US 20030190190A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2003/0190190 A1

(43) Pub. Date: Oct. 9, 2003

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(54) ARTICULATED CONCRETE JOINT MEMBER

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(21) Appl. No.: 10/381,289

(22) PCT Filed: Sep. 28, 2001

(86) PCT No.: PCT/AU01/01233

(30) Foreign Application Priority Data

Sep. 29, 2000 (AU) PR0454

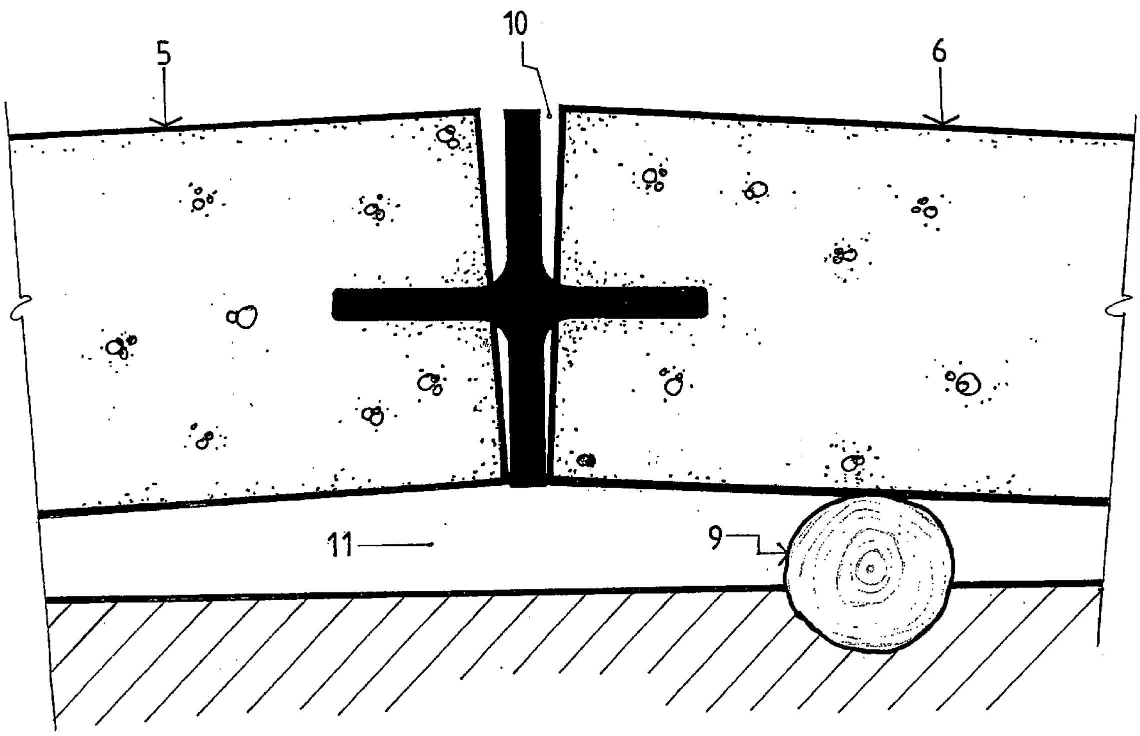
Publication Classification

(51) Int. Cl.[7] E01C 11/02

(52) U.S. Cl. 404/52

(57) ABSTRACT

An articulated concrete joint member (1) including a resilient core (2), the core (2) having connections means (3) attached thereto, the connection means (3) adapted to link two co-planar concrete slabs (5, 6) along an adjacent peripheral edge of each slab, wherein on application of an out-of-plane displacement to one of the co-planar concrete slabs (5, 6) the displacement is transmitted to the other slab through pivoting about the articulated joint member (1). In one embodiment, the articulated concrete joint member (1), which further includes crack propagation means (4), is fully immersed in the concrete slab so that the slab is subjected to extraneous loads, the slab cracks along predetermined lines of weakness (7).



