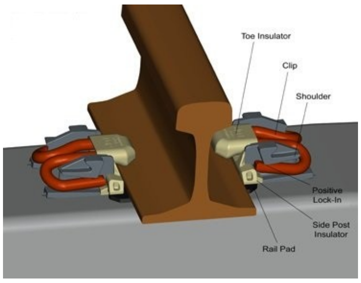
Railway noise mitigation factsheet 06: Viaducts and bridges

1.1 Overview

Bridges and viaducts are a necessary part of railway infrastructure to support tracks over roads, rivers and channels; however they produce increased levels of noise radiation because of the rolling noise radiated by the wheel and track, and vibrations generated at the wheel-rail interface which propagate into the bridge structure (Kostli *et al*, 2008; Venghaus *et al*, 2012). The vibration response of the components of the bridge is another potential source of noise.

The elevated nature of the structure means that the noise is not subject to ground absorption effects; this combined with increases in wind speed at height means that noise will propagate further from the source, particularly for receivers downwind from the source.

A variety of different approaches have been used to mitigate against noise on bridges and viaducts. These include:

- 

  Resilient rail fasteners (the devices used to secure the rail to the sleepers) and **rail pads** (used when rails are attached to concrete sleepers rather than timber sleepers; they are designed to reduce fatigue cracking of the concrete caused by impact and vibration from the passing train);

- **Floating ladder tracks** (where the track is laid on longitudinal supports (ladder sleepers) with transverse connections holding the two rails at the correct gauge distance) and **slab tracks** (ballastless track, where a concrete is used as the track-bed rather than ballast and the rails fastened directly to the track-bed);

- **Noise barriers;** height constraints mean that only wheel/rail and powertrain noise sources are likely to be screened.

1.2 Mitigation modes

Resilient rail fasteners act by isolating the vibration of the bridge structure from the rail therefore reducing noise. (Australian Rail Track Corporation Ltd, 2006).

Floating ladder and slab tracks are particularly effective at mitigating noise because they have a high bending rigidity of the ladder sleepers in the longitudinal direction, which help to disperse the wheel load. A low stiffness support of the track by resilient materials reduces the transmission of vibrations (Watanabe *et al*, 2012).

Mitigation modes for noise barriers are discussed on Factsheet 02, 'Full-height noise railway barriers'.

1.3 Design of mitigation measures

Resilient rail fasteners are fastened to the baseplate using clips and stiff rail pads. The acoustically important component is the baseplate pad, which separates the rail from the bridge structure. The assembly is fixed to a bridge by means of anchor bolts and coil springs.

Floating slab tracks consist of a reinforced concrete deck, which is supported by resilient materials in a heavy mass spring system; an example by Watanabe *et al* (2012) is being prepared for use in urban areas in Japan. The installation of a slab track often involves a complex system of crossbeams on rubber bearings under the ends of 10m length concrete bridge decks with a damping layer and ballasted track on top (Wilson, 2004). Figure 3 shows an example of a floating slab track viaduct design constructed by the Kowloon Canton Railway Corporation intended for trains travelling at speeds of up to 140 km/h; the viaduct is 21km in length

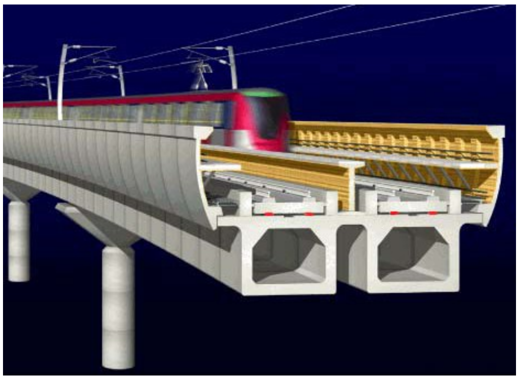
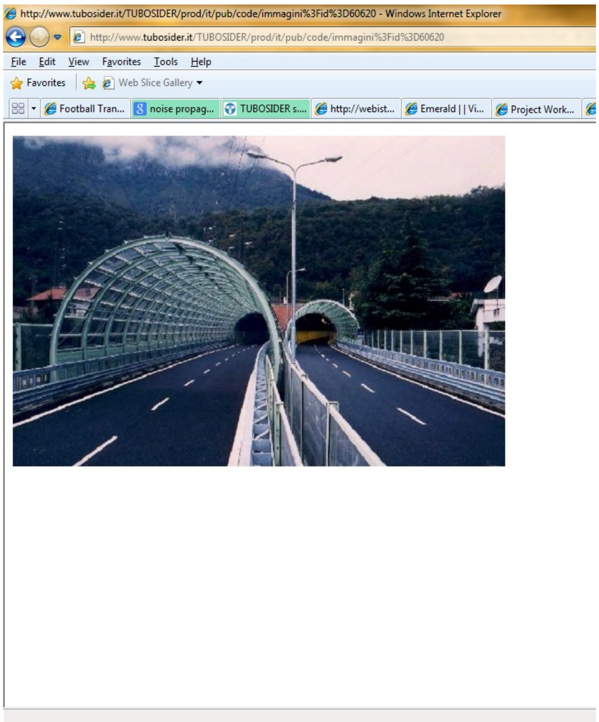


Figure 3: Kowloon Canton Railway Corporation viaduct in Hong Kong with floating slab track, absorptive noise barrier and under-walkway absorptive plenum (from Wilson, 2004)

