Experimental Study on Mechanical Behavior of Column Basements with Anchor Bolts

Takashi YAMAGUCHI, Toshiyuki KITADA, Jun OKADA, and Takashi NAKANO

Journal of Structural Engineering, JSCE, Vol. 49A, pp. 39-49, March, 2003 (in Japanese).

In this study, both monotonous loading test and cyclic loading test for column basement structures with footing concrete and anchor bolts are carried out in order to investigate the influence of the inelastic behavior of the anchor bolts and the compression failure of the footing concrete on rotational characteristics of them. As a result, it is observed that the compression failure of the footing concrete has less influences and the inelastic behavior of the anchor bolt has significant influences on the rotational characteristics of the column basement structures.

A Parametric Analytical Study on Mechanical Characteristics and Ultimate Strengths of Nielsen-Lohse Bridges

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Journal of Structural Engineering, JSCE, Vol. 49A, pp. 93-104, March, 2003 (in Japanese).

This paper presents a parametric analytical study on the mechanical characteristic and ultimate strength of Nielsen-Lohse bridges. First, trial design is conducted for various practical models according to the Japanese Specification for Highway Bridges in order to research the mechanical characteristic and ultimate strength of Nielsen-Lohse bridges. Second, the ultimate strengths of these models are calculated through elasto-plastic and finite displacement analyses by using the EPASS program. Third, the rational structural forms and design method of Nielsen-Lohse bridges are proposed based on the results of those parametric analyses.

Fundamental Study on Reliability Evaluation against Damage to Bridge Girder Ends as a System

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Journal of Structural Engineering, JSCE, Vol. 49A, pp. 781-790, March, 2003 (in Japanese).

In 2002, the Japanese Specifications for Highway Bridges has been revised and the bridge design life in Japan is redefined as 100 years. However, the actual life-cycle of shoes, expansions joints, asphalt pavement etc. are much shorter. It is, therefore, necessary to develop a maintenance strategy for these structural members. To find out the tendency of the damage to these members, a number of reliability field data with comparatively short life and on the damage were collected. The first target of this paper is to generate the probability density function on occurrence of the damage. In this study, some indexes are proposed and the reliability indexes are calculated considering the members as a series and parallel systems. The maintenance strategy for each system is discussed together with its maintenance procedure. Thus, the

value of ‘availability’ is calculated adopting the Monte Carlo simulation.

Seismic Retrofitting Techniques Using An Energy Absorption Segment for Steel Bridge Piers

Toshiyuki KITADA, Masahide MATSUMURA, and Yukitoshi OTOGURO (Hanshin Expressway Public Corporation)

Engineering Structure, Vol. 25, pp. 621-635, March, 2003.

Importance has been attached to seismic design methods considering the ductility of steel structures after the Hyogo-ken Nambu Earthquake and one of the design methods is adopted into the design method of steel bridge piers in Japan. On the other hand, it is necessary to retrofit the existing steel bridge piers not satisfying the design standard and having inadequate ductility. Dealt with in this paper are seismic retrofitting techniques for the existing steel bridge piers to be retrofitted but in case that concrete filling technique is not accepted. Instead of the concrete filling technique, proposed are two seismic retrofitting techniques installing a small part or a short segment, to which major plastic deformation is limited, in a column member of steel bridge piers for enhancing the ductile capacity of the column. The validity of the proposed techniques is investigated through a cyclic loading test and a pseudo-dynamic test. Various applications and variations of the techniques are also discussed.

Verbesserte Computerprogramme für die Bemessung von räumlichen Stahlbrückenkonstruktionen und deren Anwendung

Toshiyuki KITADA, Katsuhiro TANAKA, Masato KANO, Toshiro YAMANO, and Jun OKADA

Stahlbau 72, Heft 5, pp. 289-298, Mai, 2003 (in German).

Intrduced in this paper are five advanced computer programs, EPASS, USSP, EPASS Plus, USSP-D and J-F-C-P. EPASS is a FEM program for analyzing the ealsto-plastic and finite displacement behavior of spatial steel framed bridges consisting of cable members and structural members without local buckling. USSP is a FEM program for analyzing the elastoplastic and finite displacement behavior of thin-walled structural members by considering the local buckling. EPASS Plus is a program combining USSP with EPASS. USSP-D is developed for analyzing the dynamic, elasto-plastic and finite displacement response of steel bridge piers subjected to strong seismic actions through combining USSP with a FDM program for the dynamic response analysis. J-F-C-P is a program for the elasto-plastic and finite displacement analysis of prestressed concrete box girder bridges with corrugated steel webs by adding solid and rod elements for dealing with the non-linearity of concrete and steel reinforcements to USSP.

