No. 64 April 2022

STEEL CONSTRUCTION TODAY & TOMORROW

https://www.jisf.or.jp/en/activity/sctt/index.html

Special Issue

Japanese Society of Steel Construction





Published Jointly by

The Japan Iron and Steel Federation

JSSC Japanese Society of Steel Construction

JSSC Commendations for Outstanding Achievements in 2021—Outstanding

ACADEMIC-ARK of Otemon Gakuin

Prize winners: Mitsubishi Jisho Sekkei Inc. and Takenaka Corporation

Equilateral Triangle Structural Plane

The ACADEMIC-ARK is the project planned for building a new school campus of Otemon Gakuin on a vast plant track site development area located in the northern part of Osaka Prefecture. In the age of the internet society where students can learn without attending school, we examined the design of a school campus where human activities can be felt because it is a real space. Specifically, we proposed a school building featuring an equilateral triangle plane where the library, hall and other bustling places are surrounded by the classroom, direct facing with the windows of neighboring houses is reduced and campus plaza can be opened to the local community.

Certain restrictions were imposed on the project—a tight schedule of 29 months from the start of design to the opening of the new campus and the location of the project site at a buried cultural property survey area. In order to reduce the survey period and secure a reliable schedule, we proposed a sharp reduction of foundation area (building grounding area) by widely overhanging the building corner section and providing a first-floor center area with column-free space.

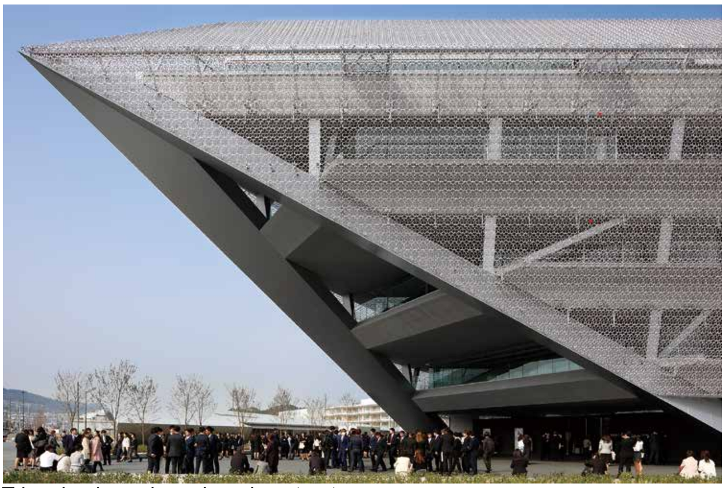
Overhanging Construction

A major seismic-resistant element provided was the seismic-resistant wall with thicknesses of 1,200 to 1,300 mm, and four walls were arranged to each side.

The huge-scale overhanging sections at three corners with an overhanging extension of about 37 m were formed using triangle-shaped framings composed of four layers of overhanging structures, and the triangle framings were structured by the minimum use of structural members by supporting the intermediate overhanging structure with suspension members.

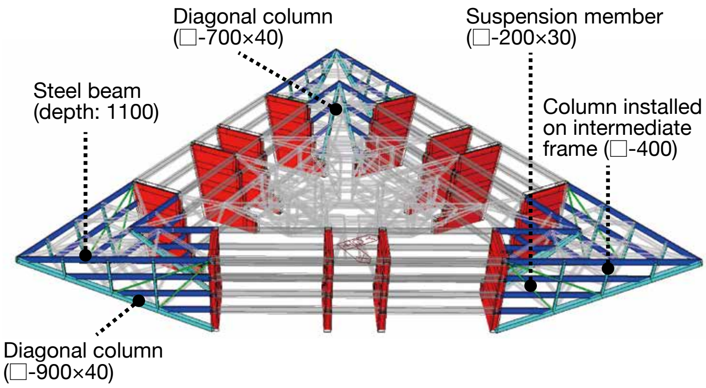
On the first floor, a large hall was arranged in which entrance ceremonies can be held, and the lower section of the library on the hall was made column-free. The library was supported with diagonal columns installed as they sandwich from the top to the bottom, which led to the creation of not only the column-free first-floor plaza but also an open rooftop garden.

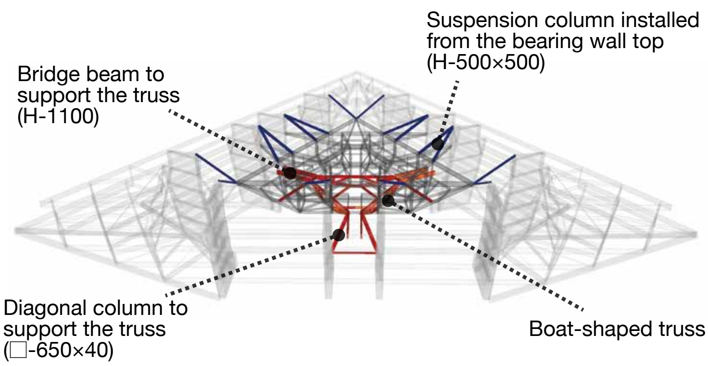
The peripheral section of the building is covered with stainless steel cast panels with a motif of "cherry blossoms," the school emblem of Otemon Gakuin. An image of the building covered only with cherry blossom petals is expressed by resisting the wind pressure with the cast panel itself and minimizing the use of supporting frames, and at the same time a characteristic façade has been realized in which its appearance changes depending on the time and angle.


Triangle-shaped overhanging structure


Column-free first-floor plaza

Framing Elevation of Overhanging Structure





SHIBUYA SCRAMBLE SQUARE The First Phase (East Tower)

Prize winners: Shibuya Station District Development Project Consortium and Shibuya Station District East Tower New Construction Consortium

Outline of Building Plan

A redevelopment project is underway around Shibuya Station located in the downtown area of Tokyo. The redevelopment scale is said to be once every 100 years, and the Shibuya Scramble Square is located in the center of the project. The low-rise floors are composed of the commercial facilities, the medium-rise floors the co-creation facilities that enhance international competitiveness, and the high-rise floors the office and other facilities. On the rooftop with a height of 230 m, an observation facility was provided that can command a view of the scramble crossing.

Outline of Structural Plan

A seismic response-control structure was adopted aiming at reducing the seismic response in the event of an earthquake. While there are some deviations in terms of framing arrangement due to the Shibuya River flowing through the site and the existence of low-rise urban core, the horizontal stiffness and strength were secured by arranging buckling-restrained braces mainly to the core periphery from lower to upper floors in a well-balanced manner, and at the same time, damage to the main framing was suppressed by adding damping performance by the use of oil dampers.

Because the optimum column span and position differ at the low-rise or high-rise floors depending on their respective applications, the truss was installed at the 18th-floor machine room at the boundary floor in order not only to switch over the column and treat the horizontal component force but also to correct the bending of the entire framing.

On the low-rise commercial facility floors where the floor height and the rate of the occurrence of shear deformation are high, the shear link-type oil damper was arranged to secure the damping performance. On the high-rise office floors where the rate of the occurrence of flexural deformation is high, in order to make use of this large flexural deformation as an effective deformation, both the buckling-restrained brace and the axial brace-type oil damper were arranged in the core framing, which led to the effective absorption of seismic energy.

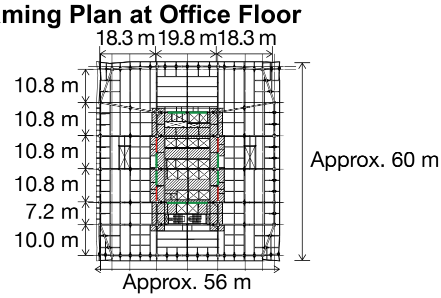
On the observation facility, the core was reinforced using the brace and the freedom in planning the peripheral observation corridor was enhanced by overhanging a cantilever truss by one layer to the periphery, which led to the securement of wide view.

Photo: SHIBUYA SCRAMBLE SQUARE

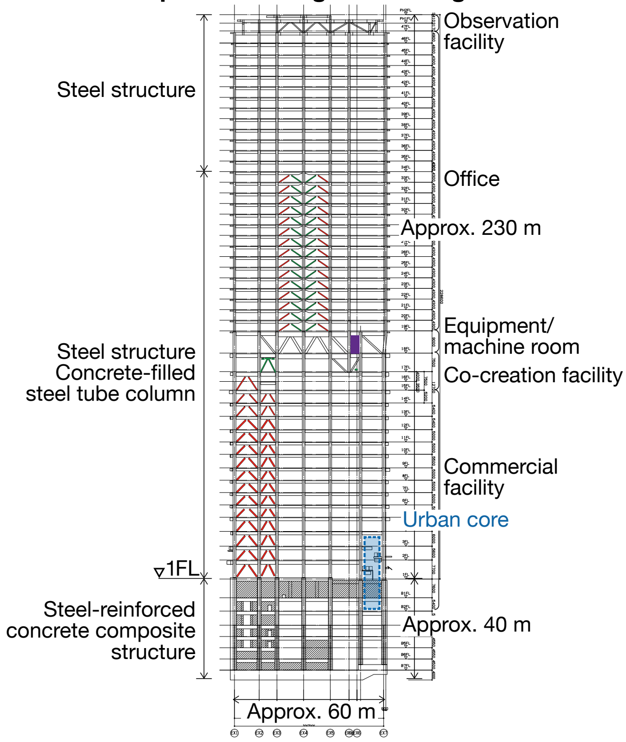
Full view of SHIBUYA SCRAMBLE SQUARE

Response-control system installed at the office floor

Framing Plan at Office Floor



Conceptual Drawing of Building Structure



“Voronoi Partition” Space Design of Sanei Construction Steel Structure Division New Office

Prize winners: Sanei Construction and Takenaka Corporation

The New Office of the Sanei Construction Steel Structure Division is a steel-structure office building planned in Osaka. Steel frames used for the construction of the building were manufactured by Sanei Construction, the project owner, as a fabricator at its neighboring fabrication plant. In order to fully appeal the advanced steel-frame fabrication technology possessed by Sanei Construction, we took on the challenge of a structural design that demonstrates dynamical steel framing.

Creation of Office Space by Means of Voronoi Partition

In the partition of the construction volume, the “Voronoi partition” geometry was adopted, which brought about a three-dimensional multi-faceted relationship between rooms and accelerated the mutual exchange of employees. In addition, the dynamic complex framing manufactured by means of the Voronoi partition led to appealing to the advanced steel-frame manufacturing technology of the project owner.

The main framing was composed entirely of steel tubes with a diameter of 318.5 mm. Pin joints were adopted for the steel tube column-to-beam connection, and a structural plan was formulated so that the stress occurring in the event of an earthquake does not become excessive for the framing. For the bolt joints used for the pin connection, the structural design was made so that the continuity of the framing employing steel tubes was not impaired.

Voronoi Steel Plate Walls

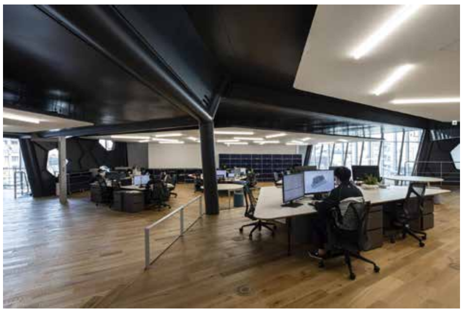
Steel plate walls were adopted as part of the seismic-resistant elements that bear 70% of seismic force. The two-dimensional “Voronoi partition” was incorporated into the design of the configuration of buckling-stiffening ribs, which led to the expression of a steel plate that gives a strong impact on visitors. Both the “Voronoi partition” steel plate wall and the buckling-stiffening rib are composed of PL-9 steel plates.