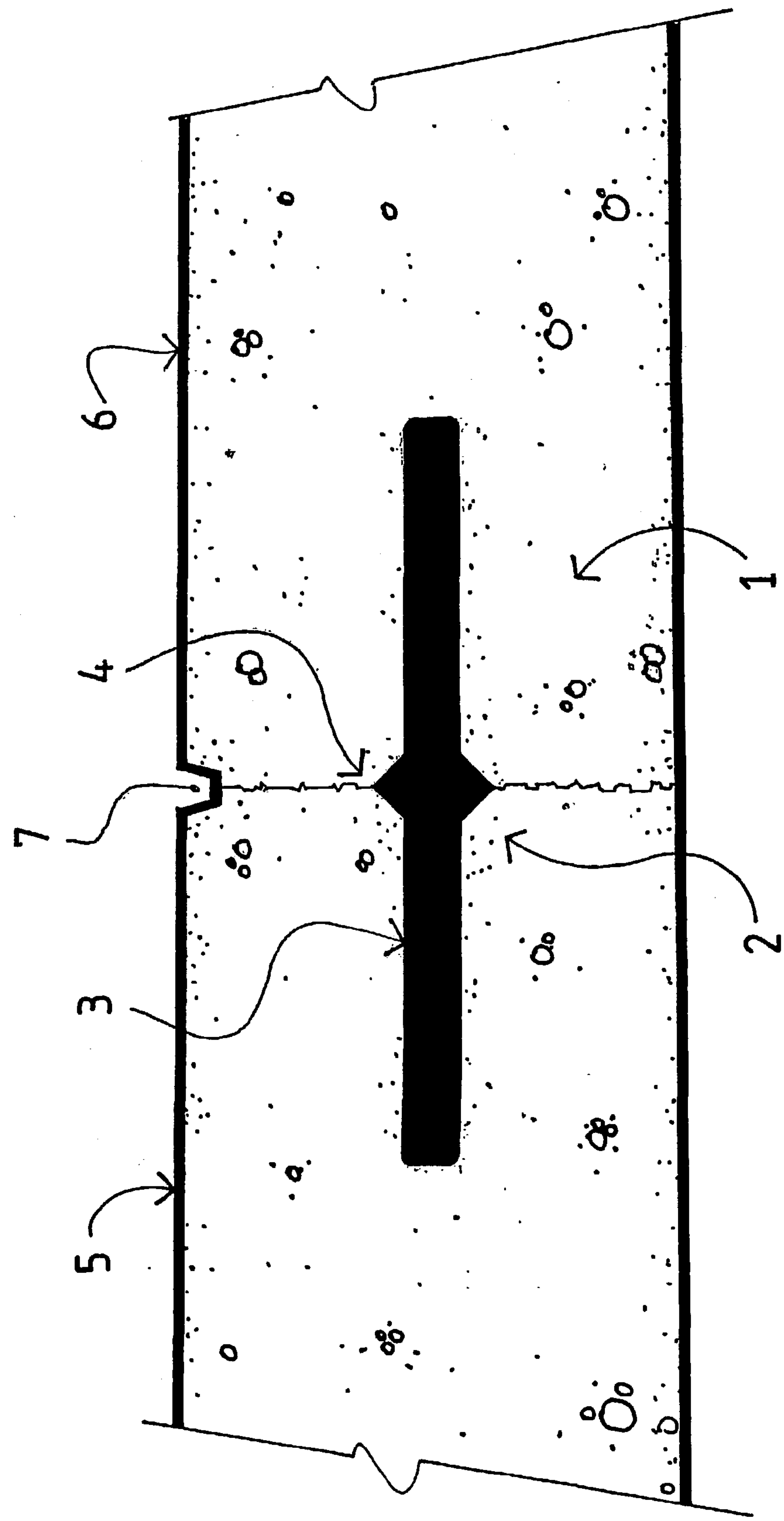


FIGURE 1

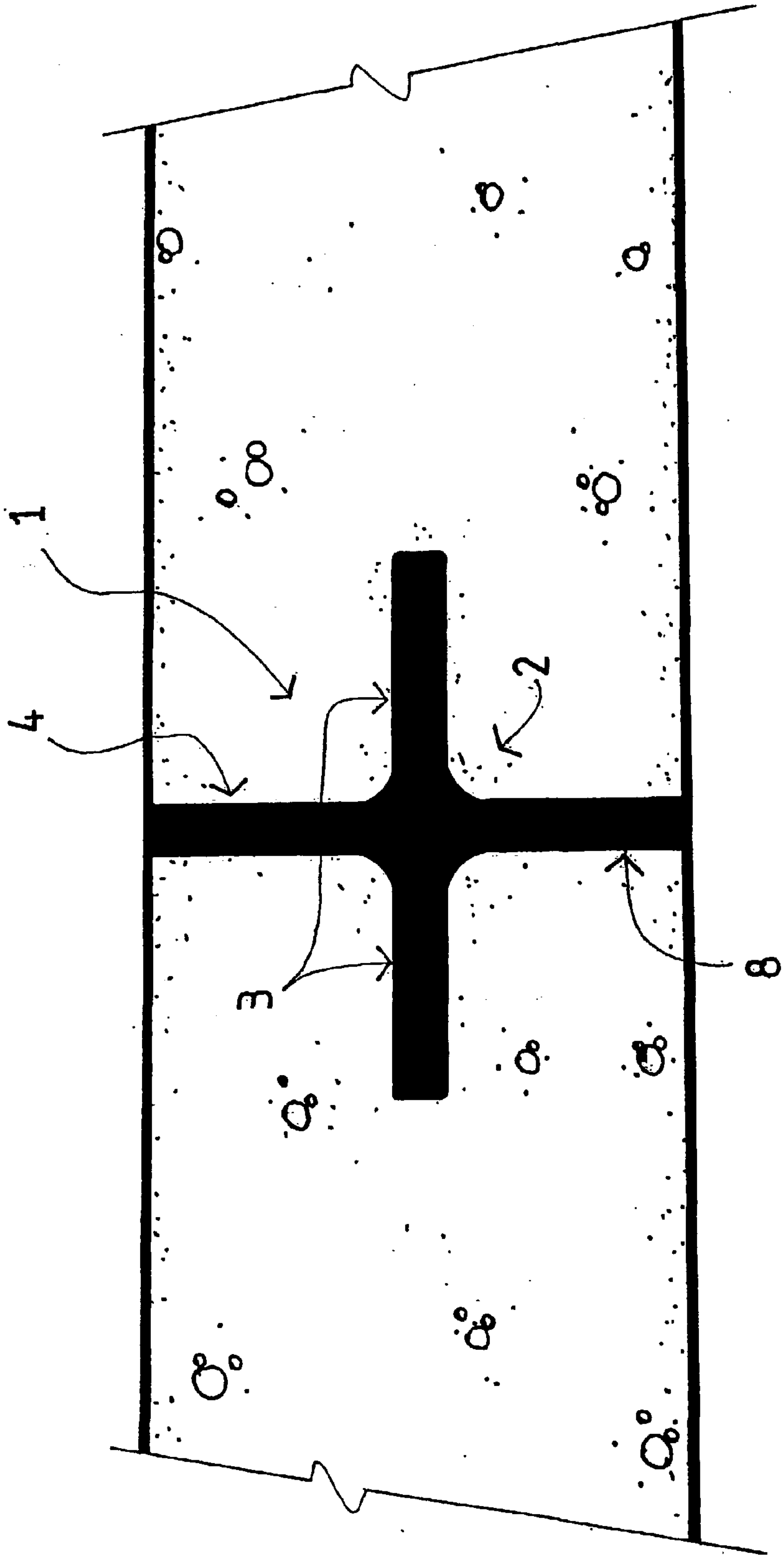


FIGURE 2

