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Fabrication Survey of Steel Components facilitates Quick Bridge Erection

Contrôles de fabrication pour le Pont Hooghly à Calcutta

Werkstattkontrolle der zweiten Hooghly Brücke in Kalkutta

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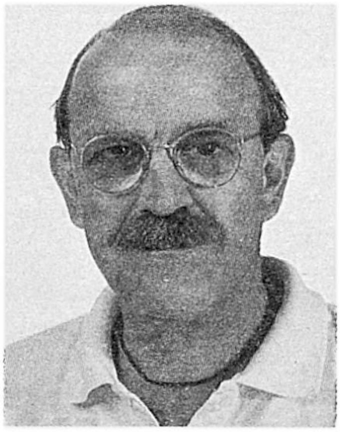

SUMMARY
Details of the fabrication survey, allowable tolerances, measurements, trial assembly and their favourable effect on the speed and accuracy of erection are described for the second Hooghly Bridge in Calcutta.

RÉSUMÉ
Des aspects particuliers du contrôle de la fabrication tels que les tolérances admissibles, l'ampleur des mesures de contrôle, l'assemblage d'essai, ainsi que leurs répercussions favorables sur la vitesse et la précision du montage sont traités dans cet article.

ZUSAMMENFASSUNG
Einzelheiten der Fertigungsüberwachung, wie zulässige Toleranzen, Umfang der Messungen, und Probezusammenbau werden in ihrer günstigen Auswirkung auf die Geschwindigkeit und Genauigkeit der Montage beschrieben.

1. INTRODUCTION

One of the world's largest cable stayed bridges is going to be completed within one year. The main components of superstructure like towers, deck grid and cables are prefabricated steel elements requiring a thourough survey at the fabrication stage

- to control imperfection, a significant load case for slender structures,
- to ensure fast erection progress without adjustment or rectification at site,
- to install cables geometrically controlled instead of using cable tensioning force as the main guidance.

2. GEOMETRY SURVEY DURING FABRICATION

1.1. Pylons

For the box sections of towers a fabrication survey procedure had to be established to control eccentricities of pylon axis either in longitudinal or in transversal direction of the bridge.

Space restrictions and progress of erection did not permit a full shop floor layout for the towers as it had been done for previous bridges. Transport and lifting facilities limited the length of a single box to a maximum of 6 m. Therefore one pylon leg comprises 19 sections up to the level of top portal.

