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(54) COMPOSITE OPEN WEB JOIST

(71) We, HAMBRO STRUCTURAL SYSTEMS LTD., an Ontario corporation incorporated under the laws of the Province of Ontario, of 1489-D Merivale Road, Ottawa 5, Ontario, Canada, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a composite structure for use in the construction of buildings such as large open span buildings. The present invention is particularly concerned with composite floor structures and a form of open web steel joist for use in such composite structures

In accordance with the present invention, we provide an open web steel joist for use in a composite structure comprising:

a top chord;

a bottom chord; and

web means disposed between the chords, wherein the top chord has a first part shaped to define at least one channel which can be substantially filled with concrete when the joist is incorporated in such a composite structure and a second part consisting of a downwardly extending flange depending from the lower end of the first part and having openings to receive spanner bars formed at intervals along its length.

Formwork can be supported between the open web joists on spanner bars inserted in the openings, which bars stabilize the joists prior to the pouring of the concrete onto the formwork.

The concrete poured on the formwork can be reinforced with a reinforcing mesh draped over the shaped part of the open web steel joists and hanging in a catenary-like shape between the open web joists to provide an effective shape for shear reinforcement.

The composite floor system utilizing the open web joists can be more economical than conventional open web joists systems and

permits a variety of forming materials. Plywood forms may be used between the open web joists giving a degree of lateral stability before the concrete is poured and the plywood forms may be reused in subsequent concrete pouring operations.

A particularly significant aspect is that the spacing between open web joists may be greatly increased over the spacings presently utilized, since the spanner bars positioned between the open web joists and the joists themselves carry the construction loads and the completed composite floor system has adequate strength to carry all design loads once the construction has been completed. It will be appreciated that several inherent advantages of composite construction are obtained; for example, a whole floor or roof structure is a single unit with increased strength and stability.

It is also within the scope of the present invention to form large span floors using the open web joists of the invention, which may be propped during construction and which when the composite system has achieved its ultimate strength are capable of supporting the design loads across the full span without propping.

Examples of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 is a perspective view of a composite floor system utilizing the applicant's open web joists, the view being from below,

Figure 2 is a perspective view from above illustrating details of the construction of open web joists in accordance with the invention,

Figure 3 is a perspective detail illustrating the notches formed in the first flange of the applicant's open web joists,

Figure 4 is a vertical section through an open web joist of the present invention,

Figures 5 and 6 are vertical sections through floor systems utilizing the open web joists of the present invention,

Figure 7 is a perspective view of an alter-

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native form of top chord for use with the present invention.

Figures 8 and 9 are vertical sections through further alternative forms of top chords for open web joists in accordance with the invention, and

Figure 10 is one part of a top chord.

Referring to Figure 1, there is shown in perspective a composite floor system including open web joists 11 in accordance with the present invention. A composite floor system is indicated generally at 10 and comprises the open web or bar joists 11 and a poured concrete slab 12 containing a reinforcing mesh 13. As illustrated in Figure 1, each of the open web joists consists of a bottom chord 14 a zig-zag bar web 15 and a top chord 16 which will be subsequently described in greater detail.

Positioned between the bar joists 11 are spanner bars 17, the ends of which are received in openings 18 formed in the top chord 16 of the open web joists. In the left hand side of the figure, the bars 17 are illustrated in a position supporting a reusable plywood form 19, and in the right hand side of Figure 1 the bars 17 are illustrated supporting a steel pan 20 of known type.

It will be noted that knock out portions 21 are shown in the vertical flanges of the open web joists 11 beneath the ends of the spanner bars 17. These pieces 21 are so formed during manufacture of the open web or bar joists 11 that they form knock out panels which can be removed after the concrete has been poured in the composite floor system and the spanner bars 17 and the formwork 19 or 20 removed and reused for the subsequent pouring of additional composite floors. It will be appreciated that the size and shape of the opening 18 in which the ends of the spanner bar 17 are fitted may depend upon the particular form of spanner bar used and similarly the size and shape of the knockout panel 21 will also vary depending upon the particular type of spanner bar used. It will be noted in Figure 1 that the spanner bars 17 on the left hand side of the drawings are shown with a substantial portion of the bar projecting below the slots 18 and in the right hand side of the figure, the substantial portion of the bar projects above the slots 18. Such a shape of spanner bar permits the use of either plywood forms or sheet metal pans merely by reversing the position of the bar during insertion. It is contemplated that the spanner bars 17 normally would be removed from the composite structure and the framework such as 19 in Figure 1 would be taken away and reused. However, it will be appreciated that a specific application might include retaining the spanner bars as part of the permanent structure.

