METHOD FOR ERECTING PARALLEL-WIRE BRIDGE STRAND

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Filed Oct. 15, 1966, Ser. No. 767,733

U.S. Cl. 14—23

5 Claims

ABSTRACT OF THE DISCLOSURE

In the erection of parallel-wire strands on a suspension bridge, slip-stopping clamps or the like are provided on each strand at predetermined locations to prevent longitudinal slip of the wires of the strand with respect to each other. The strand is drawn across the bridge "foot" fabricated on roller supports, and the strand is positioned in the cable saddles with the clamps adjacent to the ends of the bridge saddles most distant from the unreeling station.

BACKGROUND OF THE INVENTION

This invention relates to the erection of parallel-wire strands on a bridge for the formation of the main suspension cables.

So-called parallel-wire strand has recently come into prominence in the construction of suspension bridges. In the conventional "spinning" process for bridge-cable construction, individual wire loops are drawn repeatedly over the bridge structure and then formed into individual strands which are ultimately compacted into the main suspension cables of the bridge. In the parallel-wire strand method of constructing bridge cables, the strands are manufactured in a shop by preforming a number of individual wires into a strand having all the wires arranged parallel to its axis. The strand is reeled, and socketed at both ends, and then transported to the bridge site. The required number of individual shop-fabricated strands is erected by pulling each strand individually across the bridge structure, and the strands of each cable are then squeezed or compacted together to form a round main suspension cable. If all the wires of the strands are to take their proportionate share of the cable tension it is important that these wires have very nearly equal length within each span as they hang in suspension across the spans of the bridge. The uniformity of the suspended strand wires is usually determined by observing and measuring "spread" of the wires after a so-called "shaking-out," that is to say after cutting the bands or tapes which bind the parallel wires together into the strand. Each wire then falls into free suspension and the distance, or spread, between the highest and lowest wires is measured at the center of the span. Bridge cable specifications ordinarily call for a spread of no more than 12 inches, whether the strands are constructed by the spinning process or erected as shop-fabricated parallel-wire strands.

If the parallel-wire strand is fabricated in the manner shown in U.S. application 575,038 to Durkee et al., and socketed in the manner shown in U.S. application 682,465 to Baker et al., the lengths and tensions of the individual wires of each parallel-wire strand will be uniform and will have a very small spread if made in only a single span. However, when a single parallel-wire strand is to extend across several spans, difficulty has been encountered when the strands are erected by pulling the individual strands across the bridge spans on rollers or other supports. Under such circumstances large spreads have been encountered in adjacent spans due to slippage of wires relative to one another during strand erection and the resulting uneven distribution of wire length among the spans. These spreads have had to be reduced to acceptable limits by individually redistributing the wire lengths among the spans, a lengthy and costly procedure.

I have discovered that the excess spread of the individual wires on the strand in suspension across the spans of a bridge is due to friction or drag between the surface wires of the strand and the supporting rollers over which the strand is passed as it is pulled across the bridge. The outside wires are slightly retarded by such friction. If a sufficiently long strand is pulled over several supporting rollers, considerable differential length can be accumulated among the various wires in a span, particularly in the outside strand wires as compared with the inner wires. In the spans nearest the unreeling location, the outside strand wires will frequently hang below the inner wires, while in the spans farthest from the unreeling location the inside strand wires will frequently hang below the outer wires. Because even very fine-running rollers introduce some frictional drag, considerable differential wire length can be induced over a long length of strand.

SUMMARY OF THE INVENTION

I have discovered that if slip-stopping means to prevent longitudinal movement of the wires with respect to each other are applied at proper locations on a strand prior to its erection, the accumulation of differential wire length is prevented, and the corresponding spread of the strand wires in the individual spans is greatly reduced. Slip-stopping means are applied to the strand prior to pulling it over the bridge, in such locations that the slip-stopping means will finally locate adjacent to the end farthest from the unreeler of each saddle on the bridge.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic elevation of a bridge structure showing a parallel-wire strand being pulled across the bridge.

FIG. 2 is a diagrammatic elevation of a bridge structure with a parallel-wire strand in final position.

FIG. 3 is a side view of a suitable clamp for use as slip-stopping means.

