United States Patent [19]

Raaber

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[54] **REINFORCED GIRDERS OF STEEL AND CONCRETE**

[76] Inventor: **Norbert Raaber,** Haupstrasse 87a, 8010 Graz-Waltendorf, Austria

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[52] **U.S. Cl.** **52/223,** 52/723

[51] **Int. Cl.** **E04c 3/293**

[58] **Field of Search** 52/223, 723, 224, 225, 52/226

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Primary Examiner—John E. Murtagh

Attorney, Agent, or Firm—Charles E. Temko

[57] **ABSTRACT**

The invention relates to a reinforced girder, in particular of steel and concrete, in which the concrete is prestressed to avoid cracks being formed therein due to tensile stresses. The invention also discloses a method for the production of such girders.

3 Claims, 10 Drawing Figures

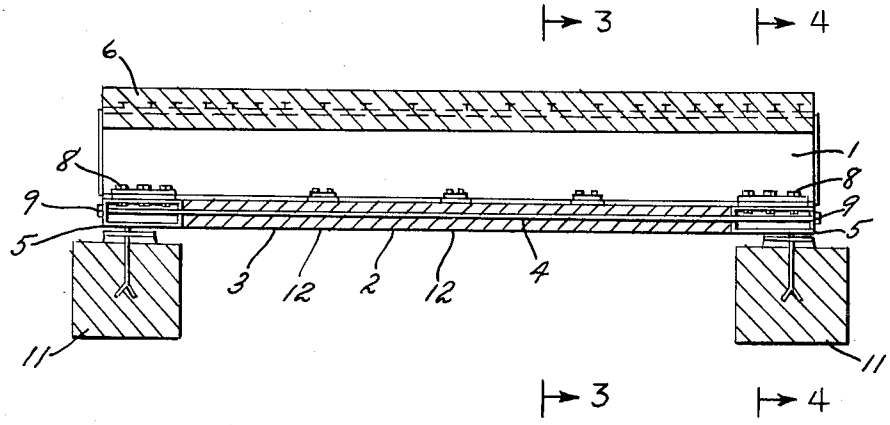


Fig.1

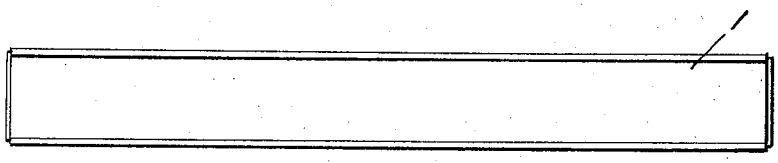


Fig.1A

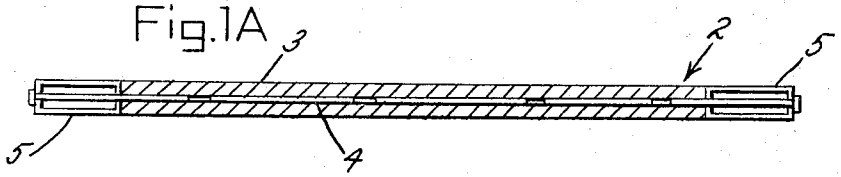


Fig. 2

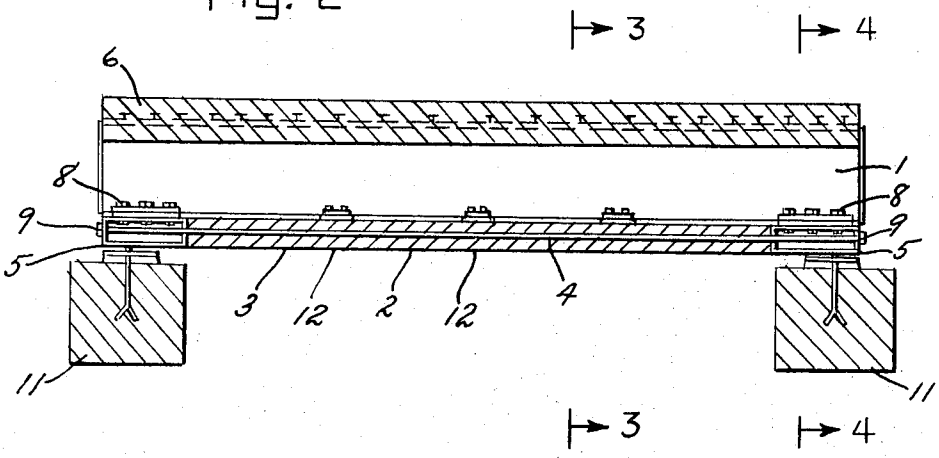


Fig. 3

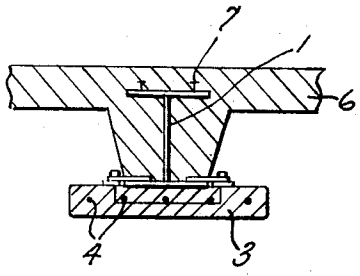


Fig. 4

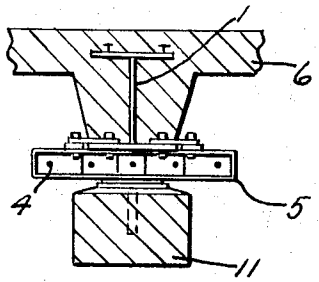


Fig. 5

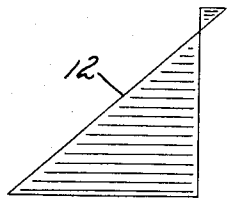


Fig. 6

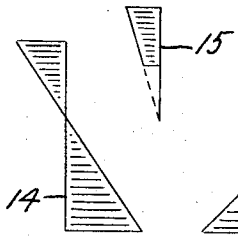


Fig. 7

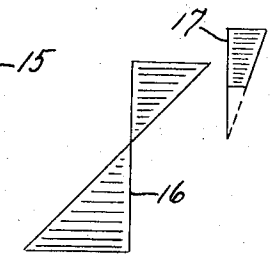


Fig. 8

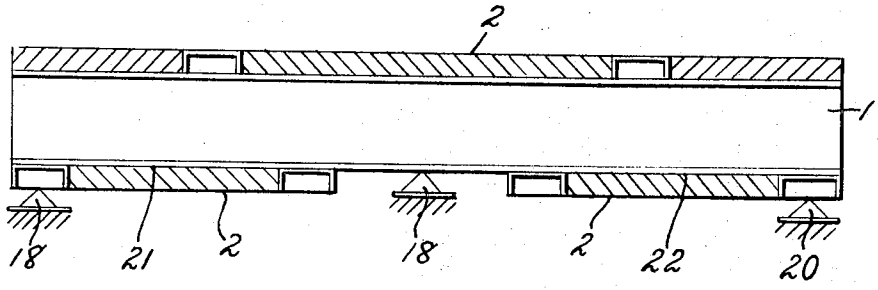
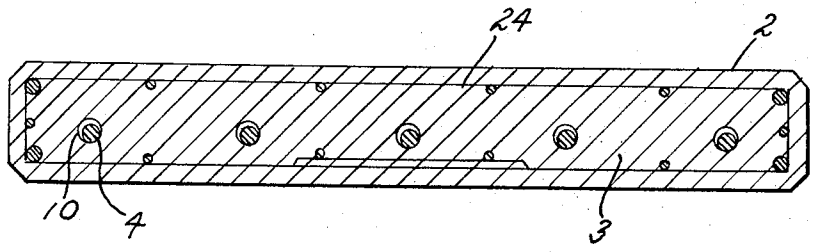


Fig. 9



REINFORCED GIRDERS OF STEEL AND CONCRETE

In order to reinforce girders of steel and concrete it is known to have reinforcing elements bonded over their entire length to the girder which is to be reinforced. In the case of steel girders such reinforcement is obtained by means of plates which are welded. It is also known to achieve reinforcement by applying concrete to a top flange, such concrete providing a direct bond due to its adhesion to the upper flange of the steel and by virtue of a plurality of dowels specially provided to this end. To reinforce girders it is also known to surround the lower flange of the steel girder with a concrete beam which is bonded over its entire length by means of dowels. However, since in this case the concrete is disposed on a zone which is subject to tensile stresses which cause cracks, the concrete is compressively prestressed, by utilizing an artificial deformation of the girder. These known measures may also be applied in combination.

In this conventional production of reinforced girders it is a particular disadvantage that the girder to be reinforced must be compressively deformed in order to produce a prestress. This requires very powerful and technologically expensive presses. Furthermore, handling of a girder reinforced with concrete on its bottom flange is rendered very difficult because of the very large overall loads which are produced and are detrimental during transportation and installation.

