Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 51 (1986)

Artikel: Quality control at erection site of Iwakuorjima bridge

Autor: Ohashi, Masamitsu / Matsuzaki, Minuro / Miyashita, Chikara

DOI: https://doi.org/10.5169/seals-39585

Quality Control at Erection Site of Iwakurojima Bridge

Contrôle de qualité sur le chantier du pont Iwakurojima

Qualitätskontrolle beim Bau der Iwakurojima-Brücke

Masamitsu OHASHI

Born 1928, received his Dr. civil engineering degree at Kyoto University, Japan. He was engaged in research at Laboratory of Civil Engineering, Ministry of Construction and in construction of big bridge projects like Kanmon Highway and Kojima–Sakaide route. Now, he is Councilor in H. S. B. A.

Minuro MATSUZAKI

Born 1936, received his civil engineering degree at Hokkaido University, Japan. He was engaged in the Construction of Ohnaruto, and Innoshima Bridges and Kojima–Sakaide route. Now he is chief of Second Engineering Department in H. S. B. A.

Chikara MIYASHITA

Born 1943, received his M. E. civil engineering degree at Nagoya University, Japan. He was engaged in Construction of Tozaki Bridge and Kojima–Sakaide route. Now, he is vice chief of the Kojima construction office in H. S. B. A.

Masahiko YASUDA

Born 1945, received his civil engineering degree at Kyoto University, Japan. He was engaged in Construction of Ohnaruto and Iwakurojima Bridges. Now, he is a staff member of 1st construction Bureau H. S. B. A.

SUMMARY

Iwakurojima bridge is a road and railway combined truss type cable-stayed bridge with a field-welded composite steel deck. This report describes the problems associated with field execution of this type of bridge and countermeasures, as well as general quality control.

RÉSUMÉ

Le pont Iwakurojima est un pont en treillis haubané avec tablier métallique composé soudé sur place. *Il sert au trafic routier et ferroviaire. Le rapport traite des problèmes concernant l'exécution* de ce type de pont ainsi que le contrôle de qualité en général.

ZUSAMMENFASSUNG

Die Iwakurojima-Brücke ist eine Fachwerk-Schrägseil-Konstruktion für kombinierten Strassen- und Eisenbahn-Verkehr. Die Stahl-Fahrbahn wurde an Ort geschweisst. Der vorliegende Beitrag beschreibt zunächst die entsprechenden Ausführungsprobleme und die getroffenen Gegenmassnahmen für die Arbeiten an der Fahrbahn und dann die übrigen Massnahmen der Qualitäts-Kontrolle.

1. OUTLINE OF IWAKUROJIMA BRIDGE AND CHARACTERISTICS OF ITS COMPOSITE STEEL DECK

Iwakurojima bridge, currently under construction on the Kojima-Sakaide segment of the Honshu-Shikoku bridge project, is Japan's first combined truss type cable-stayed bridge. At 790m in overall length and 420m in central span length, it is among the largest in the world.
Fig. 1 shows a general view of Iwakurojima bridge. It employs a double-deck truss: the upper deck will carry 4 traffic lanes, while the lower will accomodate an ordinary double-track railway and a planned double-track Shinkansen. Two 11-cable fan-shaped arrangements are employed on each side, anchored at the upper chord member panel point. The steel deck is to be combined with the upper chord member for the following reasons:

- Horizontal component of longitudinal cable tensile force is concentrated on the upper chord side.
- Combined bridges require minimal deformation and stress amplitude, which is achieved by increasing cable regidity. Therefore, upper chord members must have a cross section capable of receiving cable pre-stress.
- Upper chord member thickness and quenched and tempered steel use are reduced, eliminating the need for upper lateral members.

