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RAILWAY BRIDGE NOISE CONTROL WITH RESILIENT BASEPLATES

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This paper describes tests on a bridge on the RSA line in Sydney. The bridge was originally fitted with almost rigid baseplates on timber bearers. The noise was found to be about 90 dB(A) at a distance of 5·5 m from the track centre, and the dominant frequencies were found to be in the range between 200 Hz and 1000 Hz. Measurements were made of noise levels, and the accelerations of track components under normal service trains. Resilient baseplates were fitted on the bridge with the aim of reducing the noise level, and the measurements repeated. The total noise reduction obtained was about 6 dB(A).

1. RAILWAY NOISE ON BRIDGES

Vibrations occur in railway track components and supporting structures when trains pass [1]. Frequency range of greatest interest is from about 200 Hz to perhaps 2·5 kHz. As a result of these vibrations, sound is emitted from the vehicles, the track and the support structure. The principle source of the vibrations most relevant to sound emission is the dynamic contact force which results from roughness on the wheels of the train and on the rail. One approach to noise control on railways is therefore to reduce rail and wheel roughness, for instance by grinding the rail, or by attempting to select components which reduce the rate of roughness growth. However, such measures may be expensive. The largest contributions to total the so-called "rolling noise" are from the rail and the wheels of the vehicles.

Where tracks pass over bridges, an increase in noise level is commonly observed. This is particularly the case on steel bridges, where the structure is lightly damped and the girders may be efficient radiators of sound. Damping treatments to such bridges may be expensive and difficult or even impossible to implement. Providing damping on the track components is unlikely to make a sufficient contribution to

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Figure 1. Test site on the Bridge—Sydney.

improve overall noise levels significantly, and has the disadvantage that the components may deteriorate rapidly because of the energy absorption associated with damping.

An alternative approach is discussed here. The stiffness of the track support is reduced, with the objective of reducing the dynamic forces which are transmitted into the bridge directly below the moving loads. An associated effect is that vibrations are instead transmitted further along the rails. The change in track stiffness can therefore be expected to affect the total noise emitted in two contradictory ways—there may be a decrease in the noise component from the bridge structure, but an increase in that from the rail. The extent to which any net change is beneficial will depend on a large number of factors—among them the change in track stiffness which can be brought about; the relative contributions from the rail and the bridge; the frequency ranges of the components and the design of the bridge.

This paper describes the circumstances and results of test on a particular bridge on which resilient baseplates were introduced. The bridge was at Treacy Street near Hurstville in Sydney, Australia. The bridge is constructed from horizontal steel girders resting on brick piers and carries two parallel tracks. There is a mixture of passenger and freight traffic at a range of speeds. The length of the bridge is approximately 10 m. The track is fixed to timber bearers, which are in turn fixed to the bridge girders. In its original condition, the rail was fixed to the girders with effectively rigid rolled steel baseplates—although it should be noted that some degree of deflection does occur in the track system because of the flexibility of the timber bearers. A photograph of the bridge is shown in Figure 1.

Measurements of vibration of bridge components, and of the wayside noise were made in August 1997 [2]. Results recorded under a number of similar Tangara passenger trains travelling at approximately 65 km/h were averaged. The wayside noise level at 5·5 m from the centre of the selected track was found to be nearly

