3 .CVV古田代表との共同研究

1）斜張橋の設計法　（プレストレス決定法）

2）斜張橋の架設管理法（シム張力調整と形状管理）

3）吊り橋および斜張橋の振動制振法

構造同定法　1990 IEEE (USA)

New System Identification Technique Using Fuzzy Regression Analysis

M. Kaneyoshi — Hitach Zosen Corp., Osaka 554, Japan

H. Tanaka — Hitach Zosen Corp., Osaka 554, Japan

M. Kamei — Osaka Municipal Office, Osaka 530, Japan

H. Furuta — Kyoto University, Kyoto 606, Japan

Abstract

A new system identification method has been developed, in which measured field data were assumed to be fuzzy data and fuzzy regression analysis was applied to the process of system identification. Although the method includes fuzzy coefficients in the formulation, it can be solved without difficulty by using a linear programming algorithm. The method, called Fuzzy SI method (FSI), was applied to the construction of a cable-stayed bridge: the Shugahara-Shirokita Bridge in Osaka, Japan. The results confirm that the new system identification technique proposed here is not only simple to handle but also very practical, compared with previously developed method (i.e. SI method).

Error Factors

Error factors which are inherent in the construction of long-span suspended bridges, can be divided into three categories as follows [3]:

Structural Analysis Errors

- errors in material properties (Young' modules, etc.)
- incorrect dead load estimation
- incorrect stiffness estimation (moment of inertia, section area, etc.)
- improper boundary codition
- incorrect non-stress camber estimation
- numerical error in computation, etc.

