ABSTRACT OF CURRENT WORKS

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Influence of Relative Rigidity of Longitudinal Stiffeners upon Ductility of Stiffened Steel Bridge Piers under Strong Earthquakes

Jun OKADA, Toshiyuki KITADA and Toshiro YAMANO（Bridge and Computer Engineering Co., Ltd.）

Proceedings of Third Symposium on Nonlinear Numerical Analysis and its Application to Seismic Design of Steel Structures, JSCE, pp. 69～76, January, 2000 (in Japanese).

Dealt with in this paper is the seismic behavior and its analysis of steel bridge piers consisting of single columns with stiffened box or unstiffened circular cross section subjected to strong earthquakes like the Hyogo-ken Nanbu Earthquake. A computer program USSP･D has been already developed by the authors for predicting the elasto-plastic, finite displacement and dynamic response of steel bridge piers idealized into a vibration system with single mass by considering the local buckling of the stiffened plate or shell panels. First of all, the USSP･D is verified by using two experimental results by two pseudo-dynamic tests. Then, a parametric study by using the USSP･D is carried out in order to investigate the appropriate relative rigidity of longitudinal stiffeners in the stiffened plate panels of steel bridge piers under strong earthquakes.

Current Situation of Seismic Design of Steel Bridge Structures

Toshiyuki KITADA

Proceedings of Symposium on Researches for Civil Steel Structures, Vol.4, Foundation Kouzai Club, pp.1-8, Tokyo, January 14, 2000 (in Japanese)

The following topics are dealt with in this paper: (1) the current situation of seismic retrofitting method of existing steel bridge piers with single columns, (2) seismic design method of steel bridge piers to be constructed, (3) seismic retrofitting method of existing steel rigid framed bridge piers and steel bridge super-structures, (4) seismic design of these bridge structures to be constructed, (5) important issues on the seismic design and seismic retrofitting methods of these bridge structures obtained from a questionnaire to many bridge designers, (6) features of seismic design of steel bridge structures compared with the seismic deign of steel buildings, and (7) future research needs.

A Bridge Management System for Elevated Steel Highways

Toshiyuki KITADA, Yorimichi MAEGAWA, Ippei NAKAMURA, and Yoshiei HORIE(Hanshin Expressway Public Corporation)

Computer-Aided Civil and Infrastructure Engineering, 15, pp.147-157, 2000 (in Japanese).

The Hanshin Expressway network extends some 200km, forming the traffic arteries of the heavily urbanized Hanshin area surrounding Osaka, the second largest city in Japan. Due to restrictions on construction in mature cities, 93 % of the total length of this network is elevated, and 77 % of the elevated structures use steel girders that have numerous curves to allow complicated road alignments. These elevated structures are showing signs of damage after serving for almost 30 years under chronic overload conditions. This article describes the various types of damage that are frequently detected in elevated steel bridges and, focusing on typical fatigue-induced damage, review the repair process that begins with the investigation of causes and potential repair methods and continues through the implementation and inspection of the repair work. Propositions are presented that may enable the design of more durable steel bridges. In addition, this article briefly discusses a database system that is being used for the maintenance and management of steel bridges.

Experimental Study on Ultimate Strength and Ductility of Concrete-Filled Steel Bridge Pier Columns with Rounded Corners

Toshiyuki KITADA, Hiroshi NAKAI (Fukui University of Technology), Munetaka TOKUBAYASHI (Hanshin Expressway Public Corporation), Miyoharu SAKAGUCHI (Kozo Giken Ltd.), Takayuki KAWAZOE (Chuo Fukken Consultants Co., Ltd.)

Journal of Structural Engineering, Vol.46A, JSCE, pp.51-60, March, 2000 (in Japanese).

