Control measures for thermal effects during placement of span-scale girder segments on continuous steel box girder bridges

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6×110-m Continuous Steel Box Girder

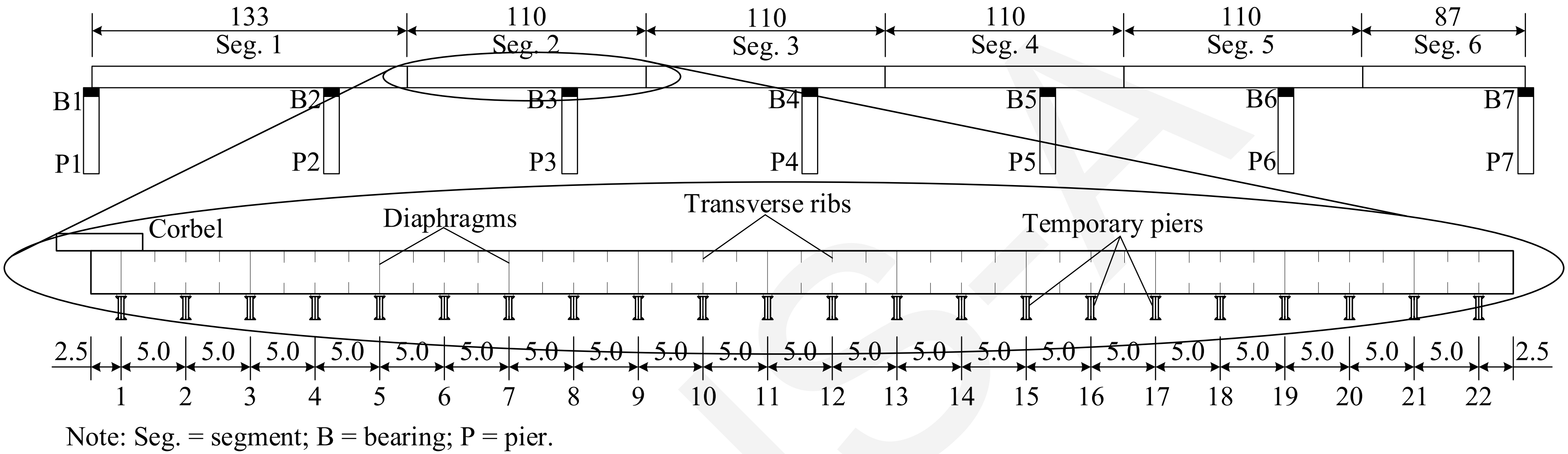


Fig. 1. Elevation of the girder segments (unit: m)

