May 5, 1953 M. R. WOLFARD 2,637,421

STABILIZED BEAM CONSTRUCTION

Filed Nov. 25, 1949 2 SHEETS—SHEET 1

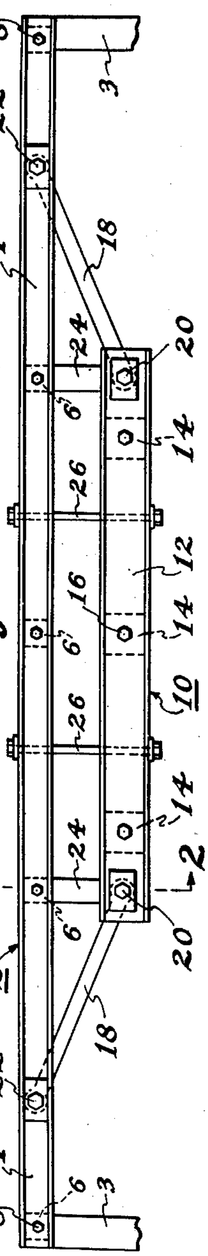


Fig. 1

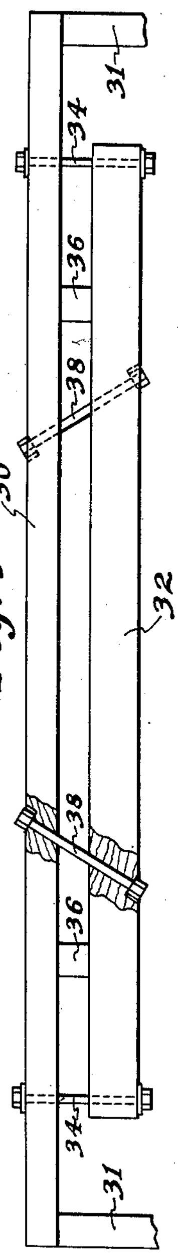


Fig. 3

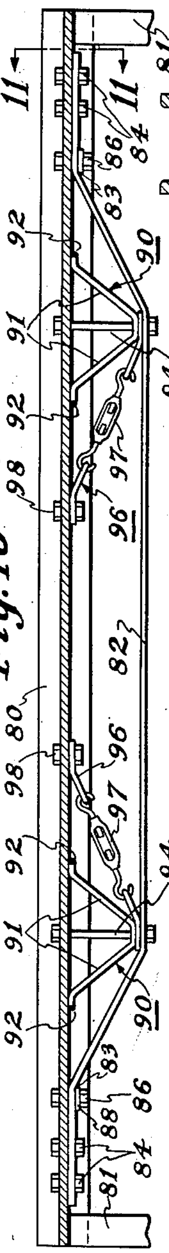


Fig. 10

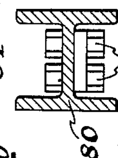


Fig. 11

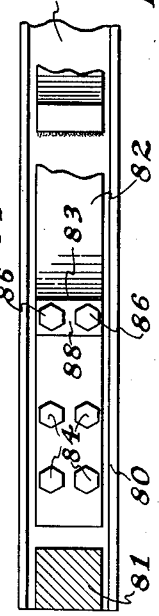


Fig. 12

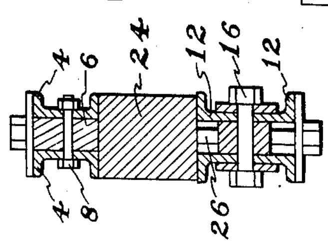


Fig. 2

Merl R. Wolfard Inventor

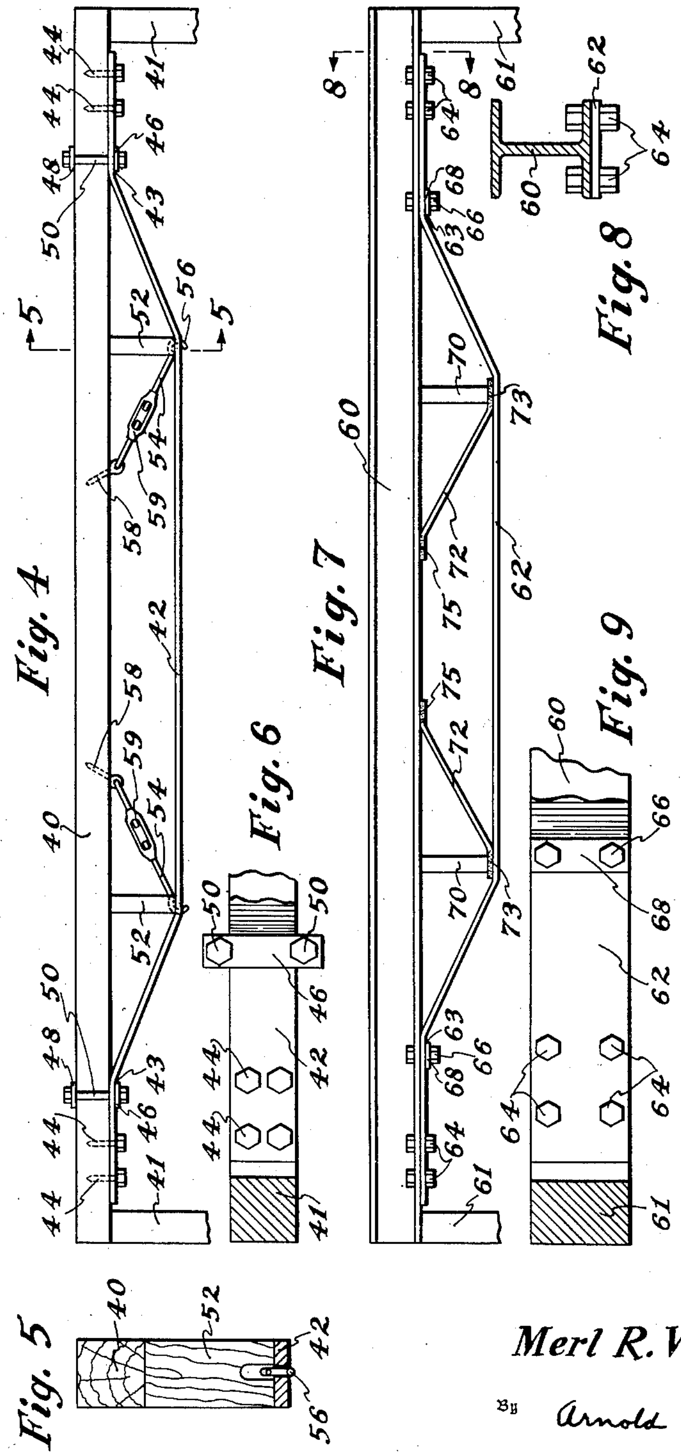
By Arnold C. Rood

Attorney

May 5, 1953 M. R. WOLFARD 2,637,421

STABILIZED BEAM CONSTRUCTION

Filed Nov. 25, 1949 2 SHEETS—SHEET 2



Merl R. Wolfard Inventor

By Arnold C. Rood

Attorney

Patented May 5, 1953 **2,637,421**

UNITED STATES PATENT OFFICE

2,637,421

STABILIZED BEAM CONSTRUCTION

Merl R. Wolfard, Cambridge, Mass.

Application November 25, 1949, Serial No. 129,384

5 Claims. (Cl. 189—37)

1

This invention relates to the stabilization of construction members, such as beams. More particularly the invention is directed to the minimizing of undulatory and vibratory movements which agitating loads tend to produce in such beams.

In one aspect, this invention is an improvement on the invention set forth in my Patent 2,333,136, in which I disclose the value of certain arrangements of struts of substantially V-form interposed between a compression element and a tension element. One aim of that invention was to attain maximum load carrying capacity with a minimum weight of material, in which instance, the suitability of the compression element was considered from the standpoint of its capacity to carry the compression load resulting from the endwise thrust applied to its ends by the tension element, this tension element itself being considered as the fundamental load-sustaining element and the element requiring control.

In this invention the primary concern is with the stabilization of a beam which in itself is sufficient, or nearly sufficient when the beam is static, to carry the loadings which may be applied to it.

The present invention is applicable to the stabilization of such beams when already in place in existing structures, for example, bridges or buildings. The invention is particularly advantageous where a bridge or building floor is required to carry loadings that produce greater vibratory disturbances than those for which such structures were designed.

