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<Lecture>

Activities to Develop Steel Construction in Japan

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AOTS

The Association for Overseas Technical Cooperation and Sustainable Partnerships

Activities to Develop Steel Construction in Japan

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Masahiro NAGATA

1. Steel Structures Applied for Seismic Design

1-1. Past Earthquake Disasters and Transition in Seismic Design Code
1-2. Seismic Retrofitting
1-3. Steel Structures Applied for Seismic Design

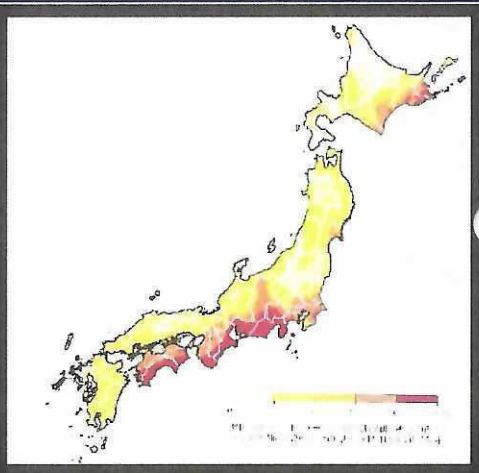
Damage from three major earthquakes in the past 100 years

	Great Kanto Earthquake	Great Hanshin-Awaji Earthquake	Great East Japan Earthquake
Date & Time	Sept. 1, 1923, 11:58	Jan. 17, 1995, 5:46	March 11, 2011, 14:46
Earthquake scale	M7.9	M7.3	M9.0
Persons dead or missing	105,000 90% burned to death	5,500 70% asphyxiation or crushing to death	18,000 90% drowned
Disaster-related death	–	900 people	3,800 people
Totally destroyed or burned houses	290,000	110,000	120,000
Total amount of damage	5.5 billion yen	9.6 trillion yen	16.9 trillion yen
GDP at the time	14.9 billion yen	522 trillion yen	497 trillion yen
Relative to GDP	37%	2%	3%
National budget at the time	1.4 billion yen	73 trillion yen	92 trillion yen

Source: Cabinet Office website "The Great Kanto Earthquake 100 years" special page

Anticipated Earthquake Damage (1)

- Disaster mitigation for earthquakes is a crucial concern.
- Improvement of seismic performance of buildings is important



Distribution of the probability of tremors with an intensity of 6 or greater over the next 30 years
(Source: National Research Institute for Earth Science and Disaster Prevention)

	Nankai Trough Earthquake	Earthquake directly hits Tokyo area
Disaster area	Tokai, Kinki, Chugoku, Shikoku, Kyushu	Around Metropolitan Area
Persons dead	323,000	23,000
Evacuee	9,500,000	7,200,000
Economic Damage	214.2 trillion yen	95.3 trillion yen

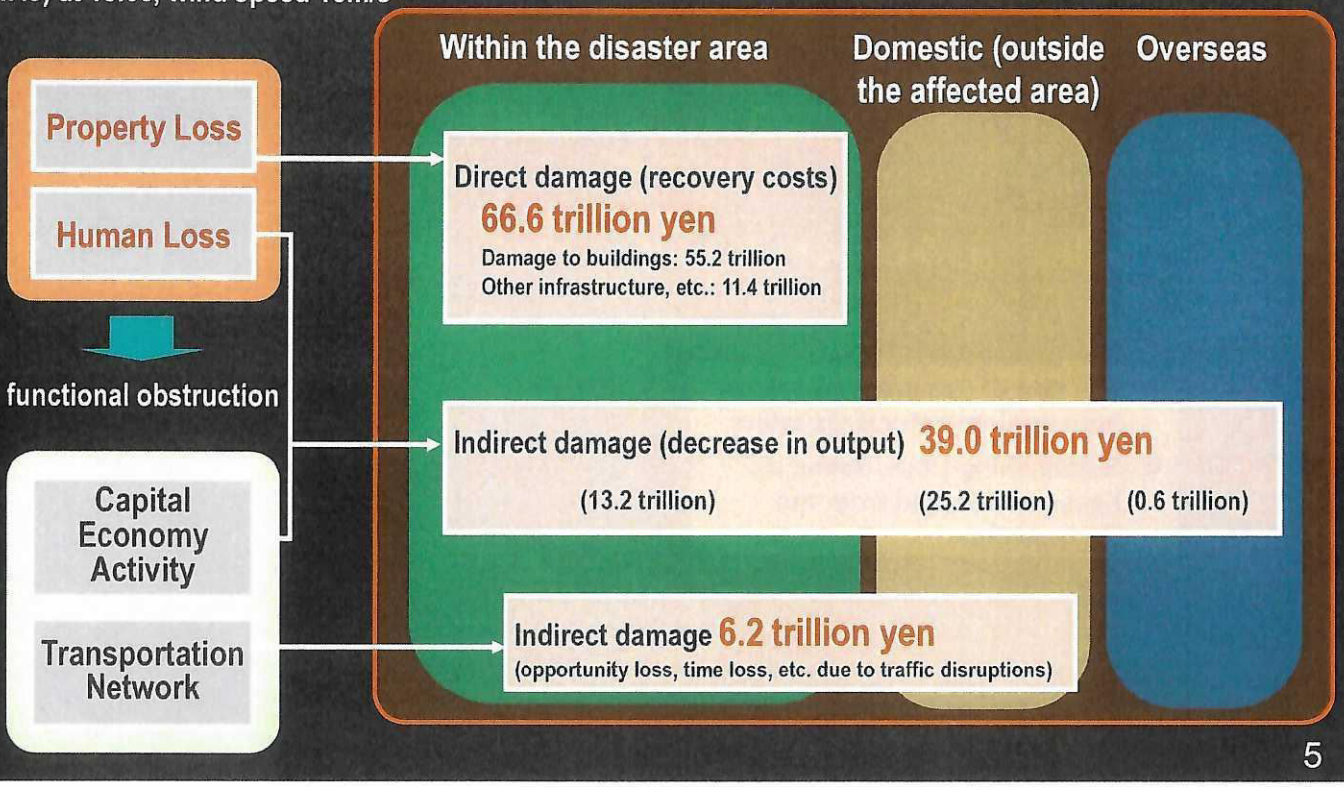
Source: Nikkei, Central Disaster Management Council, Cabinet Office

Anticipated Earthquake Damage (2)

Economic damage: 112 trillion yen

Japan's GDP, FY2021: 541 trillion yen
National budget, FY2022: 107 trillion yen

Assumed occurrence of earthquake in northern Tokyo Bay (M7.3) at 18:00, wind speed 15m/s



How to improve earthquake resistance?

It is the fate of Japanese people to fight against natural disasters.

1. Seismic Code Based on Lessons Learned from Past Disasters

- The effectiveness of the new seismic design code was widely recognized due to the damage caused by the Great Hanshin Earthquake.
- At that time, the concept of economic loss due to disasters, the evaluation of the value of buildings as social assets, and BCP business continuity also gradually began to spread, and in 1997 the government enacted the Act on Promotion of Seismic Retrofitting of Buildings, which promoted the reinforcement of existing buildings against earthquakes.

2. Increased use of seismic control and seismic isolation structures

Many buildings were damaged in the Great Hanshin Earthquake and could not be used continuously, which subsequently led to increased use of seismic control and seismic isolation structures.

3. Project to develop a design method to achieve seismic intensity 7

The seismic design method which sets the performance of the main structure to remain undamaged even if it encounters an earthquake of <seismic intensity 6+ level>, which is the level of damage allowed under the current seismic design.

Past Earthquake Disasters and Transition in Seismic Design Code (1)

1919	**Old Urban Building Regulation Law** (First building code, 31-meter building height limit)
1923	**Great Kanto Earthquake** (M7.9, direct hit to the capital, more than 105,000 dead or missing, mainly due to fires)
1948	**Fukui Earthquake** (M7.1, high collapse rate due to soft ground, severe damage to buildings with few walls)
1950	**Building Standard Law** (Predecessor to the Old Urban Building Regulation Law)

- The fate of Japanese people to fight against natural disasters
- Establishing Laws Based on Lessons Learned from the Earthquake

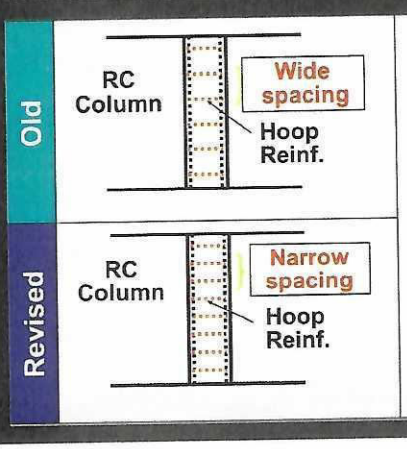
【Great Kanto Earthquake】
Severe damage to brick construction imitating Europe and the U.S., oriented toward Japan's own seismic design (RC, S, SRC)

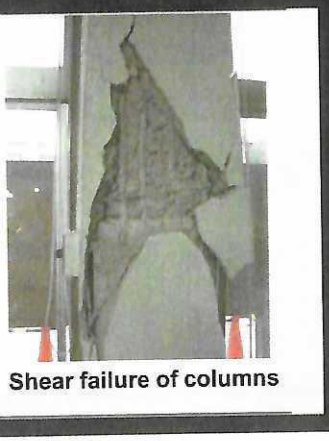
【Fukui Earthquake】
Destruction of the Department Store, obtaining useful guidelines for the seismic design of RC structures.

Past Earthquake Disasters and Transition in Seismic Design Code (2)

1968	**Tokachi-oki Earthquake** (M7.9, serious damages to RC structures)
1971	**Revised Building Standard Law** (severer restriction on column hoop reinforcement spacing)
1978	**Miyagiken-oki Earthquake** (M7.4)
	By the 1980s, about 200 seismometers had been installed throughout Japan and were used for advanced structural analysis using seismic waves, and dynamic seismic design methods were developed.
1981	**Revised Building Standard Law** (the new seismic design code)

【Tokachi-oki Earthquake】
Shear failure of RC columns is apparent.




Shear failure of columns

Past Earthquake Disasters and Transition in Seismic Design Code (3)

1981	**Revised Building Standard Law** (the new seismic design code)
1995	**Great Hanshin Earthquake** (M7.3, serious damages to the buildings constructed before 1981, the enforcement of new seismic design code)

Collapses and failures were concentrated in buildings built before 1971. In contrast, buildings designed after 1981 suffered almost no damage, and the effectiveness of the new seismic design code was widely recognized. At the same time, economic losses due to disasters, the appreciation of the value of buildings as social assets, and the concept of business continuity, known as BCP, began to spread, and in 1997 the government enacted a new law to promote the seismic retrofitting of existing buildings.

