ACECC Workshop on Harmonization of Design Codes in the Asian Region

November 4, 2006 Taipei, Taiwan

For a Better Quality of Life

Sponsor : Japan Society of Civil Engineers

Chinese Institute of Civil and Hydraulic Engineering

Co-Sponsor :

- MEXT21st Century COE Program for Disaster Prevention Research Institute (DPRI), Kyoto University
- Department of Construction Engineering, National Taiwan University of Science and Technology
- Taiwan Geotechnical Society

Venue : National Taiwan University of Science and Technology

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Prof. J. C. Chern, Chair of ACECC

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Group photo in front of Library, N.T.U

Toward Harmonization of Design Codes in the Asian Region -Overview-

Committee on ACECC, Japan Society of Civil Engineers

1 The outline of the Asian Civil Engineering Coordinating Council (ACECC)

The Asian Civil Engineering Coordinating Council (ACECC) was established in 1999 for the purpose of civil engineers' information exchange, interaction and contribution to the infrastructure development in the Asian Region, by the following initial five members: the American Society of Engineers (ASCE), the Chinese Institute of Civil and Hydraulic Engineering (CICHE), the Korean Society of Civil Engineers (KSCE), the Philippine Institute of Civil Engineers (PICE), and the Japan Society of Civil Engineers (JSCE). Subsequently, Engineers Australia (EA), the Vietnam Federation of Civil Engineering Associations (VIFCEA), and the Mongolian Association of Civil Engineers (MACE) joined with the above-mentioned five societies, thus the ACECC currently consists of eight societies/institutions.

The objectives of ACECC are stipulated in the ACECC Constitution as follows:

The objectives of ACECC

1. To promote and advance the science and practice of Civil Engineering and related professions for sustainable developments 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 such activities 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 decides necessary.
6. To provide advise to member societies/institutions to strengthen their domestic activities.
7. To achieve the above objectives, international conferences called Civil Engineering Conference in the Asian Region (CECAR) will be held on a triennial basis as the main activity of the ACECC.

Holding the Civil Engineering Conference in the Asian Region (CECAR), which is mentioned in the above Article 7, is one of the main activities of ACECC. ACECC organizes CECAR once in three years where experts in the civil engineering research and technology from industry, government and academia gather to have discussions about the problems related to civil engineering in the Asian Region and seek ways to shape the future of Asia. CECAR was held three times in the past. The 2nd was held in Tokyo, 2001 with about 730 participants, and the 3rd was held in Seoul, 2004, with about 1,000 participants including about 250 from Japan, and it is gaining increasing attention every time.

The next 4th CECAR is to be held on June 25-28, 2007 in Taipei. Please visit the following websites for details:

ACECC Website: http://www.acecc.net/
4th CECAR Website: http://www.elitepco.com.tw/4cecar/index-1E.html

2 The organization of ACECC

ACECC is comprised of the committees shown below. The Executive Committee is the top administrating board and makes final decisions as ACECC. From Japan, Dr. Yukihiko Sumiyoshi is a member of the Committee as JSCE Representative.

ACECC Organizations

Executive Committee
Planning Committee
Technical Coordinating Committee
Technical Committee

a) Inter-regional Cooperation for Great Mekong Sub-region (Chair: Prof. Osamu Kusakabe, JSCE)
b) Sumatra Offshore Earthquake and the Indian Ocean Tsunami (Chair: Prof. Fumihiko Imamura, JSCE)
c) Quantitative Risk Assessment for Hazard Mitigation (Chair: Prof. Alfredo H-S Ang, ASCE)
d) Sustainable Development of Civil Engineering (Chair: Prof. Alan Cheng-Fang Lin, CICHE)

The ACECC Secretariat is currently managed by CICHE, which is going to host the 4th CECAR.
Besides the above-mentioned committees, Awarding Subcommittee, E-publication Subcommittee have just been organized, and in Taiwan, Local Organizing Committee is now working for the 4th CECAR.
As shown in the above objectives and organizations, the issues that ACECC is addressing are quite wide-ranging.

3 ACECC Operational Task

The Planning Committee of ACECC is a committee made up of working-level people.
In order to promote the ACECC practical activities, the following operational tasks are assigned to each ACECC member, and JSCE is in charge of harmonization of design codes in the Asian region.

ACECC Operational Task

No.	Name of Task	Member in charge
1	Expert Resource Pool	KSCE (Korea)
2	Technical Resource Center	VIFCEA (Vietnam)
3	Code of Ethics	EA (Australia)
4	Asian Design Code	JSCE (Japan)
5	Civil engineering terminology dictionary	PICE (Philippines)
6	Cross-licensing	CICHE (Taiwan)
7	Public perception	ASCE (USA)

JSCE has already made a web page which lists all the code formulating organizations of the ACECC members with the linkage to them:

http://www.acecc.net/modules/tinycontent5/index.php?id=37

It provides a useful means to get the code information at each member/institution.

We are fully aware, however, that just providing this kind of information does not attain our purpose, and that it is very important that engineers who are working on code formulation exchange information, share common knowledge and have discussions toward the future. Thus, we planned to hold a workshop on design codes on November 2006 in Taipei.

The reasons we decided to have the workshop in Taiwan are: the ACECC Secretariat is currently located in Taiwan, since the workshop on the geotechnical codes was scheduled to be held in Taipei the previous day, the overseas code handling engineers are going to gather for the workshop, and since Taiwan is situated in a place closer than Tokyo to Southeast Asian countries that need infrastructure development from now, it will facilitate engineers from those countries participating in the workshop.

4 Harmonization of design codes in the Asian Region

As is well known, developing countries in the Asian region have various issues such as urban problems, environmental issues, resource problems and in addition, disaster prevention issues. In order to address these issues, infrastructure facilities are now being constructed at high speed.

Among others, as many of the large-scale construction projects need advanced technology, in many cases they are put for international biddings in which enterprises with advanced technology and experiences take part, and as one project is implemented with multicountry engineers' engagements in design, construction and consulting, in that sense, they are quite international.

In most of the Asian countries that are going to develop their infrastructure from now, it can not be said that the design codes for various facilities are well organized, and as a matter of fact, it is still the case that overseas design codes are applied to a structural design on a case-by-case bases. In other words, the integration of design codes is far behind the infrastructure development. It is also true that engineers often get into trouble in communication with each other due to the difference in the application of design codes.

In Japan, since awareness of performance-based design is becoming higher, various design codes applicable as global standard has been developed and transmitted internationally in some of the study fields. Much more efforts were poured into the achievement of mutual understandings and applicability in different countries/economies. Sharing such experience and information among ACECC and non-ACECC members is thought to be very meaningful.

Based on the above mentioned recognition, in order to have a multilateral discussion on the code formulation, we decided to have a workshop on harmonization of design codes in the Asian region in Taipei beyond the bounds of the nations and the study fields for the following objectives:

a) To share the information on activities and methodologies for formulating design codes in each country and make use of them for future activities,
b) To discuss the direction for the code harmonization in the Asian region. As well, to provide a place for discussions in the same vocabulary,
c) To transmit to the world the idea about the design code in the Asian region as the Asian voice,
d) To formulate a basis of codes such as Eyrocode 0 to comprehend all the codes in each field , and
e) To decide a direction for the discussion at the 4th CECAR.

The design codes which are used in each country and each organization have been cultivated in a long history. We know that harmonization of design codes cannot be achieved overnight. We would like to move a steady but strategic activity forward based on the discussion made at this workshop.

ACECC workshop on Harmonization of Design Codes in the Asian Region, Nov. 4, 2006, Taipei

Harmonization of Design Codes in the Asian Region

Sponsored by

JSCE: Japan society of Civil Engineers

CICHE: Chinese Institute of Civil and Hydraulic Engineering

Co-Sponsored by

MEXT21st Century COE Program
for Disaster Prevention Research Institute (DPRI), Kyoto University

Department of Construction Engineering,
National Taiwan University of Science and Technology

Taiwan Geotechnical Society

Introduction of ACECC:

The Asian Civil Engineering Coordinating Council

established on Sept. 27, 1999 in Tokyo.

Member of ACECC (in alphabetic order)

ASCE	American Society of Civil Engineers
CICHE	Chinese Institute of Civil and Hydraulic Engineering
IEAust	Engineers Australia
JSCE	Japan Society of Civil Engineers
KSCE	Korean Society of Civil Engineers
MACE	Mongolian Association of Civil Engineers
PICE	Philippine Institute of Civil Engineers
VIFCEA	Vietnam Federation of Civil Engineering Associations

Membership shall be open to worldwide professional organizations.

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.

CECAR: Civil Engineering Conference in the Asian Region

1st CECAR	February 19-20, 1998	Manila, Philippines
2nd CECAR	April 16-20, 2001	Tokyo, Japan
3rd CECAR	August 16-19, 2004	Seoul, Korea
4th CECAR	**June 25-27, 2007**	**Taipei, Taiwan**

More than 1000 participants from all over the world!!

ACECC Operational task assigned to each member

- Creation of expert resource pool (KSCE)
- Establishment of technical resource center (VIFCA)
- **Asian design codes (JSCE)**
- 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)

Code Development and related issues

Developing Countries

International projects based on bilateral or multilateral assistance,
Code development can not catch up with very rapid infrastructure development,
Without own code, or Mixture of different overseas codes,
Lack of latest code information source,

Developed Countries

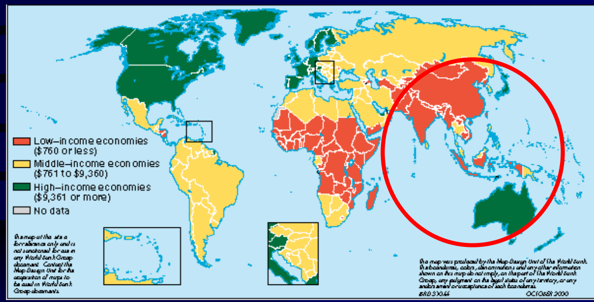
Cooperation for code development as global standard
Cooperation for creation of unified idea of design concept and terminologies

Necessity

to discuss future of code development
to exchange information on code development in each country
to enhance personal network among code writers
beyond boundaries of nations and fields of study

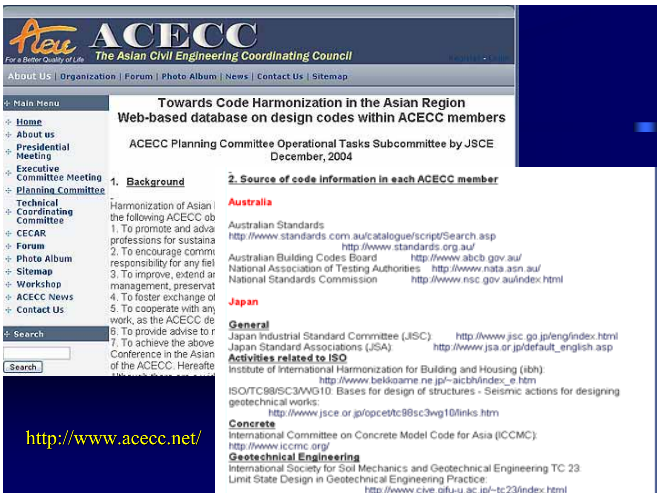
Peculiarity in Asian countries

GNP per Capita, 1998



http://www.worldbank.org/depweb/english/modules/economic/gnp/map1.htm

Wide variety of developing stages & developing rates



ACECC
For a Better Quality of Life
The Asian Civil Engineering Coordinating Council

About Us | Organization | Forum | Photo Album | News | Contact Us | Sitemap

Main Menu: Home, About us, Presidential Meeting, Executive Committee Meeting, Planning Committee, Technical Coordinating Committee, CECAR, Forum, Photo Album, Sitemap, Workshop, ACECC News, Contact Us

Search

Towards Code Harmonization in the Asian Region
Web-based database on design codes within ACECC members

ACECC Planning Committee Operational Tasks Subcommittee by JSCE
December, 2004

1. Background

Harmonization of Asian ...
the following ACECC ob...
1. To promote and adva...
professions for sustaina...
2. To encourage comm...
responsibility for any fiel...
3. To improve, extend a...
management, preservat...
4. To foster exchange of...
5. To cooperate with any...
work, as the ACECC de...
6. To provide advise to ...
7. To achieve the above...
Conference in the Asian...
of the ACECC. Hereafte...

2. Source of code information in each ACECC member

Australia

Australian Standards
http://www.standards.com.au/catalogue/script/Search.asp
http://www.standards.org.au/
Australian Building Codes Board http://www.abcb.gov.au/
National Association of Testing Authorities http://www.nata.asn.au/
National Standards Commission http://www.nsc.gov.au/index.html

Japan

General
Japan Industrial Standard Committee (JISC): http://www.jisc.go.jp/eng/index.html
Japan Standard Associations (JSA): http://www.jsa.or.jp/default_english.asp
Activities related to ISO
Institute of International Harmonization for Building and Housing (iibh):
http://www.bekkoame.ne.jp/~aicbh/index_e.htm
ISO/TC98/SC3/WG10: Bases for design of structures - Seismic actions for designing geotechnical works:
http://www.jsce.or.jp/opcet/tc98sc3wg10/links.htm
Concrete
International Committee on Concrete Model Code for Asia (ICCMC):
http://www.iccmc.org/
Geotechnical Engineering
International Society for Soil Mechanics and Geotechnical Engineering TC 23:
Limit State Design in Geotechnical Engineering Practice:
http://www.cive.gifu-u.ac.jp/~tc23/index.html

http://www.acecc.net/

Japan

General
Japan Industrial Standard Committee (JISC): http://www.jisc.go.jp/eng/index.html
Japan Standard Associations (JSA): http://www.jsa.or.jp/default_english.asp

Activities related to ISO
Institute of International Harmonization for Building and Housing (iibh):
http://www.bekkoame.ne.jp/~aicbh/index_e.htm
ISO/TC98/SC3/WG10: Bases for design of structures - Seismic actions for designing geotechnical works:
http://www.jsce.or.jp/opcet/tc98sc3wg10/links.htm

Concrete
International Committee on Concrete Model Code for Asia (ICCMC):
http://www.iccmc.org/

Geotechnical Engineering
International Society for Soil Mechanics and Geotechnical Engineering TC 23:
Limit State Design in Geotechnical Engineering Practice:
http://www.cive.gifu-u.ac.jp/~tc23/index.html

Related Institute
Ministry of Land, Infrastructure and Transport
http://www.mlit.go.jp/english/index.html
Japan Road Association: http://www.road.or.jp/index.html
Railway Technical Research Institute http://www.rtri.or.jp/index.html
Public Works Research Institute http://www.pwri.go.jp/eindex.htm
National Institute for Land and Infrastructure Management
http://www.nilim.go.jp/english/eindex.htm
Port and Airport Research Institute http://www.pari.go.jp/english/index.htm

Objectives of the ACECC workshop

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5. To decide a direction for the discussion at the 4th CECAR.

Workshop Program

Opening				
0900-0910	Opening		Prof. Jenn-Chuan Chern	Chair, Executive Committee of ACECC
			Dr. Hou Ho-Shong	Vice Minister of the Ministry of Economical Affairs
0910-0920	Overview		Dr. Horikoshi, Kenichi	Secretary General Committee on ACECC, JSCE
Country Reports				
0920-1025	**JAPAN**			
	0920-0940	Code development activities in Japan	Prof. Honjo, Yusuke	Gifu University
1320-1345	**VIETNAM** The Development of Construction Codes and Standards in Vietnam		Dr. Nguyen Ngoc Ba	Center for Standardization in Construction, Institute for Building Science and Technology
1345-1435	**TAIWAN**			
	1345-1410	Status of design codes in Taiwan	Dr. Yao-Wen Chang	Sinotech Engineering Consultants, Ltd.
	1410-1435	Concrete Building Code in Taiwan	Prof. Shyh-Jiann Hwang	National Taiwan University
1435-1450		*COFFEE BREAK*		
Special Reports				
1450-1520	Towards Harmonization of Design Code in Asia - Structural Concrete -		Prof. Ueda, Tamon	Hokkaido University
1520-1545	Harmonization of geotechnical design in Europe with structural design by means of Eurocode 7		Dr. Trevor L.L. Orr	University of Dublin
1545-1610	Emerging Trends in Seismic Design of Geotechnical Works		Prof. Iai, Susumu	Kyoto University
1610-1625		*COFFEE BREAK*		
Discussion				
1625-1705	Towards Code Harmonization in Asian Regions		Chair: Prof. Honjo, Yusuke Secretary: Dr. Horikoshi, Kenichi	
Closing				
1705-1715	Concluding Remarks		Prof. Jenn-Chuan Chern	Chair, Executive Committee of ACECC
1900-		***Reception hosted by ACECC and CICHE***		The Lu-Ming Restaurant National Taiwan University

Note:

Some papers are not included in the proceedings.

Full final proceedings will be distributed after the workshop.

Please enjoy the ACECC workshop!!

Thank you

Code Development Activities in Japan

ACECC Workshop
Harmonization of Design Codes in the Asian Region
November 4, 2006
Taipei

Y. Honjo, Gifu University

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WTO/TBT agreement:

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

WTO/TBT (1995)

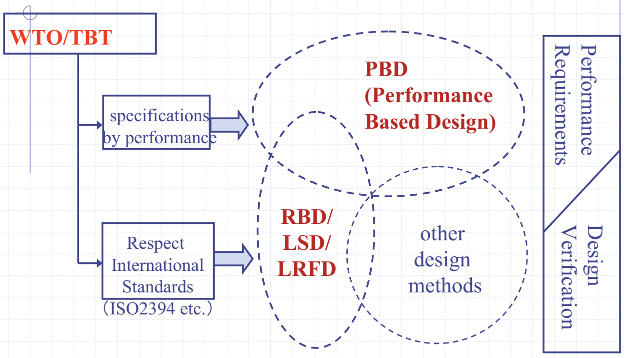
(AGREEMENT ON TECHNICAL BARRIERS TO TRADE)

Article 2: Preparation, Adoption and Application of Technical Regulations by Central Government Bodies

2.4 Wherever technical regulations are required and relevant international standards exist ... Members shall use them, or relevant part of them, as basis for their technical regulations ...

2.8 Wherever appropriate, Members shall specify technical regulations based on product requirements in terms of performance rather than design or descriptive characteristics.

WTO/TBT agreement, PBD and RBD



Implementation of PBD codes:2006

- Oct 2005 JGS PBD design principles (Geo-code 21) established.
- Railway Design Standards, Technical Standards for Port and Harbor Facilities are moving to PBD.
- Specifications for Highway Bridges are under drafting for introduction of PBD.

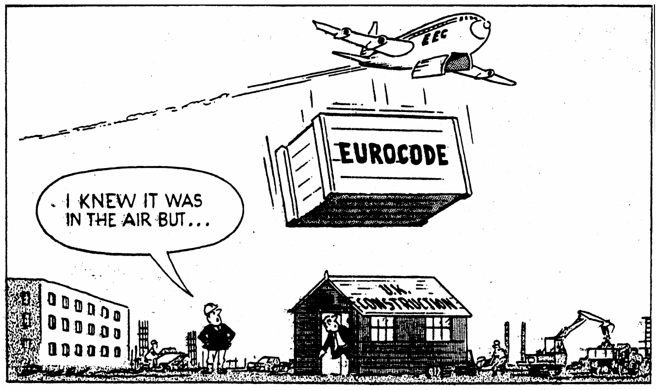
What is Eurocodes？

EN1990 Basis of design for structural Eurocodes
EN1991 Actions on structures
EN1992 Design of concrete structures
EN1993 Design of steel structures
EN1994 Design of composite structures
EN1995 Design of timber structures
EN1996 Design of masonry structures
EN1997 Geotechnical design
EN1998 Design of structures for earthquake resistance
EN1999 Design of Aluminum structures

Started in 1970's. Will complete by 2010.

Purpose of Eurocodes

- The purpose of Eurocodes is to establish a set of rules for design of civil and building structures thereby eventually replace present design rules that are different from one country to another.
  - promote construction industries with in EU region by unifying the market.
  - Strengthen the competitiveness of EU construction industry against non-EU.

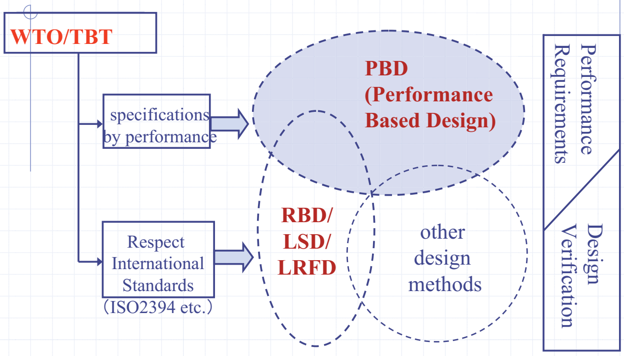


NEW CIVIL ENGINEER, 8 MARCH 1984

（UK 1984）

Impact of the Eurocodes
de jule strategy

WTO/TBT agreement, PBD and RBD

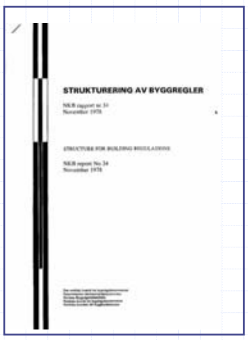


PBD

The performance approach is, in essence, the practice of thinking and working in terms of ends rather than means

(Foliente, G.C., 2000)

Performance based design(1)
performance based specifications



Structure for Building Regulations

NKB report No.34
November 1978

Defined regulation Structure for buildings
To which level regulation be enforced, and to which level it should be given to the judgment of designers.

Performance based design(2)
performance based specifications

Nordic 5 Leave	New Zealand	Australia	UK	Canada	
Goal	Objectives	Objectives	Goals	Objectives	
Functional Requirements	Functional Requirements	Functional Requirem.	Functional Requirements	Functional Requirem.	Mandatory Requirem.
Operational Requirements	Performance Requirements	Perform. Requirem. / Deem to Satisfy			
Verification Methods	Verification Methods		Performance	Acceptable Solutions	Supporting Documents (Guidance)
Acceptable Solutions	Acceptable Methods		Technical Sol.		
			Alternative Approaches		

(CIB,1998)

Performance based design(3)
Performance Matrix

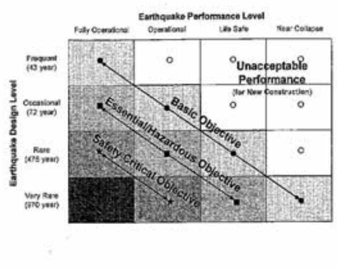


Figure 2-2: Recommended Performance Objectives for Buildings

VISION 2000
Performance Based Seismic Engineering of Buildings
(SEAOC 1995)

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

Comprehensive Design Codes Development in Japan

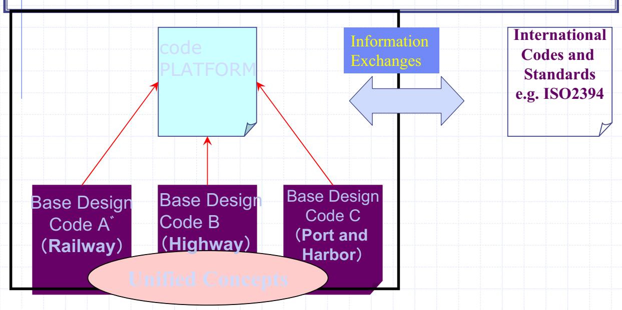
- **code PLATFORM ver.1 (JSCE, 2003)**
  Principles, guidelines and terminologies for structural design code drafting founded on performance based design concept ver. 1.
  (Japanese Society of Civil Engineers, 2003)
- **Geo-code 21(JGS, 2004)**
  Principles of Foundation Design Grounded on Performance Based Design Concept
  (Japanese Geotechnical Sciety,2004)
- **Guidelines for Actions for Civil Structures on Performance Based Design Concept (JSCE, 2007)**

Purposes of Comprehensive Design Codes development

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

Comprehensive Design Code

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



Drafting Body(2001-2002)

Ministry of Land and Transportation
↓ Contract
JSCE
↓ Contract
Consultant (Secretariat)

Committee on investigating and drafting a comprehensive design code (25 members)

Chair Osamu Kusakabe
General Secretary Yusuke Honjo

Scholars and Engineers from various fields: steel, concrete, geotechnical, seismic, wind, reliability etc.

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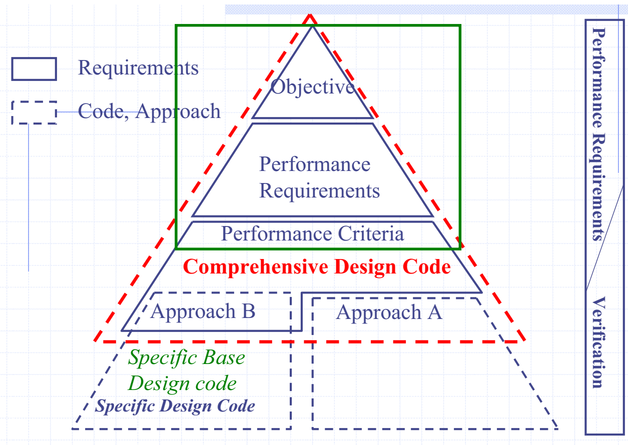


Hierarchy of Requirements and Codes

Hierarchy in performance description of a structure (1)

Objective, Performance Requirements and performance criteria

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

For examples, 'buildings shall provide sufficient safety to the residence at the time of earthquake events so that they are preserved from serious injuries and loss of lives' or 'Marginal operation of functions of a structure is preserved'.

Hierarchy in performance description of a structure (2)

Objective, Performance Requirements and performance criteria

- **Performance requirements:** The performance requirements describes the functions of a structure that should be provided to achieve the stated objective by general terminologies.

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

Hierarchy in performance description of a structure (3)

Objective, Performance Requirements and performance criteria

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

Performance Requirements is given by a Performance Matrix

= Limit states + Magnitude of Action + Importance of Structures

Description of Performance Criteria

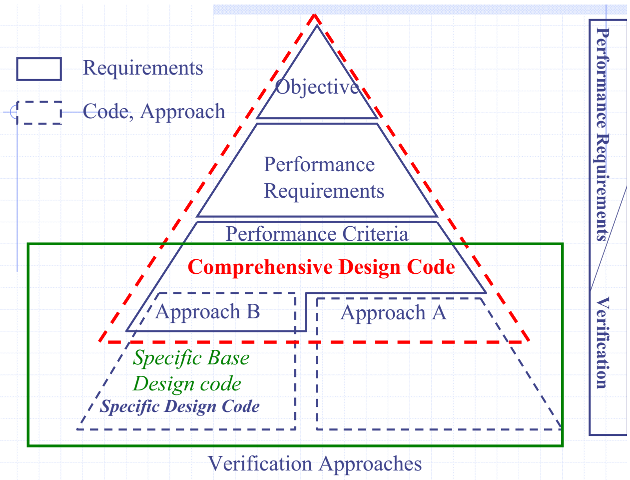
Limit states + Magnitude of Action + Importance of Structures

Damage to a Structure →

Magnitude of Actions ↓

	Serviceability Limit State	Repairable Limit State	Ultimate Limit State
High freq. Low impact	◎○△		
Medium freq. Med. Impact	◎ ○	△	
Low freq. High impact		◎	○ △

Note: ◎ Important Structure ○ Ordinary Structure
△ Easily Repairable Structure

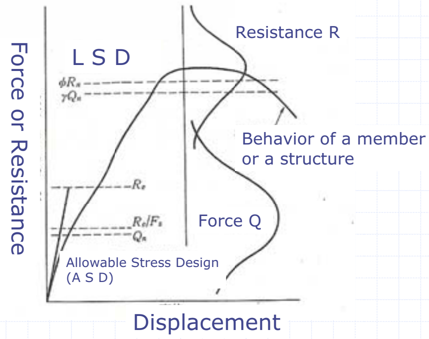


Hierarchy in Verification Methods(1)

- A Comprehensive Design Code that stands on top of both Approaches A and B
- Approach A: Fully performance based design approach.
- Approach B: A code for code writers. Limit State Design (ISO2394)

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

Limit State Design Concept:



JGS "General principles of foundation design based on the performance based concept"

Geo-code 21

General Principles of foundation design founded on performance based design concept

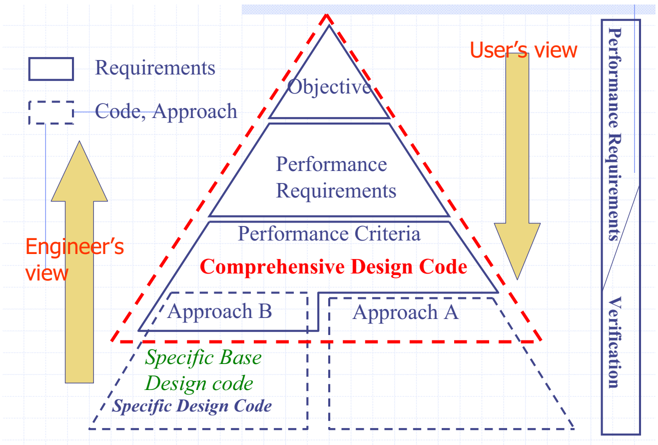
Became JGS standard in 2004.

Benefits of Performance Based Design Codes

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

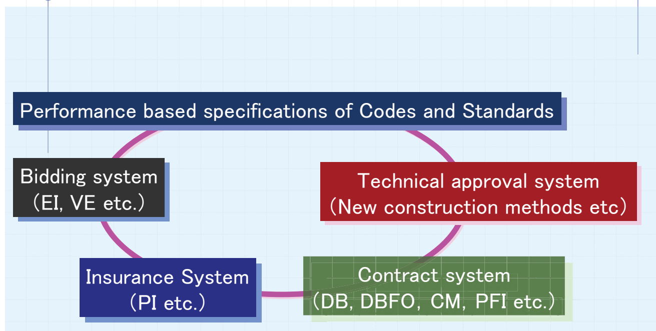
Remained Issues of PBD codes

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



Hierarchy of Requirements and Verifications

Systems to support PBD



(quoted from Horikoshi, 2005)

Asian Regional Code

- One of our next aim is to extend this activity to Asian Region
  - Asian Concrete Model Code
  - ISSMGW/TC 23 LSD in geotech. eng.
    - codes for small/developing countries
    - Workshop at Taipai, Nov 2-3, 2006

    Int. Sym. On New Generation Design Codes
    For Geotechnical Eng. Practice.

Thank you very much!

謝々

JSCE Efforts at Codification of Design in Steel Structures

E. Yamaguchi
Department of Civil Engineering, Kyushu Institute of Technology, Kitakyushu, Japan

1 INTRODUCTION

Committee on Steel Structures is one of the technical committees founded in Japan Society of Civil Engineers (JSCE). It deals with steel/composite materials and structures, and has some 15 active subcommittees at the moment, covering a wide range of technical issues.

A major role that the committee takes is to collect latest findings and developments in the field and publish them in the form of design-related books such as model codes, recommendations and guidelines. In this paper, the recent efforts of the committee in this category are summarized.

2 PAST ACTIVITIES

Committee on Steel Structures, JSCE have been putting much effort into the design-related activities. It seems that the design-related books published by the committee are aimed mainly at domestic use. As a result, most of them are prepared only in Japanese. One of the few is Design Code for Steel Structures shown in Photo 1 (Japan Society of Civil Engineers 1997). This code was prepared first in Japanese and then translated into English.

This is a model code for general steel structures. It was issued first in 1987 and employed the limit design concept. It is noted that at that time, most of the codes of practice in Japan were based on the allowable stress design concept. This JSCE code was revised and published in 1997. The English version mentioned above is the translation of the 2nd version. The following three limit states are recognized in this code:

Ultimate Limit State
Serviceability Limit State
Fatigue Limit State

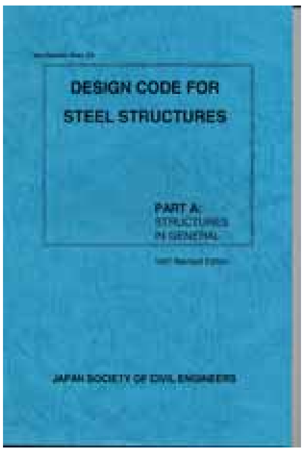


Photo 1. Design Code for Steel Structures.

Photo 2. Collapsed bridge (1995 Hyogo-ken Nanbu Earthquake).

In recent years, the performance-based design concept has emerged. Committee on Steel Structures, JSCE was well aware of it and started research into it. The results came out in 2003 as a book "For Construction of Performance-Based Design for Steel Structures". Part B of the book is a model code of the performance-based design. It consists of four major parts:

I General Provisions
II Structural Planning
III Design
IV Construction

The book presents and illustrates the way the performance-based design code should be. But it is not comprehensive yet.

Prior to the above book, Japan Society of Steel Construction (JSSC) made similar effort at the performance-based design and published the book entitled "Guidelines for Performance-Based Design of Civil Engineering Steel Structures" in 2001. This is a code for performance-based design code writers and includes the backgrounds and the underlying concept of the performance-based design. The book consists of three major parts:

I General Rules for Performance-Based Design of Steel Structures
II Manual for Verification Procedure of Steel Structure Design
III Fundamental Knowledge in Some Fields

3 CURRENT ACTIVITIES

Design codes need to be reviewed and updated, because new technologies and/or unconventional damages come out constantly. For example, in Japan, the 1995 Hyogo-ken Nanbu Earthquake, also known as Kobe Earthquake, caused an enormous amount of structural damage (Photo 2) and had a huge impact on seismic design. The 2004 Niigata-ken Chuetsu Earthquake has given second thoughts to seismic design also. In recent years, a hot issue in steel bridges is a fatigue problem: many fatigue cracks have been found in the bridges in service.

Reviewing the past activities related to design codes, Committee on Steel Structures, JSCE decides to launch a project on Design Standards for Steel/Composite Structures. To this end, a subcommittee was set up in 2004. The subcommittee has been preparing the following 6 volumes for the design standards since then:

Photo 3. Participants in the seminar in Hanoi in 2006

General Provisions
Structural Planning
Structural Design
Seismic Design
Construction
Maintenance

All the volumes should be comprehensive and based on the performance-based design concept. The target publication years are

* 2007 for the three volumes of General Provisions, Structural Planning, and Structural Design
* 2008 for the two volumes of Construction, and Maintenance.

The reason why the two volumes of Construction and Maintenance are to be published a year later is that JSCE has no preliminary design codes in these two areas and needed to start from scratch. On the other hand, the remaining three have some past work to start with.

4 INTERNATIONAL COLLABORATION

International collaboration is getting more and more important. The field of structural design codes is not an exception, not to mention Eurocodes. Committee on Steel Structures, JSCE has taken this trend seriously. It also has the intention of making Design Standards under preparation internationally acceptable in terms of design format and quality.

The committee therefore founded the International Collaboration Task Force in Subcommittee on Design Standards for Steel/Composite Structures. Also, three distinguished Korean Professors were invited to the subcommittee: Professor Young Suk Park of Myungji University, Professor Kab Soo Kyung of Korea Maritime University and Professor Dong Ho Ha of Konkuk University.

The International Collaboration Task Force has been quite active. The following activities have been done so far:

1. Meeting with Korean researchers in Tokyo in 2004
2. Meeting with Korean researchers in Seoul in 2004
3. Invitation of Professor Joel Raoul（SETRA, France）to Japan in 2004
4. Seminar and meeting with Thai researchers in Bangkok in 2005
5. Seminar and meeting with Bangladesh researchers in Dhaka in 2005
6. Seminar and meeting with Korean researchers in Seoul in 2006

Photo 4. Signing cooperative agreement in Dhaka in 2005.

7. Seminar and meeting with Vietnamese researchers in Hanoi in 2006 (Photo 3)

Collaboration for codification as well as technical issues has been discussed in these activities. With Civil Engineering Division, Institution of Engineers, Bangladesh, Cooperative Agreement between has been signed (Photo 4).

In 2007, two activities have been planned:

1. Seminar and meeting with Chinese researchers in Shanghai in January
2. Seminar and meeting with Thai researchers in Bangkok in March

5 CONCLUDING REMARKS

Some efforts of Committee on Steel Structures, JSCE at the codification of design in steel structures were reviewed. The international activities of the committee were also mentioned. Needless to say, international collaboration is very important, and in fact, Asian Model Codes and the codification issues (International Journal 2005) have been discussed in different frameworks than JSCE as well. Committee on Steel Structures, JSCE intends to further promote international collaboration especially for the codification of design in steel structures. To that end, the committee plans to publish the design standards not only in Japanese but also in English in the near future.

