*Discussion on Paper No. 6843**

Tamar Bridge

by

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Mr A. H. Toms (Research Engineer, British Railways Southern Region) wrote that during discussions with the Consultants in 1959 concerning the stability of the slope on the east side of the river in which the side-span pier was to be founded, adjacent to what was then a railway line under the jurisdiction of the Southern Region of British Railways, it was found that the epidiorite at the planned foundation level was very much more weathered than had been anticipated from the core borings, and was extensively fissured and distorted by folding and possibly faulting. The fissures in the rock were of random distribution and were open to the extent of $\frac{1}{4}$ in. or so in spite of the fact that no blasting had been necessary for excavation, which had been done entirely by hand.

57. A calculation showed that owing to the non-clayey character of the rock and the frictional properties of the surfaces of the fragments and blocks there was adequate overall stability of the hillside under pier and railway loading. Nevertheless to minimize possible initial settlement under pier loading the Consultants wisely agreed to pressure-cement grout the rock down to a depth of not less than 15 ft below foundation level.

58. The writer would also like to record here that he believed that his discussion with the Consultants at that date might have had some influence on the decision to use locked-coil ropes. Ropes of this type were incorporated in the design in 1931 for the new Chelsea bridge (on which the writer was engaged on stress computations) by Messrs Rendel, Palmer, and Tritton following the research carried out by Mr J. R. H. Otter, now a partner of that firm. A previous use of this type of rope for a suspension bridge was on the Cologne–Mulheim bridge destroyed during the last war.

Mr M. S. G. Knox (Associated Bridge Builders Ltd) wished to correct the implication in § 20 that the more usual American practice for a bridge such as Tamar would be to spin parallel wire cables. For the past thirty years, all of the very many suspension bridges with spans up to the 1600 ft of Chesapeake Bay had had cables of prefabricated parallel strands, apart from one exception; this was the recent San Pedro bridge with a span of 1500 ft, where the cables were spun as an experiment in simplified techniques for this. In either Britain or the United States the economical change-over from parallel strands to spun parallel wire cables was probably somewhere between a 1500 ft and 2000 ft span, the figure being lower for a heavy capacity bridge and higher for one designed for lighter traffic.

60. All the parallel strand bridges in America had, however, been constructed with spiral bridge strands of round wire, similar to that used for spun parallel wire cables. He wished to know the reasons for selecting locked coil strands for Tamar. A $2\frac{1}{2}$-in. diameter bridge strand would be the nearest equivalent to that used, giving a breaking load of 336 tons. The cable diameter would then be about $\frac{3}{4}$ in. greater, which was probably insignificant in costs of saddles and cable bands; the same cable diameter could probably be achieved by the American practice of using six smaller corner strands instead of the hollow spacers as at Tamar. The other features of the

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* *Proc. Instn civ. Engrs*, 1965, **31** (Aug.), 337–360.

bridge strand appeared to be all in its favour. The weight would be 4% less. All the wires would have the same tensile strength and 0·2% proof stress, whereas the locked coil strands must use 10% lower values for the shaped wires; if the proof stress was taken as the effective elastic limit, this meant that at the 100-ton mean dead load tension the factor of safety against this for the outer wires was 2·7 for the locked coil strand, as against 3·0 for the bridge strand; at a possible maximum working load 40% of ultimate, this factor was 1·9 as against 2·1. The elongation of all the wires in the bridge strand was 4% minimum, and generally 5%–6% was achieved, but only 3% could be specified for the shaped wires in the locked coil strand. The modulus of the bridge strands would be at least 24 million lb/sq. in., 8% better than the 22·1 million lb/sq. in. for the locked coil strand; this improvement would slightly reduce live load deflexions and might reduce the requirements for the stiffening truss. The galvanizing of the round wires in the bridge strand could be of a uniform high quality and thickness but thinner coatings had to be accepted for the locked coil shaped wires, particularly at their corners. Apart from these apparent advantages the bridge strand was considerably cheaper, by about 28% of the material cost for the sizes under consideration; this would have represented a saving of around £55 000 for the Tamar cables.

61. For the suspenders, while he would expect the above arguments to apply here also, particularly with relation to the quality of galvanizing of the outer wires, there might possibly be an aerodynamic advantage in the locked coil construction. High frequency vibration in some winds was commonly observed on bridge suspenders and mast guys; this might be due to the same asymmetrical lift characteristics of a spiral construction in slightly skew winds, which had caused the low frequency oscillation on some long-span transmission line crossings. If so, the locked coil exterior might be smooth enough to make a difference. Could the Author say if any vibration had been observed on Tamar suspenders?

The Author, replying to Mr Toms, agreed that it was quite true that the epidiorite on the east side anchorages was fissured and some cement grouting was carried out. There was, in fact, some blasting.

63. The question of the Chelsea Bridge ropes had been discussed with Mr Toms, and there was also much discussion on the form of construction with the manufacturers.

64. The alternative possibility of using parallel wire ropes was at one time considered.

65. Regarding Mr Knox's question concerning the use of locked coil ropes as against bridge strands of round wire, the Author was influenced by the very serious corrosion that took place on the old Widnes Transporter Bridge. This old bridge was supported by cables made up of spiral bridge strands of round wire, laid parallel. The Author had carried out many inspections during the latter period of the life of this structure and had found that the ropes had become very seriously corroded. They were strengthened firstly by the provision of additional cables and later by adding tensioning devices at mid-span in an attempt to strengthen the cable further in places where the corrosion was most serious. It was estimated that the effective section of the original cables might be as low as 30% of the original section. The condition of these cables was one of the principal factors that forced the engineers to condemn the structure. It had had a life of only about 55 years. The Author was therefore determined to avoid any possibility of such an occurrence, and the locked coil rope in his view offered a much better solution.

66. High frequency vibration had, he understood, been observed on the Tamar Bridge Suspenders, so in that connexion the locked coil ropes did not appear to be any better than those of spiral construction.