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(11)

EP 1 079 044 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.02.2001 Bulletin 2001/09

(51) Int Cl.7: **E04G 23/02**

(21) Application number: **00307351.7**

(22) Date of filing: **25.08.2000**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **25.08.1999 GB 9920091**

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(54) Structural support

(57) Method of pre-stressing two spaced components (2,10), such as a structural steel member (2) and a flat roof panel (10), wherein an expandable element (20'), preferably in the form of an inflatable tube of given length, is inserted in the space between the two components (2,10) and is expanded to generate a force acting between the two components (2,10), to pre-stress at least one of the components (2,10). Once the two com-

ponents (2,10) have been pre-stressed, rigid spacing means (6) may be placed in at least part of the remainder of the space not occupied by the non-expanded element (20') and in engagement with both components (2,10). An inflatable tube (20) may be used as the expandable element (20') and may have its opposed ends (21) sealed in a fluid-tight manner by folding and clamping (22).

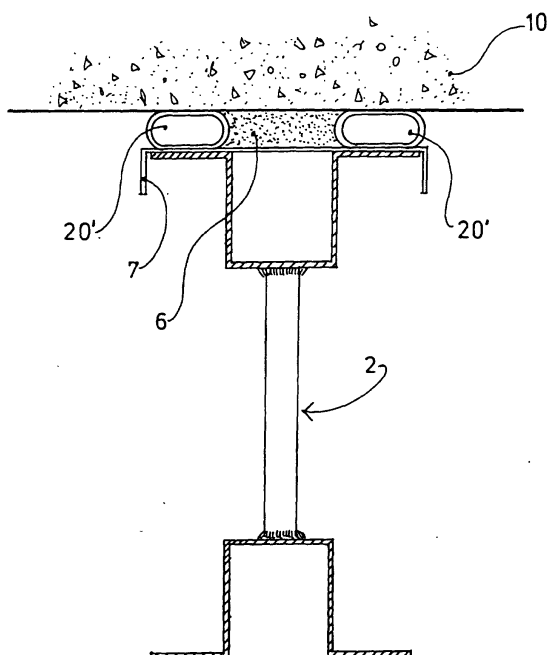


FIG.6

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Description

[0001] This invention relates to structural support especially, but not exclusively, to supporting existing roof panel structures of concrete and similar materials.

[0002] Over the past ten years, concerns have been expressed by local authorities, structural engineers and other interested parties about the in-service performance of reinforced autoclaved aerated concrete ("RAAC") panels, particularly RAAC roof panels.

[0003] Some flat roof applications have been of particular concern where long term deflections have become appreciable, with span deflection ratios of the order of 1:100 and above having been reported. In these situations, the deflected RAAC roof panels permit an increase to the imposed loading, due to additional standing rainwater causing further deflections that could in time cause the panels to fail.

[0004] In any event, RAAC panels have been used over the past twenty years or so as not only roof panels but also floor and wall components and have also been sold as not only structural members but also as insulating materials.

[0005] Inspection of existing sites incorporating RAAC roof panels has revealed excessive deflections thereof, some with span deflection ratios of more than 1:100, as discussed above. Noticeable surface cracking and, in some cases spalling, has been detected, thus causing major concern that sooner or later the panels will fail completely.

[0006] Accordingly, it is an object of the invention to provide support for a structural component, such as an existing RAAC roof panel, which overcomes, or at least substantially reduces, the disadvantages associated with, say, existing flat roof structures and other structures, as discussed above.

[0007] Accordingly, a first aspect of the invention resides in an expandable element, preferably elongate, which, when in a non- or partially-expanded condition, is capable of being located between two spaced components and which, when so-located and placed in an expanded condition, generates a force acting between the two spaced components, to pre-stress at least one of those components.

[0008] A second aspect of the invention resides in an inflatable element, again preferably elongate, which, in a deflated or partially-inflated condition, is capable of being located between two spaced components and which, when so-located and placed in an inflated condition, generates a force acting between the two spaced components, to pre-stress at least one of those components.

[0009] The expandable and/or inflatable element of the first and/or second aspect of the invention may be in the form of an inflatable tube cut to a required length and having its ends sealed in a fluid-tight manner. The element may also be provided with a valve for inflation purposes.

[0010] In a preferred embodiment, the expandable and/or inflatable element is formed from a generally flat hose, preferably of composite rubber with plastics, such as, polyester and/or nylon, reinforcing webbing and a heavy duty, protective outer plastics sheath, which is cut to a required length, as will be explained in more detail hereinbelow, and has its opposed ends folded at least once and then clamped to provide a fluid-tight seal at each end. A valve is provided in the wall of the tube in a conventional manner, for inflation purposes.

