Study on Ultimate Strength and Deformation of Compression Chord Member considering Gusset Plate in a Truss Bridge

Masahide MATSUMURA, Junpei YOSHIYAMA and Takashi YAMAGUCHI

Journal of Structural Engineering, Vol. 59A, JSCE, pp.169-179 (2013) (in Japanese)

Investigated in this study is the ultimate strength of a compression chord member in a truss bridge, which is designed according to the Specification for Highway Bridges in Japan. An adequate modeling method of the member, and the support condition of the member considering gusset plates at the end of the member are checked through FEM analysis. It is revealed that the ultimate strength and deformation of the member in the truss bridge is very much similar to those of a fixed supported column in compression. Also proposed is an economic and rational design of the truss bridge.

Strengthening Effects of Eccentric Compression Steel Columns bonded CFRP Plate of High Elastic Modulus

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Journal of Structural Engineering, Vol. 59A, JSCE, pp.190-198 (2013) (in Japanese)

In conventional strengthening techniques for existing steel structures, steel plates are additionally welded or bolted to the existing steel members to reduce working stress. Here, FRP materials can be alternatives of conventional techniques in terms of easier applicability. Among the FRPs, CFRP strips of high elastic modulus provide higher strengthening effects. Then, carried out in this paper are loading tests of eccentric and more effective compression steel columns adhered the CFRP strips separately onto the flange plates. It is concluded that strengthening effect of the CFRP strips for bending not for axial loading decreases when the CFRP strips are separately adhered onto the flange plates of the steel columns subjected to predominant compression axial force.

Structural Rationalization of the Undersurface Retrofitting Method with Splice Plates and Mortar-filling into the Trough Ribs for Existing Orthotropic Steel Decks

Yoshio TAMBA (Hanshin Expressway Technology Center), Satoshi KIMURA (Yokogawa Bridge Corp.), Takashi YAMAGUCHI, Hiroki SUGIYAMA (Hanshin Expressway Co., Ltd.), Akiko TABATA (Hanshin Expressway Co., Ltd.), and Yoshihiko TAKADA(Hanshin Expressway Co., Ltd.)

Journal of Structural Engineering, Vol. 59A, JSCE, pp.767-780 (2013) (in Japanese)

The undersurface retrofitting method (installation of splice plates between the trough ribs and filling of mortar into the trough ribs) for existing orthotropic steel decks is proposed. This retrofitting method does not require the traffic restriction. In this study, FEM analysis and static load test are carried out in order to rationalize this retrofitting method by evaluating the bolt pitch and the stress reduction effect. As a result, we understand that it is possible to apply the bolt pitch of 300(mm) to this retrofitting method and that the adhesives between the orthotropic steel deck and the splice plate are important.

Study on Mechanical Property of High Durability Friction Grip Joints with High Strength Countersunk Head Bolts for Steel Bridge Structures

Akiko TABATA (Hanshin Expressway Co., Ltd.), Hidesada KANAJI (Hanshin Expressway Co., Ltd.), Yoshihide KURONO and Takashi YAMAGUCHI

Journal of Structural Engineering, Vol. 59A, JSCE, pp.808-819 (2013) (in Japanese)

The authors focused on the high strength bolted friction grip joints with countersunk head bolts which can finish the surface of the connection plate flat smoothly and prevent from functional depression due to corrosion. In this study, we have compared the slip strength of the joints which has the optimum countersunk head angle with that of the joint with the normal high strength bolt through the standard slippage test considering variation of plate thickness and the yield strength of the base and splice plates. It was concluded from the experimental result that the slip strength of the joints with countersunk head bolts exceeds the design slip strength specified in JSHB calculated by the slip coefficient 0.45 and that its slip coefficient is about 10% lower than that with normal head bolts. It is caused by that the contact pressure of the joints with countersunk head reduces due to local yielding around the bolt holes.

Small-sized Steel Bellows as Energy Absorbing and Displacement Restraining Device for Bridge

Masahide MATSUMURA

Proceedings of the 6th Taiwan-Japan workshop on structural and bridge engineering, pp.119-123, (2013)

Characterization of Mechanical Properties of Welding Materials using Fabrication of Steel Bridges
Kuniaki MINAMI (Japan Railway Construction, Transport and Technology Agency) and Takashi YAMAGUCHI
Journal of JSCE, Ser.A1 (SE/EE), Vol.69, No.3, JSCE, pp.452-466, (2013) (in Japanese)
Recently, many kinds of welding materials were widely used in fabrication of steel bridges. It was considered that the quality of these welding materials has been remarkably improved. However, the statistical characteristics of the material are not clarified. In this paper, we have investigated the 638 of welding materials on the basis of the mill sheet in order to clarify their quality. Investigated items were tensile strength, yield strength, Charpy-absorbed-energy, elongation and yield ratio, and these mechanical properties were shown. We also showed improvement in the quality, comparing with the conventional steel data and welding procedure tests date, which were SM490Y, SMA490W, SM570Q and SMA570W.