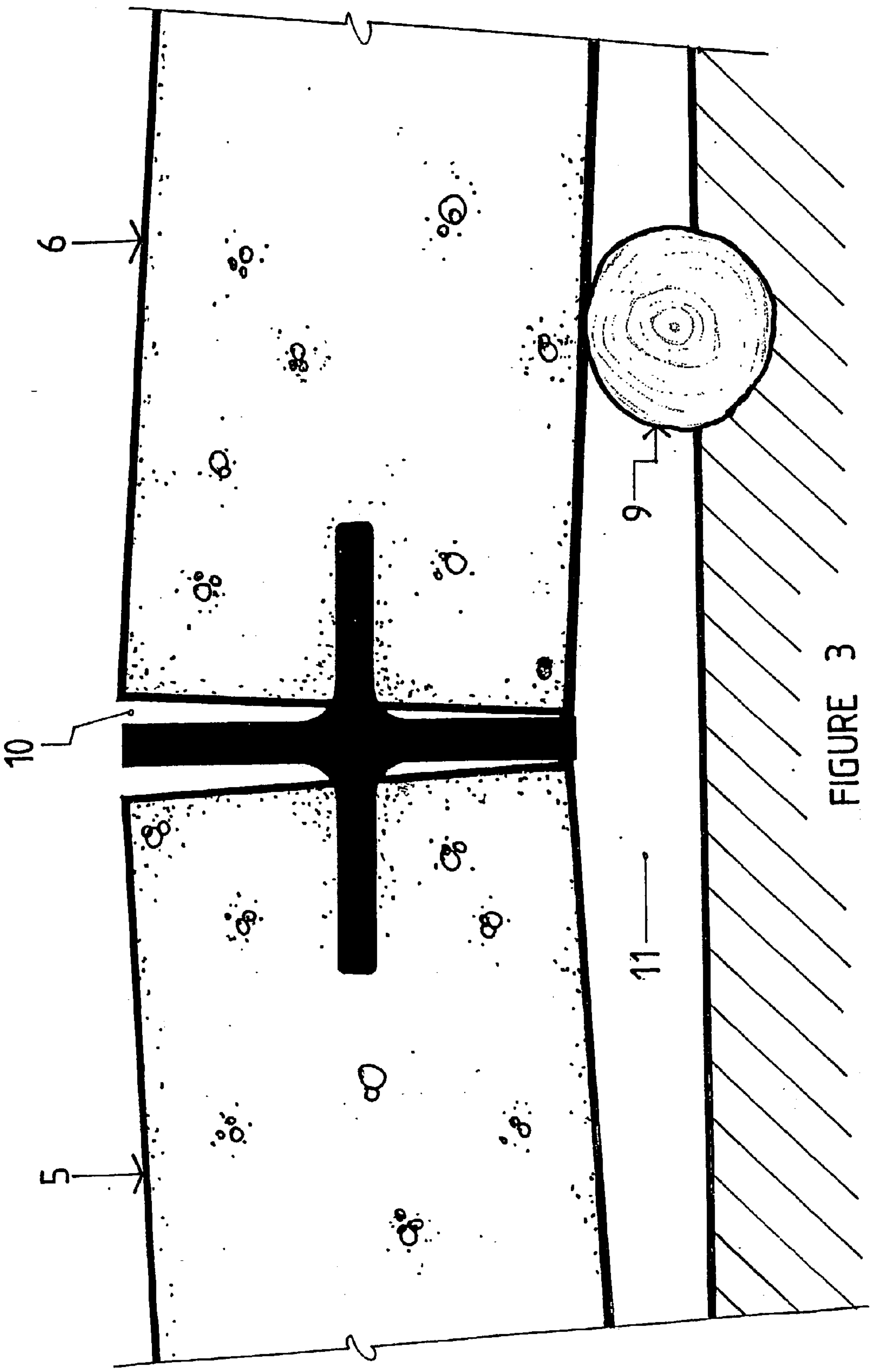


FIGURE 3

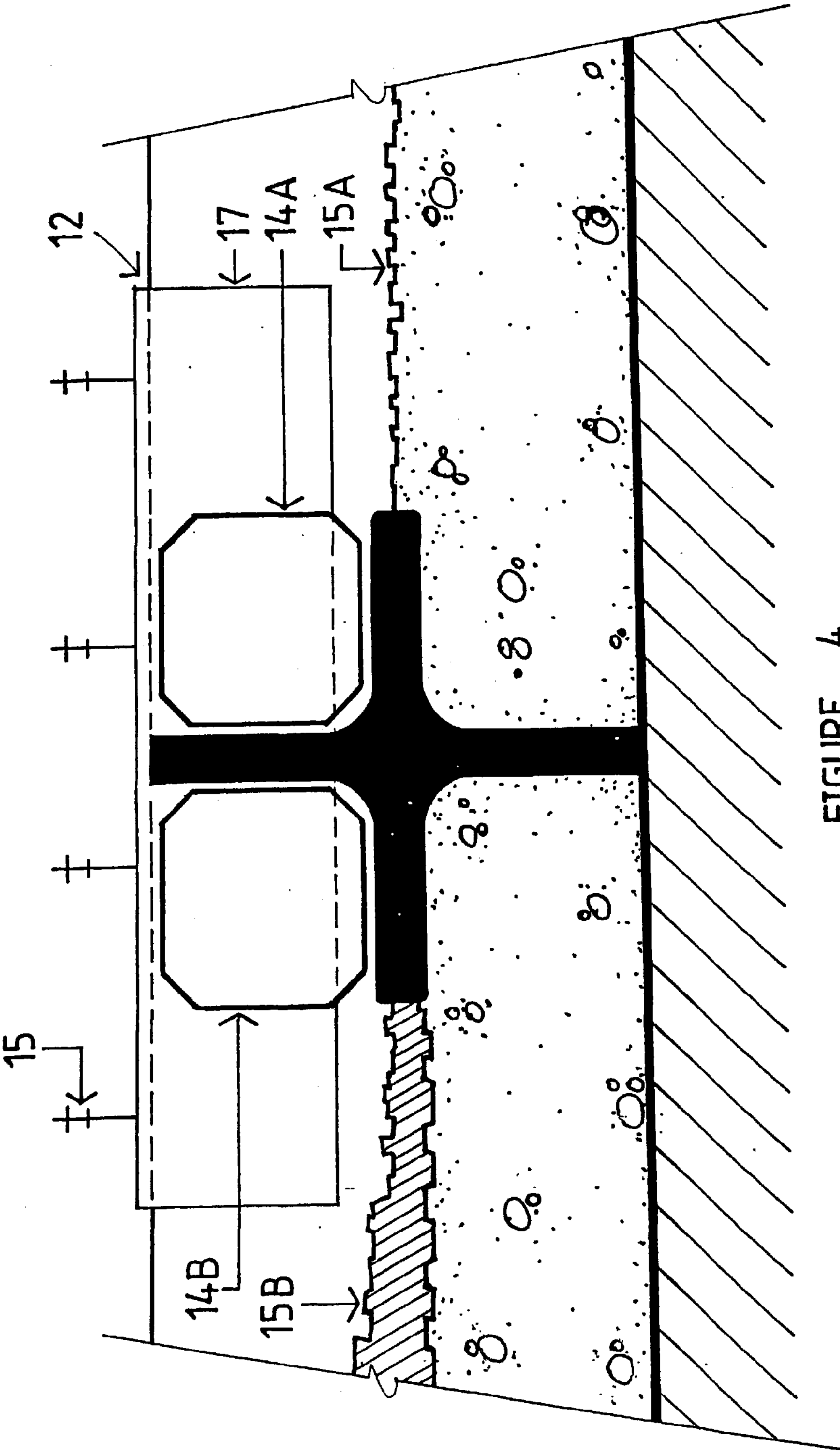


