Volume 3, Number2, Feb. 2008

Disaster Reduction News

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

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Academic Exchange Activities

1. As the chairman of the academic committee, Prof. LI Guo-qiang attended the conference entitled “The 4th China national conference on Structures in Fire”, held in Shanghai on Dec. 14-15, 2007.
2. Prof. LI Guo-qiang was invited to give a keynote speech at the Fifth International Conference on Advances in Steel Structures (ICASS2007) in Singapore on Dec. 5-7, 2007.
3. Professors SHEN Zuyan and LOU Menglin visited Taiwan invited by Ruentex Group from Dec. 1-9, 2007. During the visit, they visited Department of Civil Engineering of Taiwan University and Research Center of Earthquake Engineering for the academic cooperation.

4. Prof. SUN Limin attended the Seventh International Symposium on Cable Dynamics held in Vienna, Austria, on Dec.10-13, 2007, and gave a speech entitled “Experiment and damping evaluation on stay cables connected by cross ties”. Dr. HUNG Hongwei also attended this symposium.

5. The Second International Conference on Advances in Experimental Structural Engineering (2AESE) was successfully hosted by the State Key Laboratory for Disaster Reduction in Civil Engineering on Dec.4-6, 2007 at Tongji University, Shanghai, China. Prof. LU Xilin worked as the chair of the organizing committee and vice chair of the scientific committee. 180 people, including over 30 foreign scholars, attended the conference.

6. On November 28-30, 2007, International Symposium on Innovation and Sustainability of Structures in Civil Engineering（ISISS’ 2007） was successfully held at Tongji University, Shanghai. Prof. SHEN Zuyan, as one of Chairman, presented a keynote speech entitled “Progress and Prospect of Tall Steel Buildings in Mainland China”. 210 scholars, including more than 30 international scholars, attended the symposium.

7. Prof. XIANG Haifan, Honorary Chairman of Organizing Committee, and Prof. GE Yaojun, Chairman of Organizing Committee, organized the 4th Workshop on Regional Harmonization on Wind Loading and Wind Environmental Specifications in Asia-Pacific Economies at Tongji University in Shanghai on Nov. 19-20, 2007. Prof. GE Yaojun made a national report in this event on behalf of Chinese Wind Engineering Group.

8. Prof. GE Yaojun organized COE International Advanced School on Wind Effects on Buildings and Wind Resistant Design at Tongji University in Shanghai, and seven famous experts in wind engineering were invited to teach two to three courses in this school.

9. The fourth meeting of the fifth Academic Committee of our laboratory was held in Tongji University on Nov. 11-12. At the beginning of the meeting, two new members, Prof. G. Lee from New York State University and Prof. J.M. Ko from Hong Kong Polytechnic University, received their letters of appointment. Prof. LOU Menglin made a brief report for the preparation of the third time laboratory evaluation next March. Seven members of the core group presented their research activities within the latest five years from 2003 to 2007, among which five representatives should be selected for the evaluation report. Seventeen members attended this meeting and made valuable and informative suggestions and comments.

10. On Nov. 5-6, 2007, Prof. LI Yuanqi attended the 2nd WERC International Symposium on Architectural Wind Engineering in Atsugi, Japan, and presented an invited speech entitled “Application of Wind-induced Envelope

Responses on Wind-resistant Design of Spatial Structures".

11. Prof. LI Jie was invited to give a seminar entitled "A Physical Approach to Stochastic Dynamics" at the University of Nagoya on Oct. 31, 2007.

12. Prof. LI Guoqiang was invited to give a keynote speech at The 9th China-Korea-Japan Symposium on Srutural Steel Construction in Beijing, China on Oct.30-31,2007.

13. Dr. DAN Danhui attended the International Conference on Health Monitoring of Structure Material and Environment, HMSME2007, held in Southeast University, Nanjing, China, on Oct. 16-18, 2007, and made a speech on "DongHai Bridge Health Monitoring System, Design, Implementation and Evaluation".

14. Prof. GE Yaojun severed as Organizing Committee Chairman in charge of the organization of the 13th National Conference on Structural Wind Engineering at Dalian Technical University in Dalian, Liaoning on Oct. 11-14, 2007.

15. Prof. GE Yaojun was invited by Prof. M. Fontana, Vice President of IABSE and Chairman of Civil Engineering Department of Swiss Federal Institute of Technology Zurich (ETH in German) to visit in ETH, and made a presentation entitled "Recent Development of Long-Span Bridges in China" on Sept.24, 2007.

16. The U.S.-China Workshop on Rapid Bridge Replacement after Extreme Events was held in Shanghai on Sept. 24-26, 2007. It was hosted by the Bridge Health Monitoring and Control Laboratory of the Department of Bridge Engineering, Tongji University. Prof. SUN Limin was one of the two Chairs of the workshop. Dr. HUANG Hongwei severed as secretary, made a great contribution to the organization of this workshop. The purpose of this international workshop was to exchange ideas and experiences between U.S. and China engineers and scholars, and to discuss current technological developments on the bridge health monitoring, maintenance and replacement. Their contributions raised new thoughts on some of the important issues related to the rapid bridge replacement after extreme events.

17. On behalf of Chinese National Group of IABSE, Prof. GE Yaojun, Secretary of Chinese Group, visited the headquarter of IABSE in ETH, Zurich, Switzerland on Sept. 24, 2007, and had a formal meeting with Executive Director of IABSE, Mr. U. BRUNNER.

