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Geometric state transfer method for construction control of a large-segment steel box girder with hoisting installation

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Construction Process of Steel Box Girder

Manufacture

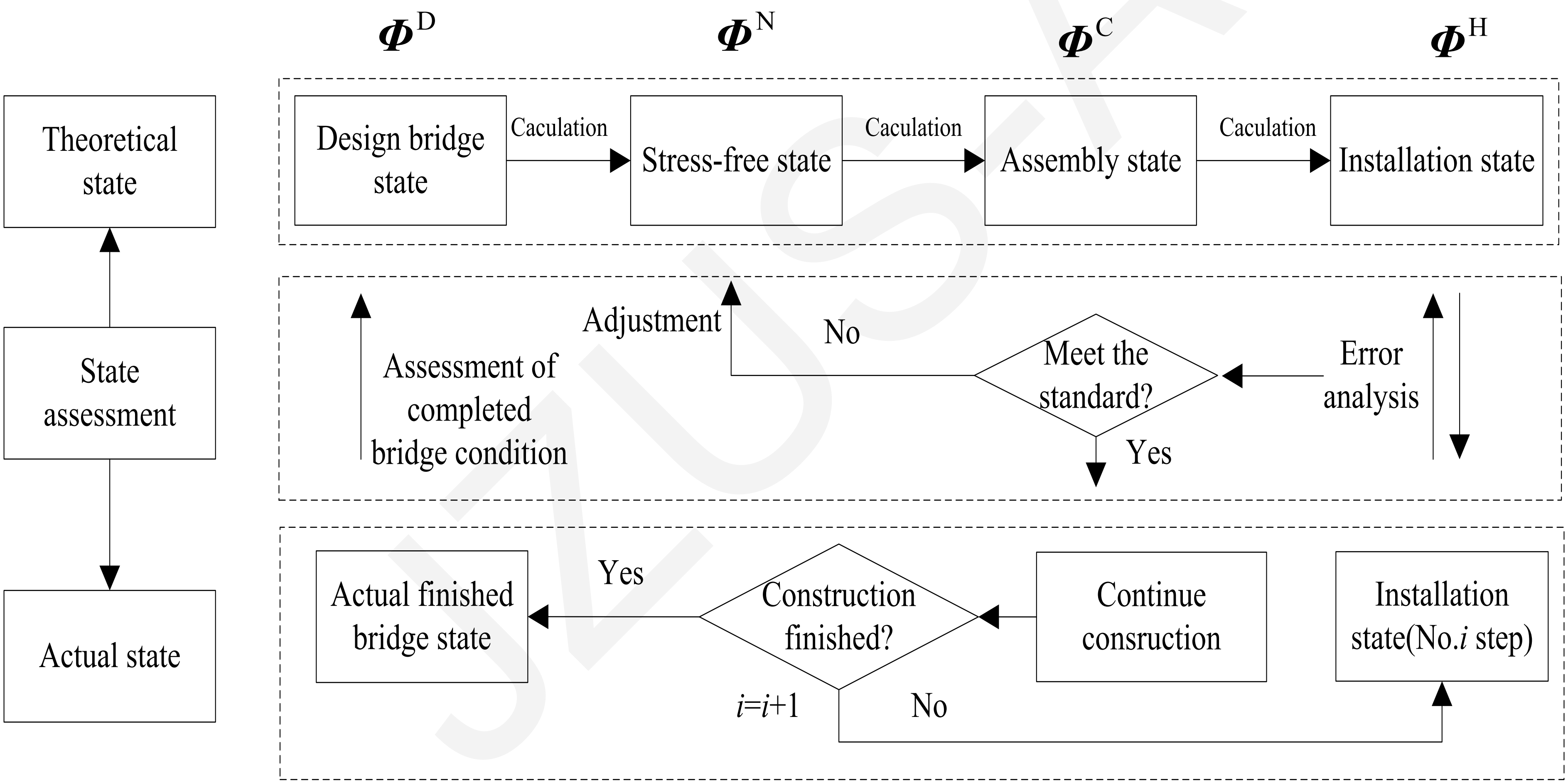
Transportation

Hoisting

Support installation

Geometric States

◆ Geometric states in the construction process of steel box girder



Geometric States Transfer

State equations

$$\boldsymbol{\Phi}^{\mathrm{N}}=\boldsymbol{\Phi}^{\mathrm{D}}+\boldsymbol{\Delta}^{\mathrm{D}}=\left[\boldsymbol{\Phi}_i^{\mathrm{N}}\right]_{i=1,2,\ldots,n}=\begin{bmatrix}\boldsymbol{\Phi}_1^{\mathrm{D}}+\boldsymbol{\Delta}_1^{\mathrm{D}}\\ \boldsymbol{\Phi}_2^{\mathrm{D}}+\boldsymbol{\Delta}_2^{\mathrm{D}}\\ \vdots\\ \boldsymbol{\Phi}_n^{\mathrm{D}}+\boldsymbol{\Delta}_n^{\mathrm{D}}\end{bmatrix}.$$

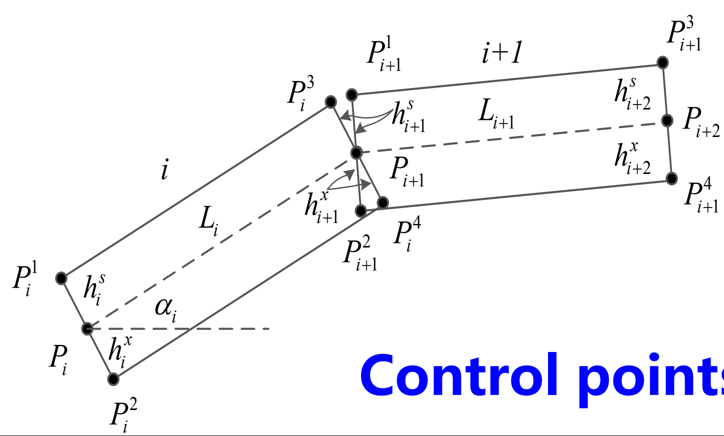
