F. TRAMS DESIGN. RESILIENT CONCRETE

D.A.T.E. 17/1/63

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MELBOURNE AND METROPOLITAN TRAMWAYS BOARD

ENGINEERING DEPARTMENT

TESTING BRANCH

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REPORT NO. I 5/1/146

INFORMATION - RESILIENT CSS (Concrete) TRACK

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ENGINEERING DEPARTMENT

TESTING BRANCH

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REPORT NO. I 5/1/146

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INFORMATION - RESILIENT CSS (Concrete) TRACK

1. SYNOPSIS:

For some years it has been known that in the standard type of concrete to street surface (CSS) tramway track constructed in Melbourne the rigidity of the concrete foundation and rail support is a maximum. While this has the advantage of providing track with good riding qualities and minimum paving maintenance, it has the disadvantage of giving rise to maximum wheel-on-rail noise as a tram, and particularly one with rough wheel tread surfaces, travels over the track. The noise is heard either as impact noise from noticeable wheel flats or as a continuous rumble or roar, and is loud enough to be a noise nuisance.

This report discusses one possible method of reducing this wheel-on-rail noise by reducing the rigidity of the rail support by means of fluted rubber rail pads used as a stringer under the base of the rail, and describes the design, and laboratory tests carried out with two sample pads to assess its suitability as a noise reducing measure.

While results of the laboratory tests have been encouraging - noise levels reduced to approximately those obtained with paved ballast track - a final assessment of this type of resilient CSS track requires the construction of a test section of tram track. This report therefore includes an estimate of the additional costs involved in constructing 100 ft. of single track, and suggests precautions to be taken during construction to ensure that the rails will in fact be resiliently supported.

2. **INTRODUCTION:**

The opening of the Bourke St. - East Preston electric tramway in 1955 and the subsequent reconstruction of other tram tracks using concrete to street surface (CSS) construction have been the occasions for numerous complaints about tramcar noise, the most objectionable of it being due to wheel flats and wheel roar.

Since 1955 a number of possible noise reducing measures (Better Driving Campaign, rails coated with "liquid envelope", and lightweight aggregate concrete) have been tried; and an extensive series of noise tests carried out to find a satisfactory solution to the problem of excessive wheel-on-rail noise (which includes wheel rumble, wheel roar and the impact noise from wheel flats). To date the success of these measures has been less than was hoped.

One of the conclusion of the series of noise tests carried out over tracks of different types of construction (to be summarized in report No. N1/1/226) is that, all other conditions being the same, wheel-on-rail noise varies with the degree of rigidity of the rail support - the more rigidly (or less resiliently) is a rail supported, the more noise will a tram make as its wheels roll over the track.

MMTB tram tracks of standard CSS design are considered to incorporate maximum rigidity of the rail support because, while their riding qualities are good and paving maintenance a minimum, wheel-on-rail noise is a maximum. The use (in CSS tracks) of timber ties and rail pads as in High St., Northcote reduces this rigidity slightly and a reduction in noise level of 1 dB can be obtained. Removing the concrete support from under the head and lip of the rail by using a 2 in. thick asphalt paving in conjunction with the timber ties and rail pads further reduces this rigidity and a noise reduction of 1 to 3 dB is possible. Little or no noise reduction is obtained with asphalt paving alone (1 dB maximum). By contrast, a noise reduction of 3 to 10 dB is obtainable with paved ballast tracks. At present however, concrete tracks are preferred because of their lower paving maintenance costs and better riding qualities. For any noise reduction to be worth while a drop in level of at least 6 dB is normally needed. A change of 3 dB is usually significant, while 1 dB is hardly worth while.

In the past, resilient rail supports made of rubber have been tried but have not yet been generally successful because, until fairly recently, insufficient information has been available for the satisfactory design of rubber rail pads. In Melbourne rubber pads were installed in a section of track in Swan St. (C.1930), and more recently (1954-5) in Queens Pde. at Merri Bridge. As far as is known neither have been very successful in reducing wheel-on-rail noise (see Appendix II).

In this report a new proposed design for resilient CSS (concrete) track is considered and discussed. The new design, evolved after a study of both the Queens Pde. - Merri Bridge design (Drg. P12406) and the results of the noise tests carried out during 1957 - 61, is a modification of the standard Melbourne CSS track design and uses a specially designed ½ in. thick continuous fluted rubber rail pad made of pure gum vulcanized natural rubber laid longitudinally between concrete foundation and the base of the rail.

