1. Prof. LI Guoqiang was invited to attend International Research Roadmapping Workshop on Fire Resistance of Structures. The workshop took place at the NIST Gaithersburg, Maryland USA Campus on May 21-22, 2014. During the conference, Prof. LI Guoqiang made an invited presentation entitled “Fire behavior of steel structures”.

2. Prof. Giovanni Crosta and his research team (Prof. Riccardo Castellanza, Dr. Paolo Frattini, Dr. Fabio De Blasio, Mr. Andrea Valaguzza) in University of Milano-Bicocca, Italy visited Prof. JIANG Mingjing’s research group in May and June, 2014. This visit strengthened the continuous collaboration between Tongji University and University of Milano-Bicocca. Prof. Crosta was appointed as the Chair Professor for the 111 Project.

3. An international Workshop on Problematic Soils and Rocks was held on Jun.12, 2014 in the Department of Geotechnical Engineering at Tongji University organized by Prof. JIANG Mingjing and Dr. LIU Fang. Over 40 participants from Italy, USA and China attended this workshop. A total of 13 oral presentations were delivered
with topics covering a variety of problematic geomaterials such as soft clay, weathered rocks, cemented sands, methane hydrate bearing sands.

4. As the Chairman of Organizing Committee, Prof. LI Guoqiang took the leadership in organizing the 8th International Conference on Structures in Fire (SiF2014). The conference took place in Shanghai, on Jun.11-13, 2014.

5. Dr. Alfonso Rodriguez Dono from the Universitat Politècnica de Catalunya, Barcelona, Spain had a three-month visit in Prof. JIANG Mingjing’s research group since June 2014. Dr. Dono delivered a presentation on Strain-softening behavior of rock masses and developed collaborative work with Prof. JIANG’s group on rock mechanics.

6. Assoc. Prof. CHEN Suwen attended the 8th International Conference on Structures in Fire (SiF2014). The Conference took place in Shanghai, on Jun.11-13, 2014. During the conference, A. Prof. CHEN Suwen made a presentation entitled “Experimental and numerical studies on damage mechanisms in cementitious coatings on structural steel members”.

7. Dr. LIU Fang attended the International Conference on Soil-Structure Interaction, Underground Structures and Retaining Walls on Jun.16-18, 2014 in St. Petersburg, Russia. Dr. Liu chaired one of the sessions and delivered an oral presentation on “Oblique pullout capacity of a single drilled pile in sandy grains cemented by methane hydrates: DEM analyses”.

8. Mr. LI Tao, a PhD student in Prof. JIANG Mingjing’s research team visited Laboratory the 3SR in Grenoble, France as an exchange student in April to June, 2014, funded by Marie Curie Actions—International Research Staff Exchange Scheme (with grant No. 294976)
1. Prof. JIANG Mingjing and his research team proposed a two-dimensional contact model for loess and implemented it into the distinct element code. This model links the water content of loess, an important parameter for loess at the macroscopic scale, to the bond strength of the liquid bridge between soil grains at the microscopic scale. This model was validated through a systematic comparison between numerical simulation and experiments under a series of complex stress paths and wetting paths.

2. Prof. JIANG Mingjing and his research team are designing device for preparing high-quality bonded spheres in order to test the contact behavior of idealized bonded particles in three dimensions. The challenge of this work lies on the repeatable shapes and geometry of well-bonded particles of different sizes. This device is essential for experimentally validate and improve the contact model used in the distinct element methods for analyzing behavior of soils or rocks.

3. Prof. LI Guo-qiang, Assoc. Prof. CHEN Suwen and YAN Xiaolei (PhD student of Prof. LI Guoqiang) have conducted experimental study on the ultimate bearing capacity of Q460 high strength steel welded H-section and box-section column sin bending and axial compression. The programme comprised seven box-section specimens and six I-section specimens, subjected to bending and axial compression. Tests on specimens of welded columns with 6 different cross sections of Q460 high strength steel were conducted. For each type of cross-section, the specimens were pin-ended columns with approximate slenderness of 35, 55 and 80, and width-thickness ratio of about 18, 12 and 8, respectively. The tests involved residual stress measurement of the welded box-section and I-section, tension and compression coupon tests, initial geometric imperfection measurement, and ultimate bearing capacity tests under eccentric load. The research also shows a comparison of the tests with column design strengths respectively given by the Chinese steel structures code GB50017-2003, the load and Resistance Factor Design Specification of the American Institute of Steel Construction, the British Standard BS5950: Part l, and Eurocode3. The design strengths are shown to be in close agreement with the tests except for GB50017-2003 which conservatively predicts the test strengths. The experimental results show that the low alloy Q460 steel has high strength; the simplified residual stress pattern is the same as the ordinary steel section, but the ratios of residual stresses are different; the ultimate bearing capacity of beam columns of high strength steel are higher than the predictions given by the Chinese code for design of steel structures.

