

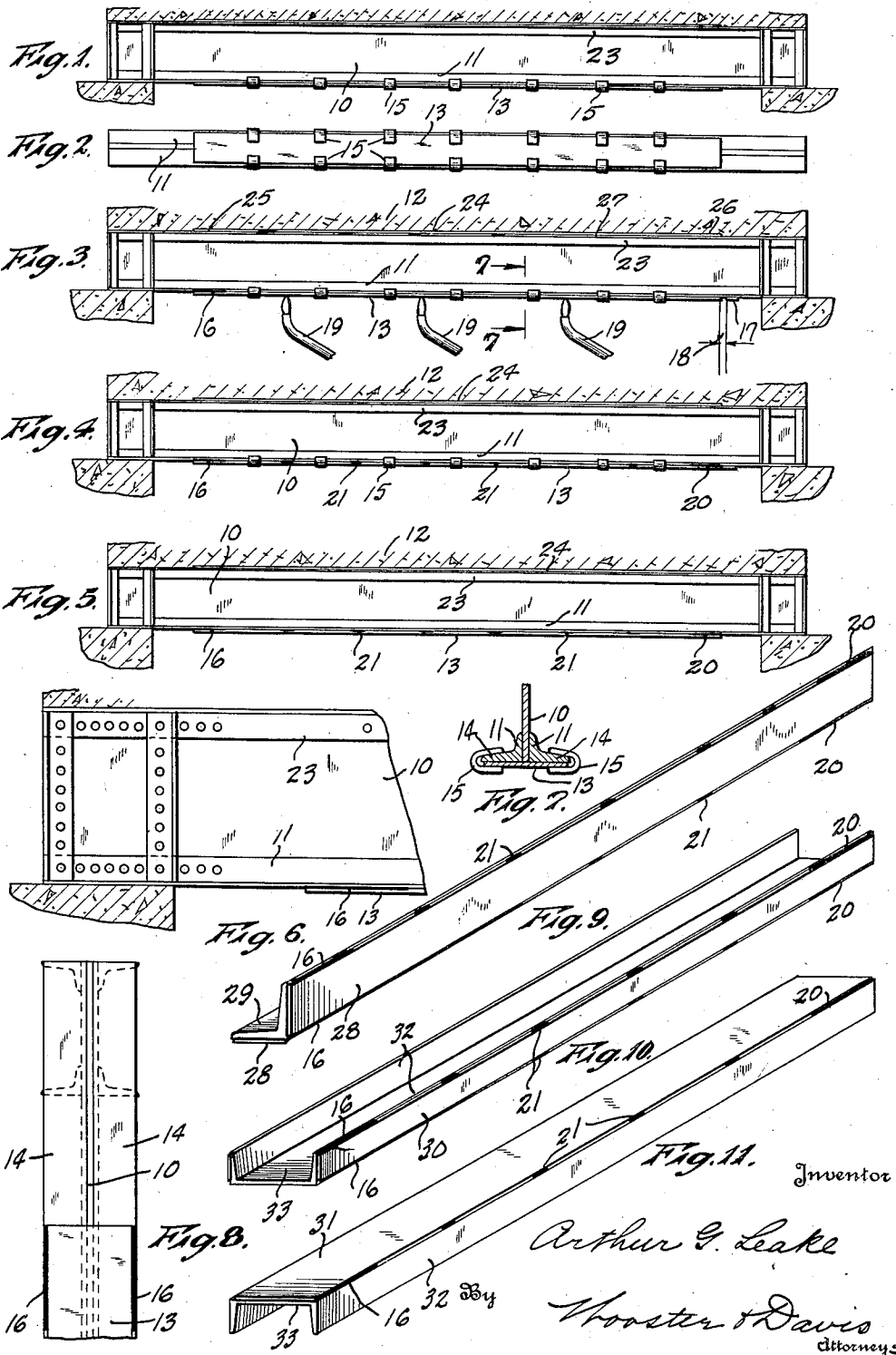
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METHOD OF STRENGTHENING STRUCTURAL MEMBERS UNDER LOAD

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METHOD OF STRENGTHENING STRUCTURAL MEMBERS UNDER LOAD

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This invention relates to a method of strengthening structural members such as beams, girders and the like while they are under load, and has for an object to provide a method of strengthening such members which will not require the removal of concrete or other structure supported by the member to be strengthened, and therefore, the work may be accomplished in a much shorter time and at a much less expense, and where traffic is involved will not require the holding up of overhead traffic and will reduce interference with other traffic to a minimum.

