

A STRUCTURAL FORMWORK MEMBER

5 The present invention relates to structural formwork members and to composite slabs that include the structural formwork members.

10 The present invention relates particularly to structural formwork members for constructing composite slabs.

15 A major, although not the only, end use application of such structural formwork members is in the construction of composite slabs that form floors in buildings (which term includes car parks).

20 Another, although not the only other, end use application of such formwork members is in the construction of composite slabs that form vertical wall panels.

25 One type of structural formwork member for constructing composite slabs that form floors of buildings includes:

- 30 (a) a base member in the form of a profiled steel sheet that has parallel ribs separated by pans; and
- 35 (b) strengthening members in the form of lattice girders formed from top chord elements that are spaced above the sheet and web chord elements that are welded to the top chord elements and to the ribs and/or pans of the sheet.

 The lattice girders may also include bottom chord elements that are parallel to the top chord

elements.

Examples of the above-described type of structural formwork member and composite slab formed from the member are disclosed in Japanese patent application JP,A,4-222739 (Hory corporation) and Australian patent 707101 (The Broken Hill Proprietary Company Limited).

The structural formwork members and the composite slabs formed from the members that are described and claimed in Australian patent 707101 are marketed by the applicant under the trade mark TRUSSDEK.

In the arrangements disclosed in the Japanese patent application and the Australian patent the steel sheet, the top chord elements, and the web chord elements (and the bottom chord elements, when present) define a series of spaced apart trusses that extend along the length of the sheet.

In use, the structural formwork members are laid on and sometimes are secured to floor supports and concrete is poured in situ to complete construction of composite floor slabs.

Accordingly, each composite floor slab includes a structural formwork member and a layer of concrete on the base member of the structural formwork member.

The structural formwork members may be constructed to extend across a span between adjacent temporary or permanent floor supports with the ends of the formwork members resting on the floor supports.

The structural formwork members may also be constructed to extend across multiple spans between temporary or permanent floor supports with the ends of the

formwork members resting on the outermost floor supports and intermediate sections of the formwork members resting on one or more floor supports that are between the outermost floor supports.

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The inventors have carried out extensive research and development work on TRUSSDEK structural formwork members and TRUSSDEK composite floor slabs formed from the members.

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One outcome of the research and development work is that the inventors have made a number of improvements to the TRUSSDEK structural formwork member and have invented an improved structural formwork member.

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In general terms, the improved structural formwork member of the present invention includes:

(a) a base member in the form of a metal sheet;
and

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(b) at least one strengthening member that is structurally connected to the base member.

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Preferably the metal sheet is a steel sheet.

The base member may be in the form of a flat sheet.

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The base member may be in the form of a profiled sheet that has parallel ribs that extend along the length of the base member and a plurality of pans between the ribs.

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Preferably the pans are flat.

The strengthening member may be located in one

of the pans.

Alternatively, the strengthening member may be located in two adjacent pans and straddle the rib between
5 the pans.

Preferably the ribs of the base member are small ribs.

10 The applicant has found that small ribs make a significant contribution to the compressive capacity of the profiled sheet in regions where there is global negative bending along the length of the sheet.

15 Typically, there is negative bending in sections of the profiled sheet that are directly over or are proximate to temporary or permanent supports for the structural formwork member.

20 This is an important issue with increasing unsupported span lengths of a structural formwork member of a given sheet thickness.

This is also an important issue with decreasing
25 sheet thickness of a structural support member spanning a given span length.

The applicant has also found that small ribs make it possible to use the structural formwork member in
30 the construction of composite slabs that will be subject to significant 2-way bending action and therefore require a significant amount of reinforcement or pre-stressing in a direction transverse to the strengthening member to strengthen the composite slabs.

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The applicant has also found that small ribs do not affect adversely the shear performance of shear

connectors that are used to connect composite slabs to supports.

5 It is preferred that the height of the ribs above the pans be no more than 20mm.

It is preferred particularly that the height of the ribs above the pans be no more than 15mm.

10 It is preferred more particularly that the height of the ribs above the pans be no more than 10mm.

15 It is preferred that the height of the ribs above the pans be no more than 20% of the height of the strengthening member above the pans.

20 It is preferred particularly that the height of the ribs above the pans be no more than 15% of the height of the strengthening member above the pans.

25 It is preferred that the height and the number of the ribs be selected so that the width of the profiled sheet is at least 80% of the width of a flat sheet prior to forming the ribs in the flat sheet and producing the profiled sheet.

30 It is preferred that the shape of the ribs facilitate interlocking of the base member and concrete that in use is poured onto and sets on the base member to form a composite slab.

35 Preferably the lengthwise extending sides of the base member include male and female formations that enable a plurality of the structural formwork members to be positioned in side by side overlapping relationship with the male member of one member and the female member of an adjacent member forming a lap joint.

The base member and the strengthening member may form a truss that extends along the length of the base member.

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The strengthening member may include a lattice girder formed from a top chord element that is spaced above the base member and web chord elements that are connected to the top chord element and to the ribs and/or
10 pans of the base member.

The lattice girder may also include bottom chord elements that are parallel to the top chord element and are connected to the web chord elements.

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The strengthening member may also be in the form of an inverted channel member.

Preferably the inverted channel member has a top
20 wall and two sides, with the sides being connected to the base member and the top wall being spaced above the base member.

Preferably the channel member is formed from a
25 roll-formed metal sheet.

Preferably the channel member is formed from a roll-formed steel sheet.

30 Preferably the roll-formed steel sheet is 0.6-1.2mm thick.

More preferably the thickness of the roll-formed steel sheet is 0.6-0.8mm.

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Preferably the height of the channel member is 80-240mm.

More preferably the height of the channel member is 130-240mm.

5 Preferably the width of the channel member, measured between the connections of the sides of the channel member to the base member, is 90-190mm.

10 Preferably the sides of the channel member converge upwardly towards the top of channel member.

15 Preferably the sides of the channel member have outwardly turned flanges to improve the connections between the sides of the channel member and the base member.

20 Preferably one or both sides of the channel member include sections that are pressed or otherwise formed out of the plane of the side or sides to provide resistance to local buckling of the structural formwork member and to increase the shear capacity of the structural formwork member.

