Effect of Cyclic Loading on Post-slip Behavior of high-strength friction-type bolted connections

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A reproduction analysis to investigate the Bolt-hole deformation and stress characteristics under cyclic loading.

BACKGROUND

Gusset plate connections in bracing members under seismic action are required to increase the number of bolts to prevent slippage. In contrast, post-slip resistance, comprising bearing and residual friction resistances, can be expected if slippage is permitted.

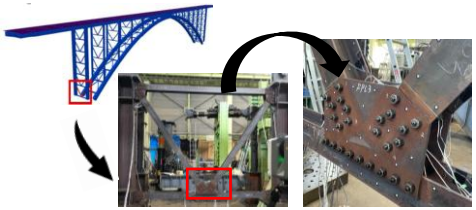


Fig.1 Connections in Bracing Members

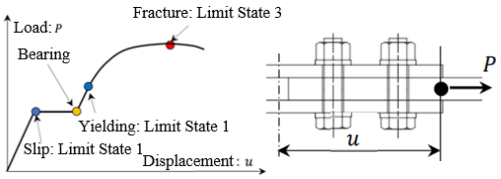


Fig.2 Limit States in Friction-type Joints

Purpose:

This study numerically investigates the post-slip behavior, focusing on bolt-hole deformation, which is closely related to local plastic strain around the hole.

METHOD

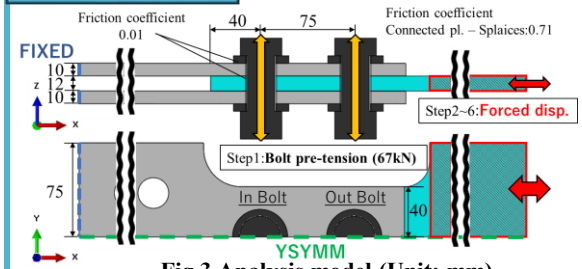


Fig.3 Analysis model (Unit: mm)

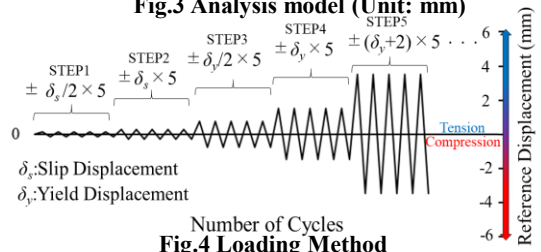
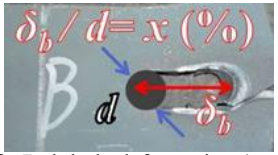


Fig.4 Loading Method

Table1 Constitutive laws

	Splices	Connected pl.	Bolts
Material	SM490Y	SM400	F10T
Young's modulus	200	193	200
Yield stress (MPa)	355.7	290.9	904.1
Poisson's ratio	0.30	0.28	0.30



δ_b:Bolt hole deformation (mm)
d : Hole diameter (= 24.5 mm)
x : Bolt-hole deformation ratio

Fig.5 Bolt-hole deformation ratio

KEYWORDS

friction-type bolted joint,cyclic loading, deformation of bolt holes

RESULTS

FE analysis validation

The numerical max. load is good agreement with the experimental load although the cyclic behavior cannot be completely calibrated due to the time-dependent change of the stick-slip characteristics.

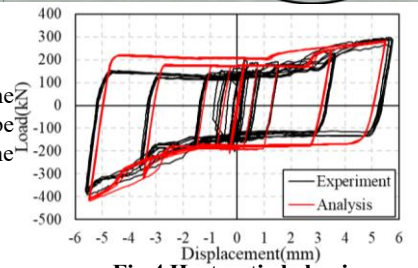
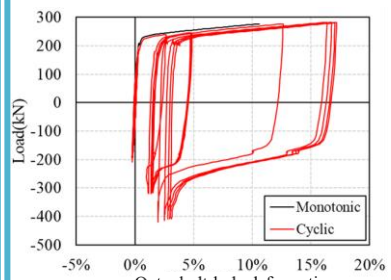
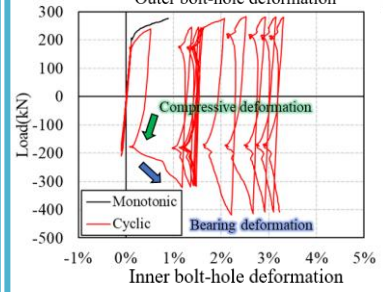


Fig.4 Hysteretic behavior





Hole deformation

The difference of inner and outer holes is the sensitivity to a cyclic action, as shown in their load vs. disp. (Fig.5). The inner bolt hole is deformed in compression state while outer one is not deformed. This tendency depends on the type of initial load and the bolt location in joints.

Stress characteristics

As shown in Fig. 6, the cross-section yield is moved and the stress around the outer hole varies historically. Therefore, the ultimate performance should be decided by the cumulative equivalent p. strain and bolt hole deformation.

Fig.5 Load versus bolt-hole deformation
(Top one: Outer hole Bottom one: Inner hole)

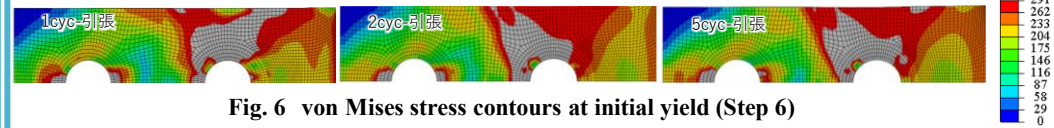


Fig. 6 von Mises stress contours at initial yield (Step 6)

SUMMARY

The local bearing deformation and stress distribution of bolt holes depend on the type of initial load and the bolt location in joints. The stress/strain tensor history and their scalar values (von Mises stress / cumulative p. strain) are also found essential for investigating the post-slip behaviour of gusset plate connections and for expecting post-slip resistance.