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Macchi

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[45] **July 1, 1975**

[54] **BEAM STRUCTURES**

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[21] Appl. No.: **432,207**

Related U.S. Application Data

[62] Division of Ser. No. 276,022, July 28, 1972, Pat. No. 3,788,023.

[30] **Foreign Application Priority Data**

Aug. 2, 1971 Italy 9633/71

[52] **U.S. Cl.** **52/227**; 52/584

[51] **Int. Cl.** **E04c 3/26**

[58] **Field of Search** ..... 52/223 R, 227, 229, 259, 52/396, 584; 264/34

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Primary Examiner—Price C. Faw, Jr.

Attorney, Agent, or Firm—McGlew and Tuttle

[57] **ABSTRACT**

A beam structure for a viaduct comprises hollow beams of reinforced concrete which are joined in end to end relationship. The end portion of each beam has an internally extending flange in which the reinforcing members of the beam are anchored. Adjacent beams are inter-connected by reinforcing cables extending across the joined ends and embedded in the adjacent flanges of the beams. The reinforcing cables and members together act to place each flange under compression. A hardenable mass injected between adjacent beams is also placed under compression by the reinforcing cables joining the two beams and provides a continuous beam structure.

6 Claims, 12 Drawing Figures

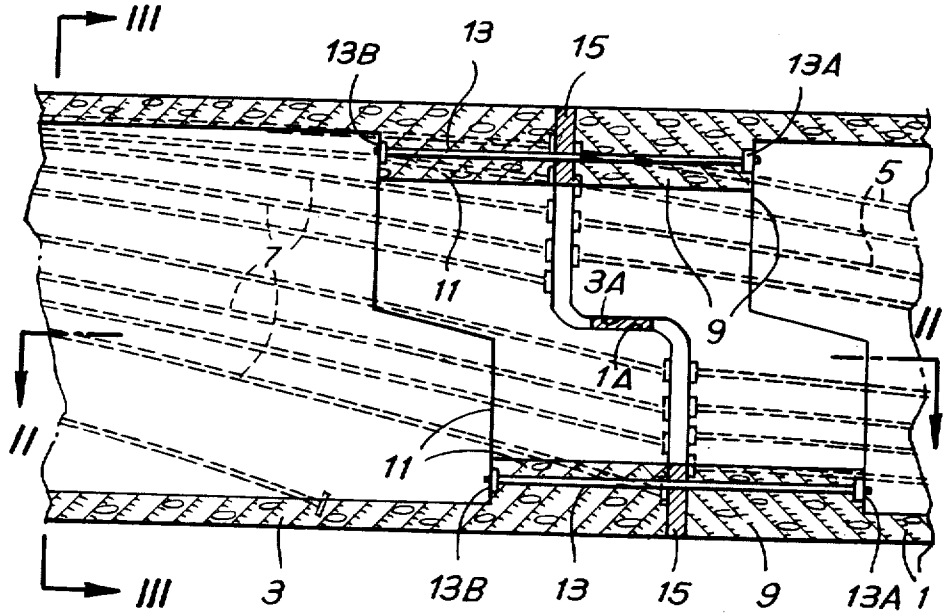


Fig.1

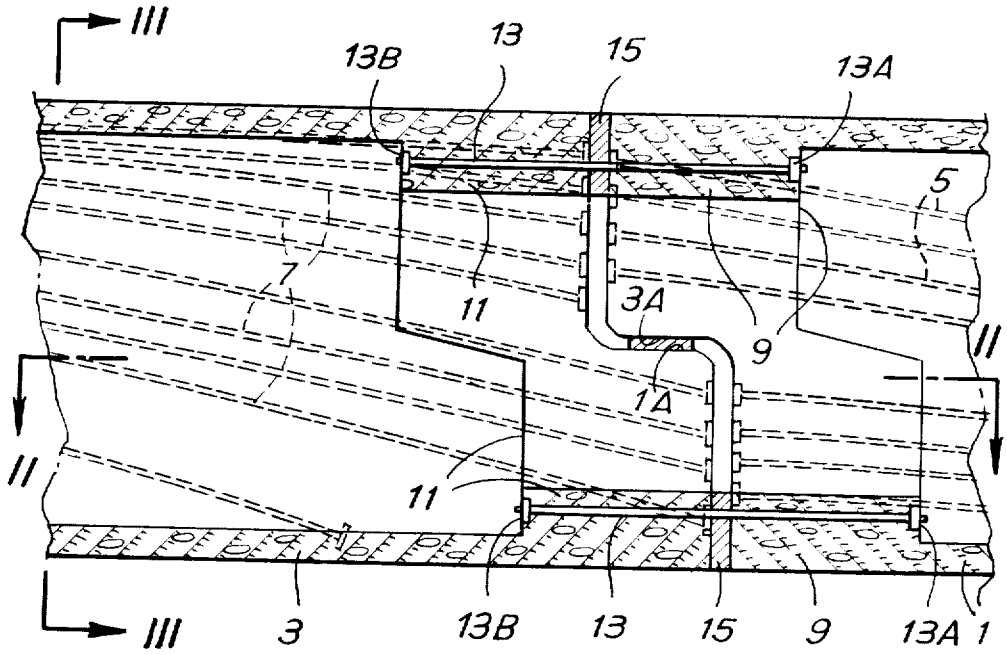
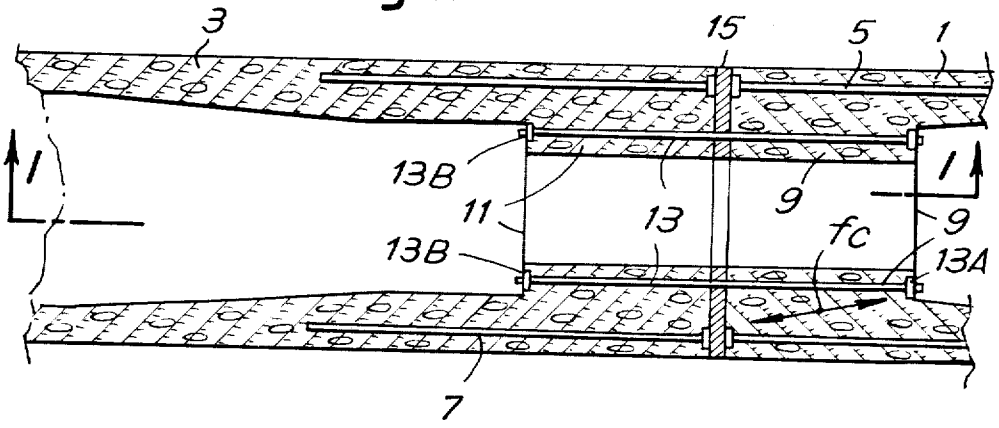

