

Yielding behavior of friction-type bolted joints with a combination of staggered and grid arrangements

Osaka Metropolitan University Graduate School of Engineering Bridge Engineering Lab Kazuha Ashiya

Assessment of Design Assumptions Based on Analytical Yielding Behavior

BACKGROUND

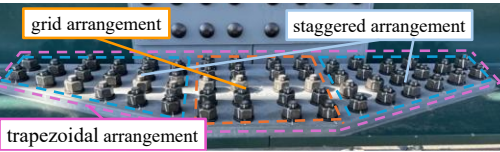


Fig. 1 Friction-type bolted joints with trapezoidal arrangement

Current design method (JSHB)

Net cross-sectional area : Calculated by using Cochrane's $p^2/(4g)$ rule $w = d_0 - \frac{p^2}{4g}$

Load sharing ratio among bolts : Assumed to be uniform

Friction effect on cross-section yield : 1.1 times increase factor

Challenges to achieve the structural rationalization

- Load-transfer mechanism, bolt load sharing, and yielding behavior is clarified
- Validity of 1.1 increase factor for turreted arrangements is verified

METHOD

Analytical cases: Total 6 Analytical cases (Dimension type-3, Joint type-2)

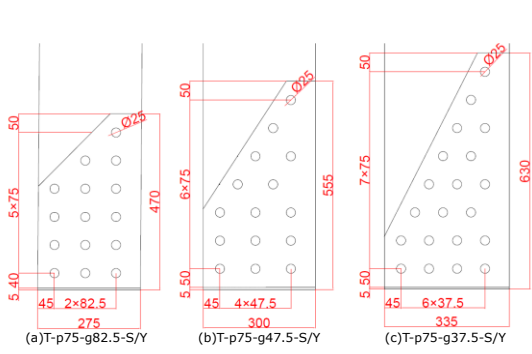


Fig. 3 Bolt arrangement of analysed cases and critical bolt locations

Friction-type bolted joints with trapezoidal arrangement (Fig.1)

- Combining staggered and grid layouts widely used in flange joints
- Decrease in bolt number toward the joint end to increases net cross-sectional area

RESULTS

Stress path

Von Mises stress tends to concentrate at tip and outermost bolts → early yielding around

Friction force distribution

Yield-critical type:

The friction force of central bolts is 35 to 62% of that of other bolts (Fig.4)

→Slip occurred at the outermost and joint clearance-side bolt rows, but not at the central bolts.

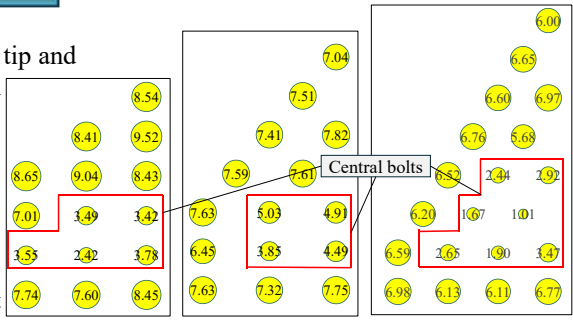


Fig. 4 Yield-critical type at net-cross section yield

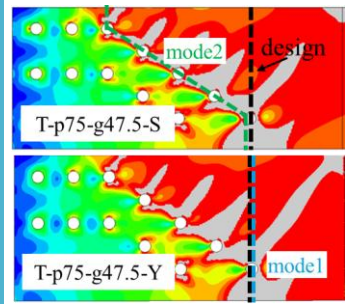


Fig. 5 The yield mode

The yield mode (Fig.5)

Limited to the following two cross-sections:

- Model1: Yield band from tip bolt's hole and an edge-side surface
- Model2: Yield band along outermost bolts to an edge-side surface

Viewpoints

Comparison between design assumptions and analytical yielding behavior

- Stress path
- Friction force distribution
- Yield mode
- Yield load

Table. 1 Design net cross-section yield resistance and yield load

Case Name	Design Assumption $1.1 * P_{dym}$	Net Cross-Section Yield Load P_{num}	P_{num} / P_{dym}
(a)I-p75-g82.5-S	5812	5298	0.91
(a)I-p75-g82.5-Y	3451	3331	0.97
(b)I-p75-g47.5-S	5964	5670	0.95
(b)I-p75-g47.5-Y	4047	3928	0.97
(c)I-p75-g37.5-S	6422	6097	0.95
(c)I-p75-g37.5-Y	4519	4402	0.97

The yield load (Table.1)

The ratio P_{num} / P_{dym} was 0.91–0.97
→The uniform application of 1.1 times increase factor appears to be inappropriate

SUMMARY

- I. In the yield-critical type joints, the load sharing among individual bolts is non-uniform.
- II. Stress concentrates at the tip bolt and the outermost bolt rows, thereby restricting two yielding modes along them.
- III. Uniform application of 1.1 times increase factor appears to be unsuitable

KEYWORDS

Trapezoidal arrangement, Friction force distribution, Yield mode