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INVESTIGATION INTO THE ANNOYANCE OF CATTLE GRID NOISE

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Cattle grids are used in peri-urban and rural areas to prevent livestock and wildlife from entering controlled areas, such as towns or residential estates, without compromising their ability to roam freely. Typically they consist of a series of metal bars across the road that are spaced such that an animal's feet would fall through the gaps if it attempted to cross. Below the grid is a shallow pit that is intended to further deter livestock from using that particular crossing point. Cattle grids are employed widely in the UK at the entrance to public land, such as common and open access areas and also extensively on private drives and country estates. The sound produced by vehicles crossing these devices can be disturbing to residents living close by, riders and their horses, people using the area as a restorative environment and people using it for recreation. As urban development extends ever further into the UK's 'green belt' there is a need to accurately establish the acoustic impacts of cattle grids. For this reason and due to the lack of available scientific information on the size and nature of the problem, measurements and recordings were made at six sites in Yorkshire (UK). In addition questionnaire surveys of residents living close to cattle grids were conducted and façade measurements taken. Results show that there is a wide variation in the maximum noise level produced by cattle grids of apparently similar design. It was further established that some residents living close to the cattle grids were disturbed by the noise and vibration and wanted them removed or modified. Means of reducing the problem are proposed.

Keywords: cattle grids, impulse loading, green belt

1. Introduction

Cattle grids are widely used to prevent animals from leaving unfenced farmland or moorland and venturing into more controlled spaces where access to the road is prevented by walls, fences or hedges. Within the United Kingdom (UK) cattle grids are often located on the urban-rural fringe and in areas of public amenity, such as National Parks, ancient commons and Areas of Outstanding Natural Beauty (AONB). These devices typically consist of a grid or regularly spaced metal bars that are placed above a shallow pit. They are designed such that an animal's leg would fall through the grid if attempts were made to cross it. Design guidance for cattle grids is set out in BSI 4008 2006 [1], which states that the individual bars that make up the grid should be spaced at 130 to 150mm range and that the running surface of the bars should be 30 – 40mm wide if of a rectangular section. Installations within the UK that are located in areas of 'common land' are covered by Section 38 of the Commons Act 2006 [2] and those elsewhere by Section 82(6) of the Highways Act (1980) [3].

Noise associated with vehicles crossing cattle grids is typically characterised by a low frequency 'brrrr' that is incongruent with the rest of the soundscape. This, and the accompanying low frequency vibration emitted from transiting traffic, are the two most common complaints that Local Authorities receive about them. Moreover disturbance to peace and quiet and to the overall tranquillity of a location by the installation, or pending installation of a cattle grid, is a concern that is regularly reported in the press and frequently articulated to the UK Government's Department of Transport inspectors during public consultations.

In 2007 a Public Enquiry was held following objection to the installation of cattle grids in the ancient Devonshire tin mining town of Chagford, which is situated at the heart of Dartmoor National Park. Here local residents complained that the noise emitted from the grids would contain jarring metallic sounds that would not only disturb the overall tranquillity of the area, but also the nature and character of local heritage sites [4]. In 2013 similar concerns were raised on Chailey Common in East Sussex, where local residents reported that the sound of cars 'clanking' over the cattle grids was so bad that their sleep was permanently disrupted [5].

Not all of the concerns about cattle grids raised in the examples given were upheld at either the local or central government levels. What they do show however, is that health and quality of life issues are often overlooked when proposing, installing or maintaining cattle grids. This position is supported by a news article that was instrumental in starting the present study. The press reported the plight of a complainant living within 50m of a cattle grid who had recorded sound pressure levels in his garden as high as 107.7dB, emanating from some of the 5800 vehicles that cross the grid every day [6,7]. He complained that the noise has significantly compromised his family's right to peace and quiet and a decent night's sleep, and a neighbour complained about permanently feeling vibrations passing through his body.

The noise emitted from vehicles crossing cattle grids is predominantly low frequency in nature with the relatively discrete impact tonals of the front and rear wheels falling <100 Hz. A reasonable amount of research into the impacts of low frequency noise on health and well-being has been carried out over the last 35 years, much of which has sought to establish a link between annoyance and infrasound, i.e. noise at frequencies below the accepted lower limit of hearing (<20 Hz).