Seismic Retrofitting Method for Circular Steel Column Members by CFRP

Toshiyuki KITADA, Masahide MATSUMURA, and Munetaka TOKUBAYASHI (Hanshin Expressway

Public Corporation)

Proceedings of the 4th International Specialty Conference, STESSA 2003, Behavior of Steel Structures in Seismic Areas, Naples, Italy, pp. 703-709, June, 2003.

Described in this paper is a seismic retrofitting method for an existing circular steel pier column by carbon fiber reinforced plastic (CFRP), which shows extremely high tensile strength and is light in weight compared with current retrofitting materials such as concrete, steel plates etc. In the method, carbon fiber sheets impregnated with epoxy resin are fixed around the pier column to restrain the occurrence of elephant foot buckling. The retrofitting effect is verified through a cyclic loading test by using 4 small-sized specimens. It is concluded that the proposed method can control the ultimate strength and improve the ductility capacity without changing the flexural stiffness of the pier column by changing the number of the layers of CFRP. Application of the seismic retrofitting method to an existing steel pier column is also discussed.

Seismic Retrofitting Method for Steel Columns Installing Energy Absorption Segment

Masahide MATSUMURA, Toshiyuki KITADA, and Atsushi NANJYO (Hanshin Expressway Public Corporation)

Proceedings of the 4th International Specialty Conference, STESSA 2003, Behavior of Steel Structures in Seismic Areas, Naples, Italy, pp. 737-743, June, 2003.

Presented in this paper is a new seismic retrofitting method for the rectangular steel column without sufficient ductility capacity in an existing steel bridge pier. It is intended in the method that plastic deformation is generated intensively only in a pre-selected energy absorption segment in the steel column to enhance the ductility capacity and to control the ultimate strength capacity of it. The structural behavior of the steel column with the energy absorption segment is investigated experimentally through a cyclic loading test and a pseudo-dynamic test. It is concluded that the sufficient ductility of the steel column can be obtained by the proposed retrofitting method with a little increment of their ultimate strength due to the retrofitting.

Simulation Technique for Understanding the Mechanical Behavior of Structures using Network Technology

Takashi YAMAGUCHI

Proceedings of the 7th Korea-Japan Joint Seminar on Steel Bridges, Korea, pp. 69-76, August, 2003.

In this paper, a simulation technique for understanding the mechanical behavior of structures using network technology is summarized. At first, importance and needs of understanding the mechanical behavior of a large structural system, such as an elevated bridge system, is discussed. Secondly, the experimental simulation method using the network technology developed is introduced. This method can realize the

structural behavior of the large structural system by using many structural experimental equipments and computers located all over the world. Finally, one application example of this method carried out by authors is introduced.

Fundamental Study on Developing Economical Gusset-less Panel Point Using High Strength Bolted Tensile Joints for Steel or Composite Truss Bridges

Kunitaro HASHIMOTO, Takashi YAMAGUCHI, Yasuo SUZUKI, and Toshiyuki KITADA

Proceedings of the 7th Korea-Japan Joint Seminar on Steel Bridges, Korea, pp. 181-189, August, 2003.

Panel points using gusset plates of truss bridges have been sometimes required to become simpler because of productivity and workability. A new panel point structure without the gusset plates is proposed in this study. The proposed panel point structure is a composite structure made of encased concrete and steel tubes connected with many high strength bolts. A loading test subjected to bending moment is carried out in order to examine the mechanical behavior of the proposed panel point. 4 different specimens are prepared. The bending strength, bending rigidity, behavior of bolt axial force, and separation between the connected chord members of the panel point are discussed on the basis of the experimental results.

Basic Study on Lateral Torsional Buckling Modes and Load Carrying Capacity of Horizontally Curved I-Girders

Keita UENO, Toshiyuki KITADA, Takashi YAMAGUCHI, Masahide MATSUMURA, and Toshiro YAMANO (JISC)

Proceedings of the 7th Korea-Japan Joint Seminar on Steel Bridges, Korea, pp. 317-327, August, 2003.

As highway viaducts in urban areas, curved bridges are often utilized because of the tight condition of land space for bridge construction. The check of the safety against the lateral torsional buckling of main curved girders is one of the most important issues in the design of horizontally curved I-girders bridges, because the curvature of the main curved girders affects more substantially the ultimate strength of the main curved girders unlike the corresponding straight girders. In this study, the load carrying capacity of a horizontally curved I-girder considering actual boundary condition is analyzed by changing the curvature of the curved main girder and the width of the compression flange. The influence of the curvature on the lateral torsional buckling mode is investigated numerically focusing on the relationship between the lateral torsional buckling mode and load carrying capacity. It is concluded that the shape of the buckling mode is classified into two types (fixed supported buckling mode and simple supported buckling mode) by the curvature.

