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EP 2 021 555 B1

Description

BACKGROUND

[0001] The present invention relates to structural engineering and more specifically to a structural member capable of use in the construction of structures such as concrete slabs and elements. The invention further relates to methods of use of the structural member including its application in preparatory formwork and as an element in a composite structure including in layered concrete. The invention also relates to structures which employ the structural member. The invention further relates to lightweight structural members used in a variety of concrete structures.

PRIOR ART

[0002] Slab beam concrete constructions is widely used in civil and structural engineering. The typical structure will comprise columns of a size dictated by applied such as dead loads and self weight and live loads and of a spacing dictated by loadings and slab spans. Reinforced and pre stressed concrete floors for buildings are generally made in one of two methods. The floors are either cast in situ using supporting temporary formwork, or are formed from pre-cast concrete planks supported on beams or walls which are then typically covered in a relatively thin in situ layer of concrete. Most major construction work of concrete buildings typically relies on the first cast in situ method in which formwork is constructed as a temporary support for structural reinforcing steel over which is poured structural concrete. Cast in situ reinforced concrete floors, require extensive formwork, are relatively time consuming and labour intensive particularly with respect to the assembly and dismantling of formwork and the time required for the in situ concrete to achieve the required strength. Existing construction systems using pre-cast elements have significant cost and other disadvantages including poor underside surface finish, ribbed profiles on the underside necessitating separate ceilings in many applications, difficulty of running services through and lack of flexibility of the type of structures which can be built. These disadvantages render in situ casting construction the preferred method of slab and floor construction.

[0003] There are currently three different types of pre-cast floor systems which are in common use in the building industry.

[0004] The first system often known as "Hollow Core" relies on the use of extruded, pretensioned, concrete generally rectangular planks which include a series of cylindrical holes or voids extending longitudinally along the plank. The planks are laid on the top of beams or walls and concrete is laid in situ over the top of the planks. This construction system can span relatively long distances, but has the disadvantage that it typically has a very poor surface finish on the underside necessitating

in many applications a false ceiling or cladding over the concrete finish. The structural planks are typically produced in quite narrow strips requiring many joints and it is difficult to put services through the floor, as it is very difficult to access the voids. Also the planks are relatively thick and the services typically have to be either hung on the underside, also necessitating false ceilings in some applications or the services may be hidden in thick topping concrete.

[0005] A second type of system commonly known as "Ultrafloor" employs pre-cast ribs in the shape of an inverted T and which are supported on walls or beams, and these ribs support a thin fibre cement panel such as a "Hardie panel" or the like extending between the ribs. A reinforced concrete floor is then laid over the ribs and panel. This floor system produces a ribbed soffit which necessitates the provision of a cover ceiling in most applications, but it does have the advantage that it is relatively easy to run services through, prior to casting the in situ layer. A further disadvantage of Ultrafloor is that it has a limited span both during concrete pouring and as a finished floor. Ultrafloor is limited in the types of floor structure which can be made from the basic panel and from the panel used in conjunction with the shell beam.

[0006] Another prior art system of floor construction is known as "Transfloor" in which a relatively thin 50mm thick plank of concrete includes longitudinally extending steel reinforcing bars in triangular arrangements of groups of three, with one bar forming an 'apex' of the triangle spaced above the upper surface of the concrete plank and joined to the other two bars with steel rods. The planks are placed on top of walls or beams and void/void formers are placed on the concrete plank between the reinforcing and a concrete layer floor laid in situ on top of the plank. In the structural engineering industry the term void typically means an absence of concrete rather than an absence of material.

[0007] Void formers are most commonly formed by polystyrene blocks although other non cementitious materials such as pipe clay or the like can be used to form voids in concrete members. This system has the disadvantage that it is limited to relatively short spans of about 7m or so. Also there is a requirement to support the floor with props and bearers at relatively close spacings of between 2 and 4m while insitu concrete is being poured and is gaining strength. Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

[0008] WO-01/88297 discloses a process for producing a light alveolar plate which, by using the same type of sliding concrete molding machine with continuous production on prestress bench, intended to prefabricate a

concrete slab of 120 cm wide by 3 cm thick, and with 4 or 5 vertical ribs, two of which being lateral. The ribs are 4 cm thick with a small upper dovetail, and the two lateral ribs have an external face with the shape of the edge of the alveolar plate. During the fabrication of this concrete plate, polystyrene arches with neckings at the upper angles are embedded between the ribs of the cast concrete, and up to the same height as the ribs, so that the concrete which will be cast in situ will adhere to the ribs thereby forming the alveolar plate itself, with the same height as the traditional substituted concrete floor slab and with the same qualities and applicable standards as the alveolar plate.

[0009] DE-538424 discloses a similar structural element.

SUMMARY OF THE INVENTION

[0010] The present invention seeks to provide an improved plank for use in forming concrete flooring which addresses and at least partially alleviates some of the problems of the prior art assemblies as discussed above.

[0011] The present invention provides a structural member capable of use in the construction of structures such as floor assemblies, concrete slabs and structural elements. The invention further provides methods of uses for the structural member including its application in preparatory formwork and as an element in a composite structure including in situ layered concrete. The invention also provides structures which employ lightweight structural concrete members.

[0012] According to an aspect of the present invention, there is provided load bearing pre formed structural element as claimed in claim 1.

[0013] According to a preferred embodiment the tapered recess has a wide portion at the upper surface of the base of the structural element and a narrow portion at or near the plateau of the formations.

[0014] Preferably the formations form longitudinal ribs along the length of the element.

[0015] Preferably each longitudinal rib is parallel to each other rib with even spacing therebetween. In an alternative embodiment, the element may be tapered along its longitudinal axis such that the ribbed formations converge in the direction of one end and diverge in the direction of an opposite end. This embodiment might be used in a case where the elements are placed in a horizontal curve. Preferably, each rib includes an outward taper such that the plateau of the formation is wider than a junction between the formation and the upper surface of the element. In one embodiment, the taper extends from the plateau of each formation at least part way towards the junction between the formation and the upper surface of the element. In another embodiment, the taper extends the full distance from the plateau to the upper surface of the base of element. In another embodiment the taper is terminated short of the plateau. In a further embodiment there is provided a shoulder associated with

the plateau which receives a cover over the recess thereby maintaining a void space in the element.

[0016] Preferably each formation has a generally dovetail geometry with a narrow portion at the junction between the upper surface of the element and the formation tapering out to a wide portion at the plateau.

[0017] According to one embodiment when two elements having one formation are abutted the upper surfaces and adjacent walls of each element combine to define a void recess which receives either a void former or overlay concrete.

[0018] According to one embodiment, the overlay layer spans between the plateaus of each said formations closing said recess thereby forming voids in said slab. The system is preferably used in the construction of a composite suspended beam and floor slab assembly. The voids improve the structural performance of the element both during construction carrying wet concrete and in the permanent composite structure. They also provide through passages for services. Preferably, the structural elements are formed in a mould which includes a steel base which imparts a smooth high quality surface finish to the element soffit. The voids reduce the weight of the element. The structural geometry of the formations allow more efficient use of concrete in that the so formed composite has a large compression flange at the top of the formations imparting to the composite a high strength to weight ratio for a given span. The elements may therefore be much thinner for a given span than a prior art conventional slab. In one embodiment the side walls of the formations are generally planar and are inclined at an angle less than 90 degrees and around 40° to 70° to the upper surface of the element. The structural element has a versatility allowing the voids to be filled with polystyrene, cement or concrete. Alternatively the voids may be retained with empty spaces.

[0019] The base portion is preferably reinforced with fabric or steel rods and/or reinforcing fibres and may be pre-stressed respectively by pre tensioning or post-tensioning. Alternatively, the element may be non stressed. In one embodiment the top of the formations receive and support a sheet of material. In use, the building slab elements may be supported on walls or transverse beams arranged to define a floor. Gaps between adjacent like elements are sealed with part of a composite layer. The void spaces in each element are sealed and an in situ layer is poured over the plateaus of each formation.

BRIEF DESCRIPTION OF DRAWINGS

[0020] The present invention will now be described according to a preferred but non limiting embodiments and with reference to the accompanying illustrations in which:

Figure 1 shows an end view of a pre-cast concrete element incorporating an intermediate formation and adjacent voids filled with a polystyrene filler.

Figure 2 shows an end view of a pre-cast concrete

element of figure 1 incorporating an intermediate formation and adjacent empty voids typically used as a spine beam.

Figure 3 shows an isometric view of the spine beam of Figure 2;

Figure 4 shows a cross sectional view of a composite beam including the element of figure 1 and including an overlay layer.

Figure 5 shows a cross section of a composite beam comprising an abbreviated element supporting associated elements and an overlay layer disposed over formation plateaus and associated elements.

Figure 6 shows a perspective view of a banded beam flooring system having two columns with drop panels and two columns without drop panels and including elements arranged for co operation with support columns. An arrangement of temporary propping for this floor system is also shown. Figure 7 shows an enlarged abbreviated end view of a portion of a pre-cast concrete element with alternative non-claimed formation geometry including shoulders.

Figure 7a shows an enlarged abbreviated end view of a portion of a pre cast concrete element with alternative non-claimed formation geometry including radiused walls.

Figure 8 shows an enlarged cross sectional view of a portion of a pre-cast concrete element with alternative non-claimed formation geometry including an abbreviated taper.

Figure 9 shows an enlarged cross sectional view of a portion of a pre-cast concrete element with alternative non-claimed formation geometry including an abbreviation in the taper near its plateau.

Figure 10 shows an enlarged cross sectional view of a portion of a pre-cast concrete element with alternative non-claimed formation geometry including an abbreviation in the taper near its plateau and radiused junction.

Figure 11 shows an enlarged cross sectional view of a portion of a pre-cast concrete element with alternative non-claimed formation geometry including a radiused junction.

Figure 12 shows an enlarged cross sectional view of a portion of a pre-cast concrete element with alternative non-claimed formation geometry including abutment shoulders and a radiused junction.

Figure 13 shows a cross sectional elevation of a composite slab including a structural element and a reinforced overlay layer and including an edge profile on a formation which transmits shear to an adjacent member at right angles to it.

Figure 14 shows a sectional view through the end of the perpendicular member of figure 13 showing the method of transmission of shear at an undercut to the ribs of this member. Figure 15 shows a perspective view of a flooring assembly which allows production of a flat plate structure or a flat slab with drop panels including an array of structural elements sup-

ported by columns according to one embodiment. In this arrangement the soffits of all the precast elements are in the same plane.

Figure 16 shows a sectional elevation view of a composite slab flooring assembly of the type shown in figure 15 including structural elements and composite slab finish regime about support columns.

Figure 17 shows an enlarged sectional elevation view of the composite slab flooring assembly including structural elements and composite slab finish regime of figure 16.

Figure 18 shows a perspective view of a composite slab flooring assembly including precast structural elements and composite slab finish regime with cast in situ band beams about support columns.

Figure 19 shows a sectional elevation view of the composite slab flooring assembly including structural elements and composite slab finish regime of figure 18.

Figure 20 shows an enlarged sectional elevation view of part of the assembly of figure 19 including structural elements and composite slab finish regime about a support column.

Figure 21 shows an enlarged sectional elevation view of the composite slab flooring assembly including structural elements and composite slab finish according to the regime of figure 6.

Figure 22 shows an enlarged view of a part of the assembly of figure 21. Figure 23 shows a cross sectional view of a shear junction between the side of a composite slab and support column or precast concrete wall-

Figure 24 shows a sectional view of a shear junction between a composite slab assembly and a support wall/ column with alternative orientation of structural element.

DETAILED DESCRIPTION

[0021] Figure 1 shows an end view of a pre-cast concrete element 1 comprising a base 2 having an underside surface 3 and upper surface 4. Element 1 further comprises formations 5, 6 and 7 which define void spaces 8 and 9. Void 8 is defined by upper surface 4 and side walls 10 and 11. Void 9 is defined by upper surface 4 and side walls 12 and 13. In the embodiment of figure 1 voids 8 and 9 are filled with polystyrene or similar lightweight material which maintains a lighter weight than an equivalent element with voids filled with concrete or cement. Element 1 typically includes reinforcing (not shown) in base 2, typically reinforced with steel bars or prestressed reinforcement above which two or more polystyrene void formers 14 and 15 preferably in the shape of an isosceles trapezium are located. Formations 5, 6 and 7 comprise ribs with longitudinal extent and whose width increases as the distance from surface 4 increases so that there is more material at the top of the formations 5, 6 and 7. The embodiment of figure 1 shows a symmetrical intermedi-

ate formation 6 which is dove tail (or inverted trapezoidal) creating voids which are trapezoidal. Increase in material at the top of the rib plateaus 16, 17 and 18 improves the performance of the element in bending in that it creates a compressive flange of higher capacity and which is more eccentric to the tensile reinforcement. This increase in bending capacity is in comparison to a prior art element having a rectangular formation were employed. Ideally walls 11 and 12 of formation 6 for instance will be disposed at an angle to surface 4 of base 2 of other than 90 degrees. In the example of Figure 1 the side walls of the ribs extend at an angle of about 50[deg.] although the angle could ideally fall within the range of about 45 to 70[deg.]. Figure 2 shows an end view of the pre-cast concrete element 1 of figure 1 with corresponding numbering and incorporating an intermediate formation 6 and adjacent empty voids 8 to 9 with no void formers. The arrangement of figure 2 would typically be used as a spine beam of Figure 2 with corresponding numbering.