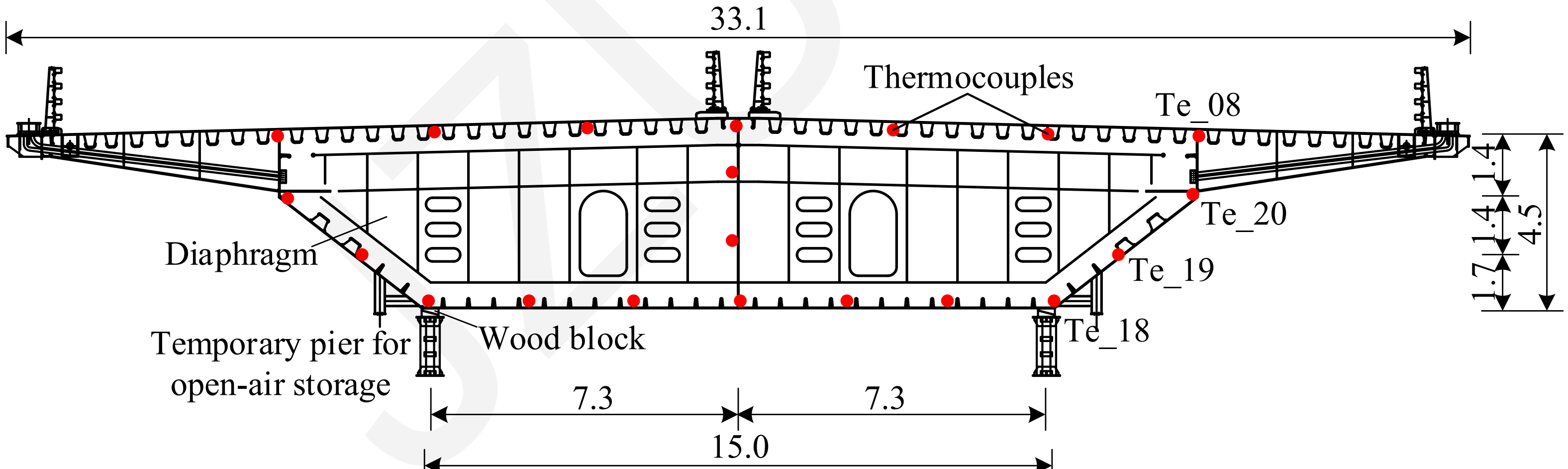
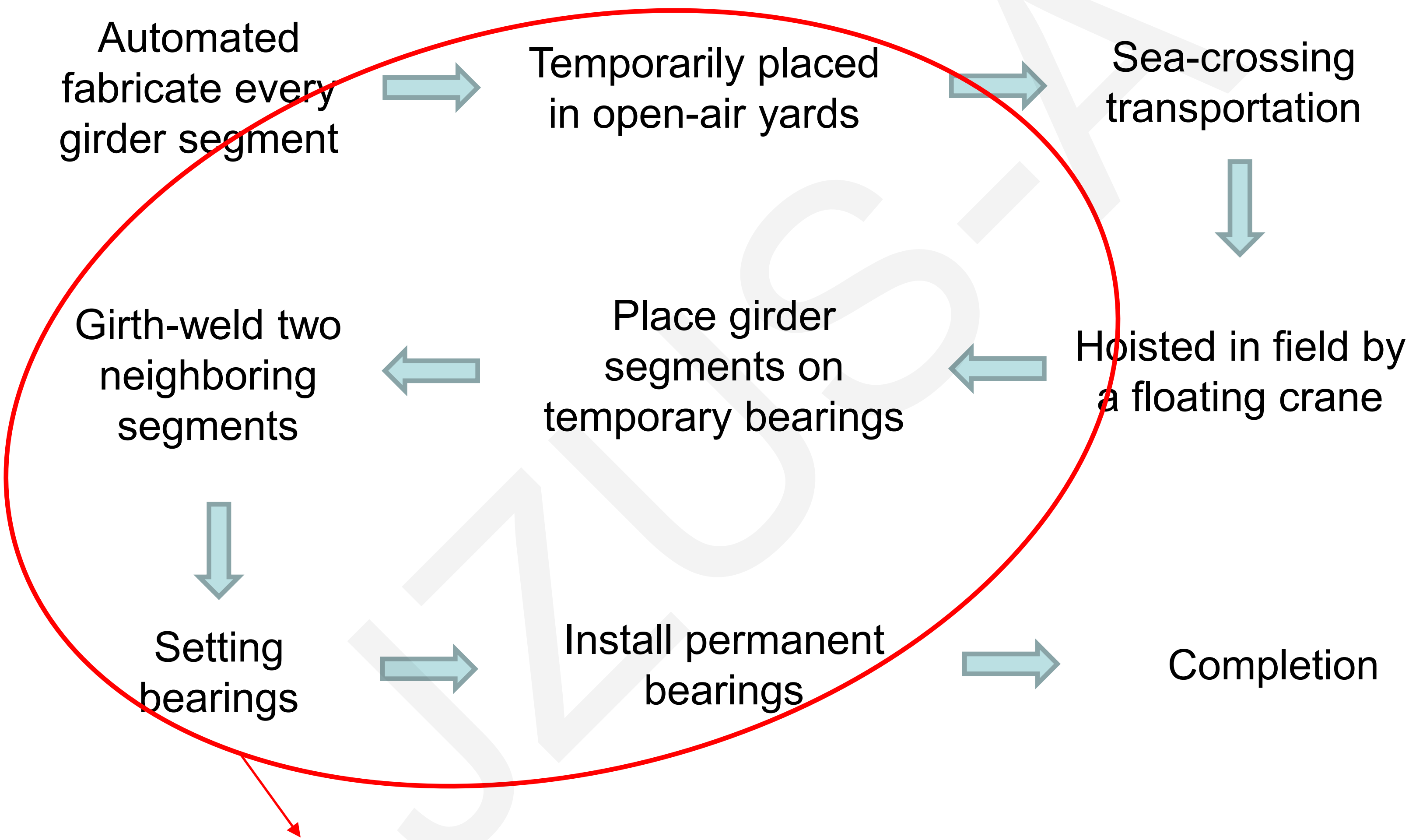


