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Abstract

INVESTIGATION OF SHEAR LAG EFFECTS ON
WELDED STEEL TENSION MEMBERS

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The stress distribution in the vicinity of connections of a tension member (such as angles, tees and channels) is non-uniform because of the combined effects of shear lag, connection eccentricity and stress concentrations. Consequently, the ultimate capacity of the member is significantly reduced. Many researchers devoted extensive efforts to the investigation of the shear lag behaviors on different kinds of connections, mostly on the bolted connection. Relatively few tests have been conducted to examine the negative effects on the welded connection. Although the current design specifications provide comprehensive designs for welded tension members, these design formulas are developed based on limited test data or from the research on the bolted connection.

Hence, an extensive research was carried out including an experimental work and an analytical study to investigate the shear lag effects. In the tests, totally 22 single angle and tee-section tension members with the welded connection were conducted. The test parameters included long or short leg connections, balanced or unbalanced weld arrangements, fillet weld lengths and different section sizes. Sixteen specimens failed in the net section, while the other six specimens failed in the weld due to the poor quality of the weld fabrication. Subsequently, the design approaches of the current specifications were evaluated based on the existing test results. It was observed that all the specifications provided conservative predictions for most of the existing data.

The un-conservative predictions were no more than about 10 percent below the corresponding ultimate loads in the tests. Over-conservatism was found for the specimens with short legs connected, in particular, in the case of the balanced welds.

Based on the test results, a nonlinear finite element model was established modeling angles, tees, welds and gusset plates. The analytical results were calibrated by the test data and provided reasonable predictions for the behaviors of the test specimens. At the critical section of the angle specimens, it was observed that significant shear lag effects existed at the middle region of the connected leg and the outer edge of the outstanding leg. The outer edges of the connected flanges of the tee-section specimens were also over-stressed. On the other hand, the tensile stresses were evenly distributed across the middle section of the clear space at the ultimate states.

According to the experimental and numerical results, a design equation was developed and combined the ideas of the designs in the specifications AISC-LRFD (2005) and BS 5950 (2001) for welded tension members. The proposed equation provided conservative and consistent predictions for the existing test results.