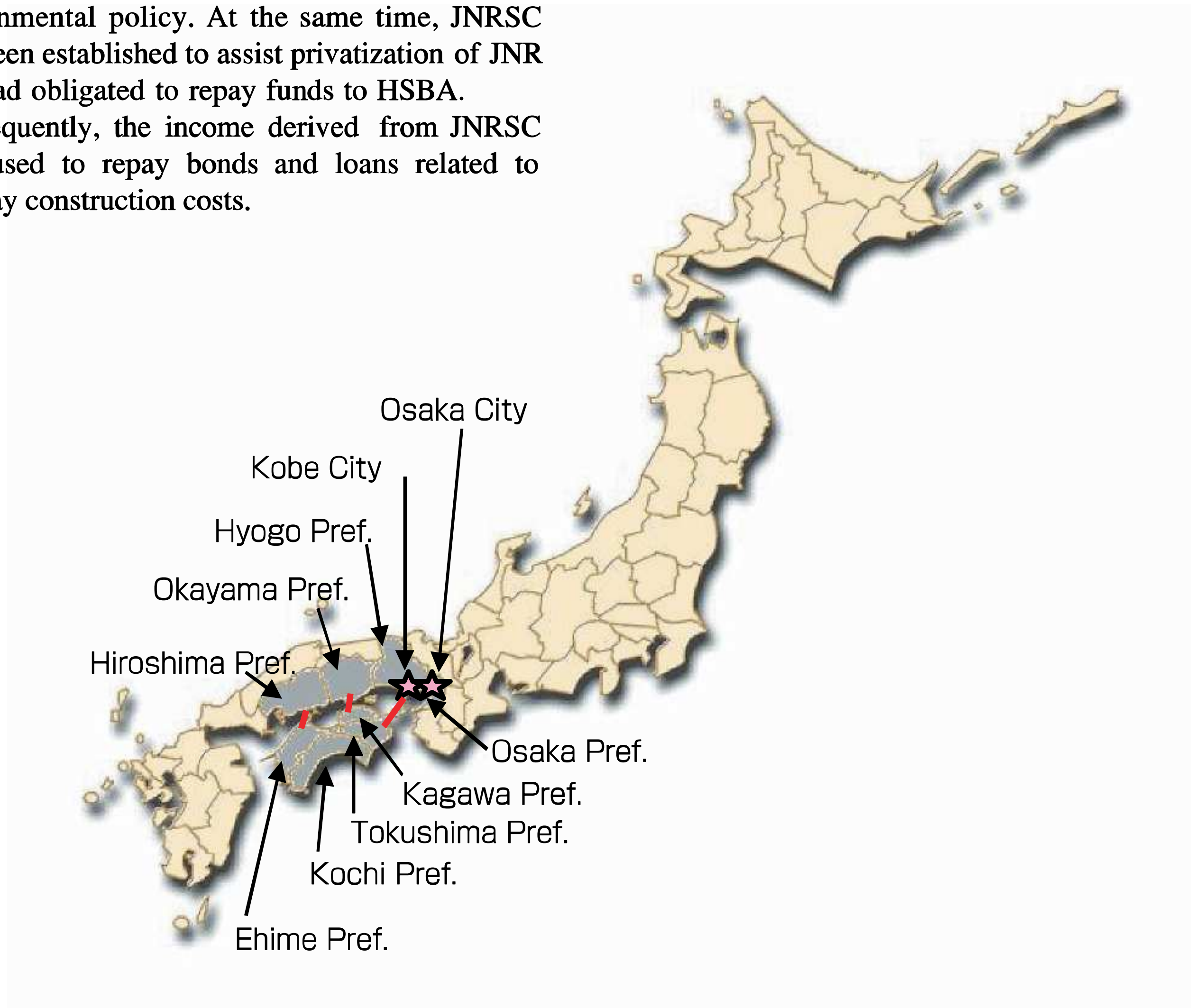
HSBA was financed through both investments and loans. The investments, which were financed without any interest, were used to lower the percentage of interest against loans outstanding. Thus, HSBA did not suffer from an excessive burden of interest on debt. Two-thirds of total investments were funded by the central government, and the rest was divided among ten local governments affected by the bridge project. The loans included government-guaranteed bonds, private sector bonds and loans. The other sources included such business income as toll revenue, income from the Japan National Railway Settlement Corporation (JNRSC), and the like.
In the initial plan to finance HSBA, the total borrowed funds spent for construction of the railway facilities had been repaid by the Japan National Railway to HSBA. However, JNR had been privatized and split up in accordance with governmental policy. At the same time, JNRSC had been established to assist privatization of JNR and had obligated to repay funds to HSBA.
Consequently, the income derived from JNRSC was used to repay bonds and loans related to railway construction costs.

Expenditure

These funds were spent for construction, operation, and research and development costs regarding the bridge project, as well as for retirement of bonds thus far issued and for loans outstanding.

Revenue and Expenditure (image)





Repayment

Highways

All funds borrowed for the construction of highways, including maintenance cost and interest, will be repaid, within 45 years from the establishment of JEHDRA, from lease charge from HSBE.

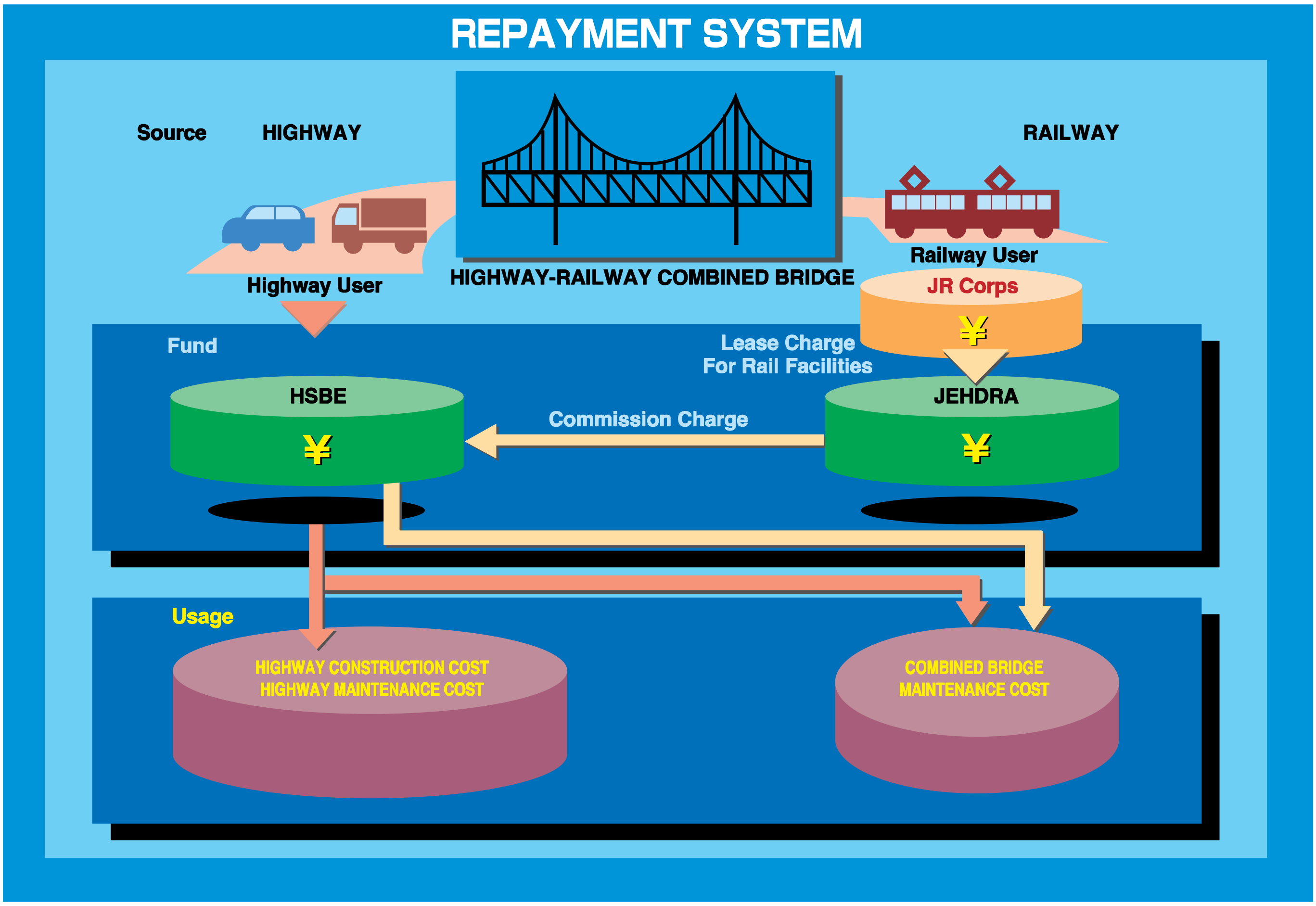
Railways

All funds loaned for the construction of railways, including interest, had been repaid by income received from JNRSC (finished in 2002). No reimbursement is required for railway maintenance costs since JEHDRA is leasing the railway facilities to the Japan Railway Corporation (JR), which conducts all maintenance on railway facilities at its own expense.

Highway-Railway Combined Bridges

All borrowed funds for the cost of construction, including interest costs, for combined bridges, were divided according to a formula into shares for highway and shares for railway that were proportional to design load factors. Each share was repaid by highway toll revenues and by income received from JNRSC (finished in 2002).

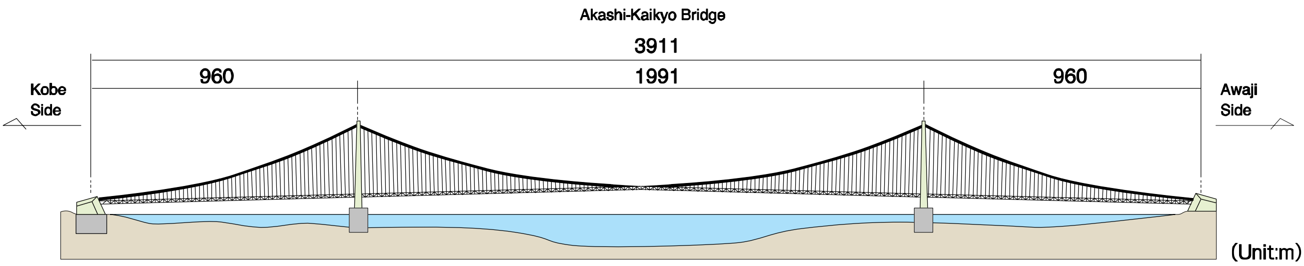
All funds for the cost of maintenance, including interest, for the combined bridges are also divided into shares, and repaid by toll revenues for the highway and by lease charge against JR for the railway.

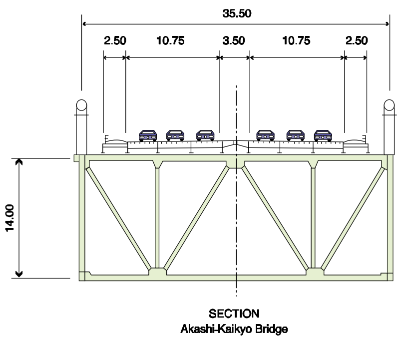


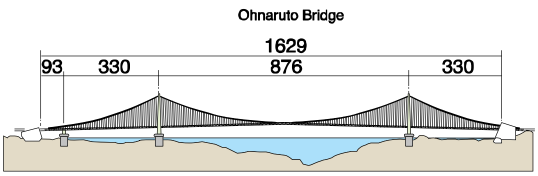
Kobe-Awaji-Naruto Expressway

- Crossing the two straits -

The eastern route, Kobe-Awaji-Naruto Expressway is about 89 kilometers long from Kobe in Honshu to Naruto in Shikoku. The Akashi-Kaikyo Bridge crosses the Akashi Strait (width : 4km) and the Ohnaruto Bridge crosses the Naruto Strait (width : 1.3km). The Ohnaruto Bridge was opened to traffic in June 1985. The Akashi-Kaikyo Bridge, the world's longest suspension bridge, was put in service in April 1998.







Ohnaruto Bridge (completed in 1985)

This is a 3-span 2-hinged stiffening-truss suspension bridge. The length is 1629 meters including a center span of 876 meters.

Akashi-Kaikyo Bridge (completed in 1998)

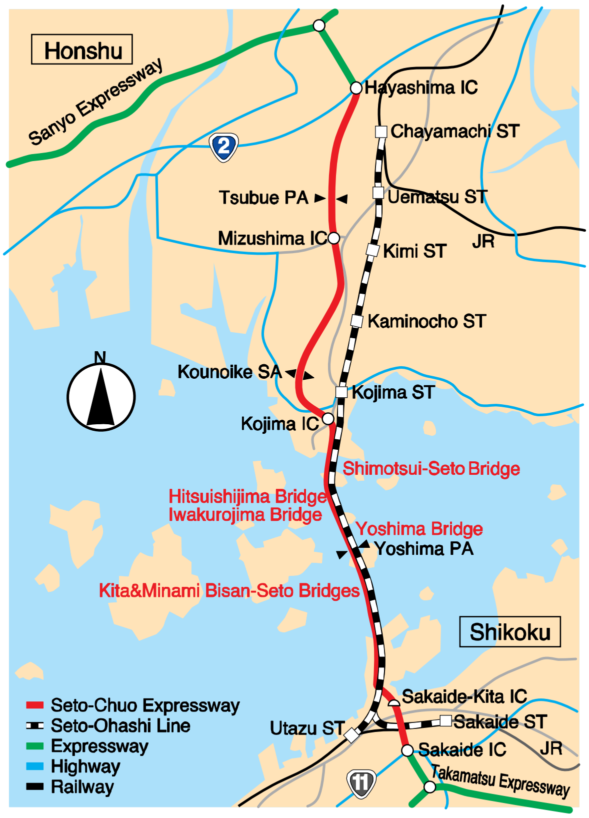
This is a 3-span 2-hinged stiffening-truss suspension bridge. The length is 3911 meters including the world's longest center span of 1991 meters.

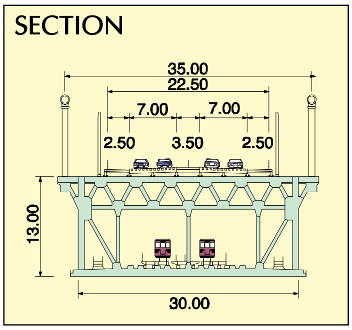
Illuminated Akashi-Kaikyo Bridge

Seto-Chuo Expressway & JR Seto-Ohashi Line

- Huge Double Deck Structures -

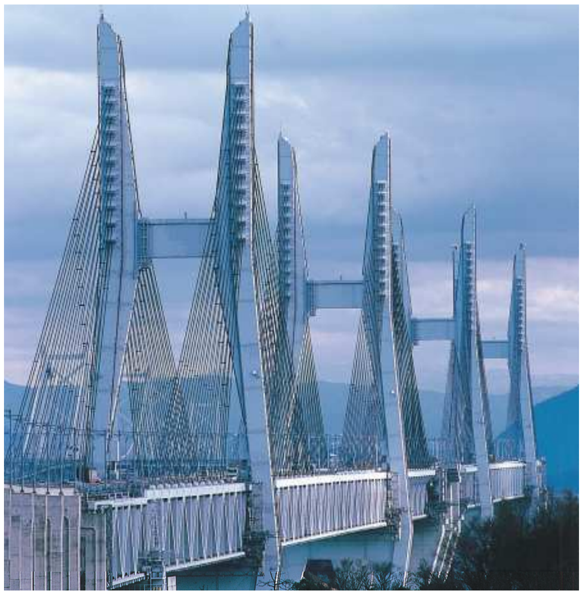
The central route, Seto-Chuo Expressway & JR Seto-Ohashi Line, is for both a highway and a railway. The total lengths of highway and railway are about 39 kilometers and 32 kilometers, respectively. They were opened to traffic in April 1988. This route consists of six long-span bridges (Shimotsui-Seto Bridge, Hitsuishijima Bridge, Iwakurojima Bridge, Yoshima Bridge, Kita Bisan-Seto Bridge, and Minami Bisan-Seto Bridge) which cross the 9.4 kilometers strait. The upper and lower decks of the stiffening girder are for highway traffic and railway. These six long-span bridges are called the Seto-Ohashi Bridges.





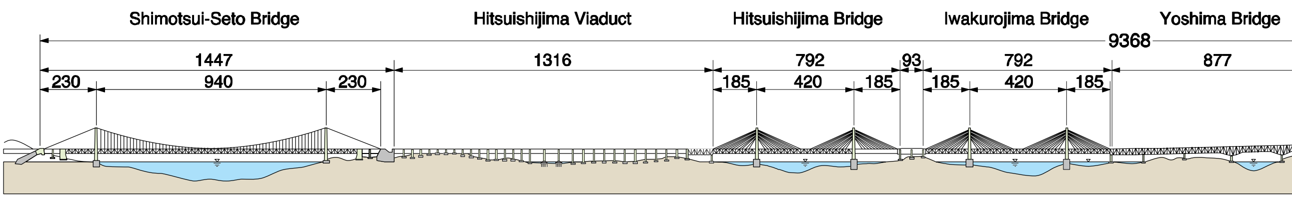
Kita & Minami Bisan-Seto Bridges

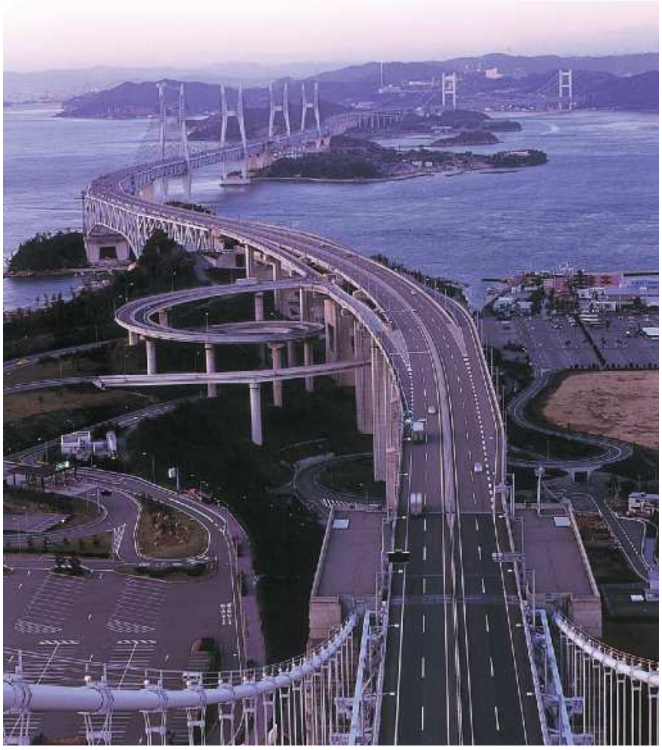
These are tandem 3-span continuous stiffening-truss suspension bridges. The anchorage set between the twins, named 4A, is a double auchorage to support huge cable tensions from both bridges.



