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(54) Shuttering for use in the construction industry

Schalung für die Baubranche

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Description

Technical Field

[0001] This invention relates to shuttering for use, particularly in the construction industry, in casting slabs or beams over a substrate, to a method of manufacturing such shuttering and to a method of casting a slab/beam over a substrate.

[0002] The invention relates, more especially, to shuttering for use in casting floor slabs or ground beams over a substrate in which upward movement is expected. The upward movement may, for example, be caused by heaving movement in a clay substrate; this is a common cause of such movement, but other factors may also cause such movement. A floor slab or ground beam cast directly on such a substrate would be at risk of cracking or breaking as a result of excessive upward movement in the substrate applying an upward force on the slab or beam, but the risk can be substantially reduced if the slab or beam can be spaced from the substrate to enable such upward movement to be accommodated.

Background of the Invention

[0003] Traditional approaches to casting slabs or beams over a substrate in which movement, particularly heaving movement, is expected have included shuttering which is intended to be destroyed by moisture emanating from the substrate or introduced deliberately after the slab has been cast. This known form has the disadvantage that it can be destroyed prematurely by moisture from other sources, for example by rainwater. A further disadvantage of this known form is the production of methane gas following its destruction by moisture.

[0004] Another established approach involves the use of shuttering which comprises a support surface on which material is cast, and a support structure of cellular construction located between the support surface and a substrate in which movement is expected. The support structure, which is made of expanded polystyrene supports the weight of the cast material but under a predetermined, higher, compressive force will fail. Shuttering of this nature is disclosed in both GB 2206637 and GB 2241976 and has proved successful commercially. Large blocks of expanded plastics material are formed and then cut into sections of the required size. As a result of this process the sections of expanded plastics material used to construct the support structure may not be of uniform density. A support structure assembled from such sections may then have characteristics (for example, maximum load prior to failure) that are not uniform across the assembled structure. Furthermore, the characteristics of a first support structure panel can differ from that of a second panel which is nominally identical to the first. Such variations can be disadvantageous, especially if it is desired to have only a small gap between the load that the shuttering can safely bear without collapse and the load at which the shuttering is required to have failed.

[0005] In GB 2390390 and GB 2417283 shuttering of the kind just described is modified by moulding it from expanded polystyrene. Shuttering formed in this way can be made with more uniform characteristics resulting in a more consistent and predictable performance of a given product of given dimensions. Such moulded products are currently manufactured and sold by the Applicants under the trade marks CELLCORE and CELLFORM. Moulding products of this kind is challenging and GB 2390390 and GB 2417283GB describe moulding procedures that make it feasible to mould such products cost effectively. A particular issue that has to be addressed is the feeding of polystyrene beads into the mould and to all parts of the support structure. In the embodiments illustrated in GB 2390390 and GB 2417283 and in the equivalent commercial products, the support structure comprises a multiplicity of four-sided cells bounded by a first set of walls extending across the structure in a first direction and a second set of walls extending across the structure in a second direction perpendicular to the first. It is challenging to feed material into the walls during the moulding process.

[0006] A support structure of the kind described above has a first supporting condition, in which it is manufactured, in which it can accommodate a given loading with very little compression of the material. The depth of the support structure of the product in this condition is referred to herein as the depth (D) of the support structure in the first supporting condition. The maximum loading at which the support structure is assured of remaining in the first supporting condition is referred to in commercial products as the "Safe Load" and during casting of a slab or beam this Safe Load should not of course be exceeded. The support structure also has a second failed condition, in which the walls have failed. The minimum loading at which this is assured of having occurred is referred to in commercial products as the "Fail Load". As the loading on the product increases from zero towards the Safe Load, so its resistance to compression is maintained, but, after the loading exceeds the Safe Load, the resistance of the product to compression stops increasing and even reduces until the product is much reduced in depth. At some much reduced depth the product will again increase its resistance to compression and there is a reduced depth at which the load that has to be applied to cause yet further reduction in depth exceeds the Fail Load. That reduced depth is therefore the depth that the support structure has at the Fail Load and is referred to herein as the depth (d) of the support structure in the second failed condition. As will be understood it is a simple matter to apply a test load to a product to establish the Safe Load and the Fail Load and also to establish the depth of the support structure in both the first supporting condition and the second failed condition.

[0007] Products of the kind referred to are used in a variety of applications and those different applications require different specifications of product. For a given application, there are two main kinds of variable to be specified: one is the amount of upward movement that the product is required to accommodate; the other is the value of the Safe Load that the product is required to accommodate, with the Fail Load preferably being only slightly higher than the Safe Load.

[0008] In current commercially available standard products the amounts of upward movement accommodated are 50mm, 100mm and 150mm. The more movement that is required to be accommodated, the greater the depth of product required in order that the difference in depth between the depth (D) of the support structure in the first supporting condition and the depth (d) of the support structure in the second failed condition is equal to the amount of upward movement to be accommodated. In commercial products that embody the invention of GB 2390390 and GB 2417283 the support structure for accommodating an upward movement of 50mm has a depth of about 95mm, a support structure for accommodating an upward movement of 100mm has a depth of about 170mm and a support structure for accommodating an upward movement of 150mm has a depth of about 245mm.

[0009] In the products just described, typical Safe Loads and Fail Loads are: a Safe Load of 20KN/m^2 and a Fail Load of 30kN/m^2; a Safe Load of 15kN/m^2 and a Fail Load of 22kN/m^2; a Safe Load of 10kN/m^2 and a Fail load of 15kN/m^2; a Safe Load of 8kN/m^2 and a Fail Load of 12kN/m^2. The Safe and Fail Loads are controlled primarily by adjusting the density of the supporting structure.

[0010] When using shuttering of the kind referred to, it is of course necessary to provide a space below the level of the slab to accommodate the shuttering and in many cases that will mean that an additional amount of excavation of the substrate is required. That extra excavation often involves extra cost.

[0011] It is an object of the invention to provide improved shuttering for use, in the construction industry, in casting slabs or beams over a substrate, to provide an improved method of manufacturing such shuttering and to provide a method of casting a slab/beam over a substrate

Summary of the Invention

[0012] According to a first aspect of the invention there is provided shuttering for use in casting a slab/beam over a substrate, comprising a hollow support structure including a plurality of spaced apart walls, the support structure being able to be placed on the substrate to support the slab/beam during casting, wherein the support structure is formed with its spaced apart walls by a moulding process and is moulded from expanded plastics material and characterized in that the support structure has a first supporting condition in which the depth of the support structure is D and a second collapsed condition in which the depth of the support structure is d, wherein d is less than 0.38D.

[0013] By providing a support structure in which the depth of the structure reduces to less than 0.38 of its original depth upon failure it becomes possible to provide an arrangement in which the amount of excavation required to provide a support structure capable of accommodating a given upward movement of a substrate is reduced, thereby reducing the cost of using the shuttering according to the invention. For example in a possible example of the invention described below, a support structure able to accommodate about 150mm of upward movement has depth D in a first supporting condition of about 215mm and a depth d in a second failed condition of about 65mm. This reduction of depth represented by d being equal to about 0.30D may be contrasted to current commercially available shuttering of the same kind where to accommodate the same 150mm of movement the supporting structure has a depth D in a first supporting condition of 245mm and a depth d in the failed condition of 95mm.

[0014] Preferably, in shuttering embodying the invention, d is less than 0.36D and more preferably d is less than 0.33D.

