STEEL DECK INSTITUTE sdi®

AMERICAN NATIONAL STANDARDS INSTITUTE/ STEEL DECK INSTITUTE

NC1.0 - 2006 Standard for

Non-Composite Steel Floor Deck

ANSI Accredited Standards Developer

1. General

1.1 Scope:

A. This Specification for Non-Composite Steel Floor Deck shall govern the materials, design, and erection of cold formed non-composite steel deck used as a form for reinforced concrete slabs.

Commentary: In the past, most of the steel decking used in the manner this specification covers was referred to as "centering," however, various roof deck units have successfully been used as non-composite forms. This specification is intended to also include these applications.

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
4. American Society of Civil Engineering (ASCE) -SEI/ASCE7-05
5. American Concrete Institute (ACI) Building Code Requirements for Reinforced Concrete – ACI 318-05
6. Underwriters Laboratories (UL) Fire Resistance Directory - http://www.ul.com/database2006

B. Reference Documents: Refer to the following documents:

1. SDI White Paper - Designing with Steel Form Deck-2003
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 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.*

Commentary: Materials are offered in A653 (A653M) grade 80 steel (galvanized) or ASTM A1008 (A1008M) grade 80 steel (uncoated). This steel has a minimum yield strength of 80 ksi (550 MPa) and is generally over 90 ksi (620 MPa). The AISI specifications allow a maximum allowable stress of 36 ksi (250 MPa) for this material.

C. Sheet steel for accessories shall conform to ASTM A653 (A653M) 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.

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.
28	0.0149	0.38	0.014	0.35
26	0.0179	0.45	0.017	0.43
24	0.0238	0.60	0.023	0.57
22	0.0295	0.75	0.028	0.71
20	0.0358	0.91	0.034	0.86
18	0.0474	1.20	0.045	1.14
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 A924 (A924M) and/or ASTM A653 (A653M).

B. Uncoated (black) shall conform to ASTM A1008 (A1008M).

C. Painted with a shop coat of primer paint (one or both sides) shall be applied to steel sheet conforming to ASTM A1008 (A1008M).

D. The finish on the steel non-composite floor deck shall be suitable for the environment of the structure.

Commentary: The uncoated finish is, by custom, referred to as "black" by some users and manufacturers; the use of the word "black" does not refer to paint color on the product. When galvanized material is used to support a reinforced concrete slab, the slab dead load is considered to be permanently carried by the deck. For any permanent load carrying function, a minimum galvanized coating conforming to ASTM A653 (A653M), G30 (Z090) is recommended.

2.4 Design:

A. Deck used as a form for structural (reinforced) concrete slab:

1. The section properties of the steel floor deck unit 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 (250 MPa) 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 NC1)

3. Load and Resistance Factor Design (LRFD): The load combination for construction are as shown in Attachment NC1. 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 the *North American Specification for the Design of Cold-Formed Steel Structural Members.*

Commentary: The loading shown in Figure 1, Attachment NC1 is representative of the sequential loading of wet concrete on the form. The 150 pound load (per foot of width) is the result of distributing a 300 pound 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 a 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). Whenever possible, the deck shall be multi-span and not require shoring during the concrete placement procedure.

4. Deck Deflection: Calculated deflections of the deck 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.

2.4 Design:

5. Minimum Bearing: Minimum 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;* the uniform loading case of wet concrete, plus the weight of the steel deck, plus 20 psf (1 kPa) construction load shall be used.

Commentary: Experience has shown that 1-1/2 inches (38 mm) of bearing is sufficient for non-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. Concrete Slab Design:
1. General: The design of the concrete slabs shall be done in accordance with the ACI *Building Code Requirements for Reinforced Concrete.* The minimum concrete thickness above the top of the deck shall be 1-1/2 inches (38 mm). Randomly distributed fibers or fibrous admixtures shall not be substituted for welded wire fabric tensile reinforcement.

Commentary: In following the ACI requirements for temperature reinforcement, the designer may eliminate the concrete area that is displaced by the deck ribs. For slabs with total depth of 3 inches (75 mm) or less, the reinforcing mesh may be considered to be at the center of the concrete above the deck. (Refer to the SDI *Designing with Steel Form Deck* for slab design information) If uncoated or painted deck is used as the form, the load from concrete slab weight must be deducted from the calculated capacity of the reinforced concrete slab. If galvanized form is used, the load from the slab weight is considered to be permanently carried by the deck and need not be deducted from the live load. If temporary shoring is used, the load of the slab must be deducted from the calculated capacity of the reinforced slab, regardless of the deck finish. Except for some diaphragm values, the deck should not be assumed to act compositely with the concrete even though strong chemical bonds can, and do, develop.