REFERENCES

Japan Society of Civil Engineers (1997) *Design Code for Steel Structures*.

International Journal of Steel and Composite Structures (2005) *Worldwide Codified Design and Technology in Steel Structures*. Vol. 5, No. 2-3.

JSCE Efforts at Codification of Design in Steel Structures

Kyushu Institute of Technology

Eiki Yamaguchi

Committee on Steel Structures, JSCE

Design Code for Steel Structures Part A

A model code

Steel structures in general

First published in 1987

Limit State Design

Revised in 1997 (English version)

Committee on Steel Structures, JSCE

For Construction of Performance-Based Design for Steel Structures (2003)

General Provisions
Structural Planning
Design
Construction

A model code of Performance-Based Design

Not very comprehensive yet

JSSC (Japan Society of Steel Construction)

Guidelines for Performance-Based Design of Civil Engineering Steel Structures (2001)

Steel structures in general

Code for PBD code writers

Guidelines for Performance-Based Design of Civil Engineering Steel Structures

I General Rules for Performance-Based Design of Steel Structures

II Manual for Verification Procedure of Steel Structure Design

III Appendices

Revision

Driving Forces:

* New design concept
  (performance-based design)
* New technology
* Unconventional types of damage

Committee on Steel Structures, JSCE

Design Standards for Steel and Composite Structures

6 Volumes in preparation:

- General Provisions
- Structural Planning
- Structural Design
- Seismic Design
- Fabrication and Construction
- Maintenance

Performance-Based Design

Prospect of Design Standards for Steel/Composite Structures

Publication:

Group A: General Provisions; Structural Planning;
Structural Design; Seismic Design

Group B: Fabrication and Construction; Maintenance

Group A: Year 2007

Group B : Year 2008

International Collaboration

Internationally Acceptable Design Standards

- Design Format
- Quality

International Collaboration Task Force

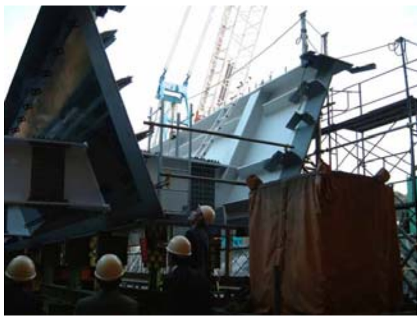
Subcommittee on Design Standards for Steel/Composite Structures

Professor Y.S. Park, Myungji University
Professor D.H. Ha, Konkuk University
Tokyo, January 26, 2004

Korea

Seoul, July 2, 2004

France



Mr. Joel Raoul（SETRA）
November 17-25, 2004

Thailand

Bangkok, January, 2005

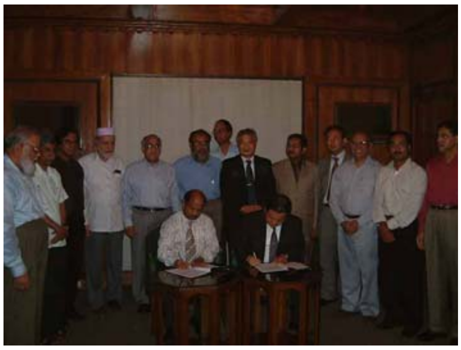
Bangladesh

Dhaka, August 10, 2005

Bangladesh

Dhaka, August 10, 2005

Bangladesh



Cooperative Agreement

Korea

KBRC（Korea Bridge Research Center）

Project funded by Korean Government for developing design codes for highway bridges

Agreement: meeting every year to exchange ideas on bridge design codes

Meeting with KBRC

Professor Koh, Hyun-Moo

March 25, 2006

Vietnam

Hanoi, September 25, 2006

Year 2007

Joint Seminar

Shanghai, China; January 16-17, 2007

Bangkok, Thailand; March 30, 2007

JSSC

Representatives of China, Korea and Japan in steel construction have a meeting every year.

2005 Meeting in Seoul:

An issue: Asian Model Code for Steel Structures

Chair: Professor S.H. Kim, Yonsei University

Codification Symposium on Steel Structures

International Symposium on Worldwide Codified Design and Technology in Steel Structures, 2004

2nd International Symposium on Worldwide Codified Design and Technology in Steel Structures, 2005

International Symposium on Codified Design of Steel Structures, 2006

Hong Kong, Singapore, China, Japan, Australia, US, UK, Netherlands, …

Professor S.L. Chang and Professor K.F. Chung
The Hong Kong Polytechnic University

Concluding Remarks

* To solve traffic jams, more than 10 overpasses were constructed recently in Bangkok, Thailand.

* For fast construction, both girders and piers are steel. The design was based on American codes (AASHTO).

* Japan has more experiences as far as steel substructures (bridge piers) are concerned. But no reference was made to Japanese experiences and codes. More exchange of information on steel design technology may be desirable.

Thank you!

Harmonization among Design Codes within the Asian Region in the Geotechnical Field

M. Suzuki
Institute of Technology, Shimizu Corporation, Tokyo, Japan

1 BACKGROUND

ISO (International Organization for Standardization) is a non-intergovernmental international organization, whose purpose is to plan worldwide standardization and development on related works, which will help the participating nations exchange materials and services, and cooperate in the area of technology and economics. One of these standards is ISO2394: General principles on reliability for structures (ISO 1998), which deals with a standard for designing structures by civil engineering and architecture.

In Europe, CEN has been investigating how to standardize such issues for the last twenty-odd years in the expectation of adapting the deliverables to designing structures in the EU and their efforts are being unified as Eurocodes. EN1990 of Eurocodes designates the basic rules for designing structures. ISO and CEN are, as can be guessed from their Vienna Agreements, are closely related and ISO2394 and EN1990 (CEN 2002) have similar contents.

Japan needs to harmonize with the structural design codes because Japan has ratified the standards of ISO. If Japan were to utilize design codes different from those designated by the ISO for designing a similar structure, flexibility toward safety in each organization would not be comparable. Harmonization, however, does not necessarily mean utilizing similar design codes; rather, it means to conform with basic frameworks of different design systems. These activities are necessary within Asian nations which possess different ground conditions and seismic hazards.

2 EUROCODE 7

European nations have been trying to unify their structural design codes, as exemplified by Eurocode 7 (EN1997) (CEN 2004), which is a standard for soils and foundations. Geotechnical engineering has been dealing with the issues of stabilization (ultimate limit state: ULS) and elasticity (serviceability limit state: SLS) by Terzaghi as the limits for these. Furthermore, Terzaghi and Peck utilized the safety factor in design codes, while Brinch Hansen brought in the partial factor design for USL and SLS.

Considering this background and the fact that Ovsen from Denmark was the first chairman of CEN/SC7, they created the first partial factor method which was unique to geotechnical engineering for Eurocode 7. However, while Eurocodes for other materials are partial factor methods which are expected to use the safety margin as load factors, Eurocode 7 was a design code focusing on material factors, and considered the large influence of the uncertainty of the soil. As a result, it could not conform with other materials and a problem occurred because two separate calculations of structures and soils using different partial factors became necessary in foundation designing. During many discussions by SC7, Germany and France suggested a combination of different partial factors, and finally a design code which recognizes both the original plan and these nations’ plan emerged. This result does not seem to conform with Eurocodes.

3 JAPANESE ACTIVITIES IN THE FIELD OF GEOTECHNICAL ENGINEERING

From 1997 to 1999, the Japanese Geotechnical Society set up a Committee to Study the Current Status Foundation Design in Japan & Its Future, chaired by Prof. Osamu Kusakabe, under the Department of Research Collaboration. The background for setting up this committee was the TBT Agreement in the 1990s which recognized the necessity of standardization of quality design, due to the swiftly popularized design standards in accordance with limit state design methods such as Eurocodes. In Japan, it was necessary to reach a consensus on rules for designing foundations of which we could be proud. The goal was to suggest a way of harmonizing the design codes of such structures as roads, ports, railways, and buildings, which had been divided through historical events. The code scheme that resulted from these activities was named “Comprehensive foundation design code: Geocode 21.” These deliverables were unveiled at the 45th symposium on geotechnical engineering sponsored by the Japanese Geotechnical Society in October 2000.

In 1998, the Department of Standardizing of the Japanese Geotechnical Society began discussing requirements for standards in the coming years, and in 1999, in view of the trends in the formulation of ISO's international standards, collected information on various codes including the ISO/TC182 (Geotechnics) and Eurocodes. During this process, the Department of Standardizing considered such matters as the influence of and opinions about design and construction standards in the field of geotechnical engineering formulated by the Japanese Geotechnical Society. As a result, the Foundation Design Standard Committee, chaired by Prof. Osamu Kusakabe, was set up in 2000 to reach consensus on the draft standard prepared by the Committee. The Committee concluded that it was becoming increasingly important to respect the international standards required by the WTO/TBT Agreement and formulate performance specifications. The Committee also concluded that Japan should adopt the limit state design methods indicated in ISO2394 and Eurocodes in formulating the country's representative design principles for foundation structures. Seismic design efforts following the Hanshin–Awaji Earthquake were also made in accordance with the limit state design principles, and the Committee concluded that these efforts to disseminate information in the international community would encourage the progress of geotechnical engineering in Japan.

Since, however, the matters under consideration were beyond the scope of deliberation by the permanent committee which examined such matters as soil surveys, in 2001 the Committee on Standardization of Foundation Design, chaired by Prof. Yusuke Honjo, was formed to develop design standards concerning foundation structures. This committee reviewed the design standards for the foundation structures being managed by different implementing bodies and developed new standards in order to achieve consistency among the design philosophies and systems for foundation structures in Japan and clarify Japan's position in connection with international consistency. The Committee also held a conference to which foundation design code experts from other countries were invited to make keynote speeches, and contributed an English translation of Geocode 21 Ver.2.0 to a journal (Honjo & Kusakabe 2002).

After that, the Committee on Geotechnical Design and Construction Standards, chaired by Prof. Osamu Kusakabe, was set up in order to form a permanent committee dealing with all geotechnical design and construction standards. Thus, a system for considering design and construction standards was established beyond the existing framework of standards mainly for soil test and geotechnical survey methods. These activities recognize the importance not only of responding to the ongoing internationalization of codes and standards and collecting ISO-related information, but also of formulating ISO standards.

In July 2004, JGS unveiled the Principles for Foundation Design Grounded on Performance-based Design Concept (tentative) and collected opinions until October. Then, following reviews by the Committee on Geotechnical Design and Construction Standards and then the Department of Standardizing and the board of directors, the document was published as the JGS Standard (JGS 2006).

Almost concurrently with these activities, the Ministry of Land, Infrastructure and Transport (MLIT) formed the Committee on the Basis of Structural Design for Buildings and Public Works at the Japan Institute of Construction Engineering and drew up the "Basis of Structural Design for

Buildings and Public Works (MLIT 2002)." Under contract from MLIT, the Japan Society of Civil Engineers (JSCE) created the Basic Research Committee on Comprehensive Design Code Development, chaired by Prof. Osamu Kusakabe, and, after discussions from 2001 to 2003, drafted the Principles, Guidelines and Terminologies for Structural Design Code Drafting Founded on the Performance-based Design Concept Ver.1.0 (code PLATFORM) (JSCE 2003).

4 JGS STANDARD

Principles for Foundation Design Grounded on Performance-based Design Concept

4.1 Composition of the standard

In order to enhance transparency and accountability regarding the performance of structures, performance requirements were hierarchically organized (see Figure 1). Today, similar hierarchies are used in many performance standards including the Nordic Code. The hierarchy of descriptions of performance requirements adopted for the JGS Standard is three-tiered: purpose, required performance, and performance specifications.

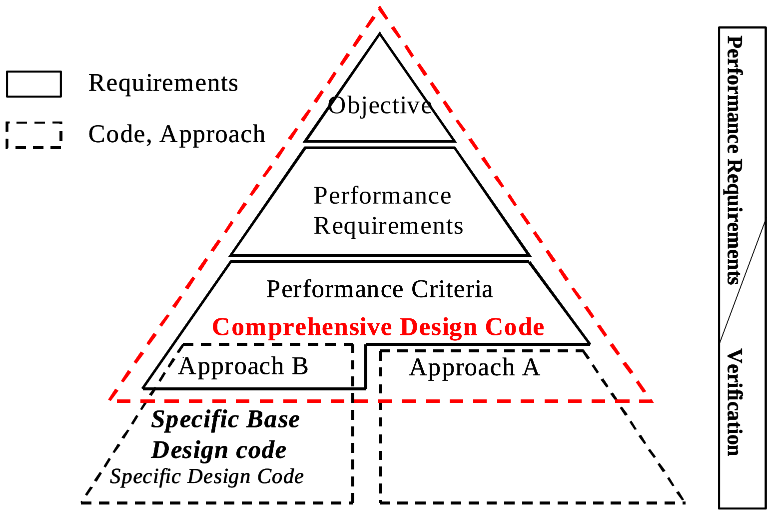


Figure 1. Hierarchy of requirements, verification and codes

Chapter 0 to Chapter 2 of the standard deal with the basics of structural design, basics of foundation structure design, and geotechnical information. Chapter 3 to Chapter 7 deal with the design of shallow foundations, design of pile foundations, design of column foundations, design of pile-supported retaining walls and design of temporary structures. Originally, REQ (required), REC (recommended) or PER (pertinent) was shown at the beginning of each item to indicate a prescribed item, a recommended item among a number of alternatives, or one or more allowable methods or alternatives, respectively. It was decided, however, to indicate these differences in the standard through expressions of different intensities.

4.2 Two approaches to the need for standardization and diversification of performance verification methods

In the international community, there is a trend toward clearly defining the performance of designed structures by means of performance specifications like those that have been used for industrial products since the TBT agreement in order to help the designer and the owner of the structure to be designed to reach a consensus, and to enhance the degree of freedom in design. There is also a strong trend toward international and regional standardization and unification of design standards. It is necessary to respond to these seemingly contradictory trends in a rational way. In order to meet the needs of these two trends simultaneously, the performance verification method of the JGS Standard allows two approaches: approach A and approach B (see Figure 1). Verification approach A is performance-based verification, and verification approach B is verification based on the design standards specific to implementing bodies (called "specific base design codes" or "specific design codes").

4.3 Design standards based on the limit state design method

The JGS Standard conforms to ISO2394 based on a probabilistic limit state design method that indicates a structural safety verification method prescribed as an international standard. If limit states are equated with various structural performance requirements for structures, the limit state design method is thought to be one of the best design methods currently available.

4.4 Standardization of characteristic values of geotechnical parameters

The design process involves determining margins of safety, taking into consideration the uncertainty associated with given loads, resisting elements and design calculation models, so that various performance requirements for structures can be satisfied. When the JGS Standard was developed, attention was focused on the fact that almost all design standards, whether in Japan or abroad, fail to deal adequately with characteristic values of geotechnical parameters. Therefore, four types of expression have been used: measured values obtained from geotechnical parameter measurement, values derived from the measured values through primary processing or correlation analysis, characteristic values chosen from the derived values as representative values, and design values used for safety verification. Characteristic values were defined as the averages of derived values. This method has been adopted to prevent geotechnical surveyors and designers from arbitrarily determining margins of safety when deciding characteristic values of geotechnical parameters. In other words, the idea is to clarify the basis for discussing margins of safety when drawing up design standards.

4.5 Principles for foundation design based on the latest knowledge

The chapters concerning different types of foundation structures aimed to make design checklists based on the latest knowledge concerning foundation design. Qualitative descriptions were used in these checklists where possible, and quantitative descriptions were kept to a minimum so that designers and design code writers can make engineering judgments in order to meet performance requirements. Some concrete examples of verification methods are also shown in the appendix because they may help disseminate information on Japan's state-of-the-art design technology among engineers in other countries.

4.6 Standardization of communication flow and qualifications of engineers

With the aim of standardizing information associated with geotechnical structure design, the JGS Standard stipulates the types and content of reports to be drawn up by geotechnical surveyors, designers and construction contractors. In view of the growing importance of various engineer qualifications needed in connection with the emergence of international common markets, an attempt was also made to stipulate qualification requirements for designers and geotechnical surveyors, but without going into great detail.

5 CONCLUSION

Although the JGS Standard is a set of design principles concerning foundation structures, earth structures were not covered by the first version because earth structures require complex procedures. Currently, there is a subcommittee on the performance evaluation of earth structures, chaired by Prof. Atsushi Iizuka, operating under JSCE's Committee of Geotechnical Engineering, and the subcommittee will continue to work until the end of this fiscal year. One of the working groups of the subcommittee is currently developing "Design Principles for Embankments," which eventually will be incorporated into the JGS Standard.

We hope to promote the adoption of the Japanese design standard in the field of geotechnical engineering among the international community through the activities of ISSMGE's ITC23 (Limit State Design in Geotechnical Engineering Practice, chaired by Prof. Yusuke Honjo).

REFERENCES

ISO (1998) ISO2394, General principles on reliability for structures.

CEN (2002) EN1990, Eurocode - Basis of structural design.

CEN (2004) EN1997-1, Eurocode 7 Geotechnical design - Part 1: General rules.

Honjo, Y. and Kusakabe, O. (2002) *Proposal of comprehensive foundation design code, Geocode21 Ver.2*, Proc. of IWS Kamakura 2002, A.A.Balkema Publishers, pp.95-106.

JGS (2006) JGS 4001-2004, Principles for foundation designs grounded on a performance-based design concept.

MLIT (2002) Basis of Structural Design for Buildings and Public Works.

JSCE (2003) Principles, guidelines and terminologies for structural design code drafting founded on the performance based design concept Ver.1.0, (code PLATFORM ver.1.0).

Workshop

Harmonization among Design Codes within the Asian Region

Geotechnical Fields

Shimizu Corporation

Makoto Suzuki

Contents

Background of Design Codes

- WTO/TBT Agreement in the 1990s recognized the necessity of standardization of quality design.
- It was becoming increasingly important to respect the international standards required by the WTO/TBT Agreement and formulate performance specifications.
- Japan should adopt the limit state design methods indicated in ISO2394.
- Seismic design efforts to disseminate information in the international community would encourage the progress of geotechnical engineering in Japan.

Toward Performance-based Design

- Cordification of structural design is important.
- Structural design is performed under uncertainties.
- Safety factor is not quantitative index.

$$Fs = \frac{R}{S}$$

- Probabilistic description of safety margin is rational.
- Partial factor design is a practical procedure.
- Revision for compliance with ISO standard.

Contradictory International Trends

- ISO and Eurocodes in Europe

  international and regional standardization, unification

- Seismic performance specification in North America

  Clearly defining the performance of designed structures in order to help the designer and the owner to reach a consensus, and to enhance the degree of freedom in design

European Nations

- ISO:ISO2394
  - General principles on reliability for structures
- CEN:EN1990
  - Eurocode - Basis of structural design
- Vienna Agreements
- WTO/TBT Agreement

Eurocode 7

- Eurocode 7 (EN1997) is a standard for soils and foundations.
- They have been dealing with the issues of stabilization (ultimate limit state: ULS) and elasticity (serviceability limit state: SLS) by Terzaghi.
- Terzaghi and Peck utilized the safety factor in design codes.
- Brinch Hansen brought in the partial factor design.
- CEN/SC7 created the first partial factor method which was unique to geotechnical engineering.

Eurocode 7

- While Eurocodes are partial factor methods expected to use the safety margin as load factors, EC7 focus on material factors.
- Large influence of the uncertainty of the soil has to be considered.
- EC7 could not conform with other materials.
- Two separate calculations of structures and soils using different partial factors became necessary in foundation designing.
- Three approaches have been adopted.

Japanese Activities in JGS

- 1997-1999
  - Committee to Study the Current Status Foundation Design in Japan & Its Future, chaired by Prof. Kusakabe
  - " Comprehensive foundation design code: Geocode 21"
- 2000
  - Foundation Design Standard Committee, chaired by Prof. Kusakabe
  - Draft JGS standard were prepared
- 2001-2003
  - Committee on Standardization of Foundation Design, chaired by Prof. Honjo
  - English translation of Geocode 21 ver.2.0

Japanese Activities in JGS

- 2004
  - Committee on Geotechnical Design and Construction Standards
  - Principles for Foundation Design Grounded on Performance-based Design Concept (tentative)
  - JGS Standard: JGS4001-2004

Japanese Activities

- 2002: MLIT
  - Committee on the Basis of Structural Design for Buildings and Public Works at the Japan Institute of Construction Engineering
  - Basis of Structural Design for Buildings and Public Works
- 2001-2003: JSCE
  - Basic Research Committee on Comprehensive Design Code Development, chaired by Prof. Kusakabe
  - Principles, Guidelines and Terminologies for Structural Design Code Drafting Founded on the Performance-based Design Concept ver.1.0 (code PLATFORM)

JGS Standard

Principles for Foundation Design Grounded on Performance-based Design Concept

A4 size 246 pages ¥2,835
[member ¥1,890]

Contents:
-standard text (chapter 0-7)
-commentary
-appendix
-standard text in English

Chapter setting up in present and the future

- BASIS OF STRUCTURAL DESIGN
- BASIS OF DESIGN OF FOUNDATION STRUCTURES
- GEOTECHNICAL INFORMATION
- DESIGN OF SHALLOW FOUNDATIONS
- DESIGN OF PILE FOUNDATIONS
- DESIGN OF COLUMN-TYPE FOUNDATIONS
- DESIGN OF RETAINING STRUCTURES
- DESIGNING TEMPORARY STRUCTURES

chapter 0 - chapter 7 in present

- EMBANKMENT
- SLOPE (or CUTTING)

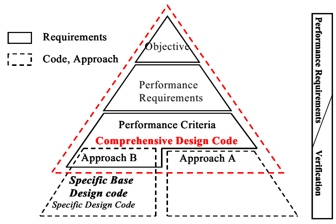
on going

- TUNNEL, CAVARN
- GROUND IMPROVEMENT
- REINFORCED SOIL

future

Composition of the standard

- Performance requirements were hierarchically organized.
- The hierarchy of descriptions is three-tiered: purpose, required performance, and performance specifications.
- Two approaches: approach A and approach B

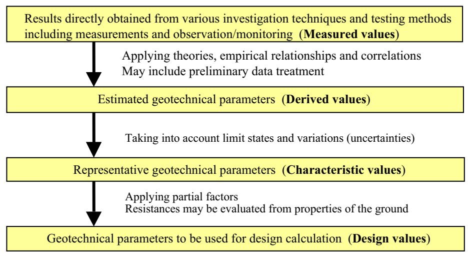


Problem Items

- Standardization of characteristic values of geotechnical parameters
  - They were defined as the averages of derived values.
- Performance regulations and verification
  - The method of the performance regulations according to the verification technique.
- What is the verification approach A?
- Checking list for each foundation designing
- No load specification
- Qualifications of engineers

Geotechnical Parameters

- Determination of geotechnical parameters



Conclusion

- JGS Standard is a set of design principles concerning foundation structures.
- There is a subcommittee on the performance evaluation of earth structure in JSCE.
- ISSMGE's ITC23 (Limit State Design in Geotechnical Engineering Practice, chaired by Prof. Honjo)

Development of Steel Design Codes in Thailand

Prakit Premthamkorn
Chair, Subcommittee on Steel Structures, Engineering Institute of Thailand
Civil Engineering Department, Mahanakorn University of Technology, Bangkok, Thailand

ABSTRACT

Engineering Institute of Thailand (EIT), the most prominent engineering professional organization in Thailand, is introduced. The code development methodology by EIT is then outlined. Problems and difficulties facing during developing and implementing the design codes are discussed. Direction of EIT's code development is also presented. Development of design codes for steel structures is given for example. Finally some aspects of harmonizing design codes among Asian countries regarding problems, difficulties and possible approaches are discussed.

1 INTRODUCTION

The Engineering Institute of Thailand (EIT) was founded in 1943 under his majesty the King's patronage. Currently, EIT consists of 8 technical committees, which are:

(1) Civil Engineering
(2) Electrical Engineering
(3) Industrial Engineering
(4) Mining, Metallurgy & Petroleum Engineering
(5) Chemical Engineering
(6) Environmental Engineering
(7) Automotive Engineering
(8) Mechanical Engineering

Each technical committee has several subcommittees to cover broader field of industry. With EIT's support and endorsement, there have been a few professional societies that stemmed from EIT's Civil Engineering subcommittees such as Thai Concrete Institute, Traffic and Transportation Engineering Society.

The management of EIT is done through Board of Directors which are elected by its members for a 4-year term. The board shall then appoint a chairman and members for each technical committee and its subcommittees. All members who are working on voluntary basis are the drive of EIT to achieve its goals to:

- Develop design codes
- Promote education, research and practice of engineering profession
- Organize technical conference and workshop for better engineering practice
- Provide technical consultation for members relating to engineering problems
- Promote harmony among domestic organizations
- Collaborate with international organizations

One apparent means to achieve the above policies is through EIT's publications such as design specifications, books, technical reports and proceedings of technical seminar and conferences.

For the Civil Engineering Committee, there are 9 subcommittees:

(1) Steel Structures
(2) Concrete
(3) Wind and Earthquake Engineering
(4) Geotechnical Engineering
(5) Transportation Engineering
(6) Water Resource
(7) Construction Management and Planning
(8) Computational Mechanics
(9) Engineering Ethics and Society Services

EIT's Civil Engineering Committee has developed design codes covering the following topics / subjects / fields:

- Design Loads
- Construction Material
- Steel Structures
- Concrete Structures
- Code of Standard Practice
- Construction Safety
- Inspection and Maintenance

The main emphasis herein is placed on the development of design codes by the Steel Structure subcommittee.

2 EIT'S CODE DEVELOPMENT METHODOLOGY

EIT welcomes comments and suggestion of referral standards from its members. However, the following referral standards are chosen as initial references for design code development in civil engineering.

Materials:

- Thai Industrial Standard (TIS)
- Others: JIS, ASTM, BS, DIN, AS

Design Specifications:

- ACI, AISC, AASHTO, and other American codes
- JSCE, Eurocode

Regarding the adopted referral standards, procedures for developing design codes are summarized below:

(1) Nomination of code for development from subcommittee
(2) Approval of EIT's Board of Director for drafting including content and budgeting
(3) Appointment of permanent committees and drafting/revision committees
(4) Drafting
(5) Public technical hearing
(6) Publish the design code
(7) Arrange seminar and training for engineers

During the process of code development, drafting committees face by a few problems resulting mainly from lack of strong financial support. Drafting committee members are working on voluntary basis, therefore, working schedule can hardly be maintained and a progress is expectedly slow. One of obvious difficulties in implementation of EIT design codes is incomplete arrays of design specifications.

In practice, several design codes may be applied to a design or construction project. Comprehensive design specifications are preferred by practitioners. As a result, EIT design codes are mostly for educational usage not for serious engineering practice. In addition, the codes are used among relatively small number of practicing engineers and thus lack economy of scale for development of non-main stream codes.

To promote the use of EIT design codes among practicing engineers, EIT is aiming to develop the comprehensive design specifications. In addition the EIT design codes must be current and incorporate research results or findings that suit local practices.

3 DEVELOPMENT OF DESIGN CODES FOR STEEL STRUCTURES: A CASE STUDY

In general EIT's design specification is divided into 3 parts, code of standard practice, design manual and supplement. For steel structures, three existing design specifications are chosen for discussion.

(1) **Specification for Structural Steel Buildings: Load Resistance Factor Design: LRFD** (SI unit), based on 2001 AISC's LRFD Code and published in 2002. It is currently used as a reference code for University courses and gaining popularity among practicing engineers.

(2) **Specification for Structural Steel Buildings: Allowable Stress Design: ASD** (Metric unit), based on 1983 AISC's ASD Code and published in 1997. This code was the first design code for steel structures; therefore it has been used as reference code for most engineers.

(3) **Design Specification for Cold-form Steel Sections** (Metric unit), based on a very old version of AISI's Code and published in 1985. This code is relatively unknown and out of date. It urgently needs revision for simplified version to suit the usage for small and secondary structure design (design manual, tables and charts).

The direction of design code development for steel structures is summarized below:

- Needs supplemental standards such as material standard (steel, bolts), welding standard, connection design manuals, standard practice.
- Member design manuals based on TIS steel section
- Connection design manuals
- Revision of load and strength factor to suit local practice
- Codes for design of specific structures (bridges and transmission towers)

Following are design specifications for steel structures, which are under development:

- Manual of steel construction: LRFD
- Manual of steel construction: ASD
- Code of standard practice for steel buildings & bridges
- Specification for structural joints using HS bolts
- Guidelines for welding inspection
- Design of hollow section
- Weathering steel
- Fire resistance for steel structures

4 HARMONIZATION OF DESIGN CODES

Due to the tide of globalization, harmonization of design codes is now a trend. The American Society of Civil Engineering and it affiliations have been probably the world most prominent and influential in development of design codes in Civil Engineering areas. EuroCode, that is resulted from harmonization of design codes in European countries, is now gaining popularity. Asian countries with their leading professional societies such as JSCE and ACECC are now facing this challenging trend. Asia with its largest number of countries and population needs some form of harmonized code to compete with the other two major continentals. Barriers and difficulties in harmonization of design codes in Asian region are as following:

- Language
- Referral standards (e.g. material standards, supplemental standards)
- Other technical issues
  - Philosophy and concepts
  - Loading
  - Geographical differences

There are many probable measures that can lead toward harmonization of design codes. Below shows the measure suggested by this author.

- Direct adoption or partial adoption of design codes among ACECC members
- Promote dialogue among societies during code development
- Exchange of information
- Create a consortium for development

5 CONCLUSION

In the path toward harmonization of design codes, understanding the similarities and differences in code development methodology among all ACECC members is essential. This paper presents code development methodology by Engineering Institute of Thailand, Problems and difficulties facing during developing and implementing the EIT design codes discussed herein are believed to be useful in the process of harmonization of design codes. To achieve the goal, barriers and differences of language, referral standards and other technical issues such as design philosophy and concept, loading and geographical differences must be overcome. An attempt to promote dialogue among societies during code development is encouraged. A consortium may be initiated for harmonization of design codes among ACECC members. To this end, the author encourages the initiation from major Asian engineering professional societies such as JSCE, and ACECC to take on the harmonization of design codes in the Asian region.

Development of Steel Design Codes in Thailand

The Engineering Institute of Thailand (E.I.T.)

Prakit Premthamkorn

Outline of Presentation

- Introduction to Engineering Institute of Thailand
- Code Development Methodology by EIT
- Development of Codes for Steel Design
- Harmonization of Design Codes

The Engineering Institute of Thailand (E.I.T)

under his majesty the king's patronage

- Thailand oldest engineering professional society
- Found in 1943
- Consists of 8 engineering subcommittees including Civil Engineering
- There have been a few professional societies that grew out from EIT's C.E subcom. Such as Thai Concrete Institute, Traffic and Transportation society, etc.

Structure of E.I.T.

Board of Directors

- **Develop design codes**
- Promote education, research & practice of engineering profession
- Organize technical conference & workshop for better eng. practice
- Provide technical consultation for members relating to eng. problems
- Promote harmony among domestic organizations
- Collaborate with international organizations

Technical Committees

1. **Civil Engineering**
2. Electrical Eng.
3. Industrial Eng.
4. Mining, Metallurgy & Petroleum Eng.
5. Chemical Eng.
6. Environmental Eng.
7. Automotive Eng.
8. Mechanical Eng.

Civil Engineering Committee

Sub-committees

1. **Steel Structures**
2. Concrete
3. Wind and Earthquake Engineering
4. Geotechnical Engineering
5. Transportation Engineering
6. Water Resource
7. Construction Management and Planning
8. Computational Mechanics
9. Engineering Ethics and Society Services

E.I.T. Publications

- **Design specifications**
  - **Civil Engineering**
  - Electrical Engineering
  - Mechanical Engineering
- Books & Technical reports
- Proceedings

Design Codes: Civil Engineering

- Design Loads
- Construction Material
- **Steel Structures**
- Concrete Structures
- Code of Standard Practice
- Construction Safety
- Inspection & Maintenance

EIT's Code Development Methodology

- Referral Standards
- Development Procedure
- Problem and Difficulties
- Direction

Referral Standards for Civil Engineering

- Materials
  - Thai Industrial Standard (TIS)
  - Others: JIS, ASTM, BS, DIN, AS
- Design Specifications
  - ACI, AISC, AASHTO, and other American codes (99%)
  - JSCE, Eurocode

Procedures for Development of Design Codes

1. Nomination of code for development from subcommittee
2. Approval of E.I.T.'s Board of Director for drafting including content, budgeting
3. Appointment of Permanent committee & Drafting/Revision committee
4. Drafting
5. Public Technical Hearing
6. Publish the Design Codes
7. Arrange seminar and training for engineers

Problems and Difficulties

- Incomplete arrays of standards
- Mostly for educational usage, not for serious engineering practice
- Lack of strong financial support
- Drafting committee members are working on voluntary basis [very very slow]
- Relatively small number of practicing engineers [lacks economy of scale]

Direction

- Complete arrays of design codes
- Incorporate research results or findings
- Design codes that suit local practices

Development of Design Codes for Steel Structures

A Case Study

Structure of E.I.T. Design Specification

- Design Specification
  - Code of Standard Practice
  - Design Manual
  - Supplement

Design Codes: Steel Structures

Existing specifications

- Specification for Structural Steel Buildings: Load Resistance Factor Design (LRFD)
- Specification for Structural Steel Buildings: Allowable Stress Design (ASD)
- Design Specification for Cold-form Steel Sections,

Specification for Structural Steel Buildings: Load Resistance Factor Design (LRFD)

- Based on 2001 AISC's LRFD Code, published in 2002
- SI unit
- Current reference code for University courses and gaining popularity among practicing engineers

Specification for Structural Steel Buildings: Allowable Stress Design (ASD)

- Based on 1983 AISC's ASD Code, published in 1997
- Metric unit
- Reference design code for most engineers

Design Specification for Cold-form Steel Sections

- Based on a very old version of AISI's Code, published in 1985
- Metric unit
- Relatively unknown
- Urgently need revision for simplified version to suit the usage for small and secondary structure design (Design manual, table, chart)

Direction

- Needs supplemental standards such as material standard (steel, bolts), welding standard, connection design manuals, standard practice
- Member design manuals based on TIS steel sections
- Connection design manuals
- Revise load and strength factors
- Codes for design of specific structures (bridges and transmission towers)

Direction

- Needs supplemental standards such as material standard (steel, bolts), welding standard, connection design manuals, standard practice
- Member design manuals based on TIS steel sections
- Connection design manuals
- Revise load and strength factors
- Codes for design of specific structures (bridges and transmission towers)

Design Codes: Steel Structures

Specifications (under development)

- Manual of Steel Construction: LRFD
- Manual of Steel Construction: ASD
- Code of Standard Practice for Steel Buildings & Bridges
- Specification for Structural Joints using HS Bolts
- Guidelines for Welding Inspections
- Design of Hollow Sections
- Weathering Steel
- Fire Resistance

Harmonization of Design Codes

"Best approach of harmonization is to learn from the design codes of each other among ACECC members and understand the differences"

Barriers of Harmonization

- Language
- Referral standards (e.g. material standards, supplemental standards)
- Other technical issues
  - Philosophy and concepts
  - Loading
  - Geographical differences

Approach

- Direct adoption or partial adoption of design codes among ACECC members
- Promote dialogue among societies during code development (e.g. new JSCE's Bridge Design Code)
- Exchange of information
- Create a consortium for development

Status of Korean Steel Code and Development of Asian Steel Code

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1. Introduction

In most Asian countries different codes and standards have been developed by adopting and modifying codes and specifications of the United States and European countries including the former Soviet Union. Therefore, the major code provisions do not agree with others and most international bidding of construction projects in Asian market requires internationally approved codes and standards. However, these international codes do not reflect the local natural conditions, socio-cultural environment, technology, and workmanship in the Asian region. Thus the demand on common standards, code and specifications for Asian construction industries keeps increasing more than ever before.

Recently the pressure for adopting the ISO Standards or Equivalent codes, such as Euro Code, AISC / AASHTO Specifications, in the bidding of, or participation in, international construction projects required by the ISO, keeps increasing under the WTO free-trade environment. Even Steel structures are widely constructed in the Asian region, the current codes of the major societies are primarily based on traditional ASD (Allowable Stress Design), and the major code provisions do not agree or interchangeable with each other. Inconveniences due to differences in code and standards in design, fabrication, erection, maintenance and management of steel structures are experienced by practicing engineers of Asian countries.

