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

Organized by Asian Civil Engineering Coordinating Council
TC-8 “Harmonization of design codes in the Asian region”

Sponsored by Japan Society of Civil Engineers
Kajima Foundation
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“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.

第2回アジア域内における設計基準の調和に関するワークショップ『将来の設計コードの方向性』は、公益信託土木学会学術交流基金および鹿島学術振興財団の助成を受け開催されております。
Introduction of the ACECC Activities and the Workshop

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 (now under revision)
   Information about 5th CECAR: 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 provides 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. Workshop Program

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<th>Sessions</th>
<th>Speakers</th>
</tr>
</thead>
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<td>09:00-09:10</td>
<td>Opening</td>
<td>Prof. Yusuke Honjo, Chair, ACECC TC-8</td>
</tr>
<tr>
<td>09:10-09:25</td>
<td>Introduction</td>
<td>Dr. Kenichi Horikoshi, Secretary, ACECC TC-8</td>
</tr>
<tr>
<td>09:25-10:00</td>
<td>Special Lecture 1</td>
<td>Prof. Junichiro Niwa, Tokyo Institute of Technology</td>
</tr>
<tr>
<td>10:00-10:10</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>10:10-10:45</td>
<td>Special Lecture 2</td>
<td>Dr. Yoshiaki Kikuchi, Port &amp; Airport Research Institute</td>
</tr>
<tr>
<td>10:45-11:20</td>
<td>Special Lecture 3</td>
<td>Dr. Koo, Jai-Dong, Korea Institute of construction technology</td>
</tr>
<tr>
<td>11:20-11:30</td>
<td>Coffee Break</td>
<td></td>
</tr>
<tr>
<td>11:30-11:50</td>
<td>Presentation from TC-8 members</td>
<td>Prof. Shyh-Jiann Hwang, National Taiwan University</td>
</tr>
<tr>
<td>11:50-12:10</td>
<td>The Current Situation of Mongolian Building Code System</td>
<td>Prof. Duinkher Yagaanbuyant, Mongolian University of Science and Technology</td>
</tr>
<tr>
<td>12:10-13:00</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<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>
</tr>
<tr>
<td>13:40-14:00</td>
<td>Necessity of Design Codes for Cambodia</td>
<td>Dr. Vong Seng, Institute of Technology of Cambodia</td>
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<tr>
<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>14:20-14:30</td>
<td>Coffee Break</td>
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<td>14:30-15:50</td>
<td>Panel Discussion (1st TC-8 Meeting)</td>
<td>Chair: Prof. Yusuke Honjo</td>
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<td>15:50-16:00</td>
<td>Closing Remarks</td>
<td>Dr. Yukihiko Sumiyoshi, JSCE Representative for ACECC</td>
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</table>
4. 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. Taweep Chaisomphob (Engineering Institute of Thailand, Thammasat University)

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)
Introduction of the ACECC Activities and the Workshop

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

1. To promote and advance the science and practice of civil engineering and related professions for sustainable development in the Asian region.
2. To encourage communication between persons in charge of scientific and technical responsibility for any field of civil engineering.
3. To improve, extend and enhance activities such as infrastructure construction and management, preservation of the precious environment and natural disaster prevention.
4. To foster exchange of ideas among the member societies/institutions.
5. To cooperate with any regional, national and international organizations to support their work, as the ACECC deems necessary.
6. To provide advice to member societies/institutions to strengthen their domestic activities.
7. To achieve the above objectives, international conferences called the Civil Engineering Conference in the Asian Region (CECAR) will be held on a triennial basis as the main activity of the ACECC.

ACECC Operational task assigned to each member

Developing Countries
- Creation of expert resource pool (KSCE)
- Establishment of technical resource center (VIFCA)
- Development of civil engineering dictionary (PICE)
- Public recognition of civil engineering profession (ASCE)
- Asian civil engineers code of ethics (EA)
- Cross-licensing of professional civil engineers (CICHE)

Developed Countries
- Cooperation for code development as global standard
- Cooperation for creation of unified idea of design concept and terminologies

Necessities
- Discuss future of code development
- Exchange information on code development in each country
- Enhance personal network among code writers beyond boundaries of nations and fields of study
ACECC Activities

1. “Web-based database on design code” within ACECC members

   http://www.acecc.net/

2. ACECC Workshop on Harmonization of Design Codes in the Asian Region (November 4, 2006 in Taipei)

3. Approval of the new TC on Harmonization of Design Codes in the Asian Region (June 25, 2007 at Executive Committee Meeting of ACECC)

4. Special Forum on Harmonization of Design Codes in the Asian Region (June 27, 2007 4th CECAR)

ACECC Technical Committee (TC-8) on Harmonization of design codes in the Asian region

Chair: Prof. Yusuke Honjo (Gifu University, JSCE)
Secretary: Dr. Kenichi Horiyoshi (Taisei Corporation, JSCE)

Terms of References of the new TC:
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.

Activity period: 2007-2010

Level of Harmonization (1)

Step 1: Share of information beyond boundaries of societies and civil eng. fields (source of code, methodolgy of code development)

Activities of this level have already been started by ACECC i.e. code information on ACECC website, and ACECC workshop on Harmonization of design codes in the Asian region Nov. 4, 2006

Steps 2-4: Harmonization of basic terminologies, design concepts, and basis of designs

Informativ to code writers
Avoid misunderstanding among engineers in practice

Level of Harmonization (2)

Step 3: Harmonized code for basis of design, Harmonized code for a specific design field, such as concrete, structural engineering, and geotechnical engineering.

Codes to be refereed by code writers in each country
Such as Eurocode 0: Basis of Design.
ISO 2394: General principles on reliability for structures.

Step 4: Harmonization extended to broader area and broader engineering field.

Asian Concrete Model Code activity toward ISO
Asian Voice to the world

Summaries of discussions

Step 1: Share of information
Step 2: Harmonization of terminologies, design concepts
Step 3: Harmonization of basis of designs
Step 4: Extension of harmonization to broader area

Necessities
1) To harmonize beyond different structures even in the same country,
2) To incorporate new concept such as sustainability,
3) To refer European experience, such as Eurocode,
4) To incorporate Uniqueness among Asian countries,
5) To cooperate governmental body, or obtain assistance, and
6) To recognize importance of continuous activities.
**objectives of the 2nd workshop**

1) Continuation of the last Special Forum at the 4th CECAR (2007)

2) First occasion where the members of ACECC TC-8 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) First TC-8 meeting, which corresponds to the panel discussion. 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) 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.

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<td>3) Plan &amp; Status of Performance Based Design Code &amp; Construction in Korea’</td>
<td>By Dr. Koo, Jai-Dong</td>
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<td>6. Closing Remarks</td>
<td>By Dr. Yukihiko Sumiyoshi</td>
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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
Outlines of the Revision of “Standard Specifications for Concrete Structures [Design], JSCE – 2007 Version”

Sept. 11, 2008
Concrete Committee of JSCE
Subcommittee on the Revision of Standard Specifications, Design Group
Junichiro Niwa (Tokyo Institute of Technology)

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.


(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 the 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, adopted from the economical viewpoint.
- Plan 2: 6-span continuous PC box girder bridge, 40 m × 6 = 240 m.
- Plan 3: 4-span continuous extradosed PC girder bridge, 40 m + 80 m + 80 m + 40 m = 240 m.
- Plan 4: 4-span continuous PC cable-stayed bridge, 40 m + 80 m + 80 m + 40 m = 240 m.

