DSA IR 22-1

DESIGN PROCEDURES FOR STEEL DECK DIAPHRAGMS WITH STRUCTURAL CONCRETE FILL: 2019 CBC

Disciplines: Structural

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Division of the State Architect (DSA) documents referenced within this publication are available on the DSA Publications webpage.

PURPOSE

This Interpretation of Regulations (IR) clarifies requirements for the design of steel deck composite diaphragms with structural concrete fill used on construction projects under DSA jurisdiction.

SCOPE

This IR is applicable to the design of steel deck diaphragms with structural concrete fill. Three design procedures are defined. Lateral load transfer and minimum reinforcement requirements are covered for each.

BACKGROUND

Concrete fill placed over cold-formed steel deck is a common floor/roof framing system used in combination with structural steel construction. Floor/roof systems of this type often serve as horizontal diaphragms resisting seismic and wind forces. As adopted by California Building Code (CBC), Section 2205A.2.1.2, American Institute of Steel Construction (AISC) 341, Section D1.5 addresses requirements for diaphragms of this type. The Steel Deck Institute Diaphragm Design Manual (SDI DDM) provides further guidance on diaphragm design. Additionally, CBC Section 2210A.1.1.3 and Steel Deck Institute Standard for Composite Steel Floor Deck-Slabs (SDI-C) address composite slabs on steel decks.

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 the American Concrete Institute (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:

1.2.1 Product evaluation services report shall be in accordance with *IR A-5: Acceptance of Products, Materials, and Evaluation Reports*.

1.2.2 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.

1.2.3 Concrete shall weigh not less than 95 pounds per cubic foot nor more than 150 pounds per cubic foot.

1.2.4 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 SDI DDM. Diaphragms designed using this method shall comply with the following:

1.3.1 Concrete shall weigh not less than 95 pounds per cubic foot nor more than 150 pounds per cubic foot.

1.3.2 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

2.1.1 Transfer lateral loads directly from the concrete by means of reinforcement dowels or welded headed stud connectors to the building frame. Do not consider deck welding to be part of the shear transfer connection.

2.1.2 Shear strength of reinforcement dowels used to transfer lateral loads shall be determined in accordance with the shear friction provisions of ACI 318 Section 22.9. Shear reinforcement shall be anchored to develop f_y in accordance with ACI 318 Section 22.9.5. Development length of the reinforcement shall not be reduced for excess reinforcement per ACI 318 Section 25.4.10.

2.1.3 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 (ϕ) of 0.65.

2.1.4 It is permitted to design steel headed stud anchors to transfer horizontal diaphragm forces to collector beams in accordance with AISC 360 Section I7 Commentary. Even when beams are designed as non-composite members one or more of the following conditions shall be met to consider the effect of ductility (slip capacity) as required by AISC 360 Section I3.2d.1:

2.1.4.1 Span less than or equal to 30 feet.

2.1.4.2 Composite action greater than or equal to 50%.

2.1.4.3 Average nominal shear connector capacity greater than or equal to 16 kip per foot.

2.1.5 Alternately, sufficient ductility (slip capacity) shall be demonstrated by direct nonlinear modeling validated by experimental data in accordance with AISC 360 Section I3 Commentary. 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 when permitted by the evaluation services report. Alternately, load transfer may be designed in accordance with 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. Alternately, load transfer may be designed in accordance with 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 18.12.7.1.

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 24.4, 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-C Sections 2.4.B.12 and 2.4.B.13. 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 24.4, considering only the net area of the concrete above the ribs.

REFERENCES:

2019 California Code of Regulations (CCR), Title 24
Part 2: California Building Code (CBC), Sections 2205A.2.1.2, 2210A.1.1.3
Steel Deck Institute Diaphragm Design Manual (SDI DDM), Fourth Edition