Study on Slip Behaviour of High Strength Bolted Friction Type Joint with Extremely Thick Plates by Using Finite Element Analysis
Toshikazu TAKAI, Xue PENG, Honghe SUN and Takashi YAMAGUCHI
IABSE Conference Rotterdam 2013, Vol. 99, 8pages (on CDROM), Rotterdam (2013)
High strength bolted friction type joints are commonly used to join members of steel bridge structures. Recently, such joints have become larger, because members of bridges tend to be large to seek structural simplicity. Since large members consist of extremely thick plates, large size joints are needed with many bolts in a line, containing thick plates including splice plates. It is of concern that many bolts and thick plates affect the slip behaviour of such large size joints. So, FEA focused on joints with many bolts and thick plates is carried out. Based on the results, it is clear that a non-uniform distribution of friction force exists. And, it is also shown that a certain combination of thicknesses of connected plates and splice plates has the large capacity of slip resistance. It is concluded that such results can be explained by the influence of the additional bending moment due to thick plates.

Study on Applicability of High Durability Friction Grip Joints with High Strength Countersunk Head Bolts for Steel Bridge Structures
Akiko TABATA (Hanshin Expressway Co., Ltd.), Hidesada KANAJI (Hanshin Expressway Co., Ltd.), Yoshihide KURONO and Takashi YAMAGUCHI
IABSE Conference Rotterdam 2013, Vol. 99, 8pages (on CDROM), Rotterdam (2013)
The authors focused on the high strength bolted friction grip joints with countersunk head bolts which can finish the surface of the connection plate flat smoothly and prevent from functional depression due to corrosion. Firstly we carried out Finite Element Analysis in order to evaluate the contact pressure of double shear connected friction joints with countersunk heads varying the angle of countersunk head. Secondly, we have compared the slip strength of the joints which has the optimum countersunk head angle with that of the joint with the normal high strength bolt through the standard slippage test considering variation of plate thickness and the yield strength of the base and splice plates. As a result, it was concluded that the slip strength of the joints with countersunk heads exceeds the required design slip strength which has specified in JSHB and that its slip coefficients is about 10% lower than that with normal head bolts.

Experimental Study on Ultimate Strength and Ductility of Steel Short Column with Longitudinal Stiffeners made of SBHS700
Keita HAMAMURA (Osaka University), Kiyoshi ONO (Osaka University), Masahide MATSUMURA, Takahiro TARUI (Osaka University) and Shinya KODA
Proceedings of the 16th Symposium on Performance-based Seismic Design Method for Bridges, pp.391-394, JSCE (2013) (in Japanese)
SBHS700 indicates higher yield strength and higher yield ratio like high strength steel. Focused on in this study is a hybrid stiffened plate, in which longitudinal stiffeners made of SBHS700 and flange and web plates made of SS400. Then compression test of short and rectangular steel hollow column with the hybrid stiffened plates are conducted. It is concluded that the use of the hybrid stiffened plate can be expects almost the same ultimate strength and higher ductility compared with non-hybrid stiffened plate.

Experimental Study on Rapture Characteristics of Knock-off Steel Side Block as Displacement Restrainers
Takahiro KANATA and Masahide MATSUMURA
Proceedings of the 16th Symposium on Performance-based Seismic Design Method for Bridges, pp.309-316, JSCE (2013) (in Japanese)
Steel side block with slit, which is designed to break when seismic fore corresponding to the ultimate shear force

the cross section with the slit is subjected, is developed and proposed as a trigger to control restricting condition of superstructure. In this study, breaking tests are carried out to understand how shape of the slit influences on breaking characteristics of the steel side block with slit. Then it is revealed that the proposed shape of the slit can provide stable break load with less fluctuation and the braking displacement is calculated based on braking mechanism of the side block.