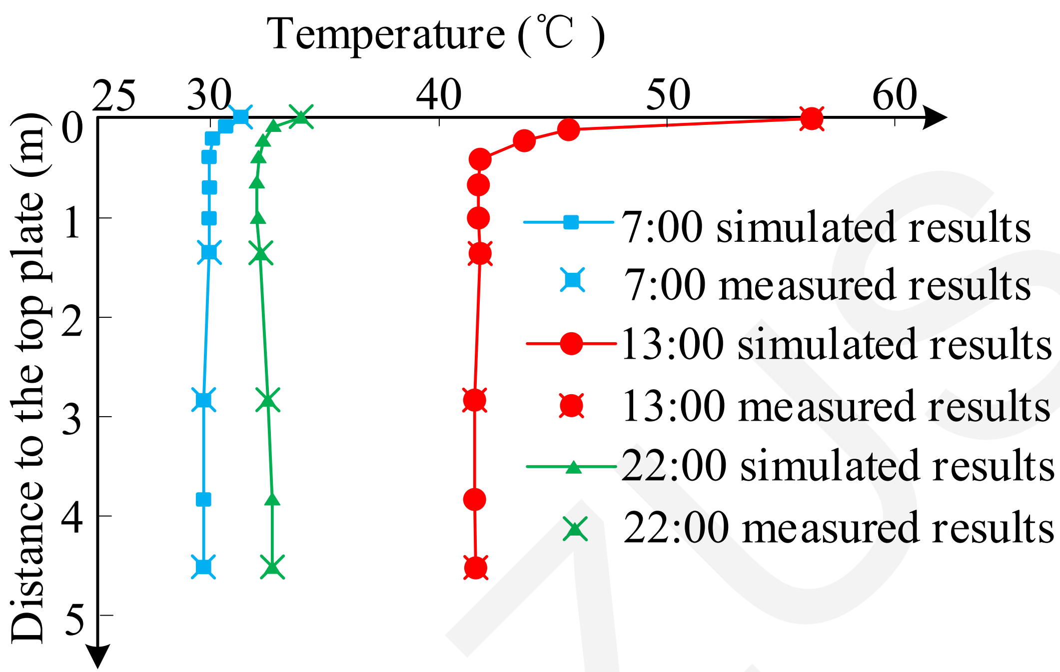
Fig. 2. Typical cross-section (unit: m)

Construction of A Continuous Steel box Girder

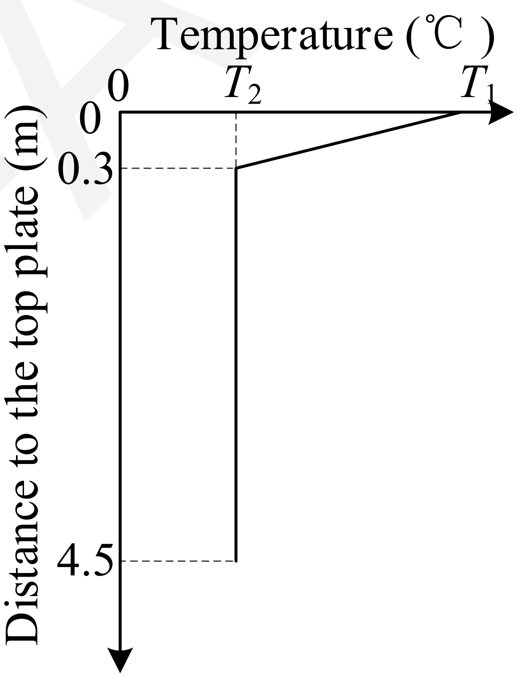


Procedures that will be affected by temperatures.