[0015] Preferably, shuttering embodying the invention has relatively thin walls. When moulding shuttering it is generally desirable to provide thick walls in order to facilitate introduction of material into the walls during the moulding process. In the present invention, however, it is preferred to ignore that general teaching and to employ relatively thin walls and accept the difficulties that arise as a result. The walls are preferably less than 15mm thick and more preferably less than 13.5mm thick. Preferably all the walls are of the same thickness but it is within the scope of the invention for the walls to be of varying thickness and in that case a minority of the walls may have a thickness greater than the preferred upper ranges given above.

[0016] In a typical process for moulding a product from expanded polystyrene the raw material employed is non-expanded beads of polystyrene. Such non-expanded beads typically have a diameter of the order of 1mm. The beads are then steamed to cause them to expand and the degree of expansion at this stage can be controlled according to the density of the expanded polystyrene material required for the final product. The size of the bead after this first stage of expansion for products that might be suitable for the present invention is likely to be in the range of 2mm to 10mm and the expanded beads have to be introduced into the mould cavity. Whilst if the expanded bead size is only 2mm, the size is fairly immaterial, when a product of relatively low density, providing relatively low Safe and Fail Loads is required, the bead size has to be relatively big. For a larger expanded bead size, it can immediately be seen that there is a significant difference between moulding a wall having a thickness of 16.5mm and a wall having any less thickness. In embodiments of the invention described below, the walls have a thickness of only 13mm. As already indicated, in the preferred embodiments of the invention, the teaching towards the use of walls much thicker than 10mm to facilitate moulding is ignored and thinner walls are employed. Various techniques may then be used to make it feasible to mould even relatively low density products and these are referred to elsewhere in this specification.

[0017] The actual depth D selected for the support structure in the first supporting condition depends upon the amount of upward movement of the substrate that is required to be accommodated. In one example where about 150mm of upward movement is to be accommodated by the shuttering, the depth D of the support structure in the first supporting condition is in the range of 200mm to 220mm and the depth d of the support structure in the second collapsed condition is more than 140mm less than the depth D in the first supporting condition. In another example where about 100mm of upward movement is to be accommodated by the shuttering, the depth D of the support structure in the first supporting condition is in the range of 140mm to 160mm and the depth d of the support structure in the second collapsed condition is more than 95mm less than the depth D in the first supporting condition. In another example where about 50mm of upward movement is to be accommodated by the shuttering, the depth D of the support structure in the first supporting condition is in the range of 70mm to 80mm and the depth d of the support structure in the second collapsed condition is more than 45mm less than the depth D in the first supporting condition.

[0018] The Safe and Fail Loads of the shuttering for given dimensions of the support structure can be adapted by selecting an appropriate density of the expanded plastics material. In examples of the support structure, the Safe Load varies between about $7kN/m^2$ and about $24kN/m^2$ while the Fail Load varies between about $10kN/m^2$ and about $30kN/m^2$. Some examples of pairs of Safe/Fail loads, all in kN/m^2, are 7/10, 9/13, 13/18, 17/23 and 24/30. Thus the Safe Load is typically about three quarters of the Fail Load. Preferably the Safe Load is at least 70% of the Fail Load.

[0019] The hollow support structure may define a multiplicity of four-sided cells bounded by a first set of walls extending across the structure in a first direction and a second set of walls extending across the structure in a second direction transverse to the first direction. Whilst it is within the scope of the invention for the first and second directions in which the walls extend to be at an angle significantly away from 90 degrees, it is preferred that the second direction is perpendicular to the first direction.

[0020] The spacing of adjacent walls is preferably uniform across the structure, preferably in the case of both sets of walls. The spacing of walls in one of the sets of walls may be the same as or different from the spacing in the other of the two directions. In a preferred arrangement of the invention the centre-to-centre spacing of adjacent walls in one of the sets of walls is in the range of 148mm to 152mm. In that same arrangement or in another arrangement, the centre-to-centre spacing of adjacent walls in one of the set of walls is in the range of 158mm to 162mm. In an embodiment of the invention described below, the spacing of the first set of walls is in the range of 148mm to 152mm and the spacing of the second set of walls is in the range of 158mm to 162mm. A spacing of about 150mm is especially suitable for a support structure that may be cut to form shuttering for beams that are 600mm wide or 450mm wide or of any other width that is an integral number of 150mm widths.

[0021] Preferably, the planes of the support walls, whilst approximately vertical, are angled to the vertical, preferably at an angle in the range of 0.5 to 5 degrees to the vertical; in an embodiment described below, the angle is about 1.3 degrees to the vertical, and larger inclinations are acceptable. Preferably, adjacent walls are angled in opposite directions, so that whilst one cell tapers in one direction through the thickness of the support structure the adjacent cells taper in the opposite direction. As explained below, such an arrangement facilitates moulding of the support structure.

[0022] According to the invention, the walls are recessed in the regions of at least some of their intersections. Preferably the recesses are formed during the moulding process but it is also possible to form them by removing material after moulding. The recesses may be provided at the top and/or bottom of the support structure. The recesses define passageways between adjacent cells in the support structure. A recess may define a passageway between only two adjacent cells, between three adjacent cells or, as in a preferred embodiment, between four adjacent cells. It is already known to provide such passageways away from the intersections of the walls to allow drainage, for example of water, from one cell to another. The provision of passageways at the intersections of the walls also serves that purpose but is able additionally to serve two other purposes: firstly, it facilitates moulding of thin walls and, secondly, it facilitates an even collapse of the supporting structure when it fails. A brief explanation of how those advantages are achieved will now be given.

[0023] A difficulty when moulding thin walls is the small physical size of the openings in the mould between opposite portions of the mould defining the space into which material has to be introduced to form the mould. The size is greatest at the intersection of walls and it is therefore preferred to introduce material into the mould cavity at that position. By providing a recess at the intersection, a bigger space is created in which to provide a point for introducing material into the mould cavity.

[0024] As already described, an advantage of making the support structure by moulding is that a more consistent product can be obtained and of course this is advantageous in facilitating prediction of the load at which the structure fails. We have found, however, that in the case of a support structure that does not employ recesses at the intersections of the walls, those intersections represent regions of increased resistance to failure and consequently there is a tendency for the structure to behave non-uniformly as the load on it is increased beyond the Safe Load. By providing the recesses, the forces on the support structure from the slab/beam and/or the substrate are no longer applied directly at the intersections and so more uniform collapse of the structure can be achieved.

[0025] Usually the support structure is open on its top face and the shuttering further comprises a top sheet of material on the top of the support structure. The sheet may be placed loosely on top of the support structure but preferably is attached to the support structure, for example by adhesive. The top sheet may be of the same width as the support structure. The top sheet may be wider than the support structure; in that case, portions of the top sheet projecting beyond the sides of the support structure may be able to be folded upwardly, for example to provide shuttering sides for a beam cast between the upwardly extending portions.

[0026] Similarly the shuttering may further comprise a bottom sheet of material on the bottom of the support structure. That sheet is preferably also attached to the support structure, for example by adhesive. The sheet or sheets of material may be of any suitable form but may comprise a polypropylene sheet which may be fluted or may comprise a sheet of expanded polystyrene with a thin sheet of polypropylene on the outside. When the sheet comprises a polypropylene sheet alone, it may be 5mm to 10mm thick.

[0027] When in use a slab or beam is cast on shuttering of the invention, a structure is formed with the shuttering below. Accordingly, the invention also provides a structure including a slab or beam cast on shuttering of the first second or third aspects of the invention.

[0028] The present invention further provides a method of manufacturing shuttering for use in casting a slab/beam over a substrate, the method including the step of moulding a support structure from expanded polystyrene material to provide shuttering of the first second or third aspects of the invention.

