Post Proceedings of

ACECC TC-8

2nd Workshop on Harmonization of Design Codes in the Asian Region - Direction of Future Design Code -

Venue: Tohoku University, Kawauchi North Campus Multimedia Education and Research Complex
Date: Wednesday, 11th September, 2008
Time: 9:00-16:00

Sponsor: Japan Society of Civil Engineers
Asian Civil Engineering Coordinating Council
TC-8 “Harmonization of design codes in the Asian region”

Co-Sponsor: Kajima Foundation
“2nd Workshop on Harmonization of Design Codes in the Asian Region - Direction of Future Design Code –“ is supported by the International Scientific Exchange Fund, JSCE, and the Kajima Foundation.

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Introduction

Introduction of the ACECC Activities and the Workshop
Introduction of the ACECC Activities and the Workshop

Yusuke HONJO, Ph.D.
Chair of ACECC TC-8
Professor, Gifu University, Japan

Kenichi HORIKOSHI, Ph.D.
Secretary of ACECC TC-8, Chair, Committee on ACECC, JSCE
Senior Research Engineer, Taisei Corporation, Japan

1. About ACECC

The Asian Civil Engineering Coordinating Council (ACECC) is an organization which was established in 1999, and now consists of the nine civil engineering societies/institutions:

- ASCE American Society of Civil Engineers,
- CICHE Chinese Institute of Civil and Hydraulic Engineering
- EA Engineers Australia
- HAKI Indonesian Society of Civil and Structural Engineers
- JSCE Japan Society of Civil Engineers,
- KSCE Korean Society of Civil Engineers
- MACE Mongolian Association of Civil Engineers
- PICE Philippine Institute of Civil Engineers
- VIFCA Vietnam Federation of Civil Engineering Associations

ACECC is now trying to invite other Asian countries.

ACECC organizes a conference that is called the Civil Engineering Conference in the Asian Region (CECAR) once in three years, in order to provide all the experts in the civil engineering profession an opportunity to discover some of the most important innovations in civil engineering technology and R&D, and advance integrated discussions on the infrastructure development in the Asian region. The CECAR conferences were held in Manila in 1998, Tokyo in 2001, Seoul in 2004 and Taipei in 2007. Over 1,000 engineers from all over the world participated in the Taipei Conference (4th CECAR). The next 5th CECAR is going to be held in Sydney from 8 - 12 August 2010.

Information about ACECC: [http://www.acecc.net/index.php](http://www.acecc.net/index.php) (now under revision)
Information about 5th CECAR: [http://www.cecar5.com/](http://www.cecar5.com/)

2. The outline of the 2nd Workshop

As part of activities of the above-mentioned ACECC, the importance of mutual coordination on creating codes to be used in common in Asia has been discussed, and JSCE has been taking initiative for working on the possible measures. While codes like ISO and Eurocodes are being formulated from a global perspective, a lot of codes such as in the fields of concrete, geotechnical and seismic engineering are being transmitted to the world from Asian countries. Under these circumstances, we held the “1st Workshop on Harmonization of Design Codes in the Asian Region” in Taipei in 2006, and significant discussions were made as the first step toward the code harmonization in the Asian region.
After that, the new ACECC Technical Committee (TC-8) on “Harmonization of Design Codes in the Asian Region” was approved to be established at the ACECC Executive Committee Meeting on June 25, 2007. Terms of references of the new TC are as follows;

1) Create and strengthen human network on code development through continuous discussions.
2) Provide the latest information on design code in the Asian region, and make it public on the website.
3) Create the glossary of terminology for basis of design, which will be based on a new concept such as performance based design.

The objectives of the 2nd workshop are considered as follows;
1) This second workshop shall be continuation of the last special forum at the 4th CECAR which is held on June, 2007. The TC-8 was officially approved by the ACECC Executive Committee Meeting.
2) This second workshop shall be the first occasion where the members of ACECC TC-8 (Harmonization of design codes in the Asian Regions) give presentations and take part in the discussions.
3) A new ACECC member has joined since the last workshop, therefore the latest information on the code development in these new members shall be reported.
4) This workshop shall make up the first TC-8 meeting, which corresponds to the sessions in the afternoon. Not only the opinions and discussions by the TC-8 members but also those from the audience shall be incorporated for the planning of future activities.
5) At this stage, we recognize that harmonization of terminology in the new design concept will be one of the most important issues. The chair of the committee, Prof. Honjo, shall provide the basic idea of this.

Now, as we are stepping forward on these issues, we would like to hold the “2nd Workshop on Harmonization of Design Codes in the Asian Region” for the purpose of mutually sharing the information and having discussions on international strategy by the engineers/researchers who are working on code formulation in different areas in civil engineering assembled in one place. We position the 2nd workshop as the workshop for “Direction of Future Design Code “, then shall start discussions toward mutual understanding of the terminology for basis of design, which will be based on a new concept such as performance based design. Since new members might participate in the workshop, the 2nd workshop also will provide them a place to share the information on their activities and strategies for formulating design code. The outline of the 2nd workshop at the present stage is as follows;
3. **Photo**

- Welcome address by Dr. Sumiyoshi
- Presentation by Prof. Honjo
- Presentation by Dr. Koo
- Lecturers of WS
- Lecturers and Participants
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<td>Prof. Yusuke Honjo, Chair, ACECC TC-8</td>
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<td>09:10-09:25</td>
<td>Introduction</td>
<td>Dr. Kenichi Horikoshi, Secretary of ACECC TC-8</td>
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<td>Prof. Junichiro Niwa, Tokyo Institute of Technology</td>
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<td>Dr. Yukihiko Sumiyoshi, JSCE Representative to ACECC</td>
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<td></td>
<td>Dr. Hiroshi Okada, Former President of ACECC, Former President of JSCE</td>
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<td>10:45-11:20</td>
<td>Special Lecture 3</td>
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<td>13:00-13:20</td>
<td>Presentation from other representatives</td>
<td>Dr. Yoshitaka Kato, Institute of Industrial Science, the University of Tokyo</td>
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<td></td>
<td>Introduction of ‘Asian Concrete Model Code (ACMC)’</td>
<td></td>
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<td>13:40-14:00</td>
<td>The Necessity of Design Codes for Cambodia</td>
<td>Dr. Vong Seng, Institute of Technology of Cambodia</td>
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<td>14:00-14:20</td>
<td>Structural Steel Design Specifications in Thailand</td>
<td>Dr. Taweep Chaisomphob, Engineering Institute of Thailand</td>
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<td>14:30-15:50</td>
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<td></td>
<td>• Forming opinions from each country</td>
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<td></td>
<td>• Direction of future design code</td>
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<td></td>
<td>• TC-8 activity plan hereafter</td>
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<tr>
<td></td>
<td>First Draft of ‘Glossary of Terminologies for Design Code.’</td>
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<td></td>
<td>Summary Report</td>
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<td>15:50-16:00</td>
<td>Closing Remarks</td>
<td>Dr. Kenichi Horikoshi, Secretary of ACECC TC-8</td>
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</table>
5. List of Participants

TC-8 members (including speakers):
Japan  Prof. Yusuke Honjo (Chair of TC-8, Gifu University)
       Prof. Eiki Yamaguchi (Kyushu Institute of Technology)
       Dr. Kenichi Horikoshi (Secretary of TC-8, Taisei Corporation)
Taiwan  Prof. Shyh-Jiann Hwang (National Taiwan University)
Mongolia Prof. Duinkher Yagaanbuyant (Mongolian University of Science and Technology)

Others (including speakers):
Japan  Prof. Junichiro Niwa (Tokyo Institute of Technology)
       Dr. Yoshiaki Kikuchi (Port & Airport Research Institute)
       Dr. Yoshitaka Kato (Institute of Industrial Science, the University of Tokyo)
       Dr. Zhang Guangfeng (Public Works Research Institute)
Korea  Dr. Koo, Jai-Dong (Korean Institute of Construction Technology)
Cambodia Dr. Vong Seng (Institute of Technology of Cambodia)
Thailand Dr. Tawee Chaisomphob (Engineering Institute of Thailand)

Organizing Members:
Mr. Masayuki Torii (Secretary General, Committee on ACECC, JSCE
Nishimatsu Construction Co., Ltd)
Mr. Masaaki Nakano (Secretary, Committee on ACECC, JSCE, Nippon Koei Co., Ltd)
Mr. Hiroyuki Yanagawa (International Affairs Section, JSCE)
Special Lecture
Outlines of the Revision of “Standard Specifications for Concrete Structures [Design], JSCE – 2007 Version”

Junichiro Niwa
Secretary General, Subcommittee on the Revision of Standard Specifications, Design Group, Concrete Committee of JSCE
Professor, Tokyo Institute of Technology, Tokyo, Japan
1. Introduction
(1) Standard Specifications of Concrete Structures were originally published in 1931.
(2) The specifications showed the ideal figure for planning, design, construction, and maintenance of concrete structures.
(3) In 1986, the concept of the limit state design method was introduced.
(4) In 2002, the concept of the performance based-design was introduced.
(5) In 2007, the latest version has been published.

(1) Extension to high strength materials (concrete and reinforcement)
(2) Introduction of findings of Fracture Mechanics (Size effect, nonlinear analysis, etc.)
(3) Revision of the predicting equation for flexural crack width
(4) Introduction of “Strut-and-Tie Model” (for D regions)

(1) The Specifications [Design] have been divided into three parts, such as the main documents, the standards, and the reference materials.
(2) The main documents maintain the style of text and comment. They present the general way for the performance verification.
(3) The standards show the simplified way to meet the performance verification within the limited conditions.
(4) The reference materials give the explanation or examples to understand the main documents.

(6) Since the structural planning is the most important work in the design stage, “Chapter 3: Structural Planning” has been newly drawn up.

(7) “Chapter 12: Design of Members” of 2002 version has been moved to the Reference Materials, because the contents are related to linear structural analysis.

(8) The items related to “Nonlinear analysis” are explained in the Reference Materials.

(9) “Chapter 13: Strut-and-Tie Model” of 2002 version has been moved to the Standards, because it is the simplified design method within the limited conditions.

(10) “Allowable stress design method” in the appendix of 2002 version has been deleted, because the contents are not examined.


(11) “The Standards” such as “Seismic Design” or “Durability Design” have been newly drawn up to promote the Specifications to practical engineers.

(12) Since “design drawings” can be considered as an interface between the design and the construction, material details which are thought in the design stage have to be clearly exhibited in design drawings.

(13) To pay attention to excessively large shrinkage of concrete, the predicted value by the conventional design equation has been increased by 1.5 times.


Chapter 1: General

Design is the action to set the required performance for a concrete structure related to the durability, safety, serviceability, restorability, environmental aspect and aesthetic viewpoint, etc.
Chapter 2: Required Structural Performance

(1) Durability, safety, serviceability, restorability, environmental aspects and aesthetic viewpoint are treated as the required structural performance.

(2) Since the seismic performance is the combined performance, it is considered to be different from others. However, to take the continuity from 2002 version, the seismic performance is treated as the required performance in Chapter 11.

Chapter 3: Structural Planning

(1) Newly drawn up in 2007.

(2) The basic ideas are described in selecting structural forms. The viewpoints of required performance, construction, maintenance, environment and economic viewpoint are considered.

Example of Structural Planning of Railway Bridge

- **The bridge length is 240 m. It passes over a river having the width around 160 m (HWL).**

- **Plan 1** 6-span PC simple girder bridge 40 m × 6=240 m.

- **Plan 2** 6-span continuous PC box girder bridge 40 m × 6=240 m.

- **Plan 3** 4-span continuous extradosed PC girder bridge 40m+80m+80m+40m=240m.

- **Plan 4** 4-span continuous PC cable-stayed bridge 40m+80m+80m+40m=240m.

Plan 1: 6-span PC simple girder bridge, is adopted from the economical viewpoint.

Example of Structural Planning of Highway Bridge

- **The bridge length is 130 m. It passes over a small-sized river and 2 roads.**

- **Plan 1** 5-span continuous PRC double girder bridge 25m+4@25.5m=127m.

- **Plan 2** 4-span continuous PRC double girder bridge 28.5m+2@35m+28.5m=127m.

Plan 2, 4-span continuous PRC double girder bridge, is adopted from the economical viewpoint and the harmonization with environment.
Chapter 4: Principle of Performance Verification

(1) The limit state corresponding to the required performances shall be established.

(2) It shall be confirmed that the structure does not reach the limit state.

(3) The current limit state design method is adopted.

(4) Verification shall be performed by Eq. (4.3.1).

\[ \gamma_f S_d / R_d \leq 1.0 \]  
(4.3.1)

where,  
\[ S_d \] : Design response value  
\[ R_d \] : Design limit state value  
\[ \gamma_f \] : Structure factor

4.8 Design Drawings

Outlines:

(1) Design drawings are the interface between the design and construction, and the design and maintenance.

(2) Items which should be written in the design drawings are prescribed in detail.

4.8 Design Drawings

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(2) Items which should be written in the design drawings are prescribed in detail.

Chapter 5: Design Values for Materials

Outlines: The shrinkage strain of concrete is increasing year by year due to the degradation of the quality of coarse aggregates. According to JIS test, the average shrinkage strain of concrete is 730 \( \mu \). The shrinkage strain is sometimes more than 1000 \( \mu \).

Chapter 7: Calculation of Response Values

(1) The calculation of response values by nonlinear analysis has been taken from the “Seismic Performance Verification – 2002”.

(2) In the verification for the chloride attack, the structure and its distance from the shoreline.

(3) The information on nonlinear structural analysis has been newly drawn up in the Reference Materials.

7.4.4 Calculation of Flexural Crack Width

The method of calculation of flexural crack width is the same as that in 2002.

\[
w = 1.1k_1k_2k_3|\epsilon_c + 0.7(\epsilon_{\text{c}} - \delta)\left[\frac{\sigma_{\text{f}}}{E_{\text{f}}} + \frac{\sigma_{\text{p}}}{E_{\text{p}}}\right] - \epsilon_{\text{cad}}\]

\( \epsilon_{\text{cad}} \): The value to consider the influence of shrinkage and creep.

It is determined depending on the verification, such as the durability of steel corrosion, or the appearance of surface cracks.

Prediction of shrinkage strain of concrete

(1) If the data of real-size test or JIS test are available, the data can be used for the design.

(2) When the test data is not available, the predicted value by the conventional design equation has to be increased by 1.5 times.

(3) The maximum value by the conventional design equation is around 800\( \mu \). The maximum value of JIS test (7 days ~ 6 months) is around 1000 \( \mu \). If the sum of the autogeneous shrinkage before 7 days and the shrinkage after 6 months is estimated as 200\( \mu \), the maximum total shrinkage becomes around 1200\( \mu \). Therefore, the predicted value has to be increased by 1.5 times.

Chapter 8: Verification for Durability

(1) Chapter 8 has been newly drawn up by merging “Chapter 7 Verification of Serviceability” (2002) and “Chapter 2 Verification for Durability” (2002).

(2) In the verification for the chloride attack, the concentration of chloride ions at the concrete surface \( C_s \) is updated according to the location of the structure and its distance from the shoreline.

(3) The difference of \( C_s \) between Japan sea side and Pacific ocean side has been taken into account.
8.2 Environmental Action

Fig. C8.2.2 Concentration of chloride ions at the concrete surface $C_c$ (kg/m²)

<table>
<thead>
<tr>
<th>Distance from shoreline (km)</th>
<th>The area with high blown chloride contents</th>
<th>The area with low blown chloride contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close to shoreline</td>
<td>Hakusado, Totsuka, Tokur, Chib showa</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kanto, Totsuka, Chub, Shikoku, Kyusyu</td>
</tr>
<tr>
<td>0.1</td>
<td>9.0</td>
<td>4.5</td>
</tr>
<tr>
<td>0.25</td>
<td>4.5</td>
<td>2.5</td>
</tr>
<tr>
<td>0.5</td>
<td>3.0</td>
<td>1.5</td>
</tr>
<tr>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

The values corresponding to the area with low blown chloride contents have been updated.

9.2.2.2 (5) [Commentary]
Design shear capacity of linear members

Eq. (C9.2.4)

$$V_{dd} = (\beta_d \cdot \beta_a + \beta_n) \beta_p \cdot \beta_s \cdot f_{dd} \cdot b_w \cdot d / \gamma_b$$

where, $\beta_n = 4.2 [100 / (a / d - 0.75)] / \sqrt{T_{cd}}$

if $\beta_n < 0$, $\beta_n = 0$.

(1) The parameter $\beta_w$ has been introduced to consider the effect of shear reinforcement.

(2) The accuracy of the estimation for shear capacity of RC deep beams is almost same as that of the existing design equation.


Chapter 9: Verification for Structural Safety

(1) The cross-sectional failure of a member, fatigue failure, and the stability of a structure are taken into account as a main target.

(2) In the shear capacity of RC deep beams, a new calculation method which can consider the effect of shear reinforcement has been prescribed.

10.3.2 Flexural Crack

$\varepsilon_{c,tol}$ should be determined to assume construction works for the structure concerned such as concrete casting and removal of formwork and support. The test value of $\varepsilon_{c,tol}$ and the age of concrete when the crack initiates should be taken into account. When the shrinkage strain obtained by JIS test method is not more than 1000μ, the following values are recommended as $\varepsilon_{c,tol}$.

Table 10.1 Recommended value of $\varepsilon_{c,tol}$ for calculating flexural crack on surface

<table>
<thead>
<tr>
<th>Material age of crack initiation</th>
<th>$\varepsilon_{c,tol}$</th>
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<tr>
<td>30 days</td>
<td>$450 \times 10^{-6}$</td>
</tr>
<tr>
<td>100 days</td>
<td>$350 \times 10^{-6}$</td>
</tr>
<tr>
<td>more than 200 days</td>
<td>$300 \times 10^{-6}$</td>
</tr>
</tbody>
</table>


Chapter 11: Verification for Seismic Performance

(1) Chapter 11 has been newly drawn up based on the “Seismic Performance Verification – 2002”.

(2) To avoid the decrease in shear capacity due to large deformation cyclic loading and maintain the safety against the input of excessive seismic loading, sufficient shear reinforcement shall be provided so that the ratio between shear and flexure capacities should exceed 2.0.
The Standards

Chapter 2: Design of Seismic Coefficient Method

2.4.3 Shear Reinforcement in the Plastic Region

Deformation ability shall be maintained by the following relationship, which is the prerequisite to make the design yield seismic coefficient spectrum.

$$\frac{V_{yd}}{V_{mu}} \geq 2.0$$

where, $V_{yd}$: Design shear capacity
$V_{mu}$: Shear force at the end of a member when the member reaches flexural capacity, $V_{mu} = M_{y} / T_{e}$

Seismic Design

- Main Documents
  Time history response analysis by a one-dimensional continuous model or a finite element model.

- Standards
  Following simplified static analyses can be used.
  (1) Static linear analysis by the design yield seismic coefficient spectrum.
  (2) Static nonlinear analysis by the nonlinear seismic coefficient spectrum.