18. Prof. GE Yaojun, Prof. SUN Limin and Dr. SUN Zhi attended the IABSE 2007 Symposium on Improving Infrastructure Bring People Closer Worldwide held in Weimar, Germany on Sep. 19-21, 2007. Prof. GE was invited to give a keynote speech entitled "Great Demand and Various Challenges-Chinese major bridges for improving traffic infrastructure nationwide". Prof. SUN gave a speech entitled "Experimental Study on Vibration Mitigation of Long Stay Cables using Cross Ties".

19. Prof. LU Xilin and Prof. GE Yaojun attended the annual meeting of IABSE 2007 in Weimar Germany on Sept. 17-18, 2007. Prof. GE was selected as a member of Outstanding Structure Award Committee of IABSE.

20. Dr. DAN Danhui attended the 6th International Workshop on Structural Health Monitoring, held in Stanford University, California, USA, on Sep. 11-13, 2007, and made a presentation entitled “Applying online identification on Donghai Bridge anywhere, anytime, and anyway”.

21. Prof. GE Yaojun was invited by Prof. M.A. HIRT, President of IABSE and Director of ICOM in Swiss Federal Institute of Technology Lausanne (EPFL in French), as a visiting Prof. for two-month visiting program in EPFL, and organized two seminars entitled “Innovative Research on Bridge Aerodynamics in China” on Sept. 10, 2007 and “Recent Development of Long-Span Bridges in China” on Sept.26, 2007.

22. Prof. Ohuchi HAJIME and his graduate and undergraduate students from Osaka City University visited the Department of Bridge Engineering, Tongji University, on September. 2-3, 2007, hosted by Prof. SUN Limin. A small symposium was held on Sep. 3, 2007, and presentations were made by students from Osaka City University and Tongji University to introduce the research work being carried out in both Prof. HAJIME’s and Prof. SUN’s laboratories.

23. Prof. LU Xilin and Prof. CHEN Airong attended the Second Cross-Strait Symposium on Disaster Reduction in Civil Engineering, held on Aug. 18-20, 2007 in Taipei. Prof. LU gave a presentation entitled “Research on the Complex High-rise Buildings with applications”. 50 people attended the symposium.

24. From Aug. 8 to Nov. 8 in year 2007, Prof. LI Jie was invited to visit Nagoya Institute of Technology. During this period, Prof. LI Jie was invited to give a seminar entitled “Stochastic Dynamics: A Physical Approach” at Nagoya Institute of Technology on Nov.3.

25. Prof. LI Guoqiang made an invited presentation in Steel and Composite Structures (ICSCS07) in Manchester, UK on Jul.30-Aug.1, 2007.

26. Dr. SUN Zhi offered a 3 days lecture entitled Smart Structure and Lab in Korea on Jul. 16-18, 2007. This lecture was a part of the international summer school hosted by Korea Advanced Institute of Science and Technology (KAIST). 9 famous professors offered lectures to 30 young talents from Tongji University and the host institution during one month.

27. Prof. LU Xilin, Prof. LI Peizhen and Dr. ZHOU Ying attended the Second KAIST-TJU Symposium on Civil Engineering, held on Jul.

16, 2007 in KAIST, Korea. They gave three presentations entitled "Performance-based Seismic Design of Shanghai World Financial Center Tower", "Comparative Study on the Dynamic Soil-Structure Interaction System with Various Soils by Using Shaking Table Model Tests", "Research on the Seismic Performance of Steel Reinforced Concrete Structural Members", respectively. 50 teachers and students attended the symposium.

28. Prof. LU Xilin attended the Korea Conference on Innovative Science and Technology, held on Jul. 11-13, 2007 in Jeju, Korea, and gave an invited presentation entitled "Study on Performance-based Seismic Design of Shanghai World Financial Center Tower" in the session of Innovative Technology of Hazard Preparedness for Super Tall Building. 80 people attended the forum.

29. On Jul. 1-6, 2007, Prof. LI Yuanqi and Mr. WANG Lei (Ph.D. student), attended the 12th International Conference on Wind Engineering in Cairns, Australia, and made presentations (co-authored with Prof. SHEN Zuyan) entitled "Wind Pressure Distribution on Flat Circular Roofs with Different Flexibility and Obliquity" and "Wind-induced Vibration of Flat Circular Roofs with Different Flexibility", respectively.

30. Prof. GU Ming and his research team attended 12th International Conference on Wind Engineering in Cairns, AUSTRALIA, on Jul. 1-6, 2007 and made 8 presentations. Prof. Gu was also invited to give a keynote speech entitled "Study on wind-rain induced vibration of stay cables of cable-stayed bridges based on quasi-steady assumption".

31. Prof. GE Yaojun attended the 12th International Conference on Wind Engineering in Cairns Australia on Jul.1-6, 2007, and made the presentation entitled "Progressive Investigation on Aerodynamic Stability of the Longest Suspension Bridge in China".