[0011] In this manner, the ends of the tube or hose do not have to be glued or vulcanised to provide the required fluid-tight seal, as it has been found that gluing or vulcanising does not yield a sufficiently effective bond between the tube or hose material to effect a fluid-tight seal which can withstand pressures of up to 250 p.s.i.

[0012] In accordance with a third aspect of the invention, there is provided a method of pre-stressing two spaced components, which method comprises inserting in the space between the two components an expandable element, preferably elongate, in a non- or partially-expanded condition, and causing the element to expand into an expanded condition, to generate a force acting between the two components, thus pre-stressing at least one thereof.

[0013] A fourth aspect of the invention resides in a method of pre-stressing two spaced components, which method comprises inserting in the space between the two components an inflatable element, again preferably elongate, in a deflated or partially-inflated condition, and inflating the element into an inflated condition such that it acts between the two components to generate a force therebetween, thus pre-stressing at least one of the components.

[0014] A fifth aspect of the invention provides a method of pre-stressing two spaced components, such as a structural steel member and a flat roof panel, by deflecting one component with respect to the other to increase the spacing therebetween, which method comprises inserting in the space between the two components an inflatable element, preferably elongate, in a non- or partially-inflated condition, and inflating the element to a predetermined pressure in dependence upon a known pressure/deflection relationship, to cause at least one of the components to be deflected away from the other component by a required amount.

[0015] The expandable or inflatable element, as the case may be, may be one in accordance with the first or second aspect of the invention defined above.

[0016] Thus, once the two components, such as structural building components, have been pre-stressed by means of either of the inventive methods, rigid spacing means, such as a structural cement, concrete, mortar or grout, can be placed in at least part of the remainder of the space not occupied by the expanded or inflated element and in engagement with both components.

[0017] During inflation or other expansion of the element, at least one of the spaced components may be

caused, by the resulting forces, to move with respect to and away from the other component and this effect is particularly useful when the invention is applied to existing roof panels, such as, RAAC roof panels, which have experienced long-term in-service deflections.

[0018] In a preferred embodiment to be described in more detail hereinbelow and as indicated above, inflatable tubes are employed and the amount of movement of the roof panels away from an associated structural member (METSEC lattice beam), such as a structural steel cradle, can be determined in advance in dependence upon a known pressure/deflection relationship which can be represented in the form of a graph.

[0019] Thus, for a required movement or deflection of, say, a previously-deflected roof panel away from an associated structural component, one or more inflatable elements can be inflated to a predetermined pressure in dependence upon a given inflation pressure/deflection relationship.

[0020] With such roof structures, and as indicated above, the other structural component may be in the form of a cradle, preferably a structural steel cradle, such as one constructed from components manufactured and sold by METSEC plc, in which case, the inventive method may be used to refurbish an existing flat roof structure of RAAC roof panels, with the structural cradle, as the other structural component, being connected to existing main beams supporting the roof panels.

[0021] Such a structural steel cradle, as designed by METSEC plc, may comprise secondary beams or joists supported on primary beams or joists which, in turn, are preferably bolted or bracketed to the existing, roof panel-supporting main beams. The top flanges of the secondary beams or joists may be suitably packed-up to follow the general contours of the underside/soffit of the roof panel(s).

[0022] Thus, by inserting one or more inflatable or otherwise expandable elements between the cradle, subsequent inflation or other expansion of the element(s) causes it to act between the cradle and roof panel(s), to move (deflect) the latter upwardly from the cradle, thereby pre-stressing the panel(s) and/or the cradle.

[0023] When an inflatable element is employed, the roof panel(s) or other structural component can be moved or otherwise deflected away from the cradle or other structural component by a predetermined amount in dependence upon a known inflation pressure/deflection relationship.

[0024] In order that the invention may be more fully understood, embodiments in accordance therewith will now be described by way of example and with reference to the accompanying drawings in which:

Fig 1 is a plan view of a typical layout of both primary and secondary joists of a structural steel cradle in association with existing joists of a flat roof structure;

Fig 2 is a section along the line II-II of Figure 1;

Fig 3 is a section along the line III-III in both Figs 1 and 2;

Fig 4 is an enlarged view of the portion marked IV in Fig 2;

Fig 5 is a partial elevation of the roof structure shown in Fig 1 at the final installation stage;

Fig 6 is an elevation, in partial section, of another flat roof structure embodying the invention at the final installation stage;

Fig 7 is a diagrammatic plan view of the embodiment shown in Fig 6 during installation thereof;

Fig 8 is a graph showing the relationship between the pressure within an inflatable element of the invention and the corresponding deflection of a roof panel; and

Fig 9 is a side elevation of a preferred form of inflatable element in accordance with the invention.