It is well known that in structures which are designed for carrying expected loads, such structures may vibrate or undulate more than can be tolerated when certain agitating loadings are applied to them. For example, when a body of soldiers cross a bridge, they are always instructed to "break step" to prevent what might be destructive vibration. Likewise, light bridge structures will safely carry the weight of traffic intended to pass over them provided the speed of travel is not too great, as is evidenced by the stationing of policemen at such bridges to prevent a prescribed limit of speed from being exceeded. Again, a bridge may carry the expected normal traffic but an occasional truck, loaded beyond the normal capacity of the bridge, may cause excessive vibration injurious to the bridge.

Also, agitating loadings carried on the floor of buildings may cause undesirable vibrations of the whole building as well as the floor itself. For example, where machinery causing vibrations is installed on one floor of a building the vibration

2

permissible on that floor may exceed that which can be permitted on other floors of the building. Or indeed, when factory machinery is installed on all of the floors of a building, the building itself may be severely damaged and its usefulness destroyed by reason of the accumulation of vibrations of the plurality of floors.

By the present invention such undulatory and vibratory movements are so effectively minimized that these and similar structures are rendered substantially immune to agitating forces which otherwise would result in destructive vibrations.

In carrying out the present invention, wherever a beam member extending across a span between supporting means is to be stabilized, an auxiliary member is used in conjunction with said beam member, the said auxiliary member extending lengthwise of the beam member and normally below it. The invention is applicable for stabilizing a beam in any other plane but will hereinafter be described as loaded from above to facilitate a clear description of the invention.

The auxiliary member is supported from the end portions of the beam member. There are struts disposed between the beam member and the auxiliary member, one in each second-fifth portion of the span from the end of the span. Preferably there is also tying means intermediate of said struts for applying a structure-loading, that is, a loading applied by the structure to the beam member intermediate of said struts for the purpose of deflecting the beam member downwardly relative to said struts when the construction is static.

The auxiliary member preferably is a tension member, but it may be or include a beam-like member possessing resistance to bending. In a preferred embodiment of the invention the auxiliary member is a tension member with the ends thereof connected to the beam member over a substantial lengthwise region of the end portions of the beam member. The innermost point of supporting contact of each connecting means with said beam member is in the range of about 4 to about 16% of the length of the span from its respective end of the span.

There is a strut disposed between the beam member and the tension member in each second-fifth of the length of the span from the end of the span. The tying means intermediate of said struts preferably comprises ties attached to the tension member at the vicinity of the lower end of each strut. Each tie extends thence upwardly and is inclined toward the center of the span to the beam member, and is there attached to the beam member. The ties have a relative length in said construction such that, when the construction is static, they apply a structure-loading to the beam member, thereby downwardly deflecting the mid-region of the beam member relative to said struts.

In the drawings,

Figure 1 is a side elevation of a stabilized beam construction embodying fundamental principles of this invention;

Fig. 2 is an enlarged transverse vertical section taken on line 2—2 of Fig. 1;

Fig. 3 is a side elevation of a stabilized beam construction wherein the beam member and a beam-like member are of wood;

Fig. 4 is a side elevation of a preferred embodiment of the invention for stabilizing a wooden beam;

Fig. 5 is an enlarged transverse vertical section on line 5—5 of Fig. 4;

Fig. 6 is an enlarged bottom view of an end portion of the construction shown in Fig. 4;

Fig. 7 is a side elevation of a preferred embodiment of the invention for stabilizing a steel beam;

Fig. 8 is an enlarged transverse vertical section on line 8—8 of Fig. 7;

Fig. 9 is an enlarged bottom view of an end portion of the construction shown in Fig. 7;

Fig. 10 is a side elevation of a construction of the invention as applied to the stabilization of a steel beam and in which the struts are of substantially V-form;

Fig. 11 is an enlarged transverse vertical section taken on line 11—11 of Fig. 10; and

Fig. 12 is an enlarged bottom view of an end portion of the construction shown in Fig. 10.

