COMPOSITE STEEL FLOOR DECK

1. Scope

This specification pertains to composite steel floor deck. Composite steel floor deck is cold formed steel deck which acts as a permanent form and as the positive bending reinforcement for the structural concrete. When suitably fastened, the steel deck also acts as a working platform for the various trades. After the concrete hardens, the steel deck and the concrete are interlocked by the shape of the deck, mechanical means, surface bond, or by a combination of these means.

2. Materials

2.1 Composite Steel Decks: Composite steel floor deck shall be fabricated from steel conforming to Section A3 of the latest edition (1986 and addenda), of the American Iron and Steel Institute, *Specification for the Design of Cold-Formed Steel Structural Members*, (AISI Specifications). The steel used shall have a minimum yield point of 33 ksi. (230 MPa).

2.1a Tolerances:
Panel length: Plus or minus ½ inch (12 mm).
Thickness: Shall not be less than 95% of the design thickness.
Panel cover width: minus 3/8 inch (10 mm), plus ¾ inch (20 mm).
Panel camber and/or Sweep: ¼ inch in 10 foot length (6 mm in 3 m).
Panel end out of square: 1/8 inch per foot of panel width (10 mm per m).

Commentary: Most composite steel floor deck is manufactured from steel conforming to ASTM A653-94, Structural Quality Grades 33, 37, 40, 50, or 80.

The tolerances reflect fabrication processes for steel deck products. Variation in cover width tolerances may vary due to trucking, storage or handling.

2.1b Finish: The finish on the steel composite deck shall be as specified by the designer and be suitable for the environment of the structure.

Commentary: Since the composite deck is the positive bending reinforcement for the slab, it must be designed to last the life of the structure; a minimum recommended finish is a galvanized coating as defined in ASTM A653-94, G60 (Z180).

2.2 Concrete: Concrete shall be in accordance with the applicable sections of chapters 3, 4 and 6 of the ACI 318 *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 be used.

Commentary: The use of admixtures containing chloride salts is not allowed because the salts may corrode the steel deck which has been redesigned as the slab reinforcement.

3. Design (Deck as a Form)

3.1 The section properties for the steel floor deck (as a form in bending) shall be computed in accordance with the AISI Specifications.

3.2 Bending stress in the deck shall not exceed 0.6 times the yield strength with a maximum of 36 ksi (250 MPa) under the combined loads of wet concrete, deck, and the following construction live loads: 20 pounds per square foot uniform load (1 kPa) or 150 pound concentrated load on a 1'0" wide section of deck (2.2 kN per m).

See Figure 1.

Commentary: The loading shown in Figure 1 is representative of the sequential loading of wet concrete on the form. The 150 pound load is the arithmetic result of 200 lb. (man's weight) x ¾. The philosophy here is to allow a 1/3 increase in stress due to the temporary nature of a man load. Decreasing the load by 25% is the mathematical equivalent of allowing a 33% increase in stress. Also the 150 pound loan is considered to be applied in a one foot width but experience has shown that a greater distribution really occurs. For single span deck applications the ability to control the concrete placement may be restricted and a 1.5 factor has been applied to the concrete load to cover this condition. (The metric equivalent of the 150 pound load over a foot of width is 2.2 kN over a meter of width.)

3.3 Calculated theoretical deflections of the deck, as a form, shall be based on the load of concrete (as determined by the design slab thickness) and the load from the steel deck, uniformly loaded on all spans, and shall be limited to L/180 or ¾ inch (20 mm), whichever is smaller. Deflections shall be relative to supporting members.
See Figure 2.

Commentary: The deflection calculations do not take into account construction loads since these are considered as 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.

3.4 Minimum bearing lengths shall be determined in accordance with the AISI Specification; a uniform loading case of wet concrete, plus deck, plus 20 psf (1 kPa) construction load shall be used.
See Figure 3.

Commentary: In the past 1-1/2 inches (40 mm) of end bearing was the minimum; this is a good "rule of thumb" that will, in general, prevent slip off. If less than 1-1/2 inches (40 mm) of end bearing is available, or if high support reactions are expected, then the designer should check the deck web crippling strength. In any case, the deck must be adequately attached to the structure to prevent slip off.

4. Installation & Site Storage

4.1 Site Storage: Steel deck shall be stored off the ground with one end elevated to provide drainage and shall be protected from the elements with a water-proof covering, ventilated to avoid condensation.

