STEEL DECK INSTITUTE sdi®

AMERICAN NATIONAL STANDARDS INSTITUTE/ STEEL DECK INSTITUTE

C1.0 - 2006 Standard for

Composite Steel Floor Deck

ANSI

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1. General

1.1 Scope:

A. This specification for Composite Steel Deck shall govern the materials, design, and erection of cold formed steel deck which acts as a permanent form and as positive reinforcement for a structural concrete slab.

B. Commentary shall not be considered part of the mandatory document.

1.2 Reference Codes, Standards and Documents:

A. Codes and Standards: For purposes of this Standard, comply with applicable provisions of the following Codes and Standards:

1. American Iron and Steel Institute (AISI) Standard-North American Specification for the Design of Cold-Formed Steel Structural Members, 2001 Edition with Supplement 2004

2. American Welding Society-ANSI/AWS D1.3 Structural Welding Code/Sheet Steel-98 Structural Welding Code-Sheet Steel

3. American Society for Testing and Materials (ASTM) A653 (A653M)-06, A924 (A924M)-06, A1008 (A1008M)-06, A820 (A820M)-06, C1399 (C1399M)-04, Test Method E2322-03, ASTM Subcommittee CO9.42

4. American Concrete Institute (ACI) Building Code Requirements for Reinforced Concrete – ACI 318-05

5. American Society of Civil Engineering (ASCE)-SEI/ASCE7-05

6. American Institute of Steel Construction (AISC)-Specification for Structural Steel Buildings, 13th Edition

7. Underwriters Laboratories (UL) Fire Resistance Directory-http://www.ul.com/database 2006

Commentary: Many fire related assemblies that use composite floor decks are available. In the Underwriters Laboratories *Fire Resistance Directory*, the composite deck constructions show hourly ratings for <u>restrained</u> and <u>unrestrained</u> assemblies. ASTM E119 provides information in appendix X3 called "Guide for Determining Conditions of Restraint for Floor and Roof Assemblies and for Individual Beams".

B. Reference Documents: Refer to the following documents:

1. SDI Composite Deck Design Handbook-CDD2-1997

2. SDI Manual of Construction with Steel Deck-MOC2-2006

3. SDI Standard Practice Details-SPD2-2001

4. SDI Diaphragm Design Manual-DDMO3-2004

2. Products

2.1 Material:

A. Sheet steel for galvanized deck shall conform to ASTM A653 (A653M) Structural Quality, with a minimum yield strength of 33 ksi (230 MPa).

B. Sheet steel for uncoated or phosphatized top/painted bottom deck shall conform to ASTM A1008 (A1008M) with a minimum yield strength of 33 ksi (230 MPa). Other structural sheet steels or high strength low alloy steels are acceptable, and shall be selected from the *North American Specification for the Design of Cold-Formed Steel Structural Members.*

C. Sheet steel for accessories shall conform to ASTM A653 (A653M)-minimum yield strength of 33 ksi (230 MPa). Structural Quality for structural accessories, ASTM A653 (A653M) Commercial Quality for non-structural accessories, or ASTM A1008 (A1008M) for either structural or non-structural accessories. Other structural sheet steels or high strength low alloy steels are acceptable, and shall be selected from the *North American Specification for the Design of Cold-Formed Steel Structural Members.*

D. The deck type (profile) and thickness (gage) shall be as shown on the plans.

Commentary: Most composite steel floor deck is manufactured from steel conforming to ASTM Designation A1008 (A1008M), Grades 33 and 40, or from A653 (A653M), Structural Sheet Steel. When specifying alternative steels, certain restrictions apply (See *North American Specification for the Design of Cold-Formed Steel Structural Members* Section A 2-3.2). 2.1A refers to the use of galvanized deck while 2.1B refers to the use of uncoated or phosphatized top/painted underside deck. In most cases the designer will choose one finish or the other. However, both types of finish may be used on a job, in which case the designer must indicate on the plans and project specifications the areas in which each is used. (Refer to Section 2.3 and the commentary of these specifications). In section 2.1D, the deck type is the particular profile of deck chosen by the designer.

2.2 Tolerance:

A. Uncoated thickness shall not be less than 95% of the design thickness as listed in Table 2.2.1:

Table 2.2.1

Gage No.	Design Thickness		Minimum Thickness	
	in.	mm.	in.	mm.
22	0.0295	0.75	0.028	0.71
21	0.0329	0.84	0.031	0.79
20	0.0358	0.91	0.034	0.86
19	0.0418	1.06	0.040	1.01
18	0.0474	1.20	0.045	1.14
17	0.0538	1.37	0.051	1.30
16	0.0598	1.52	0.057	1.44

B. Panel length shall be within plus or minus 1/2 inch (12 mm) of specified length.

C. Panel cover width shall be no greater than minus 3/8 inch (10 mm), plus 3/4 inch (20 mm).

D. Panel camber and/or sweep shall be no greater than 1/4 inch in 10 foot length (6 mm in 3 m).

E. Panel end out of square shall not be greater than 1/8 inch per foot of panel width (10 mm per m).

2.3 Finish:

A. Galvanizing shall conform to ASTM A653 (A653M).

B. Uncoated or phosphatized topside with painted underside shall be applied to steel sheet conforming to ASTM A1008 (A1008M).

