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" Sagging twin 0·4-sq.-in. copper equivalent S.C.A. conductor " †

by

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Mr N. G. Simpson (Transmission Consultant, British Insulated Callenders Construction Co. Ltd) observed that the conductor stringing for the majority of overhead lines was now a well-established technique. The advent of the British Super Grid, however, by the adoption of large twin S.C.A. conductors on long spans had warranted the consideration of hitherto unimportant factors and the general application of a greater degree of precision to erection methods. The Paper dealt effectively with those aspects of the problem.

On the question of overtensioning, some doubt might well be expressed as to the usefulness of reducing the sag of the conductors by as little as 25% for so short a time as 20 min. The operation of overtensioning was intended to deal with two problems; to bed down the conductor strands; and to reach the stage when the conductor behaved according to elastic modulus which remained constant throughout the conductor's life. To do that the conductor had to be loaded up to a tension which would not be exceeded during its life and was, in fact, something like the maximum working tension. The bedding down of the strands was dealt with in the normal operation of running out and tensioning. To deal effectively and quickly with the second point, it would be necessary to impose a complicated and expensive construction operation, with attendant hazards to clamps, pulling-up gear, and possibly to structures. In any case Mr Simpson believed that it was unnecessary for it could be dealt with in time by the conductor itself under service conditions. Some time before the programme of actual stringing of those large conductors he had been concerned with the installation of an experimental line at his firm's own works, when several spans had been erected with three sets of 0·4-sq. in.-S.C.A. conductors complete with insulators and spacers. The object had been to perform handling and running-out trials, to string the conductors to 12½% more than their correct tension, and finally over a period to take observations of sag variations, conductor twist, and vibration aspects. Furthermore the conductors for the trial had been manufactured at two different factories from machines using different methods of stranding so that a comparison could be made as to their subsequent behaviour under similar stringing conditions. Observations over a period of 14 months had shown no significant difference in the rate of settlement or twist, despite the two different stranding operations. With regard to the rate of settlement of the conductors arising from the application of the 12½% overtensioning, rather more than 30% of the settlement had occurred over the first 48 hours and practically

† Proc. Instn Civ. Engrs, Part III, vol. 4, p. 549 (Aug. 1955).

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the whole of the remaining settlement during the following 6 months, with little or no further settlement during the following 8 months.

The experimental line consisted of three spans and the consistency of behaviour appeared different from that indicated in Fig. 3, where there was as much as 4 in. difference in sag between conductors Nos 1 and 2 after about 30 days. However, in actual practice sections were longer, and inconsistencies were likely to be more apparent.

The efficiency with which sags could be adjusted and conductors lined up with twin conductors depended largely on the use of carefully designed and high-quality large-diameter freely moving sheave blocks. He thought that aspect of construction might with advantage have been brought out with more emphasis in the Paper. Turning then to the section devoted to sag correction, and in particular to Fig. 1, an obviously new departure in the technique of sag adjustment could not be criticized in principle, but he wondered if such precision was warranted in practice in view of other uncertainties. If the sheave blocks operated efficiently the need in any case for that rather complicated operation would be lessened. Incidentally if the spans of a section were reasonably equal the adjustments which the Author made should presumably balance out. What was the net adjustment after allowances have been made for each span?

Perhaps the most interesting, and for that matter controversial, parts of the Paper were those devoted to tower deflexions and the extent to which the Author made allowance for them in his sagging operations. Once again the principle could not be criticized, but when several other practical aspects and uncertainties were considered it appeared a little doubtful whether the end justified the means. For example, had account been taken of the variations in tower height which were considerable in some cases? It was possible to have a difference between minimum and maximum height of about 60 ft. There was also some variation in conductor erection tension for sections with different equivalent spans and erection temperatures; for example, for sections with an equivalent span of 600 ft that tension at 40°F was 7,700 lb. The comparable figure for 1,500 ft at 80°F was 5,700 lb. They were admittedly extreme cases, but the effects on the deflexion would also vary in a similar manner.

