EUROPEAN PATENT SPECIFICATION

IMPROVEMENTS IN AND RELATING TO DOUBLE SKIN COMPOSITE PANELS

VERBESSERUNGEN AN ZWEISCHALIGEN VERBUNDPANELEN

AMELIORATIONS APPORTEES À DES PANNEAUX COMPOSITES À DOUBLE REVETEMENT

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Description

[0001] This invention relates to double skin composite panels which comprise a layer of a filler material (usually a cementitious material such as concrete) faced with plates (usually carbon steel) and methods of producing the same. A lighter filler material such as filled synthetic resin may be employed for certain applications.

[0002] Double skin composite panels exhibit similar characteristics to those of reinforced concrete structures and are advantageous in that the facing plates act as reinforcements to enable the required strength characteristics to be achieved with structures of overall depth less than those of reinforced concrete. High reinforcement ratios are possible and the plates act as permanent shuttering for the central concrete layer.

[0003] Double skin composite panels are known which comprise two steel facing plates positioned one on each side of a layer of concrete and connected thereto by transverse cross members which extend generally normal to and are attached at their ends to both facing plates. Such panels are disclosed in GB-A-2136032, GB-A-2136033 and GB-A-2258669.

[0004] Hitherto, such double skin composite panels have been produced in situ, that is to say at the site at which they are to be installed or major sub-structures assembled. On site production not only doubles the amount of required on-site handling because each skin is handled separately but also significantly increases the production costs of the panels. Generally, these known panels comprise a combination of relatively thick facing plates, internal ties and facing plate stiffeners. They also require external support and/or internal stiffeners to the facing plates during pouring of concrete between the plates to avoid structural distortion caused by the high hydrostatic pressures produced during pouring. It has also been found necessary to limit the height from which or the rate at which concrete is poured to reduce such pressures.

[0005] Double skin composite panels of the present invention are intended to be factory produced and delivered to site as integral structures comprising facing plates secured together by transverse connecting members. The plates may be flat or curved.

[0006] The dimensions of panels in accordance with the invention are such that they are rigid enough to hold their shape during handling to enable large structures to be rapidly and accurately assembled. Individual panel sizes up to 3.5m wide by up to 18m long are feasible, minimising construction time on site. Relatively close spacing of the transverse connecting members allows concrete to be poured to high heads without distorting the structural shape of the panel and without the need for internal reinforcement or external bracing.

[0007] Panels in accordance with this invention enable double skin composite structures to be built in thicknesses that would hitherto have been impractical.

[0008] Trials and experiments conducted by the applicants have shown that, for the majority of double skin composite panels of potential commercial interest, there are limits which must be placed on facing plate thickness, plate separation and cross member spacing if the required panel strength and handliability are to be achieved. Also, that each cross member must be secured to both facing plates, preferably by welding with its longitudinal axis substantially normal to the generally parallel facing plates. These trials have also established that panels having transverse connecting members attached to both face plates can have greater strength than conventional structures having overlapping shear studs.

[0009] Thus, applicants have established that for panels of a width of from 1m to 3.5m and a length of from 2m to 18m, the spacing between the neighbouring cross members is important inter alia to prevent buckling of the plates away from the filler material (normally concrete). If this spacing is too great, there exists a high possibility that buckling will occur. Applicants have also established that there is a relationship between plate thickness and cross-member spacing which should be followed to achieve the required handliability and strength characteristics. Also, applicants have determined a range of steel plate thicknesses which provide the required strength characteristics without overly increasing the weight and handliability of the panels.

[0010] GB-A-2136033 teaches that the spacing between the transverse cross members of a double skin composite panel is preferably equal to the spacing between the facing plates of the panel. Also that the spacing between the cross members can be as high as up to four times the spacing between the facing plates but is advantageously less than twice this spacing. Neither GB-A-2136032 nor GB-A-2258669 teaches what spacings are desirable.

[0011] The present invention sets out to provide double skin composite panels having the characteristics discussed above.

[0012] By the term "double skin composite panel" is meant a panel which comprises two generally parallel facing plates joined together by a plurality of cross-members disposed in a plurality of spaced rows and aligned generally normal to the facing plates, the panel interior being subsequently filled with a filler material, e.g. a cementitious material such as concrete.