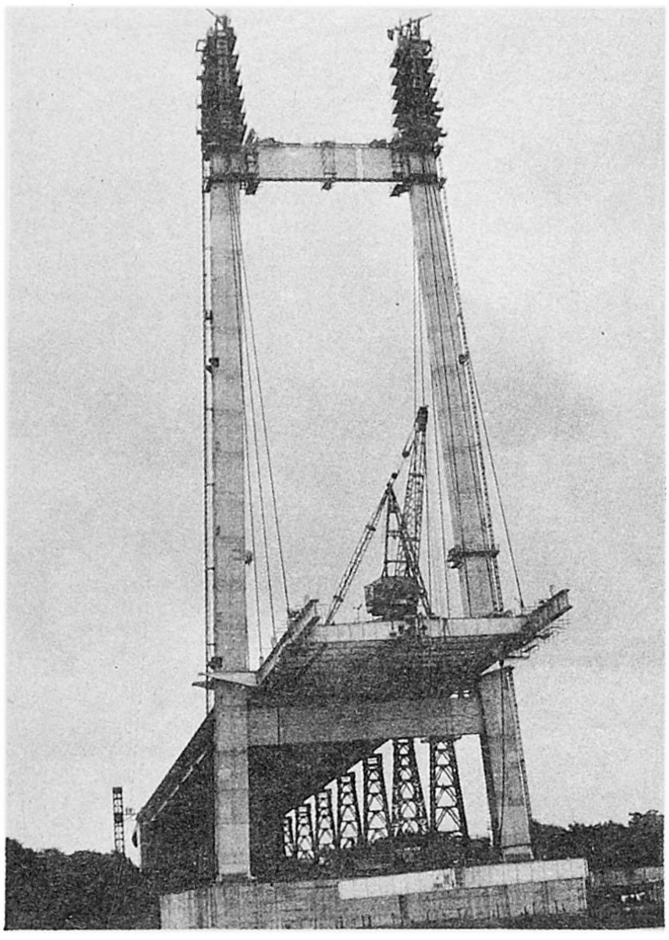

Fig. 1
H-shaped, 122 m high pylon at Calcutta side

Deviations from nominal pylon leg axis are caused mainly through skewed cutting of box section ends. On this account utmost care was taken during individual box machining. Before cutting of the second face was taken up, the box was aligned in reference to the face which was cut first. For this a dial gauge was mounted on the extended spindle of milling cutter to check perfect setting.

If cuts of an individual box are not perpendicular but planparallel (see A in Fig. 2), the amount of deviation from nominal axis is negligible, whereas non-planparallel cuts may lead to unacceptable eccentricities (see B in Fig. 2).

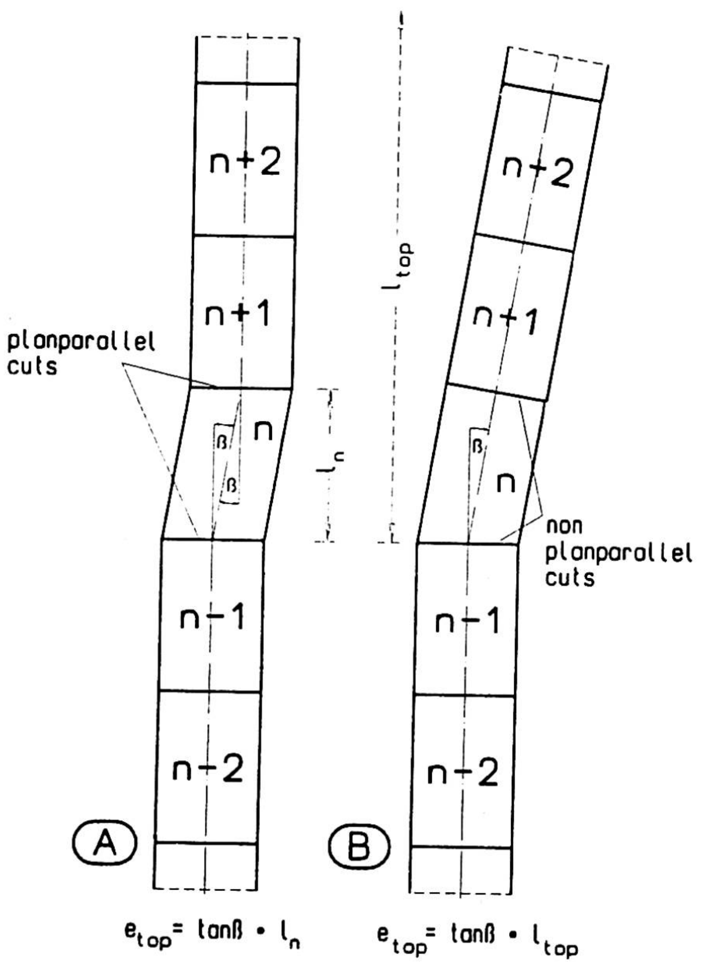

Fig. 2
Axis deviation due to skew cutting of individual section. For illustration (A) the skewed but planparallel cuts cause only a negligible shift of the axis.

An additional, but undetected deviation from the axis occurs due to a built-in error in survey procedure. Considering a 1 mm error per control assembly survey and assuming that the error accumulates in same direction for further assemblies, the deviation from nominal axis at the top amounts to 32.5 mm taking entirely 10 nos. of assemblies and the reference length is 20 m per assembly (see Fig. 3).

The undetected deviation at the tower top will increase with less reference length per assembly and more numbers of surveys. For that reason it could not be agreed to control assemblies with 3 or even 2 sections only.