FIGURE 4

FIGURE 5A

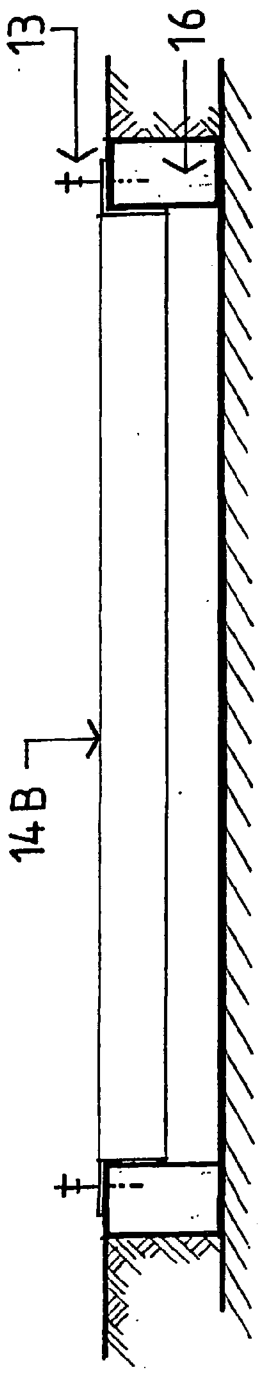
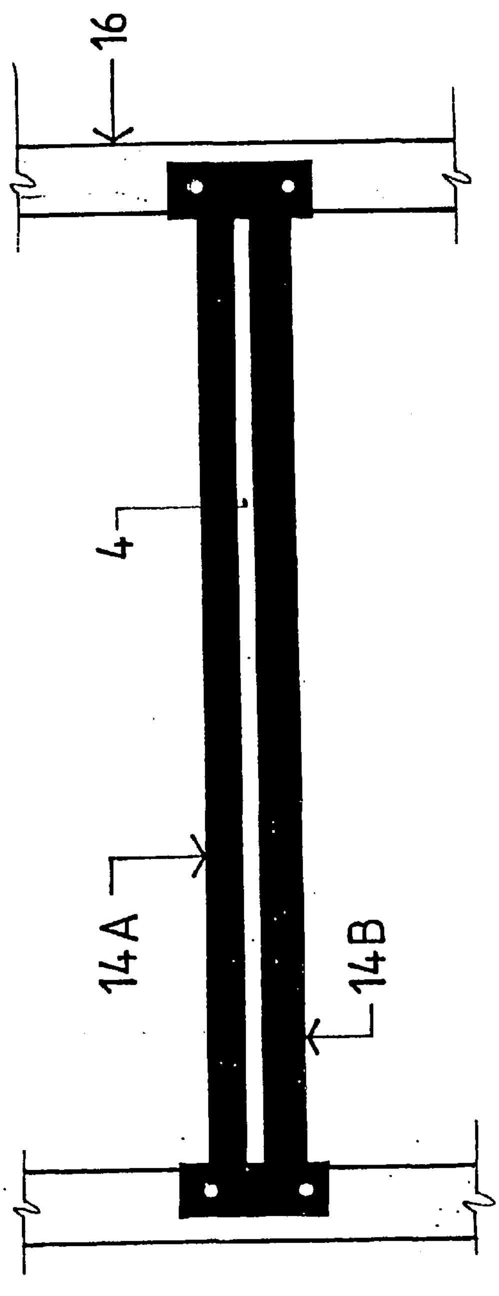


