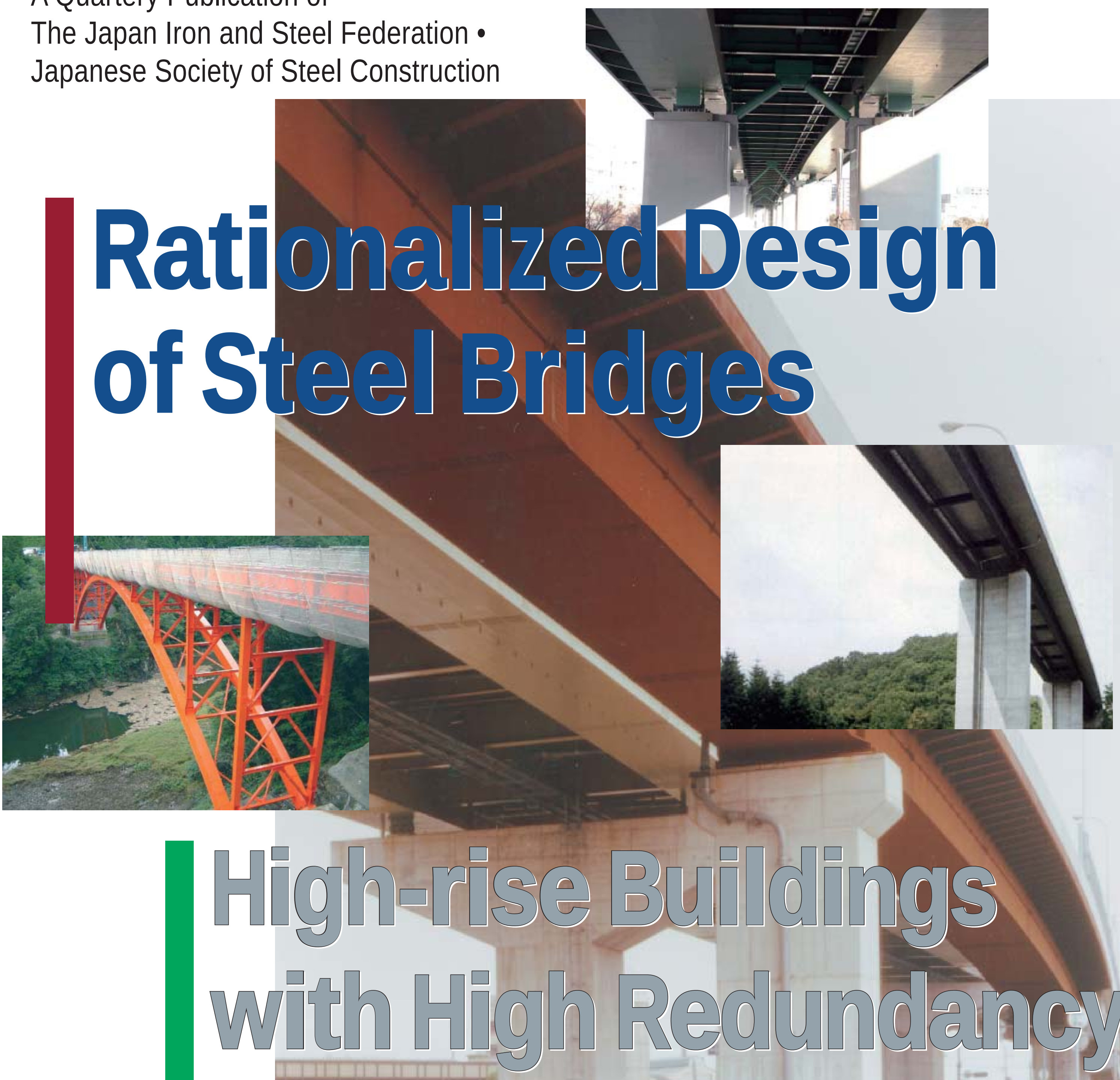
STEEL CONSTRUCTION TODAY & TOMORROW

No. 15
JULY 2006

A Quarterly Publication of
The Japan Iron and Steel Federation •
Japanese Society of Steel Construction



Rationalized Design of Steel Bridges

High-rise Buildings with High Redundancy

Steel Bridges in Japan

—Current Circumstances and Future Tasks—

by Dr. Yozo Fujino
Professor, The University of Tokyo
(Chairman, JSSC's Research Committee to Improve Steel Bridge Performance)

Yozo Fujino: After graduating from The University of Tokyo in 1972, he finished the doctor's course (Ph.D.) at Waterloo University of Canada in 1976. He has been professor of School of Engineering, University of Tokyo since 1990. His research includes design, dynamics, control and monitoring of bridges, and he has been involved in many domestic and international bridge projects.

Steel bridge construction in Japan has shown rapid growth since the 1960s. In the 1970s, a total of more than 500,000 tons of steel were annually used in steel bridge construction. Since the 1980s, a number of long-span suspension and cable-stayed bridges have been constructed, beginning with those of the Honshu-Shikoku Connecting Bridge Project. By 1999, two of the world's longest bridges had been erected—the Tatara Bridge, a cable-stayed bridge with an 890-m center span and the Akashi Kaikyo Bridge, a suspension bridge with a center span of 1,991 m.

Since 2000, the core concept in bridge construction in Japan has shifted from long-span bridges to conventional bridges, with the primary task now being to build economical bridges that meet the growing societal demand for less costly public works projects. Equally important is the task to build bridges with reduced life-cycle costs in order to offset the increasing cost of maintenance.

Countermeasures against Obsolescence

According to data on the cumulative number of bridges in Japan, highway bridges with spans greater than 15 m number about 140,000. Of these, steel bridges account for about 40% in terms of the total number and about 50% of total bridge length. Most of these steel bridges were built during the economic growth period following the 1960s, and it is predicted that the number of obsolete bridges will increase rapidly in the future. Fig. 1 shows the number of highway bridges after a lapse of 50 or longer-year service. It shows that the number of bridges over 50 years old surpasses 2,000 as of 2006 and will reach more than 10,000 ten years later by 2016 and about 20,000 in 5 years after that.

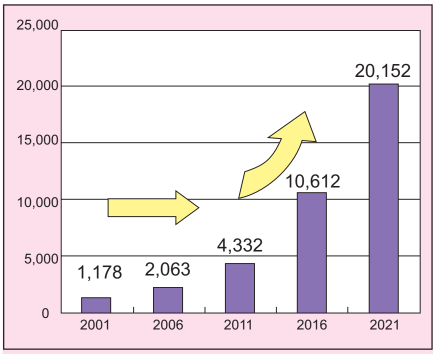
These facts clearly indicate that the issue of how to prolong the service life of existing steel bridges is a pressing concern. It has been confirmed that fatigue cracking is occurring in the main steel girders, steel floor slabs, steel piers, and other steel structures of bridges built during the period of economic growth. In order to repair and renew these ailing bridges, it will be necessary to implement countermeasures capable of holding social losses to a minimum while keeping the damaged bridges in use. In addition, new demands call for the development of parameters and methods that measure the effectiveness of repairs and refurbishment so that the adequacy of investments into such maintenance efforts can be objectively assessed.

Growing Importance of Weathering Steel Bridges

Observation of the maintenance conducted on existing steel bridges shows that repainting costs comprise the largest item of expenditure. Consequently, the use of unpainted steel bridges is gaining in importance. It is widely known that weathering steel suppresses the development of corrosion by producing a layer of densely-formed rust on weathering steel surface. The application of weathering steel reduces both the cost and frequency of repainting and promises future growth.

Fig. 2 shows the demand over time for weathering steel bridges in Japan. As clearly seen in the figure, the ratio of weathering steel bridges to all steel bridges is rapidly increasing. However, in Japan with a geographical environment that is surrounded by oceans, experience shows that the performance characteristics peculiar to weathering steel cannot be demonstrated in coastal areas affected by seaborne salts or

Fig. 1 Growing Number of Highway Bridges* More than 50 Years Old



*Bridges on national highways and major expressways
Source: "Proposition: Future Maintenance and Renewal of Road Structures," Ministry of Land, Infrastructure and Transport

Fig. 2 Increasing Applications of Weathering Steel Bridges

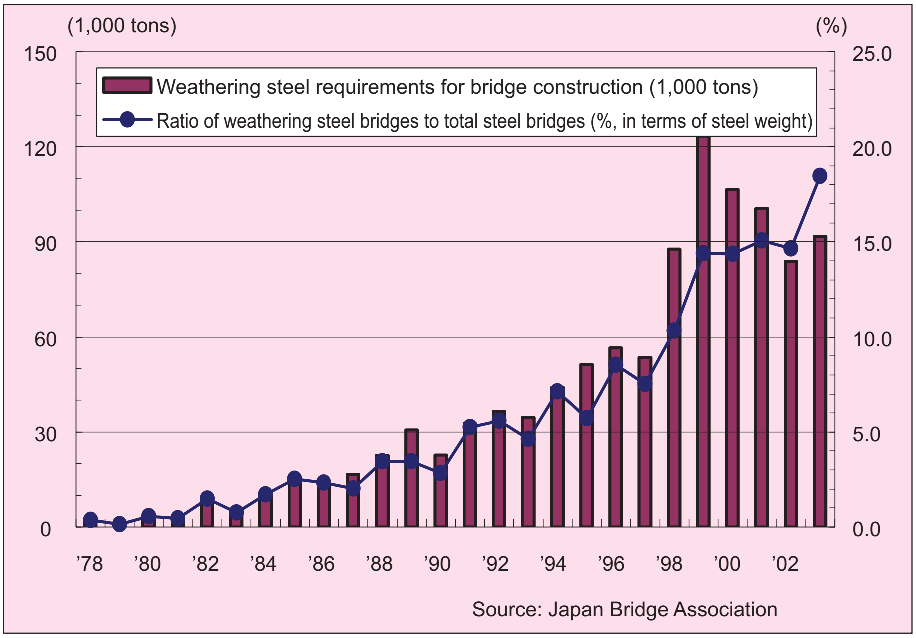
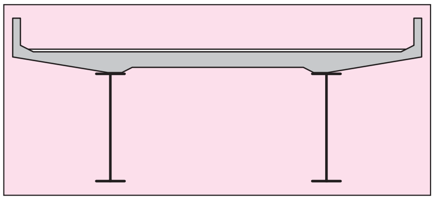


Fig. 3 Double-composite I-girder Bridge



at sites where salt is sprayed to melt snow and ice. For this reason, it is important to correctly understand the environmental conditions of the area of application when assessing the applicability of weathering steel.