FEA Study on the Slip Behavior of High Strength Multi Bolted Friction Type Joints with Thick Plates by Structural Dimensions

Xue PENG, Takashi YAMAGUCHI, Toshikazu TAKAI, Jun MURAKOSHI (Public Works Research Institute) and Mamoru SAWADA (Public Works Research Institute)

Journal of JSCE, Ser.A1 (SE/EE), Vol.69, No.3, JSCE, pp.452-466, (2013) (in Japanese)

Resent years, from the viewpoint of rational structural members of steel bridges, the high strength bolted friction type joints tend to be large. Since the slip behavior of high strength multi bolted friction type joints with thick plates is not clear, the slip strength tests for such joints had been carried out. And from the experimental results, it can be found that slip coefficient varies depending on the number of rows of bolts in a line. In this study, in order to clarify the slip behavior of such joints, FE analysis has been conducted with various structural dimensions, such as slip/yielding strength ratio, section shape of the connected plate etc. As a result, the slip coefficient of the joint with many bolts in a line becomes low because each frictional force per one bolt is unequal, and the plate width effects on the slip strength more significantly than other structural dimensions.

Analytical Study on Mechanical Behavior of Friction Grip Joints with High Strength Countersunk Head Bolts and Its Geometrical Configurations

Akiko TABATA (Hanshin Expressway Co., Ltd.), Hidesada KANAJI (Hanshin Expressway Co., Ltd.), Yoshihide KURONO and Takashi YAMAGUCHI

Steel Construction Engineering, Vol.20, No.79, JSSC, pp.19-28, (2013) (in Japanese)

The authors focused on the high strength bolted friction grip joints with countersunk head bolts which can finish the surface of the connection plate flat smoothly and prevent from functional depression due to corrosion. In this study, we carried out FE analysis varying the angle of countersunk head in order to evaluate the contact pressure of double shear connected friction joints with countersunk heads. Also, we have investigated the influence on load transferring mechanism by using countersunk head bolt for frictional joints. It has concluded that the most desirable angle of the countersunk head is 90 degrees. CD series's slip strength is about only 4% lower than that with normal head bolts.

Fundamental Study on Structural Soundness Evaluation of Existing Arch Bridge by using SOM

Yoshinori IKEDA, Takashi YAMAGUCHI, Takeshi KITAHARA (Kanto Gakuin University), Kunitomo SUGIURA (Kyoto University) and Kouji MORIWAKA

Steel Construction Engineering, Vol.20, No.79, JSSC, pp.53-66, (2013) (in Japanese)

The authors focused on the high strength bolted friction grip joints with countersunk head bolts which can finish the surface of the connection plate flat smoothly and prevent from functional depression due to corrosion. In this study, we carried out FE analysis varying the angle of countersunk head in order to evaluate the contact pressure of double shear connected friction joints with countersunk heads. Also, we have investigated the influence on load transferring mechanism by using countersunk head bolt for frictional joints. It has concluded that the most desirable angle of the countersunk head is 90 degrees. CD series's slip strength is about only 4% lower than that with normal head bolts.

Slippage Test of Frictional High Strength Bolted Joints with Adhesives for Corroded Damaged Steel Members

Yoshio TAMBA (Hanshin Expressway Technology Center), Shinya YUKITO, Takashi YAMAGUCHI, Haruyuki SAKODA (Hanshin Expressway Technology Center) , Akito HIGATANI (Hanshin Expressway Co., Ltd.) and Akiko TABATA (Hanshin Expressway Co., Ltd.)

Proceedings of the 13th East Asia-Pacific Conference on Structure Engineering and Construction (EASEC-13), 8pages (on CDROM), Sapporo, JAPAN (2013)

In this study, FE analysis for the girder ends with corrosion has been carried out in order to understand the collapse process and to evaluate its ultimate strength. At first, the strength of the girder end with various corroded damages is evaluated based on the current design standards, “Specifications for Highway Bridges in Japan”. Secondly, these collapse mechanism are analyzed from the analytical results, such as shapes of the deformation mode, stress distribution, and load-deflection relationships and so on. Finally, we had summarized a flow diagram

of a process of failure mode and the limit strength such as elastic, full-plastic and ultimate limit states taking into account for local buckling.

Strength Evaluation for a Corroded Damaged Steel Gilder End Considering Its Collapse Mechanism
Makoto USUKURA (Tokyo Consultants Co., Ltd.), Takashi YAMAGUCHI, Yasuo SUZUKI (Utsunomiya University) and Yukiko MITSUGI (Ishikawa National College of Technology)
Proceedings of the 13th East Asia-Pacific Conference on Structure Engineering and Construction (EASEC-13), 8pages (on CDROM), Sapporo, JAPAN (2013)
In this study, FE analysis for the girder ends with corrosion has been carried out in order to understand the collapse process and to evaluate its ultimate strength. At first, the strength of the girder end with various corroded damages is evaluated based on the current design standards, "Specifications for Highway Bridges in Japan". Secondly, these collapse mechanism are analyzed from the analytical results, such as shapes of the deformation mode, stress distribution, and load-deflection relationships and so on. Finally, we had summarized a flow diagram of a process of failure mode and the limit strength such as elastic, full-plastic and ultimate limit states taking into account for local buckling.