【Policy Responses】

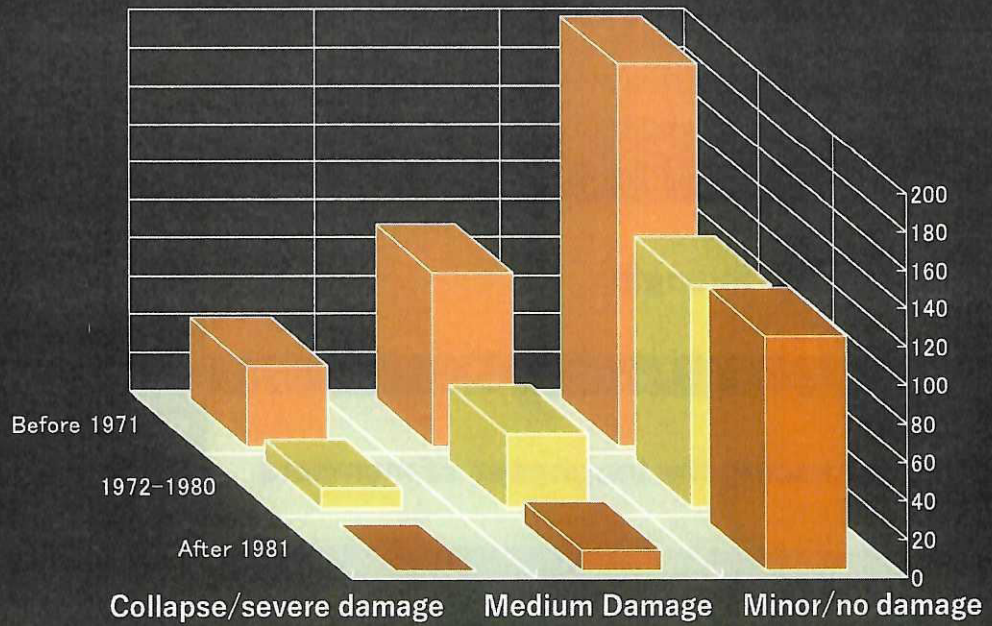
In 1997, seismic evaluation became mandatory for large buildings used by an unspecified number of people, such as hospitals, stores, and hotels, and for buildings used by vulnerable evacuees, such as schools and nursing homes.

【Future Issues】

In the Great Hanshin Earthquake, many buildings were damaged and could not be used continuously. This is because the Building Standards Law allows for damage to buildings in the event of a major earthquake of seismic intensity 5 or higher to 6 or lower, although human life is ensured. In addition, under the current earthquake resistance standards, buildings may collapse under a seismic intensity 7 class earthquake.

Examples of Damage to RC Structures in the Great Hanshin Earthquake

Survey of 631 school buildings (Source: AIJ)



Severe Damage to RC School Buildings Before the Revision of the Building Design Code;

(1) the severe restriction on the column hoop reinforcement spacing (1971)

(2) the new seismic design code (1981)

Past Earthquake Disasters and Transition in Seismic Design Code (4)

2003	**Tokati-oki Earthquake** (M8.0) (Oil tank damage by Long-period Earthquake Motions)
2004	**Indian Ocean Earthquake & Tsunami** (M9.0)
2011	**Great East Japan Earthquake & Tsunami** (M9.0, serious damages to the buildings by Tsunami, Building response by Long-period Earthquake Motions) ● **Amendment of the law to promote seismic retrofitting,** ● **Implementation of Tsunami design** ● **Study of Long-period Earthquake Motions**

Tsunami damage from the Great East Japan Earthquake

Tsunami evacuation tower

Government Building, Osaka (256 m, 55F) 10-minute shake, max. amplitude 2.7m

Seismic Retrofitting

The purpose of seismic retrofit is to increase the value of an existing building by providing seismic performance equal to or better than the current design code. In most cases, **seismic retrofits target buildings built before 1981, and the goal is to increase seismic performance to a level equal to or better than that specified in the new seismic design code.**

1. Improve Strength

2. Enhancing the toughness of members

3. Seismic Control and Isolation

Number of Seismic Control and Isolation Structures (estimate)

Vibration Control Buildings (Cumulative)

Source: The Japan Society of Seismic Isolation

- Over 1,600 buildings in total through 2021
- Adopted for most high-rise buildings
- Offices (39%), housing complexes (18%), schools & gymnasiums (8%), research facilities (8%), etc. as of 2018

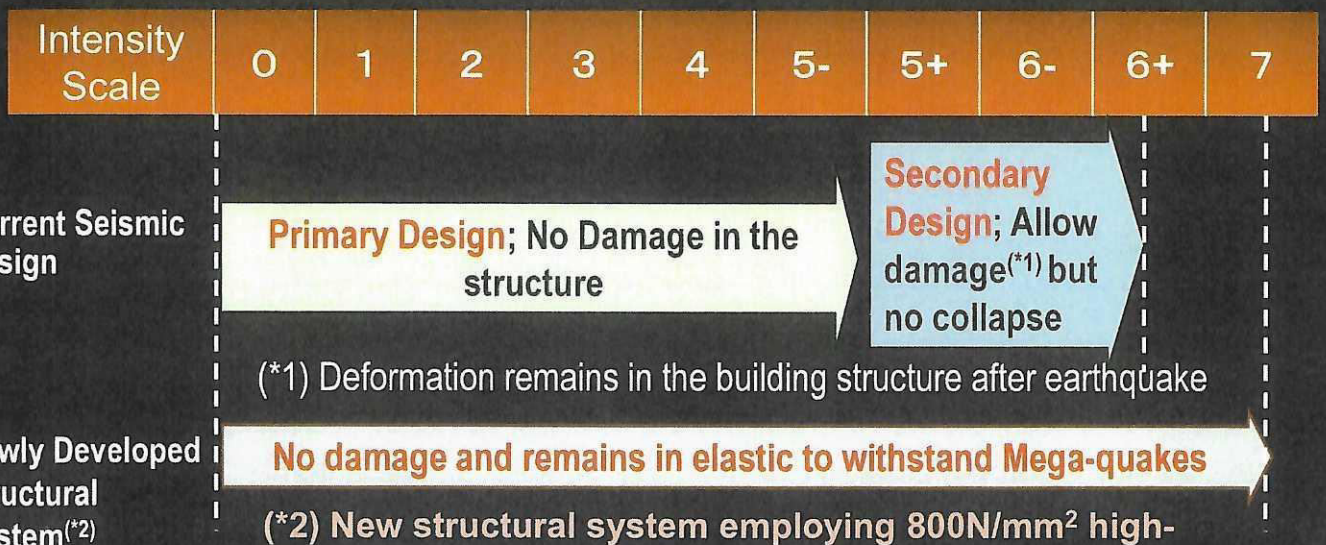
Base Isolation Buildings (Cumulative)

- Over 5,300 buildings in total through 2021
- Adopted for housing complexes (39%), offices (15%), hospitals & clinics (13%), government buildings (6%), warehouses (4%), etc. as of 2018

Structural System to Withstand Mega-earthquakes

National Project (2015-17) for the Utilization of Seismic Damage-free Building Technology;

1. ***Prevents the deterioration of social assets.***
2. ***Contributes to disaster prevention and mitigation, resulting in sustainable urban life.***



Goals for New Structural System Buildings

"Social Asset Building" protecting the safe and security of citizens

Item	Development Goals
Strength of steel	Double the strength of conventional steel
Seismic performance	Elasticity against seismic intensity 7 No damage to main structure
Durability	200 years
Column span (number of columns)	1.5 to 2 times longer spans than conventional structure (50 to 25% fewer columns)
Building system	"Skeleton-infill system", separate frame and housing units, reusable and recyclable
Change of use	Flexibly changeable applications
Construction period	Equivalent to or shorter than current construction methods
Construction cost	Less than 1.1 times cost of conventional steel structure based on current design method

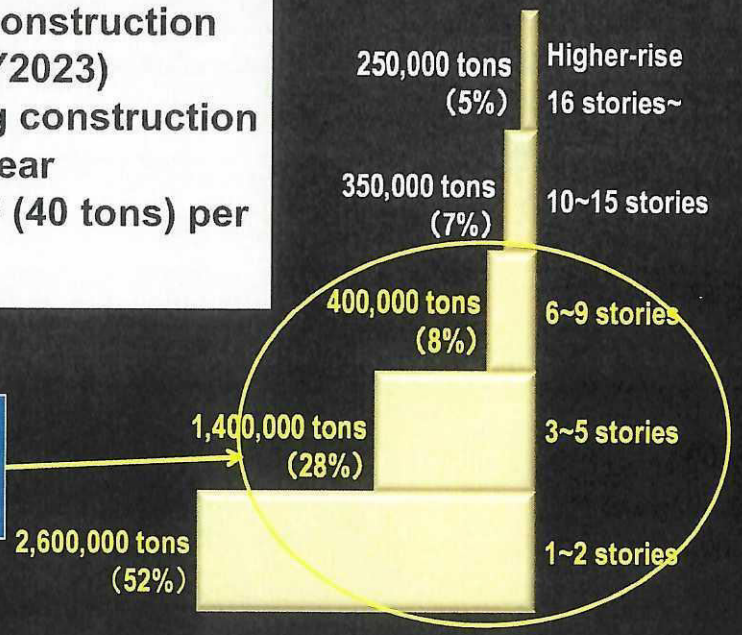
2. Importance of Laws, Standards and Codes

2-1. Characteristics of the Construction Market
2-2. Laws, Standards and Codes for Steel Construction and Seismic Design
2-3. Steel Products Suitable for Steel Construction and Seismic Design

Characteristics of the Steel Construction Market in Japan

Characteristics of Steel Construction Market

- Number of new building construction starts: 90,000 per year (FY2023)
- Floor area of new building construction starts: 38 million m^2 per year
- Average floor area: 400m^2 (40 tons) per building



The key to the development of steel structures is the middle- to low-rise building market.

Annual usage of steel products used for Steel-framed Buildings: 5 million tons

Strategies in the Mid- to Low-rise Building Market

Construction market is composed of large number of small to mid-size companies

- Design Offices: 100,000 offices
- Construction Companies: 500,000 companies
- Fabricators: 30,000 companies

In order to develop steel structures in the field of mid- to low-rise building market, a wide range of comprehensive strategies;

1. Code and Standards; Guidebooks and supplementary documents for engineers, fabricators and construction companies
2. System to ensure structural quality; Building Certification and Evaluation and Approved System for New Construction Technologies and Materials
3. Qualified Engineers and Certification of Fabrication Plants; responsible for Steel Construction
4. Educational programs; Seminars and field studies

Supposed Activities to develop steel structures

Item	Activities
Code & Standard, Guidebooks	● Guidebooks to supplement the code & standards
	● Structural Steelwork Specification & manuals, fabrication, erection, inspection, quality control etc.
	● Design manuals for fire-protection, roof and wall...
System to Ensure Structural Quality	● Building Certification
	● Structural performance evaluation for new materials and construction technology ...
Qualification and Certification System	● Qualified Engineers responsible steel construction (welding, bolt, ultrasonic testing, supervisors etc.)
	● Certification of fabrication plant
Promotion, Educational Program	● Educational program & seminar for not only engineers but general public
	● Training course for skilled workers, i.e. welding
	● Efforts toward development of steel structures by the settlement of related organization ...