[0022] Figure 4 shows a cross sectional view of a composite beam assembly 20 including an element 21 which is similar to element 1 of figure 1. Element 21 comprises formations 22, 23, 24 and 25 which define void spaces 26, 27 and 28. Void 26 is defined by upper surface 29 and side walls 30 and 31. Voids 27 and 28 are similarly defined. In the embodiment of figure 4 voids 26, 27 and 28 are filled with polystyrene which maintains a lighter weight than an equivalent element with voids filled with concrete or cement. Element 21 includes tensile reinforcing comprising a series of longitudinally extending reinforcing steel rods 32 which may, as required, be pretensioned, post-tensioned or unstressed depending on the application and the requirements for element 21. Element 21 includes three polystyrene void formers in respective voids 26, 27 and 28. Formations 22, 23, 24 and 25 comprise ribs of longitudinal extent and whose width increases as the distance from surface 29 to respective plateaus 33, 34, 35 and 36 so there is more material at the top of the formations 22, 23, 24 and 25. The embodiment of figure 4 shows symmetrical intermediate formations 23 and 24 which are dove tail (or inverted trapezoidal) creating voids which are trapezoidal. Also in base 37 of element 21 is a sheet of mesh, loose reinforcement or fibre reinforced concrete 39 to provide resilience to handling of the element 21 and help resist cracking and breaking of the element. Typically element 21 would be manufactured in a mould or extruded. Where the element is moulded, it is preferred that a mould having a steel floor is used so that the underside or soffit 40 of base 37 remains smooth. Typically, steel bars 32 will be prestressed along with an untensioned fabric 39. An approximately 20mm to 80mm layer of concrete is poured into the base of the mould so as to cover the reinforcing steel bars 32. Void formers are then put into position on the top of the base in voids 26, 27 and 28 and the remaining concrete is poured to bring the height of the rib formations ribs up to the top of the void formers. The concrete is

then allowed to set before the composite is removed from the mould. Should reinforcement 20 be pre stressed, then it is either pre tensioned before the casting of elements 37 and 22, 23, 24 and 25 or post tensioned after the concrete achieves sufficient strength. Once element 21 is erected in its final position in the structure, a relatively thin overlayer 42 is poured over element 21 evenly supporting the overlayer which adheres to plateaus 33, 34, 35 and 36. As an alternative embodiment overlay layer 42 may be factory cast prior to site installation of the composite.

[0023] Alternatively, element 21 may be extruded through a die using a relatively stiff concrete mix. Extrusion is the preferred method where polystyrene void formers are not used, although either method may be used. In use, with reference to Figure 4, a plurality of concrete elements 21 are placed on top of beams or walls (not shown) and a layer of reinforcement 43 is placed on top of the elements 21 as required. The element 21 is then covered with a relatively thin in situ layer of concrete 42. Because of the design of the elements 21 and in particular, the thickening of the ribs distal from the base 37, element 21 performs well in bending and can be much lighter than other known pre-formed elements. Thus, the system uses less concrete which reduces materials cost. Also, for a building of given height, the building will weigh less and this allows the columns and footings to be less extensive and consequently cheaper. Also as the floors are thinner, the space saved may be equivalent to one or more extra floors in a building.

[0024] Figure 5 shows a cross section of a composite beam assembly 50 including element 51 and an overlay layer 66 disposed over formation plateaus 53, 54 and 55 of formations 56, 57 and 58 which define voids 59 and 60. Located and bearing on plateau 53 is a beam element 63. Located and bearing on plateau 55 is a second element beam 64.

[0025] Because the base 49 of the element 51 is relatively thin, it is possible to place reinforcing 67 inside the voids close to the base 49 of the resultant spine beam (element 51) to resist bending of the beam. It is also possible, to place reinforcement 65 at the top of the beam when concrete overlay layer 66 is poured in situ into the spine beam 51 and over adjacent elements 63 and 64.

[0026] In a variant of the element cross-section shown in Figures 1 to 5, the rib/formation shape of the elements may be varied. Also, the representations shown in figures 1-5 are of indefinite width and it will be appreciated that the elements may include more or less than the numbers of formations/ribs illustrated.

[0027] Figure 6 shows an abbreviated section of a flooring assembly including elements employed as form work prior to pouring of an overlay layer (not shown) but analogous to overlay layer 66 of figure 5. Shown a perspective view of a banded beam flooring system 70 having two columns with drop panels and two columns without drop panels. The system shown includes elements arranged for co operation with support columns. An ar-

rangement of temporary propping 99 for this floor is also shown. Banded beam flooring system 70 includes elements arranged for co operation with support columns 71, 72, 73 and 74. The arrangement of figure 6 provides formwork of elements which will provide a base for a composite slab and band beam system similar to the arrangement of figure 4 in the slab spanning direction and figure 5 in the band spanning direction. System 70 comprises transverse elements 75 of a first span length determined according to structural design requirements. Elements 76 on the outside of columns 71 and 72 and columns 73 and 74 are abbreviated. Transverse elements 75 are supported at their ends on longitudinal spine beam elements 77 and 78. Elements 78 on the outside of columns have been abbreviated for clarity. Figure 6 shows the assembly of panels prior to the placement of reinforcement along the spine beam elements 77 and 78 and over the entire assembly including elements 75 and 76 and the placement of a concrete layer over the entire assembly. In this arrangement, conventional formwork is used to form the drop panel 79.

[0028] It should be noted that Elements 77 and 78 may or may not incorporate void formers. There are two different junctions shown between elements 77 and 78 and the columns 71, 72, 73 and 74. Columns 71 and 72 are either cast with the floor or are precast and are provided with shear keys and the spine beams 77 and 78 abut the columns. In the second form there is a drop panel 79 formed by conventional formwork which connects the spine beams and adjacent slab beams to the column.

[0029] The in situ panel 79 produced with conventional formwork may be terminated at the underside plane of the precast panels 77 and 78 or may project below the general floor soffit. Throughout the specification the term soffit will be taken to mean an underside surface of a structural member. Temporary supports 99 may be required as shown to support the whole floor assembly while concrete is being poured and until it acquires sufficient strength.

[0030] Figure 7 shows an enlarged abbreviated end view of a portion of a pre-cast concrete element 80 comprising a base 81 having an underside surface 82 and an upper surface 83. Extending from upper surface 83 are dove tail formations 84 and 85 which define void space 86. Wall 87 of formation 84 terminates at upper plateau 88 in shoulder 89. Likewise wall 90 of formation 85 terminates at upper plateau 91 in shoulder 92. A sheet 93 of fibre cement or the like can be rested on shoulders 89 and 92 spanning void space 86. This obviates the need to include a void former in void space 86. Formations 84 and 85 are generally in the shape of an inverted trapezium.

[0031] Figure 7a shows an enlarged abbreviated end view of a portion of a pre cast concrete element with alternative formation geometry including radiused walls. Element 94 comprises a base 95 having an underside surface 96 and an upper surface 97. Extending from upper surface 97 is formation 98 including walls 98a and

98b which are substantially S shaped each with opposing radii of curvature.

[0032] Figure 8 shows an enlarged abbreviated end view of a portion of a pre-cast concrete element 100 with alternative formation geometry. Element 100 comprises a base 101 having an underside surface 102 and an upper surface 103. Extending from upper surface 103 is formation 104 including walls 105 and 106. Walls 105 and 106 each have a first portion 108 disposed at an angle normal to the plane of surface 103 and a portion 107 at an angle to surface 103 other than normal. Figure 9 shows an enlarged abbreviated end view of a portion of a pre-cast concrete element 110 with alternative formation geometry. Element 110 comprises a base 111 having an underside surface 112 and an upper surface 113. Extending from upper surface 113 is formation 114 terminating in plateau 115 and including walls 116 and 117. Walls 116 and 117 are disposed at an angle less than normal to surface 113 and terminate in a perpendicular abbreviation 118.

[0033] Figure 10 shows the element of figure 9 with a radiused junction 119 between surface 113 and formation 114.

[0034] Figure 11 shows an enlarged end view of a portion of a pre-cast concrete element 120 with alternative formation 121 geometry including a radiused junction 122 between base 123 and formation 121.

[0035] Figure 12 shows an enlarged end view of a portion of a pre-cast concrete element with alternative formation geometry including abutment shoulders and a radiused junction. Element 130 comprises a base 131 having an underside surface 132 and an upper surface 133. Extending from upper surface 133 are dove tail formations 134 and 135 which define void space 136. Wall 137 of formation 134 terminates at upper plateau 138 in shoulder 139. Likewise wall 140 of formation 135 terminates at upper plateau 141 in shoulder 142. A sheet 143 of fibre cement or the like can be rested on shoulders 139 and 142 spanning void space 136. This obviates the need to include a void former in void space 136. Wall 137 terminates in a radiused portion at the junction of formation 134 and base 131. Likewise wall 140 of formation 135 terminates in a radiused portion 144 at the junction of formation 135 and base 131.

[0036] An advantage of the above elements is that where a floor is required to resist bending in a lateral as well as a longitudinal direction, and/or to locally enhance the elements shear capacity, it is possible to remove portions 143 of fibre reinforced cement formwork where present and simply fill the voids with concrete in those areas where such lateral resistance to bending and/or shear capacity, is required. Similarly it is possible, though not as convenient to remove the void formers of Figure 4 in order to allow the abovementioned local improvements of transverse bending and /or shear capacity to be implemented.

[0037] Figure 13 shows a cross sectional elevation of a composite slab assembly 150 including a structural el-

element 151 and a reinforced overlay layer 152 and including an edge profile 153 on a formation 154 which transmits shear to an adjacent abutment member 155. The arrangement of figure 13 is an example of one form of engagement between element 151 and an abutting support. Element 151 includes dovetail formations 156 as described earlier defining voids 157. Edge profile 153 of formation 154 opposes abutment 155 and is arranged to transmit shear forces between element 151 and abutment element 155. Overlay layer 158 is laid over plateaus 159 of formations 154 and is preferably reinforced with a reinforcing steel 160. Element 155 has its void formers terminated a short distance from its end to allow overlay in turn a shear connection with the edge profile 153 of Element 151. In this way a concrete layer 158 to be poured around the dovetail ribs 144 of element 155 and to thus create a shear connection between the overlay concrete 158 and the dovetail ribs 144 and in turn a shear connection is made between elements 155 and 151 as indicated by arrows 161 and 162.

[0038] Figure 14 shows element 155 rotated 90 degrees from its orientation in figure 13. Element 155 is incorporated with overlay layer 158 which forms a composite beam structure. Layer 158 co operates with element 155 via dove tail formations 144 which define trapezoidal voids 147. Void 147 includes walls 145 and 146 which receive shear forces transmitted by undercasting via overly layer 158 as shown by arrows 148 and 149. This structural effect is repeated in each void between formations 144.

[0039] Figure 15 shows a perspective view of a flooring assembly including an array of structural elements supported by columns according to one embodiment. Shown is a flooring system 170 including elements arranged for co operation with support columns 171, 172, 173 and 174. The arrangement of figure 15 provides a formwork of elements which will provide a base for a composite slab similar to the arrangement of figures 4 and 5. System 170 comprises transverse elements 175 of a first span length determined according to structural design requirements. Elements 176 on the outside of columns 171 and 172 and columns 173 and 174 are abbreviated for clarity. Elements 178 on the outside of columns have been abbreviated for clarity Transverse elements 175 are supported at their ends next to and with their soffits (underside surface) in the same plane as the soffits of the longitudinal spine beam elements 177 and 178. Elements 175 may be temporarily supported independently of the spine elements 177 and 178 or may be supported by temporarily connecting them to spine elements 177 and 178. Figure 15 shows the assembly of panels prior to the placement of reinforcement along the spine beam elements 177 and 178 and over the entire assembly including elements 175 and 176 and the placement of a concrete layer over the entire assembly. In this arrangement, conventional formwork is used to form the drop panel 179. It should be noted that Elements 177 and 178 may or may not incorporate void formers. The structure

produced by this assembly of panels has a flat and planar soffit over the entire underside of the floor. The in situ panel 179 produced with conventional formwork may be terminated at the underside plane of the precast panels 175, 176, 177 and 178 or may project below the general floor soffit.