[0025] Referring firstly to Figs 1 to 4 of the accompanying drawings, a typical grid plan of a flat roof structure with RAAC roof panels is shown in Fig 1 and comprises a structural steel cradle consisting of primary beams or joists 1 positioned at, say, 1.8m centres and supported on a continuous or sectional angle 3 bolted to existing roof beams or joists 4 which, in-service, have supported the RAAC roof panels which have undergone, again in-service, deflection in a downward direction between adjacent existing beams or joists 4.

[0026] The structural steel cradle further comprises secondary beams or joists 2 intersecting and connected to the primary beams or joists 1 and positioned at one third of the span between the existing beams or joists 4.

[0027] The top flange 5 of each secondary beam or joist 2 is suitably packed-up to follow the general contours of the underside of the corresponding RAAC roof panels (10 in Fig 5).

[0028] The remainder of the space between the beams or joists 1, 2 of the structural steel cradle and the underside of the RAAC roof panels has inserted therein a deflated, inflatable tube 20, such as that shown in Fig 9.

[0029] The length of the tube 20 is determined by the corresponding dimensions of the beams or joists 1, 2 of the structural steel cradle and the RAAC roof panels.

[0030] Depending upon the required degree of deflection of the roof panel(s) 10 away from the adjacent beams or joists 1, 2 of the structural steel cradle, the tube (s) 20 is inflated to a corresponding pressure in accordance with a given relationship, as shown graphically in Fig 8.

[0031] Thus, for example, a required upward deflection of a roof panel 10 of, say, 5 mm, necessitates the corresponding inflatable tube(s) 20 to be inflated to a pressure of 20 psi, as can be seen from graph of Fig 8.

[0032] Once the tube(s) 20 has been inflated to the required pressure and, as a consequence, the RAAC roof panel(s) 10 has been deflected by the required amount upwardly away from the corresponding beams or joists 1,2, structural, self-setting mortar 6 is forced between a lipped, upper flange 7 of the beam or joists 1,2 upon which the now-inflated tube 20' rests, and the underside of the now upwardly-deflected roof panel 10.

[0033] In this manner, inflation of the tube 20 to the required pressure, as shown at 20' in Fig 5, generates a force which acts between the associated beam or joist 1,2 and the roof panel 10, to cause the latter to deflect upwardly away from the former by the required distance, whilst also pre-stressing or pre-loading the beam or joist 1,2 and/or the roof panel 10.

[0034] Referring now to Figs 6 and 7, in this embodiment two inflatable tubes are employed and are shown in their inflated condition at 20'. As can be seen, the inflated tubes 20' carry out the same function as the single tube 20' of Fig 5 but extend along respective opposed edges of the lipped flange or plate 7 of the secondary beam or joist 2, with the structural self-settable mortar 6 located therebetween.

[0035] In this manner, the inflated tubes 20' can be deflated and removed for subsequent re-use.

[0036] Fig 7 shows a more detailed view of the arrangement of the tubes 20', with one tube extending along the length of the beam or joist 1, 2 and a pair of shorter tubes 20' located along the opposed edge of the lipped flange or plate 7, with a central gap 31 between adjacent ends of the pair of tubes 20' and respective gaps 32 between their other opposed ends and the adjacent intersecting beams or joists 2,1.

[0037] During installation, and after the tubes have been inflated to the required pressure, structural self-setting mortar is pumped through the gap 31 in the direction of the arrow A and flows between the opposed, inflated tubes 20', exiting at opposed end gaps 32, to ensure that the whole of the space defined between the opposed inflated tubes 20', the lipped upper flange or plate 7 of the beam or joist 1, 2 and the underside of the associated RAAC roof panel 10, is filled with mortar.

[0038] Again, the pressure within the inflated tubes 20' is determined by the graph shown in Fig 8, to provide the required upward deflection of the roof panel 10 away from the beam or joist 1,2.

[0039] Turning now to the inflatable tube 20 shown in Fig 9, this comprises a flexible synthetic plastics or rubberized flat tube or hose cut to the required length and having its ends sealed in a fluid-tight manner by folding, as shown at 21. Preferably, the tube 20 comprises plastics reinforcing webbing embedded in its walls, with a heavy duty, protective outer plastics sheath.

