Volume 4, Number1 , Aug. 2008

Disaster Reduction News

State Key Laboratory for Disaster Reduction in Civil Engineering, Tongji University

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Academic Exchange Activities

1. Dr. HUANG Hong-wei attended the 4th Choshu-London Memorial Symposium in Lifetime Engineering of Civil Infrastructure held in Ube, Yamaguchi, Japan, on Jan. 17th, 2008, and gave a speech entitled "Maintenance of Large Bridges based on Structural Health Monitoring System in China".

2. Prof. GE Yao-jun was invited to make an invited presentation entitled "Aerodynamic Challenges in Long-Span Bridges" at the Centenary Conference of the Institution of Structural Engineers in Hong Kong on Jan. 24-26, 2008. Prof. LU Xi-lin was invited to attend the conference and gave an invited presentation entitled "Seismic Resistance Study of Tall Buildings in China Mainland".

3. On Jan. 24-26, 2008, Prof. SHEN Zu-yan was invited by the Institute of Structural Engineers (IStructE) to attend IStructE Centenary: 1908-2008 Celebrating 100 Years of Structural Engineering held in Hong Kong Convention and Exhibition Center, and he was entitled as Fellow of IStructE (FIStructE), which is the highest grade of membership offered by IStructE.

4. From Feb. 7 to 20, 2008, Prof. SHEN Zu-yan was invited by Prof. ZHAO Xiao-ling to visit Monash University as a Visiting Academic. Two lectures entitled "Recent Research on High Strength Cold-Formed Thin-Walled Steel Structures" and "Progress and Prospect

of Tall Steel Buildings in Mainland China" were presented during the visiting, possible cooperation between Tongji University and Monash University was widely discussed and a draft of Memory of Understanding was obtained for further communication of the two universities.

5. Prof. LU Xi-lin attended the 5th International Conference on Urban Earthquake Engineering, which was held on Mar. 3-5, 2008 in Tokyo, Japan. He gave an presentation entitled "Performance-based seismic design for high-rise buildings in Metropolitan city".

6. Dr. HUANG Hong-wei attended the Intelligent Sensors and Actuators Symposium at Earth & Space 2008 Conference held in Long Beach, California, USA on Mar. 3-5, 2008, and made a presentation entitled "Studies on Effecting Factors of Damper Efficiency for Long Stay Cables".

7. Prof. GE Yao-jun was invited to make a keynote presentation entitled "Dynamic Hazard Evaluation of Major Engineering Structures: with the special interest in aerodynamic hazard evaluation projects" at the 3rd International Symposium on Wind Effects on Buildings and Urban Environment in Tokyo, Japan, on Mar. 4-5, 2008.

8. Dr. HUANG Hong-wei attended the SPIE: 15th International Symposium on Smart Structures and Materials & NDE and Health Monitoring held in San Diego, California, USA, on Mar. 9-13, 2008, and made a presentation entitled "Comparison of Various Structural Damage Tracking Techniques Based on Experimental Data".

9. On behalf of Chinese Group of IABSE, Prof. GE Yao-jun made an application presentation at the 94th Executive Committee Meeting of IABSE on Apr. 4th, 2008, to apply for IABSE Workshop 2009 with Chinese Bridge Tour on Recent Major Bridges. The Committee has approved this propose and decided this IABSE Workshop to be held in Shanghai on May 11-12, 2009 and followed by 8-day Chinese Bridge Tour.

10. The 6th National Conference on Random Vibration and Applications was held during May 9-11, 2008. About 60 participants from universities, research institutes and industrial field took part in the conference.

The conference was co-sponsored by the Random Vibration Committee of Chinese Society of Vibration Engineering, Research Institute of Physical and Chemical Engineering of Nuclear Industry and Tongji University. Prof. LI Jie and Dr. CHEN Jian-bing served as the vice Chairman and Secretary-general of the organization committee, respectively. Prof. ZHUANG B.Z. from Zhejiang University, Prof. ZHENG W.G. from Nanjing Anzheng Software Company and Prof. LIN J.H. from Dalian University of Technology gave keynote lectures. Prof. LI Jie gave invited plenary lecture in the conference. During the conference, the Random Vibration Committee held meeting and concluded that the conference was very successful and

beneficial to the promising development of random vibration and applications to various disciplines.

11. Prof. YANG Jann N., who is the professor in the Department of Civil and Environmental Engineering, University of California at Irvine, USA, was invited by Professor SUN Li-min and Dr. HUANG Hong-wei to visit Tongji University and gave a seminar entitled "Full-Scale Experimental Verification of Resetable Semi-Active Stiffness Dampers and Decentralized Structural Control", on May 15th, 2008.

12. Prof. GE Yao-jun was invited to make a keynote presentation entitled "Wind Resistance Challenges in Chinese Major Bridges" at the 18th National Conf. on Bridge Engineering in Tianjin on May 20-22, 2008.

13. Prof. Pol D. Spanos was invited by Prof. LI Jie to visit Tongji Univeristy during May 22-26 2008. Prof. Spanos is currently Lewis B. Ryon Professor of Mechanical Engineering and of Civil Engineering in Rice University, and he is a member (academe) of the National Academy of Engineering (USA) and also a corresponding member of the National Academy of Greece (Academy of Athens). He made a presentation titled "Pragmatic Methods for Probabilistic Nonlinear Mechanics" on May 23. During his visit, Prof. Spanos, Prof. LI Jie and his research team had discussed deeply many scientific issues and reached agreement for further research cooperation.