It is therefore an object of the invention to provide an improved, reinforced girder of steel and concrete, the manufacture of such girder being substantially simplified and in which the reinforcement thereof is applied only on site during installation.

BRIEF DESCRIPTION OF THE INVENTION

According to the invention, a girder of steel and/or concrete is provided with a separate, compressively prestressed reinforcement part, comprised of concrete, preferably with steel reinforcement and having a length corresponding to the zone in which tensile stresses may be expected in the associated flange of the girder to be reinforced and which is fixedly joined to said girders at the end zones.

In a further embodiment it is proposed in accordance with the invention that the reinforcement part remains slidable between the ends relative to the girder.

According to a suitable embodiment the reinforcement part is attached below the neutral fibre of the girder in order to apply a compressive force to the lower flange of the girder. The reinforcement part may also advantageously be applied above the neutral fibre on the girder in order to exert a compressive force on the top flange of the girder.

In one further embodiment of the invention reinforcement parts are provided on the lower flange of the girder along the zone in which tensile stresses are to be expected in the lower flange in the case of a continuous girder extending over one or more support positions, and that the reinforcement part is attached to the top flange in the zone of the support position at which tensile stresses are to be expected.

In another embodiment of the invention one or more additional fixed connections are provided between the girder and the reinforcement part between the ends of the girder which is to be reinforced. The said connections absorb an additional shear force which increases progressively from the middle of the zone to the end of the beam. The connections at the beam ends are load-relieved due to the distribution of the shear force.

According to a further embodiment of the invention, stressing blocks, disposed at the ends of the reinforcement part, are secured on the girder flange by means of screw-threaded bolts or by means of welding and the stressing blocks function as bearing structure.

In order to positively influence the bending stress of the reinforcement part, the tendon is preferably eccentrically disposed in the reinforcement part or curved tendons are provided.

Slack reinforcement, for example in the form of a lattice mat, is preferably provided in the reinforcement part, in particular in order to prevent cracking of the part in the finished state during transportation, in the course of installation and the like.

The invention also provides a method for producing the reinforced girder of steel and concrete explained hereinabove, the concrete being compressively prestressed in order to avoid cracking in the presence of tensile stresses.

A special inventive feature of the method is due to the fact that a separate reinforcement part, constructed of concrete and preferably having steel reinforcement, is compressively prestressed, the length of the reinforcement part corresponding approximately to the zone in which tensile stresses are expected in the associated flange of the girder to be reinforced and that the end zones of the reinforcement part are fixedly joined to the girder.

An advantageous embodiment of the method is characterized in that the reinforcement part is attached so that it remains slidable relative to the girder between the ends or defined positions connecting it to the girder.

The reinforcement in the reinforcement part is preferably prestressed and the concrete is applied so as to surround the prestressed reinforcement and to adhere directly thereon whereupon the reinforcement is released after the concrete has set.

In a further embodiment of the method according to the invention the reinforcements are provided in cavities of the concrete of the reinforcement part and the reinforcement is prestressed and anchored after the said concrete has set.

The tendons are appropriately and in particular introduced into sheathing tubes, are stressed after the concrete has set and are bonded to the surrounding concrete by means of pressure grouted cement mortar after prestressing.

In a suitable embodiment of the method the prestress is regulated after installation.

A method according to the invention proposes, in particular in order to facilitate installation, that the reinforcement part is attached to the girder which is to be reinforced only after said girder has been installed on site.

According to a further embodiment the reinforcement part is joined to the girder which is to be reinforced as far as possible in the zone of the bearings.

The measures taken according to the invention generally provide an improved reinforced girder in which stress distortion or deformation of the main girder is avoided during manufacture thereof. Installation is substantially simplified by the separate transportation, for

reasons of space and weight of the girder and reinforcement part which may then be moved into the appropriate position in order to be bonded to each other to complete installation. By contrast to conventional reinforced girders the invention offers the further advantage of not merely stiffening the girder to be reinforced with respect to moments which may occur but genuinely increasing the actual load-bearing capacity of the girder in an inventive manner so that the amount of material required for a steel girder is substantially reduced for identical expected loads.

