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Int’l Committee on Concrete Model Code for Asia Newsletter, Vol. 7, February 2006

In this issue ...

… We bring you the background as well as up-to-date information on design and code development in different parts of the world. From Europe, Professor Joost Walraven, an ICCMC honorary member tells how much efforts and tedious work were needed to bring Eurocode 2 on concrete structures close to reality. From Malaysia, Dr Jeffrey Chiang writes about Adoption of EC2 in Malaysia and the role played by ACMC 2001. From the fast moving China, Dr Kefei Li gives a up-to-date report on the new durability code system to cater for massive infrastructure construction activity in China. In addition to these valuable articles, you will as usual, find other interesting topics.

Eurocode 2 “Concrete Structures” coming to reality

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Chairman of the Project Team for EC-2

History

Bringing a continent with so many different cultures and such a long history together is a difficult task. However, that it would be so cumbersome as experienced was not expected when in 1971 the initiative for the Eurocodes was taken. After discussion over a period of 5 years on methods to be chosen and procedures to be followed the real work started in 1976. However, it turned out that there were such large differences with regard to technical level, ideas and commercial interests between the participating countries, that the progress was very slow. In 1980 an international inquiry was held, exploring whether there was still sufficient interest to go on. After a positive decision, in 1989 a first milestone was realized with the publication of the “European Guideline for Building Products”.

In 1990 the task to produce the Eurocodes was handed over to a professional organization named CEN (European Code Committee) which had a direct link to the European Parliament in Brussels. This move improved the situation. The first version of the Eurocode for Concrete Structures was published in 1991. The text of this code was the same for all countries involved. However, in many respects no agreement could be reached. Therefore the text contained about 250 so-called “boxed values”. If a value in the code was written inside of a rectangle (box), this meant that the value is only advisory. The countries had the right to deviate from this value and insert a value of their corresponding design concrete materials, time-dependent performance predictions and aids and calculation programs, to which the users were familiar. The first official version of the Eurocode (1991) was regarded as provisional. The users were invited to raise comments in order to contribute to the improvement of the code.

A so-called Maintenance Group judged those proposals for modification. This Maintenance Group was composed of about 25 members coming from various countries. As a result of this large number of experts, with various opinions, it was again very difficult to come to agreements. So, again the progress of the work was very slow. In 1998 CEN decided to change its strategy. Project Teams were installed, on average consisting of 6 experts, who got the task to adapt the code, taking not only account of the many comments made with regard to the old text, but as well to upgrade it to the most actual state of the art. The Project Teams had to present their proposals to the Maintenance Group. The members of the Maintenance Group gave their comments, after consultation with their national mirror committees. Any of the hundreds of individual comments had to be officially answered by the Project Teams, and all answers were formally documented. This way of working was tedious, but successful. In 2004, four years after the start of the Project Team for Concrete Structures, the text was ready. The final acceptance by the countries was confirmed via an international ballot. However, the attempt to get rid of the “boxed values” appeared to have been only partially successful. Altogether 112 exceptions had still to be allowed in order to reach an agreement. The new name for the “boxed values” was NDP’s (Nationally Defined Parameters).

After the official acceptance of the Eurocode by the nations in 2004 a new period started. The national mirror groups had to study the text and decide to which extent they want to use the option of defining their own national parameters. This option lasts until 2006. From 2006 the Eurocodes are allowed to be used in parallel to the national codes. It is the intention of the European Commission to withdraw the national codes in 2010. So, finally a big step ahead has been made to a European continent without frontiers, Fig. 1.

Fig. 1. The European dream: a continent without frontiers

Structure of the Eurocodes

The Eurocode on Concrete Structures is a part of a large family of codes, referring to various types of structures. In Table 1 a survey of the Eurocodes for the design of structures is given.