In the embodiment of the invention illustrated in Figs. 1 and 2, a beam member 2, which is to be stabilized in accordance with the present invention, extends across the span between the supports 3. The beam member 2 is composed of two structural steel channels 4 with their flanges facing outwardly, spaced apart by the spacers 6 and secured together by suitable means such as bolts 8. A beam-like member 10 is similarly composed of structural steel channels 12 with spacers 14, and joined together by suitable means such as bolts 16. The channels 12 are shown as being of greater cross-sectional dimensions than the channels 4. The beam-like member 10 extends lengthwise of and below the beam member 2 through the mid-portion of the span. Links 18 are secured to the beam-like member 12 at 20, adjacent to its ends, and extend thence at an incline outward and upward to the beam member 2, where the links are connected to the beam member at 22. The beam-like member 10 and the links 18 together constitute an auxiliary member supported at connections 22. These connections 22 as shown are located inwardly at a distance from the supports 3, and preferably are located at a distance of about 4% to about 16% of the length of the span from the end of the span.

Struts 24 are disposed between the beam member 2 and the beam-like member 10 at locations each within the respective second-fifth of the length of the span from the end of the span. In other words, each strut 24 is placed between one-fifth and two-fifths of the length of the span from each respective support 3. The optimum location for each strut 24 is in the neighborhood of three-tenths of the length of the span from the end of the span. Intermediate of the struts 24 any convenient tying means for drawing the

beam member 2 toward the tension member 10 may be used, such as bolts 26.

In assembling the structure of Fig. 1, for best results the beam member 2 and the beam-like member 10 should be slightly pressed apart, by a jack or similar means, when the struts are placed in position, so that structure-loading is applied to the beam member 2 at the connections 22. By increasing the tension on the bolts 26 the beam member 2 is structure-loaded intermediate of the struts 24, whereby the mid-region of the beam member 2 is deflected downwardly. This downward deflection also somewhat increases the structure-loading of the beam member 2 at the connections 22, by reason of the lever action of the beam member 2, on the top of each strut 24 as a fulcrum, tending to lift the adjacent connecting point 22. The effectiveness of this structure-loading for stabilization of the beam construction is enhanced if the resistance to bending of the beam-like member 10 is greater than the resistance to bending of the beam member 2. This follows because when, for example, a live loading is imposed on the beam member 2 intermediate of the struts 24, the first result is that it tends to reduce the tension in the bolts 26, and no substantial deflection of the beam member occurs until that tension is reduced to zero, provided that the upward deflection of the beam-like member 10 is negligible as compared with the downward deflection of the beam member 2. It follows, therefore, that the optimum effectiveness is provided when the lower ends of the bolts 26 do not move upward as the beam member 2 is deflected downward during the assembly of the structure.

Fig. 3 shows a form of the invention in which a wooden beam member 30 extends across the span between the supports 31 and is stabilized by means of a wooden beam-like member 32. The beam-like member 32 here extends from the location of its supporting connection to the beam member at one end to the supporting connection at its other end. As illustrated, these supports are bolts 34. The struts 36 hold the beam member 30 and beam-like member 32 apart from each other and are preferably somewhat nearer the end of the span than the struts shown in Fig. 1, but yet within the second-fifth of the length of the span. As illustrated, the bolts 38 for deflecting downward the mid-region of the beam member 30 are inclined upward and inward from their location in the beam-like member 32 through the beam member 30. This provides that, when the tension on the bolts 38 is increased, the upward force applied to the beam like member 32 by the lower ends of the bolts 38 is nearer to the respective struts 36 than is the downward force applied to the beam member 30 by the upper ends of the bolts 38.

Figs. 4, 5 and 6 show a preferred construction for stabilizing a wooden beam member 40 extending across the span between the supports 41. A tension member 42, preferably of metal such as steel, extends lengthwise of and below the beam member 40 with connecting means supporting said tension member 42 from said beam member 40 within each end-sixth of the span and preferably has the innermost point of supporting contact 43 of each said connecting means in the range of about 4% to about 16% of the length of the span from the end of the span. Preferably also the means holding the tension member against slip toward the center of the span is separate from and nearer to the end of the span than is that portion of the connecting means which is in the vicinity of said point of innermost supporting contact 43 with the beam member 40. As illustrated, lag screws 44 extend through the tension member 42 and into the beam member 40 and hold the tension member 42 against slip toward the center of the span. A plate 46 below the tension member 42 and a plate 48 above the beam member 40 and associated bolts 50 holding these plates against separation from each other constitute a yoke resisting the downward component of the loading applied to the beam member 40 by the tension member 42.