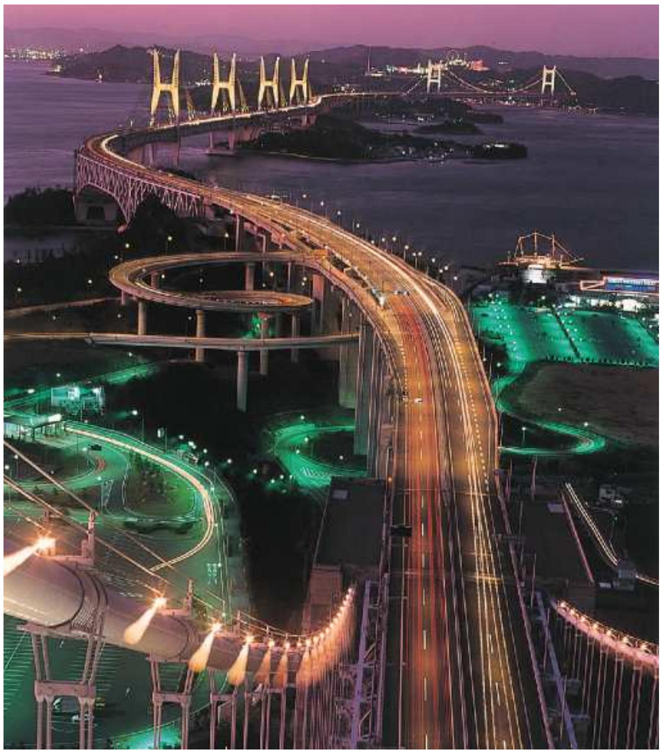
Hitsuishijima & Iwakurojima Bridges

These are tandem cable-stayed bridges. Each length is 790 meters with its center span of 420 meters. Couples of elastic supports were installed at each end of the girders to minimize seismic reactions.



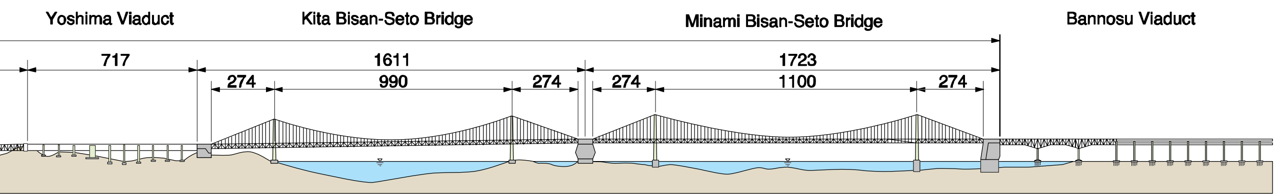


Seto-Ohashi Bridges



Illuminated Seto-Ohashi Bridges

Panoramic View of the Seto-Ohashi Bridges (from Honshu-side, completed in 1988)

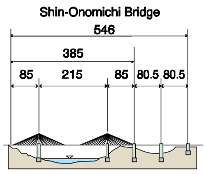


Nishi-Seto Expressway

- Linking a series of islands -

The western route, Nishi-Seto Expressway, is about 59 kilometers long (inclnding the portions of national highway) from Onomichi in Honshu to Imabari in Shikoku. This route consists of nine long-span bridges and connects seven islands. The total population of these islands is about 100,000. The long-span bridges have been opened to traffic since 1979. Finally, in 1999, the Tatara Bridge, the Kurushima Kaikyo Bridges, and the Shin-Onomichi Bridge were opened. These long-span bridges, except for the Shin-Onomichi Bridge, accommodate pedestrians, bicycles, and motorcycles (not larger than 125cc.). This is the special feature of this route among the three routes of Honshu-Shikoku Bridges.

①



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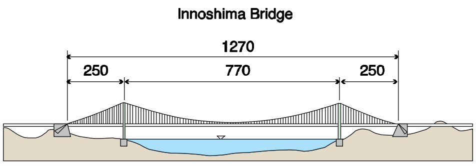
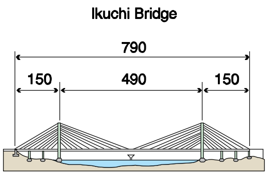


① Shin-Onomichi Bridge (completed in 1999, forefront)
This is a steel cable-stayed bridge with a center span of 215m.

③



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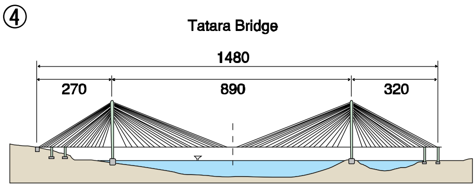
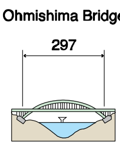


② Innoshima Bridge (completed in 1983)
This is a 3-span, 2-hinged stiffening truss suspension bridge with a center span of 770m.

⑤



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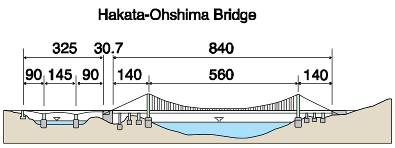

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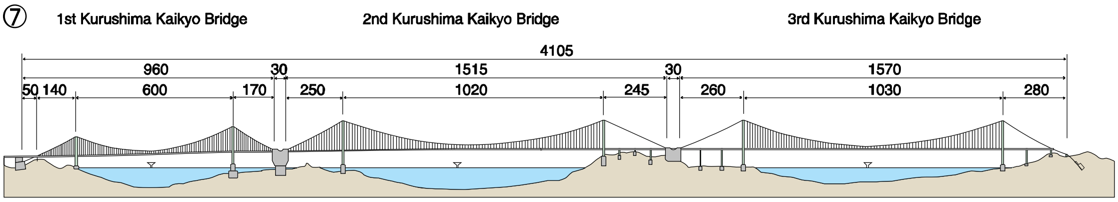
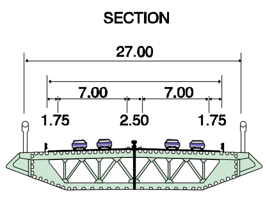
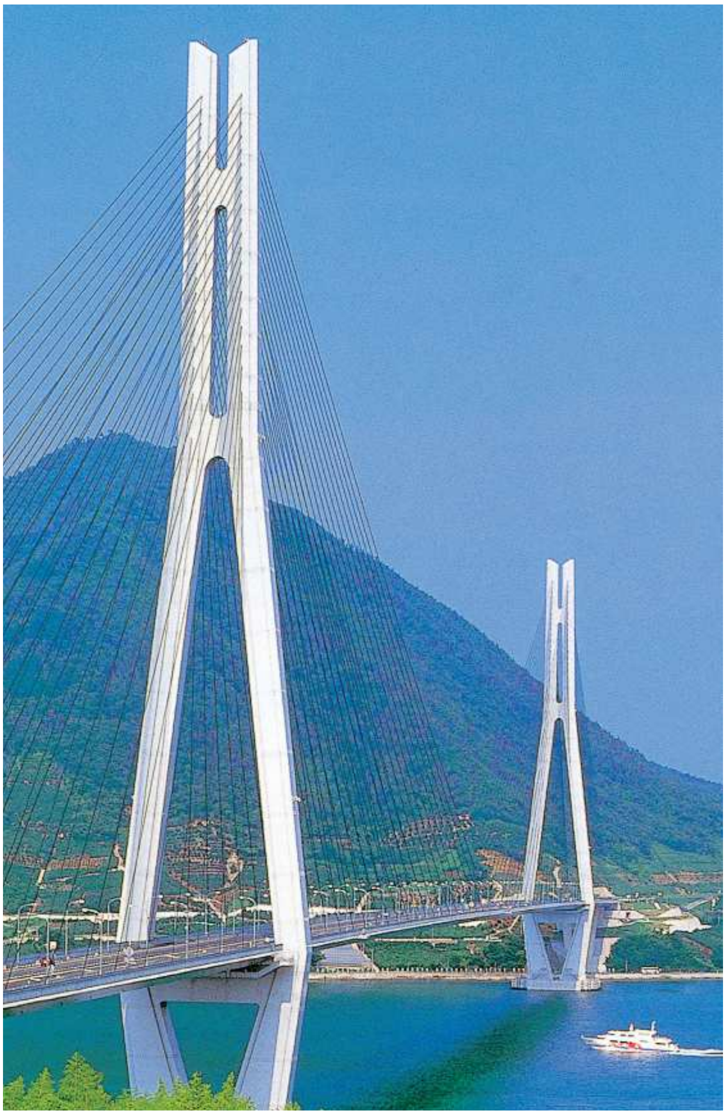




Kurushima Kaikyo Bridge

③ Ikuchi Bridge (completed in 1991)

This is a composite girder cable-stayed bridge, center span of steel and side spans of concrete.



④ Tatara Bridge (completed in 1999)

The Tatara Bridge is the world's third longest cable-stayed bridge with a center span of 890m. The cable-stayed type was selected to avoid excessive volume of earthwork to be expected at the abutment site.

⑤ Ohmishima Bridge (completed in 1979)

This is a steel, 2-hinged, solid-rib arch bridge with an arch span of 297m.

⑥ Hakata-Ohshima Bridge (completed in 1988)

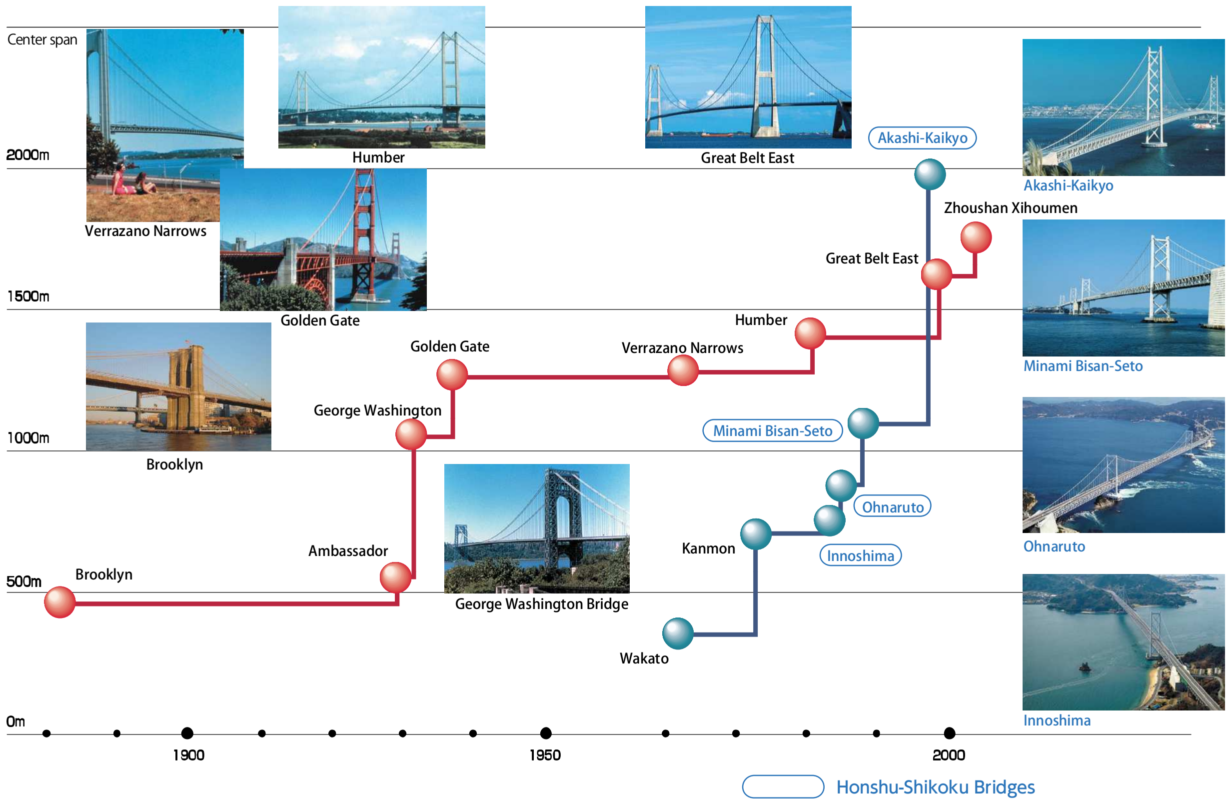
This is a single span box girder suspension bridge with a center span of 560m.

⑦ Kurushima Kaikyo Bridges (completed in 1999)

The Kurushima Kaikyo Bridges consist of three suspension bridges, they are structurally connected by a couple of double anchorages.

Progress of Center Span on Long-Span Bridges

Suspension Bridge

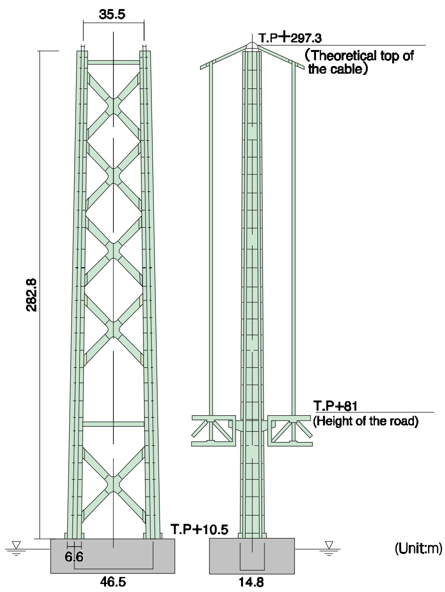


Akashi-Kaikyo Bridge

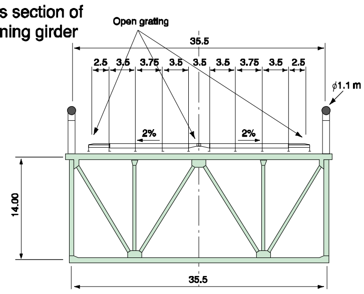
Design Specifications

Type	3-span 2-hinged suspension bridge with stiffening truss girder
Spans	960m+ 1,991m+ 960m= 3,911m
Height of road surface at center span	approx . 97m
Clearance	approx . 65m
Height of tower	approx. 297m
Cable	φ=1.1m/cable * 2 cables
Size of stiffening girder	14.0m(H) * 35.5m(W)

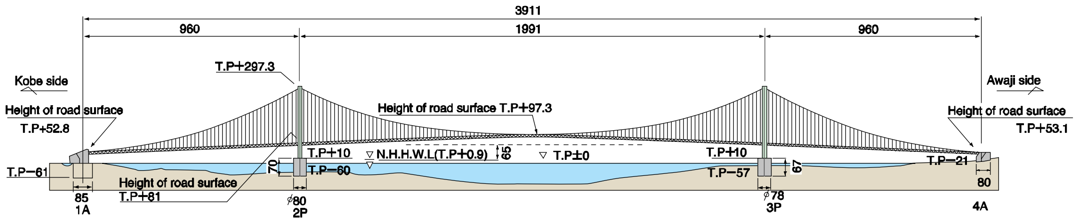
Tower



Cross section of stiffening girder

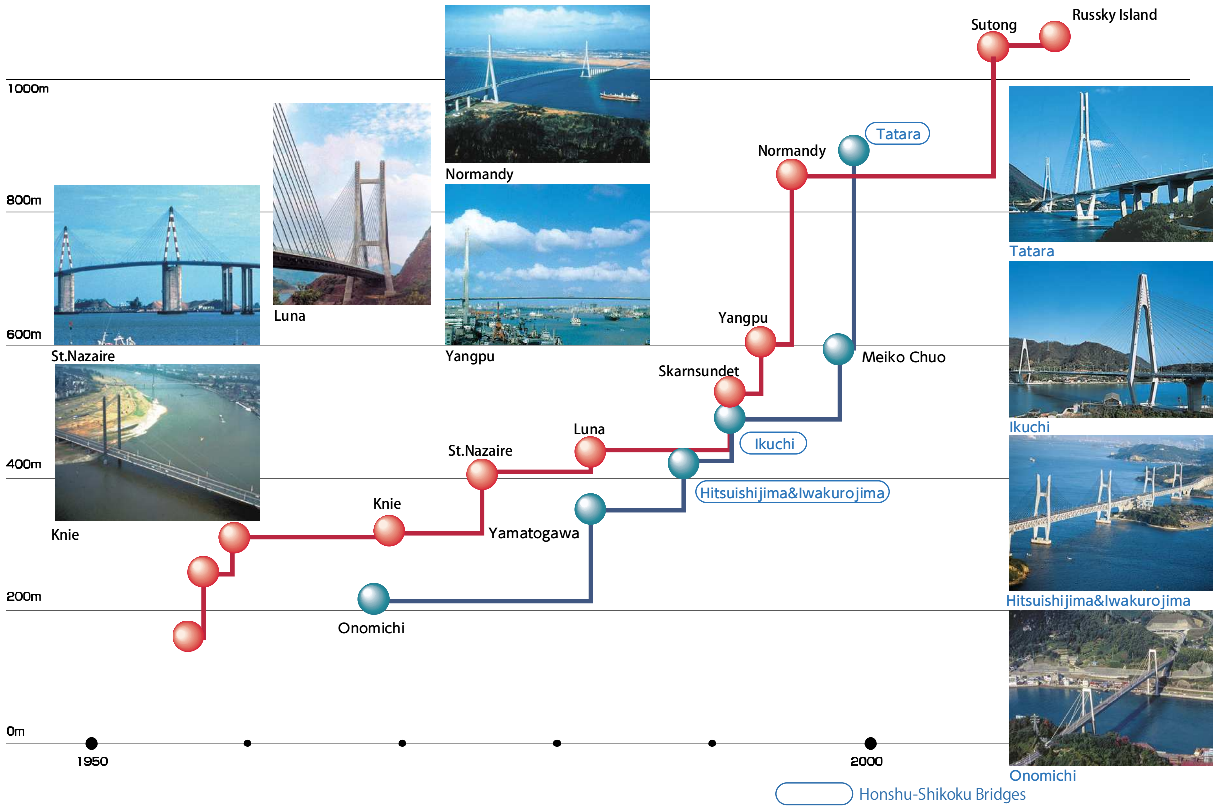


Side view



T.P·······················Tokyo Bay mean tide level N.H.H.W.L····················Near-highest high water level

