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JSSC Commendations for Outstanding Achievement in 2024—Outstanding

Chiba JPF DOME (TIPSTAR DOME CHIBA)

Prize winner: Shimizu Corporation

Building Outline

This project is a construction plan for a velodrome meeting international standards. Considering the site environment within Chiba Park, the concept was to make the building compact and rational, eliminating the sense of oppression on the surrounding area. The building has a roof shape formed by cutting an ellipse around a sphere with a radius of approximately 100 m, and its plan dimensions are 116 m long and 93 m short. The plan is to install audience stands along the short sides and lower the height of the eaves along the long sides.

Structural Outline

For the roof structure, we devised a new structural form called "ring shell" in which an elliptical steel lattice shell is stiffened with cables. An 84 m-diameter steel ring was installed at the bottom center of the large roof, and 72 cables were arranged radially in 36 directions to rationally reduce thrust force. This not only reduced the size of the tension ring on the periphery but also reduced vertical displacement and stress and improved buckling resistance. The lattice shell members were all 350-mm square steel pipes, and the size was adjusted only by the plate thickness. The roof is only 588 mm thick, including the steel members and finishing materials.

The roof joints do not use cast steel, but are made of plate materials, resulting in a simple and economical design. This allows the structure to be constructed without twisting the members. Load tests were conducted on the roof joints to confirm their fracture properties, rigidity and stress state. FEM analysis was also used to verify the strength.

Construction Outline

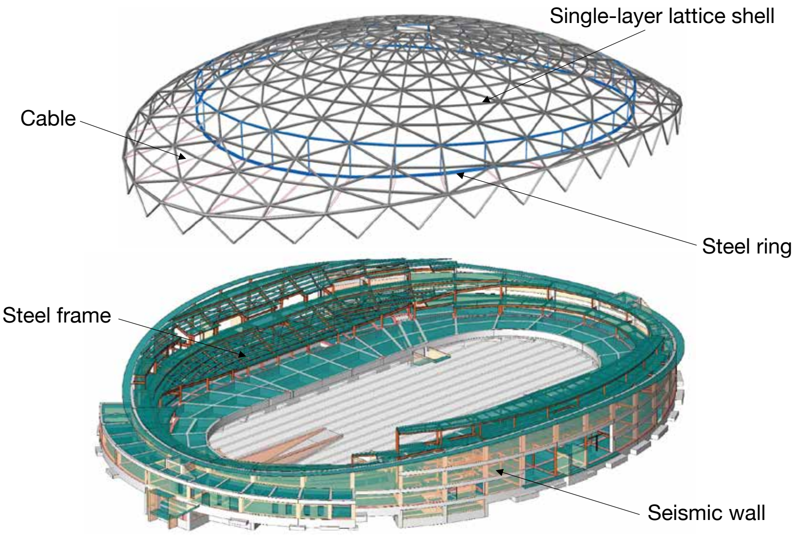
The roof structure is stable only when the members are combined to form a lattice shell. The construction procedure was to install the steel members on the temporary materials, adjust their position, fasten the bolts, weld them, and once all connections were complete, introduce cable tension and jack down the support parts. Before construction, we performed an analysis that took into account the distortion caused by on-site welding to find a procedure to minimize the impact. 3D measurements were taken, and construction was carried out while repeatedly checking for any unexpected deformation.

When tensioning, all cables had to be tensioned in a balanced manner, so an electric pump was used to tension 72 cables simultaneously. To ensure that the roof was in the designed condition, the displacement, strain, cable tension and temperature of the members were measured. The pre-construction analysis results matched well with the actual measurements.

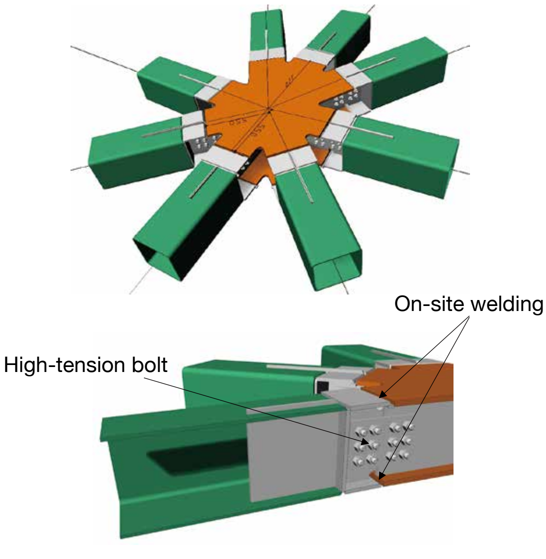

Full view of Chiba JPF DOME


Inside view of Chiba JPF DOME

Structural Outline



Roof Joints System



Yaesu Central Tower at Tokyo Midtown Yaesu

Prize Winners: NIHON SEKKEI, INC. and TAKENAKA CORPORATION

Planning Outline

Tokyo Midtown Yaesu is a high-rise multi-purpose building with a height of about 240 m. It is located in front of Tokyo Station. In this building, seven different applications are accumulated—hotel, office, exchange facility, commercial facility, elementary school, bus terminal and energy center, so it is furnished with the function appropriate as a landmark facility.

It also functions as local infrastructure that can supply electricity and heat in the event of a disaster and receive people who are unable to return home after disasters.

Structural Outline

The structural type adopted is a braced rigid-frame steel structure (column: concrete-filled steel tubes) with response-control members. Capitalizing on the concentrated arrangement of major seismic-resistant and response-control members around the core, the freedom in the floor plan was enhanced to realize rational framing in which the seven different building applications are encompassed as can be seen in a single town.

For the response-control members, not only oil dampers but also buckling-stiffening members employing low yield-point steel (LY225) were adopted in order to improve the seismic energy absorption efficiency. The flange size of H-shapes adopted for the core member center can freely be settled by the use of a hat-type spacer that was newly developed for adjusting the preciseness of clearance between the core member center and the buckling-stiffening tube. This hat-type spacer can adjust the yield strength and axial rigidity to their level according to required performance and also efficiently absorb seismic energy.

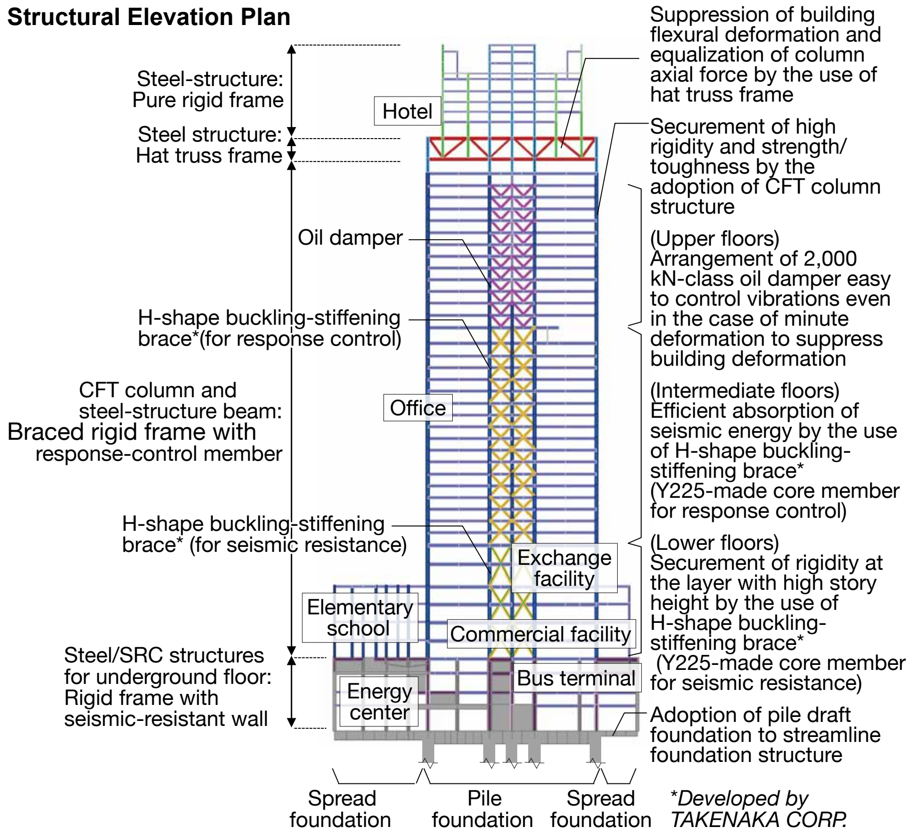
On the upper floor section, the hat truss framing was provided by means of span switching to achieve an improved seismic energy absorption efficiency of response-control members due to the suppression of flexural deformation of the building.

The compound application of the above-mentioned technologies contributes towards securing high structural safety while at the same time rationally reducing the amount of steel frame used for the entire building.

