MHM 2007

ECCOMAS Thematic Conference hosted by the Czech Technical University

Modelling of Heterogeneous Materials

with Applications in Construction and Biomedical Engineering

PROGRAM

ECCOMAS Thematic Conference

Prague, Czech Republic, 25-27 June 2007

Czech Technical University in Prague
Sunday, 24 June 2007, Dean's Conference Room

ZPB70Workshop

celebrating the approaching 70th birthday of Prof. Zdeněk P. Bažant

12:45-13:00 opening remarks

13:00-13:20 Kaspar Willam:
Multi-scale issues of softening material behavior

13:20-13:40 Ted Belytschko:
On computational methods for cracking at disparate scales

13:30-14:00 Franz Ulm:
Is C-S-H intrinsically instable?

14:00-14:20 John W. Rudnicki:
Scaling relation for compaction bands in porous rock

coffee break

14:40-15:00 Pere C. Prat, M. R. Lakshmikantha and A. Ledesma:
Fracture mechanics and size effect in the cracking of drying soils

15:00-15:20 Peter Grassl:
Size effect of buckling-driven delamination of notched sandwich beams

15:20-15:40 Miroslav Vořechovský and Drahomír Novák:
Modeling statistical size effect

15:40-16:00 Mohammed T. Kazemi and Vahid Broujerdian:
Shear design of R/C beams based on Bažant's size effect law

coffee break

16:20-16:40 Alek Zubelewicz:
Stress-induced defect structures in metals subjected to extreme loading rates

16:40-17:00 Gustavo Gioia:
Invariant path integrals and similarity fields in elastoplastic fracture

17:00-17:20 Joško Ožbolt:
Modeling of concrete at high temperature

17:20-17:40 Gianluca Cusatis:
Discrete models for the simulation of concrete behavior

17:40-18:00 Vít Šmilauer:
Micromechanical analysis of creep using Fast Fourier Transform

Microplane models I.

(special session honoring Prof. Bažant)

chaired by Milan Jirásek

26 June 2007, 14:00–15:40

Room B280

14:00–14:18	***Z. P. Bažant*** Nano-mechanics based size effect on safety factors and lifetime of quasibrittle structures	198
14:18–14:36	***G. Cusatis***, *Z. P. Bažant, A. Beghini* Microplane model for composite laminates	200
14:36–14:54	***J. Ožbolt*** Modelling of wood in the framework of microplane theory	202
14:54–15:12	***F. C. Caner***, *I. Carol* Microplane model for soft tissue	204
15:12–15:30	***A. E. Blangino***, *S. Valente, M. Barba* An approach for a constitutive relation for skeletal ligaments using a microplane model	206
15:30–15:40	General discussion	

Subject: ZPB 70 Workshop
From: Milan Jirasek <Milan.Jirasek@fsv.cvut.cz>
Date: Mon, 18 Jun 2007 18:40:29 +0200
To: Alek Zubelewicz <alek@lanl.gov>, Zdeněk Bittnar <bittnar@fsv.cvut.cz>, Gianluca Cusatis <cusatg@rpi.edu>, Ferhun Caner <ferhun.caner@upc.edu>, "Gioia, Gustavo" <ggioia@uiuc.edu>, Peter Grassl <grassl@civil.gla.ac.uk>, Goangseup Zi <g-zi@korea.ac.kr>, 김상식 교수님 <hanjib@inha.ac.kr>, Herbert Mang <Herbert.Mang@tuwien.ac.at>, Ignacio.Carol@upc.edu, "John W. Rudnicki" <jwrudn@northwestern.edu>, "Mohammed T. Kazemi" <kazemi@sharif.edu>, 김진근 교수님 <kimjinkeun@kaist.ac.kr>, Jiri Naprstek <naprstek@itam.cas.cz>, Drahomir Novak <novak.d@fce.vutbr.cz>, Josko Ozbolt <ozbolt@iwb.uni-stuttgart.de>, Peter Bartos <p.bartos@ntlworld.com>, Pere Prat <pere.prat@upc.edu>, Ted Belytschko <tedbelytschko@northwestern.edu>, Bretislav Teply <teply.b@fce.vutbr.cz>, Franz-Josef Ulm <ulm@MIT.EDU>, vit.smilauer@fsv.cvut.cz, vitek@fsv.cvut.cz, Jan Vitek <vitek@metrostav.cz>, Vladimir Cervenka <vladimir.cervenka@cervenka.cz>, Miroslav Vorechovsky <vorechovsky.m@fce.vutbr.cz>, Kaspar Willam <Willam@colorado.edu>, Yunping Xi <Yunping.Xi@colorado.edu>, "Zdenek P. Bazant" <z-bazant@northwestern.edu>