C. The finish on the steel composite deck shall be suitable for the environment of the structure.

Commentary: The finish on the steel composite deck shall be as specified by the designer and be suitable for the environment of the structure. Since the composite deck is the positive bending reinforcement for the slab, it must be designed to last the life of the structure. A galvanized finish equal to ASTM A653 (A653M)-G30 minimum is recommended. When composite deck with a phosphatized top and painted bottom is used, the primer coat is intended to protect the steel for only a short period of exposure in ordinary atmospheric conditions and shall be considered an impermanent and provisional coating.

2.4 Design:

A. Deck as a form

1. The section properties for the steel floor deck unit (as a form in bending) shall be computed in accordance with the *North American Specification for the Design of Cold-Formed Steel Structural Members.*

2. Allowable Stress Design (ASD): Bending stress shall not exceed 0.60 times the yield strength, nor exceed 36 ksi (250MPa) under the combined loads of wet concrete, deck weight, and the following construction live loads: 20 pounds per square foot (1 kPa) uniform load or 150 pound concentrated load on a 1'-0" (300 mm) wide section of deck (2.2 kN per m). The interaction of shear and bending shall be considered in the calculations. (See Figure 1-Attachment C1)

3. Load and Resistance Factor Design (LRFD): The load combinations for construction are as shown in Attachment C1. Load factors shall be in accordance with ASCE 7 (See Section 1.2.A.5). The resistance factors and nominal resistances shall be in accordance with *North American Specification for the Design of Cold-Formed Steel Structural Members.*

Commentary: The loading shown in Figure 1 of Attachment C1 is representative of the sequential loading of wet concrete on the deck. The 150 pound load (per foot of width) is the result of distributing a 300 pound (1.33 kN) man over a 2 foot (600 mm) width. Experience has shown this to be a conservative distribution. The metric equivalent of the 150 pound load is 2.2 kN per meter of width. For single span deck conditions, the ability to control the concrete placement may be restricted and an amplification factor of 1.5 is applied to the concrete load to address this condition; however, in order to keep this 50% load increase within a reasonable limit, the increase is not to exceed 30 psf (1.44 kPa). In LRFD, a load factor for construction of 1.4 is applied to this load. Whenever possible, the deck shall be multi-span and not require shoring during concrete placement.

4. Deck Deflection: Calculated deflections of the deck, as a form, shall be based on the load of the wet concrete as determined by the design slab thickness and the weight of the steel deck, uniformly loaded on all spans, and shall be limited to 1/180 of the clear span or 3/4 inch (20 mm), whichever is smaller. Calculated deflections shall be relative to supporting members.

Commentary: The deflection calculations do not take into account construction loads because these are considered temporary loads. The deck is designed to always be in the elastic range so removal of temporary loads should allow the deck to recover. The structural steel also deflects under the loading of the wet concrete.

The designer is urged to check the deflection of the total system, especially if composite beams and girders are being used. If the designer wants to include additional concrete loading on the deck because of frame deflection, the additional load should be shown on the design drawings or stated in the deck section of the job specifications.

5. Minimum Bearing: Minimum interior bearing lengths shall be determined in accordance with the web crippling provisions of the *North American Specification for the Design of Cold-Formed Steel Structural Members;* a uniform

loading case of wet concrete, plus the weight of the steel deck, plus 20 psf (1 kPa) construction load shall be used. (See Figure 3-Attachment C1)

Commentary: Experience has shown that 1-1/2 inches (38 mm) of bearing is sufficient for composite floor decks. If less than 1-1/2 inches (38 mm) of end bearing is available, or if high support reactions are expected, the design professional should check the deck web crippling capacity. The deck must be adequately attached to the structure to prevent slip off.

6. Diaphragm Shear Capacity: Diaphragms without concrete shall be designed in accordance with the SDI *Diaphragm Design Manual*, or from tests conducted by an independent professional engineer.

Commentary: Calculations of diaphragm strength and stiffness should be made using the SDI *Diaphragm Design Manual*. If testing is used as the means for determining the diaphragm strength and stiffness, then it should follow the AISI TS 7-02 test protocol.

B. Deck and Concrete as a Composite Slab:

1. General: The "SDI Method" (refer to SDI *Composite Deck Design Handbook*) shall be limited to galvanized or topside uncoated steel decks with embossments. The embossment patterns shall be typical of the manufactured steel deck with the depth of the embossment not less than 90% of the tested embossment depth. (Refer to Attachment C4 for further limitations).

The composite slab shall be designed as a reinforced concrete slab with the steel deck acting as the positive reinforcement. The deck must be suitable to develop composite interaction. Justification of this requires full scale testing as per ASTM E2322, or calculations based upon testing.

a. Allowable Strength Design (ASD) shall be permitted as an alternate design method. (See SDI *Composite Deck Design Handbook*.)

b. Standard reinforced concrete design procedures shall be used to determine ultimate load capacity. The allowable superimposed load shall then be determined by deducting the weight of the slab and the deck. Attachment C4, *Strength and Serviceability Determination of Composite Deck Slab* shall be used for strength determination.

Commentary: High concentrated loads, diaphragm loads, etc. require additional analysis. Horizontal load capacities can be determined by referring to the SDI *Diaphragm Design Manual*. Concentrated loads can be analyzed by the methods shown in the SDI *Composite Deck Design Handbook*. Most published live load tables are based on simple span analysis of the composite system; that is, the slab is assumed to crack over each support.