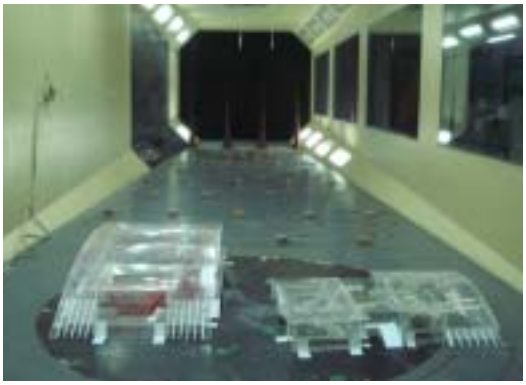
32. Prof. GU Ming was invited to give a seminar entitled "Wind-Resistant Study on Large-Scale Structures" and was invited to attend the Global Chinese Wind Engineering Forum and give an invited presentation entitled "Wind-Resistant Researches and Applications of Building Structures" in TamKang University in Taibei, China on March 31 and April 2-3 2007, respectively.

Research and Development

1. As Chief Investigator of the sub-project of the key program of National Science Foundation of China, “Basic theory and general technology on new tensile space structures” (No. 50638050), Prof. SHEN Zuyan is mainly in charge of the research work on fire-resistant design theory and aerodynamic optimum design of new tensile space structures. This project will be supported by NSFC from Jan.1, 2007 to Dec. 30, 2010. Investigation on current achievements on fire-resistant research and wind tunnel tests of typical new tensile space structures was finished for the reference of next step.

2. As Chief-editor of the Construction Industry standard “Technical Specification for Cold-formed Steel Framing of Low-Rise Buildings”, Prof. SHEN Zuyan has held seminars of the compiling committee several times for compiling the specification, specification draft for wide discussion will be ready soon.

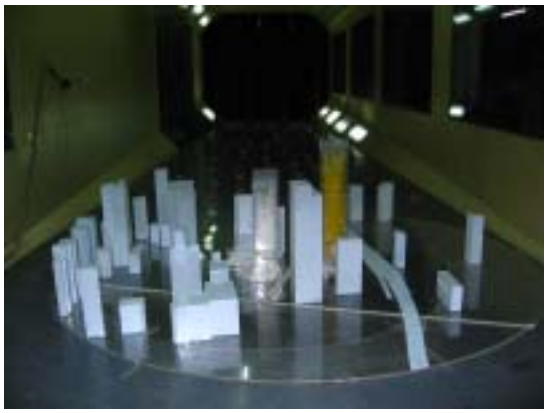
3. Prof. SHEN’s Lab at Tongji University is in charged of the project “Wind Tunnel Test and Wind Load Analysis of the Gymnasiums for the Sport Games of Fujian Province”. This project is commissioned by Headquarter of Gymnasiums Construction for the 14th Sport Games of Fujian Province, Based on wind tunnel test in TJ-2 wind tunnel at Tongji University, the mean and fluctuating wind pressure coefficients for wind-resistant design with such a complex shape(as shown in the following figure) were offered. Time-history analysis subjected to wind loading based on wind tunnel test results has been further conducted for suggesting the suitable wind-induced vibration coefficients in structural design.



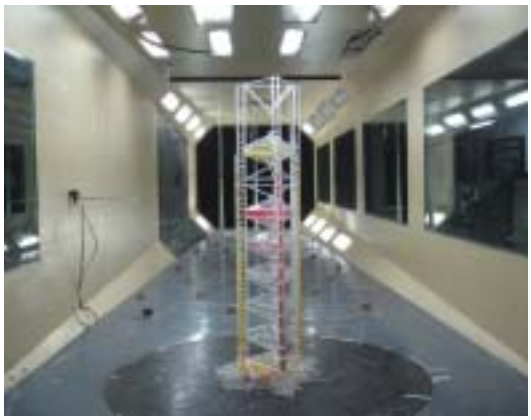
4. Prof. GU Ming and his research team recently completed the wind-resistant research on Expo Axis Project, a large-span membrane structure with a length of more than 950 meters and a width of nearly 100 meters, which is now being designed and constructed for the Expo 2010 in Shanghai. The research work includes a wind tunnel test of the scaled model for wind pressures acting on the structure, computations of static and nonlinear dynamic responses under actions of wind and actions of unfavorable combination of snow and wind loads, respectively.

5. Prof. GU Ming and his research team recently completed the wind-resistant research on Hongqiao Communications Hub in Shanghai. 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.

6. Prof. GU Ming and his team recently completed the wind-resistant research on Jingan-Jiali Center in Shanghai. The center has mainly two super-tall buildings. The tallest one has a height of 260 meters and the other 208 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 as well as pedestrian wind environment.



7. Prof. GU Ming and his research team recently completed the wind-resistant research on Olympic Broadcast Tower which will be built in Beijing for the 2008 Beijing Olympic Games. The research work includes wind tunnel tests of the scaled model for wind pressures acting on the tower, computations of static and dynamic responses as well as the equivalent static wind loads.

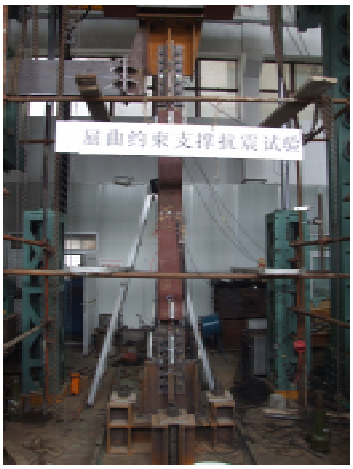


8. A novel buckling-restrained brace has been developed at Tongji University. The stiffening ribs are used in the steel sleeve to restrain the steel core from buckling. There's no any unbonding material in the steel sleeve.