Dear Participant of the ZPB70Workshop,
to be held on Sunday, 24 June, in Prague:

The workshop will take place in the Dean's Conference Room in the Civil Engineering Building of the Czech Technical University, street address Thakurova 7, Prague 6. I attach several maps showing the location of the CTU campus in the district of Dejvice.

The workshop will start with some opening remarks at 12:45, individual lectures should start at 1pm and they should be limited to 20 minutes including discussion. Both "serious" and "funny" presentations are welcome, you can also mix both. Please kindly arrive on time, unless your travel arrangements make it impossible. The conference room will be open already from 12:20. The scientific program is attached. Please kindly prepare your presentations in PDF or PowerPoint and upload them to the computer in the conference room, or test the connection of your computer to the data projector before your session. The registration fee is to be paid on spot, in cash or with a credit card. The fee amounts to 60 EUR, 80 USD or 1700 CZK, and you will get an official receipt.

After the workshop we will spend some time in the registration area of MHM 2007, enjoying Moravian wine. Then we will move to Hanavsky pavilon, a restaurant in the district of Letna with a magnificent view of Prague. To speed up the service, please kindly make your choice of one of the following menus. The first two consist of Czech meals, the other four are more "international". PLEASE KINDLY SEND ME YOUR CHOICE AT YOUR EARLIEST CONVENIENCE, I NEED TO CONSOLIDATE THE FIGURES AND INFORM THE RESTAURANT. If you require a special menu, e.g. vegetarian, please let me know.

Looking forward to meeting you on Sunday,
with my best regards,
Milan

MENUS PROPOSED FOR THE DINNER AFTER THE ZPB70WORKSHOP:

CZECH A
Marinated pikeperch
Hen with soup, home-made noodles

CONCRETE 2007 @ Taipei

台灣混凝土學會（TCI）2007 年混凝土工程研討會

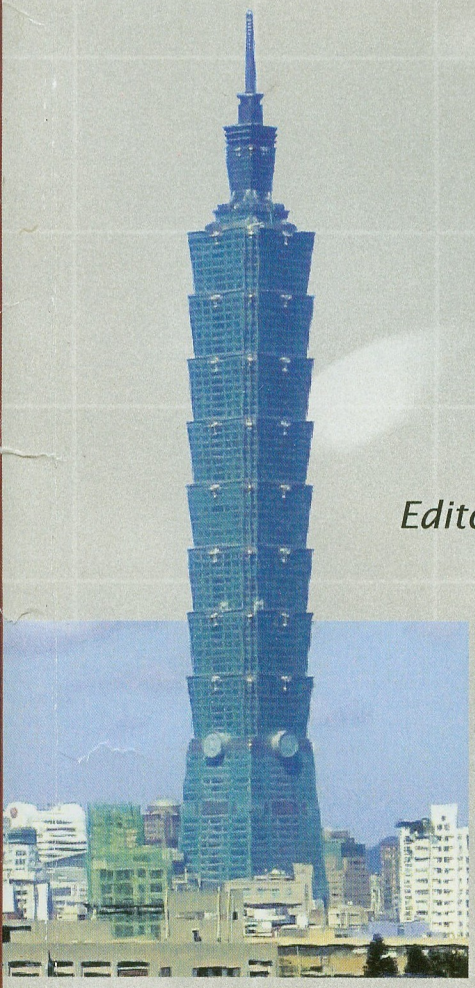
TCI 2007 Concrete Technology Conference and Exhibition

