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Porter et al.

[11] **3,712,010**

[45] **Jan. 23, 1973**

[54] **PRESTRESSED METAL AND CONCRETE COMPOSITE STRUCTURE**

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[73] Assignee: **Iowa State University Research Foundation,** Ames, Iowa

[22] Filed: **Aug. 17, 1970**

[21] Appl. No.: **64,577**

[52] **U.S. Cl.** **52/223,** 52/283, 52/336

[51] **Int. Cl.** **E04c 3/10,** E04c 3/26

[58] **Field of Search**.....52/222, 223, 225, 226, 283, 52/336, 640, 724, 725

[56] **References Cited**

UNITED STATES PATENTS

2,510,958	6/1950	Coff	52/225
736,718	8/1903	Grimm	52/225
793,358	6/1905	Doyle	52/225
894,090	7/1908	Williams	52/724
1,243,000	10/1917	Stewart	52/223 R
2,382,139	8/1945	Cueni	52/223 R
2,577,582	12/1951	Hammitt	52/225
2,637,421	5/1953	Wolfard	52/640
3,094,813	6/1963	Saxe	52/336

FOREIGN PATENTS OR APPLICATIONS

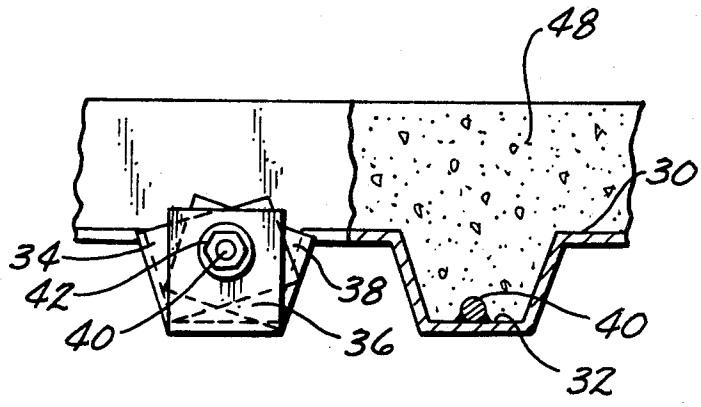
194,117	12/1957	Australia	52/336
966,988	8/1964	Great Britain	52/222

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Attorney—Zarley, McKee & Thomte

[57] **ABSTRACT**

A prestressed form of lightweight metal construction which is adapted to be supported between beams and which is adapted to support a poured concrete floor or the like. The form is prestressed by means of tendons attached at the ends thereof and at various points along the length of the form. The prestressing of the forms provides a means of cambering the forms which offset the deflection due to the dead load imposed thereon. The prestressed form and the concrete supported thereby cooperate compositely to resist live loading.