With the foregoing and other objects in view I have devised an improved method which will be more fully disclosed in connection with the accompanying drawing.

In this drawing

Fig. 1 is a side elevation of a built up girder showing the supporting abutments and the load in section.

Fig. 2 is a bottom plan view of the girder.

Fig. 3 is a side elevation similar to Fig. 1 illustrating the method of applying the strengthening element.

Fig. 4 is a similar view illustrating further steps in this method.

Fig. 5 is a view similar to Fig. 4 showing the girder at the completion of the strengthening operation.

Fig. 6 is a side elevation of one end of the girder on an enlarged scale.

Fig. 7 is a detail cross-section on an enlarged scale taken substantially on line 7-7 of Fig. 3.

Fig. 8 is a bottom plan view of one end of the girder on an enlarged scale with the strengthening member in position.

Fig. 9 is a perspective view showing how the improved method may be applied to an angle bar, and

Figs. 10 and 11 are perspective views showing how the method may be employed for strengthening channel bars.

This method is particularly adapted for reenforcing or strengthening plate and angle girders and rolled steel sections while under load, although it is not necessarily limited for use with rolled sections. In the drawings I have shown how the method can be

employed for strengthening a girder built up of plates and angle bars, and also how it can be employed for strengthening angle and channel bars. It will, of course, be understood that it is easily adapted for reenforcing or strengthening other shapes.

In Figs. 1 to 8 in the drawing I have shown how the method may be employed for strengthening a built up girder comprising a plate 10 with angle bars 11 riveted to it at the upper and lower edges thereof, which is a construction well known. In these figures I have shown how the method is employed for strengthening the lower bars or flanges of the girder which are under tension, although the same principles may be employed for reenforcing or strengthening the upper flanges or angle bars which are under compression which is more fully disclosed in my copending application Serial No. 363,867 filed May 17, 1929. The claims not limited to strengthening bars or flanges under tension are intended to cover strengthening or reenforcing bars either under tension or compression.

It is, of course, understood that in the girder illustrated in Figs. 1 to 8 the angle bars 11 and particularly the lower flanges are under tension, the load being indicated at 12, which may be a concrete structure supporting a floor or roadway. A common use for this type of structure is for supporting a roadway over railroad tracks. My method can be used to strengthen this girder without tearing up this concrete construction or interfering in any way with the traffic over it. In strengthening this member I employ a metal strengthening member 13, which in the present instance is a rolled steel plate of proper length, width and thickness. The plate is first clamped to the bottom flanges 14 by any suitable number of clamps 15, which clamps although clamping the plate against the flanges will permit the plate to expand or contract. After the plate is in position, one end thereof is welded to the flanges 14 as indicated at 16 by welding along both side edges of the plate, and also across the end if desired. A suitable marker is then placed at the desired distance from the

