A sheet metal decking unit useful in the construction of a composite floor. The sheet metal decking unit exhibits substantial wet strength (ability to support wet concrete between spaced supports); has long span capabilities; and is useful in single and multiple span applications. The sheet metal decking unit presents hold-down elements above and below the geometric mid-plane of the decking unit, and presents shear-resisting elements below the geometric mid-plane, which cooperate in the composite floor construction to achieve the composite load carrying capability of the floor. The decking unit is fully nestable in jam-free relation with others of the decking unit for packaging, storage and shipment. A side joint of the overlap type is provided which is laterally adjustable to facilitate spreading or drawing together of the decking units thereby to accommodate camber or sweep in the decking units, deviations from the specified spacing between the supporting beams, and the like.

16 Claims, 42 Drawing Figures
Sheet Metal Decking Unit and Composite Floor Construction Utilizing the Same

Background of the Invention

1. Field of the Invention
   This invention relates to a composite floor construction and a profiled sheet metal decking unit for producing the same.

2. Description of the Prior Art

Decking Unit Requirements

Sheet metal decking units intended for use in composite floor construction have a number of requirements. The metal decking units must function, during the life of the building, in a composite relationship with a covering concrete slab. However, during the construction phases of the building, the sheet metal decking units must exhibit a property known as wet strength.

Wet Strength

Wet strength is the ability of the decking unit to support a load of wet, unhardened concrete until such time as the concrete hardens and the composite load carrying properties of the structure are developed. When a sheet metal decking unit has inadequate wet strength for a particular span requirement, the decking unit must be shored or supported at one or more intermediate locations between the intended supporting beams. The intermediate supports serve in a temporary fashion to reduce the unsupported span to a distance which is within the supporting capacity of the decking unit.

Composite Characteristics

Sheet metal decking units intended for use in composite floor construction achieve a positive mechanical combination with the concrete layer which is poured thereover. The resulting floor develops predictable and reliable composite coaction between the concrete layer and the sheet metal decking units throughout the lifetime of the building. Hence the compressive load bearing properties of the concrete can be utilized in the resultant composite floor. The resultant composite floor becomes, in effect, a reinforced concrete floor wherein the concrete contributes substantially the same properties which concrete normally is considered to contribute in reinforced concrete structures, e.g., resistance to compressive stress. The sheet metal decking units provide coacting metal reinforcement for the concrete.

Wet Strength and Composite Properties Compared

A comparison of several prior art sheet metal composite decking units will serve to highlight the significance of wet strength and its comparison with composite characteristics. Consider, for example, the Shea decking unit, supra in comparison with the Curran et al. decking unit, supra. With respect to wet strength, the Shea decking unit is superior to the Curran et al. decking unit. That is, if the two units are fabricated from the same thickness of sheet metal, e.g., from 20 gauge steel and are formed with identical gross dimensions of the profile, (1.5 inches high, 24 inches wide and the same number of crests and valleys), and then the two units are covered with the identical concrete mixture to a common depth (customarily 2.5 inches above the height of the crest), then the Shea et al. decking units will span a greater distance without requiring intermediate supports than will the Curran et al. decking units. Note that in the described environment, both of the units are loaded with an identical amount of wet, unhardened concrete per square foot of floor area.

However after the concrete has hardened, these same two decking units will exhibit strikingly different load carrying capabilities for the identical span. For example the Curran et al. decking unit will accept 30 to 40 per cent greater loads (in pounds per square foot of floor area) than the Shea et al. decking units. It should be taken into consideration that the amount of load (allowable loading) which can be supported by a composite floor assembly is not an absolute factor, but instead is determined by a number of criteria which include: mid-span deflection; horizontal shear stress; tensile stresses in the sheet metal decking unit; and compressive stresses in the concrete. These criteria may vary according to a number of secondary factors such as the intrinsic properties of the materials (e.g., the ultimate yield stress of the metal or the compressive strength of the concrete); the intended use of the composite floor (e.g., apartment buildings, office buildings, parking garages, etc.); and the requirements of the applicable building code authorities.

Thus, it should be apparent that no one property of sheet metal decking unit is controlling in evaluating their utility as elements of composite floor constructions. The ultimate load carrying capability of the composite floors certainly is important. The wet strength of the sheet metal decking unit by itself likewise is important.

Balanced Section Properties

Decking sections having balanced section properties are known in the prior art. See, for example, U.S. Pat. No. 1,986,999 (E. W. Burgess, Jan 8, 1935). Such decking units in the form of heavy plate, e.g., one-quarter inch, are particularly useful in the construction of the floor structure of bridges. For heavy plate, the balance of sectional properties is achieved by distributing the metal in the decking unit, evenly above and below the neutral axis. As a result of the even distribution of metal, the amount of metal available to carry the tension stresses is the same as that available to carry the compression stresses. In the prior art, such even distribution is stated to be the ideal condition.

Composite Beam Construction

The concrete component of the concrete floors can be made to function compositely with the sheet metal decking unit and also to function compositely with the supporting steel beams of a building. Combining concrete with steel beams by means of welded studs is well known in the bridge-building arts. See U.S. Pat. Nos.
3,812,636

2,479,476 (C. P. CUENI, Aug. 16, 1949); 2,987,855 R. C. SINGLETON et al., June 13, 1961). The use of welded studs with horizontal building beams in combination with sheet metal decking units also is known, see U.S. Pat. No. 3,394,514 (R. G. LINDNER, July 30, 1968). In order to allow such building beam studs to develop effective embedment in a concrete slab, two techniques have been employed in the past. The first technique provides one wider-than-normal valley in the sheet metal decking unit to prevent stud mounting sites which are sufficiently wide to achieve the required embedment. See U.S. Pat. No. 3,394,514, supra. The other technique has been to invert prior art decking units having composite properties, so that the studs can be welded directly to the supporting beam through the wide flat coplanar components of the decking unit rather than through the narrow flat coplanar components. This inversion achieves composite beam properties at the sacrifice of some of the composite slab properties which could be achieved if the composite decking units were installed normally, i.e., if they were not inverted. The wet strength of the inverted sheet metal decking units also is reduced as a result of the inversion.

Nestability

Another important factor in the evaluation of a decking unit is its nestability which can be measured by the shipping density of the product. A nestable unit will have a greater shipping density than a non-nestable unit. At the present time typical highway truck shipments are limited to a maximum loading of 45,000 pounds. However the volume of the typical highway truck will accommodate a greater weight of a nestable decking unit than it will of a non-nestable decking unit. A typical truck load of a non-nestable decking unit, commercially available, weighs 13,000 pounds if fabricated in 20 gauge steel and 25,000 pounds if fabricated in 16 gauge steel. Thus the weight carrying capability of the truck is not fully utilized. With a suitably nestable decking unit, having its higher shipping density, the maximum weight loading can be approached. Nestability of composite floor decking units has not heretofore been accomplished. Nestability is not uncommon in profiled sheet metal roofing and sliding units (see British Pat. No. 769,526) but heretofore there have been no known sheet metal floor decking units used for composite construction, which can be nested for shipping compaction.

Joints

The prior art contains many examples of joints of the non-adjustable type, between adjacent decking units. The decking units may be joined by a conventional tongue-and-groove connection, see U.S. Pat. No. 3,394,514, supra. Decking units may be connected by a modified tongue-and-groove connection wherein the adjacent decking units present first and second upstanding abutted flanges and wherein the second upstanding flange is provided with a downwardly and outwardly inclined terminal flange overlying the first flange, see U.S. Pat. No. 925,941 (J. McMILLEN, June 22, 1909). T-shaped joints are known wherein the adjacent decking units present abutted upstanding side walls terminating in oppositely extending horizontal flange members and wherein the abutted walls are united by welding or other suitable means, see U.S. Pat. No. 2,284,923 (H. W. SHICK, June 2, 1942).