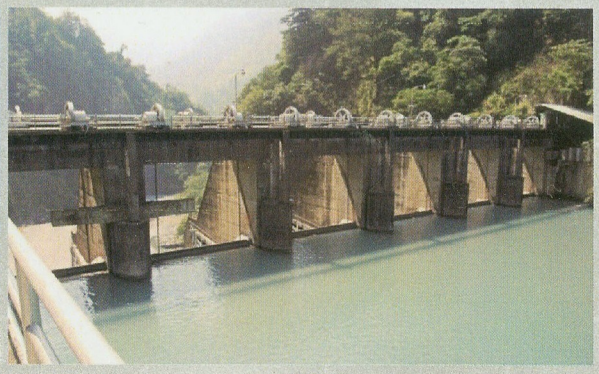
Novermber 2, 2007

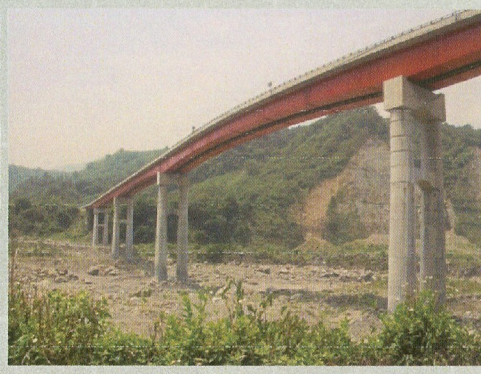
Asian Special Workshop on Concrete Technology

in honor of the 70th Birthday of Prof. Zdeněk P. Bažant

Editors Ta-Peng Chang Jenn-Chuan Chern







社團法人台灣混凝土學會

Asian Special Workshop on Concrete Technology

Proceedings of Asian Special Workshop on Concrete Technology in Honor of the 70th Birthday of Prof. Zdeněk P. Bažant

held at the National Taiwan University of Science and Technology, Taipei, Taiwan on November 2, 2007

Edited by

Ta-Peng Chang
National Taiwan University of Science and Technology

Jenn-Chuan Chern
National Taiwan University

Organizer by:

National Taiwan University of Science and Technology

Co-organizers:

Taiwan Concrete Institute

PREFACE

In the late 1907s and early 1980s, there were six Asian university engineering graduates from Japan, Korea and Taiwan, Tatsuya Tsubaki, Byung-Hwan Oh, Jenn-Chuan Chern, Jin-Keun Kim, Ta-Peng Chang and Feng-Bao Lin, who sequentially and individually rode on an airplane to fly over the vast and blue Pacific Ocean and arrived at different lands of America with a beautiful dream of receiving a Ph.D. degree in the filed of Civil Engineering over the next few years. Probably by the will of heaven, finally, they unanimously and independently at different years decided to choose Prof. Zdeněk P. Bažant as the dissertation advisor of Ph.D. program at Northwestern University (NU) Evanston, Illinois, U.S.A. and became the classmates. Many thanks to the generous financial support and keen academic guidance from Prof. Bažant over some years at NU, they eventually found that their dreams had come true after their persistent commitments to the completion of Doctoral degree with long term diligence and hard working over years. Afterwards, five of them went back to their own home countries one by one to have a university teaching job, respectively, and Feng-Bao stayed at U.S.A. and also obtained a teaching faculty position at university. Time flies like and arrow. Some decades have been passed quietly. These ever young and enthusiastic scholars have become senior and elder.