4. Prof. SUN Feifei and his master student Miss Sun Mi conducted an experiment on 6 Q690 high strength steel beam-to-column end-plate connections and 1 Q345 beam-to-column end-plate connection under cyclic loading. Results show that the moment resistance of high strength steel connections is higher than that of the mild steel one, but the rotation capacity and energy dissipating capacity of the former are much lower; the rotation capacity of high strength steel connections with rigid column is much better than the one with a rigid column; extended high strength steel end-plate
connections own higher rotation capacity and energy dissipating capacity than the flush endplate ones. The use of high strength steel leads to earlier cracking in the endplate of connections in ultimate failure mode 1.

5. Assoc. Prof. TANG Hesheng and the research team developed an evidential uncertainty quantification method for the fatigue damage prognosis under epistemic uncertainty. In order to alleviate the computational difficulties in the evidence theory based UQ analysis, a differential evolution (DE) based interval optimization for computing bounds method is developed. The computational efficiency and accuracy of the proposed method are demonstrated by experimental data of Ti-6Al-4V aluminum alloy specimens. With comparison of probability theory and interval method, the proposed method can quantify epistemic uncertainty successfully and has significant advantages in saving time and providing more information.
1. Distinct element simulation of lugged wheel performance under extraterrestrial environmental effects

Distinct element simulation of lugged wheel performance under extraterrestrial environmental effects
JIANG Mingjing, LIU Fang, SHEN Zhifu, ZHENG Min

ABSTRACT: Lunar regolith demonstrates a high angle of internal friction due to particle angularity and apparent cohesion due to interparticle short-range interaction in lunar environment. This paper investigates the mobility of lunar rovers under partial gravity. A high-efficient contact model of lunar regolith that fuses rolling resistance and van der Waals forces was employed in the distinct element analyses of model wheel tests. Soil behavior and wheel performance under an extraterrestrial environment were analyzed in comparison with that under a terrestrial environment. Results indicate that van der Waals forces enhance the macroscopic shear strength of lunar soils particularly under low confining pressures associated with microgravity conditions. In the extraterrestrial environment, the mobility of a lugged wheel becomes not as well as expected due to more slippage and sinkage than that in the terrestrial environment, while it moves more efficiently in view of tractive efficiency. Increased slip ratio and sinkage on the lunar surface are attributed to loosely packing of soil particles in microgravity conditions, where reduced wheel load plays only minor role in improving the mobility of the wheel. Van der Waals forces between soil grains are beneficial to the wheel performance due to increased strength in soils, while this contribution is overwhelmed by the effect of largely reduced confining pressure in soils due to partial gravity on the Moon.

2. Analytical solution for an infinite Euler-Bernoulli beam on a visco-elastic foundation subjected to arbitrary dynamic loads

Analytical solution for an infinite Euler-Bernoulli beam on a visco-elastic foundation subjected to arbitrary dynamic loads
YU Haitao and YUAN Yong

ABSTRACT: Analytical solution for dynamic response of an infinite beam resting on a visco-elastic foundation and subjected to arbitrary dynamic loads is developed in this paper. Fourier and Laplace transforms are utilized to simplify the governing equation of the beam to an algebraic equation, so that the solution can be conveniently obtained in the frequency domain. The convolution theorem is employed to convert the solution into the time domain. Final solutions of beam responses investigated are deflection, velocity, acceleration, bending moment and shear force. The validation of the proposed solution is verified by considering the solutions of several special dynamic loads and comparing the degraded solution to the known results. Further complicated dynamic loads, such as impulsive loads and time-lag loads, are also discussed and analytical solutions are presented. These relationships can be an effective tool for practitioners.
3. **Numerical investigation of K4-rating shallow footing fixed anti-rambollard system subjected to vehicle impact**