Steel Plate Slabs

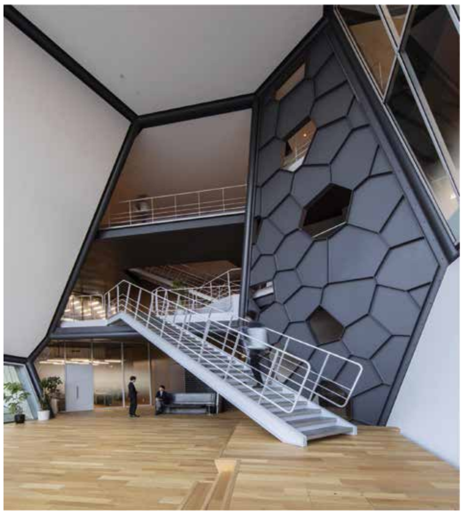
Steel plate slabs were adopted as the structural slabs, which facilitated the reduction of the visible thickness of floor members and a lightweight architectural expression. When looking up the steel plate slab, the lower plate of the plate slab appears as an aspect surface to more strikingly demonstrate the dynamical structure realized by the maximum use of steel.

The joint detail was minutely planned from the start of design, and as a result it was possible to finely and precisely finish the steel plate slab.

Full view of the new office building

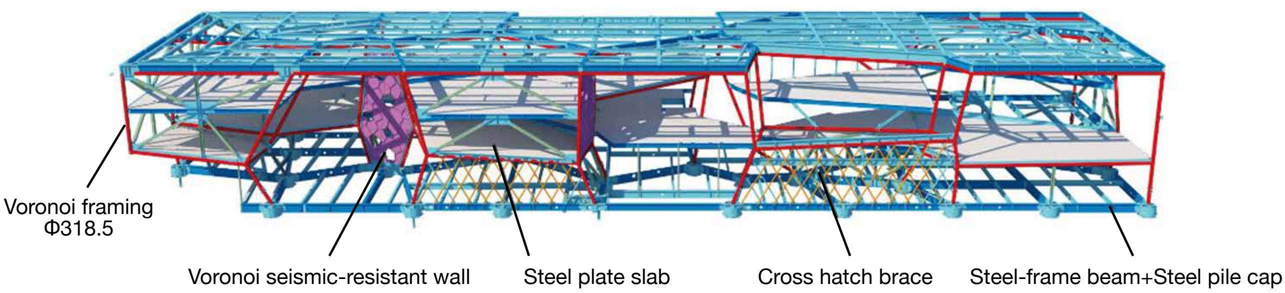


Frame joint and steel plate slab



“Voronoi partition” steel plate wall

Structural Frame Drawing



Yokohama City Hall

Prize winner: Joint venture of Takenaka Corporation and Nishimatsu Construction Co., Ltd.

Yokohama City Hall is the government office building, the eighth building of the City of Yokohama. Plans called for the construction of a new government office building that fulfills the core role in crises management, serves as an open venue for making full use of affluent citizen power and allows applications over the long term. The new government office is a steel-structure high-rise building with two basements and 32 stories aboveground, and a height of 155 m.

High Seismic Safety and Advanced Steel Construction Technologies

A mid-story isolated structure in which the base-isolation layer was arranged under the 3rd-story floor was adopted, and at the same time response-control devices were arranged to the upper and lower structures of the base-isolation layer to further enhance the mitigation of response acceleration during an earthquake. As a result, the "Kind I seismic safety*+Suppression of building tremor" were realized in this new government office building to securely meet the need for the seismic safety requested from the City of Yokohama.

In the construction of the new building, maximum demonstration of not only the strength and toughness of steel products but freedom in shaping was pursued capitalizing on both the development of elementary technologies accompanied by structural tests and new structural planning ideas—specifically, the development of the pile head joining method by CFT adopted to enhance the safety of foundation framing, the realization of atrium space that is moveable straddling the base-isolation layer employing ball joints composed of cast steel and special high-strength brass-plated steel, a rational framing plan by the use of CFT columns employing high-strength steel product (590 N/mm^2 TMCP Box Column Press). On account of these technological achievements, the basic ideas for the new building pursued by the City of Yokohama—high seismic resistance, creation of attractive space and ease of maintenance—have surely been embodied in the new building.

Throughout construction, challenging efforts were positively extended aimed at securing quality, improving safety and productivity and reducing CO_2 emissions through the reduction of the construction period by means of the top-down construction method and steel-frame construction of basement floors, the securement of welding quality in the use of high-strength steel products and the mitigation of CO_2 emissions by the use of ECM** concrete, which also made a strong contribution towards the realization of a sustainable society.

In the equipment plan, diverse kinds of eco-friendly technologies were introduced to attain the construction of the ZEBReady*** government office building.

*Securement of safety of buildings against seismic force increased by the importance factor (seismic force 1.5 times that of common buildings)
**ECM: Energy·CO_2 Minimum
***ZEB Ready (Zero Energy Building Ready): A building defined as a 50% energy-saving building compared to a reference standard building in Japan

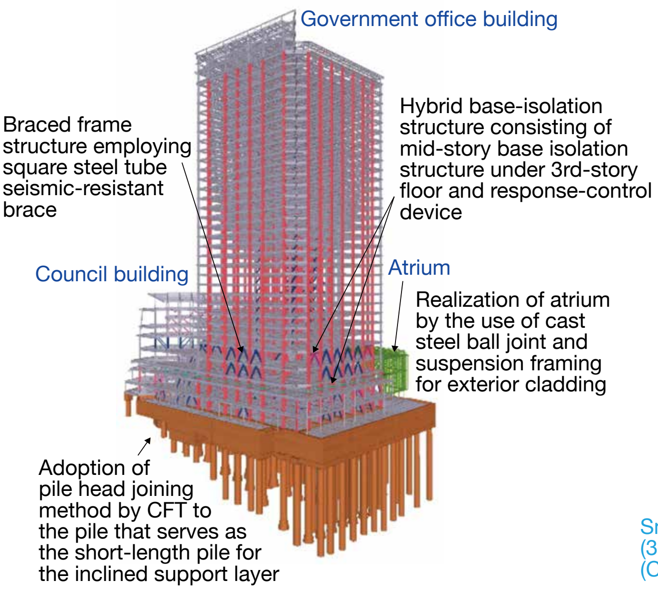
Photo: Shigeo Ogawa

Appearance of Yokohama City Hall

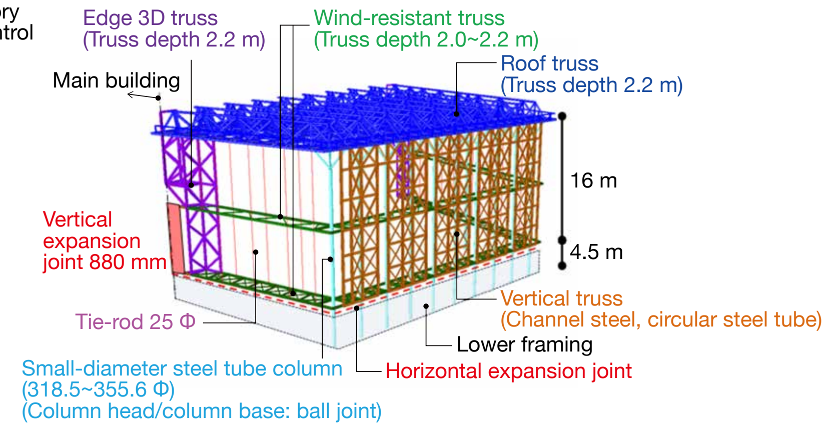
Photo: Shigeo Ogawa

Inner view of atrium

Perspective View of Structural Framing



Conceptual Drawing for Atrium



Shibuya Station on the Tokyo Metro Ginza Line

***Prize winners:** Tokyo Metro Co., Ltd.; Metro Development Co., Ltd.; Naito Architect & Associates; Tokyu Architects & Engineers, Inc.; Pacific Consultants Co., Ltd.; KAP; Joint Venture of Tokyu Construction Co., Ltd., Shimizu Corporation and Kajima Corporation; Tomoe Corporation; Miyaji Engineering Co., Ltd.; and FaB-Tec Japan Corporation*

Construction of New Shibuya Station

Shibuya Station on the Tokyo Metro Ginza Line is a link of the Land Rezoning Project of the Shibuya Station Blocks, and is a new station building relocated from the former station building. The former Shibuya Station on the Ginza Line posed some problems involved in ongoing superannuation and building conditions. To cope with this situation, the former station building located in a department store was relocated eastward by 130 m, and a new station building was constructed on an elevated track beam spanning Meijidori Avenue.

While securing the regular service of the subway line, the railway track beam was rebuilt in ways that substantially reduced the number of the piers used for the former elevated railway bridge, and then the new station building was constructed on the new railway track beam. The new station is an island-type platform serving two tracks, and the platform width was broadened to up to 12 m. Full attention was paid to securing barrier-free transport, and the Skyway (pedestrian deck), a pedestrian network that connects the east and west sides around Shibuya Station, was installed on the roof of the new station building.

Advanced Building Technologies and Members

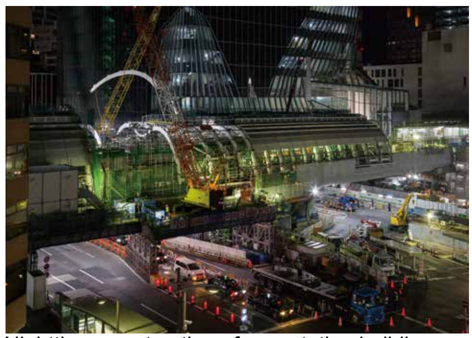
The entire station building is composed of an arch-shaped large space, and a characteristic M-shaped configuration was adopted that conforms with the dynamical performance of the building on which the Skyway is installed. The station building has a structure in which M-shaped steel arch framings with box section are arranged at a span of 2.5 m, and its configuration continuously changes due to structural conditions such as railway gradient, Skyway gradient and structural clearances imposed on the railway construction. The track beam is a 2-span half through-type steel slab/4 main box girder structure having a span length of 55 m and is supported with reverse oval cone-shaped RC piers.

Because the building was located over Meijidori Avenue and thus heavy construction machinery installed on the ground could not be used, a sliding construction method was adopted—specifically, the temporary bent was installed over the road, on which the heavy machinery was placed, further the bent for use for assembling arch framings was installed on the track, and the assembled blocks including those for roof finishing were moved to the prescribed erection positions one after another.

The new Shibuya Station is a steel-structure station building that was completed by the integrated use of civil engineering and building structures and has no precedent. To that end, the project required the extensive application of advanced technologies that not only secured regular railway service but also hurdled the difficult conditions involved in the promotion of the project in the downtown area of Tokyo.

M-shaped arch steel framings arranged in the platform

Newly-completed Shibuya Station on the Tokyo Metro Ginza Line



Nighttime construction of new station building

Local Deformation Behavior of SHS in Beam-to-Column Connection with Exterior-diaphragm Assembled by High-strength Bolts

Prize winners: Yugo Sato, Megumi Asanuma, Yuji Koetaka, Shintaro Matsuo and Tadayoshi Okada

Yugo Sato
2007: Graduated from the Graduate School of Engineering, Utsunomiya University
2007: Entered Nippon Steel & Sumikin Metal Products Co., Ltd. (currently Nippon Steel Metal Products Co., Ltd.)

Background of the Study

The target of this study is the joining method for beam-to-column connections employing square hollow section (SHS) column and H beam. In these connections, the flanges of the outer diaphragm are joined to each other by the use of high-strength bolt, and the SHS column and the outer diaphragm are joined by the use of the compressive force that works between these two members due to bolt joining. Then, the beams are connected with the webs of exterior diaphragm members by means of high-strength bolt friction joining (refer to Fig. 1).