14. Dr. SUN Zhi attended the Fourth International Conference on Advances in Structural Engineering and Mechanics held in Jeju, Korea, on May 26-28, 2008, and made a presentation entitled "An Experimental Study on Active Mass Damper Based Vibration Control of a Cable Stayed Bridge under Construction".

15. On May 26 to 31, 2008, Prof. LI Yuan-qi attended the 4th International Conference on Advances in Structural Engineering and Mechanics (ASEM'08) and the 4th International Conference on Advances in Wind and Structures (AWAS08) in Korea. He was invited to be chairman of the section T4F of ASEM'08 and of the section T4F of F2B of AWAS08, and presented speeches in the two conferences entitled "Experimental Investigation on the Shear Behavior of Self-Drilling Screw Connections" and "Universal Equivalent Static Wind Load Estimation for Spatial Structures Based on Wind-induced Envelope Responses", which are co-authored with Prof. SHEN Zu-yan.

16. As the session chairman of the organizing committee of the conference entitled "the 5th International Conference on Structures in Fire", Prof. LI Guo-qiang attended the conf., which is held in Singapore on May 28-30, 2008.

17. Dr. QUAN Yong, Dr. ZHANG Ai-she and Dr. HU Liang attended the 4th International Conference on Advances in Wind and Structures (AWAS'08) held on May 29-31, 2008 in Jeju Island, Korea. The research team of Prof. GU Ming published 8 papers in this conference: (1) M. Gu & Z.N. Xie, Interference Effects of Tall Buildings under Wind Action, (Keynote paper); (2) A.S. Zhang & M. Gu, Computation of Mean Pressure Interference Effects among Tall Buildings; (3) F. Li, M. Gu and J.J. Pan, Characteristics of Wind Load and Analysis of Wind Induced Response of Saddle Roof; (4) L. Hu, M. Gu and L. Li, Error Assessment for Original Spectral Representation Method in Wind Velocity; (5) Y. Quan & M. Gu, Across-wind Equivalent Static Wind Loads and Responses of High-rise Buildings with Rectangle Sections; (6) A. Zhang, M. Gu and D.Q. Zheng, Numerical Simulation of Wind-induced Vibration for Tall Buildings; (7) X.Y. Zhou, M. Gu, F.S.Mi and P. Huang, Analysis of Wind-Induced Responses of Dry Coal Shed under Interference Condition; (8) S.Y. Li, Z.Q. Chen and M. Gu, Theoretical Analysis of Rain-wind Induced Vibration of Stay Cable: A Coupled Two-mass Oscillator with Three Degree-of-Freedom.

Prof. GE Yao-jun and his team attended the conference, and organized a special session, "Aerodynamic Stabilization of Large Bridges", with 7 presentations and papers.

18. Prof. LU Xi-lin attended the 10th World Conference on Timber Engineering, which was held on June 1-7, 2008 in Japan.

19. Dr. HUANG Hong-wei attended the 5th International Workshop on Structural Control and Monitoring held in Dalian on June 5-6, 2008.

20. On Jun. 16-17, 2008, Prof. SHEN Zu-yan attended International Symposium on Applications of High-strength Steels in Modern Constructions and Bridges held by China Steel Construction Society in Beijing, China. An impromptu speech on requirements and basic consideration of yielding strength to tensile strength (Y/T) ratio for aseismic structural steels in China was presented.

21. Dr. PEN Jin-song, who is the assistant professor in the Department of Civil and Environmental Engineering, Oklahoma University, USA, was invited by Dr. Hongwei Huang to visit Tongji University and gave a seminar entitled "Bridging the Gap - Fusion of Data-Driven and Physics-Based Techniques for Modeling Nonlinear Dynamic Systems in Structural Engineering Applications", on June 19th, 2008.

22. Prof. SHEN Zu-yan attended several important academic events for site construction of World Expo 2010 Shanghai, including the assessment meeting for the design plan of the Main Hall of Expo 2010 Shanghai, overrun design assessment of the membrane structure and the reticulated structure of the Shanghai Expo Axle, China Hall and the Harmonious Tower, etc.

23. On June 21, 2008, Engineering Research Center of Steel Building Structures, Ministry of Education was established in Tongji University. Many experts and scholars were invited to attend the meeting. As Chairman of the Technical Committee, Prof. SHEN Zu-yan congratulated the establishment of the center, and expressed supports and expectations to the center. A lecture entitled "Consideration and Suggestion on Promoting the Development of Steel Building Structure Industry of China" was presented on the meeting.

24. Prof. LU Xi-lin was invited to attend "Seismic Rehabilitation for School Buildings" which was held on Jun. 24-26, 2008, in Korea. He gave a keynote presentations entitled "Preliminary Report of School Building Damages Survey in Sichuan Earthquake of May 12, 2008". There were 80 people attending the conference.

Research and Development

1. Research and Development of Seismic Behaviors of Steel Frames with Semi-rigid Connection: The practical approach for natural periods and effective damping ratio of semi-rigidly connected composite frames are derived. Based on the results, the earthquake action can be calculated. Then, a simplified method for aseismic design of semi-rigidly connected composite frame under frequent earthquake action is presented. The analysis model of semi-rigidly connected composite frame for elasto-plastic seismic action is proposed. Through statistical analysis, a practical method for evaluating the maximum inter-story elasto-plastic drifts is established. Because most studies of semi-rigid connection were focused on the major axis of beam-to-column joints, for the application of steel frames with semi-rigid connections, the hinge-connected steel frame with buckling restrained braces for semi-rigid minor axis joints is proposed. Shaking table tests of full-scale composite structures with semi-rigid connection and buckling restrained braces are carried out. The dynamic characteristics, seismic behavior and failure mode are recorded and analyzed. Based on the theoretical analysis and test results, the practical seismic design approach of semi-rigidly connected composite frames system are put forward.