Within each second-fifth of the length of the span there is a strut 52 disposed between the beam member 40 and the tension member 42, and holding those members apart from each other. A tie 54 is attached to the tension member 42 at the lower end of each strut 52, and extends thence upwardly and inwardly to an attachment to the beam member 40. As illustrated, the attachment of each tie 54 at its lower end is a hook 56 extending through an aperture in the tension element 42. The ties 54 are attached to the beam member 40 in any convenient manner, as by the lag screws 58. Preferably also the ties 54 have means for adjusting their length, such as turnbuckles 59.

In this construction, for best results each strut 52 should have a length such that it applies some structure-loading to the beam member 40, at the location of the bolts 50, before the turnbuckles 59 are tightened.

Figs. 7, 8 and 9 illustrate a preferred construction for stabilizing a steel beam member 60 extending across the span between the supports 61. A tension member 62 extends lengthwise of and below the beam member 60 with connecting means supporting said tension member 62 from said beam member 60 within each end-sixth of the span, and preferably having the innermost point of supporting contact 63 of each said connecting means in the range of about 4% to about 16% of the length of the span from the end of the span. Preferably also, the means holding the tension member against slip toward the center of the span is separate from, and nearer to, the end of the span than is that portion of the connecting means which is in the vicinity of said point of innermost contact 63 with the beam member 60. As illustrated, bolts 64 extend through tension member 62 and through the lower flange of beam member 60, and hold the tension member 62 against slip toward the center of the span. Bolts 66 also extend through the tension member 62 and the lower flange of the beam member 60. The bolts 66 preferably pass through holes somewhat larger than the bolts so that they act primarily to resist the downward component of the loading applied to the beam member 60 by the tension member 62 at each respective end connection. There may be a plate 68 below the tension element 62, through which the bolts 66 pass, for preventing localized stress at the location of the bolts.

A strut 70 is disposed between the beam member 60 and the tension member 62 in each second-fifth of the length of the span from the end of the span and holds those members apart from each other. A tie 72 is attached to the tension member 62 at the lower end of each strut 70 and extends thence upwardly and inwardly to an attachment to the beam member 60. As illustrated the attachment of each tie 72 at its lower end is a longitudinal line of beam

welding 73 on each side of the tie 72. The tie 72 is shown as attached to the beam member 60 also by lines of seam welding 75 on each side of the tie 72.

In assembling a construction such as illustrated in Fig. 7, the ends of the ties 72 are first located in fixed position by means of the seam welds 73 and 75, and the struts 70 are then positioned or inserted after employing, for example, an offset jack or other equivalent means to provide sufficient space for the struts between the beam member 60 and tension member 62. The length of the struts 70, when in position, should be such that they deflect the beam member 60 upwardly. Thus the beam member 60 is structure-loaded intermediate of the struts 70, and also at the lengthwise locations of the bolts 66.

Figs. 10, 11 and 12 show a construction wherein a steel beam member 80 extends across the span between the supports 81. The steel beam member 80 is shown as being of H-cross section and as placed with its flanges vertical and with its web in horizontal position and resting upon the support 81. With this arrangement the beam member 80 is relatively stiff laterally by reason of its cross-sectional shape and the beam member 80 is stabilized vertically by reason of the construction now to be described. A tension member 82 extends lengthwise of and below the beam member 80 with connecting means supporting said tension member 82 from the web of the beam member 80 within each end-sixth of the span and preferably having the innermost point of supporting contact 83 of each said connecting means in the range of about 4% to about 16% of the length of the span from the end of the span. Preferably also the means holding the tension member against slip toward the center of the span is separate from and nearer to the end of the span than is that portion of the connecting means which is in the vicinity of said point of innermost contact 83 with the beam member 80. As illustrated, bolts 84 extend through the tension member 82 and through the web of beam member 80, and hold the tension member 82 against slip toward the center of the span. Bolts 86 also extend through the tension member 82 and the web of the beam member 80. These bolts preferably pass through holes somewhat larger than the bolts so that they act primarily to resist the downward component of the loading applied to the beam member 80 by the tension member 82 at each respective end connection. There may be a plate 88 below the tension element 82 through which the bolts 86 pass, for preventing localized stress at the location of the bolts.