Moller (1984) [8] reported a study that over a 3 hour period exposed subjects to 4 infrasound conditions. These were 2 x traffic noise and 2 x quiet control conditions at two different intensity levels. The playback level of traffic noise was 70.9 dB, which equated to LAeq and the control condition was approximately 35 dB(A). The aim of the research was to establish the extent to which infrasound induced physiological and psychological responses in the subjects being tested. He concluded that infrasound slightly above the hearing threshold resulted in the feeling of pressure on the ear, which resulted in a high rating on the psychological annoyance scale, but that infrasound did not cause any of the other physiological parameters being tested, namely headache, nausea, tiredness or dizziness and that it had no influence on the circulatory system. However, what the results of his Analysis of Variance (ANOVA) did show, was that Road Traffic Noise (RTN) caused higher ratings of dizziness than either of the infrasound conditions and the quiet condition ($p<0.05$), that subjects were very annoyed by the traffic noise and associated rumble of the audible infrasound ($p<0.001$) and that RTN resulted in an increased occurrence of headache regardless of whether infrasound was audible or not ($p<0.001$). These findings are of interest to the study being reported in that the complainants discussed above had all been exposed to prolonged periods of low frequency RTN, which despite being impulsive in nature, and not knowingly infrasonic, was similar to the dB level presented by Moller. Further comprehensive information on the effects of low frequency noise can be found in

[9], which was published by the UK Government's Department of Environment, Food and Rural Affairs (2003).

The aims of this preliminary study were to investigate the size and nature of the problem and evaluate the effects on residents living close to cattle grids. It was expected that the results would be of use in further more detailed engineering, and psychoacoustic studies.

2. Methodology

2.1 Outline of approach

The methodology employed in this research is explained in detail in Watts et al (2016) and Watts et al (2017) [10, 11], therefore in the interests of brevity only an overview has been provided.

Roadside measurements of vehicle noise were carried out at 5 sites in West Yorkshire (2 near Baildon and 3 sites in Ilkley) and at 2 sites on the A684 east of Sedbergh in the Yorkshire Dales National Park. Vehicles selected for inclusion within the study were those that were freely moving and not in close proximity to other modes of transport. Measurements were also carried out using a test vehicle passing at a fixed speed for accurate comparison of noise produced across sites. Finally, façade measurements at homes where residents were affected by the noise from cattle grids were also taken.

The approach adopted included roadside measurements of the maximum noise produced by vehicles crossing the cattle grids in both directions, where safe and practical to do so, and recordings of the sound produced by a test vehicle for later analysis. LAmax was the preferred measure as the nature of the sound was less than a half a second in duration. All sites were on minor single carriageway roads where average vehicle speeds were generally in the range 40 to 50 km/h. For the purpose of characterising the noise produced a Bruel and Kjaer sound level meter type 2250 was used for capturing maximum A weighted levels using fast averaging LAmax and additionally for recording a few seconds from a test vehicle cruise-by for post processing.

2.2 Measurement of noise selected from passing traffic

The method employed was guided by the statistical pass-by standard of measurement method described in ISO 11819 - 1[12]. Due to restricted level ground at the sites the distance to middle of the nearside lane was fixed at 5m and not 7.5m as given in this standard. The approach speed to the cattle grid was measured using a radar speed meter (Bushell Velocity speed gun) positioned close to the edge of the carriageway. A sample of between 60 and 110 vehicles were obtained on the higher flow roads, but on roads carrying very little traffic it was only possible to sample between 10 and 40 vehicles. Measurements with a test vehicle were made at all sites. All measurements were conducted with a wind speed less than 2m/s and background noise levels were low <55 dB(A). Where possible measurements were also made on adjoining road surfaces (i.e. without cattle grid) with the test vehicle.

For the purpose of making detailed comparisons of the noise produced from different installations a test vehicle was used and driven over each cattle grid at a speed of 40km/h. The test vehicle, a Toyota Yaris, was a front wheel drive compact and had a wheelbase of 2.44m and a kerb weight of 830kg. The crossing speed was chosen to be close to the average observed crossing speed across sites of vehicles in the traffic stream. More detailed information relating to the calibration of the test vehicle can be found in [11].

2.3 Noise and vibration annoyance questionnaire

To determine the size and the nature of annoyance questionnaires were posted to homes within an approximate radius of 150m from cattle grids located in residential areas. Within the study these locations were referred to as Baildon (A) and Ilkley (A) both of which are shown in Figure 1. The questionnaires sought to establish annoyance values for noise and vibration and also provided residents with the option of having facade measurements taken on their property. The distances that residential properties ranged from the cattle grids was 7.7m – 122m.