25 Preferably the pressed sections are ribs or corrugations in the side or sides.

30 Preferably the axes of the ribs extend transversely to the lengthwise direction of the base member.

35 Preferably the crests and the troughs of the corrugations extend transversely to the lengthwise direction of the base member.

 Preferably the depth of the corrugations, measured between the apices of the crests and the bases of the troughs, is at least 3mm.

Preferably the wavelength of the corrugations, measured between apices of adjacent crests or between bases of adjacent troughs, is 30-60mm.

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The channel member and the base member may define a water impermeable void to minimise transverse deflection of the structural formwork member when wet concrete is poured onto the member in the construction of a composite slab and/or to provide an access pathway for building services, such as telecommunications cables, in a composite slab.

The term "water impermeable void" is understood herein to mean a volume that cannot be penetrated by wet concrete poured onto a structural formwork member.

Preferably the void is filled with fire resisting or retarding material.

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Preferably the inner surfaces of the channel member and the surface of the base member that form the void are coated with a fire resisting or retarding material.

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Preferably the void includes a sound absorbing material.

Alternatively, one or both sides of the channel member may include openings to allow access to the interior of the channel member, whereby wet concrete can flow into the volume defined by the channel member and the base member during construction of a composite slab.

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Preferably the sides of the channel member include aligned openings to allow reinforcing bars/wires/cables to be positioned to extend transversely

through the channel member during construction of a composite slab.

5 Preferably the openings are formed to minimise the possibility that the openings will weaken the channel member. The openings may include suitable reinforcement.

10 Alternatively, the channel member may be formed so that one or more sections can be filled with concrete and one or more sections can be voids. For example, the channel member may include openings near the ends of the channel member and an internal diaphragm positioned so that concrete can only flow into the end sections of the channel member. This arrangement prevents the voids from
15 interfering with the integrity of the shear connection made between a composite slab and permanent support beams.

20 Preferably the channel member includes internal or external bracing members at the ends and/or along the length the channel member to resist collapse of the channel member by transferring reaction forces acting on the channel member.

25 Preferably the channel member further includes a top chord element mounted to or retained by the channel member.

30 The top chord element may be any suitable member.

 Preferably the top chord element is a bar or a rod or a plate.

35 Preferably the top chord element is a steel bar or a steel rod or a steel plate.

 Preferably the plate is deformed, rippled or

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holed to improve mechanical interlock of the structural formwork member with concrete in a composite slab.

5 By way of example, the plate may be deformed by shaping the plate to include up-turned and/or downturned sections.

The top chord element may be mounted to the channel member by any suitable means.

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One option is to weld the top chord element to the base of the channel member.

15 Another option is to glue the top chord element to the base of the channel member.

Another option is to mount the top chord element to the channel member using web chord elements connected to the top chord element and to the channel member.

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Another, although not the only other, option is to mount the top chord element to the base of the channel member using one or more brackets that are mounted to the channel member and are formed to retain the top chord element by snap-fit or other suitable engagement.

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Preferably the bracket is in the form of a saddle that has legs that straddle the channel member and the legs have inwardly directed tabs, and the sides of the channel member have openings that receive the tabs and thereby retain the saddle on the channel member.

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Alternatively, the base of the channel member may be formed to at least partially enclose and thereby retain the top chord element.

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Preferably the base includes a transverse

section that is complimentary to that of the top chord element so that the top chord element can be snap-fitted into engagement with the base.

5 The strength of the connection of the top chord element to the channel member is preferably selected so that the failure made is by yielding the top chord element in tension or compression.

10 The structural formwork member may include a bridging member that is connected to one or both ends of the structural formwork member and/or at one or more locations along the length of the structural formwork member to enable direct load transfer from the
15 strengthening member to temporary or permanent supports for the structural formwork member.

 The bridging member is an important feature particularly, although by no means exclusively, in
20 situations in which the strengthening member includes a top chord element and web chord elements that form a truss with the base member. Specifically, the feature takes into account that the assembly of the top chord element and the web chord elements that form the strengthening
25 member is usually a basic unit of length that is repeated along the length of a structural formwork member.

 Accordingly, depending on the length of a structural formwork member, the strengthening member at
30 one or both end sections of the formwork member that rest on temporary or permanent supports may be an end of a unit or partway along the length of a unit. Similarly, if a structural formwork member continues over multiple spans, the same situation may occur at intermediate temporary or
35 permanent supports.

 The above situation is significant because the

structure of the strengthening member at the end or intermediate sections of a structural formwork member that rests directly on temporary or permanent supports can affect load transfer between the member and the temporary or permanent supports. Less than optimum load transfer may lead to reduced strength and excessive deflection or local deformation of the structural formwork member, particularly when concrete is poured onto the member to form a composite slab.

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The use of the bridging member makes it possible to use standard construction lengths of structural formwork members in a range of non-standard span length situations without compromising load transfer between the structural formwork member and temporary or permanent supports.

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The bridging member may be in the form of a chord element connected to a strengthening member.

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The chord element may be in the form of a frame.

The chord element may include a means that permits adjustable connection of the chord element to the strengthening member.

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The bridging member may also be in the form of a panel, for example formed from steel sheet or plate.

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The bridging member may also be in the form of an elongate member, such as a beam and a plate, connected to the base member of the structural formwork member.

The structural formwork member may include one or more water impermeable voids that contacts a section or sections of the base member between adjacent strengthening members to minimise transverse deflection of the section

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when wet concrete is poured onto the structural formwork member.

5 The above-described void feature is based on the applicant recognising two particular factors that contribute to transverse deflection, i.e. downward bulging, of sections of a base member that are between adjacent strengthening members in response to wet concrete loading. The factors are hydrostatic pressure of water in
10 wet concrete acting against the base member and the weight of the wet concrete.

Downward bulging can be excessive and quite noticeable on the underside of a structural formwork
15 member and, in addition to detracting from the visual appearance, may impinge on the installation of finishes and/or building services. In addition, downward bulging can add to the amount of concrete that is required to form a flat slab surface.