In addition, when initially loading a tower there was liable to be some settlement of the foundations, which in turn caused tower deflexion. Since tower deflexions were dependent upon the reactions provided by the backstays and since, in practice, the length, slope, and direction of the stays varied owing to local site conditions, the value of the reactions and corresponding tower deflexion would also change. In the Paper it was inferred that the deflexion of any one type of tower was always the same. Would the Author confirm whether that inference was correct, and if not would he say how those factors had been taken into account?

In similar work with which Mr Simpson had been concerned the use of backstays for sagging operations had been reduced to almost negligible proportions. He agreed whole-heartedly with the principle of stringing conductors at one level at one time to avoid torsional effects. Apart from that he adopted a "leap-frog" method of stringing to minimize the effects of tower deflexion. For example, he strung the earthwire and top of four conductors on one section, then moved to the adjacent section and repeated the operation. A return was then made to the first section to string the lower conductors. Backstaying was largely dispensed with, so avoiding expense and ground disturbance. On the other hand a certain amount of delay was incurred in switching gangs and operations, but overall he regarded that procedure with the minimum use of backstays to be more economical and technically satisfactory.

Finally there was one important aspect which would appear to negative to a large extent the method whereby the Author took into account that aspect of tower deflexions. The effect which a certain linear tower deflexion had on the sags of adjoining conductor sections would vary considerably with the length of those sections. Taking an extreme case for the purposes of an example, that effect was liable to be very great in the case of a short single-span section and negligible in a long multi-span section. That was apparent when it was realized that the difference between the conductor and section lengths, in the

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case of a 500-ft single span, compared with a section length of 12,000 ft at 40°F, was 1·2 in. and 242 in. respectively.

Having all those aspects in mind Mr Simpson suggested that with a selective plan of stringing as between sections, tower deflexions might be ignored for long section lengths, but should definitely be considered, perhaps with even greater accuracy, for abnormally short or single-span sections.

The Author, in reply, referred to over tensioning and explained that the figure of 25% given in the Paper referred to erection tensions which were 15% higher than design tensions on the line concerned; that resulted in overtensioning to approximately 40% of design tension. The real purpose of that overtensioning was to impose on the conductors equal loads of such magnitude that no subsequent treatment during the sagging operations would be likely to cause unequal non-elastic stretch.

He was interested to learn of the experimental line erected by Mr Simpson's firm. If full details and results could be published they would be very useful. Observations of non-elastic stretch of the conductor referred to by the Author had been continued. The results had been given by Mr McCullagh.[1] It was found that even after 12 months the sags were still increasing. At the end of that time the increase in sag for a single span of 712 ft was 28% and the increase in sag for a span in a section of ruling length of 1,177 ft was 15%.

The running-out blocks used on construction were of very good quality and consisted of light aluminium sheaves mounted on phosphor-bronze roller bearings. The required net adjustment calculated from the sag-correction chart would vary under differing constructional conditions. To quote an example, if one conductor of a pair was, say, 3 in. lower than its mate in five spans of 1,200 ft in a section being strung, then 5 × 0·4 in., i.e., 2 in., would be the net "cut-out" allowance.

All observations were made on standard-height towers, for those made up the vast majority of the route. It was agreed that towers with excessive extensions in very long or short spans would not obey the general rules but such extreme cases were rare. The variation in reaction of backstays arising from different site conditions would be nullified by tensioning the backstays until the required tower deflexions were obtained. The deflexions of towers of the same type were found to be reasonably consistent. The specified earth pressures were so low that settlement of foundations under erection conditions should be negligible.

It was noted with interest that Mr Simpson's firm still used the "leap-frog" method of stringing. The Author's firm had developed a system of running out the six conductors on both circuits simultaneously and to continue that system with "leap-frog" sagging would necessitate leaving conductors lying on the ground for longer periods with consequent increased risk of damage. It would be interesting to experiment with sagging adjacent sections simultaneously, thus entirely eliminating the need for backstays on half the section towers of a line. That would enable two "sagging" gangs to operate at the same time and might possibly be the most economical system of all.

The Author agreed that in extremely long sections the harmful effect of tower deflexions would be less noticeable on the sags concerned, but considered that it was worthwhile correcting for them in all cases.

[1] G. R. McCullagh, "Overhead Line Erection." *Electrical Review*, Dec. 1955.

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