Construction Market Structure and Characteristics

<Civil>	<Building>
Government Investment	**Private Investment**
● The clients are public organizations (professionals) ● Quality control is possible by the client ● Standards set for professionals	● The clients are private (not necessarily professionals) ● Need for quality assurance measures that do not depend on the builder ● Standards set by law

District Construction Bureau | Construction Consulting firm | Architectural Design Office (100,000 companies)

Steel Fabricator (30,000 companies)

Construction company (500,000 companies)

- (Bridges) Specifications for highway bridges
- (Port and Harbor) Technical Standards and Commentaries for Port and Harbor Facilities
- Other civil engineering specifications, etc.

- Building Standard Law, Notification
- AIJ (Architectural Institute of Japan) standards
- Design guidelines, etc.

■ Laws, design standards, and guidelines ⇒ Key to popularization of steel structures
■ GC, design firms, consultants ⇒Options other than steel structures available

Government, Academia and Industry Organizations related to Steel Construction

Government

✓ *Steel Products, JIS and ISO*

Ministry of Economy, Trade and Industry (METI)
- Manufacturing Industries Bureau
  - Iron and Steel Division
    Iron and Steel Technology Office
- Industrial Science and Technology Policy and Environmental Bureau
  - Office of Standard and Certification

✓ *Steel Products for building use and Construction Technologies*

Ministry of Land, Infrastructure, Transport and Tourism (MLIT)
- Housing Bureau
  - Housing Production Division
  - Building Guidance Division
  - Urban Building Division

Governmental Research Institute

- National Institute for Land and Infrastructure Management (NILIM)
- Building Research Institute (BRI)

Academia

- Universities
- Graduate Schools
- Technical Colleges

Academic Society and Institute

- Japanese Society of Steel Construction (JSSC)
- Architectural Institute of Japan (AIJ)
- Iron and Steel Institute of Japan (ISIJ)
- Japan Welding Society (JWS)

Government-affiliated Organization

✓ *Designated performance evaluation institution by MLIT*

- Building Center of Japan (BCJ)
- General Building Research Corporation of Japan (GBRC)
- Japan testing Center for Construction Materials (JTCCM)
- Better Living (BL)
- Japan Building Disaster Prevention Association

Industry Groups

Steel makers
- Japan Iron and Steel federation (JISF)

Structural Engineers
- Japan Structural Consultants Association (JSCA)

Construction companies
- Japan Federation of Construction Contractors (JFCC)
- The Overseas Construction Association of Japan, Inc. (OCAJI)

Fabricators
- Japan Steel Constructors Association
- Japan Steel Fabrication Association (JSFA)

Welding Engineers
- Japan Welding Engineering Society (JWES)

Home builders
- Japan Prefabricated Construction Suppliers & Manufacturers Association

3-1. Codes and Standards

Categories	Organizations in charge
• *Building Standards Law* • *Notification of MLIT*	*Ministry of Land, Infrastructure, Transport and Tourism (MLIT)* • Housing Bureau: Building Guidance Division • National Institute for Land and Infrastructure Management (NILIM) • Building Research Institute (BRI)
• *Japan Industrial Standard (JIS)*	*Ministry of Economy, Trade and Industry (METI)* Industrial Science and Technology Policy and Environmental Bureau - Office of Standard and Certification
• *Standards & Recommendations* • *JASS6 (Structural Steelwork Specification for Building Construction)*	*Architectural Institute of Japan (AIJ)*
• *Design Manuals* • *Design Guidebooks (For steel structures)*	*Japanese Society of Steel Construction (JSSC)*

Publications related to Steel Construction

JSSC office

JIS
(Japan Industrial Standard)

Building
Standards Law

Design Standards & Recommendations mainly published by AIJ (Architectural Institute of Japan)

- Technical Reports
- JSS Standards

- Steel Construction Engineering
- Proceedings of Constructional Steel

- Journal of Steel Structures & Construction
- Steel Construction Today &Tomorrow

Publications issued by AIJ (1)

Design Standards and Recommendations in the field of Steel Structures are mainly published by AIJ (Architectural Institute of Japan)

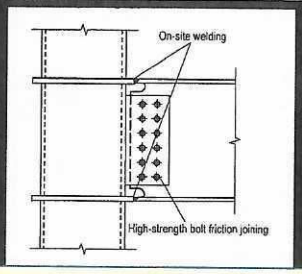
Structural Design

1	鋼構造設計規準－許容応力度設計法－ Design Standard for Steel Structures - Based on Allowable Stress Concept - (in English)
2	鋼構造塑性設計指針 Recommendations for the Plastic Design of Steel Structures
3	鋼構造限界状態設計指針・同解説 Recommendation for Limit State Design of Steel Structures
4	鋼構造座屈設計指針 Recommendations for Stability Design of Steel Structures
5	鋼管トラス構造設計施工指針 Recommendations for the Design and Fabrication of Tubular Truss Structures in Steel
6	軽鋼構造設計施工指針・同解説 Recommendations for the Design and Fabrication of Light Weight Steel Structures
7	鋼構造制振設計指針 Recommended Provisions for Seismic Damping Systems applied to Steel Structures
8	鋼構造耐火設計指針 Recommendations for Fire Resistant Design of Steel Structures

Publications issued by AIJ (2)

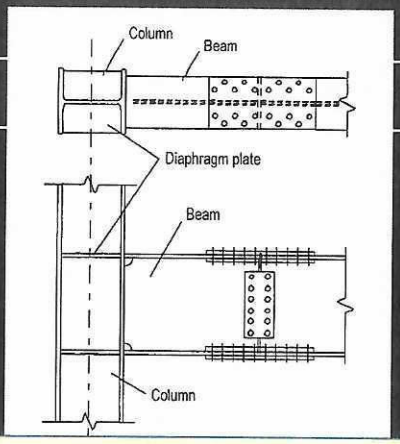
Connection

1	鋼構造接合部設計指針 Recommendation for Design of Connections in Steel Structures
2	高力ボルト接合設計施工ガイドブック Guidebook on Design and Fabrication of High Strength Bolted Connections
3	溶接接合設計施工ガイドブック Guidebook on Design and Fabrication of Welded Connections
4	各種合成構造設計指針・同解説 Design Recommendations for Composite Constructions



On-site welding

- Lots of restrictions at construction site, for example, welding position and conditions (temperature, wind protection, etc.)
- Needs for well-skilled labor



Shop welding

- Column-beam are connected by shop welding
- Beams are jointed by high-strength bolts on site
- Easy management for quality control of joints

Publications issued by AIJ (3)

1 **JASS 6, Structural Steelwork Specification for Building Construction**

(English Version)

Commentary

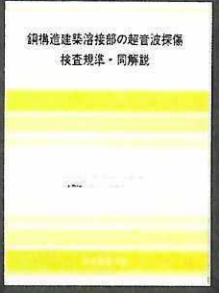
2 **Technical Recommendations for Steel Construction for Buildings**

(Part1: Fabrication)

(Part 2: Erection and Construction)

3 **Recommendations for Quality Criteria and Inspection Standards of Steel Structures**

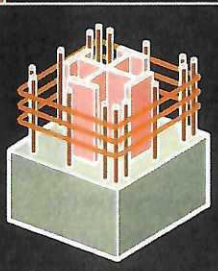
4 **Standard for the Ultrasonic Inspection of Weld Defects in Steel Structures**



Publications issued by AIJ (4)

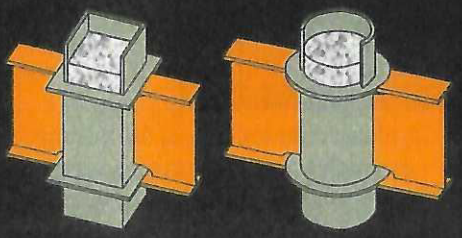
Composite and Mixed Structures

	Publications
1	鉄骨鉄筋コンクリート構造計算規準・同解説 AIJ Standards for Structural Calculation of Steel Reinforced Concrete Structures (in English)
2	鉄骨鉄筋コンクリート造配筋指針・同解説 Recommendation for Design and Placing Reinforcement on Steel Reinforced Concrete Structures
3	合成構造設計規準 Design Standard for Composite Structures
4	鉄筋コンクリート柱・鉄骨梁混合構造の設計と施工 Design and Construction of Mixed Structures Composed of Reinforced Concrete Columns and Steel Beams
5	コンクリート充填鋼管構造設計施工指針 Recommendations for Design and Construction of Concrete Filled Tubular Structures
6	コンクリート充填鋼管構造設計ガイドブック Guidebook on Design of Concrete Filled Steel Tubular Structures



SRC structure

RC-columns and Steel-beams

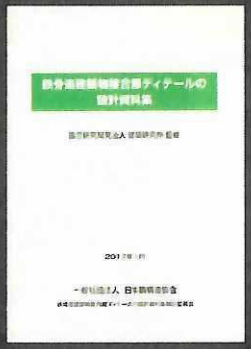


CFT structures

Publications issued by JSSC (1)

Detail Design

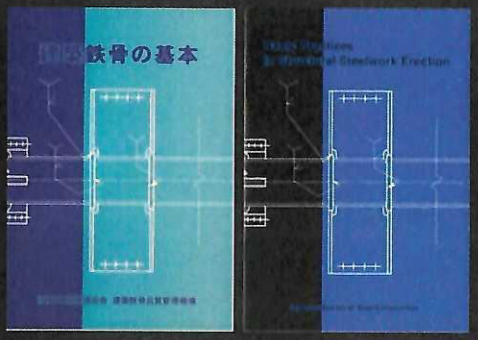
	Publications
1	鉄骨構造標準接合部 Design Standard of Bolted Connections for Steel Structures
2	鉄骨造建築物接合部ディテールの設計資料集 Design Materials of Connection Details for Steel Structures
3	建築構造用アンカーボルトを用いた露出柱脚設計施工指針・同解説 Recommendations for Design and Construction for Column Base using Anchor Bolts
4	既存鉄骨造建築物の耐震改修施工マニュアル Design and Construction Manual for Seismic Retrofit of Steel Structures

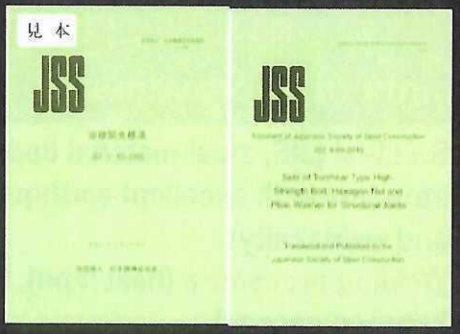


Publications issued by JSSC (2)

Steel Fabrication, Welding and Bolted Connection

	Publications
1	建築鉄骨の基本 Basic Practices in Structural Steelwork Erection (in English)
2	工作しやすい鉄骨設計 Steel Detailing for Simple Fabrication
3	溶接開先基準 Recommended Joint Preparation for Steels
4	構造用トルシア形高力ボルト、六角ナット、平座金のセット Sets of Torshear Type High-strength Bolt, Hexagon Nut and Plain Washer for Structural Joints (in English)