Photo: Shigeo Ogawa

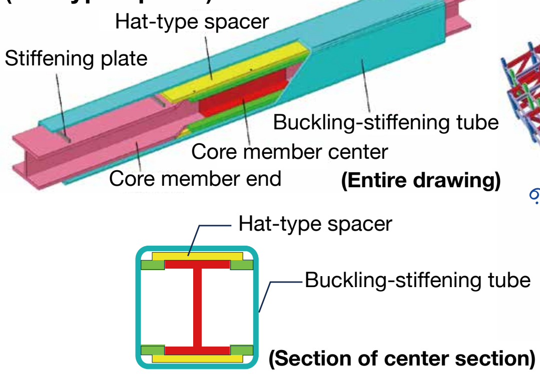
Appearance of Yaesu Central Tower

Structural Elevation Plan

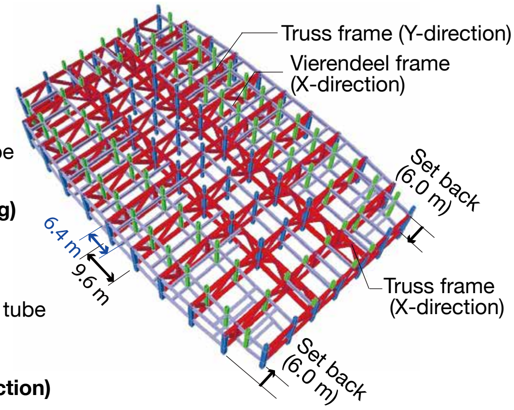


**Developed by TAKENAKA CORP.*

Buckling-stiffening Brace (Hat-type Spacer)



Hat Truss Frame



ES CON FIELD HOKKAIDO

Prize Winners: Obayashi Corporation and Joint Venture of Obayashi Corporation and Iwata Chizaki Inc.

ES CON FIELD HOKKAIDO is a baseball stadium, the home field of the Hokkaido Nippon Ham Fighters, a Nippon Professional Baseball team, which opened in Kitahiroshima City in Hokkaido in the spring of 2023. It is Japan's first natural turf field with a retractable roof system. Its distinctive aim lies in the concept that "players first" be compatible with "fans first."

The stadium is located in a snowfall and cold district—a critical issue for natural turf. In order to cope with such a strict environment, two structural systems have been incorporated into the stadium: a retractable roof that can open and close the roof every day throughout the baseball season and a glass wall installed fully on the south-east side of the stadium that can capture the low-altitude morning sunlight even when the roof is closed.

Retractable Roof

The design is characterized by the gable roof traditionally used in this region. The structure utilizes the arch effect to minimize the building height. The three-hinge frames keep the load capacity, thrust force, and the direction of the resultant force of gravity on each traveling bogie relatively constant, regardless of the roof position, which is effective for the stable opening and closing of the retractable roof. In addition, the three-hinged truss can also absorb the expansion and contraction of the truss beam caused by changes in temperature.

For the top hinge joint and also the bottom traveling bogies, oil dampers are installed to improve seismic safety.

Glass Wall

The 70-meter-high glass wall structure stands on its own. It supports the top roof and glass wall with truss columns, which are horizontally constrained by two horizontal arch structures: the middle eave and the top roof. By using structural optimization, the structural geometry was determined to maximize the transparency of the wall with satisfying structural performance.

The truss columns with narrowing down the legs enhance the concourse's circulation and create a clear open space. Opening the three large operable doors located at the bottom of the eave on the middle level, allows for integrated use of the inside and outside of the stadium, and bring wind and natural light inside.

Photo by Kawasumi·Kobayashi Kenji Photograph Office

Full view of the stadium with retractable roof system

Photo by Kawasumi·Kobayashi Kenji Photograph Office

Inside view of the stadium featuring large glass wall

Photo by Kawasumi·Kobayashi Kenji Photograph Office

The stadium in use in the snow season

Braila Bridge Spanning the Danube

Prize Winner: IHI Infrastructure Systems Co., Ltd.

Bridge Outline

The Braila Bridge is part of the national road construction project (total length: 23 km) that links Braila County with Tulcea County in eastern Romania. It was constructed as the first modern suspension bridge spanning the Danube. Its center span length extends to 1,120 m, the longest in Romania and the third longest within the EU region.

Before the construction of the Braila Bridge, the only means to cross the river in this area was by the ferry, and in bad weather, neighboring people had to cross a bridge 100 km away one way, which had led to the need to strengthen the lifeline and revitalize the economy. The opening of the bridge has made it possible to secure safe traffic in a shorter time. The newly-opened bridge is also expected to contribute not only to improved efficiency of cargo logistics between the port of Constanta, the largest port in Romania, and the eastern region of Romania but to the enhanced revitalization of the economy within the EU region.

Design and Construction

The Braila Bridge was constructed under the design-build contract for both the substructure and superstructure, but the detailed design was proceeded mainly based on the initial plan with addition of necessary revisions respecting the prevailing practices in Romania. In accordance with the Romanian standards, it is required the application of a loading test for any type of bridge, and the Braila Bridge, a suspension bridge, was no exception and was required to apply this loading test. For suspension bridges in general, it is hard to attain a precise loading test result because of the difficulty of understanding the impact of external factors such as air temperature or wind, but the loading test for the Braila Bridge confirmed a highly-accurate test result—a deviation of just 2% from the design value.

Because the construction of the Braila Bridge was the first such long-span suspension bridge project in Romania, it was made the most of technological capabilities cultivated so far in Japan—the application of an air-spinning method incorporating a newly developed control operation system in the erection of main cables and applying of modularized strand jack-type lifting device in the erection of deck segments, and so on. To that end, the first modern suspension bridge in Romania spanning the Danube was successfully opened to traffic on July 6, 2023.

Full view of Braila Bridge

Loading test underway

Erection of deck segment

Influence of Column Skin Plate Thickness on the Toughness of Electro-slag Weld Joints for Built-up Box Section Columns

Prize Winners: Toshihiro Umeda, Yong Hun Song, Ryosuke Oba, Koji Oki, Seiji Fujisawa, Tomoaki Namikawa, Takumi Ishii, Koji Morita

Toshihiro Umeda
2015: M. Eng. Kyoto University
2015-present: JFE Steel Corp.

In built-up box section columns applied in the construction of high-rise buildings, inner diaphragms and column skin plates are joined by means of electro-slag welding (ESW). While ESW is a highly efficient welding method that can weld a thick inner diaphragm with one pass, the heat input is extremely high and thus the weld toughness may be decreased. In particular, when the column skin plate is thin, the cooling rate of welds becomes low and thus there are fears of a significant lowering of toughness.

Given this, we examined the influence of column skin plate thickness on the toughness of ESW joints employing TMCP385 steel that is showing increasing application in the construction of high-rise building.

Fig. 1 shows examples of the configuration of the welding test specimen and the finite element analysis model. In this study, the weld toughness (Charpy absorbed energy at 0°C) was confirmed using a welding test with column skin plate thickness t_s and diaphragm plate thickness h set as the parameters, and at the same time, the cooling rate of the weld was confirmed by conducting thermal conduction analysis that simulates a welding test.

Fig. 2 shows the relationship between the column skin plate thickness and the toughness at the heat-affected zone (HAZ) obtained from the welding test. The HAZ toughness tends to decrease as the column skin plate thickness decreases. However, in the range where the column skin plate was comparatively thin, such as in the welding test at h=70, no clear correlation between them was observed.

In order to further analyze the results obtained from Fig. 2, these results were sorted by dividing them into the relationship between the column skin plate thickness and the cooling rate and the relationship between the cooling rate of welds and the HAZ toughness. Fig. 3 shows the relationship between the HAZ toughness and the cooling rate of welds in the analysis. There is a clear correlation, and as in previous studies, the HAZ toughness decreases as the cooling rate decreases.

Subsequently, Fig. 4 shows the relationship between the column skin plate thickness and the cooling rate of welds in the analysis. In the range where the column skin plate is comparatively thick, the cooling rate tends to decrease as the column skin plate thickness decreases, but in the range where the column skin plate is comparatively thin, the influence of the column skin plate thickness on the cooling rate decreases.

In this study, it was clarified that in the range where the column skin plate is comparatively thick, the column skin plate thickness affects the cooling rate of welds, and as a result, it also affects the HAZ toughness. However, it was clarified that in the range where the column skin plate is comparatively thin, the influence of the column skin plate thickness on the cooling rate of welds decreases, and as a result, the influence of column skin plate thickness on HAZ toughness also decreases.