菅原城北大橋の架設精度管理

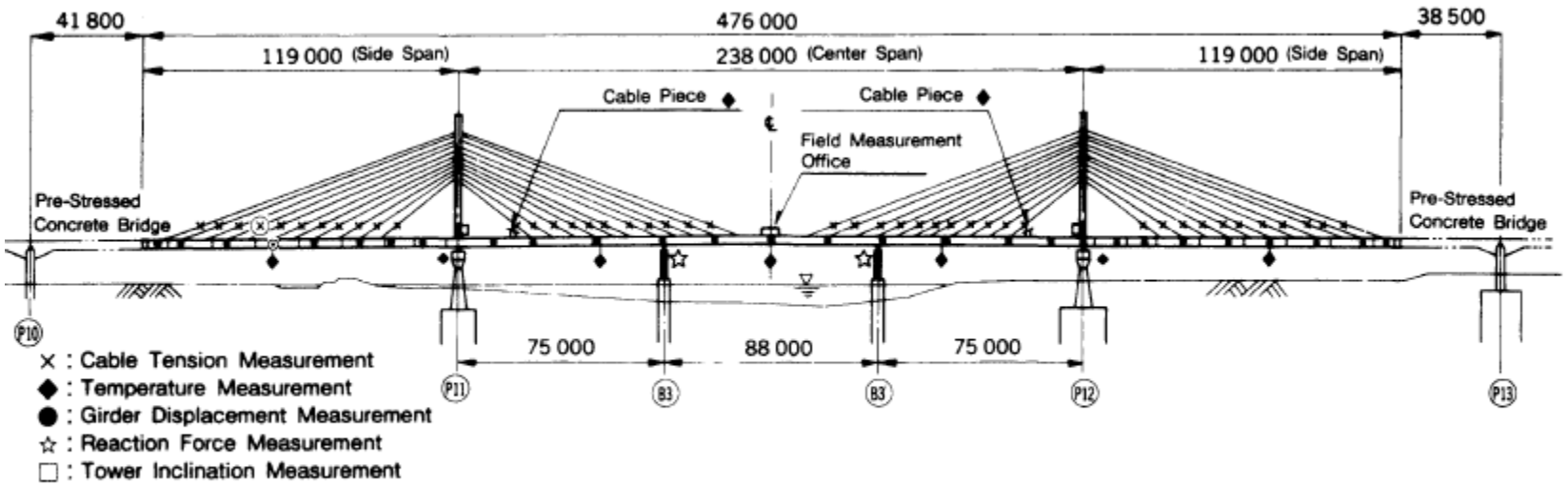


Fig. 4 General View of the Sugahara-Shirokita Bridge in Erection Stage

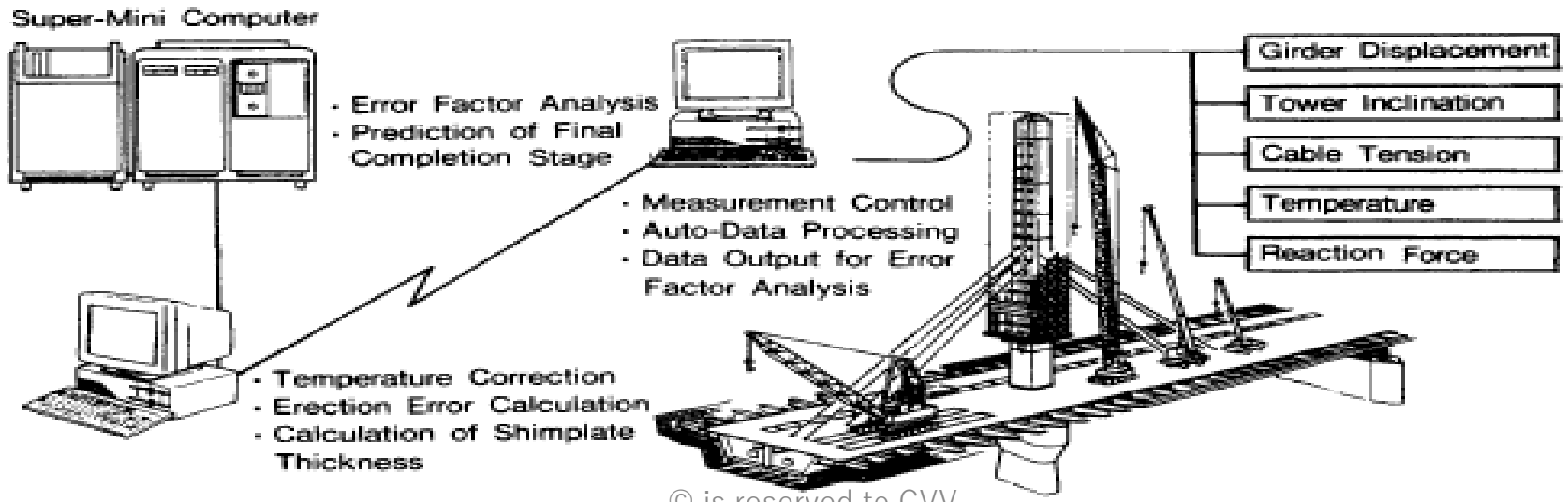


Fig. 7 Erection Control System

長大橋の架設形状管理（仁川大橋）

- 中央径間の張り出し、各STEPごとにシム調整実施（深夜）
- 計算スキームは、ファジィ満足度理論を発展させた三星理論
- EXCELで計算

ファジィ満足度理論の発展法（三星仕様）

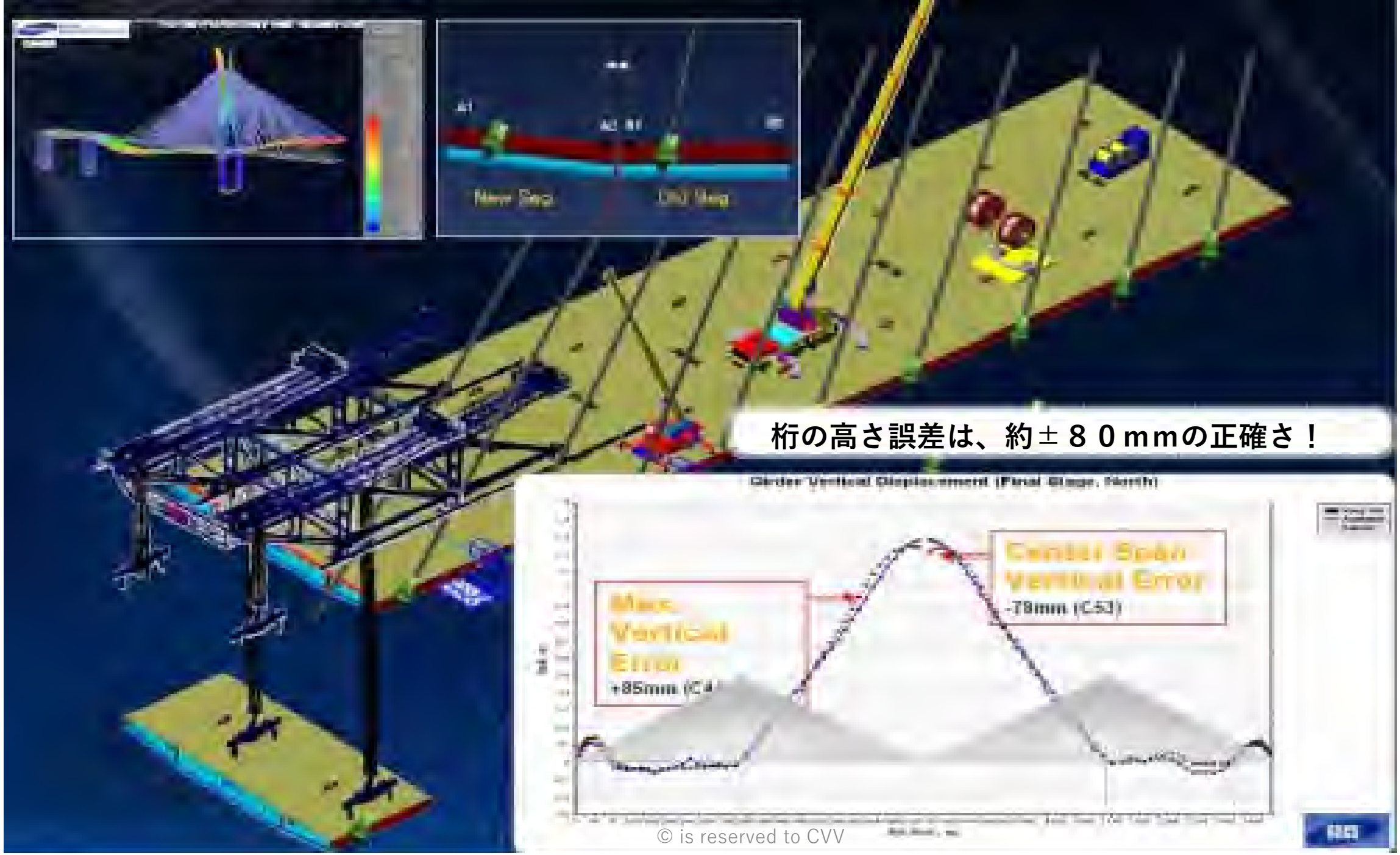
$$\underset{\Delta L_0}{\mathrm{Min}}\,\Pi = \frac{1}{2}\sum_{i=1}^{nm}\left(\frac{u_i^c - u_i^A(\mathbf{L}_0 + \Delta\mathbf{L}_0)}{\alpha_i \cdot (u_{i\max} - u_{i\min})}\right)^2 + \frac{1}{2}\sum_{j=1}^{nc}\left(\frac{T_j^c - T_j^A(\mathbf{L}_0 + \Delta\mathbf{L}_0)}{\beta_j \cdot (T_{j\max} - T_{j\min})}\right)^2$$

$$\text{subject to } u_{i\,\min} \le u_i \le u_{i\,\max}$$

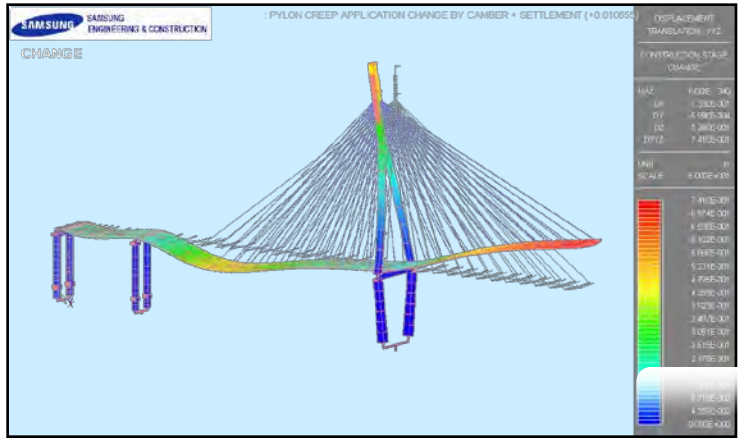
$$\text{subject to } T_{\min} \le T^A(\mathbf{L}_0 + \Delta\mathbf{L}_0) \le T_{\max} \qquad (1)$$