Shaking table test on a steel frame with semi-rigid composite connections and buckling restrained braces

(a) Status of the buckling restrained brace before test

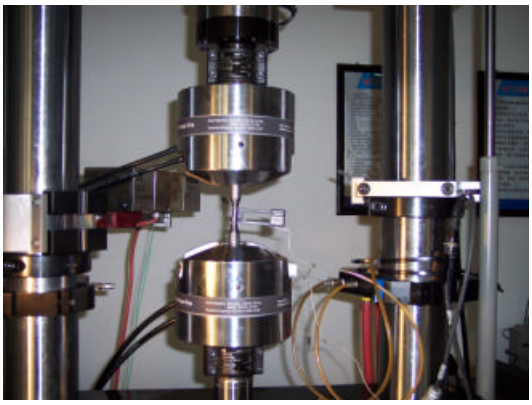
(b) Status of the buckling restrained brace after test

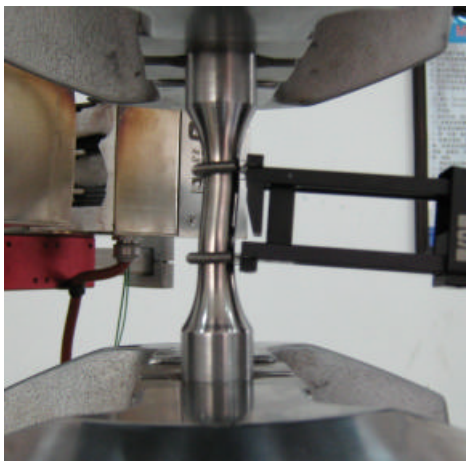
Residual deformation of the buckling restrained brace in shaking table test

2. Prof. SHEN Zu-yan and his research team recently have finished or been conducting the research work for several important projects, including,

   1) Standard tensile and strain-controlled low-cycle fatigue tests on a number of all-weld specimens subtracted from welded T-joints of Q235 and Q345, the two most widely used structural steels. Based on experimental results, a damage cumulation model for weld material has been proposed and presented. The model is based on plastic strain and takes into account the complete loading history and energy dissipation as well as the effect of the maximum plastic strain. Comparison tests are also performed on both steel and weld material to study in more detail the difference in their cyclic behavior, as well as the effect of factors including material grade, strain amplitude, loading sequence, welding sequence, and casting direction on the

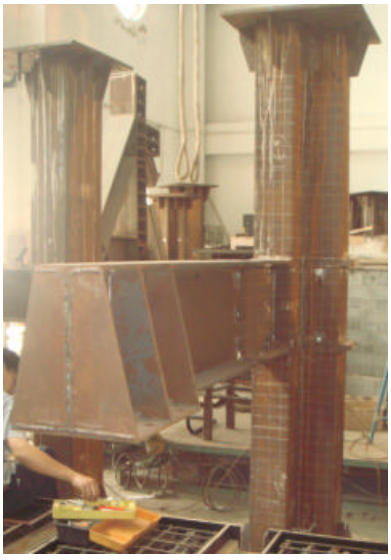
material cyclic properties. A sub-program incorporating the proposed damage cumulation model has been established and validated within the frame of the general-purpose finite element package ANSYS for analyzing specimens under cyclic loading. Such a program established from the material level can be used to obtain the hysteresis curve of welded joints and components, providing a powerful alternative to expensive structural member experiments.



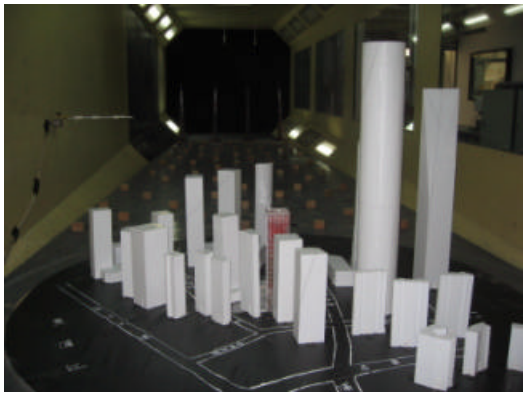


2) Static behaviors and mechanism of concrete filled steel tubular (CFSTL) beam-columns with L section were investigated including theoretical and experimental studies. The CFSTL tubular beam-columns were tested systematically considering several important experimental parameters, such as tube type of section, eccentricity and slenderness ratio. Load-deformation curves and work mechanism on CFSTL beam column were obtained and analyzed by ABAQUS, and good agreements were obtained compared with test results. Based on the systemic analysis of parameters, a practical calculational methods for bearing capacity of CFSTL beam column were developed, and the predicted values were in good agreement with the test results.

3) Experimental investigation on the performance of a novel beam-to-column moment connection suitable for the L-shaped CFT column system. A total of nine full-size beam-to-column connections consisting of L-shaped CFT column and steel H-beam were tested to investigate the seismic performance and the stress transferring mechanisms of the connections proposed by Prof. SHEN Zu-yan and his research team, taking into account of the effects of width-to-thickness, axial compression ratio, the relationship of stiffness between beam and column, angle of lateral load, and so on.