2. Load Determination: Using standard reinforced concrete design procedures, the allowable superimposed load shall be found by using appropriate load and resistance design factors (LRFD) and applicable reduction factors based on the presence, absence, or spacing of shear studs on beams perpendicular to the deck. (Refer to Attachment C4 and C5)

Commentary: By using the reference analysis techniques or test results, the deck manufacturer determines the live loads that can be applied to the composite deck slab combination. The results are usually published as uniform load tables. For most applications, the deck thickness and profile is selected so that shoring is not required; the live load capacity of the composite system is usually more than adequate for the superimposed live loads. In calculating the section properties of the deck, the AISI provisions may require that compression zones in the deck be reduced to an "effective width," but as tensile reinforcement, the total area of the cross section may be used. (See attachment C5)

Coatings other than those tested may be investigated, and if there is evidence that their performance is better than that of the tested product, additional testing may not be required.

3. Concrete: Concrete design shall be in accordance with the ACI *Building Code Requirements for Reinforced Concrete*. Minimum compressive strength (f'c) shall be a minimum of 3 ksi (20 MPa) or as required for fire ratings or durability. Admixtures containing chloride salts shall not be used.

Commentary: Load tables are generally calculated by using a concrete strength of 3 ksi (20 MPa). Composite slab capacities are not greatly affected by variations in concrete compressive strength; but, if the strength falls below 3 ksi (20 MPa) it would be advisable to check shear stud strengths. Fire rating requirements may dictate the minimum concrete strength. The use of admixtures containing chloride salts is not allowed because the salts will corrode the steel deck.

a. Minimum Cover: The minimum concrete thickness above the top of the steel deck shall be 2 inches (50 mm). When additional (negative bending) reinforcement is placed in the slab, the minimum cover of concrete above the reinforcing shall be in accordance with the ACI *Building Code Requirements for Reinforced Concrete.*

4. Deflection: Deflection of the composite slab shall not exceed 1/360 of the clear span under the superimposed live load.

Commentary: Live load deflections are seldom a design factor. The deflection of the slab/deck combination can be predicted by using the average of the cracked and uncracked moments of inertia as determined by the transformed section method of analysis. Refer to Attachment C5 of this specification or the SDI *Composite Deck Design Handbook.*

5. Suspended Loads: All suspended loads must be included in the analysis and calculations for strength and deflection.

Commentary: The designer must take into account the sequence of loading. Suspended loads may include ceilings, light fixtures, ducts or other utilities. The designer must be informed of any loads applied after the composite slab has been installed.

Care should be used during the placement of loads on all types of hanger tabs or other hanging devices for the support of ceilings so that an approximate uniform loading is maintained. The individual manufacturer should be consulted for allowable loading on single hanger tabs. Improper use of hanger tabs or other hanging devices could result in the overstressing of tabs and/or the overloading of the composite deck slab.

6. Reinforcement:

a. Temperature and shrinkage reinforcement, consisting of welded wire fabric or reinforcing bars, shall have a minimum area of 0.00075 times the area of the concrete above the deck (per foot or meter of width), but shall not be less than the area provided by 6x6-W1.4 x W1.4 welded wire fabric.

Fibers shall be permitted as a suitable alternative to the welded wire fabric specified for temperature and shrinkage reinforcement. Cold-drawn steel fibers meeting the criteria of ASTM A820, at a minimum addition rate of 25 lb/cu yd (14.8 kg/cu meter), or macro synthetic fibers "Coarse fibers" (per ASTM Subcommittee CO9.42), made from virgin polyolefin, shall have an equivalent diameter between 0.4 mm (0.016 in.) and 1.25 mm (0.05 in.), having a minimum aspect ratio (length/equivalent diameter) of 50, at a minimum addition rate of 4 lb./cu yd (2.4 kg/m^3) are suitable to be used as minimum temperature and shrinkage reinforcement.

Commentary: Neither welded wire fabric or fibers will prevent cracking; however, they have been shown to do a good job of crack control. The welded wire fabric must be placed near the top of the slab [3/4 to 1 inch cover (20 to 25 mm)] at supports and draped toward the center of the deck span. If a welded wire fabric is used with a steel area given by the above formula, it will not be sufficient as the total negative reinforcement. If the minimum quantity of steel fibers, or macro synthetic fibers, are used for shrinkage and temperature reinforcement, they will not be sufficient as a total negative reinforcement.

b. Negative: When negative moment exists, the deck shall be designed to act only as a permanent form.

Commentary: Composite steel deck does not function as compression reinforcing steel in areas of negative moment. If the designer wants a continuous slab, then negative bending reinforcing should be designed using conventional reinforced concrete design techniques in compliance with the ACI *Building Code Requirements for Reinforced Concrete.* The welded wire fabric, chosen for temperature reinforcing, may not supply enough area for continuity. The deck is not considered to be compression reinforcement. Typically negative reinforcement is required at all cantilevered slabs, or if a continuous slab is desired.

c. Distribution: When localized loads exceed the published uniform composite deck load tables, the designer shall proportion distribution reinforcement using conventional concrete design methods.

