

### **A Consideration on Seismic Response Analysis Result of Steel Truss Bridge by Focusing on Modeling Method of Connections in Steel Truss Bridge**

Hiroaki TANIUE (Osaka University), Kiyoshi ONO (Osaka University), Masahide MATSUMURA and Takao MIYOSHI (Osaka University)

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Elasto-plastic and finite element analysis of a steel truss bridge is carried out by focusing on modeling method of connections, which are designed as pinned connections so that only axial forces are subjected to the chords members in a steel truss bridge. That is, the influences of flexural rigidity of the connections on the ultimate strength of the truss bridge and on the working stress against the Level 2 Earthquake defined in the Specifications for Highway Bridges in Japan are investigated through the FEM analysis.

### **Ultimate Strength and Repairing Design Method for Stiffeners on the Support of a Plate Girder End for Highway Bridges**

Makoto USUKURA (Tokyo Consultants Co., Ltd.), Akihisa KONDO (Sogo Engineering Inc.), Takashi YAMAGUCHI, Akira HATANAKA, Yukiko MITSUGI (New Structural Engineering, Ltd.), Kunitaro HASHIMOTO (Kyoto University) and Kunitomo SUGIURA (Kyoto University)

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In this paper, the ultimate strength of the girder end with corrosion of a plate girder for Highway Bridges is studied by FEM analysis. We have dealt with the stiffener or web on the support, whose effective sectional area is lost by corrosion at the end of the bottom portion. The vertical stiffener on the support is designed as a column subjected to compression. But in the case that the thickness of the plate at the bottom end is decreased by the corrosion, it is considered that the limit state of the bottom-end is dominant. Finally, the design concept of the stiffener is also discussed.

### **Study on Mechanical Behavior of Single-Riveted Joint Damaged by Corrosion**

Kunitaro HASHIMOTO (Kyoto University), Takashi YAMAGUCHI, Yukiko MITSUGI (New Structural Engineering, Ltd.) and Kunitomo SUGIURA (Kyoto University)

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In this study, in order to clarify the mechanical behavior, and the relationship between corrosion and residual strength of single-riveted joint damaged by corrosion, experimental and analytical studies are carried out. In the experiment, are used the specimens, which cut from the demolished steel bridge members. Two types of the specimens, light and the heavy corroded joints, are prepared and tensile tests are executed. In FE analysis, corroded condition of rivet head is varied and parametric analysis is carried out. From the result, it is found that there is the influence to strength when a rivet head is corroded heavy, in case of the single riveted joint.

### **Stress Analysis of Existing Orthotropic Steel Deck for Evaluation of Fatigue Cracks Originating from Root of Weld**

Yoshihiko TAKADA (Hanshin Expressway Management Technology Center), Akiko TABATA (Hanshin Expressway Corp.), Kunitaro HASHIMOTO (Kyoto University), Kunitomo SUGIURA (Kyoto University) and Takashi YAMAGUCHI

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Significant increases in traffic intensity and wheel loads are causing fatigue cracks in orthotropic steel decks. Under traffic loading, in particular the local effect of wheel loads, longitudinal welds between deck plate and trough rib are subjected to local transverse bending moments and are susceptible to fatigue cracks. For the purpose of evaluation of crack originating from root of weld, FEM analysis modeling the full-scale orthotropic steel deck of two span continuous box girder bridge is carried out. The stress of welds which originates in a deformation of large range in deck plate is calculated. From these analytical results, it became clear that the state of the stress under different loading location affects fatigue cracks.

### **Application Effect of Rapture Controllable Steel Side Blocks for Viaduct with Isolation Bearings**

Masahide MATSUMURA, Nobuhito OCHI (Akashi National College of Technology) and Masahiko YOSHIDA (Kawakin Core-Tech Co.,Ltd.)

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Steel side blocks are set besides the seismically isolating bearings of a viaduct and are designed as a joint protector against the Level 1 earthquake. The authors suggested the CSB as rapture controllable steel side block with knock-off function and as a trigger to provide isolation effect not only in the direction of the bridge axis but also in the transverse direction against the Level 2 earthquake. In this study, the knock-off effect of the CSB in a

vibration system consisting of bridge pier-rubber bearing-mass is investigated through shaking table test. Also the installation effect of the CSB is verified through seismic response analysis of a viaduct with isolating bearings.

### **Experimental Study on the Mechanical Behavior of High Strength Bolted Friction Type Joints with Extremely Thick Plates and Many Bolts in a Line**

Takashi YAMAGUCHI, Xue PENG, Yasuo SUZUKI (Utsunomiya University) and Syuhei MIYAO  
*Steel Construction Engineering, Vol.17, No.66, JSSC, pp. 23- 33 (2010) (in Japanese)*

Recent years, from the viewpoint of rational fabrication of the steel bridges, there are some applications using extremely thick plates which thickness is more than 75mm for primary members of bridge structures. In case of joining such thick plates by using high strength bolted friction type joints, the number of bolts in a line along the member axis might be more than 10. However, the mechanical behavior of such multiple joints is not clear. In this study, the experiment for such joints has been carried out to understand the mechanical behavior of them. Discussed herein is the mechanical behavior of such joints based on the experimental results.

