Some Notes on the Elimination of Vibration and Rattle on Timber-decked Bridges.

WITH SPECIAL REFERENCE TO THE NALANDA OYA, THE DAMBULLA OYA AND THE KATUGASTOTA BRIDGES.

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INTER-RELATION OF VIBRATION AND NOISE.

That vibration and noise are, more often than not, concomitant, will readily be conceded, but it is, perhaps, not as well realised that, as Dr. Kaye, of the Physics Department, National Physical Laboratory, points out, it requires but an amazingly small expenditure of energy to produce even the loudest noises.

"It has been computed that the speech power of a cup final crowd of 10,000 converted into light is barely sufficient to keep a small electric bulb aglow throughout the game or, if converted into heat, to boil a single cup of water.

NOISE INJURIOUS TO HEALTH.

MECHANICAL EFFECTS OF VIBRATION.

"Whilst the effects of noise are harmful even to those apparently immune and its evil emphasised in the case of mental workers, young children, the fatigued, the nervous and the sick" the disruptive effects of vibration, because insidious, are very liable to be ignored or underrated. Vibration has very aptly been compared to a fluid wave striking against an obstacle afloat on it, resulting in recoil waves and the communication to the obstacle of sudden tremors or vibratory movements, minute fractions of an inch in amplitude. Thus the cumulative concussive effects of a vehicle traversing the uneven surface of a bridge platform are a
"series of irregularly spaced concussions moving along the bridge platform, each concussion producing its own wave."

The greater the amplitude of the vibrations of a bridge so disturbed by the passage of a vehicle, from its equilibrium position, the greater are the strains, and consequently the stresses in the materials of the bridge, particularly of the main girders. As the vibratory stresses are of a fluctuating and often of an alternating character, lower working stress intensities than are permissible with static loading must, of necessity, be adopted.

The problem of finding an economical and trouble-free method of silencing the old-fashioned timber-decked bridges which are so frequently met with on the roads in Ceylon has baffled the inventive genius of P.W.D. Engineers for over half a century. Various methods were tried from time to time and some achieved a measure of short-lived success, but none proved to be practical or permanent solutions of this difficult problem.

The author, therefore, makes no apology for describing in the following pages the culmination of a series of experiments which have resulted in the discovery of a simple solution of the problem which has so far been attended with astounding success.

DESCRIPTION OF TYPICAL TIMBER-DECKED BRIDGE PLATFORM, ITS DEFECTS.

Consider a timber-decked platform of the usual type. This consists of hardwood decking planks without spacing fillets between each other, laid transversely on supporting longitudinal runners and ostensibly secured to them by the generous use of that very futile contrivance known as the "caldicott clip," and at ends, as ineffectually anchored down by means of longitudinally placed old bridge plank fenders and such holding down bolts as have not already worked loose.

PHYSICAL DISCOMFORT TO USERS OF BRIDGE.

Such a system imposes little, if any, restriction on the relative movement of the deck planks. They are free to rise in a surge per-
ceding the front wheels of an advancing vehicle, are shot like nine pins against each other, are then dashed down under rear wheels and left bobbing in the wake of the now receding vehicle, whilst its hapless occupants are shaken up, and their cars assailed with deafening clatter of planks and clips and girder bracings.

Three solutions of the problem of remedying this admittedly unsatisfactory state of things suggest themselves.

(a) Replacing the timber-decked platform with a stone sett and concrete roadway on corrugated iron decking.

(b) The fixing on the existing timber decking planks of longitudinal traffic treads consisting of 2’ 6” x 1’ 1” thick mild steel chequered plates, bolted in position to decking planks.

(c) The improvement of existing timber-decked platforms so as to eliminate rattle and vibration and give a smooth surface as traffic tread.

REPLACING WITH STONE SETT PLATFORM EFFECTIVE BUT COSTLY.

(A) The first of these, by its forthright elimination of the deck plank, savours of the cutting of the Gordian knot, but in measure, as it is thoroughly effective, it is prohibitively costly. The dead and equivalent distributed live load associated with timber-decked iron bridges of the “Brotherhood” type being 75 and 40 lbs. per sq. ft. and for type P.W.D. bridges being 168 and 120 lbs. per sq. ft., respectively, it will readily be appreciated that the change over from the plank to the stone sett platform must necessitate the following:—

(1) The introduction longitudinally, under existing platform cross joists, of heavy section rolled steel joists or type lattice girders to give additional support to the former and when the span is a large one:—

(2) The building up from river bed of additional intermediate masonry or concrete piers.
METHOD (A) ADOPTED ON BROTHERHOOD BRIDGE
ON RATOTA-GAMMADUWA ROAD.

Recourse was had to both these methods in the case of the "Brotherhood" bridge of 100' clear span, on the Ratota-Gammaduwa road, Matale District. Two piers 30' feet high, faced with dressed stone masonry and concrete hearted, tapering from 28' x 8' at base to 20' x 5' at top, were provided.

Three rows of 18' x 7' x 75 lbs R.S. joists were placed across the resulting spans of 30' so as to give additional and continuous support to all the bridge cross joists. See figure (1).