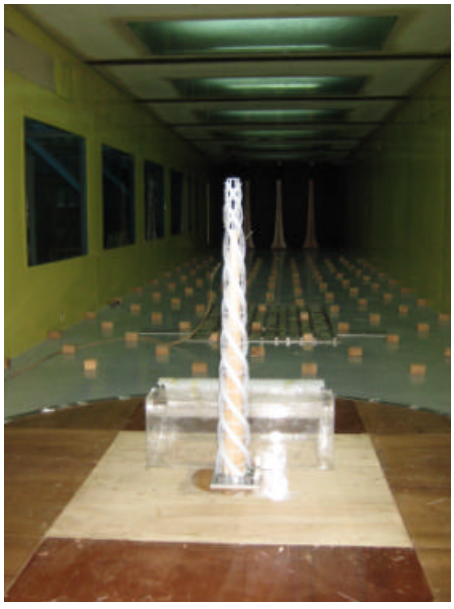


3. Prof. GU Ming and his research team recently completed the wind-resistant research on Lujiazui X3-3 Project in Pudong, Shanghai, a super-tall building with the height of 208 meters. Based on the wind tunnel test in TJ-2 wind tunnel at Tongji University, the wind loads acting on the main structure and components and cladding were acquired.



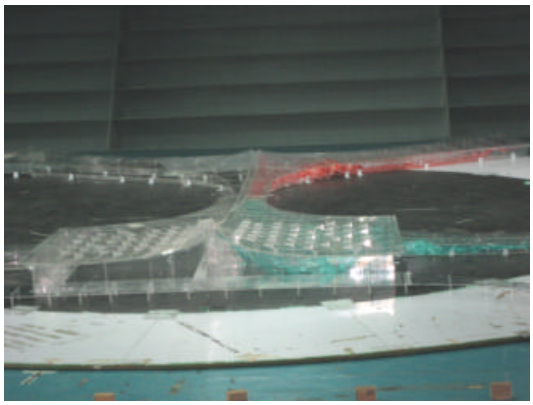
Model of Shanghai Lujiazui X3-3 Project

4. Prof. GU Ming and his research team recently completed the wind-resistant research on Expo Harmony Tower Project in Shanghai, which was rebuilt based on a chimney with the height of 165 meters. The research work includes wind tunnel tests of the scaled model for wind pressures acting on the structure, computations of the static and dynamic responses and the equivalent static wind loads.



Model of Shanghai Expo Harmony Tower in Wind Tunnel

5. Prof. GU Ming and his research team recently completed the wind-resistant research on Kun-Ming New International Airport Terminal Project, a large-span roof structure with a length of about 1120 meters and a width of about 850 meters. The research work includes wind tunnel tests of the scaled model for wind pressures acting on the structure, computations of the static and dynamic responses and the equivalent static wind loads.



Model of Kun-Ming New International Airport Terminal in Wind Tunnel

6. Prof. GE Yao-jun and his team began with a key supported program project (90715039), "Main Effects and Process Control of Wind-Induced Hazards for Super Long-Span Brides", of Ground Research Plan entitled "Dynamic Hazard Evolution of Major Engineering Structures" under Natural Science Foundation of China.

7. The key project (50538050) of National Natural Science Foundation, "Numerical Simulation Study on Dynamic Interactions between Major Structures and Special Environmental Impacts", headed by Prof. GE Yao-jun, passed the mid term evaluation with Grade A at the expert meeting of NSF in Shenzhen on January 10, 2008.

8. Prof. GE Yao-jun and his team recently completed the project, "Wind Resistance Evaluation in Preliminary Design Stage of Maanshan Bridge", which is a double main span suspension bridge with the span arrangement of 360+1080+1080+360m.

9. Professor GE Yao-jun and his team recently were awarded with the Super Grade Award of Scientific and Technology Advancement from Chinese General Company of Railway Engineering, "The Investigation about Key Technology of Three-Span Continuous Steel-lattice Arch Bridge".

10. The research team of the 863 project, "Hazard and Vibration Mitigation of Cable Stayed Bridge System with Length of Main Span over 1,000 Meter", took a technical trip to Japan from April 20th-26th, 2008, visited numbers of large span bridges including Tatara Bridge, Akashi-Kaikyo Bridge and etc. A Japan-China Workshop on Long-span Bridge Technologies was held during the trip on April 24th, 2008, in Tokyo University, Japan. The purpose of this technical trip was to study the advanced technologies in the design and construction of large span bridges in Japan, to exchange ideas and experiences between professional engineers and researchers from Japan and China, and to discuss current technological development of large span bridges.

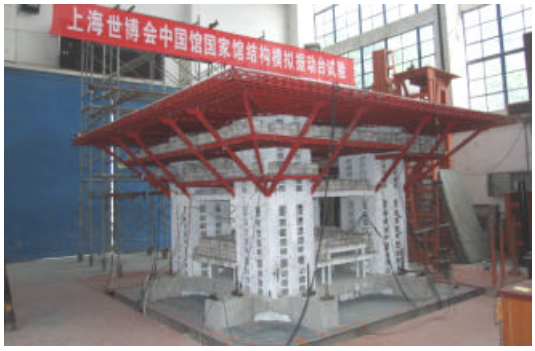
11. The annual meeting of the 863 project, "Hazard and Vibration Mitigation of Cable Stayed Bridge System with Length of Main Span over 1,000 Meter", was held successfully on February 1st, 2008 at the Department of Bridge Engineering, Tongji University. This project is supported by the Ministry of Science and Technology of China. In this meeting, all the PIs and Co-PIs were present, and the progress of each research topic was reported, the problems encountered in the research were discussed, and the working schedule for the following year was finalized.

