Experimental Study on Strengthening Method of Lower Flange Plate of I Shaped Steel Girder with Bolted Connection by High Modulus CFRP Strips

Nobuhito OCHI (Akashi National College of Technology), Masahide MATSUMURA and Nobuhiro HISABE (Mitsubishi Plastics, Inc.)

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The installation of CFRP strips of high modulus can be effective for strengthening a superannuated existing steel I girder with regard to improving its load carrying capacity. Here, shear plates of the bolted connections become obstacles in installing the CFRP strips onto the lower flange plate of I shaped steel girder. Then, experimentally investigated in this study is the strengthening effect of the methods to prevent the CFRP strips of high modulus from debonding in the vicinity of the bolted connection of lower flange plate of I shaped steel girder through a bending test. It is concluded that the proposed methods are effective to prevent debonding of the CFRP strips and further investigations are needed to develop more effective methods.

Bending and Shear Behavior of a Steel I-Shaped Girder with a Transversely Profiled Steel Web Plate

Kunitaro HASHIMOTO (Kyoto University), Takashi YAMAGUCHI, Kosuke OTSUKA (Kyoto University), Kunitomo SUGIURA (Kyoto University), Yasuo SUZUKI (Utsunomiya University) and Takuji KUMANO (JFE Engineering Corp.)

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Steel plates with varied thickness have a potential for rationalization of steel bridge design. For example, longitudinally profiled steel plates already have been adapted to flanges of an I-shaped girder / a box girder to reduce the weight of the bridge and the process of bridge construction. Recently, the analytical study on the mechanical behavior of steel girders with a transversely profiled web plate has been carried out, and it has been concluded that there exists the preferable cross sectional shape of steel plate from the viewpoint of the load carrying capacity and ductility. In this paper, the static loading tests for I-shaped girders with a profiled web plate in thickness are carried out. It is found that the web plate whose thickness is larger at the middle height of the girder has superiority for shear buckling strength; on the other hand, that the web plate whose thickness is larger at the close to flange plate has superiority for bending strength.

Seismic Performance Evaluation of a Viaduct Supported by Steel Bridge Piers with EPS

Masahide MATSUMURA, Satoshi UCHIDA (NEWJEC Inc.) and Toshiyuki KITADA

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Embedded Plastic Segment (EPS), which has been developed as a seismic retrofitting technique for existing steel bridge piers, can enhance the ductility with less increment in the ultimate strength of the column members. In this paper, the seismic performance of a viaduct of the total length 200m with 5 spans supported by the steel bridge piers with the EPS is analytically investigated. The effectiveness of the steel bridge piers with the EPS is revealed in comparison with a viaduct supported by concrete filled steel bridge piers. It is concluded that the EPS enables the reduction of the construction cost of piles and footing concrete and the enhancement of redundancy of the viaduct.

Measurements of Initial Imperfections of Longitudinally Profiled Steel Plates and Their Applied Box Cross Section

Takuji KUMANO (JFE Engineering Corp.), Yasuo SUZUKI (Utsunomiya University), Takeshi KITAHARA (Kanto Gakuin University), Kunitomo SUGIURA (Kyoto University) and Takashi YAMAGUCHI

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Recently, various kinds of high-performance steel have been developed in order to reduce construction costs and improve structural performances. LP steel plate is applied to flange plates of steel girders with a view to reduction of process for fabrication and simplifying structures. On the other hands, it is generally known that initial imperfections of steel plates affect on the characteristics of strength and deformation of steel girders. Therefore, in this study, the fabrication error of plate thickness and the residual stress distribution subjected to metal rolling and welding are measured for the actual LP plate and box cross section in order to correct the basic information of initial imperfections of LP steel plates.

Analytical Study on Mechanical Behavior of the High Strength Bolted Friction Joints with F18T Grade Super High Strength Bolts Subjected to Compression

Takashi YAMAGUCHI, Toshiyuki KITADA, Takayuki IKEDA (NTT Data Corp.) and Natsuki YOSHIOKA

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Recent years, rationalization of the joint structures is required from the viewpoint of reduction of the total cost of

steel structures. As one of such effective solutions, adoption of super high strength bolts for friction type joints, which strength is more than 1,600 MPa is considered in order to be a compact joint section with a few bolts and lines. However, the mechanical behavior of such joints, especially the behavior under compressive load, is not clear. Therefore, in this study, the mechanical behavior of the friction type joints with super/normal high strength bolts subjected to compressive load is discussed based on the FE analytical results paying attention to the maximum spacing of the bolts and contact between joint surfaces.