The prior art also contains examples of joints which permit adjustment of the decking units relative to one another to compensate for small variations in the width of the decking unit and in the size of the supporting structure. Such an adjustable joint may be provided by overlapping the lateral edges of adjacent decking units. In such an arrangement, one of the lateral valleys is offset vertically by at least one metal thickness, see U.S. Pat. No. 1,995,496 (E. W. BURGESS, Mar. 26, 1935). In a second arrangement, one of the lateral valleys is provided with a vertically offset terminal strip adapted to overlie the lateral valley of the adjacent decking units, see U.S. Pat. No. 1,986,999 (E. W. BURGESS, Jan. 8, 1935).

SUMMARY OF THE INVENTION

The principal objects of this invention are to provide an improved profiled sheet metal decking unit and an improved composite floor structure embodying such units.

Another object of this invention is to provide a sheet metal decking unit which, compared to prior art decking sections, contains significantly less metal per foot of floor area, but which (1) achieves a wet strength which is at least equal to that of prior art decking units; (2) is capable of unsupported span lengths which are at least equal to those of prior art decking units; (3) can be combined with an overlying layer of concrete to produce a composite floor structure whose composite properties substantially exceed those of prior art composite floor structures; and (4) will accommodate fully effective shear-transfer studs for composite-beam assemblies without sacrifice of the composite-slab capacity of the unit.

Still another object of this invention is to provide longitudinal ribs in a sheet metal decking unit, which serve to stiffen the intermediate and lateral valley strips of the decking unit; which serve as concrete hold-down means and as shear-resisting means in the composite floor structure; which serve as a spacer member for maintaining nested decking units in vertically spaced-apart, jam-free relation; and which may serve as a channel adapted to receive a hanger device.

A further object of this invention is to provide a sheet metal decking unit which is fully nestable in jam-free relation with others of the decking unit for the purposes of packaging, storage and shipment.

A further object of this invention is to provide a composite floor assembly which accommodates "plastic design" principles, thereby liberating the design of composite floor structures from horizontal stress considerations.

Sheet Metal Decking Unit

The present decking unit is profiled and presents alternating coplanar crest strips and coplanar valley strips which are separated by sloped web strips. The sheet metal decking unit has a geometric mid-plane, i.e., a plane equidistant from and parallel with the plane of the crest strips and the plane of the valley strips.

As will be described, the present decking unit includes various elements some of which cooperate to provide the improved wet strength properties of the present decking unit and some of which cooperate with
an overlying layer of concrete to produce an improved composite floor structure.

The decking unit is provided with first deformations which are integrally formed in certain of the valley strips and which protrude upwardly toward the geometric mid-plane. The decking unit also is provided with longitudinal ribs which are integrally formed in certain elements of the decking unit and which extend into the decking unit trough defined by confronting sloped web strips and the common valley strips. Each decking unit trough presents confronting longitudinal ribs. Each of the longitudinal ribs cooperates with the contiguous valley strip to define at least one longitudinal keying recess. The present decking unit also includes a plurality of second deformations integrally formed in each of the sloped web strips. The second deformations introduce into each of the sloped web strips, longitudinally extending gripping surfaces and transversely extending gripping surfaces. The crest strips of the decking unit may be provided with longitudinal stiffener beads which preferably extend from the crest strip toward the geometric mid-plane. The lateral valley strips — those valley strips lying on opposite sides of the decking unit — are provided with stiffened edges which permit adjacent decking units to be assembled in side-by-side overlapped relation.

Composite Floor Constructions

The present invention provides an improved composite floor construction comprising a plurality of the present sheet metal decking units assembled in side-by-side overlapped relation and covered with a layer of concrete which constitutes a continuous integral mass. All composite floor constructions must include (a) a hold-down means for resisting vertical disengagement of the concrete slab from the decking unit; and (b) shear-resisting means for resisting movement of the concrete slab longitudinally of the decking unit. The present composite floor construction includes these essential “means.” However in accordance with the present invention, the function of each of these “means” is achieved not solely by a single decking unit element but by a cooperative contribution of two or more of the decking unit elements. That is, the several elements of the present construction each contribute to the development of the functions of the aforesaid means.

In accordance with the present invention, the hold-down function is achieved by a cooperative contribution of (a) the concrete engaging and filling the longitudinal keying recesses presented by the longitudinal ribs; and (b) the concrete engaging and conforming with the longitudinally extending gripping surfaces presented by the second deformations. The shear-resisting function is achieved by the cooperative contribution of (a) the concrete engaging each of the first deformations in the valley strips; (b) the concrete engaging the transversely extending gripping surfaces of the second deformations; and (c) the gripping of the concrete by the confronting longitudinal ribs in each of the decking unit troughs.

As a result of the present composite floor structure, movement of the concrete longitudinally of the sheet metal decking units and vertical disengagement of the concrete from the sheet metal decking unit are resisted to an extent not heretofore achieved by any prior art composite floor structures. The magnitude of shear-resistance achieved in the present composite floor construction is such that horizontal shear is not considered as a limiting factor in normal usage of the present composite floor construction.

Ultimate Allowable Uniform Loading

The allowable uniform loading of any composite floor structure is some specified fraction (safety factor) of the ultimate failure load of the composite floor. In prior art composite floor design practice, two ultimate failure loads are determined, one based on the stress of the steel component and the other based on the horizontal shear stress in the composite floor. In shorter spans, for example less than 10 feet, prior art composite floor structures fail when the applied load produces a horizontal shear stress which exceeds the shear-resisting capability of the concrete decking unit composite assembly. At this applied load, the concrete separates from and slides longitudinally of the decking unit. This type of failure is known as “shear failure.” In longer spans, for example above 10 feet, prior art composite floor structures fail when the applied load produces a tensile stress in the lowermost fiber of the steel component in excess of the yield stress of the steel. At this applied load, the concrete component separates from the steel component. This type of failure is known as failure at “initial yield.” The allowable uniform loading of prior art composite floor structures based on steel stress, is some specified fraction of the “yield failure load” — that load which produces “initial yield.”

The properties of the present composite floor construction, are such that, somewhat unexpectedly and unpredictably, “shear failure” does not occur. The magnitude of shear-resistance achieved in the present composite floor construction is such that horizontal shear is not considered as a limiting factor in normal usage of the present composite floor construction.

The properties of the present composite floor construction, are such that, somewhat unexpectedly and unpredictably, failure does not occur at initial yield of the steel decking unit. Instead, a phenomenon known as “plastic hinge formation” occurs whereby with increasing load, the steel and concrete components retain their integrity beyond initial yield of the steel. The steel component continues to absorb incremental tensile stresses until the stress in the uppermost fiber of the steel component — that fiber nearest the plane of neutral stress — reaches yield stress. Yielding of the uppermost steel fiber may be termed “final yield.” At final yield, the tensile stresses are transferred to the concrete component which is inherently low in tensile strength. At final yield, the present composite floor structure fails by fracture of the concrete component. The applied load is known as the “ultimate failure load”.