In Figure 2, there is illustrated in perspec-

tive, a pair of bar joists 26 and 27 and a spanner bar 28. Each of the bar joists is provided with an opening 18 in the vertical flange of the top chord together with a knock out panel 21 which may be removed after the concrete of the composite floor is poured to release the spanner bar 28.

In Figure 3 an alternate form of spanner bar 17 is illustrated which includes a notch 29 which co-operates with the sides of the opening 18 to increase the structural rigidity of the open web joists and spanner bars during construction.

Figure 4 is a vertical transverse section through a bar joist constructed in accordance with the present invention clearly illustrating the Z-shaped cross section of the top chord 16. The chord 16 is rolled from steel sheet strip. The bottom chord 14 which, in this particular joist is shown as formed of a pair of bars, is welded to the zig-zag web 15 which in turn is welded to the top chord 16.

Figures 5 and 6 illustrate the use of spanner bars to support formwork during the pouring of concrete. Figure 5 closely resembles the left hand side of Figure 1, and Figure 6 closely resembles the right hand side of Figure 1. As before the open web joists 11 support spanner bars 17 above which in Figure 5 is mounted a plywood form 19 and in Figure 6 a steel pan 20. It will be noticed in Figures 5 and 6 that the same spanner bar is used in both cases but that in Figure 6 the offset edge 30 is positioned upwardly whereas in Figure 5 the off-set edge 30 is positioned facing down. This allows for the difference in thickness between the plywood form 19 and the steel pan 20. Thus, a single spanner bar 17 may be used to support either plywood, for example, or steel pan formwork on which the concrete composite floor may be poured. It will also be noted that the top chord 16 of the open web joists are embedded in the concrete floor and that the reinforcing mesh 13 hangs in a catenary shape between the open web joists providing the proper shear reinforcement for the concrete floor.

Figure 7 illustrates an alternative form of top chord for use in the steel joist of the present invention and consisting of a first vertical flange 40 which is connected to a first horizontal flange 41. A second vertical flange 42 is connected to the horizontal flange 41 and in turn a second horizontal flange 43 is connected to the second vertical flange 42. A plurality of openings 44 are formed in the second vertical flange 42 so that when the flanges 42 and 43 are embedded in the poured concrete floor, the concrete may pass through the openings 44 and create a firm bond between the concrete and the joist to prevent shear failure along the vertical face 42.

Figure 8 illustrates an alternative form of top chord which is modified from the top chord illustrated in Figure 4. The Z-shaped top chord 16 of Figure 4 has now been altered to a smoothly curved shape surmounting the usual vertical flange.

Figure 9 illustrates yet another alternative form of top chord which may be formed, for example, by welding together a plurality of flat strips to give the desired finished configuration.

Figure 10 illustrates an alternative form of opening in the vertical flange of the open web joist for supporting the spanner bar. As before an opening 18 is provided with a knock out portion 21. In this case the L-shaped opening 18 is formed with a downwardly directed vertical leg and a horizontally directed leg so that the knock out portion 21 consists of a small rectangular member attached at two edges to the remaining metal of the vertical flange.

WHAT WE CLAIM IS:—

1. An open web steel joist for use in a composite structure comprising:
 - a top chord;
 - a bottom chord; and
 - web means disposed between the chords, wherein the top chord has a first part shaped to define at least one channel which can be substantially filled with concrete when the joist is incorporated in such a composite structure and a second part consisting of a downwardly extending flange depending from the lower end of the first part and having openings to receive spanner bars formed at intervals along its length.

2. A steel joist according to claim 1, wherein the first part has substantially Z-shaped transverse cross-section.

3. A steel joist according to claim 2, wherein said top chord is rolled from a single sheet or strip of steel.

4. A steel joist according to claim 1, 2 or 3, wherein the web means is a zig-zag or serpentine bar-web having its apices welded to said top and bottom chords.

5. A steel joist according to any preceding claim including a knock-out adjacent each said opening, each opening being L-shaped.

6. A composite structure comprising a steel joist according to any preceding claim, wherein the first part of the joist has a top flange and an intermediate flange which are completely embedded in concrete to form at least part of a composite floor structure with said concrete.

7. A composite structure comprising a plurality of open web joists according to claim 1 or 2, supported in parallel spaced relation with the shaped part of each top chord embedded in a concrete slab.

8. An open web steel joist substantially as herein described with reference to Figs. 1, 2 and 4.

9. A composite floor structure substantially as herein described with reference to Fig. 1.

For the Applicants,
D. YOUNG & CO.,
Chartered Patent Agents.
9 & 10 Staple Inn,
London, W.C.1.

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