Fig. 1 Configuration of Welding Test Specimens and Models of Finite Element Analysis

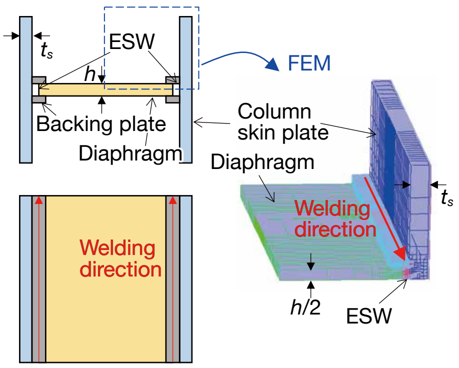
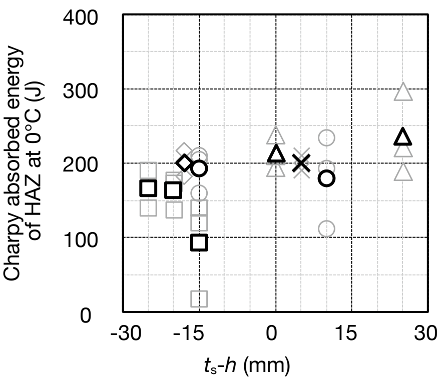


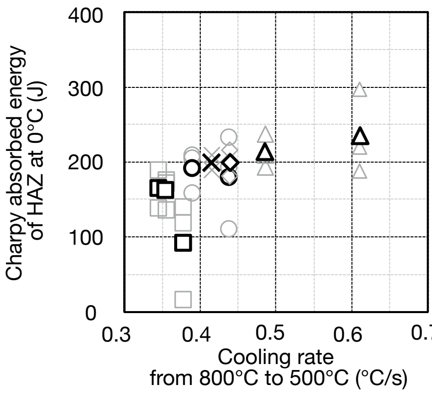
Fig. 2 Relationship between HAZ Toughness and Column Skin Plate Thickness t_s

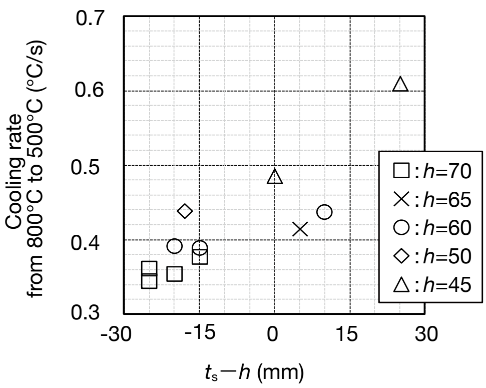
Fig. 3 Relationship between HAZ Toughness and Cooling Rate

Fig. 4 Relationship between Cooling Rate and Column Skin Plate Thickness t_s

□,□ : h=70, ×,× : h=65, ○,○ : h=60, ◇,◇ : h=50,
△,△ : h=45, black : Average of three, gray : Individual values







Rebuilding of the Kumamoto Earthquake-damaged Daiichi Shirakawa Bridge of Minami-aso Railway

Junichi Kitagawa
MM Bridge Co., Ltd.

Severe Damage and Rebuilding

The Daiichi Shirakawa Bridge is a single-track railway bridge with a total length of 166.3 m. It spans the Shirakawa River (Class A River) in Kyushu and is located between Tateno and Choyo Stations on the Takamori Line of the Minami-aso Railway. The bridge, constructed in 1927, adopts a bridge type called a 2-hinge, spandrel braced-balanced arch, a unique type of bridge rarely found in Japan. It was recommended as "Civil Engineering Structural Heritage" under the Japan Society of Civil Engineers in 2015. (See Photo 1)

In the following year, 2016, the Daiichi Shirakawa Bridge was greatly damaged by an earthquake with a maximum seismic intensity of 7 that hit Kumamoto in April of that year. Photos 2 and 3 show the damage to the bridge. The earthquake caused severe damage—support settlement and span-direction support movement due to ground deformation, and the further buckling and fracture of multiple members due to the collision of collapsed earth and sand. In addition, although the bridge itself looked sound, there were the bridge members in which the residual stress nearly exceeded the yield stress. Given such conditions, the bridge had to be rebuilt.

The following article introduces the tasks and countermeasures involved in the safe removal of this damaged special-type bridge and its rebuilding as a new bridge.

Photo 1 Daiichi Shirakawa Bridge before earthquake disaster

Photo 2 Fracture of sway bracing and lower lateral bracing

Photo 3 Deformation of lower chord members caused by collapsed earth and sand

Tasks Involved in Removing the Damaged Bridge

The difficulty in the removal of the damaged bridge was how to remove and dismantle an earthquake-stricken bridge in such a condition of unknown stress. Therefore, it was assumed that the residual stress would be momentarily released by cutting the bridge member to cause the displacement of the bridge structure, like the displacement accompanied with the impact. The displacement of the bridge structure accompanied with impact not only enhanced the further development of bridge structure damage but also caused damage to sound-quality members, and as a result there were fears of the collapse of the bridge structure and accompanying accidents of falling workers while dismantling.

Given this, the following issues were pointed out as tasks involved in safely carrying out the dismantling of the damaged bridge.

- Removal under stable multi-point support that can decrease the dead load-induced stress and deformation
- Understanding of and countermeasures against the risks by means of advanced step analysis
- Monitoring of bridge structure behavior at each removal step and countermeasures immediately taken in case of abnormality

In order to deal with these tasks, diverse countermeasures were taken for the removal of the damaged bridge, which are introduced below.

Countermeasures for Safe Removal

• Cable Erection Lifting Method

Because the bridge is located in a ravine, it was impossible to apply multi-point support using the bent, a commonly adopted system. Therefore, it was decided to adopt the cable erection lifting method to enable the dismantling of the damaged bridge after supporting the bridge panel point position at multiple points with directly-lifted strands and bridge girder-receiving beams and then reducing the stress and deformation due to the dead load and the residual stress due to the damage. The damaged bridge structure was then safely removed using this cable erection lifting method.

• Analysis of Removal Steps

In order to safely remove the damaged bridge, it was important to first reproduce the damaged condition using the analytical model and then forecast the behavior of the damaged members at each removal step. In modeling the damaged members, reproduction accuracy was enhanced by on-site confirming whether the deformation practically measured at the site coincided with the analytical value and whether local buckling and other deformations occurred at the members in which the stress in the analysis greatly exceeded yield stress.

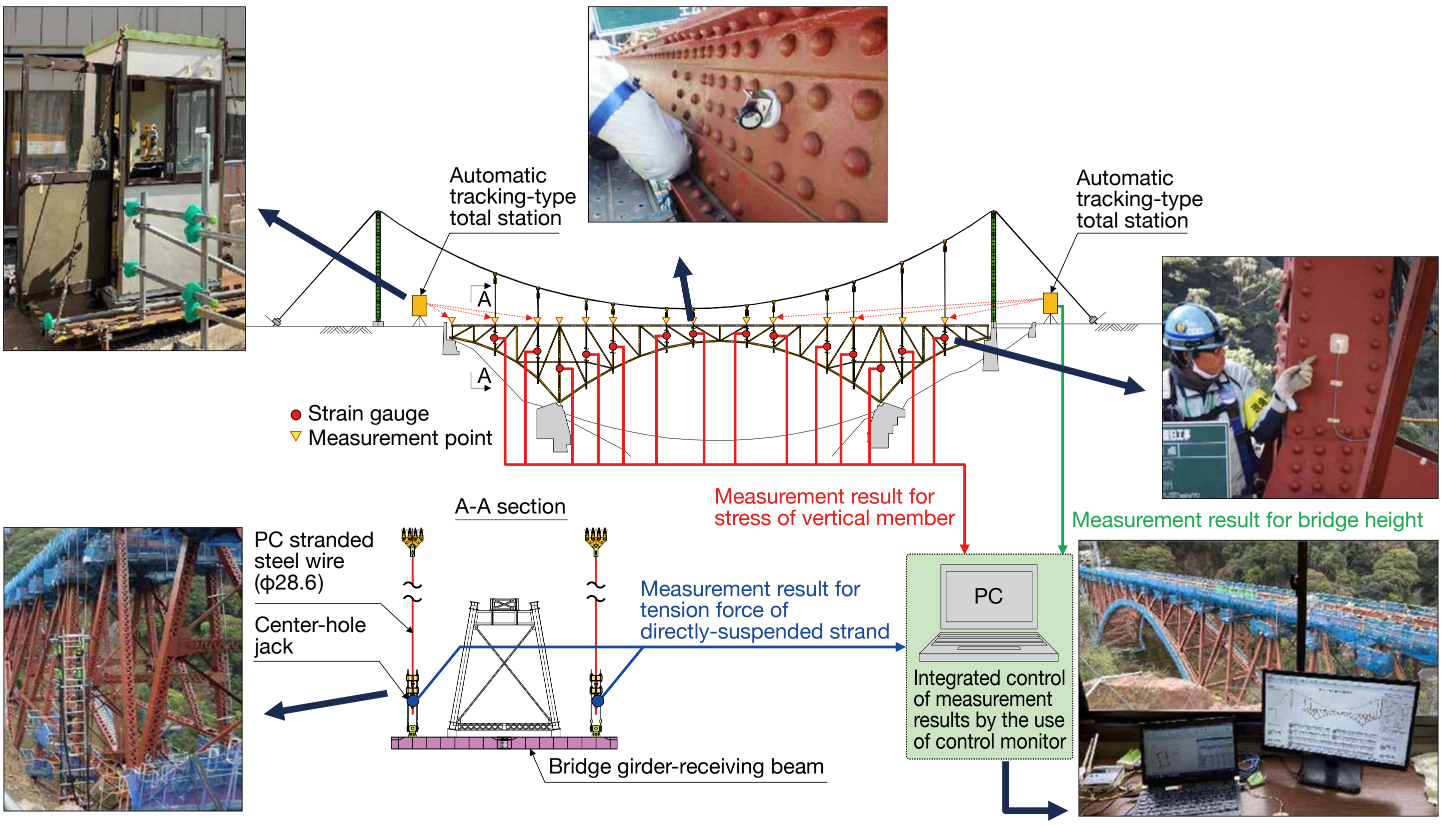
Next, a dismantling analysis was conducted following the planned removal steps to calculate the stress in each member at each dismantling step. When excess stress occurred, the detailed removal steps for producing safe stress conditions were established by adjusting the tension force of directly-lifted strands. The results (tension force of directly-lifted strands, displacement) thus obtained were set at the control value during removal.