Fundamental Study on the Dynamic Behavior of Sliding Bearing with Trigger for Bridge Structures
Takahiro KANATA, Masahide MATSUMURA, Yasuyuki NAKANISHI (NEWJEC Inc.) and Takashi YAMAGUCHI
Proceedings of the 13th East Asia-Pacific Conference on Structural Engineering, 8pages (on CDROM) (2013)
Isolation rubber bearings are widely used for damage mitigation of structures. However, isolation and damping effects tend to be optimized against the short-period earthquake grand motions defined by the Specifications for Highway Bridges in Japan. That is, as the isolation effects of the rubber bearings show strong frequency dependence, applicability against a long-period earthquake grand motion is not clear, for instance. Then the authors have focused on combination use of low friction and elastic sliding bearings, triggers and displacement restrainers for bridge bearings. Fundamental responses of the proposed bearings are checked through shaking table tests in this study and also discussed are analysis procedure of the proposed bearings with the trigger in the seismic response analysis. Application example of the proposed bearings to a viaduct is simulated through seismic response analysis. It is concluded that the analytical results show good agreement with the experimental results when considering the changes in the vibration modes and damping conditions before/after releasing the displacement of the superstructure by the triggers and the maximum displacement is approximately computed even when without considering them in the seismic response analysis.

An Experimental Study on Mechanical Properties of SBHS700 and Application of SBHS700 to Stiffened Plates
Keita HAMAMURA (Osaka University), Kiyoshi ONO (Osaka University), Masahide MATSUMURA, Takahiro TARUI (Osaka University) and Shinya KODA
Proceedings of the 13th East Asia-Pacific Conference on Structural Engineering, 6pages (on CDROM) (2013)
Higher yield strength steel plates for bridges, SBHS, has been standardized by Japanese Industrial Standard (JIS). However, there is not enough information on the mechanical properties of SBHS700 compared with SM490 and SM570. In this study, tensile tests of SBHS700 were conducted to earn the information on mechanical properties and stress-strain relationship. Moreover, axial compressive tests were conducted with the stiffened box section test specimens whose stiffeners are made of SBHS700. According to the axial compressive tests, the ultimate strength and the ductility of hybrid stiffened plates by applying SBHS700 were investigated.

Cyclic Loading Test of Small-sized Steel Bellows made of Different Steel Materials subjected to Axial Displacement
Masahide MATSUMURA, Kentaro TANAKA (Setsunan University), Hiroshi ZUI (Setsunan University) and Takashi YAMAGUCHI
Proceedings of Constructional Steel, Vol.21, JSSC, pp.125-130 (2013) (in Japanese)
Steel bellows as energy absorbing bridge connectors, having been investigated by the authors, show stable hysteresis loop and energy absorbing capacity when subjected to axial displacement. In this paper, cyclic behaviors of small sized steel bellows by bended in the same shape and made of different steel materials are investigated through cyclic loading test subjecting a larger axial displacement. Also discussed is a simplified stress-strain relationship of steel materials of the steel bellows considered in FEM analysis to approximate the load-displacement relationships and energy absorbing capacities of the steel bellows. It is concluded that a method considering the yield stress increase by bending process of steel plate is effective in the analysis of the steel

bellows but against a larger displacement where tensile load greatly increases due to strain hardening.

Effect of Ultimate Strength Behavior due to the Support Eccentricity of the Girder End with Corrosion of Highway Bridges
Makoto USUKURA (Tokyo Consultants Co., Ltd.), Yasuo SUZUKI (Utsunomiya University), Takashi YAMAGUCHI and Yukiko MITSUGI (Ishikawa National College of Technology)
Proceedings of Constructional Steel, Vol.21, JSSC, pp.193-200 (2013) (in Japanese)
In recent years, it has been well known that some of steel bridges are deteriorated by corrosion at the girder ends. On the other hand, it is reported that the support is moved by the earthquake. If the phenomenon of both events is occurred, it is expected that the ultimate strength of the girder ends decline. In this study, FE analysis for the girder ends with corrosion has been carried out in order to understand effect of ultimate strength behavior due to the eccentricity of the support of the girder end with corrosion of a plate girder for Highway Bridges.