The need of Asian Steel Code is widely recognized by academics and engineers in the region and it should be developed by Asian countries in mutual collaborative joint efforts. Since the steel industries of China-Japan-Korea are leading the steel industry in Asia as shown Table 1, the three countries should play a leading role in developing the Asian Steel Code.

The initiative efforts for development of Asian Steel Code have been made by the JSSC and the first meeting on International Standards of Steel Structures has been held successfully in Tokyo, June 2000. Since then no further significant progress has been made until the China-Japan-Korea symposium held in November 2003, where the keynotes and the panel discussions on Design Codes of Steel Buildings and Steel Bridges were made by the representatives of the three countries for better understanding the codes and specifications used in the countries. In 2006 CJK symposium held in Seoul, the panel discussion has been made to implement a road map for development of Asian Steel Code with the key agenda including organizations, strategic move, desirable workshops / meetings / symposia for ASC development, and effective hierarchical structure of the ASC standards, financial supports, and tentative construction of the

Table 1. Crude steel production statistics

- Asia (2002~2005, Unit : 1,000 Metric tones)

Country	2002	2003	2004	2005
Indonesia	2,462	2,042	2,412	2,800
Malaysia	4,722	3,960	5,698	6,300
Australia	7,527	7,544	7,414	7,757
India	28,814	31,779	32,626	38,083
Korea	45,390	45,310	47,521	47,820
Japan	107,745	110,511	112,718	112,471
China	182,249	222,413	280,486	349,362
Taiwan	18,320	18,832	19,598	18,567

International Committee on Asian Code for Steel Structures (ICACSS).

Recently, it is globally recognized that the design methods, codes and specifications for steel structures are gradually changing from the ASD-based to the LSD/ LRFD-based, whose calibration is exclusively based on reliability-based code optimization. Moreover, design codes of most of advanced countries are presently moving toward Performance-Based Design (PBD).

2. Current state of progress for Asian Steel Code

The theme of the last 6th CJK symposium, held in Tokyo, November 2003, was “Design Codes of Steel buildings and Steel Bridges”, where in the two-days sessions the keynote lectures were addressed by the keynote speakers who represent the three societies and then the panel discussions were made on the current issues of steel design codes and steel design technology as well as the current move for further development in each country.

During the past PSSC98 held in Seoul, the first informal talk was initiated by Professor Fukumoto about the necessity for organizing the ICACSS (International Committee on Asian Code of Steel Structures) and the need to have a preparatory meeting in near future, and to discuss the possibility of “Asian Code of Steel Structures”. And then the consensus was made among the representatives of the three countries and agreed upon further talk.

Consequently, the first official meeting on International Standards of Steel Structures was initiated and proposed by the International Committee of the JSSC under the leadership of Prof. Ben Gato, Prof. Fukumoto, and Prof. Takanashi, and accordingly it was successfully held in Tokyo, June 2000.

The result of the meeting was quite successful, and the representatives of the three countries made the resolutions to organize ICACSS, to have a further talk at PSSC 2001 Beijing, to prepare the constitution by preparatory group, no later than the end of 2000, through e-mail / file exchange. However, no further significant progress through formal or informal meeting was made since the first meeting though its result was quite promising and fruitful. And thus the formal organization, ICACSS, has not yet been established to discuss the Asian Code problems. But the talking about Asian steel codes or standards is informally going on among the leading figures of the three societies.

3. A road map for Asian Steel Code

For the successful development of ASC, systematic and strategic move is important. First of all, the three societies should try to discuss the key agenda such as need / goal / objective, organization, action plan, meetings / workshops, financial supports, constitution, etc., and to come up with consensus and resolutions for code development. At the meeting, the first thing to do is to clearly define the need, goad, objective of Asian Steel Code or Standards in order to persuade the academics and practitioners of the steel societies of each country.

The goal of the ASC development may be set up in three stages of sustainable development as follows:

- At first, ASC in the form of Asian Steel Model Code (ASMC) need to be developed, because it will take time to gradually shift the practice from the Allowable Stress-based code to the prescriptive Limit State-based code and finally to a Performance-based code. In the mean time, a common performance-based ASMC is more preferable to wait until academics and practitioners are familiarized with the performance-based code;
- Next, national steel codes of the prescriptive Limit State-based need to be converted to the performance-based Limit State code confirming to ASC based on the ASMC and the recommended code calibration procedure;’
- Finally, in the long run, ASC standards need to be adopted based on ASMC with some updated revision of the code.

4. Concluding remarks

It has to be admitted that there must be some problems and barriers mainly because it may be difficult to effectively promote Asian code development due to diverse backgrounds in technical, social and cultural environments of each country.

However, these problems and barriers could be overcome by open-minded leading experts of each society who really think that the development of Asian steel code or standards are really important in this world of global free trade market under the WTO system and in high competitive environment with concrete construction industry. The belief and zeal of leading experts of each society will make it possible to promote the establishment of ICACSS and to immediately start the code drafting works for development of performance-based Asian Steel Code through mutual technical collaboration and joint efforts.

Of course, once the ICACSS (International Committee on Asian Code for Steel Structure) is established, it may be important to learn a lot from the case of successful development of ACMC (Asian Concrete Model Code). However, it may be positively expected that the development of ASMC could be efficiently driven compared with ACMC because the three societies have already built up true friendship and mutual cooperation through the major countries in Asia. Moreover, the financial problem for the activities of the code committees and the working groups and the technical researches on the code development may be more easily solved through the supports from the steel industry of each society.

Though there must be problems and barriers in order to move toward the next generation performance-based ASMC and there is much more work required to reach the level of certainty necessary to implement the ASMC, the role of the major societies will become central for the development of Asian Steel Standards. Hopefully, it may be expected that the major societies could easily remove technical and social obstacles without any difficulty, come up with the consensus for the establishment of ICACSS in the near future.

Recognizing that the greatest advantage of ASMC or Asian Steel Standards, it may be positively concluded that once it is developed, it can be used, with the availability of common basis or standards, for the easy drafting of national codes conforming to international standards, which makes the three Asian countries become more competitive in international / Asian construction markets, and may provide the three societies with the vehicle driving for more close technical cooperation and development of Asian steel industries.

Status of Korean Steel Codes and Development of Asian Steel Code

Sang-Hyo Kim (Yonsei Univ.)
Young-Jong Kang (Korea Univ.)
Kyong-Ho Chang (Chung-Ang Univ.)

ACECC Workshop on Harmonization of Design Codes in the Asian Region
November 4, 2006
Taiwan

I. Current Status of Design Codes for Structures in Korea

Design Code for Highway Bridges

- approved by MOCT
- developed by KRTA (Korea Road & Transportation Association)
- contains
  1) General scope
  2) Loads and others
  3) Steel bridges (ASD)
  4) Concrete bridges (Strength Design)
  5) Substructures
  6) Seismic Design

✓ LRFD Code
- Developed in 1996, MOCT
- practically not in use
- AASHTO-LRFD: first being used for Incheon Grand Bridge

I. Current Status of Design Codes for Structures in Korea

Design Code for Buildings

- approved by MOCT
- Steel Building(LRFD) by KSSC and AIK (Architectural Institute of Korea)
- Concrete Building(LRFD) by KCI and AIK

Design Code for Steel Structures

- approved by MOCT
- developed by KSSC (Korean Society of Steel Construction)
- based on Allowable Stress Design

I. Current Status of Design Codes for Structures in Korea

Design Code for Concrete Structures

- LRFD
- approved by MOCT
- developed by KCI (Korea Concrete Institute)

Design Code for Railway Bridges

- ASD
- approved by MOCT
- developed by KSSC and KSCE (Steel Bridges)
  KCI and KSCE (Concrete Bridges)

II. Development of New Design Codes

- Demand on LRFD codes for highway and railway bridges
- Demand on Performance-based design codes
  - starts a preliminary research project to develop a design guideline supported by MOCT (2006. 10 ~ 2009. 10)
  - proposed a RFP to develop a performance-based design code for steel highway bridges (5 years project)

III. Code Harmonization in the Asian Region - Steel Structures -

- Most international bidding of construction projects in Asian market require internationally approved codes and standards.

Appendix A.

Country	Project	Period	Material Standard	Design Standard	Construction Company
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix A.

Country	Project	Period	Material Standard	Design Standard	Construction Company
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Saudi Arabia	Olefins and Benzene Plant	98-2000	ASTM	AISC	Daelim
Singapore	Capital tower	97-2000	ASTM	BS	Ssangyong
Singapore	Sun Tec City	91-97	ASTM	BS	Hyundai
Singapore	Capital tower	97-2000	ASTM	BS	Ssangyong
Taiwan	Aroma Plant	98-2000	ASTM	AISC	Daelim
Taiwan	Cogeneration Power Plant	98-2000	ASTM	AISC	Daelim
Thailand	H2S Removal Plant	92-94	ASTM	AISC	SK
Thailand	Aromatics & Reformer	94-97	ASTM	AISC	SK
Thailand	Marine Terminal Expansion	93-94	ASTM	AISC	SK
Thailand	Lube Base Oil	96-98	ASTM	AISC	SK
Thailand	Sriacha Petroleum Extension Project	91-92	ASTM	AISC	SK
Thailand	Rayong Tank Rerminal Map Ta Phut	97-98	ASTM	AISC	SK
Thailand	Sulfuric Acid Plant	96-98	ASTM	AISC	SK
Vietnam	POSLILAMA Steel Plant	95-96	KS	AISC	POSCO
Vietnam	VPS Steel Plant	93-95	KS	AISC	POSCO
Vietnam	Diamond plaza	95-99	KS	AISC	POSCO

III. Code Harminization in the Asian Region - Steel Structures -

- However, the international codes do not reflect the local natural conditions, socio-cultural environment, technology, and workmanship in the Asian region.

- The need of Asian Steel Code is widely recognized to provide the basis for common standards for steel construction industry in Asia.

III. Code Harminization in the Asian Region - Steel Structures -

- The competition with concrete construction is getting higher in construction market.

- In order to compete with concrete construction and share the construction market in Asian countries, more advanced, unified, globally acceptable codes and standards – a common performance-based standards – for steel construction is urgently required because the Asian Concrete Model Code based on the performance-based design has been developed already.

III. Code Harminization in the Asian Region - Steel Structures -

- **Who develop the Asian Steel Code?**

III. Code Harminization in the Asian Region - Steel Structures -

Table 1. Crude steel production statistics

-Asia (2002~2005, Unit : 1,000 Metric tones)

Country	2002	2003	2004	2005
Indonesia	2,462	2,042	2,412	2,800
Malaysia	4,722	3,960	5,698	6,300
Australia	7,527	7,544	7,414	7,757
India	28,814	31,779	32,626	38,083
Korea	45,390	45,310	47,521	47,820
Japan	107,745	110,511	112,718	112,471
China	182,249	222,413	280,486	349,362
Taiwan	18,230	18,832	19,598	18,567

* Source: International Iron and Steel Institute (IISI)

III. Code Harminization in the Asian Region
- Steel Structures -

- Asian Concrete Model Code (ACMC 2001) has been developed by International Committee on Concrete Model Code (ICCMC), whose members are representatives from 13 Asian countries and Australia.
- 7 professional organizations in Asian countries support the development of ACMC 2001: China – Japan – Korea, India, Indonesia, Philippines, SriLanka.

III. Code Harminization in the Asian Region
- Steel Structures -

- International Committee on Asian Code for Steel Structures (ICACSS), needs to be established, as soon as possible, in order to implement the road map for further research and development as well as code writing works.

III. Code Harminization in the Asian Region
- Current State of Progress for Asian Steel Code -

- During PSSC98 held in Seoul, the first informal talk was initiated by Prof. Fukumoto about the necessity for organizing the ICACSS (International Committee on Asian Code of Steel Structures) and the need to have further talk.
- The first official meeting on ICACSS was held in Tokyo, June 2000, by the International Committee of JSSC under the leadership of Prof. Gato, Prof. Fukumoto, and Prof.Takanashi.

III. Code Harminization in the Asian Region
- Current State of Progress for Asian Steel Code -

- 2nd formal meeting on Asian Steel Code during the 8th C-J-K symposium on Structural Steel Construction in Seoul, Oct. 2005.
- No agreement on further talks on Asian Steel Code.

ACECC Workshop on Harmonization of Design Codes in the Asian Region
Nov. 4, 2006, Taipei, Taiwan

Developing A Modern Design Code for Steel and Composite Construction in Asia

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ABSTRACT

Globalization is surely affecting us in various walks of life these days. In the construction industry nowadays, it is very trendy for engineers to think and talk about international professional recognition, worldwide consultancy service, and regional if not global codes of practice. It is well known among those of us in the construction industry that the highly acclaimed Structural Eurocodes have been officially published in the last few years, and they are expected to be adopted throughout all the European countries as definitive technical documents on the design and construction of buildings and bridges. In the last couples of years, similar code developments are engaged in many parts of the world, including a number of countries in the North America as well as in Asia.

This paper aims to present various key issues towards the development of a modern design code for steel and composite construction in Asia as an attempt to examine the huge opportunities offered in a regional code for Asia. Experiences are drawn from the recent drafting of the Hong Kong Steel Code which is compiled by a joint venture between academics and engineers over a period of two and a half years. As the situations of steel and composite building construction in Hong Kong are widely shared among the neighbouring countries, similar courses of action are recommended to increase both the efficiency and the competitiveness of the construction industry in the region.

KEYWORDS

Globalization, Construction, Codification, Steel and Composite Structures, Performance-based design

1 INTRODUCTION

Globalization is surely affecting us in various walks of life these days. After decades of infrastructure construction and technological advances in transportation, aviation as well as electronic superhighways, the world is 'flat'. Hokkaido, Xian, Bangkok, Perth and Kular Lumpur are neighbours in a real and practical sense. We all live in a global village.

In the construction industry nowadays, it is very trendy for engineers to think and talk about international professional recognition, worldwide consultancy service, and regional if not global codes of practice. In the last century, people considered hardship to leave home for work as they anticipate complete isolation from their families and folks for months if not years. Nowadays, people travel light and afar. They communicate through e-mails and cellular phones all over the world.

In the construction industry, it is a very common scene for a Japanese contractor to work in Dubai for a Chinese construction project led by an American Architect and designed by a group of Singapore and Hong Kong engineers, using many constructional materials and building products shipped from all over the world: Australia, Belgium, and South Africa. Many workers are Koreans!

The world has truly evolved into a place that globalization has already in full swing, shaping our outlook and aspiration.

It is well known to many of us that the highly acclaimed Structural Eurocodes have been officially published in the last few years after a couple of decades of drafting, development and trial applications. The Structural Eurocodes are expected to be adopted throughout all the European countries, and they serve as important technical documents for harmonization of the design and construction requirements in the European countries. Similar code developments are found in many parts of the world, such as the design code for cold formed steel structures in the North America as well as the model concrete code in Asia. More recently, there are notably a number of codification activities in several countries in Asia on steel and composite construction: Japan on steel bridges, Hong Kong on steel and composite buildings, Thailand on structural steel design. Moreover, both Singapore and Malaysia are heavily engaged into the exploration of new direction of their steel construction industries into the next decades.

2 HARMONIZED CODIFICATION

It is interesting to note that there is actually a complete change of attitude towards harmonized codification over the past few decades. In the early days of Eurocodes, there were actually considerable resistances towards the development of a single set of documents of codes of practice to be adopted throughout Europe. While some people concerned about the invasion of foreign competitors, many people simply failed to comprehend the huge opportunities which came along with the possible threats. As expected, agreements and consensus during code development did not come naturally either, and a great deal of efforts was spent in proposing suitable design rules as well as re-formulating design expressions into a consistent format. The situations were further complicated in certain cases in which only limited relevant test data were available, or several established but distinctive design methods were widely adopted in different countries.

However, nowadays, the general responses to harmonised codification are very positive, and this may be explained by the following observations. Firstly, the fundamental concepts of harmonised codification have been firmly established after many years of design development by engineers, researchers and code drafters. These concepts have been widely publicized in the literature, and they are readily adopted in subsequent design development progressively in the last two decades. Secondly, the modern design philosophy, namely, the limit state design, is widely adopted, and many design methods with rational basis rather than empirical expressions are available. This greatly facilitates re-formulation of these design methods into a consist format, if needed. Thirdly, modern design tools including rational design procedures, design rules with highly involved mathematics, and integrated analysis and design methods with finite element modelling demand the design methods to be completely rational.

In general, both the technical expertise and the resources available during the preparation of relevant background documents are often found to be instrumental to the code drafting and developing process.

3 MODERN DESIGN CODIFICATION

A review on the composition of many modern structural design codes reveals a typical layout as follows:

a) Materials
   - Physical, chemical and mechanical properties
   - Requirements on structural performance
b) Sections and dimensions
   - Typical shapes and sizes, limiting dimensions and scope of applications
c) Section capacities
   - Section capacities under single actions
   - Section capacities under combined actions

d) Member resistances
   - Member resistances under single actions
   - Member resistances under combined actions
e) System behaviour
f) Connection design
   - Force analysis methods
   - Basic resistances of fasteners, fixings and connectors
   - Detailing rules

All these sections are considered to be essential for effective control on the design of a structure, and the given layout is considered to be a simple, effective, and structured arrangement to assist a structural engineer to perform his design in practice.

In general, a practical design code is expected to provide all key design requirements and considerations for a structural engineer to perform structural design. Moreover, proven design methods are also provided to assist the structural engineer to justify structural adequacy of a structure in a professional manner. In practice, the design code is considered to be a legal document for the structural engineer in many incidents to perform his statutory duty to his client as well as to the regulatory authority. Consequently, the design clauses in the code are often written and compiled in a prescriptive approach, i.e. everything is spelled out with every use cautioned and every limit defined. While the majority of the design clauses are well controlled, there are occasions that the design becomes grossly conservative or things become unnecessarily complicated when interpretation between the lines of the design clauses is required, or the design is operating beyond the intended use of the design clauses. Hence, the prescriptive approach is generally considered to be restrictive, and little information is provided once the limits of the design clauses are crossed.

With recent advances in design development of structural design codes, performance-based approach should be considered as a major advancement which enables and promotes rational design and analysis on the structural behaviour of a structure, providing both guidance and comprehension during design. In general, the design method in a modern design-friendly code is formulated in such a way that a structural engineer is able to perform the design with comprehension on its principles when working through the design procedures. The design procedures are complied in a fashion that the structural engineer is able to make choices on the calculation efforts he is prepared to give against the structural accuracy and economy of the structure he requires. Moreover, he should be able to decide whether it is sufficient to adopt simple and conservative data, or it is necessary to evaluate specific design parameters precisely according to the situation he is dealing with. When the structural engineer is making choices and decisions as the design proceeds, he is able to control the design more rationally, engineering not just the final product, but also the design process.

With the wealth of technological knows-how available in the international communities of structural engineering, it is the right time now to exploit the enormous advantages offered by the performance-based approach to capture the research findings of many researchers all over the world, and to compile all the design information in a consistent and user-friendly format which go beyond geographical barriers.

4 GENERALIZED DESIGN RULES

It is very interesting to review the development of a number of national steel codes, and to examine some of the design methods and clauses which have evolved over the years; an illustration on member buckling check is given below. It is about to see how the use of the slenderness of a member which is a structural parameter derived from structural mechanics against elastic buckling facilitate ensures simple and direct evaluation of member resistances for hot rolled steel columns and beams, cold formed steel columns and beams, as well as composite columns.

4.1 Member Buckling Check of Hot-rolled Steel Sections in British Steel Codes

Consider the member buckling check in the British Steel Code BS449 or BS5950 (BSI, 1985; BSI, 1990; BSI, 2000). For a column susceptible to axial buckling, the slenderness of the column, λ, has been established for many years, and it is defined as follows:

$$\lambda = \frac{L_e}{r_y} \tag{1}$$

where

- L_e is the effective length of the column, depending on its restraining conditions in both directions; and
- r_y is the radius of gyration of the cross-section of the column, depending on cross-section geometry.

It should be noted that λ is an important structural parameter of a column which is a direct measure of the tendency of the column undergoing elastic buckling. Through a non-linear interaction curve, which is commonly referred as the Perry-Robertson formula, the effect of axial buckling in a real column is expressed as *a reduction in its design strength from its yield value*, i.e. *a compressive strength*. The compressive strength of a real column with material and geometrical initial imperfection is readily obtained through a specific column buckling curve after considering material yielding and geometrical instability. It should be noted that based on the section shapes and sizes as well as the bending axes during buckling of the columns, a total of four column buckling curves are established after careful calibration against test data. For columns with fabricated sections made of thick steel plates, the design methodology is the same although the design yield strengths of the columns should be reduced by 20 N/mm^2 to allow for the presence of high residual stresses due to welding.

For a beam susceptible to lateral buckling, an equivalent slenderness of the beam, λ_{LT} , is devised, and it is defined as follows:

$$\lambda_{LT} = u\,v\,\lambda \tag{2}$$

where u and v are secondary section properties of the beam related to lateral bending and torsion.

The adoption of the equivalent slenderness of the beam is a good example of harmonized codification, and both the design parameters, u and v, may be considered to be correction factors which enable lateral buckling check of a beam to be performed in a way very similar to axial buckling check of a column. Hence, the effect of lateral buckling in a real beam is expressed as *a reduction in its design strength from its yield value*, i.e. *a bending strength*. The bending strength of a real beam with material and geometrical initial imperfection is readily obtained after considering material yielding and geometrical instability. It should be noted that there is only one beam buckling curve in BS5950 while different design coefficients are adopted for hot rolled and fabricated beam sections. For standardized steel sections, tabulated values of u and v are readily found in section dimensions and properties tables.

Hence, it is demonstrated that in both buckling checks of columns and beams, the design methods are considered to be highly structured and rationally, and all design parameters and coefficients are derived explicitly with analytical formulation. However, it should be noted that the structural adequacy and economy of the design methods often hinge on one single value, the effective length of the member. Up to the very presence, there is still little or no effective means to examine the buckling behaviour of a particular member in a structure except through advanced finite element modelling, and the determination of the effective length of the member, and hence, the member slenderness, remains largely empirical.

4.2 Member Buckling Check of Cold-formed Steel Sections

In order to adopt harmonized codification, both buckling checks of cold formed steel columns and beams (BSI, 1987; BSI, 1998) are formulated in a way very similar to those of hot rolled steel sections. Hence, the effects of member buckling in real columns and beams are expressed as *reduction in their design strength from their yield values*, i.e. *compressive* and *bending strengths* respectively. Local buckling in cold formed steel members is, however, allowed for through the adoption of effective cross-sections, and no interaction between local buckling in flat plate elements of a cross-section and overall bucking with different buckling mode shapes in a member are considered at all. It should be noted that there is only one buckling curve for columns and also one buckling curve for beams.

4.3 Member Buckling Check in European Codes

It is interesting to note that the harmonized design checks for both axial and lateral buckling of steel members given in BS5950 have been adopted in Eurocode 3 (BSI, 2003) with different formulation. The design rules are re-formulated in such a way that the effects of member buckling in real steel columns and beams are expressed as *reduction to the basic section capacities of the members,* i.e. strength reduction factors, χ_c and χ_b , to the axial compression capacities and the moment capacities of the members respectively. Moreover, modified slenderness ratios are adopted, and they are defined as follows:

$$\bar{\lambda} = \frac{\lambda}{\lambda_Y} \quad \text{or} \quad \sqrt{\frac{P_c}{P_{cr}}} \qquad \text{for axial buckling of columns} \tag{3}$$

and

$$\bar{\lambda}_{LT} = \frac{\lambda_{LT}}{\lambda_Y} \quad \text{or} \quad \sqrt{\frac{M_c}{M_{cr}}} \qquad \text{for lateral buckling of beams} \tag{4}$$

where

λ_Y is a material parameter given by:

$$= \pi\sqrt{\frac{E}{p_y}};$$

E is the elastic modulus of steel;
p_y is the design yield strength of steel;
P_c is the section capacity of the column;
P_{cr} is the elastic critical buckling resistance of the column;

$$= \pi^2 \frac{EI}{L_e^{\,2}}$$

I is the second moment of area of the cross-section of the column;
L_e is the effective system length;
M_c is the moment capacity of the beam; and
M_{cr} is the elastic critical buckling moment resistance of the beam

It should be noted that the modified slenderness ratio is defined either as a ratio of the geometrical slenderness to the material parameter of the member, or a ratio of the square root of the section capacity of the member to its corresponding elastic critical buckling resistance. Hence, the design methods are "normalized" against the mechanical properties of the members, and they are equally applicable to other materials, such as metal and timber structures, provided that calibration against geometrical and mechanical initial imperfections has been performed. There are five different buckling curves for columns while four for beams, and the selection depends on the section types and sizes, and bending axes, if applicable.

4.4 Member Buckling of Composite Columns

For composite columns with concrete encased H sections or concrete in-filled hollow sections, the same design methodology has been adopted in Eurocode 4 (BSI, 2004), and the axial buckling resistances of the composite columns are based on the modified slenderness ratio which is defined as follows:

$$\bar{\lambda} = \sqrt{\frac{P_{cp}}{P_{cp,\,cr}}} \qquad (5)$$

where P_c is the section capacity of the composite column, and it is equal to the sum of the section capacities of individual components: concrete core, steel section and steel reinforcement;

$P_{cp,cr}$ is the elastic axial buckling resistance of the composite column;

$$= \pi^2 \frac{(EI)_{cp}}{L_e^{\,2}}$$

$(EI)_{cp}$ is the effective flexural rigidity of the composite column, and it is equal to the sum of the effective flexural rigidities of individual components: concrete core, steel section and steel reinforcement; and

L_e is the effective system length.

Hence, the effect of axial buckling in real composite columns is expressed as *reduction to the basic section capacities of the members,* i.e. a strength reduction factor, χ_c , to the compression capacities of the composite cross-sections of the columns. There are three different column buckling curves, and the selection depends on the section types and the bending axes.

Consequently, it is demonstrated that by adopting the same design methodology, i.e. a slenderness ratio of a member or its associated resistance ratio, the effect of buckling is readily expressed as a strength reduction factor to either the section capacity or the member resistance through a non-linear interaction curve. The same methodology is shown to be highly satisfactorily in hot rolled steel, cold formed steel as well as composite columns and beams. Moreover, the adoption of different buckling curves enables wide coverage of cross-sections of different shapes and sizes as well as bending axes when the members buckle. It should be noted that while harmonized codification is highly satisfactorily in member buckling as well as section capacities under combined actions, there are certainly room for improvement in other areas, for examples, slender beam-columns under combined compression and bending.

5 DEVELOPMENT OF THE HONG KONG STEEL CODE

The historical background of the codes of practice and the regulatory control for the construction of steel structures in Hong Kong were initially derived from the London By-laws and then BS 449. The first limit state steel code BS5950:1985 was hardly used in Hong Kong as the Buildings Authority of the Government of Hong Kong published its own steel code based on permissible stress design philosophy in 1987. The subsequent revisions of BS5950: 1990 and BS59590: 2000 were well received in Hong Kong, and they are commonly used in the design of both temporary and permanent structures.

In recognition of the stated aim of the Government of the Hong Kong Special Administrative Region to develop a technologically driven and knowledge based society in 2000, the Buildings Department commissioned a number of consultancy studies to produce codes of practice for the local construction industry: the Concrete Code, the Precast Concrete Code, the Wind Loading Code, the Foundation Code, the Demolition Code, as well as the Loading Code.

In October 2002, the Buildings Department promulgated a consultancy study entitled "*Structural Use of Steel using Limit State Approach*". After formal tendering, the consultancy study was awarded to a joint venture formed between Ove Arup & Partners Hong Kong Limited and The Hong Kong Polytechnic University in February 2003. It was required to deliver a technologically advanced and yet concise single volume document for the construction industry in Hong Kong and the Region, covering various aspects of analysis, design, fabrication and construction of steel and composite structures. The project was completed within two and a half years.

The Code is intended to encourage the effective use of structural steel in both steel and composite structures based on worldwide best practice and design philosophies presented in various national codes. With the help of an International Advisory Committee which comprises of prominent academics, researchers and engineers worldwide, the Code is able to present modern design methodologies for steel and composite structures with coordinated formulation. Moreover, the design methods are presented in consistent formats which are found to be user-friendly among practitioners. Specific guidance is also given in the Code to cover a number of important topics on high-rise buildings.

In order to provide a platform for technical exchanges on various key issues on steel and composite construction between international code developers and the project team members, international symposia as well as special sessions in international conferences were organized and participated:

- International Symposium on Worldwide Codified Design and Technology in Steel Structures, 9 – 10 February 2004, Hong Kong SAR, China
- International Conference on Steel and Composite Structures, 2 – 4 September 2004, Seoul, Korea
- International Symposium on Cold formed Metal Structures, 10 December 2004, Hong Kong SAR, China
- International Conference on Advances in Steel Structures, 13 – 15 June 2005, Shanghai, China
- Second International Symposium on Worldwide Codified Design and Technology in Steel Structures, 17 -18 June 2005, Hong Kong SAR, China
- International Symposium on Advances in Steel and Composite Structures, 2 December 2005, Hong Kong SAR, China
- Second International Symposium on Recent Developments on Fire Protection in Structures, 12 January 2006, Hong Kong SAR, China
- International Symposium on Worldwide Trends and Development in Codified Design of Steel Structures, 2 – 3 October 2006, Singapore, and 5 – 6 October 2006, Kuala Lumpur, Malaysia
- Second International Symposium on Cold formed Metal Structures, 8 December 2006, Hong Kong SAR, China

Moreover, as it was extremely important for the local construction industry to participate in the code drafting process, a number of industry-wide consultation meetings were held during the project period, and the project team was able to present various parts of the draft code to all stakeholders in order to proactively solicit their supports and contributions.

The Code was officially published in August 2005 (Buildings Department, 2005), and the complete document is available for free download in the official web-site of the Buildings Department of the Government of Hong Kong SAR (http://www.bd.gov.hk).

6 DEVELOPING A MODERN STEEL CODE IN ASIA

During the compilation of the Hong Kong Steel Code, the following observations are made which may be considered as useful guidelines in developing a national steel code or even a regional steel code in Asia.

6.1 Concrete as The Industry Norm

Concrete has long been widely used in building construction, and the construction industry is developed in such a way that many aspects of design and construction activities fit in very well with the use of concrete. Hence, concrete is generally regarded as the norm, i.e. simple and straightforward.

However, steel construction has a very different set of design and construction activities which is generally different from those of concrete construction. As steel structures are slender structures when compared with their concrete counterparts, various important design issues on their structural behaviour such as member buckling, excessive deformation and responses to fire should be considered. Moreover, it should be noted that steel construction is basically a form of prefabricated construction which replies heavily on site assembly of structural members through bolts or welding. Hence, different skills are needed in the complete production cycle: fabrication drawings, material procurement, shop fabrication, delivery, site installation, welding, corrosion and fire protection, inspection…etc. Many skilled workmen with different expertise are required on site, and guidance on established and preferred construction practice is highly desirable.

6.2 Co-ordinated Code of Practice with Consistent Methodologies

It is very important to disseminate all these technical information on the design and construction activities of steel construction in a co-ordinated code of practice with consistent methodologies to everybody in the construction industry: designers, independent checkers, regulatory authorities, construction personnel, third party inspection and quality control personnel. In the absence of such a code of practice, there will be many competing design methods and practice with different methodologies and limits of applications *ready* for adoption in the construction industry, leading to frustration, abortive work, as well as loss of efficiency and competitiveness.

In general, such a code is warmly welcomed by the construction industry, as many players in the construction industry will be benefited from the code, and probably all players will be in the long run. Moreover, it is very important to hold high-level consultation regularly with the construction industry: government departments, professional bodies, academic institutions, and specialist groups. Although they are the end-users of the code, they should be part of the drafting process, commending or criticizing the drafts as well as shaping the code into an industry-friendly document.

6.3 Development for and from The Industry

Any code of practice should be developed alongside with the current practice of the industry. This is definitely no exception for a steel code. It will be much easier to improve and expound the current practice, rather than introduce something totally new and different. A steep learning curve on steel construction will have direct impact on the construction industry, and people will simply shy away from the change, and move on with concrete. In reality, a successful implementation of a new code is believed to reply largely on the current technical levels of the local industry while advances in steel construction should be introduced to the local construction industry at a staged manner.
Moreover, it will be interesting to realize that many sectors of the construction industry have compiled a set of technical documents which fit well into their local context for their own use, such as steel building products supply, steel fabrication, welding and non-destructive tests. It will be extremely helpful to involve them and seek their active contribution at the initial phrase of the code drafting in order to avoid disappointment, or major embarrassment at a later stage.

6.4 Harmonization on Material Supply

One of the major driving forces for regional harmonized codification is the material supply. Unlike the concrete construction in which local materials are often employed, steel building products are international trades, and they are shipped all over the world for construction. With the advances in material technology and product developments in many parts of the world, a lot of building products which are developed under a specific national code are often sold to foreign countries with different design requirements and considerations. In order to justify local use of overseas building products, a great deal of effort is needed to re-design and re-test the products according to local conditions and practice. As a whole, this is a very expensive process as it tends to happen many times in the construction industry. A regional harmonized codification will be able to improve the situation greatly as any product re-development will be applicable to the region rather than merely to a single country.

6.5 International Advisory Committee

It will be highly beneficial to establish an International Advisory Committee which comprises of prominent academics, researchers and engineers worldwide. This will be one of the most important technical resources to ensure assess and integration to both the modern design methodologies and the latest international trends of codification.

7 A MODERN STEEL CODE FOR ASIA

Some essential aspects of a modern design code for Asia (Chung, 2006) are highlighted for general consideration.

7.1 Cross-referencing of Material Requirements

Due to the diversity of material sources of foreign steel building products, it is often necessary to refer to their respective national material codes. While this may be very straightforward in the majority of incidents, it may turn into a major operation if the materials do not come from the 'usual sources'. In a steel design code, while it is customary to simply cross-referencing to specific clauses of a material code, it will be extremely helpful to quote directly the specific technical requirements. In general, this will give a better picture to everybody involved about what is really required technically, i.e. all the material requirements should be written in a performance-based approach. Hence, the approach allows justifications to these requirements to be provided in a technical basis.

It should be noted that due to the complexity of steel construction, and the large number of different materials, structural sections, components and fasteners involved in steel and composite structures, the compilation of a chapter on material requirements is a major undertaking. It is interesting to note that this chapter will likely be the most 'wanted' document as such information is desperately needed in the construction industry.

7.2 Harmonized Codification for Hot-rolled Steel, Cold-formed Steel and Composite Structures

It will be highly desirable to adopt harmonized codification for hot rolled steel, cold formed steel and composite structures as far as technically feasible as this will simplify the overall design procedures in practice. It will also greatly facilitate both the learning and the application processes of these design methods as it is only necessary to get familiar with those rules with any one of these materials, probably those of steel structures.

In general, all the design clauses should be presented in a user-friendly manner to assist practical use. They should be arranged in line with regular design procedures: design strength, section classification, section capacities, member resistances, system behaviour and connection design. Design rules against both strength and stability should be rationalized, and design tables and charts should be provided.

7.3 *Preferred Construction Practice*

It is important to provide guidelines on preferred construction practice on both shop fabrication and site activities. Moreover, details on quality control on steel and composite structures should be provided, and reference to specialist documents will be highly beneficial.

8 CONCLUSIONS

Owing to rapid infrastructure developments in a number of cities and countries in Asia, there is a genuine need to develop a modern code on steel and composite buildings which is applicable throughout Asia. In this paper, experiences are drawn from the recent drafting of the Hong Kong Steel Code which is compiled by a joint venture between academics and engineers over a period of two and a half years. In general, it is considered that the situations of the steel and composite construction in Hong Kong are widely shared in the neighbouring countries, and similar courses of action are highly recommended to increase both the efficiency and the competitiveness of the construction industry in the region.

While the development of a regional steel code is a matter of codifying advanced steel construction technology within the local context in Asia, it is also a matter beyond structural engineering. The participation of professional institutions and government bodies in all the Asian countries is instrumental for the successful compilation as well as the practical implementation of the regional steel code. Nevertheless, a modern design code for steel and composite construction is emerging in Asia in the 21st century, all depending on the availability of financial resources, technical expertise as well as political will in order to accomplish the feat in good time.