12. Heshi Pagoda of Famen Temple located at Fufeng County, Shanxi Province, Western China, has an extremely irregular shape as shown in the figure. Detail studies on its seismic behavior were performed by Professor LU Xi-lin and his team in 2006, which include shaking table test and nonlinear analysis. The construction of the pagoda structure was just completed in March, 2008. At the end of May, 2008 after the Wenchuan Earthquake, Profess Lu leaded his team accomplished the on-site test on the dynamic behavior of the pagoda. Detailed inspection on whole structural members was also performed for the evaluation and qualification of the structure.

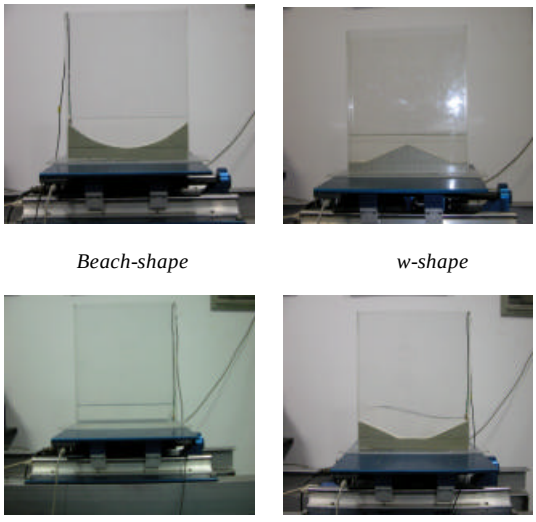
13. Kerry Jingan South Tower (KJA) is located at Jiangan District, Shanghai, and has a total height of 260 m. Two transfer stories and inclined columns were designed to fit its irregular elevation, which is out of the Chinese code. Thus, Prof. LU Xi-lin and his team designed and constructed a 1:35 scale model of KJA to investigate the seismic behavior

including dynamic characteristics, inter-story drift, the weak positions, and shear force of the irregular structure. It was concluded that in spite of the complexity of the building the structural responses can meet the requirement of the seismic code.

14. Chinese Exhibition Hall with the total height of 68 meters is located in the center of Shanghai Expo Site. The main lateral load resistant structural system consists of four reinforced concrete tubes set at four corners respectively. Rising from the elevation of 33.3m, twenty cantilever concrete-filled rectangular tubular steel braces support the cantilever floors, creating the special shape of inverted trapezoid. The symmetrical structural system is classified as vertically as well as horizontally irregular. A 1/27-scale model as shown in the figure was completed in May of 2008. Then it was tested on the shaking table subjected to a series of base excitations with gradually increased acceleration amplitude for four intensity levels, representing frequent, occasional, and rare earthquakes of Chinese intensity 7, and rare earthquakes of Chinese intensity 8 respectively. The test demonstrates that the seismic performance of the structure is favorable and can meet the requirements of the current seismic design code.



15. Shaking table test for tuned liquid damper (TLD) with sloped bottom. Under the direction of Prof. Lou, his students had completed a series of shaking table model tests for TLD with sloped bottoms as shown in following figures. The goal of the experiments is to investigate the effect of the water sloshing and particle motion in the TLD with different sloped bottoms. Based on the experiment results, a simple method for calculating the natural frequency of TLD with sloped bottoms is developed. The comparison between results of tests and calculations shows that the simple method can provide an approving procession for engineering analysis.



Beach-shape *w-shape*

flat bottom *v-shape*

Different bottom shape in TLD device

International Publications (Abstract)

1. Analysis of Restrained Steel Beams Subjected to Heating and Cooling Part I: Theory

(Published in *Steel and Composite Structures*, 8(1):1-18, 2008)

Analysis of restrained steel beams subjected to heating and cooling Part I: Theory

Guo-Qiang Li and Shi-Xiong Guo

Abstract Observations from experiments and real fire indicate that the restrained steel beams have better fire-resistant capability than isolated beams. Due to the effects of the restraints, a steel beam in fire condition can undergo very large deflection and the run away damage may be avoided. In addition, the axial forces will be induced with temperature increasing and play an important role on the behaviour of the restrained beams. The factors influncing the behavior of the restrained beams subjected to fire include the stiffness of the axial and rotational restraints, the load type on the beam and the distribution of temperature in the cross-section of the beam, etc. In this paper, a simplified model is proposed to analyze the performance of restrained steel beams in fire condition. Base on an assumption of the deflection curve of the beam, the axial force, together with the strain and stress distributions in the beam, can be determined. By integrating the stress, the combined moment and force in the cross-section of the beam can be obtained. Then, through substituting the moment and axial force into the equilibrium equation, the behavior of the restrained beams in fire condition can be worked out. Furthermore, for the safety evaluation and repair after a fire, the behaviour of restrained beams during cooling should be understood. For a restrained beam experiencing very high temperatures, the strength of the steel will recover when temperature descends, but the contraction force, which is produced by thermal contraction, will aggravate the tensile stress in the beam. In this paper, the behaviour of the restrained beam in cooling phase is analyzed, and the effect of the contraction force is discussed.