**Numerical investigation of K4-rating shallow footing fixed anti-rambollard system subjected to vehicle impact**

Bo Hu*, Guo-qiang Li, Jian-yun Sun

**ABSTRACT:** Preventing unauthorized vehicles from approaching a protected area by anti-ram bollard systems installed in the perimeter of buildings and infrastructures would consequently reduce blast and debris threats of vehicle borne improvised explosive devices. In this paper, an explicit finite-element model, which is more comprehensive than existing numerical models, was developed to simulate the performance of fixed anti-ram bollard system subjected to vehicle impact. Different materials for different locations of the foundation support, differences in weight and configuration between test vehicles and vehicle model, and more accurate contact algorithm used between truck and bollards were taken into account. The accuracy of the developed model was validated through comparing the impact results with four existing crash tests. Based on the verified numerical model, 72 numerical experiments of K4-rating shallow footing fixed anti-ram bollard systems (SFFABSs) were investigated according to orthogonal design. The minimum height of the bollard $H_{\text{min}}$ during the impact was proposed as a new deformation tolerance for K4-rating SFFABS. The new deformation tolerance is defined as the $H_{\text{min}}$ value of 564 mm or above according to SD-STD-02.01 Revision A, and a more reliable deformation tolerance is defined as the $H_{\text{min}}$ value of 587 mm or above. Orthogonal analysis for the experimental factors with respect to $H_{\text{min}}$ showed that height of the bollard, diameter of the bollard, and strength of the steel tube have greatly significant influences on $H_{\text{min}}$.

4. **Full 3D seismic analysis of a long-distance water conveyance tunnel**

(Published in *Structure and Infrastructure Engineering*, 10(1):128-140, Jan., 2014)

**Full 3D seismic analysis of a long-distance water conveyance tunnel**

CHEN Zhiyi, YU Haitao and YUAN Yong

**ABSTRACT:** A full three-dimensional seismic analysis is presented which is conducted on a newly built double-line shield tunnel used for water supply in the city of Shanghai. Comprehensive details in establishing such a large-scale analytical model are firstly presented, including determination of the control axis and finite element mesh size, nonlinear constitutive model of soils, load and boundary conditions, and definition of nonlinear contact surface accounting for soil–structure interaction. In view of its large computing scale, high-performance supercomputer is used and explicit central difference method which is provided by LS-DYNA is employed to accomplish the numerical analysis successfully. Seismic behaviour of the tunnel is thoroughly investigated regarding responses of displacement, segment internal stress and ovality of tunnel cross-section. Then a global evaluation of the seismic safety is provided based on numerical results. Further study on the effects of input ground motions shows that the given ground motions affect the value and the location of structural stresses as well as deformation type. A mitigation method fitting flexible joints is also studied and it is proved to be effective, however, especial attention should be paid to the decrease of structural stiffness in design.
5. **Modelling of steel-concrete composite structures in fire using opensees**  
(Published in *Advances in Structural Engineering*, 17(2):249-264, Feb.,2014)

