Historical Development of Building Codes in Japan

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The 1891 Nohbi Earthquake (M 7.9)
The 1891 Nohbi Earthquake (M 7.9)

"... buildings on soft ground ... suffer more than those on the hard ground."

"... we must construct, not simply to resist vertically applied stresses, but carefully consider effects due to movements applied more or less in horizontal directions."

John Milne’s note on the earthquake disaster

John Milne, 1850-1913
The 1919 Urban Building Law

Urban Building Law to regulate building construction in six major cities in Japan.

1920 Law Enforcement Order
- Height limit: 100 feet
- Structural design for timber, masonry, brick, reinforced concrete and steel constructions.

1920 Law Enforcement Regulations
- Structural design specifications
- Allowable stress design
- Quality of materials
- Dead and live loads
- No seismic requirements

The 1923 Kanto Earthquake

Naigai Building under construction
Damage of reinforced concrete buildings in Tokyo

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collapse</td>
<td>7 Bldgs</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Factory</td>
</tr>
<tr>
<td></td>
<td>Office</td>
</tr>
<tr>
<td></td>
<td>Shops</td>
</tr>
<tr>
<td></td>
<td>Houses</td>
</tr>
<tr>
<td>Severe damage</td>
<td>11 Bldgs</td>
</tr>
<tr>
<td>Major damage</td>
<td>4 Bldgs</td>
</tr>
<tr>
<td>Minor damage</td>
<td>69 Bldgs</td>
</tr>
<tr>
<td>Light damage</td>
<td>462 Bldgs</td>
</tr>
<tr>
<td>Total</td>
<td>553 Bldgs</td>
</tr>
</tbody>
</table>

Revision of Law Enforcement Regulations in 1924

Introduction of seismic design forces

- Maximum ground acceleration at University of Tokyo = 0.3 G
- Safety factor in allowable stress design = 3.0
- Seismic Coefficient = 0.3 / 3.0 = 0.1

Toshikata Sano (1880-1956)
Structural analysis methods at the time

1875 Castigliano’s theorems
1918 Slope deflection method (W. M. Wilson)
1930 Moment distribution method (H. Cross)
1932 D-value method for structural analysis (K. Muto)

After the World War II in Japan

Reconstruction of the infrastructure from the destruction
Reconstruction of the country from devastation

(1) Minimum quality of buildings
   Safety, health and usage
(2) Protection of built properties
   Construction contracts
   Quality of construction
(3) Conformation to legal requirements
   Use of land, Enforcement of code
(4) Qualification of design engineers
(5) Respect for human rights
   Right of construction
   Right of property

Needs of orderly and efficient reconstruction of the country

(1) Building Standard Law (1950)
   To safeguard the life, health, and property of people by providing minimum standards concerning the site, structure, equipment, and use of buildings.

(2) Architect Law (1950)
   To define the qualification of engineers who can design buildings and supervise construction work.

(3) Construction Trade Law (1949)
   To improve the quality of those engaged in construction trade and to promote fair construction contracts.
Building code system in Japan

Legal Documents
- Building Standard Law (1950)
- Building Standard Law Enforcement Order
  - Notifications by Minister of Land, Infrastructure and Transport (MOLIT)
  - Ordinances of Municipal Governments

Non-legal References
- AIJ Standards, Guidelines, Specifications
- JCI Guidelines, Specifications, Manuals

The 1968, Tokachi-oki Earthquake (M7.9)
Emergency Revision of Building Standard Law in 1971

Narrow spacing of column ties

Seismic technology for protection of society

(1) Development of seismic design codes,
(2) Vulnerability assessment of existing construction,
(3) Retrofit technology of vulnerable construction,
(4) Evaluation of damage of affected construction, and
(5) Repair and strengthening of damaged construction.
Protection of Existing Construction

New Buildings
(Old Technology)

Existing Buildings
(Old Technology)

Year 2007

New Buildings

Existing Buildings

Year 2027

Irregularity in structural configuration
**Torsional vibration due to eccentricity**

![Diagram showing structural walls, center of mass, center of stiffness, and eccentricity]

**Comprehensive seismic requirements in 1981**

(1) Design earthquake forces specified  
   (a) by story shear rather than horizontal floor forces,  
   (b) in terms of fundamental period of the structure,  
   (c) for serviceability and safety levels,  
(2) Examination of story shear resisting capacity at the  
   formation of a collapse mechanism under safety lateral forces,  
(3) Penalty against irregular distribution of stiffness along  
   height and eccentricity in plan between centers of mass and  
   stiffness,  
(4) Limit of story drift angle under serviceability earthquake  
   forces for the protection of architectural elements.
Revision of Building Standard Law in 1998

Introduction of performance-based design requirements

Background

- Foreign Demand to Open Construction Markets
- Fire-resistance and Fire-prevention Requirements

Difficulty

Confirmation of design to satisfy performance-based requirements by Building Officials
Thank you for your attention!

Shunsuke Otani
Chiba University
Seismological Society of Japan (1880 - 1892)

1880 Yokohama Earthquake (M5.5)
Seismological Society of Japan

President: Ichizo Hattori
Vice-President: John Milne (1850-1913)
Secretary General: W.S. Chaplin
Members:
- J. Milne
- J. A. Ewing
- T. Gray
- C. G. Knott
- T. C. Mendenhall
- John Perry
- William Ayrton

Transaction, Seismological Society of Japan

West’s equation to estimate maximum ground acceleration

\[ \alpha > \frac{b}{h} \]

The 1908 Messina, Italy, Earthquake
Quantitative Design Seismic Forces

Royal Decree No. 573, Italy, April 29, 1915

\[ P_2 = \frac{W_2}{6} \]

\[ P_1 = \frac{W_1}{8} \]