[0013] According to the present invention in one aspect there is provided a pre-fabricated double skin panel comprising two steel facing plates which, in use of the panel, are positioned one on each side of a layer of cementitious material and are connected thereto by transverse cross-members which extend generally normal to the facing plates and are attached thereto to define a double skin composite panel of steel and cementitious material, the panel being characterised in that the thickness of each facing plate is between 2mm and 32mm; the spacing between neighbouring cross-
members is between 15 and 50 times the thickness of the facing plates; and the separation between the facing plates is between 100mm and 800mm.

[0014] In a preferred construction, the cross-members are each connected to both facing plates. The cross-members may take the form of bars, tubes, webs or the like.

[0015] Preferably, the width of the panel is between 1 meter and 3.5 meters and the length of the panel is between 2 meters and 18 meters.

[0016] The thickness of each facing plate may be between 3mm and 20mm. Alternatively, this thickness may be between 6mm and 20mm. Alternatively, the separation may be between 150mm and 800mm.

[0017] In one arrangement the spacing between neighbouring cross-members is between 20 and 40 times the thickness of the facing plates. Double skin composite structures are assembled from a multiplicity of individual panels, each panel being welded to its neighbouring panel or panels.

[0018] Preferably, the ends of each cross-member are welded to the facing plates. Alternatively, the connection between some or all of the cross-members may take the form of a pin and socket connection, in which, in one arrangement the cross-member ends are each formed with a pin or deformable socket, a corresponding socket or pin (as the case may be), being secured to the inner surface of the metal plates of the panel.

[0019] The socket may comprise a suitable dimensioned hole or recess formed in the facing plate. The pin is preferably of converging cross-section and defines a friction fit within the aperture or recess.

[0020] Alternatively, each cross-member may be welded at one of its ends to the inner surface of one of the facing plates and may be formed at its other end with a pin or socket, the pin or socket co-operating respectively with a socket or pin secured to the inner surface of the other metal plate of the structure.

[0021] For assembly purposes, each facing plate may have secured to its internal surface a plate formed with a generally flat or profiled section and an inclined end section, the inclined end section acting as a guide when aligning the panel to an adjacent double skin composite panel to which it is to be welded.

[0022] In a preferred arrangement, the plate takes the form of a backing plate which is secured along and protrudes from one side of each inner face of each panel, the plates being secured to the inner faces of the respective panel and each including a first section of a length which overlaps the spacing between neighbouring panels and an end section which is inclined inwardly towards the respective panel centre.

[0023] The cross-members may be steel bars of substantially uniform cross-section along their entire length. Alternatively, the bars may be of "T" or "I" sections.

[0024] The facing plates may be generally flat or curvilinear.

[0025] The invention will now be described by way of example only with reference to the accompanying diagrammatic drawings, in which:-

Figure 1 is a perspective view of a double skin composite panel in accordance with the invention;

Figure 2 is a side view to an enlarged scale of the panel shown in Figure 1;

Figures 3 and 4 are side views of alternative cross-members for use in the panels shown in Figures 1 and 2;

Figure 5 diagrammatically illustrates an assembly of a double skin composite structure from a multiplicity of double skin composite panels as illustrated in Figures 1 to 4;

Figure 6 is a plan view from above of two neighbouring double skin composite panels ready for welding together;

Figure 7 is a scrap view of neighbouring panels during welding;

Figure 8 illustrates a spacer for use with the illustrated apparatus; and

Figures 9 to 12 are side views of alternative cross-members of panels in accordance with the invention.

[0026] The double skin composite panel illustrated in Figures 1 and 2 comprises a plurality of spaced steel cross-members 1, each welded at each of its ends to the internal surfaces of steel facing plates 2, 3. The cross-members 1 are positioned normal to the facing plates and may comprise bars, tubes, or webs. For the sake of simplicity, the cross-members will hereinafter be referred to as bars. To complete the structure the void between the plates is filled with a cementitious material, e.g. normal or lightweight concrete 5. In doing so, the bars 1 become embedded in the concrete.

[0027] As illustrated, the bars 1 are welded between flat plates. On occasions, however, it is necessary to weld bars between plates having a single curvature.

[0028] In use, panels in accordance with the invention are subjected to various forces and stresses which can, unless accommodated, result in panel failure in use. Applicants have determined that failures in a wide range of panel sizes can be prevented, or at least minimised, by ensuring that the facing plate thickness, bar separation and bar spacing fall within the ranges specified below.