Temperature Distribution Along Depth of Girder



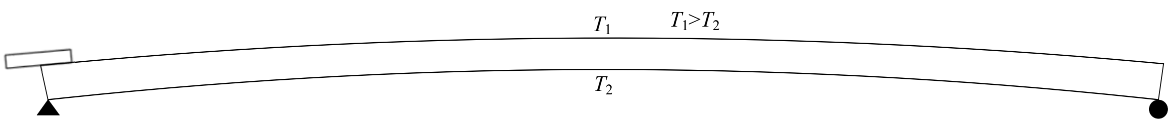
(a) results from field measurements on an extreme summer day



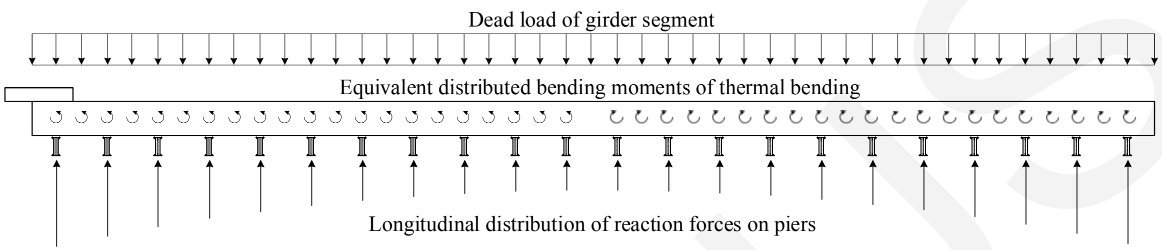
(b) a simplified scenario

Fig. 3. Vertical temperature distribution of the cross-section.

Open-air storage



(a) thermal bending.



(b) distribution of reaction forces on piers considering thermal bending

Fig. 4. Thermal effects on an open-air stored span-scale girder segment.