“Plastic hinge formation” is known in the prior art. The method of analysis employed to predict the load that will develop a plastic hinge and the location where it will occur is commonly termed ultimate-load design or plastic design. However it should be emphasized that heretofore the use of the plastic design method of analysis to predict the ultimate failure load has been limited to structural steel components, steel frameworks and composite beam constructions. For a full explanation of the plastic design method of analysis for structural steel components and steel frameworks, see L. E. Griner, "Design of Modern Steel Structures," New York: The MacMillan Company, 1960, pages 389 to 399. For a description of plastic design method of analysis for

The present invention provides the first composite floor structure of the type consisting of profiled sheet metal decking units and an overlying conforming layer of concrete, which develops a plastic hinge. As a result of this phenomenon, the present composite floor exhibits an ultimate failure load which significantly exceeds the yield failure load of prior art composite floor structures. Consequently, the ultimate allowable uniform loading of the present strength floor structure—a specified fraction of the ultimate failure load rather than the lower yield failure load—per significantly exceeds that of all prior art composite floor constructions.

Adhesive Bond

The formation of a bond between concrete and a decking unit formed from galvanized steel, is a known phenomenon. The bond is attributed to the formation of a complex calcium-zincate compound by a chemical reaction between calcium oxide from the concrete and zinc from the galvanized steel decking unit. See I. W. Benjamin, "Use of Galvanized Sheets in Concrete Reinforcement," Year Book of American Iron and Steel Institute 1965, pages 347-369. Heretofore, the bond was not considered in determining the load carrying capacity of composite floor structures. However, the profile of the present sheet metal decking unit is such that the bond is a continuing factor in the load carrying capability of the present composite floor construction.

Wet Strength Properties

The present sheet metal decking unit exhibits balanced wet strength properties, despite uneven distribution of metal on opposite sides of the geometric mid-plane of the decking unit profile. This balancing of properties is accomplished by means of the longitudinal ribs; by means of longitudinal stiffener beads in the crest strips; and by means of stiffened edges in the lateral valley strips. The longitudinal ribs contribute longitudinally undeformed metal which compensates for the reduction in structural effectiveness of the metal in the valley strips. Longitudinal stiffener beads render the crest strips structurally effective across their width under tension and compression. The lateral valley strips (those valley strips lying on opposite sides of the decking unit) are provided with stiffened edges which render the lateral valley strips fully effective across their width under tension and compression.

The result of this balance of structural properties is that the unit will resist positive and negative loading substantially equally. This balance of structural properties permits the use of long length decking units which span several beams.

Alternatively, it can be stated that the present sheet metal decking unit presents its plane of neutral stress substantially coincident with the geometric mid-plane of the unit despite the fact that the unit contains more metal on one side of the geometric mid-plane than on the other side of the geometric mid-plane.

A measure of the wet strength property of a decking unit is the strength to weight ratio, i.e., the ratio of the amount of inertia (I) of the decking unit to the weight ppr unit floor area of the decking unit. Gauge for gauge, the strength to weight ratio of the present decking unit exceeds that of the prior art decking units.

Side Joint

The lateral valley strips of the present decking unit are provided with stiffened edges which (a) render the lateral valley strips fully effective across the width, under tension and compression, and (b) permit adjacent ones of the decking unit to be assembled in side-by-side overlapped relation. Each decking unit may be adjusted laterally relative to the adjacent decking unit. The overlapped segments of the decking units may be welded or otherwise secured together.

Nestability

In the present sheet metal decking unit, the second deformations (second hold-down means) are offset from the surfaces of the sloped web strips. The slope of the web strips is such that in the absence of the second deformations, a plurality of the decking units could be assembled in a nested jam-free relation. In accordance with the present invention, the longitudinal ribs present shoulders which are positioned to be engaged by certain of the coplanar strips, for example, the valley strips, of the nested decking units. The overall arrangement is such that the shoulders maintain corresponding valley strips, corresponding crest strips and corresponding sloped web strips of the nested decking units in spaced-apart relation. Thus, despite the presence of the interfering second deformations, a plurality of the decking units can be assembled in a compact nested jam-free relation for storage and shipment.

Rib as Hanger Channel

In one embodiment of the present decking unit, each of the longitudinal ribs connect the confronting edges of spaced valley segments. The confronting edges define a lengthwise slot. The rib extends above the valley strip and has an interior width which is greater than the width of the lengthwise slot. The rib provides a channel adapted to receive and retain a hanger device. At one or more locations in the decking unit, portions of the confronting edges of the valley and of the side walls of the rib are splayed to provide an opening for receiving the head of the hanger device. The hanger devices are received in the channel and are moved lengthwise along the channel to the desired position on the decking unit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary isometric illustration of a partially completed multi-floor building showing one level having the present sheet metal decking units secured in position and showing another level having a slab of concrete poured on such units;

FIG. 2 is an isometric end view of a fragment of the sheet metal decking unit of this invention;

FIG. 3 is an end view illustrating the profile of the present sheet metal decking unit;

FIG. 4 is an enlarged, fragmentary cross-sectional view taken along the line 4—4 of FIG. 2, illustrating first hold-down means;

FIG. 5 is a fragmentary cross-sectional view, similar to FIG. 4, illustrating an alternative embodiment of the first hold-down means;

FIG. 6 is a fragmentary side view illustrating second hold-down means;
FIGS. 7 and 8 are cross-sectional views taken along the lines 7—7 and 8—8, respectively, of FIG. 6;
FIG. 9 is a fragmentary side view, similar to FIG. 6, illustrating an alternative embodiment of the second hold-down means;
FIGS. 10 and 11 are cross-sectional views taken along the lines 10—10 and 11—11, respectively, of FIG. 8;
FIG. 12 is a fragmentary side view, similar to FIG. 6, illustrating a further alternative embodiment of the second hold-down means;
FIGS. 13 and 14 are cross-sectional views taken along the lines 13—13 and 14—14, respectively, of FIG. 12;
FIGS. 15, 16 and 17 are cross-sectional views illustrating further embodiments of the second hold-down means of FIGS. 7, 10 and 13, respectively;
FIG. 18 is a fragmentary plan view illustrating shear-resisting means formed in a valley of the present sheet metal decking units;
FIGS. 19 and 20 are fragmentary cross-sectional views taken along the line 19—19 and 20—20, respectively, of FIG. 18;
FIG. 21 is a fragmentary isometric view in cross-section, illustrating a joint between adjacent sheet metal decking units;
FIG. 22 is a fragmentary isometric view, similar to FIG. 21, illustrating an alternative embodiment of the joint between adjacent sheet metal decking units;
FIG. 23 is a cross-sectional view, taken along the line 23—23 of FIG. 1, illustrating, with some exaggeration for emphasis, the present composite floor spanning across multiple supports;
FIG. 24 is an isometric view, in cross-section, as viewed along the line 24—24 of FIG. 23;
FIG. 25 is a fragmentary cross-sectional view taken along the line 25—25 of FIG. 24 illustrating composite beam construction utilizing the decking unit of FIG. 2;
FIG. 26 is an enlarged, fragmentary cross-sectional view taken along the line 26—26 of FIG. 2, illustrating the height and certain widths of a trough provided by the present decking unit;
FIG. 27 is a fragmentary cross-sectional view taken along the line 27—27 of FIG. 23, illustrating composite floor construction utilizing the decking unit of FIG. 2;
FIG. 28 is a fragmentary isometric end view, similar to FIG. 2, illustrating an alternative embodiment of the present sheet metal decking unit;
FIG. 29 is an end view, similar to FIG. 3, illustrating the profile of the sheet metal decking unit of FIG. 28;
FIG. 30 is a fragmentary cross-sectional view taken along the line 30—30 of FIG. 28, illustrating an alternative embodiment of the first hold-down means;
FIG. 31 is a fragmentary cross-sectional view, similar to FIG. 25, illustrating composite beam construction utilizing the sheet metal decking unit of FIG. 28;
FIG. 32 is a fragmentary cross-sectional view, similar to FIG. 27, illustrating composite floor construction utilizing the decking unit of FIG. 28;
FIG. 33 is a perspective illustration of a plurality of the present sheet metal decking units as they are assembled with others in a package for shipment;
FIGS. 34 and 35 are broken end views of a fragment of the package of FIG. 33 wherein three of the decking units of FIGS. 2 and 28, respectively, are shown in nested, jam-free relation;
FIG. 36 is an end view of a cellular decking unit according to this invention;
FIG. 37 is a fragmentary end view of an alternative embodiment of a cellular decking unit according to this invention;
FIG. 38 is a fragmentary isometric view illustrating a composite floor utilizing alternating sheet metal decking units of FIGS. 2 and 36;
FIG. 39 is a fragmentary perspective bottom view illustrating the use of the first hold-down means of FIG. 28 as a hanger channel;
FIG. 40 is an exploded fragmentary perspective view further illustrating the hanger device and the first hold-down means of FIG. 39;
FIG. 41 is a fragmentary cross-sectional view taken along the line 41—41 of FIG. 31; and
FIG. 42 is an exploded isometric view illustrating an alternative embodiment of a hanger device.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