[0040] A pair of clamping plates 22 is applied to each

folded end 21 of the tube 20, to ensure the integrity of the fluid-tight seal and to strengthen the ends of the tube against failure during and after inflation.

[0041] A valve 24 is provided for the inflation and/or deflation of the tube 20, to which a pressure gauge may be attached to monitor the pressure within the tube 20 during inflation.

[0042] The advantages of the invention can be summarized as follows:

reduced number of activities when compared with conventional structural roof refurbishment.

reduced disruption to the user.

reduced costs

environmentally friendly.

work can be carried out piecemeal.

reduced building down time.

existing roof panels can be made to out-perform their original life expectancy resulting in a better option than replacing them totally.

[0043] It is to be appreciated that various aspects of the structural cradle described above in relation to the preferred embodiments are the subject of patent and registered design cases in the name of METSEC plc.

Claims

1. A method of pre-stressing two spaced components (2,10), which method comprises inserting in the space between the two components (2,10) an expandable element (20') in a non- or partially-expanded condition, and causing the element to (20') expand into an expanded condition, to generate a force acting between the two components (2,10), thus pre-stressing at least one thereof.
2. A method of pre-stressing two spaced components (2,10), which method comprises inserting in the space between the two components (2,10) an inflatable element (20') in a deflated or partially-inflated condition, and inflating the element (20') into an inflated condition, such that it acts between the two components (2,10) to generate a force therebetween, thus pre-stressing at least one of the components (2,10).
3. A method according to claim 1 or 2, wherein, once the two components (2,10) have been pre-stressed, rigid spacing means (6) is placed in at least part of the remainder of the space between the two com-

ponents (2,10) not occupied by the expanded or inflated element (20'), as the case may be, and in engagement with both components (2,10).

4. A method according to claims 1, 2 or 3, wherein the expandable or inflatable element (20'), as the case may be, is elongate.
5. A method according to any preceding claim, wherein the expandable or inflatable element (20'), as the case may be, comprises an inflatable tube (20').
6. A method according to claim 5, wherein the inflatable tube (20') is cut to a required length.
7. A method according to claim 5 or 6, wherein the inflatable tube (20) has its opposed ends (21) sealed in a fluid-tight manner.
8. A method according to claim 5, 6 or 7, wherein the opposed ends (21) of the inflatable tube (20) are sealed in a fluid-tight manner by being folded at least once and then clamped (22).
9. A method of pre-stressing two spaced structural members (2,10), according to any preceding claim.
10. A method of pre-stressing two spaced components (2,10), such as a structural steel member (2) and a flat roof panel (10), by deflecting one component with respect to the other to increase the spacing therebetween, which method comprises inserting in the space between the two components (2,10) an inflatable element (20') in a non-or partially-inflated condition, and inflating the element (20') to a predetermined pressure in dependence upon a known pressure/deflection relationship, to cause at least one of the components (2,10) to be deflected away from the other component by a required amount.
11. A method according to claim 10, wherein, once the component(s) (2,10) has been deflected by said required amount, rigid spacing means (6) is placed in at least part of the remainder of the space between the two components (2,10) not occupied by the inflated element (20') and in engagement with both components (2,10).
12. A method according to claim 10 or 11, wherein the inflatable element (20') is elongate.
13. A method according to claim 10, 11 or 12, wherein the inflatable element (20') comprises an inflatable tube.
14. A method according to claim 12 or 13, wherein the inflatable tube (20') is cut to a required length.

15. A method according to claim 12, 13 or 14, wherein the inflatable tube (20) has its opposed ends (21) sealed in a fluid-tight manner.

16. A method according to any of claims 12 to 15, wherein the opposed ends (21) of the inflatable tube (20') are sealed in a fluid-tight manner by being folded at least once and then clamped (22).
17. An expandable element (20') which, when in a non-or partially-expanded condition, is capable of being located between two spaced components and which, when so-located and placed in an expanded condition, generates a force acting between the two spaced components (2,10), to pre-stress at least one of those components (2,10).
18. An inflatable element (20') which, in a deflated or partially-inflated condition, is capable of being located between two spaced components (2,10) and which, when so-located and placed in an inflated condition, generates a force acting between the two spaced components (2,10), to pre-stress at least one of those component (2,10).
19. An element (20) according to claim 17 or 18 which is elongate.
20. An element (20) according to claim 17, 18 or 19 which is in the form of an inflatable tube, preferably cut to a required length.
21. An element (20) according to claim 20, wherein the opposed ends (21) of the inflatable tube (20) are sealed in a fluid-tight manner.
22. An element (20) according to claim 21, wherein the opposed tube ends (21) are sealed in a fluid-tight manner by being folded at least once and clamped (22).
23. An element (20) according to claim 20, 21, or 22, wherein the inflatable tube (20) is formed from a generally flat hose
24. An element (20) according to any of claims 20 to 23, wherein the inflatable tube (20) comprises a composite rubber with plastics reinforcing webbing and a heavy duty, protective outer plastics sheath.
25. An element (20) according to any of claims 17 to 24 including an expansion or inflation valve (24) as the case may be.