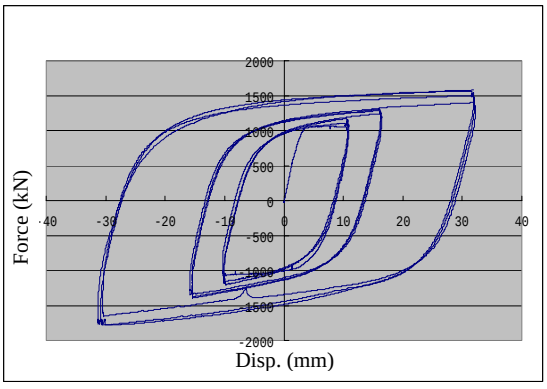
   Experimental research has been carried out on the behavior of the new buckling-restrained brace, which includes: (1) Establishing Of Hysteresis Curve Model And Stiffness

Formula For Buckling-Restrained Brace; (2) The Research For Solving Method of Inter-storey Displacement of Braced Frame Structures Under Horizontal Load; (3) A Simplified Calculation Method For Solving Elasoplastic Displacement of The Buckling-Restrained Braced Frame Under Severe Earthquakes, and others.

The domestic Q195/235 steel and low yield strength steel was used for the new type of buckling-restrained brace. Cyclic loading test was conducted on TJI buck-restrained brace (as show in the following figure).



The experimental result indicated that the buck-restrained brace has better hysteretic characteristic and ability for seismic resistance (as show in the following figure), and is a valid member for energy dissipation, which can greatly improve the seismic resistance ability of structure.



9. The project “Dynamic constitutive law of concrete and simulation of stochastic dynamic nonlinear behavior of structures” (Principle Investigator is Prof. LI Jie) , was granted as the Key Project in the Grand Research Plan “Dynamic Behavior of Grand Engineering in Disasters” by the National Natural Science Foundation of China.

10. Shanghai International Design Center (SHIDC), designed by Japanese Architect Tadao Ando, is a high-rise building with two different-height connected towers. The hybrid system of reinforced concrete core walls in conjunction with perimeter steel frames is out of Chinese code in plan and elevation layouts. Thus, Prof. LU Xilin and his research team designed and constructed a 1:15 scale model of SHIDC to investigate the seismic behavior including dynamic characteristics, inter-story drifts, the weak positions, and shear forces of the structure.

11. The Terminal Building of the Pudong International Airport Phase II has a hybrid structural system with a large span of 300m. Prof. LU Xilin and his research team carried out the shaking table test of the building model and cyclic test of the complex joints. The experimental results showed that the ultimate failure of the specimen was controlled by the welding strength. Flexural cracks near the heat

affected zone of weld initiated at 3% drift ratio and developed rapidly. Design suggestions were given to the design and construction of the project.

12. Steel Plate Reinforced Concrete Shear Wall (SPRCW) is an innovative type of composite lateral resistant structural wall, which can potentially make high-rise buildings architecturally-friendly and decrease structural weight. Few publications concerning this field can be found in China, and therefore Prof. LU Xilin and his research team conducted a series of cyclic tests on 16 SPRCW specimens with 1:2 scale. Through experimental observation and analysis, it was found that when incorporated with solid steel plate, reinforced concrete shear wall can provide much higher capacity in strength, stiffness, ductility and energy dissipation. As a result, guidelines are offered for practical application and design of SPRCW.

13. Shear stud is a new type of shear reinforcement embedded in slab-column connection to increase ultimate strength and ductility of the connection. Prof. LU Xilin and his research team designed and constructed five 1:2 scale models of slab-column connection with different ratio of shear stud to study their seismic performance. These models were undertaken quasi-static tests to investigate the seismic performance of RC slab-column connections reinforced with shear stud comprehensively, including deformation, energy dissipation, stiffness and strength.

14. The first meeting of “Earthquake Damage and Control of Urban Infrastructure” of the National Basic Research Program of China (973 Program) was held in Harbin on October 9-10, 2007, which symbolized the start of the project. Prof. LU Xilin and his team attended the meeting. They are taking charge of Project II “Earthquake Damage Evolution Mechanics of Multi-Age Buildings”.

15. HADAS damper is a typical kind of Added Damping and Stiffness (ADAS) elements, which can increase the energy dissipation capacity of a structure and decrease the

dynamic response caused by wind and earthquake excitatations through the flexural yielding deformation of mild-steel plates. Therefore, Prof. LU Xilin and his research team designed and conducted a shake table test on a three-story steel moment-resisting frame model, installed with twelve HADAS dampers under different earthquake waves and intensity levels. The seismic behavior and energy dissipation performance of HADAS damper was investigated on the basis of the experimental results.

16. The annual report of the 863 project "Hazard and Vibration Mitigation of Cable Stayed Bridge System with Length of Main Span over 1,000 Meters", was submitted on November 29, 2007. This project is supported by the Ministry of Science and Technology of China. The research progress and achievement as well as the problems encountered in the project were reported by the project PI through a detailed presentation to the officers of the Ministry of Science and Technology of China, in Beijing, on Nov.29, 2007.

17. Professors XIANG Haifan, GE Yaojun, ZHU Ledong, CHEN Airong and GU Ming were recently awarded the first class award of Shanghai Natural Science Award 2007 for the project, "Modern Theory and Method on Bridge Wind Resistance".