PROFILE

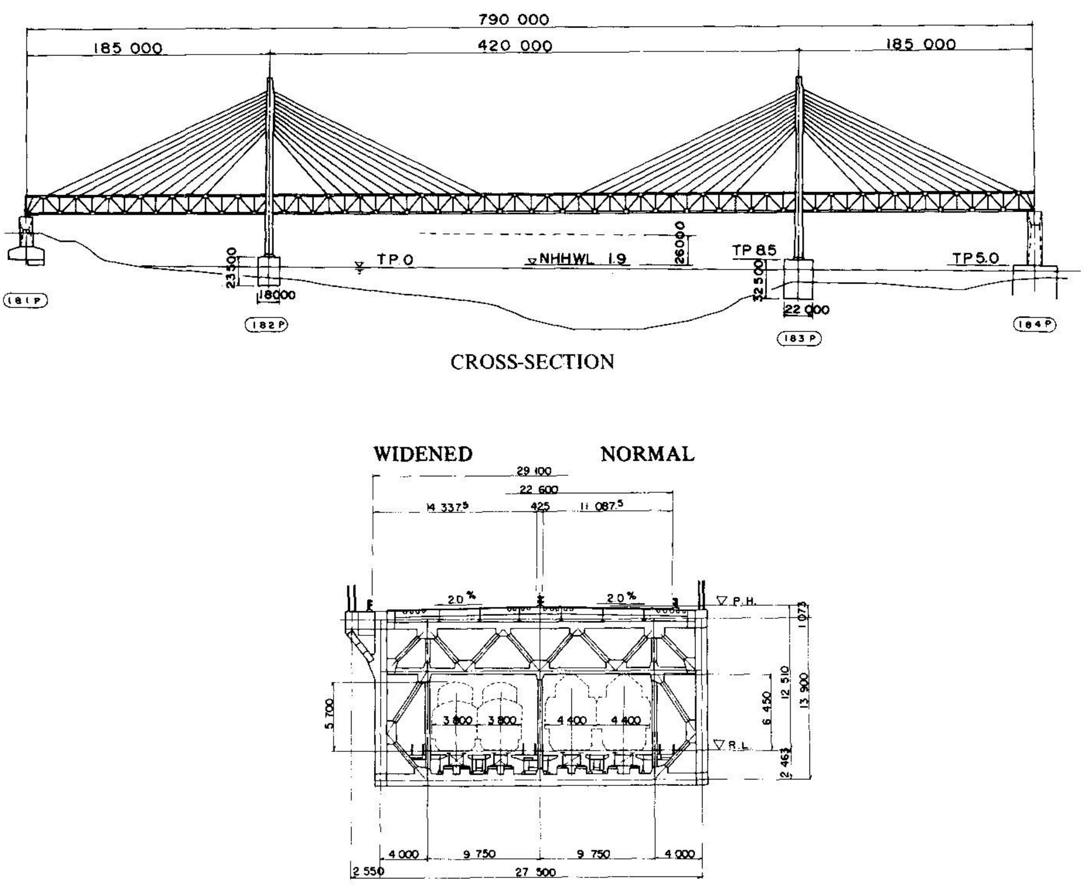


Fig. 1 General View

Steel deck is field welded to minimize damage to pavement structure and steel joint weight.

The following are problems associated with the composite steel deck:

- Field welding requires that the effects of contraction on main truss be considered during design and execution.
- Connection with main and floor trusses requires high member dimensional accuracy.

In view of the above, steel deck is longitudinally divided into three erection blocks, as shown in Fig. 2, each of which are temporarily assembled with all other members in the factory. Holes for interconnection bolts, final processing to plane dimensions and field weld groove accuracy are confirmed.