Investigated in this paper is the ultimate strength, ductility and design method of concrete-filled steel bridge pier columns with rounded comers through an experimental study by using two specimens with the different heights of the encased concrete. The horizontal displacement is applied to the specimens at the tops cyclically and incrementally keeping the axial compressive force constant. It is shown from the experimental results that the ultimate strength and ductility of concrete-filled steel bridge pier columns with rounded corners is so superior in comparison with steel bridge pier columns without filled concrete. The ductility of concrete-filled steel bridge pier columns is, however, poor in the case of the insufficient height of the filled concrete. Then, the minimum required height of the filled

concrete is discussed. Moreover, also investigated is the appropriate location of the longitudinal stiffeners for the stiffened plates

Experimental Study on Seismic Retrofitting Method of Stiffened Plates in Existing Steel Bridge Piers under Cyclic Loading

Toshiyuki Kitada, Hiroshi Nakai (Fukui University of Technology), Masahide Matsumura, Taiichi Kagayama (Hanshin Expressway Public Corporation),
Journal of Structural Engineering, Vol.46A, JSCE, pp.127-134, March, 2000 (in Japanese).

After the Hyogo-ken Nanbu Earthquake, the design method for retrofitting the stiffened plates of the existing steel bridge piers has been drafted in the Hanshin Expressway Public Corporation. In this paper, the effect of retrofitting stiffeners according to this design method upon the strength and ductility of the existing steel bridge piers is investigated through the cylic loading test by using 6 specimens. It is concluded that the sufficient ductility can be obtained in the existing steel bridge piers strengthened by this design method with the increase of the ultimate strength by only about 20%.

Study on Ultimate Strength of Plates and Stiffened Plates Made of High Strength Steel under Compression

Toshiyuki KITADA, Hiroshi NAKAI (Fukui University of Technology), Nobuhito OCHI
Journal of Structural Engineering, Vol.46A, JSCE, pp.179-271, March, 2000 (in Japanese).

In the current design method, the design curves of the ultimate strength of compression plates and stiffened plates made of high strength steel is evaluated according to a concept similar to the compression plates made of mild steel, and these are not enough rational ones. In this study, therefore, the ultimate and allowable strength curves of outstanding plates, stiffened plates, and simply supported plates under compression are derived through a parametric study based on the elasto-plastic and finite displacement analyses considering the characteristics of residual stress and stress-strain curve of high strength steel. The buckling design method of these compression plates is investigated through the analytical results.

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Elasto-Plastic Finite Displacement Analysis of Box Members Made of Steel Plates with no Yield Plateau

Katsuhiro TANAKA (Japan Information Processing Service Co., Ltd.), Toshiyuki KITADA and Toshitaka MUKAIYAMA (Akashi National College of Technology)

Journal of Structural Engineering, Vol.46A, JSCE, pp.271-279, March, 2000 (in Japanese).

First of all, demonstrated in this paper is the basic theory for analyzing the elasto-plastic and finite displacement behavior of box members made of steel plates without yield plateau. Then, the theory is verified through comparing the numerical result of a cantilever column model by a computer program modified according to the theory with the numerical one of the model idealized using plate finite elements. The suitable numerical model and the verification of the basic theory for the elasto-plastic and finite displacement analysis of steel box members with variable cross section along the member axes are investigated through comparison of the numerical results by the modified program with the experimental ones.

Causes of Buckling Damage to Upper Lateral Bracing Members in a Large Lohse Arch Bridge due To The Hyogo-Ken Nanbu Farthquake

Toshiyuki KITADA, Hanryuki SAKODA(Kawasaki Heavy Industries, Ltd.), Katsuhiro TANAKA (Japan Information Processing Service Co., Ltd.) and Taici KAGAYAMA (Hanshin Expressway Public Corporation)

Journal of Structural Engineering, Vol.46A, JSCE, pp.841-850, March, 2000(in Japanese).

The two pivot roller bearings and six upper lateral bracing members of the Rokko Island Bridge, which was a Lohse arch bridge, were collapsed and buckled respectively due to the Hyogo-ken Nanbu Earthquake occurred in January, 1995. In this paper, the causes of and process up to their failures are investigated through the free vibration analyses, response spectrum analyses and finite displacement analyses considering the elasto-plastic and finite displacement behavior of the arch members. These numerical analyses result in that the buckling damage to five lateral bracing members is caused by the lateral and vertical movement of the southern edge of the superstructure which was induced by the collapse of the two bearings. Also it is concluded that the buckling of the remained one among the six lateral bracings was caused by the vibration of the superstructure after the collapse of the two bearings.

Comparison of Test Results with Ones by Elasto-Plastic Dynamic Response Analysis of Steel Bridge Piers with Single Column under Strong Earthquakes

Jun Okada and Toshiyuki Kitada

Journal of Structural Engineering, Vol.46A, JSCE, pp.859-868, March, 2000(in Japanese).