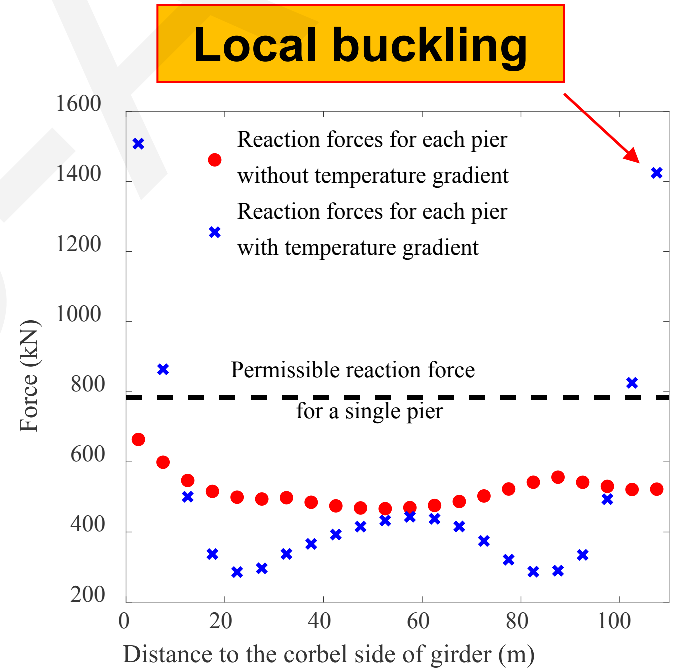


Fig. 5 Longitudinal distribution of reaction forces for each pier

Re-arrangement of Supporting Piers

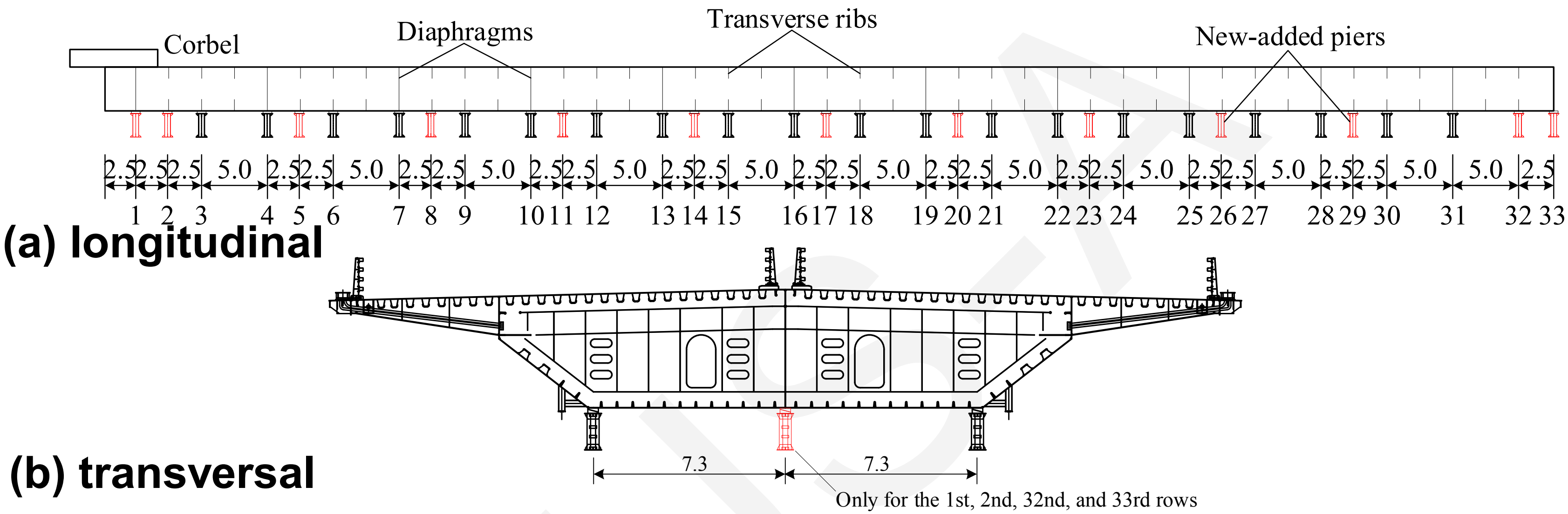
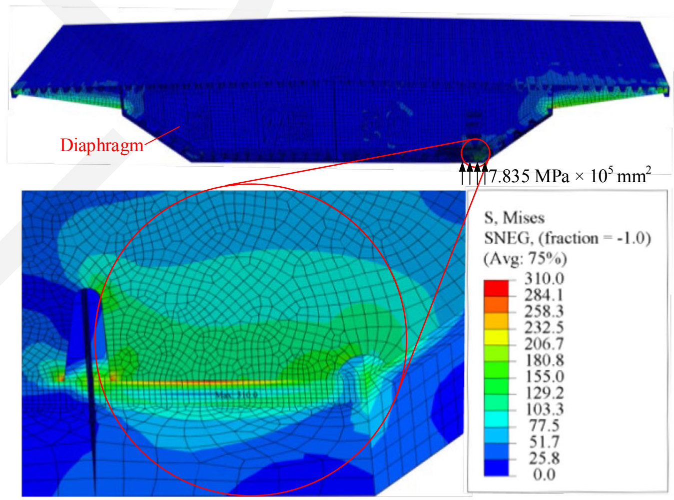
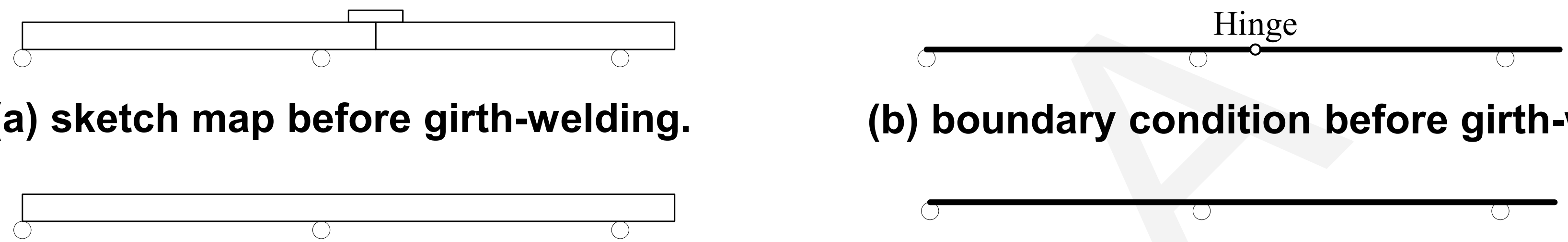