4.2 Deck Placement: Place each deck unit on supporting structural frame. Adjust to final position with accurately aligned side laps and ends bearing on supporting members.

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

4.3 Butted Ends: Deck sheets shall be butted over supports. Standard tolerance for ordered length is plus or minus ½ inch (12 mm).

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 sheets can make welded attachments more difficult. Gaps are acceptable at butted ends. If taping of butted ends is requested, it is not the responsibility of the deck manufacturer.

4.4 Anchorage: Floor deck units shall be anchored to supporting members including perimeter support steel and/or bearing walls by either welding or by mechanical fastening. This shall be done immediately after alignment. Deck units with spans greater than five (1.5 m) shall have side laps and perimeter edges (at perimeter support steel) fastened at midspan or 36 inch (1 m) intervals, whichever distance is smaller.

Commentary: This anchorage may be required to provide lateral stability to the top flange of the supporting structural members. The deck should be anchored to act as a working platform and to prevent blow off. Side lap fasteners can be welds, screws, crimps (button punching), or other methods approved by the designer. Welding side laps on thicknesses 0.028 inches (0.7 mm) or less may cause large burn holes, and is not recommended. The objective of side lap fastening is to prevent differential sheet deflection during concrete placing and therefore prevent side joints from opening. The five foot (1.5 m) limit on side lap spacing is based on experience. The deck contractor should not leave unattached deck at the end of the day, as the wind may displace the sheets and cause injury to persons or property. The SDI *Diaphragm Design Manual, Second Edition*, should be used to determine fastening requirements if the deck will be designed to resist horizontal loads. The most stringent requirements, of either section 4.4 or, if applicable, the SDI *Diaphragm Design Manual*, should be used.

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4.4a Welding: All welding of deck shall be in strict accordance with ANSI/AWS D1.3 *Structural Welding Code—Sheet Steel*. Each welder must 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. A minimum visible 5/8 inch (15 mm) diameter puddle weld or equivalent is required at all edge ribs, plus a sufficient number of interior ribs to provide a maximum average spacing of 12 inches (300 mm). The maximum spacing between adjacent points of attachment shall not exceed 18 inches (460 mm). Fillet welds, when used, shall be at least 1 inch (25 mm) long. Weld metal shall penetrate all layers of deck material at end laps and shall have good fusion to the supporting members. Welding washers shall be used on all deck units with a metal thickness less than 0.028 inches (0.7 mm). Welding washers shall be a minimum thickness of 0.056 inches (1.5 mm, 16 gage) and have a nominal 3/8 inch (10 mm) diameter hold.

Commentary: The welder may be qualified on plate or pipe under ANSI/AWS D1.1, *Structural Welding Code—Steel*, or under the provisions of other codes governing the welding of specific products, but may not be qualified for welding sheet steel. The layout, design, numbering or sizing of shear connectors is not the responsibility of the deck manufacturer. If studs are being applied through the deck onto structural steel, the stud welds can be used to replace the puddle welds. In general, stronger welds are obtained on 0.028 inches (0.7 mm) or thicker deck without weld washers. Welds on deck less than 0.028 inches (0.7 mm) are stronger with washers.

4.4b Mechanical Fasteners: Mechanical fasteners (powder-actuated, screws, pneumatically driven fasteners, etc.) are recognized as viable anchoring methods, provided the type and spacing of the fasteners 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. The deck manufacturer may recommend additional fasteners to stabilize the given profile against sideslip of unfastened ribs.

Commentary: The allowable 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 5/16 inch (8 mm) diameter minimum bearing surface (fastener head size).

5. Design Deck and Concrete as a Composite Unit

5.1 General: The composite slab shall be designed as a reinforced concrete slab with the steel deck acting as the positive reinforcement. Slabs shall be designed as simple or continuous spans under uniform loads.

Commentary: High concentrated loads, diaphragm loads, etc. require additional analysis. Horizontal load capacities can be checked by referring to the SDI *Diaphragm Design Manual, Second Edition.* 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. If the designer wants a continuous slab, then negative reinforcing should be designed using conventional reinforced concrete design techniques. The welded wire mesh, chosen for temperature reinforcing (Section 5.5), does not usually supply enough area for continuity. The deck is not considered to be compression reinforcing.

Care should be used during the placement of loads on rolled-in hanger tabs for the support of ceilings so that approximate uniform loading is maintained. Improper use of rolled-in hanger tabs could result in the over-stressing of such tabs and/or the overloading of the composite deck slab.