3 Claims, 17 Drawing Figures



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SHEET 1 OF 2

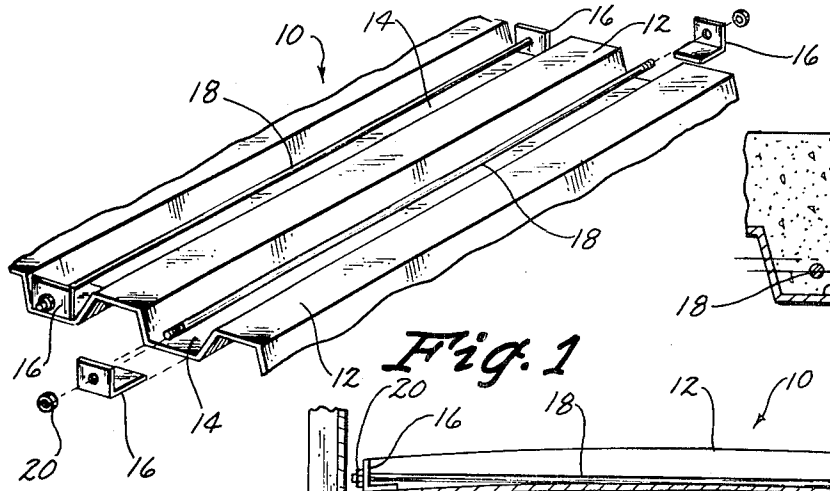


Fig. 1

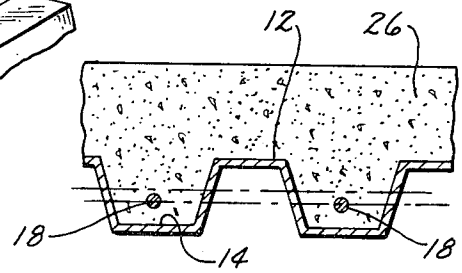


Fig. 4

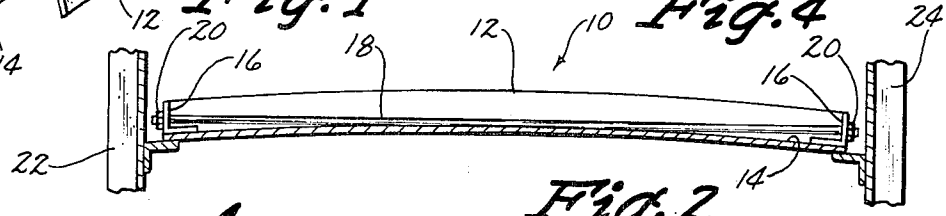


Fig. 2

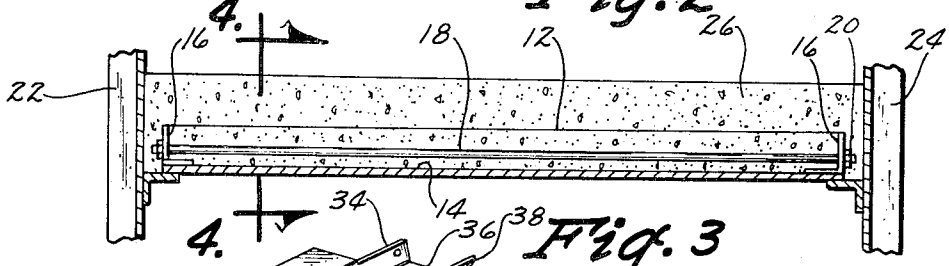


Fig. 3

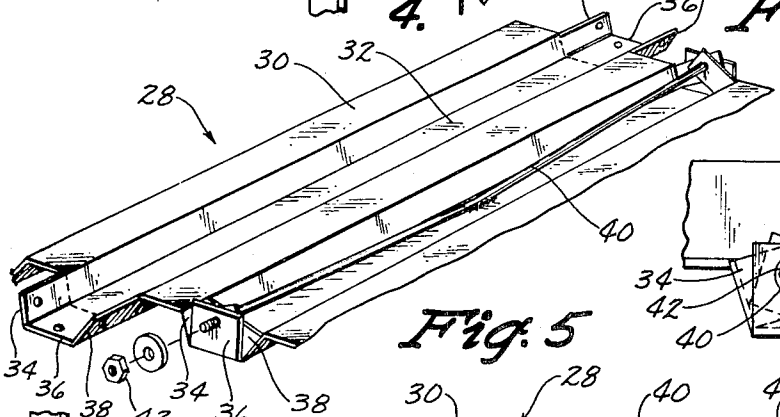


Fig. 5

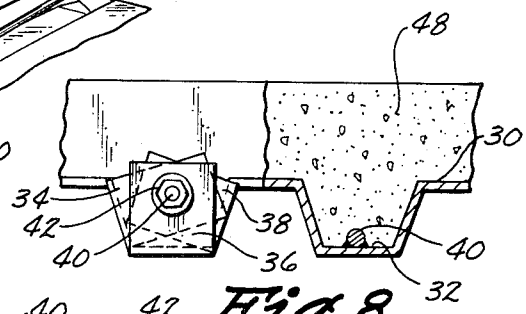