The more extensive adoption of this method is ruled out by the financial stringency which has prevailed for the past few years and has as yet, shown no signs of lifting.

MILD STEEL CHEQUERED TRAFFIC TREADS ON
NALANDA OYA BRIDGE.

(B) The second method was adopted in 1929 on the Nalanda Oya bridge, a "Brotherhood" bridge 113 feet long and open to 3-ton traffic. Two traffic treads 2' 6" wide, 5/8" thick mild steel chequered plates were provided and fastened to the deck planks with 4" x 3' coach screws at a cost of Rs. 2'07 per sq.ft. or Rs.10'35 per foot run of platform inclusive of labour and materials.

HISTORICAL.

In July, 1928, the Director of Public Works, in forwarding to the District Engineer, Nalanda, an excerpt from "The Engineer" of a letter from W. Roger Sanguineth, late State Engineer, Kedal-Malay States, describing the successful use by him of blanket rubber cushioning strips between bridge decking planks and supporting R.S. joists longitudinals, directed that a similar trial of rubber strips should be made on the Nalanda Oya bridge before the fixing of the mild steel traffic treads.

(C) Accordingly in December, 1928, the Nalanda Oya bridge was fitted with cushioning strips consisting of 2 outer rows of 3" x 5/8" and one middle row of 4" x 3/4" crepe No. 1 rubber,
procured from the Superintendent, Locknagar Group, Matale, at 60 cents per lb. or 1·20 per foot run of platform, exclusive of the cost of fixing.

These were inserted between the bridge planks and the supporting longitudinal runners. See figure (2).

NALANDA OYA BRIDGE FITTED WITH RUBBER CUSHIONING STRIPS AND TRAFFIC TREADS.

On the 24th January, 1929, the District Engineer, Nalanda, reported as follows:—“When the rubber strips were first laid, the vibration and rattle were reduced to a minimum, there being hardly any rattle, but after a fortnight the rattling recommenced due to the caldick clips working loose’ and later 'I had long bolts fixed through fenders and angle runners every 3 feet apart. This improved matters, but again the rattle was noticeable.'

The writer took over the Nalanda District in February, 1931. Not only was the rattling of planks on the Nalanda Oya bridge noticeable, but the ringing clang of flopping traffic treads, when a bus passed over the bridge, could distinctly be heard in his bungalow a ¼ mile away.

DEFECTS NOTICED ON NALANDA OYA BRIDGE.

The caldick clips, with repeated tightening up, had continued to give, so much so, that someone, apparently in desperation, had, with a hammer, bent over a large number of...these with no better result, as the planks still had considerable freedom of movement.

The coach screws holding down the mild steel traffic treads had proved a complete failure as 20% of them were found to be headless and 40% were quite loose in screw-sick holes.

SILENCING METHODS FINALLY ADOPTED ON NALANDA OYA BRIDGE.

This bridge was soon after effectively silenced by the adoption of the following very simple expedients. See figure (3).

(a) All the caldick clips were removed and their further use entirely discontinued.
(b) Hardwood spacing fillets between plank and plank were introduced.

(c) The 3 lines of rubber cushioning strips were rebedded on graded thickness of packing composed of several folds of gunny steeped in boiling asphalt of 80/100 penetration such as used for road surfacing.

The rubber cushioning strips on tarred packing were lashed to supporting longitudinal runners at intervals of about 4 feet with strands of coir string steeped in hot tar. This was purely a temporary measure, as, after the planks were bedded down by fenders and holding-down bolts, there was no tendency whatever for the rubber strips to move out of place.

(d) All existing fenders were replaced by 16 feet lengths of sound timber, with ends butting and not halved and each independently secured to the angle iron runner beneath by 8 holding-down bolts \( \frac{5}{8} \)" diameter. Owing to the insertion of the packing and rubber strips between planks and longitudinal runners, some effort was required to spring down the ends of the planks so as to secure the fenders with the holding-down bolts, giving a pronounced camber to the cross section of the platform.

(e) All the \( \frac{3}{4} \)" coach screws fastening down traffic treads were replaced by \( \frac{1}{2} \)" diameter snap-headed square-necked through bolts and nuts. The coach screw holes in the traffic treads were enlarged with a square punch so as to take the square necks of the new bolts.

(f) Before the mild steel chequered traffic treads were bolted down a 9" wide packing, approximately \( \frac{1}{2} \)" thick, consisting of several folds of gunny steeped in boiling asphalt, was laid along the middle under each traffic tread as shown in figure (3).

When the snap-headed bolts were tightened up, the traffic treads had a slightly noticeable camber and the resulting stiffening was an effective preventive against any bending of the traffic treads under the wheels of a heavily loaded vehicle.
IMPROVED SILENCING METHODS APPLIED TO THE DAMBULLA OYA BRIDGE MARCH, 1932.

Invited by his Provincial Engineer to apply the experience already gained in silencing methods to the Dambulla Oya bridge, a timber-decked Brotherhood, 94 feet long, not provided with steel traffic treads, and one in which rattle and vibration were unpleasantly conspicuous, the writer in March, 1932, was able, effectively, to silence it by the adoption of the methods detailed below, which whilst, in the main, an improvement of the Nalanda Oya methods, also embodied a new feature, the reinforced mastic traffic tread. See figure (4.)