Chapter 11: Verification for Seismic Performance

(1) In addition to Chapter 11 of the Main Documents, Chapter 2 of the Standards “Seismic Design” and Chapter 4 of the Reference Materials “Examples of Seismic Design” have been drawn up.

(2) In the Standards, the design yield seismic coefficient spectrum is given as a result of the numerous calculation for modeled ground and structures.

Chapter 2: Design of Seismic Coefficient Method

Design Yield Seismic Coefficient Method

### Design Yield Seismic Coefficient Spectrum

**Natural Period of Ground (~ 0.25 sec)**

- $0.5 \leq T_{e} < 0.9$, $K_{hy} = 0.3417 T_{e}^{-1.221}$
- $0.9 \leq T_{e} < 2.0$, $K_{hy} = 0.39$

### Equivalent Natural Period $T_{eq}$ (sec)

- $K_{hy}$: Design Yield Seismic Coefficient

Chapter 13: Structural Details for Reinforcement

- Structural details are classified into two categories. One is the structural details with quantitative provisions, and the other is the structural details with only qualitative explanation.

Chapter 14: Other Structural Details

(1) Structural details are classified into two categories. One is the structural details with quantitative provisions, and the other is the structural details with only qualitative explanation.

(2) In the Standards, “Chapter 5: Details of Reinforcements” has been newly drawn up to prescribe the cover of reinforcements, the dimension and shape of hooks, the anchorage length, etc. in the form of Tables.
Chapter 15: Prestressed Concrete

1. The description for the stress calculation and the problem of shrinkage in PRC structures has been modified and increased.
2. The calculation method for prestressing forces and ultimate flexural capacities in internal and external PC members has been shown in detail.
3. The prestressing tendons have been classified into three categories, such as internal, unbonded and external tendons.
4. When PRC structures are used in corrosive or severely corrosive environment, a plastic sheath to have the shielding effect against corrosive materials shall be used in principle.

Chapter 16: Composite Structure

1. The technical terms in the Standard Specifications [Design] – 2007 have been unified with the guidelines of composite structures, JSCE.

5. Conclusions

2. The Specifications [Design] – 2007 have three parts, such as the Main Documents, Standards, and Reference Materials.
3. The Specifications try to make the sophisticated verification technique possible and also present the simplified design method as well.
4. “Structural Planning” and “Design Drawings” are the most important issues in this revision.

Thank you very much for your attention!
New Technical Standards for Port and Harbor Facilities

Yoshiaki Kikuchi
Port & Airport Research Institute, Japan
New Technical Standards for Port and Harbor Facilities (New TSPHF)

Yoshiaki Kikuchi
Port & Airport Research Institute

2nd Workshop on Harmonization of Design Codes in the Asian Region
 pasta: Form of Future Design Code
ACEC TC6 2008.9.11

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- Difference of the former and new TSPHF
- Reliability based design method in new TSPHF
- Summary

Difference of the former and new TSPHF

Objectives and performance requirements
Function
- Protective facilities for harbors should be maintained in function under every natural situations such as geography, meteorology, marine phenomena and others. (Law Article 7)
Safety
- Protective facilities should be safe against self weight, water pressure, wave force, earthquake force and so on. (Law Article 7)

Performance verification
- Calculation of forces: The wave force acting on a structure shall be determined using appropriate hydraulic model experiments or design methods in the following procedure. (Notification Article 5)
- Safety verification of members: Examination of the safety of the members of the reinforced concrete structures shall be conducted as standard by the limit state design method. (Notification Article 34)
- Stability check: Examination of the stability of upright section of gravity type breakwater shall be based on the design procedures using the safety factors against failures. (Notification Article 48)

Concept of performance based design system in new TSPHF

Level
- Law Article 14: Calmness of navigation channels and basin should be kept in order to navigate and moor ships safely and in order to handle cargo smoothly and in order to safely maintain buildings and other facilities located in port
- Mandate: (Port and Harbor Law)

Mandatory
- Not mandatory

Performance verification: Designers can select the approach for verification
- Approach A: Designers should prove the verification of the performance requirements under an appropriate reliability. Verification results will be checked by an accredited organization or a authorized committee.
- Approach B: Designers should prove the verification of the performance requirements in accordance with technical codes prepared by the authorities

Performance criteria
- Concrete performance criteria which can be used for verification of performance requirements
- Performance should be verified by engineering procedure.

Performance requirements
- Performance which facilities are required
- Performance verification should be verified by engineering procedure.
- Guidelines which present the standard procedure of performance verification are prepared for reference.
**Definition**

**Institution for adequateness surveillance**

Reparability

Performance Requirement

- Serviceability (Possibility of damage is low or the functions of the facility would be recovered with minor repairs.)
- Reparability: The function of the facility would be recovered in relatively short period after some repairs.
- Safety: Significant damage would take place. However, the damage would not cause any lives loss or serious economic damages to hinterland.

**Performance considered in former TSPHF**

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<th>Design situation</th>
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<th>Performance Requirement</th>
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<tr>
<td>Ordinary Situation</td>
<td>Permanent actions (self weight, earth pressures) are major actions</td>
<td>Safety factors against failure shall be larger than prescribed value.</td>
</tr>
<tr>
<td>Extraordinary Situation</td>
<td>Variable actions (wave, Level 1 earthquake) are major actions</td>
<td>Safety factors against failure shall be larger than prescribed value.</td>
</tr>
</tbody>
</table>

**Performance matrix considered in new TSPHF**

<table>
<thead>
<tr>
<th>Design situation</th>
<th>Definition</th>
<th>Performance Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persistent Situation</td>
<td>Permanent actions (self weight, earth pressures) are major actions</td>
<td>Safety factors against failure shall be larger than prescribed value.</td>
</tr>
<tr>
<td>Transient Situation</td>
<td>Variable actions (wave, Level 1 earthquake) are major actions</td>
<td>Safety factors against failure shall be larger than prescribed value.</td>
</tr>
<tr>
<td>Accidental Situation</td>
<td>Accidental actions (Tsunami, Level 2 earthquake) are major actions</td>
<td>Safety factors against failure shall be larger than prescribed value.</td>
</tr>
</tbody>
</table>

**Relation between design situation and performance requirement in new TSPHF**

- Serviceability
- Reparability
- Safety
- Persistent situation
- Transient situation
- Accidental situation

**Introduction of the institution for adequateness surveillance to TSPHF**

- Although a large variety of design verification methods can be applied by introduction of performance based design code, high level of engineering knowledge is required for adequateness surveillance.
- To adequately maintain the safety of important public facilities, designs of those facilities shall be surveyed by government of accredited organization.
- Accredited organizations shall be nominated by government.

**Level 1 & 2 earthquake**

- For the verification of earthquake resistance of public structures, two types of seismic motions shall be applied such as Level1 earthquake and Level 2 earthquake.
- Level 1 earthquake: is the intensity of seismic motion which structures will encounter 1 or 2 times during its service period. This level of earthquake is the almost equivalent seismic motion as that used for the external force against conventional seismic design.
- Level 2 earthquake: is the intensity of seismic motion of which event probability is quit low. Large scale plate boundary earthquakes occurred near land or inland earthquakes will be this kind of earthquakes.

**Advantage of new TSPHF**

- Advantage of new TSPHF shall be summarized as follows:
  - Performance of facilities are clearly presented to users.
  - Fully performance based design code is introduced.
  - Designers can utilize their decision and can exercise their ingenuity.
  - Designers can propose new design method or new type of structures.
  - Building cost reduction is anticipated with ingenuity.

- In order to employ above advantages appropriately, it is required for designers and promoters to understand the thoughts and technical contents of the TSPHF correctly.
- And to guarantee to users that new technology has satisfied the demand of TSPHF, the system for checking the adequateness of proposed design to TSPHF is founded.
Changed Important technical points

- Introduction of performance based design method
  - Reliability based design method is fully introduced.
- Change of calculation procedure for the input earthquake force for design (L1 & L2)
  - Observed seismic motions in each port are utilized for the calculation of input earthquake force for design
- New seismic coefficient method (L1) with new seismic coefficient for design
  - New concept of seismic coefficient compatible with existing seismic coefficient method
  - Damage of the mooring facilities after L1 level earthquake is considered to decide the seismic coefficient.

Levels of Reliability based design method

\[ Z = R - S \]

\[ \beta = \frac{Z}{\sigma} = \frac{R - S}{\sigma} \]

\[ Pf = \Phi(\beta) \]

Reliability index and failure probability

If performance function Z and R and S are assumed to be normal probability variables. Relationship between Pf and \( \beta \) are as follows.

<table>
<thead>
<tr>
<th>Failure probability Pf</th>
<th>Reliability Index ( \beta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.E-06</td>
<td>4.75</td>
</tr>
<tr>
<td>1.E-05</td>
<td>4.27</td>
</tr>
<tr>
<td>1.E-04</td>
<td>3.72</td>
</tr>
<tr>
<td>1.E-03</td>
<td>3.09</td>
</tr>
<tr>
<td>1.E-02</td>
<td>2.32</td>
</tr>
<tr>
<td>1.E-01</td>
<td>1.29</td>
</tr>
</tbody>
</table>

If performance function Z and R and S are assumed to be normal probability variables. Relationship between Pf and \( \beta \) are as follows.

<table>
<thead>
<tr>
<th>Pf T</th>
<th>Level 3 PBD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>Level 1 PBD</td>
</tr>
<tr>
<td>0.02</td>
<td>Level 2 PBD</td>
</tr>
<tr>
<td>0.03</td>
<td>Level 3 PBD</td>
</tr>
</tbody>
</table>

Reliability based design method in new TSPHF

Reliability based design method

- Safety factor
- Allowable stress method

Deterministic

- Experience of traditional method is emphasized.
- Failure probability is explicitly considered.

Probabilistic

- Partial factors
- Limit state of materials

Traditional design method (Safety Factor Method)

<table>
<thead>
<tr>
<th>Code calibration</th>
<th>RBD method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety factor</td>
<td>Partial factors</td>
</tr>
<tr>
<td>Allowable stress method</td>
<td>Limit state of materials</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reliability index and failure probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pf T</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>0.01</td>
</tr>
<tr>
<td>0.02</td>
</tr>
<tr>
<td>0.03</td>
</tr>
</tbody>
</table>

Reliability index

-的动作和抵抗力是确定性地定义的。

Partial factor

- Partial factors are used for considering the distance between mean value and failure condition.
- Partial factors are decided from Level 2 PBD calculation.

Reliability based design method

- New concept of seismic coefficient compatible with existing seismic coefficient method
  - Damage of the mooring facilities after L1 level earthquake is considered to decide the seismic coefficient.
Performance based design in new TSPHF (in guideline)

- Reliability based design (Partial factor method)
  - Performance levels are categorized mainly by importance of the structures.
  - Not only static analysis such as seismic coefficient method but also dynamic response analysis is introduced especially in the case of important structures.
- Importance of model tests or field experiments are emphasized to include design verification procedure.

Traditional safety factor method are still used for some types of structures. In those cases, partial factors are formally used.

Design verification of gravity type of breakwater

Traditional method

Forces acting on breakwater at sliding mode of failure

\[ F_c = \mu \left( \sum W - \sum H \right) \]

- \( F_c \): Safety factor for sliding failure
- \( W \): Total vertical force
- \( H \): Total horizontal force
- \( \mu \): Coefficient of friction

Design verification of gravity type of breakwater

Ex: Verification of the sliding stability of a gravity type of breakwater

Former TSPHF

\[ F_c \leq \frac{\mu \left( W_u - U \right)}{P} \]

\[ F_c = 1.2 \]

New TSPHF

\[ F_c k \left( \sum W_0 - P_u - U_0 P_u - U_0 P_u \right) \geq \gamma_k \gamma_d f \]

\[ P_f \leq 8.7 \times 10^7 \]

\( F_c \): Safety factor
\( k \): (suffix) characteristic value
\( d \): (suffix) design value
\( f \): Friction coefficient between the upright section and rubble mound
\( W_0 \): Weight of the upright section
\( U_0 \): Uplift force
\( P \): Horizontal wave force
\( P_u \): Buoyancy acting on the upright section in still water
\( P_u \): Horizontal wave force
**Evaluation of failure probability of existing structures**

**Deciding Target system failure probability**

Reliability indices of existing structures are calculated with first order reliability method (FORM) for understanding average failure probability of existing structures. About 40 cases were examined for each type of structures and design method.

- FORM method is categorized in level 2 of RBD.
- Average system reliability index of existing caisson type breakwater is 2.38.

**Statistic parameters of design parameters**

<table>
<thead>
<tr>
<th>Wave force (PH,PU)</th>
<th>x</th>
<th>y</th>
<th>z</th>
<th>1/α</th>
<th>1/β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore wave height</td>
<td>1.0</td>
<td>0.97</td>
<td>0.94</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Wave deformation calculation</td>
<td>0.96</td>
<td>0.01</td>
<td>0.04</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Steep slope</td>
<td>1.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Foundation ground</td>
<td>1.04</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Coefficient of friction</td>
<td>1.00</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
<td></td>
</tr>
</tbody>
</table>

**Notes**

- \( \mu_{\text{rwl}} \): Coefficient of characteristic value (mean/characteristic value)
- \( \alpha \): Sensitivity of the parameter
- \( \beta \): Target reliability index
- \( \sigma_{\text{rwl,CS}} \): Mean value of the parameter
- \( \mu_{\text{rwl,CS}} \): Standard deviation of the parameter
- \( \mu_{\text{rwl,CS}} \): Characteristic value or nominal value
- \( z_{\text{fz}} \): Standard deviation of characteristic value
- \( z_{\text{fX}} \): Standard deviation of characteristic value

**Difference in former TSPHF and new TSPHF**

(1) Calculation of safety factor by former TSPHF \( F_S > 1.2 \)

\[
F_S = \frac{500}{(1.03-1.05)} \times 0.95 \times 1.2 > 1.2 \times 0 \times 0
\]

* 0.95 is coefficient of friction between concrete and rubble mound

**Partial factors used in TSPHF**

- Coefficient of variance \( \nu \)
- Deviation of the characteristic value to mean value

**Determination procedure of partial factor**

\[
Z = \frac{1 - \alpha \beta \mu_{\text{rwl,CS}}}{\mu_{\text{rwl,CS}}}
\]

**Difference in former TSPHF and new TSPHF**

(2) Calculation of performance function on sliding failure (performance function \( Z > 0 \))

<table>
<thead>
<tr>
<th>Parts</th>
<th>Characteristic value of weight (kN/m)</th>
<th>Partial factor</th>
<th>Design value of weight (kN/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caisson</td>
<td>342.0</td>
<td>1.03</td>
<td>350.2</td>
</tr>
<tr>
<td>Concrete cap</td>
<td>342.0</td>
<td>1.02</td>
<td>347.6</td>
</tr>
<tr>
<td>Sand</td>
<td>1056.6</td>
<td>1.01</td>
<td>1070.2</td>
</tr>
<tr>
<td>Concrete cap</td>
<td>342.0</td>
<td>1.02</td>
<td>347.6</td>
</tr>
<tr>
<td>Total</td>
<td>1800.0</td>
<td>1.00</td>
<td>1811.8</td>
</tr>
</tbody>
</table>

- Design value of buoyancy
- Horizontal wave force and uplift

**Reliability index of existing structures are calculated with first order FORM method for understanding average failure probability of existing structures.**

**Very complicated !!!**
\[ Z = (1811.8 - 156 - 618) \times (0.6 \times 0.79) - 520 = -28.1 \]  
\[ \text{Out} \]

If weight of caisson is increased, \( Z \) will be positive. Then...

**2. Verification by performance function**

If \( Z > 0 \), the breakwater designed is verified that sliding failure possibility of this caisson is less than \( 8.7 \times 10^{-3} \) in TSPHF.

**Difference in former TSPHF and new TSPHF**

**Verification in new TSPHF**

\[ \mu = \frac{\mu_k f_d}{\mu_k} \]

**SUMMARY**

Main points of this presentation are summarized in key words as follows:

- Performance based design (Expanding the alternatives in verification procedure)
- Introduction of the institution of design verification surveillance (Checking the design by third party institution)
- Introduction of reliability based design method (failure probability of the structure system is the rule)
- Partial factor design method is introduced.
- Change of calculation procedure for the input earthquake force for design (L1 & L2)
- Site dependent seismic force
- New seismic coefficient method (L1) with new seismic coefficient for design

It means there aren’t any new idea for the physical model for calculating the safety. Introducing partial factors is to clarify the failure probability and to make clear the sensitivity of each factor.
Development of Design Codes and Standard Specifications in Korea

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Ha-Won Song
School of Civil and Environmental Engineering, Yonsei University, Seoul, Korea

1 INTRODUCTION

According to the Agreement on Government Procurement of the World Trade Organization, each country realized the importance of the globalization of its design codes and development of performance-based design codes. For the past more than a decade, the Korean government has made many efforts to improve design codes and standard specifications. As a result of these efforts, uniformity of the design code and specification formats and the convenience of users have been partially obtained. Recently extensive researches on the development of the performance-based design codes and specifications in various sectors of the construction field in Korea are ongoing. In this paper the status of the recent development of design codes and specifications will be introduced and the future development direction of performance-based design codes and specifications will be also explained.

2 DESIGN CODES AND STANDARD SPECIFICATIONS IN KOREA

Major standards in Korea are controlled by Korean government. For example, in the field of construction, design codes and standard specifications had been administered by the Ministry of Land, Transport and Marine Affairs (previously the Ministry of Construction and Transportation), Korea. But such administrative operation and control fell short of professionalism and efficiency. Moreover, design codes and standard specifications were not established in unified manner. In particular, application of the construction codes and specifications called differently as 'standard specifications', 'codes', 'guidelines', 'handbooks', 'technical instructions', 'manual', etc. entailed many confusion. Furthermore, the problem of using different criteria in coding for the same engineering item or behaviour was experienced. Due to these reasons, the Ministry of Land, Transport and Marine Affairs delegated the management of construction codes and specifications to corresponding academic societies and associations from 1995 so that each responsible organization can establish and revise construction codes and specifications as shown in Table 1.