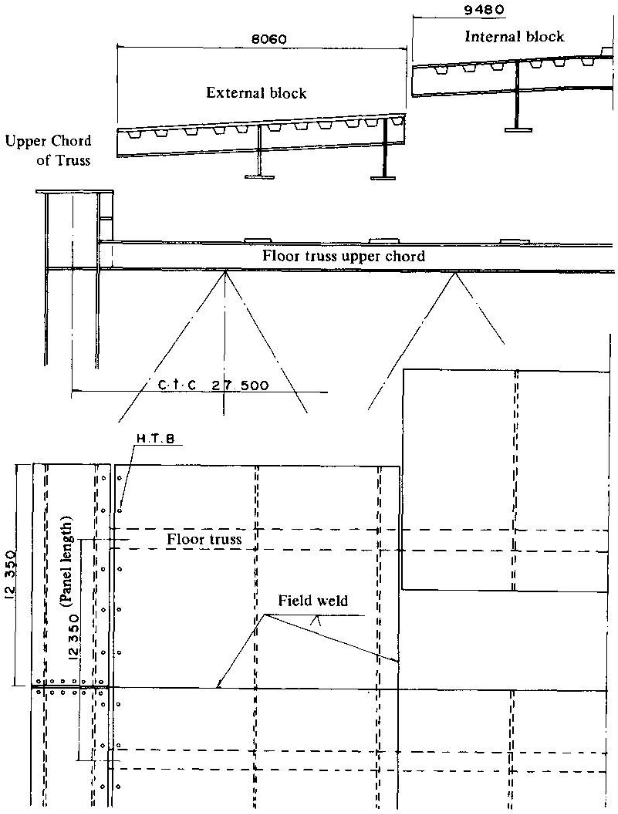


Fig. 2 Composite Steel Deck Construction

2. ERECTION METHOD OUTLINE

The Iwakurojima bridge erection sequence is roughly depicted in Fig. 3. For girder erection, an en bloc erection method is actively employed to minimize the work period and improve accuracy. To resist both dead and live loads, steel deck must be combined with main truss, necessitating simultaneous erection of block and cantilever with main truss at the factory and on the site, respectively. Fig. 4 shows the classification of girder erection methods and steel deck-upper chord member connection methods.

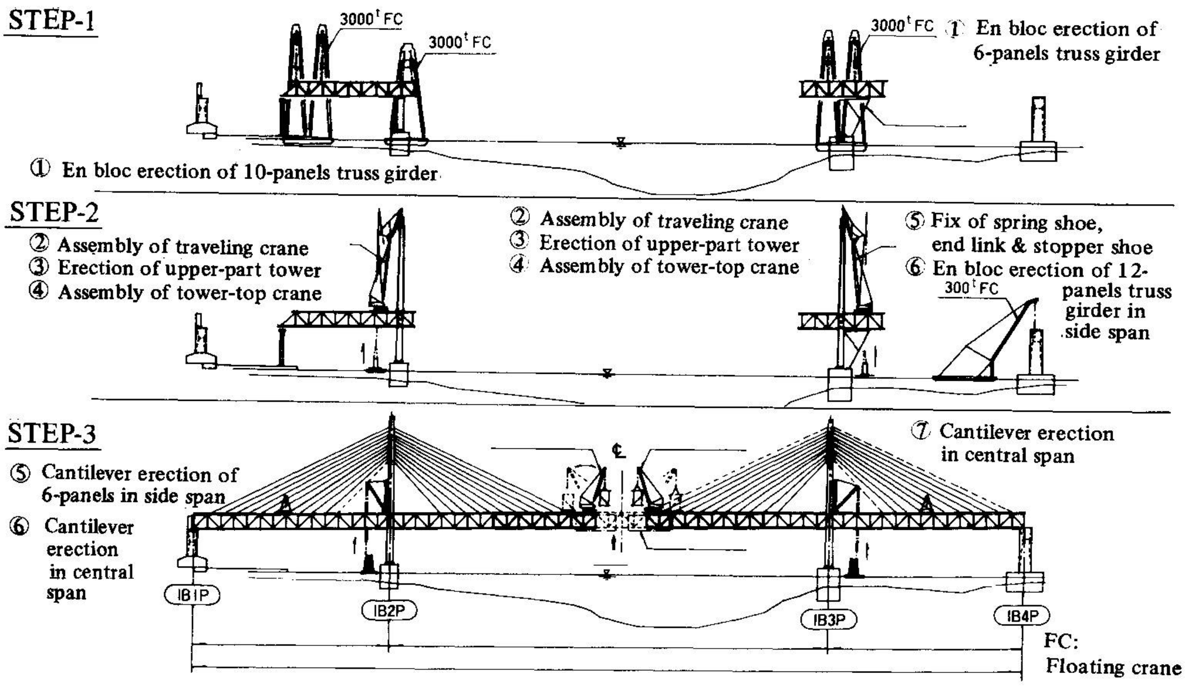
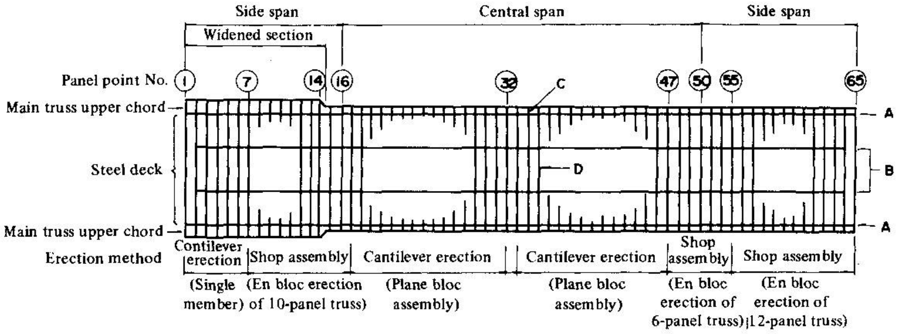


