Experimental Study on Mechanical Behavior of the Composite Steel Girder with High Strength Bolted Frictional Joints Subjected to Bending

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Journal of JSCE, Ser.A1 (SE/EE), Vol.68, No.1, JSCE, pp.16-27 (2012) (in Japanese)

Generally speaking, it is possible to make the cross section small and to reduce 20% of the weight of the steel girder by adoption of Euro code/AASHTO-LRFD to the composite girder subjected to positive bending moment. Therefore, the new design method for connections which can deal with the ultimate state after major slip is needed from the viewpoint of further rationalization of the composite steel girder bridge design.

Therefore, at Nagaoka University of Technology, the basic experiment has been carried out by authors in order to investigate the behavior of such a connection after major slip. In this study, in order to collect basic information for design of composite girder connection. Finally, based on these 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.

Study on Load Carrying Capacity of a Small Power Transmission Tower Made of Angle Steel Members

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Journal of Structural Engineering, Vol.58A, JSCE, pp.50-61 (2012) (in Japanese)

Equal angle steel members are widely used and generally bolted to other members. Then, the axial compression load eccentrically subjected to the member greatly influences on the ultimate strength and post-buckling behavior of the member. Also member buckling will influence on the ultimate strength of trussed structures, which are assemblage of the angle members. In this paper, transmission line tower consisting of equal angle steels bolted is focused on and the ultimate strength of it and the modeling method of the component members for non-linear analysis are discussed by focusing on decrease of the load carrying capacity due to the eccentric loading to the members. Through comparisons between analytical and experimental results of angle members, a plane trussed structure and an actual transmission tower, an adequate modeling method of the member is verified. Also investigated is Sensitivity Index of the member which represents the decrease ratio of the ultimate strength due to the absence of member.

Tensile and Shear Break Tests of M12 High Strength Bolts with Slit around Their Shanks

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Journal of Structural Engineering, Vol.58A, JSCE, pp.83-91 (2012) (in Japanese)

In reducing and in preventing the damage to bridge structures, knocking-off members or devices are adoptable. Then, it is important to understand their brittle fractures and to obtain their controlled and stable breaking loads. In this paper, high strength bolts inserted a slit around their shanks are dealt with among the knocking-off members and their breaking characteristics are investigated through tensile and shear break tests. It is concluded that the height and depth of the slit is not sensitive to the shear breaking load of the slitted bolts and the breaking load is approximately figured out by using the cross sectional area of the slitted part and tensile strength of the bolt material.

Experimental Study on Bending Behavior of Riveted Steel I Shaped Girder Corroded at Rivet Heads

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Journal of Structural Engineering, Vol.58A, JSCE, pp.701-709 (2012) (in Japanese)

In this paper, in order to study on bending behaviors of a riveted steel girder with corrosion damage at heads of some rivets, bending loading tests are carried out. The steel girders used as specimens were cut out from the bridge that had been used for 55 years. Considering the results of the bending experiment, it is found that the initial rigidity of the specimen with the rivet heads corroded is decreased a little. But the effect of corrosion damage at rivet heads of riveted steel I shaped girder for ultimate load is nothing.

Friction Test for High Strength Bolted Joints between the Surface of the Inorganic Zinc Rich Paint and the Different Surfaces

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Journal of Structural Engineering, Vol.58A, JSCE, pp.803-813 (2012) (in Japanese)

On the site of the maintenance and strengthening work for steel bridges, the high strength bolted friction type

joints are often applied. But, the surface preparation of the existing steel member may not be able to be processed adrasive blast-cleaning depending on site conditions. Therefore, the slip tests were carried out using splice plates processed the inorganic zinc rich paint on surfaces and connected plates varied surface preparation and the kind of painting specification on surfaces. As a result of the slip test, it was found that the slip coefficient of 0.4 or more can be ensured by the surface preparation with the power tool.