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, 25 m + 4 @ 25.5 m = 127 m.
- Plan 2: 4-span continuous PRC double girder bridge, 28.5 m + 2 @ 35 m + 28.5 m = 127 m.
- Plan 2: 4-span continuous PRC double girder bridge, 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).

\[ \gamma_r S_d / R_u \leq 1.0 \quad (4.3.1) \]

where, 
- \( S_d \): Design response value
- \( R_u \): Design limit state value
- \( \gamma_r \): Structure factor

4.5 Safety Factor

Table C4.5.2 Recommended Safety Factor

<table>
<thead>
<tr>
<th>Safety factor</th>
<th>Material factor ( \gamma_{cc} )</th>
<th>Member factor ( \gamma_{mm} )</th>
<th>Structural factor ( \gamma_{ss} )</th>
<th>Structural factor ( \gamma_{aa} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety (Section failure)*1</td>
<td>Concrete</td>
<td>Steel</td>
<td>Concrete</td>
<td>Steel</td>
</tr>
<tr>
<td>Load factor</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Service factor</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Collapse</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Seismic</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Fatigue failure*1</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Note: *1: Linear analyses → *2: Nonlinear analyses

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

Following items shall be described as the reference values.

- Types of cement
- Maximum size of coarse aggregate
- Unit cement content
- Slump or slump flow of concrete
- Water-cement ratio
- Air content

Although (6)~(9) are reference values, it shall be confirmed in the design stage that these values are fully realistic.

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 6: Load

(1) "Seismic loading" has been taken from the "Specifications of Seismic Performance Verification – 2002".

(2) Earth pressure is determined by considering the interaction between the ground and the structure and the change with age.

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) Calculation methods for section force, deflection, stress, strain, crack width, etc. are prescribed in Chapter 7.

(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.

\[
7 = 1.1k_1k_2k_3\left[k_c + 0.7(c - \theta)\right]\frac{\sigma_{pc}}{E_{pc}}(\sigma_{pc} - \frac{\sigma}{E_p}) + \varepsilon_{cst}
\]

\( \varepsilon_{cst} \) : 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 \( C_r \) is updated according to the location of the structure and its distance from the shoreline.

(3) The difference of \( C_r \) 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>Area with high blown chloride contents</th>
<th>Distance from shoreline (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido, Tohoku, Honshu, Chugoku, Shikoku, Kyushu</td>
<td>Close to shoreline 0.1</td>
</tr>
<tr>
<td>The area with low blown chloride contents</td>
<td>9.0</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)

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

where, $\beta_w = 4.2(100p_{w} \cdot (a/d - 0.75)) / \sqrt{f_{cd}}$

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

(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.

10.3.2 Flexural Crack

$\varepsilon_{cd}$ 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 $\varepsilon_{cd}$ 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 1000με, the following values are recommended as $\varepsilon_{cd}$.

Table 10.1 Recommended value of $\varepsilon_{cd}$ for calculating flexure crack on surface

<table>
<thead>
<tr>
<th>Material age of crack initiation</th>
<th>$\varepsilon_{cd}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 days</td>
<td>$5 \times 10^{-6}$</td>
</tr>
<tr>
<td>100 days</td>
<td>$3.5 \times 10^{-6}$</td>
</tr>
<tr>
<td>more than 200 days</td>
<td>$3 \times 10^{-6}$</td>
</tr>
</tbody>
</table>


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.

Chapter 10: Verification for Serviceability

(1) The verification of the appearance of structures, water-tightness, and fire resistance has been newly prescribed.

(2) The limit of crack width for the appearance of structures is determined as 0.3mm based on past records and experience.

(3) The flexural crack width can be evaluated by the following equation.

$$w = 1.1k_1k_2k_3[4c + 0.7(\varepsilon_{cd} - \phi)] \left[ \frac{\sigma_{cm}}{E_p} + \left( \frac{\sigma_{cm}}{E_p} \right)^2 \right]$$

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.
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, \( V_{mu} = M_u / \ell_a \)


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 12: Verification for Initial Cracking

(1) Chapter 12 has been newly drawn up based on the Chapter 4 Verification for Initial Crack of “Construction Performance Verification (2002)”.

(2) The simplified method to verify the performance of the structure by cracking due to the hydration heat of cement has been newly introduced in Chapter 4: Thermal Stress Analysis in the Standards.


Chapter 13: Structural Details for Reinforcement

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.

(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.

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

Yoshiaki Kikuchi
Port & Airport Research Institute

1. Definition
- Fender system should be mounted in mooring facilities.

2. Example
- Breakwater

3. Performance Requirement
- Mandatory

4. Concept of performance based design system
- Situation: Accidental, Persistent, Transient
- Performance: Damage extent

5. Provisions in former TSPHF
- Design procedure:
  - Article 34: Examination of the stability of upright section of gravity type concrete structures shall be conducted as standard by the limit methods in the following procedure.

6. Performance matrix considered in TSPHF
- Design situation:
  - Persistent Situation: Permanent actions (self weight, earth pressures) are major actions.
  - Transient Situation: Variable actions (wave, Level 1 earthquake) are major actions.
  - Accidental Situation: Accidental actions (Tsunami, Level 2 earthquake) are major actions.

7. Relation between design situation and performance requirement in new TSPHF
- Situation: Accidental and Transient
- Performance: Serviceability
Performance considered in former TSPHF

<table>
<thead>
<tr>
<th>Design situation</th>
<th>Definition</th>
<th>Performance Requirement</th>
</tr>
</thead>
<tbody>
<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 (e.g., Level 1 earthquake) are major actions</td>
<td></td>
</tr>
</tbody>
</table>

Extraordinary Situation

- Level 2 earthquake is major action
- Safety factors against failure shall be larger than prescribed value.

This design situation is applied only on earthquake proofed structures.

Level 1 & 2 earthquake

- For the verification of earthquake resistance of public structures, two types of seismic motions shall be applied such as Level 1 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.

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.

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.
  - They 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.

What is Reliability Based Design method?

- A design method which takes into consideration of failure probability of the facility or exceedance probability of limit state, which is required in design, of the facility.
- That is, failure probability of the structure is explicitly considered in reliability based design method.
Levels of Reliability based design method

1. Level 3 PBD
   - Failure probability is directly evaluated (Pf: Probability of performance function Z<0)
   - Probability of performance function Z<0

2. Level 2 PBD
   - Distance between mean value and failure condition is evaluated with reliability index β.
   - Indirectly considering the probability distribution form, β and σ are considered for evaluating failure probability.

3. Level 1 PBD
   - Partial factors are used for considering the distance between mean value and failure condition.
   - Partial factors are derived from Level 2 PBD calculation.

\[ Z = R - S \]

Reliability index and failure probability

<table>
<thead>
<tr>
<th>Failure probability Pf</th>
<th>Reliability Index β</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^{-1}</td>
<td>1.29</td>
</tr>
<tr>
<td>10^{-2}</td>
<td>2.32</td>
</tr>
<tr>
<td>10^{-3}</td>
<td>3.09</td>
</tr>
<tr>
<td>10^{-4}</td>
<td>3.72</td>
</tr>
<tr>
<td>10^{-5}</td>
<td>4.27</td>
</tr>
<tr>
<td>10^{-6}</td>
<td>4.75</td>
</tr>
</tbody>
</table>

* Performance function Z and R and S are assumed to be normal probability variables.

Safety factor method and RBD method

Safety factor cannot explain failure probability.

\[ RBD Level \]

- Level 3: Pf x Pf
  - Failure probability
- Level 2: Pf x Pf
  - Reliability index
- Level 1: Pf x Pf
  - Partial factor

Safety based design in 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.
  - Influence of quay wall is indicated by displacement or deformation. To evaluate those, high level of analytical method is needed.

- Importance of model tests or field experiments are emphasized to include design.

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

Design verification method used in new TSPHF is explained using the verification of gravity type of breakwater for example.

Verification of sliding mode of failure is presented.

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

- FORM method is categorized in level2 of RBD.

Reliability index (β)

Average system reliability index of existing caisson type breakwater is 2.38.