FIG. 1 illustrates a typical modern multi-floor building 40 having vertical columns 41 and horizontal beams 42, 43. A plurality of profiled sheet metal decking units 44 are assembled in side-by-side relation and secured to the horizontal beams 42, 43. A layer of concrete 45 is poured above the sheet metal decking unit 44 to provide a composite floor 46 for the multi-floor building 40.

Decking Unit 44

Referring to FIGS. 2 and 3, the profiled sheet metal decking unit 44 presents alternating top flange crest strips 47 and coplanar second or valley strips 48 separated by sloped web strips 49. Lateral valley strips 48a, 48b are presented at the opposite longitudinal edges of the decking unit 44. The decking unit 44 has a geometric mid-plane 50 (FIG. 3) which intersects the sloped web strips 49 and which is equidistant from and parallel with a plane 51 of the crest strips 47 and a plane 52 of the valley strips 48. The crest and valley strips 47, 48 have substantially identical widths indicated at 53, 53' respectively in FIG. 3. The decking unit 44 provides a cover width indicated at 154.

The present decking unit is formed from sheet steel having a girth of approximately 60 inches and may be provided in sheet steel thicknesses in the range of 16 gauge to 22 gauge. The sheet steel preferably is galvanized steel so as to take advantage of the aforementioned adhesive bond formed with concrete.

The decking unit 44 presents three crest strips 47 and has a cover width 154 (FIG. 3) of 36 inches. It should be evident that the present decking unit may, instead, present less than three crest strips 47, for example two crest strips 47 in which case the cover width would be 24 inches.

The sheet metal decking unit 44 includes first hold-down means 54 positioned below the geometric mid-plane 50 for resisting vertical disengagement of the concrete 45 (FIG. 1) from the decking unit 44. Second hold-down means 55 positioned above the geometric mid-plane 50 and supplementing the first hold-down means 54, is provided for resisting vertical disengagement of the concrete 45 (FIG. 1) from the decking unit 44. Shear-resisting means 56 positioned below the geo-
metric mid-plane 50 is provided for resisting movement of the concrete 45 (FIG. 1) longitudinally of the deck ing unit 44. A longitudinal stiffening bead 57 preferably is provided in each of the crest strips 47. The lateral valley strips 48a, 48b are provided with stiffened edges 58, 59 respectively.

Shear-Resisting Means 56

Referring to FIGS. 2, 3, 18, 19 and 20, the shear-resisting means 56 comprises deformations, preferably embossments 60 integrally formed in certain of the valley strips 48, centrally thereof and protruding upwardly from the common plane 52 of the valley strips 48 toward the geometric mid-plane 50 (FIG. 3). As best shown in FIG. 2, a set of the deformations 60 is provided in each of the intermediate valley strips 48 and in the lateral valley strip 48a. The deformations 60 operate effectively as shear-resisting elements. However, each set of the deformations 60 introduces localized structural discontinuities in the valley strip 48 (48a) which reduces the structural effectiveness of the valley strip 48 (48a) under tension and compression.

First Hold-Down Means 54

In the preferred embodiment the first hold-down means 54 (FIG. 4) comprises a longitudinal rib 61 integrally formed at the juncture of and extending into the region between a contiguous sloped web strip 49 and the adjoining valley strip 48 (48a, 48b). The deformations 60 reduce the structural effectiveness of the valley strips 48 (48a) under tension and compression. The longitudinal ribs 61 contribute longitudinally undeformed metal in the deck unit to compensate for this reduction in structural effectiveness of the valley strips 48 (48a).

The decking unit 44 (FIG. 2) presents decking unit troughs 103 defined by the confronting sloped web strips 49 and the common valley strip. Adjacent decking unit troughs 103 defined by the confronting sloped web strips 49 and overlapped lateral valley strips 48a, 48b. Each of the troughs 103, 103' presents confronting longitudinal ribs which, as will be described, grip the concrete thereby supplementing the shear-resisting action of the shear-resisting means 56 (FIG. 2).

Each of the ribs 61 includes a base portion 62 which is spaced apart from the valley strip 48 and extends laterally of the contiguous sloped web strip 49. A reverse-bent side wall 63 connects the base portion 62 to the valley strip 48. The reverse-bent side wall 63 cooperates with the valley strip 48 to define a longitudinal keying recess 64. The base portions 62 present shoulders 65 which lie in a common plane 66.

It is to be understood that the ribs 61 are considerably smaller than the "large ribs" of the decking unit 44. Each of the large ribs of the decking unit 44 consists of a crest 47 and the adjoining sloped web strips 49. It will be observed in FIG. 3 that the distance 67 between adjacent ribs 61 of a common valley strip 48 is less than the distance 68 between adjacent crest strips 47 and also is less than the width 53' of the common valley strip 48.

As shown in FIG. 4, each of the sloped web strips 49 may be joined directly to the base portion 62 of the rib 61. Alternatively, as shown in FIG. 5, each of the sloped web strips 49 may be connected to a vertical segment 69 which in turn is joined directly to the base portion 62 of the rib 61. The opposed vertical segments 69 serve to guide the valley strip 48 of a superjacent decking unit 44 shown in dotted outline, into engagement with the shoulders 65 during nesting of the decking units. A similar guiding function is provided by the opposed sloped web strips 49 in the embodiment illustrated in FIG. 4. Nestability of the present decking unit 44 will be fully described later in the specification.