18. Prof. GE Yaojun obtained a major 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.

19. Prof. GE Yao-Jun and his research team recently completed the project "Wind Resistant Characteristics of Xinguang Arch Bridge", which is a steel truss-rib arch bridge with a main span of 428m.

20. Prof. YE Aijun, as the Principle Investigator of the project entitled "Seismic performance and isolation study for super-long multi-span continuous girder bridge", was awarded the 2nd class Award of Science and Technology of Shanghai 2007. The research achievements have been applied to the construction of approach of Sutong Bridge, the world's longest cable-stayed bridge.

International Publications (Abstract)

1. The application of a new structural control concept for tall building with large podium structure

(Published in *Engineering Structures*, 29(8):1833-1844, 2007)

The application of a new structural control concept for tall building with large podium structure

LU Xilin, GONG Zhiguo, WENG Dagen and REN Xiaosong

Abstract The concept of coupled building control has been proposed and investigated extensively but mainly limited to theoretical and experimental studies concerning two parallel adjacent buildings. As a further step, this paper extends the applicable scope of the control concept and presents an investigation on its engineering application to a tall building (60 stories of total height of 333 m) and its surrounding large podium structure (10 stories of total height of 49 m) in order to, principally, reduce seismic torsional response of the podium structure, which results from large eccentricity of stiffness and mass distribution in podium structures. First the building is briefly described, and a macroscopic finite element model for this structure is introduced. Subsequently, the analytical model and performance test of the linking viscous fluid dampers are introduced simply. Next, seismic responses of the building subjected to two levels of earthquake with different return periods are analyzed comprehensively. The results show that using linking dampers can effectively reduce torsional seismic response of the podium structure. In addition, seismic performance of the main building can be also enhanced but in different ways. Finally, 40 linking viscous fluid dampers with maximum capacity of 600 kN for each damper were selected to connect the podium structure to the main building, and the construction of the building was completed already and put into use in the year of 2005.

2. Studies on seismic performances of the prestressed egg-shaped digester with shaking table test

(Published in *Engineering Structures*, 29(4): 552-566,2007)

Studies on seismic performances of the prestressed egg-shaped digester with shaking table test

LI Jie, CHEN Huaming, CHEN Jianbing.

Abstract The seismic response and performance of a water-filled, prestressed concrete egg-shaped digester (ESD) subjected to various earthquake inputs are investigated by shaking table test. A 1:8 scaled model structure was tested. The tests involve three stages including the empty model digester (EMD1) subjected to accelerations of relatively small peak ground acceleration (PGA), the model digester filled with half volume of water (WMD) subjected to accelerations of medium PGA and the empty model digester with water taken out (EMD2) subjected to acceleration with PGA up to a large value. According to the site condition and seismic background, two scaled ground motion accelerations, the recorded El Centro acceleration (ELA) and the artificial acceleration adopted in Guangzhou (GZA), are employed as the seismic excitations.

The natural frequency, seismic responses including the amplification factor of acceleration (AFA), the relative displacement and the strain and stress of the EMD1, WMD and EMD2, are investigated based on the test results. Some features are captured and discussed. The fluid–solid coupling effects on different responses are pointed out. Finite-element modeling computations are conducted. Comparison with the test counterparts shows a fair agreement on the whole, indicating the reasonability as an engineering model. However, detailed stochastic response analysis and reliability assessment are necessary to comprehensively capture seismic performances of the ESD. Some concluding remarks are made.

3. Wind Tunnel and CFD Study of Identification of Flutter Derivatives of a Long-Span Self-Anchored

(Published in *Computer-Aided Civil and Infrastructure Engineering*, 22:541–554, 2007)

Wind Tunnel and CFD Study of Identification of Flutter Derivatives of a Long-Span Self-Anchored

ZHU Z., GU M., and CHEN Z.Q.

Abstract The Sanchaji Bridge with a main span of 328m, located in Changsha City across Xiangjiang River, is one of the longest self-anchored suspension bridges completed in China. This paper presents results from a combined wind tunnel and CFD (computational fluid dynamics) study on identification of flutter derivatives of the bridge deck. Based on the Covariance Block Hankel Matrix (CBHM) algorithm in time domain, sectional model experiments are conducted in smooth flow in the wind tunnel to recover modal parameters and further to identify flutter derivatives from free-decay vibration records. On the other hand, based on the ALE (Arbitrary Lagrangian Eulerian) description and a second-order projection algorithm, the CFD method uses the FVM (Finite Volume Method) on staggered grids and a forced vibration manner to evaluate the flow field around the bridge deck. A least square algorithm is utilized to identify flutter derivatives from obtained aerodynamic forces acting on the bridge deck. Finally, both of the suggested methods are applied to identification of flutter derivatives of the stiffening girder of the Sanchaji Bridge. The results of suggested methods have the same trends with Theodorsen analytical solutions, and CFD results are found to be in good agreement with those from wind tunnel test, illustrating that both the wind tunnel and CFD methods can provide satisfactory predictions of flutter derivatives of a flat box girders with reasonable accuracy.