Partial factors used in TSPHF

Partial factor Coefficient of variance V Sensitivity Target reliability index Deviation of the characteristic value to mean value

<table>
<thead>
<tr>
<th>Partial factor</th>
<th>Coefficient of friction (mean/characteristic value)</th>
<th>Target reliability index</th>
<th>Deviation of characteristic value to mean value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient of friction</td>
<td>0.79 (1.088)</td>
<td>0.09 (0.150)</td>
<td>0.00 (0.000)</td>
</tr>
<tr>
<td>Coefficient of friction</td>
<td>0.77 (1.074)</td>
<td>0.07 (0.160)</td>
<td>0.00 (0.000)</td>
</tr>
<tr>
<td>Coefficient of friction</td>
<td>0.75 (1.059)</td>
<td>0.05 (0.150)</td>
<td>0.00 (0.000)</td>
</tr>
<tr>
<td>Coefficient of friction</td>
<td>0.73 (1.044)</td>
<td>0.03 (0.150)</td>
<td>0.00 (0.000)</td>
</tr>
<tr>
<td>Coefficient of friction</td>
<td>0.71 (1.029)</td>
<td>0.01 (0.150)</td>
<td>0.00 (0.000)</td>
</tr>
<tr>
<td>Coefficient of variance (response of design parameters)</td>
<td>0.09 (0.150)</td>
<td>0.01 (0.150)</td>
<td>0.00 (0.000)</td>
</tr>
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<td>0.00 (0.000)</td>
</tr>
</tbody>
</table>

Difference in statements between former and new TSPHF

Former TSPHF

Examination of stability against sliding is made using following equation. In this examination, an appropriate safety factor shall be used:

\[ F_s = \frac{S - U - H}{P} \]

- \( S \): safety factor for sliding at upright section
- \( U \): uplift force acting on the upright section
- \( H \): total horizontal force acting on the upright section

New TSPHF

The risk of the instability of breakwater under extreme design situation on wave action shall be under the limit value. Specification:

\[ F_s = \frac{S - U - H}{P} \times 0.6 \]

Note:

\( \mu \): deviation of characteristic value (mean/characteristic value)

\( \mu / \sigma \): Coefficient of variance

\( \gamma_{\mu} \): ratio of highest water level ever recorded and mean monthly-highest water level

Difference in former TSPHF and new TSPHF

Sliding failure verification in former TSPHF

(Per 1m)

<table>
<thead>
<tr>
<th>Coefficient of friction</th>
<th>Coefficient of variance (response of design parameters)</th>
<th>Coefficient of friction</th>
<th>Coefficient of variance (response of design parameters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.79 (1.088)</td>
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<td>0.71 (1.029)</td>
<td>0.01 (0.150)</td>
</tr>
</tbody>
</table>
(2) Calculation of performance function on sliding failure (performance function Z>0)

1. Calculation of design values

- Design value of weight of a caisson

\[ \text{Design value of weight} = 342.0 \times 0.98 = 335.2 \text{kN/m} \]

- Design value of buoyancy

\[ \text{Buoyancy} = 600 \times 1.03 = 618\text{kN/m} \]

- Design value of Horizontal wave force and uplift

\[ \begin{align*}
\text{Horizontal force} & = 500 \times 1.04 = 520\text{kN/m} \\
\text{Uplift} & = 150 \times 1.04 = 156\text{kN/m}
\end{align*} \]

2. Verification by performance function

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

\[ Z = (1811.8 - 156 - 618) 	imes (0.6 \times 0.79) - 520 = -28.1 \rightarrow \text{Out} \]

If Z<0, the breakwater designed is verified that sliding failure possibility of this caisson is less than 1.7X10^-3 in TSPHF.
Input seismic motion for design

- Level 1 seismic motion of probabilistic time history wave shall be appropriately selected from measured seismic motions in view of source characteristics of earthquake, propagation path, and site effect.
- Level 2 seismic motion of deterministic time history wave shall be appropriately selected from measured seismic motions and parameters of envisioned source characteristics of earthquake in view of source characteristics of earthquake, propagation path, and site effect.

- Evaluation of seismic motion at construction sites
  - Time history wave (Frequency characteristics, duration time)
  - Evaluation of site effect
    - Strong seismic motion measurement system

Seismic coefficient caring time history of seismic motion

<Former TSPHF>
Seismic design (simple method: seismic coef. method)
seismic coefficient
= (area factor) X (ground type factor) X (important factor)

<New TSPHF>
Effect of seismic motion was calculated from time history of seismic motion.

- Characteristics of seismic motion (frequency dependency, duration time) are different for each site.
- A lot of varieties exist in quay wall types, sea depths, and ground conditions.
- Serviceability of quay walls shall be kept even after level 1 earthquake.

Introduction of new seismic coefficient for verification

- Calculation of seismic coefficient for verification (gravity type of quay wall) (partial factor of 1.0 is used)

\[ k_v = 1.78 \left( \frac{D_s}{D_a} \right)^{-0.3} \alpha_{Rd} = 0.04 \]

- Structures (gravity type of quay wall) designed with seismic coefficient method with seismic coefficient for verification shall displace under the limit of residual displacement (about 30cm) of serviceability under Level 1 seismic motion in each port.

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 concept of seismic coefficient (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.
Development of Design Codes and Standard Specifications in Korea

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Ha-Won Song

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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>
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<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>
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<tr>
<td>Korea Water Resources Association</td>
<td>Standard Specification for Construction of River</td>
<td>River Design Codes</td>
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<tr>
<td></td>
<td></td>
<td>Dam 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></td>
<td>Standard Specification for Industrial/Environmental Equipments Works</td>
<td></td>
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<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>
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<td>Earthquake-proof Design Codes</td>
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<td>Construction Temporary Equipment Association of Korea</td>
<td>Standard Specification for Temporary Works</td>
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<td>Korea Water &amp; Wastewater Works Association</td>
<td>Standard Specification for Water and Wastewater Works</td>
<td>Water Supply Design Codes</td>
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<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>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.

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<thead>
<tr>
<th>Year</th>
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<td>Establishment of master plans</td>
<td>Writing Manuals</td>
<td>Steel Structures</td>
<td>Foundation structures, road subsidiary facilities</td>
<td>Tunnels, landscaping facilities, building mechanical and electrical systems</td>
<td>buildings</td>
</tr>
</tbody>
</table>

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

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

Figure 5 Roadmap of performance-based steel structure design guideline

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>
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<tbody>
<tr>
<td>Korean Society of Civil Engineers</td>
<td>General Standard Specification for Civil Works</td>
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<tr>
<td></td>
<td>Standard Specification for Urban Railroad (metro) Works</td>
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<td>Korea Concrete Institute</td>
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<tr>
<td>Korean Society for Steel Construction</td>
<td>Steel Structure Design Codes</td>
<td></td>
</tr>
</tbody>
</table>
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.
- **Steel Structure (Civil) 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.
### Development status of performance-based design codes and specifications

#### Foundation structures Sector
- 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.

#### Road subsidiaries Sector
- 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.

#### Tunnels Sector
- 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.

#### Landscaping Sector
- Development of performance codes nearly has not been implemented.
- Researches on the assessment of landscapes, thermal environments, rainwater storage and utilization and biological habitats have been performed.

#### Building mechanical systems Sector
- 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.

#### Building electrical systems Sector
- 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.

#### Performance Warranty Contracting System
- 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.
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 for concrete structures**
  - General requirement of Design codes
  - Common codes 1: principles of design
  - Common codes 2: loads and design conditions
  - Special codes: durability, fire resistance, structural resistance
  - Other design codes

- **Roadmap of performance-based building design guideline**
  - Preparation of fire-resistance performance design guideline of structural members
  - Establishment of high-temperature characteristics of structural materials
  - Survey/analysis of architectural material performance criteria and performance classification method
  - Performance classification for each member (each use)

- **Roadmap of performance-based steel structure design guideline**
  - Establishment of master plan to develop performance-based codes
  - Establishment of high level criteria for performance-oriented design
  - Suggestion of performance assessment methods
  - Analysis of the performance hierarchy of steel structures
  - Collection and analysis of performance-based design materials
  - Proposal of research project to develop performance-based Design Codes and Standard Specifications

- **Roadmap to develop performance-based design codes and specifications (general)**
  - Establishment of master plan
  - Writing Manuals
  - Pavements and Concrete Structures
  - Steel Structures
  - Foundation structures, road subsidiary facilities
  - Bridges, harbour facilities, building mechanical and electrical systems
  - other 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 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.