$$\boldsymbol{\Phi}_i^{\mathrm{N}}=\begin{bmatrix}\boldsymbol{P}_i^{\mathrm{N}}\\ \boldsymbol{\Psi}_i^{\mathrm{N}}\end{bmatrix},$$

$$\boldsymbol{\Psi}_i^{\mathrm{N}}=\left[\mathrm{I}_2\quad \mathrm{I}_2\quad \mathrm{I}_2\quad \mathrm{I}_2\quad \mathrm{I}_2\right]^{\mathrm{T}}\boldsymbol{P}_i^{\mathrm{N}}+\begin{bmatrix}-\sin\alpha_i & 0 & 0 & 0 & 0\\ \cos\alpha_i & 0 & 0 & 0 & 0\\ 0 & \sin\alpha_i & 0 & 0 & 0\\ 0 & -\cos\alpha_i & 0 & 0 & 0\\ 0 & 0 & \cos\alpha_i & 0 & 0\\ 0 & 0 & \sin\alpha_i & 0 & 0\\ 0 & 0 & \cos\alpha_i & -\sin\alpha_i & 0\\ 0 & 0 & \sin\alpha_i & \cos\alpha_i & 0\\ 0 & 0 & \cos\alpha_i & 0 & \sin\alpha_i\\ 0 & 0 & \sin\alpha_i & 0 & -\cos\alpha_i\end{bmatrix}\begin{bmatrix}h_i^{\mathrm{s}}\\ h_i^{\mathrm{x}}\\ L_i\\ h_{i+1}^{\mathrm{s}}\\ h_{i+1}^{\mathrm{x}}\end{bmatrix},$$

$$\boldsymbol{P}_i^{\mathrm{N}}=\left[S_i^{\mathrm{N}}\quad H_i^{\mathrm{N}}\right]^{\mathrm{T}},\qquad \alpha_i=\arctan\left(\frac{H_i^{\mathrm{N}}-H_{i+1}^{\mathrm{N}}}{S_i^{\mathrm{N}}-S_{i+1}^{\mathrm{N}}}\right).$$