Analytical Study on Vibration Control of Illumination Poles on Bridges by Using Wire Ropes
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The Journal of Technological Researches, The College of Engineering, Vol. 55, No.2, Kanto Gakuin University, pp.77-83 (2012) (in Japanese)
Recently, it becomes a large problem that bridge vibration induced by vehicles causes damages to not only the bridge but also 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 are 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. The effect was verified in analysis and it turned out the effect originated in the nonlinear characteristics of wire ropes.

Fundamental Study of Vibration Transfer between Bridge and Passing Vehicles
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Journal of JSCE, Ser.A1 (SE/EE), Vol.68, No.2, JSCE, pp.384-397 (2012) (in Japanese)
In this study, the heavy vehicle with excitation system that can control its axle forces passed over a bridge associated with a cargo and a passenger' s vehicle to evaluate the vibration transfer between the bridge and vehicles. As a result, it was found that when the bridge vibrates on some level at a frequency close to cargo's eigenfrequency, dominant frequencies corresponding to those found in the bridge vibration can be also found in the cargo vibration. As for the passenger' s vehicle, its vibration behavior was complicated due to high sensitivity of road roughness and it was difficult to find the frequencies corresponding to the bridge vibration in the vibration of passenger's vehicle.

Study on a Seismic Force Reduction Method of the Bridge Pier Foundation Using Energy Absorption Connector Devices
Kentaro TANAKA (Setsunan University), Takeshi KITAHARA (Kanto Gakuin University), Masahide MATSUMURA and Hiroshi ZUI (Setsunan University)
Journal of JSCE, Ser.A1 (SE/EE), Vol.68, No.4, JSCE, pp.704-712 (2012) (in Japanese)
In this paper, the energy absorption performance of steel bellows as one of energy absorption connector devices is examined through non-linear time-history analysis of a viaduct supported on lead lubber bearings, a three continuous span girder bridge considering piers and pier foundations. The effectiveness of the steel bellows on seismic force reduction is verified by focusing on the differences in the energy absorption capacity of the bellows and combination use of them. It is concluded that the steel bellows set between the girders can reduce the seismic inertia force delivered to the substructures of the viaduct effectively both against the level 1 Earthquakes and the level 2 Earthquakes defined in the Specification for Highway Bridges in Japan.

Fundamental Study on Rigid Connection Detail of Steel-Concrete Composite Rigid Frame Bridge Using Bearing Plate
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Proceedings of the Sixth International Conference on Bridge Maintenance, Safety and Management, full paper in CDROM, 8-12 July, Stresa, Italy (2012)
Recently, the number of steel-concrete composite rigid frame bridges is increasing for short and medium span length in Japan. To make this type of bridge more rational, it is important to ensure a good performance of the rigid connection, which can transfer the load from the steel girder to the abutment. Therefore, a new type of the connection detail with a bearing plate has been proposed by the authors. In this study, effectiveness and applicability of the newly proposed rigid connection detail was examined by elasto-plastic finite displacement analysis. Mechanical behavior of the connection detail up to the ultimate limit state is investigated based on them. It is found that the load can be securely transferred from the steel girder to the abutment through the bearing plate. It is concluded that the proposed connection detail can be one of the practical and effective rigid connection detail

considering easiness of construction.

Investigation of Structural Health of Timber Piles Supporting Aged Bridge
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Proceedings of the Sixth International Conference on Bridge Maintenance, Safety and Management, full paper in CDROM, 8-12 July, Stresa, Italy (2012)
In case of deciding whether a bridge should be replaced or enhanced its service life, it is important to evaluate the seismic resistance performance of the foundation because of huge amount of expense for its retrofitting. However, verification and modeling method of timber piles subjected to the earthquake are not specified in current Japanese Specifications for Highway Bridges [Japan Road Association, 2004], seismic resistance of the timber pile foundation is not clear as well as that of intact state. Osaka city has about 100 bridges supported by timber pile foundation, it is severely necessary to clarify the seismic resistance performance of it. This paper presents the experimental and analytical investigation conducted by authors, in order to evaluate the structural health of an aged timber pile and its seismic resistance performance under the strong earthquake.