Commentary: Distribution steel may be required in addition to the welded wire fabric or steel fibers. Concentrated loads, either during construction or in-service, are the most common example of this requirement. Concentrated loads may be analyzed by the methods in the latest SDI *Composite Deck Design Handbook.*

7. Cantilever Loads: When cantilevered slabs are encountered, the deck acts only as a permanent form; top reinforcing steel shall be proportioned by the designer. For construction loads, the deck shall be designed for the more severe of (a) deck plus slab weight plus 20 psf (1 kPa) construction load on both cantilever and adjacent span, or (b) deck plus slab weight on

both cantilever and adjacent span plus a 150 pound (665N) concentrated load per foot of width at end of cantilever. The load factors for bending, shear, and interior bearing shall be as required by ASCE 7. Resistance factors for bending, shear, and interior bearing shall be in accordance with the *North American Specification for the Design of Cold Formed Structural Members.*

The maximum cantilever deflection as a form, under deck plus slab weight, shall be a/90 where "a" is the cantilever length, and shall not exceed 3/4 inches (19 mm).

Side laps shall be attached at the end of the cantilever and a maximum spacing of 12 inches (300 mm) o.c. from the cantilever end. Each corrugation shall be fastened at both the perimeter support and the first interior support. The deck shall be completely attached to the supports and at the side laps before any load is applied to the cantilever. Concrete shall not be placed on the cantilever until after placement on the adjacent span.

8. Diaphragm Shear Capacity: Diaphragms with concrete shall be designed in accordance with the SDI *Diaphragm Design Manual*, or from tests conducted by an independent professional engineer.

Commentary: Calculations of diaphragm strength and stiffness should be made using the SDI *Diaphragm Design Manual*. If testing is used as the means for determining the diaphragm strength and stiffness, then it should follow the AISI TS 7-02 test protocol.

2.5 Accessories:

A. Pour stops, column closures, end closures, cover plates, and girder fillers shall be the type suitable for the application. Pour stop minimum gages shall be in accordance with the Steel Deck Institute. (See *Pour Stop Selection Table*, Attachment C2)

B. Mechanical fasteners or welds shall be permitted for deck and accessory attachment.

3. Execution

3.1 Installation/ General:

A. Support framing and field conditions shall be examined for compliance with installation tolerances and other conditions affecting performance of work of this section. All OSHA rules for erection shall be followed.

B. Deck panels shall be installed on a concrete support structure only after the concrete has attained 75% of its specified design strength.

C. Deck panels and accessories shall be installed according to the SDI *Manual of Construction with Steel Deck*, placement plans, and requirements of this Section.

D. Temporary shoring, if required, shall be installed before placing deck panels. Temporary shoring shall be designed to resist a minimum uniform load of 50 psf (2.4 kPa), and loading criteria indicated on Attachment C1. Shoring shall be securely in place before the floor deck erection begins. The shoring shall be designed and installed in accordance with the ACI *Building Code Requirements for Reinforced Concrete* and shall be left in place until the slab attains 75% of its specified design strength and a minimum of seven (7) days.

E. Deck panels shall be placed on structural supports and adjusted to final position with ends aligned, and attached securely to the supports immediately after placement in order to form a safe working platform. All deck sheets shall have adequate bearing and fastening to all supports to prevent slip off during construction. Deck ends over supports shall be installed with a minimum end bearing of 1-1/2 inches (38 mm). Deck areas subject to heavy or repeated traffic, concentrated loads, impact loads, wheel loads, etc. shall be adequately protected by planking or other approved means to avoid overloading and/or damage.

F. Butted Ends: Deck ends shall be butted over supports.

Commentary: Lapping composite deck ends can be difficult because shear lugs (web embossment) or profile shape can prevent a tight metal to metal fit. The space between lapped sheets can make welded attachments more difficult. Gaps are acceptable up to 1" (25 mm) at butted ends.

G. Deck units and accessories shall be cut and neatly fit around scheduled openings and other work projecting through or adjacent to the decking.

Commentary: It is the responsibility of the designer to designate holes/openings to be decked over in compliance with applicable federal and state OSHA directives. Care should be taken to analyze spans between supports at openings when determining those holes/openings to be decked over. When a framed opening span exceeds the maximum deck span limits for construction loads, the opening must be detailed around instead of decked over. (Minimum floor construction load 50 lbs./sq. ft. (2.4 kPa), unless specific requirements dictate otherwise).

When a framed hole/opening in floor deck is shown and dimensioned on the structural design drawings, pour stop (screed) angle is required to top of slab. When specified, cell closure angle will be provided at the open ends of deck in standard 10'-0" (3 m) lengths to be field sized, cut and installed. Alternate means to dam concrete may be used in lieu of cell closure, at the discretion of the installer, if approved by the designer.

When a hole/opening is not shown and dimensioned on the structural design drawings, no provisions for concrete retainage will be provided by the metal deck manufacturer/supplier. Metal floor decking holes and openings to be cut after the concrete pour shall not be field cut until concrete has reached 75% of its design strength and a minimum of seven (7) days.

H. Trades that subsequently cut unscheduled openings through the deck shall be responsible for reinforcing these openings based upon an approved engineered design.

3.2 Installation/Anchorage:

A. Floor deck units shall be anchored to steel supporting members including perimeter support steel and/or bearing walls by arc spot puddle welds of the following diameter and spacing, fillet welds of equal strength, or mechanical fasteners.