Fig. 8

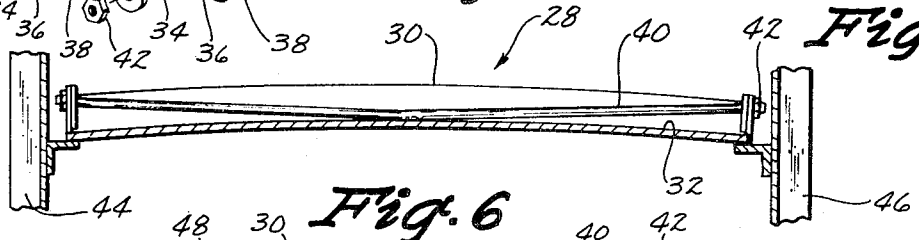


Fig. 6

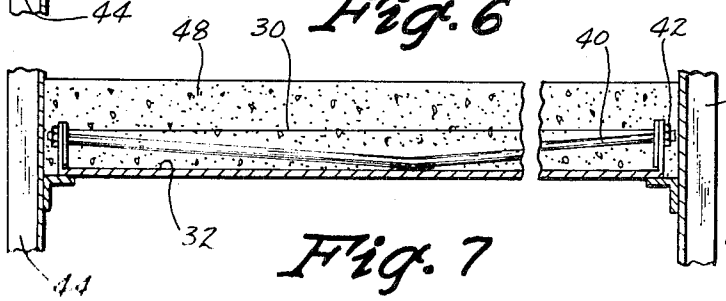


Fig. 7

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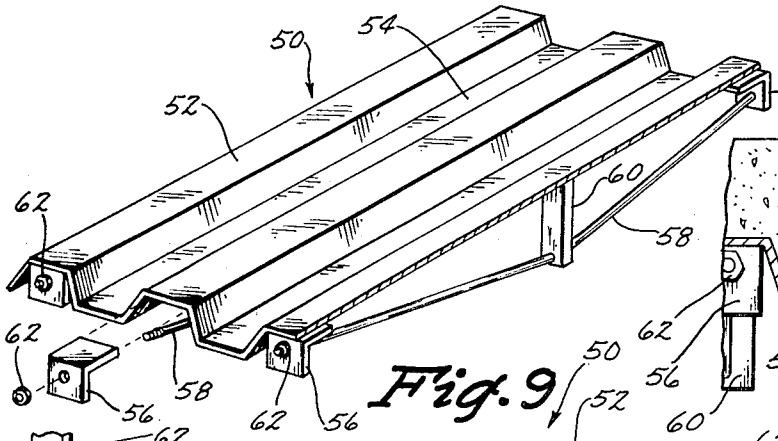


Fig. 9

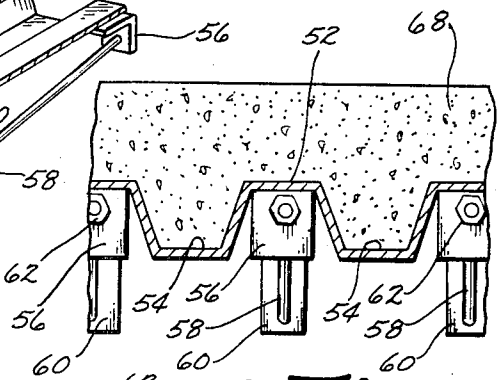
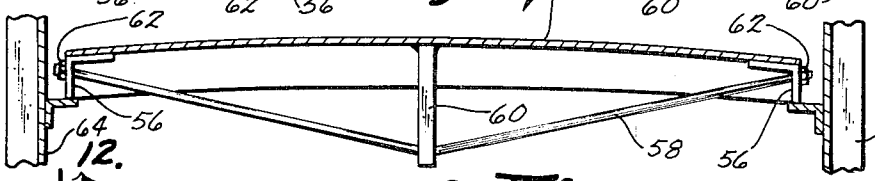
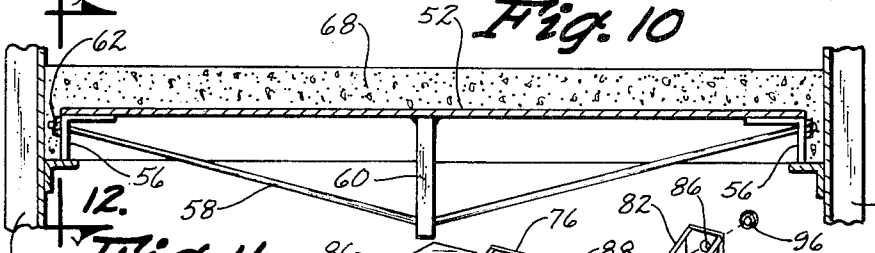


Fig. 12



12.

Fig. 10



12.

