June 6, 1939. P. W. LEISNER 2,161,176

BRIDGE CONSTRUCTION

Filed July 20, 1935

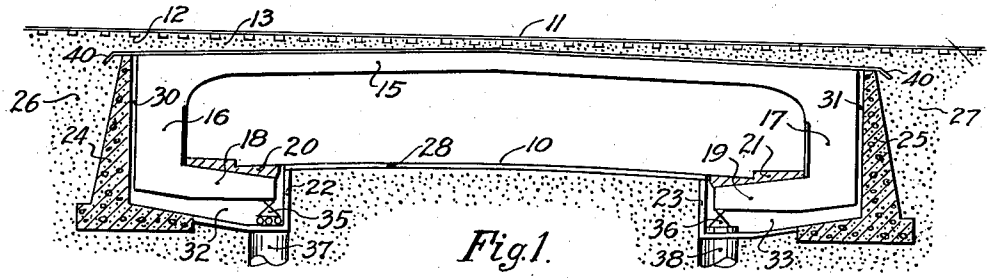


Fig.1.

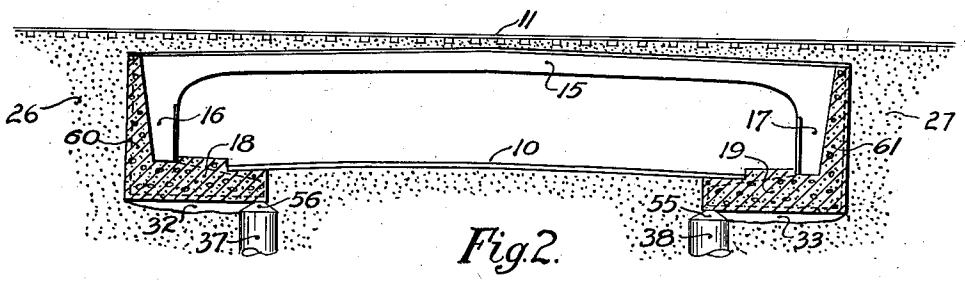


Fig.2.

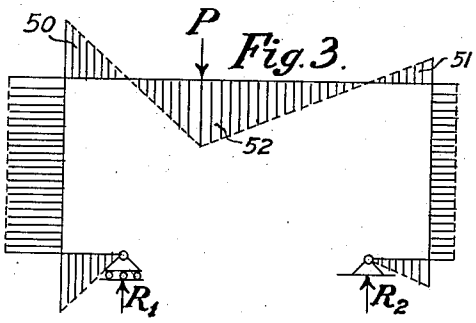
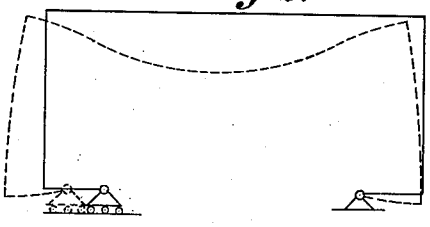


Fig.3.

Fig.4.



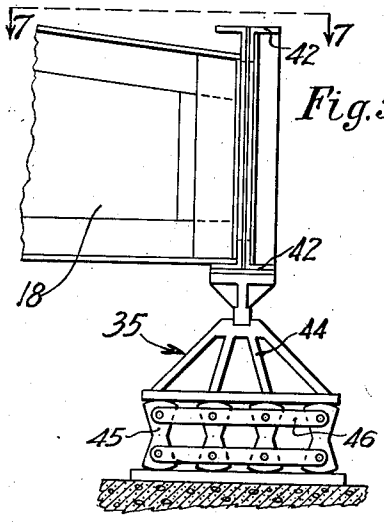


Fig.5

Fig.6.