Table 1: Eurocodes for the design of structures

Eurocode nr.	Subject	Number of parts
Eurocode 0	Basis of design	1
Eurocode 1	Loads	10
Eurocode 2	Concrete structures	4
Eurocode 3	Steel structures	14
Eurocode 4	Composite structures	4
Eurocode 5	Timber structures	3
Eurocode 6	Masonry structures	5
Eurocode 7	Soil mechanics	3
Eurocode 8	Earthquake resistant structures	6
Eurocode 9	Aluminum structures	3

One of the advantages of the Eurocodes is that all components come in one complete package (Eurocode 2 for concrete; EC3 for steel up to EC8 for Seismic design; and EC9 for aluminium). The disadvantage is that not all are ready at this moment and there are questions about code maintenance and updates. Who (which party) is going to maintain it and who is going to fund it? Currently the UK construction industry is pushing ahead with the finalization of the Eurocodes for the UK. With the existing historical connections between Singapore codes and the BS codes, Singapore can perhaps expect to receive some kind of support from the UK side to reduce cost of changing codes from the BS-based to EC-based codes. Continuing education for engineers will be needed, consultants may have to invest on new software, new design aid will have to be produced, etc. Since most designers will have to use various parts of the codes, substantial effort was invested in order to harmonize all parts and provide them with the same editorial structure.

The Eurocodes 0 and 1 are of a general nature. In EC-0 (Basis of Design) fundamentals are treated, like the definition of loads and safety values. It defines for instance the type of load to be assumed for design, making a distinction between characteristic values, combination values (reduced safety factors in case of load combinations), frequent values (e.g. for crack width control) and quasi-permanent values (e.g. for the calculation of long term deformations). In EC-1 the various loads are defined more particularly. The 10 parts of EC-1 "Loads on Structures" refer to:

1. Dead weight and imposed deformations
2. Forces occurring during fire
3. Snow loads
4. Wind loads
5. Temperature effects
6. Loads during construction
7. Incidental loads
8. Loads by traffic on bridges (Fig. 2)
9. Loads by cranes
10. Loads in silo's and containers

Fig. 2. Loads by traffic on bridges: transport of new cars across an old Roman bridge

The Eurocode on concrete structures and related parts

As shown in Table I, the Eurocode on Concrete Structures consists of 4 parts:

- General rules and rules for buildings (2004)
- Fire (2005)
- Bridges (2005)
- Containers (2006)

However, there are a number of related documents which are also needed for the design and realization of concrete structures, like the parts on materials (concrete, reinforcing steel and prestressing steel), the part on construction and the parts on precast concrete structures (with general rules and product codes). The various parts and their hierarchy are shown in Fig. 3.

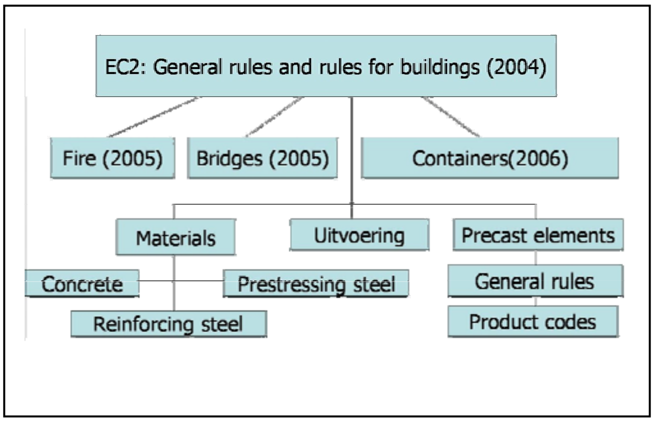

Fig. 3. Parts of Eurocode 2 "Concrete Structures" and their relation with other related codes

The concrete strength may be classified using whether cylinders or cubes. Conversion factors between the two strength values are given. The maximum concrete strength class allowed to be used in design is C 90/105 (i.e. characteristic cylinder strength, 90 MPA, or characteristic cube strength, 105 MPA). A choice can be made from various types of stress-strain relations, as given in Fig. 4.