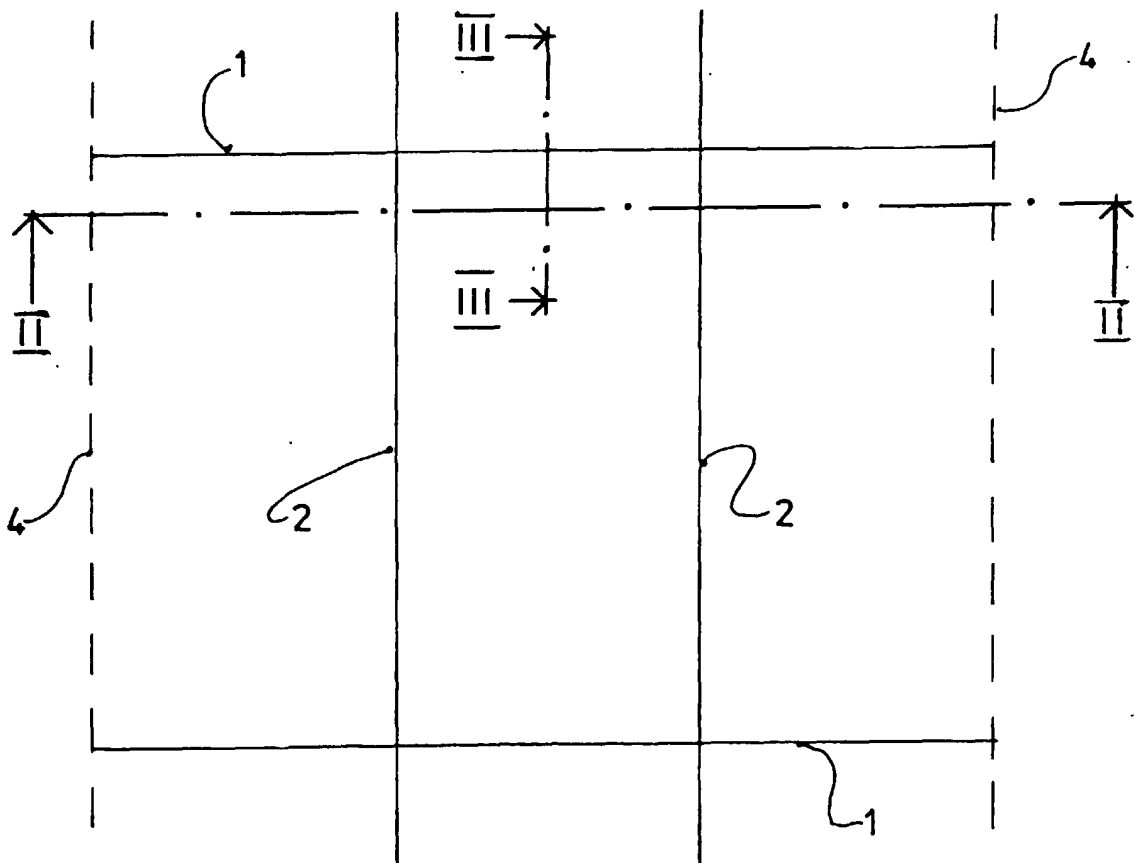


FIG.1

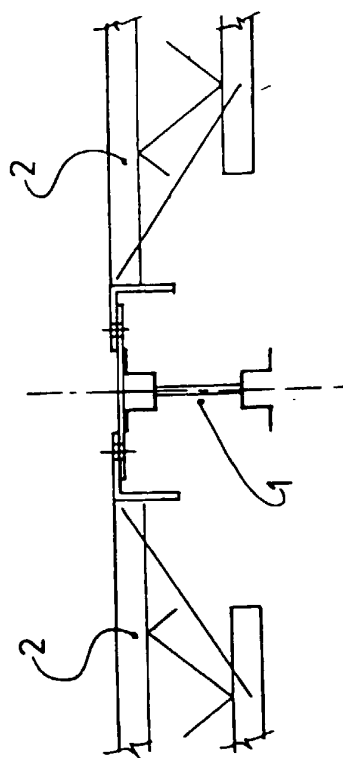


FIG. 3