Cable-Stayed Bridge

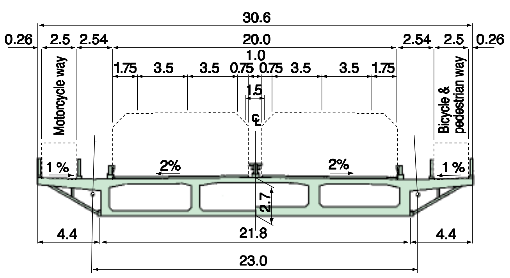


Tatara Bridge

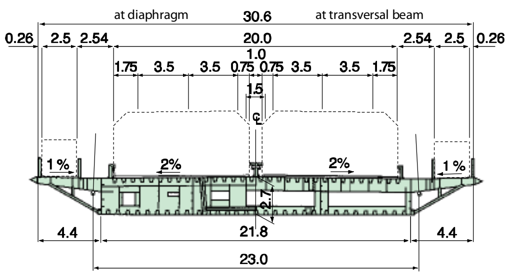
Design Specifications

Type	3-span continuous cable-stayed bridge with steel box girder and PC girder
Spans	270m+ 890m+ 320m= 1,480m
Height of road surface at center span	approx. 48m
Clearance	approx. 42m
Height of tower	approx. 226m
Cable	168 cables
Size of stiffening girder	2.7m (H) * 30.6m(W)

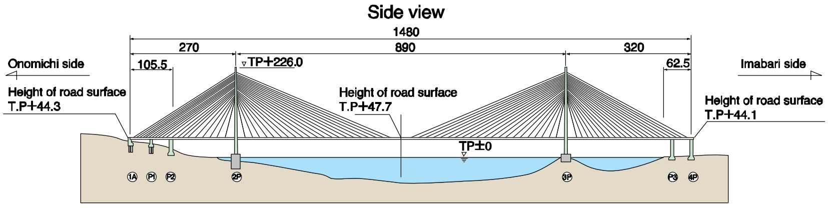
Cross section of PC girder



Cross section of Steel girder



Side view



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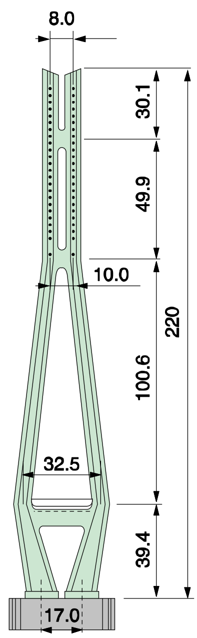
Tower



(Unit:m)

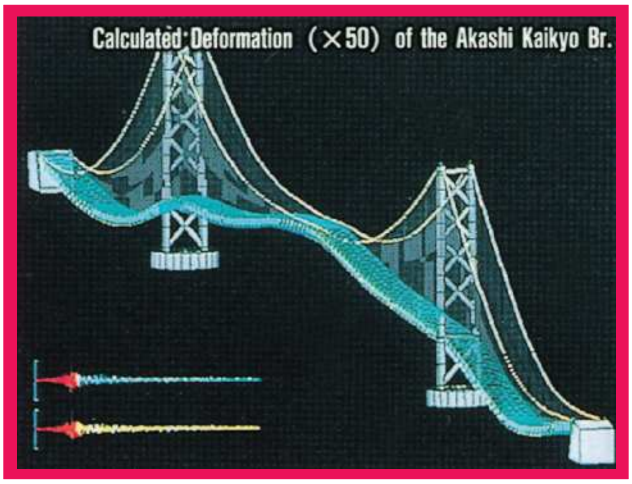
Research

Geology

To evaluate the Akashi Layer, since 40% of the Akashi Layer is a gravel ranging from 10cm to 20cm in diameter, a large-diameter boring device was developed.

Seismic design

Seismic design standards for long - span bridges were established according to ground conditions.



Oscillation of the Akashi Kaikyo Bridge by computer analysis (magnified 50 times.)

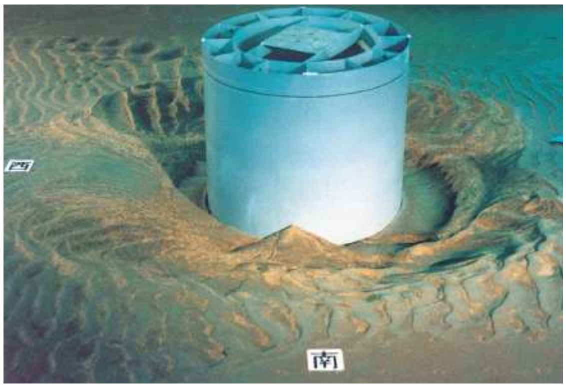
Fatigue design

The results of fatigue design were verified using a large scale fatigue testing machine.

Large scale fatigue test of various types of joints.

Hydraulic model test (scour protection)

Anti-scour measures were established after investigation by experiments.



Result of hydraulic model test (without scour protection)

Result of hydraulic model test (with scour protection)

Aerodynamic design

To inspect the aerodynamic stability of long-span bridges, a large-scale wind tunnel facility was built.

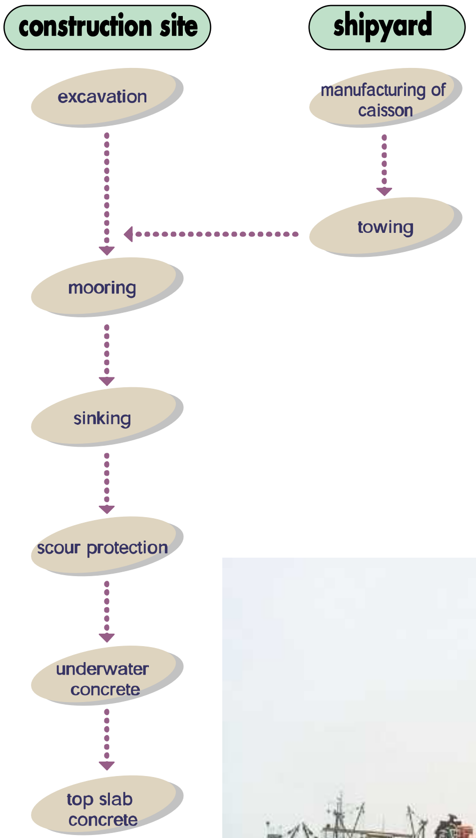
Full-model wind tunnel test to evaluate the influence of topography (Tatara Bridge, scale=1/200)

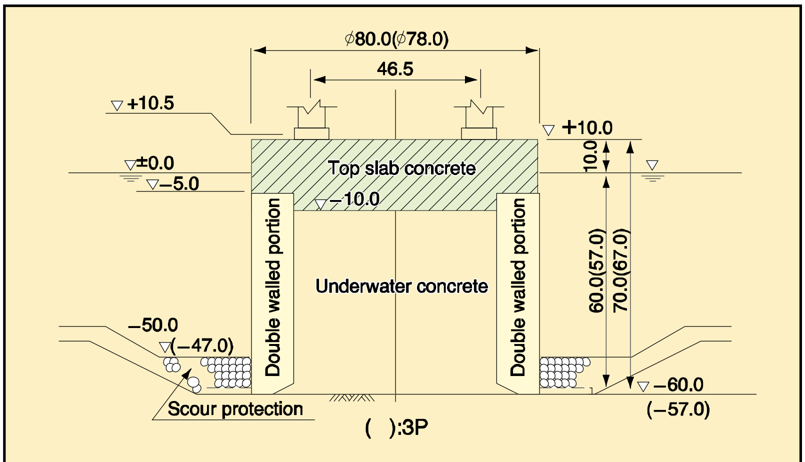
Large-scale full model wind tunnel test (Akashi-Kaikyo Bridge, scale=1/100)

Substructure of Long-Span Bridges

Underwater Foundations of Main Towers
(Akashi-Kaikyo Bridge)

Under the severe conditions such as strong tidal currents (4.5m/s) and deep water (-60m), the foundations were constructed safely and surely by using "Laying-down caisson method".
State-of-the-art technologies such as scour protection and underwater desegregate concrete were developed for substructure construction.





Main tower foundation


Excavation of the seabed using a large grab bucket dredger


Manufacturing a steel caisson

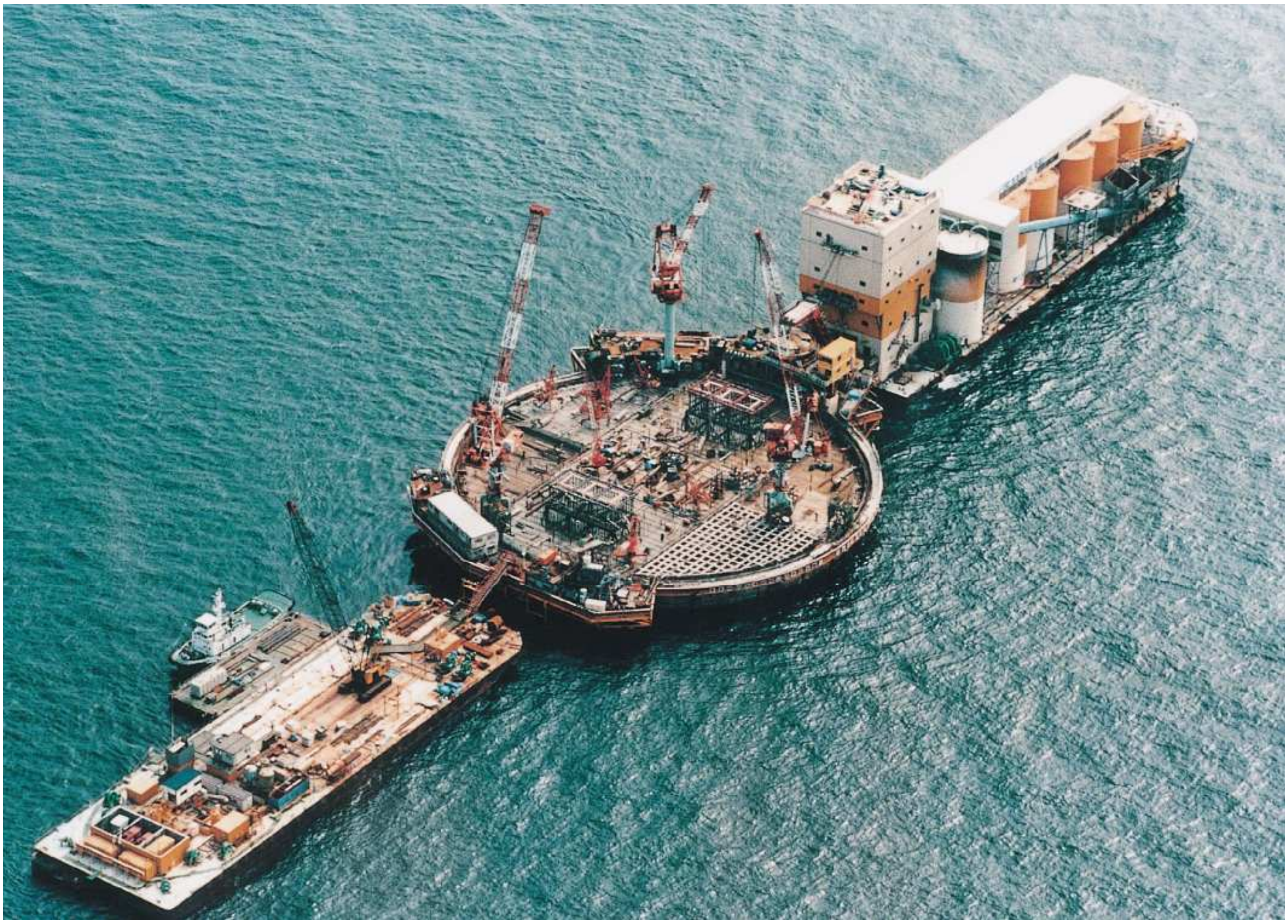

Mooring


Towing

Sinking

Casting underwater desegregate concrete

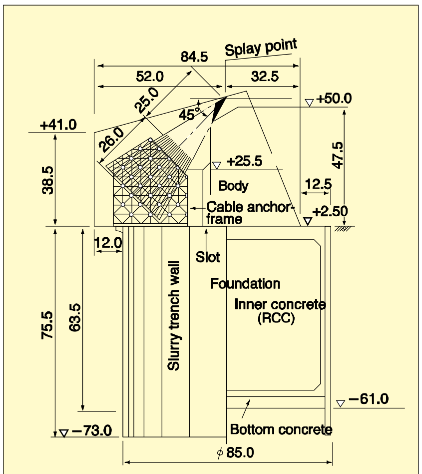
Dropping rip-rap (scour protection)



Casting top slab concrete in the open air

Anchorage (1A, located on Kobe side)
(Akashi-Kaikyo Bridge)

On the soft ground, the foundation was constructed safely and surely by using "underground slurry wall method". Various kinds of concrete, from slurry wall (rich mixed concrete) to inner concrete of foundation (lean mixed concrete), were used. Precast concrete panels were installed considering the esthetics of the outside walls. Highly workable concrete was used for anchorage body.



1A anchorage

(Unit:m)

Excavation using underground slurry wall method

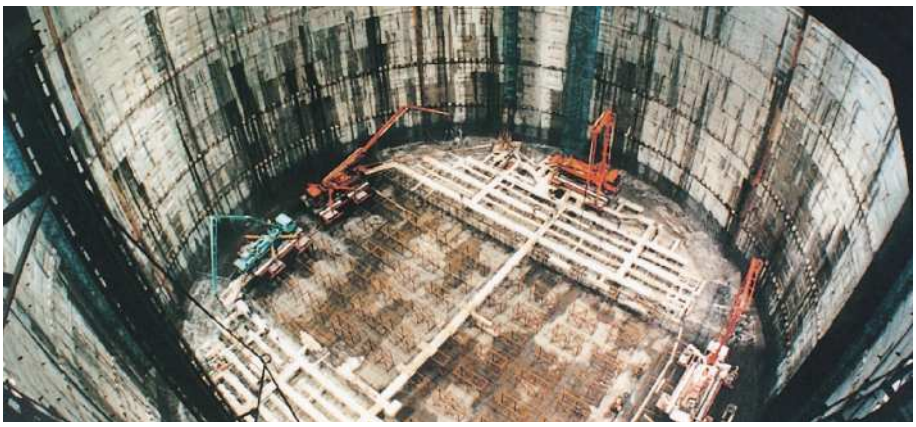
Foundation

- slurry wall
- inside excavation & inner wall
- bottom slab concrete
- inner concrete (RCC)
- top slab concrete

Anchorage Body

- installation of cable anchor frame
- anchorage body concrete

Excavation of inside of slurry wall



Construction of the bottom slab concrete

Inner concrete（Roller Compacted Concrete,RCC）

Distant view of 1A anchorage foundation work

Transportation of cable anchor frame using a floating crane

Concrete casting of anchorage body

Highly workable concrete for anchorage body

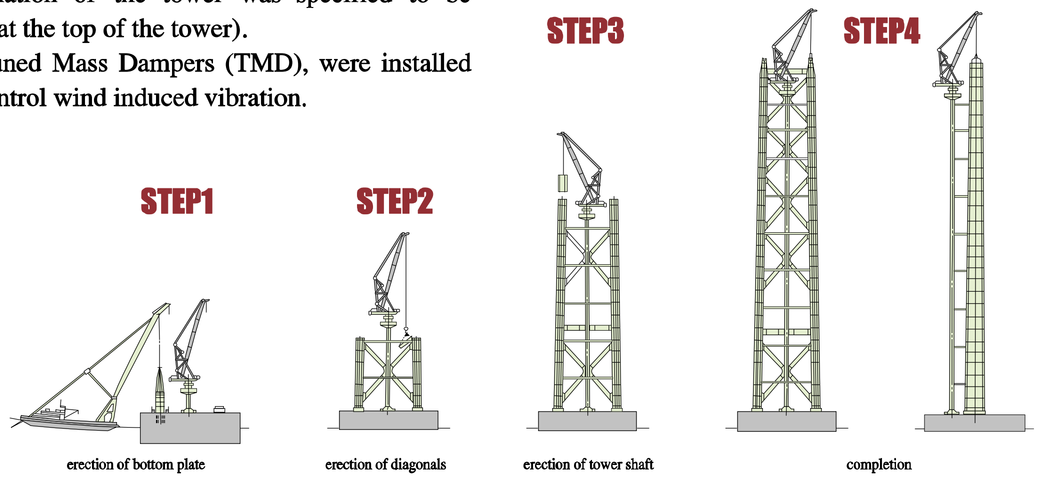
Distant view of 1A anchorage work

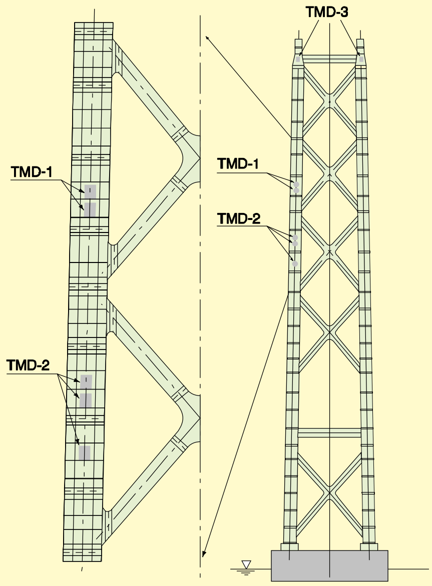
Superstructure of Suspension Bridges

Erection of Main Towers
(Akashi-Kaikyo Bridge)

The allowable inclination of the tower was specified to be 1/50,000 (about 6cm at the top of the tower).
Damping devices, Tuned Mass Dampers (TMD), were installed inside the tower to control wind induced vibration.

