

April 12, 1966

A. P. JENTOFT

3,245,186

COMPOSITE FLOOR AND APPARATUS THEREFOR

Filed Nov. 24, 1961

3 Sheets-Sheet 1

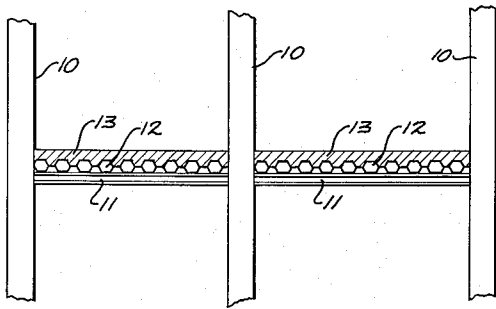


Fig. 1

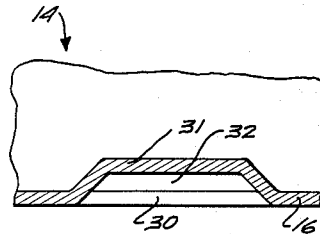


Fig. 6

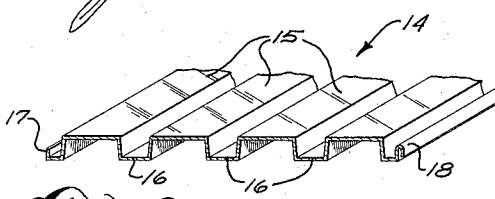


Fig. 2

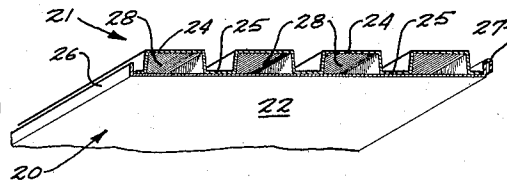


Fig. 3

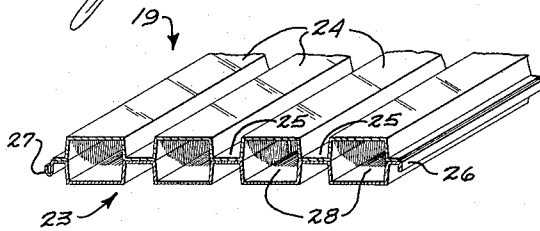


Fig. 4