5.2 Certifications: The deck manufacturer shall have submitted drawings and samples to the Steel Deck Institute and shall be certified under the S.D.I. Floor Deck Certification Program.

5.2a Load Determination—Elastic Flexural Analysis. This method of load determination is to be used if there are shear studs on the beams perpendicular to the deck in sufficient quantity to meet the minimum requirements of the American Institute of Steel Construction (AISC) Specifications. Using standard reinforced concrete design procedures the allowable superimposed load shall be found by using appropriate load resistance design (LRFD) factors to deduct the moment caused by the slab and deck weight from the calculated ultimate moment. Additional load reduction factors may be required if the number of shear studs used in the actual construction is less than needed to develop the ultimate capacity of the deck/slab. Mn=0.85 As Fy (d-a/2), the ultimate moment, where As = steel deck area in square inches per foot of width (sq. mm per m); Fy – the steel yield strength (not to exceed 60 ksi, 415 MPa); d = the distance, inches (mm), from the top of the slab to the centroid of the steel deck; a = AsFy/(0.85'cb), inches (mm); and b is 12 inches (or 1 meter).

5.2b Load Determination-Ultimate Strength Analysis. This method of load determination is to be used if there are shear studs on the beams perpendicular to the deck in sufficient quantity to meet minimum requirements of the American Institute of Steel Construction (AISC) Specifications. Using standard reinforced concrete design procedures the allowable superimposed load shall be found by using appropriate load resistance design (LRFD) factors to deduct the moment caused by the slab and deck weight from the calculated ultimate moment. Additional load reduction factors may be required if the number of shear studs used in the actual construction is less than needed to develop the ultimate capacity of the deck/slab. Mn=0.85 As Fy (d-a/2), the ultimate moment, where As = steel deck area in square inches per foot of width (sq. mm per m); Fy-the steel yield strength (not to exceed 60 ksi, 415 MPa); d = the distance, inches (mm) from the top of the slab to the centroid of the steel deck; a = AsFy/(0.85'cb), inches (mm); and b is 12 inches (or 1 meter).

Commentary: By using one (or both) of the appropriate analysis techniques, 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 (under section 3.1 of these specifications), 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.

5.3 Concrete: Concrete for composite slabs must be of structural quality as shown in ACI 318. Stresses in the concrete shall not exceed those allowed in ACI 318. However, if allowable stress design (ASD) is used, then the compressive stress in the concrete shall not exceed 0.45 f'c.

Commentary: Load tables are generally calculated by using a concrete strength of 3 ksi (20 MPa), it would be advisable to check shear stud strengths. Fire rating requirements may dictate the minimum concrete strength.

5.3a Minimum Cover: The minimum concrete above the top of the floor 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 ¾ inch (20 mm).

5.4 Deflection: Deflection of the composite slab shall not exceed L/360 under the superimposed load.

Commentary: Live load deflections are seldom a design factor. The deflection of the slab/deck combination can best be predicted by using the average of the cracked and uncracked moments of inertia as determined by the transformed section method of analysis.

5.5 Temperature and Shrinkage reinforcement, consisting of welded wire fabric or reinforcing bars, shall have a minimum

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area of 0.00075 times the area of concrete above the deck (per foot or per meter of width), but shall not be less than the area provided by 6x6-W1.4xW1.4 welded wire fabric. For those products so manufactured, shear transfer wires welded to the top of the deck may be considered to act as shrinkage or temperature reinforcement.

Commentary: If welded wire mesh is used with a steel area given by the above formula, if will generally not be sufficient to be the total negative reinforcement; however, the mesh has shown that it does a good job of crack control especially if kept near the top of the slab (3/4) inch to 1 inch cover, 20 to 25 mm).

6. Construction Practice

All deck sheets shall have adequate bearing and fastening to all supports so as not to lose support during construction. 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. Damaged deck (sheets containing distortions or deformations caused by construction practices) shall be repaired, replaced, or shored to the satisfaction of the designer before placing concrete. The cost of repairing, replacing, or shoring of damaged units shall be the liability of the trade contractor responsible for the damage.

Commentary: For temporary construction loads prior to concrete placement, it should be safe to assume that the deck will support a minimum uniform load of 50 psf (2.4 MPa) without further investigation.

6.1 The need for temporary shoring shall be investigated and, if required, it shall be designed and installed in accordance with the applicable ACI code and shall be left in place until the slab attains 75% of its specified compressive strength.