Jenn-Chuan and Ta-Peng individually went back to Taiwan about twenty years ago. Over years, the vivid and emotional memory of the sweet and bitter life they did spend on those old years at NU with Prof. Bažant has occasionally haunted their minds. As a result, they decided to invite all these other four old Asian classmates, together with Prof. Chung-Chia Yang and Prof. Masahiro Ouchi, to organize an Asian Special Workshop in honor of the 70th Birthday of Prof. Zdeněk P. Bažant, in collaboration with the 2007 Annual Convention of Taiwan Concrete Institute (TCI) and TCI 2007 Concrete Technology Conference and Exhibition. The organizers like to express their sincerest appreciation to their kind assistance to timely provide the papers to support this workshop and give the oral presentation at the workshop. In total, there are eight papers collected in this volume of proceedings covering a wide range of various concrete related fields.

We do have so many sentimental recollections on the endurance and diligence we had devoted to obtaining our Ph.D. degrees under the brilliant guidance of Prof. Z. P. Bažant at Northwestern University. We like to express our everlasting sincerest appreciation of his continuous support and influence to us at his 70th birthday.

Ta-Peng Chang
Taipei, 2007

Jenn-Chuan Chen
Taipei, 2007

Asian Special Workshop on Concrete Technology

in honor of the 70th Birthday of Prof. Zdeněk P. Bažant

in Collaboration with the 2007 Annual Conference of Taiwan Concrete Institute

Afternoon, November 2, 2007 (Friday)
IB302 Lecture Room, National Taiwan University of Science and Technology,
Taipei 106, Taiwan

SESSION SCHEDULE

1:40 ~ 2:00 pm	**Brief opening ceremony**	
	Chairperson: Prof. Ran Huang, National Taiwan Ocean University, Keelung, Taiwan	
2:00 ~ 2:15 pm	Time-dependent Behavior of Hardening Concrete under Short-time and Sustained Uniaxial Loading	Prof. Tatsuya Tsubaki *Yokohama National University, Japan*
2:15 ~ 2:30 pm	Durability and Corrosion Analysis of Reinforced Concrete Structures: Consequences on Service Life"	Prof. Byun-Hwan Oh *Seoul National University, Korea*
2:30 ~ 2:45 pm	The Development of RPC/Metal Composite for Seismic Energy Adsorption	Prof. Jenn-Chuan Chern *National Taiwan University, Taiwan*
2:45 ~ 3:00 pm	Development of a measurement device of stress due to hydration heat in concrete structures	Prof. Jin-Keun Kim, *Korea Advanced Institute of Science and Technology (KAIST), Korea*
3:00 ~ 3:30 pm	**Coffee break**	
	Chairperson: Prof. I-Kuang Fang, National Cheng-Kung University, Tainan, Taiwan	
3:30 ~ 3:45 pm	Properties of Portland Cement Composite Incorporated with Nanosilica	Prof. Ta-Peng Chang *National Taiwan University of Science and Technology, Taiwan*
3:45 ~ 4:00 pm	Seismic Assessment of Unreinforced Masonry Structures	Prof. Feng-Bao Lin *The City College of New York, USA*
4:00 ~ 4:15 pm	The Influence of Medium-high Temperature Environment on the Transport properties of Concrete	Prof. Chung-Chia Yang *National Taiwan Ocean University, Taiwan*
4:15 ~ 4:30 pm	Prospect of Demand for Concrete in East Asia in Terms of Statistics of Consumption of Cement in Europe and Japan	Prof. Masahiro Ouchi Kochi University of Technology (KUT), Japan
4:30 ~ 4:50 pm	**General discussion**	

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TIME-DEPENDENT BEHAVIOR OF HARDENING CONCRETE UNDER SHORT-TIME AND SUSTAIND UNIAXIAL LOADING

Tatsuya Tsubaki[1]

ABSTRACT

The material properties of solidifying and hardening concrete are of major importance during construction process of concrete structures because the subsequent damage in concrete is prevented by knowing those material properties. To express the material properties of concrete in extremely early ages, an evolutionary model which can be used during the whole period when solidifying and hardening concrete undergoes the transition from a viscous liquid state to a solid state is presented. The evolution of the material parameters is governed by a function of water-cement ratio and elapsed time after mixing which corresponds to the degree of hydration of concrete.

