

Values given by AISC (2005) using Table 3-21 for metal deck ribs that are perpendicular to the floor beam are given as

$$Q_n = 21.5 \text{ kip Strong studs per rib}$$

and

$$Q_n = 17.2 \text{ kip Weak studs per rib}$$

Since a shear stud could have been placed on either side of the rib along the beam length, the average of the strong and weak directions was used to give a shear stud strength of

$$Q_n = 19.4 \text{ kip Average of strong and weak}$$

The shear stud capacity was taken as $Q_{sc} = 19.5 \text{ kip}$. This value was used for forces that were both perpendicular and parallel to the metal deck ribs.

Arc Spot Weld Failure

Metal decks are used as stay-in-place formwork for composite floor construction, and are generally fastened to the beams and girders with arc spot welds (often referred to as a puddle welds). The shear strength of an arc spot weld, Q_f , can be estimated using the following equation (SDI 2007):

$$Q_f = 2.2tF_u(d - t)$$

Where

$t =$ thickness of metal deck (in.)

$F_u =$ ultimate tensile strength of steel

$d =$ nominal diameter of weld puddle

For a 5/8 in. diameter puddle weld, 20 gauge ($t=0.0358 \text{ in.}$) metal deck, and taking F_u equal to 45 ksi, one obtains a strength of approximately 2 kip per weld. As noted in Chapter 8, restraint of thermal expansion produces forces substantially greater than 2 kip, and, for this reason, the puddle welds attaching the metal deck to the girder top flange were neglected in the ANSYS finite element analyses.

Failure Loads of Shear Connections

The shear connections in WTC 7 were designed to support design gravity loads, but they were not designed for horizontal loads from the floor beams due to thermal expansion or other fire effects. Shear connections on the typical tenant floors were evaluated for horizontal and vertical failure loads for room temperature material properties, using the failure modes previously described in this section. The seated connections with a top clip (STC) and seated connection with a top plate (STP) were evaluated for horizontal loads only, as the vertical capacity of the welded seat plates for these connections (i.e., at Columns 79 and 81) was much greater than the applied vertical loads, even for full design loads. The