REFERENCES

1. British Standards Institution (1985). *BS5950 Structural use of steelwork in building*. Part 1: Code of practice for design in simple and continuous construction: hot rolled sections.
2. British Standards Institution (1990). *BS5950 Structural use of steelwork in building*. Part 1: Code of practice for design in simple and continuous construction: hot rolled sections.
3. British Standards Institution (2000). *BS5950 Structural use of steelwork in building*. Part 1: Code of practice for design of hot rolled and welded sections.
4. British Standards Institution (1987). *BS5950 Structural use of steelwork in building*. Part 5: Code of practice for design of cold formed sections.
5. British Standards Institution (1998). *BS5950 Structural use of steelwork in building*. Part 5: Code of practice for cold formed thin gauge sections.
6. British Standards Institution (2003). *BS EN 1993-1-1: 2003 Eurocode 3: Design of steel structures*. Part 1.1: General rules and rules for buildings.
7. British Standards Institution (2004). *BS EN 1994-1-1: 2004 Eurocode 4: Design of composite steel and concrete structures*. Part 1.1: General rules and rules for buildings.
8. Buildings Department, the Government of Hong Kong SAR (2005). *Code of Practice for the Structural Use of Steel*.
9. Chung, K F 2006, 'Developing a performance-based design code for steel and composite structures in Asia', *Proceedings of International Symposium on Worldwide Trends and Development in Codified Design of Steel Structures 2006*. Association of Consulting Engineers Malaysia, edited by L M Wong, T K Sooi and S P Chiew, pp. 35-45.

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Geotechnical standards in Hong Kong

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(This paper has been prepared based on the paper prepared by Pun, et al (2006) on the same topic for International Symposium on New Generation Design Codes for Geotechnical Engineering Practice, November 2 and 3, 2006, Taipei, Taiwan)

1. INTRODUCTION

Hong Kong has a very hilly terrain as shown in Figure 1 below. After the war, Hong Kong has experienced rapid economic growth, together with extensive civil engineering and building works. This resulted in the formation of a considerable number of man-made slopes and retaining walls in the dense urban environment. Before 1977, slopes and walls were designed and formed by the rules of thumb. So the slopes and walls on such hilly terrain were prone to landslides during seasonal tropical rainstorms.

Figure 1 – Hilly terrain and concentrated developments in Hong Kong

The 18th June 1972 must be the darkest day in the landslide history of Hong Kong. Tragedies struck one after another. The first occurred in the afternoon on a fill slope in Sau Mau Ping after days of heavy rain. 78 squatter huts were buried and 67 people were killed. Natural disasters make no distinction between rich and poor. In the evening on the same day, another landslide occurred at Po Shan Road in the mid-levels. A 12-storey apartment building was completely knocked down by the landslide debris, killing 71 people. Four years later in 1976, a fill slope behind Sau Mau Ping Estate collapsed during heavy rain. The landslide debris poured into the lower floors of Block 9 as shown in the photo, killing 18 people.

These three fatal landslides in the 1972 and 1976 resulted in a very great loss of life and property. So in 1977, the Hong Kong Government set up the Geotechnical Control Office to deal with slope safety problems in the territory. The GCO was renamed to the Geotechnical Engineering Office, i.e. GEO, in 1992 and is now under the Civil Engineering and Development Department of the Hong Kong SAR Government. The primary responsibilities of the GEO are setting geotechnical standards, exercising geotechnical control, upgrading sub-standard slopes and providing public education on slope safety.

Since its establishment, the GEO has strived to ensure the highest standard of slope safety in Hong Kong. The successful results can be reflected in this slide in the drastic drop in the landslide fatality rate since the GEO was formed in 1977.

2. SETTING OF GEOTECHNICAL STANDARDS IN HONG KONG

2.1 Setting Standards

An important function of the GEO is setting geotechnical standards. Since its establishment, the GEO has produced many publications covering a wide range of geotechnical engineering topics. The more comprehensive ones are called Manuals, Geoguides and Geospecs (Table 1). The main objective of publishing these documents is to allow the profession to use a series of common, up-to-date and comprehensive geotechnical standards which are appropriate to Hong Kong conditions. The documents present recommended standard of good practice for various geotechnical activities.

Figure 2 - Some publications by the GEO

Table 1: List of Manuals, Geoguides and Geospecs

Manuals:
- Geotechnical Manual for Slopes, 2nd edition
- Highway Slope Manual

Geoguides:
- Geoguide 1: Guide to Retaining Wall Design, 2nd edition
- Geoguide 2: Guide to Site Investigation
- Geoguide 3: Guide to Rock and Soil Descriptions
- Geoguide 4: Guide to Cavern Engineering
- Geoguide 5: Guide to Slope Maintenance, 3rd edition
- Geoguide 6: Guide to Reinforced Fill Structure and Slope Design

Geospecs:
- Geospec 1: Model Specification for Prestressed Ground Anchors
- Geospec 3: Model Specification for Soil Testing

Apart from the above, the GEO has also published other documents series. They document results of comprehensive literature reviews, or generally present results pf applied researches and studies. Another series is theTechnical Guidance Notes.

Up to mid-2006, the GEO has released some 300 publications. A full list of GEO publications is available from the CEDD website (www.cedd.gov.hk).

2.2 Status of the Publications

Regarding the status of GEO's publications, the prevailing government policy is that the details of all permanent geotechnical works of public or private projects shall be submitted to the GEO for checking or approval. The policy also stipulates that related activities, including investigations, designs and works, shall be carried out in accordance with the prevailing standards. A certain GEO guidance documents are adopted as local geotechnical standards by the HK SAR Government.

The standards adopted for public development projects are generally also adopted for private building and civil engineering developments in Hong Kong. This is achieved through the Buildings Ordinance (Law of Hong Kong – Chapter 123) and its related Regulations and Practice Notes.

2.3 Process of Production of Guidance Documents

The GEO prepares new standards and guidance documents as needed. In the process of producing standards or documents, the GEO will benchmark against international geotechnical standards and adapt them in Hong Kong as appropriate. This is to suit local conditions, practice and environment. Extensive consultation among practitioners is always carried out in the setting of geotechnical standards. This is to ensure that the document is considered a consensus document by interested parties in Hong Kong.

3. STANDARDS FOR DIFFERENT TYPES OF GEOTECHNICAL WORKS

Different design approaches have been adopted in Hong Kong for different types of geotechnical works. This is evolving to suit the local conditions and practices within each type of work. Traditionally, all types of works are designed using the global factor of safety approach. But developments in limit state design with the use of partial factor method has also been gaining experience in Hong Kong. Let's go through the design standards of some major geotechnical works.

3.1 Slopes Works

For slope works, the GEO first published the Geotechnical Manual for Slopes in 1979 and then a second edition in 1984. The Manual gives guidance for the standard of practice for slope design and construction. The Highway Slope Manual published in 2000 further supplements the Geotechnical Manual by giving a standard of good practice on highway slope engineering. The slope design approach adopted by the Manuals is the theoretical global stability analysis based on limit equilibrium methods. Minimum global factors of safety are stipulated for slopes of different consequence categories. Also, slopes should be designed for the groundwater conditions that would result from rainfall with a return period of 1 in 10 years.

3.2 Retaining Structures

The Geoguide 1 – Guide to Retaining Wall Design published in 1993 gives a standard of good practice for the design and construction of new permanent earth retaining wall. Besides, Geoguide 6 – Guide to Reinforced Fill Structure and Slope Design published in 2002 provides a standard of good practice for the design and construction of new permanent reinforced fill structures and slopes.

Geoguide 1 – Guide to Retaining Wall Design (GEO, 1993) recommends a standard of good practice Both Geoguides 1 and 6 share the same design approach. It is to use limit state design against the occurrence of different limit states. We generally focus on the Serviceability Limit State and the Ultimate Limit State. Then different partial factors of safety will be used for different types of loadings and material parameters. As illustrated below, the partial factor at the Ultimate Limit State for the dead weight and the drained shear strength of soil is 1.0 and 1.2 respectively. The factor for the dead weight of the retaining wall is also 1.0. But the factor for surcharge will be 1.5 to cater for more uncertainty. The design groundwater level should be based on the worst credible groundwater conditions that will arise in extreme events.

Table 2: Minimum Partial Load and Material Factors for Use in Retaining Wall Design against Ultimate Limit States

Loading/Material	**Partial Factor**
Dead load due to weight of the retaining wall, soil, rock and water	1.0
Surcharge	1.5
Seismic load	1.0
Water pressure	1.0
Unit weight of soil, rock, water and structural material	1.0
Drained shear strength and base friction angle of soil	1.2
Undrained shear strength of soil	2.0
Shear strength of rock joint	1.2
Compressive strength of rock	2.0
Permeability of soil/rock	1.0
Permeability of granular filter and drainage material	10.0

3.3 Foundation Works

The Code of Practice for Foundation issued by the Buildings Department sets the standards and provides guidelines on design and construction of foundations for private developments in Hong Kong. The GEO first published in 1996 a technical reference document on pile design in Hong Kong. The second edition was published in 2006, i.e. GEO Publication 1/2006 – Foundation Design and Construction. Piles are generally designed on the basis of an adequate global factor of safety against ultimate failures of compression, tension and lateral resistance.

3.4 Temporary Excavation

For temporary excavation, GCO Publication 1/90 – Review of Design Methods for Excavations presents a review of design of temporary excavation and lateral support systems in Hong Kong. The Publication adopts the global factor of safety approach for the design of temporary excavation works to guard the retaining structures against sliding, uplift and overturning.

On the other hand, the CIRIA Report No. C580 "Embedded retaining walls – guidance for economic design", published in 2003, gives a different design framework. They advocate soil-structure interaction analyses with the limit state partial factor method of design. Both design approaches can be adopted for design of the temporary excavation and lateral support works in Hong Kong.

3.5 Cavern Construction

There has been an increasing interest in Hong Kong in placing some facilities underground, e.g. refuse transfer stations. So the GEO Geoguide 4 – Guide to Cavern Engineering recommends standard of good practice for civil engineering aspects of rock caverns. The cavern design adopts empirical methods with rock support assessment systems, e.g. Q-system or the Rock Mass Rating (RMR) Classification.

3.6 Reclamation

For Reclamation works, the Port Works Design Manual (CEO, 2002) gives guidance and recommendations on reclamation design, covering design considerations, stability analysis, settlement assessment and monitoring. The global factor of safety approach is used when designing the foundation of marine works against slip failure.

3.7 Summary of Design Approaches

Different design approaches have been adopted in Hong Kong for different types of geotechnical works as described above. This is evolving to suit the local conditions and practices within each type of the various geotechnical works. Traditionally, all types of works are designed using the global factor of safety approach. Developments in limit state design with the use of partial factor method has been gaining experience in Hong Kong.

4. FURTHER STANDARDS AND GUIDELINES RELATED TO SLOPE ENGINEERING

Other than the basic standards documents mentioned above, the GEO has also produced a number of guidance documents on specific subjects of geotechnical works. Geoguide 2 and Geoguide 3 present recommended standard of good practice for site investigation and description of Hong Kong rocks and soils respectively. Geospec 3 – Model Specifications for Soil Testing also gives the recommended standard methods for testing of soils in Hong Kong for civil engineering purposes. Some examples of the further standards and guidelines related to slope engineering are given in Table 3 and described below.

Table 3: Further Geotechnical Standards and Guidelines Related to Slope Engineering

Subjects	**Titles of Publication**
Site investigation	• Geoguide 2 – Guide to Site Investigation • Geoguide 3 – Guide to Rock and Soil Description • TGN 3 – Use of Downhole Geophysical Methods in Identification of Weak Layers in the Ground • TGN 24 – Site Investigation for Tunnel Works
Laboratory testing	• Geospec 3 – Model Specifications for Soil Testing
Prescriptive measures	• GEO Report No. 56 – Application of Prescriptive Measure to Slopes and Retaining Walls • TGN 9 – updating of GEO Report No. 56 • TGN 13 – Guidelines on the Use of Prescriptive Measures for Rock Cut Slopes • TGN 17 – Prescriptive Soil Nail Design for Concrete and Masonry Retaining Walls
Soil nailing	• TGN 18 – Acceptance of Methods for Quality Control • TGN 19 – Installation of Soil Nails and Control of Grouting • TGN 21 – Design of Soil Nail Heads • TGN 23 – Good Practice in Design of Steel Soil Nails for Soil Cut Slopes • HKIE Publication on Soil Nails in Loose Fill Slopes: A Preliminary Study (Final Report) • GEO Report No. 133 – Non-destructive Test for Determining the Lengths of Steel Soil Nails
Drainage	• GEO Publication No. 1/93 – Review of Granular and Geotextile Filters • TGN 27 – Hydraulic Design of Stepped Channels on Slopes
Fill slope recompaction	• TGN 7 – Fill Slope Recompaction – Investigation, Design and Construction Considerations
Slope maintenance	• Geoguide 5 – Guide to Slope Maintenance • GEO Report No. 136 – Guidelines on Safe Access for Slope Maintenance
Maintenance of water-carrying services	• Code of Practice on Inspection and Maintenance of Water Carrying Services Affecting Slopes
Natural terrain	• GEO Report No. 75 – Landslides and Boulder Falls from Natural Terrain : Interim Risk Guidelines • GEO Report No. 104 – Review of Natural Terrain Landslide Debris-

	resisting Barrier Design • GEO Report No. 138 – Review of Natural Terrain Hazard Studies • TGN 22 – Guidelines on Geomorphological Mapping for Natural Terrain Hazard Studies
Landscaping	• GEO Publication 1/2000 – Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls • TGN 20 – Updating of GEO Publication No. 1/2000

Proper slope maintenance is extremely vital to the continued stability of a slope. So the GEO published Geoguide 5 – Guide to Slope Maintenance gives guidance to slope owners on good practice for slope maintenance. The guidance requires at least annual Routine Maintenance Inspections and five-yearly Engineer Inspections for Maintenance by professional geotechnical engineers for man-made slopes and walls with high consequence to life.

Soil nailing has been commonly used as a slope stabilization technique in Hong Kong since the 1980s. It is in fact in the form of a steel bar installed into a slope or retaining wall by drill-and-grout method without prestressing. GEO has been conducting a series of soil nail studies. Improved technical guidelines for soil nail design and construction have been developed and published in TGN no. 19 and 23. Besides, the GEO is in fact preparing a new Geoguide on this area.

Other than the conventional analytical approach for slope design, the GEO first formulated the Prescriptive Measures in 1995. Prescriptive measures are pre-determined, experience-based and suitably conservative works prescribed to a man-made slope and retaining wall to improve its stability. No detailed ground investigation and design analysis is required. The GEO Report No. 56 gives a standard of good practice for using prescriptive measures as improvement works on soil cut slopes and masonry retaining walls. This slide here shows how soil nailing works can be prescribed on a cut slope.

It is common in Hong Kong to have water-carrying services, no matter buried or exposed, in the vicinity of slopes. The services include water mains, stormwater and sewer drains. Leakage from these services may cause slope failure even without notable signs of leakage. Therefore the GEO takes the lead to prepare this Code of Practice which gives guidance on monitoring and maintenance of water-carrying services affecting slopes.

In 1993, the GEO started studies on risk of landslides and boulder falls from natural terrain. GEO Report No. 75 established appropriate tolerable risk criteria for risk assessment purposes. The interim societal risk criteria for natural terrain landslide hazards recommended by the report are shown in Figure 2. The risk criteria framework, adopted by many overseas countries, consists of the following three regions: (i) unacceptable region, (ii)"as low as reasonably practicable" (ALARP) region, and (iii) broadly acceptable region. Two options are available but Option 1 is preferred. They serve as a basis for the evaluation of quantitative risk assessment results. The GEO has also produced guidelines on how to conduct a natural terrain hazard study in GEO Report No. 138. Apart from hazard assessment, the design of mitigation measures is also critical. GEO Report No. 104 gives guidelines on the design of debris-resisting barriers.

In the past decade, the GEO has been making concerted efforts to provide good aesthetics to slopes and retaining walls. So they published the GEO Publication 1/2000 which provides guidance on good aesthetic design for landscape treatment and bio-engineering for man-made slopes and retaining walls.

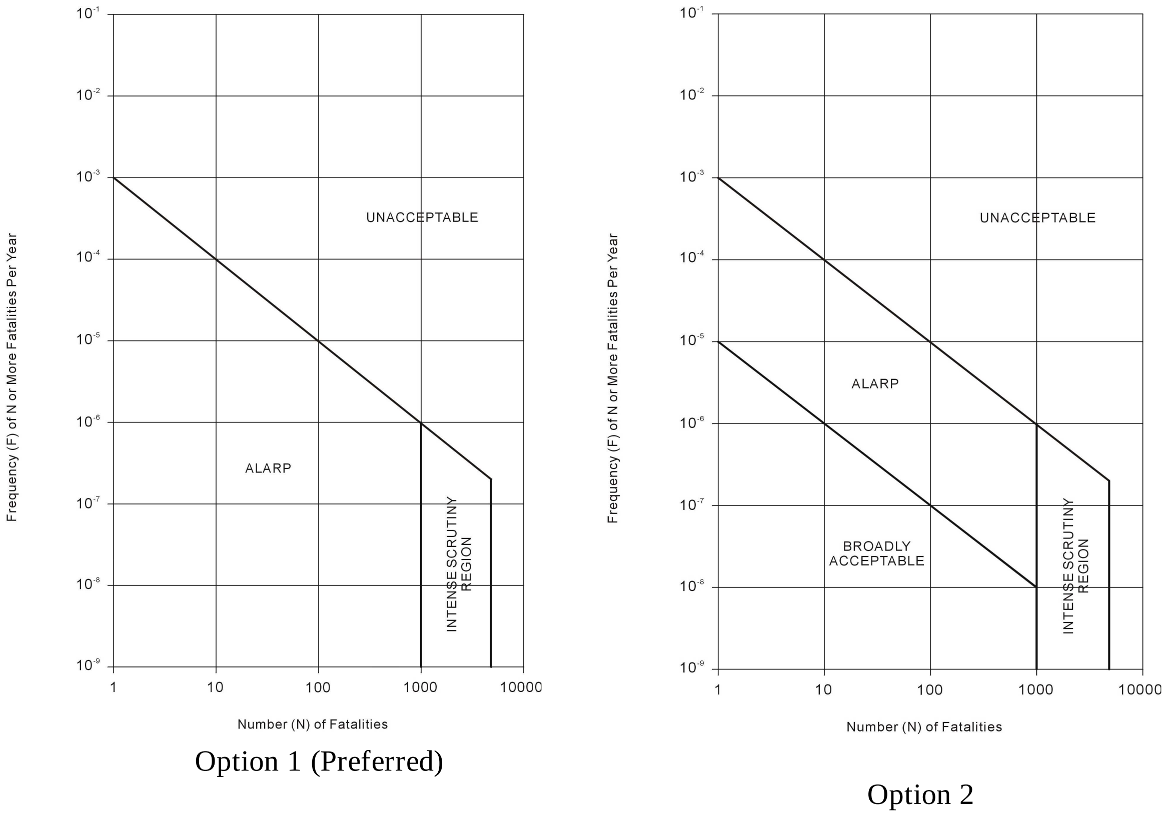


Figure 2 – The Recommended Interim Societal Risk Criteria for Landslides and Boulder Falls from Natural Terrain

4. CONCLUSIONS

There have been a number of geotechnical guidance documents produced in Hong Kong, in the form of Manuals, Geoguides, Geospecs and other publications and reports for the use of local practitioners. These documents aim to promote standards and good practice in different aspects of geotechnical engineering. These standards have been benchmarked against international ones and are adapted to suit local conditions and practices.

5. RELEVANT REFERENCES

BD (2004). *Code of Practice for Foundation.* Buildings Department, Hong Kong.

CEO (2002). *Guide to Design of Reclamation (Port Works Design Manual Part 3)*. Civil Engineering Office, Civil Engineering and Development Department, Hong Kong.

ERM (1998). *Landslides and Boulder Falls from Natural Terrain : Interim Risk Guidelines (GEO Report No. 75).* Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

ETWB (2006). *Code of Practice on Monitoring and Maintenance of Water Carrying Services Affecting Slopes*. Environmental, Transport and Works Bureau, Hong Kong SAR Government.

Gaba, A.R., Simpson, B., Powrie, W. and Beadman, D.R. (2003). *Embedded Retaining Walls – Guidance for Economic Design (Construction Industry Research & Information Association (CIRIA) Report No. C580)*. London.

GEO (1984). *Geotechnical Manual for Slopes (2nd Edition)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (1987a). *Guide to Site Investigation (Geoguide 2)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (1987b). *Guide to Rock and Soil Descriptions (Geoguide 3)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (1990). *Review of Design Methods for Excavation (GEO Publication No. 1/90)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (1992). *Guide to Cavern Engineering (Geoguide 4)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (1993). *Guide to Retaining Wall Design (Geoguide 1) (2nd Edition)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2000a). *Highway Slope Manual*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2000b). *Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (GEO Publication No. 1/2006)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2001). *Model Specification for Soil Testing (Geospec 3)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2002). *Guide to Reinforced Fill Structure and Slope Design (Geoguide 6)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2003). *Guide to Slope Maintenance (Geoguide 5) (3rd Edition)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2004a). Updating of GEO Report No. 56 – Application of Prescriptive Measure to Slopes and Retaining Walls, *GEO Technical Guidance Note No. 9*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2004b). Guidelines on the Use of Prescriptive Measures for Rock Cut Slopes, *GEO Technical Guidance Note No. 13*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2004c). Prescriptive Soil Nail Design for Concrete and Masonry Retaining Walls, *GEO Technical Guidance Note No. 17*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2004d). Updating of GEO Publication 1/2000 – Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls, *GEO Technical Guidance Note No. 20*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2005). Good Practice in Design of Steel Soil Nails for Soil Cut Slopes, *GEO Technical Guidance Note No. 23*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

GEO (2006). *Foundation Design and Construction (GEO Publication No. 1/2006).* Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

HKIE (2003). *Soil Nails in Loose Fill Slopes: A Preliminary Study (Final Report)*. Geotechnical Division of the Hong Kong Institution of Engineers.

Lo, D.O.K., 2000. *Review of Natural Terrain Landslide Debris-resisting Barrier Design (GEO Report No. 104)*, Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

Lumb, P. (1975). Slope failures in Hong Kong. *Quarterly Journal of Engineering Geology*, vol. 8, p. 31-65.

Ng, K.C., Parry, S., King, J.P., Franks, C.A.M. & Shaw, R., 2003. *Guidelines for Natural Terrain Hazard Studies (GEO Report No. 138)*. Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

Pun, W. K., Cheung, W. M. & Lui, L. S. (2006). Geotechnical Standards in Hong Kong, *Proceedings of International Symposium on New Generation Design Codes for Geotechnical Engineering Practice,* November 2 and 3, Taipei, Taiwan (Accepted for publication)

Wong, H.N., Pang, L.S., Wong, A.C.W., Pun, W.K. & Yu, Y.F. (1999). *Application of Prescriptive Measures to Slopes and Retaining Walls (GEO Report No. 56) (Second Edition).* Geotechnical Engineering Office, Civil Engineering and Development Department, Hong Kong.

Geotechnical Standards in Hong Kong

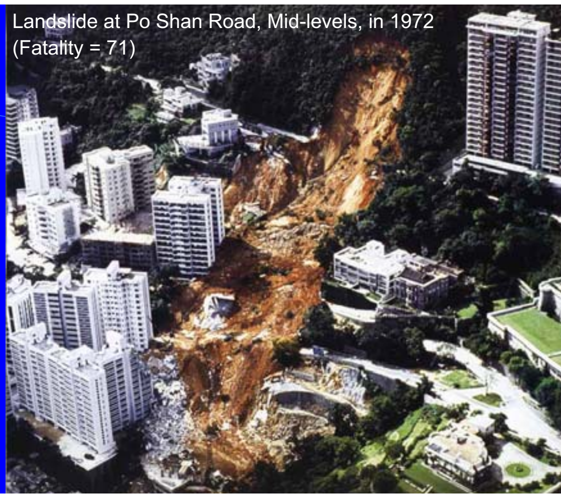
Introduction

- Hilly Terrain in Hong Kong ➔ formation of a large number of man-made slopes and retaining walls
- Before 1977, slopes & walls were formed and designed by rules of thumb ➔ prone to landslides under heavy rain

Major Disastrous Landslides in Hong Kong

Landslide at Sau Mau Ping in 1972 (Fatality = 67)

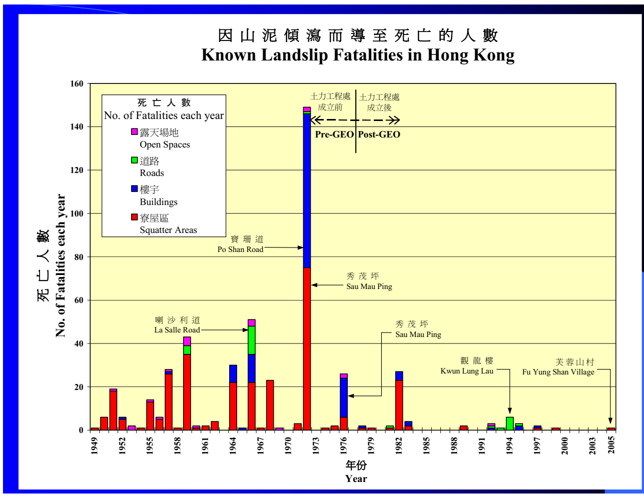
Landslide at Po Shan Road, Mid-levels, in 1972 (Fatality = 71)



Landslide at Sau Mau Ping in 1976 (Fatality = 18)

Establishment of the GCO/GEO

- The Geotechnical Control Office was established in 1977 (Renamed to Geotechnical Engineering Office, GEO, in 1992)
- Primary responsibilities:
  - Setting geotechnical standards
  - Exercising geotechnical control
  - Upgrading sub-standard slopes
  - Providing public education



Setting Geotechnical Standards

- One of the GEO's major functions : to set geotechnical standards, which should be common, up-to-date, comprehensive and appropriate to local Hong Kong conditions
- GEO has been producing guidance documents which present recommended standard of good practice for various geotechnical activities

3 Comprehensive Series of Publications

Geoguides

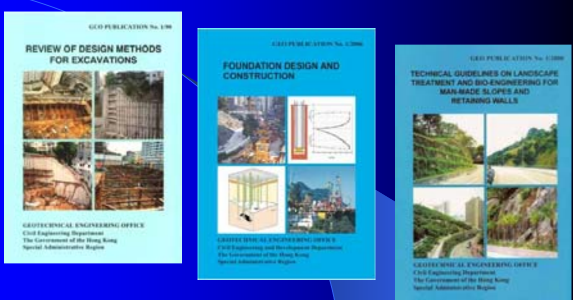
3 Comprehensive Series of Publications (Cont'd)

Manuals

Geospecs

Other Publications Series

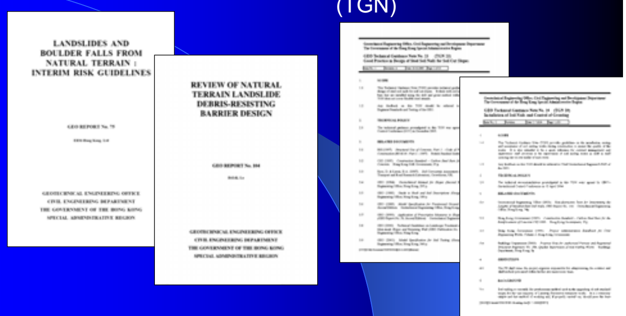
GEO Publications



Other Publications Series (Cont'd)

GEO Reports

Technical Guidance Notes (TGN)



www.cedd.gov.hk

Status of GEO's Publications

- Policy: All permanent geotechnical works of public or private projects shall be submitted to the GEO for checking or approval.
- All geotechnical activities shall be carried out in accordance with the prevailing standards.
- A certain GEO guidance documents are adopted as local geotechnical standards by the HK SAR Government

Process of Production of Guidance Documents

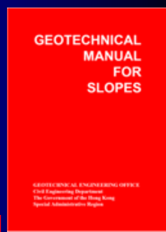
- GEO prepares new standards and guidance documents as needed, with the processes of :
  - Benchmarking against international geotechnical standards
  - Adapting the standards to suit local conditions
  - Consulting local practitioners to achieve a consensus

Standards for Different Types of Geotechnical Works

- Different design approaches are adopted in Hong Kong for different types of geotechnical works
  - ➔ To suit local conditions and practices within each type of work
- Limit state design with the use of partial factor method has been developing in Hong Kong over the traditional global factor of safety approach

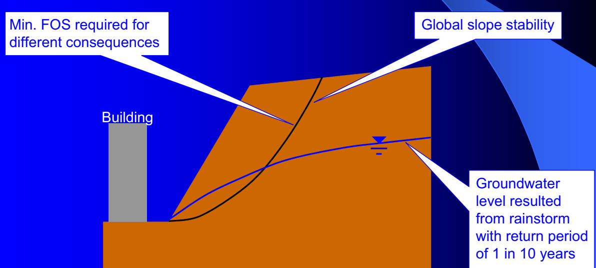
Slope Works

- Publications:
  - Geotechnical Manual for Slopes (2^{nd} Edition)
  - Highway Slope Manual



Slope Works (Cont'd)

- Adopted design approach : Theoretical global stability analysis based on limit equilibrium methods
- Minimum Global Factors of Safety (FOS) required
- Design Groundwater

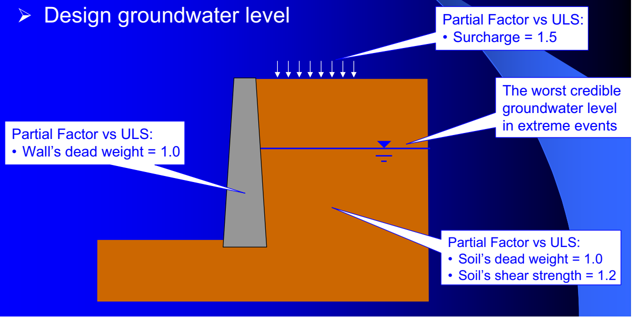


Retaining Structures

- Publication:
  - Geoguide 1 – Guide to Retaining Wall Design (2^{nd} Edition)
  - Geoguide 6 – Guide to Reinforced Fill Structure and Slope Design

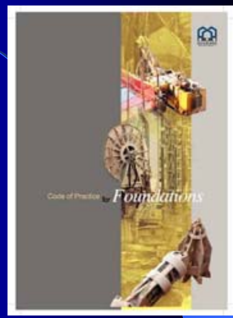
Retaining Structures (Cont'd)

- Adopted approach : limit state design against occurrence of different limit states
- Different partial FOS for different loadings & material
- Design groundwater level



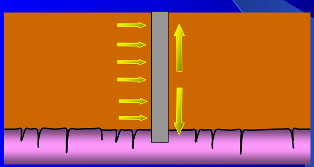
Foundation Works

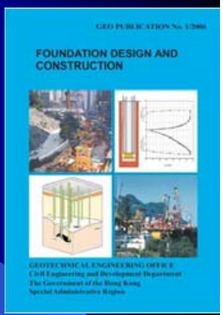
- Publication:
  Code of Practice for Foundations (published by the Buildings Department)
  - sets the standards and provides guidelines on design and construction of foundations for private developments in Hong Kong



Foundation Works (Cont'd)

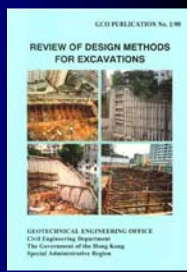
- Publication:
  GEO Publication No. 1/2006 – Foundation Design and Construction
  - adopts the global FOS approach for piles against failures in compression, tension and lateral resistance

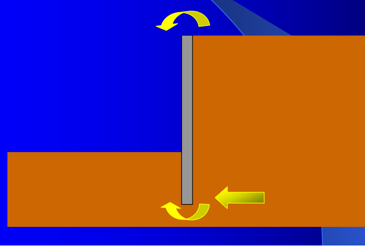




Temporary Excavation

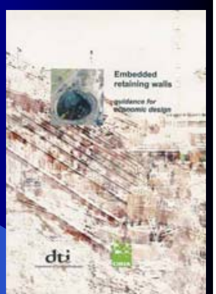
- Publication: GCO Publication No. 1/90 – Review of Design Methods for Excavations
  - adopts the global FOS approach for excavations against ultimate failures, e.g. sliding, overturning and uplifting





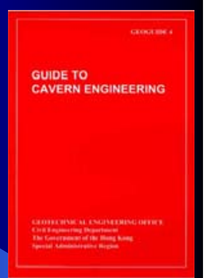
Temporary Excavation (Cont'd)

- Publication:
  CIRIA Report No. C580 – Embedded Retaining Walls - Guidance for Economic Design
  - advocates limit state partial factor method of design



Cavern Construction

- Publication:
  Geoguide 4 – Guide to Cavern Engineering
  - adopts empirical methods for cavern design using rock support assessment systems, e.g. Q-system or the Rock Mass Rating (RMR) Classification



Further Standards and Guidelines Related to Slope Engineering

Site Investigation & Laboratory Testing

- Publications:
  - Geoguide 2 – Guide to Site Investigation
  - Geoguide 3 – Guide to Rock and Soil Description
  - Geospec 3 – Model Specification for Soil Testing

Slope Maintenance

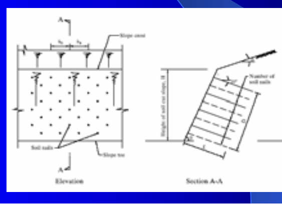
- Proper slope maintenance is extremely vital to continued stability of a slope
- Publication:
  Geoguide 5 – Guide to Slope Maintenance (3rd Edition)
  - Routine Maintenance Inspections - annually
  - Inspection by professional engineers - every 5 years

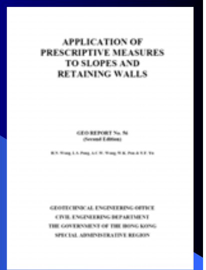
Soil Nails

- Soil nailing has been commonly used as a slope stabilization technique in Hong Kong
- Technical Guidance Notes (TGNs) :
  - TGN 19 – Installation of Soil Nails and Control of Grouting
  - TGN 23 – Good Practice in Design of Steel Soil Nails for Soil Cut Slopes
- A new Geoguide on design and construction of soil nails is underway

Prescriptive Measures

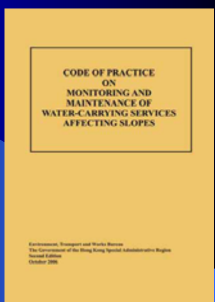
- Prescriptive Measures: Pre-determined, experience-based and suitably conservative works, i.e. soil nails, prescribed on a man-made slope/retaining wall to improve stability
- Publication: GEO Report No. 56 – Application of Prescriptive Measures to Slopes and Retaining Walls (2nd Edition)





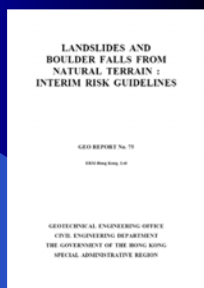
Water-carrying Services

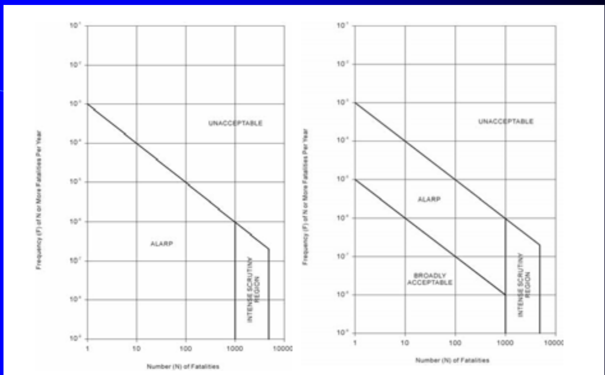
- Leakage from water-carrying services in the vicinity of slopes may cause slope failure even without notable signs of leakage
- Publication:
  Code of Practice on Monitoring and Maintenance of Water-carrying Services Affecting Slopes
  (Published by the Environment, Transport and Works Bureau)



Natural Terrain Landslide Risk

- GEO has been studying the risk of landslides and boulder falls from natural terrain
- Publication: GEO Report No. 75 - Landslides and Boulder Falls from Natural Terrain: Interim Risk Guidelines
  - Establish appropriate tolerable risk criteria for risk assessment purpose





Option 1 (preferred)   Option 2

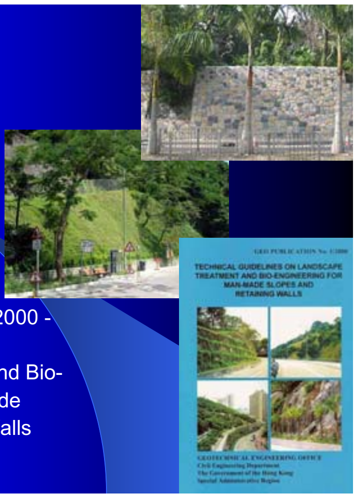
Recommended Interim Societal Risk Criteria for Landslide and Boulder Falls from Natural Terrain

Natural Terrain Landslide Risk (Cont'd)

- Some other studies:
  - GEO Report No. 104 – Review of Natural Terrain Landslide Debris-resisting Barrier Design
  - GEO Report No. 138 – Guidelines for Natural Terrain Hazard Studies

Slope Aesthetics

- GEO has been making concerted efforts to provide good aesthetics to slopes and retaining walls
- Publication:
  GEO Publication No. 1/2000 - Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls



Conclusion

- There have been a number of geotechnical guidance documents produced, in the form of Manuals, Geoguides, Geospecs and other publications and reports in Hong Kong.
- These documents aim to promote standards and good practice in different aspects of geotechnical engineering.
- The standards have been benchmarked against international ones and are adapted to suit local conditions and practices.

