DSA IR 22-1

STEEL DECK DIAPHRAGMS WITH STRUCTURAL CONCRETE FILL: 2022 CBC

Disciplines: Structural

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Division of the State Architect (DSA) documents referenced within this publication are available on the DSA Forms or 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 methodologies are defined, and the selected methodology shall be used consistently throughout the design. Diaphragm design, lateral load transfer, and minimum reinforcement requirements are covered for each methodology.

BACKGROUND

Concrete fill placed over cold-formed steel deck is a common floor or roof framing system used in combination with structural steel construction. Floor or 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 American Concrete Institute (ACI) 318 Methodology

In-plane shear strength may be determined in accordance with ACI 318 Section 18.12.9 considering only the concrete above the top of the steel deck ribs.

1.2 Product Evaluation Report Validation

In-plane shear strength may be determined in accordance with a valid product evaluation report. Diaphragms designed using this method shall comply with the following:

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

1.2.2 Design is permitted to 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 (PCF) nor more than 150 PCF.

1.2.4 The first sheet of steel decking adjacent and parallel to chords, reaction members (i.e., beams that are part of braced frames or moment frames), and collectors (on one or both sides as applicable) shall 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, which may require additional welds and side lap connections. The construction documents shall delineate these decking layout requirements.

1.3 Steel Deck Institute (SDI) Methodology

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 PCF nor more than 150 PCF.

1.3.2 The first sheet of steel decking adjacent and parallel to chords, reaction members (i.e., beams that are part of braced frames or moment frames), and collectors (on one or both sides as applicable) shall 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, which may require additional welds and side lap connections. The construction documents shall delineate these decking layout requirements.

2. LOAD TRANSFER

The transfer of lateral loads (seismic or wind) between the diaphragm and boundary members, chords, collectors, reaction members (i.e., beams that are part of braced frames or moment frames), and other elements in this load path shall be in accordance with one of the methods in this section. Seismic loads shall be determined per American Society of Civil Engineers Standard 7: Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7) Section 12.10.1.1, as modified by ASCE 7 Section 12.3.3.4 when applicable.

2.1 ACI 318 Methodology

When the diaphragm design in based on Section 1.1 above, the transfer of lateral loads shall comply with this section.

2.1.1 Lateral loads shall be transferred directly from the concrete by means of reinforcement dowels or welded headed stud connectors to the building frame. Deck welding is not permitted to contribute to the transfer of lateral loads.

2.1.2 The 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(b).

2.1.3 When evaluating the transfer of lateral loads the shear strength of welded headed stud anchors 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 lateral loads from the diaphragm to collector, chord, and frame 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 and explained in its corresponding commentary section:

2.1.4.1 Span less than or equal to 30 feet.

2.1.4.2 Composite action greater than or equal to 50 percent.

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

2.1.5 In lieu of Section 2.1.4 above, 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 Product Evaluation Report Validation

Lateral loads may be transferred entirely by welding the metal deck to the steel framing when permitted by the evaluation report. Alternately, load transfer may be designed in accordance with Section 2.1 above.

2.3 SDI Methodology

Lateral loads may be transferred entirely by welding the metal deck to the steel framing in accordance with 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. Continuity, chord, and other special reinforcement shall be provided as required by calculations; sufficient details shall be provided to demonstrate such reinforcement maintains the minimum clearance, spacing, cover, and slab thickness requirements of ACI 318. When welded wire reinforcement is specified, splice and corner sheet overlap details shall be provided to demonstrate the minimum clearance, cover, and slab thickness requirements of ACI 318 will be met.

3.1 ACI 318 Methodology

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 Product Evaluation Report Validation

The reinforcement required by the product evaluation report shall be provided. 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 SDI Methodology

The minimum temperature and shrinkage reinforcement required by SDI-C Sections 2.4.B.12 and 2.4.B.13 shall be provided. 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:

2022 California Code of Regulations (CCR), Title 24

Part 2: California Building Code (CBC), Sections 2205A.2.1.2, 2210A.1.1.3