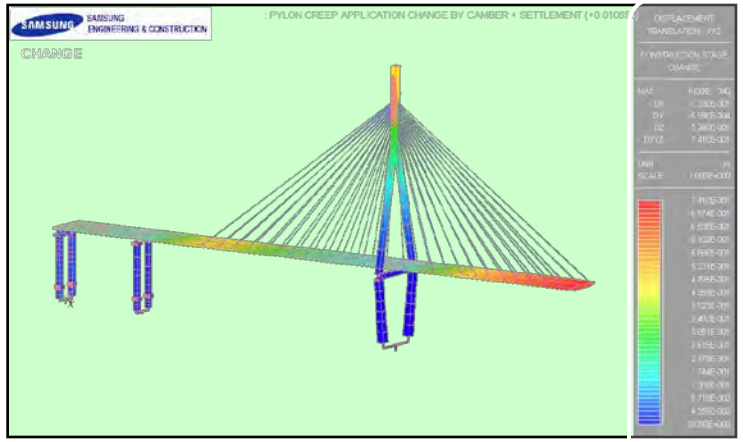
$$\text{subject to } \Delta\mathbf{L}_{0\min} \le \Delta\mathbf{L}_0 \le \Delta\mathbf{L}_{0\max}$$

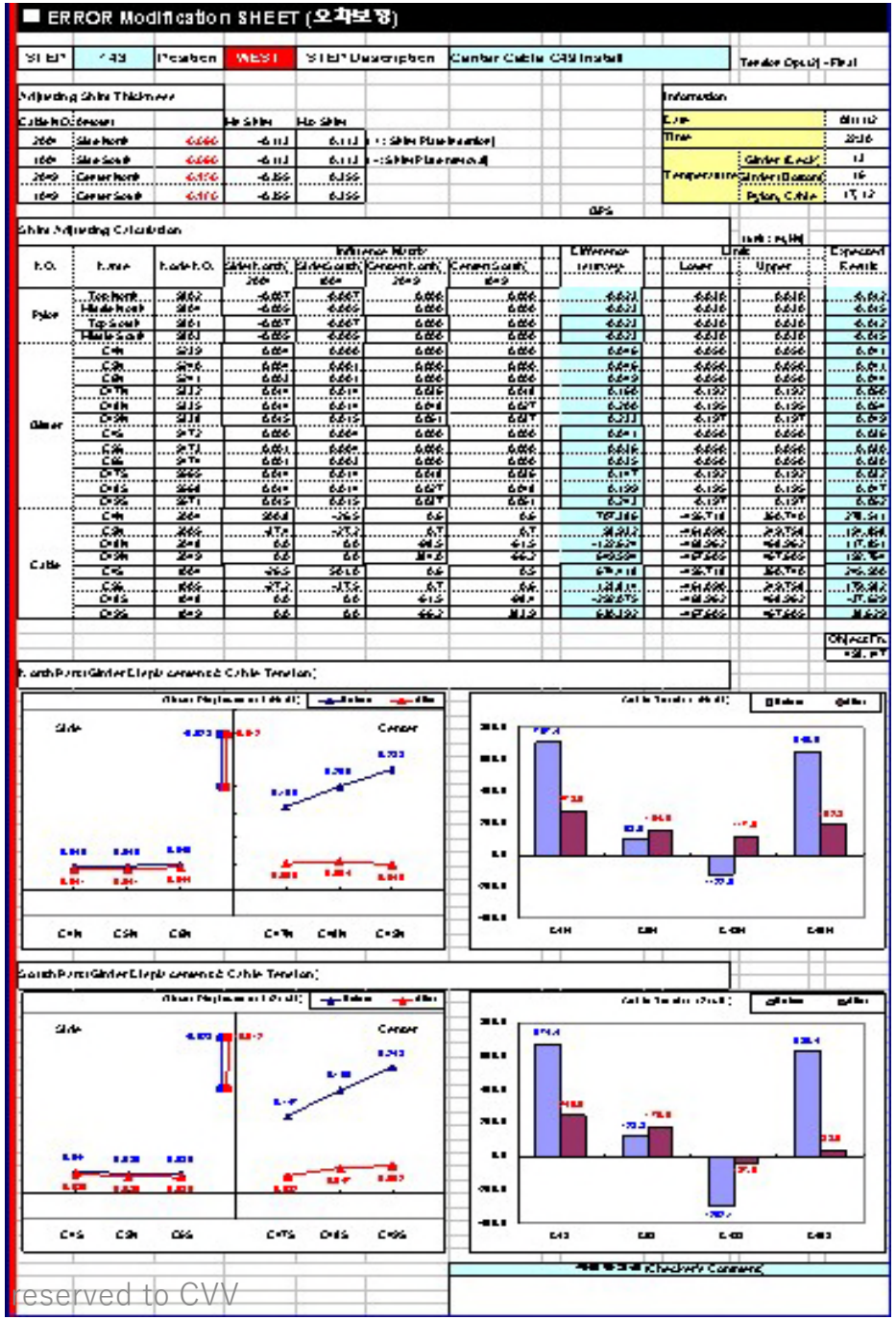
ここで、u_i^c は目標形□を、u_i^A は□際構造物の□位を示し、$u_{i\max}$ 、$u_{i\min}$ は各々構造物□位誤差の上限値と下限値を示す。T_i^c, T_i^A は目標張力及び□際構造物のケーブル張力を、$T_{\max}$ と $T_{\min}$ は各々ケーブル張力に□する管理限界値の上限値及び下限値である。L_0 はケーブルの無□力長、ΔL_0 はケーブル長さ調整量を示し、nm 及び nc は□位測定点の個□と測定ケーブルの個□である。式(1)は非線型式で、非線型拘束□件を持つ最適化問題になり、最適ΔL_0 を求めるために加重値係□α_i, β_i を調整する。