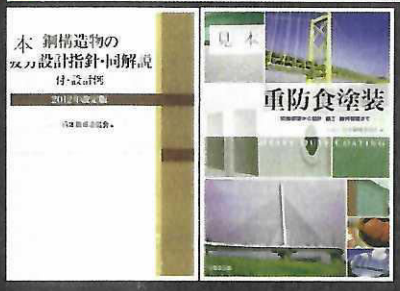




Publications issued by JSSC (3)

Others

	Publications
1	鋼構造物の疲労設計指針・同解説 Fatigue Design Recommendations for Steel Structures
2	重防食塗装 Heavy Duty Coating
3	鋼板製屋根構法標準 Standard of Steel Roofing
4	鋼板製外壁構法標準 Standard of Steel Wall
5	鋼板製屋根・外壁の設計・施工・保全の手引き Manual on Design, Construction and Maintenance for Steel Roofing and Wall
6	S造設計構法・ディテール選定マニュアル Details & Specifications of Roof, Floor, Wall, Ceiling for Steel Structures



Examples of Damage to Steel Structures in the Great Hanshin Earthquake

(Ultimate strength and collapse mechanism)

Building collapse, layer collapse

(Seismic design of Joint)

Rupture of diagonal brace joint

【Points of improvement】

- SN steel (JIS, steel material dedicated to building structure with excellent earthquake resistance and weldability)
- Welding procedure (heat input, temperature between passes)
- Brittle fracture prevention design (Charpy value)

(Welding operation)

Rupture of welded beam-column joints

Inconsistency between basic concepts of seismic design and steel standards

Based on lessons learned from past earthquake damage, "new seismic design code" was introduced in 1981. In addition to the conventional elastic design, the two-step design verifies safety against large earthquakes through the ultimate strength design (plastic design).

- Step 1; Elastic designed frames will not be damaged by small to medium sized earthquakes up to seismic intensity 5 (no deformation will remain after the earthquake)
- Step 2; Plastic-designed frames will be damaged by a large earthquake of seismic intensity 6 or greater, but will not collapse and human lives will be saved (deformation will remain in the frame after the earthquake).

Conventional steel materials such as SS and SM, which are based on elastic design, could not meet the requirement of new seismic design code (plastic design was added), and a new steel standard was required.

Mechanical properties and chemical composition of SS and SM standards

16mm < thickness ≦ 40mm

Std.	Grade	Yield strength (MPa)		Tensile strength (MPa)		Yield ratio (%)	Sharpy absorption energy (J)	Cev (%)	S (%)
		Min.	Max	Min	Max.	Max.	Min. (0℃)	Max.	Max.
JIS	SS400	235	-	400	510	-	-	-	0.050
	SM490A	315	-	490	610	-	-	-	0.035

What about seismic resistance?

What about weldability?

JIS standards for SS and SM are;

- Steel standards based on elastic design
- General-purpose standard also used in machinery and other industry sectors

Need for steel standards specifically for building structure

Relationship between Seismic Design and Steel Performance

Seismic design

(A) Frame collapse type

(B) Plastic deformation capacity of column and beam members

(C) Ultimate strength of joint
- High-strength bolt joining
- Weld joining

(D) Brittle fracture of weld joint

Performance of steel products

【Mechanical properties】
(1) Deviation of yield point, ΔYP
(2) Yield ratio, YR
(3) Elongation
(4) Impact property

【Chemical composition】
(1) C, Si, Mn, P, S
(2) C_{eq}, P_{CM}

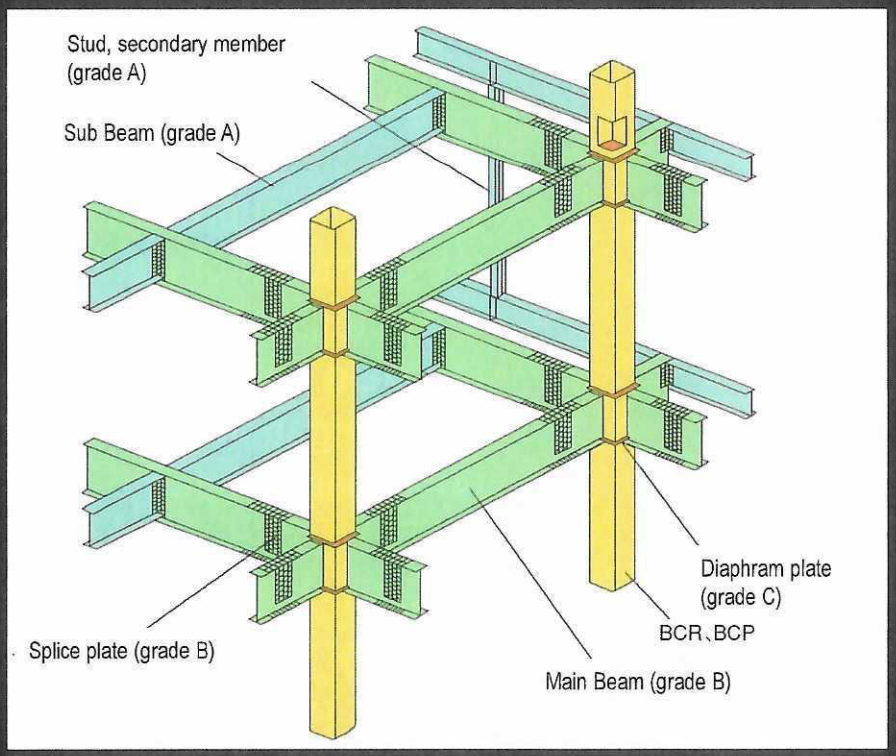
SN Steel Grade / JIS G 3136

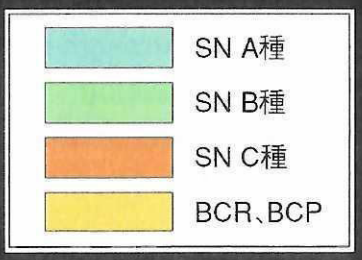
Conventional Steel Grade
- JIS SS400, SM490 etc.
- ASTM A32, A572 / EN S355 etc.
- Intended for elastic design

SN Steel Grade
- Established in 1994 in JIS G 3136
- Intended for plastic design
- Most suitable for seismic design

1. **Excellent plastic deformation capacity**
   Specification of upper limit of yield point and yield ratio
2. **Excellent weldability**
   Specification of Charpy absorption energy, Ceq and PCM
3. **Securement of thickness-direction property**
   Strict limit of P and S, Through thickness strength (Grade C only)
4. **Securement of nominal sectional dimension**
   Strict specification of minus thickness tolerance
5. **Variation of grades to meet kinds of element**
   Line-up of three steel grades (Grades A, B and C)

Use of SN Steel Grade A, B, and C in Steel Frame





Comparison between SN Steel and Other Steel Grade

Structural rolled steel (SN) for building construction use only was specified in JIS in 1994.

Std.	Grade	Yield strength (MPa)		Tensile strength (MPa)		Yield ratio (%)	Sharpy absorption energy (J)	Cev (%)	S (%)
		Min.	Max.	Min.	Max.	Max.	Min. (0℃)	Max.	Max.
JIS	SS400	235	-	400	510	-	-	-	0.050
	SM490A	315	-	490	610	-	-	-	0.035
	SN400A	**235**	-	**400**	**510**	-	-	-	**0.050**
	SN490B	**325**	**445**	**490**	**610**	**80**	**27**	**0.44*1**	**0.015**
	SN490C	**325**	**445**	**490**	**610**	**80**	**27**	**0.44*1**	**0.008**
ASTM	A572 Gr.50	345	-	450	-	-	-	-	0.050
	A992	345	450	450	-	85	-	-	0.045
EN	S355J0	345	-	-	-	-	27	0.45*2	0.030

Seismic performance

Weldability

*1 : Cev=C+Mn/6+Si/24+Ni/40+Cr/5+Mo/4+V/14 *2 : Cev=C+Mn/6+(Cr+Mo+V)/5+(Cu+Ni)/15

Line-up of SN Steel Grade Products

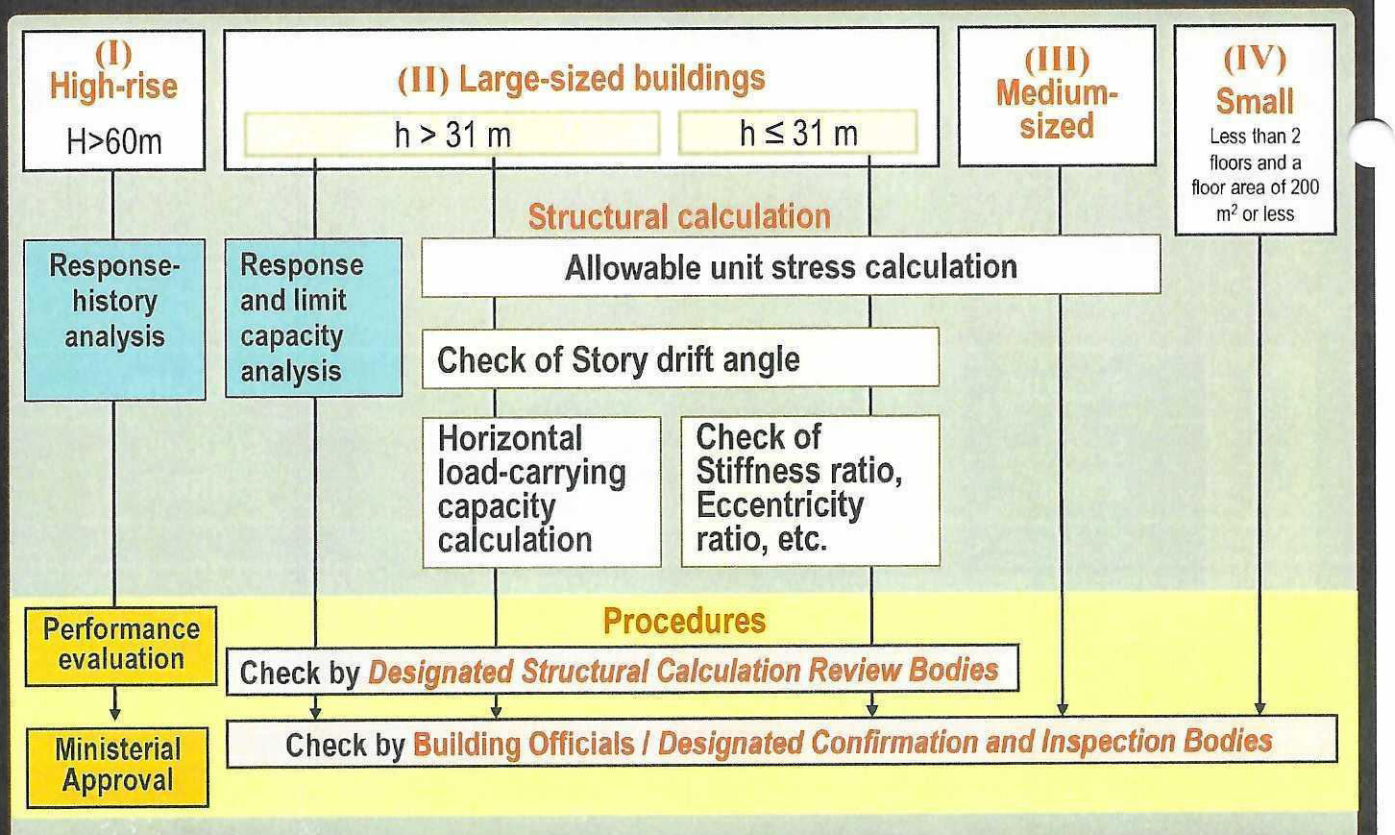
Usage	Wide-flange, plate, etc.		Circular tube	Square tube
General structures	JIS G3101	JIS G3106	JIS G3444	JIS G3466
	SS400 SS490	SM400A, B, C SM490A, B, C	STK400 STK490	STKR400 STKR490
Building structure	JIS G3136		JIS G3475	Approved Steel Product by MLIT
	SN400A, B, C SN490B, C		STKN400W, B STKN490B	BCR295 BCP235, 325