Rationalized Design of Steel Bridges

Steel bridges are faced with an environment of unprecedented severity that includes reductions of public works projects, the privatization of public highway corporations, and fatigue problems in steel bridge piers. On top of this, steel bridges have the unavoidable task of reducing costs and minimizing life-cycle costs in order to remain competitive.

As stated earlier, rationalized structures and innovative design methods are inescapable requirements for the economical construction of ordinary bridges. In Japan, technological developments are actively being promoted in the pursuit of economical methods of constructing elevated expressway bridges. In steel bridge construction, there is an ongoing shift in terms of structural types from thin-walled multiple main girders, based on the idea of minimizing the weight of the steel products applied, to double-composite I-girders (Fig. 3) that allow for an overall reduction of construction costs, including those of fabrication.

By using double-composite I-girders, great reductions are possible in required quantities of steel fabrication and in the total welding-line length, both of which add considerable cost to steel bridge construction. Currently, double-composite I-girder bridges are being increasingly adopted as the most economical bridge type. The range of application for this type of bridge and the pursuit of more economical bridges are expected to benefit from improvements in the limit state design method for double-composite girder bridges.

The issue of seismic resistance has been highlighted since the Great Hyogoken-Nanbu Earthquake of 1995. While energetic research efforts have been directed towards improving seismic design technologies, the seismic reinforcement of cable-stayed and arch bridges remains an unresolved task. To cope with these concerns, seismic design that employs buckling-restrained braces and other new design technologies has been proposed. At the same time, preparations for the publication of advanced seismic design guidelines are underway.

JSSC's Research Committee to Improve Steel Bridge Performance

In promoting the shift to the performance-specified design found in *Specifications of Highway Bridges* of Japan and the limit state design method, it is considered that these design methods allow greater freedom in design. Currently, it is required that full use be made of limit state design in reducing construction costs and minimizing life-cycle costs.

At the Japanese Society of Steel Construction (JSSC), research on infrastructure technologies aimed at reducing construction costs and improving performance-specified design has produced an accumulation of results through six years of a two-phase series of activities by the Research Committee on Next-generation Civil Engineering Steel Structures and the Research Committee on Measures for Performance-specified Design. While this research has already put several achievements to practical use, it is believed that many research results remain that, through further development, can be put to practical use in solving a variety of tasks imposed on steel bridges.

With the aim of organizing these research attainments into practical form, the Research Committee to Improve Steel Bridge Performance (Chairman: Prof. Yozo Fujino of The University of Tokyo; Deputy Chairman: Prof. Tsutomu Usami of Nagoya University) began operation in fiscal 2003. It oversees four working groups that concentrate on technical studies of the following topics.

—Working Group on Rationalized Design Methods

(Chief: Masatsugu Nagai; Deputy chief: Eiji Suzuki)

- Study of designs to use fewer web reinforcing members and the study of plastic design for composite girders; both studies are aimed at improving cost competitiveness through more rationalized steel bridge design

- Practical requirements pertaining to application of the limit state design method, example designs using new steel bridge types with higher competitiveness

—Working Group on the Improvement of Steel Bridge Durability

(Chief: Takeshi Mori; Deputy Chief: Kenji Hayashi)

- Collection and classification of examples of damage, inspection, diagnosis, assessment, repair, and reinforcement of steel bridges
- Measurement technologies for damage diagnosis and fatigue durability assessment methods
- Methods to assess the durability of repairs to sections suffering fatigue damage
- Methods to improve fatigue durability

—Working Group on Seismic Design Guidelines

(Chief: Tsutomu Usami; Deputy Chief: Shigehiro Fukaya)

- Seismic design of steel structures showing complex dynamic behaviors and advanced vibration-control design: Sample studies of cable-stayed bridges
- Seismic design guidelines for engineers and designers

—Working Group on Weathering Steel Bridges

(Chief: Eiki Yamaguchi; Deputy Chief: Yasumori Fujii, Isamu Kano)

- Applicability of weathering steel (SMA in JIS) and highly corrosion-resistant nickel-type weathering steel; methods to assess soundness of existing weathering steel bridges and to repair such bridges; studies of methods to apply supplementary rust stabilization treatment
- Drafting of recommendations for the corrosion-protection design of weathering steel bridges, data for corrosion-protection design, maintenance and repair manuals, and other necessary data

It is anticipated that the incorporation of these research attainments into the design standards will contribute to the development of steel bridge construction.

Tenth Symposium on Research into Civil Engineering Steel Structures

The Japan Iron and Steel Federation (JISF) held its Tenth Symposium on Research into Civil Engineering Steel Structures in March 2006 in Tokyo. The symposium focused on reports detailing the achievements of research projects carried out by the Research Committee to Improve Steel Bridge Performance of the Japanese Society of Steel Construction (JSSC). These projects were entrusted to JSSC by JISF. In addition, lectures were presented by a government official and a university professor on bridge buildings vis-à-vis the Quality Assurance Law and damage-control design in building construction.

The first report was a comprehensive presentation of the achievements of the Research Committee to Improve Steel Bridge Performance by Committee Chairman Yozo Fujino (professor of The University of Tokyo). This was followed by the reports of four subordinate working groups: Working Group on Rational Design Methods (chief: Masatsugu Nagai, professor of Nagaoka University of Technology), Working Group on the Improvement of Steel Bridge Durability (chief: Takeshi Mori, professor of Hosei University), Working Group on Seismic Design Guidelines (chief: Tsutomu Usami, professor of Nagoya University) and Working Group on Weathering Steel Bridges (chief: Eiki Yamaguchi, professor of Kyushu Institute of Technology).

The major topics of these reports included: the limit state design method as it applies to composite girders, technologies to improve fatigue durability and to prolong the service life of steel bridges, seismic and damage-control design guidelines, and draft recommendations for the corrosion-protection design of weathering steel bridges. An outline of these reports is introduced in the following nine pages (from 4 to 12).

Participating in subsequent discussions were project order officers and road administrators who focused on changes in the comprehensive assessment system and the framework for ordering steel bridges, as well as the tasks involved in shifting to performance-specified design methods.

A special lecture entitled "Law Concerning the Promotion of Quality Assurance of Public Works and Bridge Building" was delivered by Kazuhiro Nishikawa, National Institute for Land and Infrastructure Management. Mr. Nishikawa discussed the shift in assessing public works projects from consideration of only cost to consideration of both cost and quality; he also discussed enforcement in 2005 of the Law Concerning the Promotion of Quality Assurance of Public Works and implementation of advanced technology-proposed projects. Further, he stressed that technological excellence and reliability vis-à-vis life-cycle costs, durability, safety, and environmental performance are necessary in order to ensure the quality of public works projects.

Another special lecture was delivered by Prof. Akira Wada of the Tokyo Institute of Technology on "Damage-control Design in Building Construction and Recent Research." Prof. Wada discussed conventional beam-yielding type rigid steel-frame structures and a new damage control mechanism for steel frames, topics of interest to engineers involved in civil engineering structures.

Symposium on Research into Civil Engineering Steel Structures

Steel Bridges

—Rationalized Design Methods in Japan—

by Dr. Masatsugu Nagai
Professor, Nagaoka University of Technology

Masatsugu Nagai: After graduating from the School of Engineering, Osaka University in 1971, he finished the doctor's course in civil engineering, the Graduate School of Osaka University and entered Kawasaki Heavy Industries, Ltd. in 1973. He became professor of Nagaoka University of Technology in 1988.

Development of Performance-based Limit State Design Method for Continuous Composite Girders

Currently, the design of highway bridges in Japan is based on the allowable stress design method prescribed in *Specifications for Highway Bridges*[1]. The format is as follows.

$\Sigma f \leq h(fy/\gamma)$

Where, Σf indicates the sum of stresses, taking into account various loading combinations; fy, yield point of the materials; γ (=1.7), basic safety factor; and h (≥1.0), reduction rate of the safety factor, which takes into account the probability of the simultaneous occurrence of various loading combinations, or the overdesign factor to the allowable stress (fa = fy/1.7).

On the other hand, in AASHTO LRFD[2] and EC[3] which are based on the limit state design method, the partial factor format is adopted for checking required limit state performances.

In the allowable stress design method, or in the elastic design method, it is not possible to use bending strength in the elasto-plastic region after yielding in part of the materials. For example, in cases when a composite girder is subjected to a positive bending moment, the bending strength reaches the plastic moment in most cases. While the plastic moment of composite girders is larger than the yielding moment, 1.4~1.6 times the yielding moment, the strength of the plastic moment cannot be applied in the allowable stress design method. In such situations, it is considered indispensable that, in order to improve the competitiveness of steel bridges, a continuous composite girder design method must be developed that is based on the limit state design method. Consequently, compilation has begun on *Design Guidelines for Continuous Composite Girders*, which is based on the limit state design method.

Design Guidelines includes a wide range of issues, and because of the difficulty of fully covering all of them in the space allotted here, only the guidelines pertaining to the classification of composite girder sections are introduced.

First to be introduced is a newly established method to classify the sections of composite girders upon which the positive bending moment works (Figs. 1 and 2). The main feature of this method is that it takes into account the moment that works on steel girders during construction when defining the non-compact section. Fig. 3

Fig. 1 Stress Distribution at the Plastic Moment (Compact Section)

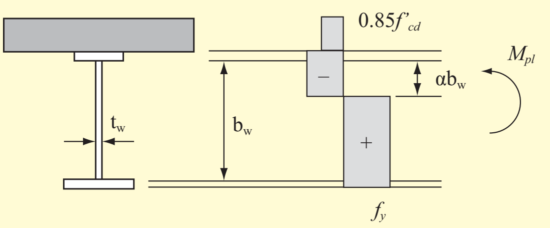
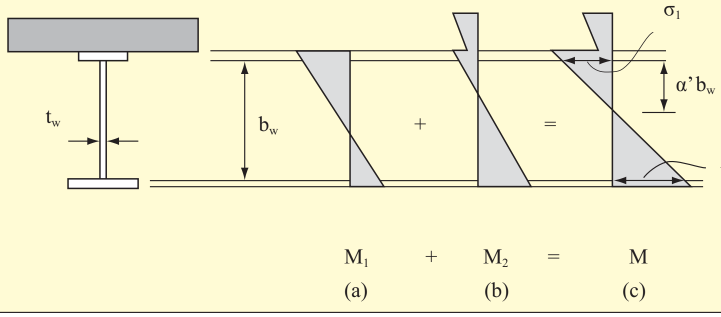


Fig. 2 Superposition of Flexure Stresses



shows the relation between the moment (M) and the curvature (ϕ) of a compact section, a non-compact section, and a slender section.