[0029] Thus Applicants have established that for panels of a size from 1m by 2m to 3.5m by 18m, the thickness of the steel facing plates must fall within the range 2mm to 32mm. Also the separation between the face plates 2, 3 must be between 100mm and 800mm, and the centre of each bar must be spaced from the centres of the neighbouring bars by a distance equal to between 15 and 50 times the thickness of the facing plates. Preferred spacing ranges are between 20 and
40 times the thickness of the facing plates. As shown the cross-members 1 are welded to the plates 2,3 at centres forming a predetermined pattern. The cross-members need not, however, form any particular pattern.

[0030] The bars 1 illustrated in Figures 1 and 2 are generally cylindrical. There may be occasions, however, when "I" or "T" shaped bars are preferable. Such a bar is illustrated in Figure 3.

[0031] The "I" section connecting member illustrated in Figure 3 includes a vertical web 6 and end flanges 7 (only one of which is shown). The member is secured to each steel facing plate 2,3 by welds 9 and the interface of each web and flange is provided with a radius 10.

[0032] Concrete introduced between the face plates and around the connecting members generates compressive forces which act generally in the direction of Arrow C towards the angle between the connecting members. The major part of the vertical component of these compressive forces as shown in Figure 3 go directly into the flanges 7 thereby urging the flanges 7 into their desired contact with the face plates.

[0033] Bending and tensile forces are still generated at the intersection of the webs 6 and flanges 7, but these do not act at the location of the respective welds 9. The radius 10 greatly reduces stress concentration factors.

[0034] In the arrangement shown, the welds 9 are primarily loaded in shear with a limited amount of direct tension. Thus, a greatly reduced and/or lower quality weld can be employed. Also, for bars the length of weld is significantly increased thereby reducing weld stresses further.

[0035] In the arrangement illustrated in Figure 4, each flange 7 is formed with stepped side portions 12 and a central depression 11, its contact with the adjoining face plate being limited to the stepped side portions 12. Such a construction of connecting member can usefully be employed where the member takes the form of a bar to be welded to the adjoining facing plates by a resistance or friction welding technique.

[0036] Turning now to Figure 5 of the drawings, as shown panels as described above with reference to Figures 1 and 2 are assembled together to produce a double skin composite structure using, for example, a crane 14. As a panel is placed in position by the crane 14, it is welded to its neighbouring panel or panels to produce a double skin composite structure of the required shape and dimensions.

[0037] As will be seen from Figure 6, secured to each of the inner surfaces of the two facing plates 2,3 is a backing plate 15. The plate 15 may be secured by, for example, welding or by adhesive. The backing plate 15 is produced from for example, carbon steel. Each backing plate 15 includes a generally flat or suitably profiled section 16 which overlaps the required spacing 17 between neighbouring panels. The backing plates 15 also include inwardly inclined sections 18 which act to assist alignment of neighbouring panels during assembly of the structure. Thus, the inwardly inclined sections 18 enter and provide guides to enable the backing plates 15 of one panel to enter the adjacent side of the neighbouring panel properly to align the panels one to the other.

[0038] The inclined sections 18 may be formed with holes to enable cement to flow from one side of the backing strip to the other during the filling operation.

[0039] As will be seen from Figure 7, during welding the generally flat section 16 of each backing plate defines one side of a reservoir for retaining molten weld metal produced by resistance heating of welding consumables. The other side of the respective reservoir is defined by a water cooled shoe 19 which is moved upwardly over the outer faces of the sides of the panels in a conventional manner. Typically welding is effected by an electro slag technique.

[0040] As illustrated in Figure 8, a spacer 20 may be positioned initially within the spacing between neighbouring panels for alignment purposes and to ensure a minimum width for welding. These spacers 20 may be removed or consumed during the welding process.

[0041] Alternative forms of cross-members are illustrated in Figures 9 to 12.

[0042] The cross-member illustrated in Figure 9 takes the form of a steel tie bar 21 welded at one end to the facing plate 2 and being formed at its other end with a socket 22. A steel pin 23 is welded to the facing plate 3 and is dimensioned to define a friction fit within the interior of the socket 22. As will be seen from this Figure, the pin tapers inwardly from its base for ease of initial location of the socket over the pin, a force up to the compressive strength of the pin being then applied to one or both steel plates to urge the pin over the socket to provide a mechanical friction connection therebetween. Thus, as the pin enters the socket the latter expands radially to create high radial forces and mobilise friction. Typically the pin and socket are produced by machining or a cold forging process.

