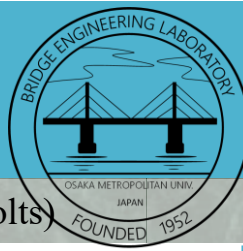


Applicability Extension of Friction-type Joints with High-Strength Countersunk Head Bolts

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Sophistication of Slip Resistance Evaluation of Single-Strap Bolted Joints (To begin with hexagonal head bolts)

BACKGROUND

- ✓ Characteristics of single-strap friction-type joints with high-strength bolts (Fig.1)
- ➡ Eccentric bending moment: Occurs under in-plane loading due to **through-thickness asymmetry**.
- ➡ Slip resistance: Reduced to less than half that of double-strap joints—driven not only by having a single friction interface, but also by the impact of eccentric bending moment.

Research Objectives

- ∴ Influence evaluation of the thickness and yield strength of connected plate and splices
- ∴ Establishing a rational design formula of slip resistance

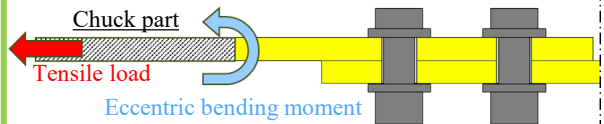


Fig. 1 Schematic diagram of a single-strap friction-type joints with high-strength bolts

METHOD

Analysis Parameters

- Slip-to-yield resistance ratio (β_d) : $0.17 \leq \beta_d \leq 1.16$
- Yield resistance ratio of splice to main plate (γ_a) : 1.00, 1.33

$$\beta_d = \frac{\mu n m N}{(w - d) \times t_c \times \sigma_y}$$

$$\gamma_a = \frac{(w - d) \times t_s \times \sigma_y}{(w - d) \times t_c \times \sigma_y}$$

n : Number of bolts
 m : Number of faying surfaces
 N : Bolt pre-tension
 w : Width
 d : Bolt hole diameter
 t_c : Connected plate thickness
 t_s : Splice plate thickness
 σ_y : Yield strength

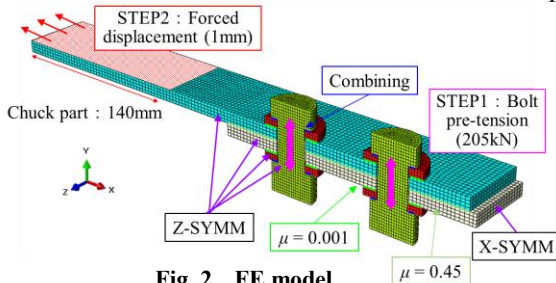


Fig. 2 FE model

Slip Load Definition

Criteria : Whichever occurs first

1. Maximum load
2. Internal relative displacement = 0.2 mm

KEYWORDS

□ Single-strap joints, Slip resistance, End stress

RESULTS

A) Applicability Limits of Slip Resistance Evaluation with β_d

- The slip coefficient becomes larger with only an increase in splice thickness, even though eccentric bending moment also occurs.
- Therefore, β_d is not an appropriate indicator for single-strap joints.

B) Proposal of Edge Yield Resistance (β_e)

- Due to the strong influence of eccentric bending moment, the upper and lower end surfaces are yielded first.
- The modified ratio β_e is calculated from the end surface yield resistance, based on a combination of tension and bending moment.

C) Relationship between β_e and Slip Coefficient

- The slip coefficient remains constant for $\beta_e \leq 1.0$ and decreases linearly for $\beta_e > 1.0$.
- β_e provides a more accurate evaluation of the slip coefficient of single-strap joints.

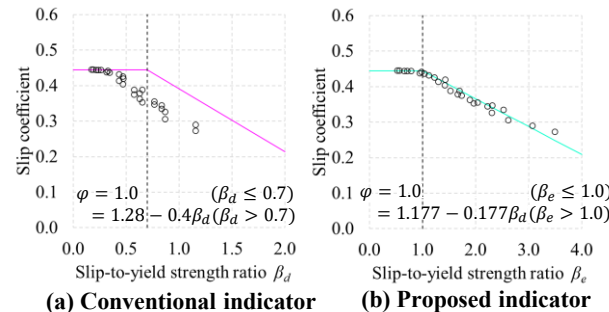


Fig. 3 Slip-to-yield strength ratio and slip coefficient

$$\sigma_{ec,es} = \frac{P}{A_{c,s}} + \frac{Pe}{I_c + I_s} y_{c,s}$$

$\sigma_{ec,es}$: End stress
 P : Tension
 $A_{c,s}$: Cross-sectional areas of both plates
 e : Eccentricity
 $I_{c,s}$: Moment of inertia of both plates
 $y_{c,s}$: Distance from centroid to end edge

SUMMARY

- Demonstrated the potential to estimate slip resistance in single-strap joints by applying the end yield resistance—which accounts for eccentric bending moment—and utilizing the proposed slip-to-yield resistance ratio (β_e).
- To investigate in detail the impact of out-of-plane stiffness variations on the slip and yield resistance of single-strap joints, assuming actual structures with stiffeners (e.g., ribs).