Discussion on A Design Method for a Emergency Crack Repair by Using High-strength Bolted Cover Plates
Chao Pan, Takashi YAMAGUCHI, Akihisa KONDO (SOGO Engineering Inc.) and Yukiko MITSUGI (Ishikawa National College of Technology)
Proceedings of Constructional Steel, Vol.21, JSSC, pp.216-223 (2003) (in Japanese)
High-strength bolted cover plates often use for a emergency crack repair, designed as a friction-type joint. A friction-type joint should be designed must not slip in service for a structural connection. Actually, even if the friction-type joint slipped, it still has the shear and bearing resistance. So a design for the emergency crack repair may consider the shear and bearing resistance for repairing crack, and it is discussed based on a performance for a design method.

Considerations on Seismic Behavior of Steel Bridge Piers installed Isolation Bearing with Triggers
Masahide MATSUMURA, Takahiro KANATA, Yasuyuki NAKANISHI (NEWJEC Inc.) and Takashi YAMAGUCHI
Proceedings of Constructional Steel, Vol.21, JSSC, pp.437-440 (2003) (in Japanese)
Resent year, from the viewpoint of rational fabrication of the steel bridges, there are some applications using Side blocks are installed besides isolating bearings for restricting displacement of superstructure. The authors consider an adoption of trigger type of steel side blocks, which restrict the displacement of superstructure against a small and medium earthquake grand motion and release it against strong earthquake grand motions, in order to obtain isolation effect even in the transverse direction of the bridge axis. In this study, the fundamental behavior of the proposed bearing system is examined by shaking table test, analysis procedure to approximate the response is proposed, and installation effects of the trigger type of steel side blocks into an isolated viaduct on bridge pier response is computed through dynamic response analysis.

Compression Tests of Steel Columns bonded CFRP Strips of High Elastic Modulus focusing on Adhesive Length
Masahide MATSUMURA, Shinya KODA, Nobuhiro HISABE (Mitsubishi Plastics Inc.) and Takashi YAMAGUCHI
Proceedings of the 7th International Symposium on Steel Structures, ISSS, Jeju, Korea, pp.92-93 (2013)
Presented in this paper is strengthening technique of steel columns using CFRP strips as alternatives of steel plates bolted in conventional one. As both the axial and flexural rigidity can be improved more effectively when the elastic modulus of the strips is higher, so applications of the CFRP strips of high elastic modulus to steel columns are focused on in this study. Then carried out are compression tests of pin-connected steel column specimens adhered the CFRP strips with different adhesive patterns onto the flange plates. It is concluded that improvements of the initial stiffness and enhancement of the elastic range can be obtained by the adhered CFRP strips unless the debonding does not occur.

Study on Dynamic Behavior of Isolated Viaduct with Triggers; Modeling and Analysis Procedure
Masahide MATSUMURA, Takahiro KANATA, Yasuyuki NAKANISHI (NEWJEC Inc.) and Takashi YAMAGUCHI
Proceedings of the 7th International Symposium on Steel Structures, ISSS, Jeju, Korea, pp.264-265 (2013)
Bridge isolation using isolation rubber bearings effectively reduces damages of bridge pier and foundation and is widely used in Japan. Here as the isolation effects are required only against a strong earthquake, the authors propose combination use of the isolation bearings and triggers, which restrict the displacement of superstructure against a small and medium earthquake grand motion and release it against a strong earthquake grand motion. In

the study, combination use of sliding bearings and the triggers are examined. Then, modeling and analysis procedure of a vibration system with the trigger is verified through shaking table test. And the break characteristics of the trigger are varied in seismic response analysis targeted a viaduct. It is concluded that the break load of the trigger greatly influences on the maximum displacement of the bridge pier and the trigger will be used for the maximum displacement control of the pier.

An Experimental Study on Seismic Performance of Hybrid Steel Piers with Vertical Ribs Made from SBHS700

Kiyoshi ONO (Osaka University), Masahide MATSUMURA and Seiji OKADA (IHI Infrastructure System Co., Ltd.)

US-Japan Bridge Workshop, 10pages (2013)

Some methods for evaluating the seismic performance of steel bridge piers have been already proposed in the previous studies. Steel bridge piers are sometimes required to have seismic performance that ductility is improved with restraining increase in ultimate strength but it is difficult to fulfill such seismic performance by the proposed methods in previous studies. By the way, "Higher yield strength steel plates for bridges" has been standardized in Japanese industrial Standard (JIS). The major feature of higher yield strength steel plates for bridges, SBHS, is high yield strength and high weldability. Among SBHS, SBHS700 has the highest yield strength and the highest tensile strength. There is possibility of fulfilling the seismic performance of steel bridge piers which has been difficult to gain so far by applying SBHS700 to them. Therefore, the purpose of this study is to investigate material properties of SBHS700 and the seismic performance of hybrid steel bridge piers whose vertical ribs are made from SBHS700.