Fig. 11

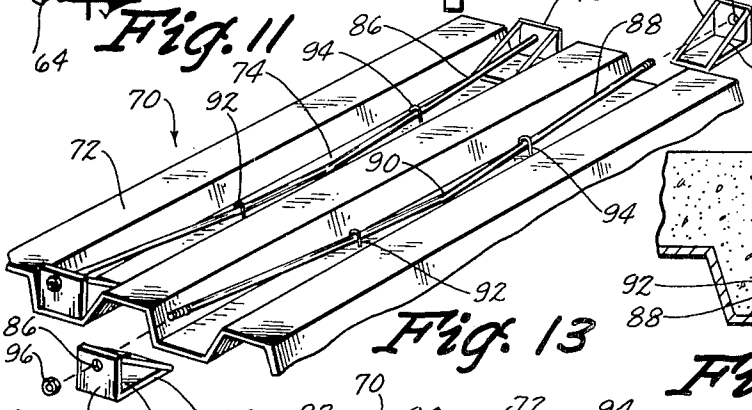


Fig. 13

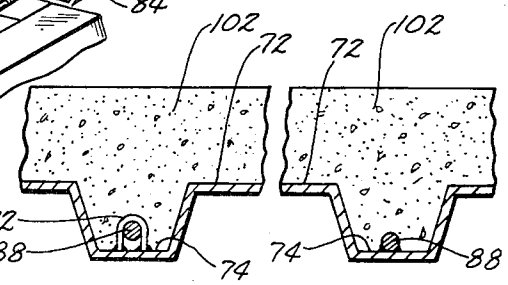
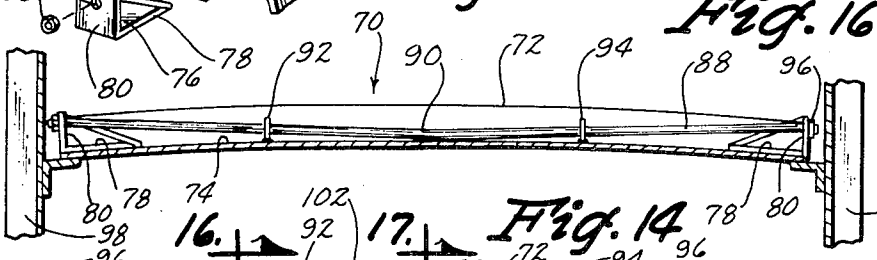


Fig. 16

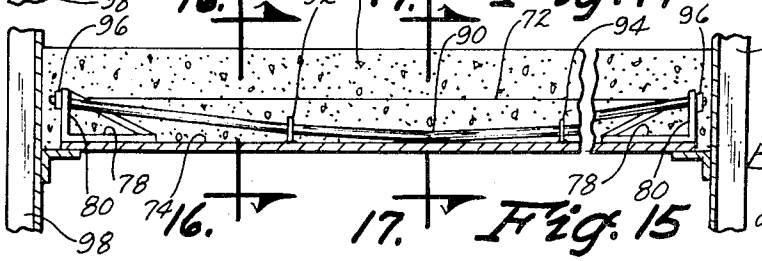
Fig. 17



16.

17.

Fig. 14



16.

17.

Fig. 15

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PRESTRESSED METAL AND CONCRETE COMPOSITE STRUCTURE

Lightweight or light gage metal forms are being used in conjunction with concrete to provide floor systems in buildings and bridges. The light gage metal form serves first as form work to support the concrete while the floor is being formed and secondly as a reinforcement for the floor system. The economy of using the light gage metal forms in conjunction with a concrete topping has been proven in that it reduces the amount of shoring and forming and does permit possible increased spans. However, the light gage metal form is very flexible and requires a considerable amount of shoring under many construction situations and also reduces the possible span length.

Therefore, it is a principal object of this invention to provide a prestressed form of lightweight metal construction.

A further object of this invention is to provide a prestressed form which is prestressed by means of tendons attached at the ends thereof.

A further object of this invention is to provide a prestressed form which is prestressed by means of tendons attached at the ends thereof and at various points along the length of the form.

A further object of this invention is to provide a prestressed form which is cambered to offset the deflection of the dead load imposed thereon.

A further object of this invention is to provide a prestressed form which cooperates with the concrete supported thereon to compositely resist live loading.

A further object of this invention is to provide a prestressed form which reduces the amount of shoring.

A further object of this invention is to provide a prestressed form which is economical of manufacture.

These and other objects will be apparent to those skilled in the art.