- Compact section

$$\frac{b_w}{t_w} \le \frac{2.0}{\alpha}\sqrt{\frac{E}{f_y}} \quad (\alpha<0.4)$$

Where, b_w and t_w indicate the height and plate thickness respectively of steel girder webs; α, parameter to define the location of the plastic neutral axis of composite section (refer to Fig. 1); E, Young's modulus of steel; and f_y, yield stress of steel products.

- Non-compact section

$$\frac{b_w}{t_w} \le \frac{1.7\Lambda}{0.67+0.33\psi}\sqrt{\frac{E}{f_y}} \quad (\psi>-1.0)$$

$$\frac{b_w}{t_w} \le 2.5\Lambda(1-\psi)\sqrt{-\psi}\sqrt{\frac{E}{f_y}} \quad (\psi\le-1.0)$$

Where, Λ is the coefficient to express the effect of the moment and is identified using the following equation.

$$\Lambda=1-0.1\left(\frac{M_1}{M_{ys}}\right)+2.31\left(\frac{M_1}{M_{ys}}\right)^2 \quad \frac{M_1}{M_{ys}} \le 0.4$$

Where, ψ indicates the parameter to express the stress gradient in the web (refer to Fig. 2); M_1, the initial moment that produced in the steel girder; and M_{ys}, the yield bending moment of steel girders.

- Slender section

Sections other than listed above

Next, in cases when the negative bending moment works on a composite girder, the conditions of the compact section (SM490Y: f_y=355 MPa), shown in Fig. 4, are proposed. The width-thickness ratio of compressed webs has an intermediate condition between AASHTO and ISO10721, and EC. On the other hand, the width-thickness ratio of compressed flanges allows the largest value.

Double-composite I-girder Bridges

Thus far in Japan, it has been customary to construct multiple main girder bridges that support roadways made of RC slabs. The main girders are made of thin plates in order to minimize weight and are strengthened with many horizontal and vertical stiffening members to prevent buckling

Fig. 3 Relations between Moment (M) and Curvature (ϕ) of Three Section Classes

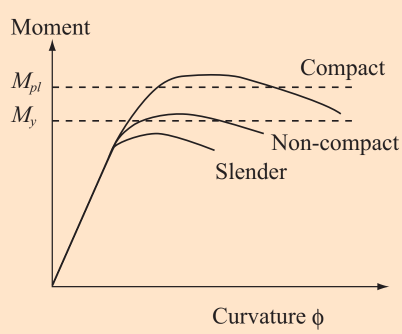


Fig. 4 Compact Section (in Negative Moment)

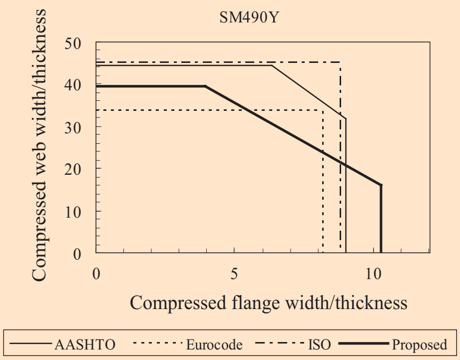


Fig. 5 Structural Innovations of I-girders

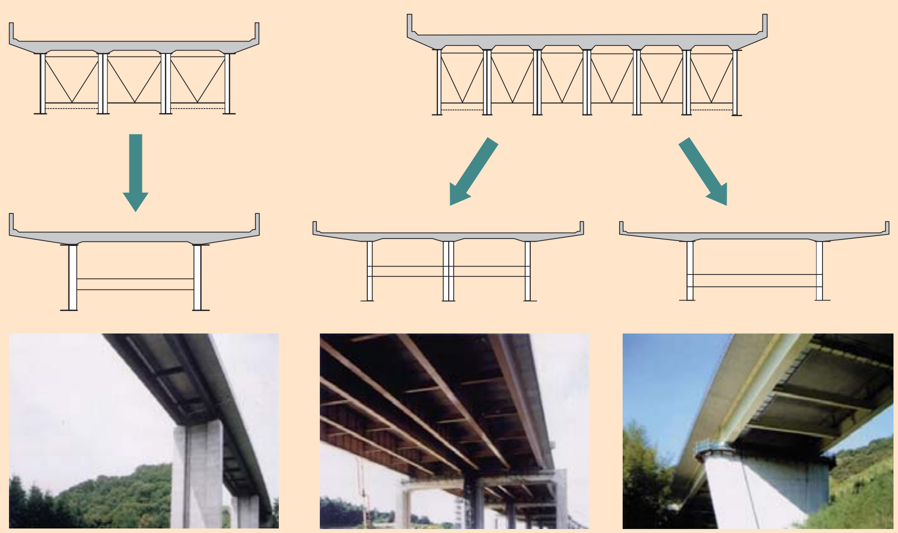
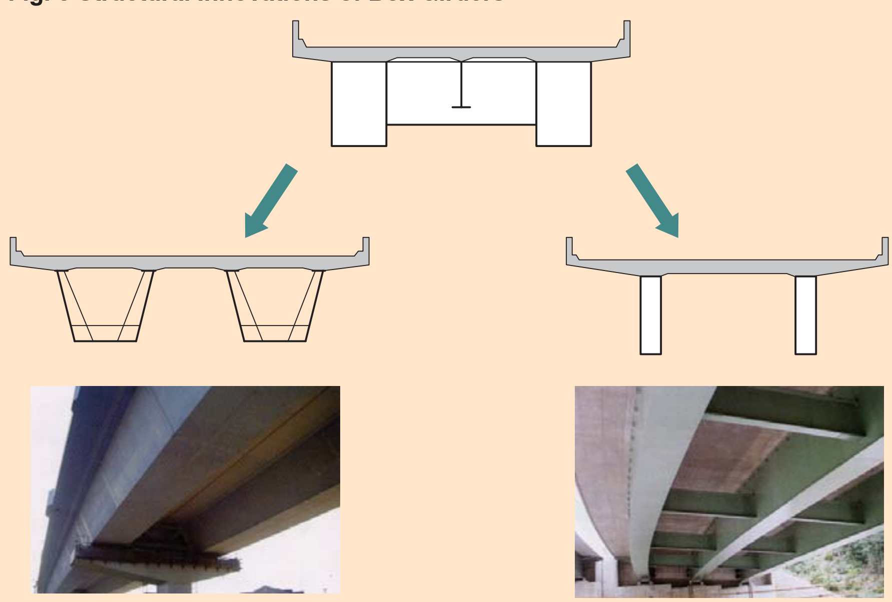


Fig. 6 Structural Innovations of Box Girders



of the steel web. In addition to stiffening members, sway bracing at about 6-m intervals as well as lower lateral bracing have been installed between the main girders. These structural systems conform to the provisions of the currently prevailing *Specifications for Highway Bridges*[1].

However, in order to meet the need to reduce construction costs, bridge structural systems in Japan are shifting to the very simple structures shown in Figs. 5 and 6. The basic concept for these simple structures is to reduce the number of main girders to a minimum and to minimize the use of stiffening members that require multi-step fabrication. Further, only small-sized cross beams are arranged between the main girders and the use of lower lateral bracing is eliminated. Currently, these bridge types are recognized as being the most economical for spans ranging from 30 to 60 m. Fig. 7 shows the number of these rationalized girder bridges that have been built so far. It can be seen from the figure that the construction of two-I-girder bridges, among others, is increasing.

Table 1 shows economical steel-bridge and concrete-bridge alternatives, according to span length. Of these alternatives, concrete bridges are judged most economical

Fig. 7 Number of Bridges Constructed (by Structural Type)

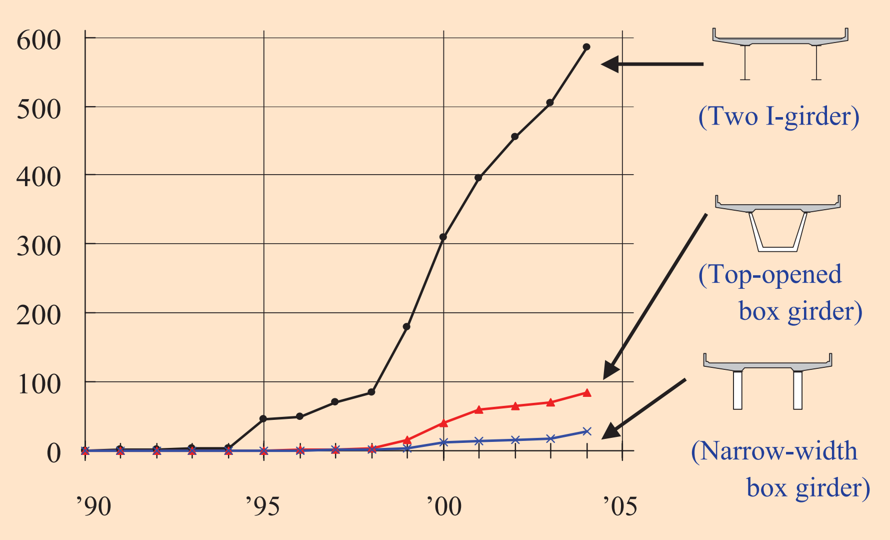


Table 1 Economic Evaluation by Bridge Type

Span	L < 30m	30m < L < 60m	60m < L
Steel alternative	Slab bridge Rolled beam bridge	Composite 2-I-girder bridge	• Truss girder bridge • Box girder bridge with steel deck
Concrete alternative	PC, RC girder bridge	PC box girder bridge	• PC box girder bridge • PC box girder bridge with steel corrugated web • Extradosed box girder bridge

Inside of a yellow frame: Competitive (economical) for spans shorter than about 30 m and longer than 60 m or 70 m. For spans of 70~120 m in particular, PC box girder bridges using corrugated steel webs are growing in application.

For the engineers involved in steel bridge construction, it is important to propose a steel bridge type that is competitive in the 70~120-m span range. A steel bridge alternative that is expected to be highly competitive in this span range is the double-composite I-girder bridge. This bridge has concrete floor slabs between two main girders that are subjected to compression at the intermediate supporting points of continuous girders. This structural system is expected to prevent the buckling of thin steel plates subjected to compression and to improve bending strength and torsional rigidity. Fig. 8 shows a conceptual drawing of cantilevered erection stage of a double-composite I-girder bridge employing rigid connection with an RC bridge pier.

The ultimate bending strength of double composite girders is expected to reach the plastic moment against positive and negative bending. That is, the cross sections of double composite girders can be classified as compact sections along the entire length of the span, thereby making it possible to determine girder sections using a design concept similar to that for steel shapes. Fig. 9 shows the examples of differences in the main girder cross-sections of a model (80+100+80 m)-span bridge in the case of designing by use of both the limit state design method (designed as compact sections) and the allowable stress design method.