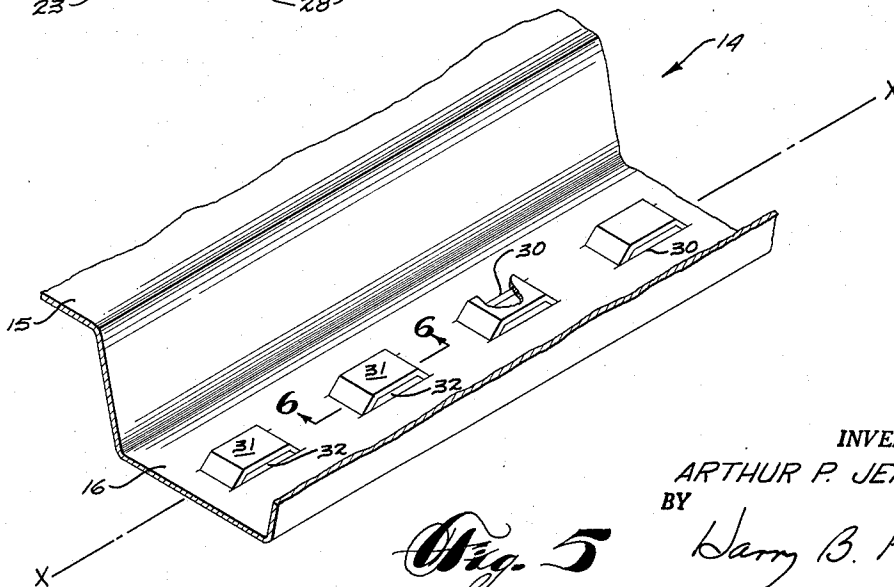


Fig. 5

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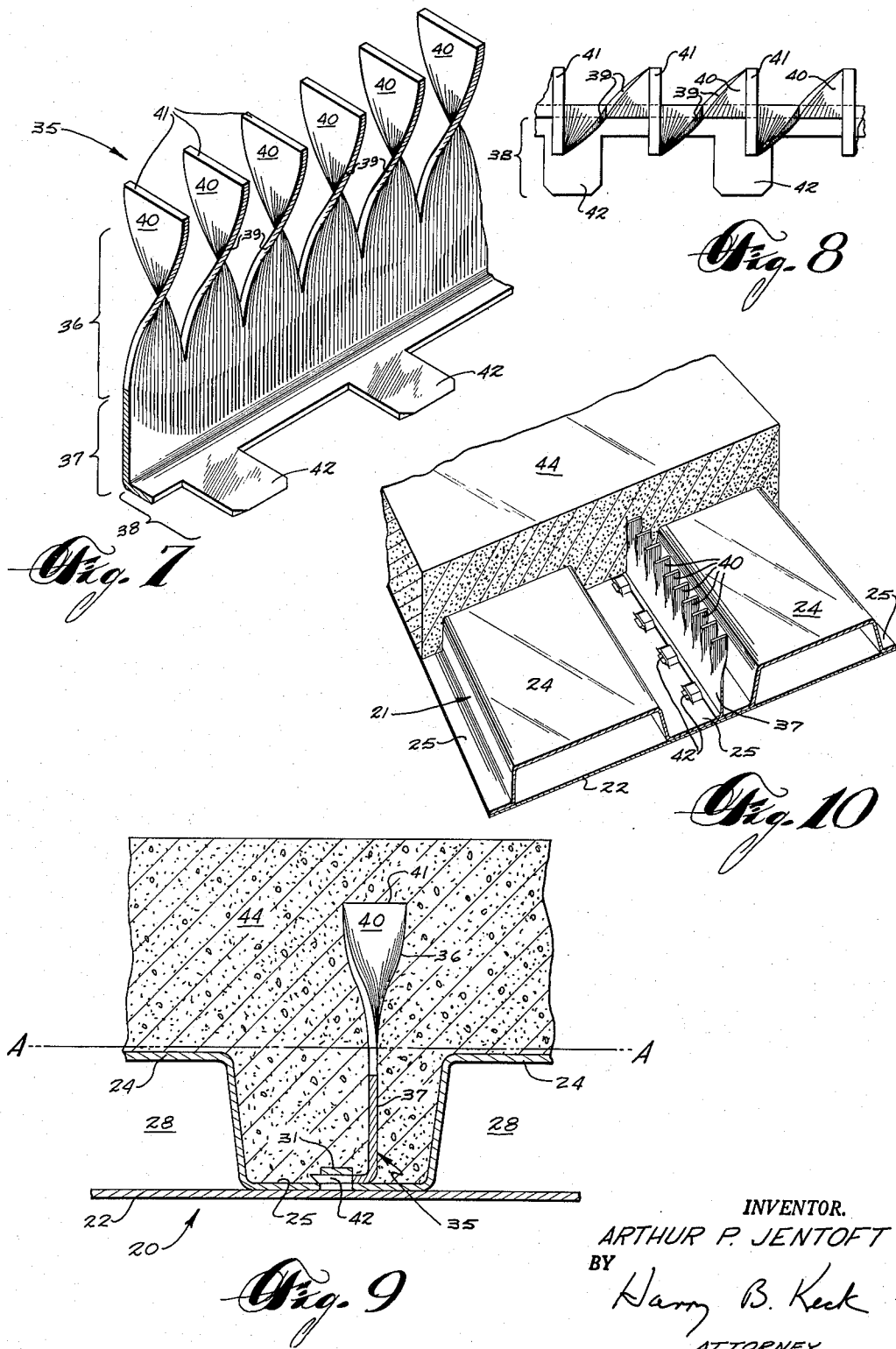
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COMPOSITE FLOOR AND APPARATUS THEREFOR

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3 Sheets-Sheet 2



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COMPOSITE FLOOR AND APPARATUS THEREFOR