Future plan

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 cooperation system for the harmonization in design codes including developing performance-based design codes in the civil engineering are very much necessary.

Thank You
Status of Design Codes in Taiwan

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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

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

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.
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

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>
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<td>Building Design Code</td>
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<td>Seismic Code and Commentary for Building</td>
<td>CPA</td>
<td>2006-01</td>
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<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>
</tr>
</tbody>
</table>

CPA: Construction and Planning Administration

List of Codes - Concrete Engineering

<table>
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<th>Code Name</th>
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<td>2002-07</td>
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<td>Design Code for Structural Concrete (Draft)</td>
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<tr>
<td>Design Code for Pre-cast Concrete</td>
<td>CPA</td>
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<td>Blast Furnace Bag Concrete Code for Public Construction</td>
<td>PCC</td>
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<td>Fly Ash Concrete Code for Public Construction</td>
<td>PCC</td>
<td>1999-08</td>
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<tr>
<td>Design Criteria for High Performance Concrete (Draft)</td>
<td>TANEES</td>
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</tr>
<tr>
<td>Application Guidelines of Self-Compacting Concrete</td>
<td>CICHE</td>
<td>2006-09</td>
</tr>
</tbody>
</table>

CICHE: Chinese Institute of Civil & Hydraulic Engineering
CPA: Construction and Planning Administration
PCC: Public Construction Commission
TANEES: Taiwan Area National Expressway Engineering Bureau

Design Code and Commentary for Structural Concrete
Specifications for Structural Concrete
Design Code for Pre-cast Concrete
Blast Furnace Bag Concrete Code for Public Construction
Fly Ash Concrete Code for Public Construction
Design Criteria for High Performance Concrete (Draft)
Draft of Concrete Design Code

Design Code for Structural Concrete

Publisher: CPA
Issued: 2002

Code Draft

Design Code and Commentary for Structural Concrete (土木 401-86a)

Publisher: CICHE
Issued: 1997

Draft of Concrete Construction Code

Specification for Structural Concrete

Publisher: CPA
Issued: 2002

Code Draft

Construction Code and Commentary for Structural Concrete (土木 402-88a)

Publisher: CICHE
Issued: 1999

List of Codes - Geotechnical Engineering

<table>
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<tr>
<td>Criteria for Site Investigation</td>
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<td>Criteria for Geotechnical Investigation</td>
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<td>Criteria for Geological Mapping and Commentary</td>
<td>CICHE</td>
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<td>Design Criteria for Building Structural Foundation</td>
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<td>Design Criteria, Specifications and Commentary for Earth Anchorage</td>
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<td>Design Criteria and Commentary for Tunneling</td>
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<td>Construction Specifications for Shield Tunneling</td>
<td>CTTA</td>
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</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
Asian Code

CICHE fully supports the establishment of a system of Asian Codes, which, however, may require government agreement and sponsorship.

If
Superior in concept, level and scope than the existing codes
Approved by APEC or ISO
Then
Respected and accepted by the governments concerned
Popularization of the Codes

Asian Code

The popularization of the Asian Codes may, at first, be mandated to the APEC engineers, and through the help of ACECC

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.
- ISO or APEC standards are welcome.
- Level 3 document of ICCMC will be elaborated.

Thank You
THE CURRENT SITUATION OF MONGOLIAN BUILDING CODE SYSTEM

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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 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

3rd 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.

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2. Objectives and directions of construction standardization, Journal of Construction Information, 2000/4, ZGHABHBNAAG, UB,

3. Journal of Construction Information, 2008, ZGHABHBNAAG, UB,
Introduction of Asian Concrete Model Code (ACMC)

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**INTRODUCTION OF ASIAN CONCRETE MODEL CODE (ACMC)**

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University of Tokyo

Tamon UEDA  
Hokkaido University

Koji TAKEWAKA  
Kagoshima University

Hiroshi YOKOTA  
Port and Airport Research Institute

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**World wide cement consumption**

<table>
<thead>
<tr>
<th>Year</th>
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<th>USA</th>
<th>India</th>
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</tr>
<tr>
<td>2005</td>
<td>1.14</td>
<td>0.1</td>
<td>0.17</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>2006</td>
<td>1.17</td>
<td>0.1</td>
<td>0.18</td>
<td>0.12</td>
<td>0.12</td>
</tr>
</tbody>
</table>

More than 50% in Asia

- 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%)

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)

**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

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

- 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 and revisions and updates of the model code.

**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 example of design, construction and maintenance guidelines confirming to the Level 1 and Level 3 documents.

The Level 3 rationale document includes example of design, construction and maintenance guidelines confirming to the Level 1 and Level 3 documents.

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

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
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**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 Ha-wong Song of Korea with the writer as Secretary. SC 7 is now drafting an umbrella code for maintenance based on ACMC.

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

**DIFFICULTIES IN CODE DRAFTING AND INTERNATIONAL COLLABORATION**

Volunteer work from limited countries
- Unfamiliarity for code drafting
- Small motivation with no direct benefit such as research grant to individual

Difficulty in being recognized by government
- Country where codes are well established shows little interest
- ICCMC is not a governmental body

Financial support is still necessary for many Asian countries to participate international collaboration.
- Country like Japan where civil and architectural structures are dealt by different organization needs unification of codes are preferable.

**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
Seismic Design Specifications for Highway Bridges in Japan

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1 INTRODUCTION

Seismic design methods for highway bridges in Japan has 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 \cite{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 \cite{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.

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>Level 1 Earthquake:</td>
<td>SPL 1: Prevent Damage</td>
<td>SPL 2: Prevent Critical Damage</td>
</tr>
<tr>
<td>Ground Motions with High Probability to Occur</td>
<td></td>
<td>SPL 3: Limited Damage for Function Recovery</td>
</tr>
<tr>
<td>Level 2 Earthquake:</td>
<td>Interplate Earthquake</td>
<td></td>
</tr>
<tr>
<td>Ground Motions with Low Probability to Occur</td>
<td>(Type-I)</td>
<td></td>
</tr>
<tr>
<td>Inland Earthquake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(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>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 Dynamic Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL 1</td>
<td>Static Verification</td>
<td>Dynamic Verification</td>
<td>Dynamic Verification</td>
<td>Dynamic Verification</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>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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2002 JRA Design Specifications for Highway Bridges, Part V: Seismic Design

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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
-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

Specifications for highway bridges with a span length of 200 m or less

Current Seismic Design Code
2002 Seismic Design Specifications for Highway Bridges

Major Revisions from the previous version(1996):
- Performance-Based Design Code Concept
- Enhance Long-Term Durability
- Inclusion of Improved Knowledge on Bridge Design and Construction Methods

Performance-Based Design Code Structure (Pyramid)

Objectives of Codes
- Performance Requirements
- Verification Methods and Acceptable Solutions

Importance of Bridges
Class Definitions
- Class A bridges: Bridges other than Class B bridge
- Class B bridges: Bridges of National expressways, urban expressways, designated city expressways, Honsyu-Shikoku highways, and general national highways
- 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: Seismic Performance Level

- SPL 1: Prevent Damage
  - Performance to keep sound functional of the bridges after earthquake
- SPL 2: Limited Damage for Function Recovery
  - Performance to assure early-recovery of bridge function after earthquake by limiting damage
- SPL 3: Prevent Critical Damage
  - Performance to prevent critical damage