Because the beam is not directly connected with the column, in the event of an earthquake, stress is transferred using the compressive force occurring from the exterior diaphragm to the column. In the separately-conducted cyclic loading test for cruciform frame, the column caused local plastic deformation due to this compression force, showing slip-type hysteretic behavior.

In this study, the experiment and analysis were conducted to confirm the local deformation behavior of the column and to establish the method for evaluating the strength of the column in which the local plastic deformation occurs (local plastic strength).

Study Methods

Fig. 2 shows the setup of the experiment. In the experiment, the basic local deformation behavior was confirmed setting the side constraint and the shear span ratio as a parameter. In the parametric analysis, the local deformation behavior was examined in detail using the width-to-thickness ratio, shear span ratio and axial force ratio as a parameter.

Study Results

The analyzed local plastic strength ${}_{AL}P_p$ shown in Fig. 3 converged to a constant value when the shear span ratio was low and gradually approached the calculated full plastic flexural strength ${}_{CB}P_p$ when the shear span ratio was high. Taking into account the stress condition at ${}_{AL}P_p$ when the shear-span ratio was low, the mechanism of the collapse due to local deformation was assumed as shown in Fig. 4. In the figure, the center of plate thickness is modelled, and the range of 1/4 the section of the column and 1/2 of the longitudinal direction is shown. The local plastic strength ${}_{CL}P_{p0}$ when the shear span ratio was low, calculated from the collapse mechanism, is shown in Fig. 3, and this calculated value corresponded well to ${}_{AL}P_p$.

Next the calculated local plastic strength ${}_{CL}P_p$ was settled from the equation of reciprocal action between ${}_{CL}P_{p0}$ and ${}_{CB}P_p$ (eq1). Fig. 3 shows ${}_{CL}P_p$. The calculated local plastic strength ${}_{CL}P_p$ corresponded well with the analyzed local plastic strength ${}_{AL}P_p$. Further, the calculated local plastic strength ${}_{CL}P_p$ corresponded well with the value obtained in the experiment.

Fig. 2 Setup of Experiment

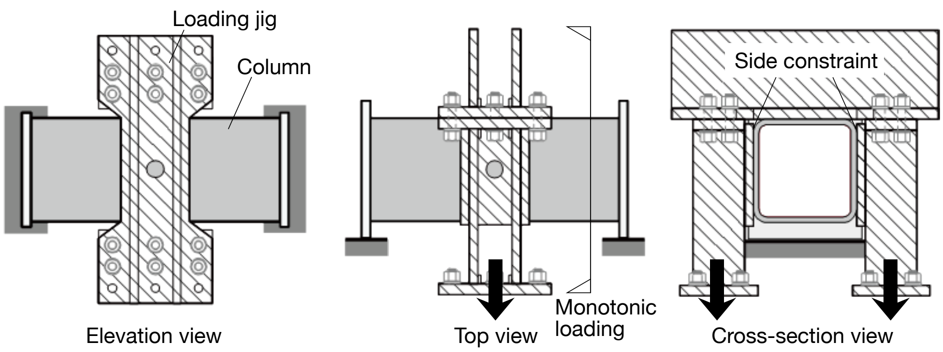


Fig. 1 Outline of Connection

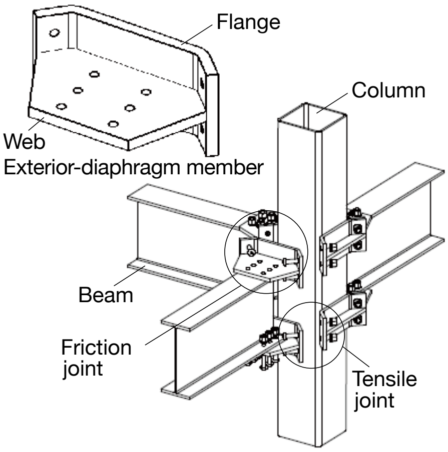


Fig. 3 Analysis Result and Calculation Result

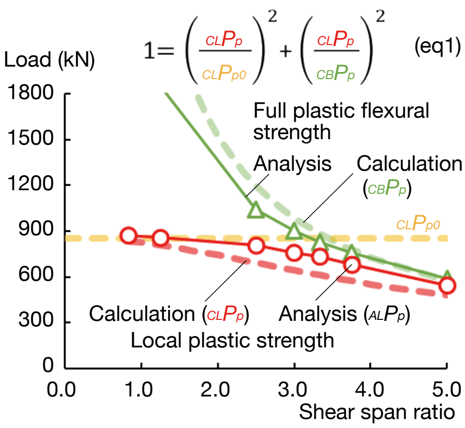
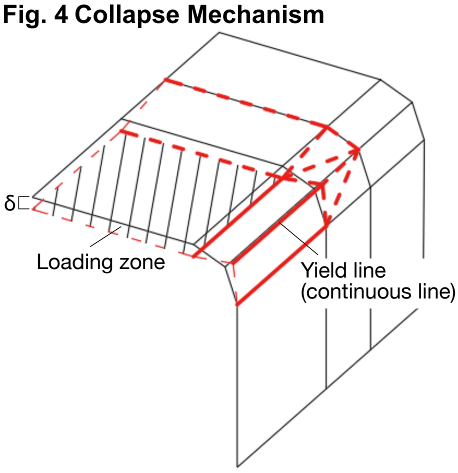


Fig. 4 Collapse Mechanism



Improvement of Fatigue Durability in Welded Gusset Joints by Carbon Fiber Sheets Using VaRTM Technique

Prize winners: Visal Thay, Takumi Ozawa, Chang Tan, Hitoshi Nakamura and Takahiro Matsui

Visal Thay
2020: Graduated from Doctoral Course of Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University
2020: Postdoctoral Researcher, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University
2020: Project Assistant Professor, Graduate School of Urban Environmental Sciences, Tokyo Metropolitan University
2021: Assistant Professor, School of Regional Design, Utsunomiya University

Introduction

This paper deals with the reduction of stress concentration and fatigue durability of typical welded gusset joints in steel bridges strengthened by externally bonded carbon fiber (CF) sheets. As a composite molding method, Vacuum-assisted Resin Transfer Molding (VaRTM) technique has been newly proposed and can be used to apply multiple CF sheets on cracked steel structures as shown in Fig. 1.

Specimens and Test Condition

The target specimens, non-strengthening and strengthening specimens using VaRTM technique, of welded gusset plates were fabricated and subjected to static load and cyclic load. Fig. 2 shows the specimen preparation by externally bonded CF sheets using VaRTM technique. The strengthening specimens were prepared with 23 layers of CF sheets (high-strength type) at each side, equivalent to the stress reduction factor of approximately 2/3 (ξ_0=0.662). The stress reduction factor is the ratio of the tensile rigidity of CFRP to that of steel plate.

Fig. 1 Schematic View of VaRTM Technique

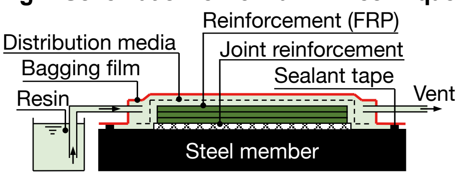
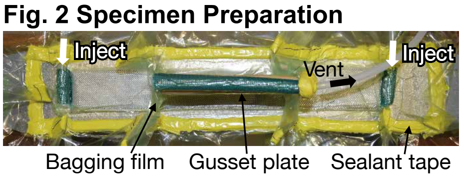
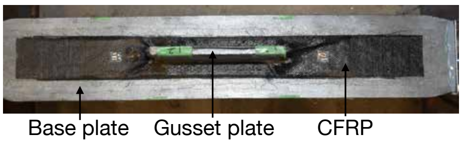


Fig. 2 Specimen Preparation



(a) Specimen during strengthening process by VaRTM technique



(b) Specimen after strengthening by VaRTM technique

Reduction of Stress Concentration

The reduction of stress concentration at the weld toe was analytically and experimentally investigated. The 3D finite element analysis model was simulated from a number of image data taken from the actual experimental specimens by a digital camera. In evaluating the reduction of stress concentration, hot-spot stress (HSS) approach with 0.4t-1.0t method (t: steel plate thickness) was adopted.

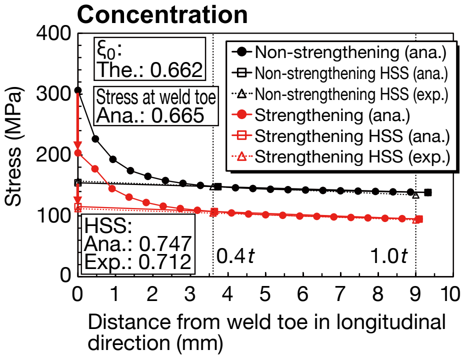
Fig. 3 shows the comparison of the reduction of stress concentration between theoretical, analytical, and experimental results. The stress reduction factor of HSS between non-strengthening and strengthening specimens from the analytical and experimental results are close to each other. Moreover, the stress reduction at weld toe between non-strengthening and strengthening specimens obtained from the analytical and theoretical results are almost the same.

Evaluation of Fatigue Durability

Fig. 4 shows the *S-N* curve of the relationship between the nominal stress range $\Delta\sigma_{sn}$ and the number of cycles from the start of the test to failure of specimen N_f from fatigue tests. In the nominal stress range of 150 MPa, the prolongation of fatigue life reached the fatigue limit (10 million cycles), while in the nominal stress range of 180 MPa, the fatigue life increased approximately 37 times, and all are over the JSSC-A grade.

Fig. 5 shows the *S-N* curve of the relationship between the converted nominal stress range $\xi_0\Delta\sigma_{sn}$ and the number of cycles from initiation of crack to failure of specimen N_p from fatigue tests. The converted nominal stress range of strengthening specimen (stress range at 120 MPa) can be plotted along with the non-strengthening specimen.

Fig. 3 Reduction of Stress Concentration



Summary

The result shows that the prolongation of fatigue lives based on the stress reduction factor ξ_0 can be quantitatively evaluated and verified. Therefore, the strengthening by externally bonded CF sheets using VaRTM technique can be determined by the stress reduction factor. It confirmed that the proposed method is also effective in delaying the lives of crack growth of N_p.

Fig. 4 Fatigue Durability of Nominal Stress Range $\Delta\sigma_{sn}$ and Number of Cycles N_f

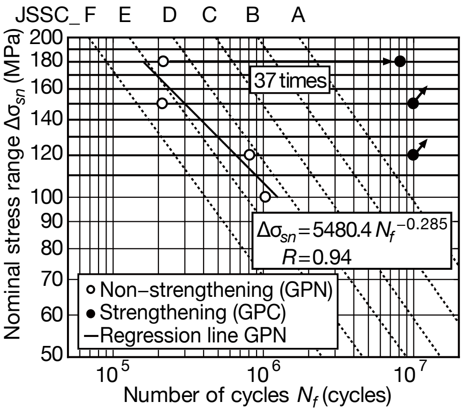
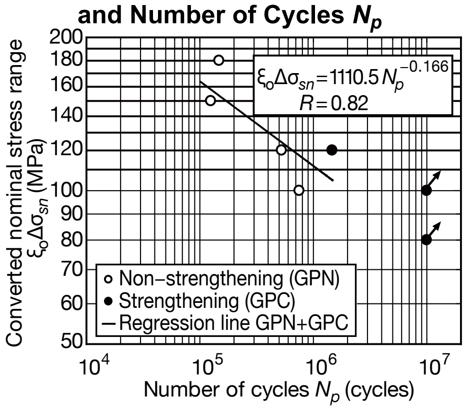


Fig. 5 Fatigue Durability of Converted Nominal Stress Range $\xi_o\Delta\sigma_{sn}$ and Number of Cycles N_p



Influence of Bolt Shape and Dimensions on Mechanical Property of 1700 MPa-Class Ultra-High Strength Bolt

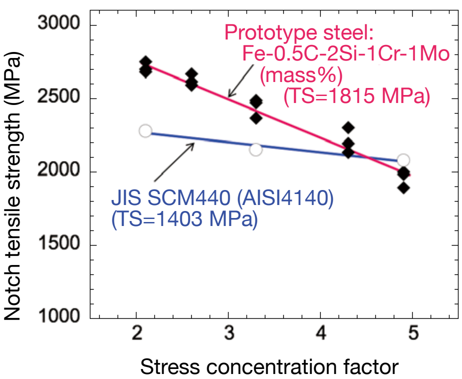
Prize winners: Yuuji Kimura, Hiroshi Masuda, Takashi Yamaguchi, Eiji Nagasaki, Hitoshi Moriyama and Kaneaki Tsuzaki

Yuuji Kimura
1993: Graduated from Graduate School of Engineering, Kyushu University
1993: Associate researcher, Kyushu University
1999: Researcher, National Research Institute for Metals
2001: Senior Researcher, National Institute for Materials Science
2009: Principal Researcher, National Institute for Materials Science
2016: Chief Researcher, National Institute for Materials Science

Increasing the strength of bolts can reduce the number and size of bolts used in joints, leading to more compact joints and improved construction efficiency. However, it is necessary to overcome delayed fracture and improve the cold formability of the material and the tensile deformation performance of the bolt products to develop bolts with even higher strength than the F14T bolts with a tensile strength of 1400-1490 MPa.