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3 Sheets-Sheet 3

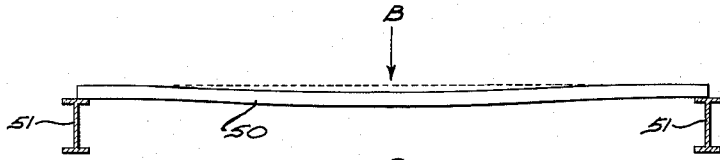


Fig. 11

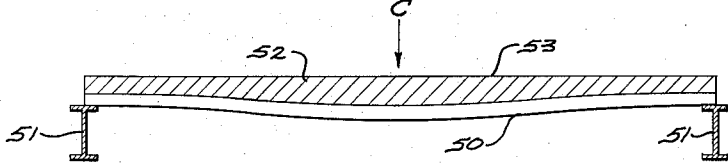


Fig. 12

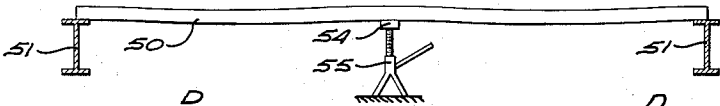


Fig. 13

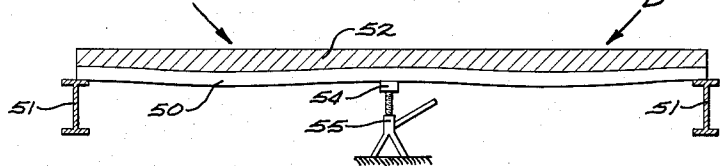


Fig. 14

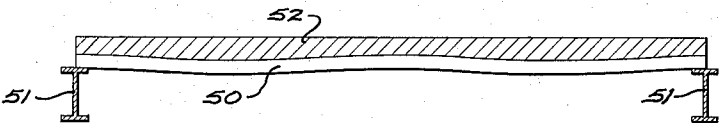


Fig. 15

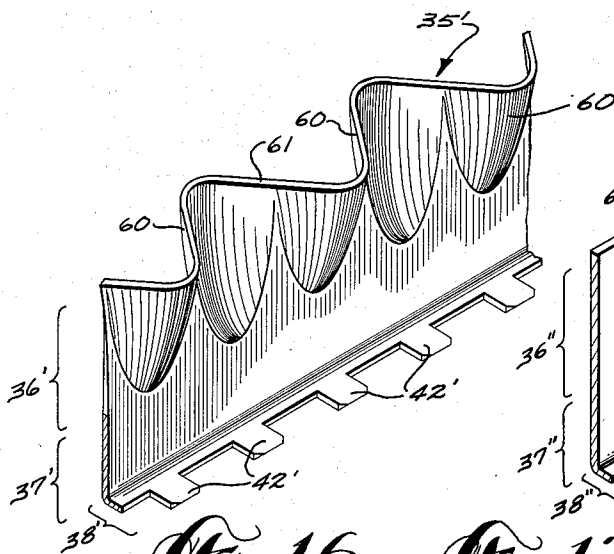


Fig. 16

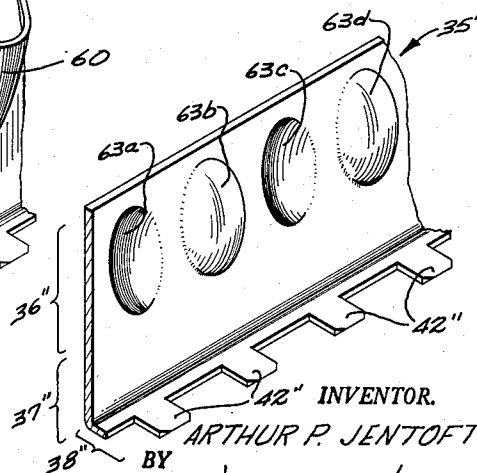


Fig. 17

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COMPOSITE FLOOR AND APPARATUS THEREFOR

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Filed Nov. 24, 1961, Ser. No. 154,444

2 Claims. (Cl. 52—334)

This invention relates to composite floor construction involving corrugated metal decking and concrete.

Corrugated metal decking is a familiar commodity of commerce which is available in two distinct forms:

(1) Corrugated decking sections, each comprising a single sheet of metal having longitudinal corrugations including alternating crests and valleys. Such decking may be seen in U.S. Patent 1,995,496, Burgess.

(2) Cellular metal flooring sections each comprising two metal elements, wherein the upper element has longitudinal corrugations including alternating crests and valleys and the lower element may be flat or correspondingly corrugated. The corrugations of the upper element cooperate with the lower element to form longitudinal cells through which electrical wiring, plumbing, ventilation air and the like may be transmitted throughout a building. Such cellular metal flooring may be seen in U.S. Patents 2,987,328, Curran; 2,950,788, Edgar.

Both forms of corrugated metal decking are utilized by being secured to horizontal beams of a building frame. A layer of concrete is poured above the corrugated metal decking to provide rigidity to the resultant floor of which the concrete forms a hardened, rigid element.

PRESENT PRACTICES

Because of the brittleness and lack of tensile strength of concrete, no credit is given to the presence of the concrete in the structural engineering design of a floor which utilizes corrugated metal decking and concrete. Instead, the floor is designed on the premise that the corrugated metal decking will provide the entire strength of the resultant floor. Accordingly in the design calculations, the corrugated metal decking must be of sufficient load-carrying capability that it will sustain the anticipated live loading of the resultant floor as well as the calculable dead loading which is presented by the weight of the concrete itself. The concrete, for structural engineering design purposes, is parasitic in that it is merely considered to rigidify the resultant flooring without contributing to the strength of the floor.

It is a well-known principle of structural engineering that concrete has a substantial capacity for sustaining compressive loading whereas it has almost negligible capability for sustaining tensile loading. Nevertheless it is equally well known that concrete and metal may coact in composite beams where metal is provided beneath the neutral axis of the resultant beam and concrete is provided above the neutral axis. In such beams the concrete will resist the normal compressive stresses which are manifested above the neutral axis while the metal will resist the normal tensile stresses which are manifested below the neutral axis.

This principle of cooperation between concrete and metal in composite construction has been applied in the construction of bridges, reinforced concrete buildings and the like. Numerous attempts have been made to utilize the principles of composite construction in the assembly of a composite flooring which includes corrugated metal decking. These prior attempts have been unsuccessful commercially for various reasons. Some of the proposed constructions depended upon the existence of a bond between the corrugated metal flooring and the concrete—the validity of such bonds is questionable. Other proposals have been abandoned because of the undue expense

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which they involved. Other proposals have been abandoned because of their failure to satisfy the requirements of various building codes.