誤差補正原理

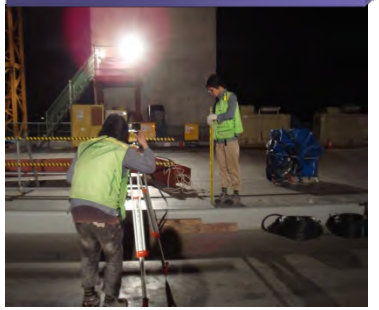






張力調整手順

測量



張力測定

結果分析

再緊張

シム量挿入

調整完了

桁閉合（GIRDER_CLOSING）

形状管理精度結果

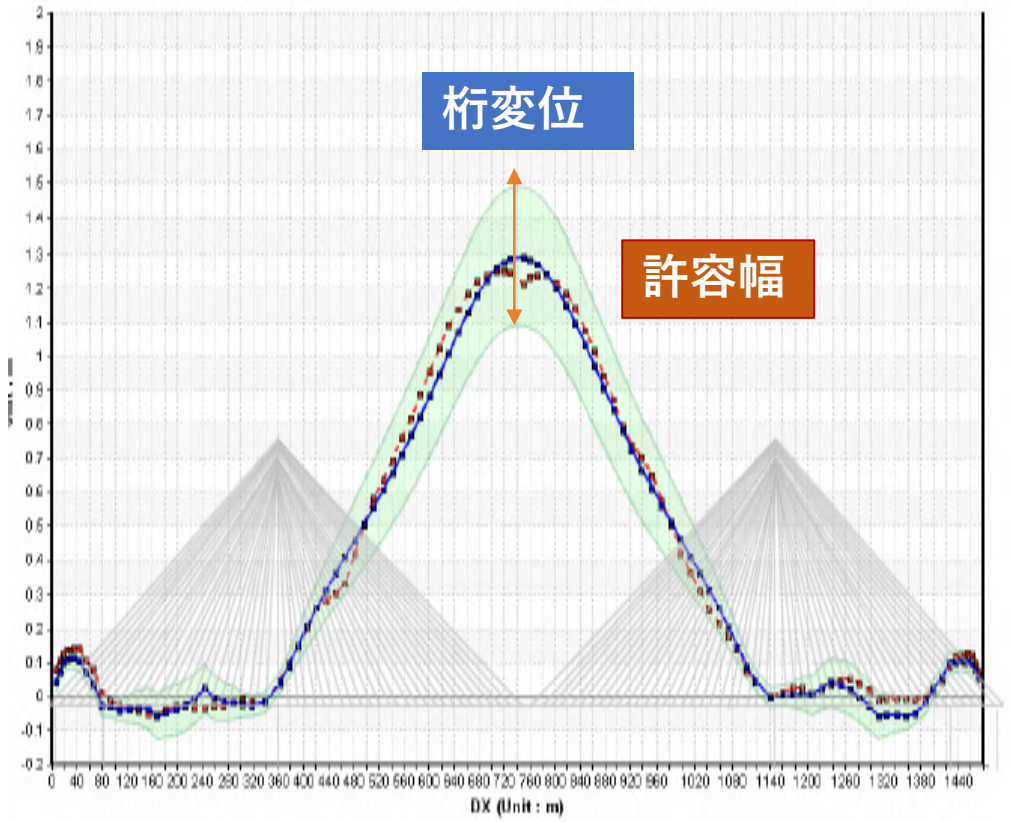


Fig. 7. Final Girder Geometry after Closing (Web in Northern Section)