The general form of the evolutionary model is a summation model with the elastic strain part, the viscoelastic strain part, the viscous strain part and the stress-independent strain part. Each part of the model is expressed in terms of the stress, the strain rate, the mix proportions such as the water-cement ratio and the degree of hydration.

The parameters for the evolutionary function are determined from three experimental methods for uniaxial loading, i.e., the pullout test, the penetraion test and the uniaxial compression test under various load levels, loading rates and ages at loading.

The model is verified for mortar and concrete using rapid hardening portland cement with the water-cement ratios between 0.37 and 0.62. Those water-cement ratios correspond to the uniaxial compressive strength of 30MPa and 60MPa.

The model can be used for modeling uniaxial behavior of hardening concrete including creep. Using this kind of model for solidifying and hardening concrete, it is possible to check the possibility of overloading in the actual construction site. It is also important to examine the possibility of cracking which occurs at extremely early ages of concrete.

INTRODUCTION

The long-time performance of concrete structures is influenced by events which occur within few hours after concrete is mixed and placed. This period is characterized by the rapid transition of concrete from the liquid state to the solid state. It is well known that the evolution of material properties of concrete is controlled by the hydration process.[1)] The progress in hydration can be quantified with the degree of hydration or the maturity. In the following, an evolutionary model

[1] *Yokohama National University, Yokohama, Japan*

THE DEVELOPMENT OF RPC/METAL COMPOSITE FOR SEISMIC ENERGY ADSORPTION

Jenn-Chuan Chern[1] and Yen-Jui Chen[2]

ABSTRACT

Reactive Powder Concrete (RPC) is a kind of high-strength and high-performance cement-based composite. The steel welded wire mesh reinforced thin reactive powder concrete plate (WMRPC) and RPC composite plate (RPCCP) have been fabricated to explore its behavior of energy dissipation subjected to reversed cyclic bending. The fabrication process of plates for the energy dissipation element has also been improved to control distribution, orientation and uniformity of steel fibers in the matrix of WMRPC and RPCCP to reach higher energy dissipation capacity. In this paper, the studies about the effect of steel welded wire mesh, metallic plate and volume fractions of steel fibers on energy dissipation of RPC plate are studied. Under both the monotonic static bending tests and the reversed cyclic bending tests, flexural strength, toughness, and energy dissipation ability of WMRPC and RPCCP are reported. The WMPRCs and RPCCPs are further arranged to become the energy dissipation system (EDS) element for the testing of its mechanical behavior under cyclic loading. A structural analysis was performed to examine the effect of installing a RPC EDS to the frame system for passive structural seismic control. The experimental results indicate that the surfaces of RPCCP flexural plates show multiple cracks and the load versus mid-span deflection curves display the pseudo-displacement-hardening phenomenon and stable hysteretic loops that enhances the ability of energy dissipation. The RPC energy dissipation element provides a superior alternative replacement for metal element in seismic passive structural control engineering applications.

INTRODUCTION

Conventional structures use the ductile capacities of its structural members to suppress the input of seismic force without causing the failure of members due to the exceeding of member ductility capacity. There are new technologies developed to control the dynamic behavior of structures and to relieve the seismic force to the major structural members subjected to strong seismic actions. These structural seismic control technologies are categorized as active, passive and hybrid control systems. The passive control system is used to dissipate the input energy from earthquake to avoid the damage to the main structural members. Seismic isolation and passive energy dissipation systems are commonly used for the passive seismic control of structures. For passive energy dissipation system, it usually provides the supplemental damping to the structural system and to reduce the structural response to earthquake motions. A structure can dissipate a large portion of the seismic input energy through inelastic deformations or friction in the energy dissipation devices. In Taiwan, two types of energy dissipation systems are often used, which are