FIGURE 5B



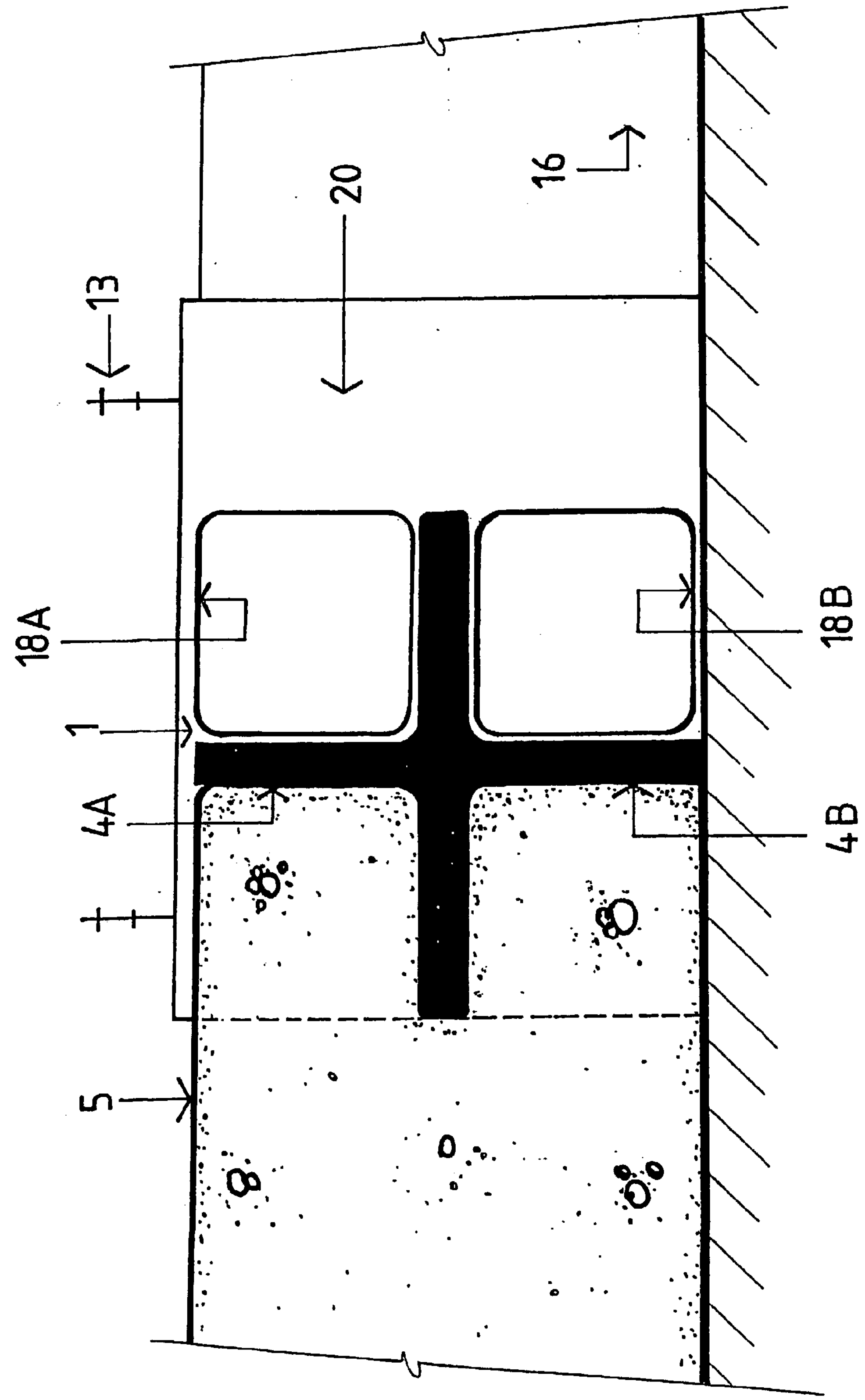


FIGURE 6

ARTICULATED CONCRETE JOINT MEMBER

FIELD OF THE INVENTION

[0001] The invention relates to the construction of pavements and concrete slabs, and in particular, the jointing method used in cases of differential movement between said slabs.

BACKGROUND OF THE INVENTION

[0002] Pedestrian thoroughfares whether associated with a road, through a park or other means, and which fall under the control and maintenance responsibility of a Municipal Council will often be formed from concrete. As such pedestrian thoroughfares carry very light traffic loads, typically, such thoroughfares or footpaths will have little or no reinforcement within the concrete.

[0003] Typically, the footpath will be formed from pavement slabs which are cast in place in significant lengths so as to economically place the pavement by limiting the number of concrete pours required when constructing the thoroughfare between locations.

[0004] As the pavement is cast in a unitary mass it is recognized that the unitary slab will eventually crack as a result of external factors and the lack of reinforcement. Such external factors can be root intrusion from nearby trees, soil heave from saturated expansive clays, soil shrinkage through drying during summer, or differential settlement of the foundation as a result of a poorly prepared base course supporting the pavement.

[0005] So as to control the number and placement of this cracking, transverse lines of weakness are placed in the concrete prior to curing. Typically, this is done by trowelling a line across the concrete, and thus provide a localised weakening of the concrete, as compared to surrounding areas. This has the dual effect of disguising the crack within this line of weakness, as well as managing the long term serviceability of the pavement by ensuring the creation of a plurality of slab units from the original unitary slab.

[0006] Unfortunately, following the initial crack at the line of weakness the interfering factor, be it soil or a tree root, will continue to affect the slab. The slab, having been broken into discrete and much smaller units, is free to lift. Further, as such interfering factors inevitably cause differential movement, in that adjacent slabs will be affected to varying degrees, the movement of one slab compared to an adjacent slab will be at a different rate and displacement.

[0007] The differential movement of one slab to the next will inevitably cause the raising of one peripheral edge higher or lower than its neighbour. Thus, the once continuous surface will be no longer, with several raised discontinuities being formed along the surface.

[0008] Thus, depending on the conditions, the once unitary slab having a flat continuous surface will comprise a plurality of discrete units providing a disjointed and discontinuous surface. Such a surface, instead of providing a convenient path for pedestrian vehicles, such as wheelchairs, prams, etc., will instead become effectively impassable for such pedestrian vehicles, not to mention becoming a hazard to foot traffic.

[0009] Thus it becomes a serious issue for Municipalities to devote funds from constrained budgets to expensive maintenance programmes to replace the pavements that have suffered differential displacements between the pavement slabs. Further, such Municipalities must maintain a contingent liability against litigation brought by pedestrians who may injure themselves by tripping and falling as a result of the raised peripheral edges of the slab units.

STATEMENT OF THE INVENTION

[0010] It is therefore an object of the invention to reduce differential displacement between concrete slabs, and so diminish the consequential detrimental effects associated with this displacement.

[0011] Hence, in a first aspect of the present invention there is provided an articulation member including a resilient core, said core having connection means attached thereto, the connection means adapted to link two co-planar concrete slabs along an adjacent peripheral edge of each slab, wherein on application of an out-of-plane displacement to one of the co-planar concrete slabs, the displacement is transmitted to the other concrete slab through pivoting about the articulation member.

[0012] In a second aspect of the present invention, there is provided a method of constructing an assembly of articulated slabs, the method including the steps of:

[0013] (i) establishing form-work adapted to receive wet concrete;

[0014] (ii) placing a plurality of articulation members along a plurality of articulation lines;

[0015] (iii) pouring of wet concrete within the form-work so as to engage the articulation members;

[0016] (iv) curing of the concrete, to form a plurality of adjacent slab units connected by the articulation members.

[0017] In one preferred embodiment of the invention, the wet concrete may fully immerse the articulation members, and consequently form lines of weakness at the articulation lines. In this embodiment, should the assembly be subject to extraneous loads, such as through soil movement or root intrusion, the assembly may crack along the lines of weakness and so form the plurality of adjacent slab units connected by the articulation members.

[0018] In a third aspect of the present invention there is provided a concrete slab, including a plurality of lines of weakness and a plurality of articulation members placed along said line of weakness wherein said slab is adapted to crack along the lines of weakness, resulting in slab portions that are articulated through connection with the articulation members.

[0019] In the case of a cast in place pavement, the articulation member will be cast within the unitary pavement. By placing the articulation member along the transverse line of weakness that is typically trowelled into the pavement when the pavement eventually cracks through the interference of soil or tree root, the unitary pavement will form two discrete slabs adjacent each other, with the adjacent peripheral edges of each slab essentially co-linear with the articulation member.