Seismic Response Analysis of a Bearing Structure Consisting of a Low Frictional Sliding Bearing and a Knock-Off Device
Masahide MATSUMURA, Yasuyuki NAKANISHI (NEWJEC Inc.), Takahiro KANATA and Takashi YAMAGUCHI
Proceedings of the 15th Symposium on Performance-based Seismic Design Method for Bridges, JSCE, pp.385-388 (2012) (in Japanese)
In this study, a new type of bearing structure for bridge; combination use of a low frictional sliding bearing and a knock-off device, is presented. In the bearing structure, the knock-off device is designed and installed to the sliding bearing as triggers in order to change dynamic vibration mode from fixed condition to unfixed one during seismic attack to enhance seismic safety of bridge structures. Fundamental effects and dynamic response of the bearing structure is investigated through seismic response analysis of a viaduct with 5 spans of continuous girder bridge.

Dynamic Response of Isolated Viaduct considering Knocking-off Effects of Displacement Restrainers
Masahide MATSUMURA and Masahiko YOSHIDA (Kawakin Core-Tech Co., Ltd.)
Proceedings of the International Conference on Bridge Maintenance, Safety and Management, IABMAS 2012, pp.3480-3485 (2012)
Displacement restrainers, which are usually set asides isolation rubber bearings to restraint transverse displacement of superstructure for damage protection of expansion joints during earthquake, can be utilized as a trigger device to differ vibration modes before/after their breaks. Then, the authors have been developing displacement restrainers with knocking-off function, called as CSB, to mitigate damage of bridge pier and/or its foundation against a strong earthquake. That is, after the CSBs break, a system vibration is expected to shift into isolated one when the breaking load controlled with high accuracy. In this study, the breaking characteristics of the CSBs are experimentally investigated through static breaking tests and the installation effects of the CSBs asides the rubber bearings are also verified through shaking table tests. Moreover the installation effects of the CSBs in a viaduct are revealed through dynamic response analysis.

Research and Design Trends on High Strength Bolted Connections for Steel Bridge Structures in Japan
Takashi YAMAGUCHI, Toshikazu TAKAI and Xue PENG
Joint Seminar on "Advanced technologies of steel and composite bridge engineering", JSCE-EIT, 29 August, Thailand (2012)
In Japan, high strength bolted joints, such as friction type joints, tensile type joints, bearing type joints are generally used for joining primary bridge structural members. In particular, the researches on the joints with super high strength bolts, joints with thick plates and many bolts in a line and so on have been conducted actively considering current design trend in Japan which prefers to use thicker steel plates. In this paper, introduced are research and design trends on high strength bolted connections for steel bridge structures in Japan. Furthermore, future of bolted connections for bridge structural members is also discussed paying attention to their qualification assurance.

Strength and Behavior of Anchoring Devices of CFRP Rods for Steel Girder Strengthening

Katusyoshi NOZAKA (Ritsumeikan University), Akira TSUKIYAMA (Ritsumeikan University), Masahide MATSUMURA, Nobuhito OCHI (Akashi National College of Technology), Toshiyuki ISHIKAWA (Kyoto University) and Nobuhiro HISABE (Mitsubishi Plastics Inc.)
Proceedings of the International Conference on Bridge Maintenance, Safety and Management, IABMAS 2012, pp.1243-1250 (2012)
For the strengthening methods of steel girders by bonding CFRP plates, continuous strengthening is not an easy task at the location of splice plates. For this case, placing CFRP rods over the splice plates can be a possible solution, and CFRP rods need to be anchored to the ends of CFRP plates at each side of the splice plates. The adhesion, between adhesive and steel girders and between adhesive and CFRP rods, becomes a key issue in this anchoring device. In this study, several shapes for anchoring device were tested to investigate the behavior and bond strength. Force transfer mechanism in this device was discussed and the effective shape was proposed.