other end of the plate, such for instance as a stop bar 17, which is placed a distance indicated at 18, Fig. 3, from the end of the plate 13 to indicate the distance the plate 13 is to be expanded to place it under the proper tension or stress as will be later explained. The plate 13 is then heated by any suitable means, such as the gas burners 19, to expand the plate to the proper length which is indicated when the end of the plate engages the stop bar 17. While the plate is thus expanded the opposite end of the plate from the weld 16 is welded to the flanges 14 as indicated at 20. The plate is then allowed to cool to normal temperature which places the plate under tension or an initial stress depending on the portion of the load which is to be carried by this plate, and which is determined by the amount to which the plate is expanded before welding the second end at 20. The plate is then welded to the flanges at points between the end welds, preferably by tack welds 21, which are welds from about one-half inch to two inches long, and any suitable numbers of these tack welds are used as is found necessary or desirable. The clamps 15 are then removed and the operation is complete. Although above I have stated that one end of the reinforcing plate is welded to the girder before it is expanded by heating, it will, of course, be obvious the same result is secured if the plate is heated first and then welded to the girder at its opposite ends. The first method is preferred as it is easier to determine when the proper change in length has been attained, because the stop or marker 17 can be used. It will be noted that as the reinforcing plate is placed under initial stress it will carry its share of the load without the girder sinking, so that the reinforcing element assumes its share of the load immediately, and relieves the strain on the angle bars 11. It is also to be noted that by this method the initial stress is put in the strengthening member without the necessity of jacking up the beam and structure, with the attendant high expense. It will further be noticed that the head room is not reduced beyond the thickness of the reinforcing plate.

If it is desired to similarly reinforce or strengthen the top bars 23 which are under compression it will, of course, be necessary to remove the concrete construction. The strengthening or reinforcing plate 24 corresponding to the plate 13 is applied in substantially the same way as is the plate 13 except that as the top flanges are under compression, instead of the reinforcing member being expanded to place it under initial stress it is contracted, that is, one end is welded to the bars 23 as shown at 25. The plate 24 is then cooled with liquid carbon dioxide (CO_2) or other suitable cooling agent until the plate is contracted to the proper length depending on the initial stress desired. The opposite

end is then welded to the bars as shown at 26 and the plate clamped to the flanges as indicated for the lower plate, and after the plate returns to the normal temperature it is tack welded to the bars at points 27 between the end welds. This method is described more in detail in my copending application above mentioned.

In Figs. 9, 10 and 11 I have indicated how the strengthening or reinforcing members or plates may be applied to angle bars or channels bars which are used either as tension members or struts in bridge or other structures. In Fig. 9 the strengthening plates 28 are applied to the flanges of the angle bar 29 in the manner described above for the plates 13 or 24 depending on whether these flanges are under tension or compression when under load.

In Figs. 10 and 11 the reenforcing and strengthening plates 30 and 31 are applied to the flanges 32 and web 33 of channel bars by the welds in the same manner as above described and of course, whether these strengthening plates are expanded or contracted for the initial stress will depend on whether the flange or web is in tension or compression when under load. It will be apparent that the strengthening members may be applied to any exposed element or portion thereof without tearing down the structure, thus greatly decreasing the cost of repair and permitting this repair while the structure is continually in use.

Having thus set forth the nature of my invention, what I claim is:

1. A method of strengthening a structural member while it is under load which comprises welding a strengthening member at one end to the structural member, changing the temperature of the strengthening member to change its length to approximately the length it will be when under load, welding the other end of the strengthening member to the structural member while the length of said strengthening member is so changed, permitting the latter member to return to a normal temperature, and after it has reached this temperature welding it to the structural member at points between the two end welds.

2. A method of strengthening a structural member while it is under load which comprises welding a strengthening member at one end to the structural member, changing the temperature of the strengthening member to a temperature different from the member to be strengthened, welding the other end of the strengthening member to the structural member while the temperature of the strengthening member is so changed, permitting the temperature of the two members to become substantially the same, and then welding the two members together at points between the two end welds.

3. A method of strengthening a structural

member while it is under load which comprises welding a strengthening member at one end to the structural member, changing the temperature of the strengthening member to a temperature different from the member to be strengthened, welding the other end of the strengthening member to the structural member while the temperature of the strengthening member is so changed, and welding the strengthening member to the structural member at points between the two end welds.

4. A method of strengthening a structural member while it is under load which comprises welding a strengthening member at one end to the structural member, heating the strengthening member to increase its length; welding the other end of the strengthening member to the structural member, allowing the strengthening member to cool, and then welding the said member to the structural member at points between the end welds.