In this study, we performed basic research to control the mechanical properties, especially tensile deformation performance, of 1700 MPa-class ultra-high strength bolts (nominal size M22) in collaboration with researchers in steel materials, bolt manufacturing, and civil engineering and construction. We successfully developed a 1700 MPa-class shank preceding yield type bolt having a waisted shank portion and new threads.

Fig. 1 Relationship between Notch Tensile Strength and Stress Concentration Factor

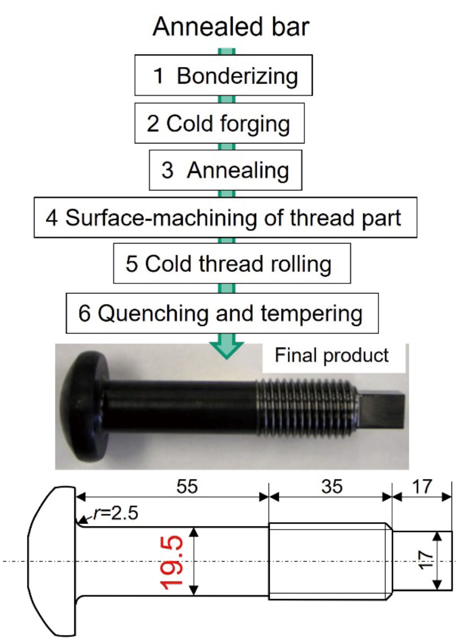


1700 MPa-Class Shank Preceding Yield Type Bolt

First, prototype low-alloy steel, which was developed as a material for 1700 MPa-class ultra-high strength bolts, showed that the tensile strength of the notched bar specimen varied greatly depending on the stress concentration factor, as shown in Fig.1. Therefore, focusing on this point, the influence of shape and dimensions on the mechanical properties of ultra-high strength bolts was investigated. Specifically, we focused on reducing the diameter of the shank portion of the bolt and allowing the shank portion to yield and deform plastically before the threaded portion to reduce the stress concentration at the threads and improve the tensile deformation capacity of the bolt.

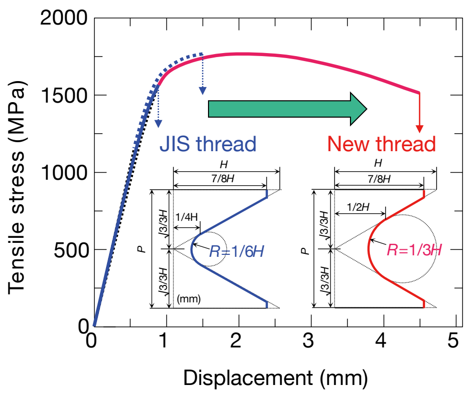
Fig. 2 shows a schematic diagram of the manufacturing process and dimensions of the shank preceding yield type bolt. Here, the shape of tension control bolts, i.e., torshear bolts (JSS Ⅱ 09-2015), whose head was easier to cold form than hexagonal bolts, was adopted as the basic bolt shape. Second, the optimum conditions for the combination of the waisted shank and the thread form were found through tensile testing on the bolt products and evaluating the decrease in axial force due to relaxation. Furthermore, the specifications of a hexagon nut compatible with the developed bolt were optimized; the height of the nut was 26.4 mm and the hardness of the nut was HV350-450.

Fig. 2 Manufacturing Process and Shape and Dimensions of Developed Bolt



As a result, we succeeded in creating a 1700 MPa-class ultra-high strength bolt with greatly improved tensile deformation capability (Fig. 3). Prototype bolts were further mass-produced from the steel material produced in 40-ton arc melting furnace, and the improvement of the bolt's tensile deformation performance was verified.

Fig. 3 Tensile Deformation Behavior of Developed Bolt



Examination of High-strength Bolt Fastening by OS Method

by Susumu Kuwahara, Associate Professor
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Weld Joining and Bolt Joining

Steel products are basic structural materials indispensable in the construction of civil engineering and building structures. Compared to concrete, wooden and other structural materials, steel products offer higher performance—far high strength and superior workability. Whether a structure that makes maximum use of these structural advantages peculiar to steel products can be realized rests on two tasks—how to effectively connect (join) the thin and slender steel products and how to make these joined steel members behave stably (stiffening of members). Weld joining and bolt joining have been firmly established as the methods for joining steel products through steady improvements made in technology and joining material production systems. Currently, these two joining methods are properly applied by taking into account their application efficiency and economic advantages in addition to their dynamic performance.

Of the joints applied in steel-structure buildings, the column-to-beam connection requires the most processing steps to finish and serves as an extremely important section in terms of the building structure and this joint is mostly formed by means of weld joining. However, diverse joining methods to form the column-to-beam connection by means of high-strength bolt joining have thus far been proposed that offer less quality-control items than those in weld joining (refer to Table 1). Further, several bolt joining methods have already been put into practical use in building construction[1].

In order to make extensive surveys and research on high-strength bolt joining and other kinds of mechanical fastening in common use, the Japanese Society of Steel Construction (JSSC) established the Subcommittee on Mechanical Fastening Technology in April 2015. It was established as a successor to the forerunner Subcommittee on High-strength Bolt Fastening Technology of the JSSC. The members of the Committee consist mainly of men of learning and experience, structural designers, construction companies, bolt/fastener makers and wrench makers.

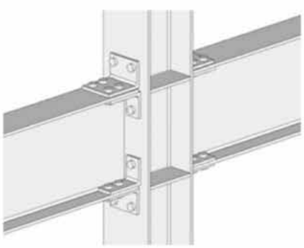
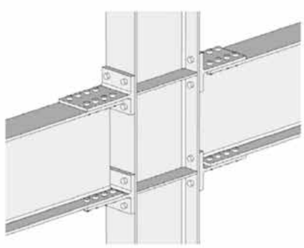
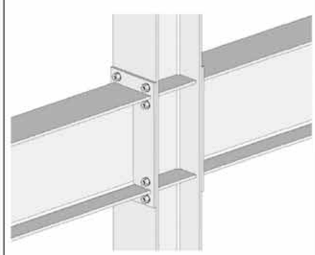
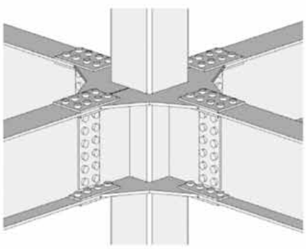
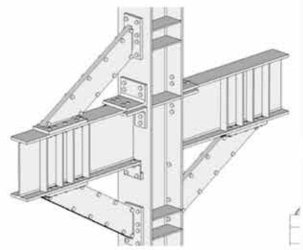
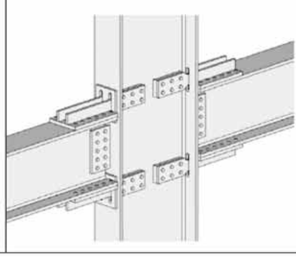
This article introduces the experiments made and research results obtained for the OS (offset slope) method (former name: new yield point method), a high-strength bolt fastening method that constitutes the basis of mechanical fastening technologies for steel structures. The OS method is an examination subject selected in the *JSSC Technical Report* No. 96 "Current and Future Developments of High-strength Bolt Joining Technology"[2] published in 2013. The OS method compares with the fail-safe (FS) bolt method and is one of the research subjects of the JSSC's Subcommittee on Mechanical Fastening Technology.

Emerging Need for Improved Bolt Fastening Methods

The mainstream of high-strength bolt fastening methods applied in the construction of civil engineering and building structures in Japan is the torque method employing mainly torque-shear (torshear)-type high-strength bolts. Its advantage lies in the ease of fastening and the fact that fastening finish can be visually confirmed with the fracture of pintails. With this method, however, the torque coefficient changes due to the temperature at the stage of fastening, storage conditions and other factors, which is likely to affect the axial force in bolt fastening. Further, fractured pintails turn to useless materials after fastening to cause wastefulness.

To solve these concerns, examinations were made of the OS method as a new bolt fastening method. The yield point method, a basic approach for the OS method, is a bolt fastening method with which the yield strength of bolts is detected from the change of load current of an electric wrench motor

Table 1 Joining Methods

Angle joining 	Split-Tee joining 	End plate joining 
Outer diaphragm joining 	Brace joining 	Others (column-to-beam joint) 

to control the fastening axial force. Accordingly, a larger fastening axial force than that of torshear-type high-strength bolts can be introduced in bolts used in the OS method. Further, because the fastening finish is controlled based on the bolt strength (yield point) less in deviation, it can be expected that the OS method will allow the introduction of a stable axial force that is almost unaffected by the torque coefficient and the stiffness (thickness of the structural member to be fastened and bolt length) at the final fastening stage.

While there is no application record of the yield point method in the field of building construction, the yield point method is the bolt fastening method that has accumulated a rich application record in the construction of Honshu-Shikoku connecting bridges, the Banshu Bridge and many other civil engineering structures. Furthermore, its application is accepted under the *Japanese Specifications for Highway Bridges* (JSHB). Meanwhile, the yield point method has shown no steady spread in its application due to the reasons cited, that is: The size of wrench is larger than that of the shear wrench in current use, which results in inferior handling efficiency; and further, in the yield point method, using the common hexagon bolt set and external reaction force-type wrench, the bolt is fastened by receiving the bolt reaction force with the neighboring bolt.

In order to solve these problems involved in bolt fastening, in the OS method, reaction force washers are used in place of common washers. The reaction force washer (Photo 1) is designed so that the washer can receive the reaction force torque by itself. Bolt fastening performance similar to that in torshear bolt fastening can be obtained by fastening the bolt using the wrench for the yield point method developed to adapt to the use of the reaction force washer (refer to Fig. 1). With this OS bolt fastening method, excess force is not applied to the neighboring bolt, and fastening can be attained regardless of the bolt arrangement. Further, this is rational as a reaction force mechanism as the reaction force is received mainly by the bolt.

In addition, the OS method offers other notable application advantages: No waste material is discharged because of the elimination of pintails. The unified fastening method can be applied regardless of the type of bolt (hot dip-galvanized and other coated bolts). Regarding the bolt configuration used in the OS method, it is possible to change the bolt head from the hexagonal shape of conventional high-strength hexagon bolts to the round shape found in torshear-type high-strength bolts, which allows for no need for bolt-head washers. Also, it is possible to save the use of materials due to the elimination of the application of bolt-head washers and the lack of waste discharge due to the elimination of pintails.