Seismic Response Behavior of Elevated Bridges Using Energy Absorbing Connecters

Kentaro TANAKA, Hiroshi ZUI (Setsunan University), and Toshiyuki KITADA

Proceedings of the 7th Korea-Japan Joint Seminar on Steel Bridges, Korea, pp. 413-424, August, 2003.

The effectiveness of a seismic energy dissipation device is analytically studied for steel continuous girder bridges supported by rubber bearings. Steel bellows are connected between adjacent girders in a row in order to reduce the damage to the steel girder bridges. The yield strength of the steel bellows are so determined as to suppress the displacement of superstructures within 20-30cm which is able to avoid the collision between adjacent girders. The effectiveness of the steel bellows as energy absorbing connectors is verified by non-linear time-history analyses.

Bending Strength Characteristics of Steel and Reinforced Concrete Beam Members Based on Reliability Theory

Namiko KOHARA, Takashi YAMAGUCHI, and Toshiyuki KITADA

Proceeding of 5th Japanese-German Joint Symposium on Steel and Composite Bridges, Osaka, Japan, pp. 263-273, September, 2003.

In recent years, many composite and mixed structures consisting of different material members have been designed and built because of their structural rationality and economical aspect all over the world. In case of the design of such structures, it is important to make the failure probability of each member of them equal as much as possible. In this study, our attention is paid to failure probabilities of steel and RC members subjected to bending moment. First of all, the ultimate and allowable bending moment of them are investigated statistically by the monotonic loading test. Statistical properties of them are discussed based on the experimental results. Secondary, the bending moment of steel members and RC members are evaluated by using the theory of reliability in order to investigate of the relationship between reliability indexes and adequate safety factors for these members. Finally the adequate safety factors of them are discussed.

Strengthening Technique for Superannuated Steel Bridge Girders Installing Pre-stressed CFRP Sheets by Externally Attached Device

Hisashi SUGIHARA, Hironori NAMIKI (Kyobashi Corporation), Masahide MATSUMURA, and Toshiyuki KITADA

Proceedings of the third international conference on current and future trends in bridge design, construction and maintenance, Shanghai, China, ICE, pp. 455-463, September, 2003.

As one of strengthening techniques for superannuated steel bridge girders with insufficient load carrying capacity, a strengthening technique by utilizing Carbon Fiber Reinforced Plastic sheets (CFRP sheets) is proposed by the authors. The strengthening effect by the CFRP sheets of high elasticity affixed to the lower flange plate of a superannuated bridge girder is investigated by a test using 3 specimens of H-shaped steel beams. For more effective use of CFRP sheets, investigated also is a strengthening technique using pre-tensioned CFRP sheets installed onto the lower flange plate. It is concluded that about 15%

improvement can be obtained in the flexural rigidity of the steel beam specimens strengthened by CFRP sheets and the yield strength increases by the pre-stress introduced into the lower flange plate through an externally attached device. And it is also revealed that theoretically predicted values of the yield load and the flexural rigidity of the strengthened steel girder are conservative compared with the experimental values concerning the strengthened effect.

Experimental Study on Interactive Buckling Behavior of Steel Compression Members with Thin-Walled Stiffened Box Cross Section

Hiromitsu MORISHITA (Takada Kiko Corporation), Yasunori YAMADA (Takada Kiko Corporation), Hiroshi NAKAI (Fukui University of Technology), and Toshiyuki KITADA

Steel Construction Engineering, JSSC, Vol. 10, No. 40, pp. 33-44, December, 2003 (in Japanese).

This paper deals with an experimental study on the interactive buckling behavior of steel compression members with thin-walled stiffened box cross section. In this study, attention is paid to the interactive behavior of local plate buckling and global column buckling, the ultimate strength, and the ductility of the steel compression members. The local plate buckling consists of the buckling of component stiffened plate panels, local plate panels between longitudinal stiffeners, and longitudinal stiffeners. Axial loading tests are carried out for the scaled down column specimens with various wide-thickness ratio of the plate panels and the slenderness ratio as columns to investigate the interactive behavior. Indices for deciding the occurrence of the bucklings are proposed by using various strain data at the middle cross sections of the specimens and the buckling phenomena of the specimens are investigated regarding the global buckling, the local plate buckling and their interactive buckling by using the indices. Effectiveness of these indices is discussed here in.