1. All welding of deck shall be in strict accordance with ANSI/AWS D1.3, *Structural Welding Code-Sheet Steel.* Each welder shall demonstrate an ability to produce satisfactory welds using a procedure such as shown in the SDI *Manual of Construction with Steel Deck,* or as described in ANSI/AWS D1.3.
2. A minimum visible 5/8 inch (15 mm) diameter arc puddle weld shall be used. Weld metal shall penetrate all layers of deck material, and shall have good fusion to the supporting members.
3. Edge ribs of panels shall be welded at each support. Space additional welds an average of 12 inches (300 mm) apart but not more than 18 inches (460 mm).
4. When used, fillet welds shall be at least 1-1/2 inches (38 mm) long.
5. Mechanical fasteners, either powder actuated, pneumatically driven, or screws, shall be permitted in lieu of welding to fasten deck to supporting framing if fasteners meet all project service requirements. When the fasteners are powder actuated or pneumatically driven, the load value per fastener used to determine the maximum fastener spacing is based on a minimum structural support thickness of not less than 1/8 inch (3 mm) and on the fastener providing a minimum 5/16 inch (8 mm) diameter bearing surface (fastener head size). When the structural support thickness is less than 1/8 inch (3 mm), powder actuated or pneumatically driven fasteners shall not be used, but screws are acceptable.

Commentary: Mechanical fasteners (screws, powder or pneumatically driven fasteners, etc.) are recognized as viable anchoring methods, provided the type and spacing of the fastener satisfies the design criteria. Documentation in the form of test data, design calculations, or design charts should be submitted by the fastener manufacturer as the basis for obtaining approval.

6. For deck units with spans greater than 5 feet (1.5 m), side laps and perimeter edges of units between span supports shall be fastened at intervals not exceeding 36 inches (1 m) on center, using one of the following methods:
   a. #10 self drilling screws
   b. Crimp or button punch
   c. Arc puddle welds 5/8 inch (15 mm) minimum visible diameter, or minimum 1 inch (25 mm) long fillet weld.

Commentary: The above side lap spacing is a minimum. Service loads or diaphragm design may require closer spacing or larger side lap welds. Good metal to metal contact is necessary for a good side lap weld. Burn holes are to be expected.

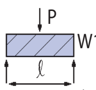
B. Accessory Attachment:

1. Pour Stop and Girder Fillers: Pour stops and girder fillers shall be fastened to supporting structure in accordance with the SDI *Standard Practice Details, and Attachment C2.*
2. Floor Deck Closures: Column closures, cell closures, girder closures and Z closures shall be fastened to provide tight fitting closures at open ends of ribs and sides of decking. Fasten cell closures at changes of direction of floor deck units unless otherwise directed.

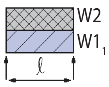
Composite Deck Construction Loading Diagrams

FIGURE 1
Loading Diagrams and Bending Moments

Simple Span Condition

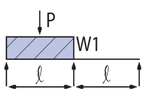


$+M = .25P\ell + 0.125W1_1\ell^2$

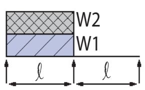


$+M = .125\,(W1_1 + W2)\ell^2$

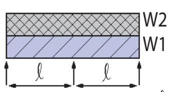
Double Span Condition



$+M = .203P\ell + .096W1\ell^2$

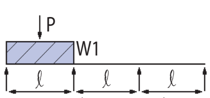


$+M = .096\,(W1 + W2)\ell^2$

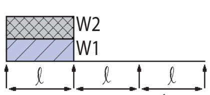


$-M = .125\,(W1 + W2)\ell^2$

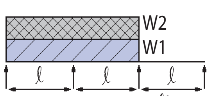
Triple Span Condition



$+M = .20P\ell + .094W1\ell^2$



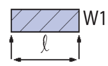
$+M = .094\,(W1 + W2)\ell^2$



$-M = .117\,(W1 + W2)\ell^2$

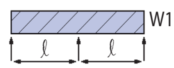
FIGURE 2
Loading Diagrams and Deflections

Simple Span Condition



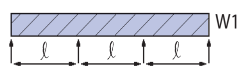
$\Delta = \frac{.0130W1\,\ell^4}{E\,I}(1728)$

Double Span Condition



$\Delta = \frac{.0054W1\,\ell^4}{E\,I}(1728)$

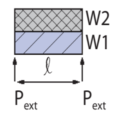
Triple Span Condition



$\Delta = \frac{.0069W1\,\ell^4}{E\,I}(1728)$

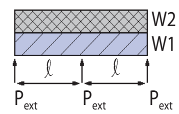
FIGURE 3
Loading Diagrams and Support Reactions

Simple Span Condition



$P_{ext} = .5\,(W1 + W2)\ell$

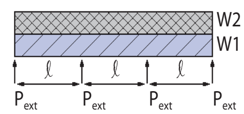
Double Span Condition



$P_{ext} = .375\,(W1 + W2)\ell$

$P_{ext} = 1.25\,(W1 + W2)\ell$

Triple Span Condition



$P_{ext} = .4\,(W1 + W2)\ell$

$P_{ext} = 1.1\,(W1 + W2)\ell$

Notes for Figures 1, 2, and 3			LRFD Load Factors
P	=	150 pound concentrated load	1.4
I	=	in^4/ft. - deck moment of inertia	
W1	=	slab weight	1.6
		+ deck weight	1.2
W2	=	20 pounds per square foot construction load	1.4
E	=	29.5×10^6 psi	
ℓ	=	clear span length (ft.)	
$W1_1$	=	$1.5 \times$ slab weight + deck weight $\leq$ slab weight + 30 + deck weight	

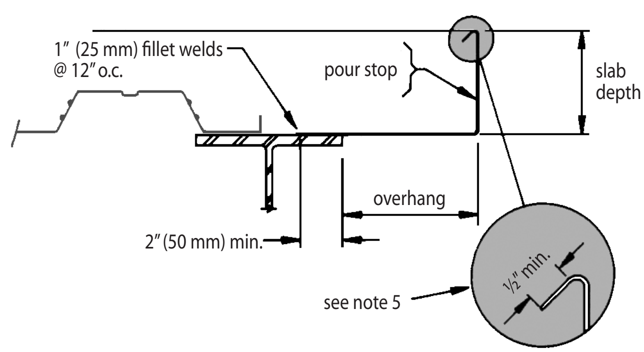
Dimensional check shows the need for the 1728 factor when calculating deflections using pound inch units.

