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CASE STUDIES OF BODY NOISE FROM A RIGID AND AN ARTICULATED TIPPER LORRY

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1. INTRODUCTION

The main objectives of this study were to examine the generation of vehicle body related noise from two types of tipper truck; a rigid and an articulated vehicle. Body noise is mainly confined to commercial vehicles and is caused by impacts of parts of the body, chassis and suspension.

The forces in the vehicle structure causing the impacts occur principally when these vehicles travel over uneven road surfaces. A possible method of control is to ensure that the road surface is in a good condition with an even longitudinal profile. The dynamic forces generated through the axles of vehicles running on the surfaces would then be minimised. Clearly, such an approach would help to alleviate the problem but the maintenance of all roads to a good and safe standard is already a principal objective of all highway authorities. Consequently, with finite resources, it is not possible to entirely eradicate small irregularities on road surfaces. It is important therefore to consider what can be done to the vehicles themselves to help reduce the incidence of vehicle body noise in the community. A possible solution to control noise from tipper vehicles would be to fit clamping devices to prevent excessive movement of the container when the unladen vehicle is in motion. This would reduce the impacts that occur between the tipper container and the chassis which generate body noise. Such body clamps are relatively low cost and, it is claimed, can be fitted to most tipper trucks. As part of the study it was intended that body clamps would be fitted to the test vehicles and any reductions in body noise noted.

It was hoped that these and later case studies would indicate whether it was appropriate for the Department of Transport to develop guidance regarding the control of body noise from commercial vehicles. The study was carried out by the Transport Research Laboratory (TRL).

2. MEASUREMENT METHOD

General

Measurements of noise were taken whilst driving the vehicles over uneven road surfaces to excite sources of body noise. The tests were carried out in three stages. Firstly the vehicles were tested in an untreated condition, i.e. with no attempts made to suppress body noise. Proprietary body clamps were then fitted and the measurements repeated under identical conditions to determine the effect of these devices. Finally, another set of measurements of the rigid vehicle was taken following additional treatments to reduce body noise.

Vehicles

Both vehicles had been subject to a number of years of operational use hauling aggregate, sand, earth or construction rubble. Neither vehicle was fitted with any form of restraint to the tipper body other than lateral guides to ensure the container centralised when lowered. This is consistent with most tipper truck designs where the container is held in position under its own weight.

The rigid vehicle was a four axle tipper truck with a permissible gross vehicle weight of 30 tonnes. The tipper container was constructed of aluminium with side hinged doors at the rear. The articulated tipper vehicle was a 2 axle tractor unit coupled to a tri-axle semi-trailer. The tipper container was constructed of aluminium with a single rear door hinged at the top. The vehicle was plated to a permissible gross vehicle weight of 32 tonnes. Both vehicles had steel leaf suspension systems and were unladen during the tests.

Body clamping devices

The design of clamping device selected comprised of a powerful latching mechanism that fitted centrally between the vehicle chassis rails and a locking bar attached to the underside of the tipper container near the front. As the tipper container lowered onto the chassis, the locking bar engaged with the latch, clamping the container firmly in place. The clamp mechanism released the container automatically when the container was raised by the hydraulic tipping gear.

Additional noise control treatments applied to the rigid vehicle

During the drive-by tests with the rigid vehicle it was noticed that in addition to noise generated by movement of the tipper container, significant levels of noise were also generated by the rear suspension. On each side of the vehicle the two rear axles were attached to either end of a centrally pivoting leaf spring. As the rear axles of the vehicle traversed the uneven road surfaces, the steel leaf spring ends appeared to impact the spring hanger stops as the loads on the axles balanced out. To identify the contribution of this noise source, wooden wedges were driven into the clearances at the end of the leaf springs to prevent the springs from impacting against their stops.

The steel leaf suspension on the semi-trailer of the articulated vehicle was also found to generate significant levels of noise caused by metal-to-metal impacts. However, because of the design of the suspension used on this vehicle it was not possible to apply the same remedial treatments.