Seismic Performance Matrix

- Type-A (Standard Bridge)
- Type-B (Important Bridge)

Example for Selection of Limit States (SPL 2)

- Repairable Limit
- Limited Nonlinear Behavior
- Elastic Limit

Principles in Selection of Members for Energy Absorption

- Reliable Energy Absorption
- No Significant Effect on Bridge Stability
- Repairable Damage and Easy to Repair (Repairability)
- Possibility to Maintain Traffic Function after Damage (Functionability)
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>
<tr>
<td>Static verification</td>
<td>Dynamic verification</td>
<td>Dynamic verification</td>
</tr>
</tbody>
</table>

Examples of Bridges

1. Bridges with simply behavior
2. Bridges with multi plastic hinges and without applicability of energy constant rule
3. Bridges with multi mode response
4. Bridges with complicated behavior

SPL 1
- Bridges with rubber bearings
- Seismically isolated bridges
- Right-frame bridges
- Bridges with steel columns
- Bridges with long natural period
- Bridges with high piers
- Cable-stayed bridges
- Suspension bridges
- Arch bridges
- Curved bridges

Verification Methods and Acceptable Solutions

Contents
- Verification Methods (Static and Dynamic Verfications)
- Effect of Soil Liquefaction
- Seismic Isolation Design
- Evaluation of the Limit State of Members
  - RC Columns
  - Steel Columns
  - Pier Foundations
  - Abutment Foundations
  - Superstructure
- Unseating Prevention Systems

Evaluation of the Limit State of RC Columns

- 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

<table>
<thead>
<tr>
<th>Items</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seating Length</td>
<td></td>
</tr>
<tr>
<td>Unseating Prevention Structure</td>
<td></td>
</tr>
<tr>
<td>Structure for Protecting Superstructure from Subsidence</td>
<td></td>
</tr>
<tr>
<td>Excessive Displacement Stopper</td>
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</tr>
</tbody>
</table>

Concluding Remarks

- Performance-Based Design Code
  - Methods to Satisfy Requirements
  - Can be modified or may be selected with necessary verifications

- 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

Collapsed Matsurube Bridge in the Iwate-Miyagi Inland Earthquake 2008

Thank You for Your Kind Attention
Necessity of Design Codes for Cambodia

VONG Seng  
Vice President, Cambodian Association of Civil Engineers, Cambodia  
Lecturer, Institute of Technology of Cambodia, Cambodia

MOM Mony  
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. 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

The main reasons of using different design codes in Cambodia are:

- 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 investments on construction industry are from different countries
**Design Codes Used Cambodian**

Construction design codes used in Cambodia
- 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.

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.
Structural Steel Design Specifications in Thailand

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

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.

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

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.
Hot rolled steel building design specifications

Table of content of E.I.T. Standard 1020-46
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

Cold formed steel building design specifications

Table of content of Draft E.I.T. Standard
6. Structural assemblies and systems
7. Connections and joints
8. Tests for special cases

Material Standard

Hot rolled steel section:

- 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
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<thead>
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<td>0.55</td>
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<td>0.035</td>
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<td>-</td>
<td>-</td>
<td>0.050</td>
<td>0.050</td>
</tr>
<tr>
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<td>-</td>
<td>-</td>
<td>0.050</td>
<td>0.050</td>
</tr>
<tr>
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<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 chemical component**

- **Carbon**
  - SM 400: 0.20
  - SM 490: 0.18
  - SM 520: 0.20
  - SM 570: 0.18
  - SS 400: -
  - SS 490: -
  - SS 540: 0.30
- **Silicon**
  - SM 400: 0.36
  - SM 490: 0.55
  - SM 520: 0.55
  - SM 570: 0.55
  - SS 400: -
  - SS 490: -
  - SS 540: -
- **Manganese**
  - SM 400: 0.50 – 1.40
  - SM 490: 1.60 max.
  - SM 520: 1.60 max.
  - SM 570: 1.60 max.
  - SS 400: -
  - SS 490: -
  - SS 540: 1.60 max.
- **Phosphorus**
  - SM 400: 0.035
  - SM 490: 0.035
  - SM 520: 0.035
  - SM 570: 0.035
  - SS 400: 0.050
  - SS 490: 0.050
  - SS 540: 0.040
- **Sulfur**
  - SM 400: 0.035
  - SM 490: 0.035
  - SM 520: 0.035
  - SM 570: 0.035
  - SS 400: 0.050
  - SS 490: 0.050
  - SS 540: 0.040

**Material Standard**

Hot rolled steel section in TIS 1227-2539

Steel grade and chemical component

- **Carbon**
  - SM 400: 0.20
  - SM 490: 0.18
  - SM 520: 0.20
  - SM 570: 0.18
  - SS 400: -
  - SS 490: -
  - SS 540: 0.30
- **Silicon**
  - SM 400: 0.36
  - SM 490: 0.55
  - SM 520: 0.55
  - SM 570: 0.55
  - SS 400: -
  - SS 490: -
  - SS 540: -
- **Manganese**
  - SM 400: 0.50 – 1.40
  - SM 490: 1.60 max.
  - SM 520: 1.60 max.
  - SM 570: 1.60 max.
  - SS 400: -
  - SS 490: -
  - SS 540: 1.60 max.
- **Phosphorus**
  - SM 400: 0.035
  - SM 490: 0.035
  - SM 520: 0.035
  - SM 570: 0.035
  - SS 400: 0.050
  - SS 490: 0.050
  - SS 540: 0.040
- **Sulfur**
  - SM 400: 0.035
  - SM 490: 0.035
  - SM 520: 0.035
  - SM 570: 0.035
  - SS 400: 0.050
  - SS 490: 0.050
  - SS 540: 0.040

**Material Standard**

Hot rolled steel section in TIS 1227-2539

Steel grade and material properties

- **Steel Grade**
  - SM 400
  - SM 490
  - SM 520
  - SM 570
  - SS 400
  - SS 490
  - SS 540
- **Min. Yield Strength (MPa)**
  - SM 400: 245
  - SM 490: 325
  - SM 520: 355
  - SM 570: 460
  - SS 400: 245
  - SS 490: 285
  - SS 540: 385
- **Ultimate Strength (MPa)**
  - SM 400: 238
  - SM 490: 315
  - SM 520: 325
  - SM 570: 450
  - SS 400: 235
  - SS 490: 275
  - SS 540: 390
- **Min. Elongation %**
  - SM 400: 23
  - SM 490: 19
  - SM 520: 19
  - SM 570: 19
  - SS 400: 21
  - SS 490: 17
- **Min. Impact Strength (Joule)**
  - SM 400: 18
  - SM 490: 19
  - SM 520: 19
  - SM 570: 19
  - SS 400: 27
  - SS 490: 47

**Material Standard**

Hot rolled steel section in TIS 1227-2539

Sectional shape

- **Angle steel**
  - Equal leg
  - Unequal leg
- **Channel steel**
- **H-section steel**
- **I-section steel**
- **T-section steel**

**Material Standard**

Cold formed steel section

- 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

Steel grade and chemical component

<table>
<thead>
<tr>
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<td>SSC 400</td>
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<td>-</td>
<td>-</td>
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</tbody>
</table>

**Material Standard**

Cold formed steel section in TIS 1228-2549

Steel grade and material properties

<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>
</tr>
</tbody>
</table>

**Material Standard**

Cold formed steel section in TIS 1228-2549

Sectional shape
Material Standard

Cold formed steel section in TIS 1228-2549

Sectional shape

<table>
<thead>
<tr>
<th>Type</th>
<th>Sectional shape</th>
</tr>
</thead>
<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

\[ U = 0.75(1.7D + 2.0L + 2.0W) \]
\[ U = 0.9D + 1.3W \]