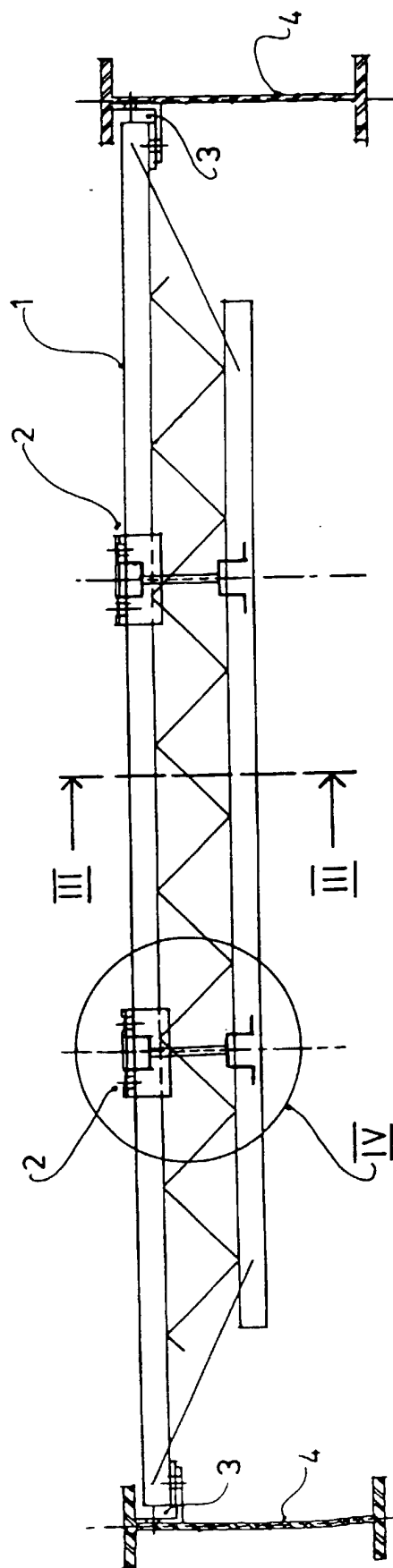
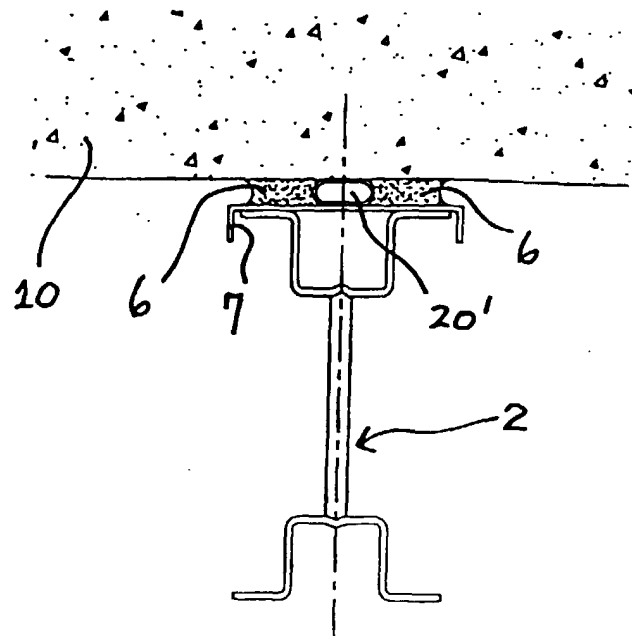
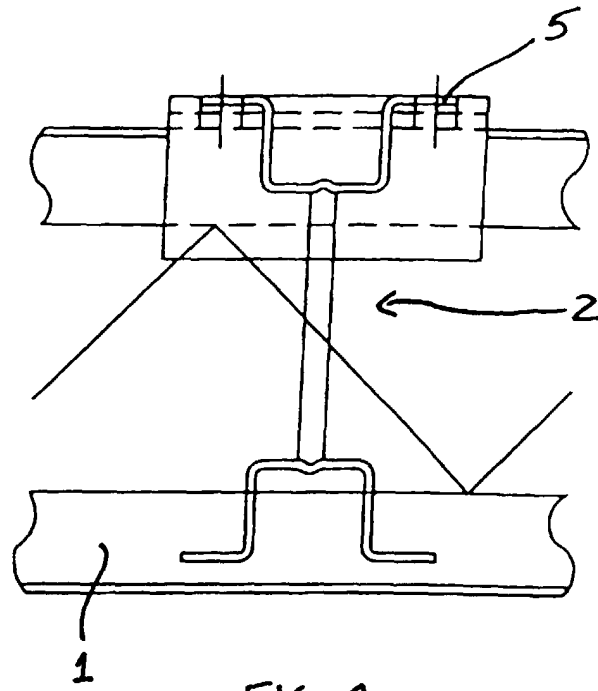