Note: In addition to an analysis of slab weight plus construction surcharge, the deck must be independently investigated for a total construction load of 50 psf. The step loads in figures 1 through 3 shall be used.

Pour Stop Selection Table

SLAB DEPTH (INCHES)	OVERHANG (INCHES) 0	1	2	3	4	5	6	7	8	9	10	11	12
	POUR STOP TYPES												
4.00	20	20	20	20	18	18	16	14	12	12	12	10	10
4.25	20	20	20	18	18	16	16	14	12	12	12	10	10
4.50	20	20	20	18	18	16	16	14	12	12	12	10	10
4.75	20	20	18	18	16	16	14	14	12	12	10	10	10
5.00	20	20	18	18	16	16	14	14	12	12	10	10	
5.25	20	18	18	16	16	14	14	12	12	12	10	10	
5.50	20	18	18	16	16	14	14	12	12	12	10	10	
5.75	20	18	16	16	14	14	12	12	12	12	10	10	
6.00	18	18	16	16	14	14	12	12	12	10	10	10	
6.25	18	18	16	14	14	12	12	12	12	10	10		
6.50	18	16	16	14	14	12	12	12	12	10	10		
6.75	18	16	14	14	14	12	12	12	10	10	10		
7.00	18	16	14	14	12	12	12	12	10	10	10		
7.25	16	16	14	14	12	12	12	10	10	10			
7.50	16	14	14	12	12	12	12	10	10	10			
7.75	16	14	14	12	12	12	10	10	10	10			
8.00	14	14	12	12	12	12	10	10	10				
8.25	14	14	12	12	12	10	10	10	10				
8.50	14	12	12	12	12	10	10	10					
8.75	14	12	12	12	12	10	10	10					
9.00	14	12	12	12	10	10	10						
9.25	12	12	12	12	10	10	10						
9.50	12	12	12	10	10	10							
9.75	12	12	12	10	10	10							
10.00	12	12	10	10	10	10							
10.25	12	12	10	10	10								
10.50	12	12	10	10	10								
10.75	12	10	10	10									
11.00	12	10	10	10									
11.25	12	10	10										
11.50	10	10	10										
11.75	10	10											
12.00	10	10											

TYPES	DESIGN THICKNESS
20	0.0358
18	0.0474
16	0.0598
14	0.0747
12	0.1046
10	0.1345



NOTES: This Selection Chart is based on following criteria:

1. Normal weight concrete (150 PCF).
2. Horizontal and vertical deflection is limited to ¼" maximum for concrete dead load.
3. Design stress is limited to 20 KSI for concrete dead load temporarily increased by one-third for the construction live load of 20 PSF.
4. Pour Stop Selection Chart does not consider the effect of the performance, deflection, or rotation of the pour stop support which may include both the supporting composite deck and/or the frame.
5. Vertical leg return lip is recommended for all types (gages).

SI Units Conversion Tables

	TO CHANGE	MULTIPLY BY
LENGTH	in to mm ft to mm ft to m	25.4 (exact) 304.8 (exact) 0.3048 (exact)
AREA	in^2 to mm^2 ft^2 to m^2	645.16 (exact) 0.092903
MASS	lb to kg 2000 lb to 1000 kg lb/ft to kg/m lb/ft^3 to kg/m^3 lb/yd^3 to kg/m^3	0.453592 0.907185 1.48816 16.0185 0.593276
FORCE	lb to N kip to kN lb/in to N/m lb/ft to N/m kip/ft to kN/m psf to kN/m^2	4.44822 4.44822 175.127 14.5939 14.5939 47.880
PRESSURE	lb/in^2 to kPa lb/ft^2 to kPa kip/in^2 to MPa	6.89476 0.04788 6.89476
SECTION MODULUS	in^3 to mm^3 in^3/ft to mm^3/m	16387.1 53763.5
MOMENT OF INERTIA	in^4 to mm^4 in^4/ft to mm^4/m	416231 1365587

Strength and Serviceability Determination of Composite Deck-Slab

Unless composite deck-slabs are designed for continuity, the load affects are assumed to act on simple spans.

C4.1 Strength for Bending
This section is used to determine the bending strength of the composite deck-slab.

A. SDI Method - With No Shear Studs on Beams
This method is used if there are no shear studs present on the beam supporting the composite steel deck.

The resisting moment, M_{no}, of the composite section is determined based on a cracked section analysis. Refer to attachment C5 for calculation of the transformed section properties.

$$\phi M_{no} = \phi F_y \left(\frac{I_{cr}}{h - y_{cc}} \right) = \phi S_c F_y$$

where
F_y = yield stress of steel deck ≤60 ksi
h = slab depth
I_{cr} = cracked section moment of inertia
M_{no} = nominal resisting moment
Y_{cc} = distance from top of slab to neutral axis of cracked section
ϕ = 0.85 and is the resistance factor

1) Limitations
The "SDI Method" shall be limited to galvanized or topside uncoated steel decks with embossments. The embossment patterns shall be typical of the manufactured steel deck with the depth of the embossment not less than 90% of the tested embossment depth. The web angle, θ, shall be limited to values between 55° and 90° and the webs shall have no reentrant bends in their flat width. The steel section depth, d_d, is limited to 3 in. (75 mm). The concrete design compressive strengths shall be between 2500 psi (17 MPa) and 6000 psi (40 MPa). The minimum concrete thickness above the steel deck shall be 2 inches (50 mm).