This invention consists in the construction, arrangements and combination of the various parts of the device, whereby the objects contemplated are attained as hereinafter more fully set forth, specifically pointed out in the claims, and illustrated in the accompanying drawings in which:

FIG. 1 is a fragmentary perspective view of the concrete form of this invention;

FIG. 2 is a longitudinal sectional view of the form of FIG. 1 in a prestressed condition prior to the concrete being placed thereon;

FIG. 3 is a view similar to FIG. 2 except that the concrete has been placed on the form thereby deflecting the same;

FIG. 4 is a sectional view as seen along lines 4 — 4 of FIG. 3;

FIG. 5 is a fragmentary exploded perspective view of a modified version of the form;

FIG. 6 is a longitudinal sectional view of the form seen in FIG. 5 illustrating the form in a prestressed condition before the concrete has been placed thereon;

FIG. 7 is a view similar to FIG. 6 illustrating the form of FIGS. 5 and 6 after the concrete has been placed thereon;

FIG. 8 is a fragmentary end view of the form of FIG. 5 with portions thereof cut away to more fully illustrate the invention and illustrating the form after the concrete has been placed thereon;

FIG. 9 is a partial exploded perspective view of another version of the form;

FIG. 10 is a longitudinal sectional view of the form of FIG. 9 illustrating the form in a prestressed condition before the concrete has been placed thereon;

FIG. 11 is a view similar to FIG. 10 but which illustrates the form after the concrete has been placed thereon;

FIG. 12 is a sectional view as seen along lines 12 — 12 of FIG. 11;

FIG. 13 is a partial exploded perspective view of still another modified version of the form;

FIG. 14 is a longitudinal sectional view of the form of FIG. 13 illustrating the form in a prestressed condition prior to the concrete being placed thereon;

FIG. 15 is a partial sectional view similar to FIG. 14 illustrating the form after the concrete has been placed thereon;

FIG. 16 is an enlarged sectional view as seen along lines 16 — 16 of FIG. 15; and

FIG. 17 is an enlarged sectional view as seen along lines 17 — 17 of FIG. 15.

The form seen in FIGS. 1 – 4 is generally designated by the reference numeral 10 and includes a plurality of alternately spaced ridges 12 and grooves 14 thereby giving the form a corrugated appearance. An L-shaped bracket 16 is secured to form 10 at the opposite ends of the grooves 14 by welding or the like as illustrated in FIG. 1 and is adapted to receive the opposite ends of the tendon or rod 18 extending therethrough. Tendon 18 is secured to the brackets 16 by means of nuts 20. The nuts 20 are tightened on the tendon 18 to cause the form 10 to be cambered upwardly in the manner illustrated in FIG. 2. The form 10 is supported at its opposite ends by beams 22 and 24 as illustrated in FIG. 2. The concrete 26 is then poured onto the form 10 and the dead weight of the concrete causes the form 10 to be deflected downwardly from its cambered position of FIG. 2 to a substantially horizontal position as illustrated in FIG. 3. Thus, the prestressing of the form 10 by the tendons 18 offsets the deflection due to the dead load of the concrete topping 26. After the application of the concrete 26, the prestressed form 10 and the concrete topping act compositely to resist live loading.

The modified version of the form of this invention seen in FIGS. 5 – 8 is generally designated by the reference numeral 28 and is comprised of a plurality of alternate ridges 30 and grooves 32 as illustrated in FIG. 5. The opposite ends of the form 28 have been slightly modified from the form 10 seen in FIG. 1 in that the ends of form 28 have been cut to provide flaps or flanges 34, 36 and 38 at the ends of the grooves 32. The flaps are folded inwardly with respect to each other so that the respective openings formed therein register to permit one end of the tendon 40 to extend therethrough as illustrated in FIGS. 5 and 8. The tendons 40 are secured at their mid-points to the form 28 by any convenient means such as welding or the like as illustrated in FIG. 6. The tightening of the nuts 42 on the tendon 40 cause the form to be prestressed to upwardly camber as illustrated in FIG. 6. The form 28 is positioned between the supporting beams 44 and 46 and the concrete 48 is then placed thereon. The dead weight of the concrete topping 48 causes the form 28 to be deflected downwardly from the position of FIG. 6 to the substantially horizontal position seen in FIG. 7. Thus, the prestressing of the form 28 provides a means of cambering the form in an upward direction to offset

the deflection due to the dead load of the topping. After the concrete topping has been applied to the form **28**, the prestressed form **28** and the concrete topping **48** act compositely to resist live loading. It should be noted that the only difference in the form **28** and the form **10** is the means of fastening the ends of the tendons to the forms and the fact that the tendon **40** is bent downwardly at its center to facilitate the attachment of the tendon **40** to the form **28**.