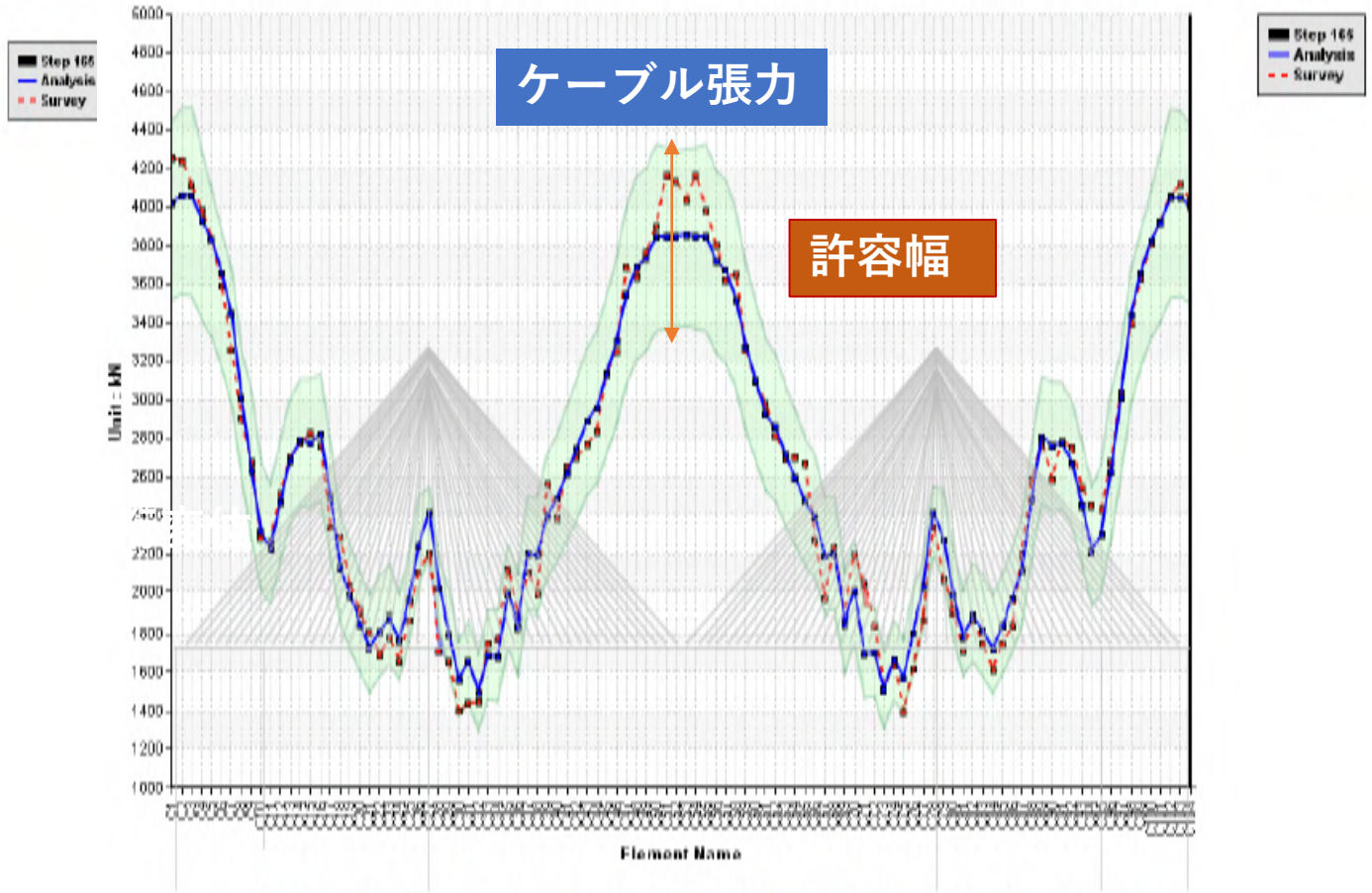
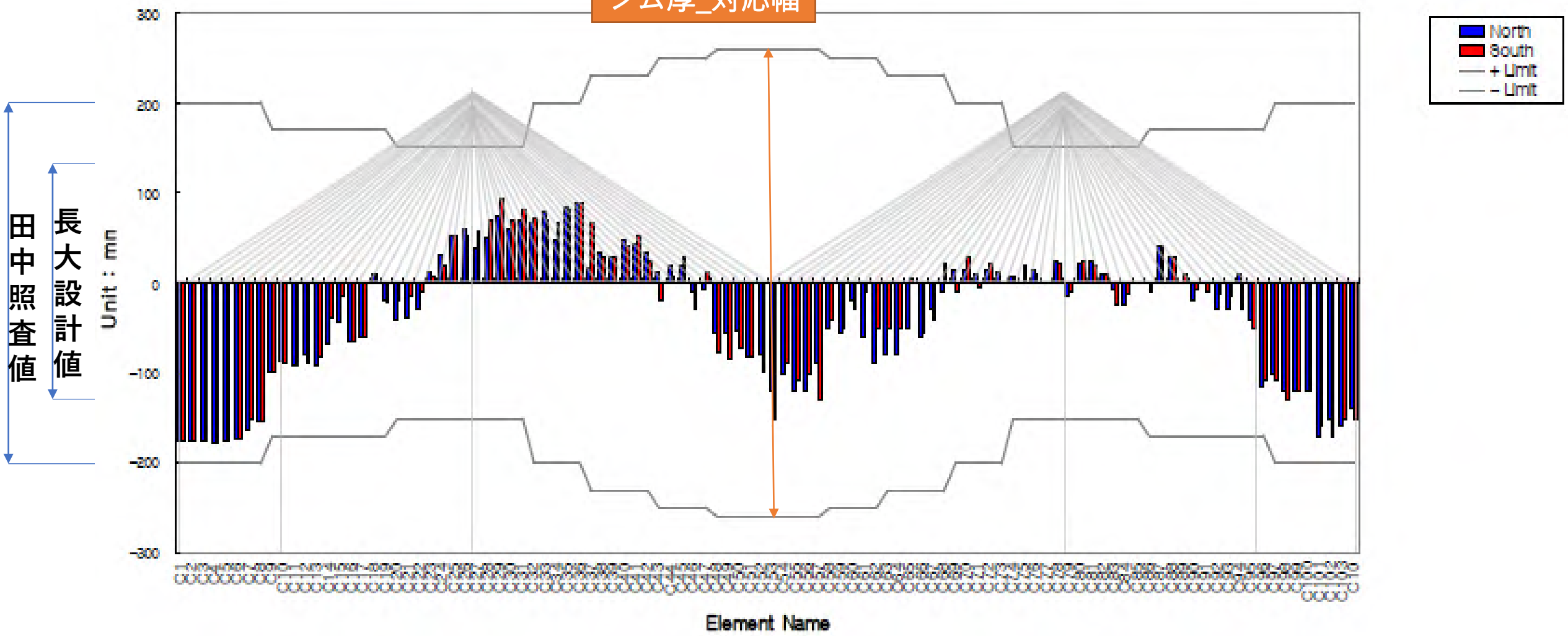


Fig. 8. Final Cable Tension Distribution after Closing (Cable in Northern Section)

Ref) DK.Im H.Tanaka JK.Yoo HS.Kim CH.Kim MG. Yoon: Development and Application of Integrated Geometry Control System in Incheon Bridge pp.134-141
Proceeding of International Commemorative Symposium for the Incheon Bridge : 23th September,2009 Songdo ConvensiA, Incheon, Korea