Noise barriers on bridges and viaducts are generally limited to heights of 2-2.5 m due to fixing and wind loading constraints. This height restriction can be overcome to some extent through the inclusion of an additional barrier in the centre of the viaduct. In the case of HS2 this may be less of an issue since all bridges and viaducts are likely to be new-build, so that it may be possible for the design of higher barriers to be taken into account. For high-speed rail, the barriers will also have to be designed to take account of the cyclic dynamic loading caused by the repeated aerodynamic pressure and suction of passing trains. It is noted from Factsheet 02, 'Full-height railway noise barriers', that barriers in excess of 4m high may be required to screen aerodynamic noise sources on the top of the train. No examples of barriers of this height have been identified in use on viaducts. If such barriers are feasible, it would be necessary to design the outer surfaces of the barrier as an architectural feature to minimise the visual impact of the structure.

The use of partial or full covers, effectively creating canopy or tunnel-type structures, has been demonstrated as being suitable for highway use (Figure 4(a) shows an example of a cover on the SS36 near Monte Barro in the neighbourhood of Milan, but no examples have been presently identified on railways; Figure 4(b) shows an example of a partial noise barrier cover where the barrier extends over the first two lanes of the road. Both examples use transparent materials) but no evidence has been found of such structures in use on railway lines.



(a) Transparent cover on the SS36 near Monte Barro in the neighbourhood of Milan (Photo: Tubosider)

(b) Transparent canopy

Figure 4: Example of full and partial covers on highways

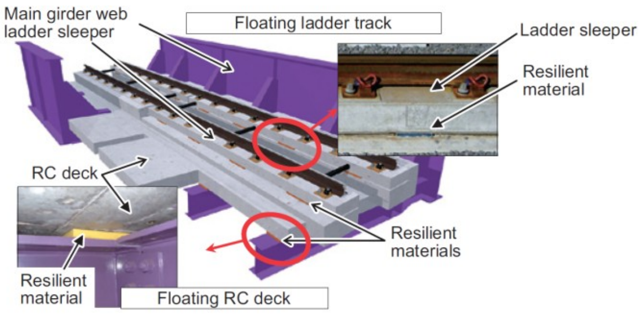
1.4 Indicative performance levels

Developments in the design of rail fasteners have been shown to provide a noise level reduction of about 8 to 10dB; Wettschureck and Diehl (2000) tested a resilient rail fastening system with "dynamically soft" baseplate pads on a steel railway bridge in Berlin, Germany carrying light rail vehicles. They found noise reductions of approximately 8 to 10dB in the frequency range above 125Hz for receiver positions directly under the viaduct and reductions of 5-6 dB(A) for the same frequency at a measurement position at a residential property 27m away, 3m below the rail height and 6m above ground. The overall change in noise level at the residential property was 6 dB(A).

Kostli *et al* (2008) looked at the installation of elastic rail fasteners on a twin track, ballastless steel bridge with steel and timber sleepers in Switzerland, used by trains passing at 72-77km/h. by the Swiss Railways (SBB). The fasteners were tested on a bridge over the river Emme at Burgdorf, which is a ballastless steel bridge with timbers between the rail fastener and the bridge. The fasteners showed a clear noise reduction for the frequency range from 80 to 400 Hz of about 10 dB and a reduction in overall noise levels of 2-4 dB(A).

Wang *et al* (2008) focused on the Arsta Bridge in Stockholm where baseplates were installed and the stiffness of the fasteners reduced in stiffness. They found significant decreases in noise level for frequencies less than 500Hz with reductions of more than 10dB (A) in some frequency bands, for commuter train passages at 70 km/h.

Floating slab tracks can also produce noise level reductions in the field of about 10 dB(A); Watanabe *et al* (2012) discussed the development of a new steel railway bridge with double floating system in Japan (Figure 5). Theoretical calculations and field tests showed that the vibration velocity noise levels for this new design, for train passages at 40 km/h were reduced by 10.5dB (A) at the main girder webs compared to a steel railway bridge tracks fastened directly to the bridge.



1.5 Illustrative costs

No generalised cost information is presented for noise mitigation on viaducts and bridges, due to the significant number of different factors, including location and terrain profile, ground conditions, design, etc. that would need to be taken into consideration.

1.6 Benefits and dis-benefits

The **benefits** of mitigation strategies for bridges/viaducts can be summarised as follows:

- Resilient rail fasteners are a cost-effective solution to noise and vibration.
- Floating slab tracks can be adapted for many different rail situations and generally do not require much maintenance and are designed for high longevity.

The **disbenefits** of mitigation strategies for bridges/viaducts can be summarised as follows:

- Some mitigation strategies can increase the static mass of the bridge construction, which then requires additional measures of reinforcement to be installed.
- There are few examples of these noise mitigation measures for structures on high speed rail although the floating slab tracks have been identified as being suitable for high speed trains.

- There may be potentially adverse visual impacts from the presence of noise barriers on viaducts; considerable care would have to be taken during the design process to overcome these impacts.

1.7 Suitability for use on HS2

The HS2 route identifies a single 3.6 km long viaduct over the Grand Union Canal and the River Colne, approximately 15 m high. Residential areas are observed to the north east (approximately 750m away) and to the south west (approximately 500m away) of the viaduct. It is recommended that noise mitigation be considered as part of the design of the viaduct; the mitigation measures outlined in this Factsheet are all potentially suitable for application on this viaduct.

1.8 References

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