The benefits which can be achieved through composite action of corrugated metal flooring and a concrete covering layer are well-known in the art. Consider a particular section of metal cellular flooring which is available in the building trade covered with 2.5 inches of 2500 p.s.i. concrete. The following Table I indicates the available spans and loadings of the resultant floor when composite action is achieved and when composite action is not achieved—i.e., according to present practices wherein the corrugated metal flooring sustains the entire loadings.

Table I.—Loadings and spans of corrugated metal flooring covered with 2500 p.s.i. concrete (2.5 inches)

Span length, feet	Loading of floor in pounds per sq. ft.	
	Based on maximum allowable stress in steel (or in concrete)	Based on live load deflection of 1/240 of the span
A. FOR THE CORRUGATED STEEL FLOORING ALONE		
6.11.....	125	125
6.15.....		33
8.....	55	8.2
9.1.....	32.5	
B. FOR FLOORING HAVING COMPOSITE ACTION		
8.....	686	443
9.1.....		125
10.....	389	
12.....	204	
14.14.....	125	

Thus it is clear that the development of composite action in a steel-concrete flooring permits the spanning of greater lengths with similar loading than is permissible by present practices. Similarly the development of composite action permits greater loading of resulting floors of comparable span than present practices.

According to the present invention I have provided a composite corrugated metal floor construction which in retrospect utilizes sound principles of structural engineering and which is relatively inexpensive to manufacture and assemble. My present composite floor construction can be utilized with both types of corrugated metal decking as set forth above.

The principal object of this invention is to provide a composite floor including corrugated metal decking and concrete which possesses a substantially increased load carrying capability. That load carrying capability may be manifested in (a) the use of lighter gauge corrugated metal decking than heretofor specified for a particular span-length; (b) the use of corrugated metal decking for spanning greater lengths than heretofor specified.

A further object is to provide a shear connector which can be readily manufactured and assembled into a flooring construction site.

A still further object of this invention is to provide a corrugated metal decking having a plurality of openings in the valleys thereof which serve as connection sites.

An even further object of this invention is to provide cellular metal flooring sections having a plurality of openings solely in the valley portions of the upper element thereof to serve as connection sites.

A still further object is to provide continuous shear connector elements in a corrugated metal decking which serve to increase the stiffness of the metal decking in addi-

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tion to providing a simple means for developing a composite action in the resulting floor.

Yet a further object of this invention is to provide for discontinuous shear connector elements which may be secured to a corrugated metal decking at selected zones wherein maximum stresses are to be anticipated.

These and other objects and advantages of the present invention will become apparent from the following detailed description of this invention by reference to the accompanying drawings in which:

FIGURE 1 is a side elevation view of a fragmentary portion of the structural framework of a typical modern building utilizing corrugated metal flooring and concrete as a floor;

FIGURE 2 is a fragmentary perspective illustration of one form of corrugated metal decking;

FIGURES 3 and 4 are fragmentary perspective illustrations of typical cellular metal flooring sections;

FIGURE 5 is a fragmentary perspective illustration of a corrugated metal decking section showing in the valley portion thereof the provision of pairs of parallel slits and an elevated band of metal therebetween;

FIGURE 6 is a fragmentary cross-section illustration of the valley of the corrugated metal decking of FIGURE 5 taken along the line 6—6;

FIGURE 7 is a fragmentary perspective illustration of the preferred embodiment of the shear connector of this invention;

FIGURE 8 is a plan view of the shear connector shown in FIGURE 7;

FIGURE 9 is a cross-section view of a corrugated metal decking section showing the present shear connector secured to the valley of the section;

FIGURE 10 is a fragmentary perspective illustration of a corrugated metal decking section having the shear connector of this invention with the concrete layer partly broken away for clarity;

FIGURES 11—15 are schematic cross-sectional views of corrugated metal decking illustrating principles of inherent sagging and shoring techniques; and

FIGURES 16 and 17 are fragmentary perspective illustrations similar to FIGURE 7 showing alternative embodiments of the shear connector of this invention.

STATEMENT OF INVENTION

According to this invention, vertical strips of metal are provided in the valleys of corrugated metal decking extending along the length of the valleys and extending above the level of the crests of the corrugated decking. The base of each vertical strip is secured to the valley and the upper portion is distorted out of the plane of the vertical strip to provide a plurality of bearing surfaces which are subsequently embedded in the concrete covering layer which is provided above the corrugated metal decking.

The upper distorted portions of the vertical strips may be cut and twisted, may be corrugated edges or may be punched dimples, for example. The vertical strips present a substantially minimum cross-section in the valley portions of the corrugated metal decking below the crests thereof.

Where the vertical strips are continuous along the length of the corrugated metal decking, the vertical portion thereof which is undistorted out of its generally vertical plane will serve as a stiffening member which adds to the stiffness of the resulting decking. The added stiffness aids the resulting decking in resisting the initial deflection which results from the dead load of the concrete covering layer.