Experimental Study on the Strengthening of Bolted Tensile Joints with a Deformable Filler Plate
Yasuo SUZUKI (Utsunomiya University), Takashi YAMAGUCHI, Akinori NAKAJIMA (Utsunomiya University) and Takahiro SHIMIZU (Utsunomiya University)
Journal of Structural Engineering, Vol.55A, JSCE, pp. 1014- 1023 (2009) (in Japanese)
In the split tee joints, the prying force occurs due to the deformation of the tee flange plates, and the prying force reduces the strength of the joint. Therefore, it is very important for this type of joints to suppress the prying force. In order to make it possible to reduce the prying force of split tee joints easily, we propose to apply the sealant named as deformable filler plate for the split tee joints consists of soft rubber and steel rings. In this study, the mechanical behavior of split tee joints with the deformable filler plate is investigated experimentally. Particularly the influence of the sealant and shapes of the tee flange plates on strength and deformation of these joints are mainly discussed.

Dynamic Response of Isolated Bridge System Considering Knocking-off of Side Block as Displacement Restrainer of Superstructure
Masahide MATSUMURA, Nobuhito OCHI (Akashi National College of Technology), Masahiko YOSHIDA (Kawaguchi Metal Industries Co., Ltd), Minoru SAKAIDA (Sakaida Bridge Engineering & Consulting) and Toshiyuki KITADA
German-Japanese Bridge Symposium, Munich, (7 pages, CD-ROM) (2009)
Displacement restrainer of the superstructure in the transverse direction of the isolated bridge, like side block, is usually installed to protect expansion joints from damage during earthquake. Here, a more rational response of the isolated bridge to mitigate damage to bridge pier and/or base structure and to enhance redundancy against a strong earthquake like the Level 2 Earthquake can be considered to be that the displacement of the superstructure against a small and a moderate earthquake like the Level 1 Earthquake is restraint and the displacement against the Level 2 Earthquake is released. For instance, steel side block, improved to have a knock-off function, will provide these responses. This study presents the outline of the side block with the knock-off function, which is the side block with a slit and developed by the authors to control the breaking load accurately, reveals the effectiveness of the knocking-off in the isolated bridge system through dynamic loading test using a small-size shaking table and verifies the influences of the breaking characteristics of the side block with the knock-off function through the dynamic response analysis of the system.

Experimental Study on Static Mechanical Properties of Glass Plate Materials for Use as Structural Members
Yugo NAGAMACHI, Toshiyuki KITADA, Takashi YAMAGUCHI and Masahide MATSUMURA
German-Japanese Bridge Symposium, Munich, (4 pages, CD-ROM) (2009)
Developments of the glass technology and fundamental researches for the structural use of the glass enable the applications of the glass plate to structures. The glass plate has been widely used in architectural structures both as structural and non-structural members and the use of the glass plate as structural members creates more attractive and functional structures. On the other hand, the use of the glass to structures in civil engineering field is not so popular, because the cost-effectiveness may be first priority in the structural design and planning. Here the use of the glass plate for structures in civil engineering field, for instance, for principal structural members of bridge can be considered to create more attractive and fascinating bridge and construction, which will bring a drastic change to images of the bridge. In the study, fundamental material properties of the glass plate are clarified through material tests. Then, a new type of glass plate beam with a joint is proposed through numerical calculations based on the material test results. Here, SGP foils is used for the joint in the beam.

Inspection and Damages of Bridge Expansion Joints in Urban High Way in Japan
Masahide MATSUMURA, Takashi YAMAGUCHI, Yoshihiko TAKADA (Hanshin Expressway Management Technology Center) and Toshiyuki KITADA
German-Japanese Bridge Symposium, Munich, (7 pages, CD-ROM) (2009)
Bridge expansion joints, installed at the edges of the girders and subjected to the impact loading of moving

vehicles, take important roles in providing smooth running of the vehicles. A proper type of the expansion joint, which can secure enough interspaces between the girders, should be selected to prevent their interaction against expansion movements with the changes in temperature and during the earthquake. Adoption of the finger joint is a general solution when larger interspaces between the girders are required. However, the finger joint is designed only against the static vertical design load corresponding to the truck live load according to the present design method in the Japanese Specification of Highway Bridges (JSHB), however some damages of the finger joint are reported. Presented in this paper are the outlines of inspection results and damages of the expansion joints, which is carried out by Hanshin Expressway Corp., and the discussion based on the test results of the two kinds of the field test passing the vehicles over the joints. It is concluded that the impact loading derived from the vehicle passing and enlarged by the faulting between the joints is not negligible in the design of the finger joint.

