Study on the Stress Transfer Mechanism of Temporary Bridge End-Plate Tension Connections under Combined Bending and Shear Loads

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Evaluation of Gap Opening, Contact Pressure Localization and Prying Action on High-Strength Bolts

BACKGROUND

- Traffic loads on temporary bridges induce *combined bending and shear* actions at structural joints, varying by load position. Therefore, the *stress transfer mechanism of end-plate connections differs* significantly from conditions of pure bending.

Pic.1 End-plate Connection

- Existing literature lacks a comprehensive evaluation correlating loading positions with the *evolution of contact conditions and bolt force transfer*.

→This paper aims to elucidate the *stress transfer mechanism* and *tension-side end-plate separation behavior* under combined loading via finite-element (FE) analysis.

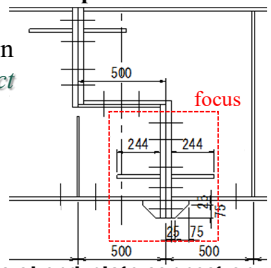


Fig.1 Schematic of end-plate connection

METHODS

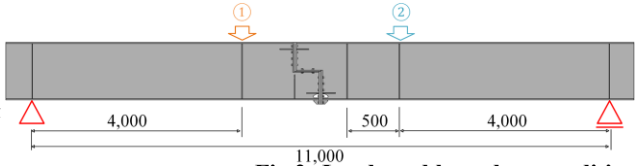
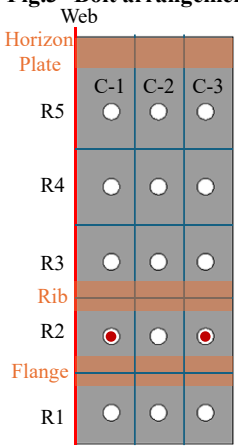


Fig.2 Loads and boundary conditions

Fig.3 Bolt arrangement



Loading Steps:

Two-step process (*bolt pretension →displacement control*). Pure bending and asymmetric shear loading configurations are simulated using *four-point* and *three-point loading* setups, respectively.

Evaluation:

The bending moment at the end-plate joint serves as the reference parameter.

Outputs & Validation:

Extracted key local responses (bolt force, separation, contact stress), rigorously verifying the *prying force (Q_{prying})* through both *contact resultants* and *force equilibrium*.

KEYWORDS

Temporary Bridge, End-Plate Connection, Prying Force

RESULTS

Bolt Force & Shear Stress (Figs. 4 and 5):

A symmetric shear accelerates the amplification of bolt force, reducing the *yield moment by 23.1%.* Furthermore, it generates localized interfacial *shear stress (up to 14MPa)* around the bolts.

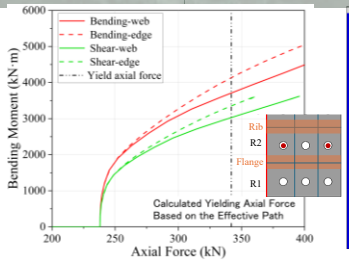


Fig.4 Load–axial force of 2nd-row edge/web bolts

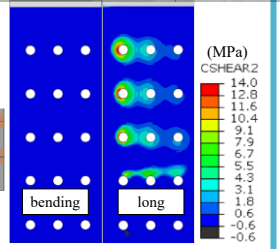


Fig.5 Vertical shear stress contours on the tension-side at 50% capacity

Gap Opening & Joint Rotation (Figs. 6 and 7):

Plate separation maximizes near the lower flange. Compared to pure bending case, the shear case expands the separation area and *increases the gap by > 34%*. This difference grows almost linearly with the *rotation angle of the joint*.

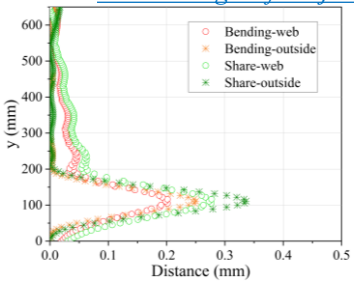


Fig.6 Vertical separation at 50% capacity

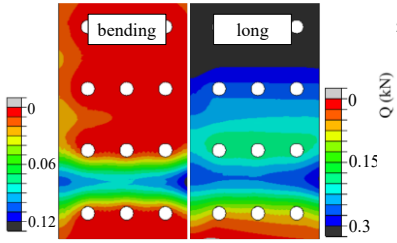


Fig.7 Bridge-axis displacement contours at 50% capacity

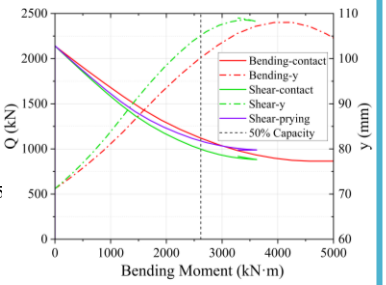


Fig.8 Load vs. resultant contact force and position

Contact Redistribution (Figs.8 and 9):

Under asymmetric loading, *contact pressure localizes and drops by ~26%* near the web. Concurrently, the contact resultant *(Q_{prying}) increases by 12.3%*, and the point of application shifts upward.

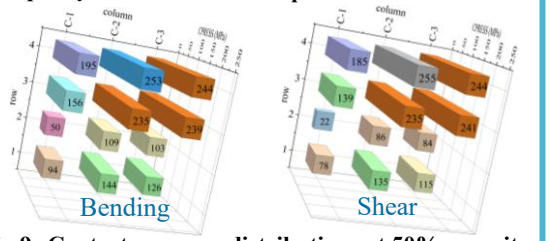


Fig.9 Contact pressure distributions at 50% capacity

SUMMARY

➢***Accelerated Deformation:*** Shear loading causes earlier *amplification of bolt force* and greater *separation of the end plate* compared to pure bending.

➢***Interface Force Redistribution:*** At 50% capacity, contact pressure at the web decreases, while the *prying resultant increases by 12.3% (shifting upward by 4.6%)*. Furthermore, the interface transmits both normal force and *local tangential shear resistance*.