**Modelling of steel-concrete composite structures in fire using opensees**  
Jian Jiang, Asif Usmani and Guo-Qiang Li

**ABSTRACT:** This paper presents the extension of the structural analysis software framework OpenSees for modeling steel framed composite structures subjected to fire including the development of a geometrically nonlinear shell element. The new shell element is formed by a combination of membrane elements and Mindlin plate bending elements using a general total Lagrangian formulation. The MITC technique (Mixed Interpolation of Tensorial Components) is applied to alleviate shear locking problems and the addition of drilling degrees of freedom is included. A new thermal load class was created to define the temperature distribution through the thickness of the shell section. The two-dimensional OpenSees material, Drucker-Prager, was modified to model the concrete in the composite deck slab at elevated temperature with temperature-dependent material properties according to the Eurocode 2. A three-dimensional finite element model of a composite structure was built in OpenSees, consisting of a flat reinforced concrete slab modeled by the developed shell element as well as concrete ribs and beams/columns modeled by three-dimensional beam elements. These components were connected by rigid link elements to model composite action. The performance of the developed model is verified and validated by a series of analytical solutions and experimental results respectively. Among these are: one-way bending of steel plates; fire tests on simply supported composite beams; and reinforced concrete slabs where membrane actions are investigated. Cardington restrained beam test and British Steel Corner test are also modeled. The reasonable agreement achieved between OpenSees predictions and experimental measurements shows the validity of the developed OpenSees extension to model composite structures in fire. The horizontal displacement of the column at floor level was modeled for the first time with reasonable agreement. This work is part of a wider project which, upon completion, will provide a user-friendly open-source computational platform for structural fire engineering analyses from fire dynamic simulation through to heat transfer analysis and mechanical analysis.

6. **Comparative study of bridge management programmes and practices in the USA and China**  
(Published in *Structure and Infrastructure Engineering*, 10(5):577-588, May,2014)

**Comparative study of bridge management programmes and practices in the USA and China**  
DAI Kaoshan, Smith Benjamin H., CHEN Shen-en, SUN Limin

**ABSTRACT:** The bridges of the USA and China are inventoried, inspected and maintained by governmental agencies, promoting efficient national infrastructure and safety through the development of bridge management technology. This paper provides a brief comparison between the USA and China concerning the ability to implement foreign bridge management technology by analysing the regulatory practices in the bridge management process and the bridge management systems in each country. The goal is to investigate possible synergistic approaches to enhance bridge monitoring through comparing the two largest bridge inventories in the world.
7. Passive hybrid system for seismic failure mode improvement of along-span cable-stayed bridges in the transverse direction

(Published in Advances in Structural Engineering, 17(3):399-412, Mar.2014)

Passive hybrid system for seismic failure mode improvement of along-span cable-stayed bridges in the transverse direction

XIE Wen, SUN Limin

ABSTRACT: This paper presents a numerical study on the seismic damages and failure modes of a trial designed cable-stayed bridge (CSB) with a central span of 1,400 m under earthquake excitations. A passive hybrid control system is proposed to mitigate the seismic damage and improve the failure mode of the CSB; this is composed of a passive control system and several supplemental nonstructural links used as sacrificial energy dissipation devices. The passive control system, including conventional viscous fluid dampers (VFDs), is presented for comparison with the hybrid system. The results show that the top and bottom regions of the tower are simultaneously subjected to severe damage under extreme ground motion, indicating that the tower experiences an unexpected failure mode with double plastic hinges, whereas the piers experience a typical flexural failure mode, with only one plastic hinge concentrated at the bottom region of the pier in the transverse direction. The effects of the proposed passive hybrid control system on seismic damage control are superior to those of the passive control system with VFDs. As a result, the passive hybrid control strategy can successfully control seismic damage and effectively improve the failure mode of the CSB so that its seismic performance meets damage control targets based on seismic damage criteria.

8. Free vibration of taut cable with a damper and a spring

(Published in Structural Control & Health Monitoring, 21(6): 996-1014, Jun.2014)

Free vibration of taut cable with a damper and a spring

ZHOU Haijun, SUN Limin, XING Feng

ABSTRACT: The damping and frequency of taut cable with a damper and a spring are investigated in this paper, which is motivated by cross-ties and damper that are both utilized in mitigation of oscillation of the stays in cable-stayed bridges or damper located near cable anchorage with rubber bushing. The dynamic characteristics of the cable-damper-spring system are analyzed on the basis of the taut string theory and considering the compatibility requirements on each constraint point. By using a transfer matrix method, the complex frequency equation of the cable-damper-spring system is derived. The complex frequency equation is further re-written in terms of real and imaginary parts. The special limiting solutions are presented. Asymptotic approximate solutions for damper and spring close to cable ends are developed with small frequency shifts between free cable and damped system mode. The effects of spring stiffness and location to maximum cable vibration damping, optimum damper constant, and frequency are also addressed when spring is not located near cable anchorage. The mode behaviors when damper and spring is parallel connected are given. The general solutions for arbitrary location of damper and spring along the cable are further discussed. The results of this study are helpful to understanding the damper parameter optimization of cable-damper-rubber-bushing system and the basic dynamics of the complex cable-cross-ties-damper system.
9. Damping of full-scale stay cable with viscous damper: experiment and analysis
(Published in Advances in Structural Engineering, 17(2): 265-274, Feb.2014)