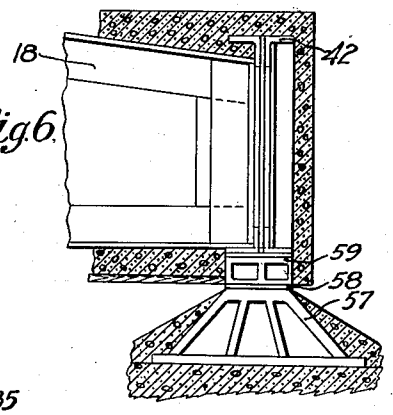
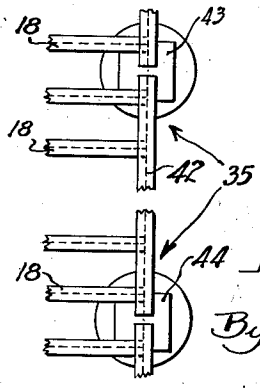


Fig.7.



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Patented June 6, 1939 2,161,176

UNITED STATES PATENT OFFICE

2,161,176

BRIDGE CONSTRUCTION

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Application July 20, 1935, Serial No. 32,400

7 Claims. (Cl. 72—56)

This invention relates to a bridge construction, and more particularly to a bridge of the type adapted to effect grade separation or produce a causeway for one roadway over another.

It is an object of the invention to produce a bridge construction of wide span which will provide a minimum vertical grade separation while retaining a maximum vertical road clearance for the lower roadway, that is, to produce a rugged, safe and satisfactory bridge of wide span with a very shallow overhead.

It is a further object of the invention to produce such a construction in which supports for the overhead between the bridge side walls may be eliminated, thereby insuring the production of a wide, clear opening for the lower roadway, maximum visability, and the elimination of dangerous obstructions thereto.

Another object is to produce such a bridge construction in which tie members connecting the side wall girders underneath the lower roadway may be eliminated, thereby eliminating obstructions beneath the lower roadway which interfere with the laying of conduits, pipe lines, and the like.

A still further and important object of the invention is to produce such a bridge construction which is wholly or substantially statically determinate whereby to facilitate the ready calculation of all stresses within the structure due to the loads applied.

More specifically, it is an object of the invention to facilitate the use of a relatively shallow overhead construction by introducing therein a counterbending bending moment which reduces the maximum live load deflection of the overhead.

Other objects and advantages of the invention will appear from the following description when taken in connection with the accompanying drawing wherein there are described certain preferred embodiments of the invention.

In the drawing, wherein like reference numerals refer to like parts throughout,

Figure 1 is a side elevation of a bridge construction embodying the principles of the invention.

Figure 2 is a side elevation of a bridge constructed in accordance with the invention in a modified form.

Figure 3 is a bending moment diagram illustrating the moments within the structure as subjected to one casually selected live load.

Figure 4 is a flexure diagram illustrating the deflection and movement of the construction when subjected to load.

Figure 5 is a partial view detail of the non-friction movable support for one of the reverse cantilever beams, shown at the left in Figure 1.

Figure 6 is a similar partial view detail showing the frictional support for the modified construction of Figure 2, and

Figure 7 is a broken view detail of the reverse cantilever support of Figure 5 and taken substantially along the line 7—7 thereof.

Generally speaking, overhead simply supported girders for bridges are classified as "deep girders" if the depth thereof is equal to or greater than one-twelfth of the length of the girder span. Girders having a depth less than one-twelfth of the span are classified as "shallow girders". In proportioning the various parts of deep girders, safe interior unit stresses for a given exterior loading upon the girder are the only requirements governing the safety of the design. On the other hand, in proportioning the various parts of simply supported shallow girders, deflection considerations are the requirements which govern the design. Competent engineering and good practice demand that the live load deflection of any such shallow girder for a given live load must not be substantially greater than the deflection would be if the depth of the girder were equal to one-twelfth of the span length. When a simply supported shallow girder conforms to this rule, its interior stresses will be safe. When a girder is merely mildly shallow, it is feasible to design its various parts, web and flanges, to bring it within maximum deflection requirements by merely increasing the web thickness and by adding more material to the flanges. In this manner the girder moment of inertia may be increased to that required by the deflection rule. However, when the shallowness of the girder exceeds a certain limit, practical considerations, such as economy, proportioning, and ease of fabrication exclude this method of decreasing deflection. Girders in this latter class may be classified as "extra shallow girders", and it is to this type of girder that the present invention particularly relates.