[0020] In laying a unitary pavement so as to connect it to an adjacent unitary pavement slab, it is common to place expansion and contraction joints between said slabs. A contraction joint is typically a resilient sheet of material that on shrinkage of the concrete during curing, the resilient material will prevent voids being created between said slabs. Similarly, and also in application to expansion joints it is known for concrete slabs to use steel dowels between said slabs. Said dowels are placed within tubes cast within the concrete so as to permit free uni-directional movement between the slabs by sliding along the dowels. The dowels being made from steel, and thus being relatively stiff, are placed to provide a transfer of out-of-plane forces between the slabs. As one slab has a substantial force applied to it, said force is transferred to the next slab by the dowels, and thus maintain a continuous surface between the slabs. The disadvantage of such a system is that in transferring this load, localized failure of the concrete at the peripheral edges of the two slabs must be prevented. Thus, the concrete portion using the dowels must be specifically reinforced and/or have a thickened portion designed into the concrete slab. Further, the placement of the dowels adds a secondary process to the placement of the pavement. Thus while a dowelling system is a useful tool for transferring displacements and loads between slabs, it is also an expensive one and usually inappropriate for general application footpaths. This can be seen by the preference of Municipalities for using on-going maintenance programmes to repair pavements rather than the extremely large capital cost of extensive use of a dowelling system. The present invention overcomes the disadvantages of the dowelling system by recognizing, firstly, that whilst a continuous surface for a pavement is essential, having that continuous surface flat is not so for a footpath. Thus whilst the lifting of a slab unit may not be preventable within reasonable cost constraints, neither should it be necessary to prevent, so long as the pavement remains serviceable and safe for pedestrian traffic.

[0021] Thus, it should be appreciated that whilst the articulation member may not be connected to two slabs in the first instance, but possibly cast within the unitary pavement slab, the invention commences functioning immediately following the controlled cracking of the pavement and thus the creation of the plurality of slab units. This should not be construed as rejecting the cast of two adjacent slabs, connected by a cast-in-place articulation member.

[0022] As discussed, the outer plane displacement that is applied to a concrete slab may be caused by tree roots, soil expansion, soil drying, or an unstable base course laid beneath the pavement.

[0023] As the core is resilient, when displacement occurs the slab will lift the articulation member which will flex and pivot relative to the two slabs. On further displacement the first slab will lift the second slab through pivoting about said articulation member.

[0024] The connection means must be capable of transferring the force associated with the change of displacement. These forces will include the mass of the slabs, friction of the second slab as it is lifted from the base course, and any cohesive force due to surrounding soil. Thus, the connection means must be capable of resisting, first tensile loads within the plane of the slab, then shear forces as the first slab is lifted out of the original plane and begins to displace the second slab.

[0025] Preferably the material of the resilient core may include rubber. The pivoting action of the articulation member is central to the core idea of the invention. Thus in order to achieve the pivoting action a resilient material such as rubber may provide an advantageous effect.

[0026] More preferably, the resilient core material may further include recycled rubber crumb. The present invention may not require a high degree of dimensional tolerance in order to function satisfactorily. Thus it may be that the formation of the articulation member is a suitable application of recycled material and thus provide an environmental benefit.

[0027] Even more preferably, the connecting means may be made from rubber also. Thus if the connecting means is also made from rubber this may provide an opportunity to form the articulation member from a single unitary extrusion of rubber, and reduce the manufacturing costs of the articulation member. Alternatively, the connection means may be made from a substantially stiffer material than rubber. As the function of the connecting means is somewhat different from the resilient core, in that it must connect to the concrete and transfer loads between the concrete slabs via the resilient core, it may be that an advantage can be gained from making the connection means from a different material that is economically and functionally more suited to this application.

[0028] More preferably, the connection means may be made from steel. As discussed the connection means may have an economic advantage in being made from a stiff material and may be further advantageously made from steel.

[0029] Preferably, the connecting means may be projections emanating from the resilient core. Whether the material from which the connecting means is made is rubber, steel or any other material, having the connecting means being projections may be well suited to the articulation member being placed at the time of pouring the cast in place pavement.

[0030] Alternatively, the connecting means may be separable projections which may connect with the slab and the resilient core. In one embodiment of the connecting means being separable projections, the connecting means may be steel spikes that pass through the core and have a "cog-type" end profile for casting within the concrete.

[0031] Alternatively, the connecting means may be an adhesive material. For instances where the pavement is pre-cast, and so use slabs which are subsequently laid, the articulation member in order to function, may be adhered to the peripheral edges of adjacent slabs during the pavement laying.

[0032] Preferably the concrete slabs may be pavement slabs for foot traffic. Alternatively the concrete slabs may be decking for a bridge or may be slabs for a cosmetic finish to said decking.

[0033] Preferably the articulation members may further include crack propagation means. Said propagation means are intended to assist in the controlled cracking of the slab by providing a line of weakness in the cast in place pavement. Thus, as an alternative to a line of weakness being trowelled into the surface of the concrete, the articulation member having a crack propagation means may provide the same or similar function and advantageously avoid the secondary process of placing these lines of weakness. Alternatively, said crack propagation means may further assist in defining the line of weakness when used with a trowelled surface.

[**0034**] More preferably, the crack propagation means may be projections directed away from the resilient core towards the upper and/or lower surface of the concrete, but not penetrating. Thus the thickness of concrete between the surfaces and the articulation member will be considerably less than that of the surrounding concrete, and thus on application of an interfering factor, the concrete will crack precisely at the required line of weakness and ensure the efficient functioning of the present invention. Preferably the articulation means may further include separation means. The separation means may be projections from the resilient core to the upper and/or lower surface of the concrete and actually penetrating said surface. As an alternative to the crack propagation means, the separation means may be projections that provide a dividing barrier between adjacent portions of the pavement, and thus may separate the pavement into discrete slabs at the time of pouring rather than as a result of cracking. In essence, the separation means may be considered transverse formwork which is conveniently placed at the same time as the articulation member. In addition to the advantages of controlling the cracking of the pavement and clearly defining adjacent slabs, the separation means may further act as a contraction joint between the slabs. Thus the articulation member may provide the multiple functions of articulating the slabs, providing contraction joints to limit gaps in the pavement caused as a result of concrete shrinkage and act as expansion joints to accommodate thermal expansion.