5. A method of strengthening a structural member while it is under load which comprises clamping a strengthening member to the structural member, welding one end of the strengthening member to the other member, heating the strengthening member to increase its length, welding the other end of said member to the structural member while the strengthening member is so heated, then permitting the strengthening member to cool to place it under tension, and then tack welding the strengthening member to the structural member at points between the end welds.

6. A method of strengthening a substantially horizontal structural member having a lower flange under tension which comprises welding a longitudinally extending plate at one end to said flange, heating the plate to increase its length, welding the other end of the plate to the flange, permitting the plate to cool to place it under tension, and then welding the plate to the flange at points between the end welds.

7. A method of strengthening a structural member while it is under load which comprises welding a strengthening member to the structural member at its opposite ends, at least one of said ends being so welded while the strengthening member is at a different temperature than the structural member so that when the members return to the same temperature the strengthening member will have an initial stress, and welding the two members together at points between the end welds.

8. A method of strengthening a structural member while it is under load which comprises welding a strengthening member to the structural member at one side of the portion to be strengthened, changing the temperature of the strengthening member to change its length to approximately the length it will be under load, and welding the strengthening member to the structural member on the op-

posite side of the portion to be strengthened while the length of said strengthening member is so changed.

9. A method of strengthening a structural member while it is under load which comprises welding a strengthening member at one end to the structural member, changing the temperature of the strengthening member to change its length to approximately the length it will be when under load, and welding the strengthening member at its other end to the structural member while the length of said strengthening member is so changed.

10. A method of strengthening a structural member while it is under load which comprises welding a strengthening member at one end to the structural member, changing the temperature of the strengthening member to a temperature different from the member to be strengthened, and welding the other end of the strengthening member to the structural member while the temperature of the strengthening member is so changed.

11. A method of strengthening a structural member while it is under load which comprises welding a strengthening member at one end to the structural member, heating the strengthening member to increase its length, and welding the other end of the strengthening member to the structural member while the strengthening member is so heated.

12. A method of strengthening a structural member while it is under load which comprises welding a strengthening member to the structural member at one side of the portion to be strengthened, heating the strengthening member to increase its length, and welding the strengthening member to the structural member at the other side of the portion to be strengthened while the strengthening member is so heated.

13. A method of strengthening a structural member while it is under load which comprises welding a strengthening member to the structural member at its opposite ends, at least one of said ends being so welded while the strengthening member is at a different temperature than the structural member so that when the members return to the same temperature the strengthening member will have an initial stress.

14. A method of strengthening a structural member while it is under load which comprises welding a strengthening member to the structural member at opposite sides of the portion to be strengthened, at least one of said welds being welded while the strengthening member is at a different temperature than the structural member so that when the members return to the same temperature the strengthening member will have an initial stress.

15. A method of strengthening a structural member while it is under load which

comprises rigidly securing a strengthening member to the structural member at opposite sides of the portion to be strengthened, at least one of said connections being made while the strengthening member is at a different temperature than the structural member so that when the members return to the same temperature the strengthening member will have an initial stress.

16. A method of strengthening a structural member while it is under load comprising rigidly securing a strengthening member to the structural member at spaced points, at least one of said connections being made while the strengthening member is heated to a temperature higher than that of the structural member so that when the members return to the same temperature the strengthening member will have an initial tensile stress.

17. A method of strengthening a structural member while it is under load comprising rigidly securing a strengthening member to the structural member, rigidly securing the strengthening member to the structural member at a location spaced from the first connection while the strengthening member is heated to a temperature higher than that of the structural member, and securing the two members together between the first two connections.

18. A method of strengthening a structural member while it is under load which comprises rigidly securing a strengthening member to the structural member at its opposite ends, at least one of said ends being so secured while the strengthening member is at a different temperature than the structural member so that when the members return to the same temperature the strengthening member will have an initial stress, and securing the members together between the first two connections.

In testimony whereof I affix my signature.
ARTHUR G. LEAKE.