Fundamental Study on Load Carrying Capacities of Steel Bridge Piers under Dozens of Cyclic Loading
Takeshi KITAHARA (Kanto Gakuin University), Kentaro TANAKA (Setsunan University), Takashi YAMAGUCHI, Yusuke KISHI (Kanto Gakuin University) and Tsuyoshi HAMANO (Kanto Gakuin University)
Journal of JSCE, Ser.A1 (SE/EE), Vol.68, No.4, JSCE, pp.499-508 (2012) (in Japanese)
Recently, long-period and long-duration time seismic waves caused by huge ocean-trench earthquakes have been observed in Japan, and a few dozen to several hundred times of cyclic shaking were occurred after principal motion in these waves. However, seismic performances of structures subjected to long- duration time motions are not clear. Therefore, this paper discusses the load bearing capacities of steel bridge piers during dozens of cyclic loading. Cyclic load carrying tests and a pseudo-dynamic test were carried out in order to investigate the cyclic load bearing capacity of steel bridge piers. More-over, complex nonlinear analyses were conducted to simulate the experimental tests. Consequently, it is found that the load bearing capacity after maximum load is decreased about 10% due to cyclic loading over 10 times. Furthermore, numerical analyses have shown a part of the reason for deterioration of load bearing capacity after maximum load.

A Design Method on Temperature Girder Deformations and Estimation Method of Seismic Maximum Displacement of Steel Bellows as Energy Absorbing Seismic Control Devices
Hiroshi ZUI (Setsunan University), Kentaro TANAKA (Setsunan University), Masahide MATSUMURA, Masahiko YOSHIDA (Kawakin Core-Tech Co., Ltd.) and Hitoshi SAGO (Takada Kiko Co., Ltd.)
Steel Construction Engineering, Vol.19, No.75, JSSC, pp.41-53 (2012) (in Japanese)
This paper proposes a design method of steel bellows as seismic control devices for girder bridges on temperature girder deformations. Steel bellows are connected between girders and abutments in order to reduce the damage of superstructures and substructures. Local plastic strains of bellows are permitted due to temperature expansion and contraction of girders considering fatigue strength. This paper also proposes an estimation method of seismic maximum displacement of steel bellows using nonlinear response spectrum. The size of bellows can be designed based on the proposed methods and the maximum displacements are estimated using nonlinear response spectrum. The estimated values are compared with calculated values by FEM and the estimated values agree fairly well with those of the non-linear time history analyses.

Fundamental Study on Arrangement of Bolted Patch Plate for Repairing Fatigue Crack
Chao PAN, Takashi YAMAGUCHI, Yukiko MITSUGI (Ishikawa National College of Technology), Kunitaro HASHIMOTO (Kyoto University), Kunitomo SUGIURA (Kyoto University), and Akihisa KONDO (Sogo Engineering Inc.)
18th Congress of IABSE, 6pages in CDROM, 19-21 September, Seoul, Korea (2012)
In Japan, the bolted patch plate method is often used for repairing the steel member with a fatigue crack on the bridge. However, it is not clear that how to arrange bolted patch plate position for repairing fatigue clack rationally and effectively. In this paper, study aims to investigate the influence of bolted patch plate arrangement for fatigue strength even though the bolted patch plate were slipped by a severe earthquake.

Finite Element Analysis on the Mechanical Behavior of High Strength Bolted Friction Type Joint with Filler Plate
Xue PENG, Toshikazu TAKAI, Honghe SUN and Takashi YAMAGUCHI
18th Congress of IABSE, 6pages in CDROM, 19-21 September, Seoul, Korea (2012)
Resent year, 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. However, to cut down on costs, some steel plates of bridge structures still use thin plates. So that, in case of joining such thick