### Damping of full-scale stay cable with viscous damper: experiment and analysis

ZHOU Haijun, SUN Limin, XING Feng

**ABSTRACT:** A full-scale cable vibration mitigation experiment was conducted by means of a 215.58-meters-long stay cable attached with a pair of viscous dampers. Test results showed that the damping of the cable was greatly increased after the installation of viscous dampers. It was found that the obtained damping of the cable with viscous dampers depended on the amplitude, and the maximum damping was smaller than the maximum attainable damping. The viscous damper showed nonlinear behaviors regarding the mechanical performances, as well as the interior stiffness. Therefore, the effect of the interior stiffness of a damper on the cable damping was also studied by using an analytical formulation of the complex eigenvalue problem. An engineering approximation concerning the damping of a taut cable with a viscous damper was proposed, where the influence of the interior stiffness was taken into account. The analytical approximate formulations were further extended to nonlinear viscous damper based on the assumption of equivalent energy dissipation in one period. It turned out that the analytical results considering effects of interior stiffness and nonlinearity were in a good agreement with the measured damping. Both the test and analytical results confirmed that damper interior stiffness would greatly reduce the maximum attainable damping, and damping would be amplitude-dependent for cable with a nonlinear viscous damper.

10. Dynamic stability and failure probability analysis of dome structures under stochastic seismic excitation
(Published in International Journal of Structural Stability and Dynamics, 14(5), Jun.,2014)

### Dynamic stability and failure probability analysis of dome structures under stochastic seismic excitation

Li Jie, Xu Jun

**ABSTRACT:** The intrinsic relationship between deterministic system and stochastic system is profoundly revealed by the probability density evolution method (PDEM) with introduction of physical law into the stochastic system. On this basis, stochastic dynamic stability analysis of single-layer dome structures under stochastic seismic excitation is firstly studied via incorporating an energetic physical criterion for identification of dynamic instability of dome structures into PDEM, which yields to sample stability (stable reliability). However, dynamic instability is not identical to structural failure definitely, where strength failure can be experienced not only in the stable structure but also when the structure is out of dynamic stability. It is practically feasible to decouple the stochastic dynamic response of dome structures to be a stable one and an unstable one according to the generalized density evolution equation (GDEE). Consequently, the global failure probability can be investigated separately based on the corresponding independent stochastic response. For unstable failure probability assessment, the failure probability is the unstable probability if the dome's failure is attributed to instability, whereas inverse absorbing is firstly implemented to get rid of the stochastic response before instability and a complementary process is filled in the safe domain immediately to finally assess the probability of strength failure after dynamic instability.
11. **Progressive collapse mechanisms of steel frames exposed to fire**  
(Published in *Advances in Structural Engineering*, 17(3):381-398, Mar., 2014)

**Progressive collapse mechanisms of steel frames exposed to fire**  
Jian Jiang, Guo-Qiang Li and Asif Usmani

**ABSTRACT:** OpenSees is an open-source object-oriented software framework developed at UC Berekeley. The OpenSees framework has been recently extended to deal with structural behavior under fire conditions. This paper summaries the key work done for this extension and focuses on the application of the developed OpenSees to study the fire-induced progressive collapse mechanisms of steel structures. The implicit dynamic analysis method (Newmark method) is applied and the influences of the load ratios, beam sizes and fire scenarios on the collapse behavior of frames are investigated. Single-compartment fire scenarios in the central bay and edge bay are considered, respectively. A total of four collapse mechanisms of steel frames are proposed by varying the three influencing factors. Most of the collapse of steel frames is triggered by the buckling of the heated columns. The thermal expansion of heated beams at early heating stage and their catenary action at high temperature have great influences on the collapse mechanisms. The most common collapse mode of steel frames are in the form of lateral drift of frames above the heated floor together with downward collapse of frames along the heated bay. As the load increases, the collapse behavior of structures is dominated by a downward collapse of the whole frame with little sign of the upper frame drift. The collapse modes of steel frames with strong and weak beams are column failure mechanism and beam failure mechanism, respectively. The former mechanism is due to the buckling of the columns below the heated floor represented by a global collapse of the frame and the latter is initiated by the premature development of plastic hinges at the ends of beams denoted by an obvious lateral drift of the heated floor. Generally, the edge bay fire is more prone to induce the collapse of structures than the central bay fire. It is found that the most dangerous situation is the frame subjected to high load ratios exposed to a central bay fire where its progressive collapse may occur as early as 250°C.