*MLIT: Ministry of Land, Infrastructure, Transport and Tourism

3. System to Secure the Quality of Steel Construction

3-1. Building Confirmation and Certification by the Minister
3-2. System for Qualified Engineers involved in Steel Construction
3-3. Certification of Steel Fabrication Plants

How to check structural safety



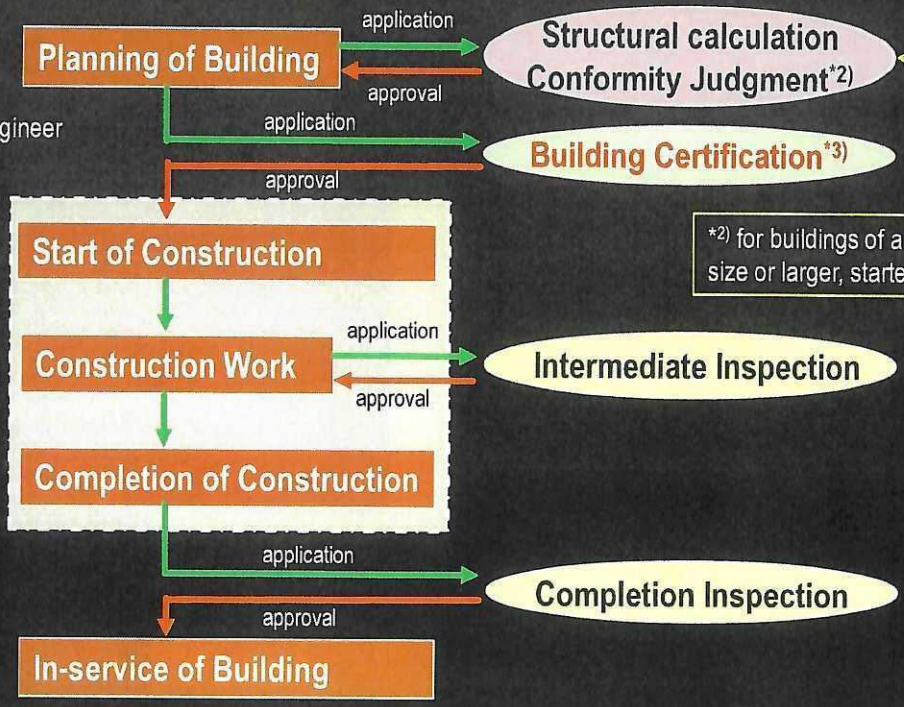
Building Certification

Design
(Registered architects*1)
*1) architect and structural engineer

Fabrication and Erection
(Fabricator and Construction company)

Construction management
(Registered architects*1)

Inspection
(Inspection company)



*2) for buildings of a certain size or larger, started in 2007

■ Approved by the Minister of MLIT

*3) **Building Certification** are required under the Building Standard Law. Buildings with a height of 60-meter and those which use new construction methods or materials need to pass performance evaluation and obtain special approval by the minister of MLIT.

Building Certification

• ***Building Standards Law Article 37*** Construction materials are notified by the Minister of MLIT	**Newly developed Construction Materials**	**Designated Construction Materials among JIS**
• ***Notification 1466 of MLIT*** Detailed technical items necessary for applying the standards Law prescribed in the notification	• TMCP plates, Jumbo-shapes • High-strength steels (590, 780N/mm²) • Low-yield point steels (100, 225N/mm²) ·····etc.	(Examples for Structural Steel) • JIS G3101 SS400, 490 • JIS G3106 SM400, 490 • JIS G3136 SN400, 490 ·····etc.

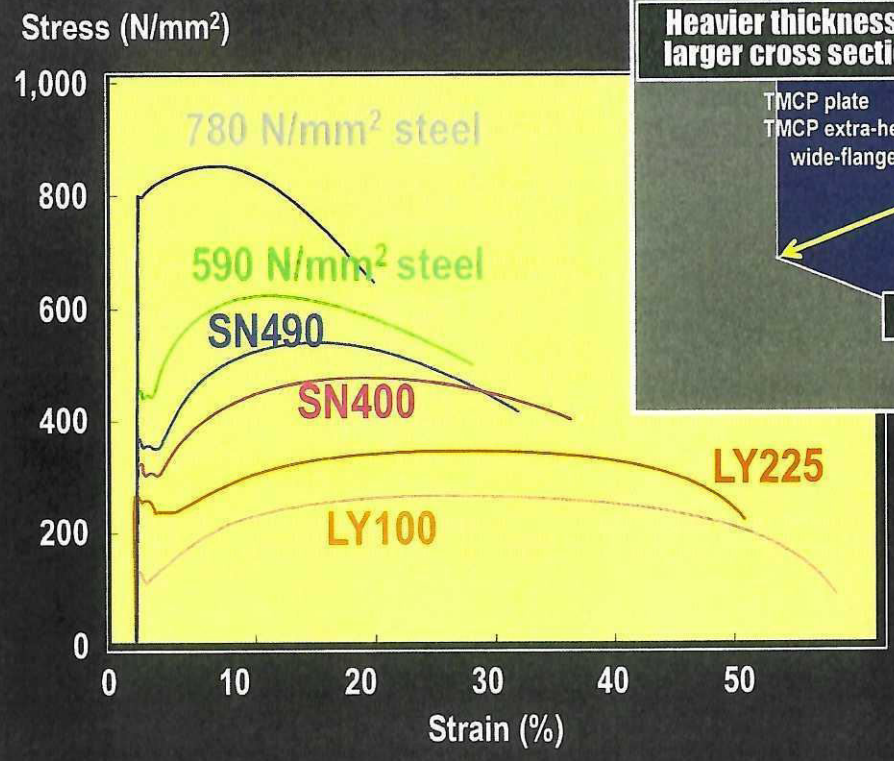
Approved by the Minister of MLIT

Designated performance evaluation institution by MLIT, to examine the quality of materials based on the following technical standard;

1. *Mechanical property (YP, TS, Yield Ratio, Elongation)*
2. *Chemical component (C, Si, Mn, P, S)*
3. *Weldability (C_{eq}, P_{CM}, Charpy Impact Value)*
4. *Shape, Dimension, mass*
5. *Production method, Inspection and Quality Control ····· etc.*

New Steel Products for Building Structures

Conventional Steel
- 400 N/mm² steel (SS400)
- 490 N/mm² steel (SM490)



< Directions of Development >

Higher strength
590N/mm² steel
780N/mm² steel

Heavier thickness & larger cross section
TMCP plate
TMCP extra-heavy wide-flange

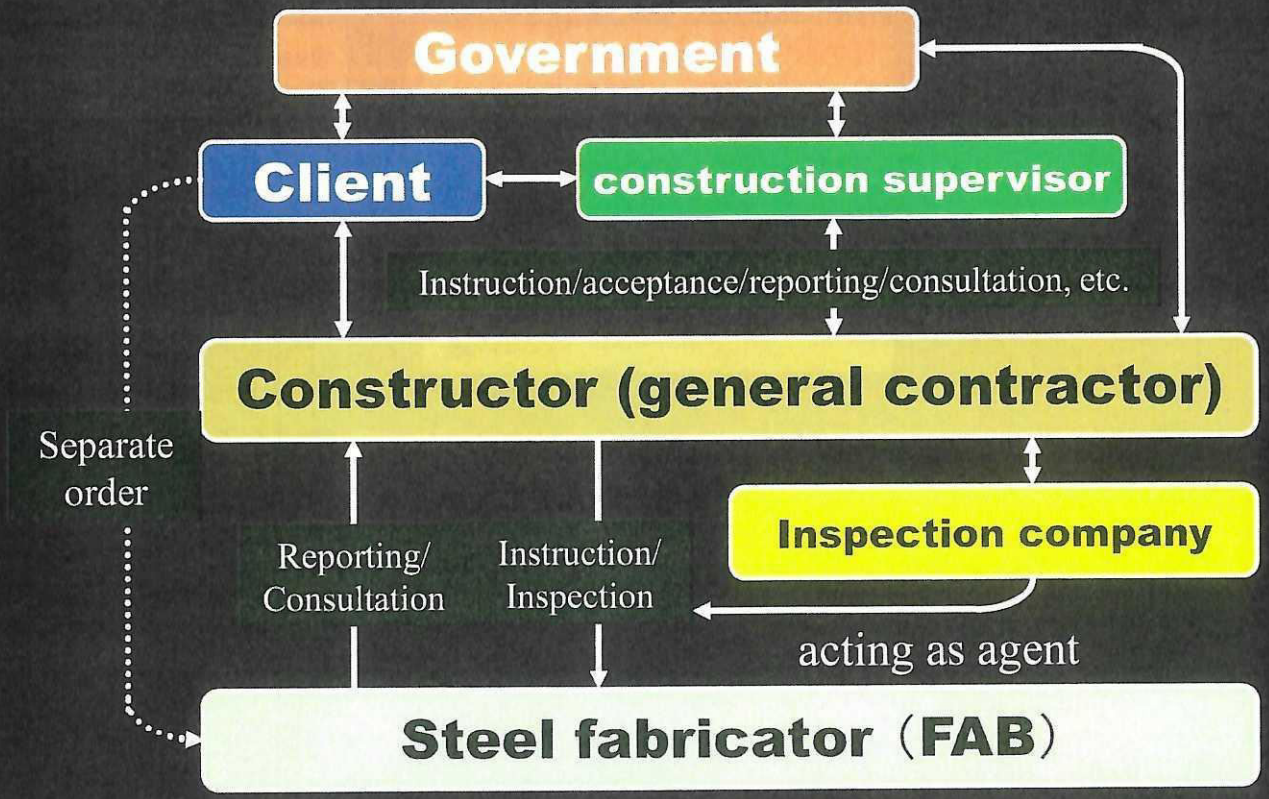
Higher performance
SN, BCR, BCP
- Weldability
- Lower yield ratio, narrow-range yield point
- Higher dimensional accuracy