FIG. 4 is a cross-section of the clamp of FIG. 3 along line 4—4.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIGS. 1 and 2 is shown a partially completed suspension bridge structure including main towers 11 and 13 mounted by main cable saddles 15 and 17 and side towers 19 and 21 surrounded by side-tower saddles 23 and 25. Anchorages 27 and 29 are located at opposite ends of the bridge.

During erection of the main suspension strands a footwalk 31 is hung in each bridge span in a position convenient for access to the free-hanging cable. Tram support strands 32 are hung from the towers of the bridge in the customary manner, and connected to the footwalk at suitable intervals by the customary footwalk support posts which for clarity have not been shown. A series of supporting rollers 33 is supported along footwalk 31 and over the towers, over which rollers 33 the strands may be pulled across the bridge. The supporting rollers 33 are ball-bearing journalized to reduce friction to a minimum. A tramway hauling rope 35 is reeled over a series of sheaves 37 supported by crossbeams resting on the tram support strands 32, and is operated by a capstan 39 powered by motor 41. A tramway carriage 43 is secured to tramway hauling rope 35 to which carriage 43 is secured the socketed end 57 of a parallel-wire strand 59 which is drawn off a shipping reel 49 and drawn over the
bridge footwalk as the tramway hauling rope 35 is moved by means of capstan 39 and motor 41 as seen in FIG. 1. As the wire strand 47 is drawn off reel 49, capstan 39 is halted when saddle marks already on the strand reach their appropriate positions opposite the bridge cable saddles. These saddle marks may be placed on the strand 47 during manufacture by the apparatus shown in U.S. application ser. No. 668,782 to Nippon or in any other suitable manner. As the parallel-wire strand 47 is unreeled from reel 49, and as each saddle mark comes off the reel 49, a slip-preventing means 51, which may conveniently take the form of the clamp 53 shown in detail in FIGS. 3 and 4, is carefully applied to the head of the wire strand 47, at a distance from the capstan 39, such that the position of the saddle mark in such position that the slip-preventing means 51 will be located several feet beyond the saddle when the strand is finally erected and positioned in the bridge saddles as shown in FIG. 2. Clamp 53 may, as shown and described, be applied in the field as the appropriate position on the strand comes off the reel during erection; or it may be applied in the shop during manufacture. Under field application conditions the strand must normally first be reformed into a uniform hexagonal shape. It will obviously be preferable in many instances to apply the clamp 53 in the shop rather than in the field. The two halves of the clamp are placed around the strand and securely tightened using the recessed bolts 55 so as to pull the two halves of the clamp tightly together. Because of the hexagonal configuration of the strand and the internal cross-section of the clamp 53, each wire of the strand is securely gripped, with a force sufficient to prevent any longitudinal wire displacement which might occur due to frictional drag on the wires during strand erection.

The parallel-wire strand 47 is pulled across the bridge footwalk, and is then lifted off the rollers 33 by any suitable means, not shown, and positioned in the saddles 15, 17, 23 and 25; and the end sockets 45 and 57 on the strand 47 are secured to anchorages 27 and 29 in the appropriate manner. The anchorage, for instance, may be a pipe-type anchorage such as shown in U.S. application 614,651 to Durkee et al. and the strand may be secured to the anchorage as shown in that application. Clamps 53 are then removed and the parallel-wire strand becomes a component of the bridge cable, joining the others already in place.