When using the limit state design method, even for a 100 m-span, the girder height at the intermediate supporting point can be held to about 3,000 mm and, further, the cross-sectional areas can be decreased by more than 20%. These results clearly show the superiority of double-composite I-girder bridges designed using the limit state design method.

In addition, enhanced competitiveness can be expected for I-girder bridges by adopting hybrid structures in which high-strength steel members are adopted for the flanges and relatively low-strength steel members for the webs. When wider width is required, twin box girder bridges composed of unstiffening steel plates (Fig. 10) can be proposed as a competitive alternative.

References:

1) Japan Road Association: Specifications for Highway Bridges, 2003 (in Japanese)
2) AASHTO: AASHTO LRFD Bridge Design Specifications, 3rd Edition, 2004
3) CEN: EC3: Design of steel structures, Part1-1: General rules and rules for building, 2003

Fig. 8 Double-composite Girder under Construction

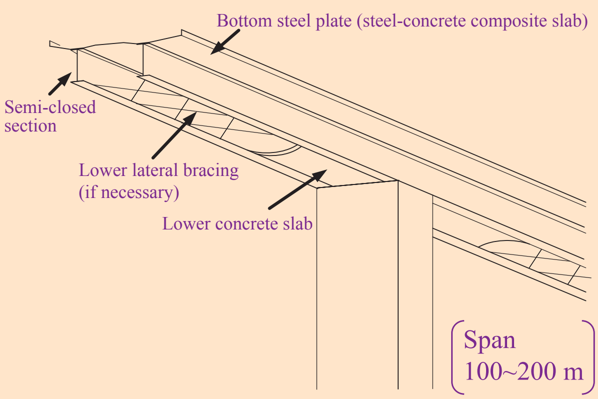


Fig. 10 Two Box Girders

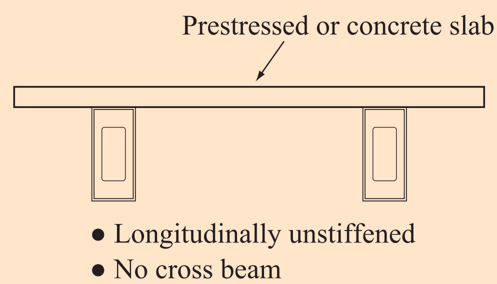
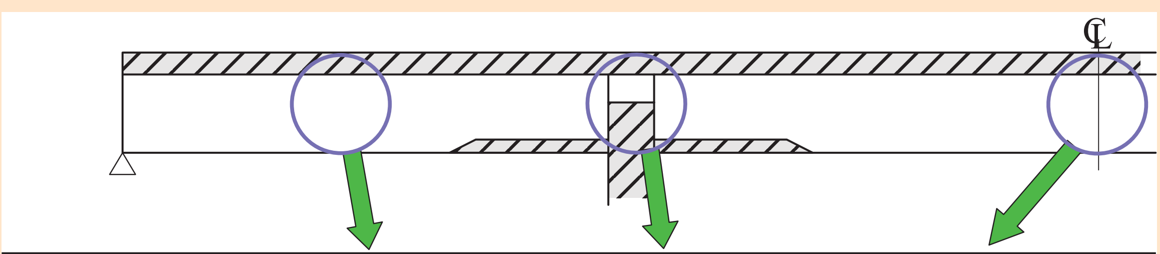


Fig. 9 Design of (80+100+80 m)-span Double–composite Girder Bridge



	LSD	ASD	LSD	ASD	LSD	ASD
Material grade	SM490Y(fy=355 MPa)		SM570(fy=450 MPa)		SM490Y(fy=355 MPa)	
Upper flange	800 × 34	800 × 47	800 × 65	800 × 120	800 × 31	800 × 32
Web	3100 × 21	3100 × 26	3100 × 36	3100 × 29	3100 × 21	3100 × 26
Lower flange	800 × 40	800 × 80	800 × 78	800 × 150	800 × 33	800 × 63
Cross-sectional area ratio	0.75	1.00	0.77	1.00	0.76	1.00

LSD: Limit state design ASD: Allowable stress design

Report of JSSC's Working Group on the Improvement of Steel Bridge Durability

Improvement of Steel Bridge Durability

by Dr. Takeshi Mori
Professor, Hosei University

Takeshi Mori: After graduating from the Department of Engineering, Tokyo Metropolitan University in 1978, he entered the School of Engineering, Graduate School of Osaka University. He became associate professor in 1990 and professor in 1996 of the Faculty of Engineering, Hosei University.

According to the *Construction Industry Handbook*, the maintenance and repair of bridges account for a steadily increasing share of all work in the construction market of Japan, having reportedly grown from a 13~15% share in the first half of the 1990s to 21.5% in fiscal 2002. In terms of new construction completed during the 15 years from 1966 to 1980, those bridges alone with spans greater than 15 m numbered about 60,000, which equals about half of all existing bridges.

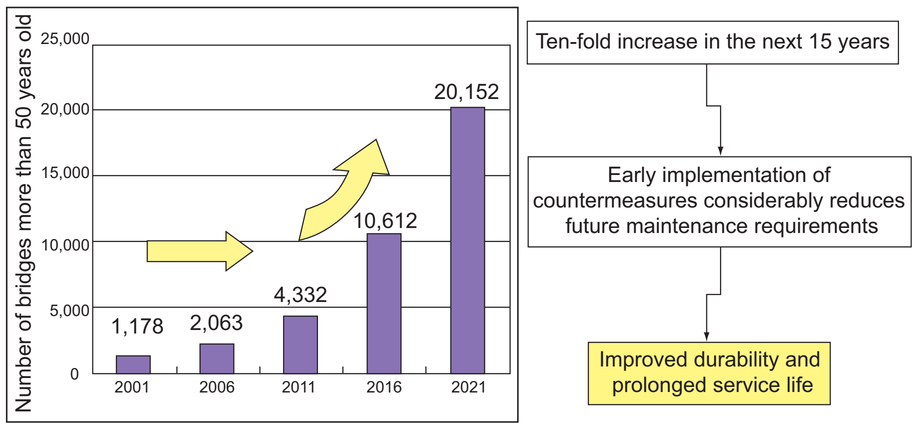
Of these 60,000 bridges, steel bridges account for about 35,000. Of these, it is estimated that bridges with a service life greater than 50 years account for about 50% (Fig. 1). Clearly, it is important to find ways during regular maintenance to improve the durability and service-life longevity of this vast number of bridges, including those that are newly installed.

Technologies to Improve Fatigue Strength and Prolong Service Life of Steel Bridges

The key factors to improve the durability of steel bridges are:

- Collection and organization of information on past damage and repairs and the effective utilization of the resulting know-how
- Establishment of accurate and efficient methods to detect damage
- Improvement of damage diagnostic technologies
- Establishment of suitable damage repair and prevention measures
- Establishment of measures to efficiently repair and reinforce damage and methods to assess the durability of repaired and reinforced sections

Fig. 1 Growing Obsolescence of Highway Bridges in Japan



*Bridges on national highways and major expressways
Source: "Proposition: Future Maintenance and Renewal of Road Structures" Ministry of Land, Infrastructure and Transport

Table 1 Technologies to Improve Fatigue Durability and Prolong Service Life of Steel Bridges (provisional title)

- Examples of Countermeasures against Fatigue Damages
- Inspection and Monitoring
- Method to Assess the Fatigue Durability of Steel Bridge Members
- Method to Assess the Fatigue Durability of Repaired and Reinforced Steel Bridge Members

Appendix: New Technologies for Repair and Maintenance

Table 1 shows the draft contents of a technical report scheduled for publication by the Japanese Society of Steel Construction (JSSC) in fiscal 2006.

Use of Grinder Finishing to Improve Fatigue Strength of Weld Joints

One of the approaches to improving the durability of steel bridges is to use grinder finishing to improve the fatigue strength of weld joints as introduced (Photo 1).

In grinder finishing, the concentration of local stress in welding toes is reduced by cutting either the toes or the entire weld with grinders to produce a smooth weld surface; undercuts and other welding defects that serve as initiation points for weld cracking are removed by a similar process. Thus, the fatigue strength of steel bridge weld joints is improved by the use of grinder finishing.

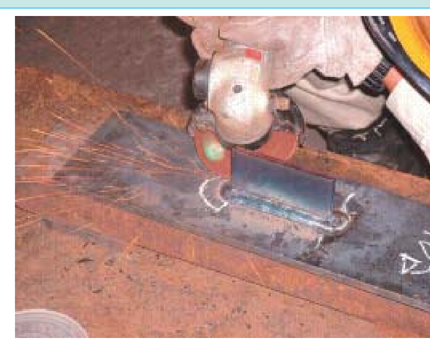


Photo 1 Example of grinder finish of out-of-plane gusset plate weld joint

Due to space restrictions, a detailed

explanation of the experiments on grinder finishing is not provided here, but fatigue test results and the calculation of the stress concentration coefficients by FEM analysis confirm that grinder finishing does in fact improve the fatigue strength of weld joints (Photos 2 and 3)—grade 2 or more in terms of JSSC's fatigue strength classifications, compared to as-welded joints. (Refer to Fig. 2)

Photo 2 Test pieces

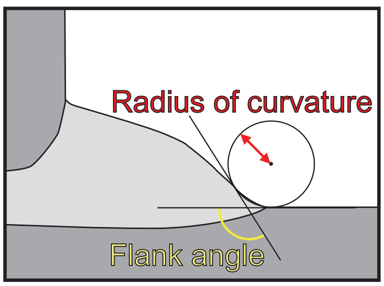


Photo 3 Configuration of welds

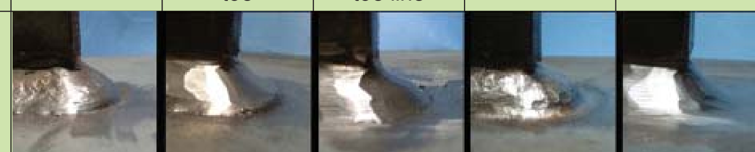
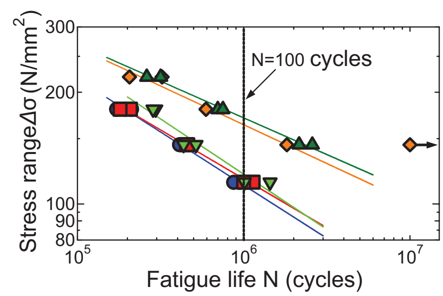
	As-welded	Untreated toe	Leaving of toe line	Burr grinder	Disc grinder
Appearance					
Radius of curvature	0.6 mm	0.5 mm	0.5 mm	5.7 mm	8.3 mm
Flank angle	120°	116°	125°	121°	147°

Fig. 2 Test Results

Legend	Test pieces	Fatigue strength at 1 million stress cycles	Comparison with as-welded test pieces
●	As-welded	112 N/mm²	-
■	Untreated toe	117 N/mm²	Improvement by 4%
▼	Leaving of toe line	120 N/mm²	Improvement by 7%
◆	Burr grinder	164 N/mm²	Improvement by 45%
▲	Disc grinder	171 N/mm²	Improvement by 52%



Report of JSSC's Working Group on Seismic Design Guidelines

Guidelines for Seismic and Damage-control Design of Steel Bridges

by Dr. Tsutomu Usami
Professor, Nagoya University (currently Meijo University)

Tsutomu Usami: After graduating from Washington University in 1970, he became an assistant of Nagoya University in 1970. Then he served as an assistant professor of Gifu University and Asian Institute of Technology. He became Professor of Nagoya University in 1987.