Second Hold-Down Means 55

As shown in FIG. 2, the second hold-down means 55 comprises a row of deformations 70 integrally formed in each of the sloped web strips 49. The deformations 70 may take the form of generally rectangular embossments 71 (FIGS. 6 to 8) which protrude from the top surface 72 of the sloped web strip 49 to provide longitudinal concrete gripping surfaces 73. Alternatively, as shown in FIGS. 9 to 11, the deformations 70 may take the form of generally rectangular indentations 74 depressed beyond the undersurface 75 (FIGS. 10, 11) of the sloped web strip 49 to provide a longitudinal concrete gripping surface 76. Alternatively, as shown in FIGS. 12 to 14, the deformations 70 may take the form of a generally rectangular embossment 77 having a lower end 78 protruding from the top surface 72 of the sloped web strip 49 to provide a longitudinal concrete gripping surface 79. In each case, the longitudinal concrete gripping surfaces 73 or 76 or 79 supplement the hold-down action of the longitudinal keying recesses 64 (FIG. 4) provided by the longitudinal rib 61, as will be hereinafter more fully described.

The deformations 71, 74, 77 may be formed by stamping or roll forming operation in a manner such that a relatively thin web 80 is formed. It will be observed in FIGS. 7, 10 and 13 that the deformations 71, 74, 77 are imperfect and for this reason are the preferred form of deformation for use in cellular metal deck units — see FIG. 36 — of the type providing electrical raceways.

FIGS. 15, 16 and 17 illustrate deformations 70' in the form of an embossment 71', an indentation 74' and an embossment 77', respectively. The deformations 71', 74', 77' may be formed by a punch-out process wherein the deformations 71', 74', 77' preferably are offset from the surfaces 72, 75, 72 respectively, by less than two sheet metal thicknesses. In addition, extremely narrow slits 39 are produced having a width which is less than one sheet metal thickness. It will be appreciated that the thus produced gripping surfaces 73', 76', 79' are freshly exposed surfaces. The deformations 70' preferably are employed only in those sheet metal decking units of this invention which are formed from a single sheet of metal, for example the decking unit 44 illustrated in FIG. 2. The decking unit 44 provided with the deformation 70' may receive a layer of concrete as illustrated in FIG. 1. The extremely narrow width and the location of the slits 39 inhibit flow of moisture and aggregate of the concrete 45, through the slits 39.

It will be observed in FIGS. 6, 8 that the deformations 71 presents transversely extending gripping surfaces 153 which supplement the shear-resisting action of the shear-resisting means 56 (FIG. 2). The deformations 74, 77 of FIGS. 9, 11 and 12, 14, respectively, similarly introduce transversely extending gripping surfaces 153.
Stiffened Edges 58, 59

Referring to FIG. 21, the lateral valley 48a comprises a valley segment 81 joined along one edge to the sloped web strip 49A and includes the stiffened edge 58. The lateral valley 48b comprises a valley segment 82 joined along one edge to the sloped web strip 49b and includes the stiffened edge 59. The valley segments 81, 82 have corresponding faces lying in a common plane, i.e., the plane 52 of the undersurfaces of the valley strips 48, 48a, 48b.

The stiffened edge 59 comprises an offset strip 83 spaced-apart from the common plane 52 by at least two sheet metal thicknesses. A stiffener strip 84 connects the offset strip 83 to the adjoining valley segment 82. The offset strip 83 terminates in an upstanding first stiffener flange 85. The offset strip 83, the stiffener strip 84, the first stiffener flange 85 and the rib 61 cooperate to increase the structural effectiveness of the lateral valley strip 48b under positive and negative loading. The offset strip 83 may be provided with spaced openings 86 (only one visible) which are useful during the installation of the adjacent decking units 44A, 44B. For example, the openings 86 may serve as pilot holes for drilling additional holes in the subjacent stiffened edge 58, to receive positive fasteners; or as weld sites.

The stiffened edge 58 includes a reverse-turned strip 87 residing between an edge strip 81a of the valley segment 81 and the offset strip 83 of the stiffened edge 59. The reverse-turned strip 87 adjoins the edge strip 81a along a leading edge 151 which is proximate to the stiffener strip 84. The reverse-turned strip 87 terminates in an upstanding second stiffener flange 88. The reverse-turned strip 87, the upstanding stiffener flange 88 and the rib 61 cooperate to increase the structural effectiveness of the lateral valley strip 48a under positive and negative loading.

It is a convenient concept when describing the joint 99 to state that the joint 99 is formed between a pair of the sheet metal decking units 44A, 44B which are arranged in side-by-side relation, and that the decking units 44A, 44B have adjacent valley segments 81, 82 which lie on the common plane 52 and which terminate in overlapping upper and lower edges corresponding to the stiffened edges 58, 59 respectively.

It will be observed in FIG. 21 that a joint 89 is provided between the adjacent decking units 44A, 44B, which is adjustable laterally through a distance indicated at 90. The joint 89 consists of three sheet metal thicknesses, that is, part of the offset strip 83, part of the reverse-turned strip 87, and a part of the valley segment 81. The structural effectiveness of each of the lateral valley strips 48a, 48b under positive and negative loading, is increased by the stiffened edges 58, 59, respectively. That is, each of the lateral valley strips 48a, 48b is individually stiffened and is rendered structurally effective over its own width. It is important to note, however, that the stiffened edges 58, 59 render the structural effectiveness of the combined lateral valley strips 48a, 48b, that is the joint 89, comparable to that of the intermediate valley strips 48.

Alternative embodiments of the stiffened edges are illustrated in FIG. 22 wherein corresponding numerals are employed to identify corresponding parts heretofore described. The adjacent decking units are identified as 44C, 44D.

The stiffened edge 58' of the decking unit 44D comprises a first offset strip 91 spaced-apart from the common plane 52 by at least two sheet metal thicknesses. An inclined stiffener strip 92 connects one edge of the first offset strip 91 to the adjoining valley segment 81. The first offset strip 91 terminates in an upstanding stiffener flange 93. It will be observed in FIG. 22 that the first offset strip 91 may include spaced-apart beads 94 which present a lengthwise trough 95. The lengthwise trough 95 is positioned centrally of the first offset strip 91 and serves as a drill guide.

The stiffened edge 59' of the decking unit 44C comprises a second offset strip 96 which is spaced-apart from a common plane 52 by at least one sheet metal thickness. A second inclined stiffener strip 97 connects one edge of the second offset strip 96 to the valley segments 82. A reverse-turned strip 98 adjoins the second offset strip 96 along a leading edge 152 which is proximate to the stiffener strip 92. The reverse-turned strip 98 extends laterally thereof toward the second stiffener strip 97. The reverse-turned strip 98 lies on the common plane 52.

It is a convenient concept when describing the joint 99 to state that the joint 99 is formed between a pair of the sheet metal decking units 44C, 44D which are arranged in side-by-side relation and that the decking units 44C, 44D have adjacent valley segments 81, 82 which lie in a common plane 52 and which terminate in overlapping upper and lower edges corresponding to the stiffened edges 58', 59' respectively.

It will be observed in FIG. 22 that a joint 99 is provided between the decking units 44C, 44D, which is adjustable laterally through a distance indicated at 100. The joint 99 consists of three sheet metal thicknesses, i.e., part of the first offset strip 91, part of the second offset strip 96, and part of the reverse-turned strip 98. The structural effectiveness of each of the lateral valley strips 48a, 48b under positive and negative loading, is increased by the stiffened edges 58', 59' respectively. That is, each of the lateral valley strips 48a, 48b is individually stiffened and is rendered structurally effective over its own width. It is important to note, however, that the stiffened edges 58', 59' render the structural effectiveness of the combined lateral valley strips 48a, 48b, that is the joint 99, comparable to that of the intermediate valley strips 48 (FIG. 2).