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The applicant has found that the use of a void as described above minimises the adverse effect of hydrostatic pressure and concrete weight by making it possible to transfer the load resulting from wet concrete
25 above a void to or to the region of the strengthening members located at the sides of the void.

The void need not function as a structural member.

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However, the structure that defines the void needs to have sufficient stiffness and strength to transfer the load resulting from wet concrete above the void to or to the region of the adjacent strengthening
35 members.

Preferably the void extends across a substantial

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part of the width of a section of a base member that is between adjacent strengthening members.

Preferably the void extends across at least 70%,
5 more preferably at least 80%, of the section of the base member that is between adjacent strengthening members.

The structural formwork member may include a plurality of voids spaced along the length of a section of
10 a base member that is between adjacent strengthening members.

The structural formwork member may also include a single void extending along the length of a section of a
15 base member that is between adjacent strengthening members.

The void may be small in terms of height so as to make it possible to use the structural formwork member in
20 the construction of composite slabs that will be subject to significant 2-way bending action and therefore require a significant amount of reinforcement or pre-stressing in a direction transverse to the strengthening member to strengthen the composite slabs.

25 The void may be defined, by way of example, by a block of material that is adhered or otherwise secured to the base member.

30 A preferred material is a lightweight material such as styrene.

The void may also be defined, by way of further example, by a volume enclosed by (i) the base member, (ii)
35 the sides of ribs of the base member or other suitable members that are adjacent to a section of the base member that is between adjacent strengthening members, and (iii)

a sheet of material spaced above the base member and extending across the section and contacting the adjacent ribs or other suitable members.

5 The void may also be defined, by way of further example, by a volume enclosed by (i) the base member and (ii) a shaped sheet, such as a curved sheet, of material that has sides that are retained by the ribs of the base member or other suitable retaining members.

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 The void may also be defined, by way of further example, by a volume enclosed by (i) the base member, and (ii) a channel member in an upturned position, with the base of the channel member spaced above the base member and forming the top of the void and the sides of the channel member extending downwardly and being structurally attached to the base member and forming two other sides of the void.

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 Preferably the void is filled with fire resisting or retarding material.

 Preferably the inner surfaces of the channel member and the surface of the base member that form the void are coated with a fire resisting or retarding material.

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 Preferably the void includes a sound absorbing material.

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 The structural formwork may also include:

(a) structural elements, such as steel bars or frameworks made up of a plurality of steel bars; and

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(b) ties that mechanically couple the

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5 structural elements to sections of the base member of one structural formwork member or to sections of the base members of adjacent structural formwork members that are in overlapping relationship to minimise transverse deflection of these sections when wet concrete is poured onto the structural formwork member .

10 This feature relates particularly to those sections that are between strengthening members.

This feature can be used as an alternative to or in conjunction with the previously-described feature of
15 the water impermeable void.

This feature is based on the applicant recognising that hydrostatic pressure of water in wet concrete acting against a base member and the weight of
20 the wet concrete are two particular factors that contribute to transverse deflection, i.e. downward bulging, particularly of sections of a base member that are between adjacent strengthening members, in response to wet concrete loading.

25 As is described above, the applicant has found that the use of structural elements as described above minimises the adverse effect of hydrostatic pressure and concrete weight by making it possible to transfer the load
30 resulting from wet concrete to the adjacent strengthening member.

The above-described feature is relevant particularly, although by no means exclusively, to
35 situations in which there are two structural formwork members laid side by side in overlapping relationship. In such situations there is a tendency for the lap joint

between the two members to separate in response to downward bulging of sections of the base members that include the lap joint.

5 According to the present invention there is also provided a composite floor slab that includes the above-described structural formwork member and a layer of hardened concrete on the member.

10 According to the present invention there is also provided a composite slab in the form of a vertical wall panel that includes the above-described structural formwork member and a layer of hardened concrete or other suitable castable panel material on the member.

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The present invention is described further by way of example with reference to the accompanying drawings of which:

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Figure 1 is based on Figure 1 of Australian patent 707101 and is a perspective view of one embodiment of a TRUSSDEK structural formwork member;

25 Figure 2 is an end elevation of an embodiment of a structural formwork member in accordance with the present invention;

30 Figure 3 is an end elevation of another embodiment of a structural formwork member in accordance with the present invention;

35 Figure 4 is an end elevation of another embodiment of a structural formwork member in accordance with the present invention;

Figure 5 is a perspective view of another embodiment of a structural formwork member in accordance

with the present invention;

Figure 6 is a section along the line 6-6 of
Figure 5;

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Figure 7 is a perspective view of a
strengthening member of another embodiment of a structural
formwork member in accordance with the present invention;

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Figure 8 is a perspective view of a
strengthening member of another embodiment of a structural
formwork member in accordance with the present invention;

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Figure 9a is a perspective view of a
strengthening member of another embodiment of a structural
formwork member in accordance with the present invention;

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Figure 9b is a perspective view of one of the
saddles of the strengthening member shown in Figure 9a;
and

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Figure 10 is an end elevation of a strengthening
member of another embodiment of a structural formwork
member in accordance with the present invention.

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Figure 11 is an end elevation of an embodiment
of a composite floor slab in accordance with the present
invention that includes another embodiment of a structural
formwork member in accordance with the present invention;

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Figure 12 is an end elevation of another
embodiment of a composite floor slab in accordance with
the present invention that includes another embodiment of
a structural formwork member in accordance with the
present invention;

Figure 13 is an end elevation of another

embodiment of a composite floor slab in accordance with the present invention that includes another embodiment of a structural formwork member in accordance with the present invention;

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Figure 14 is a side elevation of an end section of another embodiment of a structural formwork member in accordance with the present invention positioned on a floor support, the figure illustrating an embodiment of a bridging member in accordance with the present invention;

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Figure 15 is an end elevation of the arrangement shown in Figure 14;

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Figure 16 is a side elevation similar to Figure 14 which illustrates another embodiment of a bridging member in accordance with the present invention;

Figure 17 is an end elevation of the arrangement shown in Figure 16;

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Figure 18 is a side elevation similar to the side elevations shown in Figures 14 and 16 which illustrates another embodiment of a bridging member in accordance with the present invention;

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Figure 19 is an end elevation of the arrangement shown in Figure 18;

Figure 20 is a side elevation similar to the side elevations shown in Figures 14, 16, and 18 which illustrates another embodiment of a bridging member in accordance with the present invention;

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Figure 21 is an end elevation of the arrangement shown in Figure 20 along the line 21-21 in Figure 20; and

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Figure 22 is an end elevation of another embodiment of a structural formwork member in accordance with the present invention; and

5 Figure 23 is an end elevation of another embodiment of a structural formwork member in accordance with the present invention.