Table 2 shows the respective features of the OS and other bolt fastening methods. In cases when the stabilized high bolt axial force can be introduced in bolt fastening due to the adoption of the OS method, it will be possible to settle high-

Fig. 1 Outline of Bolt Fastening by Means of OS Method

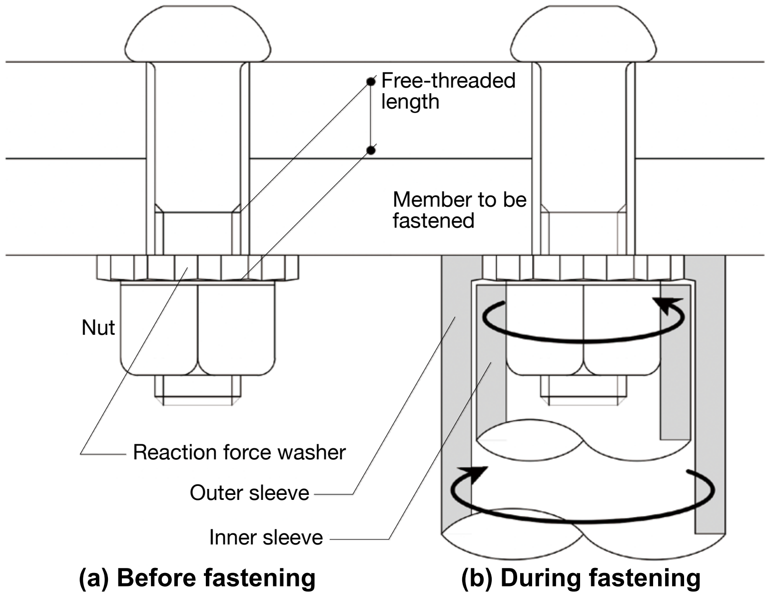


Photo 1 Reaction force washer

Table 2 Comparison of Various Bolt Fastening Methods

	Torshear bolt method	Nut rotation method	Yield point method	OS method
Fastening axial force	Bolt elastic range	Bolt plastic range (large)	Bolt plastic range (small)	
Effect on fastening axial force	Effect of torque coefficient: Large	Effect of primary fastening: Large Effect of fastening length: Large	Effect of torque coefficient: Small Effect of primary fastening: Small Effect of fastening length: Small	
Fastening (wrench)	Shear wrench to receive fastening reaction force using bolt pintail	Torque wrench	Outer reaction force-type wrench for yield point method employing neighboring bolt	Wrench for yield point method to receive the fastening reaction force using reaction force washer
Fastening control	Marking Pintail fracture	Marking	Marking	Marking (new control method)
Bot set applied	Torshear-type high-strength bolt set	JIS high-strength bolt set Hot-dip galvanized high-strength bolt set	JIS high-strength bolt set	Bolt set employing reaction force washer (regardless of kind of bolt)
Material saving	Disposal of pintail	No need for pintail	No need for pintail	No need for pintail

er design sliding strength than the conventional level. Extensive experiments have been made for the practical application of the OS method, an outline of which is explained in the following:

Axial Force of Bolts in the OS Method

In experiments made for the practical application of the OS method, an electric wrench for use for the OS method (TONE-made) was adopted and the axial force introduced in the bolt (axial force of the bolt) was measured mainly employing the electric axial force meter. Meanwhile, a short-length bolt to which the electric axial force meter cannot be applied was fastened to the practical steel plate employing the bolt gauge.

The bolt targeted in the experiment was 10T (bolt strength≧1,000 N/mm^2), M22 (shank diameter: 22 mm), and the experiment was conducted by the combined use of high-strength hexagon bolts, nuts and reaction force washers (Photo 2). The bolt was fastened in the procedure of "primary fastening→ marking→ final fastening" similar to that in practical bolt fastening. The experiments were implemented at Osaka University.

Photo 2 Bolt set used in the experiment

• Outline of Experiments

Table 3 shows the variables used in the experiment. The structural member to be fastened and the bolt length (thickness of the structural member to be fastened) are the variables that verify the effect of the stiffness of the structural member to be fastened. The offset value is the control variable that is settled by the electric wrench. In the table, the offset value indicates the calculated plastic distortion value of the free-threaded section where the free-threaded length is 17 mm, and the offset value at 1.0% in common use in the conventional yield point method is set as a standard offset value.

Three kinds of axial force in primary fastening were settled: 50 kN supposed to be applied in the field of building construction, 140 kN supposed to be applied in the field of civil engineering, and the axial force in finger tightening. Two kinds of torque coefficients were settled: the standard torque coefficient and the higher torque coefficient in the case of using non-lubrication nuts. Four kinds of free-threaded length were settled: selection in terms of the bolt length to the thickness of the structural material to be fastened and selection by taking into account the dimensional tolerances of bolt length, screw section length and washer thickness.

Based on these variables, the effects are understood in the experiments in the case of fastening the bolts with different free-threaded lengths by the use of a wrench for which the offset value is fixed in the practical fastening operations. For the bolt manufacturer and bolt length, the difference of bolt strength caused by differences in manufacturing lots was also taken into account. In the experiments, a total of 1,800 bolts were subjected to fastening—30 bolts respectively for 63 kinds of combinations of the above-mentioned variables (10 bolts each for 6 kinds using the bolt gauge).

• Precise Control of Key Values

Fig. 2 shows an example in which the bolt axial force and the nut rotation angle controlled using an electric wrench for use for the OS method are plotted for the relationship between the bolt axial force and the nut rotation angle. It can be understood from this figure that the bolt axial force and the nut rotation angle are precisely controlled.

Meanwhile, the example shown in the figure indicates cases in which the bolt was fastened using the electric axial force meter, and there are cases in which the nut rotation angle at the stage of fastening finish surpassed 120°—the target value of the nut rotation method—due to low fastening stiffness. However, the average nut rotation angle in the case of fastening steel plates (offset value of 1.0% and bolt length of 85 mm) is 114°, which is lower than 120°.

Fig. 2 Relation between Bolt Axial Force *N* and Nut Rotation Angle *θ* and Example of Fastening Results

(Dotted line: Offset straight line; x: Fastening finish point)

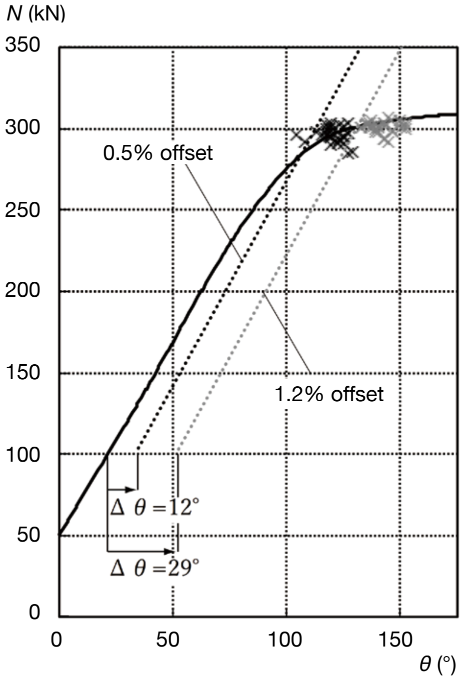


Table 3 A List of Variable Used in the Fastening Experiments

Structural member to be fastened	Electric axial force meter, steel plate
Bolt length	55 mm, 85 mm, 100 mm, 130 mm
Offset value	0.5%, 0.75%, 1.0%, 1.2%
Torque coefficient	Standard (average: 0.125), high (average: 0.162)
Primary fastening axial force	50 kN, 140 kN, finger tightening (FT)
Free-threaded length	8 mm, 12 mm, 17 mm, 20 mm
Bolt manufacturer	Company A, Company B, Company C, Company D, Company X

● Effect of Variables on Fastening Axial Force

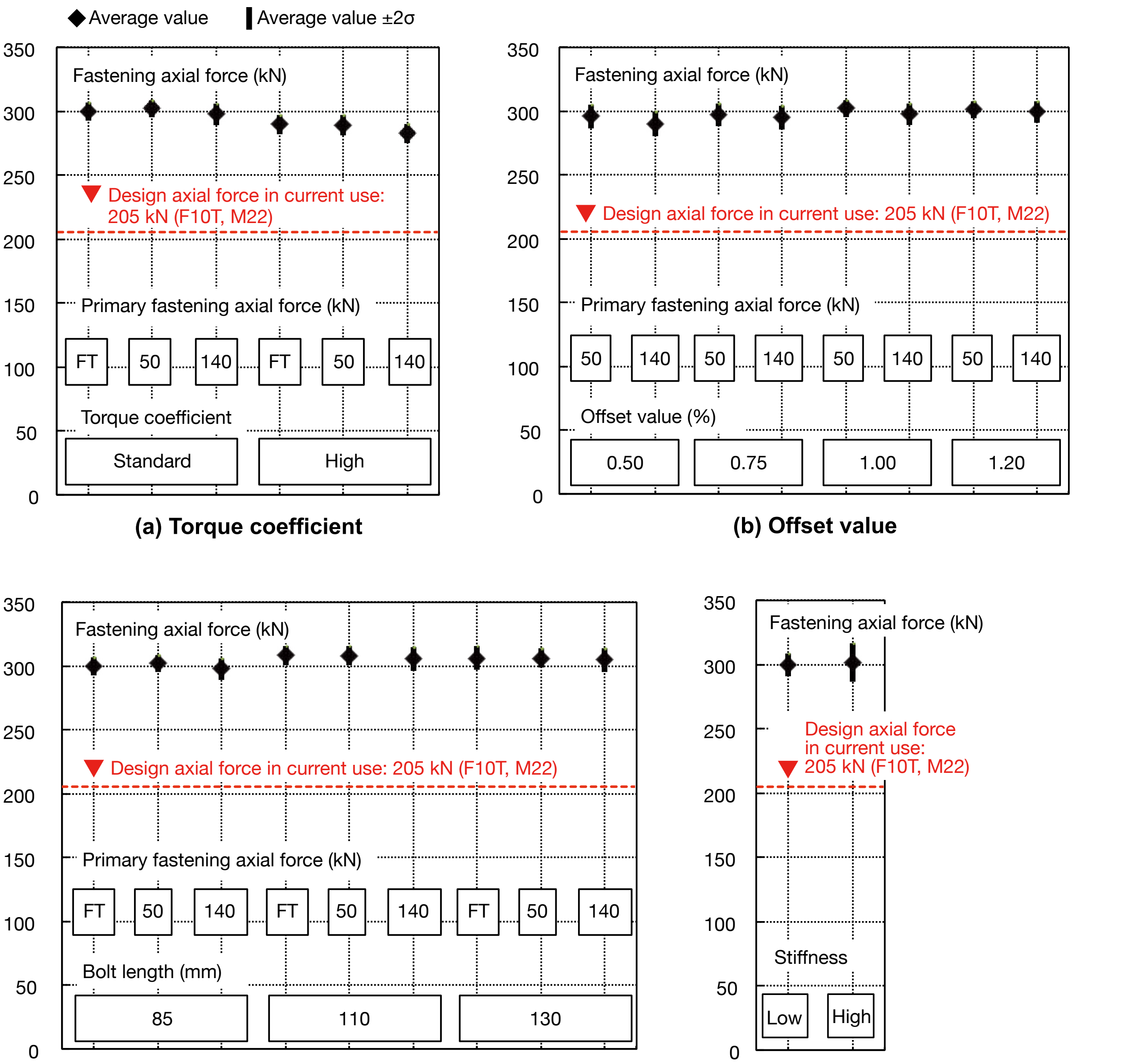
Fig. 3 shows part of the effect of experimental variables on the bolt fastening axial force. Every vertical axis in the figure indicates the bolt fastening axial force, and every horizontal axis indicates the experimental variable. The mark ♦ in the figure indicates the average bolt fastening axial force by variable, and the bold line on ♦ indicates the range of "2 times the ±standard deviation for the average values of bolt fastening axial force." In addition to the effects of major experimental variables, the figure shows differences in the effect of the primary fastening tension force (50 kN, 140 kN; finger tightening or FT: about 10 kN).