III
13B
13
15
13A
5
7
11
3A
9
II
1A
II
11
III
3
13B
13
15
9
13A
1

Fig.2


3
15
5
1
I
13B
11
13
9
I
9
13B
fc
13A
7

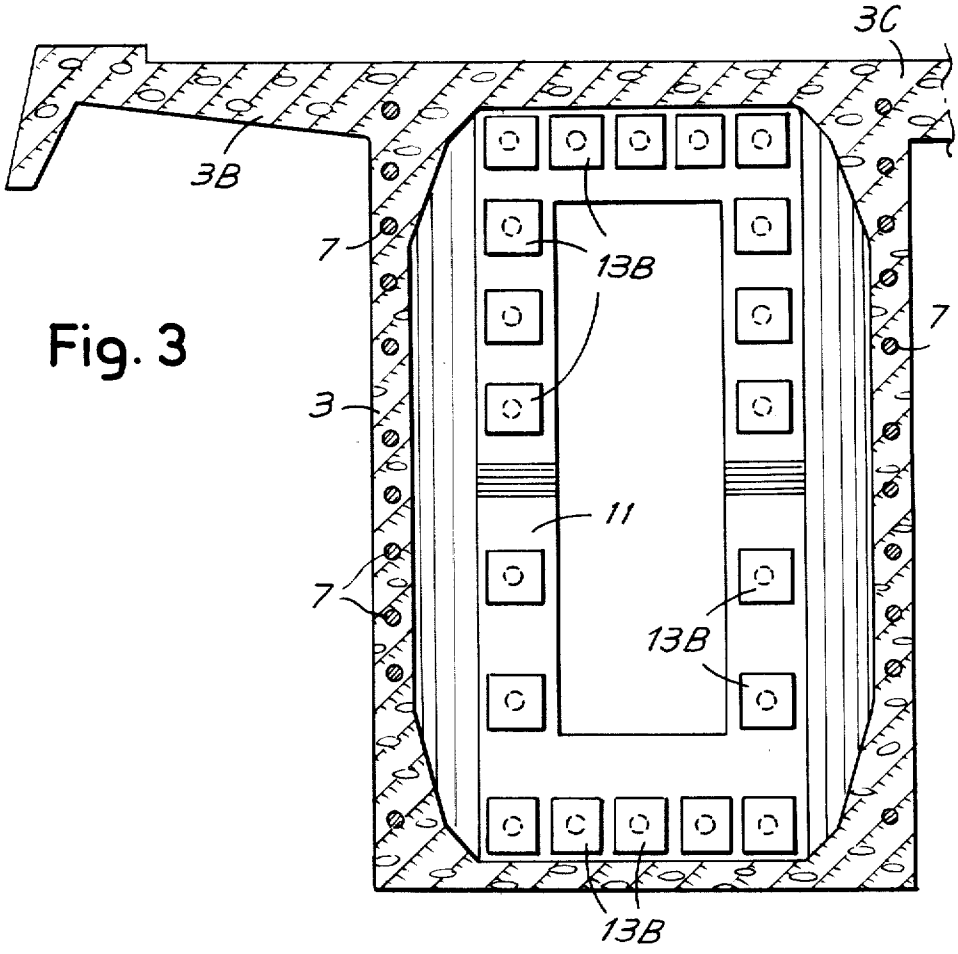
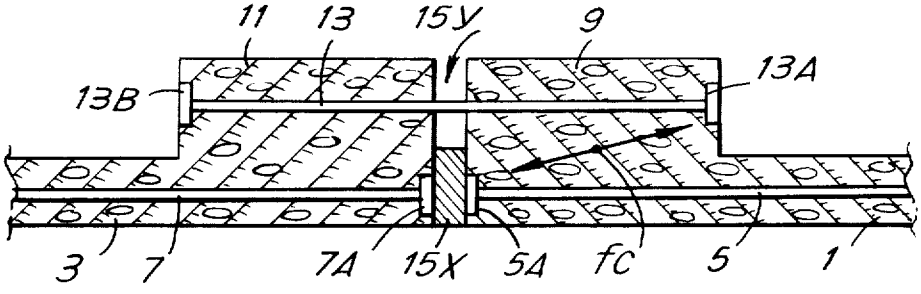