Shop floor survey for pylon legs has been executed with 4 sections per assembly horizontally laid out starting with base elements. By removing 2 rear sections and adding 2 sections at the front next assembly configuration was found. In Fig. 4 survey procedure for pylon legs is shown in principle for two subsequent assemblies. With a theodolite two perpendicular optical planes have been established. The intersecting line of these two optical planes represents nominal pylon leg axis. The offsets from the optical planes towards the wallplates of box sections were measured by scale in x-and y-direction. As a result, deviations from the axis were recorded.

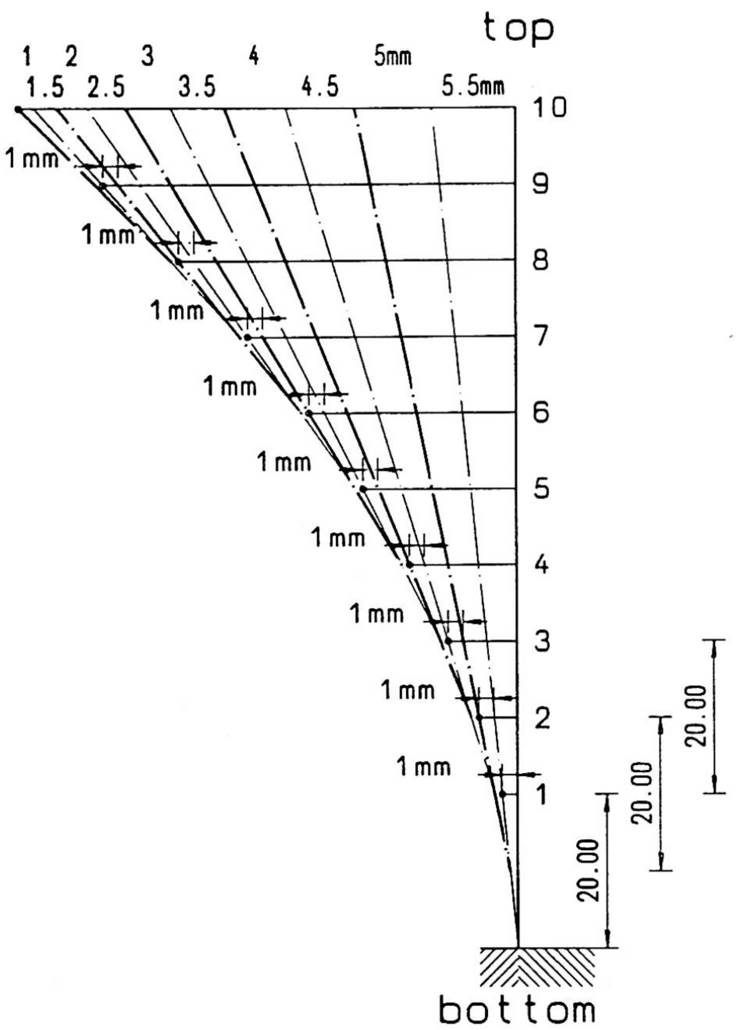

Fig. 3
Undetected deviation from nominal axis due to accumulative built-in error in control assembly survey, 10 nos. of assemblies with reference length of 20 m for each assembly lead to an eccentricity of 32.5 mm at top if built-in error is 1 mm per assembly.

Only in two cases recutting of box sections was required to keep eccentricities within acceptable limits. For all four pylon legs difference between nominal to actual axis was found to be within 25 mm for longitudinal as well as for transversal direction of the bridge. The actual length of box sections was controlled by tape measurement and differential height of two adjacent tower legs was within a couple of millimetres.

2.2. Deck grid

Since stiffness perpendicular to the web is low for longitudinal girders (I-sections), the alignment in direction of predominant stiffness only was checked at shops. Two girders with 12.3 m length each were assembled and offsets checked taking reference at the top flanges. The range of deviation from nominal to actual axis for individual longitudinal girders was limited to $\pm$ 6 mm to keep constraints during erection of cross girders low. In case survey revealed a tendency of violating the deviation criteria subsequent girders were cut in order to reduce misalignment.