[0029] The method may further include the step of introducing material into the mould at locations corresponding to intersections of the support walls.

[0030] Different moulds are required to mould shuttering of different depths and it is desirable to have as few moulds as possible. The depth of the shuttering can, if desired, be increased by placing one support structure of the invention on top of another. Such an arrangement may be desirable if an especially large amount of upward movement of a substrate is expected. In order to form shuttering of relatively small depth, the method of the invention may include the step of cutting the moulded product into two halves along a plane partway between the top and bottom of the support structure. If the moulded product is cut midway between the top and bottom of the support structure, then both halves may be employed for shuttering of relatively small depth.

[0031] The method preferably further includes the step of securing a top sheet over the support structure.

[0032] Especially when moulding support structures of relatively low density, it may be desirable to use non-expanded beads of a smaller size than are conventionally used for building products made of expanded polystyrene, in order that the size of the expanded beads introduced into the mould are not too large.

[0033] The present invention still further provides a method of casting a slab/beam over a substrate, the method including the step of placing shuttering according to any of the first second or third aspects of the invention on the substrate, and casting the slab/beam on the top of the shuttering.

[0034] The substrate may rise after casting of the slab/beam and the shuttering may then fail. Thus excess upward pressure on the slab/beam is avoided.

[0035] Similarly the shuttering of the invention and the methods of the invention as described herein are closely related. Thus, features described above in respect of the shuttering may be incorporated into the methods of the invention and *vice versa.*

Brief Description of the Drawings

[0036] By way of example, an embodiment of the invention will now be described with reference to the accompanying drawings, in which:

- Fig. 1 is a side view of a shuttering panel constructed in accordance with the invention,
- Fig. 2 is a view in the direction of arrow A, of the bottom sheet of the shuttering panel in Fig. 1,
- Fig. 3 is an enlarged side view of the shuttering of Fig. 1,
- Fig. 4 is an enlarged view of a section of the bottom sheet of the shuttering panel in Fig. 1,
- Fig. 5 is an isometric view of a hollow support structure forming part of the shuttering panel,
- Fig. 6 is a vertical section illustrating the panel in use,
- Fig. 7 is the same vertical section but shows the arrangement after the support structure has partly collapsed, and
- Fig. 8 is an isometric view of part of the structure of Figure 5, showing recesses at intersections of the walls.

Detailed Description of Embodiments

[0037] When describing embodiments of the invention, it is convenient to begin with a general description of the shuttering and thereafter describe certain particular examples of the invention and the special features that are particular to the present invention.

[0038] The shuttering panel 1 shown in Figures 1 and 2 comprises a hollow support structure 2 and a top sheet 3.

[0039] The top sheet 3 has a pair of long sides 4 and a pair of short sides 5. The top sheet 3 is formed from any suitable material. It may, for example, be heavy duty polypropylene sheet or a sheet of expanded polystyrene topped with a thin sheet of polypropylene. The support structure may be bonded to the top sheet in any suitable manner, for example by an impact adhesive.

[0040] The hollow support structure 2 comprises a plurality of support walls 6,7. The plane of each wall is substantially perpendicular to the plane of the top sheet 3. In this particular embodiment the support walls 6,7 whilst substantially perpendicular, are angled to the vertical at an angle of the order of one degree. Some of the support walls, referenced 6, run parallel to the long sides 4 of the top sheet, while the remaining support walls, referenced 7, run in a direction substantially parallel to the short sides of the top sheet 3 and therefore perpendicular to the long sides and to the walls 6. The support walls 6 extend continuously along the length of the top sheet 3 and the support walls 7 extend continuously across the width of the top sheet 3. The support walls are of a uniform thickness in order to obtain more uniform performance characteristics across the hollow support structure.

[0041] The support walls are spaced apart substantially regularly in both directions such that the support walls define cells 8,9. The cells 8,9 defined by the support walls 6,7 are approximately square in plan.

[0042] The hollow support structure 2 is formed in its hollow form by a moulding process, from expanded plastics material. In the embodiment shown the support structure is moulded from expanded polystyrene. By forming the hollow support structure by moulding rather than cutting the required hollow shape from a block of material, it is possible to mould a structure which is devoid of any bulky regions of solid material and consequently it is possible to obtain more uniform characteristics of the expanded plastics material throughout the structure.

[0043] Figures 3 and 4 show the support structure in greater detail. As a result of the moulding process the cells 8,9 defined by the support walls 6,7 taper slightly between the top sheet 3 and the bottom of the hollow support structure 2. In Figures 3 and 4, the angling of the substantially perpendicular support walls has been exaggerated. Some of the cells, referenced 8, defined by the support walls 6,7 have a larger cross section at the bottom of the hollow support structure 2 than at the top of the support structure 2. The remaining cells, referenced 9, have a smaller cross section at the bottom of the hollow support structure 2 than at the top of the support structure. The distance between adjacent walls 6,7 varies as a function of displacement from the top sheet 3 towards the substrate in a direction perpendicular to the plane of the top surface of the support structure. This tapered cell structure enables simple release of the moulded hollow support structure from the mould.

[0044] The manner in which the shuttering panel 1 is used in laying a floor slab of a building is illustrated in Figures 6 and 7. The normal surface level of the substrate 10 is shown, as is one of the piles 11 that are sunk into the substrate to support the building. A conventional ground beam 12 of reinforced concrete extends along the top of a line of piles 11, to support one of the walls of the building between which a suspended floor slab is to be constructed.

[0045] The substrate over which the floor slab is to be constructed is excavated to the required depth and the surface of the substrate is made level. Shuttering panels 13, each as shown in Figures 1 to 5, are then laid edge to edge to cover the prepared surface completely. The joins between adjacent panels are covered over, for example with a formwork tape. Full size panels may be cut to ensure the prepared surface is completely covered.

[0046] The bottom of the hollow support structure rests on the prepared surface. In Figure 6 the support structure is shown in its first supporting condition occupying a depth D.

[0047] Conventional steel reinforcement (not shown) for the suspended floor panel is then secured over the panels 13, and is spaced slightly above the tops of the panels by conventional spacers (not shown). Concrete is then laid over the support panels 13 and vibrated in the normal way.

When the top surface of the concrete has been finished, for example by tamping, the concrete is left to cure. During the laying and initial curing process, the concrete is supported by the panels 13 but, as the concrete cures, the floor slab 14 becomes self-supporting between the walls.

[0048] If heaving movement occurs in the substrate, a vertical compressive force is exerted on the support walls 6,7. Initially creep occurs in the expanded polystyrene material and, if the heaving movement of the substrate is extensive, the support walls 6,7 begin to compress. If the compressive force on the support walls 6,7 is such that it exceeds a predetermined limit, the moulding will fail. The resistance of the support walls 6, 7 to further compression will actually reduce and thus the resistance to further heaving movement reduces. Of course, if the heaving movement were to continue beyond the amount that the shuttering is designed to accommodate, the resistance to heaving movement would then increase beyond the original resistance level. Figure 7 shows the situation where there has been some heaving movement but not as much as the shuttering is designed to accommodate. Thus Figure 7 shows the support structure as it is collapsing and occupying a depth d'. If no heaving movement of the substrate occurs to bring about the breakup of the support walls 6,7 the shuttering panel 1 and in particular, the hollow support structure 2, will remain intact.

[0049] It is also possible to use shuttering of the type above to provide support on which a ground beam 12 is cast. In this case, panels of a different size are likely to be required. Typically, shuttering panels for use in casting ground beams have a width in the range 300mm to 1200mm and, most commonly 450mm and 600mm.