Where the vertical strips are discontinuous, they may be judiciously positioned along one or more of the valleys of the corrugated metal flooring where the shearing stresses of the concrete floor covering will be maximum, i.e., in the region of the end portions of a simple beam span of the corrugated metal decking.

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The preferred means for securing the present vertical strips to the corrugated metal decking comprises a plurality of spaced horizontal tongue elements bent out from the vertical strips which coincide with a plurality of elevated bands of metal pressed upwardly from the upper surface of the valley portions of the corrugated metal decking. The spaced tongue elements of the vertical strips engage the elevated bands of metal to provide a tight bond which can be achieved without the need for welding or extrinsic fastening devices.

CORRUGATED METAL DECKING—FIGURES 1, 2, 3, 4

Referring to FIGURE 1 there is illustrated a structural framework of a typical modern building having vertical columns 10 and horizontal beams 11. Corrugated metal decking 12 is secured to the horizontal beams 11 usually by welding and is covered with a layer of concrete 13 to provide a floor for the building. The corrugated metal decking 12 may consist of sections as seen in FIGURES 2, 3 and 4. In FIGURE 2, the corrugated metal decking 14 comprises a single sheet of metal having alternating crests 15 and valleys 16 with a male lip 17 on one side and a female lip 18 on the other side. Adjacent decking sections are assembled together by joining the male lips of one section with the female lip of the adjoining section. Alternatively the corrugated metal decking may comprise cellular metal flooring sections 19, 20 which are illustrated in FIGURES 3 and 4 wherein the cellular metal flooring section is formed from two elements including a corrugated upper element 21 and a lower element which is a substantially flat sheet 22 (FIGURE 3) or a correspondingly corrugated sheet 23 (FIGURE 4). The corrugated upper element 21 has alternating crests 24, valleys 25, and a male lip 26 along one edge and a female lip 27 along the other edge. The corrugated upper element 21 is secured to the lower element 22 (FIGURE 3), 23 (FIGURE 4) by means of spot welds in the valleys 25 where the corrugated upper element 21 is contiguous with the lower element 22, 23. It will be observed that the upper element 21 of FIGURES 3 and 4 is substantially identical with the corrugated metal decking section 14 of FIGURE 2.

The cellular metal flooring sections 19, 20 have a plurality of enclosed cells 28 formed beneath the crests 24 for the passage of electrical wiring, plumbing, ventilation air and the like.

Corrugated metal decking normally is fabricated from steel sheets having a thickness from about 22 gauge to about 12 gauge. After the metal decking 12 is positioned within a building framework and secured thereto, a layer of concrete 13 is applied to the upper surface of the metal decking, usually extending from about 2 to about 4 inches above the crests of the corrugated metal decking. The concrete layer is leveled and becomes the horizontal floor surface of the resulting building. Normally the concrete is covered with a decorative floor covering of tile, wood, linoleum, plastic materials, carpeting and the like.

According to the present design methods, the presence of the concrete is not considered in calculating the load carrying capability of the resultant flooring. The entire structural support must be provided by the corrugated metal decking. That structural support includes not only the anticipated live loads which will be borne by the resultant flooring but also includes the actual dead load of the concrete layer itself. Frequently metal reinforcing rods are positioned in the concrete covering layer for the express purpose of minimizing any cracking tendencies in the concrete layer, especially over the end portions of the simple beam spans of the resulting flooring. However the presence of such metal reinforcing rods is not taken into consideration in determining allowable live loads for the floor or in determining the maximum allowable lengths of the simple beam spans.

According to the present invention, it is possible to

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utilize the covering layer of concrete as a component element in the determination of load carrying capabilities of the resulting flooring.

CONNECTOR MEANS—FIGURES 5 AND 6

The preferred connector means of this invention is illustrated in FIGURES 5 and 6 wherein a plurality of pairs of parallel slits 30 is provided in a valley 16 of a corrugated metal floor section 14. Each pair of parallel slits 30 defines a band 31 of metal. According to this invention, the band 31 of metal is elevated above the level of the valley 16 to provide a pair of openings 32 which have a thickness corresponding to the thickness of metal which is utilized in the fabrication of the present shear connectors to be hereinafter described. The pairs of parallel slits 30 are provided at spaced distances along the length of the valley 16 with the slits being generally parallel to the longitudinal axis X—X of the valleys 16. The bands 31 of metal may be elevated by means of suitable punching or pressing apparatus at the time of fabrication of the corrugated metal decking sections 14.

Where the corrugated metal decking comprises cellular metal flooring, the pair of parallel slits are provided solely in the valleys 25 of the corrugated metal upper element 21 (FIGURES 3, 4). The imperforate lower element 22, 23 of the cellular metal flooring provides a tight closure beneath the openings 32.