For construction codes and specifications, the codes were categorized into ‘Design Codes’, ‘Standard Specifications’, ‘Owner's Standard Specifications’ and ‘low-level technological criteria’. Then, ‘Design Codes’, ‘Standard Specifications’, and ‘Owner's Standard Specifications’ were stipulated by the law to be subject to the deliberation of the Central Construction Technology Deliberation Committee. And the ‘low-level technological criteria’ is controlled by the academic societies, associations and owners (Fig. 1). Since the Design Codes and Standard Specifications are national codes and specifications, government subsidies are granted to each responsible organization for development or revision of Design Codes and Standard Specifications. In addition, Design Codes and Standard Specifications play a role of high-level criteria of the other construction codes and specifications as well as the ‘low-level technology criteria’. Moreover, there are construction codes for facilities, such as the Road Act and the Building Act, and construction criteria Stipulated as the Guidelines, the Public Notifications as low-level regulation.
<table>
<thead>
<tr>
<th>Responsible Organizations</th>
<th>Standard Specifications</th>
<th>Design Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korean Society of Civil Engineers</td>
<td>General Standard Specification for Civil Works</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standard Specification for Urban Railroad (metro) Works</td>
<td></td>
</tr>
<tr>
<td>Korea Concrete Institute</td>
<td>Standard Concrete Construction Specification</td>
<td>Concrete Structure Design Code</td>
</tr>
<tr>
<td>Architectural Institute of Korea</td>
<td>Architectural Standard Specification</td>
<td>Korean Building Codes</td>
</tr>
<tr>
<td>Korean Geotechnical Society</td>
<td></td>
<td>Structural Foundation Design Codes</td>
</tr>
<tr>
<td>Korean Institute of Landscape Architecture</td>
<td>Standard Specification for Landscaping Works</td>
<td>Landscape architecture Design Codes</td>
</tr>
<tr>
<td>Korea Road &amp; Transportation Association</td>
<td>Standard Specification for Road Works</td>
<td>Road Design Codes</td>
</tr>
<tr>
<td></td>
<td>Standard Specification for Construction of Bridges on Road Projects</td>
<td>Bridge Design Code on Road Projects</td>
</tr>
<tr>
<td>Korean Tunnelling Association</td>
<td>Standard Specification for Tunnelling</td>
<td>Tunnel Design Codes</td>
</tr>
<tr>
<td>Korea Water Resources Association</td>
<td>Standard Specification for Construction of River</td>
<td>River Design Codes</td>
</tr>
<tr>
<td>The Korean Institute of Illuminating &amp; Electrical Installation Engineers</td>
<td>Standard Specification for Building Electrical Installations Works</td>
<td>Building Electrical Installations Design Codes</td>
</tr>
<tr>
<td>Korean Society for Steel Construction</td>
<td></td>
<td>Steel Structure Design Codes</td>
</tr>
<tr>
<td>Earthquake Engineering Society of Korea</td>
<td></td>
<td>Earthquake-proof Design Codes</td>
</tr>
<tr>
<td>Construction Temporary Equipment Association of Korea</td>
<td>Standard Specification for Temporary Works</td>
<td></td>
</tr>
<tr>
<td>Korea Water &amp; Wastewater Works Association</td>
<td>Standard Specification for Water and Wastewater Works</td>
<td>Water Supply Design Codes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wastewater Design Codes</td>
</tr>
<tr>
<td>Korea Port &amp; Harbour Association</td>
<td>Standard Specification for Construction of Ports and Harbours</td>
<td>Port and Harbour Design Codes</td>
</tr>
<tr>
<td>Technical Safety Policy Officer</td>
<td>Standard Specification for Construction Environment Control</td>
<td></td>
</tr>
<tr>
<td>Korea Infrastructure Safety and Technology Corporation</td>
<td>Standard Specification for Slopes</td>
<td>Design Code for Slopes</td>
</tr>
<tr>
<td>Korea Rail Network Authority</td>
<td></td>
<td>Railroad Design Code</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Express Railroad Design Code</td>
</tr>
<tr>
<td>Korea Rural Community &amp; Agricultural Corporation</td>
<td>Standard Specification for Agricultural Civil Works</td>
<td>Plan and Design Codes for Improvement Projects of Agricultural Production Base</td>
</tr>
</tbody>
</table>

These Guidelines and Public Notifications are compulsory regulations. However, Design Codes, Standard Specifications and low-level technological criteria are not compulsory regulations. Therefore, if only the owners should choose these criteria as construction contract documents, that criteria may take effect as contract documents.
As a result of these efforts, the problem of overlapping construction codes and specifications together with the problem of assigning different criteria for an identical item have been removed. However, even though these efforts served to obtain uniformity of the design code and specification system and the convenience of users, securing design engineering capability and advancement and globalization of design code and specification system remain to be desired.

3 NEEDS AND DIRECTION FOR HARMONIZED CODES AND SPECIFICATIONS IN KOREA

The Korean design codes and specifications is the prescriptive codes suggesting materials and design methods for achieving the objectives and functional requirements. These kinds of codes have an advantage of being able to be directly utilized by the designer and contractor. However, the enhancement of design engineering capabilities may be faced with bottlenecks due to limitation of designer’s discretion. Therefore, it is considered to be necessary to move forward to the direction of performance-based design code and specification system by which designers and constructors are free to choose diversified design and construction methods.

According to the Agreement on Government Procurement of the World Trade Organization, technical specifications prescribed by procuring entities of each country shall be in terms of performance rather than design or descriptive characteristics, and shall be based on international standards, where such exist. Due to this reason, each country is exerting efforts to globalize its design codes. Therefore, design codes and standard specifications in Korea are also considered to be necessary to join in the performance-based globalization trend.

Depending on the types of facilities, not many performance-based design codes and specifications have been developed in Korea until recently. The status of performance-based design codes and specifications in various facility sectors in Korea are as follows.

3.1 Road Pavement Sector
Experiments and researches were conducted partially to examine road pavement performance. But technical development for evaluating road pavement performance was few.

3.2 Concrete Structure Sector
Fundamental research on the development of performance-based design technique is in its initial stages in the Korean academic communities. Both performance-based design code and standard specification is under development including durability design. But the performance of high performance concrete was not properly reflected in the design yet.

3.3 Steel Structure (Civil) Sector
Steel structural design is mostly limited to the Allowable Stress Design. Performance-based design is mainly concentrated on seismic design. Researches on the buildings that employ steel structures are being carried out. Researches on performance-based design, still, remain to be desired.

3.4 Architectural Building Sector
Efforts of introducing the performance concept in the architectural building design have long been implemented but any significant development has not been achieved so far. Since the 1990s, efforts of complying Korean Standards (KS) with an international standard like ISO has been made but full-scale performance design has not been realized. Recently, researches on performance-based design technique have been started mainly in the Korean academic communities. Relevant systems and regulations include the Building Energy Efficiency Rating System, the Green Building Certification System, regulation for floor impact sound in apartments, recommendation regulation for indoor air quality of newly built apartment and the Housing Performance Grade Indication System, etc..

3.5 Other Sectors
Researches on the area of foundation engineering have been carried out mainly in the deep foundation design based on reliability analysis. Researches on the evaluation of bearing capacity of piles and researches with a safety factor in prediction methods of bearing capacity of piles, based on reliability analysis have been performed. And researches on stochastical reliability analysis to nonlinear structures, development of reliability analysis algorithm of real structures, and reliability analysis of pile structures subject to biaxial loading have been carried out at the same time.

Among road subsidiaries, the criteria of safety barriers have been changed into performance criteria. Reflective performances of retro-reflectors are applied to delineation systems, pavement markings, road signs, re-boundable guideposts and etc.. But performance codes and specifications of road subsidiaries still remain to be desired.

In case of tunnels, the Tunnel Design Code remains mostly at material-oriented approaches. Up to now researches and introduction of technologies based on the performance in tunnel area remains to be lack.

In the area of landscaping, development of performance codes nearly has not been implemented so far but researches on the assessment of landscapes, thermal environments, rainwater storage and utilization and biological habitat have been performed.

In case of the building mechanical systems, certain levels of performance for the products and equipments are ensured by certification processes of the Korean Standards and certification systems of public institutions and academic communities. However, the maintenance of the systems is not sufficient and the criteria of high efficiency performance and durability have not been established.

In the building electrical systems, along with efforts of complying Korean Standards with IEC since the 1990s, efforts of complying Korean codes with international codes have been maintained sustainably but visible outcome is few so far. Performance evaluation system under implementation in Korea includes ultra-high speed telecommunication building certification system, intelligent building certification system, and etc..

3.6 Performance Warranty Contracting System
Researches to introduce international performance warranty contracting system for inducing improvement of facilities and the contractor’s technical innovation has not been performed.
Recently, breaking away from the bidding system of giving priority on price, introduction of an awarding system that can assess costs and technologies synthetically is under progress.

4 ONGOING DEVELOPMENT OF PERFORMANCE BASED DESIGN CODES AND SPECIFICATIONS

The project, “Master plans to develop performance-based construction codes and specifications” was carried out in 2007. This project is one of the Construction and Transportation Technology Research and Development Projects implemented by the Ministry of Land, Transport and Marine Affairs. This project is in line with the policy of “International standardization of design documents and performance-based improvement of design codes”.

Through this project, master plans for developing performance based codes and specifications for about ten different materials/facilities covering road pavement, concrete structures, steel structures, and architectural buildings has been established. The manuals for developing performance based codes and specifications for each facility were prepared. In addition, as a subsequent development project, “Standardization of Construction Specifications and Design Criteria based on Performance - Focused on Pavements and Concrete Structures” commenced in September 2006 and will end in May 2011. The research roadmap is shown in Figure 2. The research goals of this project are as follows:

(1) To develop the performance warranty specification consists of the performance based standard, pay adjustment regulation and the performance warranty contract system in pavement area.

(2) To convert the prescriptive design code to the performance based design code for concrete structures and develop the performance based design code considered the environment, material, and technique level in Korea in concrete area.

(3) To prepare performance-based and globally standardized design and construction guidelines for steel structures, buildings, foundation structures, road subsidiary facilities, tunnels, landscaping facilities, building mechanical and electrical systems.

Figure 2. Roadmap to develop performance-based design codes and specifications (general)

In this project, status and plans for developing performance-based codes and specifications or the guidelines for performance based design of the main facilities are shown in Figures 3-6:
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance based standard</strong></td>
<td>Case study of overseas performance specs and development of the logics</td>
<td>Draft preparation of performance specs and selection of pilot section for applying performance specs</td>
<td>Draft preparation of performance specs</td>
<td>Application plan preparation of performance specs</td>
</tr>
<tr>
<td><strong>Pay adjustment regulation</strong></td>
<td>Survey of material property status and establishment of test plan</td>
<td>Preparation of pay adjustment regulation draft and selection of pilot section for applying pay adjustment regulation</td>
<td>Draft preparation of pay adjustment regulation</td>
<td>Development of serviceability model of pay adjustment regulation</td>
</tr>
</tbody>
</table>

Figure 3 Roadmap of performance based pavement work specifications and contracting system

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Code system</strong></td>
<td>Evaluation of structure design code status and establishment of introduction system</td>
<td>Definition of codes for limit states</td>
<td>Evaluation of reliability (basic variables)</td>
<td>Reliability analysis (failure probability/partial safety factor)</td>
</tr>
<tr>
<td><strong>Material property</strong></td>
<td>Survey of material property status and establishment of test plan</td>
<td>Concrete stress-strain/compressive strength/autogenous shrinkage model</td>
<td>Establishment of concrete tensile strength model and dying shrinkage/autogenous shrinkage model test</td>
<td>Establishment of concrete material property model with age</td>
</tr>
<tr>
<td><strong>Durability</strong></td>
<td>Development of performance-based durability design principles and establishment of durability test plan</td>
<td>Establishment of durability design model</td>
<td>Establishment of durability design and evaluation model</td>
<td>Establishment and verification of durability evaluation program</td>
</tr>
<tr>
<td><strong>Structural resistance</strong></td>
<td>Suggestion of basic concept of performance-based design and establishment of test plan</td>
<td>Development of element deformation/strength model</td>
<td>Development of members deformation/strength model</td>
<td>Development of members deformation/strength model</td>
</tr>
</tbody>
</table>

Figure 4. Roadmap of performance-based design codes for concrete structures

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Establishment of master plan to develop performance-based codes</strong></td>
<td>Collection and analysis of performance-based design materials</td>
<td>Establishment of Korean performance-oriented design process</td>
</tr>
<tr>
<td><strong>Establishment of Korean performance-oriented design process</strong></td>
<td>Analysis of the performance hierarchy of steel structures</td>
<td>Establishment of the high level criteria for performance-oriented design</td>
</tr>
<tr>
<td><strong>Survey/analysis of architectural material performance criteria and performance test method at Korea and abroad, Review of building performance classification method</strong></td>
<td>Proposal of a research project to develop performance-based Design Codes and Standard Specifications for steel structures</td>
<td>Proposal of a research project to develop performance-based Design Codes and Standard Specifications for steel structures</td>
</tr>
</tbody>
</table>

Figure 5 Roadmap of performance-based steel structure design guideline

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Architectural materials</strong></td>
<td>Survey/analysis of architectural material performance criteria and performance test method at Korea and abroad, Review of building performance classification method</td>
<td>Performance classification for each member(use) and development of performance assessment technologies</td>
</tr>
<tr>
<td><strong>Steel structural buildings</strong></td>
<td>Understanding bottlenecks in case of converting descriptive design to performance-based design</td>
<td>Establishment of performance goal and level as per performance evaluation</td>
</tr>
<tr>
<td><strong>Survey of performance levels and comparative analysis of performance-based design process of each country</strong></td>
<td>Development of performance evaluation technologies</td>
<td>Preparation of fire-resistance performance design guideline of structural members</td>
</tr>
<tr>
<td><strong>Establishment of performance goal and level as per performance evaluation</strong></td>
<td>Development of performance evaluation technologies</td>
<td>Preparation of fire-resistance performance design guideline of structural members</td>
</tr>
<tr>
<td><strong>DB establishment of high temperature characteristics of structural materials</strong></td>
<td>Preparation of performance-based architectural material design guideline</td>
<td>Preparation of performance-based structural design guideline of steel structural buildings</td>
</tr>
</tbody>
</table>

Figure 6. Roadmap of performance-based building design guideline
According to the project, “Standardization of Construction Specifications and Design Criteria based on Performance: Focused on Pavements and Concrete Structures”, it is expected that the development of performance-based codes and specifications for pavements and concrete structures will be reflected in the Standard Specifications in near future. And also it is further expected that in case of other facilities including steel structures and architectural buildings, research and development projects for performance-based codes and specifications will be progressed on an urgent basis.

5 CONCLUSION

Since the establishment of the World Trade Organization, there is a possibility that there will be open international competition in design technologies among countries to comply with international standards based on the Agreement on Government Procurement in both domestic construction fields and foreign construction fields. In view of this trend, importance of development of harmonized performance-based improvement of design codes and specifications were realized recently in Korea. At this juncture, it seems to be encouraging to note that Asian countries are exerting their cooperative efforts for the harmonized design codes for each construction field. One of good example is that successful development of the Asian Concrete Model Code (ACMC) developed by the International Committee of Concrete Model Code (ICCMC). In Asian countries, information exchanges and mutual close cooperation for the harmonization in design codes including developing performance-based design codes in the field of civil engineering are very much necessary.

ACKNOWLEDGEMENT

The authors would like to acknowledge supports by the Construction & Transportation R&D Policy and Infrastructure Project on Standardization of Construction Specifications and Design Criteria based on Performance, the Ministry of Land, Transport and Marine Affairs, Korea.
Development of Design Codes and Standard Specifications in Korea

Jai-Dong Koo, Tae-Song Kim
And Ha-Won Song

CONTENTS
1. INTRODUCTION
2. DESIGN CODES AND STANDARD SPECIFICATIONS IN KOREA
3. NEEDS AND DIRECTION OF HARMONIZED CODES AND SPECIFICATIONS IN KOREA
4. ONGOING DEVELOPMENT OF PERFORMANCE BASED DESIGN CODES AND SPECIFICATIONS
5. CONCLUSION

INTRODUCTION

- For the past more than a decade, the Korean government has made many efforts to improve design codes and standard specifications.
- Recently intensive researches on the development of the performance-based design codes and specifications in various sectors in Korea are ongoing.
- In this paper the status of the recent development of design codes and specifications will be introduced and the future development direction of performance-based design codes and specifications will be explained.

DESIGN CODES AND STANDARD SPECIFICATIONS IN KOREA

- Had been administered by government.
  - Fell short of professionalism and efficiency.
- Construction code and specification entailed many confusion
  - Standard specifications, codes, guidelines, handbooks, technical instructions, manual, etc.
- Was delegated to corresponding academic societies and associations from 1995.

Example of Standard specifications and design codes

<table>
<thead>
<tr>
<th>Responsible Organizations</th>
<th>Standard Specifications</th>
<th>Design Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korean Society of Civil Engineers</td>
<td>General Standard Specification for Civil Works</td>
<td>Concrete Structure Design Code</td>
</tr>
<tr>
<td></td>
<td>Standard Specification for Urban Railroad (metro) Works</td>
<td></td>
</tr>
<tr>
<td>Korea Concrete Institute</td>
<td>Standard Concrete Construction Specification</td>
<td>Concrete Structure Design Code</td>
</tr>
<tr>
<td>Architectural Institute of Korea</td>
<td>Architectural Standard Specification</td>
<td>Korean Building Codes</td>
</tr>
<tr>
<td>Korean Geotechnical Society</td>
<td>Structural Foundation Design Codes</td>
<td></td>
</tr>
<tr>
<td>Korean Society for Steel Construction</td>
<td>Steel Structure Design Codes</td>
<td></td>
</tr>
</tbody>
</table>

DESIGN CODES AND STANDARD SPECIFICATIONS IN KOREA

- Construction codes and specifications were categorized into ‘Design Codes’, ‘Standard Specifications’, ‘Owner’s Standard Specifications’ and ‘low-level technological criteria’.
- Design Codes and Standard Specifications
  - National and high-level criteria.
  - Government subsidies are granted for the establishment or revision.
  - Subject to the deliberation of the Central Construction Technology Deliberation Committee.
  - Not compulsory regulations.
- Uniformity of the construction code and specification formats and the convenience of users were obtained.
- Securing design engineering capability and advancement and globalization of design codes and specification system remain to be desired.
DESIGN CODES AND STANDARD SPECIFICATIONS IN KOREA

Laws, Regulations
- Directives
- Guidelines
- Public Notifications

Design Codes
- Standard Spec and Drawings
- Manuals
- Handbooks
- Technical Instructions
- Standard Drawings

Deliberated by the Central Construction Technology Deliberation Committee
Controlled by academic societies, associations and owners

NEEDS AND DIRECTION OF HARMONIZED CODES AND SPECIFICATIONS IN KOREA

- Korean design codes and specifications is the prescriptive codes.
  - Able to be utilized by the designer and contractor.
  - May be faced with bottlenecks due to limitation of designer’s discretion.
- Necessary to move forward to performance-based design codes and specifications.
- Necessary to join in the performance-based globalization trend.

Development status of performance-based design codes and specifications

- Not many have been developed in until recently.
- Road Pavement Sector
  - Experiments and researches were conducted partially to examine road pavement performance.
  - Technical development for evaluating road pavement performance was few.

Concrete Structure Sector

- Design is mostly limited to the Allowable Stress Design.
- Performance-based design is mainly concentrated on seismic design.
  - Especially on the buildings that employ steel structures.
- Researches on performance-based design, still, remain to be desired.

Architectural Building Sector

- Any significant development performance concept in design has not been achieved.
- Full-scale performance design has not been realized.
- Recently, researches on performance-based design technique have been started mainly in the Korean academic communities.