Within each second-fifth of the length of the span from the end of the span there is a strut 90 disposed between the beam member 80 and the tension member 82, and holding those members apart from each other. As illustrated, each strut 90 is of substantially V-form with the point of the V based on the tension member 82, and the arms 91 of each V extending outwardly and upwardly to the beam member 80 where they are secured against lengthwise slip. As shown in the drawing this is accomplished by the transverse seam welds 92. The lengthwise location of each strut as being in each second-fifth of the length of the span, refers to the location of the median line of the V-strut, that is, the lengthwise location of the point of the V. This median line, as illustrated in Fig. 10, will also be the vertical line of each bolt 94 which extends through the tension member 82 at the point of the V, thence upwardly and through the web of the beam member 80. Increasing the tension on the bolts 94 provides a clamping action which tends to draw the beam member 80, at the location of each of the bolts 94, toward the point of the V of each strut 90. A tie 96 is attached to the tension member 82 at the lower end of each strut 90 and extends thence upwardly and inwardly to an attachment to the beam member 80. As illustrated each tie is a flat bar having at its lower end a hold through which the bolt 94 passes and has at its upper end a hole through which the bolt 98 extends and secures it to the web of the beam member 80. As shown each tie 96 has at its mid-portion a turnbuckle 97 by means of which the tension in the tie 96 may be adjusted.

In assembling this construction the V-strut may be placed in position with a snug fit between the beam and tension members, and the bolts 94 are then tightened. This deflects the beam member 80 toward the point of each V at the location of each bolt 94 and applies structure-loading to the beam member 80 at the location of the bolts 86. This follows by reason of the lever action on the upper end of those V-arms 91 which are adjacent to the bolts 86. The turnbuckles 97 may then be tightened to structure-load the beam member 80 intermediate of said struts 90.

It should be noted that by this invention, a stabilized beam construction is provided of such character that when an agitating force is applied at a particular location along the beam member, vibratory movement from that agitating force is largely prevented. Attention is further invited to the fact that when live-loading is imposed on the mid-region of the beam member in a stabilized construction according to this invention, no substantial movement can occur until that live-loading exceeds the tension initially incorporated in the structure-loading ties, in contradistinction to a simple beam whose movement is greatest in its mid-region. Furthermore, if the agitating force imposed on a structure of the invention is of such magnitude that it does cause some movement, the effect of that movement is localized by reason of the effective arrangement of parts in the structure of the invention, and travel of undulatory movements from one location to another along the beam member is prevented. As a whole, the invention provides an effectiveness in minimizing vibratory and undulatory movements which, so far as I am aware, has hitherto been unapproached.

I claim as my invention:

1. A stabilized beam construction, comprising, in combination, a beam member extending across a span between supporting means; an auxiliary member extending lengthwise of and below said beam member; connecting means supporting said auxiliary member from said beam member within each end-sixth of the span, the innermost point of supporting contact of each said connecting means being in the range of about 4% to about 16% of the length of the span from the end of the span; a strut disposed between the beam and auxiliary members in each second-fifth of the length of the span from the end of the span, and holding said members apart from each other; and a tie attached to the auxiliary member at the vicinity of the lower end of each said strut, each said tie thence extending upwardly at an incline toward the center of the span to the beam member and there attached to that member; each said tie having a relative length in said construction such that, when the construction is static, the beam member intermediate of said struts is structure-loaded, thereby producing downward deflection of the mid-region of the beam member relative to said struts.

2. A stabilized beam construction as in claim 1, further characterized in that each said tie includes adjustable means, thereby providing for predetermination of the structure-loading at the mid-region of the span.

3. A stabilized beam construction as in claim 1, further characterized in that the connecting means supporting the tension member in each end-sixth of the span joins the tension member to the beam member over a substantial lengthwise portion of said members.

4. A stabilized beam construction as in claim 3 further characterized in that that portion of the connecting means which is toward the end of the span comprises means holding the tension member against slip toward the center of the span; and that portion of the connecting means which is in the vicinity of the innermost point of supporting contact with the beam member comprises means resisting the downward component of the loading applied to the beam member by the tension member.

5. A stabilized beam construction as in claim 4, further characterized in that the means resisting the downward component of the loading applied to the beam member by the tension member is a yoke.

MERL R. WOLFARD.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,634,127	Wagner	June 28, 1927
2,333,136	Wolfard	Nov. 2, 1943