[0050] Shuttering of the type above can be used in many situations in which concrete slabs or beams are cast over a substrate, for example, under reinforced suspended ground and basement floors, piled beams and piled rafts. The support structure of the shuttering can compress and collapse under the load from the substrate, caused for example by swelling clay or ground heave, and allows movement and pressure release to occur. The hollow support structure 2 of the shuttering panel also serves to insulate the concrete and thus accelerates the curing of the concrete, especially in cold weather.

[0051] The dimensions of the hollow support structure are determined by the mould. The hollow support structure is produced in sections which are typically 2.4m long and 1.2m wide. When the top sheet 3 comprises simply a single polypropylene sheet, it will typically have a thickness of the order of 5mm to 10mm. When the top sheet 3 comprises a layer of expanded polystyrene on top of which there is a polypropylene sheet it may have a thickness of the order of 50mm. Other dimensions of the shuttering will be described in more detail below with reference to some particular examples. In the examples the centre-to-centre spacing of the walls 6 is 150mm and the centre-to-centre spacing of the walls 7 is 160mm.

[0052] The dimensions referred to are particularly advantageous as the most commonly used widths, 450mm to 600mm, can be easily cut from the moulded panel. Sections of support structures of these widths are generally used to support ground beams rather than cast floor slabs. The full size moulded support structure panel may be cut using a saw or a hot wire. In the case of a beam of 600mm in width, the full size panel is cut, using hot wires, into two sections. The panel is cut parallel to the long sides 4.

[0053] The thickness, number, height and/or layout of the support walls 6,7 can be varied, having regard to the conditions under which the walls are required to fail and bearing in mind that a change in the thickness and number of walls will alter the surface area over which the walls contact the substrate. For example, the size of the cells defined by the walls can be decreased by increasing the number of shorter support walls 7 and/or increasing the number of longer support walls 6.

[0054] The support structure 2 is moulded in one piece directly in the shape shown for example in Figure 5. Alternate cells are formed by projecting parts of appropriate halves of the mould and the tapering of the cells assist the withdrawal of the mould halves from the support structure after moulding. Since the support structure 2 is devoid of any bulky regions, all of it is close to a surface of the mould during the moulding process and it is therefore possible to achieve a very good uniformity throughout the structure 2 of the density of the expanded material forming the structure.

[0055] The shuttering panel shown in Figures 1 and 2 can, if required, be modified further by adding a bottom sheet similar to the top sheet which is locatable between the support structure and the substrate. This bottom sheet may be made out of a sheet of a suitable rigid material similar to that of the top sheet: it may, for example, also be expanded polystyrene. The surface may be bonded to the hollow support structure, for example by an impact adhesive.

[0056] Figure 8 illustrates the support structure 2 according to the invention. As can be seen only in this figure, the walls 6 and 7 are recessed at their intersections to create recesses 20. Figure 8 shows the recesses at the tops of the walls 6 and 7, but it should be understood that similar recesses may be provided at the bottoms of the walls. The recesses define passageways that provide fluid communication between adjacent cells, with all four cells adjoining an intersection being in communication with one another via the passageways. In addition to providing passageways for fluid communication, the recesses also have the advantage of reducing the extent to which compressive loads on the structure are borne by the intersecting portions of the walls 6 and 7, and of defining a relatively large space in a mould for an injector through which mould material can be injected into the walls 6 and 7 during moulding.

[0057] It is desirable to provide the shuttering described above as a range of products to cover different applications, according to the Safe Load that the product is required to bear and the amount of upward movement of the ground that the product is required to accommodate. Some particular examples of products that may be made available are set out below.

[0058] In all the examples the shuttering is of the kind described above with reference to Figs. 1 to 7 and the support structure has the following dimensions:

Centre-to-centre spacing of walls 6: 150mm
Centre-to-centre spacing of walls 7: 160mm
Thickness of walls 6 and 7: 13mm
Thickness of top sheet 3: 10mm

Example 1

[0059] In the first example the depth D of the walls 6 and 7 when first moulded is about 215mm. The support structure 2 is moulded from expanded polystyrene having a density of about 19kg/m^3 and this results in shuttering with a Safe Load of 9kN/m^2 and a Fail Load of 13kN/m^2 When in testing, the Fail Load of 13kN/m^2 is applied, the support structure 2 reduces in depth by about 150mm to a depth d of about 65mm.

Example 2

[0060] In the second example the depth D of the walls 6 and 7 when first moulded is about 150mm. The support structure 2 is moulded from expanded polystyrene having a density of about 28kg/m^3 and this results in shuttering with a Safe Load of 17kN/m^2 and a Fail Load of 23kN/m^2 When in testing, the Fail Load of 23kN/m^2 is applied, the support structure 2 reduces in depth by about 100mm to a depth d of about 50mm.

Example 3

[0061] In the third example the depth D of the walls 6 and 7 when first moulded is about 150mm. The support structure 2 is moulded from expanded polystyrene having a density of about 22kg/m^3 The structure is then cut in half by a hot wire to provide two structures of depth about 75mm and this results in shuttering with a Safe Load of 13kN/m2 and a Fail Load of 18kN/m^2. When in testing, the Fail Load of 18kN/m^2 is applied, the support structure 2 reduces in depth by about 50mm to a depth d of about 25mm.

[0062] Where in the foregoing description, integers or elements are mentioned which have known, obvious or foreseeable equivalents, then such equivalents are herein incorporated as if individually set forth. Reference should be made to the claims for determining the true scope of the present invention, which should be construed so as to encompass any such equivalents. It will also be appreciated by the reader that integers or features of the invention that are described as preferable, advantageous, convenient or the like are optional and do not limit the scope of the independent claims.

Claims

1. Shuttering for use in casting a slab/beam over a substrate, comprising a hollow support structure (2) including a plurality of spaced apart walls (6,7), the support structure (2) being able to be placed on the substrate to support the slab/beam during casting, wherein the support structure (2) is formed with its spaced apart walls (6,7) by a moulding process and is moulded from expanded plastics material and **characterized in that** the support structure (2) has a first supporting condition in which the depth of the support structure (2) is D and a second collapsed condition in which the depth of the support structure (2) is d, wherein d is less than 0.38D, and wherein the walls (6,7) are recessed in the regions of at least some of the intersections, the recesses defining passageways between adjacent cells.

2. Shuttering according to claim 1, in which the depth D of the support structure (2) in the first supporting condition is in the range of 200mm to 220mm and the depth d of the support structure (2) in the second collapsed condition is more than 140mm less than the depth D in the first supporting condition.

3. Shuttering according to claim 1 or 2, in which the depth D of the support structure (2) in the first supporting condition is in the range of 140mm to 160mm and the depth d of the support structure (2) in the second collapsed condition is more than 90mm less than the depth D in the first supporting condition.

4. Shuttering according to any preceding claim, in which the depth D of the support structure (2) in the first supporting condition is in the range of 70mm to 80mm and the depth d of the support structure (2) in the second collapsed condition is more than 45mm less than the depth D in the first supporting condition.

5. Shuttering according to any preceding claim, in which the hollow support structure (2) defines a multiplicity of four-sided cells bounded by a first set of walls (6) extending across the structure in a first direction and a second set of walls (7) extending across the structure in a second direction transverse to the first direction.

6. Shuttering according to claim 5, in which the spacing of adjacent walls (6,7) of the support structure (2) is uniform across the structure and the centre-to-centre spacing of adjacent walls (6,7) in one of the sets of walls is in the range of 148 to 152mm and/or the centre-to-centre spacing of adjacent walls (6,7) in one of the sets of walls is in the range of 158 to 162mm.