• Establishment of Integrated Measurement Control System

In this removal by the use of the cable erection lifting method, the bridge condition changed moment by moment at each removal step. Therefore, it was required to confirm on a real-time basis whether the analytical result deviated from the behavior at each removal step and to take timely measures when abnormal values appeared. Then, real-time measurement was conducted of the height of the bridge structure, and the tension force of directly-lifted strands and the stress occurring in vertical members to which the reaction force is directly loaded from the bridge girder-receiving beam so as to establish a system that can conduct integrated control on the control monitor. (Refer to Fig. 1)

Capitalizing on this integrated measurement control system, it became possible to undertake the real-time measurement and adjustment of the tension force of directly-lifted strands and the configuration of the bridge structure during re-

Fig. 1 Outline of Integrated Measurement Control System



moval and as a result it was possible to promote the speedy and safe removal (Photo 4).

Design of New Bridge

• Cross Section of Bridge Members

The new bridge was designed in a way that follows the bridge type and landscaping performance of the former bridge that was recommended as cultural heritage in the field of civil engineering structures in Japan. Further the design was proceeded by taking into account the following factors: maintaining a member arrangement close to that adopted for the former bridge, the adoption of a cross section and dimensions almost the same as those of the former bridge and coloring exactly the same as the former bridge. (Refer to Fig. 2)

• Seismic Design

For the Daiichi Shirakawa Bridge that was hit by the Kumamoto Earthquake, seismic design was of utmost importance. In light of this, the bridge members were designed by dynamic response analysis that takes into account L2 seismic motion. Further the seismic resistance of the superstructure was improved by increasing the plate thickness of the main girder and the size of bracing members such as sway bracing, upper lateral bracing and lower lateral bracing, and the seismic resistance of the substructure was also improved by additionally installing reinforcing piles employing high-capacity micropile method.

Furthermore, damage from the Kumamoto Earthquake was further expanded due to significant ground deformation in addition to the seismic tremor, and therefore in the new bridge design, measures were taken that prevent the bridge from being put into a critical state due to the actions that are difficult to quantitatively predict and have a large-decree uncer-

Photo 4 Removal of damaged bridge members

Fig. 2 General Structural Drawing and Comparison of Sections between New and Former Bridges

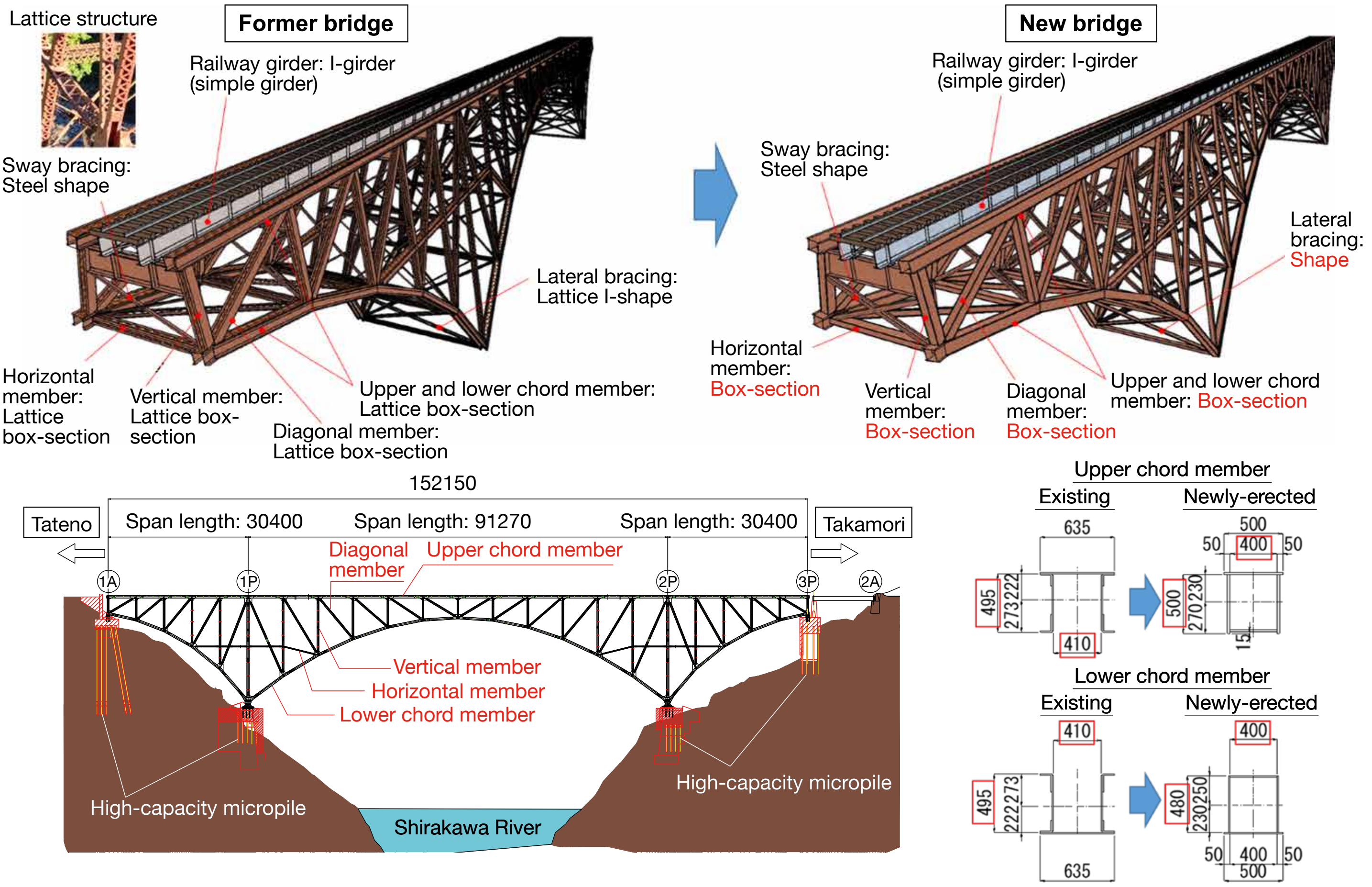


Photo 5 Partial planar temporary assembly

Photo 6 Partial solid temporary assembly

tainty, like the ground deformation. Specifically, the restoration performance of the new bridge was enhanced by securing required support length, adopting damage-control bearings and providing jack-up reinforcing points.

• Temporary Assembly

In order to secure assembly accuracy during erection, the basic rule in railway bridge construction in Japan calls for undertaking "en-bloc temporary assembly" in which an entire bridge structure is assembled all at once. However, because the height of the main girder of the new bridge was so high, about 24 m, an outdoor portal crane could not be used, which led to the combined use of the partial planar temporary assembly of divided blocks and the partial solid temporary assembly of divided blocks. In the temporary assembly of divided blocks, a standard control point was set up for each duplicated block and cumulative error management was handled by inheriting the errors occurring during each temporary assembly. (See Photos 5 and 6)

• Erection

In the erection of the new bridge, the cable erection lifting method used for the removal of the former bridge was also applied. The new bridge was safely and speedily erected by introducing the integrated measurement control system to complete the bridge demonstrating high accuracy in terms of erection. (See Photo 7)

Daiichi Shirakawa Bridge Offers Splendid Scenic Beauty

In rebuilding the Daiichi Shirakawa Bridge, a unique project that could rarely be seen in Japan was undertaken—the removal of a spandrel braced-balanced arch damaged by an earthquake and placed under unknown stress conditions.

The Daiichi Shirakawa Bridge of the Minami-aso Railway in Kyushu is part of the local public transportation facilities that are absolutely indispensable for the residents along the railway line and also serve as one of tourist attractions that remain in the memory of many people due to its scenic beauty. In light of this, it was acknowledged as a bridge to be passed down to future generations as a symbol of reconstruction from the Kumamoto Earthquake and the bridge was awarded the 2022 Japan Society of Civil Engineers Tanaka Prize, a prize that commends outstanding achievements in the field of bridge and steel-structure engineering.

The entire Minami-aso Railway line opened to traffic in July 2023. It is bustling with tourists who come to ride the trolley train, a famous tourist specialty of the Minami-aso Railway. (See Photo 8)

Photo 7 Erection of lower chord members (closing)

Photo 8 Rebuilt Daiichi Shirakawa Bridge after full opening to traffic

Robust Corrosion-prevention Technology and Rational Corrosion Diagnosis/Repair Technology for Steel Bridges

Eiji Iwasaki
Professor, Nagaoka University of Technology

In order to precisely assess the structural performance and durability of steel structures that have deteriorated over time, suppress their reduction and recover/improve them, it is necessary to establish secure and effective maintenance technologies to treat these issues. In light of this, the Working Group on Corrosion and Durability of the Research Committee on Structural Performance and Durability of Steel Bridges was established within the Japanese Society of Steel Construction. Specifically, it extended surveys and studies that focus on corrosion-induced deterioration and corrosion prevention with the following goals—the proposition of rational corrosion-prevention specifications in reply to diverse corrosion characteristics and the examination of rational diagnosis technology and repair methods for the steel structures and members that have been damaged by corrosion.