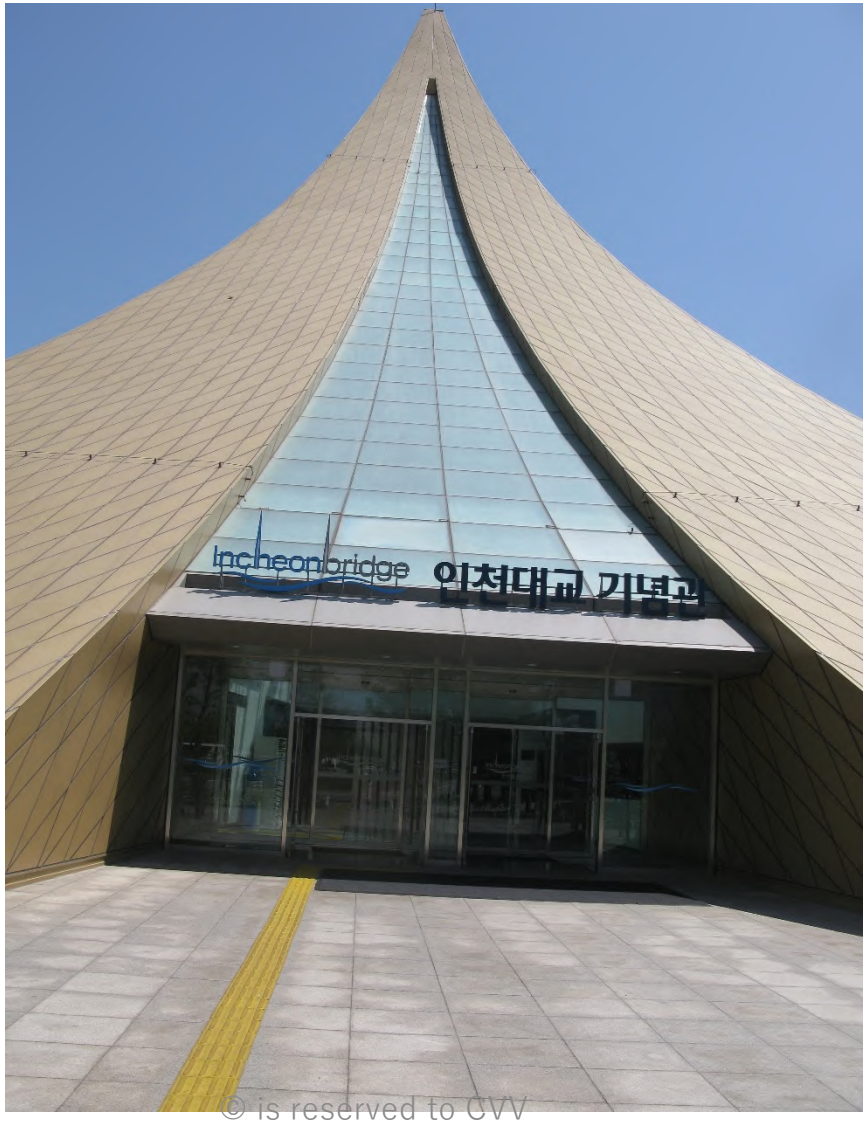
シム厚_対応幅



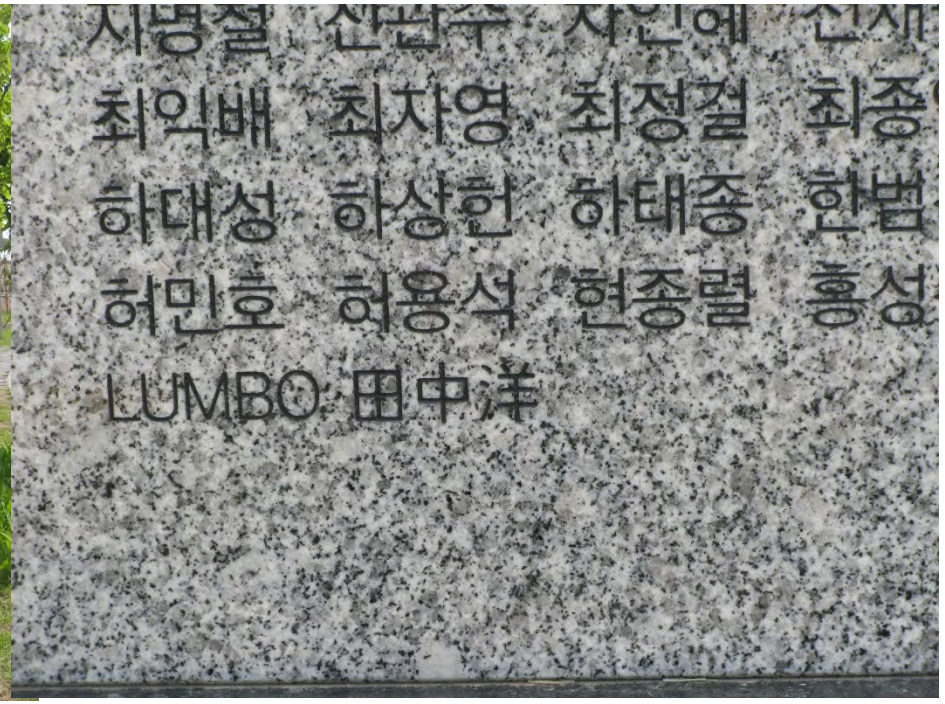
Ref) DK.Im H.Tanaka JK.Yoo HS.Kim CH.Kim MG. Yoon: Development and Application of Integrated Geometry Control System in Incheon Bridge pp.134-141
Proceeding of International Commemorative Symposium for the Incheon Bridge ; 23th September,2009 Songdo ConvensiA, Incheon, Korea