Fig. 3 Illustration of Erection Sequence



Joint		Panel Point No.	1 ~ 14	14 ~ 16	16 ~ 47	47 ~ 53	53 ~ 54	54 ~ 65	Remarks
Longi-tudinal direc-tion	A	Between upper chord and steel deck	W	W	B	W	B	W	W: Welding B: H.T.B.
	B	Between steel decks	W	W	W	W	W	W	
Trans-versal direc-tion	C	Upper chord	W	B	B	B	B	B	
	D	Steel deck	W	W	W	W	W	W	

Fig. 4 Classification of Steel Deck Connecting Methods

At the beginning of 1986, center span cantilever and cables are under construction. Completion of girder erection is planned for the autumn of 1986.

3. DESIGN CONSIDERATIONS RELATING TO MAIN GIRDER ERECTION ACCURACY

3.1 Effect of Contraction Caused by Field Welding on Main Truss Camber

As a rule, the welding sequence shown in Fig. 5 is used in bridge construction to prevent transverse weld from affecting the main truss camber. At the following welding points, however, effects on the main truss camber is unavoidable. To counteract this, appropriate measures are taken in camber fabrication:

- Field welding points on upper chord member upper flange at widened side span
- Closing point in central span
- Closing point in en bloc erection section

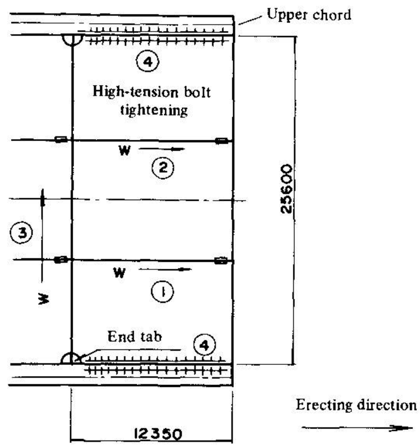


Fig. 5 Steel Deck Connecting Sequence

3.2 Fabrication and Erection Errors

In designing cross-sections of tower, girder and cable, additional stress is included to compensate for the following fabrication and erection errors:

- Main truss assembly error
- Erection error at closing point
- Tower tilt from vertical
- Cable fabrication and erection error

4. REQUIRED QUALITY AT ERECTION SITE

Erection members fabricated at the factory must meet both quality and accuracy specifications in the Fabrication Standards for Steel Bridges etc. in the

Honshu-Shikoku Bridge Project and other related standards. This section describes these required field erection quality.

4.1 Field Weld Quality

Field welds on steel deck are checked via visual inspection; moreover, X-ray and penetration inspections are carried out for welds on deck plates and trough ribs, respectively, in accordance with the Honshu-Shikoku Bridge Project Standards for Field Welding of Steel Deck.

4.2 Main Girder and Railway Stringer Erection Accuracy

- As concerns main girder field erection accuracy, vertical tolerance for designed camber is determined as follows:

  $$\delta a \leqq \pm\{25 + 0.25(L - 5)\}\text{mm}$$

  where,

  L: span length (m)

  Tolerance for each span is thus determined to be the following: Central span; ±118mm max., Side span; ±59mm max.

- Railway stringer installation accuracy

  In this bridge, railway track is fastened directly to steel stringer upper flange to reduce dead load. The small adjustment allowance for track installation, $-2 \sim +8$, necessitates an installation accuracy control value, as shown in Fig. 6.
  Target camber in this figure, the smooth longitudinal curvature of railway stringer upper flange, is determined according to completed figure of main truss camber after closing.