Fig. 6. Plan B for the arrangement of supporting piers (unit: m).



Safe

Girth-welding of Two Girder Segments



(a) sketch map before girth-welding.

(b) boundary condition before girth-welding.

(c) sketch map after girth-welding.

(d) boundary condition after girth-welding.

Fig. 7 Boundary condition change due to girth-welding of two girder segments.

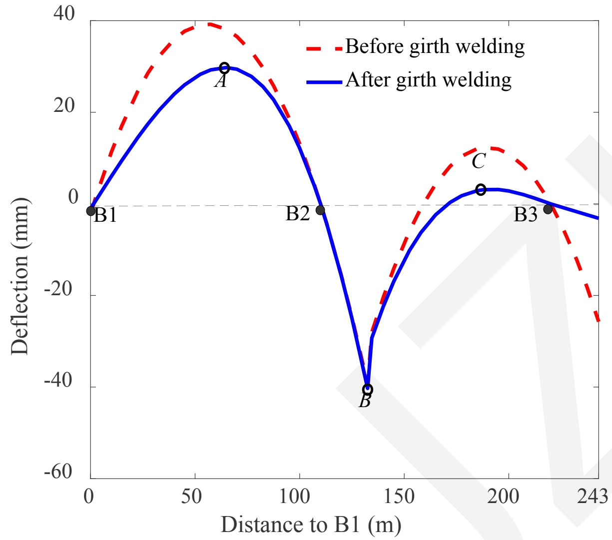


Fig. 8 Thermal deflections of two girder segments when girth-welded under vertical temperature and thermal loads disappear after completion of the weld.