4. An applied model for steel reinforced concrete columns

(Published in Structural Engineering and Mechanics , 27(6):697-711, 2007)

An applied model for steel reinforced concrete columns

LU Xilin and ZHOU Ying

Abstract Though extensive research has been carried out for the ultimate strength of steel reinforced concrete (SRC) members under static and cyclic load, there was only limited information on the applied analysis models Modeling of the inelastic response of SRC members can be accomplished by using a microcosmic model. However generally used microcosmic model, which usually contains a group of parameters, is too complicated to apply in the nonlinear structural computation for large whole buildings. The intent of this paper is to develop an effective modeling approach for the reliable prediction of the inelastic response of SRC columns. Firstly, five SRC columns were tested under cyclic static load and constant axial force. Based on the experimental results, normalized trilinear skeleton curves were then put forward. Theoretical equation of normalizing point (ultimate strength point) was built up according to the load–bearing mechanism of RC columns and verified by the 5 specimens in this test and 14 SRC columns from parallel tests. Since no obvious strength deterioration and pinch effect were observed from the load–displacement curve, hysteresis rule considering only stiffness degradation was proposed through regression analysis. Compared with the experimental results, the applied analysis model is so reasonable to capture the overall cyclic response of SRC columns that it can be easily used in both static and dynamic analysis of the whole SRC structural systems.

5. Damage Localization of Steel Beams with Rotational Restraints

(Published in *Journal of Steel Structures*, 7(1):19-25, 2007)

Damage Localization of Steel Beams with Rotational Restraints

LI Guo-Qiang, ZHANG Yang and CHEN Suwen

Abstract In this paper, a method is presented for damage localization of steel beams with indexes based on natural frequencies because natural frequencies can be easily obtained in practice. The theoretical principle that these indexes are only related to damage location of beams and not related to the severity of damages is presented. Based on this principle, the universal curve-bank of the natural frequency indexes for damage localization of beams with rotational restraints is established. The effectiveness and universality of the curve-bank have been demonstrated by identifying the damage location of two steel beam specimens with only first three natural frequencies of the beams. The approach presented may be used for monitoring the damage localization of beam-type structures, such as bridges.

6. Simplified evaluation of wind-induced interference effects among three tall buildings

(Published in *Journal of Wind Engineering and Industrial Aerodynamics*, 95(1):31–52, 2007)

Simplified evaluation of wind-induced interference effects among three tall buildings

XIE Z. N., GU Ming

Abstract The base bending moment (BBM) response and the mean BBM of grouped high-rise buildings are studied by a series of wind tunnel tests on typical tall building models using the high frequency force balance technique. Interference excitations of two upwind buildings with various heights in different upwind terrains are considered. An effective method is proposed to represent the distribution of the envelope interference factor (*EIF*) among three tall buildings. The results show that two upstream buildings cause more adverse dynamic effects on the downstream building than a single upstream building does. Significant correlations are found in the distributions of the interference factors of different configurations and upwind terrains. Relevant regression equations are proposed to simplify the complexity of the multi-parameter wind induced mean and dynamic interference effects among three tall buildings. Finally, an example of how to use the data provided in this paper and the proposed methodology is presented.

7. The number theoretical method in response analysis of nonlinear stochastic structures.

(Published in *Computational Mechanics*, 39(6): 693-708,2007)

The number theoretical method in response analysis of nonlinear stochastic structures

LI Jie, CHEN Jian-bing.

Abstract A strategy of determining representative point sets through the number theoretical method (NTM) in analysis of nonlinear stochastic structures is proposed. The newly developed probability density evolution method, applicable to general nonlinear structures involving random parameters, is capable of capturing instantaneous probability density function. In the present paper, the NTM is employed to pick out the representative point sets in a hypercube, i.e., the multidimensional random parameters space. Further, a hyper-ball is imposed on the point sets to greatly reduce the number of the finally selected points. The accuracy of the proposed method is ensured in that the error estimate is proved. Numerical examples are studied to verify and validate the proposed method. The investigations indicate that the proposed method is of fair accuracy and efficiency, with the computational efforts of a problem involving multiple random parameters reduced to the level of that involving only one single random parameter.

8. Development-process-of-nonlinearity-based reliability evaluation of structures

(Published in *Probabilistic Engineering Mechanics*, 22(3): 267-275, 2007)

Development-process-of-nonlinearity-based reliability evaluation of structures

CHEN Jian-bing, LI Jie.

Abstract A reliability evaluation approach based on the development process of the structural nonlinearity is presented. The traditional structural system reliability theory for structural safety regarding combination of failure modes is first revisited. It is seen that it stemmed from, and was heavily affected by, the assumption of perfect elasto-plasticity of materials. This will make the number of the failure modes increase in a non-polynomial form against the number of the potential plastic hinges. Moreover, the above methodology does not work appropriately in the case of nonlinearity in general form other than perfect elasto-plasticity, as commonly encountered in engineering practice. Discussions show that total information of the structure is involved in the development process of its nonlinearity, be it a deterministic case or stochastic counterpart. The information needed for reliability evaluation of structures could be extracted, for example, by capturing the probabilistic information of the extreme value of the corresponding response, which could be obtained by using the probability density evolution method. Therefore, the reliability evaluation for structural safety could then be directly evaluated without searching the failure modes. Taking a 10-bar truss as an example, the proposed method is theoretically elaborated and numerically exemplified.