Steel Structure (Civil) Sector

- Experiments and researches were conducted partially to examine road pavement performance.
- Technical development for evaluating road pavement performance was few.
Researches have been carried out mainly in the deep foundation design based on reliability analysis. Researches on the evaluation of bearing capacity of piles and researches with a safety factor in prediction methods of bearing capacity of piles, based on reliability analysis have been performed. Researches on stochastical reliability analysis to nonlinear structures, development of reliability analysis algorithm of real structures, and reliability analysis of pile structures subject to biaxial loading have been carried out.

The criteria of safety barriers have been changed into performance criteria. Reflective performances of retro-reflectors are applied to delineation systems, pavement markings, road signs, re-boundable guideposts and etc., but performance codes and specifications of road subsidiaries still remain to be desired.

The Tunnel Design Code remains mostly at material-oriented approaches. Researches and introduction of technologies based on the performance in tunnel area remains to be lack.

Performance for the products and equipments are ensured by certification processes of the Korean Standards and certification systems of public institutions and academic communities. However, the maintenance of the systems are not sufficient. The criteria of high efficiency performance and durability have not been established.

Along with efforts of complying Korean Standards with IEC since the 1990s, efforts of complying Korean codes with international codes have been maintained sustainably but visible outcome is few.

Researches to introduce international performance warranty contracting system has not been performed. Recently, introduction of an awarding system that can assess costs and technologies synthetically is under progress.
OGOING DEVELOPMENT OF PERFORMANCE BASED DESIGN CODES AND SPECIFICATIONS

- According to the policy, “International standardization of design documents and performance-based improvement of design codes”, the project, “Master plans to develop performance-based construction codes and specifications”(2007) had been carried out.

- The project, “Standardization of Construction Specifications and Design Criteria based on Performance - Focused on Pavements and Concrete Structures”(2006 ~ 2011) was commenced.

Roadmap of performance-based design codes and specifications (general)

Roadmap of performance-based pavement work specifications and contracting system

Roadmap of performance-based steel structure design guideline

Roadmap of performance-based building design guideline
**Future plan**

- It is expected that the development of performance-based codes and specifications for pavements and concrete structures will be reflected in the Standard Specifications in the future.
- It is further expected that in case of other facilities including steel structures and architectural buildings, research and development projects for performance-based codes and specifications will be progressed on an urgent basis.

**CONCLUSION**

- It seems to be encouraging to note that Asian countries are exerting their cooperative efforts for the harmonized design codes.
- One of good example is that successful development of the Asian Concrete Model Code (ACMC) developed by the International Committee of Concrete Model Code (ICCMC).
- In Asian countries, information exchanges and mutual close cooperation system for the harmonization in design codes including developing performance-based design codes in the civil engineering are very much necessary.

Thank You
Presentation from
TC-8 members and other representatives
Status of Design Codes in Taiwan

Shyh-Jiann Hwang  
Professor, National Taiwan University  
Chair, Concrete Technology Committee of CICHE (Chinese Institute of Civil and Hydraulic Engineering)
Status of Design Codes in Taiwan

Shyh-Jiann Hwang
(National Taiwan University)

Chinese Institute of Civil and Hydraulic Engineering

Geographic Setting
Taiwan
Area: 36,000 km²
Population: 23 million

Outline
- General
- Establishment
- Modification
- Harmonization
- Conclusions

General

Background
1. The government regulates the establishment of design codes.
2. The building and civil sectors use common sets of guides and specifications even though each has its own governing law and code.

Status of Design Codes

Laws & Regulations
- Building, Building Technics, Highway, Metro, Hydro-Engineering, Water Supply

Design Codes
- General
- Geotechnical Engineering
- Concrete Engineering
- Steel Structural Engineering
- Highway Engineering

Standards & Specifications
- Chinese National Standard (CNS)
- Test Standards
- Material Specifications
Code-related Laws

Drafted by the relevant government agencies with the help of experts

Enacted by the legislative body

More than 100 code-related laws in Taiwan

Codes

Drafted by relevant engineering societies

Reviewed, approved and published by the competent government authority

Modified by specialists, professors, and representatives of engineering societies and organizations before approval

20 sets of major codes in Taiwan

List of General Design Codes

<table>
<thead>
<tr>
<th>Code Name</th>
<th>Publisher</th>
<th>Issued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Design Code</td>
<td>CPA</td>
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</tr>
<tr>
<td>Seismic Design Code and Commentary for Building</td>
<td>CPA</td>
<td>2006-01</td>
</tr>
<tr>
<td>Wind-Resistance Code and Commentary for Building</td>
<td>CPA</td>
<td>1997-08</td>
</tr>
<tr>
<td>Seismic Isolation Design Code for Building</td>
<td>CPA</td>
<td>2002-04</td>
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CPA: Construction and Planning Administration

List of Codes - Concrete Engineering

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<th>Code Name</th>
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</tr>
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<td>Design Code and Commentary for Structural Concrete</td>
<td>CPA</td>
<td>2004-12</td>
</tr>
<tr>
<td>Design Code for Structural Concrete</td>
<td>CPA</td>
<td>2002-07</td>
</tr>
<tr>
<td>Specifications for Structural Concrete</td>
<td>CPA</td>
<td>2002-07</td>
</tr>
<tr>
<td>Design Code for Pre-cast Concrete</td>
<td>CPA</td>
<td>1997-08</td>
</tr>
<tr>
<td>Blast Furnace Bag Concrete Code for Public Construction</td>
<td>PCC</td>
<td>2001-04</td>
</tr>
<tr>
<td>Fly Ash Concrete Code for Public Construction</td>
<td>PCC</td>
<td>1999-08</td>
</tr>
<tr>
<td>Design Criteria for High Performance Concrete (draft)</td>
<td>TANEES</td>
<td>1995-11</td>
</tr>
<tr>
<td>Application Guidelines of Self-Compacting Concrete</td>
<td>CPA</td>
<td>2006-09</td>
</tr>
<tr>
<td></td>
<td>CICHE</td>
<td></td>
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</table>
List of Codes - Geotechnical Engineering

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<th>Code Name</th>
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<tbody>
<tr>
<td>Criteria for Site Investigation</td>
<td>CICHE</td>
<td>1993-06</td>
</tr>
<tr>
<td>Criteria for Geotechnical Investigation</td>
<td>TANEEB</td>
<td>1999-06</td>
</tr>
<tr>
<td>Criteria for Geological Mapping and Commentary</td>
<td>CICHE</td>
<td>1999-02</td>
</tr>
<tr>
<td>Design Criteria for Building Structural Foundation</td>
<td>TGS</td>
<td>2001-12</td>
</tr>
<tr>
<td>Specification and Commentary for Foundation Construction</td>
<td>CICHE</td>
<td>1998-11</td>
</tr>
<tr>
<td>Design Criteria, Specifications and Commentary for Earth Anchors</td>
<td>CICHE</td>
<td>2001-09</td>
</tr>
<tr>
<td>Design Criteria and Commentary for Tunneling</td>
<td>CICHE</td>
<td>1999-01</td>
</tr>
<tr>
<td>Construction Specifications for Tunneling</td>
<td>TANEEB</td>
<td>1993-12</td>
</tr>
<tr>
<td>Construction Specifications for Shield Tunneling (Draft)</td>
<td>CTTA</td>
<td>1999-09</td>
</tr>
</tbody>
</table>

Guides/specifications

Drafted by the relevant engineering societies

Approved by the competent government authority

Published by the engineering societies

20 sets of major guides/specifications in Taiwan

Local natural conditions

Considered in establishing safety requirements in design codes

However, international codes such as those of the US, Japan, EC, and even PRC were also referred to.
Modification

Reviewed and updated about every 3-6 years generally
Or after disasters caused by earthquakes, floods and typhoons

Lessons from Chi-Chi Earthquake

Vertical Faulting = 9.0m

1999

Lessons from Chi-Chi Earthquake

Damages of School Buildings

293 elementary and high schools were completely or partially damaged.

Lessons from Chi-Chi Earthquake

Bridge Damages

Modification-Example

Several design codes have been updated/upgraded or are being modified
To raise the level of earthquake resistance requirements based on the Chi-Chi Earthquake (M=7.3), 1999

Harmonization
Study on Mechanism of Performance Based Criteria for Public Construction

Jenn-Chuan Chern
Vice Minister, Public Construction Commission

Objective on Code Harmonization

- Unified Design Concept: Performance-Based Design
- Code Harmonization among different Fields (Building, Bridge, Highway...) in Taiwan
- Code Harmonization among different Asian Regions

Collaborative Study

- Different Disciplines: Concrete, Steel, Geotechnical, EQ...
- Different Society: CICHE, CSSE, N Cree, TS G E...
- Different Resource: ACECC, APEC, ICCMC, PLATFORM, ACMC...

International Committee of Concrete Model Code of Asia (ICCMC)

CICHE will use the format of ACMC Level 3 by ICCMC for guide and specification related to concrete engineering

The working Level 3 documents are to be prepared by each country that adopts the code by incorporating its own national concrete engineering practices.

Conclusions

- CICHE supports the code harmonization. However, government agreement and sponsorship are needed.
- Unifying Codes through performance based engineering is welcome.
- Level 3 document of ICCMC will be elaborated.

Thank You
THE CURRENT SITUATION OF MONGOLIAN BUILDING CODE SYSTEM

Ya.Duinkherjav

Prof and Chairman, Department of Civil Engineering, Head of concrete and steel testing laboratory, Mongolian University of Science and Technology /MUST/, Ulaanbaatar Mongolia

E.Ganzorig

President of Mongolian Civil Engineers Association, Assistant prof of Civil Engineering Department. MUST, Ulaanbaatar, Mongolia

Abstract

Mongolian did a choice in 1990 to step into a completely new socio-economic system from post communism. Before this time, the country used Soviet Building Codes as its own. In the period of 1990-2000 the construction industry experienced dramatic decline due to the lack of an investment. But from 2005 the situation is reversed and the industry investment is increasing year by year as an effect of a macro economics positive stimulation. Following an increased investment from abroad especially from China, Japan, Republic of Korea, Taiwan, and USA, new techniques, materials and ideas are coming to the industry. This new situation of the industry pushes us to upgrade existing Industry Building Codes System.

History of Development of Building Codes in Mongolia

Until 1960 the development of construction industry was weak, most construction work were carried out by Soviet and Chinese workers and Soviet Building Codes were used directly without any translation. In 1960-1970 education system of national engineers and technical staffs and workers is established and following this the industry development was speeded. National work force needed educational and instructional materials on native language and relating with this measurements were taken to develop National Building Code System. To develop national codes works were done in three directions: (1) direct translation and usage of Soviet Codes; (2) adapt Soviet Codes with changes and revision considering country specifics; and (3) develop new national building code. It can be said here that Mongolian Building Code System founded on Soviet building code system and keeps this root until today.

The historically the development process of national codes can be divided into the following three stages:

From 1921 to 1960, the period of no national codes and Soviet Codes were used directly;

From 1960 to 1990, adaptation of Soviet Codes with changes and revision;

From 1990 to present, development of national codes,
Current System of Building Codes

Development of enforcement of Mongolian Building Codes is primary responsibility of Ministry of Construction and Urban Development and its relevant agencies. Building codes are industry standards that building owners, designers, contractors must follow in their respective activities. Its enforcement is monitored and controlled by State Professional Inspection Authorities. National Building Code system is unitary; there are no regional codes as used in other countries.

The framework of Building Code System encloses of the following major fields:

- Urban development;
- Allocation, regionalization, and usage of land and construction sites;
- Durability and strength of structures;
- Health and safety
- Operation and maintenance
- Cost estimation

Annual budget allocated from the State for development of building codes is around 30 to 50 million tugriks.

Building code system before 2003 consisted from 3 major fields:

I. Management and economics
II. Design and specifications
III. Construction

Each one of major fields contains codes in several groups as showed below.

I. Management and economics field subdivided into the following six groups:
   1st group. Construction normative documents
   2nd group. Design requirements, engineering surveying, management of economics
   3d group. Construction administration and management
   4th group. Norms to estimate duration of design and construction stages of project
   5th group. Construction economics
   6th group. Rules of officials
II. Design and specification field subdivided into the following 11 groups:

1st group. Fundamental norm for design
2nd group. Soil and foundation
3rd group. Structure
4th group. Engineering equipments of buildings, outside engineering supplies
5th group. Transportation facilities
6th group. Hydrotechnical, power and melioration facilities and systems
7th group. Urban planning and construction
8th group. Residential and public buildings
9th group. Factory buildings and supporting facilities
10th group. Agricultural facilities
11th group. Warehouses and storage buildings

Construction field can be subdivided into 9 groups as follows:

1st group. Norms for construction and acceptance of work
2nd group. Soil and foundation
3rd group. Structure
4th group. Isolation and protective isolation, finishing
5th group. Engineering equipments of buildings, outside engineering supplies
6th group. Transportation facilities
7th group. Hydrotechnical, power and melioration facilities and systems
8th group. Mechanization in construction
9th group. Production of construction materials and products

January, 2002 statistics showed that 283 building codes were effective in the industry and from the total 23 of them are norms of Management and Economics, 94 are for Design and Specifications, and 38 are for construction, and 128 are for cost estimation. It also stated that 260 standards are used and 199 of them are Russian GOST, 12 are ISO standards, 5 are DIN standards and 44 are from other countries national standards. Foreign standards are used with translation into Mongolian. Darkhan metallurgical factory is sole domestic producer of construction rebars which was built under Japanese project and Japanese several standards are used for its products.
From 2002 new system of building codes have been using in the industry, and its classification differs from the previous system. New system has 8 subgroups.

1st group. Management methodological norms

2nd group. General technical normative documents

3rd group. Urban development and building normative documents

4th group. Normative documents for engineering equipments of buildings and outside supply systems

5th group. Normative documents for building structures and elements

6th group. Normative documents for construction materials and products

7th group. Normative documents for temporary facilities, form work

8th group. Construction economics normative documents

By August, 2008, 368 building codes are effective in the industry and from the total 23 of them are norms of Management and Economics, 89 are for Design and Specifications, and 144 are for construction and cost estimation, 30 recommendations and 56 documents are in Russian. Fig.1.

Figure 1. Effective building codes
Proposal of Change into Mongolian Building Code System

Considering today’s rapid development of Mongolian construction industry and penetration of advanced materials and techniques, it needs to bring national normative documents making close to the level of international documents. To accomplish this objective the followings are needed:

- To transfer function of development of normative documents into non-governmental organizations, especially there are already capable professional associations such as Mongolian Association of Civil Engineers, Concrete Institute and so on,
- To bring collaboration from Asian professional associations of engineers into development activities of normative documents, organize study and analyze of documents of Asian countries and seek possibility to adapt reflecting country specifics,
- To enhance effectiveness of educational and professional development systems of engineers, special attention goes to MUST and MACE.

References

1. Directives to upgrade Building Code system in new market economy, MUDBY, ZGHABHBNAAG, 2003, UB,
2. Objectives and directions of construction standardization, Journal of Construction Information, 2000/4, ZGHABHBNAAG, UB,
3. Journal of Construction Information, 2008, ZGHABHBNAAG, UB,
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Mongolian did a choice in 1990 to step into a completely new socio-economic system from post communism. Before this time, the country used Soviet Union Building Codes as its own. In the period of 1990-2000 the construction industry experienced dramatic decline due to the lack of an investment. But from 2005 the situation is reversed and the industry investment is increasing year by year as an effect of a macro economics positive stimulation. Following an increased investment from abroad especially from China, Japan, Republic of Korea, Taiwan, and USA, new techniques, materials and ideas are coming to the industry. This new situation of the industry pushes us to upgrade existing Industry Building Codes System.

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Current System of Building Codes

- Development of enforcement of Mongolian Building Codes is primary responsibility of Ministry of Construction and Urban Development and its relevant agencies. Building codes are industry standards that building owners, designers, contractors must follow in their respective activities. Its enforcement is monitored and controlled by State Professional Inspection Authorities. National Building Code system is unitary; there are no regional codes as used in other countries.
The framework of Building Code System encloses of the following major fields:
- Urban development;
- Allocation, regionalization, and usage of land and construction sites;
- Durability and strength of structures;
- Health and safety;
- Operation and maintenance;
- Cost estimation;
- Annual budget allocated from the State for development of building codes is around 30 to 50 million tugriks.

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   - 3rd group. Structure
   - 4th group. Engineering equipments of buildings, outside engineering supplies
   - 5th group. Transportation facilities
   - 6th group. Hydro technical, power and melioration facilities and systems
   - 7th group. Urban planning and construction
   - 8th group. Residential and public buildings
   - 9th group. Factory buildings and supporting facilities
   - 10th group. Agricultural facilities
   - 11th group. Warehouses and storage buildings

III. Construction field can be subdivided into 9 groups as follows:
   - 1st group. Norms for construction and acceptance of work
   - 2nd group. Soil and foundation
   - 3rd group. Structure
   - 4th group. Isolation and protective isolation, finishing
   - 5th group. Engineering equipments of buildings, outside engineering supplies
   - 6th group. Transportation facilities
   - 7th group. Hydro technical, power and melioration facilities and systems
   - 8th group. Mechanization in construction
   - 9th group. Production of construction materials and products

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Building Code System of Mongolia

1. Direction, methodology, normative document
   Comp. 10
   Comp. 11
   Comp. 12
   Comp. 13
   Comp. 14

2. General technical normative documents
   Comp. 20
   Comp. 21
   Comp. 22
   Comp. 23

3. Urban development, building and structural normative documents
   Comp. 30
   Comp. 31

4. Building facilities and building complexes normative documents
   Comp. 40
   Comp. 41

5. Building structural and building compass normative documents
   Comp. 50
   Comp. 51
   Comp. 52
   Comp. 53
   Comp. 54
   Comp. 55
   Comp. 56

6. Building materials and products normative documents
   Comp. 60
   Comp. 61
   Comp. 62
   Comp. 63
   Comp. 64

7. Provisory building and facilities normative documents
   Comp. 70
   Comp. 71

8. Building cost estimation and quantity normative documents
   Comp. 80
   Comp. 81

From 2002 new system of building codes have been using in the industry and its classification differs from the previous system. New system has 8 subgroups.

By August, 2008, 368 building codes are effective in the industry and from the total 23 of them are norms of Management and Economics, 89 are for Design and Specifications, and 144 are for construction and cost estimation, 30 recommendations and 56 documents are in Russian Fig. 1.

173 normative documents are newly approved and enforced from 1997 to 2007.

Proposal of Change into Mongolian Building Code System

- Considering today's rapid development of Mongolian construction industry and penetration of advanced materials and techniques, it needs to bring national normative documents making close to the level of international documents.