Figure 1: Baildon (A) and Ilkley (A) cattle grids

3. Results and analysis

Plots were made of the captured LAmax against crossing speed for each installation. Measurements taken of vehicles travelling in the far side lane were normalized to a distance of 5m to enable comparison. For this purpose a simple correction based on hemi-spherical spreading was used i.e. 10 log10 [(5/d)2] where d is the distance to the middle of the far side lane (in range 7.5 to 8m).

Figure 2 shows a plot of LAmax against speed for the cattle grid at two contrasting sites, the entrance to Baildon Moor (Baildon A) and on the A684 in North Yorkshire east of Sedbergh (Sedbergh A). In both cases measurements were made in the nearside lane. It can be observed from the fitted regression line that the predicted mean LAmax levels at Sedbergh are significantly higher than is the case for the site at Baildon. Note that the correlation coefficients were similar whether the actual speed or logarithm of the measured speed were used. Therefore it was decided to use the measured speed.

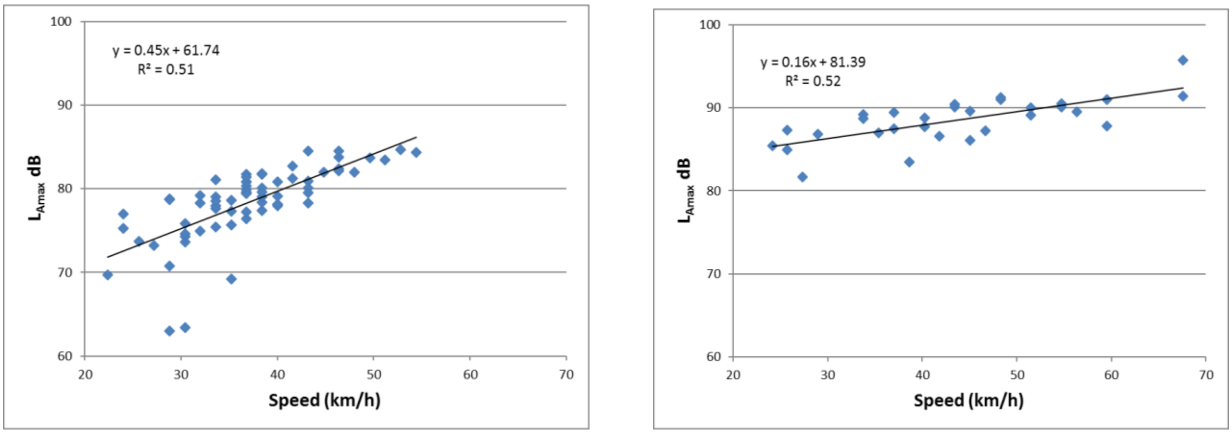


Figure 2: LAmax against crossing speed at Baildon (A) and Sedbergh (A)

For comparison purposes a speed of 40 km/h (25mile/h) was chosen across all sites as it was close to the overall average crossing speed (44 km/h). Regression analyses were carried out on the data for each site and the predicted mean LAmax at 40km/h.

3.1 Comparison of speed and maximum noise levels

In order to investigate the effects of crossing speed on LAmax in more detail a series of measurements were made with the test vehicle on a quiet residential road (Ilkley C). The purpose was to determine if significant speed restrictions down to as low as 8km/h would have a significant effect on recorded maximum levels. It was considered that such traffic calming restrictions could be an option for controlling cattle grid noise in more sensitive areas.

Measurements were conducted at crossing speeds between 8km/h and 48km/h in 1.6km/h (1 mile/h) increments. As a control, measurements were also made on the road surface approximately 50m from the cattle grid. Due to a wide speed range it was found that a logarithmic speed scale gave a slightly better fit with recorded LAmax, than did a linear scale. Figure 3 shows this relationship with speed for both cattle grid and control measurement sites. The relationships are close with R^2 values of 0.91 and 0.89 for the cattle grid and control datasets.