A computer program, USSP・D, has been already developed by the authors for predicting the elasto-plastic, finite displacement and dynamic response of steel bridge piers idealized into a vibration system with single mass by considering the local buckling of the stiffened plate elements. First of all, in this paper, the USSP・D is verified through experimental results by pseudo-dynamic tests. Then, the accuracy of the USSP・D, the necessity of the reliable test results for checking various analytical methods and the appropriateness of the analogous rule used in the pseudo-dynamic tests is discussed. Finally, a parametric study by using the USSP・D is also carried out in order to investigate the minimum required relative rigidity of longitudinal stiffeners in the stiffened plate elements of steel bridge piers under strong earthquakes.

Axial Force Measurement of High Strength Bolts by Using both Ultrasonic Longitudinal and Shear Waves

Kanaji Ueno, Takashi Yamaguchi and Shoichi Kobayashi (Kyoto University)

Journal of Structural Engineering, Vol.46A, JSCE, pp.1147-1152, March, 2000 (in Japanese).

The objective of this study is to develop a new method for measuring the axial force of high strength bolts utilized in the connections of bridge structures in service condition. At first, based on the acousto-elastic effect, the measurements of ultrasonic wave velocity are carried out. As a result, it is found that the axial bolt force can be estimated by only using a longitudinal ultrasonic wave if the initial length of the bolt is known preciously. Furthermore, another measuring method is developed when speeds of both longitudinal and shear waves are measured. By using this proposed method, it will be applicable even if the initial length of the bolt is unknown in advance.

On Causes of Loosening and Slackness of Hanger Cables in a Nielsen-Lohse Bridge due to Hyogo-ken Nanbu Earthquake

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Heavy Industries, Ltd.) Toshiyuki KITADA, Hiroshi NAKAI (Fukui University of Technology)
Steel Construction Engineering, Vol.7, No.25, JSSC, pp. 31-42, March, 2000 (in Japanese)

The Hyogo-ken Nanbu Earthquake, occurred on January 17,1995, caused serious damage to the bridge structures. Loosening was observed in a few hanger cables of two Nielsen-Lohse bridges after the earthquake. In this paper, the causes of loosening and slackness of hanger cables during this inland earthquake are investigated through the response spectrum analysis, static elasto-plastic finite displacement analysis by using the incremental seismic load and dynamic response analysis using the actually recorded earthquake wave, of one of the two Nielsen-Lohse bridges.

A seismic retrofitting method of existing steel bridge piers

Masahide MATSUMURA, Toshiyuki KITADA and Taiichi KAGAYAMA (Hanshin Expressway Public Corporation)
Bridge Management 4, edited by M. Ryall, G. Parke and J. Haring, Tomas Telford, pp.263-270, April, 2000

Design guidelines were drafted in the Hanshin Expressway Public Corporation for retrofitting the existing steel bridge piers and the recent research results. According to the guidelines, the HEPC takes the policy to retrofit the component stiffened plates without filling the column member with concrete in a steel bridge pier with box section in the case that the ultimate strength of the column member exceeds more than that of the basement structure consisting of anchor bolts and footing concrete by adopting the concrete filling method and consequently the basement structure collapses. Described in this paper are the concepts of this seismic retrofitting method in the HEPC and the validity of the seismic retrofitting method through the gradually increased cyclic horizontal displacement tests using 5 specimens. Its validity is evaluated by focusing on the ultimate strength and ductility of the specimens retrofitted according to the method.

Maintenance and management of bridges in Osaka City

Toshiyuki KITADA, Masaaki NAKANISHI (Kansai International Air Port Land Development Co.. Ltd.,) and Tadamasa ITO (Osaka Municipal Office)
Bridge Management 4, edited by M. Ryall, G. Parke and J. Haring, Tomas Telford,

pp.370-377, April, 2000

Described in this paper are the present conditions, main maintenance and repair works, bridge management system, adjustment works due to environmental reasons, main working expenses and issues on management of the bridges constructed and managed by the Public Works Bureau, Osaka Municipal Office. The present situation of the bridges in Osaka City was almost completed by the replacement of old bridges with new ones and the construction of new bridges for the first auburn planning enterprise started from 1921. These bridges were designed by using new technologies at that time and by considering fire protection too because of the knowledge of Kanto Earthquake (1923). Moreover, some bridges in Osaka after World War Ⅱ were newly constructed and retrofitted for the quick development of motorization and the holding of the Senri International Exposition (1970) in cooperation with the economic revival and high development in Japan.