The Working Group on Seismic Design Guidelines, under the Committee to Improve Steel Bridge Performance of the Japanese Society of Steel Construction, is pressing ahead with three major projects—an examination of seismic resistance in cable-stayed and other steel bridges that will show complex dynamic behavior, the development of seismic retrofitting methods for steel bridges by means of damage-control structures, and the preparation of *Guidelines for Seismic* and *Damage-control Design of Steel Bridges* as a comprehensive presentation of the two preceding efforts.

In particular, the *Guidelines* will offer a detailed introduction to performance-based seismic and damage-control design that is based on the general concept of performance-based design for steel structures.

Examination of Seismic Resistance of Cable-stayed Bridges

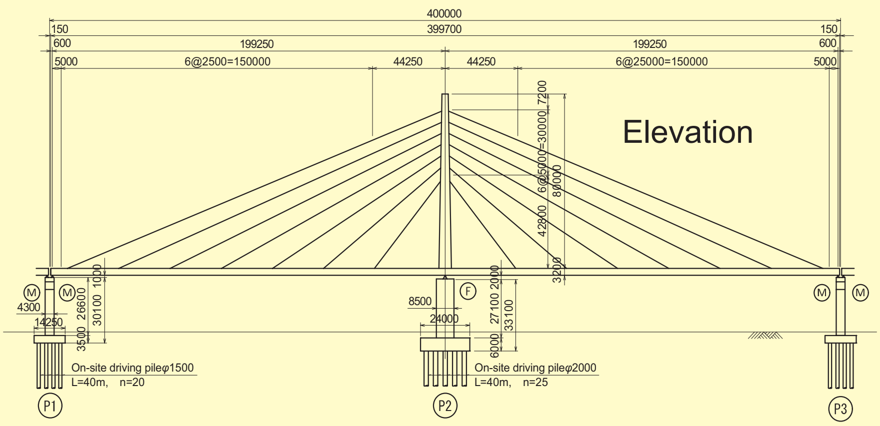
A summary of the damages inflicted on cable-stayed bridges by the Great Hyogo-ken Nanbu Earthquake of 1995 shows that damage was primarily concentrated in the bearings, while almost no damage was found in the main girders and main towers. By analyzing actual damage, a detailed analytical model of cable-stayed bridges was prepared (Fig. 1) and, based on elasto-plastic finite displacement analysis, measures were proposed to check and improve the seismic resistance of these steel bridges.

When seismic waves identical to those observed in the Higashi-Kobe Ohashi Bridge and Tsugaru-Kaikyo Ohashi Bridge were used in the analysis, it was found that damage perpendicular to the bridge axis was slight but damage in line with the bridge axis was severe in the P2 pier and the bearings (Tables 1 and 2). Two measures of reinforcement, wrapping the P2 pier with steel sheet and installing buckling-restrained brace (BRB) dampers at the end piers, were used to improve seismic resistance and were proven to be effective (Fig. 2).

Advanced Seismic Design (Adoption of BRBs)

Trial efforts are underway to improve the seismic resistance of steel bridges by incorporating into their structural system the buckling-restrained braces that are widely used in the field of steel building construction. The buckling-restrained brace introduced here effectively increases the bridge's capacity to absorb seismic energy during earthquakes through the combined use of bracing and buckling-restrained members (Figs. 3 and 4). It has been confirmed from the above-mentioned analytical models that the usefulness of vibration-control bracing can be secured by paying full attention in their arrangement within the bridge structure. Example applications of buckling-restrained braces in bridges are shown in Photo 1.

Fig. 1 Model Cable-stayed Bridge No. 1



- 2-span continuous steel cable-stayed bridge; length: 400 m; main tower height: 80 m
- Bridge pier: RC structure; fixed supports for P2 pier; mobile supports for P1 and P3 piers
- Cable: Multi-fan one-side suspended cable (7-step arrangement)
- Main tower on P2 pier: Steel one-column type; rigid connection of main tower and main girder; connection with P2 pier via pivot shoe
- Main girder: Steel floor slab/3 box girders with total width of 26 m
- Designed in conformity with Specification for Highway Bridges (1980) and JH Design Procedure (2nd version, 1979)

Table 2 Checking of Seismic Resistance

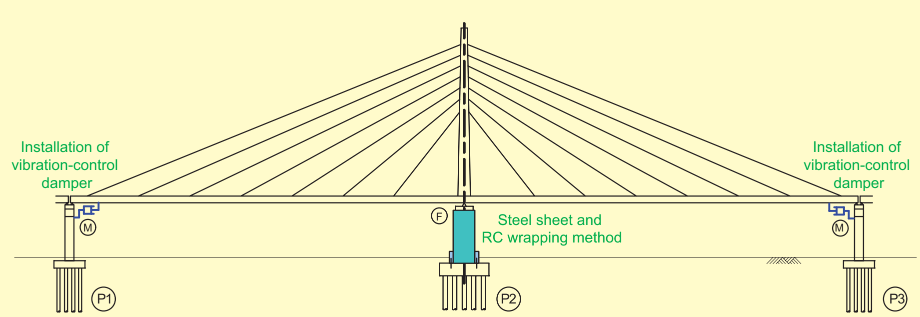
	HKB-NS-M	TGR-TR-M
Main tower	Elastic	Elastic
Bearings (P1, P3)	Max. 0.39 m	Max. 0.40 m
P1 and P3 piers	Max. 1.3 ε_{cu}	Max. 0.5 ε_{cu}
P2 pier	Max. 2.6 ε_{cu}	Max. 1.5 ε_{cu}

→ Great damages: P2 pier and bearings (P1 and P3)

>Pendel shoe Horizontal movable amount (0.21 m)

>ε_{cu} Ultimate strain

Fig. 2 Combined Use of Bridge Pier Reinforcement and BRBs



Strength reinforcement of intermediate pier by use of RC wrapping method and installation of BRBs on both end piers

	End pier (P1)		Intermediate pier (P2)			Pendel shoe
	Current bridge	After provision of countermeasures	Current bridge	After provision of countermeasures		
Response plasticity ratio μ_r	4.905	3.781	9.079	4.003	Response displacement (m) δ_r	0.207
Allowable plasticity ratio μ_a	3.832	3.832	3.768	9.676	Allowable displacement (m) δ_a	0.210
μ_r/μ_a	1.28	0.99	2.41	0.41	δ_r/δ_a	0.99
Judgment <1	NG	OK	NG	OK	Judgment <1	OK

Table 1 Target Seismic Resistance

Superstructure	$\varepsilon_a)_{max} \leq 2.0\varepsilon_y$
Bearings	Elastic limit or movable amount
Cable	Elastic limit
Substructure (RC)	$\varepsilon_{max} < \varepsilon_{cu} = 0.0035$
Buckling-restrained brace	$\varepsilon_{max} < 0.03$

Fig. 3 Buckling-restrained Brace (BRB)

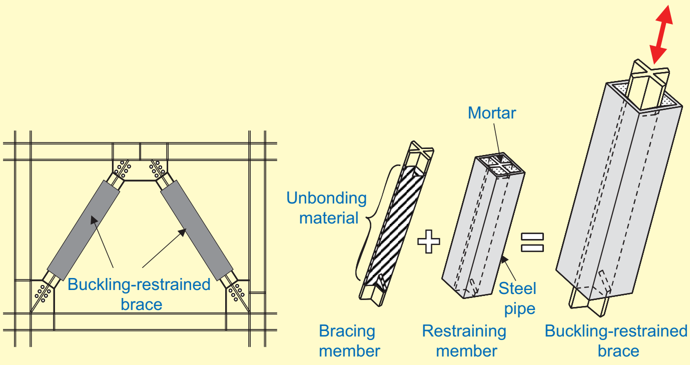
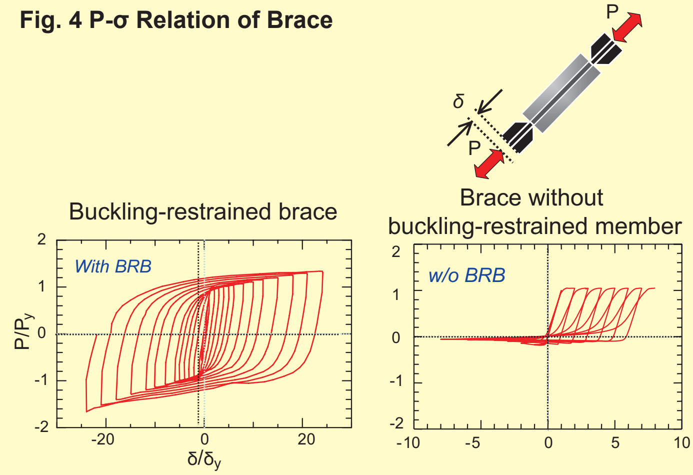


Fig. 4 P-σ Relation of Brace



Otobashi Bridge (arch bridge)

(a) Sway bracing

(b) Lateral bracing

Nagoya Expressway:
Elevated bridge falling-prevention device

Photo 1 Example applications of buckling-restrained braces in steel bridges

Report of JSSC's Working Group on Weathering Steel Bridges

Application Potential of Weathering Steel Bridges

By Dr. Eiki Yamaguchi
Professor, Kyushu Institute of Technology

Eiki Yamaguchi: After graduating from the Faculty of Engineering, University of Tokyo in 1981, he finished the doctor's course in civil engineering, Graduate School of Purdue University of the U.S. in 1987. He became professor, the Faculty of Engineering, Kyushu Institute of Technology in 2004.

Because of the unique property of suppressing the development of corrosion by a layer of densely-formed fine rust on steel surface, weathering steel is widely used in various steel structures such as bridges (Photo 1). A correct understanding of this unique property and the usage of this steel in suitable environments can allow for coating-free steel bridges to enjoy a long service life with minimum maintenance cost, leading to the growing applicability of the weathering steel to bridges (Fig. 1). In addition, a new nickel-type weathering steel applicable in severe corrosion environments has been developed, the application of which also increases steadily.

