Organization and techniques for moving heavy railway bridges

J. A. PORTER & J. O. THOMPSON

Mr P. S. A. Berridge (former bridge engineer, North Western Railway, India, and the Western Region of British Rail)

The Authors have compiled a catalogue of near-mishaps caused by using impracticable methods to slew bridge superstructures which appeared to be unnecessarily heavy. Moving 2700 tons with a haulage force of 70 tons (§ 51) may be a satisfying accomplishment. 'C'est magnifique, mais ce n'est pas la guerre.' It is not sound engineering.

82. If, instead of being 'skulldragged', the load W (tons) had been rolled-in on machined axle steel, *rolling* on rail steel, the required force F (tons), according to Indian railway practice, would have been less than 25 tons. The simple and reliable formula is:

$$F = \frac{1}{11} \times \frac{W}{10}$$

With a safe bearing pressure p (lb/lin. in.) of contact of rollers of d diameter (in.), the formula $p = 800d^1$ shows that six roller-paths, each with sixty 6 in. rollers would have made a practicable solution.

83. During the withdrawal of 155 ft bridge spans in Baluchistan² a weight of 176 tons, on sixty 6 in. dia. ex-axle rollers travelling on a pair of 75 lb FF rails, was moved at a rate of $4\frac{1}{2}$ in./min; the total load (275 tons) was hauled by hawsers direct from two small hand-winches (Fig. 8).

84. On the NWR (India) where the timetables were the same on every day in the week, the longest occupation allowed was 3 hours. When slewing in the 33rd span of the 50 span Jhelum Bridge (Fig. 9), the occupation time, cut to 76 min., was a record; in that time, the track, trough-decking and cross bracings were stripped from the old span, the old main girders were held aloft, one by one, the new 76 ton span was rolled in and jacked down, and the permanent way was restored.

85. This Paper will prove valuable if the Authors will give the costs of construction. A modern double-track steel truss span 300 ft long weighs, including tracks and ballast, less than 900 tons. Whether the advantages of using prestressed concrete instead of steel at the Frodsham bridges justified the extra cost of building a 5000 ton structure and struggling to 'skulldrag' it across 39 ft seems open to doubt.

Mr Z. J. Szembek, Posford, Pavry and Partners

I would like to add two points which are based on recent observations and experience of moving such bridges.

87. It is quite common with multi-span continuous bridges to have the end spans cantilevered during the sliding-in operation. If the intermediate piers or supports are monolithic with the deck or rigidly held at the underside of the deck and the skids are at the lower level, the oscillation or 'flapping' of the cantilevered spans produces horizontal movement of the skids. It is therefore essential to bear this in mind when designing the horizontal restraint at that level, and working out the clearances.

88. When commencing the sliding-in movement it may be necessary to apply a force almost twice that which is required to maintain a steady speed of, say, 9 in./min. In most cases, steel ropes are used, passing through a number of sheaves. Thus a large amount of energy is stored before the structure moves forward and when it does

Paper published: *Proc. Instn Civ. Engrs*, Part 1, 1972, **52**, Aug., 149-162.

Fig. 8. Rollers and roller-paths at Kachh High Bridge

Fig. 9. Rolling in the second new railway span at Jhelum Bridge in 1927. The road spans alongside prevented the old railway spans from being rolled out

so, the initial movement can be very sudden. I feel it would be very much better to apply through the winch an estimated force necessary to keep the bridge moving and to provide the rest by means of hydraulic jacks. If the bridge does not then continue to move when the jacking force disappears, the winch force should be increased and the procedure repeated. The actual winch force applied could be measured by suitable tensometer or extensometer gauges or, alternatively, by relating the speed of the driving unit to the force produced.

Mr P. R. Hart, Project Manager, M. M. Dillon Ltd

Some of the structures referred to in the Paper were described by Majid *et al.*³ and I can find no comment in either paper on why this particular method has to be used to build these bridges. In view of the fact that they are 'let as advance works' it would be most interesting to know why the decision was not made to detour the railway and build the bridges in situ.

90. My experience in Ontario has been that the latter minimizes railway interruptions and is often the most economical solution even when the costs of acquiring temporary railway rights-of-way and relocating sophisticated signalling systems are considered.

91. As the Authors are contractors, their comments, preferably with cost comparisons between the two methods, would be most informative.

Messrs Porter and Thompson

With regard to **Mr Berridge's** remarks, the force of 70 tons quoted for moving the heavy structure was the maximum, usually when overcoming the initial 'sticktion'. The force when the structures were moving was normally 20–30 tons, a similar figure to those quoted for using machined rollers.

93. Comparing rollers against PTFE slides, the reaction at the pier positions on the Frodsham bridge was 2000 tons with 6 in. dia. rollers. This would require a contact length of 915 lin. in. at each pier and if machined bullhead rails were used the number of contacts required would be 320.

94. It was the difficulty of spreading the load over this sort of area that prompted the BR design of the new sliding gear where large loads can be accepted in a compact area.

95. Referring to the time for moving the bridges generally, the actual move occupied 1–4 h. In all cases the excavation for the acceptance of the bridge was the longest single operation and involved moving a minimum of 4000 cu. yd and up to 10 000 cu. yd for the Penrith bridges.

96. No general rule can be applied to the costs of the bridges referred to because there was so much difference in the bridge locations. Initially, the track was expensive but it has now been used a number of times and the cost per use is reasonable compared with any other system.

97. **Mr Sembeck** stressed the need for careful consideration of horizontal restraints for portal or portal and cantilever structures. We have slid in a portal frame at Wigan (weight 2000 tons) where this was considered to be critical, but in the event with a single fairly stiff portal no difficulty was experienced.

98. We have found that with winches with multiple reeving there has been little tendency to surge and we have never needed auxiliary jacks. It is wise to have ample power in the hauling system.

99. **Mr Hart's** suggestion that it could be cheaper to move the rail and build the bridge in its final position may be correct in certain locations. However, there were topographical limitations which precluded this in all the bridges with which we have been involved. It may well be that there is more room to manoeuvre in Canada than in the UK.

DISCUSSION

References

1. HUNTER A. *Arrol's bridge and structural engineers' handbook*. E. & F. N. Spon, London, 1928.
2. BERRIDGE P. S. A. Withdrawing two 155 ft spans from high bridges on an Indian Frontier railway in Baluchistan. *Jnl Instn Civ. Engrs*, 1947-48, **29**, Nov., 63-71.
3. MAJID K. I. *et al.* Design of tied arch railway bridges over the M56. *Proc. Instn Civ. Engrs*, 1971, **50**, Oct., 139-160.