The usable slab capacity is limited to decks with thickness 0.0474 inches (1.20 mm) unless sufficient test data is available to support the use of the method with deck of greater thickness.

2) Continuity Over Supports
In continuous slabs, those sections subjected to negative moments shall be designed as conventionally reinforced concrete slabs. In composite slabs, moments and shears shall be calculated by an analysis or, if applicable, by the coefficients of Chapter 8 of ACI *Building Code Requirements for Reinforced Concrete*, ACI 318.

3) Allowable Stress Design
Allowable stress design (ASD) is acceptable as an alternate design method. See the SDI *Composite Deck Design Handbook*.

B. SDI Method - With Shear Studs on Beams
This method is to be used if there are shear studs present on the beam supporting the composite steel deck in sufficient quantity to develop the ultimate capacity of the section in bending, or if tests on a particular deck profile have shown that the deck is capable of developing the full ultimate moment without shear studs.

$$\phi M_{nf} = \phi A_s F_y (d - a/2)$$

where
A_s = steel deck area per unit width of steel deck
$a = \dfrac{A_s F_y}{0.85 f'_c b}$ = developed depth of concrete in the compression zone
b = unit width
d = distance from the top of the slab to the centroid of the steel deck
F_y = steel yield strength, not to exceed 60 ksi (415 MPa)
M_{nf} = nominal (ultimate) moment capacity with studs on beam
ϕ = 0.85 and is the resistance factor

This method is limited to constructions where the number of shear studs present equals or exceeds N_s, the minimum number of shear studs per foot of deck width to develop the full cross section of the steel deck.

$$N_s = \frac{F_y}{Q_n} \left(A_s - \frac{A_{webs}}{2} - A_{bf} \right) \text{, studs/unit width}$$

where
A_{bf} = deck bottom flange area per unit width of steel deck

A_{sc} = cross-sectional area of stud shear connector, in² (mm²) 1/2" and 3/4" diameter studs are acceptable

A_{webs} = deck web area per unit width of steel deck

f'_c = concrete strength, ksi (MPa)

E_c = modulus of elasticity of concrete = $w_c^{1.5}\sqrt{f'_c}$, ksi ($0.043 w_c^{1.5}\sqrt{f'_c}$, MPa)

$Q_n = 0.5 A_{sc}\sqrt{f'_c E_c} \le 0.75 A_{sc} F_u$
= nominal strength of one stud shear connector in solid concrete

The value, N_s, is to be installed along each beam. At butted end laps, studs shall be staggered to arrest both ends of the deck at the common joint. At perimeter conditions or openings (where slabs are discontinuous) all studs must engage the deck end. The value, Q_n, is subject to reduction when considering composite beam action and the stud is installed through deck. Reduction does not apply to the determination of N_s.

The following is to be used when the shear studs are present on the beam supporting the composite steel deck, but are not present in sufficient quantity to develop the ultimate capacity of the section in bending.

$$M_{np} = M_{no} + (M_{nf} - M_{no}) \frac{N_s'}{N_s} \leq M_{nf}$$

Use ϕM_{np} for the factored resistance in design.

where

M_{no} is determined from Section C4.1.A

M_{nf} as determined from Section C4.1.B

M_{np} = useable nominal moment capacity at stud density = N_s'

N_s' = the number of shear studs actually present along the beam per unit width of steel deck – 1/2″ and 3/4″ diameter studs are acceptable

N_s' is determined from Section C4.1.B

ϕ = 0.85 and is the resistance factor

C. Alternate Methods

Other rational methods for establishing composite slab strength can be used if the pertinent parameters contributing to composite slab strength (including deck cross section; steel thickness; concrete weight, strength, and type; shear transfer devices; method of loading; etc.) are considered. These analyses can include nonlinear relationships between various parameters. Sufficient tests shall be made to establish the method-test variability.

C4.2 Strength for Shear

This section is used to determine the shear strength of the composite deck-slab.

$$V_n = V_c + V_D \leq 4\sqrt{f'_c} A_c$$

where

V_c = $2\beta_c\sqrt{f'_c} A_c$, shear resistance of concrete per unit width

V_D = shear strength of the steel deck section per unit width calculated per AISI