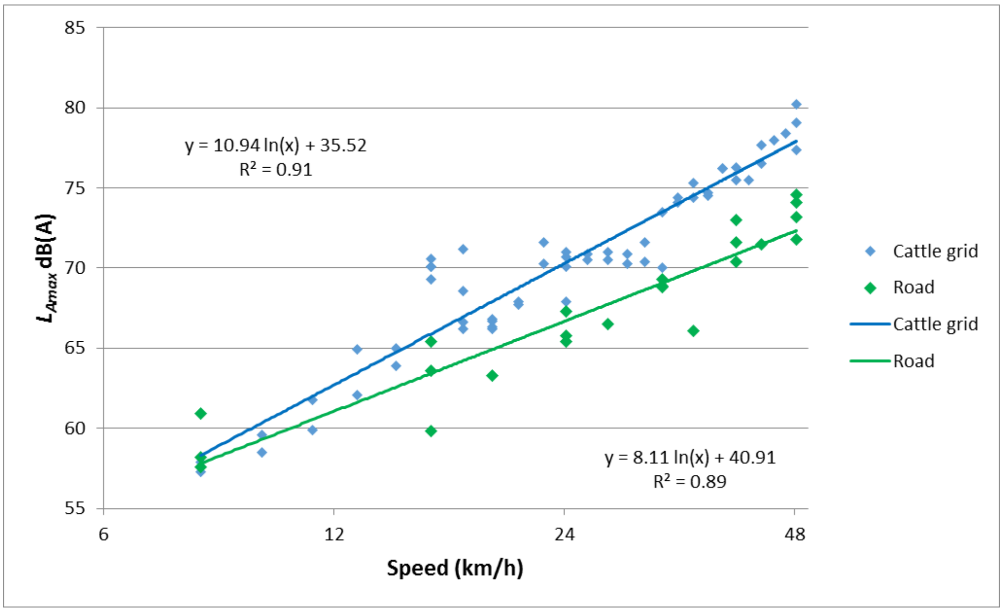


Figure 3: Variation of LAmax with speed on cattle grid and control road surface

Some of the scatter in values of LAmax particularly at lower speeds may be due to variations in engine noise depending on the low gear selected and possibly the electric fan cutting in and out. Despite these scattered points it can be seen that the trend in the difference between maximum levels produced on this cattle grid and the control reduce steadily with speed. At 48 km/h this difference is 5.1 dB(A) while at 8 km/h there is no significant difference (< 1 dB(A)).

3.2 Questionnaire results

A total of 13 questionnaires were received from the 26 that were delivered to the two cattle grid installations with houses close by, i.e. Baildon (A) and Ilkley (A). The questionnaire replies are summarized in Figure 4 below, which clearly shows that there is a tendency for ratings of annoyance to decrease with distance. The amount of screening of a property by other buildings or local topography would have a significant effect on the peak noise levels and consequently on the level of any annoyance caused so that a simple relationship was not expected. Of the 13 questionnaires completed 2 households (Baildon (A) at 32.5m and Ilkley (A) at 7.7m) reported feeling vibration in addition to noise. This inevitably resulted in a higher degree of annoyance.

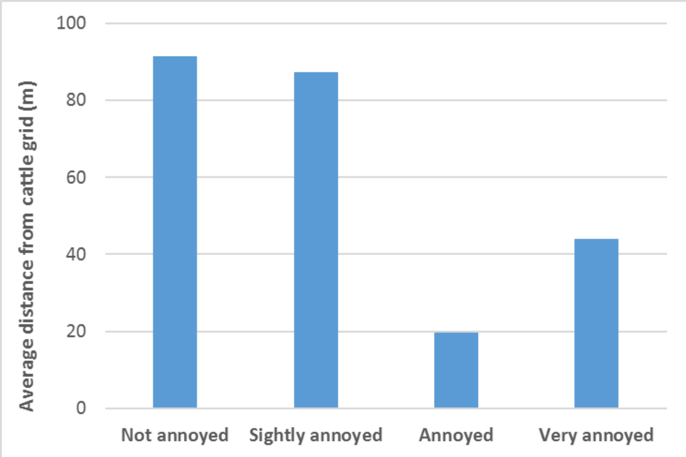


Figure 4: Average distance for different levels of rated annoyance

4. Discussion

The survey of local residents living close to the cattle grids at Baildon (A) and Ilkley (A) was limited due to the poor response rate (50%), but for those who replied it did indicate a significant problem due to both noise and vibration. As expected those living further from the cattle grids tended to be less annoyed, but individual sensitivities did mean that one resident living at a distance of 92m was very annoyed by the noise.