The Working Group on Weathering Steel Bridges, under the Committee to Improve

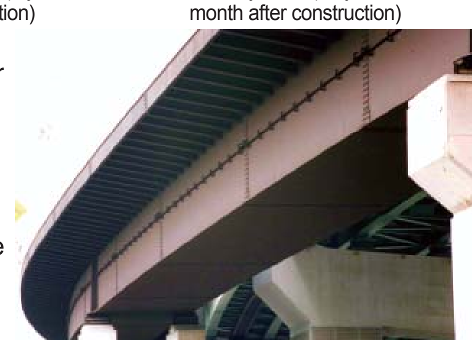
February 1982 (2 months after construction)

January 1983 (1 year and 1 month after construction)

January 1999 (17 years and 1 month after construction)

Skyway bridge in the urban area near coast

- Sanpo Approach Bridge, Osaka Coastal Line, Hanshin Expressway
- Completion: December 1981
- Coating-free weathering steel bridge



June 2004 (22 years and 6 months after construction)

Photo 1 Example of Weathering Steel Bridges

Steel Bridge Performance of the Japanese Society of Steel Construction, has made efforts to clarify various aspects of weathering steel bridges to minimize life-cycle cost by making the most of the unique property of weathering steel. The efforts include the drafting of the recommendations for corrosion-protection design, the development of maintenance scheme and the collection of relevant data. The Working Group plans to publish its achievements in the form of a 4-volume technical report shown in Table 1. Some of these achievements are described below.

Recommendations for Corrosion-protection Design of Weathering Steel Bridges (Draft)

The excellent corrosion resistance of weathering steel cannot fully be demonstrated under some environmental conditions. The key factors in overcoming such situations are becoming clear through technical studies and surveys conducted on actual weathering steel bridges.

Recommendations for Corrosion-protection Design of Weathering Steel Bridges (Draft) consists of six chapters (general, materials, structural plans, detailed designs, construction, and maintenance). Dealing with all the stages of the bridge life, *Recommendations* covers every element required for weathering steel to fully demonstrate excellent corrosion resistance. The basic design method employed is the performance-based design, and yet *Recommendations* also provides sufficient deemed-to-satisfy regulations for the corrosion-protection design of ordinary weathering steel bridges.

New Method to Assess Applicability

The methods to assess the applicability of weathering steel using environmental data have advanced rapidly in recent years. Nevertheless, because these methods are based on indirect indices, they have difficulty demonstrating accuracy. In order to solve this problem, an economical and simple means of assessing the applicability of weathering steel has been proposed. The new method has been named the "button test" (Fig. 2).

The button test is essentially an exposure test, using button-shaped weathering steel test specimens. In this method, if a steel bridge exists near the construction site of a new bridge, the exposure test will be conducted by attaching the test specimens to the existing bridge. If no appropriate bridge is available nearby, the test be conducted by installing an instrument screen. After exposed for a year, the weight losses of the test specimens due to corrosion are measured to judge the applicability of weathering steel at this particular construction site.

Several button tests have already been carried out, and the basic framework of the test procedure has been established. Technical studies are still ongoing in order to enhance the reliability of the button test even further.

Table 1 Report of Achievements by Working Group on Weathering Steel Bridges

- Volume A: Recommendations for Corrosion-protection Design of Weathering Steel Bridges (Draft)
  Scheme of corrosion-protection design, required performances, deemed-to-satisfy regulations
- Volume B: Manual to Verify Corrosion-protection Performances (data on corrosion-protection design)
  Explanation on detailed structures, performance checking methods, surface treatment
- Volume C: Maintenance and Repair Manual
  Soundness assessment methods, repair and reinforcing methods
- Volume D: Collection of Data
  Authentic data, data showing the effectiveness of proposed methods

Fig. 1 Application of Weathering Steel to Bridges

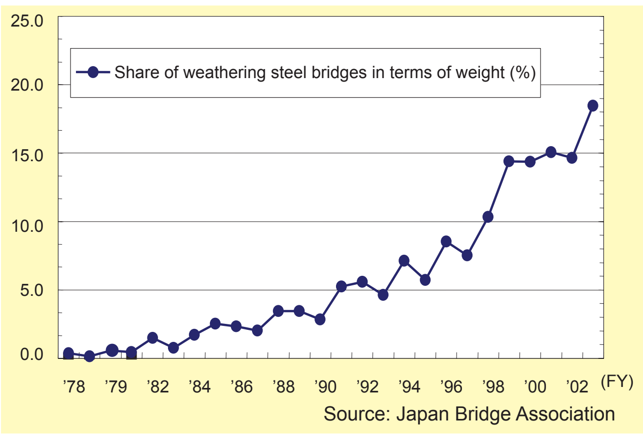
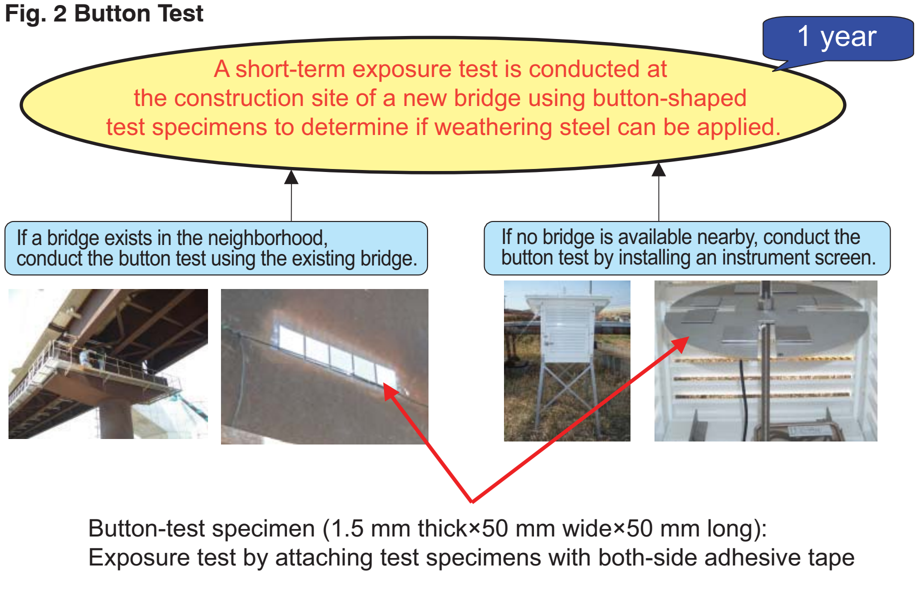


Fig. 2 Button Test



Three-part Series (3) + Extra Series

Design of High-rise Steel Buildings with High Redundancy

—Seismic-resistant Steel for Building Construction—

Since the 1980s, development efforts in the field of steel products for building construction have aimed at achieving greater strength, heavier thickness, larger cross sections, and higher performance (Fig. 1). These efforts were made to accommodate a trend toward taller, larger-scale building structures and have resulted in the marketing of an array of steel products with a wide range of strength levels up to 780 N/mm^2, as shown in Fig. 2.

SA440 steel (590 N/mm^2 grade), which is introduced in the following as one of these high-strength steel products, is experiencing considerable diffusion in the construction of high-rise, large-scale buildings in Japan.

Features of High-strength SA440 Steel

● Characteristic Mechanical Properties of SA440

Regarding the movement towards greater thicknesses and larger cross-sections, the development of a rolling method that utilizes the thermo-mechanical control process (TMCP) has led to the development and commercialization of TMCP steels for building structures with strength ratings of 490 to 520 N/mm^2. TMCP steels are used as high-strength materials for building structures that can be applied without reducing the standard design strength even when plate thicknesses surpass 40 mm.

High-strength SA440 steel was developed by making full use of TMCP and other advanced production technologies to produce every level available in terms of the characteristic performances commonly required of structural members.

The tensile strength of SA440 steel is 590 N/mm^2. The design method using SA440 steel conforms well to current prevailing design standards. Because SA440 steel can be welded in the same manner as conventional steel materials, the combined use of SA440 and conventional steel materials is expected to greatly benefit the future development of steel-structure construction.

Tables 1 and 2 show the material specifications for SA440 steel. This steel possesses

Fig. 1 Development in Steel Products for Seismic-resistant Structures

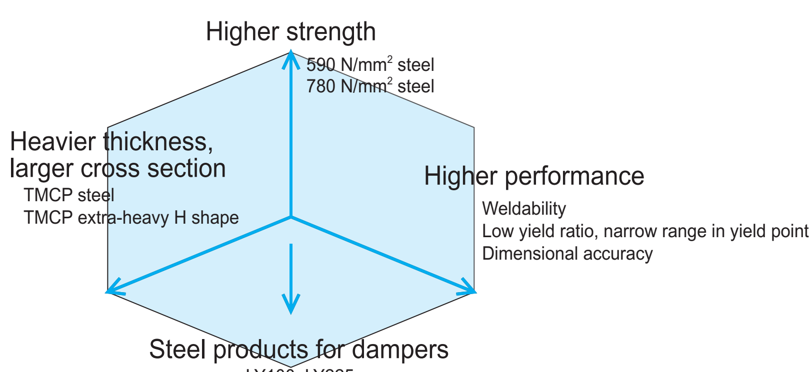
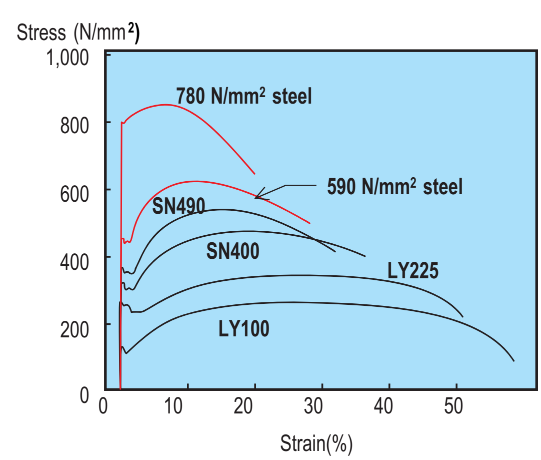


Fig. 2 Diverse Types of Steel Products for Seismic-resistant Structures



diverse performances that are necessary to secure seismic resistance in building structures. Its main features are:

- Low yield ratio: 80% or less
- Narrow range of yield point: 100 N/mm^2 (120 N/mm^2 for SN grade steel products)
- Applicability of prescribed standard design strength (=440 N/mm^2) even in cases when plate thicknesses surpass 40 mm
- High toughness: 47J or more at 0ºC in Charpy absorbed energy
- High weldability: Low in both carbon equivalent (Ceq) and weld-cracking sensitivity composition (Pcm)
- Fewer inclusions of impurities (low P and S contents)

● Difference from Current ASTM Standards for Building Structures

In the United States, steel products conform to the ASTM Standards. Table 3 shows the representative ASTM Standards used for building structures.