10 The structural formwork members shown in the figures are described hereinafter in the context of structural formwork members that can be arranged side by side in overlapping relationship and supported by temporary supports or permanent supports (such as steel beams) and are used in the construction of a composite
15 floor slab that includes the members and a layer of concrete on the members.

 Figure 1 is based on Figure 1 of Australian patent 707101. The figure illustrates a typical TRUSSDEK
20 structural formwork member 3.

 The TRUSSDEK structural formwork member 3 shown in Figure 1 includes a base member in the form of a profiled steel sheet that has two parallel ribs 5 and
25 three pans 6 that extend in the longitudinal direction of the profiled steel sheet.

 The sides of the base member include a male formation 38 and a female formation 37 that enable
30 adjacent sheets to be connected together with leakproof lap joints by inserting the male formation 38 into the female formation 37.

 The TRUSSDEK structural formwork member 3 further
35 includes two strengthening members, generally identified by the numeral 71 that extend along the length of the base member. Each strengthening member includes a lattice

girder formed from:

- 5 (a) a top chord element 7 extending parallel to the ribs 5; and
- (b) a plurality of web chord elements 9 welded to the steel sheet and to the top chord element 7 and thereby interconnecting the steel sheet and the top chord element 7.
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The chord elements 7, 9 are formed from steel bar.

15 The chord elements 7, 9 and the base member define two trusses.

The structural formwork members shown in Figures 2 to 23 incorporate a number of improvements made by the inventors to the TRUSSDEK formwork member.

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The structural formwork member shown in Figure 2 includes a base member in the form of a flat sheet 6 (rather than a profiled sheet) and strengthening members 71 in the form of inverted channel members (rather than lattice girders) welded to the flat sheet.

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Each channel member is formed from roll-formed steel sheet and has a top wall 33 and two inclined sides 35 that are welded at lower ends of the base member.

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The channel members are structural members that, with the base member, are provided to sustain the effects of bending, vertical shear, and concentrated forces at supports.

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In addition, the channel members and the base

member define a series of water impermeable voids 18.

The structural formwork members shown in Figures 3 and 4 are similar to that shown in Figure 2.

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The strengthening members of the structural formwork members shown in Figures 3 and 4 further include top chord elements 39 in the form of steel plates welded to the channel members 71.

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In addition, the structural formwork member shown in Figure 4 includes two different-sized channel members 71. This embodiment illustrates the flexibility of the subject invention.

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The structural formwork member shown in Figures 5 and 6 includes a base member in the form of a profiled sheet that has a central rib 5 and two pans 6.

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The structural formwork member also includes two strengthening members, generally identified by the numeral 31, that extend along the length of the base member.

Each strengthening member 31 is positioned in one of the pans 6 and includes:

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(a) an inverted channel member that is formed from roll-formed steel sheet and has a top wall 33 and two inclined sides 35 that are connected at their lower ends to the base member; and

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(b) a top chord element 39 that is connected to the base 33 of the channel member.

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The lower ends of the sides 35 of the channel member are formed as out-turned flanges 41 to maximise

contact with the profiled steel sheet 3. The flanges 41 are welded and/or glued or otherwise structurally connected to the base member.

5 Both sides 35 of the channel member include a series of corrugations 43 along the length of the sides 35 of the channel member. With reference to Figure 6, the corrugations 43 include crests 45 and troughs 47. Preferably, the depth D of the corrugations 43 is at least
10 6mm (note 3mm each way about the sheet centreline) and the wavelength W of the corrugations 43 is 30-60mm. The corrugations 43 are formed so that the crests 45 and the troughs 47 are transverse to the lengthwise direction of the base member. The purpose of the corrugations 43 is to
15 provide resistance to lateral buckling of the formwork member and to increase the bearing capacity at support reaction locations.

Both sides 35 of the channel member include
20 openings 47 to allow access to the interior of the channel member, whereby wet concrete can flow into the volume defined by the channel member and the base member during construction of a composite slab and thereby fill the volume. The openings 47 are at about half height of the
25 channel members. Preferably the base of the openings 47 is above the height of the ribs 5. The openings are shown as slots. Preferably the slot width is not more than 40% of the height of the channel members and the slot length of slot width ratio is not more than 2:1. Typically the
30 slot width is 45mm and the length is 90mm. Preferably there is at least 20mm of channel member above each slot - in order to provide sufficient shear resistance.

A number of the openings 47 in the sides 35 are
35 aligned to also allow reinforcing bars/wires/cables (not shown) to be positioned to extend transversely through the channel member during construction of a composite slab.

Both sides of the channel member also include a series of smaller holes 48 near the top of the channel members to allow air to escape from the channel member when wet concrete is flowing into the interior of the channel member via major openings 47.

The top chord element 39 is in the form of a rectangular cross section steel bar that is welded or glued to the base 33 of the channel member. The top chord element 39 is spaced above the base member by the height H of the channel member.

The construction of the channel member from roll-formed steel sheet makes it possible to concentrate the steel of the strengthening member as far as possible above the base member while properly supporting the steel in this position.

The embodiment of the strengthening member 31 shown in Figure 7 is similar in many respects to the embodiment shown in Figures 5 and 6.

For example, the embodiment shown in Figure 7 includes a roll-formed channel member that has a base 33 and sides 35 with out-turned flanges 41.

The main differences between the embodiments are that the top chord element 39 is in the form of a round steel bar that is supported by web chords 40 that are welded to the sides 35 of the channel member.

