Measurement of Slip in Slip-Critical Connections with Different Specification Holes

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are the primary types of beam-to-
Bolted connections are considered
ement within the connection would
ity. Little research has been done
ying the hole sizes in slip-critical
ecessary to provide a model that
tion as a function of the hole size,
ort-slotted, and long-slotted holes.
ffects of various hole sizes for
f bolts, amount of filler, and the
ns while maintaining a constant
critical connection models will be
ng, employing a universal testing
unt of slip. The results of these
sting database of testing on slip-
sidering various hole sizes, the
slip load can be improved.
will lead to more efficient, cost
connections.

ovement of the plies within a joint
The design of slip-critical joints
ype of movement. According to
ifications, slip-critical connections
lippage due to service loads, and
ure 90 to 95% of the time when
ension are applied. Typical cases
designed as slip-critical are when
tigue loading, joints that employ
nd joints where slip at the faying
e integrity of the structure. The
er consequences are critical is
hirteenth Edition by considering
tored load levels.

Methods

Design

Specimens were designed to simulate actual bolted connections. The joints consisted of A572 Gr. 50 rolled bars with clean mill scale surface while other characteristics were varied:

- **Bolt Type**
  - A325
  - A490
- **Bolt Diameter**
  - ½”
  - ¾”
  - 1”
- **Hole Type**
  - Standard
  - Oversize
- **Bolt Geometry**
  - Type A – 1 straight row
  - Type B – 2 straight rows
  - Type C – Staggered rows
- **Filler Amount**
  - No filler
  - 1 x ½”
  - 2 x ¼”
- **Number of Bolts**
  - Type A
    - 1
    - 2
    - 3
    - 5
  - Type B
    - 4
    - 6
    - 8
    - 10
  - Type C
    - 5
    - 8
    - 11

Fabrication

1. Steel cut to length
2. Holes match-drilled (4 individually-drilled)
3. Gripped end of 6” bars coped
   a. 2 reinforced with welded plate
   b. 2 reinforced with bolted plate
4. Burrs ground off
5. ½” x ½” grid drawn
6. Exact hole location determined with AutoCAD
7. Bolted together
8. Pretensioned by turn-of-nut method

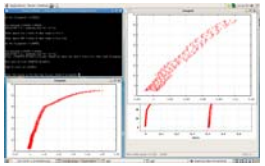
Testing

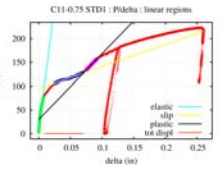
1. Installed the proper setup in the universal testing machine
   a. Mount wedges and shim plates
   b. Specimens placed into grips
   c. LVDTs were mounted to the specimen
2. LVDT check
3. Load specimen to twice the slip load
4. Unload
5. Hand measure displacement with caliper
6. Reload the specimen to failure
7. Remove specimen form machine
8. Measure angle of bending

Analysis

Data processing

- Linear regression used to identify linear regions within the curve associated with the elastic slip and plastic regions.

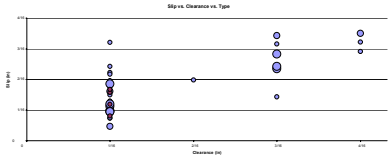




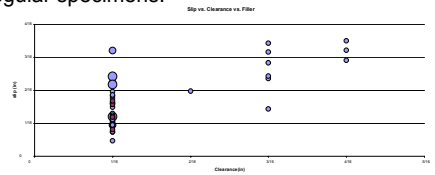
- We solve for the slip distance and the slip load by simultaneously solving the pairs of linear fits.
- The whole procedure is encapsulated in a Python script custom-written for our tests.

Results

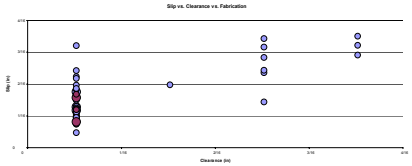
- **Specimen type**
  - A type exceeds the predicted slip, B and C types exhibit less slip than predicted.



- **Filler plates**
  - Specimens with filler plates presented larger slip than regular specimens.

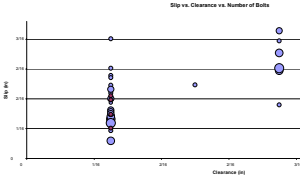


- **Fabrication and assembly**
  - Match-drilling and hole alignment increase slippage.

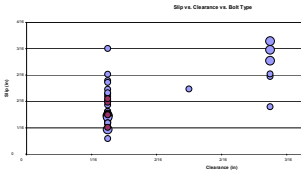


Results

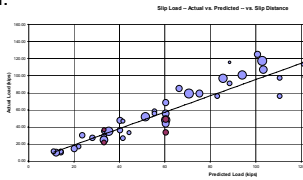
- **Number of bolts**
  - Number of bolts positively correlates



- **Type of bolts**
  - A490 bolts tend to cluster around pre



- **Predicted load vs. Experimental lo**
  - Larger variance for higher values of
  - Actual slip load estimated at around load.
  - Longer slip displacements correlate load.



Conclusion

Our hypotheses our provisional and rec
that the broad trends presented above
model to predict the slip displacement.
using higher-strength steel to delay pla
differentiate the slip region more clearly
importantly, one has to define a uniform
region as a linear or non-linear curve to

Acknowledgments

National Science Foundation (NSF) REU Program
University of Cincinnati
Dr. James Swanson, Dr. Anant R. Kukreti, Dr. Gian A
Mr. Elie G. Hantouche, Mr. Craig A. Schrader

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