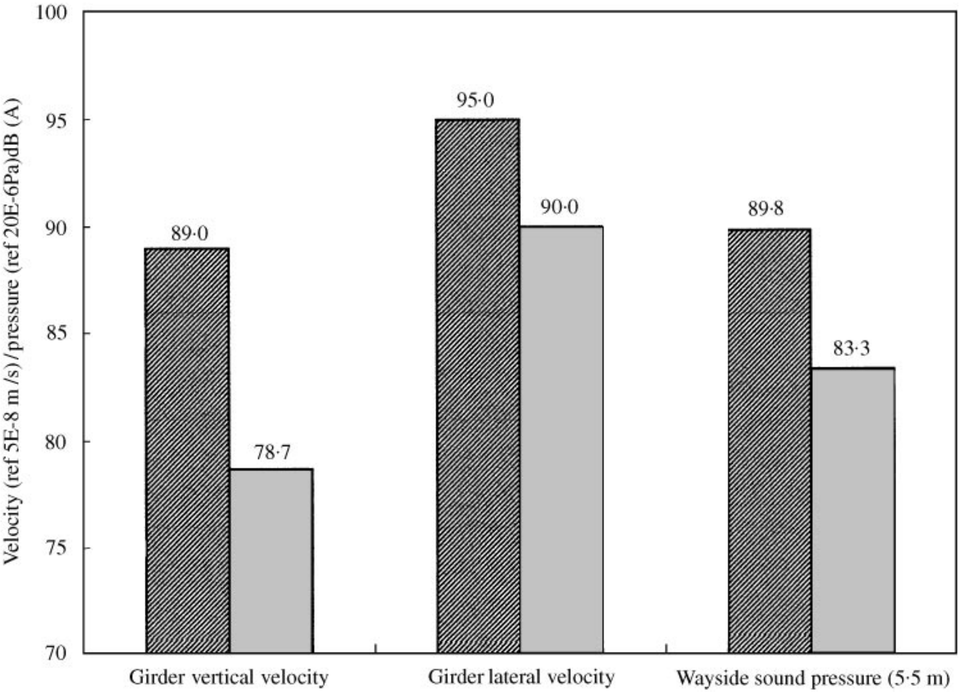

Figure 2. Total noise and vibration levels dB(A). ▨ - Rolled steel; ☐ - VIPA.

90 dB(A). The dominant frequencies were found to be between about 200 Hz and 1 kHz. The fixations on this particular track were then removed, and replaced by resilient baseplates. The particular design used was a Pandrol VIPA assembly incorporating two layers of natural studded rubber pads. As with all assemblies, the dynamic stiffness of this fastener depends on the loads and frequencies at which it is measured. A representative value for the loads and frequencies of interest here is 30 kN/mm.

The measurements were repeated in March 1998 after the change in track fastenings. Although rail head roughness was not measured before either noise measurement, no grinding had taken place in the intervening period. The rail had been in place for several years before the first measurements, and there was neither reason to suppose, nor any visible indication that the rail head condition had changed significantly. The change in wayside noise, averaged over a number of train passes, was 6 dB(A). Summary results are shown in Figure 2. The measurements are discussed in more detail below.

It can be speculated that the large net noise reduction may in part be the result of the fact that the side girder of the bridge effectively forms a noise barrier, which may reduce the effect of any increase in the noise component from the rail.

2. TRACK MEASUREMENTS

Measurements were carried out to find the acceleration of the sleeper in the vertical direction, and of the rail foot and bridge girder in both vertical and lateral

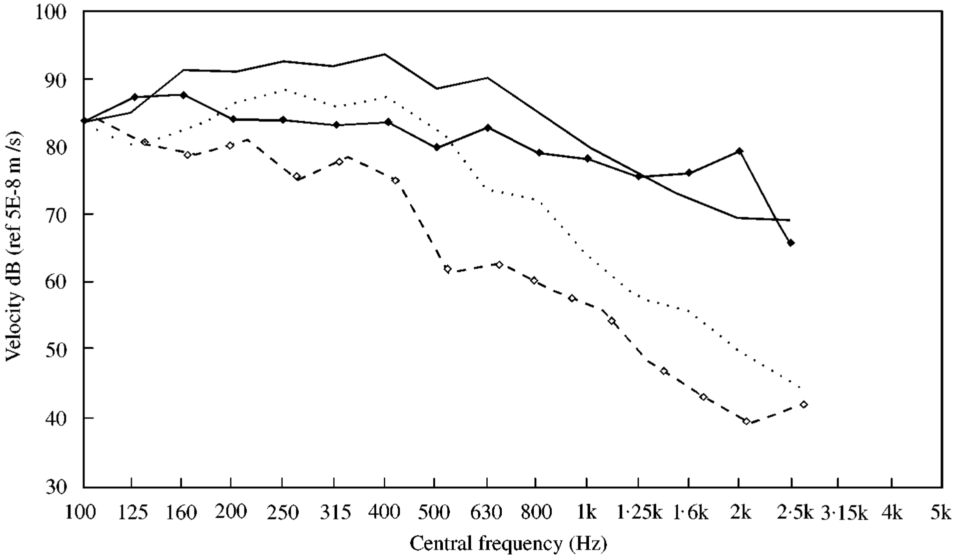

Figure 3. Bridge girder velocity—one-third octave spectrum at the centre of bridge with Tangara trains: –♦–, Rolled steel, vertical; --◇--, VIPA, vertical; ———, Rolled steel, lateral; ····, VIPA, lateral.

