# Florida Department of Transportation Research

## Steel Shear Strength of Anchors with Stand-Off Base Plates

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Sign and signal structures are often connected to concrete foundations through an annular base plate set on anchor bolts. The plate is leveled with nuts beneath it and secured with nuts above it — a “double-nut” connection. In many installations, the anchoring bolts are exposed between the concrete base and the leveling nuts, increasing shear stress on the anchor bolts, potentially to failure. Adding grout pads offers more protection against shear stress, but the extent of protection is unclear. Also, current standards allow torsional forces to be ignored for certain configurations of the connective structure.

*Wind loading on cantilevered highway signs creates large torsional forces on the base plate connections.*

In this project, University of Florida researchers addressed gaps in knowledge about connector performance and developed uniform draft design and maintenance guidelines for these systems. A literature review was conducted, existing code standards were compared, and a three-phase experimental program was completed, resulting in the development of draft guidelines.

Phase 1 used direct shear to relate stand-off distance to ultimate steel shear strength, also addressing installation method, single- and double-bolt connections, and bolt diameter. In the direct shear approach, force was applied directly at various stand-off distances to bolts set in concrete or to base plates secured by one bolt or two bolts. Loads were applied at a consistent displacement rate until anchor bolt rupture. Statistically significant differences were found between anchor bolts at all levels of stand-off distance, including within the range permitted by AASHTO for ignoring strength reductions caused by bolt bending.

In Phase 2, ungrouted and grouted circular groups of 5/8-in. and 1-in. diameter anchor bolts were installed in oversize holes and tested in torsion. The circular bolt pattern more accurately represents field specimens, and individual anchor bolts are loaded in pure shear, without method-induced tension forces. Stand-off distance, influence of grout, bolt pretensioning, and size effect were investigated for their influence on strength and behavior. Shear strengths were similar to Phase 1. Generally, grout pads resulted in higher shear strengths but at possibly unserviceable displacements. A single test in which the grout pad was retrofitted with fiber-reinforced polymer showed the highest strength of all grout tests at significantly lower displacements.

Phase 3 comprised four full-scale tests containing circular groups of six 1.25-in. diameter bolts installed in oversize holes, testing the influence of grout pads, stand-off distance, and base plate type. Loading was predominantly torsional. Grouted test behavior and strength were consistent with Phase 2 tests, even in the annular base plate. Both experimental phases appeared to accurately represent field base plate connections.

This project showed the importance of considering all stand-off distances for annular base connections of signs and signals. The large number of variables considered improved the characterization of existing connections and suggested fruitful research directions. This research will result in more secure sign and signal structures that require less maintenance and are less likely to fail under high wind loads.

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