[0040] Figure 16 shows a sectional elevation view of a column and composite slab flooring assembly of the type shown in perspective view Fig 15 taken perpendicular to the spine beams 177 and 178. Assembly includes support columns 190 and 191 each supporting respective spine elements 192 and 193. Spanning therebetween are elements 194. On opposite side of column 190 and extending from spine beam element 192 is element 195 abbreviated for clarity. On opposite side of column 191 and extending from spine beam element 193 is element 196 abbreviated for clarity. This arrangement shows the versatility and inter engagement of structural elements which on one hand may be used as a spine beam and on the other hand as transverse span beams. This also demonstrates how the elements can be arranged as formwork in advance of preparation of a composite structural slab. This also demonstrates how all the precast element may be arranged with their soffits co-planar to produce a flat soffit. Elements 195, 192, 194, 193 and 196 are overlaid with overlay layer 197 which completes the slab composite and floor assembly. Reinforcement has been omitted for clarity but it will be appreciated by persons skilled in the art that each representation of floor assembly shown herein would normally include design reinforcement in tensile regions of the composite and to control shrinkage cracking and to enhance the structure's shear capacity.

[0041] Figure 17 shows with corresponding numbering for corresponding parts an enlarged sectional elevation view of the composite slab flooring assembly including structural elements and composite slab finish regime of figure 16. This view also shows overlay layer 197. Void formers 187 have been terminated a short distance from the respective ends 185 and 186 of the panels 194 and 195 to allow the overlay concrete to flow around the dovetail ribs 188 and thus form a shear connection with the overlay concrete 197 Spine beam element 192 includes an end formation 198 having an outer profile 199 which co operates with element 194 to establish a shear connection therebetween. Overlay layer 197 locks element 192 to element 194 and assists in transmission of loads. Overlay layer 197 is in one embodiment supported by spine element 192 and covers the void formers or penetrates the voids (not shown) when the void former is absent in elements 194 and 195 thereby completing the layered composite floor structure. Voids 189 of spine element 192 will receive concrete from overlay layer 197 but in a case where void formers are used, overlay layer will sit over (bridge) voids 189.

[0042] Figure 18 shows a perspective view of a flooring assembly 180 including an array of structural elements supported by columns. Flooring assembly 180 includes

transverse elements 240 arranged for co operation with support columns 181, 182, 183 and 184. The arrangement of figure 18 provides formwork for concrete to be supplied and a base for a composite slab similar to the arrangement of figure 15. Assembly 180 comprises transverse elements 240 of a first span length determined according to structural design requirements. Elements 241 on the outside of columns 181 and 183 and elements 242 on the outside of columns 182 and 184 are abbreviated for clarity. Elements 240 are supported at their ends by longitudinal elements 243 and 244 which are cast in situ on conventional formwork. Longitudinal beams 244 and 243 provide an abutment to receive elements 240, 241 and 242.

[0043] Figure 19 shows a sectional elevation view of a composite column slab flooring assembly of the type shown in perspective view Fig 18. Figure 19 shows according to an alternative embodiment, a sectional elevation view of a composite slab flooring assembly 200 including structural elements and composite slab finish regime about support columns. Shown are support columns 201 and 202 each supporting respective cast in situ spine beams 203 and 204 which are formed with conventional formwork. Spanning between columns 201 and 202 the supply are elements 205. On opposite side of column 201 and extending from spine beam element 203 is element 206 abbreviated for clarity. On opposite sides of column 202 and extending from spine beam element 204 is element 207 abbreviated for clarity.

[0044] Figure 20 shows with corresponding numbering an enlarged sectional elevation view of the composite slab flooring assembly 200 of Fig 19 including structural elements 205 206 and 203 and composite slab finish regime of figure 19.

[0045] Figure 21 shows a sectional elevation view of a completed composite column slab flooring assembly 210 of the type shown in the perspective view of Figure 6, when a section is taken through spine beams 77 and 78. Composite slab flooring assembly 210 includes structural elements and composite slab retained about support columns. Banded beam flooring system 210 shows two columns 211 and 212 with drop panels arranged for co operation with the support columns. Flooring system 210 includes transverse elements 215 of a first span length determined according to structural design requirements. Elements 216 on the outside of columns 211 and elements 217 outside column 212 are abbreviated for clarity. Transverse elements 215 are supported at their ends on longitudinal beam elements 213 and 214. Overlay layer 218 is placed over element 215 and beam elements 213 and 214 to complete the floor slab composite. Figure 22 shows an enlarged sectional elevation view of the composite slab flooring assembly 210 of figure 21 with corresponding numbering.

[0046] Figure 23 shows a cross sectional view of a shear junction 220 between a composite slab assembly 221 and support wall/ column 222. Column includes a recess 223 which provides a key in lock for shear trans-

mission at the junction 220. Composite assembly 221 includes structural element 224 having a base 225 and extending therefrom formations 226 defining voids 227. A reinforcing ferrule 235 is embedded in column/wall 222 and engages reinforcing steel 228 which is embedded in overlay layer 229 which lies over plateaus 230. Overlay layer 229 also fills recess 223 and gap 232 between recess 223 and outer profile 233 of formation 234. The co operation between profile 233 and recess 223 when gap 232 is filled in with concrete from overlay layer 229 results in transmission of shear between precast members 224 and column 222 as indicated by arrows 235 and 236.

[0047] Figure 24 shows a sectional view of a shear junction 250 between a composite slab assembly 251 and support wall/ column 252. Column includes a recess 253 which provides a key in lock for shear transmission at the junction 250. The void formers of composite assembly 251 are terminated a short distance from the end to facilitate the undercasting of concrete around the ribs 256 of assembly 251 to facilitate the transmission of shear in a manner alike to that demonstrated in figures 13 and 14. Composite assembly 251 includes structural element 254 having a base 255 and extending therefrom formations 256 defining voids 257. A reinforcing ferrule 258 is embedded in column/wall 252 and engages reinforcing steel 259 which is embedded in overlay layer 260 which lies over plateaus 261. Overlay layer 260 also fills recess 253 and gap 262 between recess 253 and the void around the outer profile 254 at the end of element 251 and outer profile of formation 263. The co operation between recess 253 and profile formation 263 when gap 262 is filled in with concrete from overlay layer 260 results in transmission of shear between pre cast members 254 and column 252 as indicated by arrows 264 and 265. The versatile use of the structural elements described above provides distinct advantages over existing pre-formed concrete elements. The first advantage is that it is relatively easy to put services through the floor in voids between the formations / ribs of the elements. Secondly, the elements can be formed in a mould having a steel base which allows a high quality finish to the soffit of the element.

[0048] Thirdly, the provision of the voids reduces the weight of the element and the shape of the formations/ ribs provides more concrete at the upper reaches of the composite thereby providing a large compression flange at the top of the ribs where it is required which allows the elements to be much thinner for a given span.

[0049] Fourthly, the void formers may be removed to allow overlay concrete to flow around (undercast) the dovetailed formations and engage them for shear connection. This allows these units to be readily joined to adjacent structural elements with in situ concrete producing both neat appearance and a joint which is readily fire rated as opposed to the external steel connections often employed which need to be separately fire protected.

[0050] The structural elements which form the composite floor slab have the capacity for long span without

intermediate support both during construction when supporting wet concrete and when integral with the completed composite structure. Element dimensions including depth, rib shape, rib spacing, panel width, and the plan shape of the panel may be varied according to design requirements. For instance, wide panels are not restricted by fixed extrusion equipment allowing quick erection of floors with fewer joints. The elements may be tapered relative to their longitudinal axis, for instance in a case where the elements form a horizontal radiused corner. Reinforcement in both the tensile and compression regions may be varied according to design requirements. No extrusion tools are needed to fabricate panels and the formation/ rib shape and height is largely determined by the void former shape and size which may be readily changed. The elements may be fabricated as plain reinforced, pre tensioned reinforced or post tensioned reinforced members allowing for flexibility of manufacture dictated by design requirements. Since the elements are lightweight pre cast elements, this allows economic transport and efficient lift by crane.

[0051] The use of lightweight elements allows for more lightly loaded columns and consequently smaller footings. Shallow structural depth allows more efficient buildings saving on the lengths of services, facades, and allows for more useable building space in areas where there is a height restriction.

[0052] Each element has a smooth flat soffit over whole panel width which can be treated as a final finish with no mandatory need for separate suspended ceilings are claddings. The flat soffit combined with shallow structural depth and lack of ceiling space realizes economic operation of air conditioning with no wasted "dead air" between ribs or in ceiling spaces. A further advantage of the element is the access to voids during construction allowing the installation of services in the void areas and through the relatively thin base slab of the composite. The dovetail formations with void blockouts removed provide shear connections to adjacent elements which are both neat, easily made and fire resistant as opposed to the conventional methods of other pre cast systems which either require bulky expensive and unsightly corbels or exposed steelwork which requires fire protection. Very little tooling required for the manufacture of the elements which means a low cost set up, manufacture. Also mobile manufacturing plants are economically feasible. The elements may also be manufactured on the construction site. Finally, irrespective of whether the elements are manufactured with air voids or voids filled with an insulating polystyrene, a floor is created which has optimal sound, heat and fire separation properties.

[0053] It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the scope of the invention as defined by the claims. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Claims

1. A load bearing pre formed structural concrete beam for forming part of a suspended, self supporting structural concrete floor formed by a plurality of said preformed structural beams laid in side by side abutment; each said beam comprising when viewed in end or cross section:
 - a base (2) having an underside surface (3) and an upper surface (4),
 - at least two spaced apart tapered trapezoidal dovetail formations (5-7) each extending from the upper surface and each including a plateau (16-18) and a side wall defining, in conjunction with a base (2) and an opposing side wall of an adjacent formation a tapered recess, the side walls of the recess being linear and disposed at an acute angle to the upper surface of the base of the structural beam; whereby the plateau (16-18) of each said formations (5-7) as viewed in cross section has a width dimension which is greater than a width dimension at a junction of each said formations and the base; the tapered recess forming a void space which is capable of receiving a light weight filler; the structural beam capable of load bearing when simply supported at each end and having a high strength to weight ratio.
2. A structural beam according to claim 1 wherein each recess has a wide portion at the upper surface (4) of the base (2) and a narrow portion adjacent the plateau of the formations.
3. A structural beam according to claim 2 wherein each formation comprises a narrow portion near the upper surface of the base and a wide portion at the plateau of the formation such that the external angle of taper of said formations falls between 45 degrees and 70 degrees to the upper surface (4) of the base (2).
4. A structural beam according to claim 3 wherein each formation is equally spaced apart from an adjacent formation.
5. A structural beam according to claim 4 wherein the formations form longitudinal spaced apart ribs along the length of the structural beam.
6. A structural beam according to claim 5 wherein each dovetail formation has a narrow portion at the upper surface of the base and the formation tapering out to a wide portion at the plateau.
7. A structural beam according to claim 6 wherein, there are a plurality of the evenly spaced apart intermediate dovetail formations (6) running longitudinally

along the length of the beam and edge formations running longitudinally along the length of the beam each having a smaller cross section than one of the intermediate formations.