Slip Behavior of High Strength Bolted Friction Joints for Composite Girders Subjected to Bending
Natsuki YOSHIOKA, Takashi YAMAGUCHI, Masatsugu NAGAI (Nagaoka University of Technology) and Takeshi MIYASHITA (Nagaoka University of Technology)
German-Japanese Bridge Symposium, Munich, (8 pages, CD-ROM) (2009)
In recent years in Japan, various studies on rational design of steel bridges focusing on cost reduction, such as consideration of plastic behavior for ultimate state are performed. In Euro Code, AASHTO-LRFD, plastic moment is already adopted to the ultimate strength for the positive bending state of the composite girder. However, in Japan, there are a few researches about it and as a result, plastic moment is not allowed to the ultimate strength in the design specifications. Accordingly, in this study, in order to collect basic information for design of composite girder connection, FE analyses were executed referring to the experiment which has been carried out by authors. Finally, based on these analytical results, the evaluation method of ultimate bending strength of the composite girder with high strength bolted friction joints are proposed and desirable design concept of the friction type joints for composite girder bridges are summarized.

Analytical Study on Residual Load Carrying Capacity of Damaged Steel Bridge with Large Crack
Takashi YAMAGUCHI, In ho KIM (Miyaji Iron Works Co., Lid.), Toshiyuki KITADA and Kazuyuki MURAMOTO (Japan Bridge Engineering Center)
Steel Construction Engineering, *Vol.16, No.63*, JSSC, pp. 15- 25 (2009) (in Japanese)
In recent, much damage has been detected in superannuated bridges. Especially, the fatigue problems of aged steel bridges become serious in the maintenance of bridges. Recently, the serious and large crack of approximately 1.1m length was detected. In the web plate of interior main girder at the intersection of the main girder and the transverse girder, and at the location near the interior support in the center span of a three-span continuous girder bridge. If such a large crack occurs, the load carrying system of bridge should be changed and its capacity will be decreased. Accordingly, it is important to evaluate the residual load carrying capacity of damaged bridges with a large crack from the viewpoint of the management of the bridge system. The objective of this study is to investigate analytically change of the load carrying system of the various damaged three-span continuous girder bridges with four main girders.

Friction Test for High-Strength Bolted Joints with Long-Exposed Weathering Steel
Minoru SAKAIDA (SAKAIDA Bridge Engineering & Consulting), Kunitomo SUGIURA (Kyoto University), Takashi YAMAGUCHI, Shigeyuki MURAKAMI (Gifu University) and Kunitaro HASHIMOTO (Kyoto University)
Steel Construction Engineering, *Vol.16, No.63*, JSSC, pp. 37- 48 (2009) (in Japanese)
Strength and slip factor of high strength bolted friction joints were obtained through loading tests. Specimens were assembled from weathering steel base members and blasted splicing members. Weathering steel plates were cut out from lower flange plate of a bridge that was exposed for 8 years in open inland field, and it has been generated protective rust on its surface. Base members were treated in some levels of rust removing. Applied treatments are blasting, disk sanding, powered wire brushing, manual wire brushing and cloth wiping. Protective rust decreases the slip factor, and thin crystalloid rust increases it, but thick rust over 100 μm decreases it.

Assessment on Fatigue Cracks in Orthotropic Steel Decks
Kunitomo SUGIURA (Kyoto University), Kunitaro HASHIMOTO (Kyoto University), Yoshinobu OSHIMA (Kyoto University) and Takashi YAMAGUCHI
Steel Construction, Vol.2, No.3, Ernst & Sohn, pp. 175- 180 (2009)
In this study, proposed is the new health evaluation system for fatigue cracks of orthotropic steel bridge decks by measuring strain changes of the asphalt pavement on steel plate decks. In order to consider applicability of this

system, carried out are parametric FE analyses in which the type of cracks, their position, and their length are varied. From these analytical results, it is found that strain changes of the asphalt pavement on steel plate decks by the length and the positions of cracks can be significant enough to be detected.

Experimental Study on Vibration Control of Pole Type Steel Structures on Bridges by Using Damping Members/Elements

Tomohiko ISHIBASHI (Nasu Denki-Tekko Co., Ltd.), Takashi YAMAGUCHI and Kazuyuki HENMI (Nasu Denki-Tekko Co., Ltd.)

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Recently, it is pointed out that the bridge vibration due to traffic may cause fatigue damages to pole type steel structures like a lighting pole or a marker pole on bridges. As such damage tends to cause severe accidents, the vibration damage is to be eliminated as soon as possible. It is important to avoid resonance phenomenon and to increase damping effect of the steel poles with possible fatigue damages by economical techniques, because the number of pole type steel structures on bridges is large. Authors suggest two vibration controlling techniques for these steel poles, by using wire ropes and by using chloroprene rubber plates underneath the lower end plate of the steel pole. It is verified through a vibration experiment that both techniques are effective and the response displacement of the pole can be reduced substantially.