12. **Effects of stiffening rings on the dynamic properties of hyperboloidal cooling towers**  
(Published in *Structural Engineering and Mechanics*, 49(5):619-629, Mar., 2014)

**Effects of stiffening rings on the dynamic properties of hyperboloidal cooling towers**  
Zhang Junfeng, Chen Huai, Ge Yaojun

**ABSTRACT:** As hyperboloidal cooling towers (HCTs) growing larger and slender, they become more sensitive to gust wind. To improve the dynamic properties of HCTs and to improve the wind resistance capability, stiffening rings have been studied and applied. Although there have been some findings, the influence mechanism of stiffening rings on the dynamic properties is still not fully understood. Based on some fundamental perceptions on the dynamic properties of HCTs and free ring structures, a concept named "participation degree" of stiffening rings was proposed and the influence mechanism on the dynamic properties was illustrated. The "participation degree" is determined by the modal deform amplitude and latitude wave number of stiffening rings. Larger modal deform amplitude and more latitude waves can both result in higher participation degree and more improvement to eigenfrequencies. Also, this concept can explain and associate the pre-existing independent findings.
13. **Water permeability of concrete under uniaxial tension**  
(Published in *Structural Concrete*, 15(2):191-201, Jun., 2014)

Water permeability of concrete under uniaxial tension  
Yuan Yong, Chi Yang

**ABSTRACT:** Concrete structures can suffer from water permeating under stresses. This paper investigates the surface water permeability of reinforced concrete elements subjected to uniaxial tension. A testing system was developed to combine a conventional loading machine with a surface permeameter. To eliminate the effect of initial absorption of water, calibration tests were conducted on plain concrete samples with different surface saturated states. The experiment presented is designed to test the surface water permeability of a structural member under uniaxial tension. Specimens were reinforced centrally with different sizes of steel bar and fabricated with normal-strength and high-strength concrete. A uniaxial tensile load was applied from 0.10 to 0.80 of estimated ultimate cracking load in 0.10 increments. At the same time, water permeability was measured at each load step. Test results give the relationship between water permeability of concrete member and tensile load levels.

14. **Nonlinear response of structures subjected to stochastic excitations via probability density evolution method**  
(Published in *Advances in Structural Engineering*, 17(6):801-816, Jun., 2014)

Nonlinear response of structures subjected to stochastic excitations via probability density evolution method  
Peng Yongbo, Chen Jianbing, Li jie

**ABSTRACT:** Stochastic response analysis plays an increasingly important role in assessing the performance and reliability of engineering structures subjected to disastrous dynamic loads such as earthquakes and strong winds. In the past decade, a family of probability density evolution method (PDEM) has been developed where a completely decoupled generalized density evolution equation (GDEE) is proposed. The dimension of GDEE could be arbitrary and in most cases a reduced one-dimensional equation is adequate. This provides an efficient solution for stochastic response of complex engineering structures. In the present paper, PDEM is incorporated with the efficient representation of stochastic processes to implement stochastic dynamic response analysis of multi-degree-of-freedom (MDOF) systems subjected to stochastic excitations. Stochastic dynamic responses of linear and nonlinear base-excited systems are investigated by PDEM, the pseudo-excitation method and the Monte Carlo simulations. The Sobol' sequence is employed to generate representative white noise process, and a high-performance stochastic harmonic function representation with fewer random variables is employed to generate representative time histories of a stochastic process with specified power spectral density model. The involved seismic excitations are modeled by banded white noise, Kanai-Tajimi filtered stationary process, Clough-Penzien filtered stationary process and Clough-Penzien filtered process with non-stationary modulation, respectively. Numerical results reveal that PDEM is feasible for stochastic response analysis of MDOF nonlinear systems subjected to stochastic excitations with fair accuracy and efficiency.
15. **Micromechanical models for saturated concrete repaired by the electrochemical deposition method**