2.3. Cables

Actual fabricated length of cables is guided by the cutting length of wires. Each wire is cut on a wire cutting bench controlling major differences in length. After fabricating the cables the actual lengths between the cable sockets are measured under preload by calibrated steel tape.

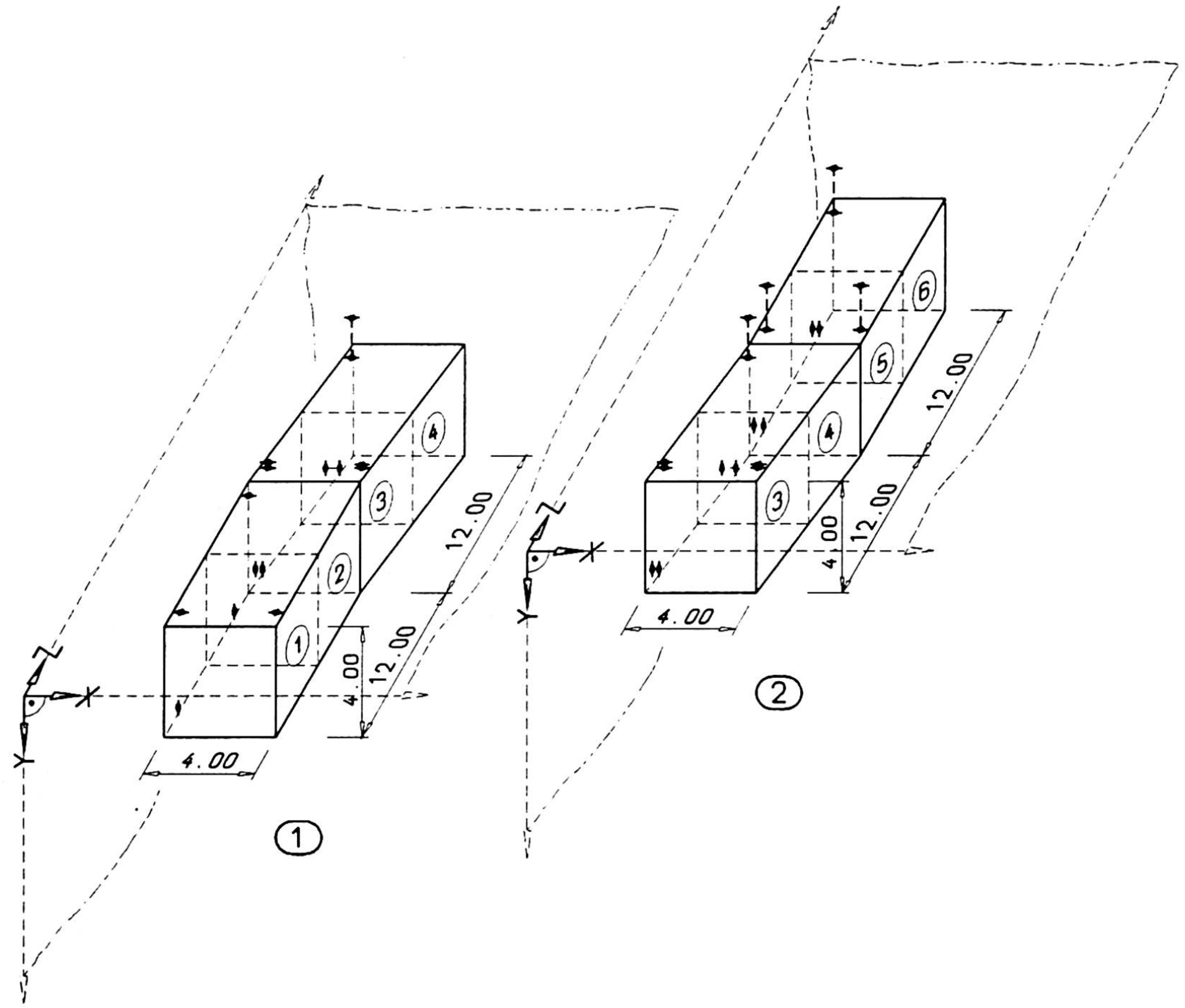

Fig. 4
Sequence of control assembly for pylon leg, offsets at boxes 3 + 4 in assembly (1) are identical to offsets at same boxes in assembly (2) achieved by analytical transformation.