Metal Distribution

Referring to FIG. 3, the distribution of metal in the sheet metal decking unit 44 is such that the plane of neutral stress of the decking unit 44 is substantially coincident with the geometric mid-plane 50, that is, the sheet metal decking unit 44 exhibits substantially identical structural properties under positive and negative loading. The decking unit 44 has more metal below the geometric mid-plane 50 than above the geometric mid-plane 50, yet the structural properties of the decking unit are balanced about the geometric mid-plane 50.

Composite Beam Construction

The objective of composite beam construction is to unite a supporting steel beam with the overlying concrete in such a manner that the steel beam and the concrete act compositely. When composite beam construction is achieved, the compressive forces are resisted by the concrete whereas the tensile forces are resisted by the steel beam. In building floor structures of
the type comprising sheet metal decking spanning between and across supporting steel beams of a building framework and a layer of concrete overlying the decking units, the concrete component can be made to act compositely with the supporting steel beams by means of shear connectors such as weld studs. However, the shear connectors are effective only when they are structurally integral with the steel beam and only when the volume of the concrete is such that effective embedment of the shear connector is achieved. For effective embedment, the shear connector must be embedded in uninterrupted concrete having a width to depth ratio of at least 2:1. The present invention is not concerned with the manner in which the shear connectors are secured to the steel beam and the resulting structural integrity. However, the sheet metal decking unit of the present invention does provide troughs adapted to receive an amount of concrete which is sufficient to achieve effective embedment of the shear connectors.

Referring to FIG. 1, welded studs 101 may be secured to those horizontal beams 42 which extend parallel with the decking units 44. The welded studs 101 may be secured directly to the beams 42 between spaced-apart lateral valley strips 48a, 48b of adjacent spaced decking units 44, or through the intermediate valleys 48 (FIG. 2). Welded studs 102 may be secured to those horizontal beams 43 which extend transversely of the decking unit 44. In either instance, the welded studs 101, 102 coat with the slab of concrete 45 to provide a composite beam construction.

It will be observed in FIG. 2 that the sheet metal decking unit provides intermediate troughs 103, each of which is defined by an intermediate valley 48 and the adjoining sloped web strips 49. As shown in FIG. 24, additional troughs 103' are provided between adjacent ones of the decking units 44.

As shown in FIGS. 23, 24 and 25, one of the welded studs 102 is provided in one or more of the troughs 103, 103' and is secured to the horizontal beam 43. The size (height and average width) of the troughs 103, 103' is such that effective embedment of the welded studs 102 is achieved. Consequently, the capacity of each welded stud 102 is utilized to achieve an effective composite beam construction.

As stated above, for effective embedment, the welded studs 101, 102 must be embedded in uninterrupted concrete having a width to depth ratio of at least 2:1. Referring to FIG. 26, it will be observed that the height of the trough 103 is indicated at H. The width of the valley strip 48 is indicated at W1. The width of the top of trough 103 is indicated at W2. In determining the width-to-depth ratio of the trough 103, it is necessary to determine the average of the widths W1 and W2. The average width of the trough 103 is indicated at W3. In a working embodiment of the present decking unit 44, W1 has a value of 4¾ inches; W2 has a value of 7¾ inches; W3 has a value of 6 inches; and H has a value of 3 inches. Accordingly, the width-to-depth ratio (6:3) of the trough 103 is the desired ratio of 2:1.

Composite Floor 46

Referring to FIG. 27, the first and second hold-down means 54, 55 and the shear resisting means 56 cooperate to achieve a positive mechanical combination of the sheet metal decking unit 44 with the slab of concrete 45. When the composite floor 46 is subjected to working loads, stresses are generated which tend to disengage the concrete 45 vertically from the sheet metal decking unit 44. Such a stress is schematically illustrated by the arrow 104. It will be observed that the longitudinal keying recesses 64 of the first hold-down means 54 resist the stress 104. Such resistance is schematically illustrated by the arrows 105. Also, the longitudinal gripping surfaces 73 of the second hold-down means 55 provide additional resistance to the stress 104. Such additional resistance is schematically illustrated by the arrows 106. Accordingly, the hold-down function in the present sheet metal decking unit 44 is achieved by the cooperative contribution of the longitudinal keying recesses 64 and the longitudinal gripping surfaces 73.

The working loads applied to the composite floor 46 also generate shear stresses (not illustrated) which tend to move (slide) the concrete 45 longitudinally of and over the decking unit 44. In FIG. 27, the shear stresses tend to move the concrete out of the plane of the drawing. Such shear stresses are efficiently counteracted by the cooperative contribution of the shear resisting means 56, the transversely extending gripping surfaces 153 (FIG. 6) of the sets of embossments 71 which protrude into the concrete 45, and the gripping of the concrete by the confronting longitudinal ribs 61 in the decking unit trough 103. It should be evident that the transversely extending gripping surfaces 153 of the alternative indentations 74, 74' (FIGS. 9, 16) and of the alternative embossments 77, 77' (FIGS. 12, 17) similarly introduce a shear resisting propensity in the sheet metal decking unit 44.

Alternative embodiments of the present decking unit and of the first hold-down means are illustrated in FIGS. 28 to 32, wherein corresponding numerals are employed to identify corresponding parts heretofore described.

FIGS. 28 and 29 illustrate a sheet metal decking unit 107 which is similar to the decking unit 44 of FIG. 2, but incorporates the stiffened edges 58' and 59' of FIG. 22. The sheet metal decking unit 107 differs from the decking unit 44 by incorporating an alternative embodiment of the The hold-down means which is identified generally by the numeral 108. In this embodiment, the first hold-down means 108 is positioned below the geometric mid-plane 50 (FIG. 29) but is formed in each of the valley strips 48, 48a, 48b.

Referring to FIG. 30, the first hold-down means 108 comprises a longitudinal rib 109 which is integrally formed in the valley strip 48 and which extends upwardly therefrom toward the geometric mid-plane 50. As stated above, the deformations 60 reduce the structural effectiveness of the valley strips 48 (48a) under tension and compression. The longitudinal ribs 109 contribute passively undeformed metal to compensate for this reduction in structural effectiveness of the valley strips 48 (48a).

Each of the ribs 109 comprises a base portion 110 vertically spaced-apart from the valley strip 48, and reverse-bent side walls 111 which converge toward the valley strip 48, whereby the interior width 115 of the rib 109 is greater than the distance 116 between the confronting edges 113. It will be observed in FIG. 30 that the valley strip 48 consists of spaced-apart valley segments 112 presenting confronting edges 113 joined to the lower ends of the reverse-bent side walls 111. Each of the reverse-bent side walls 111 cooperate with
the contiguous valley segment 112 (valley strip 48) to define a longitudinal keying recess 114.

It is to be understood that the ribs 109 are considerably smaller than the large ribs of the decking unit 107. Each of the large ribs of the decking unit 107 consists of a crest strip 47 and the adjoining sloped web strips 49. For example, the height 117 of the ribs 109 (FIG. 30) is a minor fraction of the normal distance 118 (FIG. 29) between the planes 51, 52 of the crest strips 47 and valley strips 48, and the exterior width 119 of the rib 109 (FIG. 30) is a minor fraction of the width 53 (FIG. 29) of the crest strips 47. Also as illustrated in FIG. 29, the distance 120 between adjacent ribs 109 of a common valley strip 48 is less than the distance 68 between adjacent crest strips 47; and is less than the width 53 of the common valley strip 48.