Thank You

The Development of Construction Codes and Standards in Vietnam

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1 INTRODUCTION

Vietnam is a developing country that covers 329,562 square kilometres in the South East Asia with a dense population of 84.4 million, estimated by July 2006 (CIA 2006). At present, the infrastructures of this country is still underdeveloped. With an annual GDP grow rate of around 8% in recent years and the even of becoming a member of WTO in November 2006, it is expected that the construction market in Vietnam will be promissing in the next few decades.

After the country changed the economy system from subsidized to market economy and open up the door for foreign investment early in 1990s, the construction activities in Vietnam have been overwhelmed with the various sources of investment including ODA, FDI, government or private ones. This has created a significant impact on the development of Vietnamese construction standards system, which was founded on the standard system of the former Union of Soviet Socialist Republics (USSR). More standards have been introduced or revised in harmonization with international standards, and Vietnamese engineers have been more engaged with using international or overseas standards. On the contrary, overseas engineers who come to practice in the construction industry in Vietnam also need to learn about Vietnamese construction standards system because there are still mandatory codes and standards that apply to any construction project in Vietnam territory. The application of different standards systems has sometimes created trouble in engineering communication as there are differences in the local system and overseas ones. Therefore it would be an advantage for overseas civil engineers who wish to participate in construction activities in Vietnam to gain prior knowledge about the Vietnamese construction standards system, although it would be better if a common standards system is mutually adopted or adapted amongst Asian region.

The objective of this paper is to present an overview of Vietnamese construction standards system and related regulatory documents, and the methodology of standards development carried out by the Ministry of Construction. Some ideas about code harmonization in the Asia region are also presented.

2 OVERVIEW OF VIETNAMESE CONSTRUCTION STANDARDS SYSTEM

2.1 Construction standards

The first Vietnamese construction standard was introduced in 1961 under the name "QP 01.61: Temporary code for wind load calculation". During the period from 1961 to 1990 a number of construction standards were developed with the help from the USSR and naturally they were based on the USSR standards system. In the subsidized economy, the implementation of construction standards in this period based primarily on mandatory basis with the number of mandatory construction standards accounted for about 95% of the total construction standards (Nguyen *et al.* 2003).

From 1990 to date, a large volume of construction standards has been introduced or revised to adapt to the open economy of the country. Approximately one thousand construction standards currently in use have been published in this period, which account for about 75% of the total construction standards. Many standards introduced or revised in this period are based on advanced standards from ISO/IEC, BS, and the American standards systems. The implementation of construction standards has also been changed gradually from mandatory basis to voluntary basis to align with international practice.

At present, there are approximately 1300 construction standards at national and branch levels. They are prepared, approved and managed by different ministries. The Ministry of Science and Technology (MOST) is responsible for approval and management of standards for general applications and those in the field of productions and goods such as specifications for cements, tiles, reinforcement, etc. The Ministry of Construction (MoC) is responsible for preparing, approval and management of construction standards for general application in civil engineering, for example the standard for design of reinforced concrete structures, standard for design of steel structures, or standards for check and acceptance work of construction project. Construction standards issued by the MOST or MoC are national standards. In the fields of transportation and agricultural construction there are specialized standards developed by the Ministry of Transportation (MT) and the Ministry of Agriculture and Rural Development (MARD), respectively. These standards are branch standards and are used mainly for construction projects managed by the respective ministries such as roads, dams, bridges, etc. It should be noted that the department responsible for standardization work in the MOST is the Directorate for Standards and Quality (STAMEQ) whereas responsibility for standardization work in the MoC, MT, and MARD is assigned to Department of Science and Technology in each ministry.

The coding part of each national standard consists of three fields. The first field contains the letter code indicating the type of standard and also the ministry that issues it. Before 2001 the standards issued by the MoC were assigned with the code TCXD. However new or revised standards issued from 2001 to date were assigned with the code TCXDVN to emphasize that they are standards at national level. Standards issued by the MOST are assigned with the letter code TCVN. The second field contains the number in order of issue. The last number is the year in which the standard is approved. For the coding part of branch standards, it consists of four fields, the first field is the number code of the ministry that issues the standard, the second field is the letter code TCN that indicates the standard is a branch standard, the last two fields are similar to the last two fields of the national standards. Details of the structure of the current Vietnamese construction standards system are tabulated in Table 1. It should be noted that the year of issue may be fully written or only two last digits are written.

Table 1. Structure of the current Vietnamese building standards system

Level	Code	Field	Issued by	Example
National	TCVN	General specifications, Production standards (cements, tiles, reinforcement, etc.)	MOST	TCVN 3992:1985
	TCXD, TCXDVN	Other fields in civil engineering (design, construction, planning, etc.)	MoC	TCXD 239:1998, TCXDVN 356:2005
Branch	22 TCN	Specialized in Transportation construction	MT	22 TCN 45:79
	14 TCN	Specialized in Agriculture construction	MARD	14 TCN 63:2002

Apart from national standards and branch standards, however, there are also company standards that are developed by companies themselves. The letter code of such standards is TC. These standards are usually in the field of concrete pre-cast production, and used for quality control of products within the company that develop them. At present such standards are not well recognized nor widely accepted by the construction industry in Vietnam.

2.2 Building regulations

In the process of changing the application of construction standards from mandatory basis to voluntary basis in the 1990s, it was recognized that technical regulatory documents were needed to uniformly control construction activities. In 1996 the Ministry of Construction of Vietnam introduced the first volume of a three-volume Vietnamese Building Code (VBC). This volume covers the general requirements in construction activities and requirements in the field of construction planning. One year later the last two volumes of VBC covering other aspects of construction activities were also introduced. In principle, this Building Code was based on performance based concept. It contains minimum technical requirements that must be achieved and provides guidance on possible means to achieve the requirements (deem-to-satisfy provisions) or refers to standards that can be used to meet the requirements. Compliance to this Building Code is compulsory to any construction activity in Vietnam territory regardless of the source of investment.

Although the VBC covers almost all aspects of construction activities, the content of this VBC is still too general in some fields that lead to difficulties in the implementation. Therefore, new specific codes have been issued for particular fields, which are:

- Vietnamese Plumbing Code, introduced in 1999;
- Building Code of Construction Accessibility for People with Disabilities, introduced in 2002;
- Energy Efficiency Building Code, introduced in 2005;

These specific codes are also mandatory. According to definitions in the ISO/IEC Guide 2 (2004), these codes and the VBC can be regarded as technical regulations. This type of technical regulations has existed only in construction industry in Vietnam up to date. It should be noted that the English term "code" does not indicate the specific type of these regulations, although in Vietnamese there is a specific term for this type, because it may refer to a technical regulation or to a standard.

3 THE STANDARD DEVELOPMENT PROCESS OF THE MINISTRY OF CONSTRUCTION

As stated earlier, the department responsible for the standardization work in the Ministry of Construction is the Department of Science and Technology (DST). At present, any research institutes, construction management organizations, enterprises or universities can make proposal and prepare codes and standards. However, in practice most of the construction codes and standards are prepared by three research institutes: Vietnam Institute for Building Science and Technology (IBST), Institute of Architectural Research, and Institute for Science and Technology of Building Materials. In this paper, an organization that prepares codes and standards is referred to as a standards developer.

Currently the development of a construction standard or code of the MoC follows nine steps as below:

- Step 1: Planning
  Each standards developer studies the need for new standards to be developed or existing standards to be revised and makes an annual standard development program. This program is submitted to the DST for approval before any detailed proposal for building a certain standard is made. In some cases where there is an urgent need for standards concerning the safety, health or environment issues, the development of such standards may not necessarily go through this step. It should be noted that up to date the construction standards in particular and Vietnamese standards in general are not periodically revised. They can be revised if there is clear justification on the need to revise them only.
- Step 2: Proposal for developing or revising standards.
  Once a standard program is approved, the standards developer prepares a proposal for each standard to be developed or revised. The proposal is usually initiated by a Work Group (WG) of the standards developer that will prepare the standard. This proposal must elaborate the significance, objectives, scope and methodology of developing the standard, the members of the WG to prepare it, and the cost and time to complete it. Before submitting the proposal to the DST, a review meeting for the proposal is organized at the standards developer with a witness from the DST. After the meeting, if the proposal is approved by the scientific and technical panel of the meeting then it will be submitted to the DST for consideration. Once it is approved by the DST, a contract for preparing the standard will be awarded to the standards developer by the MoC.
- Step 3: Development of the first draft.
  After being awarded the contract, the WG whose members are specified in the contract shall prepare the first draft of the standard. At the end of this step, a seminar is usually held to introduce the first draft and to gather comments from industry.

- Step 4: Making the second draft.
  After getting comments from the seminar, the first draft is amended or revised to become the second draft. Once completed, this draft is submitted to the scientific and technical committee of the standards developer for review.
- Step 5: Review of the second draft.
  The scientific and technical committee of the standards developer sends the second draft to two or three reviewers for comments and then sets up a meeting for reviewing the second draft. There is at least one witness from the DST and one invited expert from an external organization attend the meeting.
- Step 6: Making the third draft.
  After the review meeting, the second draft is corrected or amended to become the third draft. This draft is verified by the scientific and technical committee of the standards developer before being submitted to the DST for review.
- Step 7: Review of the third draft
  This step is similar to Step 5 except that the review meeting is organized by DST and run by a scientific and technical panel at ministry level. This panel is set up by DST and it usually comprises of experts from various organizations, including those that would be affected by the standard such as consultant or construction companies.
- Step 8: Making the final draft
  The final draft will be made after the review meeting at ministry level and resubmitted to the DST for approval.
- Step 9. Publication and dissemination of the standard
  Once the final draft is approved, it will be issued by the MoC and notified in the Government Gazette. Usually the standard will become effective after 15 days from the day of notification. The standard will be printed and a soft copy is uploaded to the website of the MoC (http:\\www.xaydung.gov.vn). The electronic versions of standards or codes that have been issued by MoC since 2003 are available in the website for free download. Some codes and standards published by MoC before 2003 can also be found in the website. For complicated standards, seminars may be organized to introduce them after the standards have been published to help industry to understand the standards and also to receive feedback from the users.

The limitation of this procedure is that only few people are involved in the development of the standard. The public seminar at Step 3 is occasionally held; even it is held there are usually not many people attended due to the lack of information and other constrains. The reviewing process, either at organizational level or ministry level, receives comments from only few experts in the field that the standard concerns. Therefore this procedure does not undergo the full consensus process as requested by WTO. It is the fact that before the standard is published, most people from the industry who will be affected by the standard are unaware about the content of the standard. Once it is published, any feedback from industry application can only be considered in the revised version, which usually takes a couple of years from the previous version.

To overcome this limitation, from 2005 there has been an additional step in the procedure of preparing a standard of IBST. After Step 5, the second draft is amended and uploaded to the website of IBST for comments (http://www.ibst.vn). Anyone interested can download the draft and give feedback to the Center for Standardization in Construction of IBST during the time of preparing the third draft. The feedback, if any, will be sent to the WG that prepares the draft for consideration. Discussion may be held electronically by email or via telephone or fax and updated information can be made to the third draft before it is sent to DST in Step 6. This mechanism provides industry with an opportunity to influence the content of the standard before it is published. Although this new step of IBST has not been widely known among people in construction industry, it has received many good comments and encouragements. With the introduction of a new law on standards and technical regulations, it is expected that this mechanism must be included in the preparation procedure of any standard.

4 LAW ON STANDARDS AND TECHNICAL REGULATIONS

In June 2006 a new law on standards and technical regulations has been passed by the XIth National Assembly at ninth Section and it will be effective from the first of January 2007. There will be a significant change in the development and management of the Vietnamese standards system.

Under the new law, the Vietnamese standards system will consist of standards and technical regulations. There will be only two types of standards: national standards and company standards. The branch standards will be revised to become either national standards or company standards. All national standards will have the letter code TCVN whereas company standards will have the letter code TCCS. The technical regulations will also be divided into national technical regulations, which are assigned with the letter code QCVN, and provincial technical regulations, which are assigned with the letter code QCDP. The application of standards is based on voluntary basis whereas the technical regulations must be compulsorily applied.

The preparation of national standards will be carried out by National Standards Technical Committees (NSTCs) established from experts in existing standards developers, and the authority that approve and issue national standards will be the Ministry of Science and Technology only. The procedure for developing a national standard will follow four basic steps as follows:

- Step 1: Planning.
  Organizations or individuals propose standards to be developed or revised to the MOST for consideration. Some standards, especially those subjected to periodical revision, do not necessarily go through this step but directly appointed by MOST.
- Step 2: Preparation
  The MOST assigns an appropriate NSTC to prepare the draft of a standard. Once the draft is made, the NSTC should seek for comments from concerned organizations and individuals by appropriate methods including organizing seminars.
- Step 3: Amendment and correction of the draft
  After receiving comments from concerned organizations and individuals, the NSTC makes necessary amendments and corrections to the draft and sends it to MOST for review.
- Step 4: Approval
  The review process is carried out by the MOST. If it is accepted then it will be issued by the MOST.

The procedure for developing national technical regulations is basically the same as that for developing national standards, except that the preparation and issuance are carried out by appropriate ministries, not NSTC.

It should be noted that under this law, all standards will be periodically reviewed for the applicability every three years whereas the cycle for periodical review of technical regulations is five years.

5 REGULATIONS ON APPLICATION OF FOREIGN CONSTRUCTION STANDARDS IN VIETNAM

The last decade has witness a booming in infrastructure development in Vietnam. Several large-scale construction projects have been built such as My Thuan cable-stayed bridge, Bai Chay cable-stayed bridge, National highway No. 5, Nghi Son cement plant, etc. Together with the flow of international investment in various kinds and the need for advance technology in big projects, the construction activities in Vietnam has also been internationalized gradually with the participant of many international or foreign enterprises taking part in the activities. From the code application point of view, the application of international or overseas standards in construction activities in Vietnam is inevitable.

In 1999 the MoC issued the Circular No. 07/1999/TT-BXD guiding the application of foreign standards in construction activities in Vietnam, in which standards from nine countries/organizations including ISO, EURO, USA, UK, France, Germany, Russia, Japan, and Australia may be approved for use in Vietnam by ministries managing specialized construction works after passing the reviewing process taken by relevant construction authorities of those ministries. They do not need to pass through Ministry of Construction for approval. For standards from other countries/organizations, they must be approved by Ministry of Construction before use and in the case-by-case basis only.

In recent years, the number of construction projects built with private or foreign investment has been increased significantly. This has created a demand for a better regulation on application of foreign construction standards. Along with the effort in regulatory reform in Vietnam aiming at removing unnecessary technical barriers to trade in various sectors, in 2005 the Minister of Construction issued decision No. 09/2005/QD-BXD promulgating a new regulation on application of foreign construction standard in construction activities in Vietnam. According to this regulation, the foreign construction standards may be applied to construction activities in Vietnam provided that they:

- are standards at national, regional or international level and are effective;
- meet the requirements set out in the current Vietnamese Building Code and other mandatory codes;
- comply with principles for application of foreign construction standards defined in Article 3 of the regulations;
- are considered for application and are decided for application by the Investor/Owner before basic/technical design dossiers are made.

The principles for application of foreign construction standards defined in Article 3 of the regulations are:

- To ensure that construction works and products be made and they:
  a) are safe for human use, for the works and adjacent works;
  b) meet Vietnam's regulations on ecological safety and environmental protection;
  c) yield econo-technical efficiency.
- To ensure synchronism and feasibility in construction process, from designing, construction to acceptance of works, and in the work entirely.
- To compulsorily use input data related to Vietnam's particular conditions stipulated in mandatory construction standards in the following domains:
  a) Natural and climatic conditions;
  b) Geological and hydrological conditions;
  c) Classification of seismic zones and seismic degrees.

In general all foreign construction standards may be applied in Vietnam if they meet certain requirements related to very basic local characteristics. The significant change in this regulation compared to the previous one is that it has handed over the decision of using foreign construction standard to the Investor/Owner instead of seeking approval from appropriate ministries. This is an important issue that promotes the use of foreign construction standards and facilitates foreign investors to do business in Vietnam. For construction projects funded by the State Budget, if there is a Vietnamese standard available, this standard must be applied. In special circumstances, foreign construction standards will be applied if they are approved by the Ministry of Construction or relevant ministries for projects under their respective authorities.

5 HARMONIZATION OF DESIGN CODES IN THE ASIA REGION

It is the fact that design codes from the US such as Uniform Building Code, International Building Code and from the UK and European countries such as BS 8110 and Eurocodes are well known among civil engineers in many countries in the world. The reasons for this are mainly because they are advance codes and that they are available in English language, which can be considered as the international language.

In Vietnam, design codes from the US and European countries have been increasingly used although the current design codes in Vietnam are still based on Russian codes. Due to language problem, other advance codes such as those from Japan and China are not well-known in Vietnam and thus are not welcomed. Nevertheless, they are still used in some construction projects in Vietnam.

As many design codes are being applied in Vietnam, local and foreign consultant engineers are forced to study different codes to adapt to the requirements from different construction projects. This results in the waste of time and lack of in-depth knowledge and skill necessary for design work. Moreover, communication problems amongst engineers are an additional issue that sometimes creates unnecessary troubles to concerned parties. Therefore, harmonization of design codes is essential and Vietnamese professionals are eager to participate in any activity for this work. In 2001 the Asian Concrete Model Code was published in dual languages, Vietnamese and English, after 8 years of hard work by International Committee of Concrete Model Code for Asia (ICCMC) which also includes Vietnamese professionals as members. Although this model code has little impact on daily practice, it will serve as the foundation for other practical codes to be built.

In the globalization process, Vietnam must choose an advance design codes system to follow and the Eurocode system has been being chosen. In September 2006 the first Vietnamese code on seismic design based on Eurocode 8 was introduced and the development of the codes on design of concrete and steel structures based on Eurocode 2 and Eurocode 3 is being carried out. It is expected that other design codes in the Eurocode system will be subsequently adopted soon. Considering this situation in Vietnam, the following approaches for harmonization of design codes are proposed:

(1) Develop a new Asian design codes system that can be adopted by a group of Asian countries.
This approach would take long time to complete such codes and require significant efforts from engineers and leaders of countries that join this group.

(2) Develop ISO design codes.
There are many ISO standards that are already developed as basis for design of structures, for example ISO 9194, ISO 3010, ISO 11697 etc. However the existing ISO standards are still not sufficient for design work. More efforts are needed to develop a full system of design standards that can be adopted internationally.

(3) Adopt the Eurocodes system to be used amongst a group of Asian countries.
This approach is more feasible because many Asian countries are familiar with the BS standards system and are getting use with the Eurocodes.

(4) Adopt some advance design codes systems such as the Eurocodes, Japanese codes, Chinese codes to be used amongst a group of Asian countries.
Some advance design codes from Asian countries like Japan, China may be adopted, provided that they are properly translated into English to prevent language problem in application.

6 SUMMARY AND CONCLUSIONS

This paper presents an overview of Vietnamese construction standards system and related regulatory documents. The construction standards system was basically established based on USSR system but it has been changed gradually towards European standards. Besides the standards, there are four mandatory codes in construction that can be considered as technical regulations. The current methodology of standards development carried out by the Ministry of Construction and the change in the development and management of national standards requested by a new law in Vietnam were also presented. This paper also introduces the current regulations on application of foreign construction standards to construction activities in Vietnam.

From the application of national and overseas design standards in Vietnam, it has shown that harmonization of design codes, in the Asia region in particular and in the global scale in general, is essential. Some approaches for harmonization of design codes in the Asia region were proposed, namely: Develop a new Asian design codes system, develop ISO design codes, adopt the Eurocodes system, and adopt a list of design codes systems including those from Asian countries.

REFERENCES

CIA (2006) *The World Factbook* (https://www.cia.gov/cia/publications/factbook/geos/vm.html)

Nguyen V. L., Nguyen T. H., Nguyen H. D., Nguyen V. C., and Tran Q. D. (2004) *Research on Developing a Synchronized Vietnamese Building Standards System by 2010 using Integration and Innovation Approaches.* Research Report, Ministry of Construction, Hanoi (in Vietnamese).

International Standard ISO/IEC Guide 2 (2004) *Standardization and related activities - General vocabulary.*

The Development of Vietnamese Codes and Standards in Construction

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Ministry of Construction

Contents

Introduction

- Total Area: 329,562 sq. km
- Population: 84.4 million
- GDP: $43.75 billion (2005)
- GDP grow rate: ~8%
- Infrastructure: underdeveloped

Overview of Vietnamese Construction Standards System

- National Standards: ~ 7500
- Construction Standards: ~ 1300

History of Construction Standards System

•USSR based standards
•Mandatory basis

•Towards ISO, BS, UBC, ASTM, etc.
•Voluntary basis

1961 — 1990 — present

Subsidized economy

Market economy

Structure of Vietnamese Construction Standards System

Level	Code	Field	Issue	Example
National	TCVN	General specifications, Production standards (cements, tiles, reinforcement, etc.)	MOST	TCVN 3992:1985
	TCXD, TCXDVN	Other fields (design, construction, planning, etc.)	MoC	TCXD 238:1999 TCXDVN 375:2006
Branch	22 TCN	Transportation construction	MT	22 TCN 45:79
	14 TCN	Agriculture construction	MARD	14 TCN 63:2002

Company standards: Used within company only

Building codes (regulations)

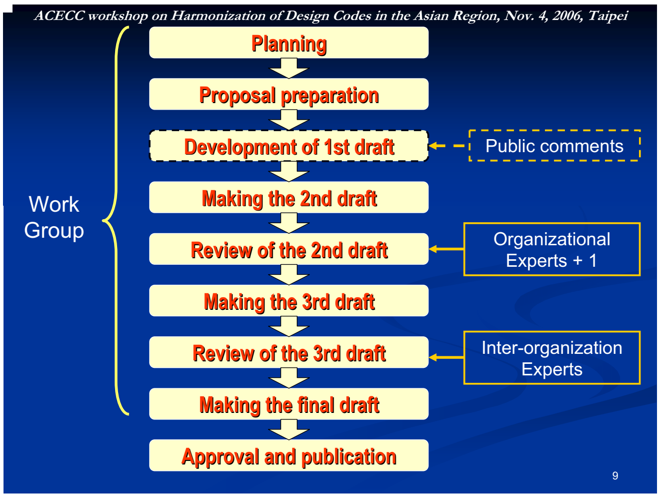
- Vietnamese Building code - Volume I (1996), Volumes II, III (1997);
- Vietnamese Plumbing code (1999).
- Building code of construction accessibility for people with disabilities (2002);
- Energy Efficiency Building code (2005);

Standards development of MoC

- Management of Standards Development: Department of Science and Technology (DST)
- Standards Preparation: Any organizations.

Mainly:

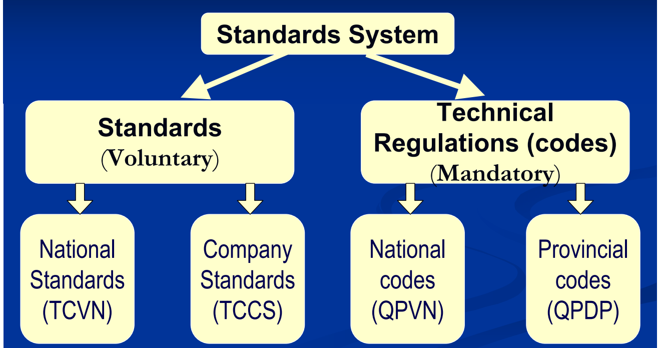
- Vietnam Institute for Building Science and Technology (IBST),
- Institute of Architectural Research, and
- Institute for Science and Technology of Building Materials.



IBST's current standards development procedure

- Add an additional step to the current procedure: **Invitation for public comments on 2nd draft** (http://www.ibst.vn)

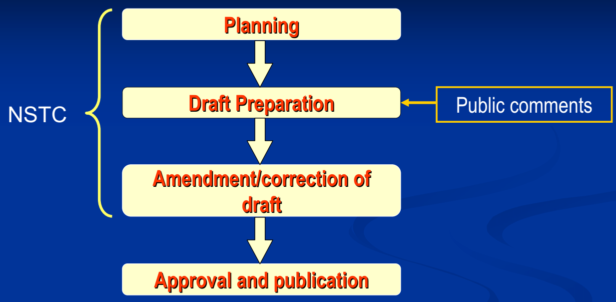
Law on Standards and Technical Regulations



Law on Standards and Technical Regulations

- **Standards:**
  - Prepared by National Standards Technical Commitees - TCVN/TC
  - Approved and issued by Ministry of Science and Technology (MOST)
- **Technical regulations:**
  - Prepared and issued by relevant ministries

Law on Standards and Technical Regulations



Regulation on application of foreign construction standards to construction activities in Vietnam

Foreign construction standards can be applied to projects in Vietnam provided that they:

- are effective national standards, regional standards, or international standards;
- comply with VBC and other mandatory codes;
- comply with principles set out in this Regulation;
- are approved by the Investor / Owner.

Principles for application of foreign construction standards

- To ensure that construction works and products be made and they:
  - a) are safe for human use, for the works and adjacent works;
  - b) meet Vietnam's regulations on ecological safety and environmental protection;
  - c) yield econo-technical efficiency.
- To ensure synchronism and feasibility in construction process, from designing, construction to acceptance of works, and in the work entirely.
- To compulsorily use input data related to Vietnam's particular conditions stipulated in mandatory construction standards in the following domains:
  - a) Natural and climatic conditions;
  - b) Geological and hydrological conditions;
  - c) Classification of seismic zones and seismic degrees.

Regulation on application of foreign construction standards to construction activities in Vietnam

- **Projects funded by the State Budget**

- Vietnamese standards must be applied if available;

- Foreign standards can be applied in special circumstances, they must be approved by Ministry of Construction or relevant ministries for projects under their respective authorities.

Harmonization of design codes in the Asian region

- Current situation in application of design codes in Vietnam

  - Local design codes: Still based on Russian system.

  - Overseas design codes: BS system (change to Eurocodes), US system (UBC, IBC, ACI, AASHTO), Japanese system, Chinese system.

- Consequence: Waste of time, lack of in-depth knowledge and skill, communication problems.

Harmonization of design codes in the Asian region

- Orientation of Vietnamese design codes: Adoption of Eurocodes
- Initial steps:

  - The first code based on Eurocode 8: TCXDVN 375:2006 "Design code for earthquake resistant of structures" was approved and issued in October 2006

  - Design codes based on Eurocode 2 and Eurocode 3 are being developed.

Harmonization of design codes in the Asian region

- Orientation of Vietnamese design codes: Adoption of Eurocodes
- Initial steps:

  - The first code based on Eurocode 8: TCXDVN 375:2006 "Design code for earthquake resistant of structures" was approved and issued in October 2006

  - Design codes based on Eurocode 2 and Eurocode 3 are being developed.

ACECC workshop on Harmonization of Design Codes in the Asian Region, Nov. 4, 2006, Taipei

Harmonization of design codes in the Asian region

- Proposed approaches:

(1) Develop a new Asian design codes system

(2) Develop ISO design codes system

(3) Adopt Eurocodes system

(4) Adopt advance design codes systems: Eurocodes, Japanese codes, Chinese codes, etc.

ACECC workshop on Harmonization of Design Codes in the Asian Region, Nov. 4, 2006, Taipei

Thank you!

ACECC Workshop on Harmonization of Design Codes in the Asian Region

Taipei, November 4, 2006

Status of Design Codes in Taiwan

Yao-Wen Chang
Senior Structural Engineer
Sinotech Engineering Consultants, Ltd

General

LAWS

- **Drafted by government agencies**
- **Enacted by legislative body**

↓

DESIGN CODES
Regulations
Specifications
Guides

Established and issued by competent authority of government

Establishment of Codes

- Initiated by competent authority.
- Drafted by relevant engineering societies.
- Reviewed by special panels comprised of specialists, professors and representatives of engineering organizations.
- Approved and issued by competent government authority.

Establishment of Codes

- For local natural conditions such as earthquake and wind effects, relevant requirements in design codes are based on local research.
- International design codes (mainly USA and Japan) were referred：
  - Concrete ： ACI 318 Building Code Requirements for Structural Concrete or AASHTO
  - Steel ： AISC Manual of Steel Construction or AASHTO
  - Bridges ： AASHTO Standard Specifications for Highway Bridges

Revision of Codes

- Design codes are revised as required based on latest research results and/or updated international codes.
- Process of revision is similar to the establishment of codes.

Building Codes

Building Technical Regulations **(建築技術規則)**

Issued by Ministry of the Interior (MOI)

Architecture Design & Construction

Structure Design
- General requirements
- Loadings
- Foundations
- Masonry structures
- Wood structures
- Steel structures
- Concrete structures
- Steel reinforced concrete structures
- Cold-formed steel structures

Equipment Design

Building Codes

Separate Volumes from Building Technical Regulations (issued by MOI)

- Specifications for Seismic Design of Buildings
(建築物耐震設計規範)
- Specifications for Wind Resistance Design of Buildings
(建築物耐風設計規範)
- Specifications for Design and Construction of Wood Structures
(木構造建築物設計及施工技術規範)
- Specifications for Foundation Design of Buildings
(建築物基礎構造設計規範)
- Specifications for Design of Steel Buildings
(鋼構造建築物鋼結構設計技術規範)
- Specifications for Design of Structural Concrete
(結構混凝土設計規範)
- Specifications for Design of Steel Reinforced Concrete Structures
(鋼骨鋼筋混凝土構造設計規範)
- Specifications for Design of Cold-formed Steel Structures
(冷軋型鋼構造建築物結構設計規範)

Highway Bridge Design Codes

Issued by Ministry of Transportation & Communications (MOTC)

- Specifications for Design of Highway Bridges (2001)
  Based on AASHTO code, but LRFD not yet adopted
  - General requirements
  - Loads and loading combinations
  - Foundations
  - Substructures
  - Reinforced concrete (ASD and LFD)
  - Prestressed concrete (ASD)
  - Steel (ASD and LFD)
  - Bearings
- Specifications for Seismic Design of Highway Bridges(2000)

Other Highway Codes

Issued by Ministry of Transportation & Communications (MOTC)

- Specifications for Highway Geometry Design
(公路路線設計規範)
- Specifications for Highway Drainage Design
(公路排水設計規範)
- Specifications for Design of Highway Tunnels
(公路隧道設計規範)
- Specifications for Design of Flexible Pavement
(柔性舖面設計規範)

Other Design Codes

- Specifications for Design of Railway Bridges (MOTC)
(鐵路橋梁設計規範)
- Specifications for Seismic Design of Railway Bridges (MOTC) (鐵路橋梁耐震設計規範)
- Design Guide for Harbor Structures (MOTC)
(港灣構造物設計基準)
- Design Standard of Urban Roads and Accessory Works (MOI) (市區道路及附屬工程設計標準)

Development of Bridge Seismic Codes In Taiwan

Development of Bridge Seismic Code

- 1960 Highway Bridge Design Specifications
  - No seismic design guidance.
  - Designers use earthquake coefficients recommended in the Engineer's Manual published by Chinese Institute of Engineers.

Development of Bridge Seismic Code

- 1987 Highway Bridge Design Specifications
  - Horizontal earthquake force calculated by coefficient method.
  - Factors include earthquake zoning, site condition, importance and fundamental period adjustment.
  - Based on 1980 Highway Bridge Code published by Japan Road Association.
  - No special details required.

13

Development of Bridge Seismic Code

- 1995 Highway Bridge Seismic Design Specs
  - Separate volume from Bridge Design Specs
  - Based on
    - Earthquake hazard analysis and spectrum study
    - Seismic codes and research in US and Japan
  - Small to moderate earthquakes
    - Resisted in the elastic range
    - No significant structural damage
  - Large earthquakes (min 475-year return period)
    - Avoid collapse of all or part of bridge
    - Plastic response permitted
    - Shear or brittle failure not allowed
  - Special ductile details required
  - Soil liquefaction evaluation

14

Development of Bridge Seismic Code

- 2000 Highway Bridge Seismic Design Specs
  - Based on the lesson learned from Chi Chi earthquake (Sept. 21, 1999).
  - Revisions
    - Earthquake zoning
    - Peak ground acceleration
    - Response spectrum
    - Vertical seismic force
    - Falling prevention design

15

Development of Bridge Seismic Code

- 2002 Highway Bridge Seismic Design Specs (DRAFT)
  - Major revisions
  - New analysis method
  - Earthquake micro-zoning
  - Near fault effect
  - Base isolation

Not approved because of different opinions from review panel

16

THANK YOU

17

ACECC Workshop

November 4, 2006

Harmonization of Design Codes in the Asian Region

Concrete Building Code in Taiwan

Shyh-Jiann Hwang (National Taiwan University)

Committee of Concrete Engineering

Chinese Institute of Civil and Hydraulic Engineering

Outline

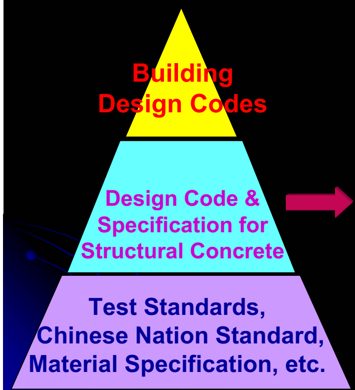
- Status of Concrete Codes
- Current Concrete Codes in Taiwan
- Code Development in CICHE

Status of Concrete Codes

Status of Design Codes in Taiwan

	Drafted by	Approved by
Regulations	Government	Legislative Body
Design Codes	Engineering Societies	Government
Standards and Specifications		

Status of Concrete Building Codes



Drafted by: Chinese Institute of Civil and Hydraulic Engineering (CICHE)

Approved by: Construction and Planning Administration (CPA), Ministry of Interior

Current Concrete Codes in Taiwan

Draft of Design Code

	Design Code	Publisher	Issued
	Design Code for Structural Concrete	CPA	2002

	Code Draft	Publisher	Issued
	Design Code and Commentary for Structural Concrete (• • •401-86a)	CICHE	1997

Draft of Construction Code

	Construction Code	Publisher	Issued
	Specification for Structural Concrete	CPA	2002

	Code Draft	Publisher	Issued
	Construction Code and Commentary for Structural Concrete (• • •402-88a)	CICHE	1999

Lessons from Chi-Chi Earthquake

Lessons from Chi-Chi Earthquake

Damages of School Buildings

293 elementary and high schools were completely or partially damaged.