DESCRIPTION OF PREFERRED EMBODIMENT

[**0035**] It will be convenient to further describe the articulation member with respect to the accompanying drawings, which illustrate possible arrangements of the invention. Other arrangements of the articulation member are possible and consequently the particularity of the accompanying drawings is not to be understood as superceding the generality of the preceding description of the invention.

[**0036**] **FIG. 1** is an elevation sectional view of the articulation member, according to the present invention.

[**0037**] **FIG. 2** is an elevation sectional view of the articulation member, according to another embodiment of the present invention.

[**0038**] **FIG. 3** is a further elevation sectional view of the articulation member, according to the present invention.

[**0039**] **FIG. 4** is a further elevation sectional view of the articulation member, according to another embodiment of the present invention.

[**0040**] **FIG. 5A** is an elevation view of the support means, according to one embodiment of the present invention.

[**0041**] **FIG. 5B** is a plan view of the support means according to **FIG. 5A**.

[**0042**] **FIG. 6** is an elevation sectional view of the articulation member according to a further embodiment of the present invention.

[**0043**] **FIG. 1** shows the articulation member (**1**) cast within a pavement. The articulation member (**1**) includes a core (**2**) about which the articulation member (**1**) can pivot. Further included are the connection means (**3**), in this case sideways projecting portions of sufficient size to engage the concrete (**5, 6**), and transfer loads from one side of the articulation member (**1**) to the other.

[**0044**] In this embodiment of the invention the articulation member (**1**) is made from a single elastomeric extrusion, such as rubber, which may also include a proportion of, or possibly entirely from, recycled rubber crumb. The environmental benefits of being able to use recycled rubber crumb from granulated car tyres will be clear.

[**0045**] It will be clear to the person skilled in the art that the core (**2**) can incorporate a portion of the articulation member (**1**), that is of a thicker section than the connection means (**3**), or be of the same size. In defining the portion of the core (**2**) rather than purely geometric description, it is important to recognize that the core (**2**) is that portion of the articulation member (**1**) that is subjected to the greatest flexural stress as load is transferred between adjacent slabs (**5** and **6**). In placing a stress based functionality to the articulation member (**1**) the connection means provide, in terms of stress, an engagement with the concrete which may be achieved through pure friction, or through a mechanical jointing with the concrete (not shown), and thus at least for a frictional engagement the primary consideration is one of maximizing surface area without unduly reducing the thickness of the concrete pavement above and below the connection means (**3**). The core (**2**) however, is required to transfer load from one pavement to the next through the transfer of flexural stress and thus, in terms of geometry need only be of a size to handle the expected flexural load, the most significant portion being the tensile load in the upper portion of the core (**2**).

[**0046**] Also included are the crack propagation means (**4**), in this case upwardly and downwardly directed projections, which create a concrete section of reduced thickness, and thus promote cracking of the concrete at that point.

[**0047**] On cracking, the pavement is effectively divided into two slab units **5** and **6**, which without the articulation member (**1**) would effectively act independently of each other. Having the articulation member (**1**) in place, however, provides for the transfer of displacement and load from one slab unit (**5**) to the next (**6**).

[**0048**] Finally, as is typically done for such pavements, a trowelled notch (**7**) is placed transversely across the pavement, so as to further reduce the section thickness of the concrete, and so promote the formation of a crack. Whilst this may be standard practice without the installation of the articulation member (**1**), it can become notionally superfluous, from a functional standard point to include such a notch (**7**) when using an articulation member (**1**) having the crack propagation means (**4**). Nevertheless, in certain circumstances, the addition of such a feature, can provide an aesthetic benefit by hiding the crack from the pavement users.

[**0049**] **FIG. 2** shows another embodiment of the articulation member (**1**), having separation means (**8**). As an alternative to using crack propagation means (**4**), the articulation member (**1**) may incorporate projections upwardly, and possible downwardly from the core (**2**), such that a divide is placed within the pavement (**5**, **6**). Thus, the slab units (**5** and **6**) are defined prior to pouring, without having to rely on a crack forming first. Among the benefits provided by the inclusion of the separation means (**8**) is the saving in expansion joints. Thus, whilst expansion joints may be provided for pavements, so as to accommodate concrete shrinkage during curing, the separation means (**8**) provides a full thickness buffer between the slab units (**5** and **6**), which may limit the formation of gaps in the pavement due to shrinkage.

[**0050**] **FIG. 3** shows the articulation member (**1**) of **FIG. 1** following the application of a severe displacement to slab unit (**6**), caused by a tree root (**9**). As pavements for pedestrian traffic are commonly placed in proximity to trees, it is common for a root (**9**) to extend underneath the pavement (**6**). As the tree grows, so does the root (**9**), the consequence being uplift of the pavement (**6**). Without he installation of the articulation member (**1**), slab unit (**6**) would be displaced upwards, independent of slab unit (**5**). Thus, a discontinuity in the pavement would be created as a result of the step the effected of slab unit (**6**). Not only does this cause a problem for vehicles permitted access to pedestrian pavements, but also becomes a hazard for foot traffic, where a user may trip and fall.

[**0051**] By including the articulation member (**1**), slab unit (**5**) is also displaced upwards to maintain the relatively continuous surface of the pavement. Whilst a crack (**10**) may form, detritus along the pavement, or even a maintenance programme of filling such a crack, is all that is required to eliminate any serviceability or aesthetic problems which may be caused. If such remedial action is required, this is minor in comparison to the maintenance cost to replace such pavements.

[**0052**] In consideration of the connection means (**3**), there may be a number of useful profiles of the concrete engaging end of the connection means (**3**) can adopt. It should be noted that this discussion is based entirely on the cast-in-place situation, where the articulation member (**1**) is placed prior to the pouring of the concrete, and thus the articulation member (**1**) becomes integral with the concrete. An alternative to this is the use of pre-cast slabs, where the connection means may include an adhesive, or other engaging means, to connect with the pre-cast slabs.