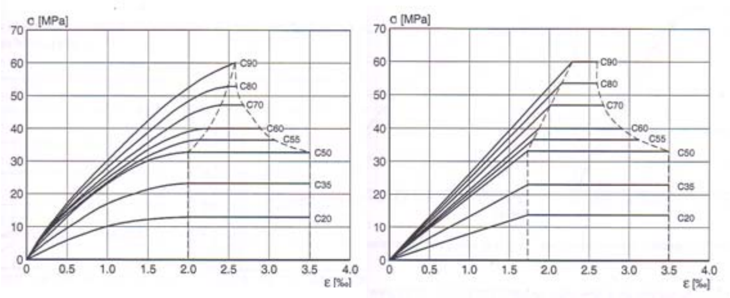

Fig. 4. Stress strain relations for concrete

With regard to durability altogether 18 environmental classes are distinguished, which are classified under the following headings

Class 1: No risk of corrosion or attack
Class 2: Corrosion induced by carbonation (4 sub classes)
Class 3: Corrosion induced by chlorides (3 sub classes)
Class 4: Corrosion induced by chlorides from sea water (3 sub classes)
Class 5: Freeze /thaw attack (4 sub classes)
Class 6 Chemical attack (3 sub classes)

Further to the environmental class, the minimum cover for reinforcement depends on:

- the length of the defined service life
- the concrete strength class used
- the type of structural member
- the application of special quality control procedures

For structural analysis four possible methods are distinguished:

- linear elastic analysis
- linear elastic analysis with limited redistribution
- plastic analysis
- nonlinear analysis

With regard to the design models for the Ultimate Limit State (bending, shear, torsion, punching) as much as possible transparency was pursued. Truss models and strut and tie models offer a solid basis for dimensioning and detailing. In many cases simplified and more sophisticated rules are offered as an alternative.

First experiences

An interesting difference amongst the various countries is the interest to use the possibility to define national exceptions. The system of Nationally Defined Parameters was chosen for the following reasons:

- Differences in climate and geography
- The agreement that the definition of the safety level and the level of durability is a matter of national decision
- Economical aspects: loss of market position by the new code is unacceptable
- Irreconcilable points of view between the countries.

Up to now the various countries show different interest in defining own parameters. Some countries, like Belgium, accept all values. Other countries, like Germany, like to use nearly all possibilities to define national values. In general, the impression is that the number of nationally chosen values will be relatively small.

The first impression of the users is that the documentation of the full set of Eurocodes is too extensive. On the other hand the majority of the users feel that the various parts are very well structured. That there is now a common basis for international tendering is welcomed by all. The free trade is stimulated and it is expected to strengthen the European economy. At this moment preparations are made for the introduction of the Eurocodes through courses, design aids and programs, and pilot projects.

Adoption of EC2 as the concrete design code of practice in Malaysia and the role of ACMC 2001

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The UK will be withdrawing its standards on concrete structures design, BS8110:1997 by 2010, as its national standards body, the British Standards Institution (BSI) has decided to adopt the Eurocode EC2 on concrete design, in line with its EU counterparts. Consequently, the existing BS documents (including BS8110) will not be maintained or upgraded.

This decision has wide ramifications to other commonwealth countries, such as Malaysia, Singapore, Hong Kong and Sri Lanka, just to name a few in this region. As such, the civil engineering profession in Malaysia through The Institution of Engineers, Malaysia (IEM) has taken the lead to make a thorough study on the next course of action, or should there be a need for action, in Malaysia, prior to 2010, which is just four years away.

An IEM Position Statement committee was formed in 2001 to make a study and offer recommendations for future directions. Various international standards on concrete design were studied. They include, BS8110, ACI318, AS3600, ACMC2001, NZS3101, Hong Kong Standards, and Eurocode EC2. After a thorough study of these standards, the committee recommended the adoption of Eurocode EC2 as the design code of practice for the local construction industry in 2003.

This was followed by the official appointment of IEM as a Standards Writing Organisation (SWO) by the national standards body (SIRIM), on the approval of the Department of Standards Malaysia (DSM). As SWO, IEM was tasked in 2004 to form a Technical Committee (TC) to look into developing a national code of practice on design of concrete structures.

Briefly, the TC decided to form Working Groups (WGs) and Study Groups (SGs) to look into various specific issues affecting Malaysian practice, that need to be studied in depth. These are listed below:

- The use of small structural elements for low-rise concrete buildings is very common in Malaysia, such as 115mm column size, to accommodate the width of brick walls or partitions. Many codes of practice do not have provisions for such elements in design, or have restrictions in terms of fire resistance.
- Creep and shrinkage in concrete structures is a major concern especially in hot and humid weather conditions in Malaysia, and other countries in tropical regions.
- The use of band beams is becoming more popular in Malaysia, particularly for office buildings and multi-storey car parks. The efficient use of floor levels and maximization of floor space, advocate the use of many structural features not provided for in current design codes of practice. Band beam is one of these.
- Besides facing harsh and hot tropical climatic conditions, concrete structures in Malaysia are also exposed to marine environments unique to local coastal regions, and also to ground soils with high water table levels. Hence, further study on concrete durability is required to provide for expected design life of concrete, as a material and structure.