SHEAR CONNECTORS—FIGURES 7, 8, 9, 10

The preferred embodiment of the shear connector 35 of this invention consists essentially of a flat ribbon of metal which has an upper portion 36, a lower portion 37 and a perpendicular flange 38. The lower portion 37 is an essentially flat sheet of metal. The upper portion 36 has a plurality of vertical slits 39 which define a plurality of tabs 40. The vertical slits 39 extend through the upper portion 36 to the lower portion 37. The tabs 40 are twisted out of the plane of the lower portion 37 by approximately 90 angular degrees about a generally vertical axis so that the upper edge 41 of each tab 40 is transverse to the vertical plane of the lower portion 37 of the shear connector 35.

A generally horizontal flange 38 has a plurality of spaced tongues 42 along its edge at distances corresponding to the spacing of the pairs of generally parallel slits 30 of FIGURE 5. The tongues 42 are so shaped that they can be introduced through the openings 32 to fit snugly under the bands 31 of metal in a valley of a corrugated metal decking station.

The shear connectors of this invention may be fabricated from sheet metal, preferably steel having a thickness from about 26 gauge to about 12 gauge.

The placement of the shear connector 35 with respect to the cellular metal flooring 20 may be seen in FIGURES 9 and 10 wherein the tongues 42 are positioned on the upper surface of the valley 25 beneath the bands 31 of metal. The lower portion 37 is beneath the level of the crests 24 of the corrugated metal decking 21. The upper portion 36 extends substantially above the level of crests 24. Preferably the upper edge 41 of the tabs 40 will be within about one-half inch of the top of a layer of concrete 44.

The neutral axis A—A of the floor of FIGURE 9 is indicated as being located near the level of the crests 24. It will be observed from inspection of FIGURE 9 that the cross-sectional presentation of the present shear connector 35 below the neutral axis A—A is negligible (i.e., the thickness of the metal strip from which the shear connector 35 is fabricated), whereas the cross-sectional presentation of the shear connector 35 above the neutral axis A—A is a maximum. The composite corrugated floor construction corresponds to a composite beam wherein the portions below the neutral axis A—A are in tension whereas the portions above the neutral axis A—A are in compression. The concrete layer 44 has little re-

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sistance to tensile stresses but has substantial resistance to compressive stresses. Accordingly the concrete layer below the neutral axis A—A can become cracked through the application of loads on the present floor. The portion of the concrete layer 44 above the neutral axis is not only in compression within itself but also in compressive engagement with the tabs 40. The tabs 40, being integrally secured to the valley 25, prevent the concrete layer 44 from separating vertically apart from the corrugated metal decking 20.

The present shear connectors 35 serve to tie the upper concrete layer to the bottom of the corrugated metal decking in a simple yet efficient manner.

The present shear connectors 35 may be provided in long lengths corresponding to the length of the corrugated metal decking. Alternatively the present shear connectors may be provided in relatively shorter lengths. The shorter lengths may be abutted end-to-end across the entire span of a corrugated metal decking or may be positioned solely in the region of the ends of each simple beam span where horizontal shear stresses are maximum.

An incidental advantage accrues when the present shear connectors are provided in continuous lengths adapted to extend along the entire length of a particular valley of the corrugated metal flooring, to wit, the lower portion 37 of the shear connector provides an added stiffness to the corrugated metal floor independently of the subsequently developed composite co-action of the concrete and metal decking. This added advantage can be visualized from an inspection of FIGURE 9 wherein the lower portion 37 of the shear connector 35 is mechanically secured to the valley 25 of the cellular flooring section 20, whereby the vertical metal of the lower portion 37 may be considered as an additional structural element in calculating the section properties of the corrugated flooring section itself, e.g., the moment of inertia, the neutral axis, and other moduli which are utilized in determining load carrying properties of the corrugated metal decking itself. In effect, the lower portion 37 of the present shear connector provides an additional vertical web element which adds to the stiffness of the corrugated metal decking section. In order to realize the benefits of the added stiffness, the present shear connector 35 must extend continuously along a single valley of the corrugated metal floor over an entire simple beam span thereof.

While maximum benefit of the present shear connector is gained when each of the valleys of the corrugated metal decking is equipped with the shear connector, nevertheless substantial increases in load carrying capability of the resultant floor are manifested when the shear connectors are placed in only one or more of the valleys of each individual section of decking.

I have found that the vertical slits 39 spaced from about one-half inch to two inches apart provide excellent results.

The shear connectors 35 need not be placed in the flooring assembly until immediately prior to the pouring of a concrete layer over the corrugated metal decking. As a consequence of this feature, the assembled corrugated decking may be utilized as a walking surface for construction workmen of various trades according to present practices. After all of the various trades have completed their assignments in the construction and no further utilization of the decking as a walking surface is contemplated, the present shear connectors may be positioned immediately prior to the pouring of concrete.

The corrugated metal decking which is utilized in the practice of this invention corresponds with that which is normally manufactured with the exception of the provision of the pairs of parallel slits 30.