To accomplish this objective the followings are needed:

- To transfer function of development of normative documents into non-governmental organizations, especially there are already capable professional associations such as Mongolian Association of Civil Engineers, Concrete Institute and so on,
- To bring collaboration from Asian professional associations of engineers into development activities of normative documents, organize study and analyze of documents of Asian countries and seek possibility to adapt reflecting country specifics,
- To enhance effectiveness of educational and professional development systems of engineers, special attention goes to MUST and MACE.
Thank you for your attention.
Introduction of Asian Concrete Model Code (ACMC)

Yoshitaka Kato
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INTRODUCTION OF
ASIAN CONCRETE MODEL CODE (ACMC)

BIG CONSTRUCTION MARKET IN ASIA

World wide cement consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>Million ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.94</td>
</tr>
<tr>
<td>1991</td>
<td>0.92</td>
</tr>
<tr>
<td>1992</td>
<td>0.94</td>
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<tr>
<td>1993</td>
<td>0.96</td>
</tr>
<tr>
<td>1994</td>
<td>0.99</td>
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<tr>
<td>1995</td>
<td>1.02</td>
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<tr>
<td>1996</td>
<td>1.03</td>
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<tr>
<td>1997</td>
<td>1.07</td>
</tr>
<tr>
<td>1998</td>
<td>1.08</td>
</tr>
<tr>
<td>1999</td>
<td>1.13</td>
</tr>
<tr>
<td>2000</td>
<td>1.17</td>
</tr>
<tr>
<td>2001</td>
<td>1.22</td>
</tr>
<tr>
<td>2002</td>
<td>1.27</td>
</tr>
<tr>
<td>2003</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Typical unit weight of cement in concrete = 300 kg/m³

1.4 billion ton cement consumption (2006)

- 4.7 billion m³ in the world
- Average unit price of concrete (m³) in Japan = 10,000 JPY
- 47 trillion JPY in the world (21 trillion JPY in China)

More than 50% in Asia

2006

1st : China (1.1 billion ton, 44%)
2nd : India (0.16 billion ton, 6%)
3rd : USA (0.1 billion ton, 4%)
4th : Japan (0.07 billion ton, 3%)

3 GROUPS IN THE WORLD CONSTRUCTION MARKET

- Europe
- America (North/South America)
- Asia (more than 50%)

How about “Model Codes”?

- Europe : Euro codes
- America : ACI codes
- Asia : did not have one

SHOULD ASIA HAVE OWN MODEL CODES?

- International big projects
- There are many players

Owner
Designer
Architect
Inspector
Contractor
Project manager

Creates confusing and misunderstanding

Common language = Common model codes

Cannot Asia use other model codes?

Inappropriateness in codes in Europe and North America (due to difference in material quality, climate, technological level and economical level)

Creates confusing and misunderstanding
TO DEVELOP ITS OWN MODEL CODE IN ASIA

- The Model Code is
  - to help the countries to develop their own codes
  - to reduce confusion/misunderstanding in multinational projects
- The Model Code should be
  - flexible in its nature to fit the diversity in Asia

HISTORY FOR ASIAN CONCRETE MODEL CODE (ACMC)

- 1992: JCI Research Committee on Concrete Model Code
- 1994: International Committee on Concrete Model Code for Asia (ICCMC)
- 1998: First draft of ACMC
- 1999: Second draft of ACMC
- 2001: ACMC 2001
- 2004: Vietnamese version for maintenance part of ACMC
- 2006: ACMC 2006

COMMITTEE MEMBERS AND MEETINGS (AS OF MAY 2007)

- ICCMC has
  - over 80 individual members
  - 6 representative members
  - 10 corporate members
  from 14 countries/economies (Australia, Bangladesh, China, India, Indonesia, Iran, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand, and Vietnam)
- ICCMC has been organizing committee meetings regularly with local institutional hosts. In total 22 meetings have been held in 12 countries/economies.

OBJECTIVES OF ICCMC

The objectives of the Committee shall be to develop and maintain a concrete model code for Asia and promote cooperation and understanding among countries in the Asia-Pacific region through the following things.

- Initiation and support of collaborative research activities relating to various aspects of concrete, and through synthesis of findings of such research;
- Dissemination of research results and experience of development activities by way of publications, symposia, workshops and/or seminars;
- Updating and revising the model code, and through development of new knowledge to meet the needs of changing time;
- Interaction with the members and keeping them aware of the activities of the Committee;

ACMC 2006

3 Parts:
- “Structural design”
- “Materials and construction”
- “Maintenance”

Scope:
All kinds of concrete structures (plain concrete, reinforced concrete, prestressed concrete, and composite structures with concrete)

2 Features:
- Performance-based concept
- Multi-level code document structure

PERFORMANCE-BASED CONCEPT

- Clear description of the required performance of a structure (in such a way that the owners and users of the structure, who are likely to be non-engineers, can understand)
- No specification on how to satisfy the required performance or how to prove that the required performance is satisfied, which means that you can choose any method if proved to be appropriate

Best way to assure easy understanding among people with different background to accommodate the diversity in technological and economical level
The common Level 1 document specifies the general principles and framework for the performance based design of concrete structures as well as for their construction and maintenance. The Level 2 document serves as an operational and practical model code with specifications for the required performance. To allow for the differences in design, construction and maintenance practices among different countries, national standards, codes of practice or design guidelines when fully developed may be simpler or more detailed than this model code. The Level 3 document includes examples of design, construction and maintenance guidelines confirming to the Level 1 and Level 2 documents.

**Common Code**

Part I Design

**Level 1 Document**

Part II Materials and Construction

Part III Maintenance

**Level 2 Document**

**Level 3 Documents**

- **AOCM 2001** - Level 3 document, "Design for Seismic Action - An example of seismic performance examination for RC building designed according to the Architectural Institute of Japan (AIJ) Guidelines"


**Level 1 Document Table of Contents**

1. Introduction
   1.1 Scope
   1.2 Document Organization
   1.3 General principles
   1.4 Performance Requirements
   1.5 Materials
2. General principles for design
   2.1 Scope
   2.2 Actions
   2.3 Analysis
   2.4 Verification and Evaluation
3. General principles for construction
   3.1 General
   3.2 Workmanship
   3.3 Quality control and assurance
4. General principles for maintenance
   4.1 General
   4.2 Basis of maintenance
   4.3 Inspection
   4.4 Deterioration mechanisms and prediction
   4.5 Evaluation and decision making
   4.6 Remedial action
   4.7 Records

**Level 3 Documents**

1. INTRODUCTION
   1.1 Scope
   This model code specifies the general principles for the verification and evaluation of the performance of all types of concrete structures as well as the structural and nonstructural components thereof, under various mechanical actions and environmental effects. The code incorporates the concept of performance based design using limit state design methodology. It is applicable to the design, construction and maintenance of concrete structures. This code provides a set of minimum requirements for the performance of construction materials, standard for workmanship, measures of quality control and appropriate construction records that must be compiled with on site in order to meet the design requirements for strengths, safety, serviceability and durability of the structure.

   Also provided are guidelines that could be adopted in countries of Asia and the Pacific region in their attempts to establish relevant national codes.

**Collaboration between “CCMC” and “ISO”**

ISO/TC 71 (Concrete, Reinforced Concrete and Prestressed Concrete) is a technical committee established to deal with all kinds of ISO documents related to concrete. There are six subcommittees under TC 71:

- SC 1: Test methods for concrete
- SC 3: Concrete production and execution of concrete
- SC 4: Performance requirements for structural concrete
- SC 5: Simplified design for concrete structures
- SC 6: Non-traditional reinforcing materials for concrete
- SC 7: Maintenance and repairs of concrete structures
ISO/TC 71 (Concrete, Reinforced Concrete and Prestressed Concrete) is a technical committee established to deal with all kinds of ISO documents related to concrete. There are six subcommittees under TC 71.

**Concrete, RC and PC TC71**

- **SC 1**: Test methods for concrete
- **SC 3**: Concrete production and execution of concrete
- **SC 4**: Performance requirements for structural concrete
- **SC 5**: Simplified design for concrete structures
- **SC 6**: Non-traditional reinforcing materials for concrete
- **SC 7**: Maintenance and repairs of concrete structures

In SC 4 there is an Ad-Hoc Working Group on a performance-based code, which was initiated by members from ICCMC, to study how to implement the performance-based concept and a regional code like ACMC, into the ISO system of codes.

SC 7, proposed by the members from ICCMC, is currently chaired by Prof Song of Korea with the writer as Secretary. SC 7 is now drafting an umbrella code for maintenance based on ACMC.

### Benefits for Asian Countries

- **For Asian Countries with Own Code**
  - Dissemination of their technology to be international code in Asia and ISO
  - Strengthening their presence in international circle such as ISO through collaboration among Asian countries

- **For Asian Countries without Own Code**
  - Development of national codes
  - Enhancement of technological level
  - Strengthening their presence in international circle

### Acknowledgments

Members in
- ICCMC chaired by Profs Byun & Ueda
- JCI Research Committee on ACMC chaired by Prof Hatanaka
- JCI Domestic Committee on ISO/TC71 chaired by Prof Uomoto

Thank you for your attention

[http://www.iccmc.org](http://www.iccmc.org)
Seismic Design Specifications for Highway Bridges in Japan

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\textsuperscript{2}Chief Researcher, Bridge and Structural Technology Research Group, Public Works Research Institute, Tsukuba, Japan

1 INTRODUCTION

Seismic design methods for highway bridges in Japan have been developed and improved based on the lessons learned from the various past bitter experiences after the Great Kanto Earthquake (M7.9) in 1923. By introducing the various provisions for preventing serious damage such as the design method against soil liquefaction, design detailing including the unseating prevention devices, a number of highway bridges which suffered complete collapse of superstructures was only a few in the recent past earthquakes. However, the Hyogo-ken-Nanbu Earthquake of January 17, 1995, caused destructive damage to highway bridges. Collapse and nearly collapse of superstructures occurred at 9 sites, and other destructive damage occurred at 16 sites [2, 3]. The earthquake revealed that there are a number of critical issues to be revised in the seismic design and seismic strengthening of bridges. Based on the lessons learned from the Hyogo-ken-Nanbu Earthquake, the design specifications for highway bridges were significantly revised in 1996 [3, 4, 5]. The intensive earthquake motion with a short distance from the inland earthquakes with Magnitude 7 class as the Hyogo-ken-Nanbu Earthquake has been considered in the design.

The current version was revised based on the performance-based design code concept with the propose to enhance the durability of bridge structures for a long-term use, as well as the inclusion of the improved knowledges on the bridge design and construction methods. The current Design Specifications of Highway Bridges was issued by the Ministry of Land, Infrastructure, Transport and Tourism on December 27, 2001. The Japan Road Association (JRA) has released it with the commentary in March 2002. This paper summarizes the current JRA Design Specifications of Highway Bridges, Part V: Seismic Design, issued in March 2002

2 PERFORMANCE-BASED DESIGN SPECIFICATIONS

The JRA Design Specifications has been revised based on the Performance-based design code concept for the purpose to respond the international harmonization of design codes and the flexible employment of new structures and new construction methods. The performance-based design code concept is that the necessary performance requirements and the verification policies are clearly specified. The JRA specifications are employed the style to specify both the requirements and the acceptable solutions including the detailed performance verification methods which are based on the existing design specifications including the design methods and the design details. For example, the analysis method to evaluate the response against the loads is placed as one of the verification methods or acceptable solutions. Therefore, designer can propose new ideas or select other design methods with the necessary verification.

The most important issue of the performance-based design code concept is the clear specifications of the requirements, which the designers are allowed to select other methods, and the acceptable solutions, which the designers can select other methods with the necessary verification. In the JRA specifications, they are clearly specified including the detailed expressions. In future, the acceptable solutions will be increased and widened with the increase of the verification of new ideas on the materials, structures and construction methods.
The code structure of the Part V: Seismic Design is as shown in Fig. 1. The static and dynamic verification methods of the seismic performance as well as the evaluation methods of the strength and ductility capacity of the bridge members are placed as the verification methods and the acceptable solutions, which can be modified by the designers with the necessary verifications.

**Figure 1. Code Structure of JRA Design Specifications, Part V: Seismic Design**

**Table 1 Seismic Performance Matrix**

<table>
<thead>
<tr>
<th>Type of Design Ground Motions</th>
<th>Standard Bridges (Type-A)</th>
<th>Important Bridges (Type-B)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1 Earthquake:</strong> Ground Motions with High Probability to Occur</td>
<td>SPL 1: Prevent Damage</td>
<td>SPL 2: Prevent Critical Damage</td>
</tr>
<tr>
<td>Level 2 Earthquake: Ground Motions with Low Probability to Occur</td>
<td>Interplate Earthquake (Type-I)</td>
<td>SPL 3: Limited Damage for Function Recovery</td>
</tr>
<tr>
<td>Inland Earthquake (Type-II)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3 **BASIC PRINCIPLES OF SEISMIC DESIGN**

Table 1 shows the performance matrix including the design earthquake ground motion and the Seismic Performance Level (SPL) provided in the revised JRA Seismic Design Specifications in 2002. There is no revision on this basic principle from the 1996 Version.

The two level ground motion as the moderate ground motions induced in the earthquakes with high probability to occur (Level 1 Earthquake) and the intensive ground motions induced in the earthquakes with low probability to occur (Level 2 Earthquake).

The Level 1 Earthquake provides the ground motions induced by the moderate earthquakes and the ground motion considered in the elastic design method in the past for a long time is employed. For the Level 2 Earthquake, two types of ground motions are considered. One is the ground motions which is induced in the interplate-type earthquakes with the magnitude of around 8. The ground motion at Tokyo in the 1923 Kanto Earthquake is a typical target of this type of ground
motion. The other is the ground motion developed in earthquakes with magnitude of around 7 at very short distance. The ground motion at Kobe during the Hyogo-ken-Nanbu Earthquake is a typical target of this type of ground motion. The former and the latter are named as Type-I and Type-II ground motions, respectively. The recurrence period of the Type-II ground motion may be longer than that of the Type-I ground motion, although the estimation is very difficult.

In the 2002 revision, the design ground motions are named as Level 1 Earthquake and Level 2 Earthquake. One more important revision on the design earthquake ground motion is that the site-specific design ground motions shall be considered if the ground motion can be appropriately estimated based on the informations of the earthquake including past history and the location and detailed condition of the active faults, ground conditions including the condition from the faults to the construction sites. To determine the site-specific design ground motion, it is required to have the necessary and accurate informations of the earthquake ground motions and ground conditions as well as the verified evaluation methodology of the fault-induced ground motions. However, the area to get such detailed informations in Japan is very limited so far. Therefore, the continuous investigation and research on this issue as well as the reflection on the practical design of highway bridges is expected.

Table 2 Key Issues of Seismic Performance

<table>
<thead>
<tr>
<th>SPL</th>
<th>Safety</th>
<th>Functionability</th>
<th>Repairability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Short Term</td>
</tr>
<tr>
<td>SPL 1: Prevent Damage</td>
<td>Safety against Unseating of Superstructure</td>
<td>Same Function as Before Earthquake</td>
<td>No Need of Repair for Function Recovery</td>
</tr>
<tr>
<td>SPL 2: Limited Damage for Function Recovery</td>
<td>Safety against Unseating of Superstructure</td>
<td>Early Function Recovery can be Made</td>
<td>Function Recovery can be Made by Temporary Repair</td>
</tr>
<tr>
<td>SPL 3: Prevent Critical Damage</td>
<td>Safety against Unseating of Superstructure</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

4 GROUND MOTION AND SESIMIC PERFORMANCE LEVEL

The seismic design of bridges is according to the performance matrix as shown in Table 1. The bridges are categorized into two groups depending on their importances; standard bridges (Type-A bridges) and important bridges (Type-B bridges). Seismic Performance Level (SPL) depends on the importance of bridges. For the moderate ground motions induced in the earthquakes with high probability to occur, both A and B bridges shall behave in an elastic manner without essential structural damage (SPL 1). For the extreme ground motions induced in the earthquakes with low probability to occur, the Type-A bridges shall prevent critical failure (SPL 3), while the Type-B bridges shall perform with limited damage (SPL 2).

The SPLs 1 to 3 are based on the viewpoints of "Safety", "Functionability" and "Repairability" during and after the earthquakes. Table 2 shows the basic concept of these three viewpoints of the SPL.

5 VERIFICATION OF SEISMIC PERFORMANCE

5.1 Seismic Performance Level and Limit States

As mentioned in the above, the seismic performance is specified clearly. It is necessary to determine and select the limit states of highway bridges corresponding to these seismic performance levels to attain the necessary performance in the design procedure of highway bridges.

In the 2002 revision, the determination principles of the limit state to attain the necessary seismic performance are clearly specified. For example, the basic principles to determine the limit
state for SPL 2 is: 1) the plastic hinges shall be developed at the expected portions and the capacity of plastic hinges shall be determined so that the damaged members can be repaired relatively easily and quickly without replacement of main members, 2) the plastic hinges shall be developed at the portions with appropriate energy absorption and with high repairability, 3) considering the structural conditions, the members with plastic hinges shall be combined appropriately and the limit states of members with plastic hinges shall be determined appropriately. Based on the basic concept, the combinations of members with plastic hinges and the limit states of members for ordinary bridge structures are shown in the commentary.

Table 3 Applicable Verification Methods of Seismic Performance Depending on Earthquake Response Characteristics of Bridge Structures

<table>
<thead>
<tr>
<th>Dynamic Characteristics</th>
<th>SPL to be Verified</th>
<th>Bridges with Simple Behavior</th>
<th>Bridges with Multi Plastic Hinges and without Verification of Applicability of Energy Constant Rule</th>
<th>Bridges with Limited Application of Static Analysis with Multi Mode Response</th>
<th>Bridges with Complicated Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL 1</td>
<td>Static Verification</td>
<td>Dynamic Verification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPL 2/SPL 3</td>
<td>Other Bridges</td>
<td>1) Bridge with Rubber Bearings to Distribute Inertia Force of Superstructure 2) Seismically Isolated Bridge 3) Rigid Frame Bridges 4) Bridges with Steel Columns</td>
<td>1) Bridge with Long Natural Period 2) Bridge with High Piers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1) Cable-stayed Bridges 2) Suspension Bridges 3) Arch Bridges 4) Curved Bridges</td>
</tr>
</tbody>
</table>

5.2 Verification Methods

It is the fundamental policy of the verification of seismic performance that the response of the bridge structures against design earthquake ground motions does not exceed the determined limit states. Table 3 shows the applicable verification methods of seismic performance used. In the seismic design of highway bridges, it is important to increase the strength and the ductility capacity to appropriately resist the intensive earthquakes. The verification methods are based on the static analysis and dynamic analysis. In the 1996 design specifications, the lateral force coefficient methods with elastic design, ductility design methods and dynamic analysis were specified and these design methods had to be selected based on the structural conditions of bridges. The basic concept is the same as 1996 one but the verification methods are rearranged to the verification methods based on static and dynamic analyses.

The static verification methods including the lateral force design method and the ductility design method are applied for the bridges with simple behavior with predominant single mode during the earthquakes. The dynamic verification method is applied for the bridges with complicated behavior, in such case the applicability of the static verification methods is restricted. In the 1996 design specifications, for the bridges with complicated behavior both the static and dynamic analyses had to be applied and satisfied. In the 2002 one, the applicability of the dynamic analysis is widened and the dynamic verification method is expected to be used mainly with appropriate design consideration.