[1] *Distinguished Professor, National Taiwan University, Taipei, Taiwan.*
[2] *Ph.D., Department of Civil Engineering, National Taiwan University, Taipei, Taiwan.*

DEVELOPMENT OF A NEW DEVICE FOR THE MEASUREMENT OF STRESS GENERATED DUE TO HYDRATION HEAT OF CEMENT

Jin-Keun Kim[1], Muhammad Nasir Amin[1] and Sang-Eun Jeon[2]

ABSTRACT

Mass concrete generates internal heat during the hydration period that occurs very soon after the casting of concrete. This internal heat causes the generation of stress which can leads to severe immature thermal cracking of concrete structures. So, the utmost responsibility of a concrete engineer is to handle this problem with great care to free the concrete structures from any danger of such an initial defects. In order to tackle this problem, it is necessary to measure the stress generated due to hydration of cement very accurately along with other influencing uncertain early age properties of concrete such as elastic modulus, thermal dilation coefficient, and transitional thermal creep and so on. Numerous analytical and experimental techniques have been proposed but limitations were still exists in both type of methods which are being used for measuring stress and other important properties. In this paper, a recently developed device is presented which is proposed to measure the thermal stress in concrete along with its various other uses of measuring aforementioned uncertain early age properties. The effects of these uncertain properties of concrete on stress development can be incorporated by placing the device in a temperature and humidity control chamber due to the simultaneous development of temperature in the restrained specimen from the very beginning. The temperature history at any location in the real structure obtained from the prior temperature distribution analysis can be programmed in the chamber which will be followed by the specimen to measure the stress at the corresponding location. The test results show that the stresses estimated by this newly developed device agreed well with the general stress variations in actual structures.

Keywords: *Thermal stress; elastic modulus; thermal dilation coefficient; developed device; degree of constraint*

INTRODUCTION

When constructing a mass concrete structure such as dam or a large-scale structure like an electric power plant, concrete is placed in huge quantities at the same time causes the temperature to reach up to bout 40-70°C specifically due to the heat of hydration of the cement. Such a high temperature could rise the generation of thermal stress crossing the tensile limit of the designed concrete and the cracks develop from tensile stresses which usually results from a temperature drop. The generation of thermal stresses is a well known major cause for the early age thermal cracking of most massive hardening concrete structures which generally influenced

[1] *Department of Civil and Environmental Engineering, Korea Advanced Institute of Science and Technology (KAIST), 373-1 Guseong-dong, Yuseong-gu, Taejon 305-701, South Korea*
[2] *Civil Engineering Team, Samsung Plaza Building 15F, 263 Seohyeon-dong, Bundang-gu, Seongnam, Gyeonggi 463-721, South Korea*

Properties of Portland Cement Composite Incorporated with Nanosilica

Ta-Peng Chang[1] and Jeng-Ywan Shih[2]

ABSTRACT

In this study, microstructures and engineering properties of Portland cement pastes with five dosages of nanosilica particles in liquid form at water/cement ratios of 0.45, 0.55 and 0.65 are investigated. The variables under investigation include compressive strength, zeta potentials and microstructures, as determined by nuclear magnetic resonance (NMR), nitrogen adsorption and mercury intrusion porosimetry (MIP). Results show that, after adding pozzolanic materials, cementitious properties of the Portland cement composites are improved such that their strength development becomes better than that of the control ones. The pozzolanic reaction is accelerated due to the addition of nanosilica. Once the dense C-S-H gel in the hydrated cement composite is formed, the porosity of the composite becomes smaller, resulting in high compressive strength and low coefficient of permeability. The composite cement pastes with 0.6% nanosilica by weight of cement have an optimum compressive strength, an increase of about 43.84%. The aqueous solution with 1.08 % nanosilica by weight of water has a maximum zeta potential in absolute value. Both the microstructures of such cement composites with nanosilica show a solid and stable structure.