The modified version of the form seen in FIGS. **9** – **12** is generally designated by the reference numeral **50** and is comprised of a plurality of alternately spaced ridges **52** and grooves **54**. L-shaped brackets **56** are secured to the undersides of the ridges **52** at the opposite ends thereof by welding or the like and are adapted to receive the opposite ends of a tendon **58** extending therethrough. The tendon **58** is bowed downwardly and a post **60** connects the center of the tendon **58** with the underside of the form **50** as illustrated in FIG. **10**. The tightening of the nuts **62** on the tendons **58** causes form **50** to be prestressed thereby creating an upward camber as illustrated in FIG. **10**. The form or forms **50** are then placed between the supporting beams **64** and **66** (FIG. **10**) and the concrete **68** is then placed thereon. The dead weight of the concrete **68** causes the form **50** to be deflected downwardly from the position of FIG. **10** to the position of FIG. **11**. Thus, the tightening of the nut **62** on the tendons **58** prestresses the form **50** to camber the form upwardly to offset the deflection due to the dead load of the concrete topping **68**. After the topping **68** has been applied to the form **50**, the prestressed form **50** and the concrete topping **68** act compositely to resist live loading.

The modified version of the form of this invention seen in FIGS. **13** – **17** is generally designated by the reference numeral **70** and includes a plurality of alternately spaced ridges **72** and grooves **74**. A bracket **76** is secured to form **70** at opposite ends of the grooves **74** by any convenient means such as welding or the like as illustrated in FIG. **13**. Each of the brackets **76** include a horizontal base portion **78**, vertical portion **80** and support arms **82** and **84** extending between the upper end of vertical portion **80** and the outer end of base **76** as best seen in FIG. **13**. Each of the brackets **76** have an opening **86** formed therein adapted to receive one end of the tendon **88** extending therethrough. The tendons **88** are bent downwardly to facilitate the attachment of their mid-point **90** to the form **70** by welding or the like as illustrated in FIG. **14**. Tendon **88** is also tied to the form **70** by means of spaced apart U-bolts **92** and **94** or the like extending therearound and secured to form **70** by any convenient means such as welding or the like. The form **70** is prestressed by simply tightening the nuts **96** on the tendon **86** to cause the form **70** to be cambered upwardly to the position illustrated in FIG. **14**. The form or forms **70** are then placed between the supporting beams **98** and **100** (FIG. **14**) and the concrete **102** (FIG. **15**) is then placed thereon. The dead weight of the concrete topping **102** causes the form **70** to be deflected downwardly from the cambered position of FIG. **14** to the level position of FIG. **15**. Thus, the prestressing of the form **70** to cause an upward camber offsets the deflection due to the dead load of the concrete topping **102**. After application of the concrete topping **102**, the prestressed form and the concrete topping **102** can act compositely to resist live loading.

The various versions of the prestressed form of this invention illustrate the fact that the tendon employed therein may be of various drape patterns which would depend on the need and efficiency of construction. It can be appreciated that the prestressed forms of this invention could be of any length or width depending upon the particular construction requirement. The prestressed forms of this invention reduce the amount of shoring required in various construction techniques and thus substantially reduce the cost of the construction. The prestressed light gage metal form illustrated in the drawings is a major improvement in floor system construction in bridges, buildings, parking garages, etc. While the drawings illustrate the forms to be of the corrugated type, the forms could be of a flat metal construction. It should be noted that the forms may be supported by two or more supporting beams. In other words, the forms could pass over several supporting beams. Thus it can be seen that the invention accomplishes at least all of its stated objectives.

Some changes may be made in the construction and arrangement of our prestressed light gage metal form and the method of making the same without departing from the real spirit and purpose of our invention, and it is our intention to cover by our claims, any modified forms of structure or use of mechanical equivalents which may be reasonably included within their scope.

We claim:

1. In a concrete structure,

a plurality of elongated metal sheet members having opposite ends,

a plurality of spaced apart tendon rods secured at their opposite ends to the opposite ends of said sheet members and stressing said sheet members to cause said sheet member to be normally cambered,

concrete material on said sheet member, said concrete material holding said cambered sheet members in a position at least partially straightened with respect to said normal cambered position,

said sheet members having a plurality of alternate ridges and grooves formed therein extending between said opposite ends,

said rods being mounted in said grooves,

said sheet member having foldable flap elements at the ends of said grooves,

said flap elements being folded upon themselves,

the opposite ends of said rods extending through and being detachably secured to said folded flap elements.

2. The structure of claim **1** wherein said rods are also secured to said sheet members intermediate the ends thereof.

3. The structure of claim **1** wherein said rods are also secured to said sheet members midway between the ends thereof.

* * * * *