The effect of the thickness of the structural member to be fastened, the bolt length, the offset value and the torque coefficient on the fastening axial force is less, and the axial force is nearly 300 kN. The effect of the axial force in primary fastening and free-threaded length on the fastening axial force is also less.

Regarding the variable of the bolt manufacturer (bolt yield strength) with an effect larger than other variables, even the average deviation of the fastening axial force remained within a maximum of 6%. The reason for this is attributable to the difference in bolt strength depending on the bolt manufacturing lot, and the deviation becomes slight in the case of making the bolt axial force dimensionless in terms of the bolt strength.

When the torque coefficient is high due to the use of non-lubrication nuts, the bolt yields in an earlier stage than the case of standard torque coefficients and the stiffness lowers due to the torque working on the bolt at the stage of fastening. Because of this, the axial force of the bolt also lowers by 4%. When the OS method will be put into practical use, it is considered desirable that bolt manufacture control is managed in terms of the standard torque coefficient.

Fig. 3 Effect of Experimental Variables on Fastening Axial Force (1)



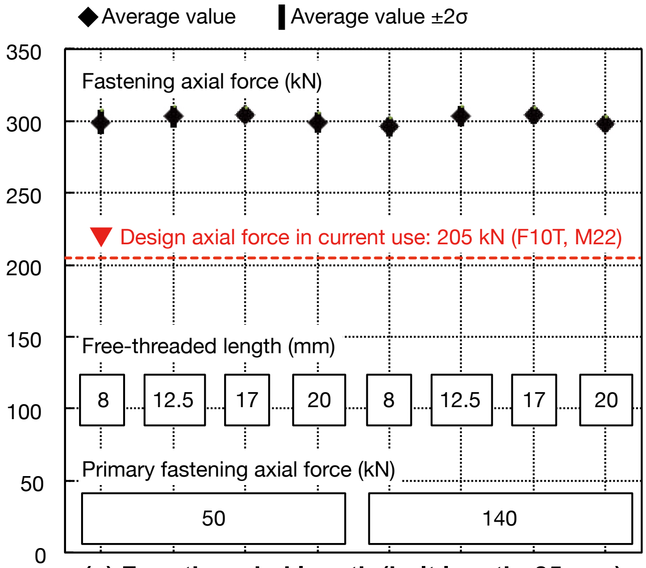
(a) Torque coefficient

(b) Offset value

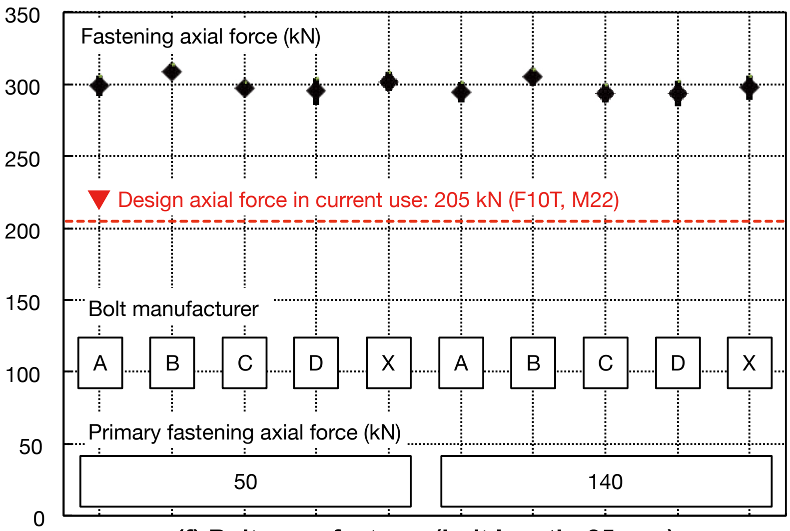
(c) Bolt length

(d) Stiffness of member to be fastened

Fig. 3 Effect of Experimental Variables on Fastening Axial Force (2)



(e) Free-threaded length (bolt length: 85 mm)



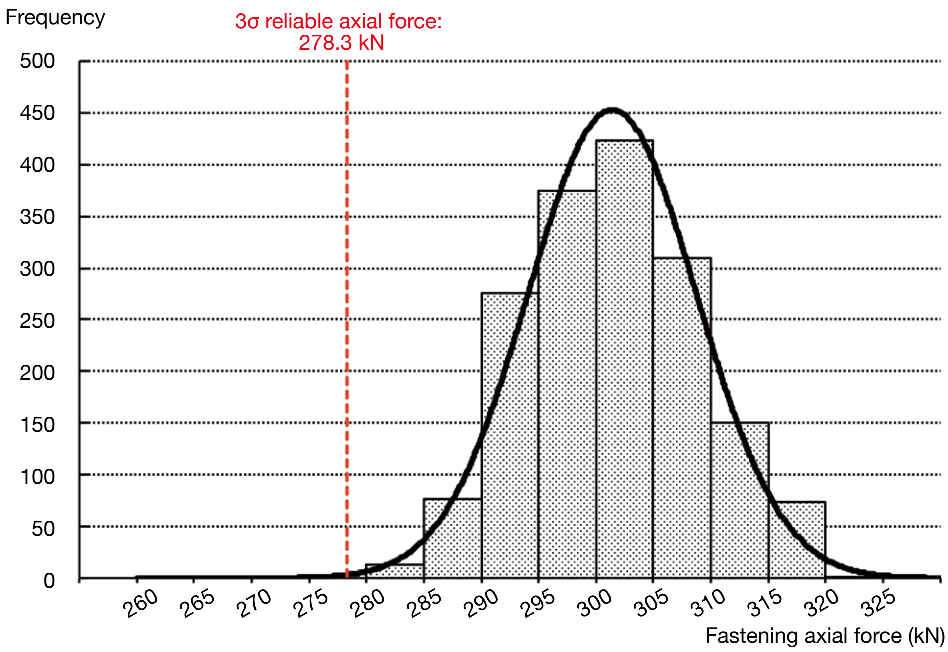
(f) Bolt manufacturer (bolt length: 85 mm)

• Higher Axial Force

Fig. 4 shows the frequency distribution of bolt axial force in the OS method. This figure was prepared by excluding test specimens using the non-lubrication nut from among the variables examined in the fastening experiment and by setting as a sample the test specimens (1,700 specimens in total) using the variable within the range for which practical application is supposed.

As seen in the figure, the average fastening axial force is 301.1 kN, the standard deviation σ is 7.6 kN, and the average-3σ (3σ reliable axial force) is 278.3 kN. The design bolt axial force in current use for F10T (bolt strength$\geqq$1,000 N/mm^2), M22 is 205 kN. It was thus confirmed from the re-

Fig. 4 Frequency Distribution of Axial Force of Bolt Fastened by the Use of New Yield Point Method (1,700 Bolts)



sults of these experiments that an axial force in terms of the average axial force of 1.46 times the current level and a 3σ reliable axial force of more than 1.35 times the current level can be stably introduced in bolt fastening by the use of the OS method.

Relaxation of Bolt Axial Force

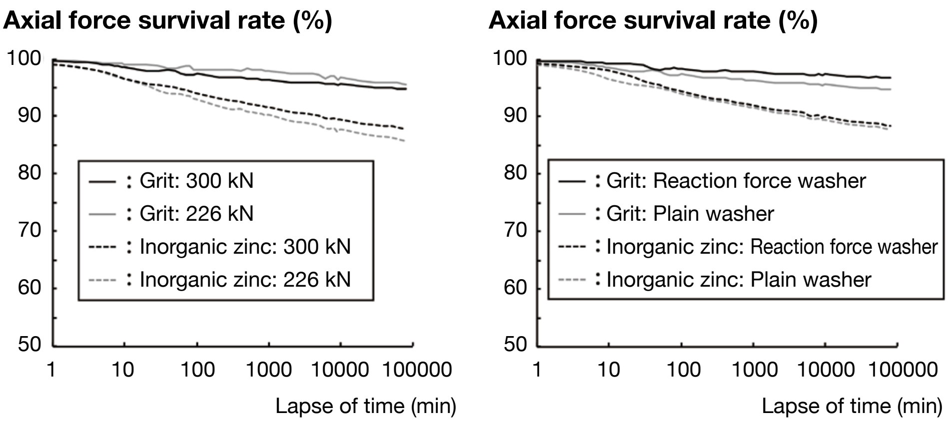
An experiment was conducted to grasp the effect of the introduction of high-strength bolt axial force employing the OS method and the adoption of reaction force washers on relaxation. The bolt subjected to this experiment was 10T, M22. Table 4 shows the variables used in the relaxation experiment. The transition in the bolt axial force was measured targeting 5 bolts respectively for 16 kinds of combinations of various experimental variables. Fig. 5 shows examples of the experimental results over a 2-month period after the introduction of axial force.

Almost no effect was observed of axial force and washer configuration on relaxation as shown in the figure, and thus it can be said that the relaxation level by the use of the OS bolt fastening method is nearly the same as that by the use of other bolt fastening methods. The reduction rate of the bolt axial force to the initial-stage bolt axial force (bolt axial force after 30 seconds from fastening finish) was about 3% in the case of grit blasting and 8~12% in the case of inorganic zinc-rich paint blasting.

Table 4 A List of Variables Adopted in Relaxation Experiment

Axial force of bolt	226 kN (standard bolt axial force), 300 kN (OS method)
Washer configuration	Plain washer, reaction force washer
Friction surface treatment method	Grit blasting, inorganic zinc-rich paint blasting
Bolt length	85 mm, 130 mm

Fig. 5 Examples of Relaxation Experiment Results (Bolt Length: 85 mm)



Future Development and Tasks about OS Method

As explained in the above, the OS method is a high-strength bolt fastening method having high application potential. The research results introduced above were published in detail in the JSSC's *Technical Report* No. 118 (November 2019): Examinations of High-strength Bolt Fastening by Means of the New Yield Point Method (OS Method)[3]. In 2020, JSSC newly established the Subcommittee on the Preparation of JSS Specifications Relating to the OS Method to promote the extensive examination of the practical application of the OS method.

The current state and future development and tasks involved in the promotion of the practical application of the OS method are introduced in the following:

• Electric Wrenches for Use with the OS Method

This wrench is a key to promoting the practical application of the OS method, and continued examinations on the wrench are being called for. In the examinations, fastening experiments were conducted mainly targeting the high-strength bolt set of M22, F10T.

Then, a wrench was manufactured that can be applied for M16, hot-dip galvanized high-strength and other bolts and operation tests were conducted, in which experimental results similar to those of M22, F10T were obtained. In 2020, another type of wrench was manufactured that is lighter in weight and smaller in size than those manufactured at the stage of initiating the experiments.

• High-strength Bolt Set for Use with the OS Method

It will be possible using the OS method to adopt bolts with a bolt head like the round head of torshear-type bolts and to eliminate the application of bolt-head washers in cases when the proper measure to prevent axis rotation is provided under the bolt head. Because of no need for pintails in the OS method, necessary materials can be saved by about 19% in the case of the M22×85 mm hexagon bolt compared to the case of hexagon high-strength bolt sets.

• Confirmation of Delayed Fracture Resistance

Currently, high-strength hexagon bolt sets for use for the yield point method are provided for the construction of steel bridges. While their dimensions, configuration and mechanical properties are the same as those of conventional high-strength bolt sets, its delayed fracture resistance is examined by taking into account bolt fastening by the use of the plastic range of bolts. This high-strength hexagon bolt set for use for the yield point method has a rich application record in the construction of Honshu-Shikoku connecting bridges, and thus the possibility of the occurrence of delayed fracture is considered low, but continued examinations are being called for to improve its delayed fracture resistance.