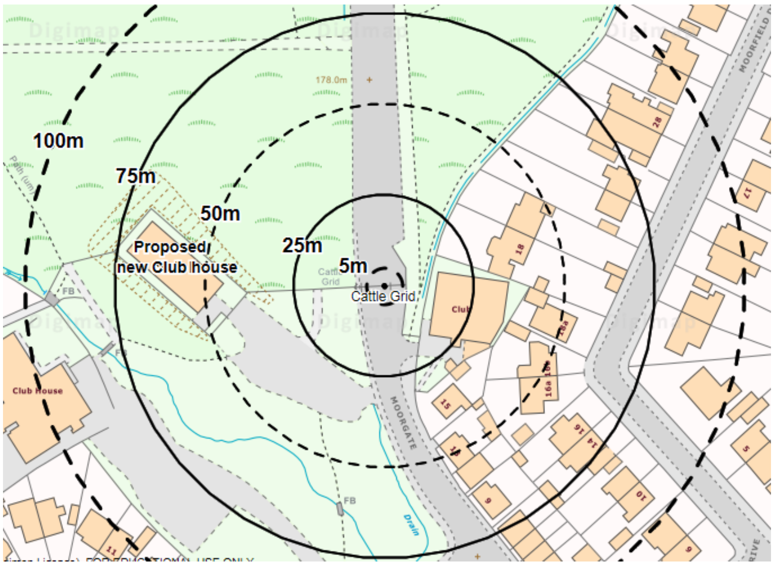
The problem in this case appeared to be night-time disturbance that resulted in the original complaint that prompted this study [6]. Such occurrences are covered by World Health Organisation (WHO) guidelines for community noise exposure [13]. These have set a LAmax limit of 60 dB(A) outside bedroom windows. From Figure 5 and it can be seen that the residential property closest to the cattle grid (32.5m) exceeds this limit. The same is true for residents living within 7.7m of Ilkley (A) grid. The base data (5m) presented in Figure 5 were obtained from the test vehicle passing over the cattle grid at a constant speed of 40 km/h (25mph), however, at greater speeds and with different vehicles, significantly increased LAmax values are possible.

As was noted at the Baildon (A) site an increase of LAmax with speed is on average 0.45 dB(A) per km/h increase. So with a crossing speed of 54 km/h (33mph) on average the LAmax would be expected to increase by over 6 dB(A), taking it to 85.3 dB(A) and sufficient to exceed the recommended WHO guideline value at night for all properties within 50m. This issue is of particular concern during night time as many cars speed out of the village and onto Baildon Moor, where they tend to congregate. Using an average LAmax value of 90 dB(A) at 5m from the Baildon (A) cattle grid and applying the distance attenuation relationship discussed above, it can be seen from Figure 5 that the 60 dB(A) WHO guideline value extends beyond 100m. This potentially impacts on more than 20 properties within line of sight of the cattle grid.

A further consideration is that the low frequency impulse sound produced is tonal in nature, which can add significantly to the level of disturbance experienced. For example, in BS 4142 [11] in the case of industrial noise with tonal character affecting residential properties, a penalty of up to 6 dB(A) has been specified while for impulsive noise a 9dB(A) adjustment is possible. However, it is unclear to what extent these corrections apply to short duration sounds where LAmax levels are being recorded. There were two cases in the small sample of 13 where both noise and vibration produced by vehicles crossing the cattle grid was noticed. In these cases the assessed annoyance was at the highest i.e. rated as “very annoyed”. However, more generally it has been shown that where both noise and vibration are experienced both additive and interaction effects can occur, so there is the potential for these higher levels of annoyance [12].

4.1 Potential impacts on future developments

From Figure 5 it can be seen that approximately 60m west of the Baildon (A) cattle grid is a building annotated as the ‘proposed new club house’ and that approximately 40m south west of this building is the original golf club. In January 2016 Bradford Metropolitan District Council granted planning permission to the golf club (application 14/00591/NMA01) authorising it to demolition the existing club house and in its place build 5 new houses. In addition the Local Authority approved the demolition of the building annotated as the ‘proposed new club house’ and authorised the construction of a new 2 story club house in its place. In its current position patrons of the golf club, which regularly include wedding and funeral gatherings, are currently experiencing around 53 dB (LAmax) for vehicles crossing the grid at 40km/h and around 64 dB(A) for vehicles with a datum value at 5m from the grid of 90 dB (LAmax). When the new houses are erected on this site it is anticipated that these values are unlikely to change significantly. However, patrons of the new club house, which is to be orientated in more northerly direction than the existing building and includes a 2nd floor terrace overlooking the moor and gold course, are going to be within approximately 60m of the cattle grid. Noise exposure in this new location will be around 60 dB (LAmax) for vehicles crossing the grid at 40km/h and around 70 dB(A) for vehicles with a datum value at 5m from the grid of 90 dB (LAmax).