(Published in *Materials and Structures*, 47(6):1067-1082, Jun., 2014)

**Micromechanical models for saturated concrete repaired by the electrochemical deposition method**  

Zhu Hehua, Chen Qing, Yan Zhiguo, Ju J.Woody, Zhou Shuai

**ABSTRACT:** Cracks significantly deteriorate the in situ performance of concrete members and structures, particularly tunnel structures embedded in saturated soft soils. To investigate the mechanical mechanism of the electrochemical deposition method (EDM), which is a newly developed healing method for cracked concrete under an aqueous environment, micromechanical models are proposed based on the saturated concrete microstructure and the EDM's healing mechanism. In this framework, two types of homogenization methods are presented to predict the effective properties of concrete repaired by the EDM, which analytically illustrate the deposition healing process by micromechanics. The micromechanical models consider the volume fractions of water and deposition products, the water effects (including further hydration and viscosity in pores), and the shapes of the pores in the concrete. Furthermore, the proposed micromechanical models are compared with available experimental results, extreme states during the EDM's healing process, and the Voigt upper bound and the Reuss lower bound, thus illustrating the feasibility and capability of the proposed micromechanical models. Finally, the influences of the deposition product properties on the healing effectiveness of the EDM are investigated based on the proposed micromechanical framework.

16. **Sensitivity analysis of the early-age cracking risk in an immersed tunnel**

(Published in *Structural Concrete*, 15(2):179-190, Jun., 2014)

**Sensitivity analysis of the early-age cracking risk in an immersed tunnel**  

Liu Xian, Yuan Yong, Su Quanke

**ABSTRACT:** Engineers know only too well that early-age cracking accounts for the decrease of long-term serviceability for a majority of infrastructure. In immersed tunnels, early-age cracks may leave paths for aggressive media, which lead to deterioration and thus compromise durability. On the other hand, the cracking risk in concrete structures depends on a number of factors, such as material properties, construction methods, curing measures, etc., which make decisions complex. This work presents the results of a sensitivity analysis of early-age behavior for an immersed tunnel cast in situ. Numerical modelling and local sensitivity methods are employed to evaluate the sensitivity of early-age cracking to casting temperature, formwork conductivity, formwork removal time, curing temperature and ambient temperature. The numerical results indicate that the casting and curing temperatures appear to be the most dominant factors with regard to the whole fabrication period. This study provides a realistic method for determining the uncertainty analysis of concrete structures at an early age, and identifies the most important factors during the fabrication of immersed tunnel segments, which is beneficial for further decisions related to the control of early-age cracking.
17. Estimation of fracture trace length distributions using probability weighted moments and L-moments
(Published in Engineering Geology, 168:69-85, Jan., 2014)

**Estimation of fracture trace length distributions using probability weighted moments and L-moments**

Li Xiaojun, Zuo Yulong, Zhuang Xiaoying, Zhu Hehua

**ABSTRACT:** The characterization of fracture trace length distributions is an initial and essential step in estimating three-dimensional fracture size distributions. Present challenge mainly lies in the accurate depiction for the distributional nature of trace lengths from various sizes of trace data, especially for small samples. The present paper is an attempt to solve this problem by using probability weighted moments (PWMs) and L-moments. To quantify the statistical property of trace lengths, the PWMs and L-moments of true trace lengths on an infinite surface from the measured trace lengths by an irregular convex window are estimated. A distribution-free method is then developed using the maximum entropy principle with PWMs for estimating the quantile functions of true trace lengths. Since there is no assumption regarding the type of trace length population distribution, the estimation obtained is distribution-free. For practicing engineers, a method using L-moments for estimating the common trace length distributions is also suggested. Examples that are tested showing the present method provides good approximations of the quantile functions and probability density functions of true trace lengths. The method is effective even for problems with outliers or highly skewed trace data, and can be used as a reliable tool for inferences from various sample sizes with good accuracies.

