

# DESIGN PROCEDURES FOR STEEL DECK DIAPHRAGMS WITH STRUCTURAL CONCRETE FILL

**Disciplines:** Structural

**History:** Issued 03-08-16

**PURPOSE:** The purpose of this Interpretation of Regulations (IR) is to describe the Division of the State Architect (DSA) requirements for the design of steel deck composite diaphragms with structural concrete fill.

**1. DIAPHRAGM DESIGN:** The in-plane shear strength of metal deck diaphragms with concrete fill shall be determined in accordance with one of the following methods per AISC 341 Section D1.5:

**1.1 Diaphragms designed in accordance with ACI 318:** In-plane shear strength may be determined in accordance with ACI 318 considering only the concrete above the top of the steel deck ribs.

**1.2 Diaphragms designed in accordance with a product evaluation report:** In-plane shear strength of metal deck diaphragms with concrete fill may be determined in accordance with a valid product evaluation services report. Diaphragms designed using this method shall comply with the following:

- Product evaluation services report shall be in accordance with IR A-5.
- Design may use 100 percent of the evaluation services report published design values and need not be reduced per IR A-5 Section 4.2.
- Concrete shall weigh not less than 95 pounds per cubic foot or more than 150 pounds per cubic foot.
- The first sheet of steel decking adjacent and parallel to chords, reaction members and collectors (on one or both sides as applicable) is required to be a full width sheet, unless the partial panel width is evaluated in accordance with the split panel requirements of SDI DDM, Section 2.6. The construction documents shall indicate these decking layout limitations.

**1.3 Diaphragms designed in accordance with SDI DDM:** In-plane shear strength may be determined in accordance with Steel Deck Institute Diaphragm Design Manual (SDI DDM). Diaphragms designed using this method shall comply with the following:

- Concrete shall weigh not less than 95 pounds per cubic foot or more than 150 pounds per cubic foot.
- The first sheet of steel decking adjacent and parallel to chords, reaction members and collectors (on one or both sides as applicable) is required to be a full width sheet, unless the partial panel width is evaluated in accordance with the split panel requirements of SDI DDM, Section 2.6. The construction documents shall indicate these decking layout limitations.

**2. LOAD TRANSFER:** Transfer of lateral loads between the diaphragm and the boundary members, chords, collector elements, and elements of the horizontal framing system shall be as follows:

**2.1 Diaphragms designed in accordance with ACI 318:** Transfer lateral loads directly from the concrete by means of reinforcement dowels or welded headed stud connectors

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to the building frame. Do not consider deck welding to be part of the shear transfer connection.

Shear strength of reinforcement dowels used to transfer lateral loads shall be determined in accordance with the shear friction provisions of ACI 318 Section 11.6. Shear reinforcement shall be anchored to develop  $f_y$  in accordance with ACI 318 Section 11.6.8. Development length of the reinforcement shall not be reduced for excess reinforcement per ACI 318 Section 12.3.

The design shear strength of welded headed stud anchors when evaluating the transfer lateral (seismic or wind) loads shall be determined by multiplying the nominal shear strength calculated in accordance with AISC 360, Equation I8-1, by a resistance factor ( $\phi$ ) of 0.65.

It is permitted to design steel headed stud anchors to transfer horizontal diaphragm forces to collector beams in accordance with AISC 360, Section 17 Commentary provided the collector beams contain enough anchors to ensure a minimum of 25 percent composite action even if the beams are designed as non-composite members. Other design methods may be permitted subject to DSA approval.

- 2.2 Diaphragms designed in accordance with a product evaluation report:** Lateral load may be transferred entirely by welding the metal deck to the steel framing in accordance with the evaluation services report or as indicated in Section 2.1 above.
- 2.3 Diaphragms designed in accordance with SDI DDM:** Lateral load may be transferred entirely by welding the metal deck to the steel framing in accordance with the SDI DDM or as indicated in Section 2.1 above.
- 3. MINIMUM REINFORCEMENT:** The minimum reinforcement ratio for metal deck diaphragms with structural concrete fill shall be in conformance with this section. Provide continuity, chord, and other special reinforcement as required by calculations and provide sufficient details to demonstrate such reinforcement maintains the minimum clearance, spacing, cover, and slab thickness requirement of ACI 318. When welded wire reinforcement is specified, provide sufficient splice and corner overlap details between sheets to maintain the minimum clearance, cover, and slab thickness requirement of ACI 318.
  - 3.1 Diaphragms designed in accordance with ACI 318:** The minimum reinforcing steel in the structural concrete fill on metal deck shall not be less than that required by ACI 318, Section 21.11.7.1.
  - 3.2 Diaphragms designed in accordance with a product evaluation report:** Provide minimum temperature and shrinkage reinforcement as indicated in the product evaluation report. In no case shall the minimum temperature and shrinkage reinforcement perpendicular to the direction of the ribs be less than that specified in ACI 318, Section 7.12, considering only the net area of the concrete above the ribs.
  - 3.3 Diaphragms designed in accordance with SDI DDM:** Provide minimum temperature and shrinkage reinforcement as indicated in SDI-C1.0, Section 2.4.B.6. In no case shall the minimum temperature and shrinkage reinforcement perpendicular to the direction of the ribs be less than that specified in ACI 318, Section 7.12, considering only the net area of the concrete above the ribs.

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### REFERENCES:

ACI 318-11  
AISC 341-10, Section D1.5  
AISC 360-10, Section I8  
SDI DDM, Third Edition, 2004  
SDI-C1.0, 2012

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This Interpretation of Regulations (IR) is intended for use by the Division of the State Architect (DSA) staff, and as a resource for design professionals, to promote more uniform statewide criteria for plan review and construction inspection of projects within the jurisdiction of DSA which includes State of California public elementary and secondary schools (grades K–12), community colleges and state-owned or state-leased essential services buildings. This IR indicates an acceptable method for achieving compliance with applicable codes and regulations, although other methods proposed by design professionals may be considered by DSA.

This IR is reviewed on a regular basis and is subject to revision at any time. Please check the DSA website for currently effective IRs. Only IRs listed at <http://www.dgs.ca.gov/dsa/Resources/IRManual.aspx> at the time of plan submittal to DSA are considered applicable.