\( W \) = 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>150</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>
</tbody>
</table>

7. (a) Market place, department store, meeting hall, theatre, restaurant, reading room in a library, and parking area or garage

(b) Hall, stair, hallway of commercial building, university, college or school

8. (a) Warehouse, stadium, museum, factory, storage room

(b) Hall, stair, hallway of market place, department store, meeting hall, theatre, restaurant and library

9. Library space or garage for shelf

10. Parking area or garage for truck

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>500</td>
</tr>
<tr>
<td>8. (a) Warehouse, stadium, museum, factory, storage room</td>
<td>600</td>
</tr>
<tr>
<td>(b) Hall, stair, hallway of market place, department store, meeting hall, theatre, restaurant and library</td>
<td>800</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>
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<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.
Appendix

First Draft of

“Glossary of Terminologies for Design Code”
### Glossary of Key Terms for Structural Design Codes founded on Performance based Design Concept
Completed by JSCE (May 2008)

<table>
<thead>
<tr>
<th>Code Platform</th>
<th>Definition</th>
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<tbody>
<tr>
<td>code PLATFORM</td>
<td>Terminology defined in 'Principles, guidelines and terminologies for structural design code drafting founded on the performance based design concept ver.1.0 (code PLATFORM ver.1.0)', March 2003, JSCE.</td>
</tr>
<tr>
<td>ISO2394</td>
<td>Terminology that is defined in ISO2394 (3rd version. 1998) and should be in accordance with the definitions in and revisions to ISO2394.</td>
</tr>
<tr>
<td>Geo-code 21</td>
<td>Terminology defined in 'JGS 4001·2004 Principles for Foundation Design grounded on a Performance-based Design Concept (Geo-code 21)', completed English translation in March 2006.</td>
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<tr>
<td>ISO13822</td>
<td>Terminology that is defined in ISO13822 (1st version. 2001) and should be in accordance with the definitions in and revisions to ISO13822.</td>
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<td>ACMC2006</td>
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</table>
| 1  | Terms relating to structural response, resistance, material properties and geometrical quantities | Fractile value                | The value of a random variable with a cumulative probability lower than specified.
  **NOTE:** Expressed like “x% fractile is y.”                                                                                                                                                                                                                                                                                           | MLIT2002     |          |
<p>| 2  | Terms relating to structural response, resistance, material properties and geometrical quantities | Design value                  | The design value is the value obtained by multiplying a partial factor by a characteristic value in the case of an MFA partial factor format.                                                                                                                                                                                                 | Geo-code 21  |          |
| 3  | Terms relating to structural response, resistance, material properties and geometrical quantities | Demand, response value S      | The physical quantity that occurs in the structure due to an external force.                                                                                                                                                                                                                                                                                                                      | JSCE2001     |          |
| 4  | Terms relating to structural response, resistance, material properties and geometrical quantities | Capacity, limit value of performance R | The limit value allowed for the response value. A physical quantity that is determined according to the type of “limit state.” If the response value exceeds the limit value, the performance requirement is not satisfied.                                                                                                                                             | JSCE2001     |          |
| 5  | Terms relating to structural response, resistance, material properties and geometrical quantities | Statistical uncertainty       | Uncertainty related to the accuracy of the distribution and estimation of parameters                                                                                                                                                                                                                                                                                                                  | ISO2394      |          |
| 6  | Terms relating to structural response, resistance, material properties and geometrical quantities | Basic variable                | Part of a specified set of variables representing physical quantities which characterize actions and environmental influences, material properties including soil properties, and geometrical quantities.                                                                                                                                                                                                 | ISO2394      |          |
| 7  | Terms relating to structural response, resistance, material properties and geometrical quantities | Primary basic variable        | Variables whose value is of primary importance to the design results.                                                                                                                                                                                                                                                                                                                                 | ISO2394      |          |
| 8  | Terms relating to structural response, resistance, material properties and geometrical quantities | Limit state function          | A function $g$ of the basic variables, which characterizes a limit state when $g(X_1, X_2, ..., X_n) = 0$: $g &gt; 0$ identifies with the desired state and $g &lt; 0$ with the undesired state.                                                                                                                                                                                                 | ISO2394      |          |
| 9  | Terms relating to structural response, resistance, material properties and geometrical quantities | Reliability index, $\beta$    | A substitute for the failure probability $P_f$, defined by $\beta = -\Phi^{-1}(p_f)$, where $\Phi^{-1}$ is the inverse standardized normal distribution.                                                                                                                                                                                                                                                | ISO2394      |          |</p>
<table>
<thead>
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<th>#</th>
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<th>Term</th>
<th>Definition</th>
<th>Reference</th>
<th>See also</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Terms relating to structural response, resistance, material properties and geometrical quantities</td>
<td>Reliability element</td>
<td>Numerical quantity used in the partial factors format, by which the specified degree of reliability is assumed to be reached.</td>
<td>ISO2394</td>
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<td></td>
<td>Terms relating to structural response, resistance, material properties and geometrical quantities</td>
<td>Element reliability</td>
<td>Reliability of a single structural element which has one single failure dominating failure mode.</td>
<td>ISO2394</td>
<td></td>
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<tr>
<td></td>
<td>Terms relating to structural response, resistance, material properties and geometrical quantities</td>
<td>System reliability</td>
<td>Reliability of a structural element which has more than one relevant failure mode or the reliability of a system of more than one relevant structural element.</td>
<td>ISO2394</td>
<td></td>
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<tr>
<td></td>
<td>Terms relating to structural response, resistance, material properties and geometrical quantities</td>
<td>Model</td>
<td>Simplified mathematical description or experimental set-up simulating actions, material properties, the behavior of a structure, etc.NOTE:Models should generally take an account of decisive factors and neglect the less important ones.</td>
<td>ISO2394</td>
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<td></td>
<td>Terms relating to structural response, resistance, material properties and geometrical quantities</td>
<td>Model uncertainty</td>
<td>Related to the accuracy of models, physical or statistical.</td>
<td>ISO2394</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Assessment</td>
<td>Total set of activities performed in order to find out if the reliability of structure is acceptable or not.</td>
<td>ISO13822</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Rehabilitation</td>
<td>The improvement of the resistance of a structure to performance deterioration with time.</td>
<td>code PLATFORM</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Upgrading</td>
<td>Efforts to enhance the mechanical performance of a structure.</td>
<td>code PLATFORM</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Damage</td>
<td>Changes in condition of a structure that may have an adverse effect on its performance.</td>
<td>ISO13822</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Deterioration</td>
<td>The reduction of performance and reliability of a structure with time.</td>
<td>ISO13822</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Deterioration mode</td>
<td>A model of deterioration with time representing the performance of a structure as a function of time.</td>
<td>ISO13822</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Inspection</td>
<td>A nondestructive test conducted in the field to determine the present state of a structure.</td>
<td>ISO13822</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Investigation</td>
<td>The collection of data and evaluation through inspection, data surveys, loading tests and other testing.</td>
<td>ISO13822</td>
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<td></td>
<td>Terms on performance assessment of existing structures</td>
<td>Loading test</td>
<td>A test conducted applying the load or imposed displacement to evaluate the behavior or properties of an entire structure or part thereof or to estimate load bearing capacity.</td>
<td>ISO13822</td>
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<td>#</td>
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<td>Term</td>
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<td>1</td>
<td>Terms on performance assessment of existing structures</td>