Application of Energy Absorbing Connecters to Elevated Bridges

Kentaro TANAKA, Hiroshi ZUI (Setsunan University), and Toshiyuki KITADA

Steel Construction Engineering, JSSC, Vol. 10, No. 40, pp. 53-63, December, 2003 (in Japanese).

The effectiveness of energy absorbing connecters is investigated for steel continuous girders supported by rubber bearings. Steel bellows as energy absorbing devices are connected between girders in a row. The influence of boundary conditions is examined using two models consisting five on seven segments in which a continuous steel girder is treated as one segment. The periods of each segment are changed in various kinds by combining several rubber bearings and each case is examined. Yield strengths of steel bellows are so decided as to avoid the collision between girders. The effectiveness of steel bellows as energy absorbing connectors is confirmed by non-linear time-history analyses.

Analytical Study on Effect of Internal Struts on Strength and Ductility of Thin-walled Box Columns

Masahide MATSUMURA, Toshiyuki KITADA, Kazuaki TANI, and Hidenao HAYASHI (Hanshin Expressway Public Corporation)

Journal of Earthquake Engineering, JSCE, Vol. 27, p.122, December, 2003, CD-ROM Version (8pages) (in Japanese).

Bracing members are widely used in rigid framed structures in buildings to increase the ductility performance and to avoid the serious damage of them. The overall buckling of stiffened plates results in the less ductility of the thin-walled steel columns. Proposed in this paper is a strengthening technique to prevent the overall buckling of the stiffened plates of steel columns with rectangular cross section by attaching internal struts inside of the box cross section. To evaluate the strengthening effect by the internal struts, thin-walled stiffened box columns with various values of the bucking parameters of the constituent stiffened plates are investigated analytically.

Proposal of Rupture Properties Controllable Structure for Steel Side Blocks of Bridge Bearings

Minoru SAKAIDA (Teikoku Engineering Consultants, Inc.), Masahiko YOSHIDA (Kawaguchi Metal Industries Co., ltd), Toshiyuki KITADA, and Masahide MATSUMURA

Journal of Earthquake Engineering, JSCE, Vol. 27, p.259, December, 2003, CD-ROM Version (8pages) (in Japanese).

A joint protector takes an important role in the seismic isolation design of a bridge structure and requires to deliver reliably the lateral force caused by the Level 1 earthquake specified in Japanese Specifications for Highway Bridges to the bridge substructure. However, steel side blocks on bridge bearings having the function as the joint protector are not designed by considering their breaking load precisely, which should be less than the load carrying capacity of the foundation structure supporting the bridge. Proposed in this study is a new structural detail of the steel side block with a lateral slit in it and its simple design method, which can control the breaking strength by the slit width. The effectiveness of the structural detail is verified analytically through the comparison between proposed side blocks and the others.

Experimental Study on Rupture Properties of Steel Side Blocks of Bridge Bearing

Masahiko YOSHIDA (Kawaguchi Metal Industries Co., ltd), Minoru SAKAIDA (Teikoku Engineering Consultants, Inc.), Masahide MATSUMURA, Toshiyuki KITADA, and Masaki MORITA (Kawaguchi Metal Industries Co., ltd)

Journal of Earthquake Engineering, JSCE, Vol. 27, p.260, December, 2003, CD-ROM Version (8pages) (in Japanese).

Steel side blocks of bridge bearings having the function as a joint protector should be designed to keep the response displacement of a bridge against the Level 1 earthquake, defined by Japanese Specifications for

Highway Bridges, within the specified displacement and to break reliably at the expected lateral load in the design for avoiding the failure of the foundation structures supporting the bridge. Effectiveness of the design method for the side block with a lateral slit in it to control its breaking strength is investigated through a loading test by using actual-scale specimens and reduction ones. It is concluded that the breaking strength of the side block can be controlled by adjusting the slit depth and by inserting the frictionless material in the slit and can be estimated by a simple design formula.

Study on Steel Bridge Pier System Consisting of Plural Columns of Steel Tubes

Masahide MATSUMURA, Toshiyuki KITADA, Shigeki OKASHIRO (NEWJEC Inc.), and Hisashi SUGIHARA

Proceedings of the 7th Symposium on Ductility Design Method for Bridges, pp.181-184, January, 2004 (in Japanese).

After the Hyogo-ken Nambu Earthquake, required in steel bridge pier are high seismic performance and low construction cost mainly. Proposed in this paper is a new bridge pier system consisting of plural column members made of steel tubes. Also described are a trial design according to the design concept and a FEM analysis for demonstrating a seismic performance of the pier system against the elastic response acceleration of 1,000 gal. It is concluded that basic characteristics of the new pier system are verified and applicability to the actual structure will be discussed in succession.