To cope with such a situation, the following concept may also be feasible—the delayed fracture resistance is to be improved by purposely adopting bolts with low strength and not by changing the bolt axial force using the OS method.

• Post-fastening Inspection and Fastening Control

In order to inspect the bolt after fastening by the use of the OS method, the measurement of nut rotation by means of marking is considered appropriate. The approach to confirm fastening by means of marking has shown no change since the start of application of high-strength bolts, and thus it is required to develop new fastening inspection and confirmation methods that replace the conventional marking method that take into account the higher fastening efficiency.

Given this, expectations are high for the development of advanced fastening inspection and fastening control methods employing IC tags, mobile terminals, MR Gear and other advanced technologies.

• Unified Fastening/Inspection Methods for Various Kinds of Bolts

Capitalizing on the unified fastening/inspection methods, it becomes possible to conduct fastening control for any kind of bolt such as high-strength hexagon bolts, high-strength hot-dip galvanized bolts and other coated bolts. In addition, the unified fastening/inspection methods allow not only for the unification of the specifications of wrenches used for bolt fastening but also the mitigation of the time and cost burden required for bolting workers to acquire necessary technologies and qualification. In this regard, it will be necessary to prepare training materials in the future.

• Joint Design Method

It is possible to improve design sliding yield strength by the use of the OS method. However, because the allowable strength of high-strength bolts is settled and retained-strength joints are required to be provided based on the Building Standard Law of Japan, it is impossible to simply decrease the number of bolts to be used. Thus, it becomes necessary to establish a joint design method that conforms to the OS method.

In cases when this joint design method will be put into practical application, it will be possible to design more compact joints than the joints of high-strength bolts in conventional use, which will thus allow the saving of energy and materials, and the saving of labor in bolt fastening operations as well. In addition, because this joint design method is a technology that can be applied not only to heavy, thick, high-strength steel products but also general-purpose steel structures or a wider range of general steel products, this method is expected to bring about far-reaching effects. In examining the maintenance and repair of steel bridges, an emerging task surrounding the social infrastructure, the joint design method that conforms to the OS method will serve as an effective means.

Towards Improved Mechanical Fastening Technology

Weld joining, mechanical fastening and other diverse kinds of joining methods by means of the combined use of these two methods are currently being applied. In doing so, certain criteria are cited to determine what kind of joining methods should be selected at the stage of design of joints. Among these judgement criteria are not only the change in the condition at the steel-frame manufacturing site such as reducing number of welding engineers and ongoing technical development of welding robots but also the change in conditions at the design site such as in the standardization of bolt joint design and improvement of approval/licensing environments that allows the easy application of new joining methods. Moreover, these criteria are apt to be affected by global economic conditions.

On top of this, in the case of examining the decreasing number of weld engineers and subsequent soaring of personal expenses, and further how to secure the quality under the situation of ongoing global operations of product-manufacturing sites, it is fully accepted that there will be an increasing need for a method to form steel-structure joints by means of mechanical fastening with less quality control items compared to weld joining.

In the case of forming joints by means of mechanical fastening, we consider that the OS method can serve as an important, basic technology for use for fastening high-strength bolts.

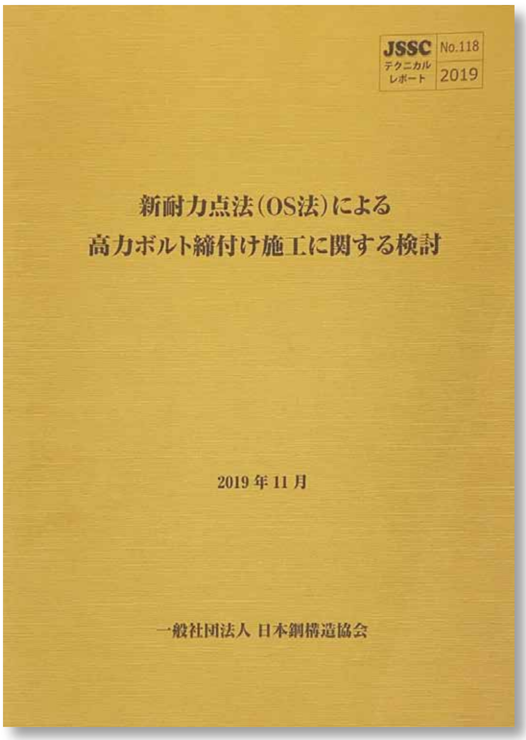


Photo 3 *Technical Report* No. 118: Examination of High-strength Bolt Fastening by OS Method

Acknowledgement

These experiments were conducted with the aid of the JSPS Scientific Research Subsidy of the Japan Society for the Promotion of Science and Steel-structure Research/Training Subsidy of the Japan Iron and Steel Federation. Certain helps and advice were given from the members of the Subcommittee on Mechanical Fastening Technology, the Working Group on Joining Elements and the Working Group on Structures of the Japanese Society of Steel Construction. We express our thanks to all concerned.

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SUS Lining Applied in the Jacket-type Pier at Tokyo International Cruise Terminal

by Rokusui Yui, JFE Engineering Corporation

Increasing Size of Cruise Ships

International cruise ships have recently shown a trend towards larger sizes. Because of this, large-size cruise passenger ship that enters the Port of Tokyo cannot cross the Rainbow Bridge, a suspension bridge constructed in the port, and accordingly there have been many cases in which large-size ships cannot come alongside the Harumi Passenger Ship Terminal (Harumi Wharf). (Refer to Photo 1)

In order to accept these large-size cruise ships that enter the Port of Tokyo, the Tokyo Metropolitan Government planned the construction of a new cruise terminal at the Tokyo Waterfront City located outside the Rainbow Bridge—the Tokyo International Cruise Terminal to which world-class cruise ships can come alongside. Construction started in 2015, and the new cruise terminal started operations in 2020.

The new terminal project proceeded with a lot of construction work, among which the major work was:

- Removal and relocation of existing structures
- Construction of pedestrian bridge
- Foundation work for terminal facilities
- Mooring wharf construction (pier and dolphin)
- Terminal building construction

For the foundation work for the terminal facilities and the mooring wharf construction, a jacket-type pier method was adopted from the viewpoint of reducing the construction term and for economic advantage (Photo 2).

Jacket-type Pier

The jacket-type pier was developed as a structure for use as an offshore platform used mainly for developing ocean-floor resources. It is a structural type applied to the reduction of construction work to a minimum level and for shortening the on-site construction term in the sea area where water depth is high and oceanographic/meteorological conditions are severe. Specifically, a jacket (steel pipe truss structure) assembled on land is installed on steel pipe piles driven into the seabed, and the jacket and pipe piles are integrated by means of welding or grouting to allow for the jacket-type pier to resist the external force working on it.

When compared to a conventional pile-type pier, a jacket-type pier is lighter in terms of the total weight and allows the mitigation of seismic inertia force in the event of an earthquake. In addition, its rigidity is comparatively high, and thus the deformation occurring when the external force works when bringing a ship alongside the pier can be suppressed to a low level.

Outline of Steel Jacket

Fig. 1 shows a grand plan for the new wharf. The foundation section (41 m in width, 252 m in total extension) of the terminal pier is composed of 4 jackets, and the 370 m-long mooring pier section of the mooring wharf (30 m in width, 430 m in total extension) is composed of 7 jackets. These jackets were installed employing a crane barge, as shown in

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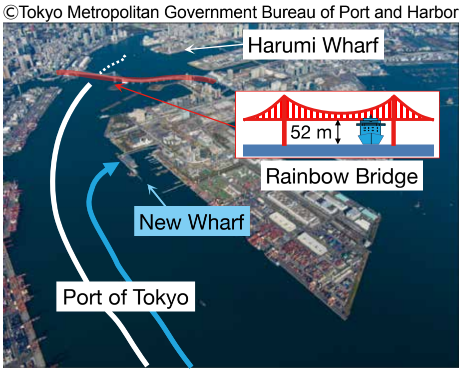
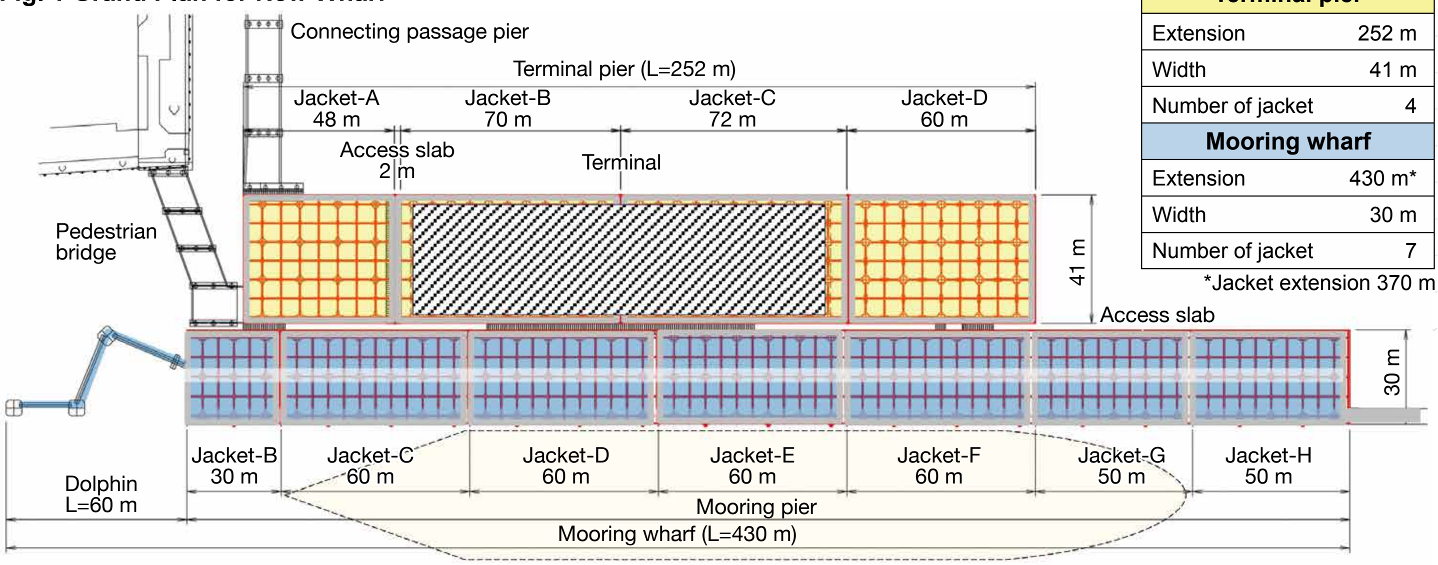


Photo 1 Location of conventional and new wharves in the Port of Tokyo

Photo 2 Steel jacket used for mooring pier construction

Fig. 1 Grand Plan for New Wharf



Terminal pier	
Extension	252 m
Width	41 m
Number of jacket	4
Mooring wharf	
Extension	430 m*
Width	30 m
Number of jacket	7

*Jacket extension 370 m

Photo 3 Installation of jacket (mooring pier) using crane ship

Photo 3.

The pier section was designed as a seismically-reinforced pier that can deal with level 2 seismic motion so that it can be used for the transport of emergency supplies in the event of a disaster.

The upper half of the jacket in common use is exposed to splash and tidal zones, and thus for the steel jacket, its application environment is very severe.

SUS Lining Applied in the Jacket

As a countermeasure against corrosion of the steel jacket, the conventional method thus far adopted is the combined use of super high-build coating (heavy-thick corrosion-protection coating) and cathodic protection. However, from considerations to the lifecycle cost, seawater-resistant stainless steel lining (SUS lining) is increasingly being adopted for part of the section to which the super high-build coating is applied.