5.3 Major Revisions of the Verification Methods of Seismic Performance

(1) Verification of Abutment-Foundation on Liquefiable Ground against Level 2 Earthquake

In the 1996 design specifications, the performance of the abutment-foundations was not verified in detail. This is because 1) the serious damages to abutment-foundations were not found in the past earthquakes when the soil liquefaction was not developed, 2) abutment-foundation is affected by the backfill soils during earthquakes and the effect of the inertia force of abutment itself is relatively small comparing with the pier-foundations, 3) since abutments generally resist against back-fill earth pressure, the abutment-foundations tend to develop displacement to the direction of
the earth pressure that is to the center of bridges, then it is generally low probability to have the unseating of superstructures.

On the other hand, recently, the dynamic earth pressure against Level 2 Earthquake based on the modified Mononobe-Okabe theory has been proposed and the behavior of the abutment-foundations can be evaluated during the Level 2 earthquakes. Based on investigations using the modified Mononobe-Okabe theory, it is shown that the abutment-foundations designed according to the Level 1 Earthquake generally satisfy the performance requirement during the Level 2 Earthquake. Therefore, based on these results, the performance of the abutment-foundations only on the liquefiable ground shall be verified in order to give the necessary strength to the foundations and to limit the excessive displacement even if the nonlinear behavior is expected in the abutment-foundations.

(2) Verification of Strength and Ductility of Steel Column

In the 1996 design specifications, the concrete infilled steel columns was designed according to the static ductility design methods using the response evaluation based on the energy equal theory. The force-displacement relation was based on the experimental data of steel columns. On the other hand, steel columns without infilled concrete was designed based on the dynamic analysis because the applicability of the static response evaluation was not verified.

In the 2002 design specifications, new and more appropriate force-displacement relation models for steel columns with and without infilled concrete are proposed based on the experimental data of steel columns which has been made before and after the last 1996 revision. Using these new models, the seismic performance is verified based on the dynamic analysis.

(3) Verification of Strength and Ductility of Superstructure

Generally, the seismic design of superstructures is not critical except the portion around the bearing supports which are the connection between superstructure and substructures. However, the seismic design sometimes becomes critical in the design of rigid frame bridges and arch bridges in the longitudinal direction, and in the design of bridges with relatively long spans to the bridge width in the transverse direction.

The nonlinear behavior of superstructures against cyclic loading is investigated in the recent research. Therefore, the verification method of the limited nonlinear performance for the superstructures is newly specified with the assumption of energy absorption at the plastic hinges in the columns.

6 CONCLUDING REMARKS

This paper presented an outline of the current JRA Seismic Design Specifications of Highway Bridges issued in 2002. Based on the lessons learned from the Hyogo-ken-Nanbu Earthquake in 1995, the "Part V: Seismic Design" of the "JRA Design Specifications of Highway Bridges" was totally revised in 1996, and the design procedure moved from the traditional Seismic Coefficient Method to the Ductility Design Method. Major point of the revision was the introduction of explicit two-level seismic design methods. In the 2002 revision, the target point of the revision is to be based on the performance-based design code concept and to enhance the durability of bridge structures for a long-term use, as well as the inclusion of the improved knowledges on the bridge design and construction methods. It is expected to have the circumstances to employ the new ideas on the materials, structures and constructions methods to construct safer, more durable and more cost-effective bridges in the future.
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15.4 Structural Details of Bearing Support  
15.5 Stopper for Excessive Displacement  
16. Unseating Prevention Systems  
16.1 General  
16.2 Seat Length  
16.3 Unseating Prevention Structure  
16.4 Settlement Prevention Structure  
16.5 Unseating Prevention Structure in Transverse Direction

Appendix : References  
1. References on Earthquake and Active Fault  
2. References on Design Earthquake Ground Motion  
3. References on Ductility Design Method  
4. References on Dynamic Earth Pressure and Dynamic Water Pressure for Level 2 Earthquake  
5. References on Dynamic Analysis  
6. References on Liquefaction Evaluation  
7. References on Lateral Spreading induced by Liquefaction and the Design Method  
8. References on Strength and Ductility Characteristics of Reinforced Concrete Columns  
9. References on Strength and Ductility Characteristics of Steel Columns  
10. References on Strength and Ductility Characteristics of Prestressed Concrete Superstructures
SEISMIC DESIGN SPECIFICATIONS FOR HIGHWAY BRIDGES IN JAPAN

Guangfeng ZHANG, Dr. Eng.
Public Works Research Institute
Sep. 11, 2008

Current Design Codes for Highway Bridges

Specifications for Highway Bridges
-2002 Version-
Issued by Japan Road Association (JRA)

- Part I: Common
- Part II: Steel Bridges
- Part III: Concrete Bridges
- Part IV: Substructures
- Part V: Seismic Design

Current Seismic Design Code

Performance-Based Design Code Concept
- Design requirements are clearly specified
- Existing detailed design methods are specified as verification methods and the examples of acceptable solutions

Performance-Based Design Code Structure (Pyramid)

Importance of Bridges

Class Definitions

Class A bridges
- Bridges of National expressways, urban expressways, designated city expressways, Honsyu-Shikoku highways, and general national highways

Class B bridges
- Double-section bridges and overbridges of prefecture highways and municipal roads, and other bridges, highway viaducts, etc., especially important in view of regional disaster prevention plans, traffic strategy, etc.
Design Earthquake Ground Motions

Two-Level Design Concept

Level 1 Earthquake Ground Motion
Earthquake ground motion with high probability of occurrence for the bridge service life (for Elastic Design)

Level 2 Earthquake Ground Motion
Earthquake ground motion by strong earthquake with low probability of occurrence for the bridge service life (for Ductility Design)

Type I: Interplate-type Earthquake (e.g. Kanto Earthquake)
Type II: Inland-type Earthquake (e.g. Kobe Earthquake)

Seismic Performance Levels and Limit States

SPL 1: Prevent Damage
Performance to keep sound function of the bridges after earthquake

SPL 2: Limited Damage for Function Recovery
Performance to secure early-recovery of bridge function after earthquake to limiting damage

SPL 3: Prevent Critical Damage
Performance to prevent critical damage

Principles in Selection of Members for Energy Absorption

- Reliable Energy Absorption
- No Significant Effect on Bridge Stability
- Reparable Damage and Easy to Repair (Repairability)
- Possibility to Maintain Traffic Function after Damage (Functionability)

Example for Selection of Limit States (SPL 2)

General Continuous Multi-Span Bridge
- Reparable Limit
- Limited Nonlinear Behavior
- Elastic Limit

Seismic Performance Matrix

<table>
<thead>
<tr>
<th>Type-A (Standard Bridge)</th>
<th>Type-B (Important Bridge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 EQ.</td>
<td>SPL 1: High Probability to Occur</td>
</tr>
<tr>
<td>Level 2 EQ.</td>
<td>SPL 2: Keeping Sound Functions of Bridges</td>
</tr>
<tr>
<td>Type I EQ. Interplate EQ.</td>
<td>SPL 3: No Critical Damage</td>
</tr>
<tr>
<td>Type II EQ. Inland EQ.</td>
<td>SPL 2: Limited Damage for Function Recovery</td>
</tr>
</tbody>
</table>
Selection of Verification Methods

<table>
<thead>
<tr>
<th>SPL 1</th>
<th>SPL 2</th>
<th>SPL 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static verification</td>
<td>Dynamic verification</td>
<td>Dynamic verification</td>
</tr>
</tbody>
</table>

Example of Bridges

- Bridges with rubber bearings
- Seismically isolated bridges
- Right-frame bridges
- Bridges with steel columns
- Bridges with low natural period
- Bridges with high piers
- Cable-stayed bridges
- Suspension bridges
- Arch bridges
- Curved bridges

Verification Methods and Acceptable Solutions

- Verification Methods (Static and Dynamic Verifications)

Unseating Prevention System

- Evaluation of Failure Mode, Lateral Strength and Ductility Capacity
- Calculation of Lateral Strength and Displacement, Shear Strength
- Stress-Strain Curve of Concrete Considering the Lateral Confinement and Earthquake Type
- Structural Details for Improving Ductility Performance

Unseating Prevention System

- Seating Length
- Unseating Prevention Structure
- Structure for Protecting Superstructure from Subsidence
- Excessive Displacement Stopper

Concluding Remarks

- Performance-Based Design Code
  - Performance requirements are clearly specified
  - Existing design methods are specified as verification methods and examples of acceptable solutions
  - Designers have more freedom in selecting design method

The End

- Thank You for Your Kind Attention
Example for Selection of Limit States (SPL 2)

Frame Type Bridge

- Repairable Limit
- Limited Nonlinear Behavior

Static Verification

Demand ≤ Capacity

Static Analytical Methods
- Seismic Coefficient Method
- Ductility Design Method

- Loads caused by EQ. are applied statically
- Nonlinear response displacement is estimated based on Energy Constant Rule
- Applicability of static analysis is limited only for simple structures

Force Reduction Factor

\[ c_s = \frac{1}{\sqrt{2\mu_a - 1}} \]

Base on
- Ductility Design Concept
- Energy Constant Rule

Allowable Ductility Ratio

\[ \mu_a = \begin{cases} 
\frac{\delta_y - \delta_f}{a\delta_y} & : \text{Flexural failure} \\
1.0 & : \text{Shear failure after flexural yielding} \\
1.0 & : \text{Shear failure} 
\end{cases} \]

Safety factor \( \alpha \)

<table>
<thead>
<tr>
<th>Seismic Performance</th>
<th>Type I EQ.</th>
<th>Type II EQ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL2</td>
<td>3.0</td>
<td>1.5</td>
</tr>
<tr>
<td>SPL3</td>
<td>2.4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Type I: Interplate Type
Type II: Inland Type

Dynamic Verification

Demand ≤ Capacity

Maximum response value of structural members

- Cross sectional force: \( F_D < P_D \)
- Curvature: \( \theta_D < \theta_u \)
- Deformation: \( \delta_D < \delta_u \)

Check points
- Unexpected yielding occurs in structural members
- Bridge does not become unstable due to yielding

Energy Constant Rule

Energy absorptions for elastic structure and elasto-plastic structure are equal

- \( P_L \): Elastic Lateral Force
- \( P_y \): Yield Force
- \( \delta_y \): Elastic-plastic Displacement
- \( \delta_f \): Elastic Displacement
- \( \delta_u \): Yield Displacement

Lateral force can be reduced due to Ductility Capacity of structures

Allowable lateral disp.

\[ k_{h0} = c_s \cdot c_x \cdot k_{h00} \]

Demand < Capacity

Check points
- Unexpected yielding occurs in structural members
- Bridge does not become unstable due to yielding
Effects of Seismically Unstable Ground

Unstable Ground during Earthquake
(1) Extremely soft soil layer
(2) Sandy layer affecting the bridge due to liquefaction and the lateral spreading

Seismic Performance Verification
Following cases are verified
(1) Neither liquefaction nor liquefaction-induced lateral spreading will occur
(2) Liquefaction will occur
(3) Liquefaction-induced lateral spreading will occur

Seismically Isolated (Menshin) Bridges

Concept of Seismically Isolated Bridges
Reduction of inertia force of superstructure by
1) Increase natural period
2) Enhance damping performance

Acceptable Conditions of Seismically Isolated (Menshin) Bridges
- Firm ground and stable ground
- High stiffness of the substructure, and short natural period of the bridge
- Multi-span continuous bridge

Seismic Isolation Bearings

Lead Rubber Bearing (LRB)
High Damping Rubber Bearing (HDR)

Strain-Stress Curve of Concrete

\[ \sigma_{u} = \sigma_{c} - E_{c}(\varepsilon_{c} - \varepsilon_{f}) \]
\[ \varepsilon_{c,i} = \frac{1}{E_{c}} \left( \frac{\sigma_{c,i}}{\sigma_{c}} \right)^{n_{c}} \]

\[ \varepsilon_{c} = 0.002 - 0.033\frac{\sigma_{u}}{\sigma_{c}} \]

\[ \sigma_{u} = \sigma_{c} - 3.8E_{c}\varepsilon_{c,i} \]

\[ \varepsilon_{c} = 0.002 - 0.033\frac{\sigma_{u}}{\sigma_{c}} \]

- \( \sigma_{c} \): Design strength of concrete
- \( \varepsilon_{c} \): Yield of lateral confining reinforcement
- \( E_{c} \): Sectional area
- \( n_{c} \): Spacing
- \( d \): Effective length
Necessity of Design Codes for Cambodia

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Vice President, Cambodian Association of Civil Engineers, Cambodia
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President, Cambodian Association of Civil Engineers, Cambodia
Managing Director, Mony Engineering Consultants Ltd, Cambodia

1 INTRODUCTION

The best opportunity for Cambodia to make her own design codes is to follow the activities of the harmonization of design codes in the Asian Region and to produce her own national application documents. This paper presents the current use of different design codes in Cambodia and the problem and difficulties of using different design codes. The objective of this paper is to present the necessity of design codes for Cambodia with the consideration of local conditions such as materials, climate, skilled labour, equipments and construction method.

2 CAMBODIAN SITUATION

2.1 General situation
Cambodia is a country situated in the Southeast Asia and surrounded by Laos, Vietnam, Thailand and gulf of Siam. It has a saucer-shaped with gently rolling alluvial plain drained by the Mekong River and shut off by mountain ranges which the Dangrek Mountains formed the frontier with Thailand in the northwest and the Cardamom Mountains and the Elephant Range are in the southwest. About half of the land is tropical forest. There are many rivers to collect the water from high land to the plain. In the rainy season the water from the high land and Mekong River flows into a big reservoir of Tonle Sap Lake.

The modernized construction including buildings and road network development was started in Cambodia before 1960s. However, all most all of these constructions had been damaged by the civil war that suffered the country about 20 years from 1970 to until end of 1980s. After finished the civil war, rehabilitation and redevelopment of buildings and infrastructures have been aggressively carried out by people and the new government.

![Figure 1](image1.png)
![Figure 2](image2.png)

Figure 1. A heavy truck caused the collapse of a bridge on National Road 7 on May 14, 2004

Figure 2. The collapse of a bridge on the road from Siem Reap to Banteay Srey temple on April 10, 2004
The rehabilitation and maintenance of the road networks is now most critical and urgent requirement for the country. The large numbers of bridges along the national roads do not cope with the existing traffic loads as they were design to cater lower loads than the prevailing one.

There are many cases of bridge collapse due to overloading and/or due to poor structural design. In addition, there were no enough bridges to provide access to all part of the country throughout a year. As a result, large parts of the country remain isolated during rainy season.

The demands of buildings are increasing rapidly as the increasing speed of population (10.7 million in 1993 and 14.0 million in 2006) and the economic growth (GDP growth rate: 13.4% in 2005, 10.0% in 2004) in which construction increased 20.1% in 2005 due to political stability and the development plan of new government. Based on the knowledge of the authors, most buildings constructions are not in good quality.

2.2 Climate
Cambodia has a tropical monsoon climate, with the wet southwest monsoon occurring between November and April and the dry northeast monsoon the remainder of the year. Temperatures in Cambodia are fairly uniform throughout the Tonle Sap Basin area, with only small variations from the average annual mean of around 25°C. The maximum mean is about 28°C; the minimum mean, about 22°C. Maximum temperatures of higher than 32°C, however, are common and, just before the start of the rainy season, they may rise to more than 38°C. Minimum temperatures rarely fall below 10°C. The relative humidity is high at night throughout the year; usually it exceeds 90 percent. During the daytime in the dry season, humidity averages about 50 percent or slightly lower, but it may remain about 60 percent in the rainy period.

3 DESIGN CODES USED IN CAMBODIA

The main reasons that the different design codes are used in Cambodia are explained in the following paragraphs.

The rehabilitation and redevelopment of infrastructures are executing by the government with the Official Development Assistance so call ODA from the developed countries, such as Japan, France, Australia, USA and Germany. However, it can be observed the fundamental problem that those works are still not be done by local engineers and technicians. Because, all most all of rehabilitation and reconstruction infrastructure works are carried by the contractors coming from donor countries themselves and they apply their own design standards and technologies to the works. Although Cambodian design standards have already been set up under the Australian ODA scheme, it is still not suitable for local conditions.

In case, the construction is done by local engineers, the design codes used are different among engineers themselves because of Cambodian engineers who got the formation abroad such as in Japan, European countries and United States etc., they used the design codes of those countries, and for Cambodian engineers who got the formation inside the country they used the design codes that they learned from their own professors who also teach different design codes based on their own experiences and knowledge.
For the constructions which are done by foreign investments, they used engineers from their own country to work with local engineers by applying their own design standards.

Based on the knowledge of the authors, the popular design codes used in Cambodia are ACI, AISC /LRFD AASHTO, European Codes (EuroCode), French Codes, Russian Codes, JSCE standards and Australian Standard.

4 PROBLEM AND DIFFICULTIES

On Cambodian market, the construction materials are imported from various countries except some raw materials such as sand and crushed stone. In each design code, it requires the materials with quality defined in code. Therefore it is quite difficult to find the materials to be suitable to the design code used. It is also difficult to check the quality of materials to satisfy the design codes used due to the lack of equipment for testing, the test condition, test method and the capable of engineers about those design codes.

The different design codes used in Cambodia are not suitable for local conditions such as climate, materials, skilled labour, equipment, and construction method. It is high risk to use these design codes without studying and doing research.

5 NECESSITY OF DESIGN CODES FOR CAMBODIA

For the future development of the country of Cambodia, it is important to set up a kind of system that all the construction works shall be carried out by local engineers and technicians. The design codes are necessarily required for Cambodia to ensure the quality of construction in term of economical development.

At present time with her own capability, Cambodia will not be able to develop her own design codes without foreign assistance. However by expecting the Asian Codes will develop with the consideration of the environment in regional area of Asia, Cambodia would be able to profit from these codes to make her own national application documents.

REFERENCES

A dissertation submitted to Kochi University of Technology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, 2006, Vong Seng, Design of prestressed concrete bridge girder using self-compacting concrete for Cambodian rehabilitation, Japan


Proc. ACECC Workshop on Harmonization of Design Codes in the Asian Region (2006), Taipei, Ueda T., Towards Harmonization of Design Codes in Asia- Structural Concrete- p101-104. Taiwan
Cambodian Situation

- Before 1970: Buildings, infrastructures in Cambodia were developed
- During 1970's and 1980's: almost all constructions, infrastructures including road networks had been destroyed by the war
- After finished the civil war (1991): rehabilitation and redevelopment of the infrastructures have been aggressively carried out by new government.
- Recent years: a number of bridges were collapsed due to overloaded vehicles and/or poor structural design. Most building constructions are not in good quality

Design Codes Used in Cambodia

Examples on recent bridge damages

- A heavy truck caused the collapse of a bridge on May 14, 2004 on National Road # 7 in Kratie province
- A bridge on the road from Siem Reap City to Banteay Srey temple was destroyed on April 10, 2004 following the passage of a convoy of heavy trucks carrying timber.