3. EFFECT ON ERECTION

After completion of pylons and advanced deck grid and cable erection, it has been confirmed, that the erection of Second Hooghly Bridge really has been facilitated by the accurate fabrication:

- the geometrical accuracy of the pylons is very satisfactory, eccentricities at top of free standing towers are within 40 mm and thus very much below values taken for design. As per design data criteria for maximum eccentricity due to unstraightness of tower legs is

1/750 of length, i.e. 140 mm in longitudinal direction of bridge at top portal level. It may be mentioned that setting of individual pylon legs at site was done with 4 elements corresponding to first control assembly at shops. By using identical shop survey points at site and relying on sufficient reference length of 4 sections an accurate profile for pylons was achieved.

- no adjustment or rectification at joints was necessary at site leading to fast, uninterrupted erection. Portal girders could be closed without major problems and quality of butt contacts is indicating proper matching of longitudinal girders.
- erection surveys for the deck grid and for the towers are showing conformity with the erection stage analysis.

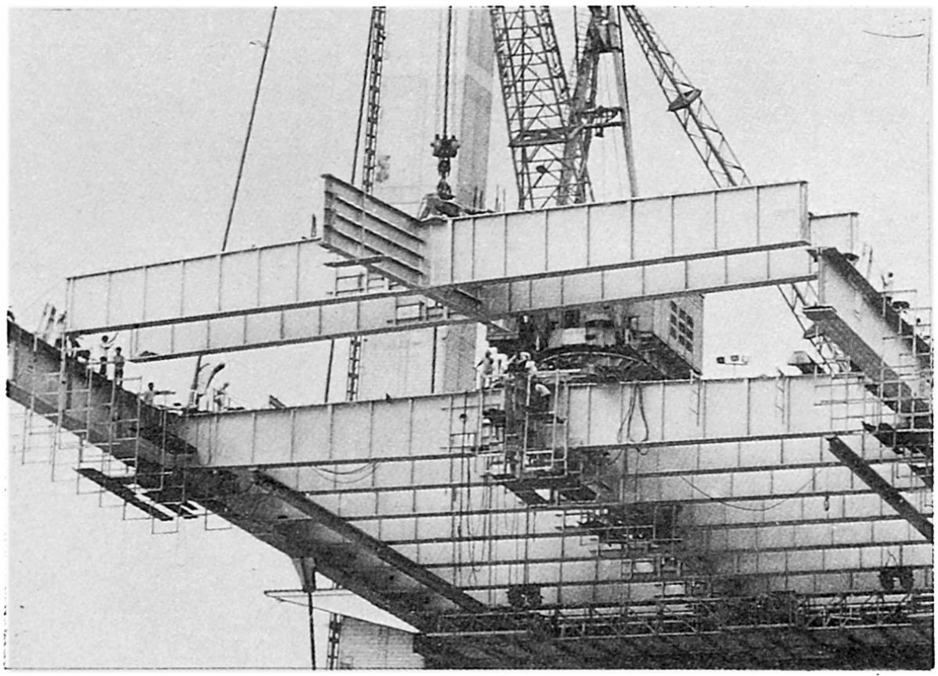

Fig. 5
Preassembly of middle girder and 4 cross girders being lifted. Both main girders are already in final position.

knowing actual fabrication geometry of steel components and actual location of concrete piers the deviations with reference to nominal bridge design geometry were evaluated and adjusted by height of shim packs positioned at pylon head anchors. Hence, erection of the Second Hooghly Bridge is principally guided by geometry meaning more comfort for site. Cable tensioning force is recorded only as a second order check.

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