Procedure for tower erection

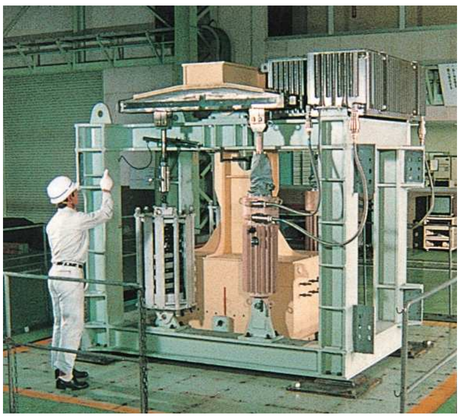




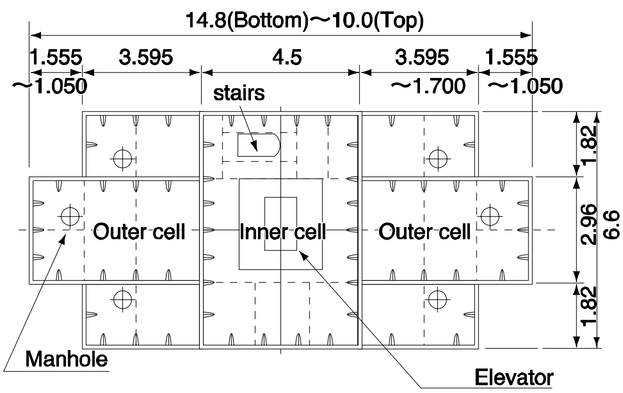
Locations of Tuned Mass Dampers

Polishing cross-section of tower shaft using large scale facing machine

To control the inclination of the towers and to assure the metal touch at connections, each end of the tower shaft blocks was polished up to 0.0125 mm ruggedness.



Tuned Mass Damper

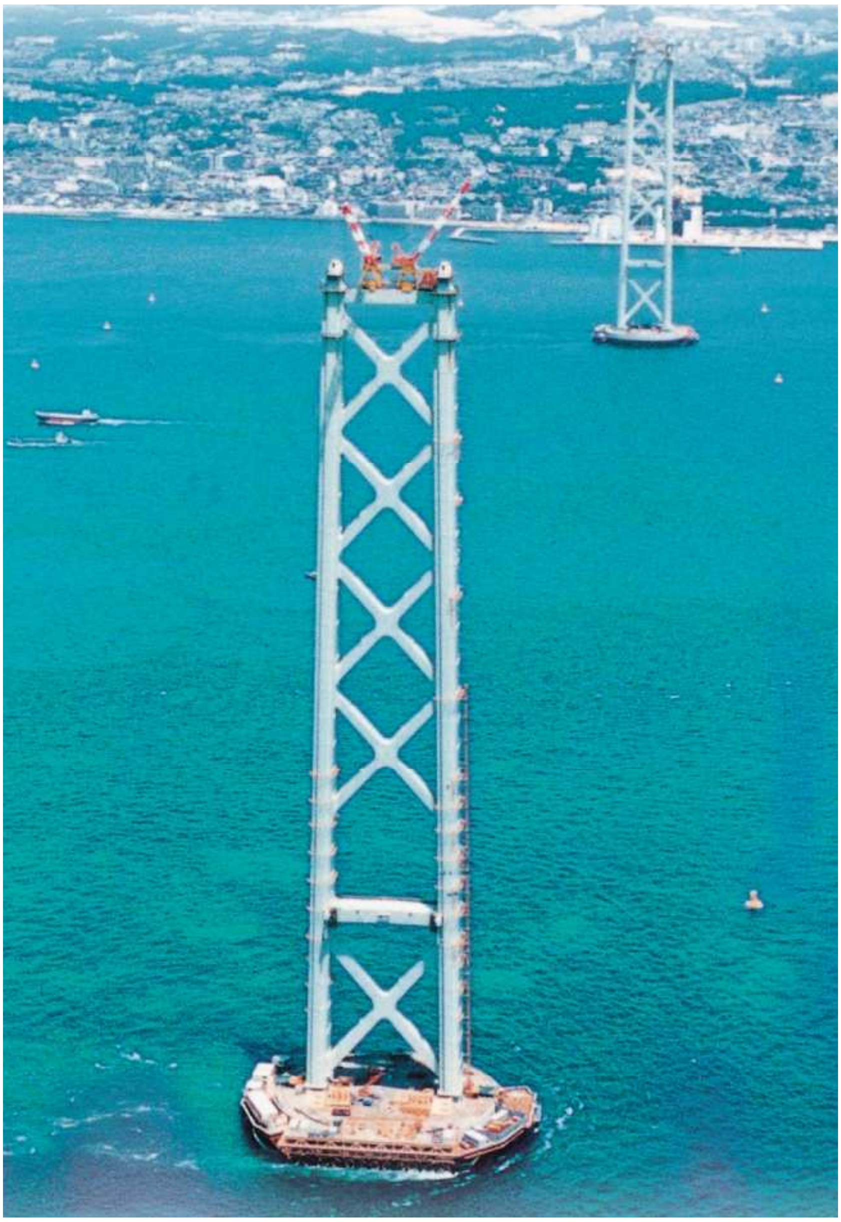


Cross section of tower shaft

Grinding concrete surface before installation of bottom plate

Erection of diagonals

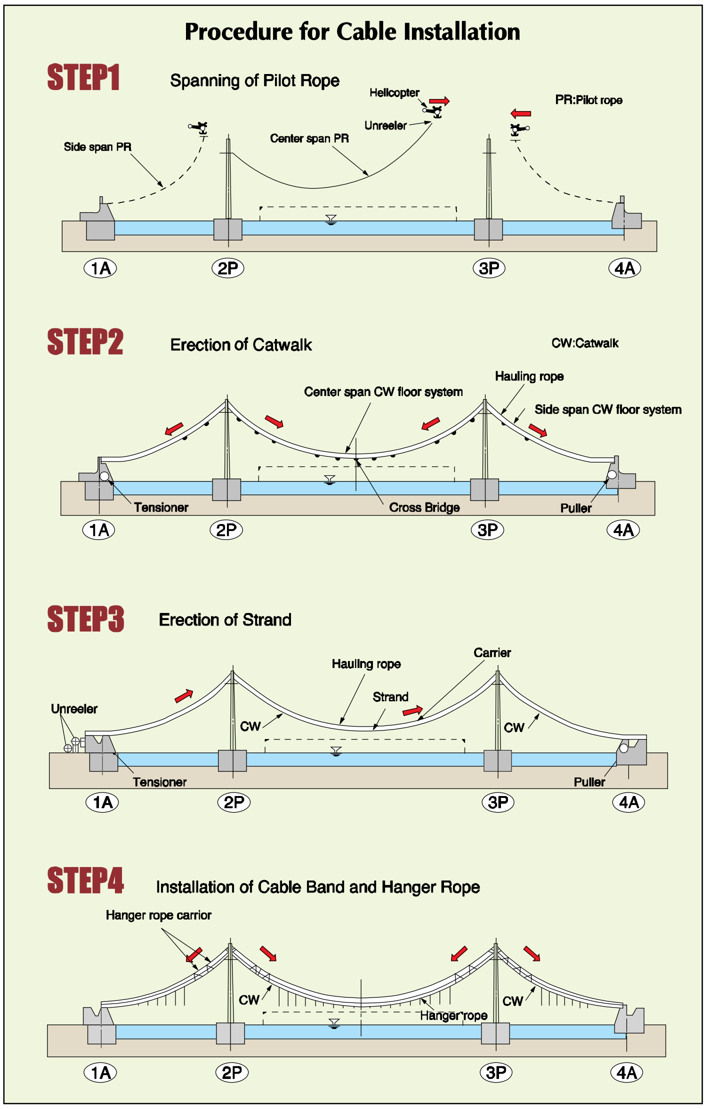
Climbing crane used for tower erection



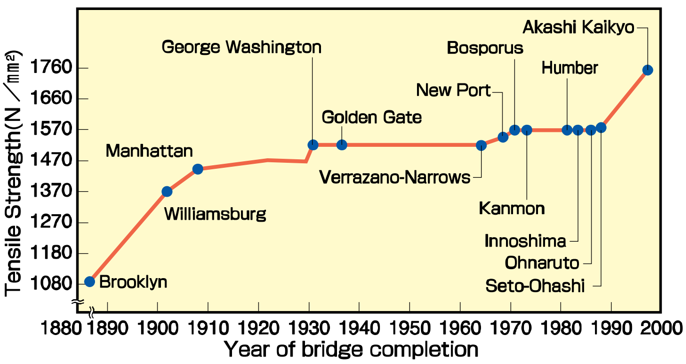
Completion of main towers

Cable Installation
(Akashi-Kaikyo Bridge)

A pilot rope, which is light-weight and made of high strength poly-aramid fiber (ϕ 10mm), was spanned using a helicopter. Newly developed high tensile strength wire of 1760N/mm² made it possible to use only one cable per side instead of two. Total length of wire used in the main cables is 300,000 kilometers, enough to circle the earth 7.5 times.



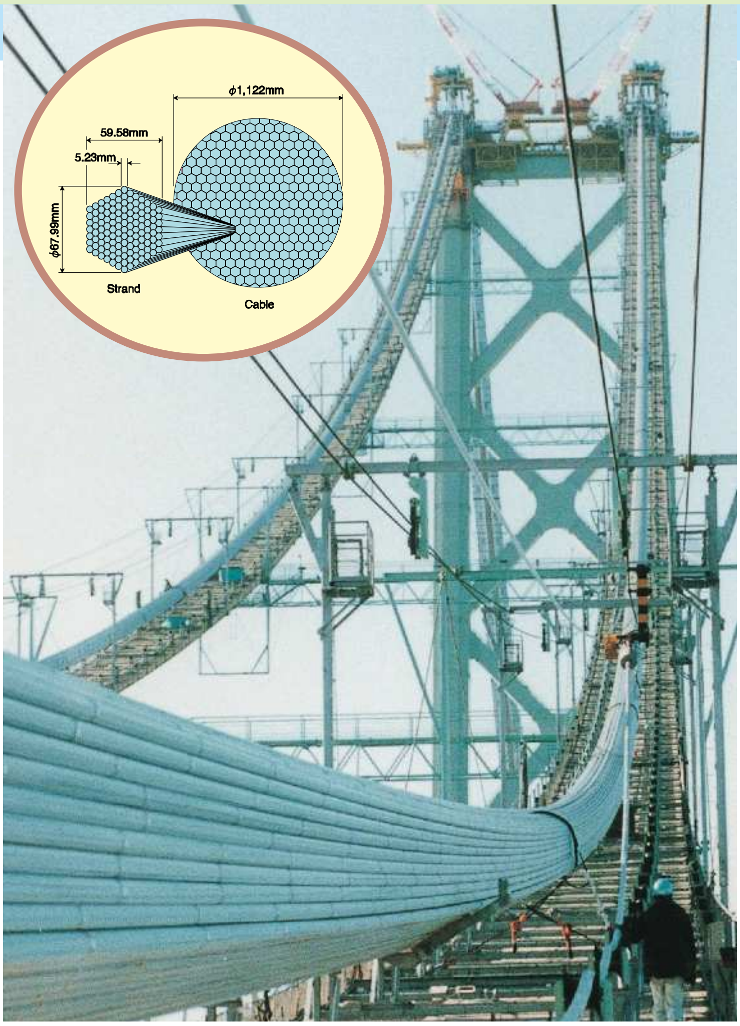
Strength improvement of wires for suspension bridges




Spanning of a pilot rope across the strait by a helicopter


Completion of a catwalk rope


Erection of cable strand



Erection of cable strand

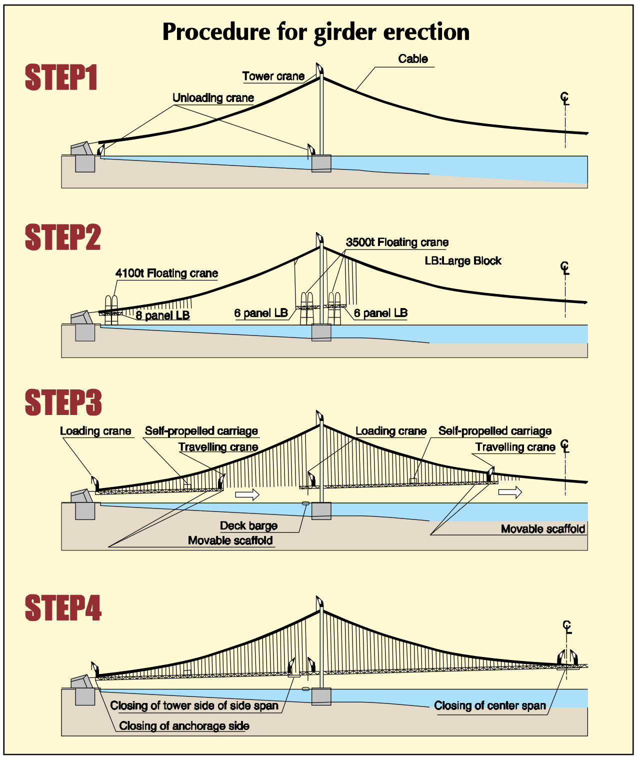

Installation of cable band

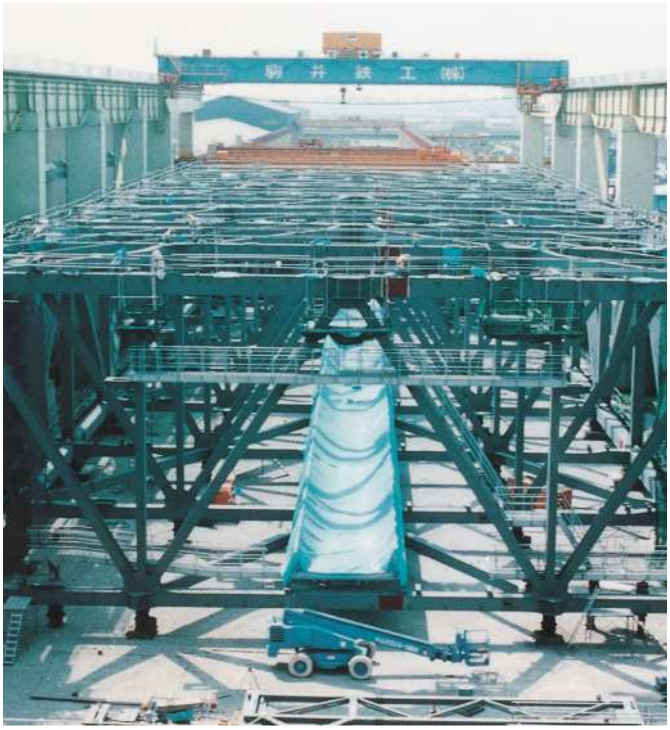

Installation of hanger rope


Distant view of cable works

Stiffening Girder Erection (Plane Element Erection Method)
(Akashi-Kaikyo Bridge)

After comparing streamlined box girder with truss girder, the latter was chosen because of its aerodynamic stability and economy. In order to reduce the weight of the girder, high strength steel was used.

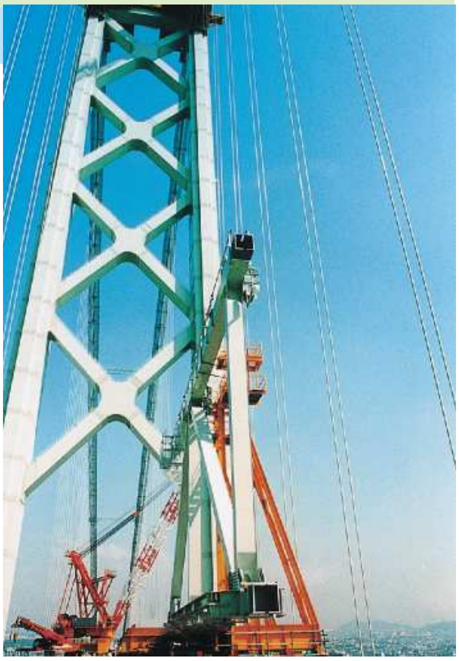




Temporary assembly of panel blocks (at factory)

Large block erection near 1A anchorage

Large block erection near main tower



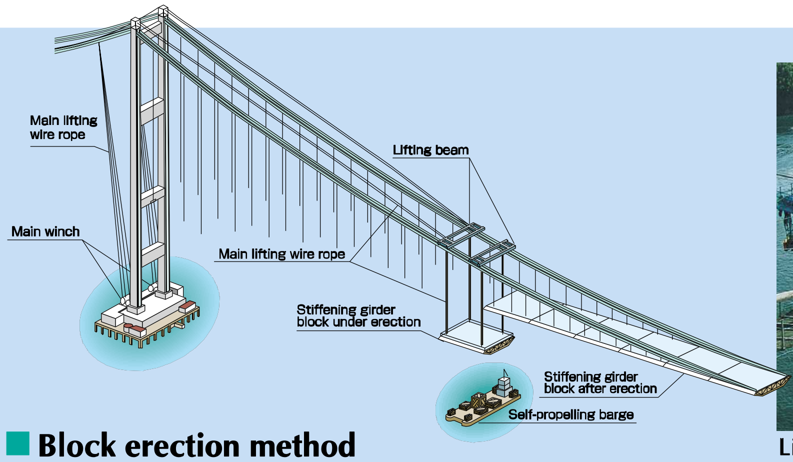
Transportation of plane element

Plane element installation

Girder closing

Stiffening Girder Erection (Block Erection Method)
(Kurushima Kaikyo Bridge)

Block erection method was applied using self-propelling barge because of the severe environmental conditions such as strong currents (5m/s), deep water (maximum depth=-100m), and heavy traffic (1,000 vessels/day).
As a result, working time per cycle was drastically reduced from the conventional 3 hours to only 30 minutes.