Cambodian Situation

Per capita GDP in US$ in current and constant prices 1993-2005

- Population 10.7 million in 1993 and 14.0 million in 2006
- Economic growth: GDP growth rate: 13.4% in 2005 and 10.0% in 2004 in which construction increased 20.1% in 2005

Design Codes Used in Cambodia

- Official Development Assistance (ODA) from the developed countries such as Japan, France, Australia, USA and Germany, they use their own standard
  Although Cambodian road and bridge design standards have already been set up under the Australian ODA scheme, it is still not suitable for local conditions.
- Engineers are got the formation in different design codes
- Foreign invesements on construction industry are from different countries
Design Codes Used Cambodian

- ACI, AISC /LRFD AASHTO
- Eurocodes
- French codes
- Russian codes
- JSCE standard
- Australian Standard
- British Standard

Problem and Difficulties

On Cambodian market, the construction materials are imported from various countries except some raw materials such as sand and crushed stone.

In each design code, it requires the materials with quality defined in code.

Therefore it is difficult to find the materials to be suitable to the design code used.

It is also difficult to check the quality of materials to satisfy the design codes used due to the lack of equipment for testing, the test condition, test method and the capable of engineers about those design codes.

Problem and Difficulties

The different design codes used in Cambodia are not suitable for local conditions such as

- Climate
- Materials
- Skilled labour
- Equipment
- Construction method

It is high risk to use these design codes without studying and doing research.

Necessity of Design Codes for Cambodia

For the future development of the country of Cambodia, it is important to set up a kind of system that all the construction works shall be carried out by local engineers and technicians. The design codes are necessarily required for Cambodia to ensure the quality of construction in term of economical development.

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Structural Steel Design Specifications in Thailand

Dr. Taweep Chaisomphob
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Department of Civil Engineering, Sirindhorn International Institute of Technology, Thammasat University, Thailand
Structural Steel Design Specifications in Thailand

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Chairman, Steel Structure Committee
Engineering Institute of Thailand
Department of Civil Engineering
Sirindhorn International Institute of Technology
Thammasat University

Topics

- Engineering Institute of Thailand Under H.M. the King’s Patronage
- Hot rolled steel building design specifications
- Cold formed steel building design specifications
- Material standards
- Design loads
- Remarks on Thai design standard

Engineering Institute of Thailand Under H.M. the King’s Patronage

The Engineering Institute of Thailand (EIT), founded in 1943, is a sole professional association in engineering discipline in Thailand. Currently, EIT has over twenty four thousand members in various disciplines, including Civil, Electrical, Mechanical, Industrial, Mining, Environmental and Chemical Engineering, etc.

Objective

- Conduct and promote the continuing education, research, publication in engineering.
- Promote and support engineering career.
- Set up the code, specification, regulation for engineering practice.
- Provide engineering consultants.
- Provide engineering ethics.

EIT provides academic documents in 6 types

1. Text
2. Experienced book
3. Code of practice
5. Technical terms
6. Journal & Magazine

Hot rolled steel building design specifications

- At present, EIT standard 1020-51 for hot rolled steel building follows AISC (American Institute of Steel Construction) design specification, entitled “Load and Resistance Factor Design Specification for Structural Steel Buildings”, which was issued in 1999.
- This AISC specification provides a limit state design method including strength and serviceability limit states.
2. Design Requirements
3. Frames and Other Structures
4. Tension Members
5. Column and Other Compression Members
6. Beams and Other Flexural Members
7. Plate Girders

---

8. Members under Combined Forces and Tension
9. Composite Members
10. Connections, Joints, and Fasteners
11. Concentrated Forces, Ponding, and Fatigue
12. Serviceability Design Considerations
13. Fabrication, Erection, and Quality Control
14. Evaluation of Existing Structures

---

• EIT standard for cold formed steel building is now under drafting, and follows AISI (American Iron and Steel Institute) design specification, entitled “North American Specification for the Design of Cold-formed Steel Structural Members”, which was issued in 2007.
• This AISI specification provides an integrated treatment of Allowable Strength Design (ASD) and Load and Resistance Factor Design (LRFD) by including the appropriate resistance factors for use with LRFD, and the appropriate safety factors for use with ASD.

---

• In Thailand, steel material standard for hot rolled structural steel sections is TIS (Thai Industrial Standard) 1227-2539
• This standard follows JIS G 3192 and JIS G 3106
## Material Standard

**Hot rolled steel section in TIS 1227-2539**

### Steel grade and chemical component

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SM 400</td>
<td>0.20</td>
<td>0.36</td>
<td>0.60–1.40</td>
<td>0.035</td>
<td>0.035</td>
</tr>
<tr>
<td>SM 490</td>
<td>0.18</td>
<td>0.55</td>
<td>1.60 max.</td>
<td>0.035</td>
<td>0.035</td>
</tr>
<tr>
<td>SM 490</td>
<td>0.20</td>
<td>0.55</td>
<td>1.60 max.</td>
<td>0.035</td>
<td>0.035</td>
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<tr>
<td>SM 570</td>
<td>0.18</td>
<td>0.55</td>
<td>1.60 max.</td>
<td>0.035</td>
<td>0.035</td>
</tr>
<tr>
<td>SS 400</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.050</td>
<td>0.050</td>
</tr>
<tr>
<td>SS 490</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.050</td>
<td>0.050</td>
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<tr>
<td>SS 540</td>
<td>0.30</td>
<td>-</td>
<td>1.60 max.</td>
<td>0.040</td>
<td>0.040</td>
</tr>
</tbody>
</table>

### Steel grade and material properties

#### Steel grade

<table>
<thead>
<tr>
<th>Steel Grade</th>
<th>Min. Yield Strength (MPa)</th>
<th>Ultimate Strength (MPa)</th>
<th>Min. Elongation %</th>
<th>Min. Impact Strength (Joule)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM 400</td>
<td>245</td>
<td>450-510</td>
<td>23</td>
<td>18</td>
</tr>
<tr>
<td>SM 490</td>
<td>325</td>
<td>490-610</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>SM 520</td>
<td>350</td>
<td>520-640</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>SM 570</td>
<td>460</td>
<td>570-720</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>SS 400</td>
<td>245</td>
<td>490-540</td>
<td>21</td>
<td>17</td>
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<tr>
<td>SS 490</td>
<td>285</td>
<td>540-640</td>
<td>19</td>
<td>15</td>
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<tr>
<td>SS 540</td>
<td>400</td>
<td>540-640</td>
<td>19</td>
<td>15</td>
</tr>
</tbody>
</table>

### Sectional shape

<table>
<thead>
<tr>
<th>Type</th>
<th>Sectional shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angle steel</td>
<td><strong>Equal leg</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Unequal leg</strong></td>
</tr>
<tr>
<td>Channel steel</td>
<td></td>
</tr>
<tr>
<td>H-section steel</td>
<td></td>
</tr>
<tr>
<td>I-section steel</td>
<td></td>
</tr>
<tr>
<td>T-section steel</td>
<td></td>
</tr>
</tbody>
</table>

## Material Standard

**Cold formed steel section in TIS 1228-2549**

### Steel grade and chemical component

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>SSC 400</td>
<td>0.25</td>
<td>-</td>
<td>-</td>
<td>0.050</td>
<td>0.050</td>
</tr>
</tbody>
</table>

### Steel grade and material properties

#### Steel grade

<table>
<thead>
<tr>
<th>Steel Grade</th>
<th>Min. Yield Strength (MPa)</th>
<th>Ultimate Strength (MPa)</th>
<th>Min. Elongation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSC 400</td>
<td>245</td>
<td>400-540</td>
<td>21</td>
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</tbody>
</table>

### Cold formed steel section in TIS 1228-2549

- In Thailand, steel material standard for cold formed structural steel sections is **TIS (Thai Industrial Standard) 1228-2549**
- This standard follows **JIS G 3350**
Material Standard

Cold formed steel section in TIS 1228-2549

Sectional shape

<table>
<thead>
<tr>
<th>Type</th>
<th>Sectional shape</th>
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<tbody>
<tr>
<td>Light angle steel</td>
<td>Equal leg</td>
</tr>
<tr>
<td></td>
<td>Unequal leg</td>
</tr>
<tr>
<td>Light channel steel</td>
<td></td>
</tr>
<tr>
<td>Lip channel steel</td>
<td></td>
</tr>
<tr>
<td>Light Z steel</td>
<td></td>
</tr>
<tr>
<td>Lip Z steel</td>
<td></td>
</tr>
<tr>
<td>Hat steel</td>
<td></td>
</tr>
</tbody>
</table>

Design Load

• In Thailand, the design load is specified in the Building Control Act, B.E. 2522, issued by Department of Public Works and Town & Country Planning, Thai Ministry of Interior.

• This act is necessary for securing the buildings in safety and good condition, and provides various type of regulations (procedure, area restriction, fire safety, construction safety, equipment, shape of building, etc.).

Design Load

From the Ministerial Regulation No. 6, B.E 2527, under the Building Control Act, B.E 2522, the load factor and load combination are given:

(1) Case of no wind loads

\[ U = 1.7D + 2.0L \]

where

- \( U \) = required strength
- \( D \) = dead load
- \( L \) = live load

(2) Case of wind loads considered

\[ U = 0.75(1.7D + 2.0L + 2.0W) \]

or

\[ U = 0.9D + 1.3W \]

where \( W \) = wind load

Design Load

Minimum uniformly distributed live load for building design in Ministerial Regulation No. 6, B.E 2527

<table>
<thead>
<tr>
<th>Type and Occupancy or Use</th>
<th>Live Load (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Roof</td>
<td>30</td>
</tr>
<tr>
<td>2. Concrete canopy or roof</td>
<td>100</td>
</tr>
<tr>
<td>3. Habitation, bathroom, toilet, kindergarten</td>
<td>150</td>
</tr>
<tr>
<td>4. Condominium, dormitory, row-houses, hotel</td>
<td>200</td>
</tr>
<tr>
<td>5. Office and Bank</td>
<td>250</td>
</tr>
<tr>
<td>6. (a) Commercial building, portion of row or row building to be used commercially, college and school</td>
<td>300</td>
</tr>
<tr>
<td>(b) Hall, stair, hallway of a suite, dormitory, hotel, hospital, office, and bank</td>
<td></td>
</tr>
</tbody>
</table>

Design Load

Minimum uniformly distributed live load for building design in Ministerial Regulation No. 6, B.E 2527

<table>
<thead>
<tr>
<th>Type and Occupancy or Use</th>
<th>Live Load (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. (a) Market place, department store, meeting hall, theatre, restaurant, reading room in a library, and parking area or garage</td>
<td>400</td>
</tr>
<tr>
<td>(b) Hall, stair, hallway of commercial building, university, college or school</td>
<td></td>
</tr>
<tr>
<td>8. (a) Warehouse, stadium, museum, factory, storage room</td>
<td>500</td>
</tr>
<tr>
<td>(b) Hall, stair, hallway of market place, department store, meeting hall, theatre, restaurant and library</td>
<td></td>
</tr>
<tr>
<td>9. Library space or garage for shelf</td>
<td>600</td>
</tr>
<tr>
<td>10. Parking area or garage for truck</td>
<td>600</td>
</tr>
</tbody>
</table>
### Design Load

Minimum wind pressure for building design in Ministerial Regulation No. 6, B.E 2527

<table>
<thead>
<tr>
<th>Height (m)</th>
<th>Wind Pressure kPa (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>0.5 (50)</td>
</tr>
<tr>
<td>10-20</td>
<td>0.8 (80)</td>
</tr>
<tr>
<td>20-40</td>
<td>1.2 (120)</td>
</tr>
<tr>
<td>&gt;40</td>
<td>1.6 (160)</td>
</tr>
</tbody>
</table>

### Remarks on Thai Design Standard

- EIT (Engineering Institute of Thailand) steel building design standards are based on American standards: AISC and AISI specifications for hot rolled steel and cold formed steel, respectively.
- There are no Thai structural steel design standards for infrastructures such as bridges. At present, the design of infrastructures adopts the standards of developed countries, such as AASHTO specifications for steel bridges.
Summary

Discussion Report of the Workshop
JAPANESE EXPERIENCE TOWARD PERFORMANCE BASED DESIGN

Two aspects of the background as to how the performance based design concept was introduced into Japan were explained as follows:

After enforcement of the WTO-TBT agreement 1995, the government enforced a policy of deregulation in 1998. In 2002, there was another 3 year plan of regulation reform promotion. Among various political actions, what had direct relationship to our business was the revision of the various technical standards, and in 2003, revision work for Technical Standard for Port and Harbor Structure (TSPHS) and Specification for Highway Bridges (SHB) started in 2003. In 2007 the revision of TSPHS had completed whereas that of SHB is still underway. These are the government activities.

There are also the activities by professional societies. In the Japanese Geotechnical Society (JGS), a committee organized in 1997 proposed a draft on the performance based design model code, which is called Geo-Code 21, whose first draft was completed in 2001 and the final version was published in 2004. Besides the JGS, there are similar activities in the fields of steel and concrete. Ministry of Land, Infrastructure, Transport and Tourism (MLIT) gave a project to Japanese Society of Civil Engineers (JSCE). The ministry asked to draft a basic code for the performance based design, which is called “Code PLATFORM ver. 1” (Principles, guidelines and terminologies for structural design code drafting founded on the performance based design concept ver.1.0) and had completed in 2003. The new Technical Standard for Port and Harbor Structure (TSPHS) is heavily based on the concept of this “Code PLATFORM ver.1”.

It looks from outside that the government had a firm and constant policy and the professional society followed it from the very initial stage, and had developed basic concepts, and eventually those concepts were developed to the final practical code. So it seems to be a very successful and happy story but the reality is slightly different.

For a country like Japan WTO-TBT agreement is one of the basic policies for industry and trade. The purpose of this agreement was to ensure the technical regulations and standards not to create unnecessary barriers to international trade. It is stated in the agreement that technical regulations should be based on the international standards, and also they recommended performance based regulations, rather than the specific regulations. (i.e. It is regulated in the Article 2, Item 2.4 of the agreement, the WTO members should use technical regulations based on the product requirement in terms of performance.) This was one of the starts of the performance based design. Based on this agreement, the deregulation policy of the government started in 1998. This was a very important project for the Japanese government, the head of which was the Prime Minister himself.
However, the real impact to code harmonization came at the next stage. The 3 years plan for regulation reform promotion started in 2001. MLIT had their own program on restructuring of public work costs, and among them there was a revision of the technical standards for the port and harbor facilities to performance based version, and also review of the highway bridge specifications. Based on the above policies, there has been a basic stream for the performance based design.

The movements at the top government toward the directions explained above had not been really known by the engineering societies until 2003. It was lucky that the performance based code like code PLATFORM ver.1 was ready when the code writers of TSPHF started to work on the revision of this code toward the performance based design.

Finally, the authors would like to express their experience on the development of these codes since 1997. When we started to work on the performance based design code at JGS in 1997. We were not really sure that whether PBD can be really a future concept for design code. However, this concept and design code written on this concept became popular very quickly, and this is now the basic concept to lead this area.

It should be noted that the PBD is not an engineer driven concept but is government policy driven. Therefore it has become popular very quickly. Performance based design is a user/administrator oriented approach as you find in the Nordic Five Level, it is not engineers who developed this, but the government/administrators who developed this concept.

2. PERFORMANCE BASED DESIGN

We may divide the designs into two parts, that is, performance requirement, and if such requirement is set, we need to have some verification method. And the international agreement is, as far as the performance requirement are concerned, we have to use performance based design, or you can call it performance based specification to specify what we require for the structure, then after the performance requirement is set, we need to verify it and based on the international standard like ISO2394, limit state design method is recommended to verify the performance. Performance based design and limit state design, or reliability based design, is not a controversial concept but actually they are supplementing each other.

![Figure 1 WTO/TBT agreement, PBD and LSD/RBD](image)

Dr. Foliente worked on the performance based design for the buildings, and described as: “Performance approach is, in essence, the practice of thinking and working in terms of end rather than means.”

It is very useful to review the history of performance based design. There are two important sources of the performance based design as shown below:
2.1 Nordic Five Level

One of them is called Nordic Five Level and this is first proposed in the document titled "Structure for the building regulations." published in 1978 in Scandinavia. Here, the word "structure" means the structure of regulations rather than building structures. In the preface, it is stated as follows:

<table>
<thead>
<tr>
<th>Nordic 5 Leave</th>
<th>New Zealand</th>
<th>Australia</th>
<th>UK</th>
<th>Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>Functional Requirements</td>
<td>Operational Requirements</td>
<td>Verification Methods</td>
<td>Acceptable Solutions</td>
</tr>
<tr>
<td>Objectives</td>
<td>Functional Requirements</td>
<td>Performance Requirements</td>
<td>Verification Methods</td>
<td>Acceptable Solutions</td>
</tr>
<tr>
<td>Goals</td>
<td>Functional Requirements</td>
<td>Performance Requirements</td>
<td>Deem to Satisfy</td>
<td></td>
</tr>
<tr>
<td>Objectives</td>
<td>Functional Requirements</td>
<td>Performance Requirements</td>
<td>Alternative Approaches</td>
<td></td>
</tr>
<tr>
<td>Acceptable Solutions</td>
<td>(CIB,1998)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Figure 2 Nordic 5 Levels](image)

The system of rules which now governs building in the Nordic countries is made up of legislation, regulations and other building rules. In the action program of the Nordic Council of Ministers for the Nordic co-operation which the building sector is stated that the system of rules should in the first place be structures into a limited number of levels characterizing the purpose of the regulations from the comprehensive objective of the statute down to the technical solution. In this way cooperation would be facilitated even if the administrative system varies from country to country.

What is meant is that they would like to harmonize their regulations in the Scandinavian countries, but even in the Scandinavian countries the structure of regulations are different and very difficult to harmonize. So initially the performance based design concept was aimed at harmonizing the regulation system and this is the structure they have developed. This is what is called Nordic Five Levels, originally proposed so its performance requirement is given by three levels; Goal, Functional, and Operational requirements (Figure 2). And after the requirement is set, they have specification method and the acceptable solutions. And only this part is mandatory, and in this way, people can harmonize their regulation structures relatively easily. Because of this merit, many other countries followed their regulations.

2.2 Vision 2000

The other source is from California, USA. In early 1990s, there were several earthquakes which caused considerable economic damage especially to the buildings. They found that there was a communication gap between the designers and the owners of the buildings. The owner were told by the designers that their buildings were seismic resistant. However when the earthquakes happened, even though the buildings did not collapse, there was considerable damage inside, all the equipments were destroyed and there were some injured people. The owners realized that seismic resistance by the engineers was that they would not collapse during the earthquake, however, for the owners, they thought even after a serious earthquake, the building should be fully operational. Subsequently, they proposed a performance matrix in the report “Vision 2000” in 1995 by Structural Engineering Association of California. The owners of buildings can choose the requirement, and the designer can design the building based on the requirement. This will minimize a communication gap between designers and building owners.
2.3 New Codes on Performance Based Design (PBD) concept

Several design codes based on PBD concept have been developed in Japan by 2005. Code PLATFORM ver.1 and Geocode 21 are some of the earlier results of these codes. The contents are actually a combination of the Nordic Five Level and the performance based matrix and this is similar to what Dr. Kikuchi presented in this workshop. It started from the objective of structure by general terminology then performance requirement is the requirement for the structure to fulfil this objective in general terminology and then performance criteria that is a breakdown of the performance requirement by verifiable work. So we propose to use the performance based matrix. Therefore, it becomes clearer and of course for the verification part we proposed to use the LRFD.