Effect of Tensile and Shear Force on Mechanical Behavior of High Strength Bolted Tensile Joints

Takashi YAMAGUCHI, Yasuo SUZUKI, Toshiyuki KITADA, and Kunitomo SUGIURA (Kyoto University)

Journal of Constructional Steel Research, Vol. 60 Elsevier, pp. 1545-1560, February, 2004.

Most of the past studies on high strength bolted tensile joints have dealt with the local load transferring mechanism of the connections, such as split tee joints subjected to only tension, for simplicity. However, in order to apply these joints to bridge structures, the overall behavior of such connections must be made clear considering actual load combinations consisting of axial force, bending moment and shear force. In this study, therefore, the loading tests of connections using this type of joints for box cross sections are carried out, paying attentions to the effect of the load combinations on the rigidity and strength. Based on the experimental results, the applicability to the connections of bridge structural members is discussed.

Debonding of Adhesive in Post-tension Strengthened Steel Bridge via CFRP by Means of Finite Element Analysis

Hiroaki OZASA (Kyoto University), Masaki HOJO (Kyoto University), Mototsugu TANAKA (Kyoto University), Masahide MATSUMURA, Toshiyuki KITADA, and Hironori NAMIKI (Kyobashi

Corporation)

Proceedings of 33rd FRP Symposium, pp. 348-350, March, 2004 (in Japanese).

In this study, debonding of adhesive in the post-tension strengthened steel bridge by CFRP is investigated analytically by using finite element analysis. The effects of the geometrical factors and the post-tension value on the total debonding energy release rate, G_{total}, are analyzed for the case that pure bending is applied to the strengthened steel beam. G_{total} decreases with the increase of the distance between the edge of CFRP and the location of introduction of the post-tension, L, and is takes a constant value under the condition, L>100 mm. G_{total} increases with the increase of the debonding length, a, and is takes a constant value under the condition, a>12.5 mm. This means that the initiation of debonding brings the instable fracture. G_{total} increases linearly with the increase of the value of pre-stress and the temperature difference. This result indicates that the balance between G_{total} and the post-tension value is quite important for the optimum design of the post-tension strengthening by CFRP. It is also suggested that the condition of the strengthened steel beam is severe in summer if CFRP is bonded in winter from the viewpoint of debonding. One of the smart and cheap ways to avoid the onset debonding between CFRP and steel beam is to suppress opening defection at the end of bonded CFRP by attaching the holding plates. The effect of suppressing crack opening defection by the steel plate is also discussed.

Experimental Study on Development of Composite Gusset-less Truss Panel Points Using High Strength Bolted Tensile Joints

Takashi YAMAGUCHI, Kunitaro HASHIMOTO, Yasuo SUZUKI, and Toshiyuki KITADA

Journal of Structural Engineering, JSCE, Vol. 50A, pp. 1409-1418, March, 2004 (in Japanese).

The objective of this study is to obtain the fundamental data for developing a new and rational panel point structure of truss bridges from mechanical and economical rationality points of view. Then, the new panel point structure without the gusset plates is proposed in this study. The proposed panel point is a composite structure made of concrete and steel tube connected with high strength bolts. A loading test subjected to bending moment and shear force is carried out in order to examine the mechanical behavior of the proposed panel point. 3 specimens are prepared paying attention to difference of the panel point structure. From the experimental results, slippage behavior and bending behavior of the panel point, the behavior of the bolt axial force, and the separation of the joint section are discussed.

Fundamental Study on Bending Strength Characteristics of Steel and Reinforced Concrete Girder Bridges through Reliability Theory and Live Load Simulation

Takashi YAMAGUCHI, Toshiyuki KITADA, and Namiko KOHARA

Journal of Structural Engineering, JSCE, Vol. 50A, pp. 1399-1408, March, 2004 (in Japanese).

In recent years, many composite and mixed structures consisting of different material members have been

designed and constructed because of their structural rationality and economical aspect all over the world. In case of the design of such structures, it is important to make the failure probability of each member of them equal as much as possible. In this study, the safeties of typical steel plate girder bridges and RC girder bridges are evaluated by using the reliability theory. The load effect in calculating the probabilities of exceeding the serviceability and ultimate limits due to the live load is determined by the simulation using the actual vehicle distribution data and the Monte-Carlo method. And the probability characteristics of the largest bending moment that occurred in an arbitrary cross section of the model bridges are evaluated. The resistance is determined based on the experimental results for steel and RC beam specimens. Finally, the failure probabilities of steel bridges and RC bridges are discussed considering the obtained reliability indexes.