The invention initially relates to a girder of steel and concrete. However, the invention may also be applied to girders constructed wholly of steel or wholly of concrete respectively which may also be already installed on site.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be explained by reference to embodiments relating to the accompanying drawings in which:

FIGS. **1** and **1A** show a diagrammatic view of girder to be reinforced and of a reinforcement part;

FIG. **2** is a top flange composite girder, completely installed by means of the reinforcement part; FIG. **3** is a sectional view along the line I—I of FIG. **2**;

FIG. **4** is a sectional view along the line II—II of FIG. **2**;

FIG. **5** is a stress diagram of a simple top flange composite girder at midspan under operational load;

FIG. **6** is a stress diagram of the same top flange composite girder at midspan under tensile stress;

FIG. **7** is a superimposition of the stress diagrams of FIGS. **5** and **6**;

FIG. **8** is a longitudinal view of a continuous girder shown schematically; and

FIG. **9** is a schematic view showing the construction of a reinforcement cage for the reinforcement part in which the tendons are eccentrically disposed.

DESCRIPTION OF THE DISCLOSED EMBODIMENT

FIG. **1** shows a steel girder **1** which is to be reinforced. An I-girder, provided with flanges, as shown in FIGS. **3** and **4**, appears to be particularly suited to this end.

A separate reinforcement part **2**, compressively prestressed, is provided to reinforce the girder **1**. The reinforcement part **2** consists of concrete and steel reinforcement or tendons **4** which terminate in stressing blocks **5**.

FIG. **2** is a longitudinal section through a structure comprising the girder **1**, which is to be reinforced, and the reinforcement part **2** as shown in FIG. **1**. The girder **1** in FIG. **2** is provided with a top flange concrete member **6** which, as is known, is directly bonded to the girder **1** by means of dowels **7**. At the lower flange of the girder **1** the reinforcement part **2** is secured to the stressing blocks **5** by screw-threading means **8**. The concrete **3** of the reinforcement part **2** is compressively prestressed between the stressing blocks **5** by means of the tendons **4**. FIGS. **3** and **4** indicate the manner in which five tendons **4** are disposed to extend in parallel and adjacent to each other. In the drawings the tendons **4** are provided at their ends with screwthreaded portions on which nuts **9** are disposed to permit tightening. It is, of course, also possible to provide the reinforcement part **2** with tendons other than those shown. For example, suitable anchorings must be provided for non-circular tendons or tendon assemblies.

In particular it is possible to prestress the reinforcement or tendons **4** in the reinforcement part **2** and thereafter to apply the concrete so that the said concrete surrounds the prestressed reinforcement and adheres directly thereto. The tendons are released after the concrete has set and adhesive stresses of the concrete prevent the said tendons contracting to their original length, so that a compressive stress is produced in the concrete. It is of course also possible for prestressing to be performed against the set concrete. In this case the tendons **4** will be disposed in sheathing tubes **10** as indicated in FIG. **9**. The tendons **4** are stressed by means of presses applied to the tendon end after the concrete has set and are bonded to the surrounding concrete **3** of the reinforcement part after prestressing by means of pressure-grouted cement mortar. To this end it is advantageous if the tendons may be retensioned at any time after the first prestress has been applied and for as long as the sheathing tubes **10** are still open. In this way it is possible, for example, for creep losses in the concrete to be substantially compensated.

The stressing blocks **5** consist of steel and are so constructed that they may be utilized directly as abutments during prestressing and after the concrete **3** has set, namely by directly transmitting or distributing the compressive forces, resulting from compression, onto the end face of the reinforcement part **2**. The example of a top flange composite girder, representing the statically optimum utilization, is shown in sectional form after installation in FIGS. **3** and **4**. The function of the stressing blocks **5** is to absorb the shear forces which occur in loading at the level of the lower edge of the girder and to distribute such forces over the individual tendons **4**, it being another function of the said blocks to divert the vertical compressive forces from the girder to supports **11**. As a rule the stressing blocks **5** therefore function as bearing structures and as far as possible the bearing part **2** is fixedly joined in the zone of the supports **11** to the girder **1** which is to be reinforced. To perform these different functions the stressing blocks **5** are preferably constructed in box form and are additionally stiffened in the interior of the box, a feature which is not shown. The invention basically utilizes the fact that high tensile steel of restricted elongation may be employed as understressing means.