7. Shuttering according to any preceding claim, in which the plane of each support wall (6,7) is approximately vertical but is angled to the vertical.

8. Shuttering according to any preceding claim, further comprising a top sheet (3) of material on the top of the support structure (2).

9. Shuttering according to any preceding claim, in which the thickness of the walls (6,7) is less than 15mm.

10. A structure including a slab or beam cast on shuttering according to any preceding claim.

11. A method of manufacturing shuttering for use in casting a slab/beam over a substrate, the method including the step of moulding a support structure (2) from expanded polystyrene material to provide shuttering according to any of claims 1 to 9.

12. A method according to claim 11, including the step of introducing material into the mould at locations corresponding to intersections of the support walls (6,7).

13. A method according to claim 11 or 12, including the step of cutting the moulded product into two halves along a plane partway between the top and bottom of the support structure.

14. A method of casting a slab/beam over a substrate, the method including the step of placing shuttering (12) according to any of claims 1 to 9 on the sub-

strate, and casting the slab/beam (13) on the top of the shuttering.

Patentansprüche

1. Schalung zur Verwendung beim Gießen von einer Platte oder einem Balken über einem Substrat, wobei die Schalung eine hohle Trägerstruktur (2) aufweist, welche eine Vielzahl von voneinander beabstandeten Wänden (6, 7) aufweist, wobei die Trägerstruktur (2) auf dem Substrat angeordnet werden kann, um die Platte oder den Balken während des Gießens zu tragen, wobei die Trägerstruktur (2) mit ihren voneinander beabstandeten Wänden (6, 7) mit einem Formgebungsprozess geformt ist und aus expandiertem Kunststoffmaterial geformt ist, **dadurch gekennzeichnet, dass** die Trägerstruktur (2) einen ersten tragenden Zustand, in welchem die Tiefe der Trägerstruktur (2) einen Wert D besitzt, und einen zweiten kollabierten Zustand aufweist, in welchem die Tiefe der Trägerstruktur (2) einen Wert d besitzt, wobei d kleiner als 0,38D ist, und
wobei die Wände (6, 7) in den Bereichen von mindestens einigen von ihren Kreuzungen mit Aussparungen versehen sind, wobei die Aussparungen Durchgänge zwischen benachbarten Zellen bilden.

2. Schalung nach Anspruch 1,
wobei die Tiefe D der Trägerstruktur (2) in dem ersten tragenden Zustand im Bereich von 200 mm bis 220 mm liegt und die Tiefe d der Trägerstruktur (2) in dem zweiten kollabierten Zustand um mehr als 140 mm geringer als die Tiefe D im ersten tragenden Zustand ist.

3. Schalung nach Anspruch 1 oder 2,
wobei die Tiefe D der Trägerstruktur (2) in dem ersten tragenden Zustand im Bereich von 140 mm bis 160 mm liegt und die Tiefe d der Trägerstruktur (2) in dem zweiten kollabierten Zustand um mehr als 90 mm geringer als die Tiefe D in dem ersten tragenden Zustand ist.

4. Schalung nach einem der vorhergehenden Ansprüche,
wobei die Tiefe D der Trägerstruktur in dem ersten tragenden Zustand im Bereich von 70 mm bis 80 mm liegt und die Tiefe d der Trägerstruktur (2) in dem zweiten kollabierten Zustand um mehr als 45 mm geringer als die Tiefe D in dem ersten tragenden Zustand ist.

5. Schalung nach einem der vorhergehenden Ansprüche,
wobei die hohle Trägerstruktur (2) eine Vielzahl von vierseitigen Zellen bildet, die durch einen ersten Satz von Wänden (6) begrenzt sind, welche sich längs der Struktur in einer ersten Richtung erstrecken, und einen zweiten Satz von Wänden (7) begrenzt sind, welche sich längs der Struktur in einer zweiten Richtung quer zu der ersten Richtung erstrecken.

6. Schalung nach Anspruch 5,
wobei der Abstand von benachbarten Wänden (6, 7) der Trägerstruktur (2) gleichmäßig über die Struktur ausgebildet ist und der Abstand von Mittezu-Mitte von benachbarten Wänden (6, 7) in einem der Sätze von Wänden im Bereich von 148 mm bis 152 mm liegt und/oder der Abstand von Mittezu-Mitte von benachbarten Wänden (6, 7) in einem der Sätze von Wänden in dem Bereich von 158 mm bis 162 mm liegt.

7. Schalung nach einem der vorhergehenden Ansprüche,
wobei die Ebene von jeder Stützwand (6, 7) ungefähr vertikal ist, aber gegenüber der Vertikalen geneigt ist.

8. Schalung nach einem der vorhergehenden Ansprüche,
die ferner einen oberen Flächenkörper (3) aus einem Material an der Oberseite der Trägerstruktur (2) aufweist.

9. Schalung nach einem der vorhergehenden Ansprüche,
wobei die Dicke der Wände (6, 7) weniger als 15 mm beträgt.

10. Struktur mit einer Platte oder einem Balken, der auf der Schalung nach einem der vorhergehenden Ansprüche gegossen ist.

11. Verfahren zum Herstellen einer Schalung zur Verwendung beim Gießen von einer Platte oder einem Balken über einem Substrat,
wobei das Verfahren einen Schritt umfasst, bei dem eine Trägerstruktur (2) aus expandiertem Polystyrolmaterial geformt wird, um eine Schalung gemäß einem der Ansprüche 1 bis 9 zu bilden.

12. Verfahren nach Anspruch 11,
das einen Schritt umfasst, bei dem ein Material in die Form an Orten eingeführt wird, welche Kreuzungen der Tragwände (6, 7) entsprechen.

13. Verfahren nach Anspruch 11 oder 12,
das einen Schritt umfasst, bei dem das geformte Produkt in zwei Hälften geschnitten wird, und zwar längs einer Ebene, die zwischen der Oberseite und der Unterseite der Trägerstruktur liegt.

14. Verfahren zum Gießen einer Platte oder eines Balkens über einem Substrat,

wobei das Verfahren einen Schritt umfasst, bei dem eine Schalung (12) gemäß einem der Ansprüche 1 bis 9 auf dem Substrat angeordnet wird, und einen Schritt umfasst, bei dem die Platte oder der Balken (13) auf der Oberseite der Schalung gegossen wird.

Revendications

1. Coffrage pour une utilisation dans la coulée d'une dalle/poutre au-dessus d'un substrat, comprenant une structure de support creuse (2) incluant une pluralité de parois espacées (6, 7), la structure de support (2) étant apte à être placée sur le substrat pour supporter la dalle/poutre pendant la coulée, dans lequel la structure de support (2) est formée avec ses parois espacées (6, 7) par un procédé de moulage et est moulée à partir d'une matière plastique expansée et **caractérisé en ce que** la structure de support (2) a un premier état de support dans lequel la profondeur de la structure de support (2) est D et un second état écrasé dans lequel la profondeur de la structure de support (2) est d, dans lequel d est inférieur à 0,38D, et dans lequel les parois (6, 7) sont évidées dans les régions d'au moins plusieurs de leurs intersections, les évidements définissant des voies de passage entre des cellules adjacentes.

2. Coffrage selon la revendication 1, dans lequel la profondeur D de la structure de support (2) dans le premier état de support est dans l'intervalle de 200 mm à 220 mm et la profondeur d de la structure de support (2) dans le second état écrasé est supérieure à 140 mm inférieure à la profondeur D dans le premier état de support.

3. Coffrage selon la revendication 1 ou 2, dans lequel la profondeur D de la structure de support (2) dans le premier état de support est dans l'intervalle de 140 mm à 160 mm et la profondeur d de la structure de support (2) dans le second état écrasé est supérieure à 90 mm inférieure à la profondeur D dans le premier état de support.