Some of the results attained in the field of steel bridges are introduced below:

Corrosion-prevention Specifications in Response to Corrosion Characteristics by Erection Environment and Structural Part of Steel Bridges

In steel bridges, corrosion does not develop uniformly over an entire bridge structure but corrosion conditions differ depending on each structural part. Therefore, it is considered important to examine an effective corrosion-prevention method for every corroded part from the standpoint of the reduction of lifecycle cost and the erection of more robust bridge structures. In order to meet such a need, the Working Group demonstrated a corrosion-prevention method that notices the respective corroded parts of steel bridge.

In steel bridges, there are many cases in which corrosion develops at specified bridge sections such as girder ends. Given this, regarding carbon steel-stainless steel hybrid bridges in which stainless steel is adopted for girder ends (Fig. 1), the Working Group specified the steel grade to be applied and then examined its weldability and fabricability and its lifecycle cost.

High-performance Corrosion-prevention Technology for Easy-to-Corrode Structural Sections of Existing Bridges

In the recoating of steel structures such as steel bridges, it is required to apply nearly five layers of coating, and thus the prolonged coating time and securing the necessary labor are increasingly becoming problematic. In order to cope with such circumstances, the Working Group examined the coating specifications to facilitate process-saving while at the same time maintaining heavy-duty corrosion-prevention performance by applying heavier-thick undercoats.

The examination targets covered the undercoat+topcoat two-layer coating structure (Fig. 2). In order to confirm the corrosion-prevention performance of five kinds of two-layer coatings prepared by changing the topcoat material and the undercoat material, the Working Group implemented a cyclic corrosion test and an outdoor exposure test (Fig. 3). In these tests, in order to simulate the recoating of corroded practical bridges, channels were fabricated on the test specimens using

Fig. 1 Image of Bridge Employing Stainless Steel in Girder Ends

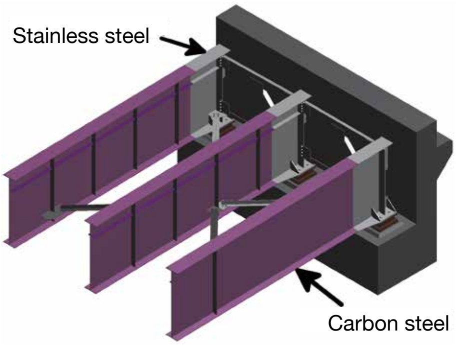


Fig. 2 Comparison of Coating Film Structure between Conventional and Labor-saving Painting

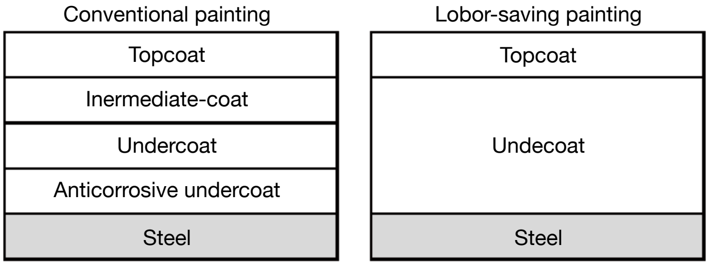


Fig. 3 Example of Outdoor Exposure

conical drills. No abnormality was found in the coating film after the lapse of five months, and the exposure is continuing.

Assessment of Structural Redundancy for Rational Inspection and Diagnosis

When a certain bridge member is damaged, the bridge collapses or the deflection becomes so large as to spoil the serviceability. To cope with such situations, it is considered rational to verify the time and cost required for repair and for the reinforcement of these damaged members and to minimize the forecast value for damage relative to the cost required for maintenance.

Taking into account this kind of optimization, the Working Group showed a method to assess the structural redundancy, examples of structural redundancy of truss bridges and Langer bridges and the effect of floor slabs on the assessment of the redundancy of multi-main girder bridges. For example, in order to reproduce behaviors of practical bridges, it is important to minutely model the panel points (Fig. 4), and in the case of adopting rigidly-joined structures, it was shown that there is a possibility of overestimating redundancy.

Assessment of Soundness of Steel Members with Corrosion Damage

In steel truss bridges, there is a risk of impairing the structural stability of an entire bridge structure when the main member is damaged. Meanwhile, because steel truss bridges are composed of diverse kinds of members, there are diverse patterns in corrosion damage, and thus the quantitative soundness diagnosis method based on the mechanical rationality of damaged sections has not yet been established.

In light of the above, the Working Group made surveys of examples of the corrosion damage of truss bridges to show an example of soundness assessment of damaged truss bridges. Specifically, surveys were made of two cases of corrosion damage—one in which corrosion damage occurs in the main plate gusset section just above the joint section with lower chord members and another in which corrosion breaks occur in the weld of compressive diagonal members (Fig. 5), proposing a simple assessment method for the stress condition and buckling strength in these two corrosion damage cases by no use of finite element analysis.

Clarification of Mechanical Mechanisms in the Reinforcement of Cross Sections of Corrosion-damaged Members

In repair using high-strength bolt patch plates for steel members subjected to axial force, like diagonal truss members, the thickness of the patch plate is commonly designed assuming that the axial force occurring in the steel member of the corrosion-damaged structure is fully borne by the patch plate. However, as shown in Fig. 6 (c), the axial force transmission in the reinforcement by the use of the patch plate of steel members of damaged structures differs from the axial force transmission in the joint (Fig. 6(a)) and further in sound members, and thus the axial force is redistributed in the neighborhood of corrosive section, thereby showing a complex behavior in axial force transmission.

In light of the above, the Working Group derived a formula for estimating the axial force to be borne by the patch plate based on the proportional axial force and the displacement conditional expression.

Fig. 4 Detailed Model of Truss Bridges

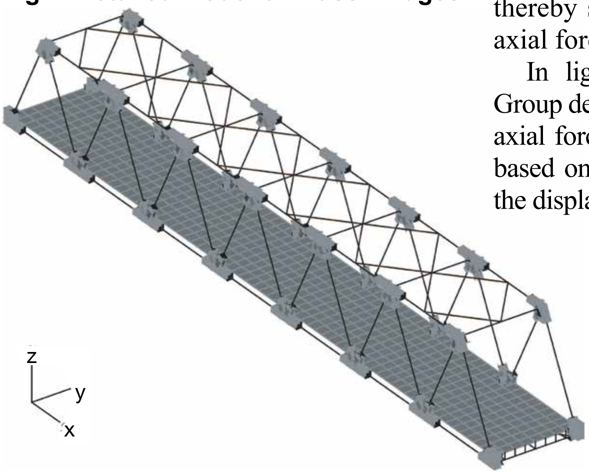


Fig. 5 Local Buckling of Compression Diagonal Members due to Corrosion Breaks at Welds

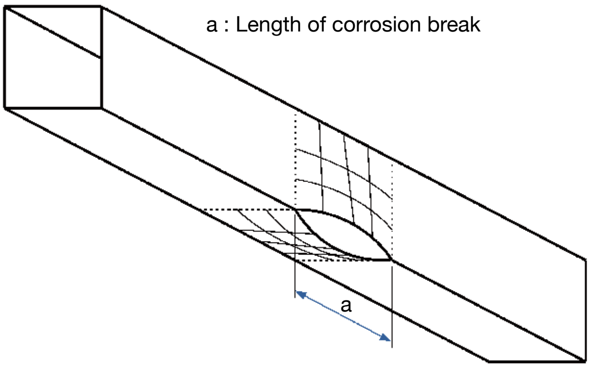
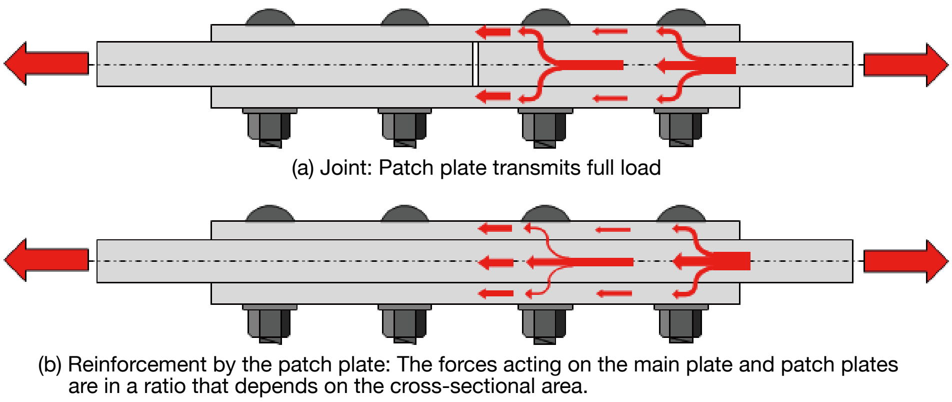


Fig. 6 Conceptual Drawing of Reinforcement and Repair Using Patch Plates



(c) Repair by the patch plate: The forces acting on the main plate with the cross-sectional defect and the patch plates are not shared in proportion to the cross-sectional area ratio.

Sumida River Terrace Pedestrian Bridge —Application of Duplex Stainless Steel

Hiroyuki Yokomizo
Yada Industry Co., Ltd.

Bridge Erection Employing Duplex Stainless Steel

The erection of the Sumida River Terrace Pedestrian Bridge is a link of the Sumida River Terrace Continuation Project being promoted by the Bureau of Construction of the Tokyo Metropolitan Government. In this erection, fabrication and on-site erection of two bridges—Tsukishima River Terrace Connecting Bridge and Oshima River Terrace Connecting Bridge—were undertaken.