[0043] Turning now to the arrangement illustrated in Figure 10, the connector in this embodiment comprises a cross-member in the form of a tubular (or partially tubular) tie bar 24 whose open ends extend over and are deformed by pins 25 secured to each face plate 2,3.

[0044] In Figure 11, the cross-member illustrated comprises a tie bar 26 whose ends define pins 27 which extend into and deform sockets 28 secured to each face plate. Only one end of the bar 26 may define a pin, the other comprising a socket or being simply welded to the other facing plate.

[0045] In Figure 12, a steel pin 29 is dimensioned to define a friction fit within the interior of a socket 30. In this embodiment the socket comprises a shaped aperture in the facing plate 2. The cross-section of the pin 29 tapers to assist location of the pin within the aperture and to ensure a good friction fit between the pin and the
A pre-fabricated double skin panel comprising two steel facing plates (2, 3) which, in use of the panel, are positioned one on each side of a layer of cementitious material and are connected thereto by transverse cross-members (1) which extend gener-ally normal to the facing plates and are attached thereto to define a double skin composite panel of steel and cementitious material, the panel being characterised in that the thickness of each facing plate (2, 3) is between 2mm and 32mm; the spacing between neighbouring cross-members (1) is between 15 and 50 times the thickness of the facing plates; and the separation between the facing plates (2, 3) is between 100mm and 800mm.

2. A panel as claimed in Claim 1 characterised in that each cross-member (1) is connected at its ends to both facing plates (2, 3).

3. A panel as claimed in Claim 1 or Claim 2 wherein the cross-members (1) are produced from steel.

4. A panel as claimed in any one of the preceding Claims characterised in that the thickness of each facing plate (2, 3) is between 3mm and 20mm.

5. A panel as claimed in any one of the preceding Claims characterised in that the thickness of each facing plate (2, 3) is between 6mm and 20mm.

6. A panel as claimed in any one of the preceding Claims characterised in that the separation between the facing plates (2, 3) is between 150mm and 800mm.

7. A panel as claimed in any one of the preceding Claims of a width of between 1 metre and 3.5 metres and a length of between 2 metres and 18 metres.

8. A panel as claimed in Claim 1 characterised in that the spacing between neighbouring cross-members (1) is between 20 and 40 times the thickness of the facing plates (2, 3).

9. A panel as claimed in any one of the preceding Claims characterised in that the cross-members (1) are welded to the facing plates (2, 3).

10. A panel as claimed in any one of Claims 1 to 8 characterised in that each cross-member (1) is connected to one or both facing plates (2, 3) by a pin and socket connection (22, 23).

11. A panel as claimed in any one of the preceding Claims characterised in that each facing plate (2, 3) has secured to its internal surface at one or more edges a backing plate (15) formed with a generally flat or profiled section (16) and an inclined end section (18) capable of acting as a guide during assembly of the panel to an adjoining panel.

12. A panel as claimed in Claim 11 whereby the back-
A panel as claimed in any one of Claims 1 to 12 characterised in that each cross-member (1) comprises a steel bar.

A panel as claimed in Claim 13 wherein each steel bar is of substantially uniform cross-section along its entire length.

A panel as claimed in Claim 13 wherein each steel bar is of "I" or "T" section.

A pre-fabricated double skin composite panel as claimed in Claim 1 wherein the cross-members (1) are connected to the facing plates by connections which comprise a pin or socket (23, 22) welded to the internal surface of one or both facing plates (2, 3) and a complementary socket or pin (22, 23) carried by one or both ends of the cross-members (1) and dimensioned to receive the pin or for insertion into the socket of the adjoining facing plate.

A panel as claimed in Claim 16 wherein the pin (23) and/or the socket (22) is deformable on assembly.

A panel as claimed in any one of the preceding Claims characterised in that the facing plates (2, 3) are generally flat.

A panel as claimed in any one of Claims 1 to 17 wherein the facing plates (2, 3) are generally curvilinear.