Corrected on 21/6/6

The procedure for designing the rubber pad is outlined in Appendix I. In addition, and in order to obtain maximum resilience from the rail pad and provide a seal between rail and concrete, sponge rubber is placed under, and hot-pour rubberized bitumen at the side of the rail head and lip, while a sliding fit is allowed between the rail web (painted with bituminous paint) and tie bars. Details of this type of construction are given in Appendix III.

Recently, and since this design was evolved, a technical paper by Dr. E. Korber describing tram tracks laid on rubber foundations in the city of Vienna has been received. The Viennese track designs which are in some ways similar to the present proposed design are discussed in section 6.5 of this report. They are considered to have been very successful.

On 15/1/62 a memo describing the proposed design using fluted rubber rail pads was sent by the Testing Engineer to the Civil Engineer for his consideration. On 7/3/62 the Civil Engineer asked that rail-concrete test blocks (one including a prototype rail pad, the other in standard CSS construction) be made so that comparative load-deflection and, if possible, noise tests could be carried out.

Accordingly, two 1-ft lengths of rail, a rubber rail pad, and moulds etc. were prepared, and on 7/5/62 the concrete cast to form two rail-concrete test blocks (see Appendix III). The blocks were considered ready for tests on 11/5/62. After the tests on the 1ft long blocks another resilient CSS block, 3ft. long was made on 29/6/62 for further load-deflection tests. This block, because of two tie bar holes in the rail web, was fitted with two "tie-bolts" with greased washers, the nuts being fairly tight although just loose enough to allow sliding in the plane of the rail web.

In these tests the rubber rail pads used were of vulcanized natural rather than a synthetic rubber. From the information available in technical books such as Payne & Scott, "Engineering Design with Rubber", the "pure gum" natural rubber used has the best elastic and resilient properties.

3. PURPOSE OF REPORT:

The purpose of this report is to record and discuss the results of the comparative load-deflection, repeated load and noise tests in order to assess as far as possible the performance of the rubber rail pad resilient type of track construction. The report will also include an estimate of the cost of the extra materials required in the construction of a test length of tram track, and an indication of the precautions to be taken during its construction.

4. TESTS CARRIED OUT:

Apart from several noise tests, all tests were carried out on the two lft. and the one 3ft. rail - concrete test blocks.

4.1 Compression Load-Deflection Tests:

Compression load-deflection tests to measure the deflection of a rail on a rubber rail pad both alone and in concrete blocks under vertical loads up to 6 tonf applied at the centre of the rail were carried out in the Avery Universal and Amsler Compression testing machines.

The 1ft. block was given two series of tests on 11/5/62 and 23/5/62. On 11/5/62 this block (as yet without the rubberized bitumen rail sealer and Permelastic primer) was given five load-deflection cycles (load increased and decreased as rapidly as possible) in the Amsler machine up to a maximum vertical load of 5 tonf. On 23/5/62, after the bitumen rail sealer had been placed, this block was given four load-deflection and ten load cycles, and a further load-deflection cycle (all to 5 tonf in the Amsler machine).

On 27/6/62 the 3ft. length of rail and rubber pad (before being cast in concrete) was tested in the Avery machine to a maximum compression load of 20 000 lbf (= 8.9 tonf). The test consisted of four load-deflection cycles to obtain deflection at the centre of the rail, two to obtain deflection at the ends, and one more to obtain centre deflection. On 3/7/62 the completed 3ft rail-concrete test block was given three load-deflection cycles (in the Amsler machine with loads up to 6 tonf) to obtain deflection at the centre of the rail, and ten load cycles (to 5 tonf) to observe the behaviour of the rail - and concrete-to-bitumen bonds which incorporated an epoxy-resin primer in this block. During the first load-deflection cycle the test was observed closely to obtain the load required to overcome the initial "binding" between rail and concrete and "tie bolts".

Throughout each load-deflection test two dial gauges (placed at the ends of the rail) were used to measure the deflection. Figure 1 below shows the 1ft block set up in the Amsler machine. To measure deflection at the centre of the rail the dial gauges were used to measure the distance between the base of the test block and a rigid bar moving with the top platen of the testing machine. To ensure that the load was applied only at the centre of the rail a short block (approximately 1 x 1 x ¼ in. high) was placed between the rail head and the rigid bar. To measure deflection at the ends of the rail a similar procedure was used except that a more flexible bar was used and the positions of bar and short block were reversed.

FIGURE 13.

An end view of the completed standard CSS test block.

FIGURE 14

An end view of the nearly completed resilient CSS test block showing the gaps for the rubberized bitumen rail sealer, the sponge rubber pads under the head and lip of the rail, and the rubber rail pad with longitudinal flutes. (A similar view of the completed resilient CSS test block is given in Figure 5 at the conclusion of the report).