<td>Maintenance</td>
<td>Total set of activities performed during the design working life of a structure to enable it to fulfill the requirements for reliability.</td>
<td>ISO13822</td>
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<td>2</td>
<td>Terms on performance assessment of existing structures</td>
<td>Monitoring</td>
<td>Frequent or continuous observation or measurement of the condition of a structure or the action applied to the structure. Monitoring generally takes place over a long period of time.</td>
<td>ISO13822</td>
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<td>3</td>
<td>Terms on performance assessment of existing structures</td>
<td>Remaining working life</td>
<td>The period during which an existing structure is assumed to be maintained and placed in service.</td>
<td>ISO13822</td>
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<td>4</td>
<td>Terms on performance assessment of existing structures</td>
<td>Accidental action</td>
<td>Action whose chance of occurrence is very small but the intensity is very high compared to the variable actions.</td>
<td>ACMC2006</td>
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<td>5</td>
<td>Terms on performance assessment of existing structures</td>
<td>Action</td>
<td>Mechanical force or environmental effect to which the structure (or structural component) is subjected.</td>
<td>ACMC2006</td>
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<td>6</td>
<td>Terms on performance assessment of existing structures</td>
<td>Aerodynamic shape factor</td>
<td>Factor to account for the effect of geometry of structure on the surface pressure due to wind.</td>
<td>ACMC2006</td>
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<td>7</td>
<td>Terms on performance assessment of existing structures</td>
<td>Aggregate</td>
<td>Normally inert materials such as river gravel, river sand, sea sand, crushed rock, etc. which are used as ingredients to produce concrete or mortar.</td>
<td>ACMC2006</td>
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<td>8</td>
<td>Terms on performance assessment of existing structures</td>
<td>Alkali-aggregate reaction</td>
<td>The reaction between alkali in concrete and the reactive substances in the aggregates.</td>
<td>ACMC2006</td>
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<td>9</td>
<td>Terms on performance assessment of existing structures</td>
<td>Analysis (Assessment)</td>
<td>Acceptable methods of evaluating the performance indices or verifying the compliance of specific criteria.</td>
<td>ACMC2006</td>
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<td>10</td>
<td>Terms on performance assessment of existing structures</td>
<td>Autogeneous shrinkage</td>
<td>Volume decrease due to loss of water in the hydration process causing negative pore pressure in concrete.</td>
<td>ACMC2006</td>
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<td>11</td>
<td>Terms on performance assessment of existing structures</td>
<td>Basic wind speed</td>
<td>Hourly mean wind speed or 3-second peak gust wind speed with a specified probability of exceedence, measured at 10 meters above open country terrain with few, well scattered obstructions.</td>
<td>ACMC2006</td>
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<td>12</td>
<td>Terms on performance assessment of existing structures</td>
<td>Biological degradation</td>
<td>The physical or chemical degradation of concrete due to the effect of organic matters such as bacteria, lichens, fungi, moss, etc.</td>
<td>ACMC2006</td>
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<td>13</td>
<td>Terms on performance assessment of existing structures</td>
<td>Bleeding</td>
<td>Segregation between water and the other ingredients in concrete causing water to rise up to the surface of the freshly placed concrete.</td>
<td>ACMC2006</td>
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<td>14</td>
<td>Terms on performance assessment of existing structures</td>
<td>Carbonation</td>
<td>Action caused by chemical reaction between calcium hydroxide in concrete and carbon dioxide in the environment, resulting in a denser surface for the carbonated concrete and reduction of alkalinity in the carbonated portion.</td>
<td>ACMC2006</td>
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<td>15</td>
<td>Terms on performance assessment of existing structures</td>
<td>Characteristic strength</td>
<td>Unless otherwise stated in this code, the characteristic strength of material refers to the value of the strength below which 5% of all test results would be expected to fall.</td>
<td>ACMC2006</td>
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<td>16</td>
<td>Terms on performance assessment of existing structures</td>
<td>Chemical admixtures</td>
<td>Admixtures which are usually used in small quantities typically in the form of liquid and can be added to the concrete both at the time of mixing and before placing to improve various concrete properties such as workability, air content and durability, etc.</td>
<td>ACMC2006</td>
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<td>17</td>
<td>Terms on performance assessment of existing structures</td>
<td>Coarse aggregate</td>
<td>Aggregate which has almost all its particles retained on a 5mm-size test sieve.</td>
<td>ACMC2006</td>
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<td>18</td>
<td>Terms on performance assessment of existing structures</td>
<td>Damage control</td>
<td>A means to ensure that the limit state requirement is met for restorability or reparability of a structure.</td>
<td>ACMC2006</td>
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<td>19</td>
<td>Terms on performance assessment of existing structures</td>
<td>Deformability</td>
<td>A term expressing the ability of concrete to deform.</td>
<td>ACMC2006</td>
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<td>Degree of deterioration</td>
<td>The extent to which the performance of a structure is degraded or the extent to which the deterioration has progressed from the time of construction, as a result of its exposure to the environment.</td>
<td>ACMC2006</td>
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<td>Design return period</td>
<td>Inverse of the annual probability of exceedence.</td>
<td>ACMC2006</td>
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<td>Design life</td>
<td>Assumed period for which the structure is to be used satisfactorily for its intended purpose or function with anticipated maintenance but without substantial repair being necessary.</td>
<td>ACMC2006</td>
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<td>Design wind pressure</td>
<td>Potential pressure available from the kinetic energy of the design wind speed.</td>
<td>ACMC2006</td>
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<td>Design wind speed</td>
<td>Wind speed for use in design. It is derived from regional basic wind speed taking into consideration the wind direction, topography, height, importance of structure, design life, size and shape of the structure.</td>
<td>ACMC2006</td>
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<td>Deterioration factor</td>
<td>The factor affecting the deterioration process.</td>
<td>ACMC2006</td>
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<td>Deterioration index</td>
<td>An index selected for estimating and evaluating the extent of the deterioration process.</td>
<td>ACMC2006</td>
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<td>Deterioration prediction</td>
<td>Prediction of the future rate of deterioration of a structure based on results of inspection and relevant records made during the design and construction stages.</td>
<td>ACMC2006</td>
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<td>Drag</td>
<td>Force acting in the direction of the wind stream.</td>
<td>ACMC2006</td>
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<td>Drying shrinkage</td>
<td>Volume decrease due to loss of moisture from concrete in the hardened state which is usually serious in hot and dry environment.</td>
<td>ACMC2006</td>
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<td>Durability design</td>
<td>Design to ensure that the structure can maintain its required functions during its service life under environmental actions.</td>
<td>ACMC2006</td>
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<td>Durability grade</td>
<td>The extent of durability to which the structure shall be maintained in order to satisfy the required performance during its design life. This affects the degree and frequency of the remedial actions to be carried out during that life.</td>
<td>ACMC2006</td>
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<td>Durability limit state</td>
<td>The maximum degree of deterioration allowed for the structure during its design life.</td>
<td>ACMC2006</td>
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<td></td>
<td></td>
<td>Durability prediction</td>
<td>Prediction of the future degree of deterioration of the structure based on data used in its design.</td>
<td>ACMC2006</td>
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<td>Dynamic approach</td>
<td>An approach based on dynamic analysis to assess the overall forces on a structure liable to have a resonant response to wind action.</td>
<td>ACMC2006</td>
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<td>Dynamic response factor</td>
<td>Factor to account for the effects of correlation and resonant response.</td>
<td>ACMC2006</td>
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<td>Early age state</td>
<td>The state of concrete from final setting until the achievement of the required characteristic strength.</td>
<td>ACMC2006</td>
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<td>Environmental actions</td>
<td>An assembly of physical, chemical or biological influences which may cause deterioration to the materials making up the structure, which in turn may adversely affect its serviceability, restorability and safety.</td>
<td>ACMC2006</td>
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<td>Equivalent static approach</td>
<td>An equivalent or quasi-static approach in which the kinetic energy of wind is converted to equivalent static pressure, which is then treated in a manner similar to that for a distributed gravity load.</td>
<td>ACMC2006</td>
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<td>Term</td>
<td>Definition</td>
<td>Reference</td>
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<td>1</td>
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<td>Erosion</td>
<td>The physical degradation of the concrete surface due to abrasive actions like rubbing, water stream action, tyre friction, etc.</td>
<td>ACMC2006</td>
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<td>2</td>
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<td>Exposure factor</td>
<td>Factor used to account for the variability of the wind speed at the site of the structure due to terrain roughness and shape, height above ground, shielding and topographic conditions.</td>
<td>ACMC2006</td>
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<td>3</td>
<td></td>
<td>Fatigue loads</td>
<td>Repetitive loads causing fatigue in the material which reduces its strength, stiffness and deformability. Fatigue loads are considered as variable loads.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Fine aggregate</td>