2. Theoretical and Experimental Studies on Aerodynamic Instability of 2-dimensional Circular Cylinder with Moving Attachment

(Published in *Journal of Fluids and Structures*, 24:200–211, 2008)

Theoretical and experimental studies on aerodynamic instability of 2-dimensional circular cylinder with moving attachment and parametric studies

M. GU and L. HUANG

Abstract Rain–wind induced vibration of cables in cable-stayed bridges is a worldwide problem of great concern. The effect of the motion of water rivulets on the instability of stay cables has been recognized as one of the mechanisms of this complex phenomenon. In order to investigate how the motion of rivulets affects the unstable vibration of cables without considering the effects of axial flow and axial vortex, a real three-dimensional cable was modeled as a two-dimensional circular cylinder, around which an attachment representing the rivulet can move. This could also be regarded as a new kind of two-dimensional 2-dof dynamic system. This paper studies the aerodynamic instability of the system theoretically and experimentally. Equations governing the motions of the cylinder and the attachment are first established. The Lyapunov stability criterion is applied to the equations of motion to derive the criterion for the unstable balance angle of the attachment. Moreover, a new two-dimensional 2-dof cable model system with a movable attachment is designed and tested in a wind tunnel. Parametric studies are carried out to investigate the effects of major factors such as wind speed, frequency and damping of the dynamic system on the unstable balance angle of the rivulet attachment. Theoretical and experimental results match well. These results may be valuable in elucidating the mechanism of rain–wind induced vibration of stay cables.

3. Effect of Rain on Flutter Derivatives of Bridge Decks

(Published in *Wind & Structures, An international Journal*, 11(3), 2008)

Effect of rain on flutter derivatives of bridge decks

Ming GU and Shu-zhuang XU

Abstract Flutter derivatives provide the basis of predicting the critical wind speed in flutter and buffeting analysis of long-span cable-supported bridges. Many studies have been performed on the methods and applications of identification of flutter derivatives of bridge decks under wind action. In fact, strong wind, especially typhoon, is always accompanied by heavy rain. Then, what is the effect of rain on flutter derivatives and flutter critical wind speed of bridges? Unfortunately, there have been no studies on this subject. This paper makes an initial study on this problem. Covariance-driven Stochastic Subspace Identification (SSI in short) which is capable of estimating the flutter derivatives of bridge decks from their steady random responses is presented first. An experimental set-up is specially designed and manufactured to produce the conditions of rain and wind. Wind tunnel tests of a quasi-streamlined thin plate model are conducted under conditions of only wind action and simultaneous wind-rain action, respectively. The flutter derivatives are then extracted by the SSI method, and comparisons are made between the flutter derivatives under the two different conditions. The comparison results tentatively indicate that rain has non-trivial effects on flutter derivatives, especially on and , and thus the flutter critical wind speeds of bridges.

4. A Pratical Design Method for Semi-rigid Composite Frames under Vertical Loads

(Published in *Journal of Constructional Steel Research*, 64: 176-189, 2008)

A pratical design method for semi-rigid composite frames under vertical loads

Jing-Feng Wang & Guo-Qiang Li

Abstract Although the benefits of semi-rigid connections and composite action of slab are extensively documented in the design of steel frames, they are not widely used much in practice. The primary cause is lack of appropriate practical design methods. In this paper, a practical method suitable for the design of semi-rigid composite frames under vertical loads is proposed. The proposed method provides the design of the connections, beams and columns for semi-rigid composite frames at the ultimate and serviceability limit states. The rotational stiffness of beam-to-column connections for calculating the deflection of the frame beams and the effective length factor of columns are also determined. In addition, the accuracy of the proposed design method is verified by a pair of tests carried out on full-scale semi-rigid composite frames. Moreover, a design example is proposed to demonstrate the application of the proposed design method. It is shown that the proposed design method not only takes into account the actual behavior of the beam-to-column connections and its influence on the behavior of the overall structures, but is also simple and convenient for a designer to use in engineering practice.

5. Recent Development of Bridge Aerodynamics in China

(Published in *Journal of Wind Engineering and Industrial Aerodynamics*, 96(6-7), 2008)

Recent Development of Bridge Aerodynamics in China

Y.J. Ge and H.F. Xiang

Abstract The recent development of long-span bridge aerodynamics in China is introduced with the emphases on theoretical contributions, probability-based assessment and aerodynamic vibration control. The theoretical development is composed of full-mode-participation method, some new findings in flutter mechanism and stabilization and computational fluid dynamics (CFD) techniques and application, and some probabilistic assessment approaches are proposed and applied in wind-induced vibration including flutter instability, buffeting response and vortex-induced vibration. The final aspect focuses on the aerodynamic vibration of long-span bridges experienced in China.

6. Nonlinear finite element analysis of high-strength concrete columns and experimental verification

(Published in *Earthquake Engineering and Engineering Vibration*, 7(1), 77-90, 2008)

Nonlinear finite element analysis of high-strength concrete columns and experimental verification

Xilin Lu and Shaolin Chen

Abstract This paper describes a nonlinear finite element (FE) analysis of high strength concrete (HSC) columns, and verifies the results through laboratory experiments. First, a cyclically lateral loading test on nine cantilever column specimens of HSC is described and a numerical simulation is presented to verify the adopted FE models. Next, based on the FE model for specimen No.6, numerical simulations for 70 cases, in which different concrete strengths, stirrup ratios and axial load ratios are considered, are presented to explore the effect of these parameters on the behavior of the HSC columns, and to check the rationality of requirements for these columns specified in the China Code for Seismic Design of Buildings (GB 50011-2001). In addition, three cases with different stirrup strengths are analyzed to investigate their effect on the behavior of HSC columns. Finally, based on the numerical results some conclusions are presented.