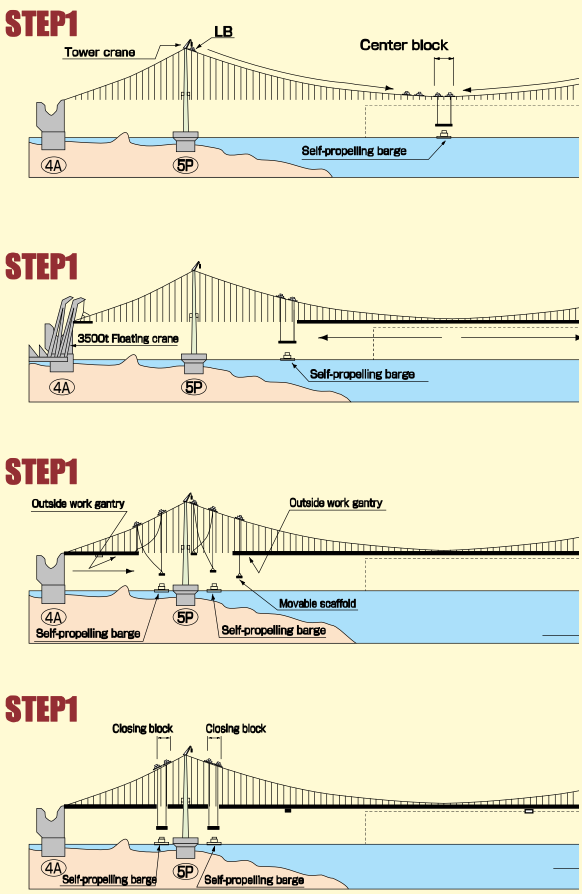


■ **Block erection method**

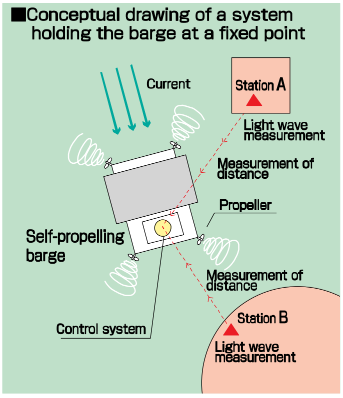
Lifting beam

Stiffning girder sections, each about 36 meter length, were fabricated at the shop and placed on a self-propelling barge for transport to a site below each erection point. Then they were hoisted up into position using lifting beams and secured to hanger ropes.

Procedure for girder erection

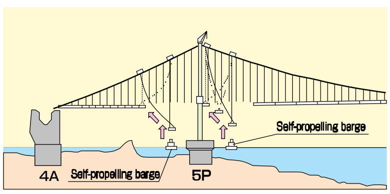


■ Self-propelling barge



To facilitate lifting under severe condition in the strait, a self-propelling barge was newly developed. The barge is equipped with computer-controlled omni-directional propellers mounted at each corner of the barge,and it can maintain its position at a fixed point without mooring ropes.

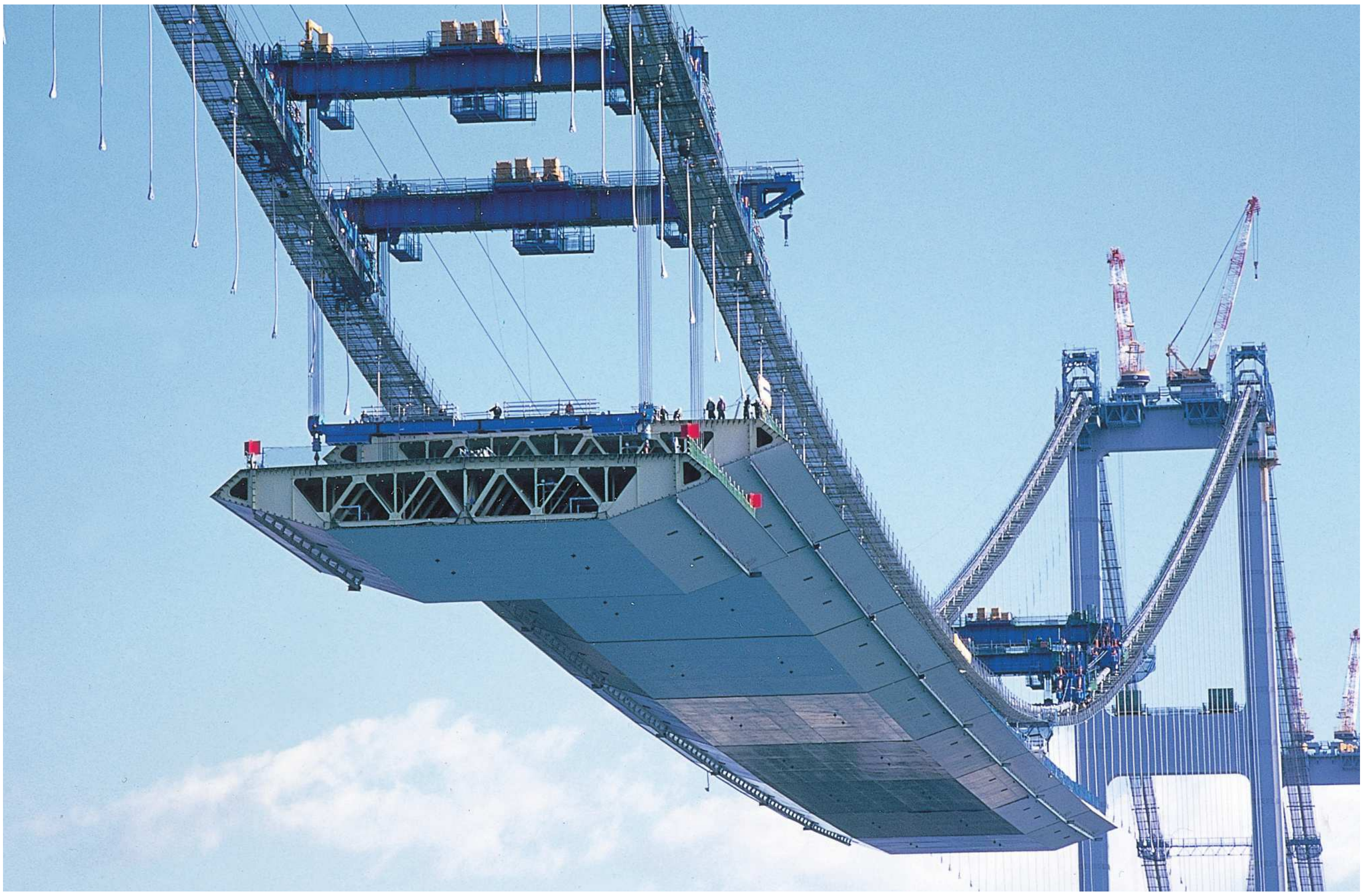
■ Erection by shifting horizontally



Since the self-propelling barge cannot access the erection point such as in shallow waters and on the ground,stiffening girder blocks are moved to the point using two lifting beams.

Shifting (left side of tower)

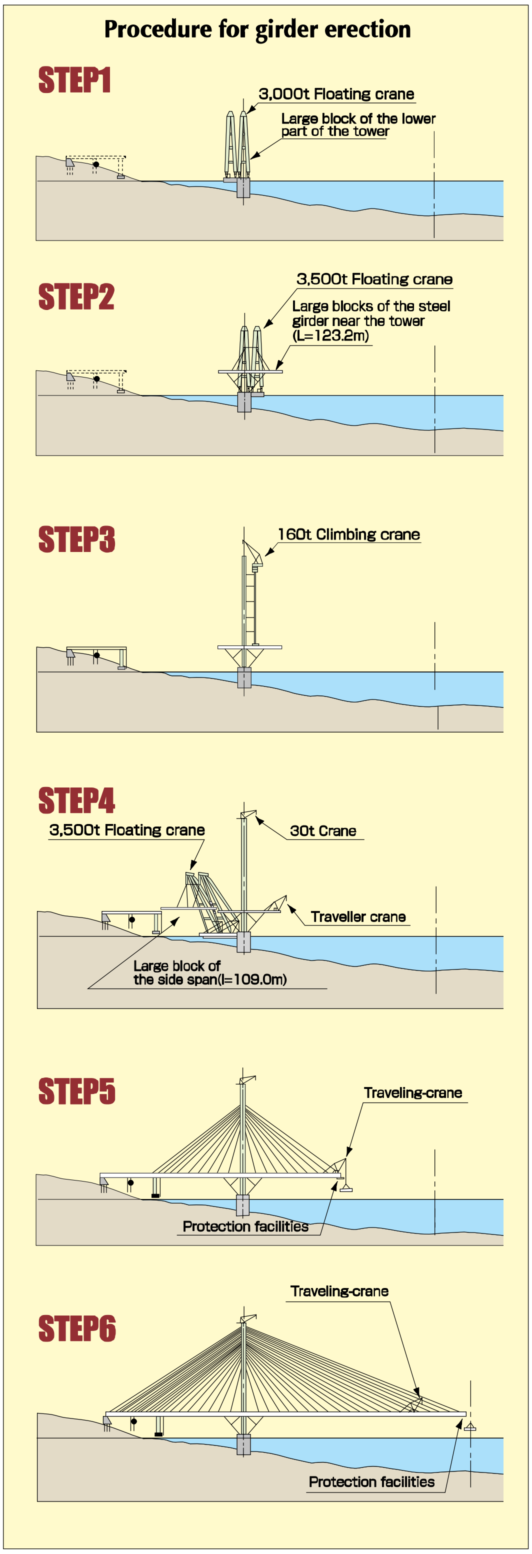

Start of hoisting up by lifting beams


Hoisting up

Superstructure of Cable-Stayed Bridges

Erection of Superstructure
(Tatara Bridge)

Large block erection method using a floating crane was carried out as much as possible.
The box girders and cables were erected from both towers by the balanced cantilever method.



Large block erection of bottom part of tower

Large block erection of main girder connecting tower

Erection of tower

Large block erection of side-span girder

Balanced cantilever erection

Completion of tower erection

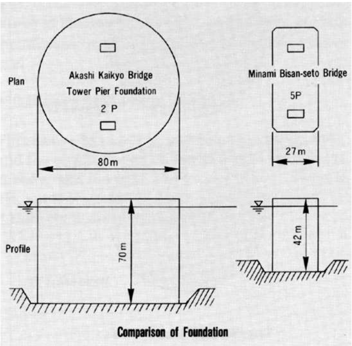
Indent cable

Erection of closure segment

Highly Developed Bridge Technologies

Evaluation of bedrock

Investigation and Evaluation methods of bedrock for mass foundation of long-span bridges were developed. These methods realized the rational and economical design for mass foundation structures and were applied to the design of important structures such as atomic power plant.



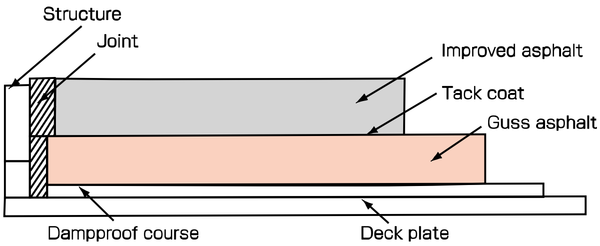
Seismic design

The seismic design standard which innovated new ideas obtained through experiments was established. In the case of Akashi-Kaikyo Bridge, a new seismic design standard which introduced the ideas of non-linearity of the bearing layer as well as dynamic interaction between the ground and foundation was formed.

Comparison of Tower Foundation
Akashi-Kaikyo Br.
Minami-Bisan-Seto Br.

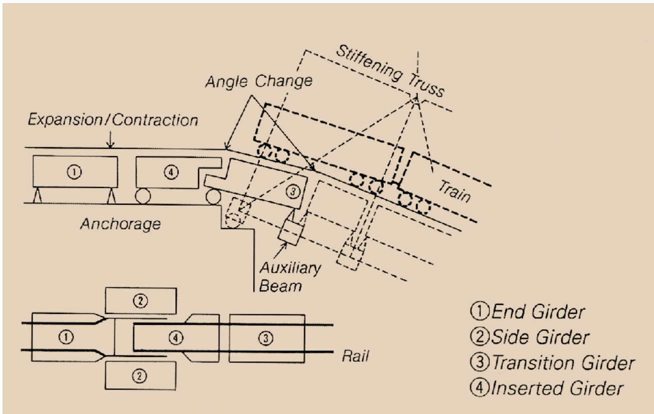
Pavement for steel deck plate

Dead load was reduced by applying guss asphalt on steel deck plate.



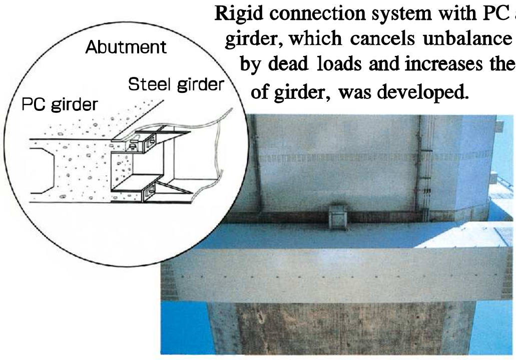
Railway movement joint system

Railway movement joint system which absorbs large movement at expansions was developed



Hybrid PC-steel girder system

Rigid connection system with PC and steel girder, which cancels unbalance moment by dead loads and increases the stiffness of girder, was developed.



Steel buffer system

Steel buffer system which can protects the piers from the ship collision and reduces the damage to the ship by absorbing energy was developed.

Vibration test by using actual bridge

Vibration characteristics (attenuation ratio, natural frequency) based on the vibration test by using a large scale vibration machine were verified.

Effects of Hyogoken-Nanbu earthquake on the Akashi Kaikyo Bridge

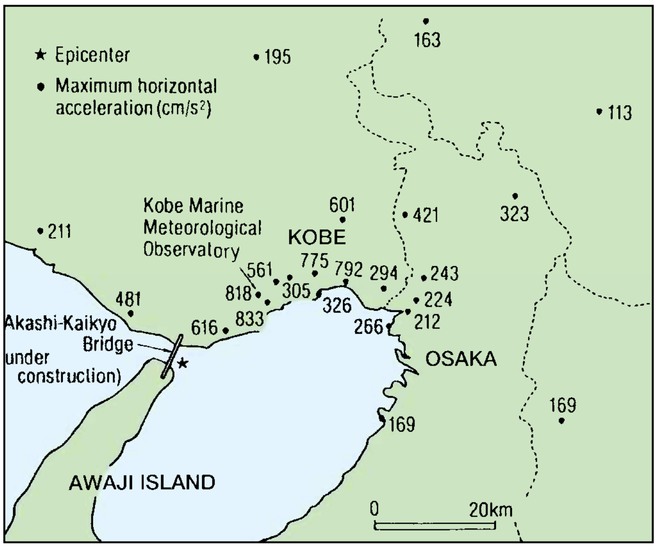
There are few countries that suffer as many earthquakes as Japan. As a consequence, the general understanding is that roads, railways, and bridges are designed and constructed with emphasis on earthquake resistance. Yet the devastating January 1995 earthquake that hit the Kobe area (which is known as the Great Hanshin Earthquake) caused incredible havoc, and many houses, buildings, roads, and railways suffered considerable damage. This catastrophe revealed that many issues to learn about earthquakes and their effects still existed. Although this earthquake caused a new fault in the seabed right below the partially finished the Akashi Kaikyo Br., no damage was reported to the bridge structure itself.

In designing and constructing various bridges, the motion of each bridge structure as well as that of the ground on which it stands is carefully analyzed. This is done by analyzing earthquake motion likely to hit the area. This allowed HSBA to identify the probable effects by such earthquakes on the bridge. The results were then carefully reflected in the actual design, ensuring that they are quite resistant to large earthquakes. In the field of seismic design, the following subjects had been studied and clarified by HSBA :

- Characterization of seismic motion ranging from short-cycle to long-cycle vibrations
- Prediction of the interactive motion between the ground and foundation
- Practical method for analyzing the foundation response on the ground
- Characterization of strength and deformation of ground

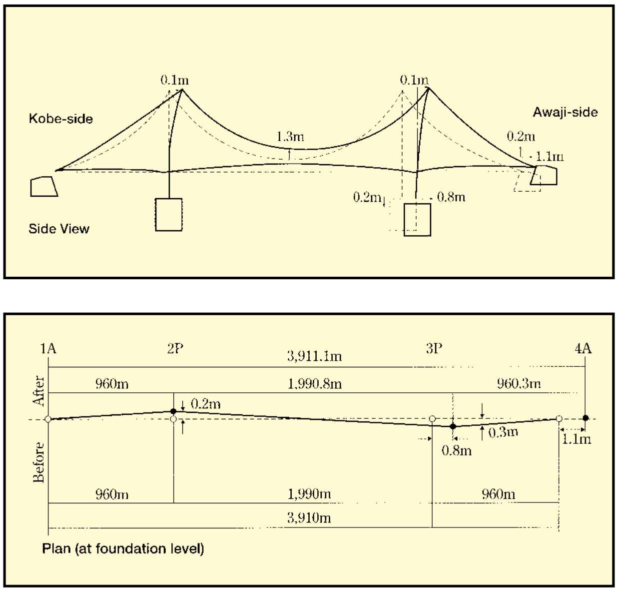
That the Akashi Kaikyo Br. was undamaged after the Great Hanshin Earthquake was attributed to the following three major reasons : (1) the inherent suppleness of suspended structures ; (2) selection of an appropriate site based on thorough geological survey to avoid active faults ; and (3) seismic design techniques adopted in details of suspended structures.