plates and thin plates by using high strength bolted friction type joints, it becomes serious problem for joining such thick plate and thin plate by using the filler plate. And, it is lack of enough technical information of influence about thickness of filler plate. Under the background, the tensile experiment about filler plates with extremely thick plates is carried out in 2010. Based on these experimental results, the reduction rate of slip coefficient becomes high as the thickness of the filler plate increase. For complementing experiment results, and solving slipping mechanical of filler plates in detail, the finite element analysis (FEA) has been carried out.
In this study, the FEA model is 1/4 of experimental specimens. About models, the thickness of the connected plates are 50mm-38mm, 60mm-38mm, 75mm-38mm and the thickness of the filler plates are 12mm, 22mm, 37mm. Focusing on FEA results, the relationship between slip coefficient and thickness of plate has been discussed. Also, the mechanical behavior including slip load relationship, slip coefficient, relative displacement, and reduction rate of bolt axial force of such joint was studied. It is understood that slip coefficient becomes low as the thickness of plate increase since bending moment between the connected plate and splice plate had occurred.

Applications of Steel Bellows with Different Steel Material for Seismic Safety of a Viaduct
Shinya HIRAHARA, Masahide MATSUMURA, Hiroshi ZUI (Setsunan University), Kentaro TANAKA (Setsunan University) and Takashi YAMAGUCHI
Proceedings of the 9th German-Japanese bridge symposium, 6pages in CDROM, Kyoto, Japan (2012)
Bridge isolation using high damping rubber bearings, which makes vibration period of the bridge long, is very effective to enhance the seismic safety of a viaduct. The authors have been investigated adaptabilities of steel bellows as girder connecters and have been reported that the steel bellows are effective for damage mitigation of the bridge due to stable energy absorbing capacities of the bellows. In this study, the influence of stress-strain relationship of the steel bellows on vibration control effect of elevated bridge is investigated by FEM analysis. 5 span continuous girder bridge supported by 6 bridge piers is used in the analysis and the steel bellows made of 3 types steel materials are installed at the both ends of the girder ends. The steel bellows is modeled by spring elements, of which the load-displacement relationship and an equivalent damping coefficient were decided by referring to cyclic and dynamic loading tests results in the axial direction of the steel bellows. It is concluded that all the steel bellows can provide stable vibration controlling effects.

Loading Test and Monitoring of the Newly Constructed Portal Rigid-frame Bridge in Osaka
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Proceedings of the 9th German-Japanese bridge symposium, 9pages in CDROM, Kyoto, Japan (2012)
Recently, the number of steel-concrete composite rigid frame bridges for short and medium span length is increasing in Japan. Structural features of this type of the bridge are rigid connections between steel girders and RC abutments without expansion joints. Application of this type of the bridge can expect enhancement of the service life, reduction of the life cycle cost and improvement of earthquake resistance due to no bearings and expansions. However, structural performance of the rigidly connected part and vibration characteristic of the bridge are not clear, so a conservative design method has been done frequently. Moreover the performance after aged deterioration is not clear too. Carried out in this study are the actual bridge instrumentations to clarify structural performance of the rigidly connected part and vibration characteristic of the bridge. In addition, initial data of the bridge is measured before in-service and the aged change for the next 2 years also will be investigated.

Experimental Study on Slip Behavior of High Strength Bolted Joints for Underwater Steel Structure
Honghe SUN, Takashi YAMAGUCHI, Kyoichi NAKAYASU (Hitachi Zosen Corp.), Toshiaki MORII (Hitachi Zosen Corp.) and Masahide MATSUMURA
Proceedings of the 9th German-Japanese bridge symposium, 7pages in CDROM, Kyoto, Japan (2012)
In recent years, the growing needs for the refurbishment of the superannuated hydraulic steel gates become a problem to be solved. Most of field joints of them are welded on site in spite of some difficulties in welding such as thermal strain concentrations, work space limitations and so on. On the other hand, high strength bolted frictional type joints are hardly applied to their refurbishment because of the following unclear points; a slip coefficient with water ingress, decrease of bolt axial force by corrosion, delayed fracture of the high strength bolt and so on. If the high strength bolted frictional type joints can be applied to them, it widely contributes to improve the workability, reliability and economic efficiency. In this study, slip behavior of the high strength bolted frictional joints subjected to tensile load is investigated by focusing on water pressure, bolt axial force and the difference of plates' thickness. Based on the experimental results, the slip coefficient is revealed in the case of water ingress into the frictional surface.