The section to which SUS lining is applied is the standard part of steel pipes exposed to the splash and tidal zones (Fig. 2). The repair frequency of steel jackets exposed to severe corrosion environments, splash and tidal zones, can be reduced by the use of SUS lining having high durability and high corrosion resistance. In addition, easy maintenance becomes feasible with SUS lining. (See Photo 4)

Similar SUS lining has been applied in the pier of the D runway of Haneda Airport for which extralong-term years are required to retain durability.

SUS Lining Applied in the New Pier Construction

Regarding the corrosion-protection method applied in the pier of the Tokyo International Cruise Terminal, super high-build coating and cathodic protection were properly applied with the boundary of L.W.L.-1.5 m as shown in Fig. 2.

For the SUS lining in this wharf, SUS312L stainless steel with a thickness of 0.4 mm was applied as the basic lining member. In the boundary section between SUS lining and super high-build coating, super high-build coating is lapped over the SUS lining to continuously protect the boundary section from corrosion.

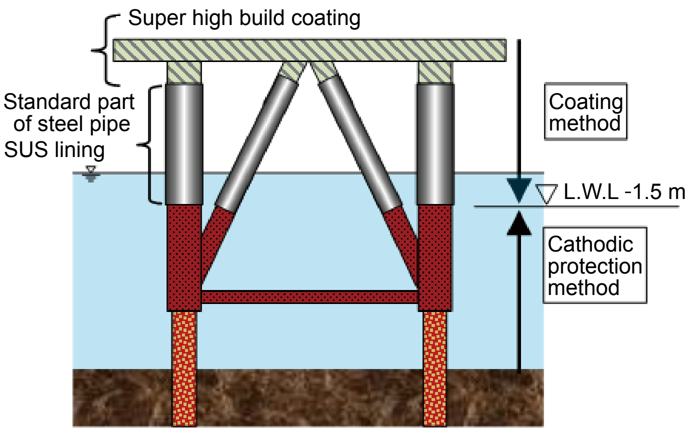
Maintenance-saving SUS Lining

In the repair of coastal steel structures exposed to splash and tidal zones, drying-up and other large-scale preparations are required. Depending on the situation, there are cases in which operations of the facility in use need to be suspended during the repair period.

It is considered that the application of maintenance-saving corrosion-protection measures in important facilities and difficult-to-maintain structural sections will bring about large advantages in terms of efficient facility operations and maintenance cost reduction.

We hope that the construction of steel structures employing SUS linings will increase so as to contribute to the substantial improvement of maintenance-saving infrastructure.

Fig. 2 Plan of Corrosion Protection of Jacket



Super high build coating	Organic zinc rich primer	Coating thickness 20 µm
	Epoxy resin coating	Coating thickness 2500 µm
SUS lining	SUS312L	Thickness 0.4 mm

Photo 4 SUS lining just after setting on jacket

Photo 5 Upper girder of steel jacket at terminal side

©Tokyo Metropolitan Government Bureau of Port and Harbor

Photo 6 Full view of Tokyo International Cruise Terminal

The 7th China-Japan-Korea Tall Building Forum in 2021

by Dr. Masayoshi Nakai, Director of CTBUH Japan Structures Committee, International Committee of Japanese Society of Steel Construction (JSSC); Engineering Fellow, Engineering Department, Takenaka Corporation

Organizer members mainly from Tongji University in China (view immediately after the forum); Fourth from the right is Prof. Guoqiang Li, the representative of China

About the China-Japan-Korea Tall Building Forum

This forum is an international conference on high-rise buildings organized by academic experts and structural engineers from China, Korea, and Japan as part of the initiatives of the CTBUH (Council on Tall Buildings and Urban Habitat) in Asia region.

Professor Emeritus Sangdae Kim at Korea University, who served as Chairman of the CTBUH from 2009 to 2011, proposed this idea in 2012, and after discussions among Professor Guoqiang Li (China representative of CTBUH at that time), Professor Emeritus Akira Wada at Tokyo Institute of Technology, Professor Emeritus Yukio Tamura at Tokyo Polytechnic University and members of the CTBUH Japan Structures Committee, International Committee of Japanese Society of Steel Construction, it was decided to jointly hold the conference in three countries.

As a rule of this one-day forum, a total of nine people at a minimum, three each from Japan, China, and Korea, will give a lecture on experimental or analytical research on high-rise buildings, structural design and construction of actual tall buildings, and so on. In addition to the forum, a site tour to the high-rise buildings under construction or completed at the venue will also take place.

Since it was first held in Shanghai in 2014, it has been held in three countries every year: 2015 (Seoul), 2016 (Tokyo), 2017 (Chongqing), 2018 (Busan), and the sixth in 2019 was held in Nara, the ancient capital of Japan.

The 7th China-Japan-Korea Tall Building Forum, Hybrid Forum in 2021

The seventh forum was scheduled to be held in Suzhou, China in 2020, but it was postponed to last year due to the COVID-19 pandemic. A hybrid conference based at Tongji University in Shanghai was proposed. In the afternoon of Tuesday, November 16, 2021, the seventh forum was held, using the videoconference system "Zoom" for Japanese and Korean participants. In addition, this year's forum is organized by CHEE-ASC (Committee of High-rise Habitat Environment—The Architectural Society of China) and co-organized by the CTBUH Japan Structures Committee and the Korean Council on Tall Buildings and Urban Habitat.

There were about 30 Chinese participants at Tongji University and a peak of about 200 online participants from China, Japan and Korea, and active questions and discussions took place at each lecture, including the use of the Zoom chat function.

At the beginning of the forum, Professor Guoqiang Li gave opening addresses as the representative of CHEE-ASC, followed by Professor Yuko Tamura from Chongqing University as the representative of Japan and Dr. Kwangryang Chung (President of Dongyang Structural Engineers Group Co., Ltd.) from Korea.

After that, there were 5 lectures on structural design, research and construction management of high-rise buildings from China, 3 lectures on case studies, structural design and construction of high-rise buildings from Korea, and 3 lectures on structural design of tall buildings from Japan (11 lectures in total). The outline of each lecture is described below.

- First, Dr. Kyoung Sun Moon, Associate Professor at Yale University, gave a lecture on the case studies of conjoined mega-tall buildings, including those histories, structural characteristics and sustainability.
- "Suzhou IFS (International Finance Square)" introduced by ECADI (East China Architectural Design & Research Institute) is a skyscraper with a height of 450 m and 95 stories that was completed in 2019 in Suzhou, the ancient city of China, and served for hotel, office and residence. The outline of the structural engineering, including the performance-based seismic design, was explained.
- TJAD (Tongji Architectural Design Group Co., Ltd.) announced the structural design of "Silk Road Centre Building" planned in Xian, China, which has a height of 498 m, 101 stories and a "damped outrigger" system.
- Dr. Kwangryang Chung explained the design concept and structural design of the "Cheongna City Tower (Tower Infinity) " which is to be built near Incheon International Airport in Seoul. The tower is an entertainment facility that includes an observation deck, in which the invisibility illusion will be achieved with a LED façade system. It will be about 450 meters tall, making it the sixth tallest tower in the world when completed.
- Introduced by Mr. Ahmad Abdelrazaq from Samsung C & T Corporation of Korea, "Merdeka PNB 118" is a 118-story complex (consisting of office, residence, hotel and retail) under construction in Kuala Lumpur, Malaysia and will be 644 meters tall, making it the second tallest building in the world after Burj Khalifa. In addition to the outline of the structural design, details of construction planning such as quality control of cast-in-place concrete, etc. and current construction situation were explained. It should be noted that Leslie. E. Robertson (who passed away at the beginning of 2021) was involved in the structural design of this building in the fundamental design phase and ARUP was responsible for

structural engineering of record.

- Shanghai Construction Group introduced smart construction management and risk management based on information technologies on a high-rise building named "New City Center" under construction in a dense urban area of Shanghai.
- Tongji University presented two research results: an experimental study on the seismic damage characteristics of RC shear walls of high-rise buildings, and a study on the dynamic characteristics of the "damped outrigger" system, in which a damping device is installed between the outrigger tip and the outer column.
- In the lectures from Japan, Mr. Tomonobu Isobe from Taisei Corporation introduced the structural design of a high-rise building, in which a seismically-isolated layer is placed between the middle-to-low stories (used for office and retail) of steel framed structure and the upper stories (used for residence) of RC structure. In addition to the characteristics of the mid-story isolation system and its performance-based seismic design (PBSD), detailed explanations were given on the CFT, the seismic isolation device, and the well designed joint system with the cast-in-place concrete column.
- Mr. Shunsuke Nakajima from Obayashi Corporation introduced a "dual frame system" of a high-rise building in which a rigid RC core frame is connected to a base-isolated RC frame independently surrounding this core with hydraulic dampers. The former, the latter is served for parking lot, residence, respectively. The following were explained in detail: concept and the PBSD of this system, construction method using precast concrete member and its actual process.
- At the end of the forum, Mr. Hidenori Karasaki from Nihon Sekkei Inc. gave a lecture on a case of realizing an RC high-rise building with a high aspect ratio of 6.0 by a vibration control system incorporating oil dampers between twin RC core walls. This building has a height of 237 m and 54 stories, and will be served for residence, hotel and retail. The characteristics, analytical model and the PBSD of this damping system were explained in detail.

Towards the 8th China-Japan-Korea Tall Building Forum in 2022

In closing, Prof. Guoqiang Li thanked the participants for their interesting presentations and meaningful discussions at this forum, which unfortunately took place online due to the COVID-19.

Finally, the nearly 5 hour forum came to a successful conclusion with hopes that the 2022 forum will be held in Korea in one place.

JSSC International Committee

Message from the Chairman

by 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, among which are surveys and research, technological development and the spread of steel construction for Japan and overseas. At the same time, it has promoted tie-up operations with related overseas organizations. Aimed at spreading Japan's steel construction technologies and developing overseas markets, the JSSC's International Committee took charge of editing Issue No. 64.

Issue No. 64 features an article titled "Examination of High-strength Bolt Fastening by OS (Offset Slope) Method"—a research initiative aimed at developing the latest mechanical fastening technologies for steel structures. The OS method has notable features. Specifically, in high-strength bolt fastening by means of the OS method, it is possible to introduce more stable and larger axial force than that in torshear-type high-strength bolt fastening, and it is also possible by the use of reaction force washers to put in practice more rational fastening with higher efficiency than that in the conventional yield point method. In this feature article, experiments made toward the practical application of the OS method are introduced.

In the Special Article: Stainless Steel in this issue, the Tokyo International Cruse Terminal is introduced in which stainless steel lining was applied to its jacket-type pier. In addition, this issue introduces the JSSC Commendations for Outstanding Achievements in 2021 in the field of steel construction (five projects) and thesis (three papers).

In the page of JSSC Events, an outline is reported of the 7th China-Japan-Korea Tall Building Forum held at Tongji University, China on November 16, 2021, via a remote conference system. The Forum is one of the operations of CTBUH.

Throughout 2021 a variety of global activities were greatly affected by COVID-19, and many new ingenious schemes were introduced, including the promotion of international activities using remote access tools or services. The impact of COVID-19 is expected to continue in 2022, but we want to expect new developments. We would like for everyone to understand the activities of JSSC and at the same time we would like to hear your opinions at any time.

STEEL CONSTRUCTION TODAY & TOMORROW

Published jointly by

The Japan Iron and Steel Federation
3-2-10, Nihonbashi Kayabacho, Chuo-ku, Tokyo 103-0025, Japan
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URL http://www.jssc.or.jp/english/index.html

Edited by
Committee on Overseas Market Promotion, The Japan Iron and Steel Federation
Chairman (Editor): Keiji Ando

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