1) ASTM A992: Standards for wide-flange beams (H-shapes) of electric-furnace steelmakers in the U.S.

- Standards cover only 345 N/mm^2 class steel and do not cover high-strength steel.
- Maximum yield ratio is high: 85%.
- Charpy impact value is to be agreed upon between users and producers.

2) ASTM A913: Standards for steel products of Arcelor

- While high-strength steel (70 ksi=485 N/mm^2) is specified, the yield ratio is not specified for steel products other than 345 N/mm^2 steel; as a result, A913 is not suitable for use as a seismic-resistant steel.

3) ASTM A572: Standards for heavy plates in the U.S.

- While high-strength steel is specified, this standard is different from the standard for wide-flange beams that are widely used in building structures in the U.S.
- Yield ratio is not specified; thus, A572 heavy plates are not suitable for use as seismic-resistant steel.

In contrast to the above, SA440 steel is a high-strength seismic-resistant steel (with a specification for yield ratio) that is suitable for welding applications (with specifications for Ceq and Pcm); it can also be used in building structures in the form of heavy steel plates in combination with H-shapes. It is regarded as a seismic-resistant material that will satisfy any specific performance required for seismic-resistant applications.

● Outline of Structural Design Method Employing SA440 Steel (Regulations in Japan)

Regulations require that structural designs employing SA440 steel conform to the "*Guidelines for Designing and Welding of High-performance 590 N/mm^2 Steel (SA440 Steel) for Building Structures,*" published by the Japan Iron and Steel Federation. On the premise that structural

Table 1 Specifications for Mechanical Properties of High-performance 590 N/mm^2-class Steel Products for Building Structures (SA440B, SA440 C)

Grade	Plate thickness (t mm)	Tension test				Charpy absorbed energy$^{2)}$ (J)	Through-thickness reduction of area$^{3)}$ (%)
		Yield strength$^{1)}$ (N/mm^2)	Tensile strength (N/mm^2)	Yield ratio (%)	Elongation (test specimen) (%)		
SA440B	19 ≤ t ≤ 100	440 ≤ YS ≤ 540	590 ≤ TS ≤ 740	≤ 80	20 ≤ (No. 4) 26 ≤ (No. 5)	47 ≤	—
SA440C							25 ≤

Notes: 1) Yield strength: Yield point or 0.2% offset yield strength
2) Impact test: 0°C, L direction, position 1/4 the plate thickness
3) Through-thickness reduction of area: 3 specimens are subjected to the test, and the value of 15% or more in each test and the average value of 25% or more in 3 test values are accepted.
Remarks: 1) SA440C shall be subjected to the ultrasonic flaw detection test (JIS G 0901) and pass as the grade Y.

Table 2 Specifications for Chemical Composition of High-performance 590 N/mm^2-class Steel Products for Building Structures

(Unit: mass %)

Grade	Plate thickness (t mm)	C	Si	Mn	P	S	Ceq$^{1)}$	Pcm$^{2)}$
SA440B	10 ≤ t ≤ 40	≤ 0.18	≤ 0.56	≤ 1.60	≤ 0.030	≤ 0.008	≤ 0.44	≤ 0.28
	40 < t ≤ 100						≤ 0.47	≤ 0.30
SA440C	10 ≤ t ≤ 40				≤ 0.020		≤ 0.44	≤ 0.28
	40 < t ≤ 100						≤ 0.47	≤ 0.30

Notes: 1) Carbon equivalent

$$Ceq = C+Si/24+Mn/6+Ni/40+Cr/5+Mo/4+V/14 \ (\%)$$

2) Weld-cracking sensitivity composition

$$Pcm = C+Si/30+Mn/20+Cu/20+Ni/60+Cr/20+Mo/15+V/10+5B \ (\%)$$

Notes: 1) Each of Ceq or Pcm can be applied.
2) Alloying elements other than those listed in the table can be added if necessary.

Table 3 Comparison between SA440 Steel and ASTM Steel Products for Building Structures in Current Use

Standards		Type of products	Plate thickness (t mm)	Weldability: Ceq (%)	Weldability: Pcm (%)	Tension test: Yield strength (N/mm²)	Tension test: Tensile strength (N/mm²)	Tension test: Yield ratio (%)	Tension test: Elongation (test speci-men) (%)	Charpy absorbed energy (J)	Thickness-direction reduction of area (%)
High-strength steel standards	SA440B SA440C	Plates, shapes (tubes)	19-100	t ≤ 40: ≤ 0.44	t ≤ 40: ≤ 0.28	440-540	590-740	≤ 80	JIS 4: ≥ 20 JIS 5: ≥ 26	≥ 47 at 0°C	≥ 25 (Type C)
				t > 40: ≤ 0.47	t > 40: ≤ 0.30						
ASTM standards	A992	Shapes	A6	Group 4, 5: ≤ 0.47: others ≤ 0.45	—	345-450	450-	≤ 85	GL=200: ≥ 18 GL=50: ≥ 21	S5	S8
	A913	Shapes	A6	≤ 0.38	—	345-450	450-	≤ 85	GL=200: ≥ 18 GL=50: ≥ 21	S5	—
				≤ 0.40		415-	520-	—	GL=200: ≥ 16 GL=50: ≥ 18		
				≤ 0.43		450-	550-		GL=200: ≥ 15 GL=50: ≥ 17		
				≤ 0.45		485-	620-		GL=200: ≥ 14 GL=50: ≥ 16		
	A572	Plates, shapes, bars	A6	—	—	290-	415-	—	GL=200: ≥ 20 GL=50: ≥ 24	S5	—
						345-	t ≤ 20: 485-		GL=200: ≥ 18 GL=50: ≥ 21		
							t > 20: 455-				
						380-	485-		GL=200: ≥ 17 GL=50: ≥ 20		
						415-	520-		GL=200: ≥ 16 GL=50: ≥ 18		
						450-	550-		GL=200: ≥ 15 GL=50: ≥ 17		

designs employing SA440 steel will conform to design methods employing general steel products (shown in the Enforcement Order of the Building Standard Law of Japan), the *Guidelines* describes regulatory items involved in the design of SA440 steel members.

Accordingly, conformability has been established between design methods using SA440 steel and those using general steel products. When building composite SA440 steel-general steel structures, if the SA440 steel members are designed based on the *Guidelines* and the general steel members are designed based on the Enforcement Order, SA440 steel design can be conducted in the same manner as conventional structural design.

Example Applications of High-strength SA440 Steel in Japan

Because SA440 steel features not only low Ceq, instead of heavy thickness, but also high weldability, it is widely used as a column material for large-scale, high-rise buildings, represented by the Tokyo Metropolitan Government office building complex. In response to the increasing use of high heat-input welding in the manufacture of steel-frame members such as weld built-up box-section column members, applications of TMCP steel (a version of SA440 steel) in the construction market have grown to include all structural steel plates with thicknesses greater than 40 mm.

Photo 1 shows the Landmark Tower, the tallest building in Japan. Constructed as part of the Minato Mirai 21 Project, an urban development project under way in Yokohama, this building is representative of the use of 590 N/mm²-class steel as a building construction material.

Steel with a High Strength Level of 780 N/mm²

As mentioned above, high-strength steel with a strength rating of 780 N/mm² is being marketed in Japan, and applications for it in building structures are steadily increasing. Steel of this type has been developed that offers not only high seismic resistance but also enhanced construction efficiency, such as excellent weldability similar to that of the high-strength steels with strength levels below 590 N/mm². Because 780 N/mm²-grade steel has a yield strength twice that of 490 N/mm^2-grade steel, building construction that makes the most of this steel's high strength characteristics is now available.

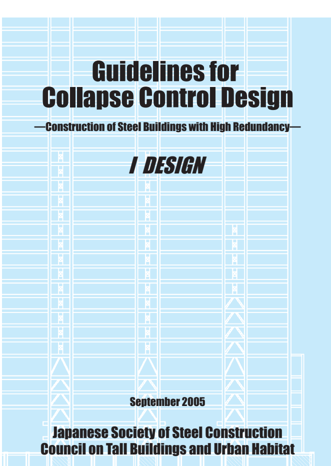
SA440 Steel: Effective in Enhancing Structural Redundancy

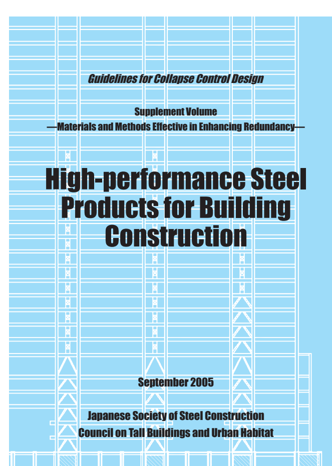
SA440 steel meets the need for steel products with greater cross-sectional size and strength and accommodates the trend toward taller, larger-scale building construction. At the same time, it secures seismic resistance through improvements in plastic deformation capacity and weldability. SA440 steel is well regarded as a structural material that effectively enhances structural redundancy in buildings.

SA440 steel, introduced above, and other high-performance steel products that are used for building construction in Japan and that are conducive to enhancing the structural redundancy of high-rise buildings are introduced in "*Guidelines for Collapse Control Design: High-performance Steel Products for Building Construction*". It is recommended that readers refer to this source, too.

Photo 1 Yokohama Landmark Tower

- Location: Yokohama, Kanagawa
- Floor area: 388,201.72 m^2 Tower 231,060 m^2
- No. of floor: 70 stories
- Structure: S and SRC
- SA440 steel application: Column





Guidelines for Collapse Control Design

Single copies of either, both or three documents—Guidelines I Design and II Research, and Supplement Volume—may be obtained free of charge by e-mailing or faxing to the following:

Market Development Group
Market Research & Development Division
The Japan Iron and Steel Federation
E-mail address: sunpou@jisf.or.jp
Fax: 81-3-3667-0245

Fourth Southeast Asia Steel Construction Seminar

The Fourth Southeast Asia Steel Construction Seminar was held in Ho Chi Minh City in Vietnam on November 18, in Hanoi in Vietnam on November 22, and in Kuala Lumpur in Malaysia on November 24, 2005. Jointly organized by the Japan Iron and Steel Federation (JISF) and the Japanese Society of Steel Construction (JSSC), the seminar was first held in 2002 with the aim of spreading steel construction among the countries of Southeast Asia and was conducted in collaboration with government agencies, organizations, and universities involved in construction in each of the participating nations. As a rule, the seminar is held annually in two countries, with sessions being held first in one country and then in the other.