8. A structural beam according to claim 7 wherein, the taper extends the full distance from the plateau to the upper surface (4) of the base. 5
9. A structural beam according to claim 8 wherein the formations support a cover over the recess closing the void space between formations. 10
10. A structural beam according to claim 9 wherein the voids are left empty. 15
11. A structural beam according to claim 9 wherein, the voids are filled with a lightweight filler is selected from polystyrene, cement or concrete. 20
12. A structural beam according to claim 11 wherein the longitudinal edge formations are asymmetrical.
13. A structural beam according to claim 12 wherein, the formations intermediate the edge formations are symmetrical. 25
14. A structural beam according to claim 13 wherein an outer edge face of longitudinal formations have a shoulder whose geometry transmits shear forces between abutting beams. 30
15. A structural beam according to claim 14 wherein the beam is tapered towards one end and relative to a longitudinal axis of the beam 35

Patentansprüche

1. Lasttragender, vorgeformter Strukturbetonträger zum Bilden eines Teils eines aufgehängten, selbsttragenden Strukturbetonbodens, der durch eine Vielzahl der vorgeformten Strukturträger gebildet ist, die Seite an Seite aneinander gelegt sind; wobei jeder der Träger, im End- oder Querschnitt betrachtet, Folgendes aufweist: 40
 - eine Basis (2) mit einer Unterseitenfläche (3) und einer oberen Fläche (4)
 - mindestens zwei voneinander beabstandete, sich verjüngende, trapezförmige Schwalbenschwanzbildungen (5-7), die sich jeweils von der oberen Fläche aus erstrecken und jeweils ein Plateau (16-18) und eine Seitenwand umfassen, die in Verbindung mit einer Basis (2) und einer gegenüberliegenden Seitenwand einer benachbarten Formation eine verjüngte Aussparung definiert, wobei die Seitenwände der 45

Aussparung linear sind und in einem spitzen Winkel zur oberen Fläche der Basis des Strukturträgers angeordnet sind; wobei das Plateau (16-18) jeder der Formationen (5-7), im Querschnitt gesehen, eine Breitenabmessung aufweist, die größer ist als eine Breitenabmessung an einer Verbindung jeder der Formationen und der Basis; wobei die sich verjüngende Aussparung einen Hohlraum bildet, der in der Lage ist, ein leichtes Füllmaterial aufzunehmen; wobei der Strukturträger tragfähig ist, wenn er an jedem Ende einfach abgestützt ist, und ein hohes Verhältnis von Festigkeit zu Gewicht aufweist.

2. Strukturträger nach Anspruch 1, wobei jede Aussparung einen breiten Abschnitt an der oberen Fläche (4) der Basis (2) und einen schmalen Abschnitt angrenzend an dem Plateau der Formationen aufweist.
3. Strukturträger nach Anspruch 2, wobei jede Ausformung einen schmalen Abschnitt nahe der oberen Fläche der Basis und einen breiten Abschnitt am Plateau der Ausformung aufweist, so dass der äußere Verjüngungswinkel der Ausformungen zwischen 45° und 70° zur oberen Fläche (4) der Basis (2) liegt.
4. Strukturträger nach Anspruch 3, wobei jede Formation gleichmäßig von einer benachbarten Formation beabstandet ist.
5. Strukturträger nach Anspruch 4, wobei die Formationen in Längsrichtung beabstandete Rippen entlang der Länge des Strukturträgers bilden.
6. Strukturträger nach Anspruch 5, wobei jede Schwalbenschwanzformation einen schmalen Abschnitt an der Oberseite der Basis aufweist und die Formation sich zu einem breiten Abschnitt am Plateau verjüngt.
7. Strukturträger nach Anspruch 6, bei dem eine Vielzahl der gleichmäßig beabstandeten, in Längsrichtung des Trägers verlaufenden Schwalbenschwanz-Zwischenausbildungen (6) und in Längsrichtung des Trägers verlaufende Kantenausbildungen vorhanden sind, die jeweils einen kleineren Querschnitt als eine der Zwischenausbildungen aufweisen.
8. Strukturträger nach Anspruch 7, wobei sich die Verjüngung über die gesamte Distanz vom Plateau zur oberen Fläche (4) der Basis erstreckt.
9. Strukturträger nach Anspruch 8, wobei die Formationen eine Abdeckung über der Aussparung tragen, die den Hohlraum zwischen den Formationen schließt.

10. Strukturträger nach Anspruch 9, wobei die Hohlräume leer gelassen sind.
11. Strukturträger nach Anspruch 9, bei dem die Hohlräume mit einem leichten Füllstoff gefüllt sind, der aus Polystyrol, Zement oder Beton ausgewählt ist.
12. Strukturträger nach Anspruch 11, wobei die longitudinalen Kantenausbildungen asymmetrisch sind.
13. Strukturträger nach Anspruch 12, bei dem die Ausformungen zwischen den Kantenausbildungen symmetrisch sind.
14. Strukturträger nach Anspruch 13, wobei eine Außenkantenseite der longitudinalen Ausbildungen einen Absatz aufweist, dessen Geometrie Scherkräfte zwischen aneinanderstoßenden Trägern überträgt.
15. Strukturträger nach Anspruch 14, wobei der Träger zu einem Ende hin und relativ zu einer Längsachse des Trägers verjüngt ist.

Revendications

1. Poutre en béton structurelle préfabriquée porteuse destinée à former une partie d'un plancher en béton structurel autoportant suspendu formé par une pluralité desdites poutres structurelles préfabriquées posées en butée côte à côte ; chaque poutre précitée comprenant, lorsque vue en bout ou en coupe transversale :
 - une base (2) ayant une surface inférieure (3) et une surface supérieure (4),
 - au moins deux formations en queue d'aronde trapézoïdales effilées espacées (5-7) s'étendant chacune à partir de la surface supérieure et comprenant chacune un plateau (16-18) et une paroi latérale définissant, conjointement avec une base (2) et une paroi latérale opposée d'une formation adjacente, un évidement effilé, les parois latérales de l'évidement étant linéaires et disposées selon un angle aigu par rapport à la surface supérieure de la base de la poutre structurelle ;
 - ce par quoi le plateau (16-18) de chaque formation précitée (5-7), vu en coupe transversale, a une dimension de largeur qui est plus grande qu'une dimension de largeur à une jonction de chaque formation précitée et de la base ; l'évidement effilé formant un espace vide qui est capable de recevoir une charge de remplissage légère ; la poutre structurelle étant capable d'être porteuse lorsqu'elle est simplement supportée à chaque extrémité et ayant un rapport résistance/poids élevé.

2. Poutre structurelle selon la revendication 1, dans laquelle chaque évidement a une partie large à la surface supérieure (4) de la base (2) et une partie étroite adjacente au plateau des formations.
3. Poutre structurelle selon la revendication 2, dans laquelle chaque formation comprend une partie étroite près de la surface supérieure de la base et une partie large au plateau de la formation de telle sorte que l'angle externe d'effilement desdites formations est compris entre 45 degrés et 70 degrés par rapport à la surface supérieure (4) de la base (2).
4. Poutre structurelle selon la revendication 3, dans laquelle chaque formation est espacée de manière égale d'une formation adjacente.
5. Poutre structurelle selon la revendication 4, dans laquelle les formations forment des nervures espacées longitudinales le long de la longueur de la poutre structurelle.
6. Poutre structurelle selon la revendication 5, dans laquelle chaque formation en queue d'aronde a une partie étroite à la surface supérieure de la base, et la formation s'effilant jusqu'à une partie large au plateau.
7. Poutre structurelle selon la revendication 6, dans laquelle il y a une pluralité des formations en queue d'aronde intermédiaires uniformément espacées (6) s'étendant longitudinalement le long de la longueur de la poutre, et de formations de bord s'étendant longitudinalement le long de la longueur de la poutre, ayant chacune une section transversale plus petite que celle des formations intermédiaires.
8. Poutre structurelle selon la revendication 7, dans laquelle l'effilement s'étend sur toute la distance allant du plateau à la surface supérieure (4) de la base.
9. Poutre structurelle selon la revendication 8, dans laquelle les formations supportent une couverture sur l'évidement fermant l'espace vide entre des formations.
10. Poutre structurelle selon la revendication 9, dans laquelle les vides sont laissés vides.
11. Poutre structurelle selon la revendication 9, dans laquelle les vides sont remplis d'une charge de remplissage légère choisie parmi du polystyrène, du ciment ou du béton.
12. Poutre structurelle selon la revendication 11, dans laquelle les formations de bord longitudinales sont asymétriques.

13. Poutre structurelle selon la revendication 12, dans laquelle les formations intermédiaires aux formations de bord sont symétriques.

14. Poutre structurelle selon la revendication 13, dans laquelle une face de bord externe de formations longitudinales a un épaulement dont la géométrie transmet des forces de cisaillement entre des poutres en butée.

15. Poutre structurelle selon la revendication 14, dans laquelle la poutre est effilée vers une extrémité et par rapport à un axe longitudinal de la poutre.

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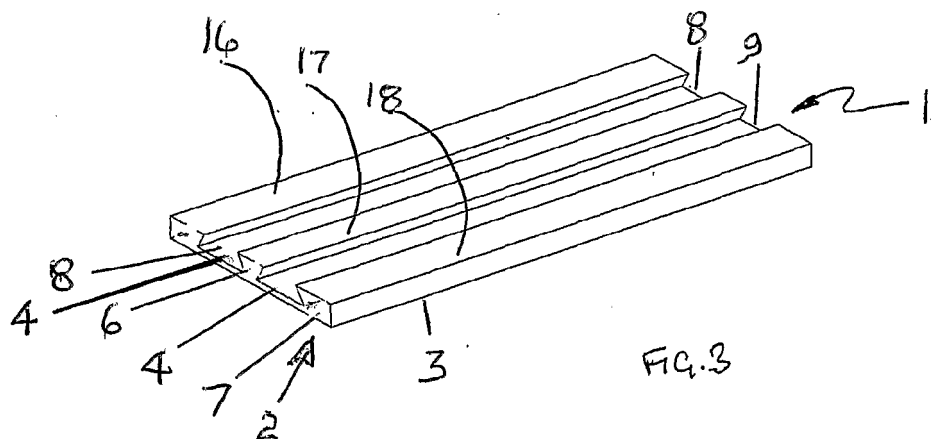
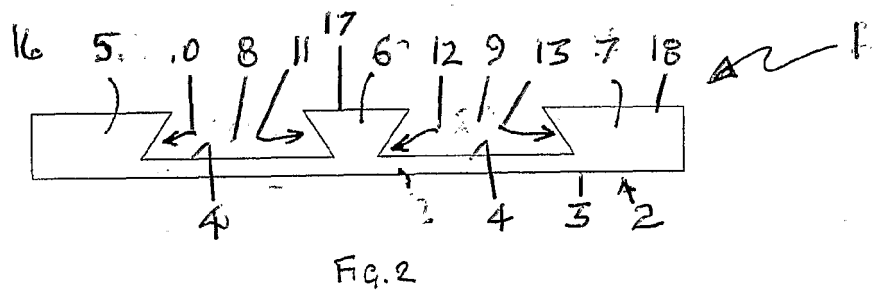
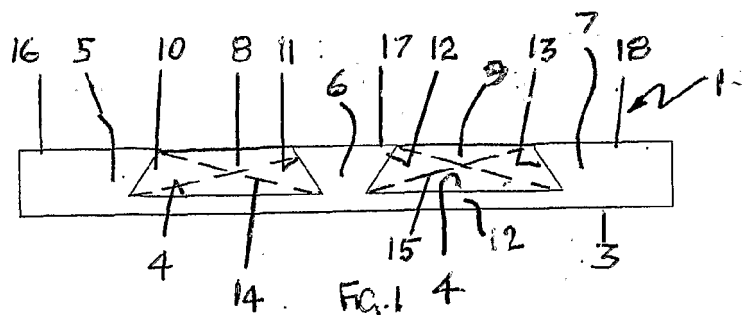
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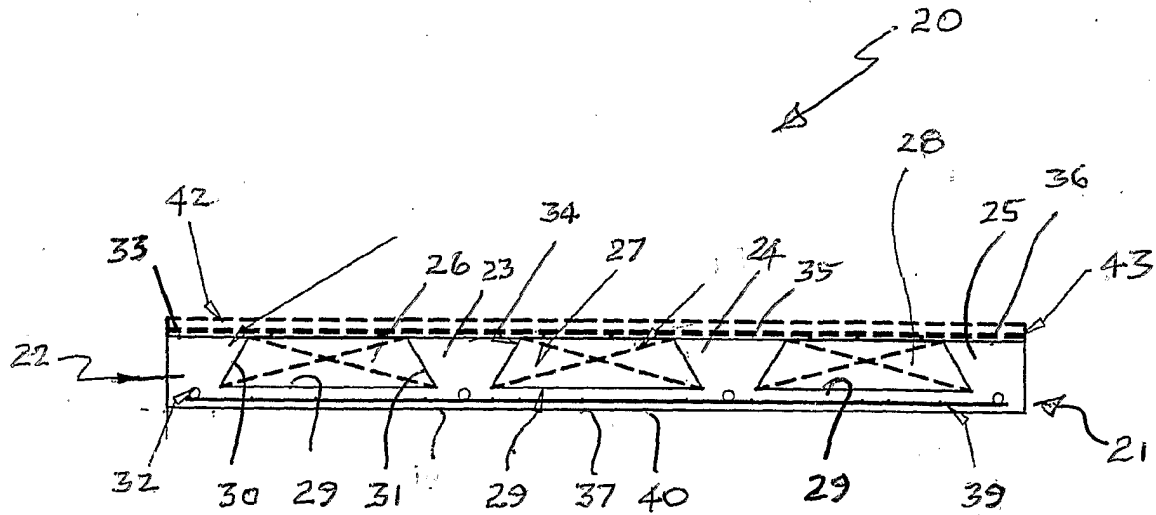