Fig. 3

Fig. 4



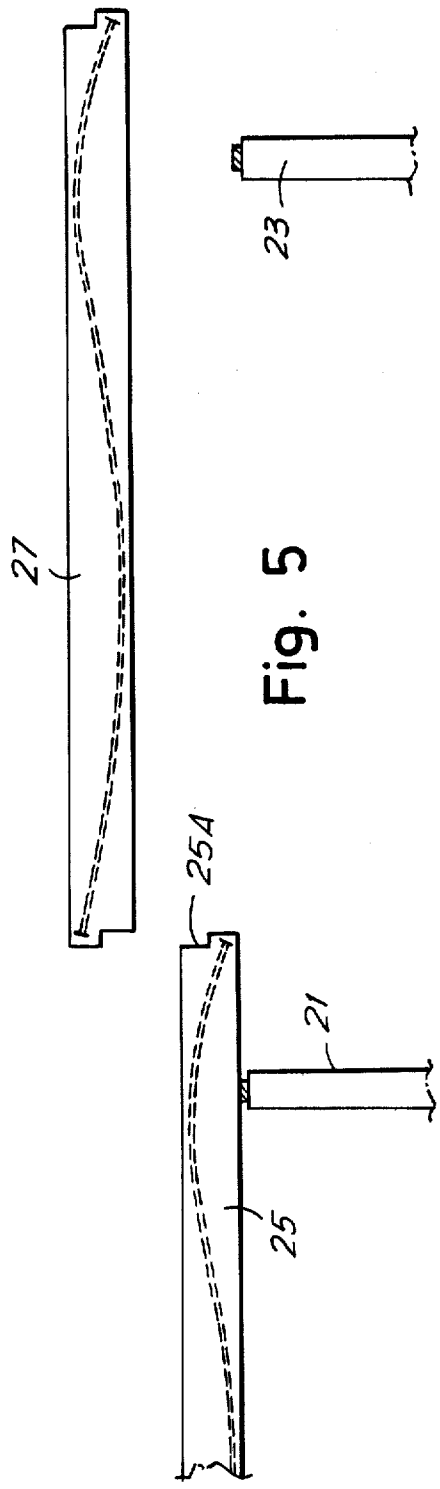


Fig. 5

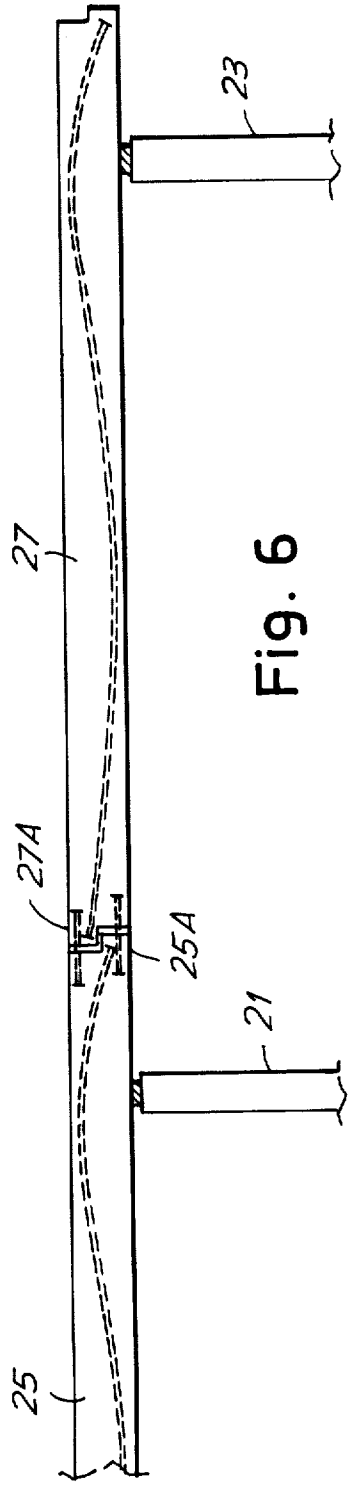


Fig. 6

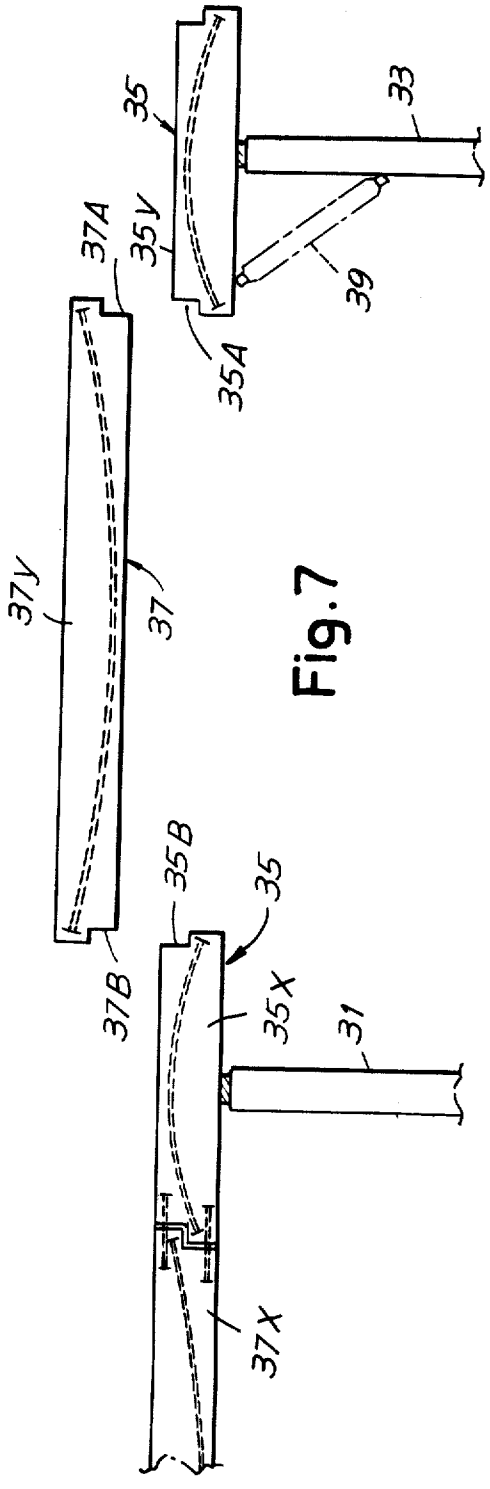

35
33
37A
35Y
39
35A
37Y
37
35B
35
37B
35X
31
37X

Fig. 7

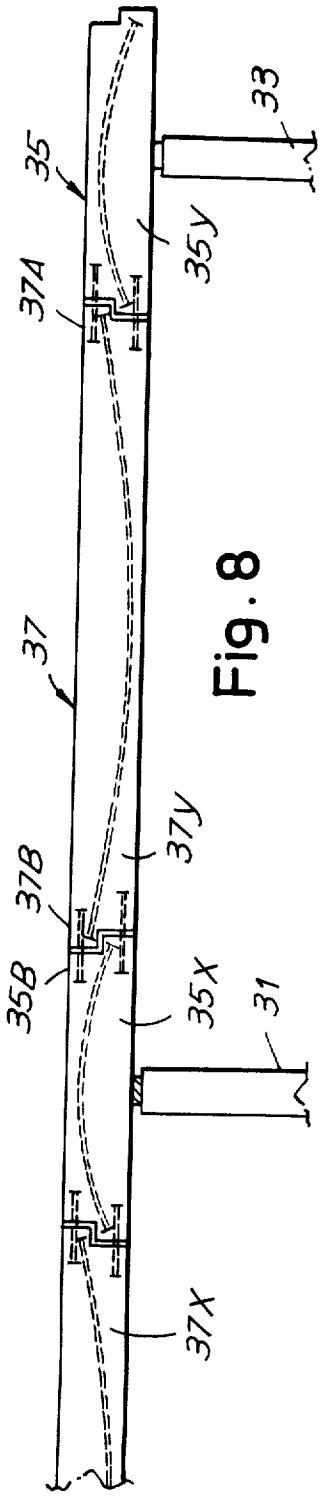

35
33
35Y
37A
37
37Y
37B
35B
35X
31
37X

Fig. 8

Fig.9

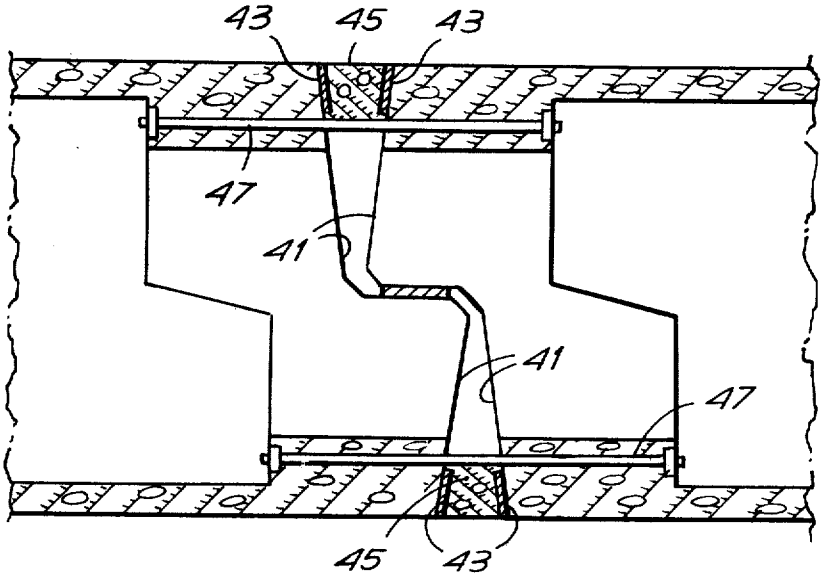


Fig.10

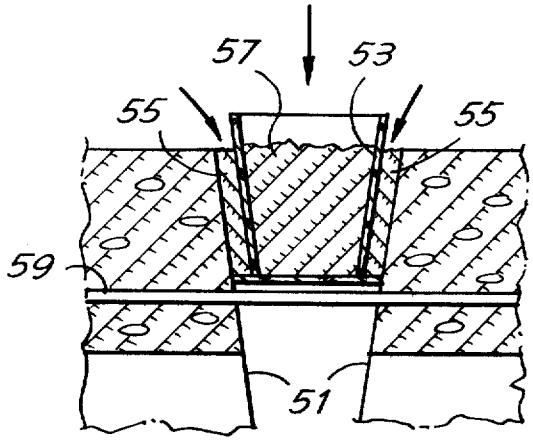


Fig. 11

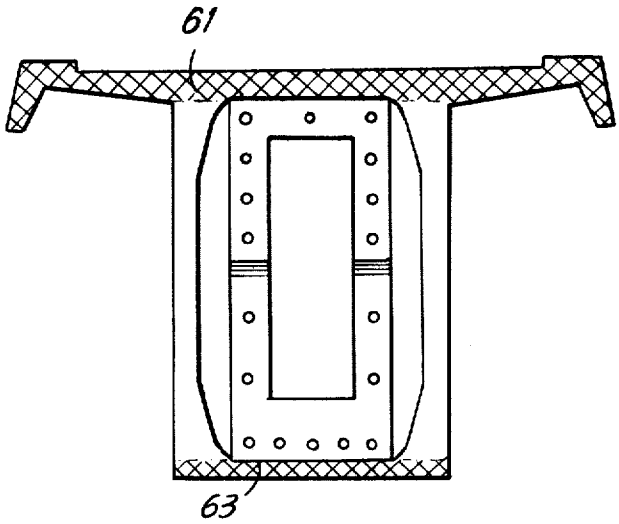
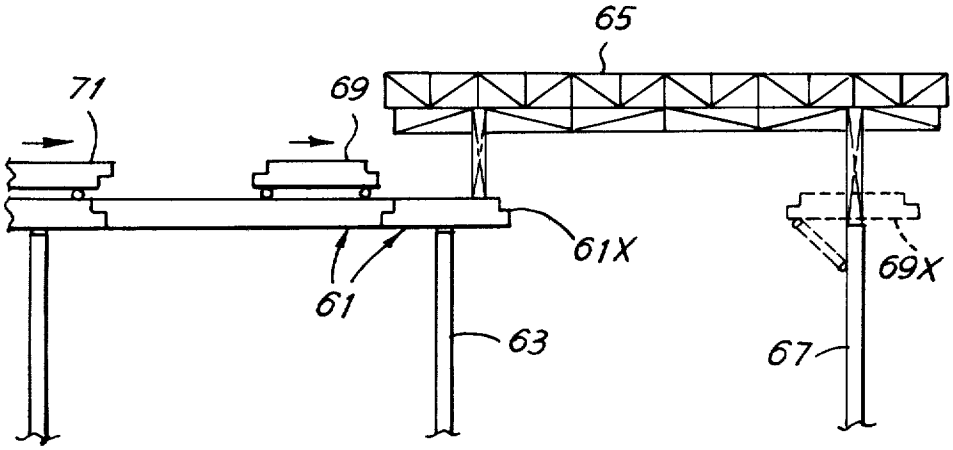


Fig. 12



BEAM STRUCTURES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a division of application Ser. No. 276,022, filed July 28, 1972, and now U.S. Pat. No. 3,788,023, issued Jan. 29, 1974.

FIELD AND SUMMARY OF THE INVENTION

The present invention relates to beam structures for use in bridges and viaducts for example.