9. Stochastic seismic response and reliability analysis of base-isolated structures

(Pubilished in Journal of Earthquake Engineering, 11(6): 903-924,2007)

Stochastic seismic response and reliability analysis of base-isolated structures

CHEN Jianbing, LIU,Weiqing PENG Yongbo, LI Jie

Abstract Stochastic seismic response analysis and reliability evaluation of base-isolated structures are conducted combining the physical stochastic ground motion model and the probability density evolution method. Three cases are investigated, including the base-isolated structure subjected to frequent earthquake of intensity 8, the identical super structure with fixed base subjected to frequent earthquake of intensity 7, and the base-isolated structure subjected to rare earthquake of intensity 8. Comparative studies reveal and verify some features of performances of base-isolated structures from the point of view of random vibration. The base-isolated super structure behaves like a near rigid body when subjected to small earthquakes while under strong earthquakes the first mode shape dominates the responses with ignorable effects of higher-order mode shapes. The response and earthquake action on the super structure could be reduced by one degree of intensity. Dynamic reliabilities against different response indices of the structure in different cases are evaluated. The investigations show that stochastic seismic response analysis and reliability assessment could provide indices for decision making more objective than just a few selected deterministic ground motions as usually employed in practice.

10. Control of wind induced vibration of long span bridges and tall buildings

(Published in *Frontiers of Architecture and Civil Engineering in China*, 1(1):51–62, 2007)

Control of wind induced vibration of long span bridges and tall buildings

GU M.

Abstract With the rapid increase of scale of structures, research on controlling wind-induced vibration of large scale structures, such as long-span bridges and super tall buildings, has been a problem of great concern. In view of the fact that for the wind induced vibration of large scale structures the vibration frequencies and damping vary with wind speed, passive, semi-active and active control strategies are studied to improve the wind-resistance performance of the structures in this paper. The multiple tuned mass damper system is applied to control vertical bending buffeting response, and then a new semi-active lever-type tuned mass damper with an adjustable frequency is proposed to control vertical bending buffeting and torsional buffeting and flutter over the whole velocity range of bridge decks. Finally, a control strategy named Sinusoidal Reference Strategy is developed for adaptive feedforward control of wind-induced vibration of super-tall buildings. A MDOF general building aeroelastic model with a square cross-section was tested in a wind tunnel. The present study shows that the present strategies can reduce vibration effectively, and can adapt to wind-induced vibration control of large structures with dynamic uncertainties and modeling errors.

11. Non-linear finite element analysis of axially restrained steel beams at elevated temperatures in a fire

(Published in *Journal of Constructional Steel Research*, 63(9):1175-1183, 2007)

Non-linear finite element analysis of axially restrained steel beams at elevated temperatures in a fire

LI Guoqiang, WANG Peijun, JIANG Shouchao

Abstract A method is presented for the analysis of the non-linear structural behavior of axially restrained steel beams at elevated temperatures, which employs the axis arc-length and section rotation of the deformed beam as basic variables. The novelty of the proposed formulation is an inclusion of a balance function that measures the error of the equilibrium between the internal- and external-forces in a cross-section of the beam. This strategy can easily deal with the geometric non-linearity and elasto-plasticity of steel at elevated temperatures. Each node for representing the section of the beam has two degrees of freedom in the proposed method. It is more computationally economical than the traditional beam element, which has three degrees of freedom. An example beam is studied to verify the proposed method. Parameters including the load ratio, axial restraint stiffness ratio, transversal and longitudinal temperature gradient, are studied. The middle-span's deflection, axial force and moment, along with the strain and stress distribution across the section, are calculated at elevated temperatures. The comparison with results from the finite element method employing shell elements shows that the method presented here is precise.

12. Stability analysis of semi-rigid composite frames

(Published in *Steel and Composite Structures*, 7(2):119-134, 2007)

Stability analysis of semi-rigid composite frames

WANG Jing-Feng, LI Guo-Qiang

Abstract Based on stability theory of current rigid steel frames and using the three-column subassemblage model, the governing equations for determining the effective length factor (μ-factor) of the columns in semi-rigid composite frames are derived. The effects of the nonlinear moment-rotation characteristics of beam-to-column connections and composite action of slab are considered. Furthermore, using a two-bay three-storey composite frame with semi-rigid connections as an example, the effects of the non-linear moment-rotation characteristics of connections and load value on the μ-factor are numerically studied and the μ-factors obtained by the proposed method and Baraket-Chen's method are compared with those obtained by the exact finite element method. It was found that the proposed method has good accuracy and can be used in stability analysis of semi-rigid composite frames.

13. Simulation study of SRS-based adaptive feedforward vibration control

(Published in *Wind & Structures*, 10(2):209-214, 2007)

Simulation study of SRS-based adaptive feedforward vibration control

PENG F.J., GU M., NIEMANN H.

Abstract Active structural control has turned out to be an effective mean to reduce wind induced response, and a number of control algorithms have been developed. However, most of these algorithms are generally based on an accurate model of the structure to be controlled (Housner, et al. 1997, Yang, et al. 2004). In this paper, Sinusoidal Reference Strategy is developed for the adaptive feedforward vibration control and some properties of the control system are discussed. Numerical simulations are conducted on reducing wind-induced vibration of Jin Mao Building. The results show the remarkable vibration reduction can be obtained, and the control system is quite robust to dynamic uncertainties and modeling errors.