Lower yield point
- LY100, LY225

New performance
High-temperature property
- Fire-resistant steel

Durability
- Weathering steel
- Stainless steel

Industry Relationship Involved in Steel Fabrication and Construction



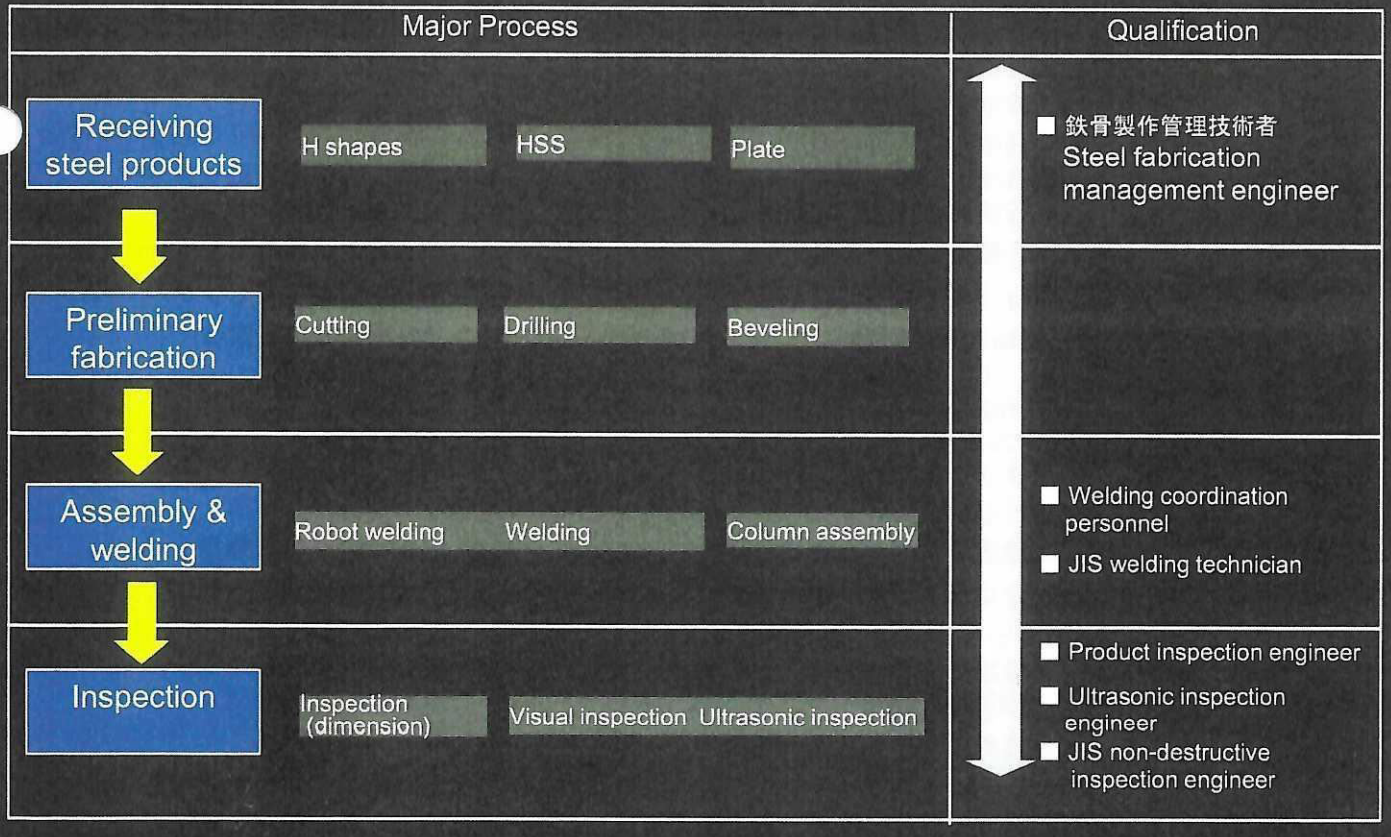
Source: JASS 6, published by AIJ

Efforts to Secure Quality of Steel Construction Industry

During the bubble period around 1990, cases of cracked steel plates and defective steel frames occurred, despite the efforts of the steel construction industry. A committee with members from government, industry and academia was set up by the Ministry of Construction to make the following recommendations;

	Recommendations	Contents
1	Responsibilities of the person in charge in each field	Necessity of introducing self-accountability and qualification system, etc.
2	Ensuring quality of steel product	Use of JIS standard products, mill sheets, need for steel specifically for building structure, etc.
3	Quality optimization of steel fabrication	Establishment of a fabrication plant certification & registration system and qualified engineer related to steel construction
4	Inspection and Testing Companies	Clarification of internal & incoming inspections, development of inspection qualification system, independence & neutrality of inspection services
5	Establishment of integrated institutions	Establishment of a body to take necessary measures on a wide range of technical, economic, standard and qualification issues across the steel construction industry in order to promote and develop steel structures.

Fabrication Process & Required Qualification



Erection Process & Required Qualification

Major Process	Qualification
現場施工、仮設計画 Planning and management	■ 鉄骨工事管理責任者 Supervisor for steel construction works
柱脚・アンカーボルト施工 Anchor bolt & base mortar	
鉄骨建方 Erection	
高力ボルト接合 High-strength Bolted Joint	■ 高力ボルト接合管理技術者 Administrative engineers for high-strength bolted joint
現場溶接接合 Site Welding	■ 溶接管理技術者 Welding coordination personnel ■ JIS溶接検定 JIS welding technician
検査 Inspection	■ 建築鉄骨超音波検査技術者 Building steel frame ultrasonic inspection engineer

Engineer Qualifications for Steel Structures

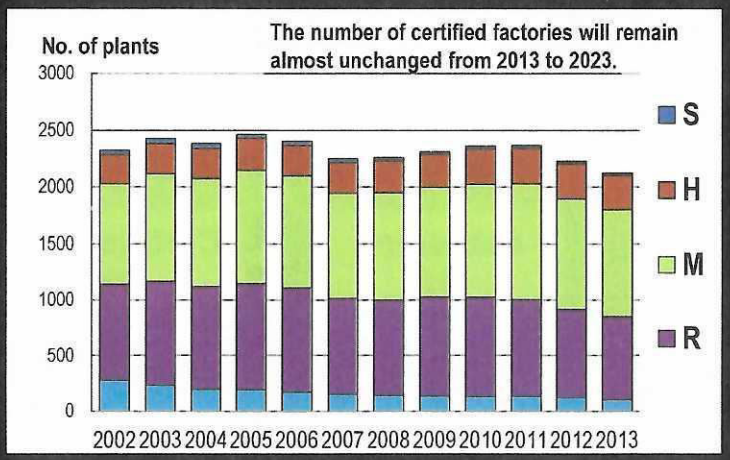
業務	資格名称 Name of Qualification	審査機関／登録機関 Examination and registration organization
建築確認 Building Certification	建築主事	（公財）建築技術教育普及センター
	確認検査員	（公財）建築技術教育普及センター
	構造計算適合判定員*)	（一財）日本建築防災協会
Building Desing	（建築基準適合判定資格）	
設計 Steel Fabrication	一級建築士、二級建築士	（公財）建築技術教育普及センター
工場製作全般	１、２級鉄骨製作管理技術者	（一社）鉄骨技術者教育センター
検査関連	建築鉄骨製品検査技術者	（一社）鉄骨技術者教育センター
Inspection	建築鉄骨超音波検査技術者	（一社）鉄骨技術者教育センター
Welding Management	JIS非破壊検査技術者	（一社）日本非破壊検査協会
溶接管理	特別級、１、２級溶接管理技術者	（一社）日本溶接協会
溶接技能	JIS溶接技能者	（一社）日本溶接協会
Welding Skills	AW検定技能者	（一社）AW検定協会
溶接技能	エンドタブ溶接技能者	日本エンドタブ協会
	スタッド溶接技能者	日本スタッド協会
ロボット溶接	建築鉄骨溶接ロボット型式認証	（一社）日本ロボット工業会
Robot Welding	建築鉄骨ロボット溶接オペレター	（一社）日本溶接協会
	AWロボット溶接オペレター	（一社）AW検定協会
工事現場施工管理	１、２級施工管理技士	（一財）建設業振興基金
Onsite Construction Management	鉄骨工事管理責任者	（一社）日本鋼構造協会
高力ボルト	建築高力ボルト接合管理技術者	（一社）日本鋼構造協会
High-strength Bolt Installation Management	溶融亜鉛めっき高力ボルト施工管理技術者	溶融亜鉛めっき高力ボルト技術協会
	溶融亜鉛めっき高力ボルト施工技能者	溶融亜鉛めっき高力ボルト技術協会

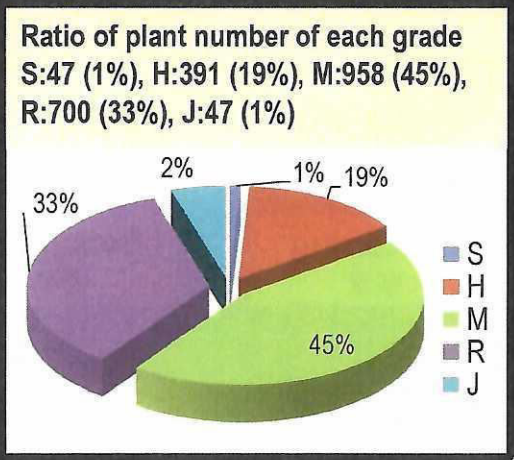
Steel Fabrication Industry in Japan

1. Number of companies by industry group as of 2023

Japan Steel Construction Association (JSCA)	21
Japan Steel Fabricators Association (JSFA)	2,178
Japan Bridge Association (JBA)	31
Japan Steel Tower Association (JSTA)	13
Companies not belonging to a group	Several hundreds to several thousands