4. Coffrage selon l'une quelconque des revendications précédentes, dans lequel la profondeur D de la structure de support (2) dans le premier état de support est dans l'intervalle de 70 mm à 80 mm et la profondeur d de la structure de support (2) dans le second état écrasé est supérieure à 45 mm inférieure à la profondeur D dans le premier état de support.

5. Coffrage selon l'une quelconque des revendications précédentes, dans lequel la structure de support creuse (2) définit une multiplicité de cellules à quatre côtés délimitées par un premier ensemble de parois (6) s'étendant à travers la structure dans une première direction et un second ensemble de parois (7) s'étendant à travers la structure dans une seconde direction transversale à la première direction.

6. Coffrage selon la revendication 5, dans lequel l'espacement des parois adjacentes (6, 7) de la structure de support (2) est uniforme à travers la structure et l'espacement centre à centre des parois adjacentes (6, 7) dans l'un des ensembles de parois est dans l'intervalle de 148 à 152 mm et/ou l'espacement centre à centre des parois adjacentes (6, 7) dans l'un des ensembles de parois est dans l'intervalle de 158 à 162 mm.

7. Coffrage selon l'une quelconque des revendications précédentes, dans lequel le plan de chaque paroi de support (6, 7) est approximativement vertical mais est en biais par rapport à la verticale.

8. Coffrage selon l'une quelconque des revendications précédentes, comprenant en outre une feuille supérieure (3) de matériau au-dessus de la structure de support (2).

9. Coffrage selon l'une quelconque des revendications précédentes, dans lequel l'épaisseur des parois (6, 7) est inférieure à 15 mm.

10. Structure incluant une dalle ou une poutre coulée sur un coffrage selon l'une quelconque des revendications précédentes.

11. Procédé de fabrication d'un coffrage pour une utilisation dans la coulée d'une dalle/poutre au-dessus d'un substrat, le procédé incluant l'étape de mouler une structure de support (2) à partir d'une matière polystyrène expansée pour fournir un coffrage selon l'une quelconque des revendications 1 à 9.

12. Procédé selon la revendication 11, incluant l'étape d'introduire de la matière dans le moule à des emplacements correspondant à des intersections des parois de support (6, 7).

13. Procédé selon la revendication 11 ou 12, incluant l'étape de couper le produit moulé en deux moitiés le long d'un plan à mi-chemin entre le haut et le bas de la structure de support (2).

14. Procédé de coulée d'une dalle/poutre au-dessus d'un substrat, le procédé incluant l'étape de placer un coffrage (12) selon l'une quelconque des revendications 1 à 9 sur le substrat, et de couler la dalle/poutre (13) au-dessus du coffrage.

Figure 1

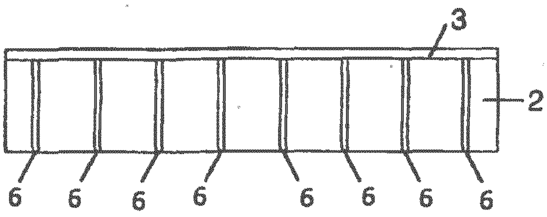
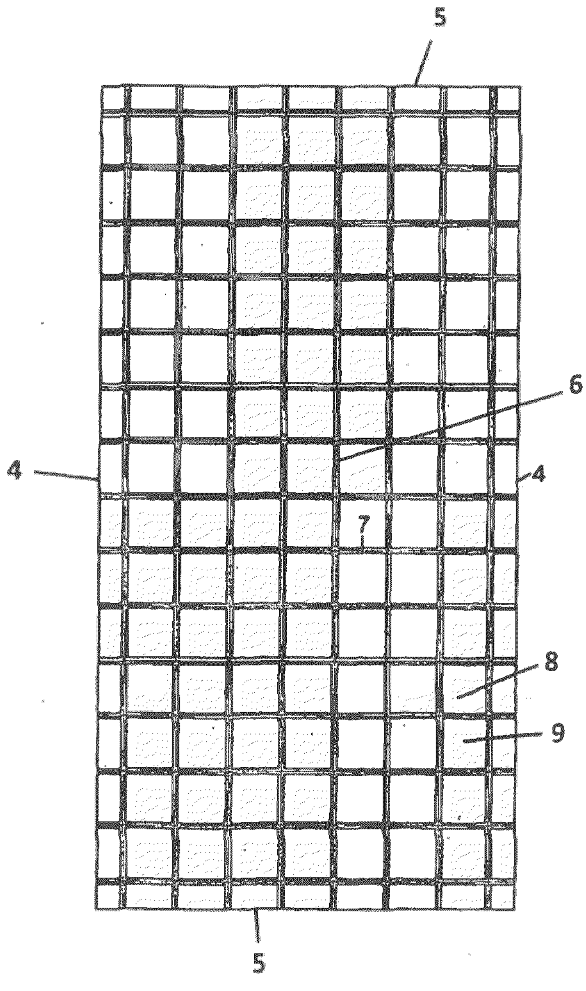