While the present shear connectors are preferably secured to the corrugated metal decking in the manner already illustrated and described, nevertheless, similar shear connector elements may be secured by other suitable means, for example, by welding or by the use of fasteners such as rivets, screws and the like to provide the requisite

mechanical bond between the shear connectors and the corrugated metal deck. For example, in FIGURE 7 the tongues 42 might be eliminated and the present shear connector might be welded or bolted directly to the valley of a decking section through the flange portion 38. In the interest of minimizing on-site welding and bolting, however, the illustrated embodiment is preferred.

Regardless of the specific mechanical fastening means, the lower portion of the present shear connector presents negligible cross-sectional area below the neutral axis of the resultant floor in a plane transverse to the axis of the valleys; similarly the present shear connector presents a maximum cross-sectional area above the neutral axis of the resultant floor in such transverse planes.

In some instances with the present invention it may be desirable to provide shoring for the corrugated metal decking during the pouring of the concrete until the concrete has an opportunity to harden. This is especially true in relatively long spans of the corrugated metal decking. The dead load of the wet concrete must be sustained entirely by the corrugated metal decking until the concrete has set. In some instances, the mere weight of the wet concrete may be sufficient to cause failure of the corrugated metal decking alone. By providing suitable shoring in the central portion of the otherwise unsupported decking, the length of unsupported span is reduced and the metal decking alone is enabled to sustain the wet concrete load. After the concrete has hardened, the concrete and the metal decking becomes a composite structure which is enabled to sustain not only its own dead weight, but also appreciable live loading thereafter.

This shoring principle can be illustrated in an exaggerated movement in FIGURES 11 through 15. A corrugated metal deck 50 is shown secured to horizontal beams 51. The mere weight of the corrugated metal decking 50 alone will cause the decking to sag somewhat as indicated at B in FIGURE 11. Thereafter the addition of wet concrete 52 applies a further dead loading to the metal decking 50 to cause greater sagging as indicated at C in FIGURE 12. Actually the sagging at the central portion of the decking requires the use of incremental quantities of concrete in order to provide a level floor walking surface 53. The necessary added weight of incremental wet concrete resulting from the inherent sagging increases the total dead loading and creates even further sagging.

Where, however, the corrugated metal decking is shored at a central portion as seen in FIGURE 13 by means of a beam 54 and a jack 55, the decking 50 can be maintained substantially level. Thereafter the addition of wet concrete 52 as seen in FIGURE 14 will cause slight sagging as indicated at D.

After the concrete 52 has hardened, as seen in FIGURE 15, removal of the shoring beam 54 and jack 55 results in very little sag in the composite floor. This results because the floor seen in FIGURE 15 is truly composite in its resistance to loading.

ALTERNATIVE EMBODIMENT—FIGURE 16

An alternative embodiment of the shear connector of this invention is illustrated in FIGURE 16 wherein the shear connector 35' is fabricated from a strip of sheet metal and has an upper portion 36', a lower portion 37' and a generally horizontal flange 38'. The horizontal flange has a plurality of spaced tongues 42'. This embodiment differs from that of FIGURE 7 in that the upper portion 36' is corrugated instead of having twisted tabs. The corrugations 60 in the upper portion 36' extend out of the plane of the lower portion 37' and provide bearing surfaces above the neutral axis of the floor assembly in which the shear connector is utilized. It should be apparent that the shear connector 35' has negligible cross-sectional presentation below the neutral axis of the floor whereas it has a substantial cross-sectional presentation above the neutral axis as a result of the corrugations 60. The corrugations 60 are substantially entirely above the

crests of the corrugated metal flooring with which they are used. The sinuous upper edge 61 of the shear connector 35' extends preferably within about one-half inch of the top level of the concrete layer above the decking.

A still further alternative embodiments of this invention is illustrated in FIGURE 17 wherein a shear connector 35'' has an upper portion 36'', a lower portion 37'' and a horizontal portion 38'' including tongues 42''. The upper portion 36'' has a plurality of punched-out dimples 63 which may be punched in alternating directions from the sheet of metal forming the shear connector 35'' as specifically shown in FIGURE 17. It will be observed that the dimples 63a and 63c all are presented convexly outwardly away from the direction of the tongues 42'' whereas the dimples 63b and 63d are presented convexly outwardly toward the direction of the tongues 42''. The alternating directions of the dimples 63 tends to offset the strains in the shear connector which might otherwise cumulate and introduce a tendency toward curvature of the entire shear connector. Nevertheless, the dimples 63 may be entirely presented in the same direction if desired. The dimples 63, it will be observed, provide a maximum cross-sectional bearing surface presentation in their upper portion 36'' and a minimum cross-sectional presentation in their lower portion 37'.

EXAMPLES

A metal cellular flooring of the type shown in FIGURE 3 was obtained having an upper element 21 fabricated from 18 gauge steel and a bottom element 22 fabricated from 16 gauge steel. The steel had a working stress of 20,000 p.s.i. A covering layer of concrete was provided having a working stress in compression of 2500 p.s.i.