Fig 4

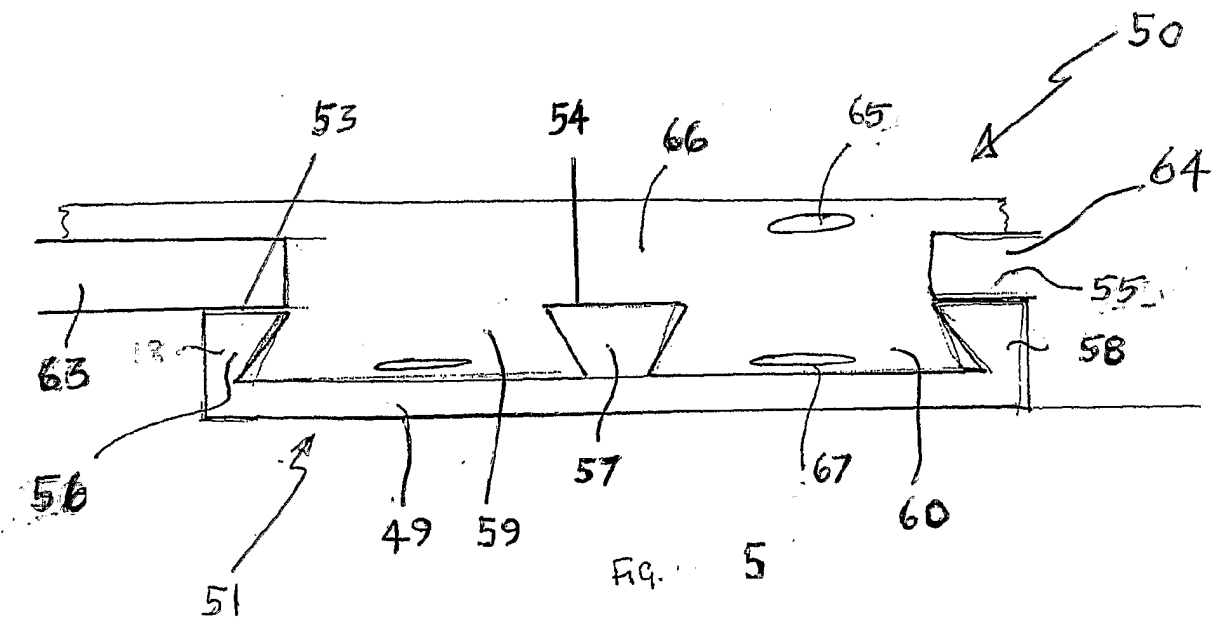


Fig. 5

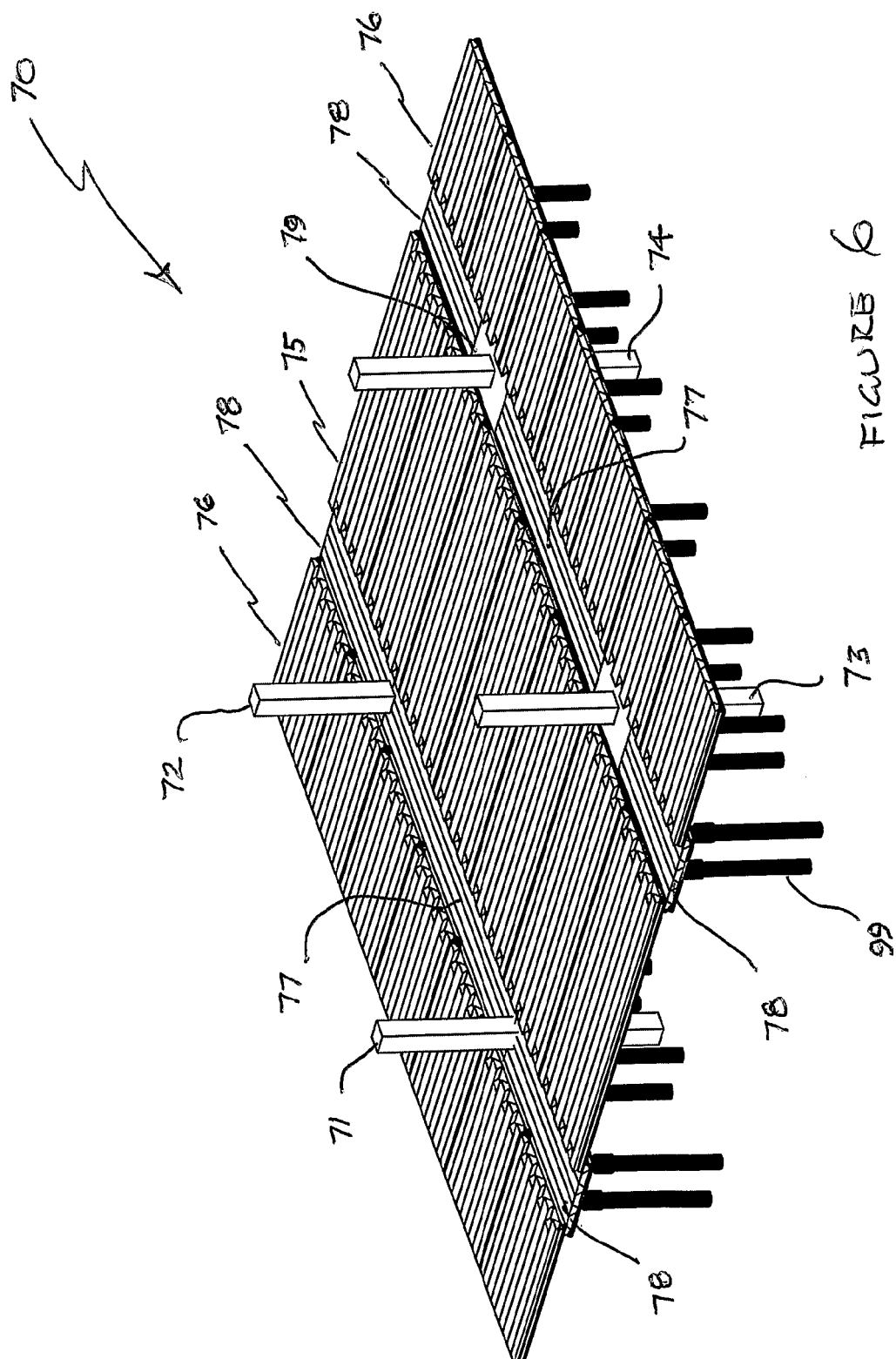
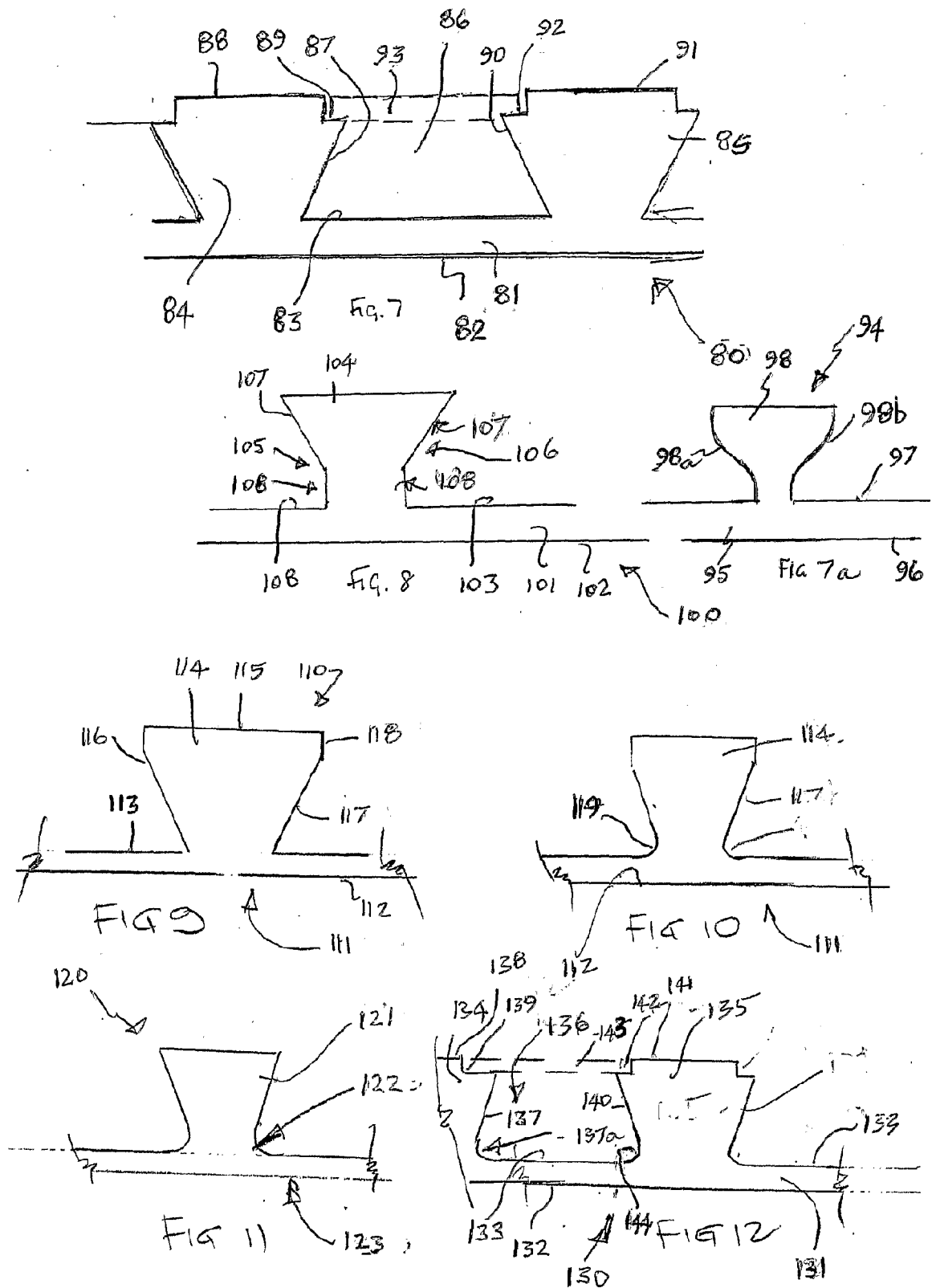