The embodiment of the strengthening member 31 shown in Figure 8 is similar in many respects to the embodiment shown in Figures 5 and 7.

For example, the embodiment shown in Figure 8

includes a roll-formed channel member that has a base 33 and sides 35 with out-turned flanges 41 and openings 47 formed in the sides 35.

5 There are a number of differences between the embodiments.

 For example, the embodiment shown in Figure 8 also includes stiffening ribs 51 that are pressed from the
10 planes of the sides 35 of the channel member rather than the corrugations 43 of the embodiment shown in Figures 5 and 6. The axes of the ribs 51 are transverse to the lengthwise extending direction of the profiled steel sheet 3 (not shown).

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 In addition, the base 33 of the channel member of the embodiment shown in Figure 8 is shaped as a key-hole formation and the top chord element 39 has a complementary circular cross-section and is received in
20 and retained by the key-hole formation.

 The embodiment of the strengthening member 31 shown in Figures 9a and 9b is similar in many respects to the embodiments shown in Figures 5, 6 and 8.

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 The main difference between the embodiments is that the embodiment shown in Figures 9a and 9b includes detachable saddles 61 that mount the top chord element 39 onto the channel member. The saddles 61 straddle the base
30 33 of the channel member and engage the sides 35 of the channel member at spaced intervals along the length thereof. The saddles 61 also include semi-circular channels 63 that receive and retain the top chord element 39 by snap-fit engagement. The saddles 61 engage the
35 sides 35 of the channel member by means of inwardly directed tabs 69 that are formed in the legs 67 and extend into spaced openings (not shown) in the sides 35 of the

channel member.

In the embodiment shown in Figure 10 the top chord element 39 is in the form of a plate that is welded to the base 33 of the channel member. Typically, the plate is 5mm thick. The plate includes up-turned and down-turned wings 79.

To maximise mechanical interlock with concrete the plate may be deformed (for example, with upturned and downturned sections as shown in Figure 10), rippled, and/or holed.

The plate is preferred in situations where high lateral stability, large flexural stiffness, and large tensile and compressive capacity are required.

The structural formwork member shown in Figure 11 includes a base member in the form of a profiled steel sheet that has a series of ribs 5 and pans 6 and two strengthening members 71 in the form of lattice girders that include two chord elements 7, web chord elements 9, and bottom chord elements 8.

The strengthening members 71 are positioned so that each strengthening member 71 straddles an outer rib 5 of the base member with the web chord elements 9 being welded to two pans 6 of the base member. The present invention is not limited to this arrangement and also extends to arrangements in which the strengthening members are located wholly in the pans 6 - as shown in Figure 5.

The width of the left-hand pan 6 as shown in Figure 11 is selected to be sufficiently wide and the position of the left-hand strengthening member is selected to be close to the rib 5 on that side so that there is a clear space for shear connectors, such as headed studs

(not shown), to be welded to an underlying steel beam (not shown) or fixed to other floor supports.

The width of the right-hand pan 6 as shown in Figure 11 is selected to be relatively narrow and, as a consequence, the right-hand strengthening member is close to the male formation 38. With this arrangement, in use, the right-hand strengthening member will be positioned close to and thereby support a joint between overlapping (and thereby interlocking) adjacent sheets.

One standard sized structural formwork member 3 has strengthening members formed from 12mm diameter steel bar and is constructed so that the top chord elements 7 are 120mm above the pans 6, the centre to centre spacing of the web chord elements 9 of each strengthening member is 78mm at their base, the centre to centre spacing of the strengthening members (ie. the centre to centre spacing of the top chord elements 7) is 166mm, and the left-hand strengthening member is 60mm from the female formation 37.

The ribs 5 include downwardly converging sides 43 and a flat top wall 45. The downwardly converging sides 43 of the ribs 5 facilitate interlocking of the base member with concrete to contribute toward the longitudinal slip resistance developed between the base member and the concrete. In addition, as is described hereinafter in more detail, the downwardly converging sides 43 can be used to assist in retaining a void former 27 on the base member.

One standard sized structural formwork member 3 has ribs 5 that have a height of 12mm above the pans 6 and a top wall width of 50mm.

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The ribs 5 shown in Figure 11 are small ribs.

The ribs 5 are small in the context of the height of the top chord element of the strengthening members above the pans 6.

5 The ribs 5 are also small in the context of the relationship of the height of the ribs 5 above the pans 6 and the height of the top chord elements 7 above the pans 6. Specifically, in the context of the standard sized structural formwork member discussed above, the
10 relationship is 12mm versus 120mm, ie the height of the ribs is 10% of the height of the top chord elements.

 The ribs 5 are also small in the context of the width reduction of a flat sheet of steel strip that is
15 required to form the structural formwork member 3. Specifically, in the context of the above-described standard sized structural formwork member, a 630mm wide flat strip was roll-formed to form a 500mm structural formwork member having the profile shown in the figures,
20 ie a width reduction of 79%.

 The structural formwork member 3 shown in Figure 11 also includes a plurality of retaining members 19 in the pans 6. The retaining members 19 facilitate
25 interlocking of the base member with concrete so that good longitudinal slip resistance can be developed between the base member and the concrete and to prevent vertical separation of the base member and hardened concrete. In addition, as described hereinafter, the retaining members
30 can be used to assist in retaining a void former 27 to the base member.

 The structural formwork member 3 shown in Figure 11 also includes a void former 27 positioned in a section
35 of the base member that is between the strengthening members 71.

The void former 27 is in the form of an inverted channel member that has a top wall 33 and two sides 35 that diverge from the top wall 33 and contact the base member of the structural support member 3.

5

The void former 27 is retained on the base member by the retaining members 19. Specifically, the dimensions of the void former 27 are selected so that there is an interference fit between the void formers 27 and the retaining members 19.

10

Alternatively, or in addition, the void former 27 and the retaining members 19 may be provided with tabs (not shown) and openings (not shown) to facilitate interlocking of the void formers 27 and the retaining members.

15

The void former 27 may be open-ended.

20

Alternatively, the void former 27 may be formed with closed ends (not shown). For example, the ends of the void former 27 may be closed by inserts such as polystyrene plugs or thin steel plates.