14. Testing of semi-rigid steel-concrete composite frames subjected to vertical loads

(Published in *Engineering Structure*, 29(8):1903-1916, 2007)

Testing of semi-rigid steel-concrete composite frames subjected to vertical loads

WANG Jing-Feng, LI Guo-Qiang

Abstract A pair of tests carried out on full-scale semi-rigid composite frames with two stories and two bays are reported. The composite frames undergoing tests are composed of steel columns and steel-concrete composite beams. The beam-to-column connection consists of a flush end plate welded to the beam end and bolted to the column flange. To investigate the influences of semi-rigid connections and composite action of the slab on the performance of the steel frames, the overall response of the frame specimen, the connection behavior, and the beam's behavior when subjected to vertical loads have been measured and analyzed. The nonsymmetrical loading effect is also considered. It is found that the composite endplate connection, which is semi-rigid and of partial strength, has reasonable strength and stiffness, and its rotation capacity satisfies the ductility requirement of no less than 30 mrad for earthquake-resistance. The effects of the flexibility of the connections and the composite action of the slab on the strength, stiffness, and ductility of steel frames must be properly considered in the design.

15. Damage Identification of Substructure for Local Health Monitoring

(Accepted for publication in Journal of Smart Structures and Systems)

Damage Identification of Substructure for Local Health Monitoring

HUANG, H. W. and YANG, J. N.

Abstract A challenging problem in structural damage detection based on vibration data is the requirement of a large number of sensors and the numerical difficulty in obtaining reasonably accurate results when the system is large. To address this issue, the substructure identification approach may be used. Due to practical limitations, the response data are not available at all degrees of freedom of the structure and the external excitations may not be measured (or available). In this paper, an adaptive damage tracking technique, referred to as the sequential nonlinear least-square estimation with unknown inputs and unknown outputs (SNLSE-UI-UO) and the sub-structure approach are used to identify damages at critical locations (hot spots) of the complex structure. In our approach, only a limited number of response data are needed and the external excitations may not be measured, thus significantly reducing the number of sensors required and the corresponding computational efforts. The accuracy of the proposed approach is illustrated using a long-span truss with finite-element formulation and an 8-story nonlinear base-isolated building. Simulation results demonstrate that the proposed approach is capable of tracking the local structural damages without the global information of the entire structure, and it is suitable for local structural health monitoring.

16. Experimental Study and Spring-component Modelling of Extended End-plate Joints in Fire

(Published in *Journal of Constructional Steel Research*, 63: 1127-1137, 2007)

Experimental Study and Spring-component Modelling of Extended End-plate Joints in Fire

WANG Wei-Yong , LI Guo-Qiang, DONG Yu-Li

Abstract In order to investigate the fire-resistant capacity of extended end-plate joints, an experimental study was performed by using furnace on four full-scale specimens made with H-shaped steel. The failure characteristics and failure modes of the extended end-plate joint specimens in fire were obtained from the experiment. The influence of rib stiffener and depth of end-plate on fire-resistant capacity of the joints was found by comparing the capacity of the joints with and without rib stiffener and different depth of end-plate. In addition, this paper also describes a spring-component model employed for predicting the behaviour of extended endplate bare-steel joints at elevated temperature. The components of a joint are considered to be consisting of spring components with predefined mechanical properties, i.e. stiffness and strength. The response of the joints subjected to elevated temperature can be predicted by assembling the components, the stiffness and strength of which are assumed to degrade with increasing temperatures based on the recommendations presented in the Chinese Technical Code on Fire Safety of Steel Building Structure. It is demonstrated that the results from the model agree with the experimental data quite well.

17. Vibration based structural health monitoring: wavelet packet transform based solution

(Published in *Structure and Infrastructure Engineering: Maintenance, Management, Life-Cycle Design & Performance*, 3(4):313-323, 2007)

Vibration based structural health monitoring: wavelet packet transform based solution

SUN, Z. and CHANG, C.C.

Abstract One prominent problem for vibration-based structural health monitoring is to extract condition indices which are sensitive to damage and yet insensitive to measurement noise. In this paper, a condition index extraction method based on the wavelet packet transform (WPT) is proposed. This transform leads to the formulation of a novel condition index: wavelet packet signature (WPS). The sensitivity of the WPS to the change of structural parameters is derived and validated on a five-degrees-of-freedom spring-mass system. Results show that the WPS is significantly more sensitive to the stiffness change than the natural frequencies and the mode shapes. Its sensitivity is slightly better or comparable to that of the modal flexibility matrices depending on the location of damage. A variability analysis is also performed to study the effect of measurement noise on the proposed WPS. Results show that the WPS does not show any significant variation even under the presence of 10 dB noise. To illustrate the potential of the WPS a damage indicator is formulated and used to monitor the health condition of the structural system. An experimental study on a 3-story frame shows that when incorporated with a statistical process control approach, the WPS-based damage indicator can distinctly identify the presence of damage in the system.

List of Other Recent Publications

1. SHEN Zuyan, GUO Xiaonong, LI Yuanqi. State-of-the-arts of Research on Aluminum Alloy Structures. *Journal of Building Structures*, 28(6): 100-109, 2007.
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5. LI Yuan-Qi, WANG Lei, Yukio TAMURA, SHEN Zu-Yan. Wind Pressure Distribution on Flat Circular Roofs with Different Flexibility and Obliquity. *The 12th International Conference on Wind Engineering*, 503-510, 2007, Cairns, Australia.
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