FIGURE 6



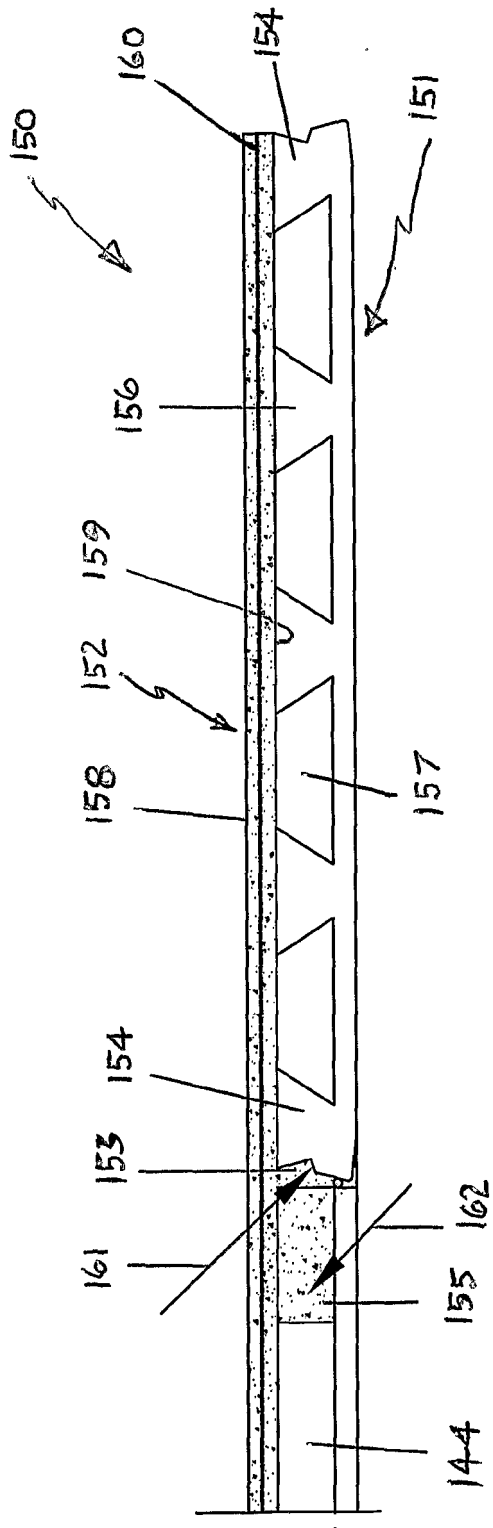


FIGURE 13

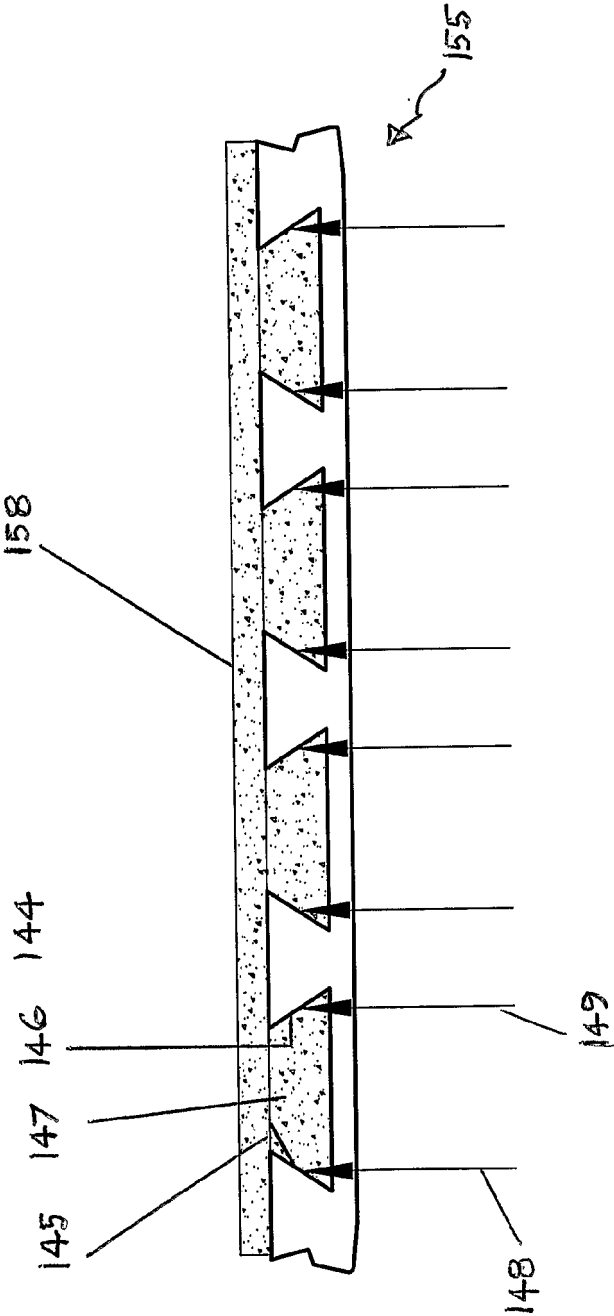


FIGURE 14

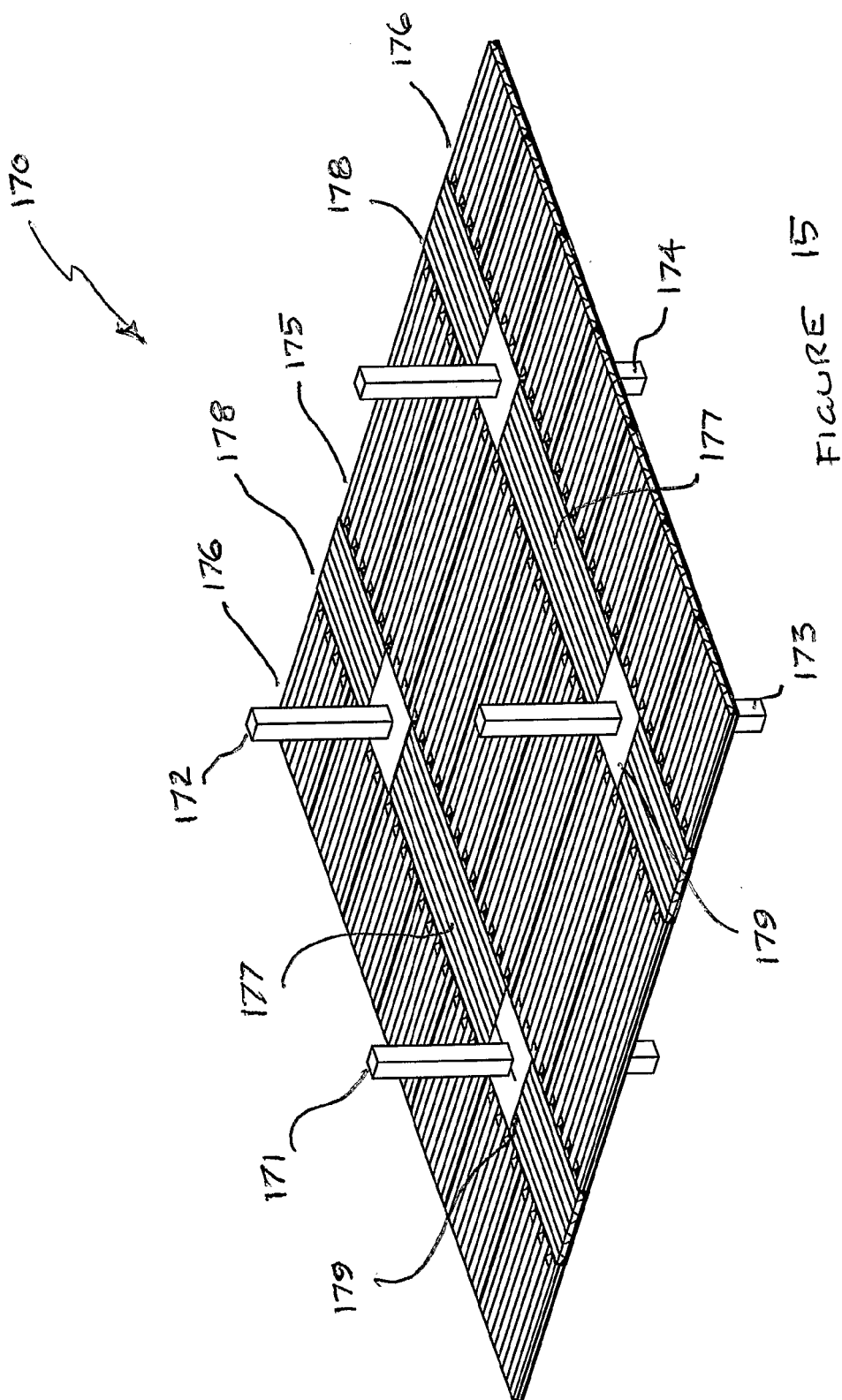
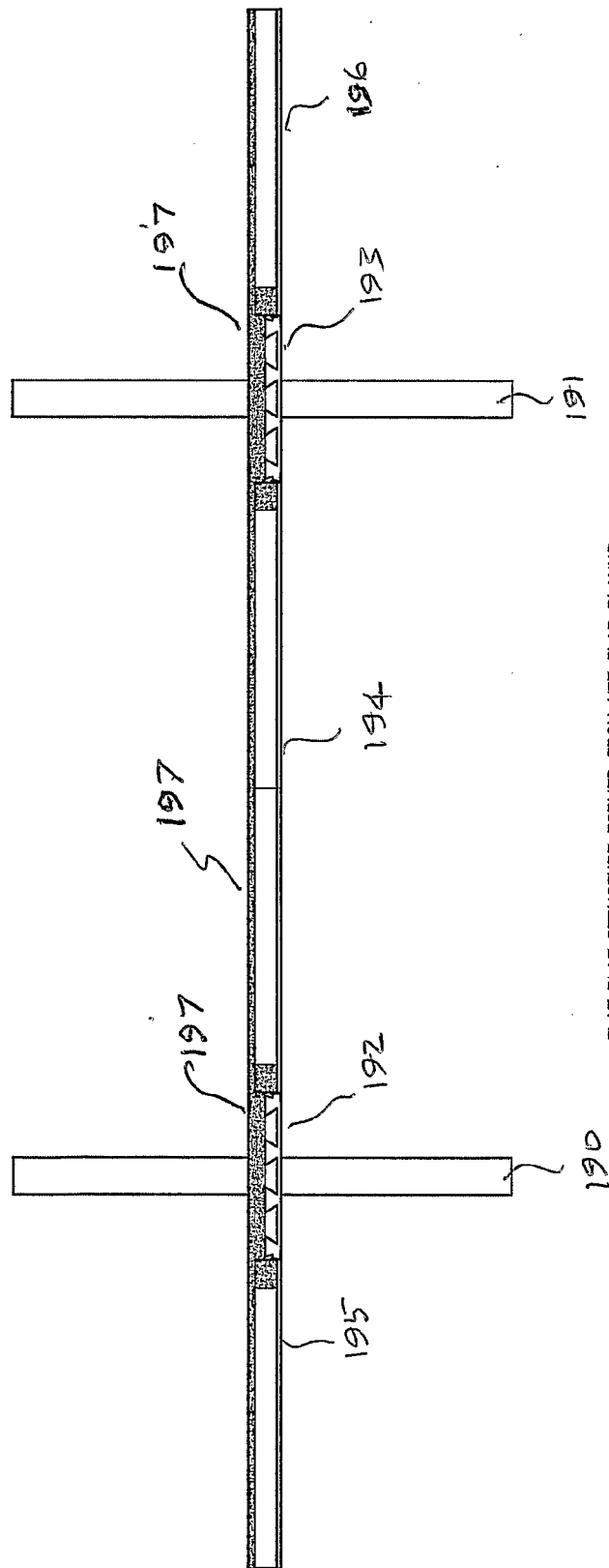
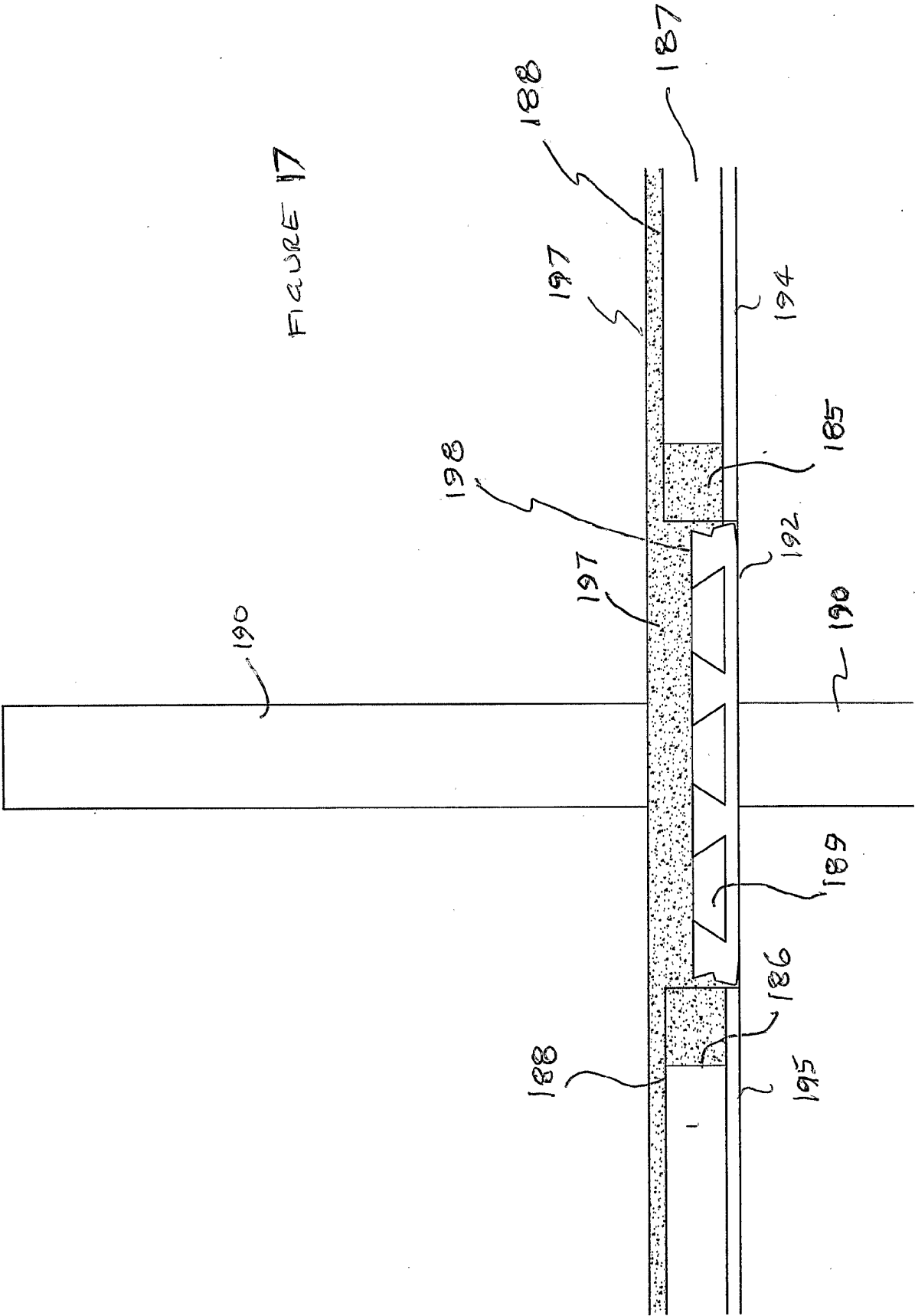