Figure 3 Recommended performance objectives for buildings

2.4 Can Performance Based Design (PBD) be a basic concept for code harmonization in Asia?

When Structural Eurocodes started their work in 1970’s, they employed the limit state design concept, which was a bland new concept at that time, to harmonize their design codes. A new concept is required to harmonize codes in the Asian region. We propose to use this PBD concept.
to harmonize the design codes in Asian region because some countries in our region are now starting their work towards this direction.

3 GLOSSARY OF TERMINOLOGIES FOR DESIGN CODE

The first draft of “Glossary of Terminologies for Design Code” was introduced by one of the author of this paper (Yusuke Honjo), which is included in the proceedings. Various codes were referred to make the draft. Since any of the definitions was revised at this stage, there may be some inconsistency. It may be necessary to discuss the inconsistency, although there is an opinion that we should respect the original definitions.

During the workshop it was confirmed that all participants agree to create such Glossary of terminologies. The terminologies should be based on the concept of the performance based design. It is necessary to clarify what the performance based design is so that all the members have the common understanding.

The definition of PBD in the present draft has been taken from JSCE 2001, guideline for performance based design for civil engineering steel structures by JSCE.

A design methodology for designing a structure exclusively to satisfy performance requirements regardless of the structural format, structural material, design procedure or construction method. This design methodology explicitly presents the objectives of the structure and the performance requirements to achieve the objectives, defines the performance criteria to provide the performance requirements (functions) and provides the functions satisfactorily by securing the performance requirements throughout the working life of the structure. Similar terms include performance-based design, performance based specification, performance-expressing design and performance-oriented design.

4 FUTURE ACTIVITIES OF TC-8

We have realized that some countries are very interested in levelling up theirs codes, and the performance based design concept may be the best for levelling up. On the other hand, it is also true that some countries also need their daily design codes which can be used even today. It may be not easy to solve both issues at the same time. For the latter issue, JSCE may be able to offer some information or to arrange some meetings between those countries.

What we create from now has no legal power to enforce anyone to do anything but it is a recommendation for the future code. If we can create a good concept or an ideal code, we are able to attract more people and countries. We need to have more concrete idea what performance based design is, and what would be the contents of the basic code. These discussions should be made in the next stage of TC-8 activities. We should make the committee document, and send this to all the members for their comments. In Hanoi next April, we can make it final.

5 OTHER TOPICS

Governmental Policy and Engineering Association

Since we belong to engineering association, we cannot get any information on governmental policy. However it is true that the governmental policy can accelerate code development activities drastically. Generally the revision work by the government is very conservative. It is not easy to implement a new concept such as performance based design or even the limit state design. In such situations, the work of professional engineering society as represented as the Geo Code 21 or the Code Platform will be very effective. These ideal codes were developed without any
governmental restrictions. These ideal works can be refereed as needed basis. Engineers also follow the ideal codes.

**Necessity of activities by young engineers**

It is important to invite young code drafters to our activities. According to the experience of Japanese Geotechnical Society, they intentionally picked up prospective young code drafters typically under 40 years old. Now after 10 years later, these people have become key persons in code developments. Through the work of code drafting, they discussed intensively, which have resulted in the creation of strong human network.

5.2 Funds for Activities

Funding is always very important issue. Geotechnical Society has got a fund from the government. Although it was not big amount, but sufficient enough for 24-25 people to gather occasionally and make discussions as well as to cover printing cost and transportation. We need to apply for such fund continuously for the continuous activities.

6. CONCLUDING REMARKS

This workshop is the first workshop since the formulation of the TC in 2007. Through today’s workshop, we were able to learn, and exchange our code development problems in each country as well as the future direction for us to go. As you may know in Asian countries, we have similar natural conditions and we have similar types of disasters, so we can cooperate for the common code development together. ACECC will strongly continue this activity on code harmonization.

Finally we would like to give sincere thanks especially to the following organizing members in JSCE committee for ACECC:

Prof. Eiki Yamaguchi (Kyushu Institute of Technology, Vice Chair of JSCE Committee for ACECC)
Mr. Masayuki Torii (Nishimatsu Construction Co., Ltd, Secretary General of JSCE Committee for ACECC)
Mr. Masaaki Nakano (Nippon Koei Co., Ltd, Secretary of JSCE Committee for ACECC)
Ms. Emiko Serino (Secretary of JSCE Committee for ACECC)
Mr. Hiroyuki Yanagawa (JSCE)
Performance based Design concept and Design code development in Japan
- Two different stories on the same event -

Y. Honjo, chair of ACECC TC-8
Gifu University

Story one:
one side of story on PBD in Japan

1995 WTO/TBT agreement enforced
1997 JGS committee for PBD started
1998 Three year plan for Deregulation
2001 1st draft of Geo-code 21.
2001 Three year plan for regulation reform promotion
2003 revision work for TSPHS started and SHB started.
2003 MLT/JSCE code PLATFORM ver.1 published
2004 Geo-code 21 published
2007 TSPHS completed, SHB revision underway.

WTO/TBT agreement:

- WTO/TBT was enforced in 1995, and is applied to all WTO member countries.
- Purpose of the agreement is to ensure that technical regulations and standards ... do not create unnecessary obstacles to international trade.
  - Technical regulations should based on international standards, if such exist.
  - Performance based regulations.

WTO/TBT (1995)
(AGREEMENT ON TECHNICAL BARRIERS TO TRADE)

Article 2: Preparation, Adoption and Application of Technical Regulations by Central Government Bodies
2.4 Wherever technical regulations are required and relevant international standards exist ... Members shall use them, or relevant part of them, as basis for their technical regulations ...
2.8 Wherever appropriate, Members shall specify technical regulations based on product requirements in terms of performance rather than design or descriptive characteristics.

Government Policy for deregulation (1)

- Headquarters for Administrative reform (Head the Prime Minister)
  - ‘Three years plan for Deregulation’
March, 1998 the cabinet decision
1) All economic regulation should be eliminated in principle. The social regulations should be minimized. All regulation should be eliminated or deregulated.
2) Rationalization of regulation methods. For example, tests can be outsourced from the private sector.
3) Simplification and clarification of the contents of the regulations.
4) International harmonization of the regulations.
5) Speed up of the regulation related procedures.
6) Transparency of the regulation related procedure.

Government Policy for deregulation (2)

- ‘Three years plan for regulation reform promotion’
March, 2001 the cabinet decision
1) Realization of sustainable economic development by promotion of economic activities.
2) Realization of transparent, fair and reliable economic society
3) Secure diversified alternatives for life styles.
4) Realization of economic society that is open to the world.
Background in Administrative Aspects

- ‘Three years plan for promotion of regulation reform’ March, 2001, the cabinet decision
  - For Codes and Standards, Harmonized to International Standards, Performance based Specification
  - Revision of Common specifications for civil works
  - Review of Highway Bridge Specifications
  - Revision of Technical Standards for Port and Harbor Facilities to performance based.

WTO/TBT agreement, PBD and RBD

Events calendar

1995 WTO/TBT agreement enforced
1997 JGS committee for PBD started
1998 Three year plan for Deregulation
2001 1st draft of Geo-code 21
2001 Three year plan for regulation reform promotion
2003 revision work for TSPHS started and SHB started.
2003 MLT/JSCe code PLATFORM ver.1 published
2004 Geo-code 21 published
2007 TSPHS completed, SHB revision underway.

What is PBD ?

Performance approach (PBD) is, in essence, the practice of thinking and working in terms of end rather than means.

(Follente, G.C. 2000)

Structure for Building Regulations, NKB report No.34, Nov. 1978, Preface

The system of rules which now governs building in the Nordic countries is made up of legislation, regulations and other building rules. In the action program of the Nordic Council of Ministers for the Nordic co-operation which the building sector is stated that the system of rules should in the first place be structures into a limited number of levels characterizing the purpose of the regulations from the comprehensive objective of the statute down to the technical solution. In this way co-operation would be facilitated even if the administrative system varies from country to country.
Performance-based design

A design methodology for designing a structure exclusively to satisfy performance requirements regardless of the structural format, structural material, design procedure or construction method. This design methodology explicitly presents the objectives of the structure and the performance requirements to achieve the objectives, defines the performance criteria to provide the performance requirements (functions) and provides the functions satisfactorily by securing the performance requirements throughout the working life of the structure. Similar terms include performance-based design, performance-based specification, performance-expressing design and performance-oriented design.

Objectives of Code PLATFORM

- Provide a framework of a structural design code based on performance based concept.
- Define structure to define performance requirements.
  Objective – Performance Requirements – Performance Criteria
- Define the elements of Performance Criteria
  Limit states – design situations – time
- Performance verification procedure by performance concepts vs. by codes

Drafting Body (2001-2002)

Ministry of Land and Transportation

Contract

JSCE

Contract

Consultant (Secretariat)

International Codes and Standards e.g. ISO2394

Unified Concepts

Performance Matrix

VISION 2000

Performance Based Seismic Engineering of Buildings

( SEAO 1995 )

A tool for dialogue between the owner and the designer on performances of a buildings

Comprehensive Design Code

- Describing basic rules of design code, e.g. concepts, terminologies and procedures.
- A code for code writers

Base Design Code A (Railway)
Base Design Code B (Highway)
Base Design Code C (Port and Harbor)

Contract Consultant (Secretariat)

Ministry of Land and Transportation

Contract JSCE

Chair Osamu Kusakabe
General Secretary Yusuke Honjo

Scholars and Engineers from various field: steel, concrete, geotechnical, seismic, wind, reliability etc.
Objective
Performance
Requirements
Performance Criteria
Comprehensive Design Code
Specific Base
Design Code
Specific Design Code
Approach B
Approach A
Hierarchy of Requirements and Verifications

Description of Performance Criteria

Limit State Design Concept:
The concept Eurocodes are based

Performance based specification
Structure of Port and Harbor Facilities

Story Two:
The other side of the story.
Conclusion

- PBD is NOT engineer driven, it is government policy driven.
- PBD is user/administrator oriented approach, not engineer oriented approach.
- Because of these reasons, it has become popular in very short period of time.

Objective

Performance

Requirements

Performance Criteria

Comprehensive Design Code

Approach B

Approach A

Hierarchy of Requirements and Verifications

Benefit of Performance Based Design Codes

- Higher accountability and transparency to the users of the codes. Easier to understand the intention of the code writers to the users.
- Easier to harmonize the design codes under different social and legal systems.
- Construction cost reduction is expected by introduction of new technologies?
- Easier to keep consistency of the description of the design code.

Remained Issues of PBD Codes

- How to find an interface between the top down approach of users and administrators, and bottom up approach of engineers or code writers. (User's thinking vs. Engineers' thinking)
- A social system is required to judge performance of structures based on PBD.
- Judgment for flaw (=defect) in the design when done by PBD.
**Table of Contents**

1. Definition of terminologies
2. General (scope and framework)
3. Performance requirements of structures
4. Verification procedures
5. Structural design reports

**Comprehensive Design Codes Development in Japan**

- **code PLATFORM ver.1 (JSCE, 2003)**
  Principles, guidelines and terminologies for structural design code drafting founded on performance based design concept ver. 1.
  (Japanese Society of Civil Engineers, 2003)

- **Geo-code 21 (JGS, 2004)**
  Principles of Foundation Design Grounded on Performance Based Design Concept
  (Japanese Geotechnical Society, 2004)

**Purposes of Comprehensive Design Codes development**

- Propose an ideal design code based on performance based concept.
- Harmonize design concepts and terminologies in major Japanese design codes.
- Dispatch our technology to the world by a single voice.

**Hierarchy in performance description of a structure (1)**

- **Objectives:** The objective is the final social requirement of a structure with respect to one specific performance (e.g. structural performance) described in the general terminologies.

  For examples, "buildings shall provide sufficient safety to the residence at the time of earthquake events so that they are preserved from serious injuries and loss of lives or Marginal operation of functions of a structure is preserved."
Performance requirements: The performance requirements describes the functions of a structure that should be provided to achieve the stated objective by general terminologies.

Example: 'A structure shall not collapse during an earthquake' or 'Damage to a structure shall be controlled to an extent whereby marginal operation is preserved.'

Performance Criteria: The performance criteria specify the details that are necessary to fulfill the functional statements. In principle, they should be quantitatively verifiable in structural design.

Performance Requirements is given by a Performance Matrix

\[ \text{Performance Requirements} = \text{Limit states} + \text{Magnitude of Action} + \text{Importance of Structures} \]

A Comprehensive Design Code that stands on top of both Approaches A and B

Approach A: Fully performance based design approach.

Approach B: A code for code writers. Limit State Design (ISO2394)

It is believed that the Limit State Design Method is one of the most suitable method to realize Performance Based Design (PBD).

Limit State Design Concept:

- Force or Resistance
- Displacement
- Allowable Stress Design ($A_S$)
- Behavior of a member or a structure
- Resistance $R$
- Force $Q$

Events calendar

1995 WTO/TBT agreement enforced
1997 JGS committee for PBD started
1998 Three year plan for Deregulation
2001 1st draft of Geo-code 21.
2001 Three year plan for regulation reform promotion (revision work for TSPHS started.)
2003 MLT/JSCE code PLATFORM ver.1 published
2004 Geo-code 21 published
2007 TSPHS completed
Government Policy for deregulation (1)

Headquarter for Administrative reform (Head the Prime Minister)
'Three years plan for Deregulation (1998-2000)'
March, 1998 the cabinet decision
1) All economic regulation should be eliminated in principle. The social regulations should be minimized. All regulation should be eliminated or deregulated.
2) Rationalization of regulation methods. For example, tests can be outsourced from the private sector.
3) Simplification and clarification of the contents of the regulations.
4) International harmonization of the regulations.
5) Speed up of the regulation related procedures.
6) Transparency of the regulation related procedure.

Government Policy for deregulation (2)

'Three years plan for regulation reform promotion'
1) Realization of sustainable economic development by promotion of economic activities.
2) Realization of transparent, fair and reliable economic society
3) Secure diversified alternatives for life styles.
4) Realization of economic society that is open to the world.

Government Policy for deregulation (3)

Revision of Port and Harbor Law

Article 56 Item 2-2
(Before revision)
Those port and harbour facilities, such as navigation channels and basins, protective facilities for harbours and mooring facilities, should comply with the law that specifies such matter if such a law exists. In addition, their construction, improvements and maintenance should comply with 'Technical standards of port and harbour facilities' that is specified as a ministerial ordinance by the ministry of land and transportation.

(After revision)
Those port and harbour facilities, such as navigation channels and basins (they are termed facilities covered by TSPHF), should comply with the law that specifies such matter if such a law exists. In addition, construction, improvements and maintenance concerning performances of the facilities covered by TSPHF should conform with 'Technical standards of port and harbor facilities' that is specified as a ministerial ordinance by the ministry of land and transportation.

Background of Revision

- Bases for design of civil and building structures (MLT, 2002)
- JGS-4001-2004 (Geo-code 21)

- Harmonized and Consistent with the International Codes and the Comprehensive Codes.

Background in Administrative Aspects

- 'Three years plan for promotion of regulation reform'
  March, 2001, the cabinet decision
  → For Codes and Standards,
  Harmonized to International Standards,
  Performance based Specification

- Ministry of Land and Transportation,
  Program on Restructuring of Public Works Costs,
  March, 2003 →
  - Revision of Common specifications for civil works
  - Review of Highway Bridge Specifications
  - Revision of Technical Standards for Port and Harbor Facilities to performance based.
**Performance Requirements**

<table>
<thead>
<tr>
<th>Definition</th>
<th>Performance Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance of structural response (deformation, stress etc.) against actions.</td>
<td>Serviceability</td>
</tr>
<tr>
<td>The functions of the facility would be recovered with minor repairs.</td>
<td>Serviceability</td>
</tr>
<tr>
<td>Significant damage would take place. However, the damage would not cause any lives loss or serious economic damages to hinterland.</td>
<td>Serviceability, Repairability and safety</td>
</tr>
<tr>
<td>Performance requirements on structural dimensions concerning usage and convenience of the facilities.</td>
<td>Serviceability, Repairability and safety</td>
</tr>
</tbody>
</table>

**Summary of Basic Performance Verification Methods**

- **Allowable Performance Verification Methods**
  - Reliability Based Design (RBD) Method
  - Numerical methods (NM) capable of evaluating structural response properly.
  - Model tests.
  - Methods based on past experiences.

- **Design situation**
  - **Major Actions**
  - **Recommended performance verification procedures**
    - Permanent situation and Variable actions (wave, level 1 earthquake) are major actions.
    - Self weight, earth pressures, live load, wave, wind, ship etc. (Level 1 earthquake).
    - Non-linear response analysis considering self-structure interactions.
      - Reliability Based Design (RBD)
      - Pseudo-static procedure (e.g. seismic coefficient method)
    - Permanent and Variable Actions
      - Numerical procedure to evaluate displacements and damage extents.

**Conclusion**

PBD and RBD are the international standards. (Impact of WTO/TBT)

1. The design codes are to be based on PBD for describing performance requirements, and the design verification should be based on RBD/LSD/LRFD.

2. The Technical Standards on Port and Harbour Facilities has been revised April 2007 based on PBS concept and LSD. The comprehensive design codes that have been developed in the professional societies played some important role.

3. Design codes are just a part that realize performance oriented design of structures. Other parts need to be developed in parallel.
Events calendar

1995 WTO/TBT agreement enforced
1997 JGS committee for PBD started
1998 Three year plan for Deregulation
2001 1st draft of Geo-code 21.
2001 Three year plan for regulation reform promotion
   (revision work for TSPHS started and SHB started.)
2003 MLT/JSCE code PLATFORM ver.1 published
2004 Geo-code 21 published
2007 TSPHS completed

Revision of Port and Harbor Law

Article 56 item 2-2

(Before revision) Those port and harbour facilities, such as navigation channels and basins, protective facilities for harbours and mooring facilities, should comply with the law that specifies such matter if such a law exists. In addition, their construction, improvements and maintenance should comply with "Technical standards of port and harbour facilities" that is specified as a ministerial ordinance by the ministry of land and transportation.

(After revision) Those port and harbor facilities, such as navigation channels and basins (they are termed facilities covered by TSPHF), should comply with the law that specifies such matter if such a law exists. In addition, construction, improvements and maintenance concerning performances of the facilities covered by TSPHF should conform with "Technical standards of port and harbor facilities" that is specified as a ministerial ordinance by the ministry of land and transportation.
Attachment

First Draft of

“Glossary of Terminologies for Design Code”
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