<td>Aggregate which has almost all its particles passing through a 5mm-size test sieve.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Finishability</td>
<td>The property of concrete at the fresh state which indicates the ease of finishing to obtain a neat surface.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Formwork</td>
<td>Total system of support for freshly placed concrete including the mould or sheathing, all supporting members, hardware and the necessary bracings.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Freezing and thawing</td>
<td>The effect of freezing and thawing of the pore water in concrete, causing its deterioration if repeated continuously.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Fresh state of concrete</td>
<td>The state of concrete after mixing until the completion of placing.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Function</td>
<td>The task which a structure is required to perform.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Grout</td>
<td>A mixture of cementitious material and water with or without admixtures.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Hardened state of concrete</td>
<td>The state of concrete after achieving the required strength.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Importance</td>
<td>Rank assigned to a structure according to the likely overall impact caused by its failure, due to deterioration, to satisfactorily perform its functions as determined at the time of design.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Irregular structures</td>
<td>Structures having unusual shapes such as open structures, structures with large overhangs or other projections, and any building with a complex shape.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Laitance</td>
<td>Substances brought up to the concrete or mortar surface by bleeding water and precipitated at the surface giving a contaminated appearance.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Limit state</td>
<td>A critical state specified using a performance index, beyond which the structure no longer satisfies the design performance requirements.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>Limits of displacement</td>
<td>Allowable deformation of structure in terms of such parameters as interstorey drift and relative horizontal displacement, to control excessive deflection, cracking and vibration.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>Long-term performance index</td>
<td>Index defining the remaining capacity of a structure in performing its design functions during the design life.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>Maintenance</td>
<td>A set of activities taken to ensure that the structure continues to perform its functions satisfactorily during its design life.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>Mechanical forces</td>
<td>An assembly of concentrated or distributed forces acting on a structure, or deformations imposed on it.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>Mineral admixtures</td>
<td>Admixtures which are normally used in large quantities in power form and are added at the time of batching in order to improve certain properties of the concrete.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Category</td>
<td>Term</td>
<td>Definition</td>
<td>Reference</td>
<td>See also</td>
</tr>
<tr>
<td>----</td>
<td>----------------------------------</td>
<td>------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
<td>----------</td>
</tr>
<tr>
<td>1</td>
<td>Category</td>
<td>Mix proportions</td>
<td>Proportions or quantities of the ingredient or constituent materials to produce concrete or mortar of a desired quality.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Category</td>
<td>Model</td>
<td>Mathematical description or experimental setup simulating the actions, material properties and behavior of a structure.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Category</td>
<td>Monitoring</td>
<td>Continuous recording of data pertaining to deterioration and/or performance of structure using appropriate equipment.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Category</td>
<td>Normal concrete</td>
<td>Concrete which is commonly used in construction; it does not include special constituent materials other than Portland cement, water, fine aggregate, coarse aggregate and common mineral and chemical admixtures; it does not require any special practice for its manufacturing and handling.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Category</td>
<td>Overall performance index</td>
<td>Index indicating the overall performance of the structure.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Category</td>
<td>Partial performance index</td>
<td>Index indicating a partial performance of the structure.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Category</td>
<td>Partial safety factor for material</td>
<td>For analysis purposes, the design strength of a material is determined as the characteristic strength divided by a partial safety factor.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Category</td>
<td>Performance</td>
<td>Ability (or efficiency) of a structure to perform its design functions.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Category</td>
<td>Performance index</td>
<td>Index indicating structural performance quantitatively.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Category</td>
<td>Permanent actions</td>
<td>Self-weights of structures inclusive of permanent attachments, fixtures and fittings.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Category</td>
<td>Plastic shrinkage</td>
<td>Shrinkage arising from loss of water from the exposed surface of concrete during the plastic state, leading to cracking at the exposed surface.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Category</td>
<td>Plastic state</td>
<td>The state of concrete from just after placing until the final setting of concrete.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Category</td>
<td>Reliability</td>
<td>Ability of a structure to fulfill specified requirements during its design life.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Category</td>
<td>Remaining service life</td>
<td>Period from the point of inspection to the time when the structure is no longer useable, or does not satisfactorily perform the functions determined at the time of design.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Category</td>
<td>Remedial action</td>
<td>Maintenance action carried out with the objective of arresting or slowing down the deterioration process, restoring or improving the performance of a structure, or reducing the danger of damage or injury to the users or any third party.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Category</td>
<td>Repair</td>
<td>Remedial action taken with the objective of arresting or slowing down the deterioration of a structure, or reducing the possibility of damage to the users or any third party.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Category</td>
<td>Restorability (or reparability)</td>
<td>Ability of a structure to be repaired physically and economically when damaged under the effects of considered actions.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Category</td>
<td>Robustness (or structural insensitivity)</td>
<td>Ability of a structure to withstand damage by events like fire, explosion, impact, instability or consequences of human errors.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Category</td>
<td>Safety</td>
<td>Ability of a structure to ensure that no harm would come to the users and to people in the vicinity of the structure under any action.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Category</td>
<td>Segregation</td>
<td>Separation of one or more constituent materials from the rest of the concrete, such as bleeding, aggregate blocking, etc.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Category</td>
<td>Term</td>
<td>Definition</td>
<td>Reference</td>
<td></td>
</tr>
<tr>
<td>---</td>
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<td>---</td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>Service life</td>
<td>The length of time from the completion of a structure until the time when it is no longer usable because of its failure to adequately perform its design functions.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Serviceability</td>
<td>Ability of a structure to provide adequate services or functionality in use under the effects of considered actions.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Settlement</td>
<td>Sinking of the concrete surface after placing due to bleeding and/or escaping of the entrapped and entrained air in the concrete.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Shores</td>
<td>Vertical or inclined support members designed to carry the weight of the formwork, concrete and other construction loads.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Special concrete</td>
<td>Concrete other than normal concrete including lightweight concrete, rollercompacted concrete, self-compacting concrete, fiber reinforced concrete, anti-washout underwater concrete, etc.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Stiff and flexible structures</td>
<td>Stiff structures refer to those that are not sensitive to dynamic effects of wind, while flexible ones are those that are sensitive to such effects.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Strengthening</td>
<td>Remedial action applied to a structure with the objective of restoring or improving its load bearing capacity to a level which is equal to, or higher than, the original design level.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Surface finishing</td>
<td>Action, such as trowelling, applied to the exposed portion of concrete to obtain a neat surface.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Temperature cracking</td>
<td>Cracking caused by thermal stress which arises from differential temperatures in the concrete mass.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Threshold level of</td>
<td>Minimum acceptable level of performance of a structure.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Tributary area</td>
<td>Area of building surface contributing to the force being considered, due to wind actions, and projected on a vertical plane normal to the wind direction.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>Ultimate limit state</td>
<td>Limit state for safety.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>Variable action</td>
<td>Action due to a moving object on the structure as well as any load whose intensity is variable, including traffic load, wave load, water pressure, earth pressure, and load induced by temperature variation.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>Wind tunnel test</td>
<td>Test modeling the atmospheric boundary layer characteristics, to obtain wind speed multipliers and/or pressure coefficients.</td>
<td>ACMC2006</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>Workability</td>
<td>The term expressing the ease with which concrete can be placed, compacted and ACMC2006</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>