Lessons from Chi-Chi Earthquake

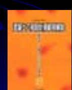
Bridge Damages

Model of Taiwan Concrete Codes

American Concrete Institute

Building Code Requirements for Structural Concrete (ACI 318-95) **1995**

Chinese Institute of Civil and Hydraulic Engineering



Design Code and Commentary for Structural Concrete (• • •401-86a) **1997**

Construction Code and Commentary for Structural Concrete (• • •402-88a) **1999**

Code Units in Taiwan

Length	Force	Mass	Time
m	kgf	kg	sec

Design Code for Structural Concrete

- General Requirements
- Analysis and Design
- Flexural and Axial Loads
- Shear and Torsion
- Development and Splices of Reinforcement
- Two-way Slab System
- Walls
- Footings
- Precast Concrete

Design Code for Structural Concrete

- Composite Concrete Flexural Members
- Prestressed Concrete
- Shells and Folded Plate Members
- Strength Evaluation of Existing Structures
- Special Provisions for Seismic Design
- Structural Plane Concrete
- Appendix: Strut-and-tie Model
  Anchoring to Concrete
  Working Stress Design

Specification for Structural Concrete

- General Requirement
- Concrete Materials
- Concrete Mixtures
- Formwork
- Steel
- Joints and Embedment
- Concrete Mixing and Conveying
- Concrete Placing
- Concrete Finishing

Specification for Structural Concrete

- Concrete Curing and Protection
- Mass Concrete
- Prestressed Concrete
- Self-Compacting Concrete
- Shot Concrete
- Quality Control
- Examination and Inspection
- Evaluation and Acceptance of Concrete
- Check and Acceptance

Code Development in CICHE

Task Force of Concrete Codes

Establishment	Year
Chinese Institute of Hydraulic Engineering	1931
Chinese Institute of Civil Engineering	1936
Chinese Institute of Civil and Hydraulic Engineering (CICHE)	1974
Committee of Concrete Engineering	1965

Development of Design Code

Design Code		Year	Note
Cover	Version		
	• • •401-56	1967	
	• • •401-59	1970	
	• • •401-68	1979	
	• • •401-80	1991	
	• • •401-84	1995	
	• • •401-86	1997	
	• • •401-86a	2002	Adopted by CPA
	• • •401-93	2004	

Prepared by: Working Group on Concrete Design
Committee of Concrete Engineering
Chinese Institute of Civil and Hydraulic Engineering

Design Code of • • •401-56

(1967)

Reference
- Taiwan Power Company, "Design Code of Reinforced Concrete"
- ACI 318-63

Content
- Working Stress Design

Design Code of • • •401-59

(1970)

Reference
- • • •401-56
- ACI 318-63

NEW
- Ultimate Strength Design (Appendix)

Design Code of • • •401-68

(1979)

Reference
- • • •401-59
- ACI 318-77

NEW
- Ultimate Strength Design (Text)
- Working Stress Design (Appendix)
- Special Provisions for Seismic Design (Appendix)

Design Code of • • •401-80

(1991)

Reference
- • • •401-68
- ACI 318-89

NEW
- Special Provisions for Seismic Design (Text)

Design Code of • • •401-84

(1995)

Reference

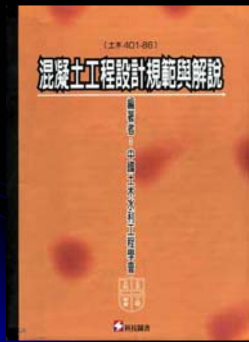
- • • •401-80
- ACI 318-89

NEW

- Commentary

Design Code of • • •401-86

(1997)



Reference

- • • •401-84
- ACI 318-95

NEW

- Drawings and Specifications
- Structural Plain Concrete
- Unified Design Provisions for RC and PC

Design Code of • • •401-86a

CICHE

(2002)

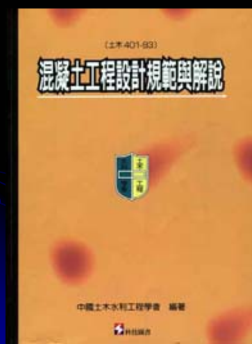
CPA

Reference

- • • •401-86
- Building Design Code, CPA

Design Code of • • •401-93

(2004)



Reference

- • • •401-86a
- ACI 318-02

NEW

- Load Factors
- Strength Reduction Factors
- Strut-and-Tie Model
- Anchoring to Concrete

Development of Construction Code

Construction Code		Year	Note
Cover	Version		
	• • •402-57	1968	
	• • •402-70	1981	
	• • •402-80	1991	
	• • •402-88	1999	
	• • •402-88a	2002	Adopted by CPA
	• • •402-94	2005	

Prepared by: Working Group on Concrete Construction
Committee of Concrete Engineering
Chinese Institute of Civil and Hydraulic Engineering

Construction Code of • • •402-57

(1968)

Reference

- CICHE, "Construction Code of Concrete Engineering," 1956
- ACI Committee 301, "ACI Standard Specifications for Structural Concrete for Building," 1956

Construction Code of • • •402-70
(1981)

Reference
- • • •402-57
- ACI 301-75
- ACI 318-77

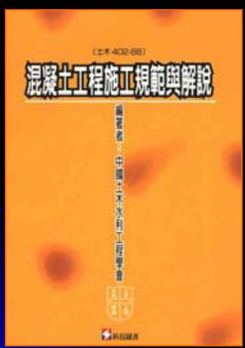
New
- Prestressed Concrete

Construction Code of • • •402-80
(1991)

Reference
- • • •402-70
- ACI 301-88
- ACI 318-89

New
- Commentary
- Concrete Conveying
- Special Concrete
- Quality Control

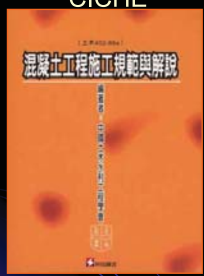
Construction Code of • • •402-88
(1999)



Reference
- • • •402-80
- ACI 301-96
- ACI 318-95

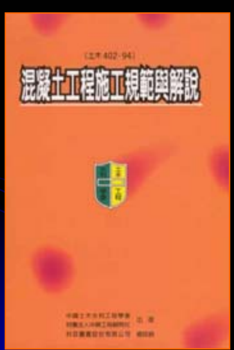
Construction Code of • • •402-88a

CICHE (2002) CPA



Reference
- • • •402-88
- Building Design Code, CPA

Construction Code of • • •402-94
(2005)



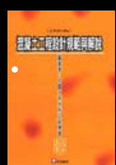
Reference
- • • •402-88a
- ACI 301-99
- ACI 318-05

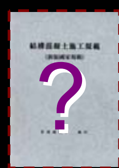
New
- Self-Compacting Concrete

Recent Efforts

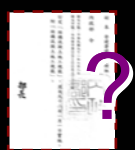
CICHE CPA

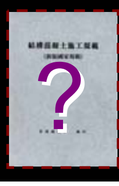
• • •401-95





• • •402-94





Future Efforts

- Development of Concrete Codes
- Harmonization of Design Codes in the Asian Region

Thanks for your attention

The Geotechnical and Civil Engineering Design Codes of China

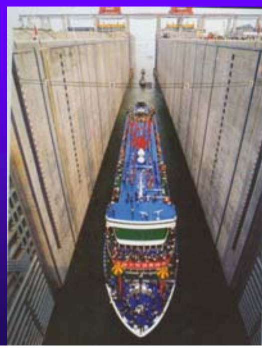
Zhang Weimin

Nanjing Hydraulic Research Institute

Nanjing , China

(水利部交通部南京水利科学研究院　章为民)

1. History



1.1 1950—1960s

Background

- The National first Five-Year Plan, 156 projects that the Soviet Union help to build.
- The Soviet Union design codes be used.
- The Soviet Union design codes mainly been adopted and these codes come into being the foundation of Chinese Standard system.

•The main used design codes before 1960

The Soviet Union design codes

《Industries and civil building natural ground design standards and technological regulations》

《 civil building and industry construction work geology survey standard》

《 industry construction work and civil building geology survey speediness operate tentative code》

《 soil test rules of the building foundation 》

《 railway lead worker person handbook by project geological drillings》

Chinese initial design standard:

- Geotechnical test manual》， 1953
  Nanjing Hydraulic Research Institute
  Water Resources Ministry
- The tentative code of natural grounds》,1954
  Construction Ministry
- 《Tentative code of Design load 》， 1954
  Construction Ministry

1.2 1960～1970's

- On the basis of the Soviet Union Design Codes, combine domestic engineering practice , The Chinese standard began to be established.
- 《project geologic map types and legend》, 1959, Ministry of Water Resources and Power Industry
  《 railway bridge design specification》 , 1960 , Ministry of Railways
- 《railway tunnel design specification》 , 1960 , Ministries of Railways

《survey detailed rules and regulations of at railway project geologies》, 1960 Ministries of Railways

《 High Stove design tentative specification》, 1966, Ministry of Metallurgical Industry,

《the wet settlement of yellow soil standards》,1966,

Ministry of Construction

… …

1.3 1970～1990's

Two large scale design code works,

- Start at 70's, Ministry of Water resources and Power Industry, Ministry of Construction, Ministry of Communications, Ministry of Railways and Ministry of Metallurgical Industry, issued their own design codes.
- behind the reform and opening, the national code issued and the industry codes revision continuously.
- the local standards issued in Shanghai, Fujian, Guangdong, Zhejiang, Tianjin, Beijing……

The US Standards, UK and Europe Standards, and Japan standards have been referenced also.

- 《Foundation design specification for industry and civil construction》, TJ 21-77,1974
- 《Yellow soil district building standards》,1979, TJ 25-78
- 《 High building's case shape foundation design and construction rule》, 1981, JGJ 6-80
- 《 Industry and civil building pouring pile design and construction 》, JGJ No. 4-80, 1985

1.4 1990's～

- new technology、new methods were used in the codes
- the codes been required closed to the international standard (ISO)
- Standard system and standard series have been formed

2. The Standard System

《The standardization law of People's Republic of China》 (December 29,1988)

《The management method of the national standards on construction engineering》(December 30,1992)

- **National standard (GB)**
- **Industry (profession, occupation) Standard**
- **Local Standard (DB)**

● National standard (GB)

- For the technical requirement that need to unify in the nation-wide, should establish the national standard. standardization department of the State Council responsible for the administration
- requirement on quality,safety, hygiene, environment
- term, symbol, measurement unit and system
- general assessment and evaluation method
- engineering project general IT requirement;
- the other general technical control requirement

Industry (profession, occupation) Standard

- For the technical requirement that has no national standard and need to be unified in the certain profession, can make the industry standard .
- The relevant administrative department of the State Council is responsible.
- The industry standard should put on records to national standardization administrative department.

There are 58 kinds of industry standards in China. That covered the almost all fields:

Agriculture(NY), Forestry(LY), Machinery(JB) Automobile(QC), Boat(CB), Aviation(HK), Medicine(YY), Chemical engineering(HG), Petroleum chemical(SH), Ocean (HY), Finance(JR), Hygiene(WS),

Building construction (JG), City public construction(CJ), Water resources (SL), Communication(JT), Power(DL), Railway(TD), Environmental protection(HJ), Build material(JC), Land management(TD), Coal(MT), Metallurgy(YB), Colored metallurgy(YS), Petroleum(SY), Survey(CH) , Public safety(GA)

……

Local Standard (DB)

For the hygiene, safety and environment requirement that has no national standard and need to be unified in province,autonomous region , can make the Local standard .

Local Government responsible for the Local standard works

Beijing (DB11) Tianjing(DB12) …….

Shanghai(DB31) Jiangsu(DB32) …….

Guangdong(DB44) ……

China Standards on Geotechnical Eng.

National	34	Petroleum	5
Architecture	22	Petro-chemical	8
Hydro	32	Chemical	4
Electric power	24	Mining	4
City	10	Forest	2
Mining & metal	42	Broadcast	1
Railway	32	Nucleus	1
Road	18	Standard committee	11
Water carriage	11	Local	50
Coal	7		
Total	318		

3. Standard classification

- Mandatory standard: It ensures health standard and law, administrative statute of the personal safety as well as the property safety should regulate.
- Recommendation standard. recommendation standard now with(/T) : The standard beyond the mandatory standard is the recommendation nature
- The standard by standardization committee of China's engineering construction, named as CECS, nationwide standard valid, all giving a recommendation nature.

- Engineering construction standard system classified as 24 fields in China :

(1) plan (2) survey (3) house building

(4) geotechnical engineering (5) structure

(6) disaster prevent (7) engineering evaluation

(8) fire prevention (9) environment

(10)water supplies and drainage

(11)heat and air supplies

(12) broadcast and communication eng.

(13) automation eng. (14) railways

(15) transport eng. (16) hydraulic eng.
(17) electric eng. (18) mining eng.
(19)Industry kiln and stove (20) piping eng.
(21)industry equipment (22) industry technics
(23) weld (24) others

3 Main industry fields and standards

3.1 Building construction works

- Amount more than 130 volumes.
- National standard 17 volumes .
- the scope of application is wide, the civil building, the industrial building , Urban architecture have a wide range and influence.

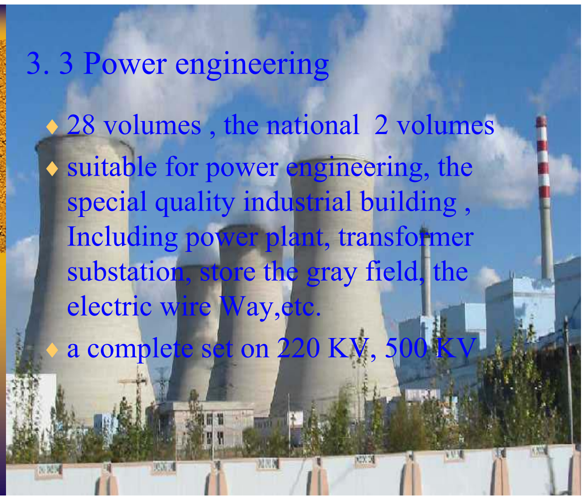
3.2 Water resources and hydroelectric power

- amount to 40 volume , national 8 volume
- the particularities of hydroelectric project, itself become body separately by standard standard.

- Based on the standards, the world level building projects have been designed.

- Three gorge project
- Transferring Southern water to the North project
- SutongYangtze river bridge, span 1088 m, the Deepest Foundation (120m)
- Double curves arch dam(Small gulf 292 m high),
- Concrete faced rock fill dam (Shuibuya 233 m high),
- Roller concrete gravity dam (dragon beach 216.5m high),
- Underground power plant (dragon beach, 388.5m long， 28.5m wide, 74.6m high)

- Geotechnical test standards is authoritativeness in the country.
- Relatively full geosynthtics standards in the country.



3. 3 Power engineering

- 28 volumes , the national 2 volumes
- suitable for power engineering, the special quality industrial building , Including power plant, transformer substation, store the gray field, the electric wire Way,etc.
- a complete set on 220 KV, 500 KV

3.4 The mining and metallurgy

- The second largest, total 45 volumes , national 3 volumes
- 20 volumes on survey

3.5 Railway project

- 33 volumes, national standard 1 volume
- have their specialties,line shape projects, long tunnel, bridge, the geological condition changeable.

3.6 Road

- 18 volumes
- similar to railway, have their own specialties also: road surface ?…
- In the highway developing process in China recent years, these codes make a important role

3.7 water carriage

- 11 volumes ,
- port projects, and water way projects

ISO /TC182

P-member

Activities Soils classifications

Thank you

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Towards Harmonization of Design Code in Asia- Structural Concrete -

Ueda T.
Chairman, International Committee on Concrete Model Code for Asia
Division of Built Environment, Hokkaido University, Sapporo, Japan

1 INTRODUCTION

Asia contributes one third of the world construction market, while the remaining two thirds are shared equally by Europe and North America. The cement consumption, which is a good index for construction industry size, in Asia is now well above 50% of the world consumption. China is ranked 1st followed by India. In China the cement consumption is 10 times of that in Japan in 2005. Besides the big size of construction industry, it should be noted that there are many international projects for construction industry in Asia. Those facts imply the necessity of international codes for construction industry.

With this background, internationalization of code for structural concrete has been paid attention since the early 1990's. International Committee on Concrete Model Code for Asia (ICCMC) was established in 1994. This paper introduces briefly Asian Concrete Model Code (ACMC) which was issued by ICCMC and the collaboration between ICCMC and ISO to make ACMC as a basis for ISO coded.

2 ICCMC

Before establishment of ICCMC, Japan Concrete (JCI) Institute set up a Research Committee on Concrete Model Coe to conduct feasibility study of concrete model code in Asia with collaboration of many Asian countries in 1992. The JCI committee disclosed that there are three types of countries:

- Country without domestic code
- Country with domestic code, which is a copy of codes in developed countries
- Country with domestic code, which is developed in the country

Many countries in Asia showed necessity and feasibility of concrete model code in Asia like Eurocode in Europe and ACI Code in North America with the following reasons:

- Nationalism
- Technological readiness
- Inappropriateness for adoption of codes in Europe and North America, which can be explained by difference in
    - Material type and quality
    - Climate
    - Technological level
    - Economical level
    - Social system for construction labor

Considering the situation in Asia, a model code should be

- A model for countries to develop own codes
- Flexible to diversity within Asia in terms of material available, climate, technological level, economical level and social system

ICCMC has its history as below:

1992 Establishment of JCI Research Committee on Concrete Model Code
1994 Establishment of ICCMC
1998 1st Draft of ACMC
1999 2nd Draft of ACMC
2001 ACMC2001 (2001 Edition of ACMC)
2003 Vietnamese Version of ACMC2001
2006 ACMC2006 (2006 Edition of ACMC)
2006 Chinese Version of ACMC2006

As of November 2006, ICCMC collects over 80 individual members, 6 representative members (representing concrete related institution) and 10 corporate members from the following 14 countries/economy; 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 in 12 countries/economy.

3 ACMC

The latest version of ACMC,ACMC2006, contains three parts (Part1: Design, Part 2: Materials and Construction, and Part 3: Maintenance), which covers all kinds of concrete structures (un-reinforced concrete structures, reinforced concrete structures, prestressed concrete structures, and composite structures with concrete). Its two main features as follows:
- Performance-based concept
- Multi-level document structure

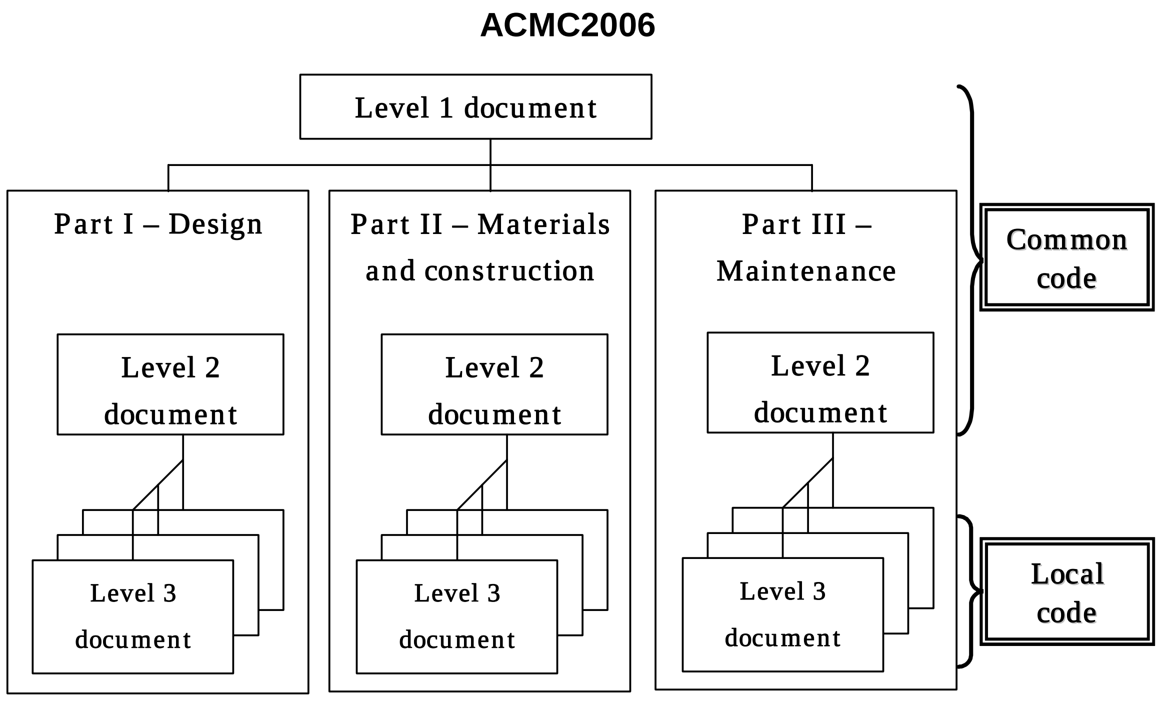


Figure 1. Multi-level document structure of ACMC.

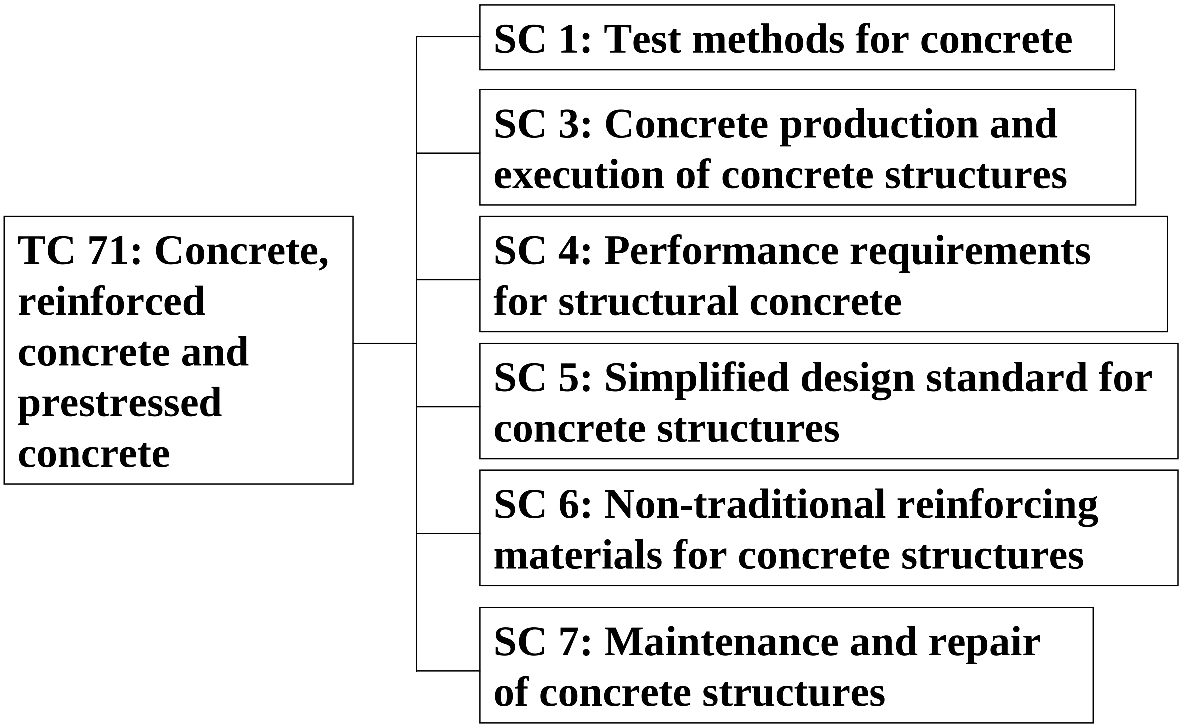
The performance-based concept only specifies performance requirements, while verification method for the requirement is not mandatory, meaning that any method can be used once it is proved appropriate. The multi-level document structure allows to have documents common to any country and any structure (common code) and documents specific to particular country or particular structure (local/specific code) (see Figure 1). Level 1 and 2 documents are the common code, while Level 3 document is local/specific code. Both the performance-based concept and the multi-level document structure are suitable for the model code, which deals with the big diversity in Asia.

ICCMC has been issuing Level 3 documents since 2001. There are two types of Level 3 document: national code type and technical report type. The list of Level 3 documents is as below:

(1) "An example of design for seismic actions – performance examination of RC building designed according to the Architectural Institute of Japan (AIJ) Guidelines", 2001. *(Technical Report)*"Vietnam Construction Standard TCXDVN 318: 2004 - Concrete and Reinforced Concrete Structures - Guide to Maintenance", 2004. *(National Code)*"Guidelines for Maintenance and Rehabilitation of Concrete Structures against Chloride Induced Deterioration", 2004. *(Technical Report)*"The Standard Specification for Materials and Construction of Concrete Structures in Japan", 2005. *(National Code Type)*4 COLLABORATION BETWEEN ICCMC AND ISO

Figure 2. ISO/TC 71 and Subcommittees.

In SC 4 there is an Ad-Hoc WG on performance-based code, which was initiated by members from



ICCMC, to study how to implement the performance-based concept and regional code like ACMC into the ISO codes. SC 7, proposed by the members from ICCMC, is currently chaired by Prof Song of Korea with the author as Secretary. SC 7 is now drafting an umbrella code for maintenance based on ACMC.

As seen above, the network in ICCMC has been successfully established a Asian tem work to disseminate technology in Asia and to enhance the voice from Asia in ISO activities.

5 ISSUES RELATED TO INTERNATIONALIZATION OF CODE IN ASIA

There are some difficulties with internationalization of code in Asia as follows:

- 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
- China and Taiwan issue

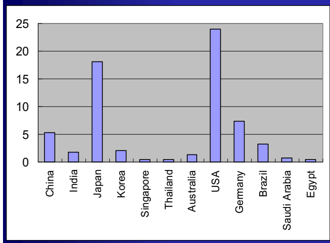
- Organizations responsible for preparing codes are various among different countries, such as non-governmental and governmental organization.
- Country like Japan where civil and architectural structures are dealt by different organization needs unification of codes are preferable.
- Financial support is still necessary for many Asian countries to participate international collaboration.
- Country with more advanced technology is expected to take leadership for code drafting.

Towards Harmonization of Design Code in Asia - Structural Concrete -

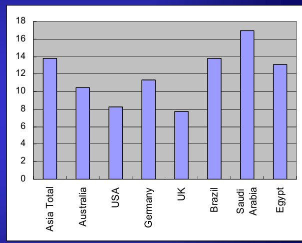
アジア域内における設計基準の調和に向けて
—コンクリート工学分野—

UEDA Tamon, Hokkaido University
北海道大学 上田 多門

Big Construction Market in Asia (in 2000)



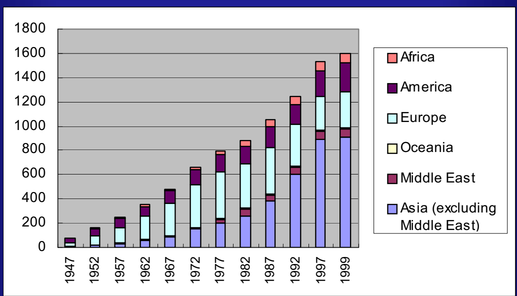
% in world construction market



% of construction in GDP

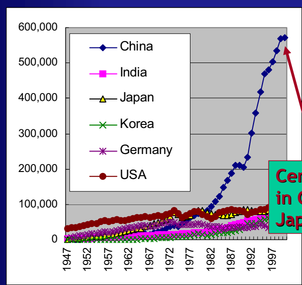
Asia: 1/3 of world market

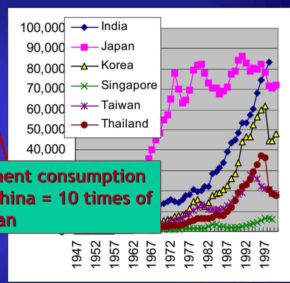
Big Construction Market in Asia



Worldwide cement consumption

1st: China, 2nd: India → More than 50% in Asia





Cement consumption in China = 10 times of Japan

Fast growing of construction in Asia

Three groups in the world construction market:

Europe: 1/3 of World Market

America (North/South America): 1/3 of World Market

Asia (including Oceania): 1/3 of World Market

There are model codes:

- ACI codes
- Euro Codes
- *Asia needs one. → Asian Concrete Model Code*

Codes and Standards in Asia

3 cases
- Have no codes yet
- Adopt other countries' codes
- Develop their own codes

Big projects → International team
↓
Codes from various countries are used in one project.
↓
Creates confusion and misunderstanding

Need of development of its own code in first and second cases:

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

Considering those fact, the best solution is

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 multi-national 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 → Chinese-translated version in 2006

Committee members and meetings (as of Aug 2006)

Over 70 individual members

8 representative members

Over 20 corporate members

From 13 countries (Australia, Bangladesh, China, India, Indonesia, Iran, Japan, Korea, Malaysia, Philippines, Singapore, Thailand, and Vietnam)

22 Committee meetings in 12 countries/economy since 1994

Local committees in Japan, Korea and Thailand

13 member countries

ACMC

ACMC2006

ACMC 2006

3 Parts:

Structural design, materials and construction, and 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

Comparison among model codes

Items	ACMC 2006	Eurocode 2	ACI 318
Covered region	Asia and Pacific	Europe	North and South America
Design method	Performance -based design	Limit state design	Ultimate strength design

Performance-based concept

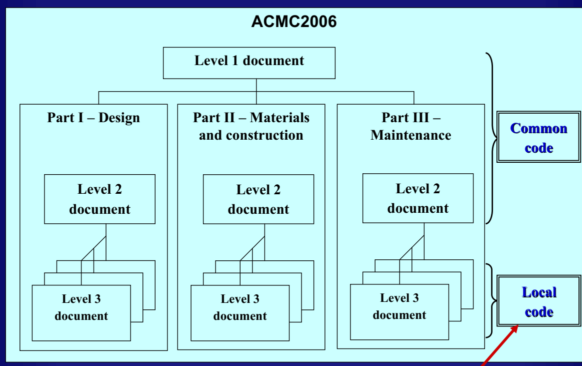
- Clear description of the required performance of a structure (in such a way that the owners and users of the structure, who are likely to be non-engineers, can understand)
- No specification on how to satisfy the required performance or how to prove that the required performance is satisfied, which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

Multi-level document structure



For particular region/economy or types of structure

Level 3 Documents

(1) "An example of design for seismic actions – performance examination of RC building designed according to the Architectural Institute of Japan (AIJ) Guidelines", 2001.

(2) "Vietnam Construction Standard TCXDVN 318: 2004 - Concrete and Reinforced Concrete Structures - Guide to Maintenance", 2004.

(3) "Guidelines for Maintenance and Rehabilitation of Concrete Structures against Chloride Induced Deterioration", 2004.

(4) "The Standard Specification for Materials and Construction of Concrete Structures in Japan", 2005.

Financial Support to ICCMC

Membership
- Corporative members
- Individual members

Japanese government
- MEXT as Scientific Grant-in-Aid（科研）
- MLIT as project on internationalization of codes（沿岸技術センターからの委託）
- METI as project on strengthening of Japanese presence in ISO（規格協会からの委託）

Other Japanese organization
- JCI
- Overseas Construction Association of Japan

Other Asian Countries
- KCI, Engineering Institute of Thailand
- Hosting organizations for ICCMC meeting

Relation to ISO

TC 71: Concrete, reinforced concrete and prestressed concrete

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

Relation to ISO

ISO/TC71

- Enhancement of Asian presence
  - TC71, SC1, SC3, SC4, SC5, SC6 and SC7
- Establishment of new SC
  - SC7 "Maintenance and Repair of Concrete Structures"
  - Chairman from Korea and Secretary from Japan
  - ISO umbrella code to be drafted based on ACMC
- Initiation of discussion on "Performance-based Concept"
  - ACMC is with performance-based concept while ISO codes basically with limit state concept

Asian Model Code:
Benefit for Asian Countries

For Asian Countries with Own Code

- Dissemination of their technology to be international code in Asia and ISO
- Strengthening their presence in international circle such as ISO through collaboration among Asian countries

For Asian Countries without Own Code

- Development of national codes
- Enhancement of technological level
- Strengthening their presence in international circle

Asian Model Code:
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
- China and Taiwan issue

Asian Model Code:
Other Issues

(1) Organizations responsible for preparing codes are various among different countries, such as non-governmental and governmental organization.

(2) Country like Japan where civil and architectural structures are dealt by different organization needs unification of codes are preferable.

(3) Financial support is still necessary for many Asian countries to participate international collaboration.

(4) Country with more advanced technology is expected to take leadership for code drafting.

Thank you for your attention

Web site for ICCMC

www.iccmc.org

Harmonization of Geotechnical with Structural Design Codes in Europe

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ABSTRACT: The Eurocode programme for the development of a set of harmonised codes for structural design, including Eurocode 7 for geotechnical design, is described. The main features of the limit state design method for the Eurocodes set out in EN 1990 are outlined. The challenges faced by the drafters of Eurocode 7 in preparing a code that was consistent with EN 1990, took account of the special features of soil and geotechnical design, and was acceptable to the European geotechnical community, are explained. The design issues that had to be overcome included the scope of Eurocode 7, the definition of the characteristic value of a soil parameter, the value of the partial factor on permanent loads in geotechnical design, the application of partial factors to soil parameters or resistances, the treatment of water pressures and forces, and the accommodation of national design practices. How these challenges and design issues were overcome is explained. It is concluded that Eurocode 7 will harmonize geotechnical design throughout Europe and will harmonize geotechnical with structural design codes in Europe.

1 EUROCODE PROGRAMME

1.1 Reasons for the Eurocodes

Since the 1950s there has been movement towards greater economic and political cooperation and integration in Western Europe. This led to the establishment of the European Economic Community (EEC) in 1957, which has developed and expanded to become the European Union (EU) with 25 member states at present in 2006. The concept of the Structural Eurocodes was conceived in 1975 by the Commission of the European Economic Community (EEC) for the following reasons:

- To remove of the obstacles to trade in construction that exist in Europe due to different national standards through the creation of a set of common harmonized design standards for all construction materials and hence to facilitate the exchange of construction services and improve the functioning of the internal market in Europe,
- To provide a set of common European design standards to be used as reference documents for member states to prove compliance of building and civil engineering works with the essential requirements regarding mechanical resistance, stability and safety in the case of fire in the European Council's Construction Products Directive with which all the building regulations in the European member states must comply. Where applicable, the national building regulations will refer to the Eurocodes, stating that structural and geotechnical work complying with them and the National Annexes to the Eurocodes will be deemed to satisfy the requirements in the building regulations.
- To improve the competitiveness of the European construction industry internationally.

Ten Eurocodes for structural and geotechnical design are being prepared, as shown in Table 1. Eurocode EN 1990 provides the basis of design that is used in all the Eurocodes; Eurocode 1 provides the actions, i.e. loads, to used in structural design; Eurocodes 3 – 6 and 9 provide the rules for the design of structures using the following main structural materials: concrete, steel, composite steel and concrete, timber, masonry and aluminium alloy; Eurocode 7 provides the rules for geotechnical design, i.e. designs involving soil material; and Eurocode 8 provides the rules for the design of structures for earthquake resistance.

Table 1: Set of Eurocodes and the number of Eurocode parts

Eurocodes	Titles of Eurocodes	Numbers of parts
EN 1990	Basis of structural design	1
EN 1991	Eurocode 1: Actions on structures	10
EN 1992	Eurocode 2: Design of concrete structures	4
EN 1993	Eurocode 3: Design of steel structures	20
EN 1994	Eurocode 4: Design of composite steel and concrete structures	3
EN 1995	Eurocode 5: Design of timber structures	3
EN 1996	Eurocode 6: Design of masonry structures	4
EN 1997	Eurocode 7: Geotechnical design	2
EN 1998	Eurocode 8: Design provisions for earthquake resistance of structures	6
EN 1999	Eurocode 9: Design of aluminium structures	5
	Total	58

Initially the Eurocode work was carried out under the direction of the European Commission. However progress on the Eurocodes was slow, partly because the volume of the Eurocode work increased as the number of Eurocode parts was increased to 58, as shown in Table 1 and partly because the European Commission was not established to prepare codes or standards. Hence it was decided in 1989 to transfer the work of preparing the Eurocodes from the European Commission to CEN, the European Committee for Standardization, so that they could be published by CEN as EuroNorms (ENs), i.e. as European Standards. The Eurocodes were transferred to CEN in 1990 and a technical committee, TC 250, was established to oversee the preparation of the Structural Eurocodes. A sub-committee, SC, with a secretariat provided by one of the European standards organizations, was established for each Eurocode; for example in the case of Eurocode 7, sub-committee SC7 was established and the Dutch Standardization Organization, NEN, became the secretariat for Eurocode 7. Progress on the Eurocodes became much faster once the Eurocode work was transferred to CEN and the different sub-committees of TC 250 were established.

1.2 Eurocode Design Method

Since the aim of the Eurocodes is to produce a common set of harmonised design codes for all structural materials, they are all based on the same limit state design method that is set out in the head Eurocode, EN 1990. By having the codes for geotechnical and structural design based on the same design method, geotechnical design is harmonized with structural design. The Eurocode design method is the limit state design method, which involves checking that the occurrence of all ultimate limit states (ULSs) and serviceability limit states (SLSs) is sufficiently unlikely. Ultimate limit states are checked using calculations involving design parameter values obtained by applying partial factors to characteristic parameter values as to achieve a certain target reliability. Thus this limit state method is based on reliability, with the characteristic values and the partial factors chosen so as to achieve the target probability of failure, although they are also chosen so that the resulting designs do not differ too much from the designs obtained using the existing design codes. Since most of the Eurocodes are for the design of structures using manufactured materials, the design method in EN 1990 focuses on structural design.