	LAmax	
5m datum	79.3	90.0
25m	65.3	76.0
50m	59.3	70.0
75m	55.8	66.5
100m	53.3	64.0

Predicted figures are based on a passage time <0.5sec. The observed passage frequency at 40km/h was identified as 45.5Hz.

Figure 5: 25m concentric circles radiating from Baildon (A) cattle grid with associated LAmax values

Given the difficulty in attenuating low frequency RTN using noise control devices, it is likely that patrons using the new club house will experience high levels of noise and vibration annoyance, especially when trying to enjoy the outdoor terrace on summer evenings.

A potential solution has been proposed by Watts et al (2017) [11], that involves raising the cattle grid 75mm above the road surface with ramps 1850mm long on either side, creating a profile that would be similar to that recommended for a regular flat top speed control hump used in the UK. Such humps produce an expected crossing speed for light vehicles in the region of 24 km/h (15mph). Figure 6 shows a suggested design in plan.

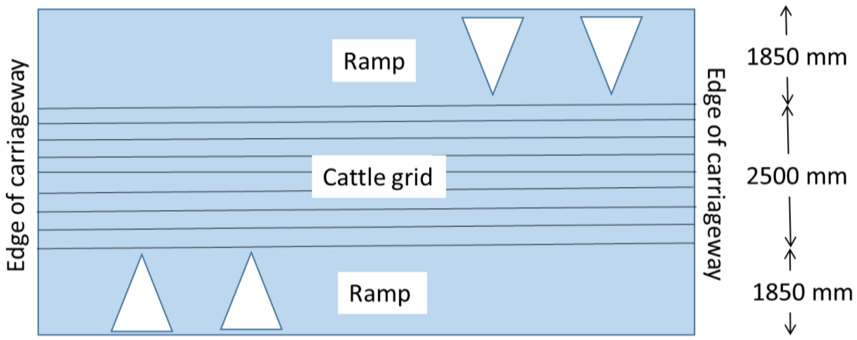


Figure 6: Plan view of proposed cattle grid hump

5. Conclusions

Noise from cattle grids is a long standing problem within the UK and one that is getting worse with urban sprawl and the associated increased levels of traffic. The low frequency nature of the noise emitted from vehicles crossing these devises is difficult to mitigate and causes significant sleep disturbance to those most affected by it. None of the cattle grids that were included in this study conformed to the British Standard (BSI 4008 2006) [1] and the one most discussed, (Baildon (A)), had an anti-skid treatment applied to the cross bars, which potentially contributes to the feeling of vibration experienced by those in the immediate vicinity. Future research into the psychoacoustic qualities of the noise emitted in terms of annoyance is required..

REFERENCES

1. British Standards Institution: BS 4008:2006. Specification for cattle grids. London: BSi; (2006).

2 UK Government (2006). Commons Act (2006).

3 UK Government (1980). Highways Act (1981)

4 Report to the Secretary of State for Transport, Devon County Council (2008). Proposal to install cattle-grids in the Chagford area at Runnage Bridge, Langaford Bridge, Higher Stiniel and Weddicott cross

5 Mid Sussex Times (2013). Shockingly noisy cattle-grids are destroying peace on the commons

6 Telegraph and Argus (2013). Plea for relief from Baildon cattle-grid noise

7 UK Highways Agency (2009). Post Opening Project Evaluation. A650 Bingley Relief Road Five years after study.

8 Moller, H. (1984). Journal of Low Frequency Noise, Vibration and Active Control. Physiological and Psychological Effects of Infrasound on Humans 3(1).

9 UK Department for the environment, Food and Rural Affairs (Defra) (2003). A Review of Published Research on Low Frequency Noise and its Effects

10 Watts, G., Pheasant. R and Khan. A. (2016). Noise and disturbance caused by vehicles crossing cattle grids. Applied Acoustics 116, 87-93.

11 Watts, G., Pheasant, R. and Khan, A. (2017). Investigations of noise and disturbance from vehicles crossing cattle grids and examination of options for mitigation. Applied Acoustics, 116, 87-93.

12 ISO 11819-1:1997, Acoustics - Measurement of the influence of road surfaces on traffic noise - Part 1: Statistical Pass-By method", International Standards Organisation, Geneva, 1997

13 World Health Organisation (WHO), Guidelines for community noise, ed Berglund B, Lindvall T and Schwela D. WHO, Geneva, 1999.