6.2 Prior to concrete placement, the steel deck shall be free of soil, debris, standing water, loose mill scale and all other foreign matter.

6.3 Care must be exercised when placing concrete so that the deck will not be subjected to any impact that exceeds the design capacity of the deck. Concrete shall be placed from a low level to avoid impact, and in a uniform manner over the supporting structure and spread toward the center of the deck span. If buggies are used to place the concrete, runways shall be planked and the buggies shall only operate on planking. Planks shall be of adequate stiffness to transfer loads to the steel deck without damaging the deck. Deck damage caused by roll bars or careless placement must be avoided.

7. Additional Information and Comments

7.1 Parking Garages: Composite floor deck has been used successfully in many parking structures around the country; however, the following precautions should be observed:

1. Slabs should be designed as continuous spans with negative bending reinforcing over the supports;

2. Additional reinforcing should be included to deter cracking caused by large temperature difference and to provide load distribution; and,

3. In areas where salt water; either brought into the structure by cars in winter or carried by the wind in coastal areas, may deteriorate the deck, protective measures must be taken. The top surface of the slab must be effectively sealed so that the salt water cannot migrate through the slab to the steel deck.
A minimum G90 (Z275) galvanizing is recommended, and, the exposed bottom surface of the deck should be protected with a durable paint.

The protective measures must be maintained for the life of the building. If the protective measures cannot be assured, the steel deck can be used as a stay in place form and the concrete can be reinforced with mesh or bars as required.

7.2 Cantilevers: When cantilevers are encountered, the deck acts only as a permanent form; top reinforcing steel must be proportioned by the designer.

7.3 Composite Beams and Girders: Most composite floor deck sections are suitable for use with composite beams. The AISC Specification specifically provides for the use of this type of construction.

7.4 Fire Ratings: Many fire rated assemblies that use composite floor decks are available.

7.5 Fireproofing: The metal deck manufacturer shall not be responsible for ensuring the bonding of fireproofing. The adherence of fireproofing materials is dependent on many variables; the deck manufacturer (supplier) is not responsible for the adhesion of adhesive ability of the fireproofing.

7.6 Dynamic Loads: Dynamic loading, e.g., fork lifts, can, over a period of time, interfere with the mechanical bond between the concrete and deck which achieves its composite action via web indents. Reinforcing steel running perpendicular to the deck span and placed on top of the deck ribs is often used with this type of loading to distribute concentrated loads.

7.7 Other Criteria: Composite Steel floor deck may be used in a variety of ways, some of which do not lend themselves to a standard “steel deck” analysis for span and loading. There are, in these cases, other criteria which must be considered besides that given by the Steel Deck Institute. Make sure this investigation starts with a review of the applicable Codes and that any special conditions are included in the design.

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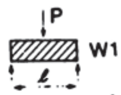
FIGURE 1

Loading Diagrams and Bending Moments

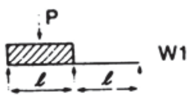
Simple Span Condition



$+M = .25P\ell + .188W1\ell^2$

$+M = .125(1.5W1 + W2)\ell^2$

Double Span Condition

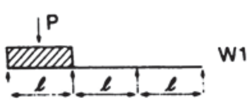


$+M = .203P\ell + .096W1\ell^2$

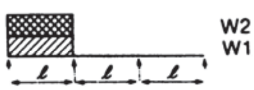
$+M = .096(W1 + W2)\ell^2$

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

Triple Span Condition



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



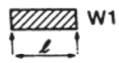
$+M = .094(W1 + W2)\ell^2$

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

FIGURE 2

Loading Diagrams and Deflections

Simple Span Condition



$\Delta = \dfrac{.0130W1\ell^4}{EI}(1728)$

Double Span Condition

$\Delta = \dfrac{.0054W1\ell^4}{EI}(1728)$

Triple Span Condition

$\Delta = \dfrac{.0069W1\ell^4}{EI}(1728)$

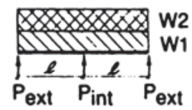
FIGURE 3

Loading Diagrams and Support Reactions

Simple Span Condition

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

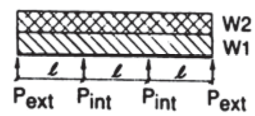
Double Span Condition



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

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

Triple Span Condition



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

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

Note for Figures 1, 2 and 3

P = 150-pound concentrated load
W1 = slab weight + deck weight
W2 = 20 pounds per square foot construction load
ℓ = span length (ft.)