2. Number of certification of steel fabrication plants; 2,118 as of 2023



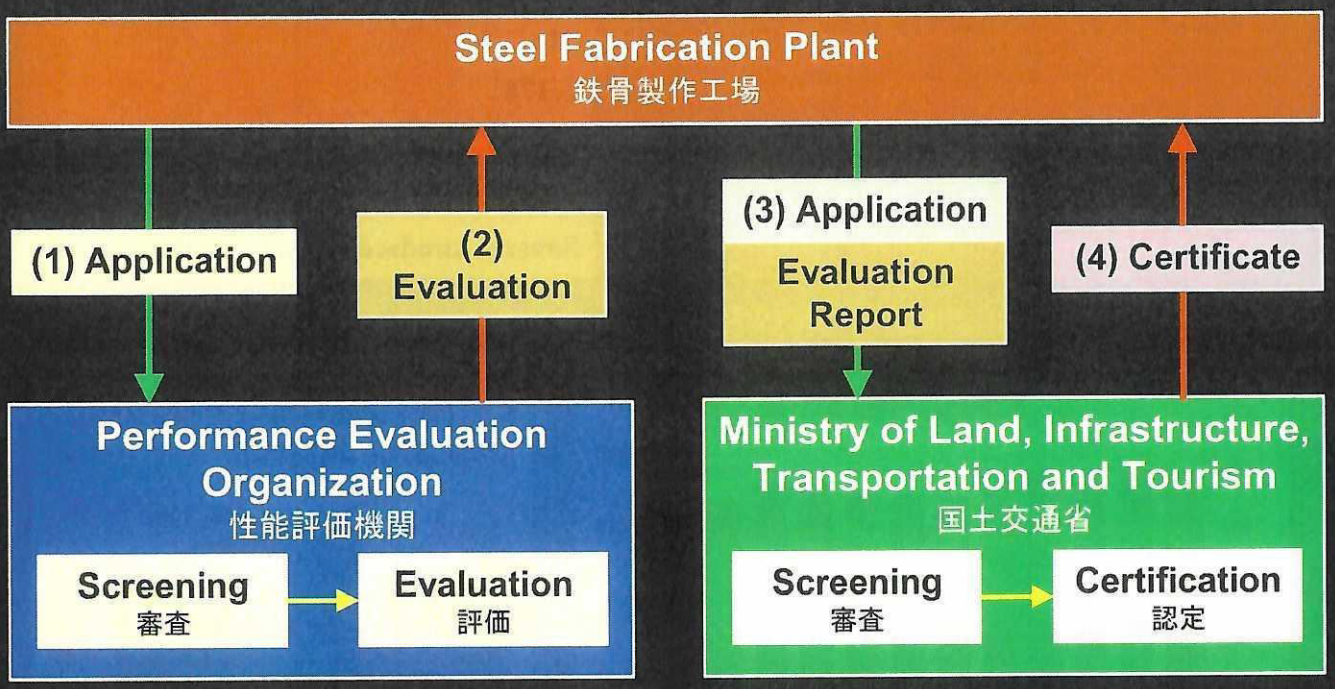


Grade of Steel Fabrication Plant

Fabrication Plants are categorized to S, H, M, R and J grade based on building sizes and steel materials used.

grade	Building sizes	Steel materials used		Welding position
		strengths	thickness	
S	Super high-rise	all	No limit	Flat, horizontal, vertical
H	High-rise	520N	60mm or less	Flat, horizontal, vertical
M	Middle to high-rise	490N	40mm or less	Flat, horizontal
R	Middle to high-rise 5-story, 20m or less 3,000㎡ or less	490N	25mm or less	Flat position
J	Low-rise 3-story, 13m or less 500㎡ or less	400N	16mm or less	Flat position

Certification Process



Outline of Plant Investigation

Document review 書類審査	Plant investigation (documents) 工場審査（書類等の確認）	Plant investigation (operation) 工場審査（実施の確認）
(1) Organization chart of quality control and fabrication process 品質管理体制図及び製作工程図 (2) Summary of in-house standards 社内基準の一覧 (3) Type of production facilities 製造設備の種類 (4) Type of inspection facilities 検査設備の種類 (5) Production record 製作実績リスト	(1) QC organization of the plant 工場の品質管理体制等 (2) Preparation of drawing standard for shop drawing 工作図作成基準の整備 (3) Preparation of fabrication standard 工作基準の整備 (4) Preparation of inspection standards 検査基準の整備 (5) Preparation of drawing standard for fabrication procedure 製作要領書作成基準の整備 (6) Preparation of standard for outsourcing management 外注管理基準の整備 (7) QC of shop drawing 工作図又は加工図の品質管理 (8) QC of fabrication procedure 製作要領書の品質管理	(1) QC of main material 主要材料の品質管理 (2) QC of processing 加工の品質管理 (3) QC of assembly 組立の品質管理 (4) QC of assembly inspection 組立検査の品質管理 (5) QC of welding 溶接の品質管理 (6) Inspection method of products 製品の検査方法等 (7) Type of production facilities 製造設備の種類 (8) Type of inspection facilities 検査設備の種類 (9)Method of in-house education 社内教育の方法

Certification of Steel Fabrication Plants

■ **Merit for customers to order to certified plants**

(1) The fabrication plants are reliable.
(2) Fabricated steel structure has superior structural performance.
(3) The performance of welded part is guaranteed.
(4) Easy to obtain building permit and pass final inspection by local government.

Design Office and Construction Companies in Japan are familiar to this Certification System and place orders for steel work on the "Qualified Fabrication Plants".

Secondary effects: Improvement of technical capabilities of the industry as a whole (bottom-up effect) by showing evaluation criteria (clear targets)

4. Activities to Develop Steel Construction

4-1. Activities of JSSC to develop steel construction, as an example for the activities and roles of association
4-2. Activities and roles of association

JSSC stands for "Japanese Society of Steel Construction".

Purpose of Establishment & Mission

JSSC is a Non-Profit Organization established in 1965.

- For 60 years, JSSC has worked to develop the steel construction and improve the related technologies in Japan and overseas.

- JSSC has achieved numbers of remarkable results such as researches and developments related to steel construction, and establishments of codes and standards of structural steel and their applications.

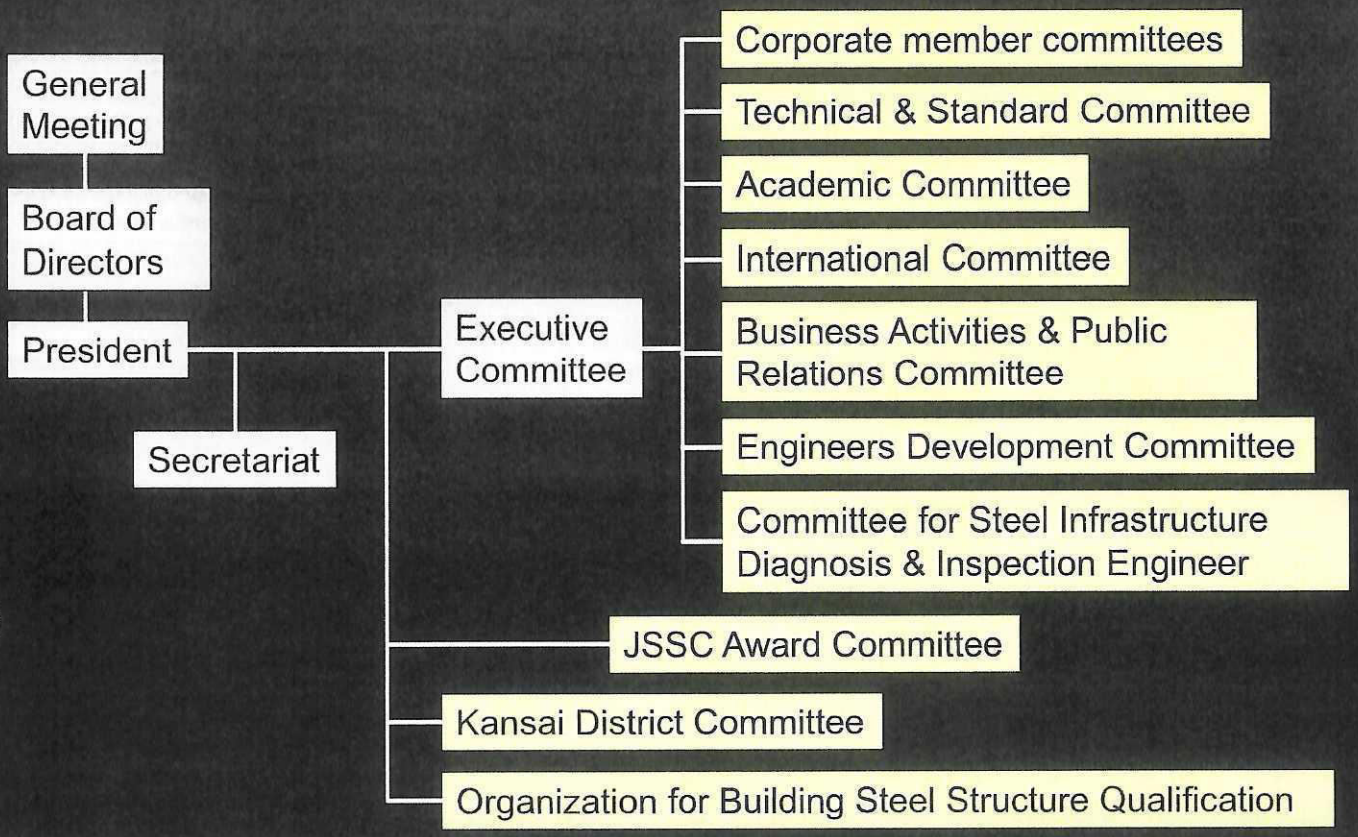
Membership of JSSC

As of March 2023

Category	Member	Number
Corporate Member	Companies related to structural steel and steel construction.	140 companies*1)
Individual Member	Individuals engaged in scholarly research or business related to structural steel & steel construction	572 individuals
Associate Member	Individuals working or studying in the field regarding steel construction	68 individuals (including 40 students)
Special Member	Institutional organizations or academic societies regarding steel construction	53 organizations
Honorary Member	Individuals outstanding contributions either to the development of steel construction or JSSC activities	42 individuals

*1) Steel manufacturing, stainless steel, building products, fabrication, construction, housing, design & engineering, coating, power & gas, railway and trading company etc.

Organization of JSSC



Main Activities of JSSC

1. Researches and Standardizing Activities, including Sponsored Researches & Joint Researches
2. Academic Activities
3. International Activities
4. Achievement and Research Awards
5. Symposia, Seminars and Forums
6. Publications
7. Human Resource Development
8. Activities of Certifying Qualified Engineers Responsible for Steel Construction and Steel Infrastructure Diagnosis & Inspection

1. Sponsored and Joint Researches

	1995FY～ 2000FY～	2005FY～	2010FY～
	▼ Jan. 1995 Great Hanshin Earthquake		▼ Mar. 2011 the great East Japan Earthquake
Seismic Design Prevention and mitigation technologies for natural disasters	▼ 1995-1997 Technology Development Project conducted by MLIT & Kozai club **Development of Structural Safety Improvement Technology Utilizing New-Generation Steel** **Japan US collaborative investigation on seismic design** (two lessons from the Hanshin Earthquake in 1995 and the Northridge Earthquake in 1994.)	▼ 2006-2008 JSSC/JISF **Development of innovative structural system applying advanced 800N/mm2 high-strength steels**  ▼ 2003 BCJ/BRI/JISF **Design manual for beam-column connection enable to prevent a brittle fracture of a beam flange**	▼ 2013-15 Technology Development Project conducted by MLIT **Development of function sustaining technologies for buildings used as Disaster Prevention Bases** (Mega-Earthquake, Tsunami and Tornado etc.) ▼ 2012-13 JSSC/JBDPA **Seismic repair method of existing steel-framed buildings** (structural members, exterior wall and ceiling, etc.) 
Rationalization of design and fabrication, Quality Improvement	▼ 1996- started the research of steel-framed house led by Kozai club **Steel-framed house (light gage steel shape)** 	 ▼ 2008-10 JSSC/BCJ **Development of Pre-engineered building, factory and warehouse**    ▼ 2007-09 JSSC/JISF/JPCSMA **Development of sheet welding technologies for housing** 	▼ 2009-11 JSSC/JSFA **Development of advanced automatic welding technologies for steel square tube**

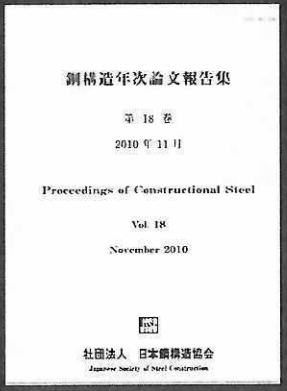
2. Academic Activities

Publicity of "Steel Construction Engineering"

Since the first issue in March of 1994, this has been published as quarterly journal of research & development in the field of steel construction, involving public participation and pay-distributed to general public as well as JSSC members.