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

Commentary: The use of admixtures containing chloride salts is not allowed because the salts will corrode the steel non-composite floor deck.

3. Cantilever Loads: When cantilevered slabs are encountered, 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 (1kPa) 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 shall be in accordance with ASCE7. Resistance factors for bending, shear, and interior bearing shall be by the *North American Specification for the Design of Cold-Formed Steel Structural Members.*

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

Side laps shall be attached at the end of the cantilever and a maximum spacing of 12 inches (300 mm) on center from 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.

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 NC2)

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 requirements for 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 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 indicated on Attachment NC1. 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.

Commentary: Staggering deck ends is not a recommended practice. The deck capacity as a form and the load capacity of a non-composite deck/slab system are not increased by staggering end joints, yet layout and erection costs are increased.

F. Lapped or Butted Ends: Deck ends shall be either lapped or butted over supports. Gaps up to 1 inch (25 mm) shall be permitted at butted ends.

G. Deck units and accessories shall be cut and neatly fit around 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 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 angles will be provided at the open ends of deck 1-1/2 inches (38 mm) deep or deeper, in standard 10 feet (3 m) lengths to be field sized, cut and installed. Typically, non-composite floor decks that are less than 1-1/2 inches (38 mm) deep do not require or use cell closure. Alternate means to dam concrete may be used in lieu of cell closure, at the discretion of the installer, if approved by the project engineer.

3.1 Installation/General:

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 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. Form 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 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. Welding washers shall be used on all deck units with metal thickness less than 0.028 inches (0.7 mm). Welding washers shall be a minimum thickness of 0.0598 inches (16 gage, 1.50 mm) and have a nominal 3/8 inch (10 mm) diameter hole.

3. Where welding washers are not used, a minimum visible 5/8 inch (15 mm) diameter arc puddle weld shall be used. Weld metal shall penetrate all layers of deck material at end laps and shall have good fusion to the supporting members.

4. Weld spacing: Fastening pattern shall allow slabs to be designed on a continuous basis.

5. When used, fillet welds shall be at least 1-1/2 inch (38 mm) long.

6. 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 shall be 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 (powder actuated, screws, 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.

7. For deck units with spans greater than five 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 NC2.*

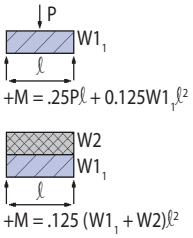
2. Floor Deck Closures: Column closures, cell closures, and Z closures shall be fastened to provide tight fitting closures at open ends of ribs and sides of decking. Fasten cell closures at changes of direction of floor deck units unless otherwise directed.

Commentary: Cell closures are generally not used on form deck of 1-5/16 inch (33 mm) depth or less.

Concrete Form Construction Loading Diagrams

FIGURE 1
Loading Diagrams and Bending Moments

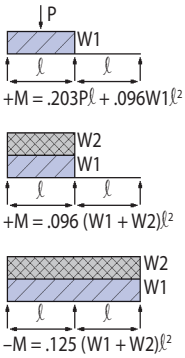
Simple Span Condition



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

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

Double Span Condition

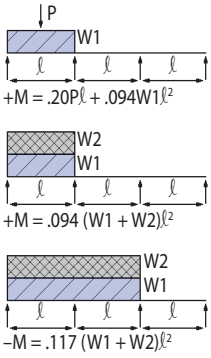


$+M = .203P\ell + .096W1\ell^2$

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

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

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

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

Notes for Figures 1 and 2 — **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 x slab weight + deck weight ≤ slab weight + 30 + deck weight	

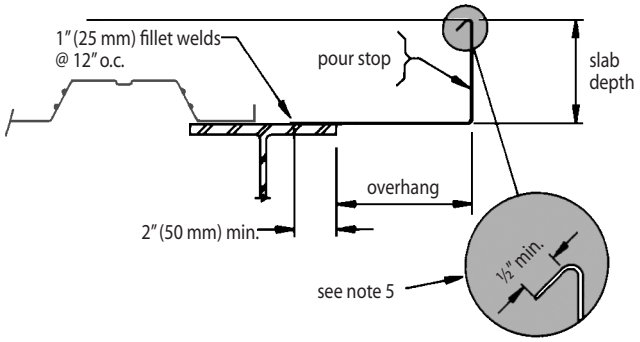
Dimensional check shows the need for the 1728 factor when calculating deflections using pound inch units.

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 and 2 shall be used.

SDI 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).