Study on Ultimate Strength and its Evaluation Method of Steel Compression Plates with Rounded Part

Miyoharu SAKAGUCHI (Kozo Giken Co., LTD), Toshiyuki KITADA, Hiroshi NAKAI(Fukui University of Technology), Munetaka TOKUBAYASHI (Hanshin Expressway Public Corporation) and Masato KANO（Bridge and Computer Engineering Co., Ltd.）

Steel Construction Engineering, Vol.7, No.26, JSSC, pp. 31-42, June, 2000 (in Japanese)

This study deals with the ultimate strength and method for evaluating that of steel compression plates with a rounded part through the elasto-plastic and finite displacement analysis based on a finite element method. In this analysis, the residual stress distribution idealized on the basis of the data measured in a steel stiffened stub column with rounded corners is considered. Main parameters of the analysis are the modes of initial deflection, radius-to-thickness ratio of a rounded part and breadth of flat parts. Finally from the results of the analysis, the method for evaluating the ultimate strength and the appropriate location of longitudinal stiffeners for the stiffened stub columns with rounded corners are proposed.

Technical seminar II for engineering staffs at Osaka City Government

Toshiyuki KITADA and Masahide MATSUMURA

Technical seminar II for engineering staffs at Osaka City Government, pp.1-20, July, 2000

This paper is used as a textbook in the technical seminar II for engineering staffs at Osaka City Government held in 1999. Summarized in the paper is basic knowledge for seismic design of steel bridges for the help of understanding a new way of seismic design method of steel bridges to be constructed and seismic retrofitting method of existing steel bridges. The article consists of 3 topics; 1) Basic of vibration engineering for structural design, 2) Basic of seismic design method for steel bridges and 3) Buckling and ultimate strength of column member in the shape of stiffened box cross-section and circular one.

Some Issues on Development of Rational and Economical Bridge Management System of Steel Bridge Structures

Toshiyuki KITADA

Proceedings of Repair and Strengthening Technologies on Steel Structures, Vol.7, JSSC, pp.65-78, Osaka, June, 2000 (in Japanese)

The following issues on development of rational and economical management system of steel bridge structures are dealt with in this paper: (1) the definition of bridge maintenance, (2) development of methods for evaluating the safety of existing steel bridge structures and public announcement of results of the evaluation, (3) priority of repair of damage, (4) countermeasures for the maintenance of steel bridge structures with less financial resources, (5) development of rational system for maintenance, repair and strengthening, (6) decision of bridge life, (7) effective use of estimated cost for maintenance, (8) development of effective feed back system, (9) replace methods for old bridges, (10) unification of terminologies for bridge management, (11) rationalization of maintenance inspection works using monitor bridges, monitor bridge members and monitor elements, (12) rationalization of inspection methods, (13) methods for getting sufficient estimated cost for maintenance, (14) relationships between maintenance and aesthetics, and between maintenance and seismic performance, (15) development of new materials and new technologies, (16) standardization and spare members, (17) education for bridge maintenance, (18) collection of maintenance using IT, and (19) development of methods for emergency maintenance and repair.

Development of Pararell Pseudo-dynamic Testing System using Internet

Yoshihiro KISHIMOTO, Yoshikazu SUZUKA, Eiichi WATANABE (Kyoto University), Toshiyuki KITADA, Takashi YAMAGUCHI, Kazutoshi NAGATA (Kyoto University) and Kunitomo SUGIURA (Kyoto University)

Proceedings of the 25th Symposium on Civil Engineering Information Processing System, Vol.9, JSCE, pp.111-120, October, 2000 (in Japanese)

With improved Internet in all over the world, it has become popular to share the information with other computers through it. Consequently, in order to understand the dynamic response behavior of structures considering interaction between structural members experimentally, a pseudo dynamic parallel testing system using Internet is developed. And applicability of this developed system is discussed based on the results of a simulated elevated bridge system, consisting of two piers and one girder.