A_c = concrete area available to resist shear, see Figure C1

β_c = 1.0 if concrete density exceeds 130 lbs/ft^3, 0.75 otherwise

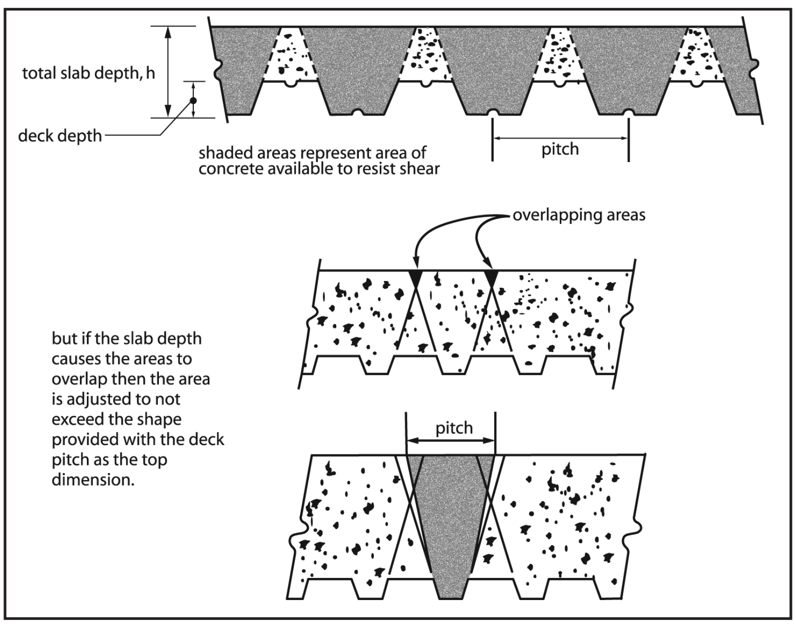


Figure C

C4.3 Deflection

The deflection of the composite slab shall not exceed span/360 under superimposed load. The deflection can be predicted using the average of the cracked and uncracked moment of inertia as determined from the transformed section method of analysis.

Section Properties of Composite Deck - Slabs

C5.1 Transformed Composite Neutral Axis

The distance y_{cc} from the extreme compression fiber of the concrete to the neutral axis of the transformed composite section shall be determined from Figure C5.1 and Equation C5-1.

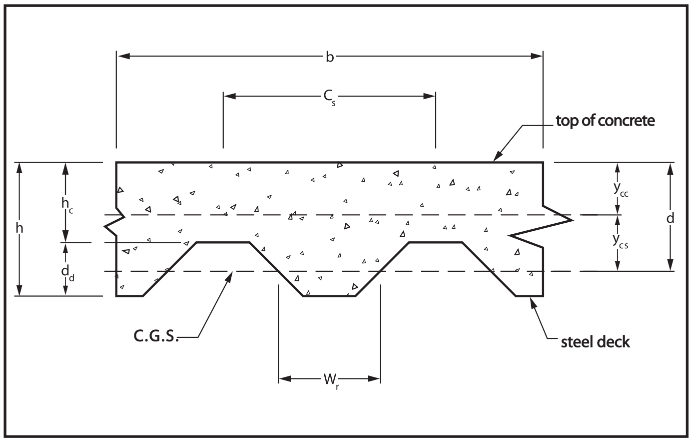


Figure C5.1-Composite Section

Note: 1. Section shows non-cellular deck. Section shall be either cellular, a blend of cellular and non-cellular deck, or non-cellular deck

2. C.G.S. = centroidal axis of full cross section of steel deck

3. Cs = pitch

4. N.A. = neutral axis of transformed composite section

5. Wr = average rib width

C5.2 Moment of Inertia of Cracked Section

When y_{cc} is equal to or less than the depth of concrete, h_c, above the top of steel deck, that is, $y_{cc} \le h_c$, then

$$y_{cc} = d\left\{\sqrt{2\rho n + (\rho n)^2} - \rho n\right\} \qquad \text{(C5-1)}$$

where

$\rho = \frac{A_s}{bd}$

A_s = area of steel deck per unit slab width

b = unit slab width (12 inches in imperial units)

d = distance from top of concrete to centroid of steel deck

n = modular ratio = $\frac{E_s}{E_c}$

E_s = 29500 ksi

$E_c = \gamma^{1.5}\sqrt{f'_c}$ ksi

γ = concrete density, lbs/ft^3

f'_c = concrete strength, ksi

If $y_{cc} > h_c$ use $y_{cc} = h_c$.

The cracked moment of inertia $\mathbf{I}_c$ is

$y_{cs} = d - y_{cc}$ (Use y_{cc} from Equation C5-1.)

$$\mathbf{I}_{cr} = \frac{b}{3n} y_{cc}^3 + A_s y_{cs}^2 + \mathbf{I}_{sf} \qquad \text{(C5-2)}$$

where

$\mathbf{I}_{sf}$ is the moment of inertia of the full (unreduced) steel deck per unit slab width.

C5.3 Moment of Inertia of Uncracked Section

For the uncracked moment of inertia

$$y_{cc} = \frac{0.5bh_c^2 + nA_s d + W_r d_d (h - 0.5d_d)\frac{b}{C_s}}{bh_c + nA_s + W_r d_d \frac{b}{C_s}} \qquad \text{(C5-3)}$$

The uncracked moment of inertia is

$y_{cs} = d - y_{cc}$ (Use y_{cc} from Equation C5-3.)

$$\mathbf{I}_u = \frac{bh_c^3}{12n} + \frac{bh_c}{n}(y_{cc} - 0.5h_c)^2 + \mathbf{I}_{sf} + A_s y_{cs}^2 + \frac{W_r b d_d}{nC_s}\left[\frac{d_d^2}{12} + (h - y_{cc} - 0.5d_d)^2\right] \qquad \text{(C5.4)}$$

C5.4 Moment of Inertia of Composite Section

The moment of inertia of composite section considered effective for deflective computations is given by

$$\mathbf{I}_d = \frac{\mathbf{I}_u + \mathbf{I}_{cr}}{2} \text{ (Transformed to steel)} \qquad \text{(C5.4)}$$