The longitudinal keying recesses 114 provided by the longitudinal ribs 108 resist vertical disengagement of an overlying layer of concrete from the decking unit 107. As will hereinafter be more fully described, each of the ribs 109 presents a channel 121 adapted to receive and retain a danger device (not illustrated in FIG. 30); and the ribs 109 present shoulders 65 which lie in a common plane 123 and which adapt the decking unit 107 to be nested in jam-free relation.

FIG. 31 illustrates a composite beam construction utilizing the sheet metal decking unit 107. The shear stud 102 is positioned between the longitudinal ribs 109 and is secured to the horizontal beam 43 through the valley strip 48.

FIG. 32 illustrates a composite floor 46' incorporating the sheet metal decking unit 107 and the layer of concrete 45. When the composite floor 46' is subjected to working loads, stresses are generated which tend to disengage the concrete 45 vertically from the sheet metal decking unit 107. Such a stress is schematically illustrated by the arrow 124. The longitudinal keying recesses 114 of the longitudinal ribs 109 resist the stress 124. Such resistance is schematically illustrated by the arrows 125. The longitudinal gripping surfaces 73 of the second hold-down means 55 provide additional resistance to the stress 124. Such additional resistance is schematically illustrated by the arrows 126.

Accordingly, the hold-down function in the present sheet metal decking unit 44 is achieved by the cooperative effort of the longitudinal keying recess 114 and the longitudinal gripping surfaces 73.

The working loads applied to the composite floor 46' also generate shear stresses (not illustrated) which tend to move (slide) the concrete 45 longitudinally of and over the decking unit 107. In FIG. 32, the shear stresses tend to move the concrete 45 out of the plane of the drawing. Such shear stresses are efficiently counteracted by the cooperative contribution of the shear resisting means 56, the transversely extending gripping surfaces 153 (FIG. 6) of the embossment 71 which protrude into the concrete 45, and the gripping of the concrete 45 by the confronting longitudinal ribs 109 in the decking unit trough 103. It should be evident that the transversely extending gripping surfaces 153 of the alternative indentation 74, 74' (FIGS. 9, 16) and of the alternative embossments 77, 77' (FIGS. 12, 17) similarly introduce a shear resisting propensity in the sheet metal decking unit 107.

NESTABILITY OF DECKING UNIT

FIG. 33 illustrates a package 127 consisting of a plurality of the decking units 44 (107) assembled in nested relation and retained by banding straps 128. A fragment of the package 127 is illustrated in FIGS. 34 and 35 wherein three of the decking units 44 and 107 respectively, are assembled in nested jam-free relation.

It will be observed in FIGS. 34 and 35 that the web deformations 71 (second hold-down means 55) are offset from the top surfaces 72 of the sloped web strips 49. The slope of the web strips 49 is such that in the absence of the web deformation 71, the decking units can be assembled in nested jam-free relation.

It will now become apparent that the longitudinal ribs 61 (FIG. 34) and the longitudinal ribs 109 (FIG. 35) serve a further function. That is, the shoulders 65 presented by the ribs 61, 109 extend into the region between one of the sloped web strips 49 and the adjoining valley strip 48. The shoulders 65 thus are positioned to be engaged by the intermediate valley strips 48 and the lateral valley strips 48a, 48b of the additional nested units thereby to maintain corresponding valley strips 48 (48a, 48b) corresponding crest strips 47 and corresponding sloped web strips 49 of the nested decking units in spaced-apart relation. This precludes mechanical jamming of the deformations 71. The alternative deformations 71' FIG. 15, 74 FIGS. 9 to 11, 74' FIG. 16, 77, FIGS. 12 to 14 and 77' FIG. 17 similarly introduce a jamming propensity which is precluded by the described unit nesting on the shoulders 65.

ELECTRICAL WIRING DISTRIBUTION

FIG. 36 illustrates a metal cellular decking unit 134 assembled from the decking unit 44 and a flat sheet 135. The metal cellular decking unit 134 presents three raceways 139 for distributing electrical wiring. It will be appreciated that the flat sheet 135 may span between only two or three of the valleys 48 to provide metal cellular decking units having one or two electrical raceways 139.

FIG. 37 illustrates a metal cellular decking unit 136 comprising the metal decking unit 44 providing snap-in pans 129. Each of the pans 129 spans the distance between the sloped web strips 49 and lies in a common plane 52 of the valley strips 48. Each of the pans 129 includes side flanges 130 which are adapted to be introduced into the concavity presented by the longitudinal ribs 61 and then secured in place by spot welds 131. Each of the pans 129 cooperates with the sloped web strips 49 and the common crest strips 47 to provide electrical raceways 132. An advantage of this arrangement is that the valley strips 48 are retained as elements of a single metal thickness and hence facilitate the installation of shear studs.

FIG. 38 illustrates an electrical wiring distributing composite floor 133. In the composite floor 133, alternating sheet metal decking units 44 and metal cellular decking units 134 are utilized to support and coat with the overlying layer of concrete 45. The opposite longitudinal edges of the decking unit 134 provided with stiffened edges similar to those of the sheet metal decking unit 44, 107. Consequently, the decking unit 134 is mated with the decking unit 44 to provide a joint 89 similar to that illustrated in FIG. 21. The metal cellular decking units 134 provide the electrical raceways 139 through which electrical wiring of various electrical services, e.g., telephone, power and signal, is distributed throughout the composite floor 133.
RIBS 109 AS HANGER CHANNEL

It will be observed in FIG. 39 that the confronting edges 113 of adjacent valley segments 112 define a longitudinal slot 140 exposing the interior of the longitudinal channel 121 of the ribs 109. Depending from the valley strip 48 is a hanger device 149 having a head 142 captively retained within the channel 121 of the rib 109. As best shown in FIG. 40, the dove-tail profile of the head 142 of the hanger device 141 corresponds to the dove-tail profile of the channel 121. The hanger device 141 is provided with an opening 143 adapted to receive a suspending element, such as a hanger wire (not illustrated). The hanger device 141 is conveniently formed from aluminum alloy by conventional extrusion processes. As best shown in FIGS. 39 and 41, an opening 143 may be provided at one or more locations in the decking unit 107 through which the head portion 142 of the hanger device 141 may be introduced into the channel 121. As best shown in FIG. 41, portions of the confronting edges 113 of the side walls 111 are spayed to provide the opening 143.

FIG. 42 illustrates a hanger device 144 which avoids the need of the decking unit opening 143 (FIG. 39). The hanger device 144 consists of two hanger segments 145a, 145b having head portions 146a, 146b and mating faces 147. The hanger segments 145a, 145b are provided with aligned openings 148 adapted to receive a pin 149; and aligned openings 150 adapted to receive a suspending element, such as, a hanger wire (not illustrated).

To install the hanger device 144, the head portions 146a, 146b are inserted separately through the slot 140 (FIG. 39) at spaced locations. Thereafter, the hanger segments 145a, 145b are moved together to engage the mating faces 147 whereby the hanger device 144 takes a form similar to that of the hanger device 141, see FIG. 39. The hanger segments 145a, 145b are secured together, for example, by means of the pin 149 and a speed nut 151. The hanger device 144 is now ready to receive a suspending element.

SUMMARY

The present invention provides an improved sheet metal decking unit which when assembled with an overlying slab of concrete, produces a floor construction having composite load carrying capacity. The decking unit exhibits substantial wet strength and has long span capabilities. The decking unit exhibits balanced structural properties under positive and negative loading. Consequently, the present sheet metal decking unit can be used as a continuous element spanning across a plurality of spaced supports.