Influence of Bolt Arrangements on the Mechanical Behavior of One-Side High Strength Bolted Tensile Joints

Yasuo SUZUKI, Toshiyuki KITADA, Takashi YAMAGUCHI, Kunitomo SUGIURA (Kyoto University) and Hisayuki AKIYAMA (Komai Tekko Inc.)

Journal of Construction Steel, Vol.8, Japanese Society of Steel Construction(JSSC), pp.461-468, November, 2000 (in Japanese).

In Japan, one-side high strength bolted tensile joints are not utilized to connect primary members of bridge structures in spite of their good characteristics such as high fatigue endurance, workability and good appearance. One of the reasons is rack of the specification prescribed its own arrangement for one-side high strength bolted tensile joints. Therefore, in this study, the mechanical behavior of this type of joins with multiple bolt lines is investigated experimentally. In particular, the influence of bolt arrangements such as distance between the bolts along the tee web plate, and thickness of the flange plate are discussed considering the strength and the deformability of them. As a result, one side-high strength bolted tensile joints with thick flange plate is effective for the connection of bridge structures.

Elasto-Plastic, Finite Displacement and Dynamic Response Analysis of Steel Bridge Piers with Single Cylindrical Columns Considering Initial Deflection

J. Okada and T. Kitada

The 1st International Conference on Structural Stability and Dynamics, Taipei, Taiwan, pp. 819～824, December, 2000

Dealt with in this paper is the influence of the radius-thickness ratio and the initial deflection on the ultimate strength and ductility of steel bridge piers having single unstiffened cylindrical columns for bridge piers subjected to constant axial force and gradually increased horizontal displacement or horizontal seismic motion. Firstly, a parametric study through elasto-plastic and finite displacement analysis is carried out by varying the radius-thickness ratio and the shape of initial deflection in order to investigate the ultimate strength and ductility of cylindrical columns. Secondly, elasto-plastic, finite displacement and dynamic response analysis is executed for investigating the seismic behavior of cylindrical columns considering initial deflection subjected to the strong earthquake of the level 2 and type Ⅱ specified in the Japanese Specifications for Highway Bridges (JSHB). A concluding remark to be noted is that the ultimate strength and ductility of thin-walled cylindrical columns depends on not only greatly the radius-thickness ratio but also the initial deflection.

A Concept for Seismic Design Method of Steel Bridge Piers by Introducing Plastic Deformation to Specified Part

Masahide MATSUMURA, Toshiyuki KITADA, Sheng-Jin Chen (National Taiwan University)

Proceedings of the 3rd Symposium on Ductility Design Method for Bridges, Ductility Design Subcommittee, Earthquake Engineering Committee, Japan Society of Civil Engineers (JSCE), pp.271-276, December, 2000 (in Japanese)

A seismic design method considering ductility of structures is adopted to the design of steel bridge piers to be constructed newly and to be retrofitted. Mentioned in this paper firstly are structural details for the enhancement of seismic performances of existing steel bridge piers without substantially changing the value in stiffness and strength of them. And current seismic retrofitting methods for thin-walled stiffened column members in steel bridge piers by using the plastic deformation to a specified part not to the lowest part of the column member are sorted out and discussed. Lastly suggested is a seismic design method

for retrofitting the column member in steel bridge piers by utilizing the plastic deformation by considering workability in repair work and repairability after being damaged.

Retrofitting Methods Placing Short Ductile Panel in Bridge Pier Columns

Masahide MATSUMURA and Toshiyuki KITADA

Memoirs of the Faculty of Engineering, Osaka City University, Vol. 41, pp. 29-38, December, 2000

In retrofitting existing steel bridge piers and enhancing their ductility against strong earthquake, a method stiffening still more the component stiffened plates is used in case that a concrete filling method can not be adopted. The method can improve the ductility of the existing steel piers, but seems to be not economical. In this paper, a seismic retrofitting method, which makes a pre-selected short panel of steel cross section placed in a bridge pier column weak and ductile comparing with the other parts of the bridge pier column, is proposed. The validity of the method is investigated through an elasto-plastic finite displacement analysis by using analytical models corresponding to a part of a component stiffened plate of a steel bridge pier column and a cyclic loading test by using 3 specimen. Based on the results of these investigations, structural details for enhancing the ductility and mitigating the ultimate strength increment are proposed for newly constructed steel bridge pier columns.