Among the major features in the erection of these two bridges were the application of resource-saving duplex stainless steel (SUS821L1) in bridge superstructure members and the resultant application advantages—not only the suppression of increases of the bridge weight due to the design of long-span bridges, but also the mitigation of maintenance burdens and the reduction of lifecycle costs. While there has been a case of bridge construction employing duplex stainless steel in Japan, these two bridges are the first of their kind as bridges having lengths of 40 to 50 m.

An outline of the erection of Tsukishima River Terrace Connecting Bridge and Oshima River Terrace Connecting Bridge is introduced below:

Outline of Bridge Structure

Table 1 shows an outline of the two bridges. Both are stainless steel plate simple girder and straight-type bridges, moreover they adopt wooden floor slabs.

While the vertical slope of the Oshima River Terrace Connecting Bridge is level, the center span section of the Tsukishima River Terrace Connecting Bridge is raised by about 1 m taking into account the passage of ships under the bridge.

Structural Materials Applied

The resource-saving duplex stainless steel (SUS821L1), the structural material adopted for these two bridges, is composed of a dual-phase structure with about half ferrite and half austenite with a chemical composition in which chrome (Cr) is increased by about 25% and nickel (Ni) is decreased by about 5%.

Because of the dual-phase structure thus provided, this type of duplex stainless steel is a lightweight material in which the material weight is reduced by about 40% compared to that of SUS304 while demonstrating a strength two times that of SUS304. In addition, the content of Ni which governs the stainless-steel cost is reduced in resource-saving duplex stainless steel. Consequently, it is accepted as an economical material among duplex stainless-steel products.

Fabrication

The fabrication of stainless-steel members was undertaken in Koriyama City in Fukushima Prefecture. As the duplex stainless steel has high hardness and thus strain straightening is difficult, extreme attention was paid from the planning stage to prevent the occurrence of strain during welding.

Table 1 Outline of Sumida River Terrace Pedestrian Bridge

Design dimension	Tsukishima River Terrace Connecting Bridge	Oshima River Terrace Connecting Bridge
Structural type	Wooden floor slab/stainless steel plate simple girder bridge	Wooden floor slab/stainless steel plate simple girder bridge
Length	39.50 m	47.50 m
Span length	38.70 m	46.40 m
Total width	3.80 m	3.80 m
Effective width	3.0 m	3.0 m
Material for superstructure	Duplex stainless steel (SUS821L1)	Duplex stainless steel (SUS821L1)
Material for floor slab	Wooden floor slab t=30 mm	Wooden floor slab t=30 mm


Photo 1 Temporary assembly (front: Tsukishima River Bridge; back Oshima River Bridge)


Photo 2 Ground assembly (front: Oshima River Bridge; back: Tsukishima River Bridge)

Photo 3 Erection of Tsukishima River Terrace Connecting Bridge

Photo 4 Erection of Oshima River Terrace Connecting Bridge

Furthermore, new devices used to absorb strain were incorporated by providing two splicing sections on the cross-girder position. After the completion of the fabrication of bridge members, the temporary assembly of practical structures at the factory was carried out to confirm the dimension and quality in terms of its design. (See Photo 1)

Ground Assembly

After the temporary assembly, the completed bridge blocks were transported to the quay yard in Chiba Prefecture to undertake the ground assembly. The main girder section and cross beam upper flange were joined by means of on-site welding, and the cross-girder web and lower flange were spliced by the use of high-strength stainless steel bolts. Bolt fastening was confirmed by referring to the nut rotation method. (See Photo 2)

Examination of Erection Method

Among the erection plans, the most significant part was the plan for the mooring facility used to bring the barge close to the bridge erection position. As for the Oshima River flood gate, an original plan for the barge mooring facility was worked out where an anchor bolt was attached to the flood gate structure.

However, the barge mooring fitting could not be allowed directly to the flood gate structure since it was the one of the most important infrastructures in Tokyo Metropolitan area. It was required to examine other barge mooring facilities.

As a result, the following two barge mooring facilities were examined, and after the approval, two barge mooring facilities were installed:

- A barge mooring facility was installed that draws the barge from the river center close to the abutment, in which the anchor bolt is driven on the abutment and the barge mooring metal fitting is fixed to draw the barge closer to the abutment using a wire.
- A barge mooring facility was installed to move the barge from the neighborhood of the abutment to the bridge erection position, in which a sinker with a weight of about 24 tons (a weight used to be sunk underwater) was installed in front of the Oshima River flood gate and the barge was moved to the bridge erection position by the use of the wire connected to the sinker. In the installation of the sinker, slinging operation by divers was implemented under the low-visibility water.

On-site Erection Method

In the erection of the Tsukishima River Terrace Connecting Bridge, a patrol boat was allocated to the Sumida River, and the bridge was erected by means of tandem lifting by the use of two floating crane ships with a lifting capacity of 200 tons (Photo 3).

In the erection of the Oshima River Terrace Connecting Bridge, two table lifts with a maximum lifting capacity of 250 tons were installed, on which the bridge structure was installed. Bridge erection was started after waiting for the tide level in the Tokyo Bay to reach AP+1.3 m at high tide and settled at the stage of erection planning. The barge was moved by adjusting the wire cable of a winch, and the bridge was erected on the designed position finally. (See Photo 4)

As the gap between the bridge girder and abutment was only 50 mm for both abutments A1 and A2, the erection work was carefully undertaken while constantly contacting operators, which thus led to the successful erection of these two bridges. (See Photo 5)

Photo 5 Completion of Oshima River Terrace Connecting Bridge

Acknowledgements

We would like to express our deepest gratitude to the Koto Flood Control Office of the Tokyo Metropolitan Government, NIPPON STEEL Stainless Steel Corporation and everyone involved in the construction for their guidance and cooperation extended to this project.

PACIFIC CENTURY PLACE JAKARTA

Hidetoshi Ito
TAKENAKA Corporation

High-rise Steel-structure Building

The PACIFIC CENTURY PLACE JAKARTA was completed in November 2017 in the business district redevelopment area in Jakarta, the capital of Indonesia where high economic development continues. It is a high-rise office building featuring a novel design and an exterior form that stand out among the surrounding skyscrapers within the city of Jakarta. (See Photo 1)

Among the design requests from the project owner was the realization of Premier Grade A Office (a premier office representing the respective cities). At the stage of structural design, the adoption of a steel structure was requested while also securing high seismic safety and economic efficiency worthy of Premier Grade A Office.

Photo 1 Full view of PACIFIC CENTURY PLACE JAKARTA

Table 1 Building Outline

Name:	PACIFIC CENTURY PLACE JAKARTA
Location:	Jenderal Sudirman, Jakarta, Indonesia
Project owner:	Pacific Century Premium Development Limited
Design:	Takenaka Corporation, PWD (architecture), GISTAMA (structure), ASDI (M&E)
Construction:	Joint operation of PT Takenaka Indonesia and TOTAL (local construction company)
Construction period:	January 2015~November 2017
Structural type:	Steel and reinforced-concrete composite structure, steel structure, reinforced-concrete structure, concrete-filled steel tube column, reinforced-concrete core wall, flat slab-type underground floor
No. of floors:	7 underground floors, 41 aboveground floors, two-story penthouse
Height:	209.25 m
Building area:	3,633 m^2
Total floor area:	148,375 m^2

The following article introduces an outline of the structural design of the full-fledged steel-structure high-rise office building and an outline of the steel-structure construction that was attained to ensure quality on par with Japan, as requested by the project owner.

Building Outline

The major dimensions of the building are shown in Table 1.

Fig. 1 shows the floor plan of typical office floors. While the RC-structure center core, a local common system in high-rise office building construction in Indonesia, was adopted for the core area, a steel-frame structure with column spans of 10.8 m was adopted for the peripheral area. Incidentally, at the corner area, the use of corner columns was eliminated by providing large-span cantilever beams, which led to the realization of office space with high openness.

Fig. 2 shows the cross section of the building. The building is composed of offices on the 8th to 41st floors and an office lobby, shops, parking lots and equipment/machine rooms at podium/underground floors.

Current State of Steel-structure Buildings in Indonesia

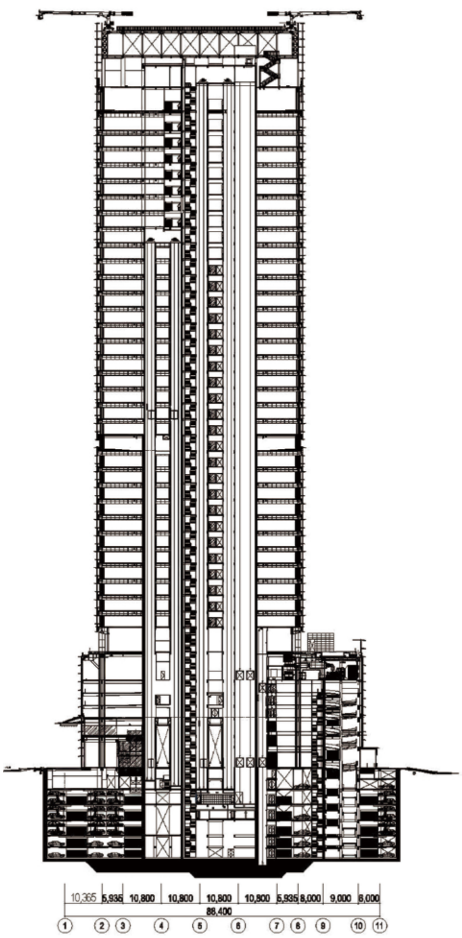
RC structures have commonly been adopted in the construction of high-rise office buildings in Indonesia, and steel structures are not in wide-spread use. Among the reasons for fewer applications of steel structures in Indonesia are:

- Few steel product sizes and kinds can locally be procured. Still more, high tariffs are imposed on imported steel products, thereby leading to the cost of imported products higher than those of domestically procured products.
- Steel-frame fabrication plants that can handle large-size members have not yet been developed.
- The construction market is mainly composed of RC structures, and local construction companies are not accustomed to using steel structures. On the contrary, those companies are skilled in RC-structure construction, and as a result there is no clear difference in construction time between steel and RC structures.