Example 1.—Without the present shear connectors, the described cellular flooring can sustain a live load of 125 pounds per square foot over a span of 6.2 feet without exceeding a deflection of $\frac{1}{240}$ of the span length at center-span. The term "live-load" comprehends the added load after the weight of the concrete has been applied to the deck.

The same cellular metal flooring will sustain a live load of 40 pounds per square foot over a span of 6.63 feet without exceeding a live load deflection of $\frac{1}{360}$ of the span length at the center.

The same cellular steel flooring was mounted on a 14-ft. span and developed an initial deflection of 1.31 inches at center-span due to the weight of concrete. The weight of concrete was 40 pounds per square foot of decking. Subsequent application of live loading to the span developed a uniform increase in stress of both concrete and steel until the live loading reached 39 pounds per square foot. The mid-span deflection at that loading was 1.44 inches. Hence the live load deflection was 1.44—1.31 or 0.13 inch. The bond between the concrete and the steel ruptured when the live load exceeded 39 pounds per square foot and the entire floor failed. The actual live load deflection at failure was about $\frac{1}{1300}$ of the span length.

Example 2.—The same metal cellular flooring described in Example 1 was equipped with the shear connectors of this invention fabricated as shown in FIGURE 7. The overall height of the shear connectors was 3.25 inch. The lower portion 37 of the shear connector was 1.25 inches high. The upper portion 36 of the shear connector was 2.0 inches in height. The vertical cuts 39 were 0.75 inch apart. The crests 24 were elevated above the valleys 25 by 1.6 inches. A comparable layer of concrete (2500 p.s.i. compression strength, 2.5 inches thick) was poured above the metal cellular flooring on a 14-ft. span.

The resulting floor sustained a live load of 125 pounds per square foot without exceeding a center-span, live-load deflection of $\frac{1}{240}$ of the span length. A total live load of 917 pounds per square foot was applied before failure of the floor.

Example 3.—A metal cellular floor as described in Example 2 was provided in a 19-ft. span length. The floor was subjected to a live load of 40 pounds per square foot without exceeding a mid-span live load deflection of $\frac{1}{360}$ of the span length.

Note.—In each of Examples 2 and 3 the present shear connectors were provided in each of the three valleys 25 of the metal cellular floor section.

Example 4.—Three sections of metal cellular floor as described in Example 2 were provided with the present shear connectors as follows:

Section 4-A.—Three continuous lengths of 18-gauge shear connectors, one in each of the three valleys 25.

Section 4-B.—Two continuous connectors of 14 gauge steel, one in each of the lateral valleys 25 of the cellular floor section.

Section 4-C.—One continuous shear connector of 16-gauge steel in the center valley 25 of the cellular floor section.

Section 4-A. failed at 293 pounds per square foot live loading; **Section 4-B** failed at 327 pounds per square foot live loading; **Section 4-C** failed at 258 pounds per square foot live loading.

Note.—In each of Examples 2, 3 and 4, the metal cellular floor sections were coated with a film of grease prior to the pouring of concrete in order to avoid any possible formation of an adhesive bond between the concrete and the surface of the cellular metal floor. That type of bonding accounted for the slight development of composite load carrying action which appeared in the 14-ft. span test of Example 1.

According to the provisions of the patent statutes, I have explained the principle, preferred embodiment and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. A building having a structural frame and a plurality of generally horizontal metal flooring elements secured to said frame and having corrugated upper surfaces including alternating longitudinal crests and valleys, a layer of concrete above each of said metal flooring elements and defining a neutral axis, and means connected between said concrete and said flooring elements and providing composite coaction of said concrete and said metal flooring elements, said means comprising a plurality of individual shear connectors, each said shear connector comprising a metal strip having a lower portion below the said crests and an upper portion extending a substantial distance above said neutral axis and above said crests; the said lower portion comprising a continuous essentially flat sheet of metal extending vertically from and secured at its base to one of said valleys and extending longitudi-

nally therealong; the said upper portion of said connectors including a plurality of vertical slots extending below the level of said crests and defining a plurality of tabs, the said tabs being twisted out of the plane of the said lower portion above said neutral axis and terminating immediately of said concrete above said crests, the said tabs at their tips being transverse to the general plane of said lower portion, and the said concrete layer surrounding each of the said shear connectors.

2. The structure as claimed in claim 1 including a plurality of parallel slits in the said valleys of the said flooring elements, said pairs of slits being spaced longitudinally along the said valleys and defining a band of metal, the said band of metal being elevated above the upper surface of the said valleys; the lower portion of said shear connector having a plurality of longitudinally spaced tongues extending laterally from the lower portion thereof and corresponding in spacing to the said pairs of slits, each of said tongues being engaged over a said pair of slits, and beneath the said band of metal and above the upper surface of said valley whereby the said shear connector is secured to the said metal flooring element.

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