[**0053**] **FIGS. 4, 5A** and **5B** show a support means (**12**) which is used to assist in the placement of the articulation member (**1**). In some circumstances it may be advantageous to hold the articulation member (**1**) in place during the pouring of the concrete in order to form the pavement. In certain circumstances, because the specific gravity of rubber is such that the articulation member (**1**) may float in the denser concrete (typical specific gravity of 2.2 to 2.4) it may be advantageous to have a bracket which when connected to the form-work (**16**) can resist the floatation of the articulation member (**1**) as the concrete approaches and amerces the connection means (**3**). Therefore, in one embodiment of the invention, there is provided a support means (**12**) comprising an assembly of angle members (**14A**, **14B** and **17**). Member (**17**) is fixed to the form-work (**16**) through nails (**13**). Further elements (**14A** and **14B**) are fixed to the angle (**17**) and are oriented so as to run parallel to the direction of the articulation member (**1**). Members (**14A** and **14B**) are oriented so as to provide a close fitting gap into which the upper separation means (**4**) can slide with the fit such that the members (**14A** and **14B**) once engaged with the articulation member (**1**) will enclose the upper portion of the separation means (**4**) and bear down upon the connection means (**3**). Thus, is the fully installed condition, the support means will comfortably engage the articulation member (**1**) ready for the pour of concrete. The degree to which the support means (**12**) is required will depend upon a number of factors, and so the level of concrete at which the support means (**12**) is no longer required may be at a point (**15A**), and thus just up to the connection means (**3**), or to a point (**15B**) where the concrete has amerced the connection means (**3**). In either case and as determined by those installing the articulation member (**1**), once the articulation member (**1**) is securely engaged with the concrete, the support means (**12**) may be removed and the concrete pour continued.

[**0054**] **FIG. 6** shows an alternative arrangement of the support means (**19**), which is used as a means to finish a portion of a pavement (**5**), but where it is expected that further work is required, and so the articulation member (**1**) is used as a terminating barrier, ready for further additions to the pavement to be added. The support means (**19**) includes parallel members oriented so as to enclose the connection means (**3**) on the side of the articulation member (**1**), to which the future pavement will be added. A lower member (**18B**) is placed abutting the lower portion (**4B**) of the separation means and the connection means (**3**), and a further member (**18A**) placed abutting the upper portion (**4A**) of the separation means (**4**), and the opposing side of connection means (**3**). These members are fixed to the form-work (**16**) through nailing a connecting bracket (**20**) which is fixed to the supporting elements (**18A** and **18B**).

[**0055**] Thus, on completion of a portion of the pavement (**5**) there will be projecting from that portion an articulation member (**1**) having a protruding connection means (**3**) which is supported and confined by the support means (**19**), which is subsequently fixed to the form-work (**16**).

The claims defining the invention are as follows:

1. An articulation member including a resilient core, said core having connection means attached thereto, the connection means adapted to link two co-planar concrete slabs along an adjacent peripheral edge of each slab, wherein on application of an out-of-plane displacement to one of the co-planar concrete slabs, the displacement is transmitted to the other concrete slab through pivoting about the articulation member.

2. The articulation member according to claim 1, wherein the material of the resilient core material includes rubber.

3. The articulation member according to claim 1 or **2**, wherein the resilient core material includes recycled rubber crumb.

4. The articulation member according to claims **2** or **3**, wherein the connecting means, at least partially, is made from rubber.

5. The articulation member according to any one of claims 1 to 3, wherein the connection means, at least partially, is made from a non-resilient material.

6. The articulation member according to claim 5, wherein the non-resilient material includes a metallic portion.

7. The articulation member according to any one of the preceding claims, wherein the connecting means is integral with the resilient core.

8. The articulation member according to any one of claims 1 to 6, wherein the connecting means are mountable on the resilient core.

9. The articulation member according to claims **5** or **6**, wherein the connecting means are metallic spikes passing through the resilient core.

10. The articulation member according to claims **5**, **6** or **9**, wherein the connecting means have a cog-type profile at terminal ends of said connecting means distal from the resilient core.

11. The articulation member according to any one of claims 1 to 5, wherein the connecting means includes an adhesive surface adapted to adhere to the peripheral edges of adjacent slabs.

12. The articulation member according to any one of the preceding claims, wherein the concrete slabs are pavement slabs for foot traffic.

13. The articulation member according to any one of claims 1 to 11, wherein the concrete slabs are decking slabs for a bridge.

14. The articulation member according to any one of the preceding claims, wherein the articulation member further includes crack propagation means.

15. The articulation member according to claim 14, wherein the crack propagation means includes at least one projection directed towards a top surface of the slab.

16. The articulation member according to claim 15, wherein the crack propagation means further includes at least one projection directed towards a bottom surface of the slab.

17. The articulation member according to any one of claims 1 to 13, wherein the articulation member further includes separation means for providing a barrier between adjacent slabs.

18. The articulation member according to claim 17, wherein the separation means are at least two projections emanating from the resilient core, and extending to or beyond an upper and lower surface of the slabs.

19. The articulation member according to claim 17 or **18**, wherein a cross-sectional shape of the articulation member is substantially cross-shaped with the connecting means directed in a horizontal plane, and the separation means directed in a vertical plane.

20. The articulation member according to claim 19, wherein the separation means and connecting means intersect at the respective mid-points of the separation means and connecting means.

21. A method of constructing an assembly of articulated slabs, the method including the steps of:

(i) establishing form-work adapted to receive wet concrete;

(ii) placing a plurality of articulation members along a plurality of articulation lines;

(iii) pouring of wet concrete within the form-work so as to engage the articulation members;

(iv) curing of the concrete to form a plurality of adjacent slab units connected by the articulation members.

22. The method of constructing a concrete slab according to claim 21, wherein said articulation member is the articulation member according to any one of claims 1 to 20.

23. The method of constructing a concrete slab according to claim 21 or **22**, wherein step (ii) further includes placement of support means, said support means adapted to engage, at least one, articulation member during the pouring step.

24. The method of constructing a concrete slab according to claim 23, wherein the support means includes an assembly of members adapted to connect directly to the form-work so as to engage the, at least one articulation member so that the articulation member is maintained in a desired configuration and position during the pouring step.

25. The method of constructing a concrete slab according to claim 23 wherein the support means engages the at least one articulation member by encompassing an upper portion of the separation means and engaging the connection means so as to prevent uplift of the articulation member.

26. A concrete slab, including a plurality of lines of weakness and a plurality of articulation members placed along said line of weakness wherein said slab is adapted to crack along the lines of weakness, resulting in slab portions that are articulated through connection with the articulation members.

27. The concrete slab according to claim 26, wherein the articulation member is the articulation member according to any one of claims 1 to 20.

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