From the above, the difference in cost between steel and RC structures in Indo-

Fig. 1 Floor Plan of Typical Floor

Fig. 2 Cross Section of Building



nesia is larger than that in Japan, making steel-structure construction more expensive in Indonesia. Also, the advantage obtained by the use of steel structures in terms of construction time is not so great, and the construction market in Indonesia is in a situation in which steel structures are difficult to adopt.

Outline of Structural Design

• Outline of Structural Design

In Indonesia where RC structures are commonly adopted, this building was constructed by the use of the steel-frame structure adopting RC-structure core walls and CFT (concrete-filled steel tube) columns for peripheral area. This was the first full-scale steel-structure office building to which the new seismic design standards established in 2012 in Indonesia were applied.

Incidentally, in order to secure high seismic safety for this steel-structure high-rise building, a request from the project owner, seismic design was conducted to resist seismic force by an extra 25% over that stipulated in the new seismic design standards mentioned above.

• Structural Design of Aboveground Structure

Fig. 3 shows the framing plan of typical floors.

The plane configuration of typical floors is a rectangular shape measuring 55.1 m×45.5 m. The office space has a width of 12~14 m. Peripheral columns are installed at an interval of 10. 8 m.

RC-structure seismic-resistant walls with thicknesses of 450~800 mm were adopted for the core area.

• CFT Columns

Fig. 4 shows the typical column cross section on typical floors.

The columns adopted for the building were CFT (concrete-filled steel tube) columns with encased reinforcing bars inside the columns. The steel column sections range from 1,400 mm in diameter and 25 mm in wall thickness to 1,000 mm in diameter and 10 mm in wall thickness. The beam-to-column connection was finished by the use of through-column with outer diaphragms (Fig. 5). Because the steel tube column walls are thin, or 10 mm at minimum, the beam-to-column connection was reinforced using steel plate ribs to secure the sectional stiffness and strength of the columns.

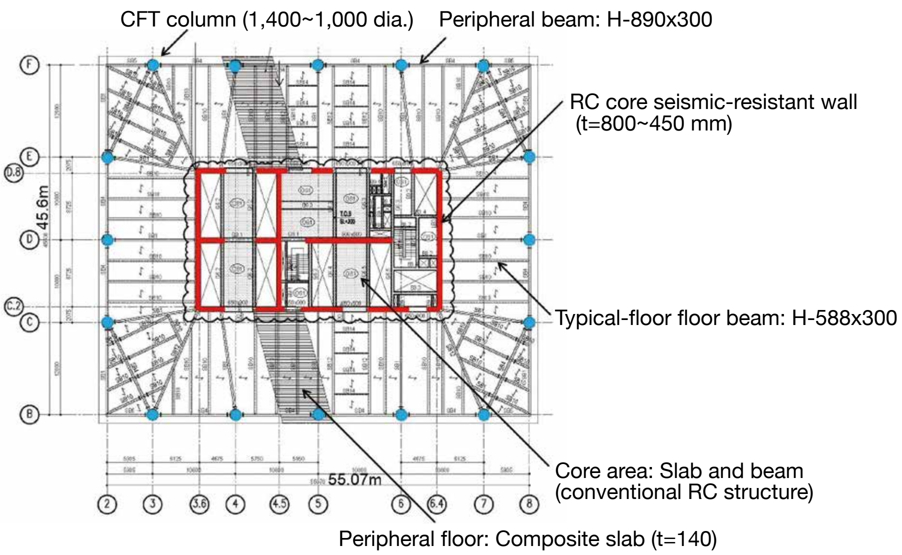
The strength of steel tubes was set at Fy=345 N/mm^2, and that of filling concrete was set at fc'=45~55 N/mm^2.

Fabrication and Erection of Steel-frame Members

• Mockup Preparation Preceding Steel-frame Fabrication

In the selection of steel-frame fabricators, surveys were made of the fabrication plants operating in Jakarta, and Murinda, a local company, was final-

Fig. 3 Framing Plan of Typical Floor



ly selected taking into account their fabrication record, the difficulty of fabrication of steel-frame members for this building and fabrication capacity.

Prior to the fabrication of steel-frame members used for this building, the full-scale mockup of beam-to-column connections employing CFT columns was prepared to confirm in advance the various tasks involved in the fabrication and erection of the steel-frame members. The results thus confirmed were fully applied in the practical erection work (Photo 2).

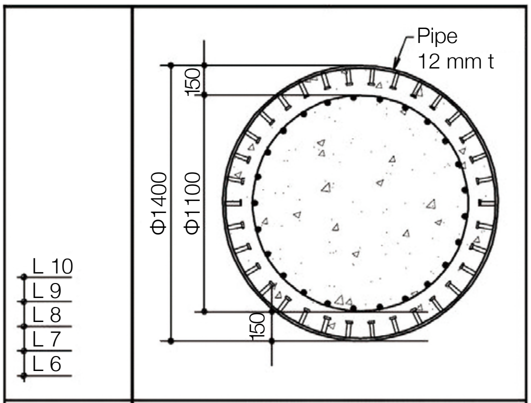
• On-site Erection of Steel-frame Members

Supervisors dispatched from Japan instructed local workers on the on-site erection of steel-frame members to ensure erection quality on par with that in Japan.

For the concrete filling of the inside of steel tube columns, the method of dropping-in concrete inside the steel tube columns was adopted for each on-site weld point of steel tube columns (Photo 3).

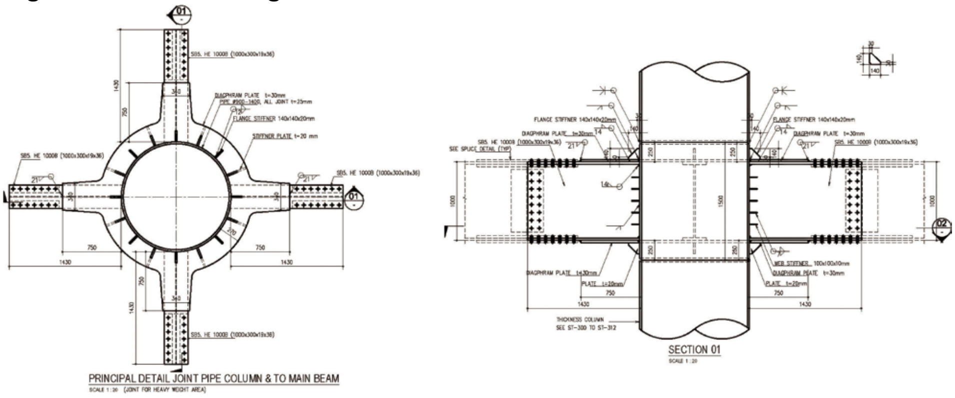
Photo 4 shows the construction of the aboveground structure just prior to raising the upper-floor framing.

Fig. 4 Typical Column Cross Section of Typical Floor



Dimension	Φ1400 + Pipe 12 mm t	
Main bars	25 D 32	
Stirrups	D10–200 (Spiral)	D10–200 (Spiral)
Position	End stirrups	Mid stirrups

Fig. 5 Detailed Drawing of CFT Beam-to-Column Connection



Steel-structure Building with High Seismic Resistance and Quality

The PACIFIC CENTURY PLACE JAKARTA—the first full-fledged steel-structure high-rise office building using CFT (concrete-filled steel tube) columns in Indonesia—has successfully been completed. It is said to boast quality on par with Japan. This is the result of our efforts to meet the challenge of realizing this sort of building in this country.

In the future, based on the experience of constructing this steel-structure high-rise building in Indonesia, we intend to make a wide range of social contributions, focusing on the wide dissemination of Japan's excellent earthquake-resistant technologies overseas; especially those for the design, fabrication and construction of earthquake-resistant steel structures, which have been acquired through many earthquake disasters in Japan.

Photo 2 Preparation of mockup of beam-to-column connection at fabrication plant

Photo 3 Placement of filling concrete inside CFT column

Photo 4 Erection of steel frame on high-rise floor

2024 China-Japan-Korea Tall Building Forum in Shenzhen, China

Dr. Masayoshi Nakai
Director of CTBUH Japan Structures Committee,
International Committee of Japanese Society of Steel Construction

This forum is an international conference organized primarily by academic experts and structural engineers from China, Korea, and Japan as part of the initiatives of CTBUH (Council on Tall Buildings and Urban Habitat, headquartered in Chicago, USA) in Asia. Since its inception in Shanghai in 2014, it has been held annually, except for 2020 when it was cancelled due to the COVID-19 pandemic, and this marks its 10th meeting.

