

# The Influence of Misalignment on the Bolt Pre-tension and Slip Coefficient of High-Strength Bolted Friction-type Joints in Steel Box Girder

To elucidate bolt pre-tension and contact state variations in misaligned joints

## BACKGROUND

High-strength bolted friction joints (hereafter called joints) are commonly used in in-situ assembly. However, the **slip coefficient decrease when misalignment occurs at the joints**

- ☑ Previous studies:
  - I. **Strip-type joints** with multiple rows(1 line) focusing on the axial force of bolts and slip strength
  - II. **Several estimation formulas** for the reduction of residual slip strength ratio have been proposed;
- ❑ Pending issues: Actual joints are likely to exhibit smaller pre-tension reductions in due to misalignment than those calculated by existing formulas, since **boundary condition** in the two situations(Design & Actual) differ.
- **Goal of Research:** Elucidation of the relationship among actual structural configurations misalignment and slip-critical joint performance.

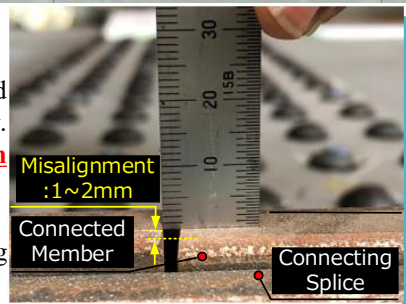


Fig. 1 As-built inspection

## RESULTS

• **First row (P1, P5, P9, P13)** is the **greatest**, at around 50%. Because of the significant **vertical deformation** at the position of the row 1, line 1 bolt (P1) due to the tightening of the second row.

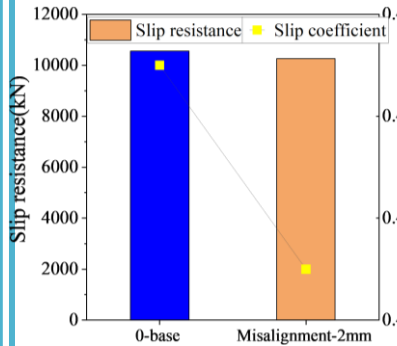


Fig.5 Slip resistance

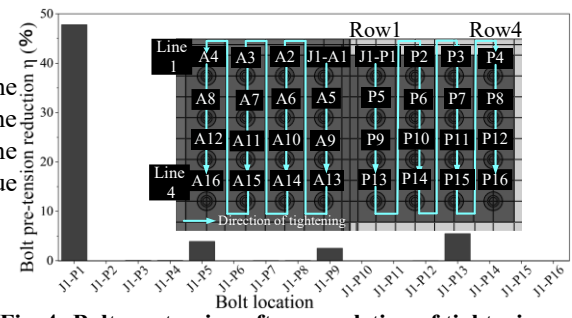


Fig. 4 Bolt pre-tension after completion of tightening

- Although the decrease of bolt pre-tension is approximately 50%, the **total bolt pre-tension decreased** by a maximum of **2.8%** compared to the case where the misalignment was 0 mm.
- **The slip resistance decreased** by a maximum of **7.7%**; considering Coulomb friction, the bolt pre-tension decreases 2.8%, correspondingly caused 7.7% the loss of slip resistance due to **uneven contact**(Fig.6)

## METHOD

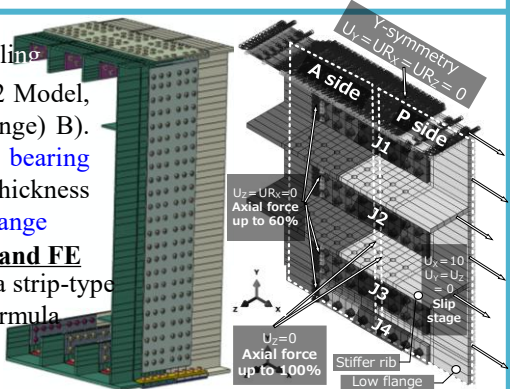
### I. FE Method

Parameter: A). Modeling

range →(a)**Actual cross-sectional model**(1/2 Model, **Analyzing**)(b)**Partial model**(only Lower Flange) B). **Boundary condition** →(a) Set a **pin-roller bearing at centroid of section**; (b) **Fixed** in the thickness direction of the **neutral plane on the lower flange**

### II. Comparison of the estimation formula and FE

☑ Previous studies: A mechanical model of a strip-type joint has been developed, and a predictive formula for the residual slip resistance ratio of joint has been proposed.



(a) Actual cross-sectional (b) Partial Fig. 2 FE Model

Connecting splice shear parameter  $\lambda = 0.1(E/G)(t_s/a)^2$   $t_s$ : thickness,  $a$ : end distance Bolt pre-tension/ using in bending the connecting splice (Eq.1)

$R_3/P_0 = C_4 \times E/c\sigma_{YB} \times b\delta/A_B \times (t_s/a)^3 \times S/12$  Residual slip resistance ratio(Eq.2)  $r = 1 - R_3/nP_0$   $C_4$ : Reaction force(Fig.3 pivot 3), S: fix factor (By FE)

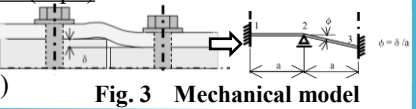


Fig. 3 Mechanical model

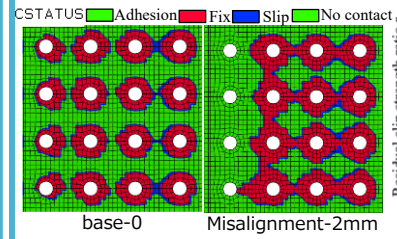


Fig.6 Contact status

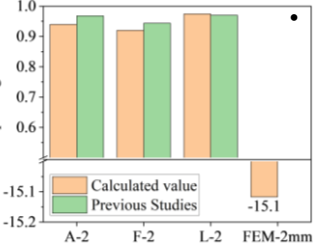


Fig.7 Comparison of the estimation formula and FEM results

The calculated value is very close to the literature value, but differs significantly from the analytical value, resulting in an error of -15.1. Because the parameters S(Eq.1) constituting the formula were identified based on the results of the finite element analysis.

## SUMMARY

- In the partial model, the **reduction of the bolt pre-tension and slip resistance decreased** by **2.8%** and **7.7%**, respectively.
- **As some parameters in the prediction equation is identified using finite element analysis, it is necessary to perform the analysis on the actual cross-section.**

## KEYWORDS

❑ Misalignment, Bolt Pre-tension, Slip Resistance