Applications of New Technologies in Japan – Positive Collaboration between Design and Construction

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Today’s Topics

- Japan is Green, featured with “Wood Culture”.
  Traditional use of line (1D) elements (rather than plane (2D) elements)
  Popularity of steel as extension of wood

- Japan loves “detailing”, which characterizes Japanese architecture.
  Complicated roofing details, exquisitely crafted eaves, complex connections using interlocking, etc.
  Similar appreciation to modern buildings

- Japan loves handcraft and manufacturing.
  Relatively high public status for “manufacturers”
  Love to new invention and sophisticated engineering
  Excessive “technology-driven” attitude, leading to Galapogisization.
Today’s Topics

- Japan exercises positive collaboration between design and construction (manufacturing)
  Equal partnership between design and construction
  Quality assurance by disciplined construction

- Japan uses “peer-review” for introduction of new technology.
  Acceptance of new technologies beyond what is explicitly stated in codes/regulations
  Fast track by peer-review versus slow standardization
Japan is Green, featured with “Wood Culture”.

- Traditional use of line (1D) elements (rather than plane (2D) elements)
- Popularity of steel as extension of wood
Japan, a country blessed with mountains and wood.

Areas Covered by Green
Wood – traditional material for constructions

Example Wooden Houses
Yes, steel is very popular in Japanese Construction.
Resemblance between Wood and Steel Construction

Framing slender members

Rigid connections between beams and columns
Application to Large Structures by Wood and Steel

Todaiji Temple, World Largest Wooden Building

Nagoya Dome, Made of steel trusses
Application to Towers by Wood and Steel

Toji Pagoda,
Tallest Wooden Tower

Eiffel Tower

Tokyo Tower
Special Structures Using Novel Technologies

Tokyo Sky Tree (634 meter)

Mode Gakuen

Nagoya Dome
Japan and Steel

Japan is destined to use and love steel by culture.

Steel is characterized by
“fast construction (preparation done in factory)”,
“quality control (fabricated in factory)”, and
“versatile applications (from small, large, tall, strange....)
Japan loves “detailing”, which characterizes Japanese architecture.

- Complicated roofing details, exquisitely crafted eaves, complex connections using interlocking, etc.
- Similar appreciations to modern buildings
Today’s Topics

We inherited many of those masterpieces for the past fifteen centuries
Connection made of exquisite interlocking
くみものの（組物）

出組でくみ 平等院鳳凰堂
二手先ふたてさき 室生寺金堂
二手先ふたてさき 室生寺五重塔

なかぞなえの（中備）

墓股かえるまた 長保寺多宝塔
組物の構造

三手先みてさき 室生寺五重塔 三手目
三手目みてさき 室生寺五重塔 二手目
一手目の肘木 堂内では梁
Japan loves Handcraft and Manufacturing.

- Relatively high public status for "manufacturers"
- Love to new invention and sophisticated engineering
- Excessive "technology-driven" attitude, leading to Galapogisization.
Respect to Craftsmanship

- Armor
- Umbrella
- Pottery
- Doll
- Sword
- Fan
- Ceramic
- Iron
- Bamboo ware
- Wood Carving
- Mask
- Lacquer
- clothes
Respect to Craftsmanship (continued)

Japanese is “good with hands”.

Weaving

Knitting

Weaving

Swordsman
Innovation of Steel Construction in Japan

Japan loves “innovation” via “manufacturing”.

Material-Oriented Development
- High-Performance Steel
- Ultra High-Strength Steel
- Fire-Resisting Steel
- High Toughness Steel
- Ultra High-Strength Bolts
- Low-Yield Steel
- Energy-Friendly High-Strength Steel

Devise-Oriented Development
- Buckling-Restrained Braces
- Concrete Filled Steel Tubes (CFT)
- etc.
High-Performance Steel

– Introduction of “SN Steel Grade” –

- Controlled Yield Strength
- Controlled Ultimate Strength
- Controlled Yield to Ultimate Strength Ratio
- Adopted in JIS (Japan Industrial Standards)

(a) Yield point

(b) Yield ratio
Fire-Resisting Steel

- Higher resistance against temperature
- Less requirement for fire insulation

[Graph showing the comparison between fire-resistant steel and general steel, highlighting the 2/3 yield strength at 350 and 600 °C.]
Low-Yield Steel

- Lower yield strength (100 MPa to 200 MPa)
- Larger uniform strain
- Larger strain hardening in cyclic loading
- Used as damper material
Buckling Restrained Braces

Brace is good in providing both strength and stiffness if it does not buckle.

Short Brace
(no buckling)

Long Brace

Intermediate Brace
Example of Buckling Restrained Braces

Stiffening steel pipe

Low-yield–strength steel

a-a section

Stiffening steel pipe

Low-yield–strength steel
Buckling Restrained Braces

Restraining of buckling of brace wrapped by encasement

Types of encasement

Example of Debonding Details

Steel brace
Debonding material
Mortar
Steel Tube
Concrete Filled Steel Tube (CFT)

Familiarities to Composite Structures
– Use of SRC for decades

SRC (Steel Encased RC) Composite Slab

CFT
CFT - Construction

Push-in of Concrete
A new venture for further innovation

New ultra high strength steel

thermo-mechanical control process

- CO₂
- Alloying elements

Environment-friendly

- Resources saving
- Reusable

Stress (N/mm²)

- New high-strength steel
- Conventional steel SN400

Strain (%)

5 10 15 20

500 600 700 800
Galapogosization

Excessive “technology-driven” attitude (relative to business-driven), leading to Japanese Galapagisization.