Noise measurement procedure

Measurements of vehicle drive-by noise were carried out on the TRL test track by running the tipper vehicles over three surface types: a smooth surface, and two uneven surfaces representing a ramp and a trench. The uneven surfaces were representative of discontinuities that might be found on the public roads caused by repair work or differential settlement beneath the road surface. The dimensions of the road surface irregularities were based on survey data from previous TRL studies [1,2]. The ramp was constructed of plywood and had a longitudinal length of 0.6m and a maximum height of 25mm. The trench constructed in the test track surface had a concave profile and was 1.2m in longitudinal length. The maximum depth at the centre of the trench was 40mm. Both of the uneven test surfaces spanned the width of a standard road lane.

Noise measurements were taken at a microphone located 7.5 metres from the centre line of the test surfaces at a height above the track of 1.2m. For all measurement conditions, the microphone was located on the nearside of the vehicle. For both vehicles, drive-bys were carried out at a steady speed across the three test surfaces over a range of speeds from 20 km/h to 60 km/h. Vehicle speed was monitored using a radar speed meter positioned at the track side. For each drive-by test, a time history of the A-weighted noise level was recorded as the vehicle passed through the test site. The maximum A-weighted level was also captured. Each drive-by condition was performed twice and the average of the two L_{Amax} readings was taken as the result.

3. RESULTS AND DISCUSSION

Rigid vehicle

The averaged maximum noise levels obtained from each drive-by test for the rigid vehicle are shown in Figure 1. It can be seen from the Figure that relative to the drive-by noise levels obtained alongside the smooth surface, the maximum noise levels generally increased substantially when the vehicle was driven over the uneven surfaces. Typically the noise levels were increased by 4-10 dB(A) for the ramp and 1-8 dB(A) for the trench dependent on vehicle speed. When the body clamp was fitted, no significant noise reductions were recorded during drive-bys over either test surface. In some cases the noise level actually increased slightly.

Figure 2 shows example time histories of drive-by noise generated by the rigid vehicle passing over the trench at 30 km/h. The time history represented by the thicker line shows the noise level recorded after the body clamp had been fitted to the vehicle. As mentioned above, it was discovered that high levels of body noise from this vehicle were generated by metal-to-metal impacts between parts of the rear suspension. The dominant noise peaks shown for each test condition shown in Figure 2 occurred when the rear axles traversed the trench and was caused mainly by metal-to-metal impacts in the suspension.

When the remedial treatments discussed earlier were applied, and the tests were repeated over the ramp, reductions of between 0-8 dB(A) were achieved relative to the untreated condition. Repeat tests over the trench yielded noise benefits of up to 3 dB(A). Figure 3 compares example time histories of drive-by noise alongside the ramp both before and after treatment to the suspension. It can be seen that, following treatment, the dominant suspension noise peak at this speed was reduced considerably.

Figure 1 Drive-by noise levels obtained for the rigid vehicle

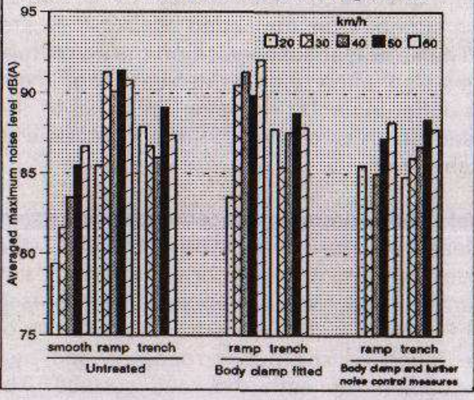


Figure 2 Drive-by noise from the rigid vehicle crossing the trench at 30 km/h

(comparison of noise levels before and after fitting the body clamp)

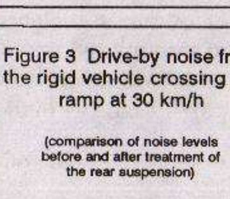
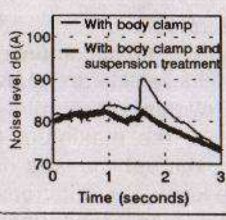


Figure 3 Drive-by noise from the rigid vehicle crossing the ramp at 30 km/h

(comparison of noise levels before and after treatment of the rear suspension)



Articulated vehicle

Figure 4 shows the maximum noise levels measured during drive-bys of the articulated vehicle. In this case, relative to drive-bys over the smooth surface, noise levels increased by 19-23 dB(A) alongside the ramp. Noise levels alongside the trench were 20-29 dB(A) greater than those measured alongside the smooth surface. It should be noted that the maximum noise levels for the unclamped vehicle exceeded 106 dB(A) in several cases. When the measurements were repeated after the body clamp had been fitted, drive-by noise alongside the ramp was not significantly reduced. However, when the vehicle was driven over the trench, noise levels were found to be reduced by up to 6.3 dB(A) as a result of clamping the tipper container.