平成22年度　田中賞　（作品部門）

仁川大橋記念館



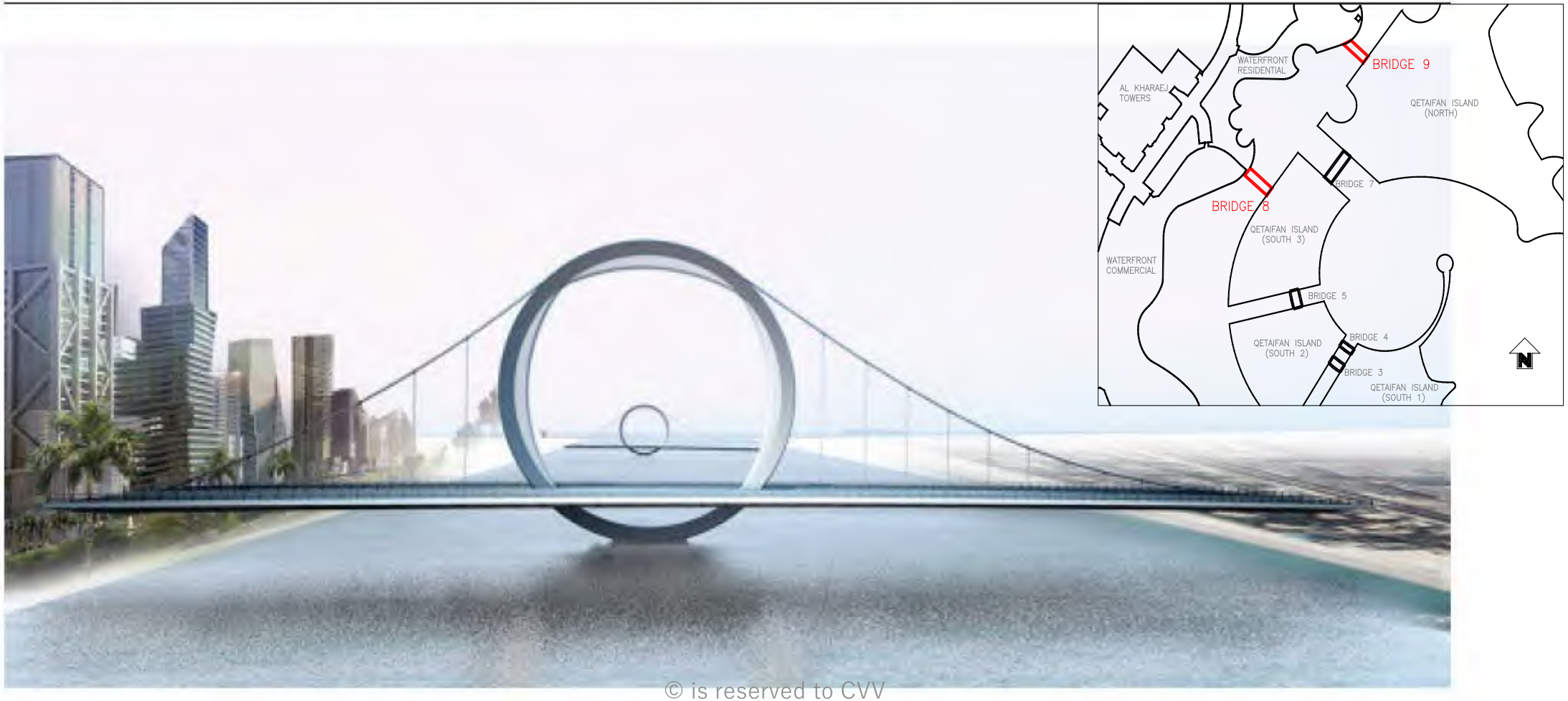
記念碑　刻印

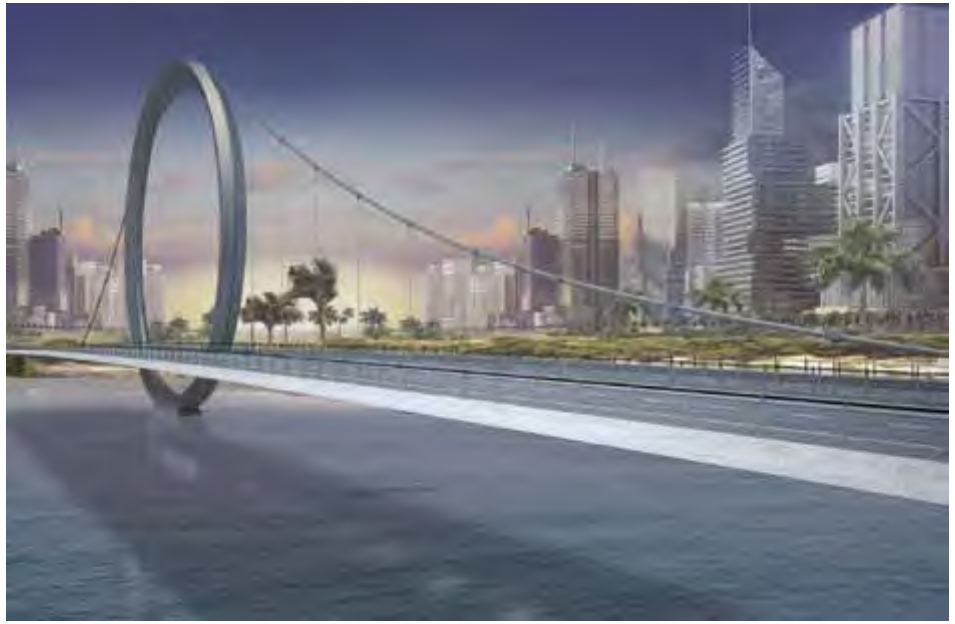


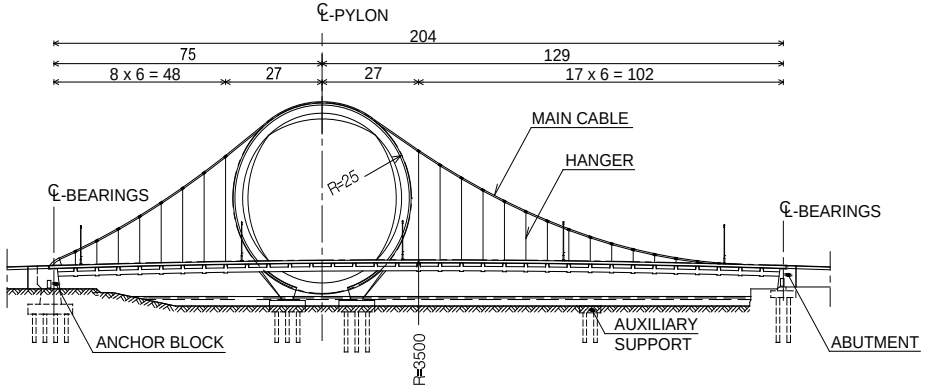
韓国に名を残した!!