As a result of the above areas identified as critical in the local context, the TC has formed the following Working Groups (WG) to undertake the required detailed study by various professional engineers, university academics and researchers:

- WG1 – Allowances for thin structural element in residential buildings up to two-storey in height
- WG2 – Concrete creep and shrinkage based on local conditions
- WG3 – Design of band beams for floor system
- WG4 – Durability of concrete structures

Groups of TC members are allocated the task to study topics, which are regarded as areas in their field of expertise. These are called Study Groups (SG) and the topics of study are as follow: flexural; shear; torsion; columns; prestressing works; serviceability; flat slabs/general slab design; stability; detailing /constructability; deep beams/strut & tie models; materials & analysis. If the need arises to probe in detail, the SG may be converted to a WG.

In a parallel development, a project was approved for undertaking by ICCMC to "re-draft" the Eurocode EC2 as a Level 3 document, forming part of ACMC2001. It is envisaged that this project would clarify the concept of ACMC2001 and present it as a flexible model code, having a user-friendly format able to accommodate any international codes of practice.

Malaysia has come some way since 2001 when the dilemma was first realized on the withdrawal of BS8110 by 2008 (now revised to 2010). IEM has taken the lead to state and recommend its stand on this issue, in which the Eurocode EC2 was touted as the possible replacement for BS8110 as the de facto Malaysian Standards on design of concrete structures. As a newly appointed standards writing organization, IEM is chairing the Technical Committee in drafting the Malaysian Standards on concrete design. The work is on going, and in a separate development, ICCMC is providing support and encouragement in developing a Level 3 document on design based on Eurocode EC2 requirements. Hopefully, it will bring forth the intricacies of EC2, as a practical design standard for Malaysia, and project ACMC2001 as a useful model code for the region.

References

(1) British Standards Institution, "BS 8110 Structural Use of Concrete Part 1 – Code of Practice for Design and Construction", 1997, p. 118.

(2) Comite' European de Normalisation (CEN), "prENV 1992-1-1 Eurocode 2: Design of concrete structures – Part 1. General rules and rules for buildings", Nov. 2002, p. 226.

(3) The Institution of Engineers Malaysia (IEM), "Position Paper for Concrete Codes of Practice in Local Construction Industry After 2008", December 2003, p. 24.

(4) International Committee on Concrete Model Code for Asia, "ACMC 2001: Asian Concrete Model Code – Level 1 & 2 Documents", Mar. 2001, p. 72.

Concrete durability code development in China: a state-of-the-art report

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The on-going massive infrastructure construction activity in China dates back to the beginning of 1980's. After more than twenty years of continuous construction, especially of concrete works, the problems of durability have been highlighted in recent years. Recent investigation data has shown that the average service life of residential buildings is merely 40 years, and only 20 to 30 years for industrial buildings before undergoing major retrofit. It is even less for structures exposed to marine environments. Considering the huge consumption of concrete as the main building material in China, the design and maintenance of durable concrete structures make economical sense as well as sustainable development sense.

In 2000, the Chinese Engineering Academy set up a special consulting project: “Safety and Durability of Civil Engineering Structures” which led to the drafting of the first code-like technical document on concrete structure durability. This code drafting project, headed by Academician Professor CHEN Zhao-yuan, produced the first durability guide of the Chinese Civil Engineering Society for concrete structures. It is called the ‘Guide to Durability Design and Construction of Concrete Structures (CCES01-2004)’. Its second edition was published in October 2005.