Patentansprüche

1. Vorfabriziertes, zweischaliges Verbundpaneel, bestehend aus zwei Verblendstahlplatten (2, 3), die bei der Benutzung des Paneels auf je einer Seite einer Schicht aus zementartigem Material zu liegen kommen und über diese Schicht durch quer verlaufende Verbindungsglieder (1) verbunden sind, die sich allgemein senkrecht zu den Verblendplatten erstrecken und daran befestigt sind, um ein zweischaliges Verbundpaneel aus Stahl und zementartigem Material zu schaffen, wobei das Paneel dadurch gekennzeichnet ist, daß die Dicke einer jeden Verblendplatte (2, 3) zwischen 2 mm und 32 mm liegt; daß der Abstand zwischen benachbarten Querverbindungsgliedern (1) zwischen 15 und 50 mm so groß ist wie die Dicke der Verblendplatten; und daß der Abstand zwischen den Verblendplatten (2, 3) zwischen 100 mm und 800 mm liegt.

2. Paneel nach Anspruch 1,
dadurch gekennzeichnet, daß jedes Querverbindungsglied (1) mit seinen Enden an beiden Verblendplatten (2, 3) festgelegt ist.

3. Paneel nach den Ansprüchen 1 oder 2, bei welchem die Querverbindungsglieder (1) aus Stahl hergestellt sind.

4. Paneel nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, daß die Dicke jeder Verblendplatte (2, 3) zwischen 3 mm und 20 mm liegt.

5. Paneel nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, daß die Dicke einer jeden Verblendplatte (2, 3) zwischen 6 mm und 20 mm liegt.

6. Paneel nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, daß der Abstand zwischen den Verblendplatten (2, 3) zwischen 150 mm und 800 mm liegt.

7. Paneel nach einem der vorhergehenden Ansprüche mit einer Breite zwischen 1 m und 3,5 m und einer Länge zwischen 2 m und 18 m.

8. Paneel nach Anspruch 1,
dadurch gekennzeichnet, daß der Abstand zwischen benachbarten Querverbindungsgliedern (1) die 20- bis 40-Fache der Dicke der Verblendplatten (2, 3) beträgt.

9. Paneel nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, daß die Querverbindungsglieder (1) an den Verblendplatten (2, 3) angeschweißt sind.

10. Paneel nach einem der Ansprüche 1 bis 8,
dadurch gekennzeichnet, daß jedes Querverbindungsglied (1) mit einer oder mit beiden Verblendplatten (2, 3) durch eine aus Stift (23) und Fassung (22) bestehende Anordnung verbunden sind.

11. Paneel nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, daß an der Innenseite einer jeden Verblendplatte (2, 3) an einem oder mehreren Rändern eine Rückhalteplatte (15) festgelegt ist, die einen allgemein flachen oder profilierten Abschnitt (16) und einen schrägen verlaufenden
Endabschnitt (12) aufweist, die als Führung während des Zusammenbaus eines Paneels mit einem benachbarten Panel wirken.


13. Panel nach einem der Ansprüche 1 bis 12, dadurch gekennzeichnet, daß jedes Querverbindungsglied (1) aus einem Stahlstab besteht.

14. Panel nach Anspruch 13, bei welchem jeder Stahlstab einen im wesentlichen gleichförmigen Querschnitt über die gesamte Länge aufweist.

15. Panel nach Anspruch 13, bei welchem jeder Stahlstab einen "I"- oder "T"-Querschnitt aufweist.

16. Vorfabriziertes, zweischaliges Verbundpanel nach Anspruch 1, bei welchem die Querverbindungsglieder (1) an den Verblendplatten durch Verbindungsstücke angeschlossen sind, die aus einem Stift oder einer Fassung (23, 22) bestehen, die an der Innenseite einer oder beider Verblendplatten (2, 3) angeschweißt sind und die komplementären Fassungen oder Stifte (22, 23) von einem oder beiden Enden der Querverbindungsglieder (1) getragen werden und so dimensioniert sind, daß sie den Stift aufnehmen bzw. in die Fassung der benachbarten Verblendplatte eingepasst werden.