The invention provides a beam structure, for bridges and viaducts, and like structures, comprising a plurality of beams of prestressed reinforced concrete lying in end to end relationship, and a rigid junction between each pair of adjacent end portions of the beams to make the structure continuous.

The invention further provides a beam structure comprising two beams lying in end to end relationship, with each beam having elongate reinforcing members extending under tension between opposite end portions, and reinforcing means coupling the adjacent end portions of the two beams under tension, the reinforcing members and reinforcing means in each adjacent end portion overlapping one another and being anchored at axially spaced locations in the end portion to place under compression that portion of the beam lying between the anchorings.

BRIEF DESCRIPTION OF THE DRAWINGS

Beam structures embodying the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings in which:

FIG. 1 is a fragmentary longitudinal section of a beam structure, the section being taken on the line I—I of FIG. 2;

FIG. 2 is a fragmentary longitudinal section taken on the line II—II of FIG. 1;

FIG. 3 is a fragmentary cross-section taken on the line III—III of FIG. 1;

FIG. 4 is a detail of FIG. 2 to an enlarged scale;

FIGS. 5 and 6 are fragmentary side elevations of a viaduct structure respectively during and after its erection;

FIGS. 7 and 8 are fragmentary side elevations of another viaduct structure respectively during and after its erection;

FIG. 9 is a fragmentary side elevation indicating one form of junction between two beams;

FIG. 10 is a fragmentary side elevation indicating another form of junction between two beams.

FIG. 11 illustrates zones between adjacent beams into which a hardenable mass can be injected.

FIG. 12 is a side elevation of the viaduct of FIGS. 7 and 8 illustrating how a beam is fitted into position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIGS. 1 to 4, two beams 1 and 3 are coupled in end to end relationship. The end portion of the beam 3 has a step 3A which supports a step 1A of complementary shape in the adjacent end portion of the beam 1. The end faces of the adjacent end portions of the beams define a gap to allow a limited amount of relative longitudinal movement between the beams while the two steps 1A, 3A are in intimate contact with one another. The two beams are prefabricated and each has

a hollow, that is an annular, cross-section (see FIG. 3) with laterally extending flanges 3B, 3C as for a viaduct. The flanges 3B and 3C are arranged so that they can be continuously joined to parallel beams of similar structure extending along opposite sides of the beam 3. The internal cavity of each beam enables the two beams 1 and 3 to be readily anchored in end to end relationship.