This 106-page document covers seven technical aspects: (1) General principles for durability design; (2) Terms and symbols; (3) Basis of design; (4) Concrete materials; (5) Details and Crack Control; (6) Construction methods and (7) Additional protective measures. In the appendices, the recommendations for test methods are presented for anti-cracking performance of cement-based materials; chloride rapid migration test; numerical models for chloride migration in concrete; and, the durability articles for post-tensioned prestressed structures. The main concepts expounded in this guide are structure service life, environmental action and material durability performance. The choice of concrete material for a specified environmental exposure class is formulated in a qualitative manner and some quantitative models are included for estimating the chloride ingress process in concrete. In addition, very detailed specifications are given on concrete member protection and detailing. Thus, this CCES guide is a useful reference manual for both structural designers and constructors.

Technical papers on this guide are proposed based on both local case investigations and the relevant durability provisions in current concrete design codes, such as Eurocode, ACI code and British Standards. This guide also serves as a useful reference which generated a series of specified durability codes: “Code for durability design of concrete structures” (in draft form) by the Chinese Ministry of Construction; “Specification for deterioration prevention of highway concrete structures” (in the press) by the Chinese Transportation Ministry; “Provincial guide for durability design of concrete structures DBJ14-S6-2005” published in 2005 by Shangdong provincial authorities.

These specifications and codes are expected to limit the potential future loss due to premature durability failure of concrete structures built in the present and on-going massive construction activity. However, these codes in their present forms are far from perfect and the provisions can only be a compromise between the lack of knowledge on some fundamental mechanisms of material durability processes and the urgent needs for a general guide for in situ practice. The provisions and the codes themselves, therefore, are to be continuously improved and updated as new research results become available. To this end, the following tasks are being undertaken: (1) understanding of salt attack on concrete elements; (2) enrichment of *in situ* durability data at both material and structural levels; (3) harmonization of Chinese durability code system with the international systems, e.g. those of the ISO and ICCMC.

Vietnam-Japan joint seminar on concrete engineering

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The Seminar held on 8-9 December 2005 in Ho Chi Minh City, Vietnam was organized by the Vietnam Federation of Civil Engineering Association (VIFCEA) and the Japan Society of Civil Engineers (JSCE) and hosted by the Ho Chi Minh City University of Technology (HCMUT).

More than 200 experts, engineers and researchers from universities, research institutes and companies attended. The eleven reports presented at the seminar included six from the Japanese and five, the Vietnamese experts. The reports focused on the durability design of concrete structures, concrete technology under the conditions of hot and humid climate of Vietnam and the use of special and advanced concretes and technologies in Vietnam.

At the seminar, Dr Hiroshi Yokota, an ICCMC member, presented the performance-based concept in the design of concrete structures adopted in the ACMC 2001 and JSCE Standard. Professor Nguyen Tien Dich further clarified the concept for the Vietnamese experts and participants because at present it is a new aspect in the design of concrete structures in Vietnam.

The seminar ended with an aim for a joint activity in the field of concrete structures and technology between the VIFCEA and JSCE in the near future.

ICCMC activities since June 2005

Annual meeting, Qingdao, P.R. China

The ICCMC had its annual meeting on 29-30 October 2005, in Qingdao, China. Twenty three members from 10 countries (namely Australia, China, Indonesia, India, Japan, Korea, Malaysia, Philippines, Thailand and Vietnam) and 6 observers attended the meeting. Qingdao Technological University of which ICCMC member Professor Tie-Jun Zhao is a senior academic hosted the meeting.

Group photo in the meeting room

Prof Tie-Jun Zhao passing on the banner of ICCMC annual meeting to Dr Dradjat Hoedajanto, who will host the next annual meeting in Bali, Indonesia

This annual meeting was held in conjunction with the international workshop on “Durability of Reinforced Concrete Structures under Combined Mechanical and Climatic Loads”, which was jointly organized by Qingdao Technological University’s Centre for Durability Studies, the Socio-Environmental Engineering Group of Hokkaido University and the Research and Development wing of Aedificat Institute Freiburg. The annual meeting mainly focused on updating: the Asian Concrete Mode Code, ACMC 2001 to a newer version ,ACMC 2006; the Level 3 documents being developed; and the drafting of code on “Maintenance and Repair of Concrete Structures for the ISO”.