7. Analysis of Restrained Steel Beams Subjected to Heating and Cooling Part II: Validation and Parametric Studies

(Published in *Steel and Composite Structures*, 8 (1):19-34, 2008)

Analysis of restrained steel beams subjected to heating and cooling Part II: Validation and parametric studies

Shi-Xiong Guo and Guo-Qiang Li

Abstract This paper presents the results of a validation and parametric study for the theory presented in the companion paper. The parameters investigated include the stiffness of the axial and rotational restraints, load ratio, depth-span ratio of the beam, the yield strength of steel, load type and the temperature distribution in the crosssection of the beam.

8. Spectral Characteristics and Correlation of Dynamic Wind Forces on a Super-tall Building

(Published in *The Structural Design of Tall and Special Buildings*, 17: 471–489, 2008)

SPECTRAL CHARACTERISTICS AND CORRELATION OF DYNAMIC WIND FORCES ON A SUPER-TALL BUILDING

J.Y. FU, Q.S. LI, J.R. WU, Z.H. NI, Z.N. XIE and M. GU

Abstract The 88-storey Jin Mao Building located in Shanghai has a height of 420·5 m and is the highest building in mainland China. Dynamic wind force components on the super-tall building were measured by high-frequency force balance technique in a boundary layer wind tunnel for the cases of an isolated Jin Mao Building and the existing surrounding condition under suburban and urban boundary layer flow configurations. Spectral characteristics of along-wind and across-wind components and, in particular, the cross-correlation and coherence among various wind loading components are presented and discussed in detail. Furthermore, the effects of upstream terrain conditions and surrounding buildings on the spectra, cross-correlation and coherence are investigated. The experimental results show that such effects are significant. Finally, an empirical formula for estimation of the across-wind overturning moment spectrum for the super-tall building is presented. Comparisons of the spectra determined by the proposed formula and those obtained from wind tunnel tests are made to examine the applicability of the proposed formula.

9. Influences of Equilibrium Atmosphere Boundary Layer and Turbulence Parameter on Wind Loads of Low-rise Buildings

(Published in *J. Wind Eng. Ind. Aerodyn.* 2008, online in doi:10.1016/j.jweia.2008.02.014)

Influences of equilibrium atmosphere boundary layer and turbulence parameter on wind loads of low-rise buildings

Wei YANG, Yong QUAN, Xinyang JIN, Yukio TAMURA and Ming GU

Abstract In this paper, the influences of two important problems in computational wind engineering (CWE), which are the modeling of equilibrium atmosphere boundary layer (ABL) and the specification of turbulence model parameters, on the numerical simulations of wind pressure distributions on a typical low-rise building are investigated sequentially through detailed comparisons between the numerical results and the wind tunnel test data. The capability of the proposed inflow turbulence boundary conditions in constructing equilibrium ABL is verified, and the effect of the turbulence parameters on the numerical results is illustrated. The combination of the carefully considered inflow boundary conditions, and the turbulence parameters can improve the numerical simulation accuracy of the wind pressures of the low-rise building. The present work seems to be helpful to further realize the importance of these two problems as well as to provide a referential study to the accuracy improvement of CWE.

10. Wind Tunnel Tests and Numerical Simulations of Wind Pressures on Buildings in Staggered Arrangement

(Published in *J. Wind Eng. Ind. Aerodyn.* 2008, online in doi:10.1016/j.jweia.2008.02.013)

Wind tunnel tests and numerical simulations of wind pressures on buildings in staggered arrangement

Aishe ZHANG and Ming GU

Abstract This paper presents numerical and experimental investigations of wind-induced interference effects on the pressure distributions on a building adjacent to another one in staggered arrangement. The wind tunnel tests were carried out in a low-speed boundary layer wind tunnel. Mean and fluctuating pressure and moment measurements on the principal building with interference from surroundings at different wind directions are obtained. The numerical predictions for pressure distribution on the principal building are performed by solving the Reynolds-averaged Navier–Stokes (RANS) equations using the renormalization group (RNG) k–ε turbulence model and then compared with the measurements. The computational method is based on a pressure correction algorithm of the SIMPLEC-type. The simulated pressure, base force and base moment coefficients in different wind directions are generally in good agreement with the corresponding wind tunnel data.

11. Shake table model testing and its application

(Published in *The Structural Design of Tall and Special Buildings*, 17(1):181-201, 2008)

Shake table model testing and its application

Xilin Lu, Gongkang Fu, Weixing Shi and Wensheng Lu

Abstract This paper presents a study of shake table testing for aseismic design of structure systems. Two reinforced concrete structure models of different scales were used first to implement and demonstrate the similitude concept using available testing equipment. This concept was then applied to a 33-story reinforced concrete building's scaled model, using multidirectional simulated seismic excitations. The test results were used to evaluate and modify the original design. Some of these results were also verified using field testing after the building's construction was completed. Comparison of the results between the model test and the full-scale test shows that testing based on dynamic similitude using shake table are useful although not perfect and can provide supplementary data for decision making in engineering design.