### **Seismic Devices for Isolated Bridge**

Masahide MATSUMURA

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Several types of seismic devices of isolated bridges in Japan are introduced and explained in this paper. Through the discussions it is concluded that seismic retrofit scheme for bridge structures are gradually changing by assembling some advanced features and seismic devices. Then the combination use of several seismic devices for damage control enables seismic retrofit of existing bridge structures to satisfy the design requirements. Also development and widespread uses of seismic response analysis and experimental approach to assure the performance of seismic devices surely help in evaluating the seismic safety of bridge structures.

### **Experimental Study on Vibration Control of Pole Type Steel Structures on Bridges**

Tomohiko ISHIBASHI (Nasu Denki-Tekko Co., Ltd.), Takashi YAMAGUCHI and Daisuke OKAZAKI (Nasu Denki-Tekko Co., Ltd.)

*Steel Construction Engineering, Vol.17, No.66, JSSC, pp. 35- 44 (2010) (in Japanese)*

Recently, it becomes a large problem that bridge vibration induced by vehicles causes damages to not only the bridge but also a pole type steel structures, such as lighting poles, marker poles on the elevated bridge. Since such damage tends to cause more severe damage, the vibration problem should be solved. As a number of such poles is large enough, it is important to improve damping performance of the steel pole with cheap cost. Then the authors suggested a vibration controlling technique for a steel pole by using wire ropes. It was found through the vibration experiment that the technique functions effectively and the vibrations of the pole can be reduced.

### **Study on Bending Strength Evaluation of Non-Composite and Composite I Girders by Reliability Analysis**

Kunitaro HASHIMOTO (Kyoto University) and Takashi YAMAGUCHI

*5th International ASRANet Conference, 14-16 June, Edinburgh, UK (8pages, CD-ROM)*

In this study, in order to evaluate bending strengths of non-composite and composite I girders, sensitivity analysis by FE analysis and reliability analysis by RSM are carried out. At First, sensitivity analysis is carried out for non-composite and composite I girders by using FE analysis because there are many uncertain factors relating to their bending strengths. Next, reliability analysis is carried out by RSM. In RSM, two random variables are determined by the results of the sensitivity analysis. From the results of these analyses, it is found that reliability index and fracture probability are almost same values for composite girders of two models in this study. And it is also cleared that reliability indexes and fracture probability are different values between non-composite and composite girders.

### **Study on Probabilistic Fatigue Assessment of Existing Orthotropic Steel Decks**

Yoshihiko TAKADA (Hanshin Expressway Management Technology Center), Masaki OCHI, Takashi YAMAGUCHI and Masahide MATSUMURA

*5th International ASRANet Conference, 14-16 June, Edinburgh, UK (8pages, CD-ROM)*

Recent considerable increase in traffic intensity and wheel loads are causing fatigue cracks in orthotropic steel decks in urban expressway in Japan. Under traffic loading, longitudinal welds between deck plate and trough rib are subjected to local transverse bending moments due to local wheel loads, and are susceptible to fatigue cracks. The stress occurred in trough rib to deck plate welds is strongly influenced by actual-working load and run position of vehicles. In order to evaluate the remaining fatigue life and fatigue durability of existing orthotropic steel decks rationally, probabilistic fatigue evaluation should be needed. At first, weight distributions of various

vehicles are modeled by log normal distribution based on the Live load simulation results., And FE analysis for an orthotropic steel deck of the actual steel bridge is performed to estimate the stress ranges due to running vehicles Secondary, The stress range and frequency by various vehicles are clarified by Reign flow method considering running position along the transverse direction of the vehicles. Finally, probabilistic fatigue assessment of existing orthotropic steel decks is carried out by using obtained results.

#### **On Method for Reducing Earthquake Force of the Pier Foundation Using Energy Absorption Connectors**

Kentaro TANAKA (Kanto Gakuin University), Takeshi KITAHARA (Kanto Gakuin University), Hiroshi ZUI (Setsunan University) and Masahide MATSUMURA

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In this paper, the energy absorption performance of the steel bellows as one of the energy absorbing bridge girder connectors is examined for reducing earthquake force of the pier foundation by means of a non-linear time-history analysis. The effectiveness of the steel bellows on the seismic response is verified using a three-span girder bridge model supported on lead rubber bearings.