Fundamental Study on Characteristics of Extremely Low Cycle Fatigue Crack of Steel Members in Bridges

Shigeharu YAMANE (Mitsubishi Heavy Industries Bridge & Structures Engineering Co,. Ltd.), Toshiyuki KITADA, Takashi YAMAGUCHI and Masahide MATSUMURA

Journal of Constructional Steel, Vol.17, JSSC, pp. 289- 294 (2009) (in Japanese)

Extremely low cycle fatigue crack phenomenon is not yet clarified enough. In this paper, crack initiation mechanism in a range of the repetition number of several times to 20 is clarified by the extremely low cycle fatigue experiment focusing on strain at crack initiation point and fractography of the crack fracture. It is concluded that the crack is not brittle but ductile in the case of the extremely low cycle experiment using the specimens with welding part and notches at their central part.

A Fundamental Experiment on Mechanical Behavior of Panel Point of Steel Truss Bridges

Shinsuke YOSHIDA (Kyoto University), Takashi YAMAGUCHI, Kunitaro HASHIMOTO (Kyoto University) and Kunitomo SUGIURA (Kyoto University)

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In this study, in order to clear the mechanical behavior of panel point of steel bridges using high strength bolted frictional connection, tensile loading experiment is carried out. In the experiment, two specimens modeled the panel points of steel truss bridges which the gusset plate and the diagonal member are connected by high strength bolts are prepared. One has the ordinal gusset plate whose thickness is 9 mm, and the other has thin (6 mm) gusset plate in which is considered the decrease of the thickness due to corrosion. From the result of this experiment, it is found the collapse behavior of panel points of steel truss bridges and it is suggested the optimum calculating method for yielding strength of such panel point.

Study on Methods for Effectively Using Down-Sized Vibration Table to Evaluate Seismic Performance of Bridge Structures

Yasuyuki NAKANISHI (NEWJEC Inc.), Masahide MATSUMURA, Toshiyuki KITADA and Takashi YAMAGUCHI

Journal of Constructional Steel, Vol.17, JSSC, pp. 415- 420 (2009) (in Japanese)

Dynamic response analysis requires many idealizations regarding the unknown factors, such as dumping coefficient, dynamic characteristics of material, etc, but simulates the dynamic behavior the idealized of structure, although it's unknown whether the predicted behavior is exact. While shaking table test without idealizations shows dynamic response. Using a down-sized specimen, the dimensional reduction from a full scale is same question as to the realization of exact behavior, but the cost effectiveness will be much attractive. Then the shaking table test using down-sized specimens are carried out in this study to examine the advantages and disadvantages. Also the experimental results are compared with the numerical ones using the idealized analytical models. Effectiveness of using down-sized specimen in the small shaking table in evaluating seismic performance of steel structures is discussed comparing experimental and analytical results.

Repairing Design of Stiffeners on the Support of a Plate Girder for Highway Bridges

Kennichi SATO (New Structural Engineering, Ltd.), Yukiko MITSUGI (New Structural Engineering, Ltd.), Takashi

YAMAGUCHI, Kunitaro HASHIMOTO (Kyoto University) and Kunitomo SUGIURA (Kyoto University)
Journal of Constructional Steel, Vol.17, JSSC, pp. 673- 680 (2009) (in Japanese)
In this paper, the repairing design of stiffeners on the support of a plate girder for Highway Bridges is studied referring the literature and executing simple calculation. We treated the stiffener on the support, whose effective sectional area is decreased by corrosion at is the end of the bottom portion. From the viewpoint of the performance based design, we considered the role of the each member/element that consists of the girder on the support. The mechanics of resistance and the limit states of them are discussed. In the case that the thickness of the plate at the bottom end is decreased by the corrosion, the bearing limit state of the bottom-end is dominant.

Fatigue Failure Assessment Considering Actual-working Load and Running Position of Orthotropic Steel Deck by Using BWIM
Yoshihiko TAKADA (Hanshin Expressway Management Technology Center) and Takashi YAMAGUCHI
Memoirs of the Faculty of Engineering, Osaka City University, Vol.50, pp. 55- 61 (2009)
Recent considerable increase in traffic intensity and wheel loads causes fatigue cracks in orthotropic steel decks in Hanshin Expressway. From results of the periodic inspection, fatigue cracks are detected by 167 spans in 1347 spans in orthotropic steel decks as of April, 2009. Under traffic loading, in particular the effect of local wheel loads, longitudinal welds between deck plate and trough are subjected to local transverse bending moments and are susceptible to fatigue cracks. The stress in trough to deck plate welds is strongly influenced by actual-working load and run position .Then, in orthotropic steel decks in Kobe route of Hanshin Expressway, measurement of the load of actual-working traffic and generating stress is performed by Bridge-Weigh-In-Motion. This paper presents the outline of fatigue failure in orthotropic steel decks. Next, Fatigue failure assessment based on this measurement results are described.