The use of "extra shallow girders" in the overhead of a bridge construction effecting a grade separation produces a correspondingly very shallow overhead which reduces the vertical distance necessary between the grade levels to give the desired and necessary overhead clearance to the lower roadway. The use of extra shallow girders is, therefore, extremely advantageous, and in the

past various attempts have been made to satisfactorily employ them in bridge constructions. Thus the girders instead of being "simply supported" at their ends have in various instances been incorporated as part of a more extended structure such as a rigid arch, a two-hinged arch, or a two-hinged arch with a bottom tie member connecting the arch ends. Such constructions may take a variety of forms. However, difficulty is generally encountered in the production of such constructions for the reason that the conditions for providing arch supports are generally absent, and a number of considerations, such as the desirability of leaving the sub-surface of the lower roadway free of obstructions, prevent the use of a bottom tie member. By means of the present invention the use of a very shallow girder is permitted by the provision of a new and improved frame structure which, for convenience, has been designated as a reverse cantilever rigid frame.

Referring now to the drawing, and first to Figure 1 wherein there is illustrated one preferred embodiment of the invention, the reference numerals 10 and 11 designate the levels, respectively, of the lower and upper roadways. In the drawing the upper roadway is shown as carrying a railroad track 12 supported upon suitable ballast 13. However, it is to be understood that the invention is applicable not only to railroad bridges, but to bridges effecting grade separations generally, as well as to bridges of other types and for other uses. The reverse cantilever frame comprises a main overhead girder 15, side wall girders 16 and 17 supporting the ends of the overhead, and bottom reverse cantilever beams or girders 18 and 19 extending inwardly, respectively, from the lower ends of the side wall girders. All of the girders are fabricated as a single integral construction, and together form a rigid reverse cantilever frame member. For convenience of illustration the fabricating parts of the several girders are not shown in detail. The reverse cantilever beams 18 and 19 support the portions 20 and 21 of the lower roadway, which are illustrated in the embodiment shown as sidewalks of suitable construction. Masonry retaining walls 22 and 23 are provided for retaining the material of the lower roadway 28 in position away from the cantilever beams, and retaining walls 24 and 25, also preferably of masonry, are provided for retaining the earth fills 26 and 27 of the upper roadway in position. It is to be noted that the retaining walls 22, 23, 24 and 25 are spaced from the frame structure, open spaces 30 and 31 on the outside of the side wall girders, and open spaces 32 and 33 beneath the reverse cantilever beams being provided. These spaces permit the unrestricted movement of the frame when subjected to load as will later appear.

The cantilever beams 18 and 19 are supported respectively at their inner ends by supports indicated generally at 35 and 36 which are mounted upon caisson pillars 37 and 38. These supports constitute the entire supporting means for the frame. The caisson pillars 37 and 38 can be omitted and replaced with pile foundation, or slab foundation, if desired, wherever soil condition permits.

Several reverse cantilever frames constructed as above described are preferably spaced laterally of the bridge structure at suitable intervals, as best indicated in Figure 7, the number and spacing of the frames being determined by the width and service requirements of the bridge. An apron member 40 is supported on top of the frames and prevents the falling of the ballast 13 between the frames.

The support 36 for the reverse cantilever beam 19 is fixed to the beam and to its caisson support 38, and constitutes a fixed support for one end of the frame. The support 35 for the other end of the frame, as shown in detail in Figures 5 and 7, comprises an anti-friction roller supporting arrangement. Referring to Figures 5 and 7, the several reverse cantilever beams 18 are preferably carried upon a cross beam 42 which is, in turn, supported at its ends by two support castings 43 and 44. The support castings are carried upon the caissons by means of the segmental rollers 45, suitably linked together by links 46, so that the rollers move in unison. The segmental rollers permit the free movement of the castings 43 and 44 with respect to their supporting caissons within the limits of the flexure of the frame and, accordingly, support the frames at one end for non-frictional and free movement laterally.