Study on Mechanical Property of Higher Yield Strength Steel Plates for Bridges
Takahiro TARUI (Osaka University), Kiyoshi ONO (Osaka University), Masahide MATSUMURA and Jumpei YOSHIYAMA
Proceedings of the 9th German-Japanese bridge symposium, 6pages in CDROM, Kyoto, Japan (2012)
Higher yield strength steel plates for bridges, SBHS has been standardized by Japanese Industrial Standards (JIS). In order to use SBHS for bridges generally, it is important to grasp the mechanical property of SBHS. However, there is not enough information on the mechanical property of SBHS500 and SBHS700. In this study, tensile tests of SBHS500 and SBHS700 were conducted to gain the information on the mechanical property and the stress-strain relationship. The test specimens were cut along rolling direction and perpendicularly to rolling direction. Based on the test results, the information on the mechanical property and stress-strain relationships of SBHS500 and SBHS700 were gained and the feature of them was investigated.

Analytical Study on Strengthening Effects of U-shaped Attached Plates onto Steel Deck Plates with U-ribs
Satoshi KIMURA, Takashi YAMAGUCHI, Yoshio TAMBA (Hanshin Expressway Management Technology Center), Hiroki SUGIYAMA (Hanshin Expressway Co., Ltd.) and Masahide MATSUMURA
Proceedings of the 9th German-Japanese bridge symposium, 6pages in CDROM, Kyoto, Japan (2012)
Prevention of fatigue cracks at orthotropic steel deck consisting steel box girders of viaducts in urban area is one of major concerns to be solved urgently. Then, a strengthening method by filling mortar into the existing U-shaped ribs and adding inverted U-shaped attached plates between the existing ones by high strength one-side bolts and adhesives is proposed. This strengthening method does not require the traffic restriction. In this study, FEM analysis is carried out in order to clarify the strengthening effects of the method by focusing on the bolt pitch connecting both the U-shaped attached plates. Also adhesion effects of the adhesive applied the contact surfaces between the deck plates and the additional U-shaped attached plates are investigated. It can be concluded that adhesion is necessary to obtain sound strengthening effect by the strengthening method. In addition, the differences of the bolt pitch do not provide significant changes on the minimum principal stress.

Seismic Retrofit for a Network Arch Bridge with Slit-type Knock-off Bearings
Koichi SUGIOKA (Hanshin Expressway R&D Co., Ltd.), Nobuhiro MASHIMA (Hanshin Expressway Co., Ltd.), Hiroaki MATSUSHITA (Hitachi Zosen Corp.), Takehiko HIMENO (Kawakin Core-Tech Co., Ltd.) and Masahide MATSUMURA
Proceedings of the 15th World Conference on Earthquake Engineering, 10pages, Lisbon, Portugal (2012)
Seismic retrofit of an existing network arch bridge against large-scale (Level 2) earthquake ground motions was performed by modifying existing fixed steel bearings into slit-type knock-off bearings. Three-dimensional non-linear dynamic response analyses were carried out considering site-specific ground motions. It was confirmed that shear panel dampers as passive energy-dissipation were needed on both fixed-side and movable-side pier tops to avoid the potentially difficult retrofit work for the undersea pier anchors and foundations. The authors proposed slit-type knock-off bearings with the knock-off function as triggers against the Level 2 earthquake ground motions to provide isolation effect. Performance tests of the slit-type knock-off bearings were conducted to verify the required performance for the seismic retrofit design.