#### **Dynamic Response of Bridge System with Knocking-off Members**

Masahide MATSUMURA, Masahiko YOSHIDA (Kawakin Core-Tech Co.,Ltd.) and Nobuhito OCHI (Akashi National College of Technology)

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Displacement restrainer restrains transverse movement of superstructure of isolated bridges to protect expansion joints from damage during earthquake. Here to mitigate damage of bridge pier and/or its foundation and to enhance redundancy of the isolated viaducts in a strong earthquake, it can be considered that the displacement of the superstructure against a small and moderate earthquake is restraint and the displacement against a strong earthquake is freed to shift to isolated condition. Knock-off members will provide these responses of the vibration system. This study presents the outline of some of displacement restrainers having the knock-off function and reveals the effectiveness of the knock-off in the isolated bridge system through dynamic loading test using small-size shaking table. It is also analytically verified the influences of the breaking characteristics on seismic response of the system.

#### **Technical Front of Steel Bridges in Japan**

Toshiyuki KITADA, Takashi YAMAGUCHI and Masahide MATSUMURA

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Described in this paper is the technical front on the design method, design load, seismic design, buckling stability, connection and maintenance of steel bridges in Japan. That is to say, shown is what has been clarified, in particular, what is not still clarified in the behavior and design of steel bridge structures, and what should be developed in the future, in order to hand down the information on the technical front of the steel bridge engineering from the generation who constructed many laborious steel bridges such as the Akashi Strait Bridge, the longest suspension bridge in the world to the next generation. Also included in the paper are items which the first author could not achieve in Osaka City University until his retirement for the age limit. The technical front on the wind-resistance design, fabrication method and erection method is out of the subject of the paper, because of a little knowledge of the authors in these fields.

#### **Repair Design for Fatigue Crack by Adding Steel Plates with High Strength Bolts**

Yukiko MITSUGI (New Structural Engineering, Ltd.), Takashi YAMAGUCHI, Akihisa KONDO (Sogo Engineering Inc.) and Kunitaro HASHIMOTO (Kyoto University)

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In case of adding steel plates for repairing a fatigue crack, fit bolts are generally used considering high load transferring capacity compared with high strength bolted frictional joints. But it is reported that execution of this repairing method is difficult from the viewpoint of constructability. In this paper, repairing method for fatigue cracks by adding steel plates with high strength bolted joints are discussed. First of all, the required performance of this method is summarized. Secondary, considering such required performance, applicability of adding method with high strength bolted frictional and bearing joints is discussed based on the mechanical behavior of this type of joints by using actual application examples.

#### **Consideration on Seismic Design Method of Viaduct with Steel Bellows as Semi-rigid Girder Connectors**

Hiroshi ZUI (Setsunan University), Kentaro TANAKA (Kanto Gakuin University), Masahide MATSUMURA and

Masahiko YOSHIDA (Kawakin Core-Tech Co.,Ltd.)

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Mutual interactions like contacts and collisions between superstructures and devices attached at the ends of the superstructures influences on seismic response of a viaduct with some seismic isolation devices. Preferably recommended is to adopt an analysis model, which can consider their interactions, in order to ensure seismic safety of the viaduct in the seismic design. Then, focused on in this study is a combination use of steel bellows and 2 types of the expansion joints, which have different allowable displacement, and the steel bellows are designed to have different load-displacement relationships to prevent their contacts and collisions. The effectiveness of the combined use of them is investigated and clarified through seismic response analysis.

#### **A Consideration of Seismic Response of a Viaduct Considering Collisions of Expansion Joints and Knocking-off Effect of Mounting High Strength Bolts of Them**

Masahide MATSUMURA, Kazuyuki ISHIHARA, Toshiyuki KITADA and Takashi YAMAGUCHI

*Journal of Constructional Steel, Vol.18, JSSC, pp. 419- 424 (2010) (in Japanese)*

Expansion joints may disturb an isolating function of a viaduct when the transverse displacement of the superstructures is influenced by the collision of the expansion joints during a strong earthquake. In this paper, seismic response of a viaduct is clarified on condition that the expansion joints limit the transverse displacement of the superstructures during a strong earthquake and the necessity of the expansion joints with knock-off function is described. Then, the high strength bolts installed a slit is considered to provide the knock-off function of the expansion joints and the breaking characteristics of them are verified through static breaking test.

#### **Experimental Study on Installation Effect of Longitudinal Stiffener Bolted to Steel Bridge Piers**

Masahide MATSUMURA, Toshiyuki KITADA and Yoshihiko TAKADA (Hanshin Expressway Public Corporation)

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Stiffener strengthening technique, adding additional stiffeners and strengthening flange plates, is adopted to enhance ductility and buckling strength of existing stiffened plate in an existing steel bridge pier. However, in this technique, the additional stiffeners are welded and the flange plates are bolted. That is, quality assurance of the welded part and workability in a narrow space in the steel bridge pier are to be improved to suggest more economical and rational strengthening technique for retrofitting the existing stiffened plate. Then focused on in this study is a strengthening technique using L-shaped strengthening member joined with high strengthening bolts to the plate panel between the existing stiffeners. The effectiveness of this technique against cyclic load is investigated through cyclic loading test. It is concluded that the L-shaped and bolted stiffener effectively works in changing the buckling mode of the plate panel and shows a sound strengthening effect as in the case of the welded stiffeners.