The time at which the reinforcement part is suspended from or secured to the girder **1** which is to be reinforced may be selected at will and is defined in particular in accordance with the transportation requirement and installation conditions, the size or weight of the girder structure also playing a part. As may be seen particularly by reference to FIG. **1**, the girder **1** is not deformed during manufacture when prestress is applied to the reinforcement part **2** and the appropriate devices may therefore be constructed to a small physical size. The question as to whether bonds are provided between the girder **1** and the reinforcement part **2** in addition to the fastenings at the ends of the reinforcements parts **2** on the girder **1**, depends on the static conditions. However, additional bonds **12** as illustrated in FIG. **2** may be provided between the ends or stressing members **5**, the said bonds absorbing a shear force in addition to the vertical loading. The connections at the

ends of the reinforcement part **2** are thus load-relieved owing to the resultant shear force distribution.

The stress characteristics in the steel girder **1** are illustrated in FIGS. **5** to **7.**

The stress diagram **12** according to FIG. **1** shows the stress characteristics plotted against the cross-section of the steel girder **1** (FIG. **3**) as part of a simple top flange composite girder in the midspan under operational load. The diagram **13** shows the continuation of the stress characteristics under the same conditions in the bonded top flange concrete slab **6** (FIG. **3**). Since the center of gravity is disposed closer to the upper girder edge than to the lower girder edge it appears clearly that the steel top flange is stressed to a substantially lower degree than the bottom flange. Slight tensile stresses occur at the lower edge of the concrete slab.

FIG. **6** shows the tensile action on the same composite girders. The diagram **14** relates to the stress characteristics in the steel section, the diagram **15** to the stress characteristics in the concrete slab. Stresses, precisely opposite to those of FIG. **5,** are produced both in the steel section as well as in the concrete slab.

FIG. **7** shows the superimposition of the diagrams according to FIGS. **5** and **6.** Diagram **16** of the steel section refers to a balanced ratio of maximum stresses applied to the lower and upper flanges respectively. The stress acting on the upper slab edge in the concrete slab **6** is reduced in accordance with diagram **17.** No further tensile stresses occur.

FIG. **8** shows the invention associated with a girder **1,** extending as a so-called continuous girder over a bearing position **18** from an end bearing position **19** to a second end bearing position **20.** Reinforcement parts **2** are attached to the girder **1** along the zones **21, 22** in which tensile stresses are expected in the bottom flange of the girder **1.** A reinforcement part **2** is also provided in the zone of the bearing position **18** in which tensile stresses are expected in the top flange.

FIG. **9** shows a reinforcement part as a sectional view to an enlarged scale. The tendons **4** are inserted in sheathing tubes **10** and are tensioned after the concrete **3** has set. After stressing the tendons **4** are bonded to the surrounding concrete **3** by means of pressure-grouted cement mortar. The reinforcement part **2** is also provided with slack reinforcement **24** to prevent cracking, particularly during manufacture and transportation. The slack reinforcement is advantageously constructed of a wire mesh mat **24,** corresponding to the length of the reinforcement part **2,** and curved into a closed tube. In FIG. **9** the tendons **4** are eccentrically disposed in the reinforcement part **2** relative to the median axis. The bending stress of the reinforcement part **2** may be influenced and controlled by these measures.

The measures explained hereinabove in the sense of the problem upon which the invention is based may also be advantageously utilized on existing structures and the measures according to the invention for reinforcement of the girders may be used in the most diverse combinations as indicated by the example of a continuous girder shown in FIG. **8.**

I wish it to be understood that I do not consider the invention limited to the precise details of structure shown and set forth in this specification, for obvious modifications will occur to those skilled in the art to which the invention pertains.

I claim:

1. Reinforced girder construction comprising: a non-pre-stressed steel girder of elongated configuration having a principal axis, said girder having first and second ends, and a pre-stressed concrete reinforcing member interconnected to said steel girder solely at said first and second ends thereof, said reinforcing member being slidably related to said girder therebetween.

2. Structure in accordance with claim **1,** said steel girder including at least one laterally extending flange, said reinforcing member exerting a compressive force thereon.

3. Structure in accordance with claim **1,** said concrete reinforcing member including an elongated section of concrete, and a steel tendon extending through said section of concrete, stress blocks at each end of said concrete section, said tendon extending through said stress blocks, and threaded means on the ends thereof for tightening said blocks thereagainst.

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