1.3 Development of a Eurocode

The stages in the development of a Eurocode for a particular material include a European stage followed by a national stage. The European stage involves first identifying a model limit state code for that material, then preparing an ENV, i.e. pre-standard, version of the Eurocode for provisional use. Trial calculations are carried out using the ENV and then, on the basis of experience with using the ENV and comments received, work is carried out to convert the ENV into a prEN, or a draft EN Eurocode. After publication of the prEN, a vote is taken to convert the prEN into a full EN, i.e. a EuroNorm or European Standard. CEN then translates the agreed text of the Eurocode into the three official CEN languages, English, French and German, and publishes the EN version. The date when

CEN publishes the EN version of a Eurocode is known as the date of availability, DAV. Many of the Eurocode parts have now been published as ENs, for example Part 1 of Eurocode 7, which was published in November 2004 as EN 1997-1.

The national stage in the development of a Eurocode begins after the publication of the EN version when there is first a 2-year National Calibration Period during which each national standards organisation has to publish the Eurocode as a national standard with its National Annex, for example in Ireland Part 1 of Eurocode 7 will be published as IS EN 1997-1. The National Annex of a country contains the values of the NDPs, i.e. nationally determined parameters, which are the values of the partial factors and other parameters whose values are left to national choice in the Eurocodes, that are to be used with the Eurocode in that country. There is then a 3-year Coexistence Period during which either the Eurocodes or the national standards may be used, although all government contracts will be carried out using the Eurocodes. At the end of the Coexistence Period, all national standards that cover the same areas as the Eurocodes must be withdrawn. Since most of the Eurocodes refer to other Eurocodes, they cannot be used in isolation, and hence it is planned that all the Eurocodes will be complete by 2010 for the start of what has been termed the Eurocode Era.

2 DEVELOPMENT OF EUROCODE 7

When it was decided in 1981 to start work on Eurocode 7, there was no model limit state code for geotechnical design. The only country in Western Europe that had a limit state geotechnical design code at that time was Denmark. Hence Dr. Niels Krebs Ovesen from Denmark was invited to chair a committee consisting of representative from the EEC countries to prepare a model limit state code for Eurocode 7. This model code was produced in 1987 and was used as the basis for the pre-standard version of Part 1 of Eurocode 7, published in 1994 as *ENV 1997-1: Geotechnical Design: General Rules*. Following a trial period with use of the ENV, comments were received on the text and a committee was established to convert the ENV into a prEN. The prEN version of Eurocode 7 was voted on and approved by all the CEN European member states in April 2004. CEN then published the EN version of Eurocode 7 in November 2004, which is the DAV for Eurocode 7. The 2-year Calibration Period for Eurocode 7, during which each country has to prepare its National Annex with its nationally determined parameters, expires in November 2006. The Coexistence Period for Eurocode 7 lasts for three years until November 2009. However, since Eurocode 7 depends on some of the other Eurocodes, it will probably be 2010, as noted above, before Eurocode 7 will be the only standard for geotechnical design in Europe.

3 CHALLENGES IN DEVELOPING EUROCODE 7

The committee drafting Eurocode 7 was faced with the following challenges, which were to produce a code for geotechnical design that was:
1) Consistent with EN 1990 and thus harmonized geotechnical design with structural design
2) Took account of the special features of soil and geotechnical design, and
3) Was acceptable to the European geotechnical engineering community.

3.1 Consistency with EN 1990

EN 1990 was originally drafted for structural design and for manufactured materials. Since at the time when work started on Eurocode 7, there was little experience in Western Europe of using the limit state design method for geotechnical design and since the use of reliability-based partial factors applied to characteristic parameters values is so different to the traditional design method using overall factors of safety, many geotechnical engineers were not happy with adopting the EN 1990 limit state design method in geotechnical design. The use of a statistical approach to select the characteristic value of a geotechnical parameter was not considered to be appropriate, particularly the definition of the characteristic value as the 5% fractile. Also, as explained in Section 3.3, it was considered that the partial factor of 1.35 in EN 1990 for permanent unfavourable loads was inappropriate for many geotechnical design situations, e.g. slope stability.

Table 2: Differences between features of soil and steel and the consequences for design

Soil features	Steel features	Consequences for geotechnical design
Natural material	Manufactured	Properties need to be determined, not specified
2 phase	Single phase	Need to consider behaviour of water as well as soil
Non-homogeneous	Homogeneous	Characteristic value not 5% fractile of test results
High variability	Low variability	Need judgement when selecting characteristic value
Frictional	Non frictional	Need care factoring favourable and unfavourable loads
Compressible	Non compressible	Design is often controlled by SLS rather than ULS
Non-linear	Linear	SLS calculations often difficult –ULS design used

3.2 Taking Account of the Special Features of Soil and Geotechnical Design

The special features of soil compared to other structural materials and the influence of these factors on geotechnical design needed to be taken into account in Eurocode 7 that harmonises geotechnical design with structural design. The special features of soil compared to other structural materials, such as steel, and the consequences of these for geotechnical design are listed in Table 2. How these features were accommodated in developing a Eurocode 7 that was consistent with EN 1990 is outlined in Section 3.

3.3 Acceptability by the European Geotechnical Community

Throughout Europe, different national geotechnical design practices have been developed that involve different ground investigation and soil testing methods and equipment, and different geotechnical calculation models. These different design practices have developed as a result of different ground conditions, climatic conditions and design traditions in Europe; for example in the sandy soils in the Netherlands the cone penetration test (CPT) is commonly used, in the stony glacial soils in north-western Europe, the standard penetration test (SPT) is commonly used, while in the cohesive soils in France, the pressuremeter is mostly used. Other reasons for the different design practices in Europe are the different regulatory regimes and cultures; for example in Germany the geotechnical design calculation methods are all prescribed in the national standards while in the UK, the calculation methods are not prescribed; the national standard provides the principles for geotechnical design and hence is a code of good practice rather than a prescriptive standard. In moving towards a common harmonised European code for geotechnical design, it transpired that the different national practices in Europe and the valuable experiences embodied in them would have to be accommodated in order to have Eurocode 7 accepted by the European geotechnical community.

4 DESIGN ISSUES IN HARMONIZING GEOTECHNICAL AND STRUCTURAL CODES

In order to address the challenges listed above and harmonize the geotechnical Eurocode with the other structural Eurocodes, the following six specific design issues arose:

a) The scope of Eurocode 7
b) The definition of the characteristic value of a geotechnical parameter
c) The value of the partial factors on permanent loads
d) The application of partial factors to material parameters or resistances
e) The treatment of water pressures and forces
f) The accommodation of different national design practices

How these design issues were treated in the development of Eurocode 7 is explained in the following sections.

4.1 Scope of Eurocode 7

The Structural Eurocodes include only standards for design, not for the testing of materials. However, in geotechnical design, the determination of properties of the ground properties is the first and an important part of all geotechnical designs. Hence TC 250 agreed that the scope of Eurocode 7 should include the requirements for ground investigations and the evaluation of geotechnical parameters. Thus there are two parts of Eurocode 7:

- *Part 1: General rules*
- *Part 2: Ground investigation and testing*

New European standards are being prepared by CEN for the procedures and equipment for carrying out geotechnical field and laboratory tests. These are not design standards and so are not Eurocodes nor are they part of Eurocode 7.

4.2 Characteristic Value of a Geotechnical Parameter

The EN 1990 statistical definition of the characteristic value as a 5% fractile of an unlimited test series was not considered appropriate for geotechnical design because actual soil failures are normally controlled by the mean value on the failure surface and not by localised low strength values. Since the volume of soil involved in a soil test is much less than that involved in an actual failure, the characteristic strength should be based on a 95% confidence of the mean strength on the failure surface, not on the 5% fractile of the test results. For this reason and because of the limited amount of geotechnical data normally available, the drafters of Eurocode 7 were concerned that a purely statistical definition of the characteristic value was not appropriate for geotechnical design. Hence the following definition for the characteristic value of a geotechnical parameter is given in Eurocode 7: *The characteristic value of a geotechnical parameter shall be <u>selected</u> as a <u>cautious estimate</u> of the value affecting the occurrence of the <u>limit state</u>.* Each of the underlined words in this definition is important because they show that in geotechnical design the characteristic value has to be selected, i.e. judgement has to be used; it is a cautious estimate, i.e. it is a conservative value; and its value depends on the limit state, i.e. the type of failure and the volume soil involved in the limit state.

4.3 Partial Factors on Permanent Loads

In structural design, the partial factor on unfavourable permanent loads is 1.35 and on favourable permanent loads is 1.0. In geotechnical design, where the permanent loads are often due to the weight of the soil, these partial factors can cause problems because it is often difficult to tell which part of a permanent load due to the soil is unfavourable and which favourable, for example in slope stability analyses. Applying different partial factors on favourable and unfavourable loads can lead to horizontal ground being predicted as being unstable; this is clearly illogical. In geotechnical design, uncertainty in the permanent loads is usually much less than the uncertainty in the soil properties or resistances. Since soil is frictional, if the normal load is part of resistance and is increased, then the design resistance is also increased, which is unsafe. For these reasons a partial factor of 1.0 for unfavourable permanent loads in geotechnical designs was accepted by TC 250 at the ENV stage.

4.4 Partial Factors on Soil Parameters or Resistances

The ENV version of Eurocode 7 had a materials and load factor approach, with partial factors on soil parameters not resistances, and loads. This involved three Cases: A, B and C, with different sets of partial factors for each Case. Some countries in Europe wanted factors on resistances instead of factors on soil parameters and therefore the EN version of Eurocode 7 was produced with three Design Approaches with different sets of partial factors allowing partial factors on either soil parameters or on resistances, i.e. allowing either a either a materials or a resistance factor design. The 3 Design Approaches are:

- DA1, with two Combinations, which is a materials and load factor approach where Combinations 1 and 2 are equivalent to the Cases B and C in the ENV version. In principle two calculations are required with this Design Approach, although it is often clear which Combination controls the design.
- DA2, which is a resistance and load factor approach. Only one calculations is required using this Design Approach.
- DA3, which is a materials and load factor approach, like DA1, with Combinations 1 and 2 combined. Only one calculations is required using this Design Approach.

4.5 Treatment of Water Pressures and Forces

The significance of saturated soil being a 2-phase material, consisting of soil particles and water, and the importance of considering the effects and consequences of water pressures and forces when evaluating safety in geotechnical designs, is recognised in Eurocode 7. Water pressures and forces are treated as permanent actions. Additional ultimate limit states are defined in Eurocode 7 for the following design situations where failure is largely due to water pressures or forces, with little or no soil strength involved:

- UPL - Uplift due to hydrostatic pore water pressures
- HYD - Heave failure due to seepage pressures

Separate sets of partial factors provided for UPL and HYD.

4.6 Accommodating Existing National Design Practices

Eurocode 7 provides the principles for geotechnical design, with very few equations and only a few calculation methods given in Annexes for guidance, not as code requirements. National design practices include valuable geotechnical experience in the form of existing national investigation, testing and design calculation methods. Many countries were not prepared to accept Eurocode 7 unless these national practices could be accommodated. Since Eurocode 7 is not prescriptive, the valuable experience embodied in these practices will not be lost because Eurocode 7 may be complemented by non-conflicting national standards that provide additional design rules reflecting national design practice and experience. Schuppener and Vogt(2005) have outlined how non-conflicting national geotechnical design codes are integrated with national EN version of Eurocode 7.

5 TRAINING IN AND PROMOTION OF EUROCODES

When the Eurocodes are introduced, there will be a great need for training and promotion because many of the limit state design concepts in Eurocode 7 are new to European geotechnical engineers. The use of the Eurocodes will be promoted in European engineering schools and as part of continuing professional development. An awareness campaign is planned which will include conferences on the Eurocodes. In addition, guidance documents, handbooks, manuals and design aids will be required as well as software and associated training. Thomas Telford is publishing a set of Designers' Guides to the Eurocodes; an example of these is the *Designers' Guide to Eurocode 7* by Frank et al.(2004). Another publication is the *Proceedings of the International Conference on the Evaluation of Eurocode 7* by Orr(2005).

6 CONCLUSIONS

After the decision 31 years ago to create the set of Eurocodes for structural design, the complete set of Eurocodes is nearly ready for use. Eurocode 7 provides European engineers with a common standard for geotechnical and so harmonizes geotechnical design in Europe. Through being consistent with EN 1990, Eurocode 7 harmonizes geotechnical with structural design codes in Europe. In achieving this, the drafters of Eurocode 7 have taken account of the special features of soil and geotechnical design and have accommodated the different existing national geotechnical design practices in Europe. From 2010 only the Eurocodes will be used for geotechnical and structural design in Europe – i.e. the Eurocode Era will have begun. Since Eurocode 7 provides the principles of geotechnical design and is not prescriptive, it is applicable worldwide, as well as in Europe.

REFERENCES

Frank R., Bauduin C., Driscoll R., Kavvadas M., Krebs Ovesen N., Orr T. and Schuppener B. (2004) *Designers' Guide to Eurocode 7*, Thomas Telford, London

Orr T.L.L. (2005) *Proceedings of the International Workshop on the Evaluation of Eurocode 7*, Trinity College, Dublin, Department of Civil, Structural and Environmental Engineering, Trinity College, Dublin

Schuppener B and Vogt N. (2005) European limit state geotechnical design codes and how we integrate national geotechnical design codes, *Proceedings of the International Workshop on the Evaluation of Eurocode 7*, 21-31, Department of Civil, Structural and Environmental Engineering, Trinity College, Dublin

Harmonization of Geotechnical with Structural Design Codes in Europe

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ACECC Workshop on Harmonization of Design Codes in the Asian Region
Taipei: 4 November 2006

Development of Eurocodes

- Since 1950s movement towards greater economic and political cooperation and integration in Western Europe
- 1957 - Establishment of European Economic Community (EEC) which is now the EU with 25 countries
- 1975 – EEC decided to prepare the Structural Eurocodes
- Reasons for the Eurocodes
  - to remove the obstacles to trade in construction through the creation of a set of common harmonized design standards for all construction materials in place of existing different national standards
  - to improve the internal market
  - to provide a set of common design standards as reference documents to prove compliance of building and civil engineering works with the requirements regarding mechanical resistance, stability and safety in the case of fire in the EU's Construction Products Directive
  - to improve the competitiveness of the European construction industry internationally

Eurocode Programme

The following 10 Eurocodes are being prepared:

- EN 1990: Basis of structural design
- EN 1991 Eurocode 1: Actions* on structures

Design standards for different structural materials:

- EN 1992 Eurocode 2: Design of concrete structures
- EN 1993 Eurocode 3: Design of steel structures
- EN 1994 Eurocode 4: Design of composite steel and concrete structures
- EN 1995 Eurocode 5: Design of timber structures
- EN 1996 Eurocode 6: Design of masonry structures
- EN 1999 Eurocode 9: Design of aluminium alloy structures

- EN 1997 Eurocode 7: Geotechnical design
- EN 1998 Eurocode 8: Design of structures for earthquake resistance

*Note: Actions = Loads

Eurocode Parts and Organisation

- The 10 Eurocodes have 58 parts
- For example: Eurocode 2: Design of Concrete Structures has 4 parts
  - Part 1: General rules and rules for buildings
  - Part 2: Rules for structural fire design
  - Part 3: Rules for the design of bridges
  - Part 4: Rules for the design of liquid retaining and containment structures
- Eurocode 7: Geotechnical Design has 2 parts:
  - Part 1: General rules
  - Part 2: Ground investigation
- Eurocode work initially organized under European Commission
  - Number of parts and scale of work increased
  - Progress slow
- 1990 – Eurocode work transferred to CEN – European Committee for Standardization
  - TC 250 for Structural Eurocodes, SC (sub-committees) formed for each Eurocode
  - Much faster progress
  - CEN can publish Eurocodes as ENs (EuroNorms), i.e. European Standards

Stages of a Eurocode - European

- Model limit state code identified
- ENV – pre-standard Eurocode prepared
- Trial calculations using the ENV
- Conversion to a prEN (pre EN standard)
- Vote taken to convert prEN to a full EN Eurocode
- Publication of Eurocode by CEN as an EN , e.g. EN 1997-1
- Date of publication by CEN as an EN is the DAV - Date of Availability
- EN version of each Eurocode contains recommended values for partial factors, γ and other parameters left for national choice

Stages of a Eurocode - National

- Each country is responsible for the level of safety of the structures in that country
- Hence each country must choose the values of the partial factors and other parameters, known as Nationally Determined Parameters, NDPs, to be used with each Eurocode in that country
  - Each country is expected to use the recommended γ values
  - If other γ values chosen, then country will have to give CEN reason
- NDPs are published in the National Annex to accompany each Eurocode when it is published in each country
- After the DAV, each country has a maximum of 2-years in a National Calibration Period to prepare a National Annex and issue the Eurocode as a National Standard, e.g. IS EN 1997-1 for Eurocode 7 Part 1 in Ireland

Stages of a Eurocode
- Implementation

- After publication of National Standard version of a Eurocode with the National Annex, there is 3-year Coexistence Period – either the Eurocode or national standard may be used
- At end of DAV, all national standards covering the same aspects as the Eurocodes must be withdrawn and only the Eurocode used
- Since each National Annex will be different, so when deigning to a Eurocode, one must use the Eurocode with the National Annex for the country in which the structure is to be constructed
- Aim is that the values chosen for γ values will converge
- Since Eurocodes are interdependent, the full implementation of the Eurocodes cannot occur until they are all available
- Planned all Eurocodes available by 2010 for start of Eurocode Era

Eurocode Design Method

- EN 1990 provides the design method to be used for all the Eurocodes for the design of all structures
- Objective creating a set of common harmonized design standards for all structural materials - involves harmonizing geotechnical design with structural design
- Eurocodes all based on the same limit state design method
- Involves checking ultimate and serviceability limit states
- Partial factors applied to characteristic parameter values
- Definition of characteristic values and determination of partial factor values are reliability/probability based
- Focus is on structural design

3 Challenges in Drafting Eurocode 7

3 challenges were to prepare a geotechnical code that:

1. Was consistent with EN 1990 - harmonized geotechnical design with structural design in the other Eurocodes
2. Took account of special features of soil and geotechnical design
3. Was acceptable to all of the European geotechnical engineering community

Similar challenges would be faced elsewhere, for example in Asia, when preparing modern geotechnical design codes that harmonize geotechnical design with structural design

1. Consistent with EN 1990

- EN 1990 was originally drafted for structural designs involving manufactured materials, such as steel
- As there was little experience in Western Europe in the use of the limit state design method in geotechnics, many geotechnical engineers were not happy with applying the probability based design method in EN 1990 to geotechnical design
- The use of a statistical approach to select the characteristic value of a geotechnical parameter was not considered to be appropriate, particularly the definition of the characteristic value as the 5% fractile of test results
- The partial factor of 1.35 in EN 1990 was considered inappropriate for many geotechnical design situations, e.g. slope stability

2. Special Features of Soil and Consequences

Comparison between Soil and Steel

Soil	Steel	Consequences
Natural	Manufactured	Properties determined not specified
2 phase	Single phase	Consider water as well as soil
Non-homogeneous	Homogeneous	Characteristic value not 5% fractile of test results
High variability	Low variability	Need judgement selecting characteristic value
Frictional	Non-frictional	Need care factoring permanent loads
Compressible	Non-compressible	Design often controlled by SLS – not by ULS
Non-linear	Linear	SLS calculations often difficult – design using ULS calculation

3. Acceptable to all of the European Geotechnical Community

- Throughout Europe, there are different national geotechnical design practices involving different:
  - Ground investigation methods
  - Soil testing methods
  - Geotechnical design methods
- Different design practices are due to different:
  - Ground conditions
  - Climatic conditions
  - Design traditions
- Also due to different regulatory regimes and cultures, e.g.
  - In Germany the calculation methods are all prescribed in the national standard
  - In the UK, the calculation methods are not prescribed and the standard is a code of good practice
- To be acceptable to the European geotechnical community, the different design practices needed to be accommodated

6 Design Issues in Harmonizing Geotechnical and Structural Design

- Scope of Eurocode 7
- Definition of the characteristic value of a geotechnical parameter
- Value of the partial factor on permanent loads
- Application of partial factors to soil parameters or resistances
- Treatment of water pressures and forces
- Accommodation of national design practices

Scope of Eurocode 7

- Eurocodes include only standards for design, not for testing of materials
- Determination of ground properties part of the geotechnical design process
- Agreed scope of Eurocode 7 should include requirements for ground investigations and the evaluation of geotechnical parameters
  - Eurocode 7 is a comprehensive design code covering all aspects of geotechnical design: investigation, determination of parameters, design, monitoring and maintenance
- Hence there are two parts of Eurocode 7:
  - *Part 1: General rules*
  - *Part 2: Ground investigation and testing*
- New European standards being prepared by CEN for carrying out geotechnical field and laboratory tests – not Eurocodes and not part of Eurocode 7

Characteristic Value

- EN 1990 statistical definition of the characteristic value as a 5% fractile of an unlimited test series not considered appropriate for geotechnical design because
  - Soil failures are controlled by the mean value on failure surface
  - Volume of soil tested much less than that involved in a failure
  - Hence strength based on mean of test results, not 5% fractile
- Concern by drafters of Eurocode 7 that a purely statistical definition of the characteristic value is not appropriate for geotechnical design due to limited test data
- Definition in Eurocode 7:
  - *The characteristic value of a geotechnical parameter shall be selected as a cautious estimate of the value affecting the occurrence of the limit state*

Partial Factor on Permanent Loads

- In structural design partial factor on unfavourable permanent loads = 1.35 and on favourable permanent loads = 1.0
- In geotechnical design, this can cause problems:
  - Often difficult to tell which part of load is unfavourable and which favourable – e.g. in slope stability analyses
  - Can lead to horizontal ground being predicted as unstable - illogical
  - Uncertainty in loads usually much less than uncertainty in soil properties or resistances
  - Since soil is frictional, if normal load as part of resistance is increased, then the design resistance is increased, which is unsafe
- Partial factor γ_G = 1.0 for unfavourable permanent loads was accepted by TC 250 for geotechnical design at the ENV stage

Partial Factors on Soil Parameters or Resistances

- ENV had a materials factor approach with partial factors on:
  - Loads (actions)
  - Soil parameters, not resistances
- 3 Cases: A, B and C (different sets of partial factors)
- Some countries in Europe wanted factors on resistances instead of factors on soil parameters
- EN 1997 produced with 3 Design Approaches allowing either a materials or a resistance factor design
  - DA1, with 2 Combinations, is a materials and load factor approach equivalent to Cases B and C
  - DA2 is a resistance and load factor approach
  - DA3 is a materials and load factor approach – like DA1, with Combinations 1 and 2 combined

Treatment of Water Pressures

- 2-phase nature of soil – soil particles and water
- Importance of water pressure when evaluating safety in geotechnical designs is recognised in Eurocode 7
- Water pressures and forces are treated as permanent actions
- Additional ultimate limit states are defined where failure largely due to water pressures with little or no soil strength involved:
  - UPL - Uplift due to hydrostatic pore water pressures
  - HYD - Heave failure due to seepage pressures
- Separate sets of partial factors provided for UPL and HYD

Accommodation of National Design Practices

- Eurocode 7 provides the principles for geotechnical design, with very few equations and no calculation methods provided are code requirements.
- National design practices include valuable geotechnical experience in the form of existing calculation methods and national investigation, testing and design methods
- Since Eurocode 7 is not prescriptive, this valuable experience need not be lost as Eurocode 7 may be supplemented by national standards that are non-conflicting with Eurocode 7
- National standards can provide additional design rules reflecting national design practices and experience

Training and Promotion

- When the Eurocodes are introduced, there will be a great need for training and promotion – for example many of the concepts in Eurocode 7 are new to European geotechnical engineers
- Use of Eurocodes will be promoted in European engineering schools and as part of continuing professional development
- An awareness campaign is planned which will including conferences on the Eurocodes
- Guidance documents:
  - Handbooks, manuals and design aids
- Software and associated training

Designers' Guide to Eurocode 7

- One of a series of guides to the use of Eurocodes
- Includes explanations to Eurocode text
- Includes fully worked design examples using the 3 Design Approaches
- Published by Thomas Telford – Institution of Civil Engineers, London

Evaluation of Eurocode 7

Proceedings of an International Workshop on Eurocode 7 held in Dublin in 2005

- Contents:
  - Review of Workshop
  - Design examples
  - Complete set of model solutions
  - Papers on limit state design including design for serviceability and use of FEM
  - Solutions to examples using different Japanese design codes
- 320 Pages
- To order email Trevor Orr:

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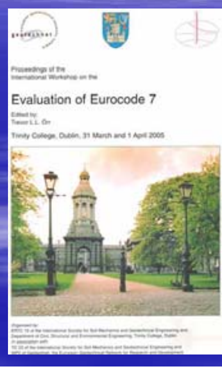

Conclusions

- 31 years after deciding to create the set of Eurocodes for structural design, the complete set of Eurocodes is now nearly ready for use
  - Patience is required when introducing new codes
- Eurocode 7 provides geotechnical engineers with a common standard and so harmonizes geotechnical design in Europe
- Eurocode 7 is consistent with EN 1990 and so harmonizes geotechnical design with structural design
- This has been achieved by
  - Taking account of the special features of soil and geotechnical design
  - Accommodating existing national design practices

- Eurocode 7 is a comprehensive code, covering all aspects of geotechnical design:
  - Ground investigation and determination of parameter values
  - Geotechnical design
  - Monitoring
  - Maintenance
- Since Eurocode 7 focuses on the principles of geotechnical design, it is applicable worldwide, as well as in Europe
- When using Eurocode 7 it will be necessary to use it with the National Annex and g values for the country where the construction is to take place
- From 2010 only the Eurocodes will be used for geotechnical and structural design in Europe – i.e. the Eurocode Era will have begun

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Emerging Trends in Seismic Design of Geotechnical Works

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1 INTRODUCTION

Geotechnical works typically consist of soil and structural parts such as buried structures (e.g. buried tunnels, box culverts, pipelines, and underground storage facilities), foundations (e.g. shallow and deep foundations, and underground diaphragm walls), retaining walls (e.g. soil retaining and quay walls), pile-supported wharves and piers, earth structures (e.g. earth and rockfill dams and embankments), gravity dams, landfill and waste sites. The seismic performance of geotechnical works is significantly affected by ground displacement. In particular, soil-structure interaction and effects of liquefaction play major roles and pose difficult problems for engineers.

Objective of this paper is to review how these problems have been dealt with in the development of seismic design codes. Port structures in Japan will be taken as a representative example of geotechnical works. In particular, the paper discusses how we learned the lessons from the case histories during past earthquakes. The paper then discusses the emerging trends in seismic design of geotechnical works. The paper concludes with a proposal that will be useful for designing new and large geotechnical works that have to meet the rapidly growing social and economic demands in Asia.

2 EARTHQUAKES AND SEISMIC CODE DEVELOPMENT (1964-1999)

Large damaging earthquake have occurred in Japan almost every five years as shown in Fig. 1. In particular, large earthquakes with Richter magnitude 7.5 or larger occurred along the boundaries of the Pacific, Eurasian, Philippine, and North American plates. Earthquakes with smaller Richter magnitude can also be devastating when they occur in the vicinity or an urban area. The 1995 Hyogoken-Nambu earthquake is a typical example.

Table 1 shows major earthquakes occurred in Japan since 1964 Niigata earthquake, together with the relevant research activities and application to design practice in ports and airports in Japan. This table suggests that a large earthquake and associated damage to port structures posed new priority research subjects, triggering the new research projects. After a certain period of time for research and further establishment or maturity of the research results, these results were adopted for design practice in terms of design code, standard, guidelines, or manuals. The correspondence between the occurrence of earthquakes and the research developments may be easily recognized in this table. The earthquake engineering in Japan has been developed hand-in-hand with the case histories of seismic damage.

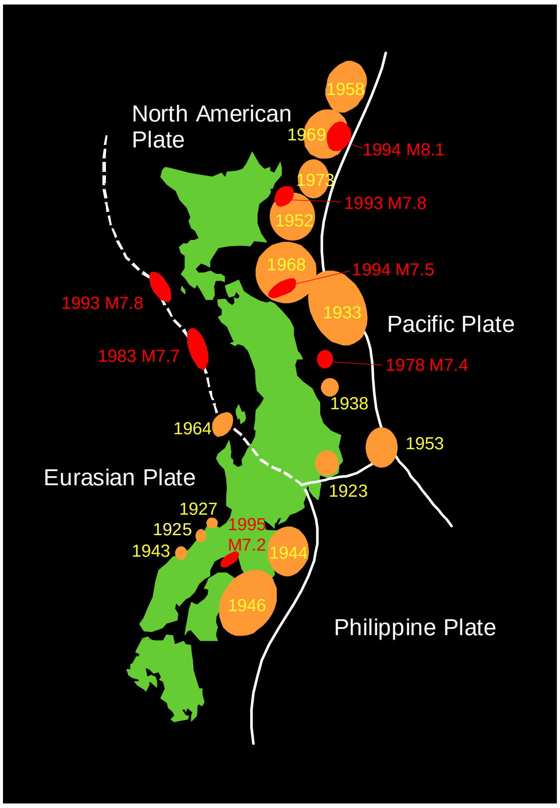

Fig. 1 Earthquakes in Japan (1923-1999)

Let us review some of the items shown in Table 1 in order to appreciate in a more tangible manner how the earthquake engineering research and design practice have been developed in Japanese.

Table 1 Major earthquakes and research results/application to practice

Earthquakes	Year	Research results/application to practice
1964 Niigata	1964	Initiation of strong motion recordings in port areas
1968 Tokachi-oki	1970	Liquefaction criterion proposed for design practice
1973 Nemuro-oki	1975	Seismic coefficient method re-evaluated
1978 Miyagiken-oki	1979	Design standard of port structures
1983 Nihonkai-chubu	1984	Guidelines for measures against liquefaction
	1984	Strategic plan for seismic hazard mitigation in port areas
	1989	Measures against liquefaction specified in design standard
1993 Kushiro-oki	1993	Measures against liquefaction (densification and gravel drains) demonstrated
1993 Hokkaido-Nansei-oki	1993	Handbook for measures against liquefaction
1994 Hokkaido-Toho-oki		
1994 Sanriku-Haruka-oki	1994	Measures against liquefaction (preloading) demonstrated
1995 Hyogoken Nambu	1995	Methodologies for evaluating earthquake induced deformation established
	1997	Level 1 and 2 earthquake motions specified for design practice
	1997	Performance based design method introduced in measures against liquefaction
	1997	Implementation of effective stress analysis in design practice (FLIP)
	1998	Initiation of earthquake motion recording in airports
	1999	Implementation of measures against liquefaction for runways
	1999	Implementation of seismic performance based design in design standard
	2001	PIANC: International Guidelines for Seismic Design of Port Structures

3 CONVENTIONAL DESIGN (SIMPLIFIED LIMIT EQUILIBRIUM DESIGN)

1964 Niigata earthquake caused extensive liquefaction and serious damage to port structures, triggered the strong research needs on liquefaction. Liquefaction induced damage to a bridge is shown in Fig. 2. The research results, combined with the shaking table tests of saturated sand deposit and field investigations during 1968 Tokachi-oki earthquake, were summarized in 1970, after 6 years from the earthquake, as a liquefaction criterion using SPT N-values and gradation of soil[1)].

Fig. 2 Damage to Showa-Ohashi bridge due to liquefaction during 1964 Niigata earthquake

1968 Tokachi-oki earthquake produced a wealth of strong motion records through the network of strong motion recording deployed throughout port areas in Japan in 1964. In particular, peak ground accelerations exceeded 0.2g in Hachinohe, Aomori, and Muroran ports. Seismic coefficients used for pseudo-static analysis of quay walls were re-evaluated based on the back-analysis using the peak ground accelerations and performance of quay walls[2)]. With an additional study for 1973 Nemuro-oki earthquake[3)], the results of the studies were compiled as a relation between the peak ground acceleration and the seismic coefficient in 1975[4)]. It took almost 8 years from the initiation of this research to complete for application.

Many sheet pile quay walls in Akita port were damaged during 1983 Nihonkai-chubu earthquake as shown in Fig. 3. The peak ground acceleration was 0.2g. Most of the damaged quay walls were associated with liquefaction of backfill soil. One quay wall that did not suffer damage in Akita port was constructed at the non-liquefied site. This case history initiated a high priority research project for establishing guidelines for measures against liquefaction. The research project was intensively performed, and the research results were adopted for practice design in less than one year. In particular, guidelines for measures against liquefaction were drafted and completed in 1984. A strategic plan was set up in the same year by the Ports and Harbours Bureau, Ministry of Transport, for mitigating catastrophic damage to ports in Japan.

Effectiveness of the measures against liquefaction was demonstrated in 1993 Kushiro-oki earthquake. Despite the strong earthquake motion with a peak ground acceleration of 0.3g, the quay walls with measures against liquefaction suffered no or minor damage.

With respect to the airport facilities, the 1993 Kushiro-oki earthquake demonstrated seismic resistance of a 60m high embankment constructed for runway expansion in the mountainous area.

The earthquakes following this event, including 1993 Hokkaido-Nansei-oki, 1994 Hokkaido-Toho-oki, 1994 Sanriku-oki earthquakes, registered peak ground accelerations ranging from 0.3 to 0.5g, being one level higher than the accelerations recorded before 1993, demonstrated that the seismic design procedure adopted for practice were effective and adequate for mitigating seismic hazards.

To summarize, the conventional design was based on the simplified limit equilibrium analysis and liquefaction assessment that were separately performed. If required, measures against liquefaction were implemented. The conventional design was proven to be effective by the case histories during earthquakes up to the peak ground accelerations of 0.3 to 0.5g level.

Fig.3 Damage to a sheet pile quay wall at Akita port during 1983 Nihonkai-Chubu earthquake (After Akita prefecture)

4 PERFORMANCE BASED DESIGN

The 1995 Hyogoken-Nambu earthquake drastically changed the affirmative recognition of the seismic design. The peak accelerations during this earthquake ranged from 0.5 to 0.8g, causing catastrophic damage to highly developed and modernized urban areas as shown in Fig. 4 and 5[5]. This triggered the research towards establishing the performance based design. This posed a challenge in earthquake engineering especially because of the complex soil-structure interaction phenomenon occurring in the port structures, including liquefaction. The research, however, was completed within several months using underwater shake tables and numerical analysis based on effective stress analysis. The results of the analysis were immediately adopted for restoration of damaged quay walls and seismic design for new structures. As shown in Table 1, these results were compiled into the guidelines for measures against liquefaction, and performance based approach adopted in design standard[6,7].

The goal is to overcome the limitations present in conventional seismic design. Conventional building code seismic design is based on providing capacity to resist a design seismic force, but it does not provide information on the performance of a structure when the limit of the force-balance is exceeded. If we demand that limit equilibrium not be exceeded in conventional design for the relatively high intensity ground motions associated with a very rare seismic event, the construction/retrofitting cost will most likely be too high. If force-balance design is based on a more frequent seismic event, then it is difficult to estimate the seismic performance of the structure when subjected to ground motions that are greater than those used in design.

In performance-based design, appropriate levels of design earthquake motions must be defined based on its variability and corresponding acceptable levels of structural damage must be clearly identified. Two levels of earthquake motions are typically used as design reference motions.

The acceptable level of damage is specified according to the specific needs of the users/owners of the facilities and may be defined on the basis of the acceptable level of structural and operational damage given in Table 2[8]. The structural damage category in this table is directly related to the amount of work needed to restore the full functional capacity of the structure and is often referred to as direct loss due to earthquakes. The operational damage category is related to the amount of work needed to restore full or partial serviceability. Economic losses associated with the loss of serviceability are often referred to as indirect losses. In addition to the fundamental functions of servicing sea transport, the functions of port structures may include protection of human life and property, functioning as an emergency base for transportation, and as protection from spilling hazardous materials. If applicable, the effects on these issues should be considered in defining the acceptable level of damage in addition to those shown in Table 2.