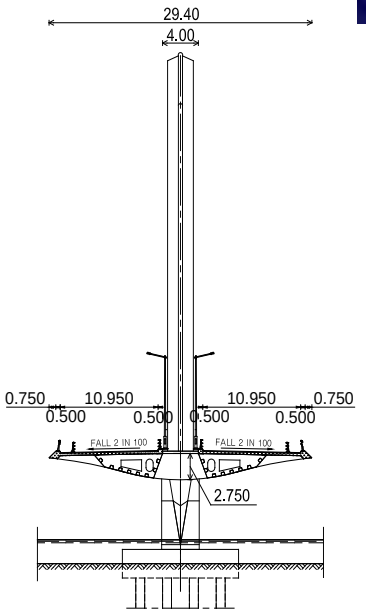
自碇式つり橋のケーブル張力調整

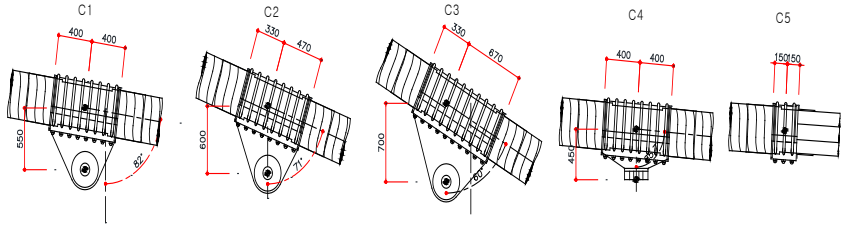
Lusail City Bridges (Qatar)

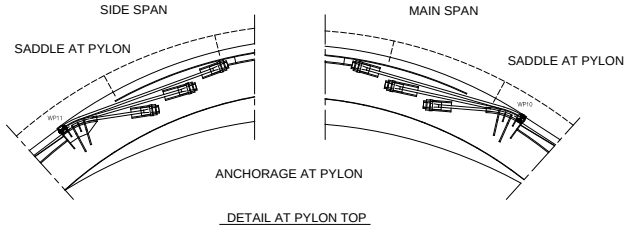




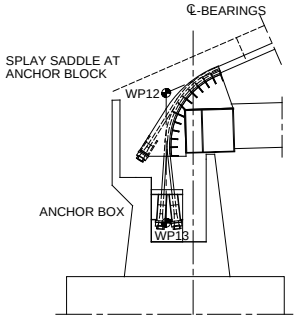




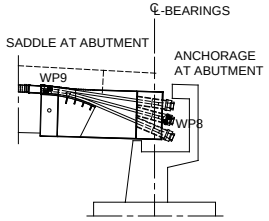




DETAIL AT PYLON TOP



DETAIL AT ANCHOR BLOCK



DETAIL AT ABUTMENT

シム量の計算（ファジィ満足度理論）　　技術顧問　田中　洋

【Lusail　BR 8　Side-Span】　Hanger Tension Adjustment by Fuzzy Satisfaction Concept　- SHEET BY DR . TANAKA -　SAMSUNG C'T

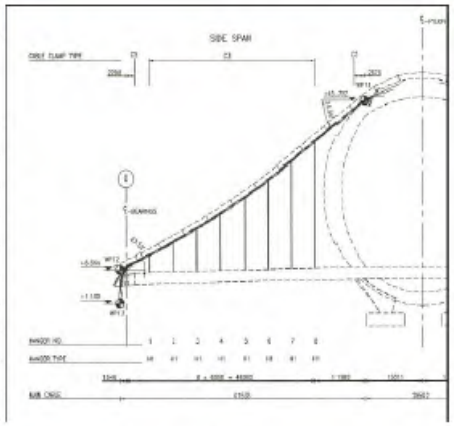
STEP	15	Description	After Bent Removal

Adjusting Shim Thickness [mm]

OUTPUT　INPUT [KN]

(+): Shim insertation; (-)Shim removal

Hanger No.	Mem.No.	Amount	Min.Shim	Max. Shim	After Adjustment	Target Design Value	Survey	Allowances (-) %	Allowances (+) %
1	2009	9	−100	100	1,857	1,707	1,500	-10	10
2	2008	−6	−100	100	1,746	1,605	1,900	-10	10
3	2007	−8	−100	100	1,746	1,605	1,800	-10	10
4	2006	0	−100	100	1,745	1,605	1,800	-10	10
5	2005	8	−100	100	1,756	1,615	1,650	-10	10
6	2004	−11	−100	100	1,561	1,615	1,600	-10	10
7	2003	8	−100	100	1,767	1,625	1,800	-10	10
8	2002	−8	−100	100	1,672	1,648	1,700	-10	10



Shim Adjustment Calculation

Influence Unit: 10 mm

Unit :[KN]

Influence Matrix

Hanger No.	1	2	3	4	5	6	7	8
1	164.522	−62.039	−4.457	0	0	0	0	0
2	−62.039	134.719	−56.635	−5.813	0	0	0	0
3	−4.457	−56.635	125.143	−50.607	−6.708	0	0	0
4	0	−5.813	−50.607	116.332	−45.133	−7.296	0	0
5	0	0	−6.708	−45.133	108.224	−40.205	−7.684	0
6	0	0	0	−7.296	−40.205	100.729	−35.98	−8.511
7	0	0	0	0	−7.684	−35.98	93.172	−34.311
8	0	0	0	0	0	−8.511	−34.311	79.405

Hanger No.	Difference (survey-target)	Error Limit Lower	Error Limit Upper	Final Result
1	-207	−171	171	150
2	295	−161	161	141
3	195	−161	161	141
4	195	−161	161	140
5	35	−162	162	141
6	-15	−162	162	−54
7	175	−163	163	142
8	52	−165	165	24

Hanger Tension Graph　Unit: [KN]