FIG. 2



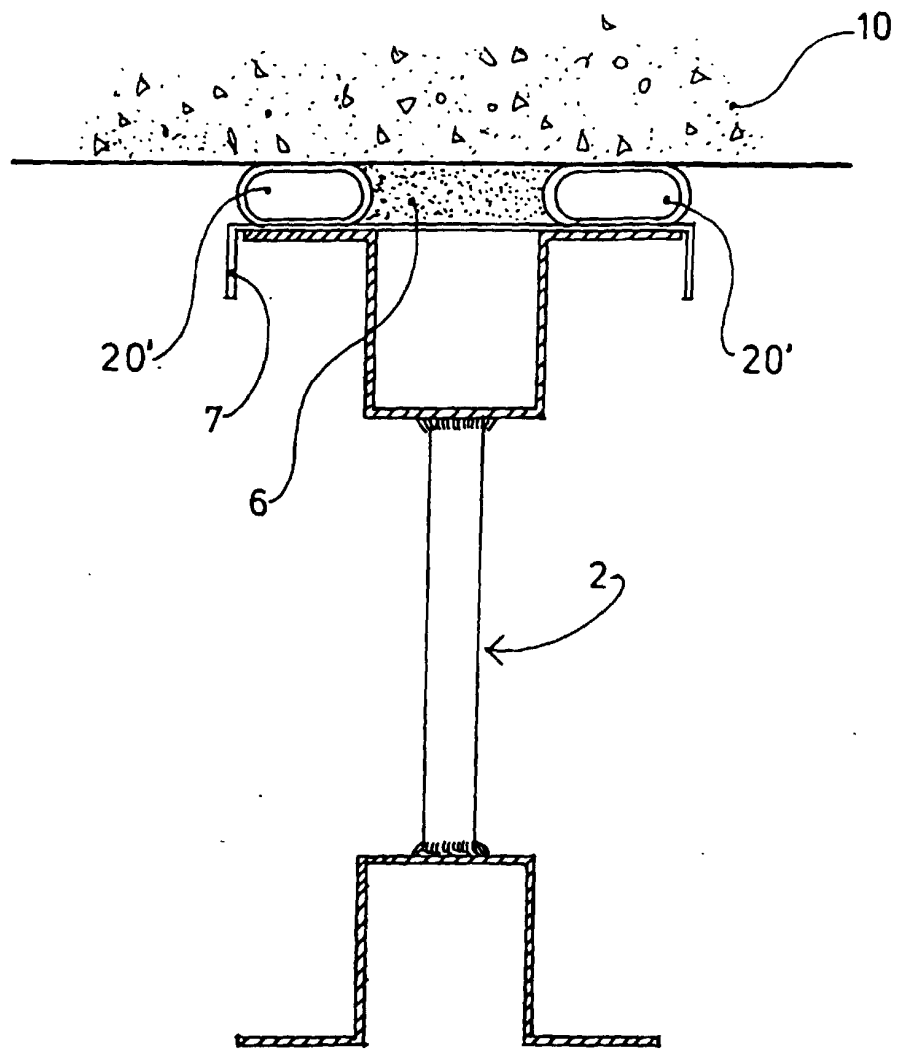


FIG. 6

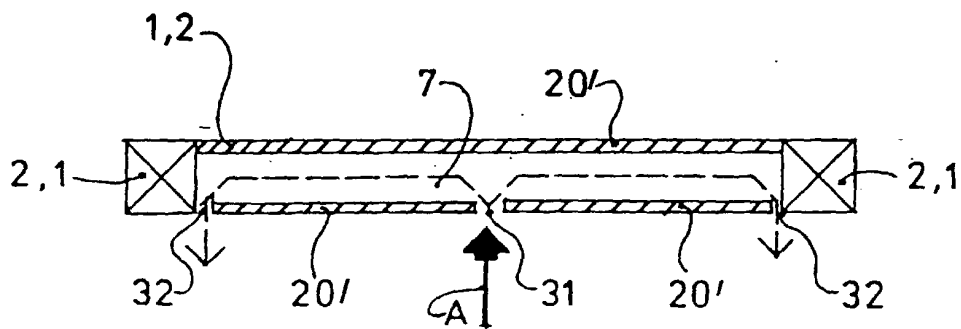


FIG. 7

Graph at centre span to show how deflection can be regulated by inflation pressure