Recorded seismic acceleration(Main event on Jan.17,1995)



Fault Caused by the Great Hanshin Earthquake

As of Jan.23,1995



Relative deformation of Akashi-Kaikyo Bridge

Maintenance Policy

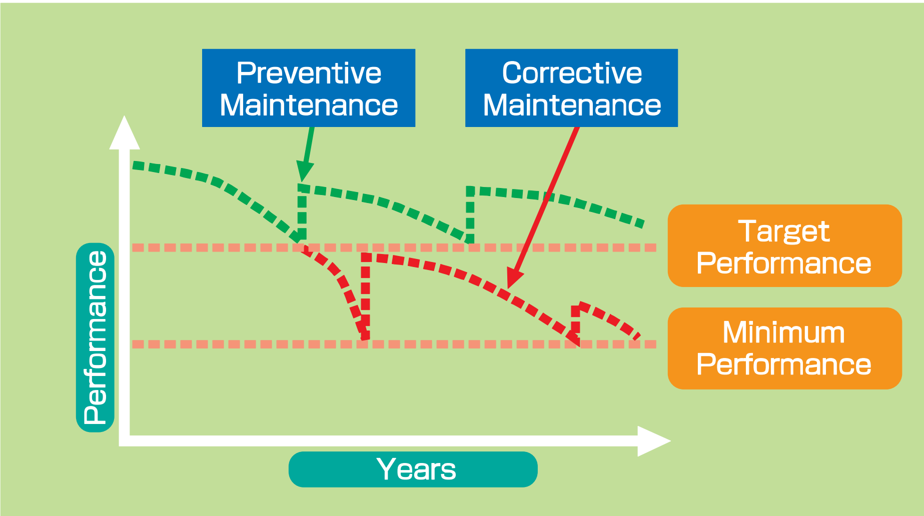
Preventive Maintenance

HSBE has been managing and operating long-span bridges to keep them in sound conditions more than 200 years.

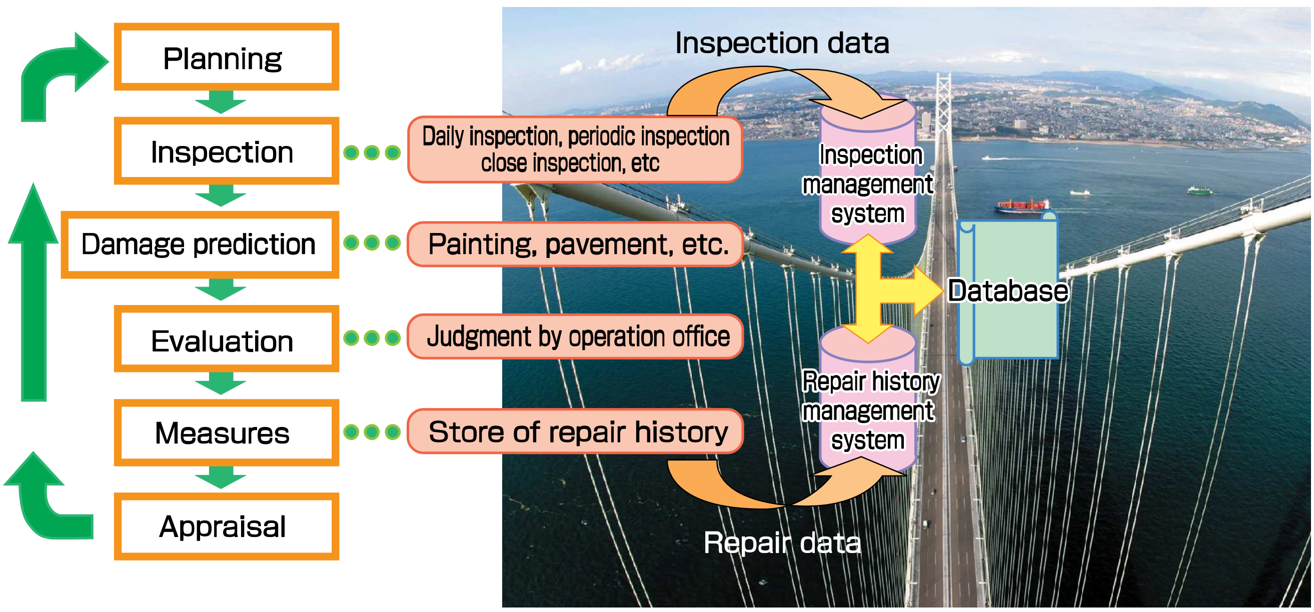
- The concept of "preventive maintenance" has been set up for keeping long-span bridges in good conditions for a long time under severe natural surroundings.
- Inspection, operation and management system have been established to carry out maintenance work efficiently.
- Appropriate countermeasures have been adopted, if necessary, to remove the falling down of concrete flake, road signs, etc. whose damage affects the safety for the third persons.

"Preventive maintenance" is to conduct adequate measures before the performance of structures reduces.

Difference between "preventive maintenance" and "corrective maintenance"



Flowchart of "preventive maintenance"



Maintenance Technologies

Maintenance Facilities

Maintenance vehicles

It is very difficult to inspect Honshu-Shikoku Bridges, because they are high structures above the sea level and many vehicles are passing through on the bridges and ship under the bridges, and a lot of trains in the girders of the Seto-Ohashi Bridges. Under these circumstances, many maintenance vehicles had been installed around long-span bridges to inspect the structures safely and surely.
We have many kinds of maintenance vehicles such as maintenance vehicles for outside girder, for inside girder, and for cable, according to each structural type. The number of maintenance vehicles amounts to 158.
Aluminum alloys have been used for the main members of the vehicles to ensure their durability and to reduce their dead load.


Maintenance vehicle for outside girder (Akashi-Kaikyo Bridge)


Maintenance vehicle for inside girder (Akashi-Kaikyo Bridge)

Painting robot for boxgirders

We have developed Painting Robot with rotating brush, roller painting, supporting arms and traveler in order to make an effective repainting for box girder bridges.
This painting robot is set on the movable maintenance platform. We can repaint the whole area of box girder by longitudinal moving of platform itself and transverse moving of robot.
We can automatically repaint more than 500 m² per day and improve the painting quality, cost saving and working safety. Moreover, we can reduce the manpower for the work.


Movable maintenance platform

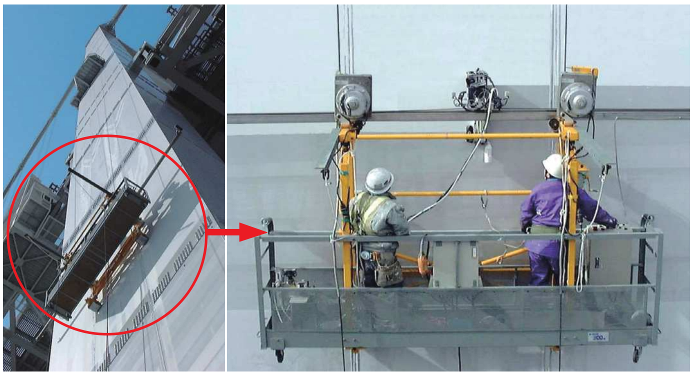

Painting work on inclined web


Painting robot for box girder

Painting robot for tower

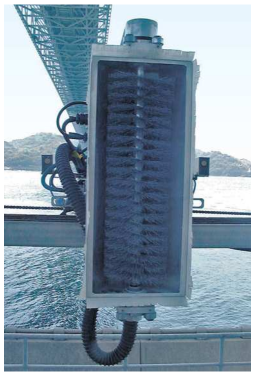
We have developed painting robot for towers to save cost and manpower. The robot consists of the magnetic wheel gondola, painting roller and so on. Paints are not scattered by using roller during painting work, and surface treatment work can be conducted automatically by replacing roller to rotating brush. Paint dusts are also not scattered during the work, because they are collected by an exclusive dust collector.

The robot can automatically paint steel surface at the speed of more than 500 m^2 a day (ten times as fast as the speed by manpower). Therefore, the robot performance improves painting quality and enables us to save cost and manpower.



Re-coating

Painting roller



Rotating brush

Magnetic wheel gondola

Conventionally, gondolas are used for the repainting of the main tower of bridge. However, as gondolas shake in the wind, the efficiency of the work decreases and it becomes danger. We have developed a magnetic wheel gondola with strong magnets in order to stick it on the tower wall.

Because the magnet of the wheel can fix the axle to optional direction getting maximum sucking force, the gondola can get the maximum sucking force on every wall.

In addition, the gondola can move diagonally by steering, although conventional gondola was not able to do. The wheel of the gondola does not damage painting, because the wheel is covered with rubber.

There are an object for tower wall and an object for diagonal and horizontal member in the gondola, and it can be approached all over the tower member.

Gondola for tower wall

For diagonal and horizontal member
(work on under side of diagonal member)

Magnetic wheel

diagonal and horizontal member
(work on sideboard of diagonal member)

Vacuum-sucker wheel gondola

The inspection of high concrete structures is very difficult because we can not access there easily. Conventionally, scaffoldings were set to inspect the structures. However, it was a waste of cost and time. Furthermore, using a normal type gondola for such an inspection was also not efficient, because the gondola was easily swung by wind and reaction force was not taken during repair work.

Under these circumstances, we have developed a gondola with vacuum-sucker wheels, which sticks to the structure surface by vacuum power. The gondola can move without being swung by wind, and labors can carry out repair work in stable condition when using a chipper, etc.

A vacuum-sucker wheel equips expansion system which enables it to move on and suck the surface even with a gap of 200 mm bump.

Gondola

Vacuum-sucker wheel

Under repair work

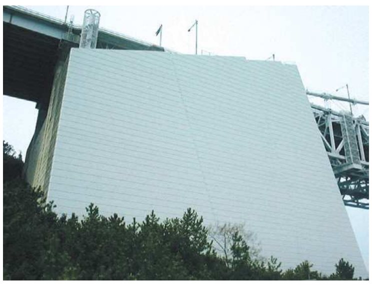
For Substructures

Prolonging the life of concrete structures

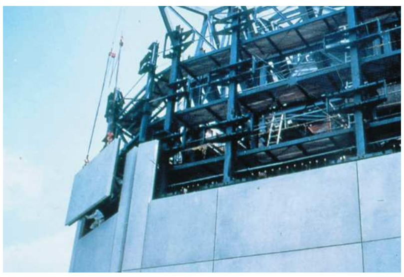
The environmental conditions for the concrete structures of Honshu-Shikoku Bridges are so severe that we have to maintain them with the utmost care and cost. Moreover, it is very difficult to approach the parts of them because of the height to pass marine traffic. Therefore, we conduct highly accurate investigations rather than usual for these structures and select the suitable maintain/repair method for these concrete structures. And some of the structures are employed Pre-cast Concrete Panels or Paint Coating on surface concrete in order to prolong the life and to keep the beauty.

The procedure of the investigations for concrete structures is as follows; 1. sampling concrete core, 2. grasping the deterioration degrees of the concrete as to salt damage, neutralization, crack, corrosion of steel bars, etc., 3. evaluating the soundness and predicting future damage based on the results, and 4. judging whether countermeasure should be prepared or not.

Measurement of chloride-ion



Paint coating on Ohnaruto 1A

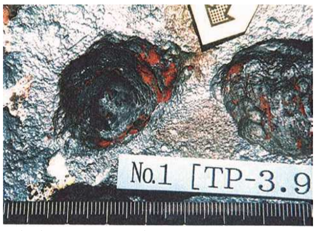


Pre-cast concrete panel
on Akashi-Kaikyo Bridge

Electro Deposit Method for underwater steel structures

The Laying-down caisson method has been employed for construction of underwater foundations of Honshu-Shikoku Bridges. We found pitting corrosions on the surface of steel caissons as the result of the inspection of these underwater parts. We employed the Electro Deposit Method, which is one of countermeasures for corrosion of underwater structures

Steel caisson



Pitting corrosion

Adherent substance

The principle of the method is as follows; 1. by passing slight electric current in the sea, substances whose main ingredients are calcium carbonate, magnesium hydroxide and so on are generated from calcium or magnesium ion in the sea water by electrolysis, 2. they are deposited on the surface of steel caissons in order to cover the steel surface. The electro deposit linings protect the surface of steel caissons from corrosion and ensuring long-life of the steel structures under seawater is expected.

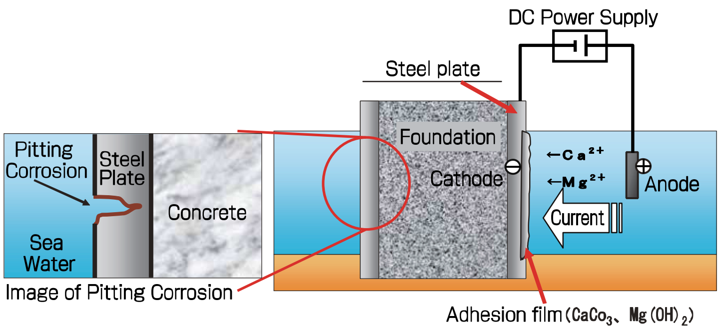


Image of Electro Deposit Method

Retrofitting of multi-column foundations

The top slabs and pillars of multi-column foundations of Ohnaruto Bridge have been made of reinforced concrete. We found that seismic capacity of the multi-column foundations was not sufficient after the seismic verification. Steel piles were installed around each pillar just as a protective member of the pillar during the original design. We obtained in the seismic verification that the seismic capacity would be secured if the steel piles were regarded as structural members. Therefore, corrosion protection of the steel piles has been carried out to keep the piles in good condition.
Petrolatum type rust preventive wax and titanium cover to protect the wax have been selected as corrosion protection measures.

Multi-column foundation

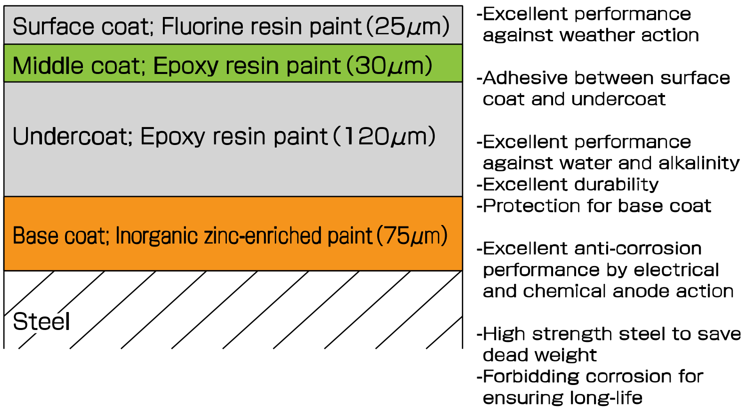
Corrosion protection

For Superstructures

■ Reducing life cycle cost by adopting long-life painting

Painting on the steel members of Honshu-Shikoku Bridges, which is long-life rust-proof type, consists of three layers. The base coat is thick-coating type and inorganic zinc-enriched paint, which includes zinc powder richly and has excellent anti-corrosion performance by electrical and chemical sacrificial anode action. The undercoat, which protects the base coat, is epoxy resin paint which has excellent durability and performance against alkalinity. In addition, fluorine resin paint, whose performance is excellent against chemical action and weather action, is applied as the surface coat.

We have been trying to expand the re-coating cycle by developing paint performance and to aim at reducing life cycle cost of painting.



Long-life rust-proof type paint

Exposure test for painting

Re-coating

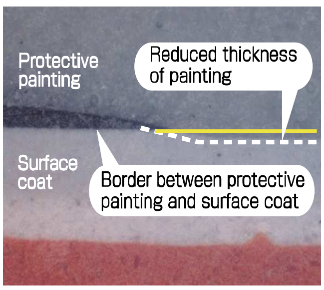
■ Re-coating

Coating area of the steel members in Honshu-Shikoku Bridges amounts to about 4 million m^2. Therefore, the re-painting cost is very high among the maintenance cost.

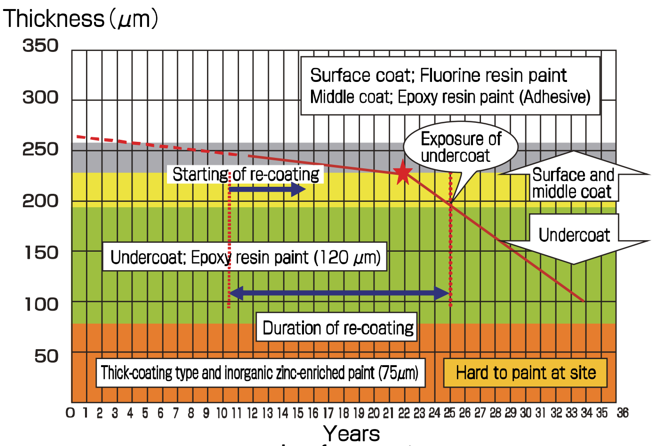
We anticipate that not only the painting cost becomes higher but also the re-coating cycle shortens more if the base coat, inorganic zinc-enriched paint, is re-coated. Therefore, we have set up the maintenance concept for the painting, which is keeping the base coat in sound condition. The concept shows that re-coating work has to be completed until the top layer of the undercoat (i.e. middle coat) which protects the base coat and the undercoat wear off.