1. Caldicott clips were entirely done away with and the method of fixing of fenders was identical with that employed on the Nalanda Oya bridge.

2. Crepe rubber cushioning strips, as fitted to the Nalanda Oya bridge, but \( \frac{1}{8} \)" thick, as \( \frac{1}{4} \)" strips were unobtainable, were procured from the Superintendent, Aloovihara Group, Matale, at 25 cents per lb.

PACKING PROVIDED OVER ALL RUNNERS.

3. All longitudinal runners, inclusive of the three fitted with rubber cushioning strips, were provided with graded thickness of packing laid on top of runners and composed of several folds of gunny steeped in boiling asphalt. These were, in addition to being lashed with coir string steeped in tar, also secured with a strand of No. 10 S.W.G. galvanized wire at intervals of about 4 feet.

SPACING FILLETS SPIKED TO ONE VERTICAL FACE OF EVERY PLANK TO GIVE EVENNESS AND CONTINUITY OF TREAD.

4. All movement of planks was prevented and improved ventilation secured by spiking 2 hardwood spacing fillets 2' 0" long \( \times \) 34" deep \( \times \frac{1}{8} \)" thick using 2¼" rose nails, to one vertical face of each plank at 4' 6" centres. The top of the fillet was flush with the top of the decking planks and gave a continuity of surface along wheel tracks by bridging the spaces between the planks. See figure (4).
Mastic Carpet with Gunny Reinforcement.

5. Finally, when the holding-down fender bolts had been securely tightened up, and all planks were bone dry, and working on a 6 feet length at a time, the wheel tracks, 2' 0" wide, consisting of planks and top edges of spacing fillets, were treated with a coat of boiling hot asphalt well rubbed in with bass brooms. Whilst this coat was still hot and tacky a layer of gunny, obtained from rice bags, was laid on, more boiling asphalt was then poured on the gunny and again well worked in with bass brooms and finally sanded with good quality coarse sand. As a precaution against the heated surfacing material running over the edges of the 2' 0" wide tracks, old bridge planks were laid on the outer edges until the sanding had been completed.

Sample of Mastic Carpet Removed from Dambulla Bridge after One Year and Three Months' Use.

To those sceptical of either the wearing and the weathering qualities or the proper adhesion of the mastic carpet to the surface of the planks, an examination of the accompanying sample taken at random from the Dambulla Oya bridge on 20th June, 1933, that is after about 1 year and 3 months weathering and service under 3-ton traffic, should prove convincing.

Cost of Silencing Methods.

The cost per foot run of silencing platform, inclusive of the cost of rubber cushioning strips and all labour and materials, but exclusive of the cost of replacing defective bridge planks, amounted to Rs. 3.20.

Katugastota Bridge.

The end of April, 1932, saw the completion of the first attempt at the adoption of silencing methods on the Katugastota bridge, a Brotherhood type bridge with a platform width of 24 feet, inclusive of two foot tracks each 3 feet wide.

1. The upper surfaces of 3 longitudinal T iron runners were cushioned with scrap rubber cushioning strips procured from the Manager, North Matale Estate, 4" X ½" weighing approximately 1 lb. per foot and costing 25 cents per lb.
2. Two outer longitudinal runners adjacent to the foot tracks were similarly fitted with packing composed of factory belting.

3. Some of the caldicott clips were replaced by circular dished mild steel washer plates and bolts procured from the Factory.

The cost of the work, inclusive of all materials and labour, was Rs. 2.40 per foot run of platform.

This experiment, however, proved a failure within six months of completion and for the same reason that a similar experiment carried out on the Nalanda bridge in 1929 failed, viz., the retention of the unsatisfactory caldicott clips as a means of fixing the planks.

**FINAL SILENCING OF KATUGASTOTA BRIDGE.**

The necessity for falling into line with the silenced Dambulla Oya bridge in the same Province becoming overwhelmingly apparent, a start was made in November, 1932, and the work completed, except for one bay, in February, 1933. *See figure (5).* The extra width of the Katugastota bridge platform necessitated (a), in addition to the outer fenders, the fixing down of the planks along the centre line of the platform by means of a flat iron secured by holding-down bolts to the centre longitudinal runner, (b) the provision of 4" tar surfaced traffic treads instead of 2, to take two lines of traffic moving in opposite directions. The cost of this work, inclusive of all materials and labour amounted to Rs. 4.33 per foot run of platform.
"BROTHERHOOD" BRIDGE OF 100 FEET CLEAR SPAN ON RATTOTA-GAMMADUWA RD., MATALE DISTRICT

ELEVATION

SECTION

NOTE
EXISTING WORK SHOWN FULL BLACK,
ALTERATIONS SHOWN DOTTED BLACK.
FIG. 5.

KATUGASTOTA BRIDGE

SECTION
SCALE 1/2 TO A FOOT

DETAIL AT D
SCALE 3/8 INCH TO A FOOT

2 1/2 ROSENAILS FOR SPIKING FELT TO ONE VERTICAL FACE OF EACH PLANK.