The present decking unit incorporates longitudinal ribs which perform multiple functions in the decking unit. For example, the longitudinal ribs 61, 109 compensate for the reduction in structural effectiveness of the valley strips; provide longitudinal keying recesses which resist vertical disengagement of the concrete slab from the decking unit; and present shoulders which adapt the decking units to be nested in jam-free relation. The longitudinal rib 109 also may serve as a longitudinal channel adapted to receive a hanger device.

In a composite structure with overlying conforming concrete, the present decking unit exhibits plastic hinge development which enables the structure to be designed according to the principles of plastic design thereby achieving still greater allowable loading than otherwise allowable from other design principles.

1. In a composite floor construction including a profiled sheet metal decking unit presenting alternating coplanar crest strips and coplanar valley strips separated by sloped web strips, and decking unit troughs defined by confronting sloped web strips and the common valley strip, said decking unit having a geometric mid-plane intermediate of and parallel with the plane of said crest strips and the plane of said valley strips; a layer of concrete covering said sheet metal decking unit and conforming with the profile thereof; hold-down means for resisting disengagement of said layer of concrete vertically from said decking unit; and shear-resisting means for resisting movement of said layer of concrete longitudinally of said decking unit; the improvement in said complete floor construction comprising:

- a set of first deformations integrally formed in certain of said valley strips and protruding upwardly therefrom into said layer of concrete;
- longitudinal ribs, each integrally formed at the juncture of and extending into the region between one of said sloped web strips and one of said valley strips, said ribs residing entirely below said geometric midplane and cooperating with the adjoining valley strip to define longitudinally extending keying recesses presented between the ribs and the valley strips, said keying recesses being filled by said concrete, each said decking unit trough presenting confronting longitudinal ribs; and
- second deformations integrally formed in each of said sloped web strips, said second deformations introducing concrete gripping surfaces offset from the concrete engaging surfaces of the sloped web strips;

the function of said hold-down means being achieved by the cooperative contribution of:
- a. said concrete engaging and filling said longitudinal keying recesses presented by said longitudinal ribs; and
- b. said concrete engaging and conforming with certain of said concrete engaging surfaces presented by said second deformations; and

the function of said shear-resisting means being achieved by the cooperative contribution of:
- a. said concrete engaging each of said first deformations in said valley strips;
- b. said concrete engaging others of said concrete gripping surfaces presented by said second deformations; and
- c. the gripping of said concrete by said confronting longitudinal ribs in each of said decking unit troughs.

2. The improvement of claim 1 wherein said longitudinal ribs include

- base portions disposed between said valley strips and said geometric mid-plane, and extending laterally from the adjacent sloped web strips, and
- reverse-bent side walls, one for each of said longitudinal ribs, said reverse-bent side walls cooperating with the valley strips to define said longitudinal keying recesses.
3. The improvement of claim 2 wherein said base portions reside in a common plane which is generally parallel with said coplanar valley strips.

4. The improvement of claim 1 wherein said decking unit is formed from galvanized steel and a reliable adhesive bond is presented at the interface of said concrete and said decking unit.

5. The improvement of claim 1 wherein said certain of said concrete gripping surfaces extend longitudinally of said sloped web strips; and said others of said concrete gripping surfaces extend transversely of said sloped web strips.

6. In a profiled sheet metal decking unit adapted to be covered with a layer of concrete and to coact compositionally therewith, said decking unit having a top surface and an undersurface and presenting alternating coplanar first strips and coplanar second strips, and sloped web strips connecting adjacent ones of said first strips and said second strips; said decking unit having a geometric mid-plane intermediate of and parallel with the plane of said first strips and the plane of said second strips; the improvement comprising:

a set of deformations integrally formed in each of said certain of said coplanar second strips, between the opposite longitudinal edges of said certain of said coplanar second strips and on one side of said geometric mid-plane, each said set of deformations introducing localized structural discontinuities in the second strip which reduce the structural effectiveness of the second strip under tension and compression;

longitudinal ribs, each disposed entirely below said geometric mid-plane, and each integrally formed at the juncture of and extending into the region between one of the sloped web strips and the adjoining second strip, said longitudinal ribs cooperating with the adjoining second strip to define longitudinally extending keying recesses each presented between the rib and the second strip, said longitudinal ribs introducing longitudinally undeformed metal to compensate the reduction in structural effectiveness of said certain of said second strips; and a plurality of second deformations integrally formed in each of said sloped web strips and presenting gripping surfaces offset from said top surface of said sheet metal decking unit.

7. The profiled sheet metal decking unit of claim 6 wherein said coplanar second strips include lateral second strips, one at each of the opposite longitudinal sides of the decking unit, and wherein said lateral second strips having stiffened edges which render said lateral second strips fully effective across their width under tension and compression.

8. The improvement of claim 7 wherein the distribution of metal in said decking unit is such that the plane of neutral stress of said decking unit is substantially coincident with said geometric mid-plane.

9. The improvement of claim 7 wherein said longitudinal ribs comprise

base portions spaced-apart from said coplanar second strips and extending laterally from the adjacent sloped web strips, and reverse-bent side walls, one for each of said ribs, said reverse-bent side walls adjoining said coplanar second strips and cooperating therewith to define longitudinal keying recesses.

10. The improvement of claim 9 wherein said base portions reside in a common plane which is generally parallel with said coplanar second strips.

11. The improvement of claim 7 including a longitudinal stiffener bead integrally formed in each of said coplanar first strips for rendering said coplanar first strips fully effective across their width under tension and compression.

12. The improvement of claim 11 wherein said longitudinal stiffener beads extend from said first strips toward said geometric mid-plane.

13. The improvement of claim 6 wherein said longitudinal ribs comprise

base portions disposed between said second strips and said geometric mid-plane, and extending laterally from the adjacent sloped web strips, and reverse-bent side walls, one for each of said ribs, said reverse-bent side walls cooperating with the contiguous second strips to define said longitudinal keying recesses.

14. The improvement of claim 13 wherein said base portions reside in a common plane which is generally parallel with said coplanar second strips.

15. The improvement of claim 6 wherein said certain of said gripping surfaces extend longitudinally of said sloped web strips; and others of said gripping surfaces extend transversely of said sloped web strips.

16. A profiled sheet metal decking unit for multiple long span applications and adapted to support an overlying layer of wet concrete, said sheet metal decking unit having a top surface and an undersurface and including alternating coplanar first strips and coplanar second strips, and sloped web strips connecting adjacent ones of said first strips and said second strips, said coplanar second strips including lateral second strips, one at each of the opposite longitudinal sides of the decking unit, said decking unit having a geometric mid-plane intermediate of and parallel with the plane of said first strips and the plane of said second strips, the improvement comprising:

longitudinal ribs, each disposed entirely spaced-apart from said geometric mid-plane, and each integrally formed at the juncture of and extending into the region between one of said slope web strips and one of said second strips, said ribs cooperating with the second strips to define longitudinally extending keying recesses each presented between the rib and the second strip, said longitudinal ribs introducing longitudinally undeformed metal in said decking unit which enhances the structural effectiveness of said decking unit;
said lateral second strips having stiffened edges which render said lateral second strips fully effective across their width under tension and compression; and

a set of deformations integrally formed in each of said certain of said coplanar second strips, between the opposite longitudinal edges thereof, each said set of deformations introducing localized structural discontinuities in the second strip which reduce the structural effectiveness of the second strip under tension and compression;
said longitudinal ribs compensating for the reduction in structural effectiveness of said certain of said second strips.