Figure 2



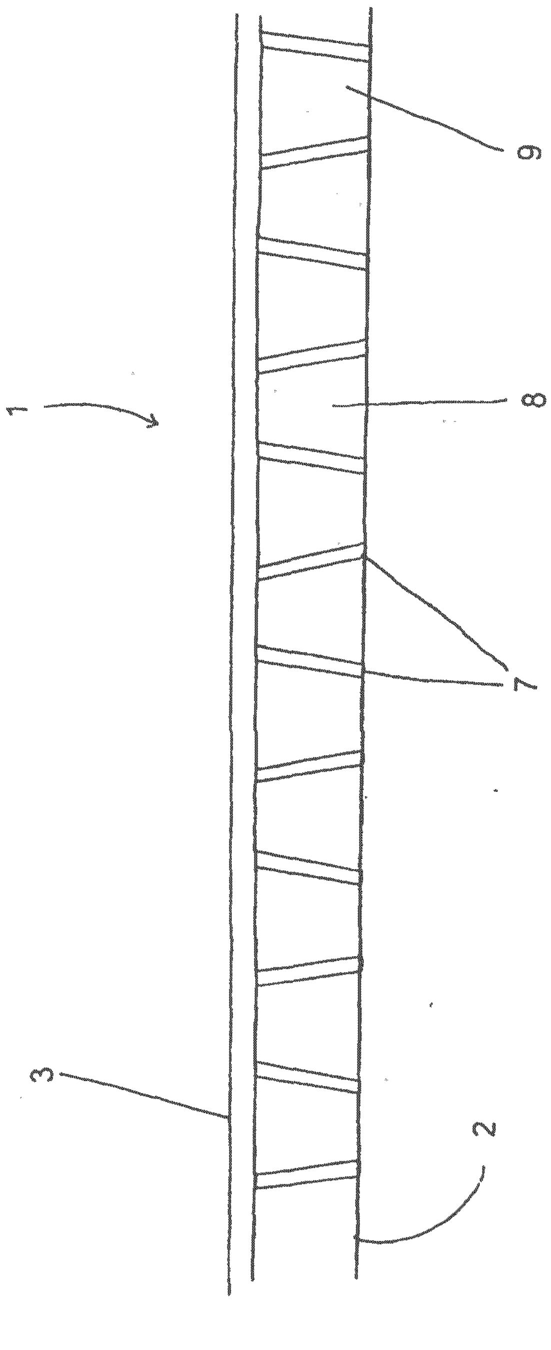


Figure 3

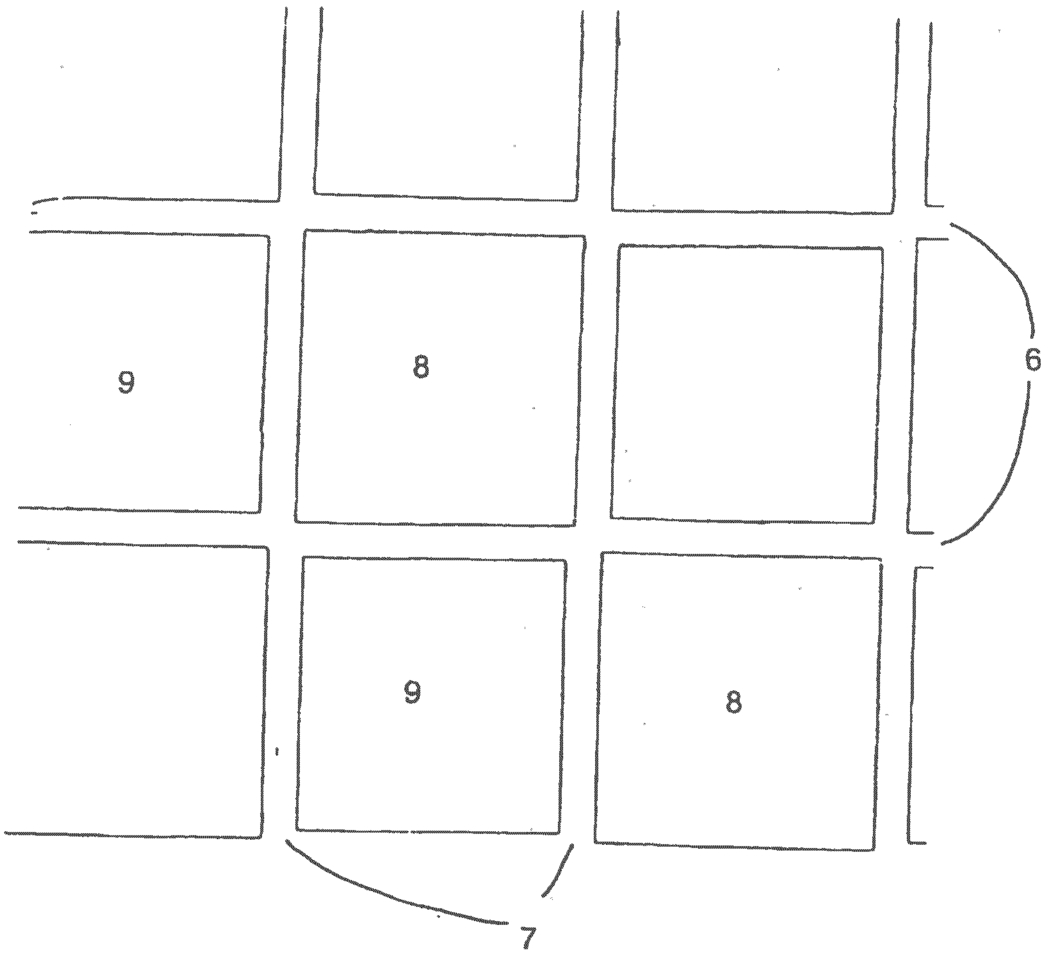


Figure 4

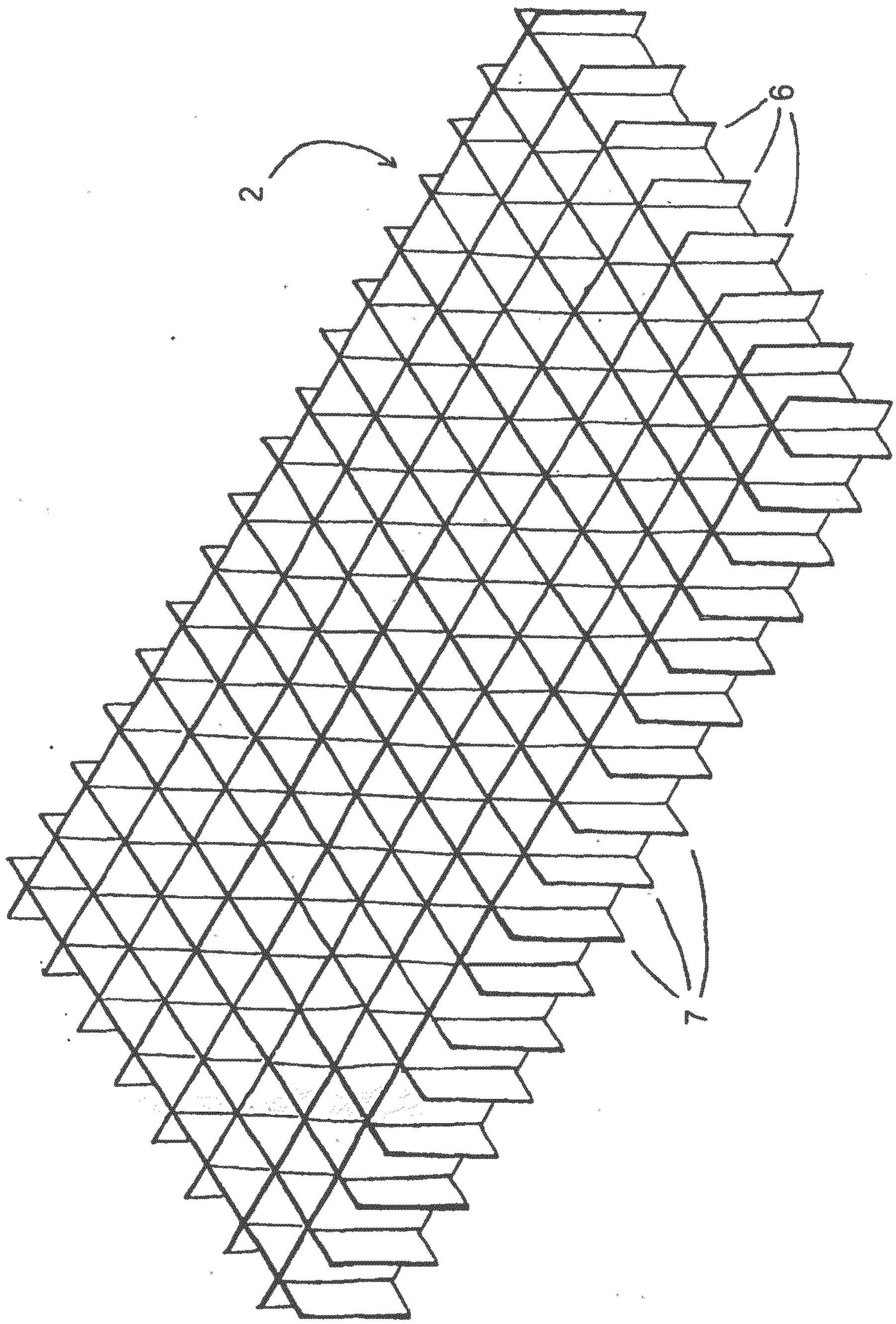


Figure 5

Figure 6

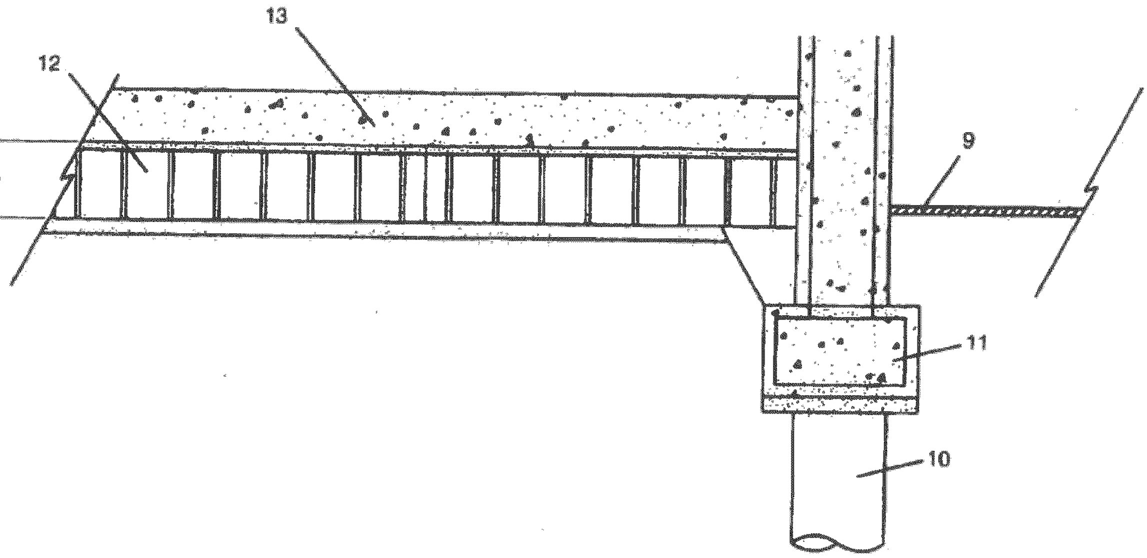