FIGURE 15



FLAT PLAT STRUCTURE FORMED FROM VEE SLAB PLANKS

Figure 16



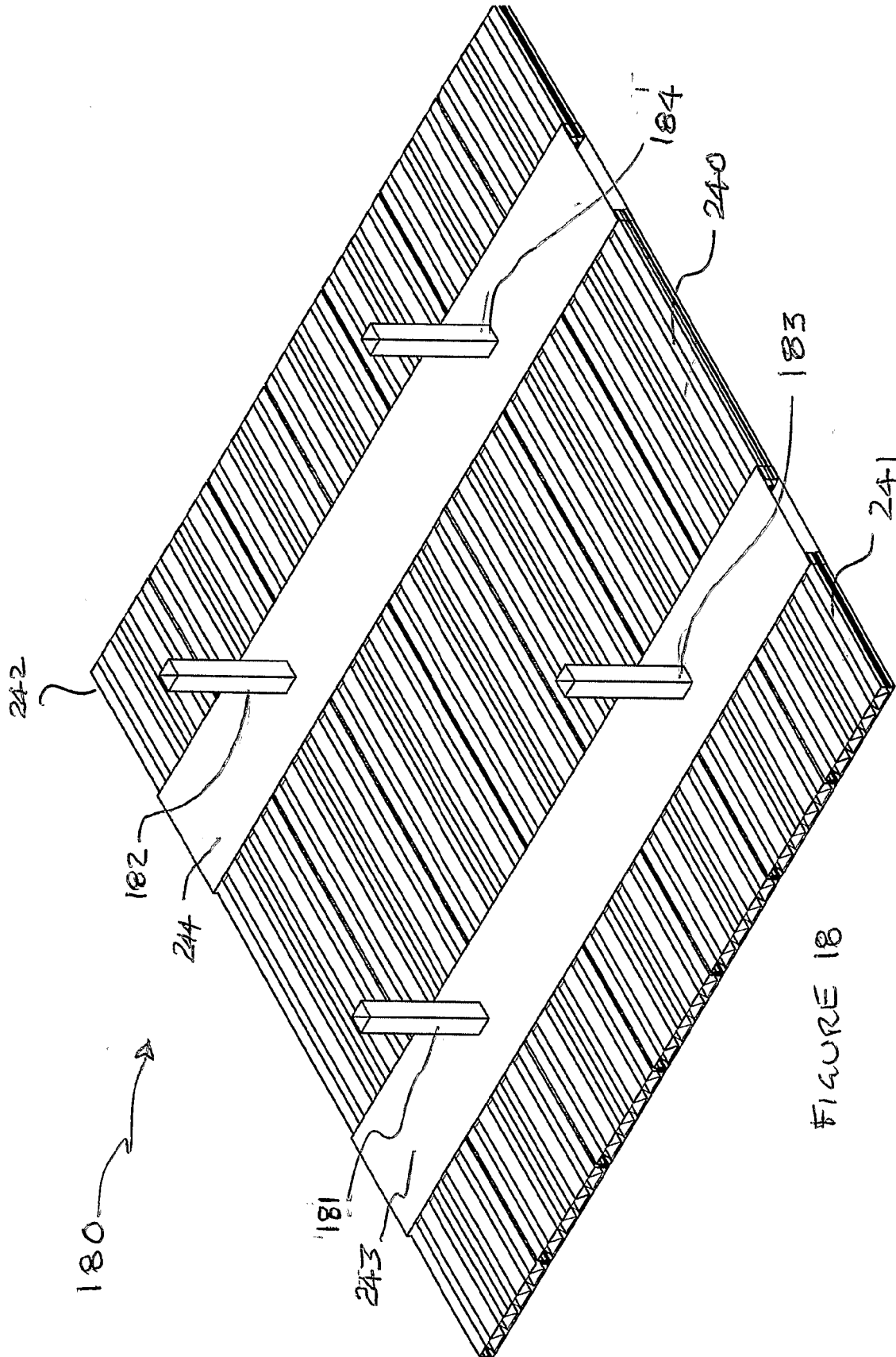
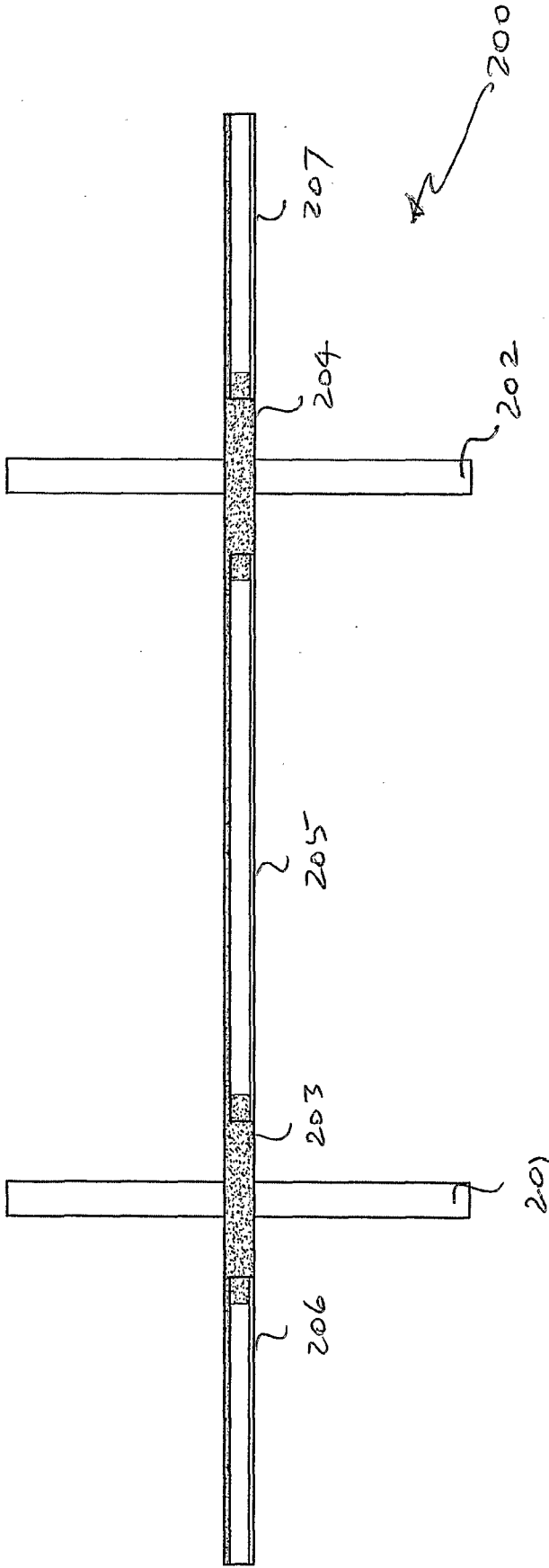