Keywords: *Portland cement composite, nanosilica, microstructures, compressive strength, zeta potential*

INTRODUCTION

Mineral admixtures are crucial during the hydration of high performance concrete. Among these mineral materials, the pozzolanic materials, such as fly ash, slag, silica fume etc., are traditionally chosen and partially added to the cementitious powder to improve consolidation and durability of concrete. These conventional supplementary cementitious materials are used for making high performance cement-based composites with enhanced strength and abrasion resistance as well as reduced permeability and drying shrinkage because of their filling effect of decreasing porosity and the pozzolanic reactions, in which the calcium hydroxides ($Ca(OH)_2$) while the calcium silicate hydrates (C-S-H) is produced [1-2].

Owing to the innovation of science and technology, materials at nanoscale have been developed. Lots of research reports suggest that the strengthening mechanism of nanomaterials should be considered in the study of the concrete properties and the enhancement of their function. In order to improve the properties of cement-based composites, siliceous materials with high purity and fine size are introduced. In the past decade, nanoparticles of 1-100 nm in size draw enormous

[1] *Professor, Department of Construction Engineering, National Taiwan University of Science and Technology, Taipei 10672, Taiwan (R.O.C.)*
[2] *Assistant Professor, General Education Center, Ming-Chi University of Technology, Taipei 243, Taiwan (R.O.C.)*

SEISMIC ASSESSMENT OF UNREINFORCED MASONRY STRUCTURES

Fei Zeng[1] and Feng-Bao Lin[1]

ABSTRACT

Unreinforced masonry structures such as buildings and bridges constitute a significant portion of existing structures around the world. Many of these constructions have historic, cultural, and transportational importance. Masonry structures are particularly vulnerable to earthquake excitations due to the fact that the integrity of these structures relies mainly on the axial load induced by gravity and the joining material between masonry blocks such as mortar which is apt to crack when subjected to tension caused by earthquake lateral forces. The recent earthquakes in various countries have caused great damage and destruction to masonry bridges, religious temples, and other monumental buildings. These incidents further enlightened the vulnerability of masonry structures and the need to reliably assess their seismic capacity. One key aspect in the assessment and evaluation process of a masonry structure is to create a sound structural model and carry out a reliable seismic analysis. Probably the most accurate finite element modeling is to treat the masonry as a two-phase material and model block units and mortar joints separately. However, this approach would not be feasible for a large-scale masonry structure because of its vast demand in terms of the computer memory and running time. In this paper, the seismic assessment of the unreinforced masonry tower of the Brooklyn Bridge is investigated assuming the block units and mortar joints are smeared out and the masonry is treated as a homogeneous anisotropic continuum. The equivalent material properties of the masonry are obtained based on the analytical framework of the finite-volume direct averaging micromechanics model. Parametric analyses are performed on a repeating unit cell to understand the effect of elastic moduli and volume fraction of mortar joints on the equivalent properties of the unit cell. Nonlinear time-history analyses of the masonry tower are performed using three selected historical earthquake records. Preliminary results indicate that the whole tower retains the global structural stability with some local damages appear in the corner regions between the arches and the base of the tower. The maximum drift at the top of the tower is less than the target displacement estimated based on FEMA-273.

INTRODUCTION

A masonry structure can be considered as a two-phase composite medium composed of masonry blocks and mortar joints, normally arranged periodically. For periodic composite materials, the homogenization techniques represent a powerful tool and are getting more and more attention among the masonry community because the techniques are needed for the analysis of large-scale masonry structures, especially when seismic or explosive loads are involved. A number of homogenization techniques have been developed in the past to derive average homogenized

[1] *The City College of New York, New York, NY 10031, USA*

THE INFLUENCE OF MEDIUM-HIGH TEMPERATURE ENVIRONMENT ON THE TRANSPORT PROPERTIES OF CONCRETE

Chung Chia Yang[1] and Jong Sheng Yo[1]