17. Panel nach Anspruch 16, bei welchem der Stift (23) und oder die Fassung (22) beim Zusammenbau deformierbar ist.

18. Panel nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Verblendplatten (2, 3) allgemein flach ausgebildet sind.

19. Panel nach einem der Ansprüche 1 bis 17, bei welchem die Verblendplatten (2, 3) allgemein gekrümmt ausgebildet sind.

Revendications

1. Un panneau préfabriqué à double paroi comprenant deux plaques opposées (2, 3) en acier qui, lors de l'utilisation du panneau, sont disposées de part et d'autre d'une couche de matière à base d'un ciment et sont reliées entrelacées par des éléments transversaux (1) qui s'étendent généralement perpendiculairement par rapport aux plaques opposées et sont fixées à celles-ci pour définir un panneau composite à double paroi en acier et en matière à base d'un ciment, le panneau étant caractérisé en ce que l'épaisseur de chaque plaque opposée (2, 3) est entre 2mm et 32mm ; l'espace ment entre les éléments transversaux (1) voisins est entre 15 et 50 fois l'épaisseur des plaques opposées ; et la séparation entre les plaques opposées (2, 3) est entre 100mm et 800mm.

2. Un panneau selon la revendication 1, caractérisé en ce que chaque élément transversal (1) est fixé à ses extrémités aux deux plaques opposées (2, 3).

3. Un panneau selon la revendication 1 ou la revendication 2 dans lequel les éléments transversaux (1) sont produits en acier.

4. Un panneau selon l'une quelconque des revendications précédentes, caractérisé en ce que l'épaisseur de chaque plaque opposée (2, 3) est entre 3mm et 20mm.

5. Un panneau selon l'une quelconque des revendications précédentes, caractérisé en ce que l'épaisseur de chaque plaque opposée (2, 3) est entre 6mm et 20mm.

6. Un panneau selon l'une quelconque des revendications précédentes, caractérisé en ce que la séparation entre les plaques opposées (2, 3) est entre 150mm et 800mm.

7. Un panneau selon l'une quelconque des revendications précédentes ayant une largeur entre 1 mètre et 3.5 mètres et une longueur entre 2 mètres et 18 mètres.

8. Un panneau selon la revendication 1, caractérisé en ce que l'écartement entre les éléments transversaux (1) voisins est entre 20 et 40 fois l'épaisseur des plaques opposées (2, 3).

9. Un panneau selon l'une quelconque des revendications précédentes, caractérisé en ce que les éléments transversaux (1) sont soudés aux plaques opposées (2, 3).

10. Un panneau selon l'une quelconque des revendications 1 à 8, caractérisé en ce que chaque élément transversal (1) est raccordé à une ou deux plaques opposées (2, 3) au moyen d'un connecteur mâle-femelle (22, 23).
11. Un panneau selon l'une quelconque des revendications précédentes, caractérisé en ce que chaque plaque opposée (2, 3) comporte fixé à sa surface interne à un ou davantage de bords, une plaque de renforcement (15) ayant une section (16) généralement plate ou profilée et une section terminale inclinée (18) capable d’agir comme guide pendant l’assemblage du panneau avec le panneau adjoin.

12. Un panneau selon la revendication 11 dans lequel la plaque de renforcement (15) est fixée le long et fait saillie à partir d’un côté de chaque face interne de chaque panneau, le plaques de renforcement (15) étant fixées aux faces internes du panneau respectif et chacune comprenant une première section (16) d’une longueur qui s’étend au-delà de l’extrémité du panneau, et une section terminale (18) qui est inclinée vers l’intérieur vers le centre du panneau.

13. Un panneau selon l’une quelconque des revendications 1 à 12, caractérisé en ce que chaque élément transversal (1) comprend une barre en acier.

14. Un panneau selon la revendication 13 dans lequel chaque barre en acier a une section transversale sensiblement uniforme sur la totalité de la longueur.

15. Un panneau selon la revendication 13 dans lequel chaque barre en acier a une section I ou T.

16. Un panneau composite préfabriqué à double paroi selon la revendication 1 dans lequel les éléments transversaux (1) sont raccordés aux plaques opposées par des connections qui comprennent une cheville ou une douille (23, 22) soudées à la surface interne d’une ou des deux plaques opposées (2, 3) et une douille ou cheville complémentaires (22, 23) portées par une ou les deux extrémités des éléments transversaux (1) et dimensionnées pour recevoir la cheville ou pour l’insertion dans la douille de la plaque opposée adjointe.

17. Un panneau selon la revendication 16 dans lequel la cheville (23) et/ou la douille (22) est déformable sur l’assemblage.

18. Un panneau selon l’une quelconque des revendications précédentes, caractérisé en ce que les plaques opposées (2, 3) sont généralement plates.

19. Un panneau selon l’une quelconque des revendications 1 à 17 dans lequel les plaques opposées (2, 3) sont généralement curvilignes.