We have been carrying out the site survey for the painting to check coat thickness, gloss degree, coat adhesion degree, etc. each five years. Based on the trend of coat thickness surveyed, we predict exposure time of the base coat and finalize the starting time of re-coating as shown in the coat aging curve.

Site survey for painting



Coat section



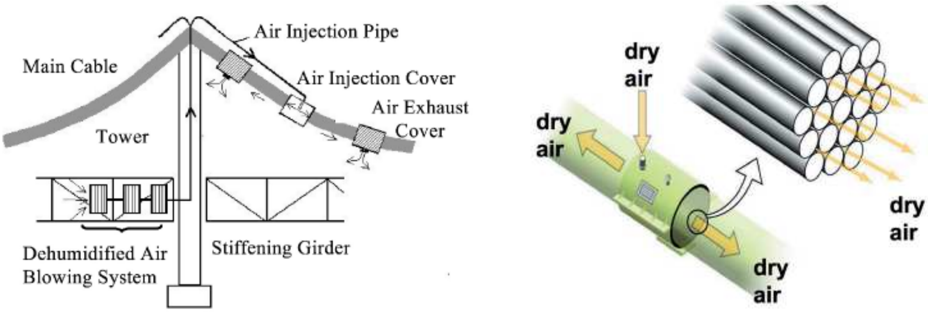
Example of coat aging curve

Dry Air Injection System for main cables of suspension bridges

The conventional anti-corrosion method for the main cables of previous suspension bridges (Innoshima, Ohnaruto, Ohshima and Bisan-Seto Bridges) is such a system composed of zinc galvanization of steel wires, and obstruction of seepage of rain water into the cables with paste applied to the cables and with wrapping as well as painting.
However, survey on these bridges revealed that prevention of seepage of water was insufficient, and water and some rust on the wires were found. This shows that conventional anti-corrosion method is not adequate countermeasure for cables under the high humidity and wide-range temperature change in Japan.
Since the re-erection of main cable is almost impossible, Dry Air Injection System has been developed and installed in order to protect the main cable from corrosion by drying the inside of main cable. In all Honshu-Shikoku Bridges, this system had been installed. The system is now being operated to target the relative humidity of 40 %, meanwhile it is said that the limit relative humidity for corrosion processing is about 60 %.


Main cable just constructed

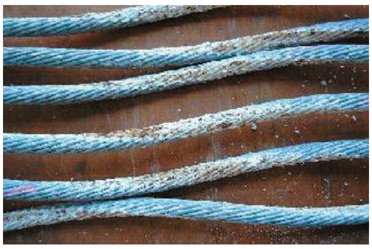

Injection cover



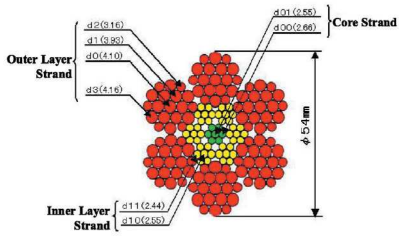
Dry Air Injection System

Non-destructive inspection for suspender ropes of suspension bridges

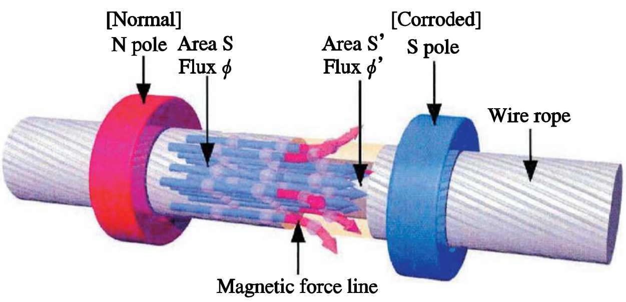
We have developed a non-destructive inspection technique that is an electromagnetic method (main flux method) to identify internal corrosion of suspender ropes. It is possible to reduce the life cycle cost of suspension bridge because we can realize the appropriate repair time and select the adequate repair method by the calculation based on the data acquired from using this non-destructive inspection method. The degree of corrosion can be identified as follows; 1. magnetizing a suspender rope strongly, 2. measuring the flux degree (the number of magnetic line in the section) in the rope, and 3. evaluating the corroded section area using the relative relationship between the flux degree and the intact sectional area.


Corroded outer layer strands


Corroded inner layer strands



Cross section of suspender rope



Principle of Main Flux Method

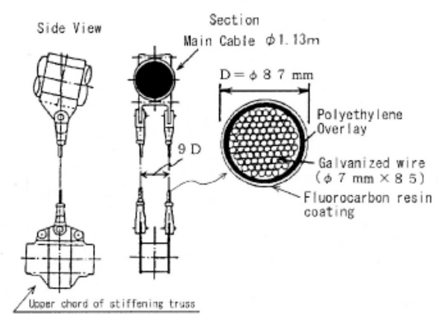

Investigation in the field

■ Vibration controll of wind induced oscillation of suspender ropes

The suspender rope of Akashi-Kaikyo Bridge, the towers of which are 297m above sea, is Parallel-Wires Strand wire covered by Poly-Ethylene tube, and two suspender ropes at one panel point. The longer ones are more than 200 m.

The distance of each rope at one panel point is about 9 times of diameter, and it is said that generating an oscillation is difficult in this condition. However, a large amplitude oscillation had been observed at the downstream side suspender rope.

Therefore, in order to improve the aerodynamic characteristic of rope, we investigated in detail about the generating condition, the oscillation characteristic, and its control method of such a vibration through the wind tunnel test. We found that vibration was controlled by winding up trip wires, 10 mm in diameter, spirally around a suspender rope. Moreover, we checked the most suitable wire diameter and twisting pitch by wind tunnel test, and we set it all longer suspender ropes of the bridge by using newly developed machine. By this countermeasure, the oscillation has been controlled and not observed in large amplitude.



Detail of suspender rope of Akashi-Kaikyo Bridge

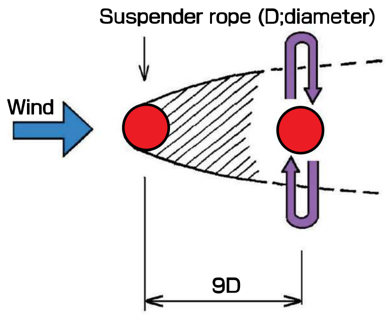


Image of oscillation of suspender rope

Installation of trip wire

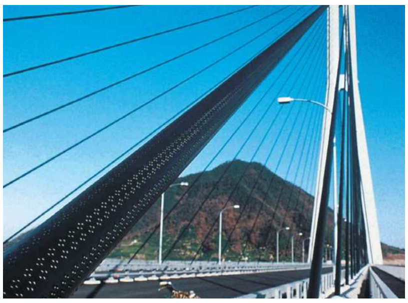
■ Vibration control for cables of cable stayed bridges

The stay cables of Tatara Bridge are much longer than that of former constructed cable stayed bridges. We anticipated that rain vibration during wind and rain might occur because their natural frequencies were lower.

We developed an indent cable which had dispersive concave marks on the cable surface, because a huge damping device might be required to control the vibration. As a result, the vibration has been controlled aerodynamically by installing the cables.

In addition, we developed a high-damping rubber, which was installed at the cable anchorage in the girder, as an anti-vibration measure for cables against vortex-induced oscillation.

The oscillations have been controlled by these countermeasures, and not observed during typhoon or strong wind.



Indent cable

Surface of indent cable

Vibration control by high-damping rubber

■ Dry Air Injection System for box girders

We usually paint the steel surface on the inside of box girders to prevent corrosion. On the other hand, we did not paint the inside of the box girder in Shin-Onomichi Bridge, and installed Dry Air Injection System. We are trying to control the humidity inside the girder not to corrode the steel members. The paint area inside box girders is about four times as large as that outside box girders. Therefore, we aim at saving both initial painting cost and re-coating cost by reducing the painting inside the box girder.

The outline of the system is to install the air-conditioner inside the girder, to circulate dry air using U-ribs of its steel deck as an air duct, and to keep relative humidity in the box girder less than 60 %.

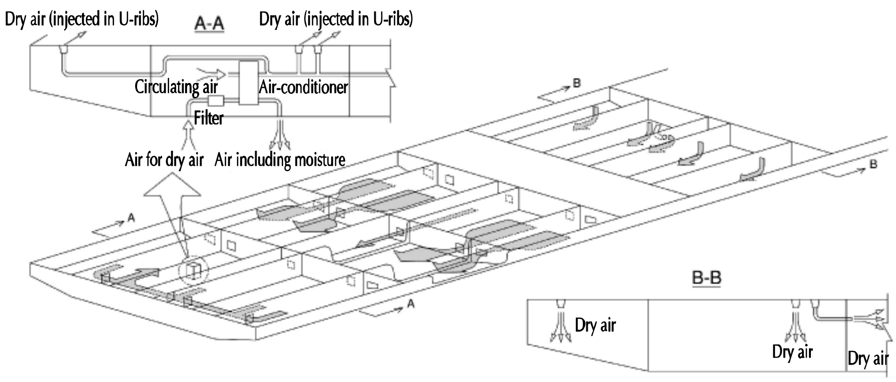
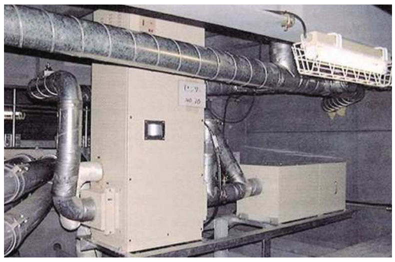


Image of Dry Air Injection System for box girders



Dehumidification facility

Air duct to U-rib

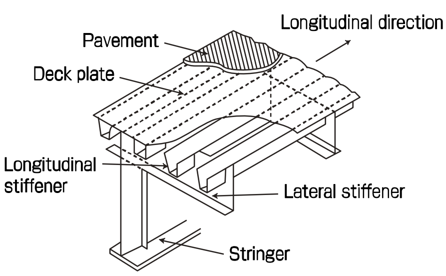
■ Repair technique for pavement on steel deck

Pavement on steel deck of long-span bridges consists of two layers. The base is guss (mastic) asphalt and the surface is improved asphalt. The pavement area in Honshu-Shikoku Bridges amounts to about 470,000 m².

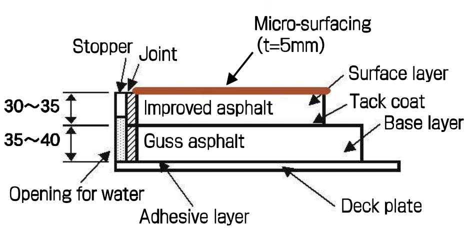
In general, cut and cast method or replacing method is used for the repair of pavement. However, if these methods are applied for the repair of the pavement on steel deck, the cost may generally be higher. Therefore, we have set up the maintenance concept of the pavement on steel deck to reduce its maintenance cost, which is that the base should not be damaged by maintaining the surface adequately.

We have developed micro-surfacing method which is one of surface treatment methods according to the maintenance concept of the pavement.

This method is to spread thinly slurry mixture of aggregates, early strength improved asphalt emulsion, water, cement and admixtures on the pavement. The features are to be able to execute the work at room temperature and to be able to open for traffic right after the work because of rapid curing.



Structures of steel deck



Pavement structure

Micro-surfacing method

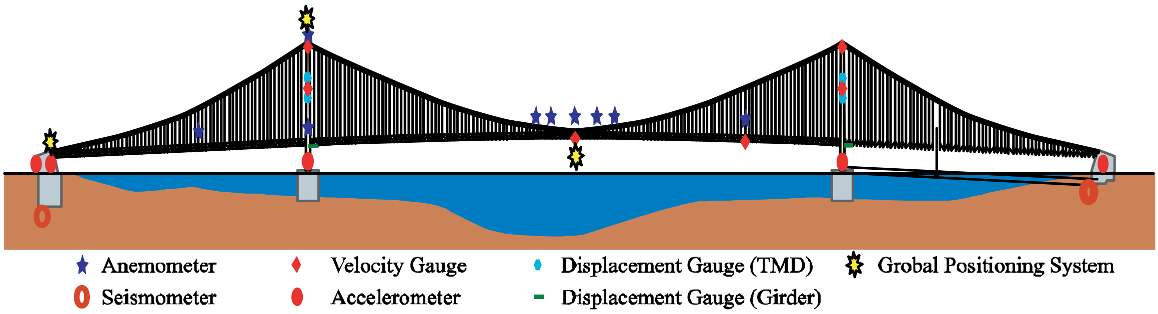
Bridge monitoring system

Honshu-Shikoku Bridges are much longer-span structures than previous constructed ones. Therefore, their deformation induced by natural forces such as strong wind and earthquakes are very large and the behavior is very complicated. Such behaviors were analyzed during the design stage. Observing the actual behavior by using bridge monitoring system, we can confirm the adequacy of the design method and can utilize the knowledge for long-term maintenance work. The knowledge may also be useful and helpful for future long-span bridge design, construction and maintenance.

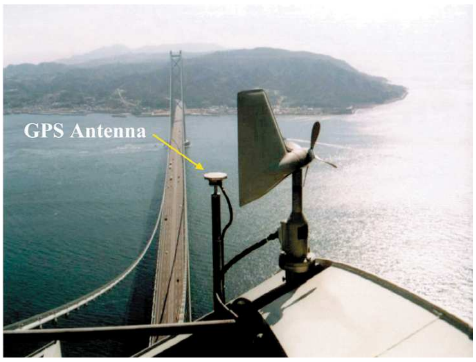
In the Akashi-Kaikyo Bridge, various monitoring devices such as seismography, anemometer, accelerometers had been installed and their data have been recorded.

The below shows the layout of the monitoring devices. The record will be accumulated and analyzed to ensure the structural safety by monitoring the behavior of the bridge. They can also be used as precious information about characteristics of long span bridge and nature such as coherence, scale of the eddy, etc. of the gusty wind and so on.

In addition to the system, GPS (Global Positioning System) was introduced to monitor seasonal, daily and hourly behavior of the bridge, which may be governed mainly by temperature and live loads.



Monitoring system for the Akashi-Kaikyo Bridge



GPS sensor on Akashi-Kaikyo Bridge

Traffic Control

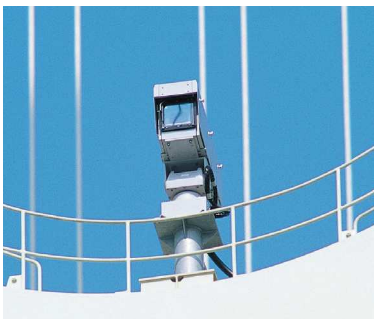
HSBE must keep the highway in a good quality to guarantee a safe, smooth, and speedy traffic flow to the users. Therefore, HSBE developed an efficient system to gather data on traffic conditions such as accidents and traffic congestion, and on weather conditions such as rainfalls and winds. These data are quickly diagnosed and appropriate measures are taken, including offering information on the roadside LED information panels and highway broadcasting, etc. In the case of emergency occasion such as a traffic accident, HSBE cooperatively works with the highway police and fire departments.

Information Gathering

Traffic Control Center

ITV (Monitoring camera)

The video cameras monitor various portions of the highway such as tunnels, interchanges, and bridges, where occurrence of an accident or a fire might be fatal. Live images are transmitted to the monitoring TV in the Traffic Control Center, and the staff can observe traffic conditions at any time in the office.



Emergency telephone

Emergency telephones locate at every 1 km interval along the highway on land, every 500 m on the bridges across the strait, and every 200 m in tunnels. The users are able to call the Traffic Control Center in the case of emergency.

Weather observation system

The system measures ambient temperature, wind direction and speed, rainfall, visibility, etc. along the highway, and the data are transmitted to the Traffic Control Center.

Highway patrol cars

Squad cars patrol along the highway several times a day to search for abnormalities on the road. If the squad discovered an accident or a fallen object, or other abnormality, the staff report precise information on the case to the Traffic Control Center by radio, and every efforts are made to settle the case, which might cause secondary accidents.

Information Providing

LED map information panels

The LED map information panel displays a simplified map of the relevant road network with some information on traffic congestion and travel times to typical destinations. It helps users in making decisions to choose suitable drive routes.

Highway radio

Highway broadcasting system offers information on congested areas, accidents, temporal regulations on the highway, etc., which can be listened to through car radio.

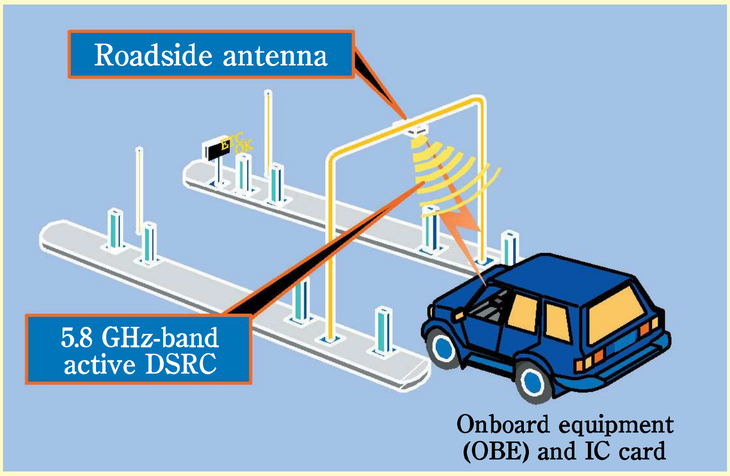
ETC (Electronic Toll Collection system)

ETC is one of the road businesses which has been promoting by the government, and it had been introduced at Honshu-Shikoku Bridge Expressways on April 1st , 2004.

Main objectives of this system are to reduce traffic congestion, and achieve the smooth flowing of vehicles particularly through toll gate by eliminating the need to stop for payment.