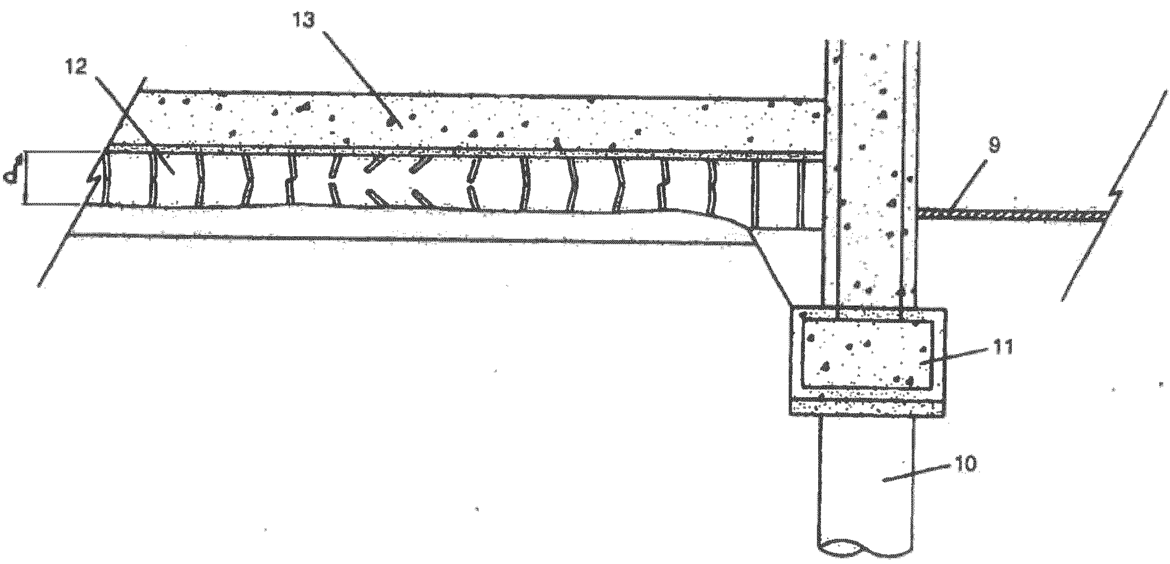


Figure 7



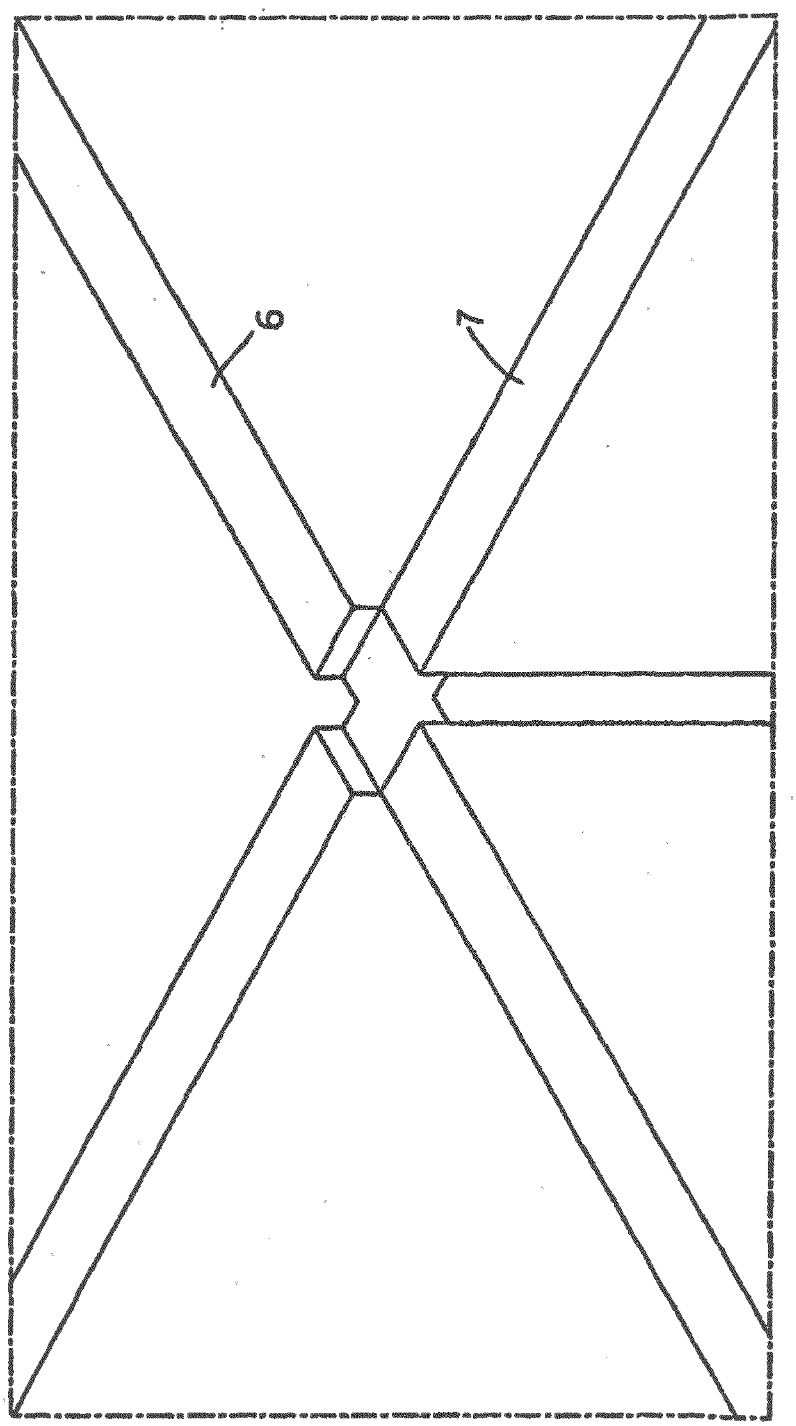


Fig.8

REFERENCES CITED IN THE DESCRIPTION

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