25

When positioned on the base member as shown in Figure 11, the void former 27 and the base member define a void in the section of the base member that is between the strengthening members.

30

The purpose of the voids is to reduce the adverse effect of (i) hydrostatic pressure of water acting against the base member when wet concrete is poured onto the section of the base member that is between the strengthening members 71 and the base member and (ii) the weight of the wet concrete required to form a composite slab.

35

Preferably the voids achieve this purpose by taking up volume and transferring load resulting from the wet concrete above the voids to the strengthening members 71.

5

It is not essential that the voids be hollow spaces. In this context, the relevant requirement is that a void be a space that remains a space under the weight of wet concrete and cannot be penetrated by wet concrete.

10

Thus, a void may be defined by a block of solid material, such as styrene, that is secured to the base member.

15

It is also not essential that a void occupy the whole of the width of the section of the base member that is between the strengthening members. The requirement is that the void extends across a substantial part of the width of the section.

20

The structural formwork member shown in Figure 11 forms part of a composite floor slab. Specifically, the floor slab includes the structural formwork member, a layer of concrete 4 on the member, and transverse reinforcement 14.

25

The structural formwork members 3 shown in Figures 12 and 13 have the same basic construction as the structural formwork member 3 shown in Figure 11.

30

The main difference between the Figure 11 and Figure 12 structural formwork members 3 is the construction of the void former 27. Specifically, the void former 27 is a relatively shallow void former 27 in the form of a curved sheet of suitable material that is positioned so that opposite sides are retained by the retaining members 19.

35

The use of a shallow void former 27 makes it possible to use the structural formwork member 3 in the construction of a composite slab that will be subject to 2-way bending action. Specifically, as shown, the shallow void former 27 makes it possible to locate transverse pre-stressing ducts and cables 46 in the composite slab - as required when there is 2-way bending action. Whilst not shown in Figure 12, but nevertheless as shown in Figure 13, upper and lower transverse reinforcement 49 may be used as an alternative to the use of transverse pre-stressing. The shallow void former 27 also makes it possible to locate a longitudinal duct 44 housing service cables sufficiently low down in the slab.

15

The main difference between the Figures 11 and 12 and the Figure 13 structural formwork members 3 is that the Figure 13 member includes a third strengthening member straddling the central rib 5 and therefore does not require a void former 27.

20

Figure 13 also illustrates the preferred locations of headed studs 48 that may be used to secure the formwork members 3 to floor supports, such as steel beams (not shown).

25

The structural formwork members 3 shown in Figures 2 to 13 further include bridging members at one or both ends or at positions along the length of the structural formwork member to facilitate optimum load transfer in use of the member to temporary or permanent supports. Various embodiments of bridging members are described hereinafter with reference to Figures 14 to 21. The bridging members are generally identified by the numeral 11 in these figures.

30
35

In use, in order to construct a floor:

- 5 (a) a number of the structural formwork members are positioned to rest on temporary or permanent floor supports 13, such as vertical walls and horizontal beams, with the bridging members 11 enabling load transfer from the strengthening members 71 to the floor supports 13; and
- 10 (b) concrete is poured onto the formwork members and forms a plurality of composite floor slabs (as shown in Figures 11 to 13).

15 Depending on the requirements in any given situation, the structural formwork members may extend across a single span between adjacent floor supports 13 and be supported only at the ends by these floor supports 13 or may extend across multiple spans and be supported at the ends by the outermost floor supports and at one or
20 more locations along the length of the structural formwork members by the intermediate floor support or supports 13.

In practice, the spans between floor supports 13 may be 5m or more. Particularly with spans of this order,
25 it is important that there be optimum load transfer from the structural formwork members to the floor supports 13.

Typically, structural formwork members are constructed away from a building site and are transported
30 to the site. Typically, the strengthening members include a basic unit of length L (as can be seen in Figure 14) that is repeated along the length of the structural formwork members.

35 Depending on the length of a structural formwork member, the strengthening member 71 at one or both end sections of the member that, in use, rest on floor

supports 13 may be an end of a unit or part way along the length of a unit. As indicated above, these are important considerations because the structure of the strengthening member 71 at end or intermediate sections of a structural formwork member that rest directly on floor supports 13 can affect load transfer between the structural formwork member and the floor supports 13.

More specifically, less than optimum load transfer may lead to reduced strength and excessive deflection or local deformation of the structural formwork member, particularly when concrete is poured onto the member to form a composite floor slab.

As illustrated in the four embodiments shown in Figures 14/15, 16/17, 18/19, and 20/21 the bridging member 11 is connected to at least one end of a structural formwork member and/or at one or more locations between the ends of the structural formwork member to enable optimum load transfer from the strengthening member 71 to the floor supports.

In the case of the Figures 14/15 embodiment, the bridging member 11 is a triangular frame 15 formed by bending a length of steel bar. The frame 15 is connected to the structural formwork member 3 by welding:

- (a) apex 17 of the frame 15 to the top and web chord elements 7,9; and
- (b) apices 19, 21 of the frame 15 to the bottom chord elements 8.

The position of the frame 15 is selected so that, in use, the base 23 of the frame 15 is above the floor support 13.

Optimum positioning of the frame 15 may necessitate cutting and/or bending one or more of the top chord element 7, the bottom chord element 8, and the web chord elements 9. The dotted line identified by the numeral 23 in Figure 14 illustrates the position of the web chord elements 9 in the as-constructed structural formwork member. It is evident from the figure that in order to correctly position the frame 15 it was necessary to cut the top and web chord elements 7, 9 and to bend the web chord elements 9 upwardly to contact the top chord element 7.

In the case of the Figures 16/17 embodiment the bridging member 11 includes:

15

(a) a mounting block 29 that has a hollow core that can receive the top chord element 7 and can be slid along the top chord element 7 to a required position, and then bear against web chord element 9, or else be swaged, welded, or otherwise connected to the top chord element 7 in that position;

20

(b) a pair of chord elements 37 each connected at one end to the block 29 and arranged to extend downwardly from the block 29; and

25

(c) a pair of bottom chord elements 51 that are parallel to the axis of the core of the block 29 and can be swaged, welded, or otherwise connected to the bottom chord elements 8 of the formwork member 3.