This year's forum was hosted by Tongji University in China, co-organized by CTBUH Japan Structures Committee and Korean CTBUH, and held at the "Shenzhen Crowne Plaza" in Shenzhen on Friday, July 26, 2024. Eight participants each from Japan and Korea visited Shenzhen, and together with Chinese core members, speakers, and general participants, approximately 70 people attended this forum.

At the opening of the forum, Prof. Guoqiang Li from Tongji University, the representative of China, gave an opening address as the host, followed by greetings from Dr. Masayoshi Nakai from Takenaka Corporation, representing Japan and Prof. Myung Sik Lee from Dongkkuk University representing Korea, expressing their gratitude for holding the face-to-face meeting in China after seven years.

Prior to the lectures from each country, as a keynote speech from the host country, Mr. Lianjin Bao from East China Architectural Design and Research Institute presented the architectural planning and structural benefits of mid- and high-rise buildings with suspended frames, as well as new processes of structural design and construction, through several architectural examples in China.

After that, there were three sessions with three speakers each from China, Japan, and Korea, for a total of nine presentations. At the end of each session, questions from the audience were directed to three speakers, leading to lively discussions about the content of each presentation.

The summaries of three presentations from China are as follows:

- The "LEXIN Group Headquarters" (32 stories and composite structure of RC and Steel), planned as the new headquarters of a major fintech company, features an innovative design in which the building's base is truncated with a triangular pyramid. The owner's representative explained its design concept and several challenges in structural design and construction.
- A presentation was given on a proposed structural system that couples flexural and shear structures with viscoelastic connectors, and additionally incorporates seismic isolation devices in the intermediate layers of the shear structure. The analysis methodology and results were explained.
- A report was presented on the steel erection of twin towers (193 m/212 m) with six suspended structures each, detailing the construction process and accuracy control using temporary supports and bracing.

The outlines of three presentations from Korea are as follows:

- A presentation titled "Tall Wood Buildings for Sustainable Vertical Urbanism" explained the trends of high-rise timber buildings while introducing case studies from around the world.
- The structural scheme of a 260 m-tall mixed-use building planned in Shenyang (China) and a 190 m-tall residential building planned in Daegu (Korea) was introduced, including comparative studies of structural systems based on RC cores.
- The presentation introduced efforts to ensure structural stability of the 555.7 m-tall

Photo 1 Lecture delivery from Dr. Kushima

Photo 2 Lecture delivery from Mr. Kimura

Photo 3 Lecture delivery from Mr. Shimizu

Photo 4 Group photo of core members and speakers of the forum

"Lotte World Tower" completed in Seoul in 2017, including mock-up tests and structural strength experiments of member connections of mega-structures, and structural health monitoring at the construction stage.

Furthermore, the summaries of three presentations from Japan are as follows:

- Dr. Soichiro Kushima from Takenaka Corporation introduced the development of an integrated structural design and calculation system that incorporates three narrow AI functions (building research, cross-section estimation, and member design) and BIM functionality into the conventional structural design system, while giving demonstrations of its system operation on screen (Photo 1).
- Mr. Yutaka Kimura from Taisei Corporation presented a structural design case study (Akasaka Trust Tower) of a 210 m-high, 43-story high-rise building, where seismic performance of the whole building was improved by controlling the period and damping of the seismic isolation layer installed at the 38th floor level (Photo 2).
- Mr. Kan Shimizu from Kajima Corporation presented a structural design case study (SHIBUYA Tower and Central Building in the "Shibuya Sakura Stage") where structural rationalization was achieved by connecting two buildings of different heights (180 m and 90 m) with joint dampers (i.e., buckling-restrained braces) at the top level of the lower building, eliminating the need for expansion joints and reducing damping devices in the lower building (Photo 3).

At the closing ceremony, Prof. Yukio Tamura from Chongqing University, Prof. Akira Wada (Chairman of CTBUH Japan Structures Committee), and Prof. Sang-dae Kim from Korea (former President of CTBUH) expressed their gratitude for the meaningful discussions that took place during this gathering, and the forum concluded successfully (Photo 4). Finally, Prof. Myung Sik Lee announced that the next forum will be hosted by Korea and is scheduled to be held in Busan in September 2025.

In the afternoon of the day before the forum, a technical tour was organized to visit the following three construction sites in Shenzhen.

- At the above-mentioned "LEXIN Group Headquarters," participants observed the complex steel erection and curtain wall installation process. The giant transfer diagonal braces are distributed from the first to sixth floors on the south and west sides of the building. These braces have a steel box section of 1400×1400×120 mm, weighing 260 tons with a span of 43 m (Photo 5).
- At the "Shenzhen Bay Culture Park" designed by MAD Architects, they examined the construction status of RC shells and waffle slabs.
- "The CITIC Financial Centre Shenzhen is a complex development consisting of two towers and podium buildings, designed to establish a landmark around Shenzhen Bay. The taller tower, with a height of 300 m and 63 stories, consists of a reinforced concrete core and perimeter frame system of columns and beams, employing a structural system called 'Frame-Core-Belt Truss' (Photos 6 and 7).

While economic slowdown in China has been reported, construction in Shenzhen remains vibrant. Although this was my first visit to a Chinese construction site in seven years, I could clearly observe the significant advancement in construction technology.

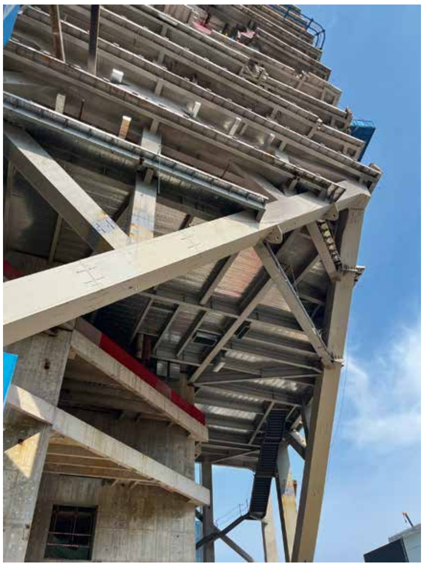



Photo 5 Construction site of the "LEXIN Group Headquarters"

Photo 6 Construction site of the "CITIC Financial Center Shenzhen"

Photo 7 Group photo of tour participants at the "CITIC Financial Center Shenzhen"

Message from the President of the Japanese Society of Steel Construction

Mitsumasa Midorikawa
President, Japanese Society of Steel Construction
(Professor Emeritus, Hokkaido University)

In October 2020, the Japanese government declared that it would aim to be carbon neutral by 2050. Carbon neutrality is an approach that absorbs or removes greenhouse gases to reduce them to zero emissions. This is important for creating a sustainable society as a means to cope with global warming.

In 2021, the government published "Energy-saving and other measures and implementation for houses and buildings to contribute to a decarbonized society." Among the specific goals set with 2030 as the target year were newly-built houses and buildings to attain energy-saving performance at the level of ZEH (net Zero Energy House) and ZEB (net Zero Energy Building) standards and 60% of newly-built single-family homes to install photovoltaic power generation equipment. In order to achieve these goals, mandatory compliance with energy-saving standards is being promoted and the deadline is approaching in five years.

Now it is strongly required for all those involved in steel structures to continue their commitment to a decarbonized society in cooperation with society as a whole.

Message from the Chairman of the International Committee

Hiroshi Katsuchi
Chairman, International Committee
(Professor, Yokohama National University)

The Japanese Society of Steel Construction (JSSC) has conducted a wide range of activities pertaining to steel construction—surveys and research, technological development, the spread of steel construction in Japan and overseas and the improvement of steel construction technologies. In addition, JSSC has promoted tie-ups with related overseas organizations. Aimed at spreading Japan's steel construction technologies and developing overseas markets, the JSSC's International Committee took charge of editorial planning and compiled Issue No. 73 of *Steel Construction Today & Tomorrow*.

Issue No. 73 takes up the rebuilding of and repair technologies for steel bridges as a Feature Article. Specifically, two articles are introduced—from planning and design to member manufacture and erection pertaining to the rebuilding of the Kumamoto Earthquake-stricken Daiichi Shirakawa Bridge of the Minami-aso Railway and research achievements pertaining to robust corrosion-prevention technology and rational corrosion diagnosis/repair technology for steel bridges. In the Feature Article: Stainless Steel, an outline is introduced that reports the erection of the Sumida River Terrace Pedestrian Bridge that aimed at reducing the bridge weight and the lifecycle cost by the use of duplex stainless steel. In the Overseas Steel Construction Project, PACIFIC CENTURY PLACE JAKARTA, a high-rise building project in Indonesia, is taken up.

In addition, this issue introduces the JSSC Commendations for Outstanding Achievements in 2024 in the field of steel construction (four projects) and technical papers (one paper).

In the pages about JSSC International Events, the 2024 China-Japan-Korea Tall Building Forum held in Shenzhen, China in 2024 is introduced.

The Japanese Society of Steel Construction will hold its sixtieth anniversary in 2025. JSSC is determined more than ever before to further promote international activities related to steel construction and efforts toward the urgent issue of carbon neutrality. We would like everyone to understand the activities of JSSC and would also like to hear your opinions at any time.

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