Each beam is provided with a plurality of precompression cables. In the beam 1 a plurality of cables 5 extending the length of the beam 1 are anchored at opposite ends to corresponding opposite end portions or heads of the beam 1. In the beam 3 a plurality of cables 7 extending the length of the beam 3 are anchored at opposite ends to corresponding opposite end portions or heads of the beam 3.

Each end portion of each beam is provided with a relatively thick internally extending flange, the dimension of the flange in the axial direction of the structure being greater than that in the transverse dimension. The end flange 9 of the beam 1 lies adjacent the end flange 11 of the beam 3. The concrete material forming the two flanges 9 and 11 (which flanges are advantageously stepped in conformity with the stepped end portions of the two beams) is arranged to retain coupling cables 13 designed to operate in traction. The opposite end portions 13A and 13B of each cable (like the precompression cables) are anchored on the inner surfaces of the respective flanges 9 and 11. Before the cables 13 are tensioned, a hardenable mass, for example concrete or an epoxy resin, is injected into the gap between the adjacent heads of the two beams 1 and 3 to form a shim 15. This shim 15 is, after it has been allowed to harden, subjected to compression by tensioning the cables 13. This also results in the material of the flanges 9 and 11 being subjected to compression. The axial thickness of the flanges 9 and 11 and the anchoring of the end portions 13A of the coupling cables 13 and the end portions 5A and 7A of the precompression cables 5 and 7 are such that they produce a compression effect on the material between the anchorings, as indicated by the double arrow f_c of FIG. 4. In this way, the material of the flanges 9 will be subjected to substantially only compressive stresses which act barycentrically to reduce hyperstatic or redundant reactions.

In order to decrease the number of the coupling cables 13 and to maintain the hardened mixture 15 under a relatively high compressive stress, the cross-sectional area of the hardened mixture 15 can be reduced to that designated in 15X in FIG. 4. The mixture here occupies a cross-sectional area equivalent to that of the adjacent beam beyond the flanges. This reduction in the cross-sectional area enables a good efficiency for the flexure actions to be obtained while using only a relatively small number of coupling cables 13. These cables then can be protected by putty injected into the residual space 15Y (see FIG. 4) after the beams have been coupled and placed under stress.

FIGS. 5 and 6 show a viaduct structure having two adjacent supporting posts or piers 21 and 23 and a beam 25 partially supported by the pier 21.

As shown in FIG. 5 a prefabricated beam 27 is about to be laid onto the pier 23 with its end portion 27A about to rest on the end portion 25A of the beam 25. Once the two end portions 25A, 27A are brought into contact they are axially coupled in the hereinbefore described manner either immediately after the beam 27 is in position as shown in FIG. 6 or, and advanta-

geously, after a delay which allows the complete relaxation of the steel of the precompression cables and the shrinkage and fluage of the concrete to take place.

In another viaduct structure shown in FIGS. 7 and 8, two adjacent piers 31 and 33 each carry a beam 35. The two beams 35 are arranged to be linked by beam 37. The beams 35 are designed so as to take predominantly negative moments, while the beam 37 is designed so as to take predominantly positive moments, the precompression cables being correspondingly arranged between adjacent end portions of the beams.

In the construction of the viaduct after the beam 37X which extends between the beam 35X in the pier 31 and its adjacent beam on the preceding pier (not shown) has to be located in position (by a procedure to be described for the subsequent beam), the beam 35Y is laid in a balanced condition on the pier 33. The beam is temporarily secured to the pier by a tie-rod 39. Then the beam 37Y is launced into position with one end portion 37A engaging the end portion 35A of the beam 35Y, and with its other end portion 37B engaging the end portion 35B of the beam 35X. After the launch, the beams 37Y and 35Y are coupled by coupling cables extending through the flanges of the beams. Thereafter the fluage of the concrete is allowed to settle and shrink before the coupling cables are tensioned to place the concrete under stress. The subsequent spans are formed in the same manner.

In FIG. 9 shows a section through a modified junction between two beams which allows a temporary seal between the two beams to be readily demolished, and replaced by a more permanent seal after the structure has been allowed to settle and the stresses reach a state of equilibrium.