30

In the case of the Figures 18/19 embodiment the bridging includes a plate 35 that is spot welded to the undersurface of the pan 6 of the formwork member 3.

35

In the case of the Figures 20/21 embodiment the bridging member 11 is the same triangular frame construction as shown in the Figures 14/15 embodiment. In the case of the Figures 20/21 embodiment the frame 15 is
5 positioned so that the base of the frame is above the intermediate floor support 13 shown in the figures.

The structural formwork members 3 shown in Figures 22 and 23 are the same basic construction in many
10 respects as the structural formwork members 3 shown in the previously-described figures.

Figures 22 and 23 illustrate alternative options to minimise transverse deflection, ie downward bulging, of
15 sections of profiled steel sheets that are between adjacent strengthening members.

Figures 22 and 23 illustrate overlapping structural formwork members. In these situations, the
20 sections of the profiled steel sheets that are in question are the adjacent side sections of the overlapping sheets, including male formations 38 and female formations 37 that form lap joints 61 of the sheets.

In the arrangement shown in Figure 22 the formwork member includes a structural element in the form of a steel bar 63 that is connected at opposite ends to the adjacent strengthening members and a centrally located tie 65 that is connected at one end to the bar 63 and is
25 formed as a hook that engages the lap joint 61.
30

In the arrangement shown in Figure 23 the structural formwork member includes a structural element in the form of a framework of steel bars 63 that are
35 arranged in a pyramid shape with a central apex located above the lap joint 61 and the steel bars extending downwardly and outwardly with the lower ends of the bars

63 butting against ribs 5 that are immediately adjacent the strengthening members.

5 In both arrangements shown in Figures 22 and 23, the steel bars 63 and the framework of steel bars 63 transfer load to the strengthening members 71 and thereby resist downward deflection of the overlapping sections of the profiled steel sheets when wet concrete is poured onto the sheets.

10

The above-described embodiments are examples of many possible embodiments of structural formwork members in accordance with the present invention.

15

Many modifications may be made to the preferred embodiments of the present invention that are described with reference to the accompanying drawings without departing from the spirit and scope of the invention.

20

By way of example, whilst the void formers 27 shown in Figures 11 and 12 are retained on the base member of the structural formwork members 3 by engaging the retaining members 19, the present invention is not so limited and extends to any suitable means of retaining the void formers to the base member.

25

By way of further example, whilst the base member is described as being formed from steel sheet, the present invention is not so limited and the base member may be formed from any suitable metallic or non-metallic material.

30

CLAIMS:

1. A structural formwork member includes:
 - 5 (a) a base member in the form of a profiled metal sheet, the base member including parallel ribs and plurality of pans between the ribs, the ribs being small ribs; and
 - 10 (b) at least one strengthening member that is structurally connected to the base member.
2. The structural formwork member defined in claim 1 wherein the height of the ribs above the pans of the
15 base member is no more than 20mm.
3. The structural formwork member defined in claim 1 wherein the height of the ribs above the pans of the
20 base member is no more than 15mm.
4. The structural formwork member defined in claim 1 wherein the height of the ribs above the pans of the
base member is no more than 10mm.
- 25 5. The structural formwork member defined in any one of the preceding claims wherein the height of the ribs above the pans of the base member is no more than 20% of the height of the strengthening member above the pans.
- 30 6. The structural formwork member defined in any one of claims 1 to 4 wherein the height of the ribs of the base member above the pans is no more than 15% of the height of the strengthening member above the pans.
- 35 7. The structural formwork member defined in any one of the preceding claims wherein the height and the number of the ribs of the base member is selected so that the width

of the base member is at least 80% of the width of a flat sheet prior to forming the ribs in the flat sheet and producing the base member.

5 8. The structural formwork member defined in any one of the preceding claims wherein the strengthening member includes a lattice girder formed from a top chord element that is spaced above the base member and web chord elements that are connected to the top chord element and
10 to the ribs and/or pans of the base member.

9. The structural formwork member defined in claim 8 wherein the lattice girder also includes bottom chord elements that are parallel to the top chord element and
15 are connected to the web chord elements.

10. The structural formwork member defined in any one of claims 1 to 7 wherein the strengthening member is in the form of an inverted channel member.

20 11. The structural formwork member defined in claim 10 wherein the inverted channel member has a top wall and two sides, with the sides being connected to the top wall member and the base being spaced above the base member.

25 12. A structural formwork member includes:

(a) a base member in the form of a metal sheet;
and

30 (b) at least one strengthening member in the form of an inverted channel member that is structurally connected to the base member.

35 13. The structural formwork member defined in claim 12 wherein the base member is in the form of a flat metal sheet.

14. The structural formwork member defined in claim 12 wherein the base member is in the form of a profiled metal sheet and includes parallel ribs that extend along the length of the base member and a plurality of pans between the ribs.

15. The structural formwork member defined in claim 14 wherein the ribs are small ribs.

10

16. The structural formwork member defined in any one of claims 12 to 15 wherein the channel member has a top wall and two sides, with the sides being connected to the base member and the base being spaced above the top wall member.

15

17. The structural formwork member defined in any one of claims 12 to 16 wherein the channel member is formed from a roll-formed metal sheet.

20

18. The structural formwork member defined in claim 17 wherein the roll-formed sheet is 0.6-1.2mm thick.

19. The structural formwork member defined in claim 17 wherein the thickness of the roll-formed sheet is 0.6-0.8mm.

25

20. The structural formwork member defined in any one of claims 12 to 19 wherein the height of the channel member is 80-240mm.

30

21. The structural formwork member defined in any one of claims 12 to 19 wherein the height of the channel member is 130-240mm.

35

22. The structural formwork member defined in any one of claims 12 to 21 wherein the width of the channel

member, measured between the connections of the sides of the channel member to the base member, is 90-190mm.

23. The structural formwork member defined in any one of claims 12 to 22 wherein the sides of the channel member have outwardly turned flanges to improve the connections between the sides of the channel member and the base member.