Characteristic of Tensile Strength and Charpy Absorbed Energy of Welded Joints for Steel Bridge Structures
Kuniaki MINAMI (Japan Railway Construction, Transport and Technology Agency) and Takashi YAMAGUCHI
Journal of JSCE, Ser.A1 (SE/EE), Vol.68, No.3, JSCE, pp.623-634 (2012) (in Japanese)
Many kinds of steel are widely used in steel bridge structures. This report summarized the welding procedure tests carried out in 2003-2010. In these welding tests, four kinds of steel were employed to fabricate welded joint specimens, which were SM490Y, SMA490W, SM570Q and SMA570W. In this report, the results of tensile strength and Charpy absorbed energy were shown. Tensile strength exceeded to the nominal base metal strength for all tensile coupon specimens. Charpy absorbed energy of HAZ (heat affect zone) also exceeded to 200J on an average in many type of steel. However, there were a few cases that an average of Charpy absorbed energy of Depo (weld metal) is beyond 100J, regardless of welding wire and welding method. It has been shown that the mechanical properties, such as tensile strength and Charpy absorbed energy, of welding materials does not exceed to that of steel material.

Experimental Study on Cyclic Loading Behavior of Rivet Jointed Panel Point Damaged by Corrosion
Takamasa FUJIMOTO (Kyoto University), Kunitaro HASHIMOTO (Kyoto University), Kunitomo SUGIURA

(Kyoto University) and Takashi YAMAGUCHI
Proceedings of Constructional Steel, Vol.20, JSSC, pp.349-356 (2012) (in Japanese)
In this study, cyclic loading experiment is carried out in order to clarify the mechanical behavior and the relationship between corrosion of rivet head and residual strength of rivet jointed panel point. In the experiment, non-damaged and damaged rivet jointed panel point specimens are subjected to cyclic load, which cut from the demolished steel bridge members. From the result, it is found that the residual strength of damaged rivet jointed panel point showed almost consistent result with the non-damaged specimen. On the other hand, it is found that energy absorption performance decreases because the rivet is slipping out.

Basic Study on the Performance after the Slip for Bolted Joint for Friction Type
Mami NISHIKAWA (Ishikawa National College of Technology), Yukiko MITSUGI (Ishikawa National College of Technology), Takashi MATSUNAMI (Ishikawa National College of Technology) and Takashi YAMAGUCHI
Proceedings of Constructional Steel, Vol.20, JSSC, pp.371-376 (2012) (in Japanese)
Bolted joint for friction type is designed supposing that slip is not occurred. However, after bolted joint for friction type is slipped, the joint resists through shear and bearing mechanism. In order to study the performance of the bolted joint for friction type after the joint slipped, we carried out the examination on the bolted joint. It is concluded that the capacity of joint after it slipped can be below the slip load. The capacity of the joint after slip is influenced by the distance of end. Therefore, it is necessary that the distance of end is designed on the viewpoint break of the end to expected the capacity of the joint after slip.

Experimental Study on the Behavior of Anchoring Devices for Strengthening of Steel Girders with CFRP Rods
Katsuyoshi NOZAKA (Ritsumeikan Univsrsity), Akira TSUKIYAMA (Fuji Engineering Co., Ltd.), Masahide MATSUMURA, Nobuhito OCHI (Akashi National College of Technology), Toshiyuki ISHIKAWA (Kyoto University) and Nobuhiro HISABE (Mitsubishi Plastics Inc.)
Proceedings of Constructional Steel, Vol.20, JSSC, pp.647-654 (2012) (in Japanese)
Repair and strengthening technique using CFRP strips of high elasticity to steel bridge members provide an easy adoptability and an effective strengthening effect. When considering application of the technique to a lower flange plate of steel I-shaped girder, pointed out are difficulties in installation of the CFRP strips at the connection parts due to projection of the splice plates. Then a new strengthening technique using CFRP rods to the projecting part is devised to prevent debonding and to ensure stress reduction at the edges of the strips. Then in this study, a strengthening effect using an anchor part made of CFRP cover filled with epoxy resin and CFRP rods connecting the anchor parts is experimentally checked through pull-out tests.