Short seminar at Dalian University of Technology, P.R. China

The research group of Dr Wei-Qiu Zhong, who is the leader of the ICCMC promotional project in China invited ICCMC delegates to conduct a short seminar at Dalian University of Technology (DUT), China. A delegation comprising the ICCMC Chairman Professor Tamon Ueda, its Vice Chairman (Policy) Professor Ha-Won Song, its Executive Council member Mrs. Werawan Manakul, and its Administrative Manager (AM) Dr Jianguo Dai visited, DUT on 31 October, 2005 for this seminar. Professor Ueda gave a lecture titled “Durability Design Concept in Asian Concrete Model Code (ACMC) and its Future Direction” while Professor Song’s lecture was on “Maintenance Code Concept in the ACMC and Deterioration Prediction of Concrete Structures”. The ICCMC delegates also visited “The State Key Laboratory on Coastal and Offshore Engineering” at the DUT.

Keynote lecture on ACMC in Tripoli, Libya

On behalf of the ICCMC Chairman Professor Tamon Ueda, Professor Yew-Chaye Loo presented a keynote paper titled “International Committee on Concrete Model Code for Asia –Its Roles and Activities (co-authored by Tamon Ueda and Yew-Chaye Loo)” for “The First Symposium on African code for Concrete”, which was held on 28-29 November 2005 in Tripoli, Libya. Professor Loo also delivered a specialist lecture on “Advances in Serviceability and Strength of Normal and High-Strength Concrete Structures”. Participants of this symposium had come from Nigeria, South Africa, Senegal, Egypt, Algeria, Kuwait, the UK, the Netherlands, Australia, Turkey, the USA and the Great Jamahiriya of Libya. The symposium aimed at setting a mechanism to formulate the African code for concrete that specifies the essential requirements for concrete construction in Africa in terms of safety and economy.

ICCMC-ISO task force meeting in Seoul, Korea

The ICCMC-ISO Task Force held a meeting in Seoul, Korea in the afternoon of 27 November 2005. The meeting preceded the 13th Plenary Session of the ISO/TC71, which was held from 28-30 November, 2005 at Seoul.

Lecture on ACMC in Hangzhou, P.R. China

Professor Ueda giving lecture at the Forum

Invited by Professor Wei-Liang Jin of Zhejiang University, China, the ICCMC chairman Professor Tamon Ueda and its AM Dr Jianguo Dai attended the “Chinese Engineering Technology Forum on Durability of Concrete Structures” from 10-12 December, 2005 in Hangzhou, China. Professor Ueda gave a lecture on “Asian Concrete Model Code (ACMC) and its L3 document on Maintenance for Chloride Attack (co-authored by Tamon Ueda and Jianguo Dai)” at the forum. The visit paved the way for some effective communication between the ICCMC and the Chinese team on the development of a regional code.

Delegates at the Chinese Engineering Technology Forum on Durability of Concrete Structures

Lecture on ACMC in Hamirpur, India

Dr Umesh Kumar Sharma delivered a lecture on "Asian Concrete Model Code and Its Scope" during the National Workshop on "Concrete Mix Design" organized by Department of Civil Engineering, National Institute of Technology, Hamirpur, India, 9-10 February 2006. The workshop was attended by about 85 engineers from the construction industry.

Member on the move

►► Dr Jianguo Dai left Hokkaido University in January 2006 to join the Japan Port and Airport Research Institute in Yokosuka.

Next ICCMC meeting

Next meeting will be held in conjunction with the Second International Conference of Asian Concrete Federation, Bali, Indonesia in November 2006.

Conferences

The Second ***fib*** Congress 2006, 5-8 June 2006, Naples, Italy
http://www.naples2006.com/

Extending the Life of Bridges; Concrete + Composites, Buildings, Mansonry + Civil Structures, 13-15 June 2006, Edinburgh, Scotland. http://www.structuralfaultsandrepair.com

The Tenth East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-10), 3-5 August 2006.
http://www.easec10.net/

The Second International Conference of Asian Concrete Federation, Bali, Indonesia, 20-22 November 2006.

The 8th International Concrete Conference on Concrete in Hot & Aggressive Environments, 27-29 November 2006, Bahrain.
http://www.engineer-bh.com/icce/intro.htm

Joining ICCMC

ICCMC membership is open to anyone interested in concrete. Visit our website to apply on-line or write to Dr Jianguo Dai (admin@iccmc.org) for more information.

www.iccmc.org

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