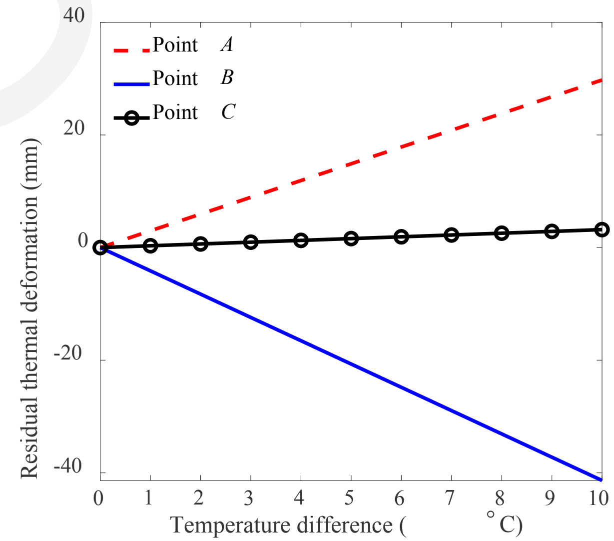
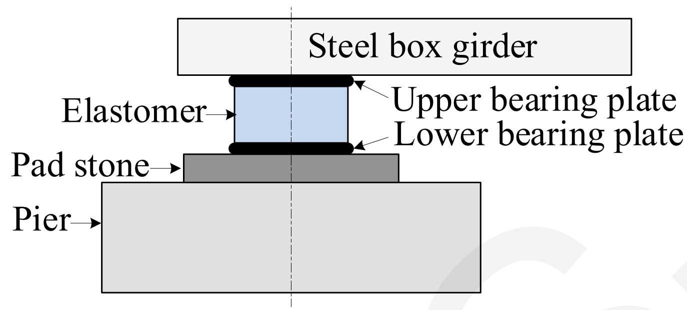
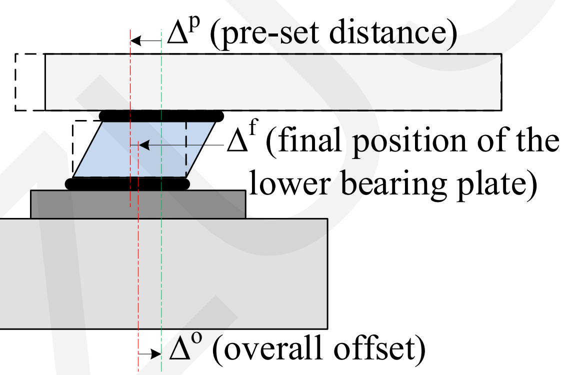


Fig. 9 Residual thermal deflections of three typical points after girth-welding with different vertical temperature differences on the girder.

Setting bearings



(a) design state of bearing.



$$\Delta_j^{\mathrm{p}} = -c_{nj}\alpha L_{nj}(T^{\mathrm{d}} - T_j^{\mathrm{a}}) - \sum_{i=m+1}^{n} c_{ij}\boldsymbol{l}_{ij}^{\mathrm{T}}\frac{\boldsymbol{\sigma}_{ij}}{E},$$

$$\Delta_j^{\mathrm{f}} = \Delta_j^{\mathrm{p}} + \Delta_j^{\mathrm{o}}.$$

$$\Delta_j^{\mathrm{o}} = c_{nj}\alpha L_{nj}(T_j^{\mathrm{a}} - T^{\mathrm{d}}) + \sum_{i=1}^{m} c_{ij}\boldsymbol{l}_{ij}^{\mathrm{T}}\frac{\boldsymbol{\sigma}_{ij}}{E}.$$

(b) pre-setting distance for bearing.

Fig. 10. Pre-setting distances for a sliding bearing.

Conclusions

a. In the open-air storage of a span-scale girder segment, the temperature gradient along the depth of the girder segment will greatly increase the maximum reaction force on temporary piers and cause local buckling of the bottom plate under the girder segment. Based on a simulation with field-measured temperatures, an improved arrangement plan involving additional support piers is proposed to reduce the maximum reaction force. In the field application of the improved arrangement plan during open-air storage, no local buckling was observed.

b. During girth-welding of two girder segments, the temperature difference before and after girth-welding caused some residual thermal deflections on the girder due to a change in the boundary conditions of the structure. The vertical temperature difference in girth-welding should be controlled within 1 ℃ to reduce the maximum residual thermal deflection. This can be realized by performing girth-welding in a specific period at night, such as after 22:00 h. In the field application of this control measure during girth-welding, the residual thermal deflections were controlled within 5 mm.

Conclusions

c. The pre-set distance of bearings should include the variation in the length of the bottom girder plate due to three factors: dead load, temperature gradient, and uniform temperature change. Here, we propose formulas for the pre-set distance, overall offset, and final position for sliding bearings, in which the parameters are determined based on the field-measured temperature data. In the field application of these formulas during bearing installation, the residual pre-set distances for bearings were controlled within 20 mm after the structural temperature was changed to their assumed design installation temperature.

d. The proposed control measures have successfully controlled the thermal effects in the span-scale girder segment placement of a continuous steel box girder in the HZMB, and thus they are also applicable to other continuous steel box girder bridges.