1	Relative difference between target camber and actual installation height of railway stringer upper flange	10mm max.
2	Relative difference in deviation from target value between adjoining panel points of railway stringer upper flange	6mm max. (Maximum positive error among four points) − (Maximum negative error among four points) $\leqq 6^{mm}$
3	Relative difference in deviation from target value between 4 points at same panel point of railway stringer upper flange	3mm max. Difference between errors at four points $\leqq 3^{mm}$

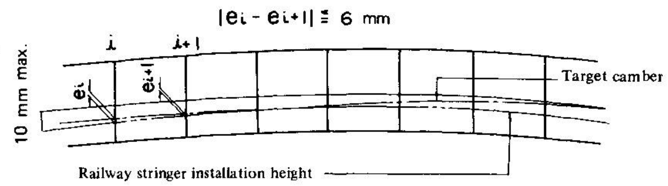


Fig. 6 Railway Stringer Installation Accuracy

5. QUALITY CONTROL AT ERECTION

5.1 Erection Work and Quality Control

The erection method used in bridge construction is outlined in 2. Field quality control for cantilever and cable erection is roughly classified into the following categories:

- Quality control of joints as to welding, bolt connection and painting, etc.
- Control of completed girder figure: camber, linearity, etc.
- Control of cable tension and truss member stress at erection

Fig. 7 shows the overall flow chart for girder and cable erection and quality control which includes the items above.