As shown in FIG. 9, the adjacent end faces 41 of the two beams are inclined with respect to the vertical so as to define a gap which diverges with increasing distance from the common longitudinal axis of the beams. Spacers 43 of a detachable material (such as metal sheets, layers of synthetic resin, or artificial rubber and neoprene) are mounted on each end face 41 and a mass 45 is cast in the gaps between the spacers 43 to form a temporary seal between the beams. When the mass has hardened, it is placed under compression by tensioning the coupling cables 47 which extend through the adjacent flanges of the two beams. In this manner, the structure is made continuous. After a delay during which settlement has had time to take place, the coupling cables are loosened and the sealing 45 is removed. This is readily accomplished because of the presence of the spacers 43 and because the sealing mass is wedge-shaped, the mass can be removed in complete blocks with the aid of jacks or the like, or it can be broken in to fragments and removed fragment by fragment. A fresh hardenable mass is then injected between the beams.

In the modified junction between two beams shown in FIG. 10, the concrete mass is formed with the aid of a mold of plastic or other material which has been lowered into the gap between adjacent end faces 51 of two beams. The mold has two flanges which are arranged to engage the end faces 51 to form gaps between the side walls of the mold and the end faces 51. Concrete is thereupon cast both into the gaps between the walls of the mold and the end faces 51 to form blocks 55 and is also cast into the mold 53 itself to form an additional block 57. After sufficient time has been allowed for setting, the coupling cables 59 are loosened and the mold 53 together with the block 57 are removed to leave the blocks 55 in position. The mold 53 can thereafter be demolished. Thereafter the remaining gap between the beams is sealed in a more permanent manner.

In this manner it is possible both to assure the immediate continuity of the launched structure and to subsequently relieve the over-stresses produced by casting the temporary concrete blocks before the complete structure has had time to settle.

The temporary sealing such as the ones denoted by 45 or 57 respectively in FIGS. 9 and 10 can advantageously be provided in the zone 61 or the zone 63 of the beam as indicated in FIG. 11.

An advantage of providing a temporary seal between beams is that the resulting continuous structure formed can be used almost straight away to carry new beams to be added to the structure into their required positions. This simplifies and speeds constructional operations since the launching bridge need not be made to traverse all the piers in order to pick up fresh beams from one end of the structure but can remain in a position where it is required, that is, at the end of the thus far completed structure.

In the construction of a continuous beam structure as indicated in FIG. 12, lifting equipment 65 for lifting successive beams into position has one leg mounted on the over-hang portion 61X of the completed length of the continuous beam 61 and its other leg mounted on a subsequent pier 67. Prefabricated beams 69 and 71 are conveyed along the completed length of the continuous beam 61 until they reach the equipment 65, whereupon the beam 69 is raised by the equipment and laid onto the pier 67 as indicated by broken lines 69X. Thereafter the beam 71 is raised by the equipment and laid between the beam 69 and the over-hang 61X.

The two beams 69 and 71 are then coupled by coupling cables as is the beam 71 with the over-hand portion 61X. Thereafter temporary casings are made at the beam junctions.

It will be appreciated that because the temporary casting is readily removable (which casting provides an initial continuity of the beam structure with the associated advantages) the resultant stresses resulting from settlements of the bonds, fluage of the concrete and relaxation of the steel cables can be readily relieved.

This continuous beam structure is particularly advantageous where the continuous beam structure has to follow a curved path and also for bridging spans in excess of 30 to 40 linear meters and up to 100 linear meters.

I claim:

1. A beam structure, comprising

two beams

means supporting the two beams in end to end relationship, each beam having elongate reinforcing members extending under tension between opposite end portions,

reinforcing means coupling the adjacent end portions of the two beams under tension, the reinforcing members and reinforcing means in each said adjacent end portion overlapping one another, and

means anchoring the reinforcing members and reinforcing means at axially spaced locations in the end portion to place under compression that portion of the beam lying between the anchorings.

2. A beam structure according to claim 1, wherein each end portion of the beam has a flange to which the anchoring means are secured, each flange having a dimension in the axial direction of the structure which is greater than that in the transverse direction of the structure.

3. A structure according to claim 2, wherein each beam is of hollow cross-section.

4. A structure according to claim 3, wherein the flanges are internal of the beam.

5. A structure according to claim 2, including a hardened means extending between the adjacent end portions of the beams, the hardened mass being subjected to a compression force by the reinforcing means.

6. A structure according to claim 5, wherein the hardened mass has a cross-sectional area smaller than that of the flanges.

* * * * *