ABSTRACT

The reinforced concrete dry cask storage of spent nuclear fuel is exposure to the about 95°C temperature environment during its lifetime. This paper discussed the transport properties of concrete made with sixteen types of concrete mixes exposed at 95°C temperature and room temperature. In this study the electrochemical technique is applied to accelerate chloride ion migration in concrete to estimate the breakthrough time and the chloride flux. The non-steady-state migration coefficient and the steady-state migration coefficient were calculated from the modified Fick's second law based on measurements of the breakthrough time and the chloride flux. Test results show that the non-steady-state migration coefficients and steady-state migration coefficients are increased many times under the temperature of 95°C. But the compressive strength of concrete, the difference between in room temperature and at 95°C temperature showed a minor difference.

Keywords: *concrete; medium-high temperature; ACMT; migration coefficient*

INTRODUCTION

Since the reinforced concrete dry cask storage of spent nuclear fuel is long-term exposure to medium-high temperature (about 95°C), temperature plays an important role in the use of concrete for dry cask storage of spent nuclear fuel. Because temperature may change the pore structure of concrete, it is important to understand the effects of medium-high temperature on the transport properties of concrete used in dry cask storage of spent nuclear fuel.

Pore structure is one of the major characteristics and influences on both the mechanical behavior and the transport properties of cement-based materials. Since the durability of cement-based materials depends on the transport properties, pore structure has significant implications for durability.

The effect of temperature on the mechanical property of concrete is the subject of many publications. Castillo and Durrani [1] notes that at temperatures in the range 100-200°C the compressive strength decreased to about 8% for normal strength concrete. From the results of mercury porosimetry measurements, Noumowe et al. [2] pointed out that the total porosities and the shape of the distribution curves indicate that between 22°C and 120°C the porous structure of each concrete is not significantly modified. However, the influence of a medium temperature about 95°C on the transport properties of concrete is rarely determined.

[1] *Institute of Materials Engineering, National Taiwan Ocean University, Taiwan, R.O.C.*

PROSPECT OF DEMAND FOR CONCRETE IN EAST ASIA IN TERMS OF STATISTICS OF CONSUMPTION OF CEMENT IN EUPORE AND JAPAN

Masahiro OUCHI[1]

ABSTRACT

Prospect of the demand for concrete in the eastern Asian countries was discussed in terms of the statistics of the consumption of cement in the developed countries in the world like Japan and European countries as the preceding countries of the investment for the construction and the consumption of cement both in Japan and Taiwan in the near future was estimated.

Asia's share of the consumption of cement, especially in East Asia has been increasing in the world. On the other hand, the consumption of cement in Japan and Taiwan is now decreasing and it is possible that the peak of the consumption may not break the record. The prospect of the consumption of cement is indispensable because the future for the construction and related industry has to be planned.

The annual increasing rate of concrete was defined as the ratio of the annual consumption of cement to the accumulated consumption of cement. According to the statistics of some of the European developed countries, that is, U.K., France, Denmark, and Sweden, whose annual increasing rate was less than that of Japan, it was found that the annual increasing rate of concrete has been stable at around 0.02 to 0.01 for over ten years. The author assumed that the increasing rate would converge at 0.02 to 0.01 both in Japan and Taiwan and estimated the consumption of cement in the near future.

INTRODUCTION

Prospect of the demand for concrete in the eastern Asian countries was discussed in terms of the statistics of the consumption of cement in the developed countries in the world like Japan and European countries as the preceding countries of the investment for the construction. The reasons why the consumption of cement shall be the index are as follows:

(1) Component of concrete: the most common construction material

(2) Almost constant unit content in concrete : 300 kg/m^3

(3) Sufficient & reliable data from the early 20th century all over the world

The author assumed that the amount of consumption of cement shall be in proportion to the amount of structure constructed.

[1] *Kochi University of Technology, Kochi, JAPAN*