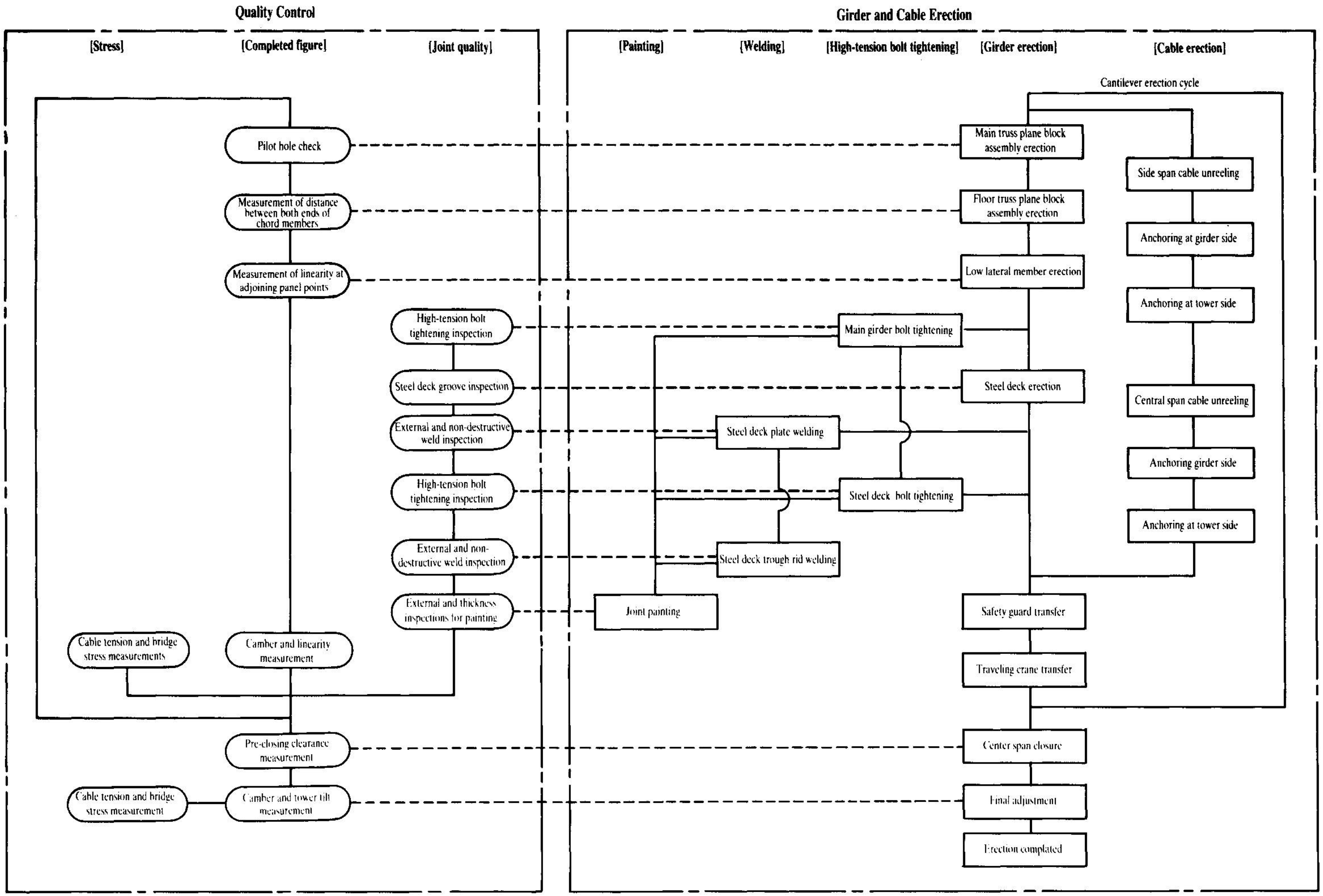


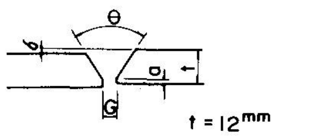
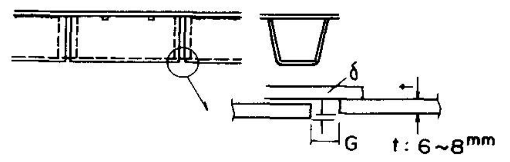
Fig. 7 Overall Flow Chart

5.2 Quality Control for Field Welds

Field weld quality control is roughly classified as follows:

- Welding procedure test under conditions similar to the filed prior to actual erection
- Control of welding conditions and joint geometry
- Quality inspection as specified in 4.

Table 1 Welding Method and Tolerance in Joint Geometry

Weld Point	Welding Method	(mm) G	(mm) δ	(°) θ	(mm) o	Remarks
Deck plate butt weld	Submerged arc welding	3^{+7}_{-3}	0 ± 2	50 ± 5	1 ± 1	
	CO_2-gas arc automatic welding	7^{+3}_{-4}	0 ± 2	50 ± 5	1 ± 1	
Trough rib butt weld	Shielded metal arc welding	10^{+5}_{-1}	0 ± 2			

5.3 Erection Accuracy Control

5.3.1 Erection accuracy control in the field

The following two methods may be used for erection accuracy control of central span girder cantilever and cables:

1. Duplication of factory fabrication accuracy is emphasized; no cable shim adjustment may be made during erection (bolt hole control method); and
2. Optimum cable shim is determined at each erection phase based on the results of erection calculations using configuration, stress, temperature measured in site and erection conditions (measurement control method).

Method 1 has been applied, as a rule, in the construction of Iwakurojima Bridge. Configuration and stress are measured to confirm accuracy during erection and after completion.

5.3.2 Erection accuracy control by adjusting main truss and steel deck bolt holes

In main truss erection, upper and lower chord member bolt holes, into which drift pins are driven during shop assembly, are used as erection pilot holes (into which drift pins are initially driven during erection) to reproduce figures in shop assembly.
In Steel deck welding, both deck plate and upper chord are connected and fixed by driving drift pins into bolt holes drilled during 3-dimensional shop assembly.
After welding, drift pins and temporary connection bolts are removed to release residual stress and thus minimize the effect of steel deck welding contraction on main truss figure.

5.3.3 Configuration and stress measurement

Table 2 shows the measured configuration and stress for the Iwakurojima bridge.

Table 2 Configuration and Stress Measurement

Items to Be Measured	Measurement Point	Measurement Method
Girder figure	Main truss lower chord member, surface	Measure water head using manometer.
Grider linearity	Upper chord member, tip	Measure shift from observation foundation using transit.
Cable tension	Near lower anchoring points	Use tension meter.
Tower tilt from vertical	Tower top	Measure diagonal distance from tower base of 2P and 3P using geodimeter.
Girder stress	Steel deck and lower/upper chord members, panels Nos. 16, 32, 49, 56	Use strain gauge.
Support reaction	Tower link, end link	

5.3.4 Railway stringer erection accuracy

Railway stringer erection accuracy is to be adjusted by machining adjuster plate at stringer supporting point.

6. RESULTS AND DISCUSSION

- The composite structure and erection methods used for this bridge minimize the effect of contraction upon cantilever erection part resulting from field welding of steel deck. Thus even should a composite steel deck be used, erection accuracy equal to that of an ordinary non-composite steel deck or bolt-connected steel deck can be obtained.
- Erection difficulties associated with contraction resulting from field welding of steel deck include the following: difficulty in inserting floor truss due to longitudinal welding; and wider than usual weld root opening at joint with next panel steel deck due to transverse welding. The former may be offset using erection jigs, while the wider root opening in the latter case, as it remains within tolerance, will not be considered a problem in post-welding inspection.
- Final erection accuracy, stress measurement, cable shim adjustment and railway stringer erection accuracy shall be discussed in a subsequent paper.