The bending moment diagram for the reverse cantilever rigid frame, as it acts when subjected to a casually selected live load P, is shown in Figure 3. The reverse cantilever beams 18 and 19 are supported only at their inner ends, this action being insured by the open spaces 32 and 33 provided beneath the beams. It is apparent, therefore, that the sole supports R1 and R2 for the overhead girder are spaced inwardly from the ends thereof which, as will be seen by reference to the moment diagram, introduces a counterbending moment into the ends of the overhead girder as represented at 50 and 51. The introduction of this counterbending moment reduces the bending moment 52 and, accordingly, reduces the maximum deflection which the overhead girder will experience due to the load. It is to be noted that the introduction of the counterbending moments, which reduce the maximum deflection in the main overhead girder and, accordingly permit the use of an extra shallow girder, is effected by the nature of the construction of the reverse cantilever rigid frame. While a very shallow overhead girder thus may be used, no intermediate vertical supports between the side girders of the frame are required, and, likewise, bottom tie members connecting the lower ends of the side girders, are eliminated. The very shallow overhead girder insures a maximum roadway clearance for the lower roadway with a minimum vertical displacement between the two roadway levels 10 and 11. The elimination of intermediate vertical supports insures maximum visibility for the lower roadway and the elimination of dangerous roadway obstructions, and the elimination of tie members insures that the subsurface of a lower roadway shall be clear for the introduction of conduits, pipes, and the like. The use of a bottom tie member is also objectionable for the reason that the member is subject to sagging due to the washing out or other inadvertent removal of the supporting soil therebeneath, and exposed to injury incident to the laying of pipes and the like beneath the street level. Sagging of the tie member or material injury resulting in its destruction may cause the collapse of the main bridge structure.

A typical deflection diagram for the frame is shown in Figure 4. As will be seen, the action of the live load causes the downward deflection of the reverse cantilever beams 18 and 19 into the free spaces 32 and 33 provided therebeneath, and the displacement of the freely movable sup-

port 35 to the left. By reason of the fact that the entire reverse cantilever rigid frame is mounted for free movement around the single fixed support 36, the direction and magnitude of all of the external forces upon the frame may be determined. Accordingly, the frame is a wholly statically determinate body, in which the interior stresses in any part thereof, due to the external forces, may be readily determined. This constitutes a very material advantage in design as it is difficult to determine the stresses which are set up in a frame structure which is not statically determinate, and this difficulty frequently leads to errors in design and to the failure of such structures in service.

In Figure 2, there is illustrated a reverse cantilever rigid frame construction, in which one of the supports 55 is fixed to the inner end of its reverse cantilever beam 19 and to its supporting caisson 38 as in the embodiment of the invention first described, but in which the support 56 for the other end of the frame, instead of being non-frictionally mounted as in the embodiment of Figure 1, constitutes a frictional movable support member between its reverse cantilever beam 18 and its supporting caisson 37. The details of this frictional support are shown in Figure 6. As illustrated, the support casting 57, of which there are two arranged in the positions of supports 43 and 44 of the first described embodiment, is fixed to its supporting caisson, and has, at its top, a friction plate 58, preferably of non-corrosive metal alloy upon which the support 59 frictionally bears. As the frame is subjected to deflection, due to the application of loads, the support member 59 will frictionally slide upon the plate 58, the action being more restricted but generally similar to that previously described. All of the advantages adherent in the first described embodiment are present, except that the introduction of a frictional resistance to lateral movement of the support renders the frame construction statically indeterminate to this extent.

In the embodiment of Figure 2 the concrete retaining walls 60 and 61 are shown directly embracing the reverse cantilever means. The construction is otherwise substantially the same, and it will be noted that the spaces 32 and 33, to facilitate the movement of the frame when subjected to load, are present as in the first described embodiment of the invention. In this instance, however, the compressibility of the material of the fills 26 and 27 is relied upon to permit the necessary lateral displacement of the girder side walls.