12. The principle of preservation of probability and the generalized density evolution equation

(Published in *Structural Safety*, 20:65-77, 2008)

The principle of preservation of probability and the generalized density evolution equation

Jie Li and Jianbing Chen

Abstract The present paper aims to provide a uniform and rigorous theoretical basis for the family of newly developed probability density evolution method. Conservation laws are among the most important features of continuum systems, so is the principle of preservation of probability for stochastic dynamical systems. The classical Liouville equation together with its Dostupov–Pugachev extension is firstly discussed. They could be reasonably thought to hold for stochastic systems where the randomness could be characterized by finite random variables but unfortunately they are unfeasible for practical applications because of analytical and numerical intractability. The generalized density evolution equation in conjunction with its numerical implementation procedure is then discussed with assistance of the formal solution. Comparing the Liouville equation and the generalized density evolution equation finds that the former is essentially based on the state space while the latter is on the ground of substantial particle description. The principle of preservation of probability is accordingly revisited from the two descriptions: the state space description and the random event description. On the clear basis, the generalized density evolution equation is derived once again in a more natural way. Underlying problems open for investigations and practical applications and possible extensions are outlined.

13. Shaking table test and numerical analysis of RC frames with viscous wall dampers

(Published in *Journal of Structural Engineering*, 34(1):64-76, 2008)

Shaking table test and numerical analysis of RC frames with viscous wall dampers

Xilin Lu, Ying Zhou and Feng Yan

Abstract This paper presents a comprehensive investigation on viscous wall dampers (VWD) used for seismic response mitigation of reinforced concrete (RC) frames. First, a shaking table test on a large-scaled three-story RC frame with VWD and another identical three-story RC frame without any dampers was carried out. A total of three types of earthquake excitations were inputted to the shaking table to evaluate the effects of VWD on seismic response mitigation. The influence of different earthquake input intensities on seismic performance of VWD were also examined. From the experiment, this paper further assessed the performance of VWD on seismic retrofitting of a partly damaged RC frame. The test results show that the main effect of installing VWD is to provide a large amount of supplemental damping to the RC frame, and at the same time the stiffness of the structure is also raised moderately as an accessorial effect. As a result, the displacement responses of the RC frame can always be reduced significantly, while the acceleration responses and the base shear of the RC frame were reduced in some test cases, but increased in other cases. The test results of seismic retrofit also show that seismic responses of the damaged RC frame can be alleviated evidently by the installation of VWD and, therefore, installing VWD is an effective retrofitting approach for RC frames. After test investigation, elastic and inelastic seismic responses of the RC frame were numerically simulated using finite element software Sap2000 and Canny99, respectively. A good agreement of experimental results and analysis results verified the analytical method and model used for RC structures with VWD.

14. Across-wind Dynamic Response of High-rise Building under Wind Action with Interference Effects from One and Two Tall Buildings

(Published in *The Structural Design of Tall and Special Buildings*, 2008, online in Wiley Interscience (www.interscience.wiley.com). DOI: 10.1002/tal.393)

Across-wind dynamic response of high-rise building under wind action with interference effects from one and two tall buildings

Z.N. XIE and M. GU

Abstract Systematic studies on the across-wind dynamic interference effects on two and three tall buildings are presented in this paper. It is found that surrounding and upstream interfering building(s) can significantly affect the acrosswind load on the interfered principal building. Generally speaking, two interfering buildings can cause more adverse dynamic effects on the principal building than a single one does. The results show that the maximum interference factor (IF) among three buildings increases 80% over that between two buildings in terrain category B which has been defined in Chinese load code for design of building structures; a noticeable difference of 29% of IF is also observed in terrain category D. Vortex shedding from the upstream buildings can lead to vortex-induced resonance, resulting in excessive across-wind loads on the downstream building. Although interference effects in terrain category D are much smaller than those in exposure category B, the maximum IF is found to be 1·83 in the case of three buildings with the same size in terrain category D and 2·27 in other configurations.

15. Strategy for selecting representative points via tangent spheres in the probability density evolution method

(Published in *Int. J. Numer. Meth. Engng*, 74:1988-2014, 2008)

Strategy for selecting representative points via tangent spheres in the probability density evolution method

Jianbing Chen and Jie Li

Abstract A strategy of selecting efficient integration points *via* tangent spheres in the probability density evolution method (PDEM) for response analysis of non-linear stochastic structures is studied. The PDEM is capable of capturing instantaneous probability density function of the stochastic dynamic responses. The strategy of selecting representative points is of importance to the accuracy and efficiency of the PDEM. In the present paper, the centers of equivalent non-overlapping tangent spheres are used as the basis to construct a representative point set. An affine transformation is then conducted and a hypersphere sieving is imposed for spherically symmetric distributions. Construction procedures of centers of the tangent spheres are elaborated. The features of the point sets *via* tangent spheres, including the discrepancy and projection ratio, are observed and compared with some other typical point sets. The investigations show that the discrepancies of the point sets *via* tangent spheres are in the same order of magnitude as the point sets by the number theoretical method. In addition, it is observed that rotation transformation could greatly improve the projection ratios. Numerical examples show that the proposed method is accurate and efficient for situations involving up to four random variables.

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1. WANG Pei-jun, LI Guo-qiang, Non-Linear Analysis of Elastically Axial-Restrained 2D Steel Beams at Elevated Temperatures in Fire Based on Arc Length Coordinate Method, *Engineering Mechanics*,25(1):137-144,2008
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