Steel Construction Symposia

This was set up in July of 1993, and since then, is held as an academy session of "Steel Construction Symposia". The reports presented in the Symposia can be read in "Proceedings of Constructional Steel.



3. International Activities

International Organization that JSSC has a membership

- Pacific Council of Structural Steel Association (PCSSA)
  Pacific Structural Steel Conference (PSSC) is the **International Congress sponsored or co-sponsored by JSSC**
- International Association for Bridges and Structural Engineering (IABSE)
- Council for Tall Buildings and Urban Habitat (CTBUH)

3-1. PSSC Pacific Structural Steel Conference

Pacific Council of Structural Steel Associations (PCSSA)

- American Institute of Steel Construction (AISC)
- Australian Institute of Steel Construction (AISC)
- Canadian Institute of Steel Construction (CISC)
- Chilean Steel Institute
- China Steel Construction Society (CSCS)
- Indonesian Steel Construction Society (ISSC)
- Japanese Society of Steel Construction (JSSC)
- Korean Society of Steel Construction (KSSC)
- Mexican Institute of Steel Construction
- Malaysian Structural Steel Association
- Singapore Structural Steel Society (SSSS)
- Thailand Structural Steel Society

The **PSSC** (Pacific Structural Steel Conference) has been consecutively successfully held for eleven times since it was founded in 1986.

No.	Year	Host Country
1	1986	*New Zealand*
2	1989	*Australia*
3	1992	*Tokyo, Japan*
4	1995	*Singapore*
5	1998	*Soule, Korea*
6	2001	*Beijing, China*
7	2004	*Long Beach, U.S.A.*
8	2007	*Taupo, New Zealand*
9	2010	*Beijing, China*
10	2013	*Singapore*
11	2016	*Shanghai, China*
12	2019	*Tokyo, Japan*
13	2023	*Chengdu, China*

5. Activity Promoting Steel Structures

JSSC "Steel Construction Symposia", held once a year

Lectures and Discussion Meeting

Academy Session

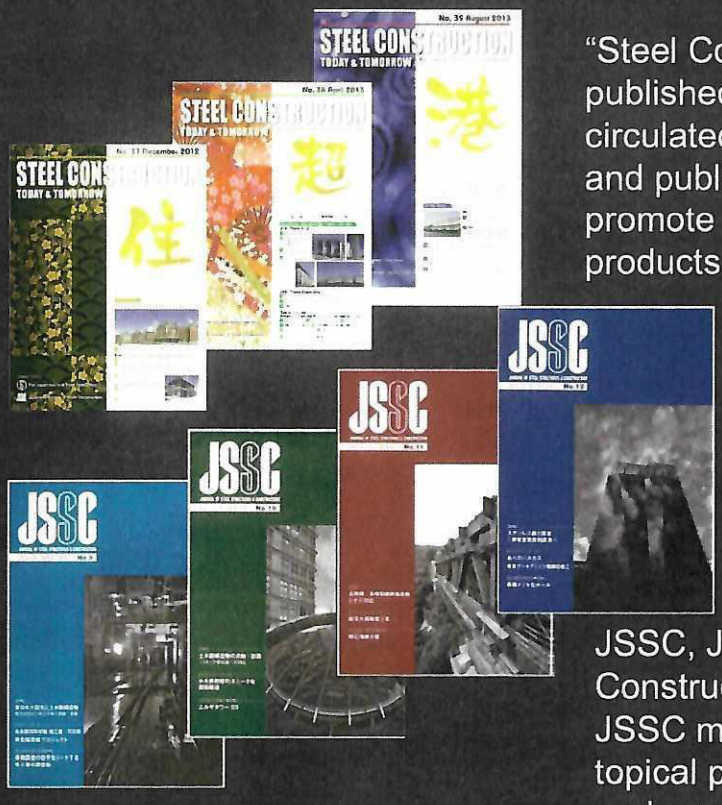
Presentation of "Proceedings of Constructional Steel".
(120 to 130 papers per year)

Exhibition by corporate members

Member get-together party

Prize-giving for Outstanding Presenters under 35 years old

6. Publications



"Steel Construction Today & Tomorrow" is the published three times per year. SCT&T is circulated to interested persons, companies and public organizations around the world to promote a better understanding of steel products and application in the construction.

JSSC, Journal of Steel Structures & Construction, is the quarterly journal issued for JSSC members and carries the information on topical projects, new products or methods, and overseas news (In Japanese).

7. Building Steel Structure Qualification

In 1996, for the quality control of constructional steel structure, JSSC formed Organization for Building Steel Structure Qualification as an organization responsible for qualifying examination system cooperating with relevant organizations and the Administration.
At present, approximately 16,500 registrants are in operation. In addition, this organization is now working on, for the better quality of steel construction, technical problems of steel construction and educational problems of young engineers.

Course and examination for certified engineers

Categories	Registrants
Supervisor for Steel Construction Works	8,396
Administrative Engineer for High-strength Bolted Joints	7,992
Stainless steel building structure fabrication management engineer	37
Stainless steel high strength bolt joint installation engineer	106
Welding Technician for Stainless Steel Building Structures	39
Total	16,570

As of April 2023

Supposed Activities to Develop Steel Structures

(Assumed Roles)

(Code & Standard, Guidebooks)

"Standards and Recommendations" as technical guidelines for steel construction

(Quality securing structural system)

Structural Performance Evaluation for new materials and technologies

(Qualified engineers and plant certification)

1) **"Qualification System for engineers and skilled workers"**,
- Evaluation, examination method
- Continuing professional development

2) **Steel fabrication plant certification**

(Development, Educational Program)

Developing and **promoting steel structures**

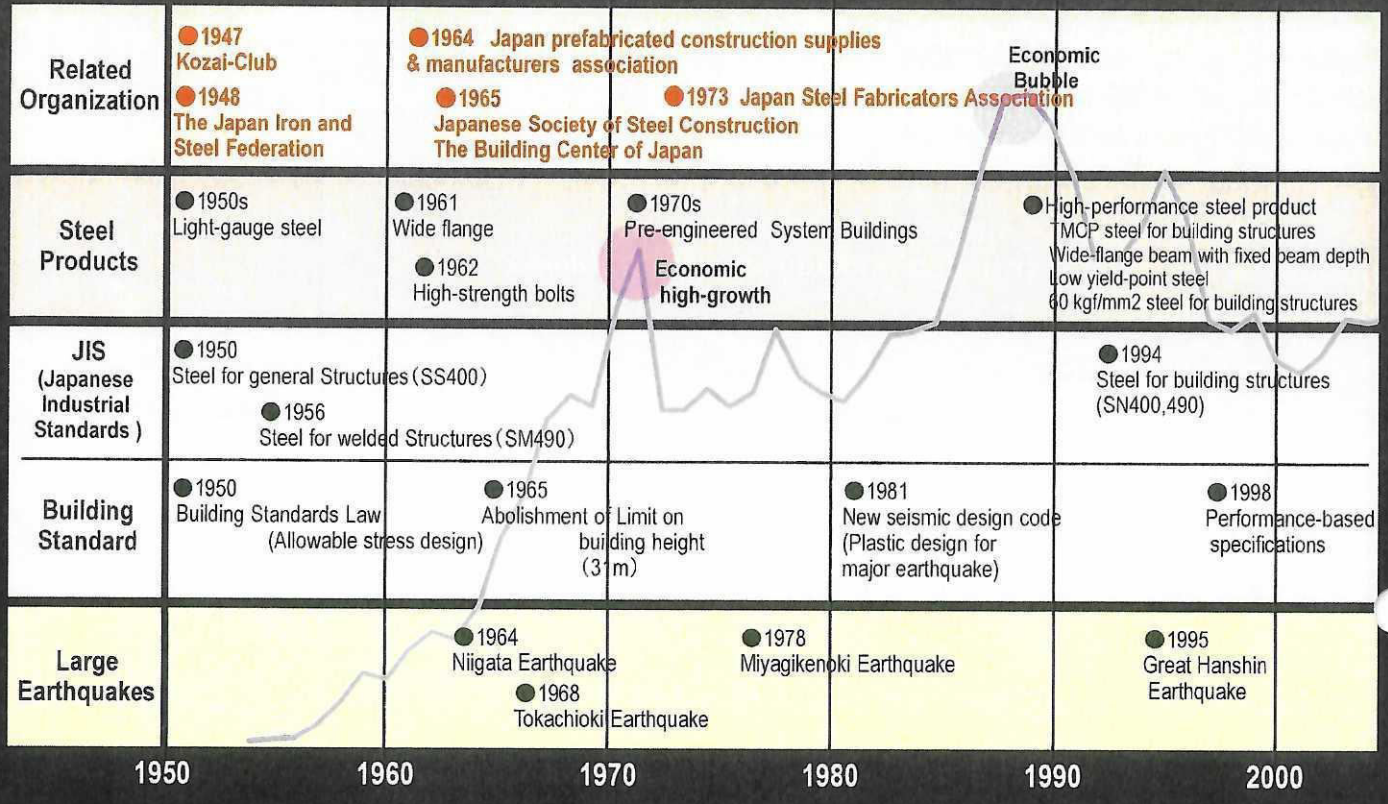
Educational program and Training for engineers and skilled workers

(Activities of Association)

※ JSSC activities are from 1. to part of 8.

1.	Research and Standardizing
2.	Academic Activities
3.	International Activities
4.	Achievement & Research Awards
5.	Symposia, Seminar and Forums
6.	Publications
7.	Human Resource Development
8.	Qualified Engineers and Plant Certification
9.	Structural Performance Evaluation for New materials and technologies

Efforts to Develop Steel Structures in Japan



Government-industry-academia Collaboration to Develop Steel Structures

Establishment of an "Activity Body" to lead the overall development of steel structures is required.

	Japan	Activities	India
Government	METI, MLIT, BRI, etc.	● Standards and Codes ● System to Ensure Structural Quality ● Qualification, Certification System (Assuming collaboration with industry)	?
Industry	Related Organization (Engineers, Construction Company, Fabricator, Steel maker), JSSC	● Promotion activities ● Educational Program for human resource development	?
Academia	Universities	● Establishment of Technology and Research Infrastructure	?