As the strands 47 are drawn over the bridge footwalk structure on rollers 33 the frictional drag of the rollers tends to retard the outside wires of the strand. Over a long length, this drag is considerable and it is necessary to build up the trailing portion of the strand. When slip-stoppers such as clamps 53 are applied to the strand, however, this wire slip is prevented from traveling past the clamp. Thus in FIG. 1 all the wire split from socket 57 to the first slip-stopper 51a on the strand is concentrated adjacent to the leading side of slip-stopper 51a. Likewise all the wire slip between slip-stoppers 51a and 51b becomes concentrated adjacent to the leading side of slip-stopper 51b. Similarly, all the wire slip between slip-stoppers 51b and 51c is concentrated on the leading side of slip-stopper 51c. When the strand 47 is now positioned in the saddles by transferring from the rollers 33 and allowed to hang in free suspension from the anchorage 29 to side-saddle 25 with slip-stopper 51a in the position shown in FIG. 2, the strand wires in this span assume their free-hanging tension with the result that all the wires between socket 57 and slip-stopper 51a are restored to uniform conditions along the strand between these two positions. Otherwise all the accumulated wire slip trapped in the strand between side-saddle 25 and slip-stopper 51b is pulled out uniformly along the strand, all the wire slip accumulated between main cable saddle 17 and slip-stopper 51c is redistributed along the main span between the two main towers 11 and 13, and all the accumulated wire slip between main saddle 15 and slip-stopper 51d is redistributed along the span between main tower 11 and side tower 19, and all the accumulated wire slip between side tower saddle 23 and anchorage 27 will likewise be redistributed along this span. Since most of the wire slip is accumulated adjacent to the leading side of the slip-stoppers 51, it will be seen that almost all of the accumulated slip in each span is pulled out when the strand is placed in suspension and only the negligible amount of slip built up between slip-stopper 51a and side tower saddle 25, between slip-stopper 51b and main tower saddle 17, between slip-stopper 51c and main tower saddle 15, and between slip-stopper 51d and side tower saddle 23 is retained. Such little differential wire length in the sections of the strand is insufficient to cause any significant stress differentials within the completed cables and is therefore of no practical significance whatsoever.

However, if all the slip-stoppers 51 were positioned on the opposite side of the respective adjacent saddles from that shown in FIG. 2, all the accumulated wire slip built up adjacent to the leading end of each slip-stopper would fall within a saddle and would be retained or trapped thereby the friction between the strand wires and the saddle, not only creating misalignment of wires and crossed wires and the corresponding deleterious stress condition of the wires in this span, but contributing to the unacceptable differential lengths among the wires in the spans between the towers. While substantially all wire slip in the saddle locations could be eliminated by positioning a slip-stopper on either side of each saddle instead of on only one side as illustrated, this expedient is unacceptable, as a certain amount of slip of the wires past each other in the erected strand must be allowed within the saddles in order to compensate for the bending of the strand over the saddles. This "bending slip" redistributes itself along a length of strand within each span, where it is compensated for by the length of the free-hanging strand and by the strand curvature, which is opposite to that within the saddle. In some cases, however, it may be desirable to locate an intermediate slip-stopper approximately midway in each span to further localize the build-up of wire-slip, particularly in long spans, but ordinarily this is not necessary.

Other types of slip-preventing means 51 may be applied to the strand in place of the clamps 53. For instance, the wires of the strand can be glued together in appropriate locations with a strong adhesive or the like having sufficient strength to prevent longitudinal movement of the wires with respect to each other. In the case of a glued-type slip-stopper, the slip-stopper does not need to be removed prior to connecting the parallel-wire strands together into the suspension cables of the bridge because the glue falls chiefly within the strand interstices and therefore does not add any appreciable bulk to the strand, and thus does not interfere with such compaction. However, it is desirable to space such slip-stoppers so that they do not all fall at the same cross-section of the cable adjacent to each saddle. Obviously adhesive type slip-stopper means is practical only for shop application.

What is claimed is:

1. A method for erecting parallel-wire strands on a bridge comprising:
   (a) securing the wires of said strands against longitudinal displacement relative to each other by the application of slip-stopping means at predetermined locations on said strands.
   (b) towing the strands across the bridge supported upon anti-friction means.
   (c) positioning the strands in saddle means on the bridge structure with a slip-stopping means located adjacent to the far side of each saddle means with reference to the direction of towing the strands across the bridge.

2. A method for erecting parallel-wire strands on a bridge according to claim 1 wherein the slip-stopping
means are positioned only adjacent the far side of each saddle.

3. A method for erecting parallel-wire strands on a bridge according to claim 1 wherein additional slip-stopping means are positioned in the center of at least some of the spans, but not adjacent the near side of the saddles.

4. A method for erecting parallel-wire strands on a bridge according to claim 1 wherein the slip-stopping means comprises mechanical clamping means.

5. A method for erecting parallel-wire strands on a bridge according to claim 4 additionally comprising removing said clamping means prior to compacting said parallel-wire strands into the final bridge suspension cables.

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