18. Velocity shear flow over rectangular cylinders with different side ratios
(Published in Computers & Fluids, 96:35-46, Jun., 2014)

**Velocity shear flow over rectangular cylinders with different side ratios**

Cao Shuyang, Zhou Qiang, Zhou Zhiyong

**ABSTRACT:** Large Eddy Simulation (LES) is carried out to investigate the velocity shear flow over rectangular cylinders with different side ratios of B/D = 1, 5 and 8 (B: breadth of the cylinder, D: depth of the cylinder). The shear rate is expressed by a dimensionless shear parameter, defined by the oncoming velocity gradient, the cylinder thickness and the upstream velocity at the center plane of the cylinder. The Reynolds number based on the cylinder depth and the upstream velocity at the center plane of the cylinder is 22,000. Particular attention is devoted to variations with side ratio of shear flow and aerodynamic forces acting on the rectangular cylinders. It is shown that the side-ratio-dependent Strouhal number remains almost unchanged with shear parameter. The shear flow patterns around the rectangular cylinders vary with side ratio, resulting in a side-ratio-dependent aerodynamic force. An interesting finding is that the lift forces on the rectangular cylinders with B/D = 5 and 8 act from the high-velocity side to the low-velocity side, while for B/D = 1 they act from the low-velocity side to the high-velocity side. The stagnation point moves to the high-velocity side almost linearly with shear parameter for all investigated side ratios, implying that the movement of stagnation point to the high-velocity side is an inherent behavior in shear flow. In addition, the unsteady flow structures and the mechanism for the change of aerodynamic force with side ratio in shear flows are investigated.
19. **Study on seismic performance of a super-tall steel-concrete hybrid structure**  
(Published in *Structural Design of Tall and Special Buildings*, 23(5):334-349, Apr., 2014)

**Study on seismic performance of a super-tall steel-concrete hybrid structure**

Jiang Huanjun, Fu Bo, Liu Laoer, Yin Xiaowei

**ABSTRACT:** Many steel-concrete hybrid buildings have been built in China. The seismic performance of such hybrid system is much more complicated than that of steel structure or reinforced concrete (RC) structure. A steel-concrete hybrid frame-tube super-tall building structure with new type of shear walls to be built in a district of seismic intensity 8 in China was studied for its structural complexity and irregularity. Both model test and numerical simulation were applied to obtain the detailed knowledge of seismic performance for this structure. First, a 1/30 scaled model structure was tested on the shaking table under different levels of earthquakes. The failure process and mechanism of the model structure are presented here. Nonlinear time-history analysis of the prototype structure was then conducted by using the software PERFORM-3D. The dynamic characteristics, inter-story drift ratios and energy dissipation conditions are introduced. On the basis of the comparison between the deformation demand and capacity of main structural components at individual performance level under different earthquake level, the seismic performance at the member level was also evaluated. Despite the structural complexity and code-exceeding height, both experimental and analytical results indicate that the overall seismic performance of the structure meet the requirements of the Chinese design code.

20. **Discrete element method simulation and experimental validation of particle damper system**  
(Published in *Engineering Computations*, 31(4):810-823, 2014)

**Discrete element method simulation and experimental validation of particle damper system**

Lu Zheng, Lu Xilin, Jiang Huanjun, Masri Sami F.

**ABSTRACT:** Purpose - The particle damper is an efficient vibration control device and is widely used in engineering projects; however, the performance of such a system is very complicated and highly nonlinear. The purpose of this paper is to accurately simulate the particle damper system properly, and help to understand the underlying physical mechanics.  

Design/methodology/approach - A high-fidelity simulation process is well established to account for all significant interactions among the particles and with the host structure system, including sliding friction, gravitational forces, and oblique impacts, based on the modified discrete element method. In this process, a suitable particle damper system is modeled, reaction forces between particle aggregates and the primary structure are incorporated, a reasonable contact force model and time step are determined, and an efficient contact detection algorithm is adopted.  

Findings - The numerical results are further validated by both special computational tests and shaking table tests, with good agreements to the experimental results. The method is shown to be effective and accurate to simulate the particle damper system.  

Originality/value-The approaches described in this paper provide an efficient numerical way to investigate complex particle damper systems.
List of Other Recent Publications (SCI, EI index)