Island of Galapagos

Famous Japanese Galapagos Cellphone

Global Standard Smartphone
Today’s Topics

- Japan exercises collaboration between design and construction (manufacturing)
- Equal partnership between design and construction
- Quality assurance by disciplined construction
Design versus Construction

Design
- Architecture
- Structures
- Environment

R/ D
- Structures
- Environment
- Amenity

Construction

Japanese Way:
- Positive Interaction among sectors
- Culture of respect to manufacturing
Clean, Disciplined Construction

Management of Hundreds of Technicians of Various Occupations

Morning Assembly

Gymnastic Exercises

Instruction Session for Cranes

Schedule Checking
Clean, Disciplined Construction

Efforts to Maintain Clean Construction Site

Cleaning Truck Tires

Sweeping

Keeping things tidy and in order

Slogans
Clean, Disciplined Construction

Safety Control and Management

Covering Construction Site

Daily Check of Safety Issues

Lifelines

Attention to Level Difference
“Construction” (relative to “Design”) has more direct impact on business.

“Details” (relative to “Fundamentals”) are the heart of structural engineering in particular in the Japanese construction society.

Two notable examples:

• Rapid growth of base-isolation after Kobe
• Significant difference in solutions after Northridge and Kobe
免震
Significant Growth of Applications to Base-Isolated Systems after 1995 Kobe
Road to Acceptance of New Technologies

Long-term hesitance to accept new technologies until perceived equivalence of “COST”

Continuing efforts for promotion

In the right place at the right time

Necessary Conditions

Solid background for technologies

Availability of physical and human resources

Damaging Earthquake
Long-term hesitance to accept new technologies until perceived equivalence of “COST”

Continuing efforts for promotion

In the right place at the right time

Necessary Conditions

Solid background for technologies

Availability of physical and human resources

Without Solid Existence of “Construction Industry”, Nothing could be Constructed.

Damaging Earthquake
Fractures of Welded Beam-to-Column Connections
– damage similar to those observed in 1994 Northridge –
Fractures of Welded Beam-to-Column Connections
– damage similar to those observed in 1994 Northridge –
Different Approaches for Post-Earthquake Design and Construction Efforts

Strengthening Joints
• Smaller holes or No-holes
• HAZ-tough steel
• High-toughness welds
• Higher quality control
Different Approaches for Post-Earthquake Design and Construction Efforts

Reducing Stresses Applied to Joints

- Haunches and Ribs
- RBS
Seismic Performance of Welded Beam-to-Column Connection – U.S.-Japan Comparison

Test Results and Performance

<table>
<thead>
<tr>
<th>Japan’s No-Hole</th>
<th>US RBS</th>
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<tr>
<td>( \frac{M_m}{M_p} )</td>
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NOHOLE1

RBS1

Conventional
Seismic Performance of Welded Beam-to-Column Connection – U.S.-Japan Comparison

Japan’s No-Hole

Engineered Solutions Not Unique

Solutions Acceptable by Construction Industry are the “Practical” Solution!

Test Results and Performance
Japan uses “peer-review” for introduction of new technology.

- Acceptance of new technologies beyond what is explicitly stated in codes/ regulations
- Fast track by peer-review versus slow standardization
Japanese Design/Construction Hierarchy

Main body for low-rise

for Large Construction
- Inelastic analysis
- 3D analysis
- Time history analyses
- Site specific ground motions

for Small Construction
- Elastic analysis
- Static analyses

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Peer-Review since 1980s

For Large, Special Construction
- Inelastic analysis
- 3D analysis
- Time history analyses
- Site specific ground motions

- Multiple agencies do exercise peer-review.
- Peer-review commonly consist of a few (two to three) individuals including people from academia and industry.
- Peer-review period is commonly one to three months.
Transfer Function

Modelling of Source and Propagation

Fault or plate

Input Motion

Modelling of Structure

Surface Soil $V_s < 400 \text{ m/s}$

Engineering Bedrock $V_s > 400 \text{ m/s}$

Source Bedrock $V_s > 3000 \text{ m/s}$

Time History Analysis Procedure
Approval of Construction/ Design Methods

- Multiple agencies do exercise “approval of construction/ design methods.
- Peer-review commonly consist of a few (two to three) individuals including people from academia and industry.
- Peer-review period is commonly one to three months.

Example Approval Objects:

Negative Aspects of Peer-Review

Positive Aspects:
- Prompt acceptance and according exercises to practical applications → CFTs, BRBs, High-strength concrete, dampers, isolation, control, etc.
- Explicit collaboration between research and practice → acceptance of dampers, control, isolation, etc.

Negative Aspects:
- Little incentives to write explicit codes that can generalize design/ construction. → Lack of general design of BRBs and CFTS.
- Limited dissemination beyond Japan → “Galapagosization” problem
Japan is Green, featured with “Wood Culture”.

Japan loves “detailing”, which characterizes Japanese architecture.

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Japan exercises positive collaboration between design and construction (manufacturing).

Japan uses “peer-review” for introduction of new technology.
I wish the very best of a great success in the advancement of design and construction of building structures in Turkey. I would be happy if today’s presentation of mine is of any help in further, positive collaboration, both research and practice, between Turkey and Japan.