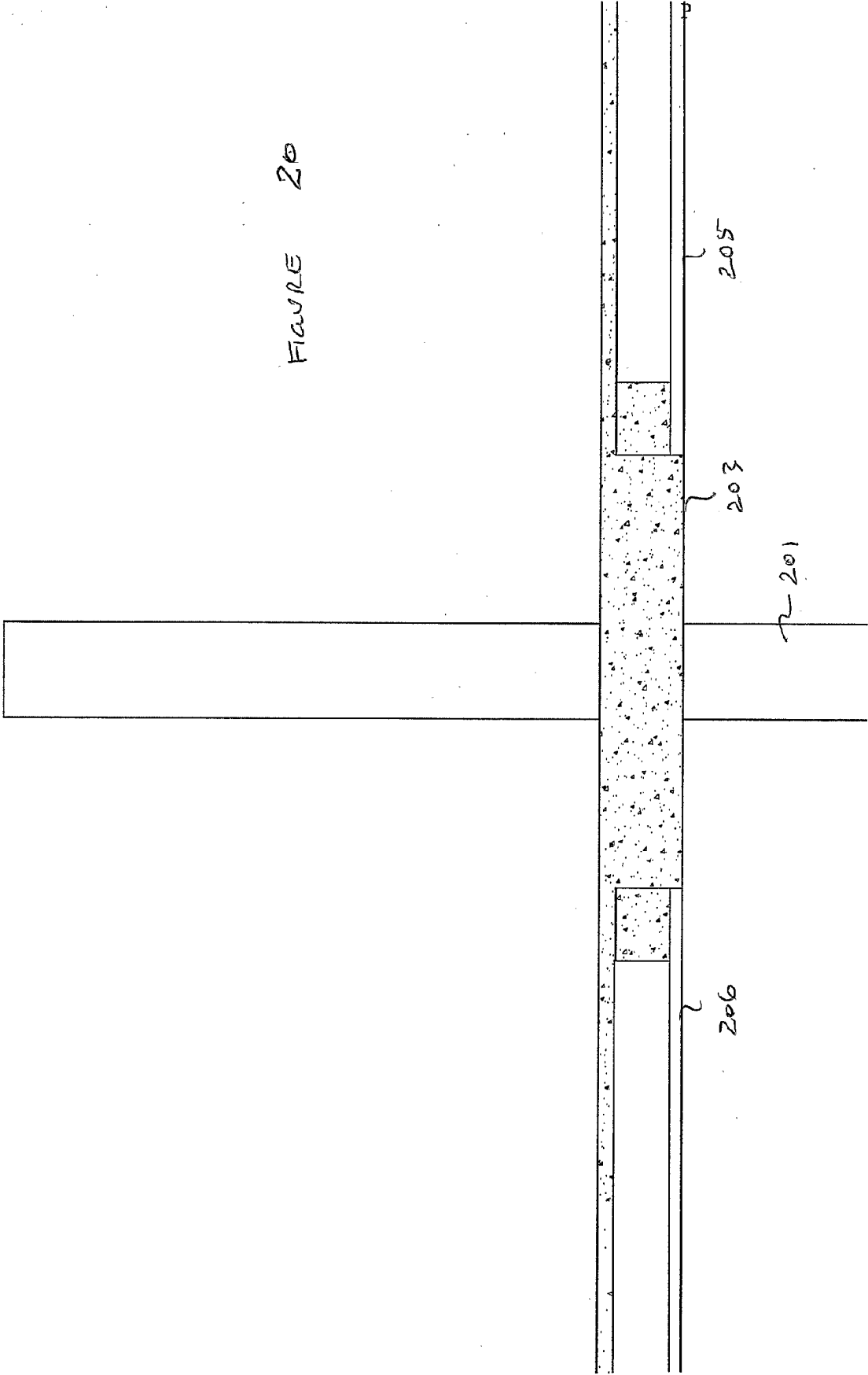
FIGURE 18

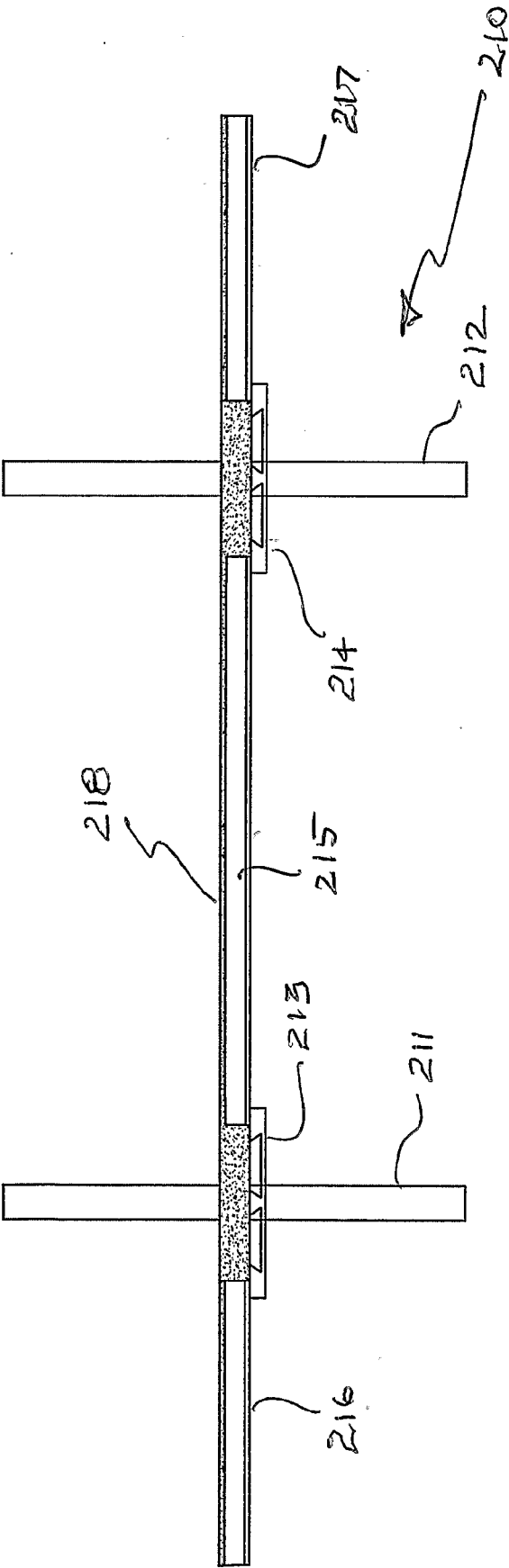


FLAT PLAT STRUCTURE FORMED FROM VEE SLAB PLANKS AND AN INSITU BAND

FIGURE 19

FIGURE 20





BANDED STRUCTURE USING VEESLABS FOR BANDS AND SLABS

FIGURE 21

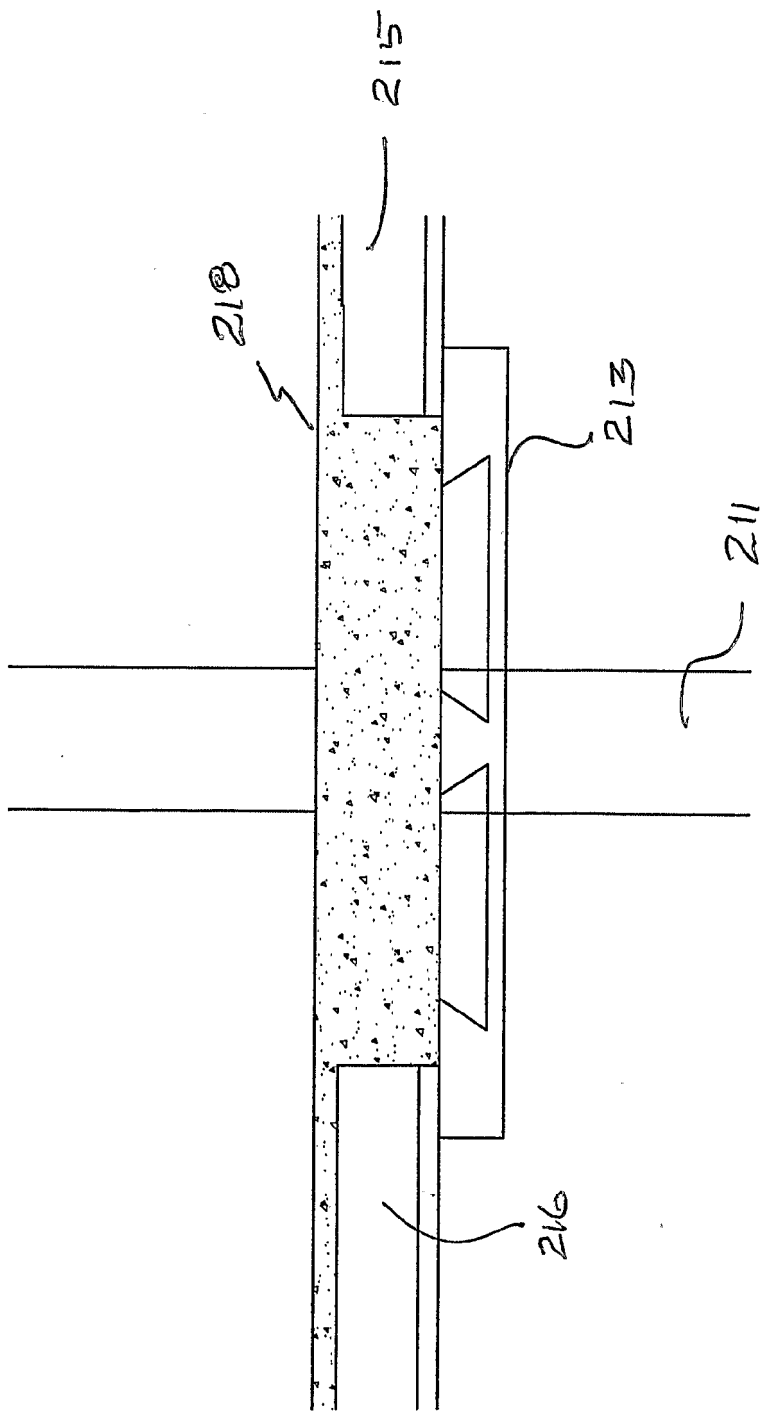
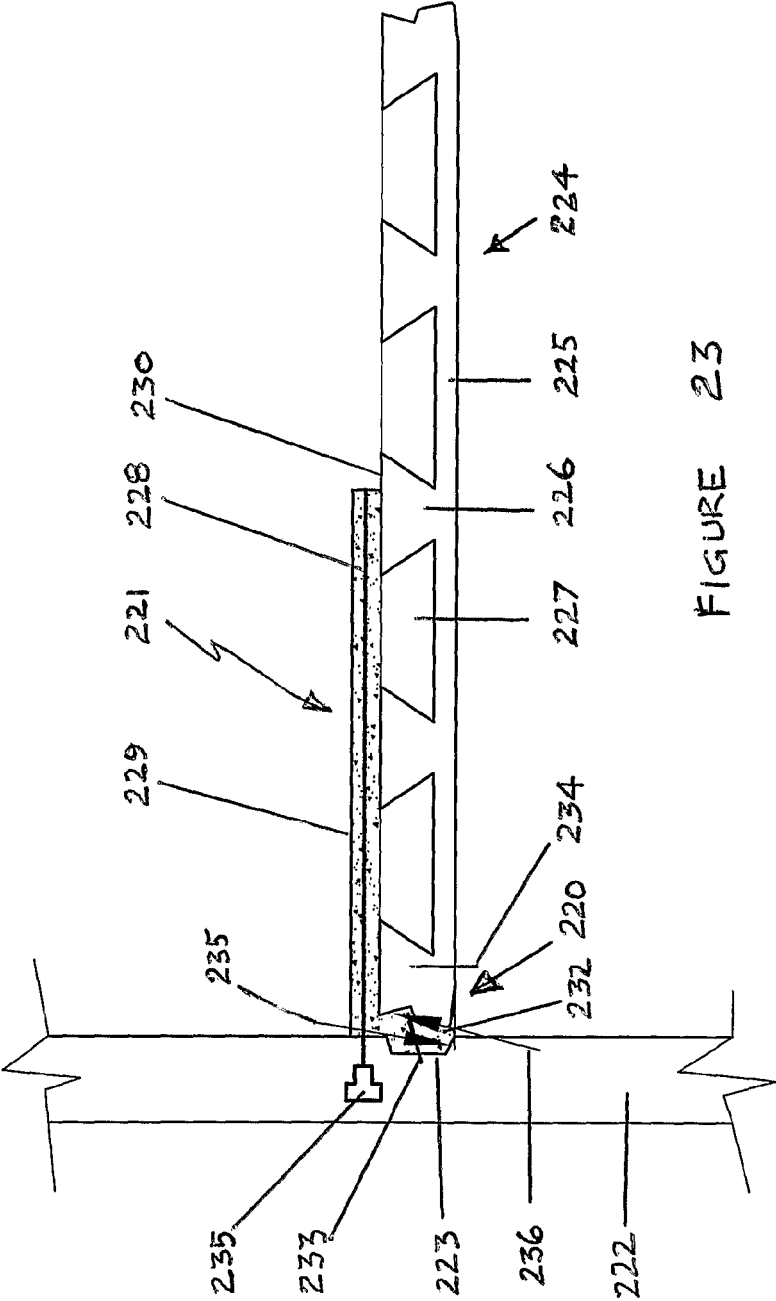


FIGURE 22



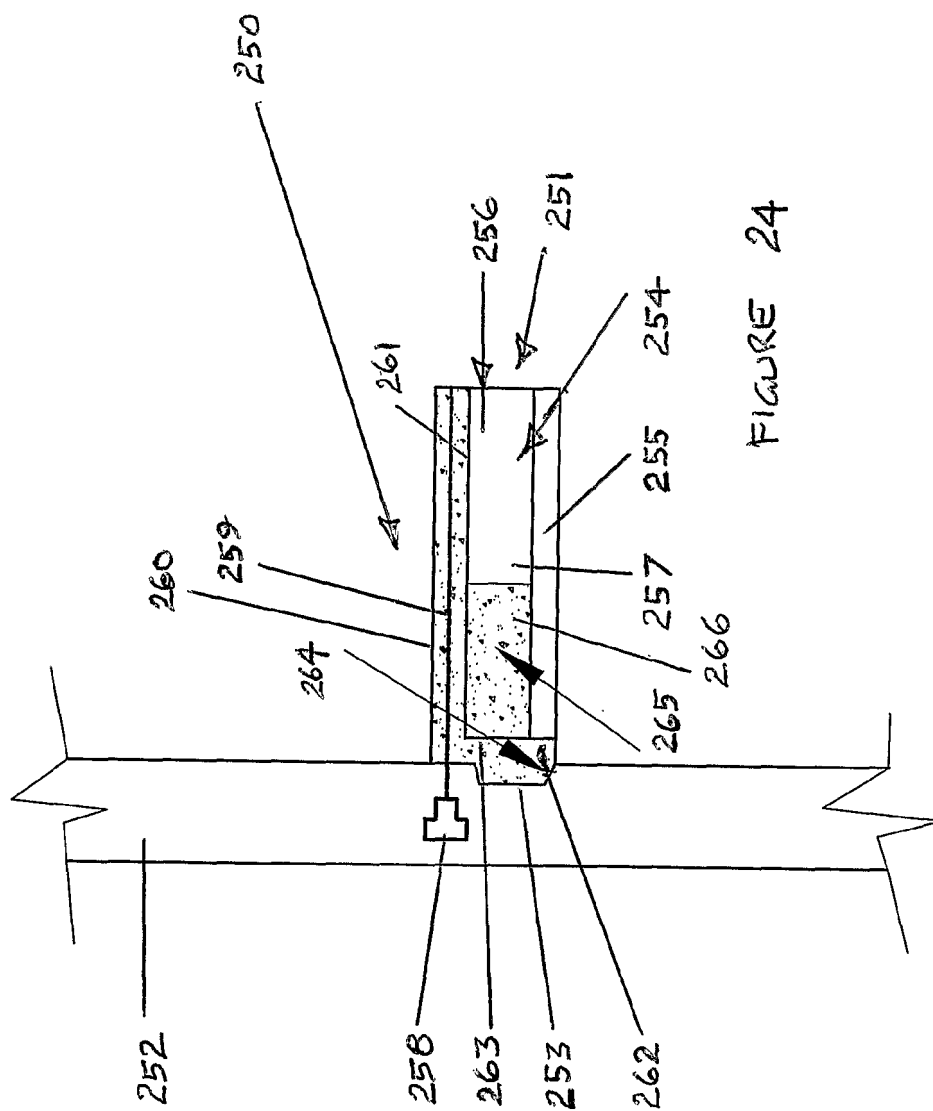


FIGURE 24

REFERENCES CITED IN THE DESCRIPTION

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