This is done through a wireless transmission of toll information between an antenna set up at the toll gate and radio transmitter in the car.

This system consists of three integral parts, the ETC card (IC card), the radio transmitter in the car (onboard equipment), and the toll gate's ETC antenna.



Long-span Bridge Engineering Center

Honshu-Shikoku Bridges consist of 17 long-span bridges in the three routes. Long-span bridge engineering, which have been successively developed and improved, is an important property of Japan. Honshu-Shikoku Bridge Authority (HSBA) had established the Long-span Bridge Engineering Center to effectively and responsibly preserve and improve the long-span bridge engineering.
Honshu-Shikoku Bridge Expressway Company Limited (HSBE), which was newly established from HSBA, took over this organization.

Role and Business of Long-span Bridge Engineering Center

1) Engineering Developments
   - Solve challenging and/or long-term technical issues for long-span bridges in cooperation with the maintenance section.
2) Information Center
   - Collect and broadcast information about domestic/overseas long-span bridge projects and their technology.
3) Technical Support
   - Support an agency of road administrator concerned with a long-span bridge project by utilizing accumulated technology through construction/maintenance of the Honshu-Shikoku Bridges.
   - Provide total support for long-span bridge projects including investigation, planning, design, construction and maintenance.
   - Dispatch experienced engineers to administrator's offices for support of construction management about design, construction and maintenance of long-span bridges.
   - Offer technical advice on planning, design, construction and maintenance of long-span bridges.

Organization of Long-span Bridge Engineering Center

1) Engineering Management and Corrosion Engineering Division
   - Engineering Development for Long-span Bridges
   - Information Service on Long-span Bridges
   - Consulting Services on Long-span Bridges
   - Corrosion Engineering for Long-span Bridges
2) Wind and Earthquake Engineering Division
   - Aerodynamic and Seismic Design of Long-span Bridges
   - Design Survey on Geotechnics
3) Inspection and Structural Engineering Division
   - Inspection and Health Diagnostic of Long-span Bridges
   - Structural Engineering of Long-span Bridges

Access and Request

Engineering Management and Corrosion Engineering Division
Long-span Bridge Engineering Center
Honshu-Shikoku Bridge Expressway Company Limited (HSBE)
http://www.jb-honshi.co.jp/english/
Urban Ace Sannomiya Bld., 4-1-22 Onoe-dori, Chuo-ku, Kobe, Hyogo Prefecture 651-0088, Japan
TEL: +81-78-291-1071, FAX: +81-78-291-1359

Present Results of Overseas Technical Assistance

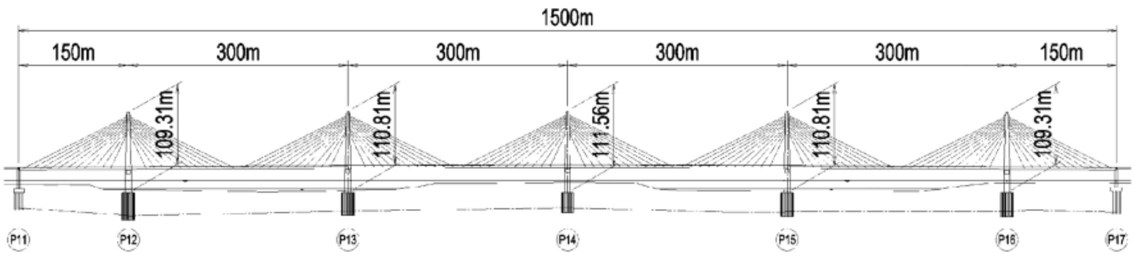
Technical Support for Overseas Project

1) Technical support for long-span bridge projects

Honshu-Shikoku Bridge Expressway Company Limited (HSBE) is ready for providing technical cooperation, for example dispatch of qualified engineers, construction management etc., on any stage of long-span bridge projects such as survey, planning, design, construction and maintenance.

HSBE dispatched an engineer to Nhat Tan Bridge project in Hanoi, Vietnam to supervise the construction work in October 2009 to August 2012 .

Progress in Dec. 2012



Nhat Tan Bridge (provided by Nippon Engineering Consultants Co., Ltd.)

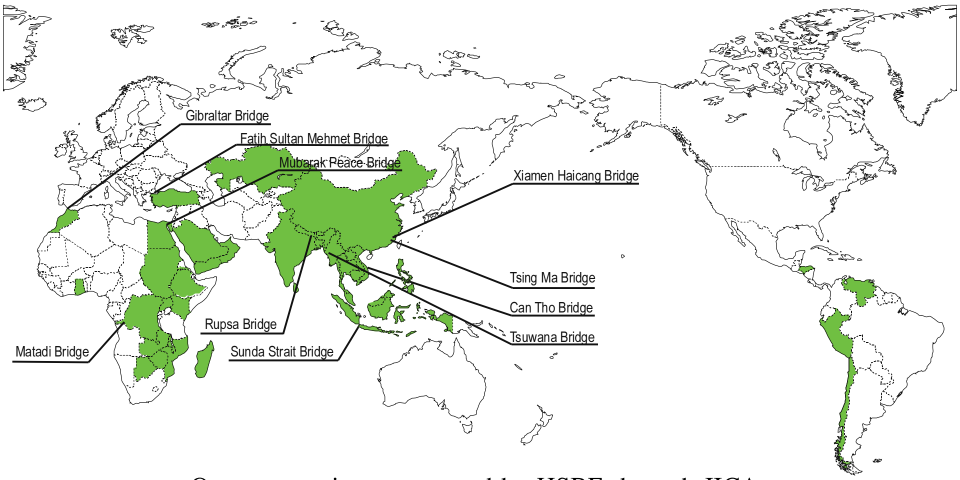
The total length of Nhat Tan Bridge is 3,080 m, including six continuous-span cable-stayed bridge whose total length is 1,500 m (the longest span length is 300 m). The number of lanes is six. The Bridge is to be one of the longest bridges in Vietnam. The construction of the Bridge was planned as the memorial monument for the relocation of the capital to Hanoi, the 1,000th anniversary. The construction work of the Bridge is being progressed as a Japanese loan project. The Bridge is called "Japan-Vietnam Friendship Bridge"

2) Technical cooperation through Japan International Cooperation Agency (JICA)

- Dispatch of experts

HSBE has dispatched 56 JICA long-term experts to 16 countries and 232 JICA short-term experts to 45 countries. They have provided technical knowledge on planning, design, construction or maintenance of highways and bridges to each governmental organization.

HSBE has dispatched two engineers to Egypt and Kenya as JICA long-term experts as of March 2013. Their main mission is to support capacity development for governmental engineers on maintenance techniques. HSBE also dispatched an engineer to Democratic Republic of Congo as a JICA short-term expert in 2012.



Overseas projects supported by HSBE through JICA

- Examples of technical cooperation for long-span bridge projects
  Matadi Bridge (completed in 1983)

Matadi Bridge is a suspension bridge with a total length of 702m and a central span length of 520m.
When the Bridge was constructed, HSBE dispatched three engineers as JICA long-term experts for supplying technical assistance, 1979 to 1984. About 27 years after the completion, HSBE again dispatched two engineers as JICA short-term experts to confirm the present condition of the Bridge in May to June, 2010. Technical support for the maintenance of the Bridge will be continued by HSBE from now on.

Suez Canal Bridge (completed in 2001)

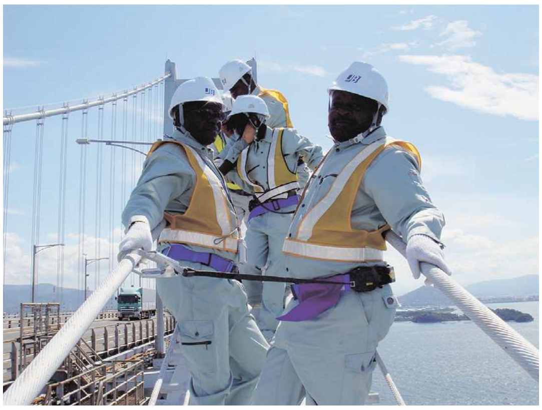
Suez Canal Bridge, known as Egyptian-Japanese Friendship Bridge, is a cable-stayed bridge, which links the continents of Africa with Asia, with a total length of 3.9km and a maximum span length of 404m. When the Bridge was built, HSBE dispatched two engineers as JICA long-term experts for construction supervision, 1998 to 2002. HSBE again dispatched two engineers as JICA short-term experts in 2010 and 2011, and has dispatched an engineer as a JICA long-term expert since March 2012 to improve the capability of the governmental engineers who operate the Bridge

Capacity Development of Overseas Engineers

HSBE has received a lot of overseas engineering groups and has supported their capacity development by using its own knowledge, experience and expressway assets.

HSBE has conducted country focused long-term technical trainings in Japan for the Philippines, Indonesia, Ethiopia, Kenya and Democratic Republic of Congo, as well as multinational long-term technical group trainings, committed by JICA since 2007. HSBE makes a training program according to the specification from JICA, coordinates and conducts the training normally about for one month. In the training, various maintenance technologies developed for highway structures and long-span bridges are lectured to trainees. Through technical visits to Akashi-Kaikyo Bridge, Seto-Ohashi Bridges, Tatara Bridge and so on, trainees can experience inspection and repair technique for highways and bridges.
In 2012, HSBE conducted three country focused long-term technical trainings and a multicounty long-term technical group training in Japan as follows.

- Kenya: Training for “Road maintenance”
  Kenyan National Highway Authority, Urban Roads Authority and Rural Roads Authority were newly established to improve management and operation work. In 2012, nine engineers from each organization joined the training for their capacity development. The term of the training was from May 14 to June 5. A JICA expert from HSBE has been cooperating with the organizations.
- Democratic Republic of Congo: Training for “Capacity development for management”
  Three officers of the Organization of Equipment between Banana and Kinshasa (OEBK), which operates Matadi Bridge, attended the training from July 17 to 27, 2012. The training was firstly held to do capacity development for management of the officers concerned and it will be continued another two years or more.
- Democratic Republic of Congo: Training for “Capacity development for bridge inspection skill”
  Three engineers of the Organization of Equipment between Banana and Kinshasa (OEBK), which operates Matadi Bridge, attended the training from August 27 to September 21, 20120. The training has been held to do capacity development of the engineers concerned since 2009 and it will be continued another two years or more.
- Multinational: Training for “Comprehensive Bridge Engineering”
  The training was held for technical capacity enhancement of mid-level engineers who are in charge of bridge engineering in developing countries from September 28 to November 2, 2012. Twenty-one engineers from ten countries attended the training. The course topics mainly concern design, construction/construction supervision, maintenance and repair of Steel Bridges, PC Bridges and RC Bridges.



Training for the engineers of D. R. Congo

Training for the multinational engineers of Comprehensive Bridge Engineering

Training for the engineers of Kenya

Technical Exchange with Overseas Organizations

1) Host of international conference

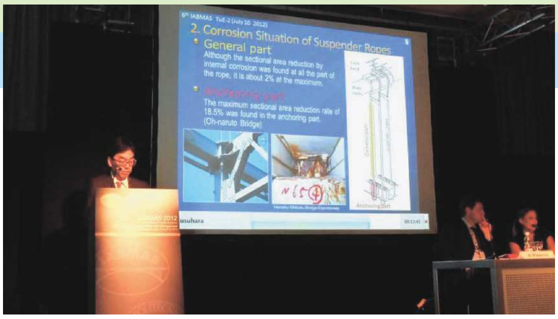
HSBE has provided a lot of technical information on long-span bridge engineering through international conferences.

HSBE hosted the 6th International Cable Supported Bridge Operators' Conference (ICSBOC) in May, 2008, Takamatsu. The ICSBOC is hosted by well-known three long-span bridge operators, HSBE, Sund & Baelt Holding A/S in Denmark and New York State Bridge Authority in USA, every two or three years. HSBE hosted the Conference in 2002 in Kobe.
At the Conference in 2008, 107 long-span bridge operators joined from eight countries such as USA, UK, Denmark, Norway, Sweden, China, Korea, and Japan. The number of presentations was 21 (11 from overseas and 10 from Japan).

The 6th International Cable Supported Bridge Operators' Conference hosted by HSBE, May, 2008

2) Participation in international conferences

HSBE has participated in a lot of international conferences such as PIARC (World Road Association), IRF (International Road Federation), IABSE (International Association for Bridge and Structural Engineering), IABMAS (International Association for Bridge Maintenance and Safety), REAAA (Road Engineering Association of Asia and Australasia), UJNR (US-Japan Cooperative Program in Natural Resources) etc. and has made presentations on technical information on long-span bridge Engineering.



IABMAS 2012, Italy

The 7th ICSBOC, 2010, China

3) Mutually technical exchange

HSBE has been promoting to make positive relationships to share valuable experiences on long-span bridge technology with foreign organizations.

With respect to this circumstances, HSBE has signed sister bridge affiliations with foreign long-span bridge operators to promote mutually technical exchange.

Honshu-Shikoku Bridges	Sister Bridges	Country	Date of Signing
Seto-Ohashi Bridges	Golden Gate Bridge	USA	April, 1988
Seto-Ohashi Bridges	Fatih Sultan Mehmet Bridge	Turkey	July, 1988
Akashi-Kaikyo Bridge	Great Belt Bridge	Denmark	June, 1998
Tatara Bridge	Normandy Bridge	France	May, 1999
Seto-Ohashi Bridges	Oresund Bridge	Denmark-Sweden	May, 2008

Golden Gate Bridge

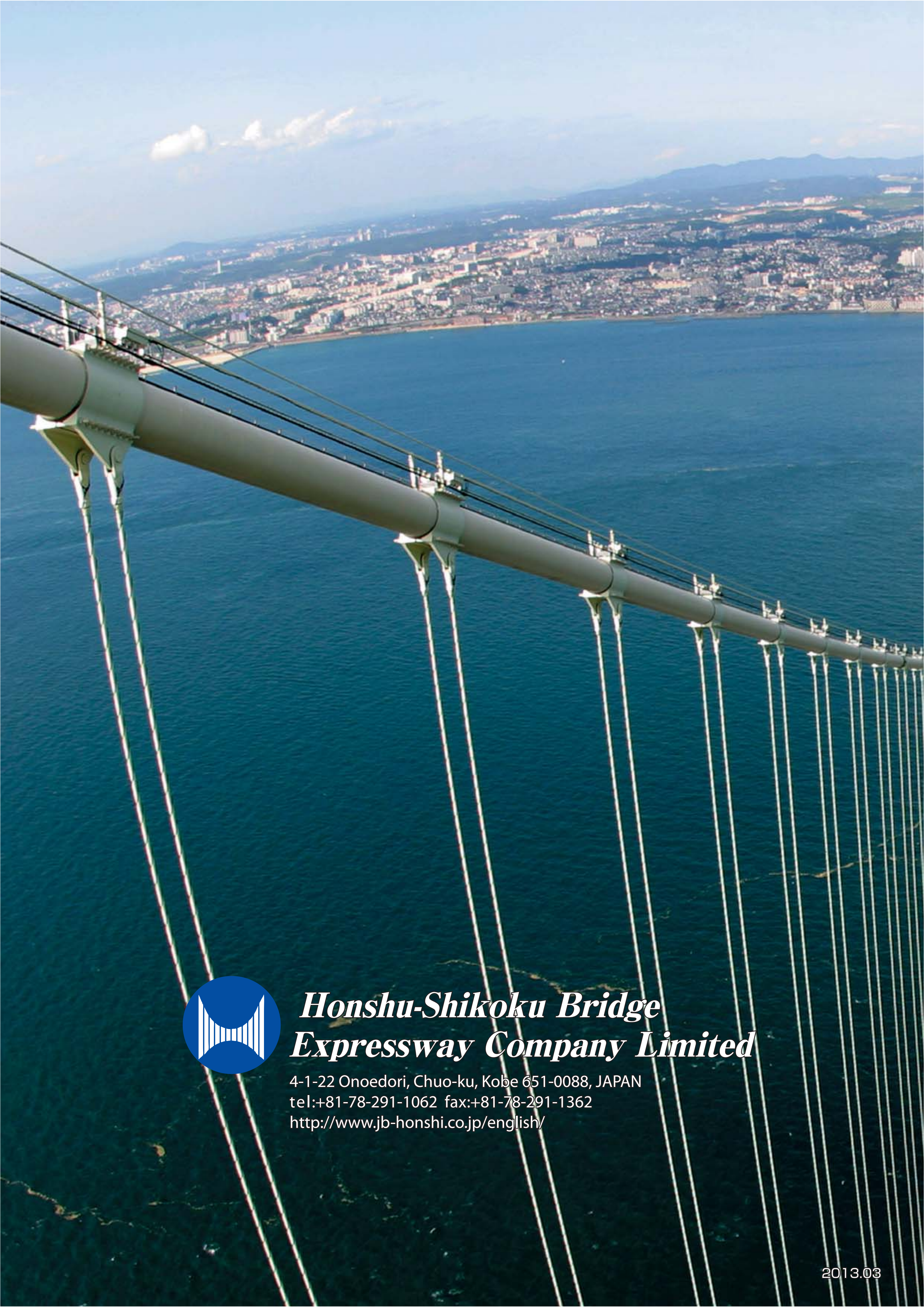
Oresund Bridge

HSBE also signed the memorandum of understanding (MOU) for mutually beneficial relationship with Korea Expressway Corporation (KEC) in May, 2009 to promote technical cooperation and personnel exchange. Both HSBE and KEC are managing and operating expressways including long-span bridges. In addition, the role of both the organizations is to construct, manage and operate expressways. We, Both HSBE and KEC, are responsible for making efforts to improve our technology for customers to use expressways safely, easily and comfortably.

HSBE has held the technical conference with KEC to exchange mutually technical information every year according to the MOU.

Signing Ceremony with KEC

The 5th Technical Conference



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