Transitive relationship

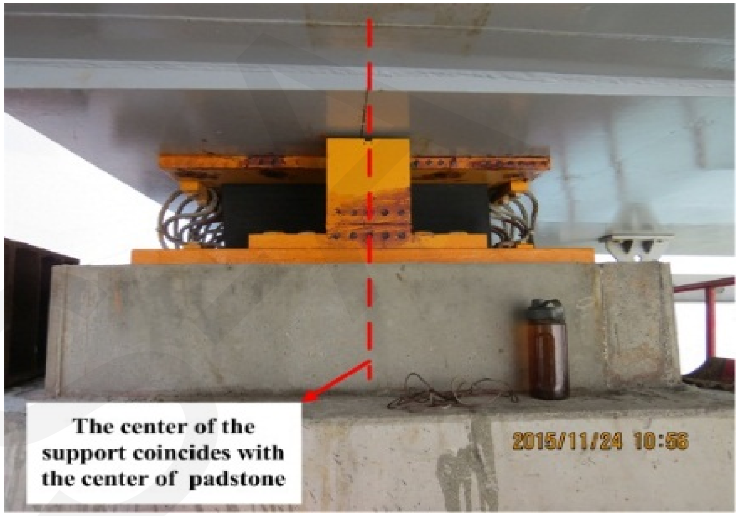
$$\boldsymbol{P}_{i+1}^{\mathrm{N}}=\boldsymbol{P}_i^{\mathrm{N}}+L_i\left[\cos\alpha_i\quad \sin\alpha_i\right]^{\mathrm{T}}\quad(i=1,2,\cdots,n).$$



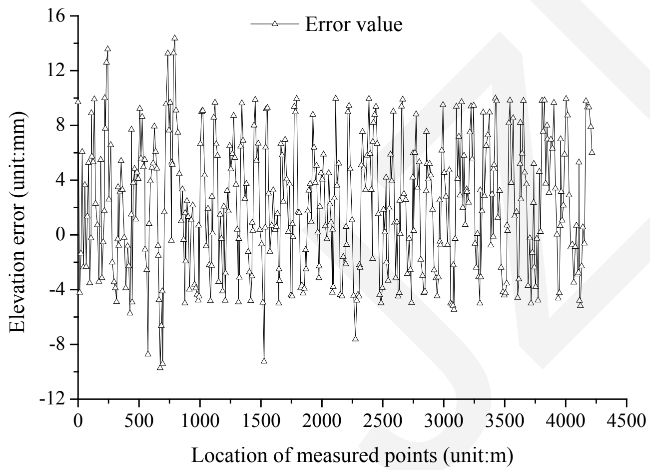
Control points

Results and Conclusions

Annular joint connection



Precise installation of support



Elevation errors of steel box girders

On-site picture after completion of steel box girders

Results and Conclusions

- The geometric state control indexes, that is the manufacturing parameters of top and bottom slab, the width of annular joints of large-segment steel box girders, and the support positions, of large-segment steel box girders were determined. The geometric state equation and state transfer matrix of large-segment steel box girders under different states were deduced by taking the mileage and elevation of control points as basic state variables. The measurement data show that the difference between the width of the annular joint of the top and bottom slab was less than 2 mm in the stress state, the eccentricity of bridge support was less than 20 mm, and the elevation error of the bridge deck was within −10 to +15 mm, which met the control accuracy requirements.

- The geometric state control method, which takes the mileage and elevation of the control points of a bridge as the basic state variables, can realize the control of complex geometric relation transmission in the process of bridge construction. This method is universal and can be further applied to the geometric state control of the bridge construction of ectopic installation and multi-state conversion, such as incremental launching construction and segmental assembling construction.