# Variation of Bolt Axial Force and Friction Coefficient in High-Strength Bolted Frictional Joints under Cyclic Loading

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Clarify the cyclic behavior through experiments

## BACKGROUND

Under seismic loading, the Frictional Joints shown in Figure 1 is prone to slip, while reinforcement by increasing the number of bolts is impractical.

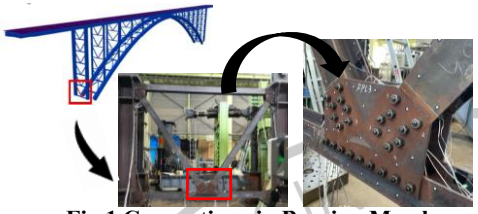

Fig.1 Connections in Bracing Members

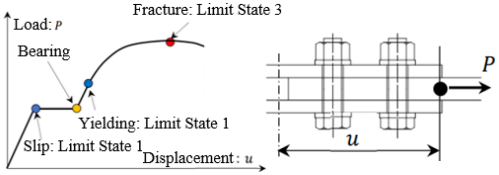


Fig.2 Limit States in Bolted Friction Joints

As shown in Figure 2, after slip occurs, the bolts transition to bearing and continue to transfer load. To allow slip, it is necessary to define a second limit state prior to fracture.

**Purpose:**

Investigation of the Cyclic Behavior of High-Strength Bolted Friction Joints after Slip

Cyclic loading experiments were carried out on the joints to examine the influence of axial force and frictional property variations on slip behavior.

## METHOD

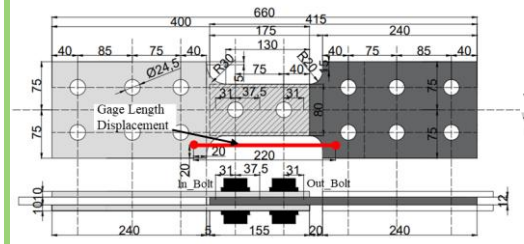


Fig.3 Structural Specifications:Unit(mm)

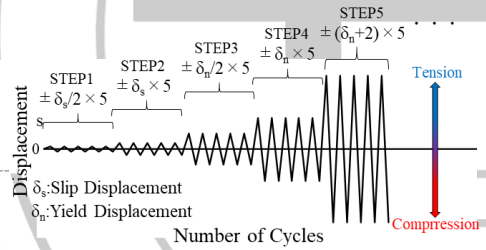


Fig.4 Loading Method

The loading sequence was divided into slip and yielding ranges. Each step included 5 loading cycles.

**Table1 Test Conditions**

| Base Plate Thickness(mm) | Yield Strength (kN) | Axial Force (kN) | slip coefficient | Slip resistance (kN) | β | Tensile strength (kN) |
|---|---|---|---|---|---|---|
| 12.00 | 193.5 | 67.0 | 0.71 | 190.6 | 0.99 | 290.0 |

**Measured Parameters**

- Bolt axial force
- Strain on the faying surface
- Displacement between gauge points

## RESULTS

**Hysteretic behavior**

As shown in Fig.5 After slipping, cyclic loading caused rust on the faying surface to wear off, resulting in a stable bilinear response.

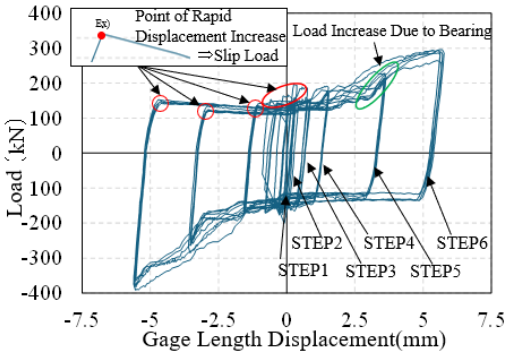


Fig.5 Hysteretic behavior

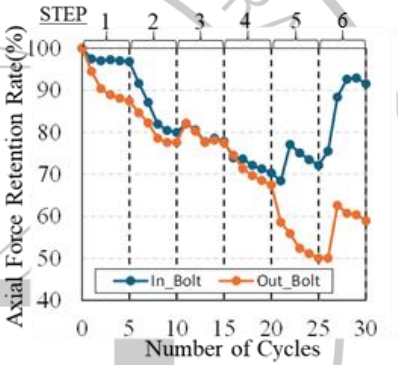


Fig.6 Transition of Residual Bolt Axial Force Ratio

**Transition of Residual Bolt Axial Force Ratio**

1)Axial force decreased due to surface adaptation and rust abrasion, even before slip

2) Axial force increased with displacement due to compression-induced plate deformation.

**Variation of Friction Coefficient**

The friction coefficient is expected to stabilize in the range of 0.65 to 0.7 by the fifth cycle of each loading step. This is considered to be due to the rust being worn off, leading to stabilization of the faying surface.

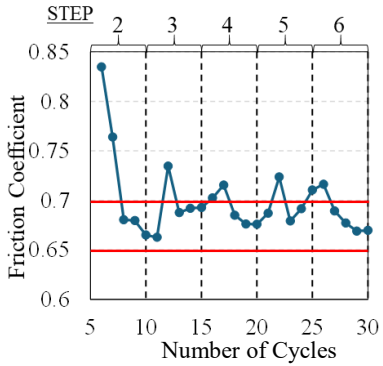


Fig.7 Variation of Friction Coefficient

## SUMMARY

- Cyclic loading caused initial axial force reduction due to rust wear
- Axial force increase due to plate compression at large displacements
- Friction coefficient stabilization toward 0.65–0.7.

**KEYWORDS** Friction-Type Bolted Joint , Cyclic Loading ,Limit States