Once the design earthquake levels and acceptable damage levels have been properly defined, the required performance of a structure may be specified by the appropriate performance grade S, A, B, or C defined in Table 3. In performance-based design, a structure is designed to meet these performance grades.

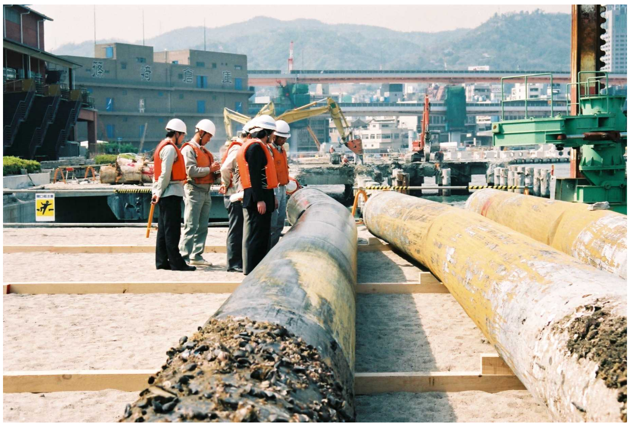

Fig. 4 Damage to steel piles for pile-supported-wharf in Kobe Port during 1995 Hyogoken-Nambu earthquake

Fig. 5 Damage to a caisson quay wall at Kobe port during 1995 Hyogoken-Nambu earthquake

Table 2 Acceptable level of damage in performance-based design*

Acceptable level of damage	Structural	Operational
Degree I : Serviceable	Minor or no damage	Little or no loss of serviceability
Degree II: Repairable	Controlled damage**	Short-term loss of serviceability***
Degree III: Near collapse	Extensive damage in near collapse	Long-term or complete loss of serviceability
Degree IV: Collapse****	Complete loss of structure	Complete loss of serviceability

* Considerations: Protection of human life and property, functions as an emergency base for transportation, and protection from spilling hazardous materials, if applicable, should be considered in defining the damage criteria in addition to those shown in this table.
** With limited inelastic response and/or residual deformation
*** Structure out of service for short to moderate time for repairs
**** Without significant effects on surroundings

Table 3 Performance grades S, A, B, and C

Performance grade	Design earthquake	
	Level 1(L1)	Level 2(L2)
Grade S	Degree I: Serviceable	Degree I: Serviceable
Grade A	Degree I: Serviceable	Degree II: Repairable
Grade B	Degree I: Serviceable	Degree III: Near collapse
Grade C	Degree II: Repairable	Degree IV: Collapse

5 EMERGING TRENDS IN DESIGN

Emerging trends in design may be summarized as follows.

5.1 From Design-for-Construction to Design-for-Performance

The concept of operational damage introduced in the performance based design plays a significant role in emerging trends in design. In conventional design, construction of a good geotechnical work was the sole objective of design. In the emerging trends in design, providing appropriate function and service rather than a physical construction becomes the final objective of design. There is an important paradigm shift from structure-oriented to performance-oriented approach.

5.2 From Standardized-Design to Site-Specific-Design

Conventional design relied on the standardized earthquake loads such as those specified by design spectra and seismic coefficient. If needed, variability of these loads was considered in a framework such as reliability design methodology but the loads were standardized. In the merging trends in design, site-specific earthquake motions are used for achieving the optimum design best suited for the construction site.

5.3 From Analysis-of-Structural/Foundation Parts to Analysis-of-Soil-Structure-System

Conventional design was based on the analysis of structural or soil part idealized to fit to the simplified methodologies. In the emerging trends in design, analysis of whole soil-structure system and identification of failure modes are the bases.

In fact, these emerging trends in design are incorporated in the International Standard (ISO) on seismic actions for designing geotechnical works[9)].

5.4 Further emerging trends: Producing Service

The discussions on these emerging trends in design can be extended further. By expanding the concept of performance-oriented approach, a new horizon of design will become apparent. In stead of trying to reduce the cost for construction, the new objective of design will be to increase the service produced by the designing process. In stead of constructing buildings and producing things based on the concept of production efficiency through mass production process and ending up producing unnecessary products and infrastructures, the new objective of design will be to offer performance and service required by the society and human.

The concept of offering performance and service further triggers us to have a new look at civil engineering structures. In stead of trying to optimize individual structures for construction, we can define a system consisting of a group of structures and try to optimize it. The structural system can be as large as an entire urban system. In this case, we can look at this system as built environment rather than social infrastructure. Once we establish the function and objective of the built environment, then we can further expand our design approach for natural environment and the interaction between the built and natural environments. In stead of using conventional materials such as steel and concrete, new materials and intelligent technologies may offer a completely new performance and service. In stead of trying to maintain the old infrastructure based on life-cycle management, we can renovate and redevelop those infrastructures to achieve required and enhanced performance and service. Based on these merging trends, objective of the seismic design may be transformed into the new objective to create a space of safety and security in the decade to come.

The approaches and new concepts in design discussed above will be useful for designing new and large geotechnical works that have to meet the rapidly growing social and economic demands in Asia.


Fig. 6 Large waterfront development, Singapore (Penta Ocean)

6 DESIGNING LARGE URBAN AREA AGAINST COMBINED HAZARDS

The extreme event of tsunamis, such as those caused by the Sumatra earthquake of 2004 to the Sumatra area[10] might not be easy to cope with the design strategy discussed in the previous chapter. The height of the tsunamis ranged from 5 to 30m. Over a 3km inland from the coast line was affected by the tsunami. The coastal area, as shown in Fig. 7, was washed away due to the combined effects of liquefaction during the earthquake and erosion by the tsunami. Long distance such as tens of kilometers should be covered for appropriate vulnerability assessment.

One way to cope with this is to use a simplified design charts. In fact, sets of design charts were developed based on a series of parametric studies on embankments and gravity structures[11]. These design charts are incorporated in a spread sheet format. Input data required are (1) basic parameters defining the cross section of structures, (2) geotechnical conditions as represented by SPT N-values, and (3) earthquake data, as represented by wave form, peak ground acceleration, or distance and Alternative way to cope with this extreme event is set up a reasonable strategy to evacuate and recovery. In order to enhance the quality of evacuation, education, early warning system, and better city planning could be beneficial. Constructing a reasonable set of evacuation lands with enough height may be also useful. These evacuation lands may be utilized for either community facilities, parks or religious purpose facilities such as mosques and temples for daily use of residents. In this way of combining the objectives of the facilities in stead of pursuing the sole objective, better planning for mitigating disasters may be achieved.

Securing the robust evacuation root is also important. In the example of the district shown in Fig. 7, at least one bridge should be robust enough to allow evacuation immediately after the earthquake. In the highly developed urban area, fires, collapse of buildings and other associated events that close the evacuation root must be evaluated for better planning of evacuation.

Early recovery of the damaged urban areas should also be well planned. Emergency base for recovery, hospitals, and other important facilities should be robust enough to be functional in the extreme event.

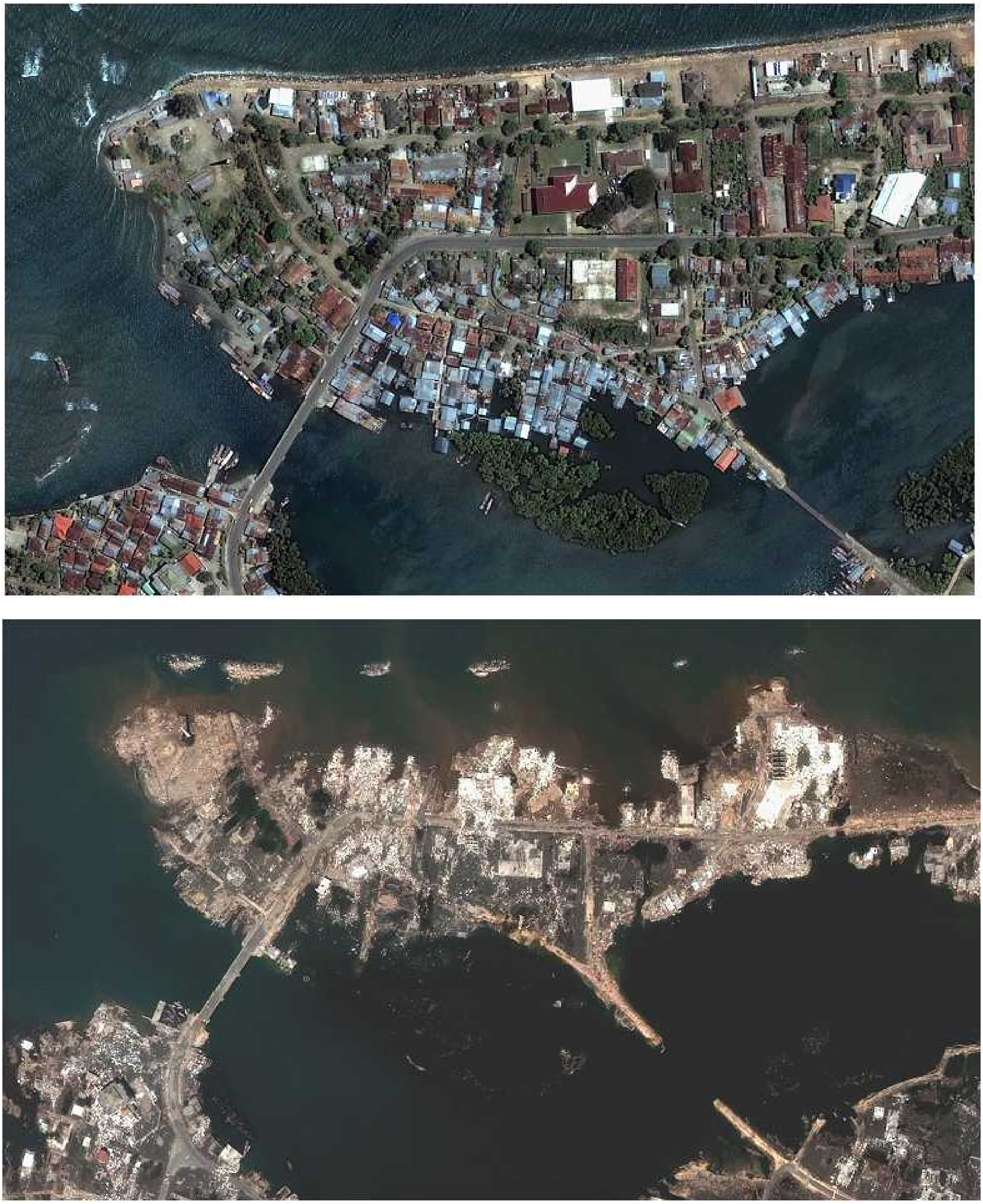

Fig. 7 Coastal area of Banda Aceh, Indonesia, before (above) and after (below) the Indian Ocean-Sumatra earthquake of 2004 (after Quickbird)

6 CONCLUSIONS

Increasing the robustness of geotechnical works is an important design consideration. The paper reviews how we learned the lessons from the case histories during past earthquakes. The emerging trends in design discussed in this paper may be summarized as follows:

(1) In conventional design, construction of a good geotechnical work was the sole objective of design. In the emerging trends in design, providing appropriate function and service rather than a physical construction becomes the final objective of design. There is an important paradigm shift from structure-oriented to performance-oriented approach.
(2) Conventional design relied on the standardized approach. If needed, variability in these standardized values was considered in a framework such as reliability design methodology in a standardized manner. In the merging trends in design, site-specific approach is adoped for achieving the optimum design best suited for the construction site.
(3) Conventional design was based on the analysis of structural or soil part idealized to fit to the simplified methodologies. In the emerging trends in design, analysis of whole soil-structure system and identification of failure modes are the bases.
(4) The discussions on these emerging trends in design can be extended further. By expanding the concept of performance-oriented approach, a new horizon of design will become apparent. In stead of trying to reduce the cost for construction, the new objective of design will be to increase the service produced by the designing process. In stead of constructing buildings and producing things based on the concept of production efficiency through mass production process and ending up producing unnecessary products and infrastructures, the new objective of design will be to offer performance and service required by the society and human.
(5) Designing large urban area against combined hazards such as those cause by the Sumatra earthquake of 2004 poses new challenge in design. One way to cope with this is to use a simplified design charts. In fact, sets of design charts were developed based on a series of parametric studies on embankments and gravity structures. Alternative way to cope with this extreme event is set up a reasonable strategy to evacuate and recovery. In order to enhance the quality of evacuation, education, early warning system, and better city planning could be beneficial. Combining the objectives of the facilities such as an emergency purpose and community or religious gathering purpose in stead of pursuing the sole objective may be beneficial to better planning for mitigating disasters.

These emerging trends in design will be useful for designing new and large geotechnical works that have to meet the rapidly growing social and economic demands in Asia.

REFERENCES

1) Tsuchida, H. (1970): Prediction of and measures against liquefaction of sandy ground, Seminar of Port and Harbour Research Institute, pp.(3)-1～(3)-33 (in Japanese)
2) Katayama, T., Nakano, T Hasumi, T., and Yamaguchi, K. (1969): Evaluation of current seismic design based on the case histories of 1968 Tokachi-oki and other earthquakes, Technical Note of Port and Harbour Research Institute, No.93 (in Japanese)
3) Mitsuhashi, I., and Nakayama, T. (1974): Evaluation of current seismic deign based on the case histories of 1973 Nemuro-oki and other earthquakes, Technical Note of Port and Harbour Research Institute, No.184 (in Japanese)
4) Noda, S., Uwabe, T., and Chiba, T. (1975): Relation between seismic coefficient and peak ground acceleration for gravity quay walls, Report of Port and Harbour Research Institute, Vol.14, No.4, pp.67-111 (in Japanese)
5) Earthquake damage investigation committee (ed) (1995): Study on damage to port structures during Hyogoken-Nambu earthquake, Technical Note No.813 (in Japanese)

6) Ports and Harbours Bureau, Ministry of Transport (ed) (1997): Handbook on liquefaction remediation of reclaimed land (Revised), Coastal Development Institute of Technology (in Japanese) (in English by Balkema)
7) Ports and Harbours Bureau, Ministry of Transport (ed) (1999): Design standard for port and harbour facilities and commentaries (in Japanese) (in English by Overseas Coastal Development Institute, Japan)
8) PIANC (2001): Seismic Design Guidelines of Port Structures, Balkema, 474p.
9) Iai, S. (2005): International Standard (ISO) on seismic actions for designing geotechnical works – an overview, Soil Dynamics and Earthquake Engineering, 25, pp.605-615
10) Tobita, T., Iai, S., Chairullah, B., and Asper, W. (2006). Recon-naissance report of the 2004 Sumatra-Andaman, Indo-nesia, Earthquake - Damage to geotechnical works in Band Aceh and Meulaboh-. Journal of Natural Disas-ter Science, 28, 1, (Accepted).
11) Higashijima, M., Fujita, I., Ichii, K., Iai, S., Sugano, T., and Kitamura, M. (2006). Development of a simple seismic performance evaluation technic for coastal structures. 2006 Ocean Development Symposium. Vol.22, pp.511-516

Emerging trends in seismic design of geotechnical works

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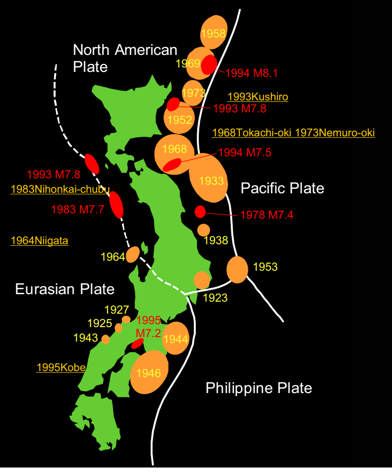
earthquake.mpeg

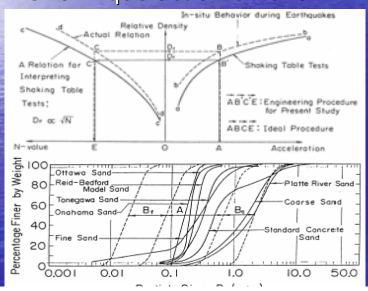
Earthquakes and Seismic Code Development (1964-1999)

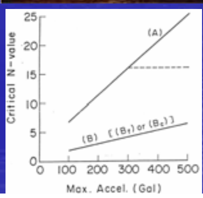


(1)Liquefaction criterion

(1964Niigata)

- 1964 Strong motion recording(Tsuchida/Kurata)
- 1970 Liquefaction criterion

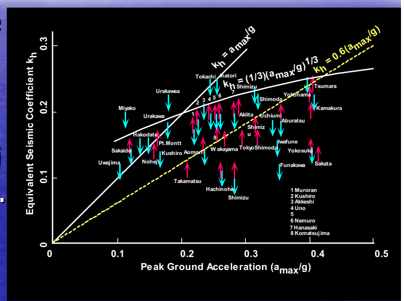




(2)Pseudo-static method

(1968Tokachi-oki/1973Namuro/1978Miyagi PGA=0.2~0.3g)

- 1968 Hachinohe (Tsuchida/Kurata)
- 1969 Katayama
- 1974 Mitsuhashi
- 1975 Noda et al.
- 1979 Design code



(3)Measures against

(1983Nihonkai-Chubu)

- 1984 Manual
- 1984 Strategic plan by Ministry of Transport (high performance quay walls)
- 1989 Design code (revision)

(4) Effectiveness of measures against liquefaction)

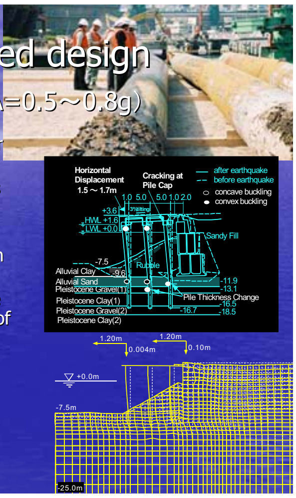
1993Kushiro/1993Hokkaido-Nanseioki/1994Hokkaido-Tohooki/1994Sanriku-Harukaoki PGA=0.3~0.5g)

- 1993 Effectiveness of measures against liquefaction
- 1993 Effectiveness of seismic design of high embankments
- 1993 Handbook on liquefaction remediation
- 1994 Effectiveness of overconsolidation

High embankment for Kushiro Airport

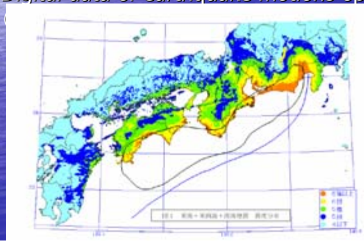
(5)Performance based design
(1995Hyogoken-Nambu PGA=0.5～0.8g)

- 1995 Numerical analysis/underwater shake table tests
- 1997 Level 1&2 earthquake motions
- 1997 Performance design for liquefaction remediation
 (Handbook on liquefaction remediation (revised))
- 1997 FLIP open to public use (Finite element code for evaluating degree of damage to soil-structure systems)
- 1998 Strong motion recording for airports
- 1999 Liquefaction remediation for airport runway (Tokyo International Airport)
- 1999 Design code (revision)



Emerging Trends in Seismic Design of Geotechnical Works (2000～)

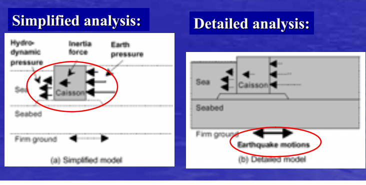
- Imminent Large Earthquakes (Government)
- Strong motion records→ Scenario earthquake motions (Nozu)
- Digital data of earthquake motions open to public

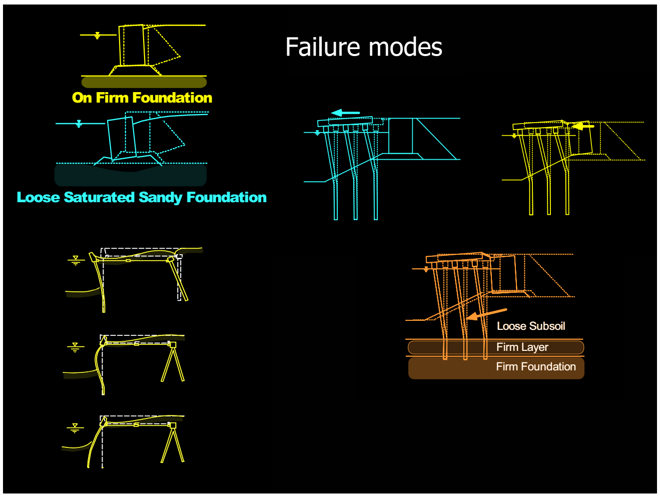


中央防災会議HPより

Performance Based Design

- Structure oriented→ Performance oriented
- Standardized earthquake loads(Seismic coefficient/Design spectra)→ Site-specific earthquake motions
- Analysis of Structural Part→ Analysis of Soil-Structure System



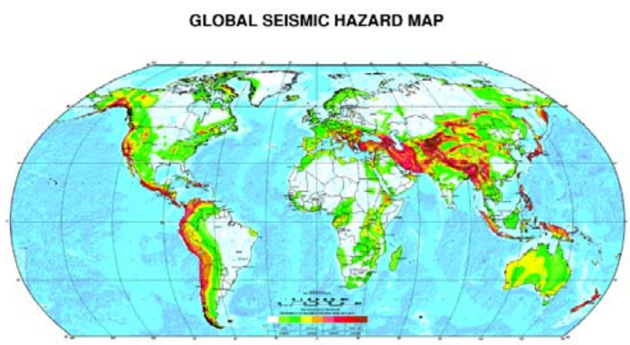


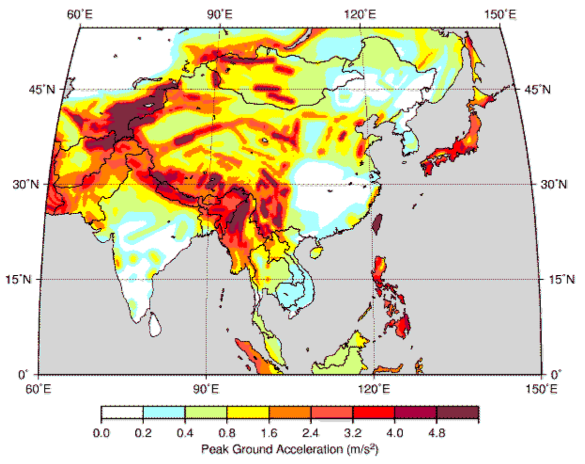
Globalization and seismic code development

earthquake.mpeg

- Handbook on liquefaction remediation 1997
- UBC→IBC 2000
- PIANC Seismic Design Guidelines for Port Structures 2001
- ISO23469 Seismic Actions for Designing Geotechnical Works 2005
- USA/NEES Grand Challenge Program 2006

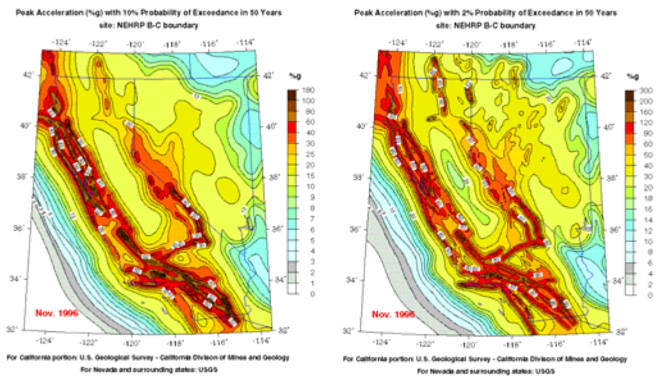
Global Seismic Hazard Assessment Program GSHAP
http://seismo.ethz.ch/GSHAP/

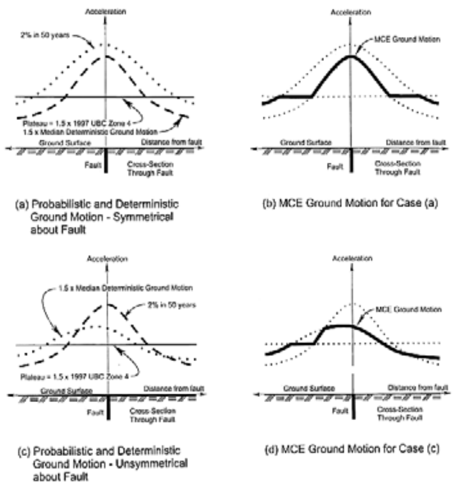




NEHRP http://eqhazmaps.usgs.gov/

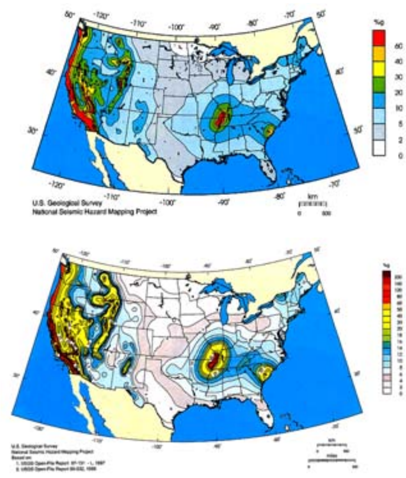
Postal code search





MCE Ground Motion Map

IBC2000



MCE

NEHRP

Eurocode 8 Design of structures for earthquake resistance

- Part 1: General rules, seismic actions and rules for buildings
- Part 2: Bridges
- Part 3: Strengthening and repair of buildings
- Part 4: Silos, tanks and pipelines
- Part 5: Foundations, retaining structures and geotechnical aspects
- Part 6: Towers, masts and chimneys

Fundamental requirements

– No-collapse requirement:

The structure shall be designed and constructed to withstand the design seismic action defined in Section 3 without local or global collapse, thus retaining its structural integrity and a residual load bearing capacity after the seismic events. The design seismic action is expressed in terms of: a) the reference seismic action associated with a reference probability of exceedance, P_{NCR}, in 50 years or a reference return period, T_{NCR}, and b) the importance factor γ_I (see EN 1990:2002 and (2)P and (3)P below) to take into account reliability differentiation.

NOTE 1: The values to be ascribed to P_{NCR} or to T_{NCR} for use in a Country may be found in its National Annex. The recommended values are P_{NCR} =10% and T_{NCR} = 475 years.

NOTE 2: The value of the probability of exceedance, P_R, in T_L years of a specific level of the seismic action is related to the mean return period, T_R, of this level of the seismic action as: $T_R = -T_L / \ln(1- P_R)$. So for a given T_L, the seismic action may equivalently be specified either via its mean return period, T_R, or its probability of exceedance, P_R in T_L years.

Fundamental requirements

– Damage limitation requirement:

The structure shall be designed and constructed to withstand a seismic action having a larger probability of occurrence than the design seismic action, without the occurrence of damage and the associated limitations of use, the costs of which would be disproportionately high in comparison with the costs of the structure itself. The seismic action to be taken into account for the "damage limitation requirement" has a probability of exceedance, P_{DLR}, in 10 years and a return period, T_{DLR}. In the absence of more precise information, the reduction factor applied on the design seismic action according to 4.4.3.2 may be used to obtain the seismic action for the verification of the "damage limitation requirement".

NOTE 3: The values to be ascribed to P_{DLR} or to T_{DLR} for use in a Country may be found in its National Annex. The recommended values are P_{DLR} =10% and T_{DLR} = 95 years.

Network for Earthquake Engineering Simulation (NEES)

The facilities fall into five general categories:
Shaking tables
Tsunami wave basin
Geotechnical centrifuges
Field experimentation and monitoring
Large-scale laboratory experimentation

Emerging trends
(Construction→ Service)
Seismic design of urban system

1995Kobe

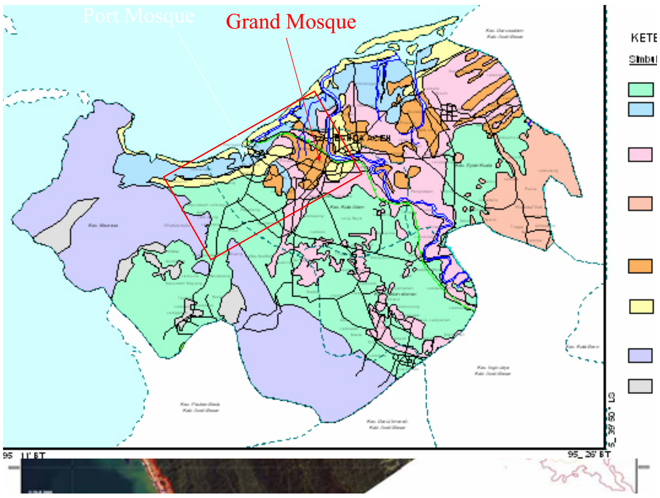
- Digital data of strong motion open to public(Nozu/Kurata)2001
- Oil tank damage 2003
- Blast experiments of urban system in Tokachi(Sugano)2004
- Emergency system (Access and deployment)
- Real-time monitoring for hazard mitigation

2003Tomakomai

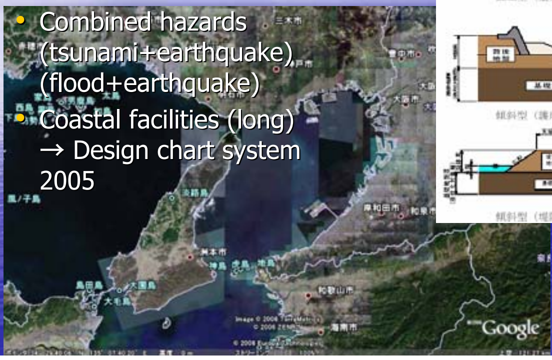
1964Niigata

(after Mainichi)

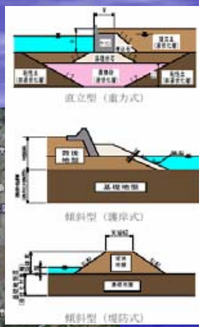
Source: Digitalglobe Analysis



Emerging trends
（Measures for wide area and combined hazards）



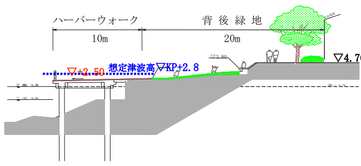
- Combined hazards (tsunami+earthquake) (flood+earthquake)
- Coastal facilities (long) → Design chart system 2005



Coastal facilities（Coastal protection →Coastal service）

New type

Kobe City



Conventional type

Future directions
（Cost reduction→ Service increase）

- Construction→ Performance
- Performance→ Developing new service
  e.g.）Built environment（urban system）, Natural environment（bio system）
- Steel & concrete→ New materials and IT
- Combined engineering (Hard/soft)
- Maintenance→ Renovation/Redevelopment
- Seismic design→ Creating a space of safety and security


Egypt


Dubai


Singapore

Conclusions

- Design for construction → Design for performance
- Standardized approach → Site-specific approach
- Segment (structure or soil part) design → System (soil-structure system) design → Built environment design
- Cost reduction → Service increase
- Emerging trends appropriate for rapidly growing social and economic needs in Asia

Toward Harmonization of Design Codes in the Asian Region -Summaries of Discussion Session-

Yusuke Honjo, Gifu University, Japan
Kenichi Horikoshi, Committee on ACECC, JSCE

After the reports from each country and the special reports, a discussion session was provided chaired by Prof. Yusuke Honjo of Gifu University, Japan. Code harmonization is such a big issue that cannot reach a conclusion in a one-day workshop. Continuous information exchanges and discussions are necessary.

Followings are the contents of the discussion session at the workshop.

1) It was recognized that there are a wide variety of design codes in each field in each country, which have been influenced by many other countries, such as Russia, USA, Europe, and Japan. Although it seems that harmonization is not easy, we should realize that we have common natural conditions, such as climates, ground types and disasters in the Asian region.
2) As for the code harmonization, we need to differentiate between short-term and long-term targets. The short-term target can be to encourage code writers in each field to make dialogs, and look for the possibility of harmonization. Creating a glossary of terminology may also be a nice step for the harmonization.
3) As an immediate target, we will have a special forum of this subject at the 4th CECAR next June. It may be possible to prepare a report from each field, as well as to provide a draft of 'Glossary of terminology' for the basis of design.
4) As for the long-term target, we should learn from the Eurocode experience. When the Eurocode project started about 30 years ago, the limit state design concept was very new and this concept was a base for the harmonization. Therefore, if we try to harmonize design codes in the Asian region, a new concept such as 'performance based-design' is necessary. Asian concrete model code introduced at this workshop can be a pilot model. This model code has already applied to the performance based-design concept as well as multi-level code document.
5) A civil engineering society is not the only body to deal with design codes. It is necessary to exchange information with other professional groups such as concrete and steel institutes, and architectural institute. Professionals from other bodies should be invited to the ACECC related events. At the same time, we should realize the difficulty to reach agreements with all the bodies in a short period. However, since the documents that a civil engineering society is producing are not legally effective, it is possible to start our activities without full agreements by the related bodies.
6) Eurocodes are the government oriented projects and they have close ties with European Union. Whereas, the problem is that the engineering society has a committee of a certain field with responsibility of related code development and it's up to the government to authorize them. The government has the right for the final decision. Writing up a model framework does not imply immediate application of practice of design codes.
7) In terms of the code harmonization as the long-term target, flexible framework is necessary for further revisions to avoid conflicts. Once we set up the initial version of a code, we always have to be aware of the revision and modification that should come from needs from individual countries as well as the overall region.

8) Clear motivation is necessary. Creation of future ISO can be one of the motivations for code harmonization. The concrete model code was created to fill in the missing parts of the current ISOs. If other codes have already good documentations, it is very difficult to create another code of the same parts. Therefore, it is important to identify what is the current problem with the ISOs.

9) The situation for ISO 23469, which is applied to geotechnical work, was slightly different. The basic motivation was that most of the top level experts are not happy with the current design codes. They aim to build something that will be adopted as the state of practice in the coming decade. The code development is always behind the progress of engineering. Therefore, for the general framework of ISO, they should do something as flexible as possible to accommodate something coming into part of design practice.

10) Although the role of the government is very important for code harmonization, we should not consider too much about political constrains. It is more important to discuss what is the ideal code applicable as a result of harmonization. This will attract more people in the world.

11) We believe that discussions at this workshop will be the first step toward code harmonization in the Asian Region. This workshop could provide a basis for further discussions especially at the 4th CECAR.

To be continued to the 4th CECAR

Summary of the ACECC Workshop

November 4, 2004

Taipei

What we have found today?

- Variety of design codes
  - By countries/regions,
  - By type of structures, i.e. Building, Highway bridges, railways, port and harbor etc.
  - By type of materials, i.e. steel, concrete, composite, geotechnical, seismic etc.
- Variety of vocabulary
- WSD vs. LSD and LRFD
- Complex influences of US, Europe, Russia, China, Japan etc. and own code developments.

CHAOS!?

Common background

- WE are in the same region of the world.
  similar natural conditions, such as climate, ground conditions, seismic conditions, disaster phenomena, etc.
- WTO/TBT agreement and performance based specifications
- International standards: ISO
- Regional code developments: Eurocodes, North America
- LSD and LRFD

Immediate target

- It is encouraged each fields to make dialogs and look for possibilities to harmonize and develop Asian regional code.
- Do we need to harmonize our terminologies especially to look for codes based on PBD concept?
- 'Glossary of terminologies for basis of design based on PBD concept'?

Longer term target:

Eurocodes 30 years

- Do we need a basis of design code like Eurocode 0 or ISO2394?
  - LSD concept => ISO2374, EC0
  - PBD => Need a document?
- Can Performance Based Design concept be bases for harmonizing regional codes?
  - Performance based concept
  - Multi-level code document structure
- From the special reports
  - Can Asian Structural Concrete code be a pilot model?
  - What are the lessons we learnt from Structural Eurocodes and ISO23469 activities?

Toward 4th CECAR Special Forum for 'Design Code'

- Publish the presentations at this workshop by January 2007 (ACECC executive committee meeting)
- Report from each filed for harmonization
  - Concrete
  - Steel / Composite
  - Geotechnical
  - Seismic design
- First draft of 'Glossary of terminologies for bases of design based on PBD concept'?

Policy

- We look for a code that will show the future view of design codes. (This is not codes to be immediately applied to daily practice.)
- Based on PBD concept. However, PBD may mean different from a person to person. What is definition of PBD?
- Should follow and harmonized with WTO/TBT agreements and ISO standards.

Tasks of each filed

- It is encouraged each filed to harmonize and develop Asian regional code.
  - Do we need general concepts to follow?
  - Can Asian Structural Concrete code can be a pilot model?
  - What are the lessons we learnt from Structural Eurocodes and ISO23469 activities?