Figure 4 Drive-by noise levels obtained for the articulated vehicle

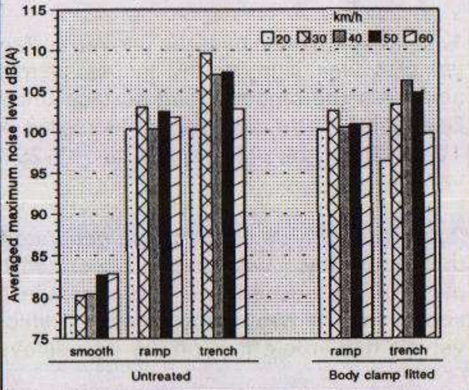


Figure 5 Drive-by noise from the artic. vehicle crossing the trench at 30 km/h
(comparison of noise levels before and after fitting the body clamp)

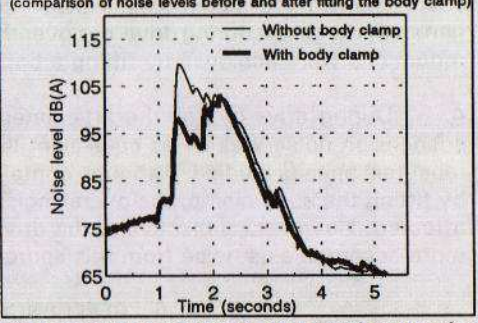


Figure 5 shows example noise level time histories recorded alongside the trench both before and after the body clamp was fitted. These example time histories were recorded during drive-bys at 30 km/h. When the tipper container was not clamped, the dominant noise peak was caused by the container impacting against chassis. The Figure clearly shows this noise peak to be reduced by over 10 dB(A) after fitting the clamp. Following this treatment, the metal suspension of the semi-trailer became the dominant noise source. This was also found to be the case at other test speeds studied.

The body clamp also had the effect of reducing impact noise caused by movement of the tipper container when the vehicle passed over the ramp. In this case, the suspension noise from the semi-trailer was at an equivalent level to the container noise at most test speeds. There was therefore little change to the overall noise level captured during the drive-by. However, subjectively, the drive-by noise was judged to be more acceptable as a major component of the drive-by noise had been reduced.

4. CONCLUSIONS

1. When driven over the uneven surfaces, the noise from both tipper vehicles was significantly increased relative to the noise measured alongside the smooth road surface under equivalent test conditions. Depending on drive-by speed, increases in noise level were between 1-10 dB(A) for the rigid vehicle and 19-29 dB(A) for the articulated vehicle.

2. An analysis of the noise generated by the rigid vehicle showed that body noise was largely generated by metal-to-metal impacts in parts of the suspension, particularly in the region of the suspension supporting the two rear axles of the vehicle. Fitting body clamps to this vehicle had little effect on the overall levels of body noise.

3. Body noise from the articulated vehicle was mainly generated by movement of the tipping container and metal-to-metal impacts in the suspension of the semi-trailer. Noise from container movement was generally dominant during drive-bys over the trench and significant noise reductions were achieved by fitting a body clamp.

4. During drive-bys of the articulated vehicle over the ramp, the suspension noise was at an equivalent level to the container noise at most test speeds studied. Although container impact noise was reduced by fitting the body clamp, the overall noise level was, in this case, little affected. However, subjectively, the drive-by noise was judged to be more acceptable as noise from this source had been reduced.

5. REFERENCES

1. G.R. Watts, 'Case Studies of the Effects of Traffic Induced Vibrations on heritage buildings', Transport Research Laboratory Research Report RR156. Transport Research Laboratory, Crowthorne, UK, (1988).
2. G.R. Watts, 'The Effects of Traffic Induced Vibrations on heritage buildings - Further Case Studies', Transport Research Laboratory Research Report RR207. Transport Research Laboratory, Crowthorne, UK, (1989).