The 2005 seminar marks the third time that the event was held in Hanoi, following previous events in 2002 and 2004. It was the second time for Kuala Lumpur following the 2003 event and the first time for Ho Chi Minh City. This was the first time ever that sessions were held in three cities. An outline of the 2005 seminar is shown on the back cover.

Ho Chi Minh City Seminar

The seminar held in Ho Chi Minh City was the first to be located in that city and was jointly conducted by JISF, JSSC, and the University of Transport in Ho Chi Minh City (UT-HCMC), a university operated by the Vietnamese Ministry of Transport (MOT). Because a number of construction projects are being promoted in the vicinity of Ho Chi Minh City, the seminar focused on civil engineering, in particular on port and harbor construction.

In the opening ceremony, Dr. Tran Canh Vinh, Rector of UT-HCMC, and Chairman Takeshi Katayama, JISF Committee on Overseas Market Promotion (a seminar sponsor), delivered opening addresses.

In the seminar session, the keynote address was delivered by Prof. Osamu Kiyomiya of Waseda University who introduced the design standards used for port and harbor steel structures in Japan. Other presentations by Japanese speakers covered seismic design for port and harbor piers and corrosion-protection design for steel structures.

Representing the Vietnamese side, Dean Nguyen Ba Trung of UT-HCMC delivered a lecture on the present status and future prospects of steel bridges in Vietnam. In this lecture, he indicated that there was great potential need for steel construction, mainly in infrastructure development in the country.

Communications in seminar sessions between Vietnam and Japan proceeded quite smoothly due to the excellent simultaneous Japanese-Vietnamese interpretation provided by Mrs. Nguyen Thi Tuyet Trinh, lecturer of the University of Transport and Communications. Seminar participants numbered about 100, mainly from universities, MOT, and other government agencies.

Hanoi Seminar

The Hanoi Seminar was held jointly by JISF, JSSC, and the Ministry of Transport (MOT) of Vietnam and with added support by the Embassy of Japan in Vietnam.

In the opening ceremony, opening addresses were delivered by MOT, Chairman Takeshi Katayama, JISF Committee on Overseas

Ho Chi Minh Seminar

Opening address by Rector Tran Canh Vinh of University of Transport in Ho Chi Minh City

Seminar setting at Ho Chi Minh City seminar

Hanoi Seminar

Opening address by First Secretary Tetsuro Ikeda of the Embassy of Japan in Vietnam

Seminar setting at Hanoi seminar

Market Promotion (a seminar sponsor), and First Secretary Tetsuro Ikeda of the Embassy of Japan in Vietnam, a distinguished guest.

In the morning session on ports and harbors, the keynote address was delivered by Prof. Osamu Kiyomiya of Waseda University on the design standards used for port and harbor steel structures in Japan. This was followed on the Japanese side by lectures on seismic design for port and harbor piers and corrosion-protection design for steel structures.

In the lecture from the Vietnamese side, Dr. Pham Van Hoi, Institute of Construction of MOET, introduced the current state of civil engineering structures in Vietnam.

In the afternoon session on steel bridges, Prof. Kentaro Yamada of Nagoya University delivered the keynote address on steel bridge design standards in Japan. In the session on new steel-structure technologies, lectures were presented by the Japanese side that introduced guidelines for collapse control design—construction of steel buildings with high redundancy—and discussed high-friction, high corrosion-resistant Zn alloy-coated steel wire.

The reports from the Vietnamese side consisted of a presentation on the repair of railway/highway bridge floor slabs by Dr. Pham Van He, the Institute of Transport Science & Technology under the control of MOT, and a presentation on the shop manufacture of steel box beams of suspension bridges constructed in Vietnam by Mr. Duong Van Sang, Mechanical & Construction-Engineering Co.

Mutual understanding between the two countries was deepened by the MOT reports mentioned above, which has led to the acquisition of information useful for effectively continuing future seminars. Further, communications between the two countries proceeded quite smoothly due to the excellent simultaneous Japanese-Vietnamese interpretation of Mrs. Nguyen Thi Tuyet Trinh, lecturer at the University of Transport and Communications. About 150 persons participated in the seminar, mainly from universities, MOT, MOC, and other government agencies.

Lecture by Prof. Kentaro Yamada of Nagoya University

Lecture by Prof. Osamu Kiyomiya of Waseda University

Kuala Lumpur Seminar

The Kuala Lumpur seminar was hosted jointly by JISF, JSSC, and the Malaysian Structural Steel Association (MSSA) and was held with the support of the Construction Industry Development Board (CIDB) of Malaysia. The seminar was also supported by the Ministry of Public Works and the Embassy of Japan in Malaysia.

The seminar opened with the delivery of opening greetings by Chairman Takeshi Katayama, JISF Committee on Overseas Market Promotion, Counsellor (Economic Section) Takuya Sasayama of the Embassy of Japan in Malaysia, President Y. Bhg. Tan Sri Dato' Ir. Hj. Zaini Omar of MSSA, and Minister of Works Y.B Dato' Seri S Samy Vellu.

The seminar session began with a keynote address by Prof. Kentaro Yamada of Nagoya University on steel bridge design standards in Japan. This was followed by an introduction of steel construction technologies applicable in Malaysia by Prof. Kentaro Yamada, Prof. Osamu Kiyomiya of Waseda University, and by three engineers from Japan's steelmakers.

Two reports were made by MSSA members on the current state of large space-truss structure construction in Malaysia and the promotion of construction projects in the Middle East. In Malaysia, the superiority of steel construction in terms of shorter construction periods, labor savings, high-quality structures, environmental issues, and other factors has been highly assessed. Also, MSSA, in tie-up with government organizations, is promoting diverse activities aimed at expanding the use of steel structures, particularly in the building construction field.

Kuala Lumpur Seminar

Greeting by Counsellor (Economic Section) Takuya Sasayama of the Embassy of Japan in Malaysia

Greeting by President Y. Bhg. Tan Sri Dato' Ir. Hj. Zaini Omar of MSSA

Greeting by Works Minister Y.B Dato' Seri S Samy Vellu

Executive guests and lecturers at the Kuala Lumpur seminar

Seminar setting at Kuala Lumpur seminar

JISF and JSSC plan to continue holding such seminars in Southeast Asian countries in the future with the major aim of promoting sound development and the diffusion of steel construction.

Outline of Southeast Asia Steel Construction Seminar for 2005

Seminar Sessions
—Ho Chi Minh City, Vietnam; November 18 at University of Transport in Ho Chi Minh City
—Hanoi, Virtnam; November 22 at Melia Hanoi Hotel
—Kuala Lumpur, Malaysia; November 22 at Hotel Nikko Kuala Lumpur

Keynote Addresses and Lectures
—Japan
Keynote Addresses
•" Development of Steel Bridge Design Standards and Project Examples in Japan" *
by Kentaro Yamada, Professor, Graduate School of Environmental Studies, Nagoya University
•" Development of Design Standards of Port and Harbor Steel Structures in Japan"**
by Osamu Kiyomiya, Professor, Waseda University
•" Development of Design Standards and Seismic Design of Port and Harbor Steel Structures in Japan"***
by Osamu Kiyomiya, Professor, Waseda University
•" Development of Seismic Design of Port and Harbor Steel Structures in Japan"****
by Osamu Kiyomiya, Professor, Waseda University
Lectures
•" Development of Design Standards of Port and Harbor Steel Piled Piers and Examples of Design and Construction in Japan"
by Takeshi Oki, Staff Deputy Manager, Construction Materials & Services Center, JFE Steel Corporation
•" Establishment of Corrosion-protection Design Methods for Steel Structures and Future Development in Japan"
by Hiromasa Nakano, Manager, Construction Technology Department, Sumitomo Metal Industries, Ltd.
•" Development of Steel-structure Buildings and Structural Redundancy in Japan"*
by Yukio Murakami, Deputy Manager, Construction Materials & Services Center, JFE Steel Corporation
•" High Corrosion Resistance Zn Alloy Coated Steel Wire with High Friction"***
by Satoshi Sugimaru, Manager, Wire Rod Quality Control Department, Nippon Steel Corporation
*Hanoi and Kuala Lumpur seminars
**Ho Chin Minh seminar
***Hanoi seminar
****Kuala Lumpur seminar

—Ho Chi Minh City, Vietnam
Lectures
•" Present Status and Future Prospects of Steel Bridges in Vietnam"
by Nguyen Ba Trung, Dean, University of Transport in Ho Chi Minh City

—Hanoi, Vietnam
Lectures
•" Overall Picture on Current Research of Application and Development of Steel Structure in Civil and Industrial Construction in Vietnam"
by Pham Van Hoi, Assistant Professor and Colleagues, Department of Steel and Wooden Structures, Institute of Construction, Hanoi, MOET
•" Research for Technological Solution for Repairing of Steel Plate Surface of Thang Long Bridge"
by Dr. Pham Van He, The Institute of Transport Science & Technology, MOT
•" Introduction on New Technology for Manufacturing of Steel Box Beams of Rod Suspending Bridge of Thuan Phuoc, Da Nang Province"
by Mr. Duong Van Sang, The Mechanical & Construction-Engineering Co., No 623

—Malaysia
Lectures
•" Design and Construction of Large Clear Span Buildings The Strarch Perspective"
by Dr. Peter William Key, Kencana STRARCH Sdn Bhd
•" Doing Business In Overseas (Middle East)"
by Mr. Rohan Raj, Eversendai Corporation

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Representative examples of rationalized design of steel bridges: prolonged service life realized by unpainted weathering steel bridge, seismic reinforcement by use of vibration-control devices, and economical design through minimum use of main girders.
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A quarterly magazine published jointly by
The Japan Iron and Steel Federation
3-2-10, Nihonbashi Kayabacho, Chuo-ku, Tokyo 103-0025, Japan
Phone: 81-3-3669-4815 Fax: 81-3-3667-0245
Chairman: Akio Mimura
URL http://www.jisf.or.jp
Japanese Society of Steel Construction
Yotsuya Mitsubishi Bldg. 9th Fl., 3-2-1 Yotsuya, Shinjuku-ku, Tokyo 160-0004, Japan
Phone: 81-3-5919-1535 Fax: 81-3-5919-1536
President: Akira Chihaya
URL http://www.jssc.or.jp

Editorial Group
JISF/JSSC Joint Editing Group for Steel Construction Today & Tomorrow
Editor-in-Chief: Takeshi Katayama

The Japan Iron and Steel Federation
● Beijing Office
Rm. 609, Jongtai Tower, 24 Jianguomenwai-Street, Chaoyang-District. Beijing. 100022, China
Phone/Fax: (010) 6515-6678
Phone: (010) 6515-6699 (Ext. 30221)