24. The structural formwork member defined in any one of claims 12 to 23 wherein one or both sides of the channel member include sections that are pressed or otherwise formed out of the plane of the side or sides to provide resistance to local buckling of the structural formwork member and to increase the shear capacity of the structural formwork member.

25. The structural formwork member defined in claim 24 wherein the pressed sections are ribs or corrugations in the side or sides.

26. The structural formwork member defined in claim 25 wherein the axes of the ribs extend transversely to the lengthwise direction of the base member.

27. The structural formwork member defined in claim 25 or 26 wherein the crests and the troughs of the corrugations extend transversely to the lengthwise direction of the base member.

28. The structural formwork member defined in any one of claims 12 to 27 wherein the channel member and the base member define a water impermeable void to minimise transverse deflection of the structural formwork member when wet concrete is poured onto the member in the construction of a composite slab and/or to provide an access pathway for building services, such as

telecommunications cables, in the completed composite slab.

29. The structural formwork member defined in any one of claims 12 to 28 wherein one or both sides of the channel member include openings to allow access to the interior of the channel member, whereby wet concrete can flow into the volume defined by the channel member and the base member during construction of a composite slab.

10

30. The structural formwork member defined in any one of claims 12 to 29 wherein the sides of the channel member include aligned openings to allow reinforcing bars/wires/cables to be positioned to extend transversely through the channel member during construction of a composite slab.

15

31. The structural formwork member defined in any one of claims 12 to 30 wherein the channel member further includes a top chord element mounted to or retained by the channel member.

20

32. The structural formwork member defined in claim 31 wherein the top chord element is a bar or a rod or a plate.

25

33. The structural formwork member defined in claim 32 wherein the plate has up-turned and/or down-turned sections to improve mechanical interlock of the structural formwork member with concrete in a composite slab.

30

34. A structural formwork member includes:

35

- (a) a base member in the form of a metal sheet;
- (b) at least one strengthening member that is structurally connected to the base member;

and

- 5 (c) a bridging member that is connected to one or both ends of the member and/or at one or more locations along the length of the member to enable direct load transfer from the strengthening member to temporary or permanent supports for the structural formwork member.

10

35. The structural formwork member defined in claim 34 wherein the bridging member is in the form of a chord element connected to the strengthening member.

15

36. The structural formwork member defined in claim 35 wherein the chord element is in the form of a frame.

20

37. The structural formwork member defined in claim 35 or 36 wherein the chord element includes a means that permits adjustable connection of the chord element to the strengthening member.

25

38. The structural formwork member defined in claim 34 wherein the bridging member is in the form of a panel formed from steel sheet or plate.

30

39. The structural formwork member defined in claim 34 wherein the bridging member is in the form of an elongate member, such as a beam and a plate, connected to the base member of the structural formwork member.

35

40. The structural formwork member defined in any one of claims 34 to 39 wherein the strengthening member includes a lattice girder formed from a top chord element that is spaced above the base member and web chord elements that are connected to the top chord element and to the base member.

41. The structural formwork member defined in claim 40 wherein the lattice girder also includes bottom chord elements that are parallel to the top chord element and
5 are connected to the web chord elements.

42. The structural formwork member defined in any one of claims 34 to 39 wherein the strengthening member is in the form of an inverted channel member.

10

43. The structural formwork member defined in claim 42 wherein the inverted channel member has a top wall and two sides, with the sides being connected to the top wall member and the base being spaced above the base member.

15

44. A structural formwork member includes:

(a) a base member in the form of a metal sheet;

20

(b) a plurality of strengthening members that are structurally connected to the base member; and

25

(c) a water impermeable void that contacts a section of the base member between adjacent strengthening members to minimise transverse deflection of the section when wet concrete is poured onto the structural formwork member.

30

45. The structural formwork member defined in claim 44 wherein the void does not function as a structural member.

35

46. The structural formwork member defined in claim 44 or 45 wherein the void extends across a substantial part of the width of the section of the base member that

is between adjacent strengthening members.

47. The structural formwork member defined in claim 44 or 45 wherein the void extends across at least 70% of the section of the base member that is between adjacent strengthening members.

48. The structural formwork member defined in any one of claims 44 to 47 includes a plurality of voids spaced along the length of the section of the base member that is between adjacent strengthening members.

49. The structural formwork member defined in any one of claims 44 to 47 includes a single void extending along the length of the section of the base member that is between adjacent strengthening members.

50. The structural formwork member defined in any one of claims 44 to 49 wherein the void is small in terms of height so as to make it possible to use the member in the construction of composite slabs that will be subject to significant 2-way bending action and therefore require a significant amount of reinforcement or pre-stressing in a direction transverse to the strengthening member to strengthen the composite slab.

51. The structural formwork member defined in any one of claims 44 to 50 wherein the void is defined by a block of material that is adhered or otherwise secured to the base member.

52. The structural formwork member defined in any one of claims 44 to 50 wherein the base member is in the form of a profiled metal sheet that has lengthwise extending ribs and pans between the ribs.

53. The structural formwork member defined in claim

52 wherein the void is defined by a volume enclosed by (i) the base member, (ii) the sides of ribs of the base member or other suitable members that are adjacent to a section of the base member that is between adjacent strengthening members, and (iii) a sheet of material spaced above the base member and extending across the section and contacting the adjacent ribs or other suitable members.

54. The structural formwork member defined in any claim 52 wherein the void is defined by a volume enclosed by (i) the base member and (ii) a shaped sheet of material that has sides that are retained by the ribs of the base member or other suitable retaining members.

55. The structural formwork member defined in claim 52 wherein the void is defined, by way of further example, by a volume enclosed by (i) the base member, and (ii) a channel member in an upturned position, with the base of the channel member spaced above the base member and forming the top of the void and the sides of the channel member extending downwardly and being structurally attached to the base member and forming two other sides of the void.

56. A composite floor slab that includes the structural formwork member defined in any one of the preceding claims and a layer of hardened concrete on the member.

57. A composite slab in the form of a vertical wall panel that includes the structural formwork member defined in any one of the preceding claims and a layer of hardened concrete or other suitable castable panel material on the member.