Either form of the invention provides a structure which will effectively span a wide, clear opening. In Figure 1 the construction is a statically simple structure. In Figure 2 it is a combination of the form in Figure 1 and a favorable form of a two-hinged arch, the two-hinged arch being a statically indeterminate structure with one redundant. In the form of Figure 2 the various parts of the frame are proportioned to resist the interior stresses and deflections which develop in case the support 56 should move substantially freely as in the statically simple structure, and to resist the interior stresses and deflections which develop in case the support, due to frictional resistance, remains substantially stationary as in the statically indeterminate structure. The most favorable frame is the one in which the length of the reverse cantilever beams is such as to induce the main girder to bend upward a permissible amount under live load if the supports move, and to bend downward under the same live load a like amount if the supports remain fixed.

It is obvious that various changes may be made in the preferred embodiments of the invention specifically illustrated and described. The invention is, therefore, not to be restricted to the precise embodiments used for the purpose of illustration, but only as indicated in the following claims.

The invention is hereby claimed as follows:

1. A bridge frame comprising an overhead girder, a pair of upright girders rigidly secured to the overhead girder contiguous the ends thereof for supporting the overhead girder, and a pair of bottom girders rigidly secured to the upright girders and extending inwardly from the lower ends thereof, said bottom girders being substantially horizontally disposed and extending generally toward each other but having their inner ends spaced apart, and said bottom girders being of a length substantially equal to that of the upright girders.

2. A bridge frame comprising an overhead girder, a pair of uprights rigidly secured to the overhead girder contiguous the ends thereof for supporting the overhead girder, a pair of bottom beams of a length substantially that of the uprights rigidly secured to the uprights and extending inwardly from the lower ends thereof, said bottom beams extending generally toward each other but having their inner ends spaced apart, and supports for the bottom beams arranged inwardly of the uprights, said supports being the sole supporting means for the frame, there being open spaces provided beneath the outer ends of the bottom beams, whereby said outer ends are free to move downwardly as the frame is deflected due to the application of loads thereto.

3. A bridge construction comprising a plurality of alined frames; each of said frames comprising an overhead girder, a pair of upright girders rigidly secured to the overhead girder contiguous the ends thereof for supporting the overhead girder, and a pair of bottom girders rigidly secured to the upright girders and extending inwardly from the lower ends thereof; transverse supporting beams for supporting the inner ends of the alined sets of bottom girders, and means for supporting the ends of said transverse supporting beams.

4. A bridge frame comprising an overhead girder, a pair of uprights of a length substantially equal to the height of the overhead secured to the overhead girder contiguous the ends thereof for supporting the overhead girder and for imparting bending moments thereto, and means for supporting the uprights comprising laterally extending members secured to the lower ends of the uprights at substantially right angles, said members being supported at a point spaced laterally inwardly from said uprights and being of a length substantially no less than that of the uprights.

5. In a bridge frame, an overhead span girder of substantially uniform cross section throughout its length, a support structure for supporting the girder contiguous its end, and a support means for supporting the support structure, said support means being arranged so that an extension of its resultant supporting line of force lies in a plane transverse to the girder which is spaced inwardly from the point at which the support structure is secured to the girder, said support

means forming the sole support for the support structure.

6. A bridge frame comprising an overhead girder, a pair of uprights secured to the overhead girder contiguous its ends for supporting the overhead girder, a pair of bottom girders of a length substantially no greater than that of the uprights and secured to the uprights and extending inwardly from the lower ends thereof, said bottom girders extending generally toward each other but having their inner ends spaced apart, and supports for the bottom girders contiguous the inner ends thereof, one of said supports being fixed against lateral movement and the other being mounted for lateral movement, said supports constituting the sole supporting means for the frame whereby said frame is rendered wholly statically determinate.

7. A bridge frame comprising an overhead girder, a pair of uprights secured to the overhead girder contiguous its ends for supporting the overhead girder, a pair of bottom girders of a length substantially no greater than that of the uprights and secured to the uprights and extending inwardly from the lower ends thereof, said bottom girders extending generally toward each other but having their inner ends spaced apart, and supports for the bottom girders contiguous the inner ends thereof, said supports constituting the sole supporting means for the frame whereby said frame is rendered wholly statically determinate.

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