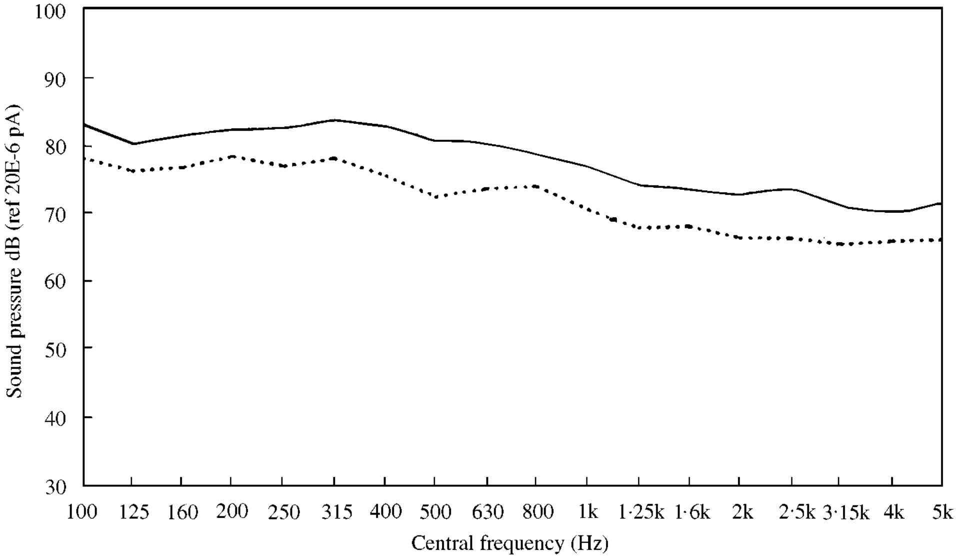

Figure 4. Wayside noise—one-third octave spectrum at 5·5 m at the centre of bridge with Tangara trains; ——, rolled steel, -----, VIPA.

directions. Accelerations were measured using B&K type 4371 and 4370 accelerometers, with B&K type 2635 charge amplifiers. Since radiated noise power from structural vibration is proportional to the mean-square surface velocity, results are presented in terms of velocity levels. The conversion was made by dividing by angular frequency after spectrum analysis.

Bridge girder vertical and lateral velocities data recorded have been analyzed to give the one-third octave band frequency spectrum. The girder velocities on the rolled steel plates track and the VIPA baseplates track at the centre of bridge are shown in Figure 3. The bridge girder vibration velocity with VIPA baseplates track is 10 dB(A) lower in the vertical direction and 5 dB(A) lower in the lateral direction than that on the rolled steel plates track (Figure 2).

Sound pressure level was measured at two positions, at 5·5 m from the track centre (1·2 m above rail head) and under the bridge (2·0 m below rail head), using B&K type 4189 microphones with B&K type 2669L microphone pre-amplifiers. The signal from pre-amplifier output was amplified to a suitable voltage level using B&K type 59351 dual microphone power supply. Digitally recorded signals for the noise measurements on the track were transferred to a computer and analyzed to obtain the frequency spectrum, and the linear and A-weighted levels. Sound pressure levels were also analyzed using B&K type 2260 analyser with BZ7202 software. The one-third octave noise spectrum at wayside at the bridge centre is shown in Figure 4.

3. CONCLUSIONS

The measurements have shown that the installation of resilient Pandrol VIPA baseplates on a particular steel bridge in place of rigid baseplates resulted in a reduction of wayside noise of 6 dB(A). It seems clear that the level of any noise reduction on a steel bridge which follows from the installation of resilient baseplates will depend on a large number of factors. However, the results of these tests show that under the right circumstances, significant reductions can be achieved by this means. This is important because the installation of resilient baseplates will in many circumstances be a relatively inexpensive option.

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