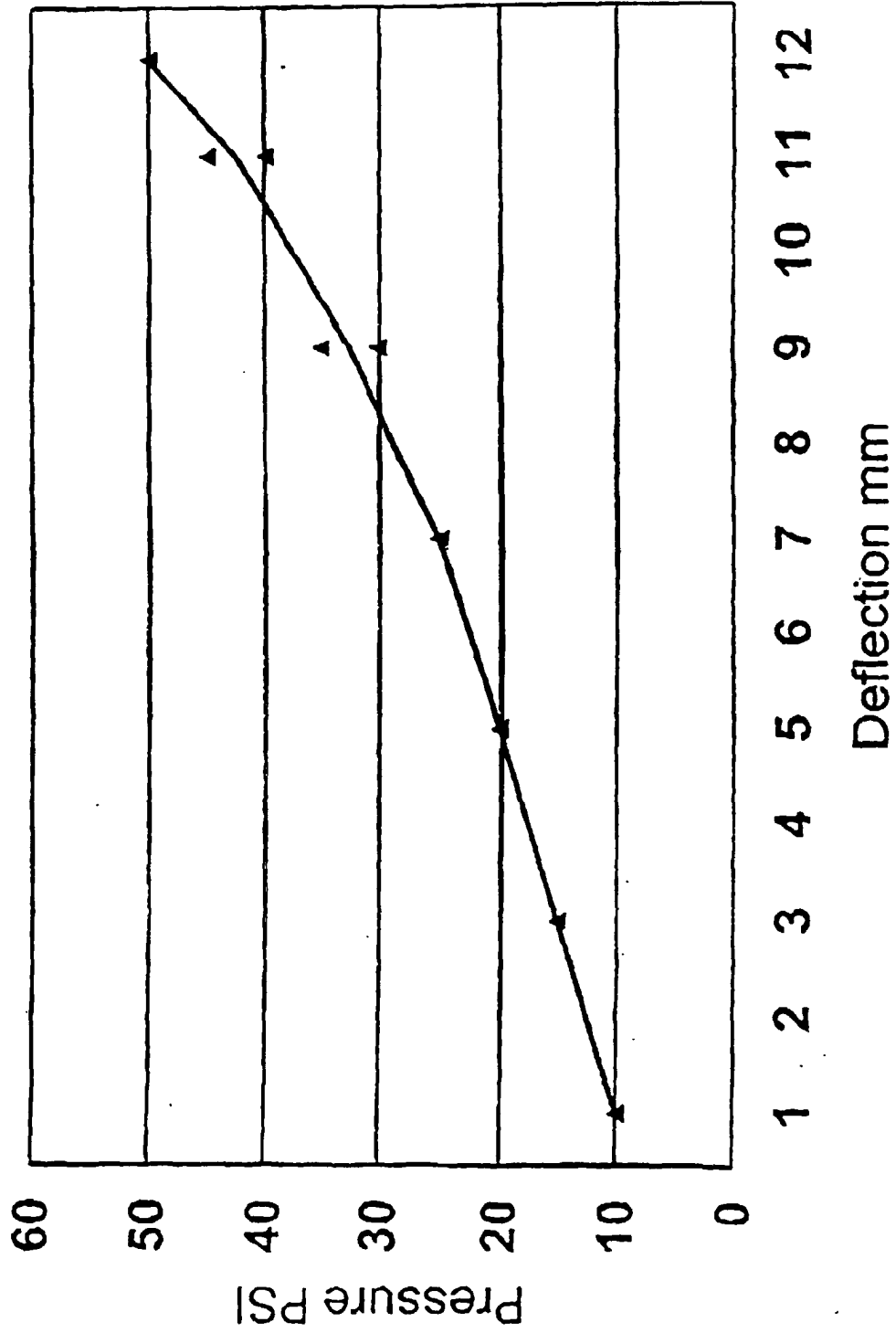


FIG. 8

