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Ministry of Transportation and Highways

NOISE CONTROL EARTH BERMS

Guidelines for the Use of Earth Berms to Control Highway Noise

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Highway Engineering Branch

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Background

Since 1989, the Ministry of Transportation & Highways of B.C. (MoTH) has had a noise impact mitigation policy which applies to all new or upgraded freeway and expressway projects. This policy is intended to prevent excessive noise impacts at residences and educational facilities and requires that mitigation measures be considered wherever project-related noise increases are predicted to exceed certain limits. Where such mitigation measures are warranted, cost-effective and widely supported by the directly affected community, they are to be carried out. Mitigation measures generally take the form of noise barriers constructed within MoTH right-of-way. Three basic configurations are employed: walls, earth berms or berm/wall combinations. The MoTH policy limits the height of walls to 3 m, but no such limit exists for earth berms or berm/walls. Given their natural appearance and potentially lower costs, earth berms have often been the preferred form of mitigation where space is available.

Since the MoTH noise policy requires that mitigation measures achieve average noise reductions of 5 dBA or more, it is crucial that the relative noise reduction capabilities of the three forms of noise barriers be well understood. While experimental assessments to date have yielded mixed results, some highway noise prediction models assign a noise reduction bonus of 3 dBA to earth berms in recognition of their relatively broad and soft tops. To assess the validity of this "soft top correction" and to explore the effects of adding walls to the tops of earth berms, ***MoTH has funded research by the U.B.C. Mechanical Engineering Department (through the Professional Partnership Program) and Wakefield Acoustics Ltd.***

Results of U.B.C. Scale Modeling of Noise Barrier Performance

Mechanical Engineering graduate student Todd Busch, under the supervision of Dr. Murray Hodgson, developed a 1/31.5 scale model of a highway section in the department's anechoic chamber and tested a large number of noise barrier configurations. The key results of these experiments are listed below. Supplementary comments and interpretations by Wakefield Acoustics Ltd. are intended to assist MoTH staff in appreciating how these findings can be applied in the effective implementation of the Ministry's noise policy. Table S-1 illustrates the optimal forms which noise barriers should take in various situations while Table S-2 demonstrates the appropriate and inappropriate use of landscaping/vegetation near noise barriers.

1. Model earth berms with normal surfaces (i.e., representative of grass over soil) were found to provide ***about 2 dBA less noise reduction than walls of the same height and position.*** The poorer performance of berms is felt to be due to sound waves which strike the berm's inclined front face and are; 1. reflected/scattered towards the crest of the berm, or 2. transformed into "surface" waves at the air/berm interface and then propagate along the berm face, over its crest and into the sound shadow zone behind it.

2. Berms with more gentle slopes (e.g. 3:1 or flatter) will tend to more effective at both reflecting/scattering sound waves towards the berm crest and at fostering surface waves. They therefore may be expected to provide from 0.5 to 1 dBA less noise reduction than steeper (e.g., 1.5:1 and 2:1 slopes) berms of the same height and location.

3. The slopes of earth berms consume substantial space, so that berms cannot be built as close to the traffic (the noise source) as can noise walls. Since the performance of a noise barrier improves as it is moved closer to either the noise source or the receiver, this may give walls another performance advantage over earth berms. The magnitude of this advantage varies with source-to-receiver distance and with receiver elevation, but ***it can amount to another 1 to 2 dBA, bringing the total advantage of a wall over an equivalent berm of normal softness to 3 to 4 dBA.***

4. The top profile, or shape of the berm top, does not appear to significantly influence berm performance, with flat-topped and round-topped berms showing only a slight (about 0.5 dBA) advantage over wedge-shaped berms.

5. ***Berms with highly sound absorptive surfaces perform substantially (4 to 5 dBA) better than berms with normally absorptive grassy surfaces.*** This major improvement appears to result from the near total suppression of reflected/scattered sound waves as well as surface waves and from the additional absorption of energy from sound waves passing over the berm's very soft top. Berms with very wide flat tops should then perform better than those with narrower tops.

6. ***It appears then that the so called "soft-top correction" does exist, but only for berms with surfaces substantially more sound absorptive than normal grassy surfaces.*** It remains to be seen whether such surface can be achieved in practice. Some potential may lie in the use of light-weight admixtures such as vermiculite and pearlite or perhaps fine wood chips or bark mulch. The sound absorption capabilities of such materials in combination with soil need to be evaluated.

7. When walls were added to the tops of normal earth berms, rather than being diminished, the overall performance of the resulting berm/walls (for the same total barrier height), was improved by an average of 1.5 dBA for the various height and slope combinations tested. ***It appears that when a wall is used to elevate the barrier top above the berm surface, the berm-reflected/scattered sound waves have a greater tendency to cancel, or at least not reinforce, the direct waves at the top of the barrier. In addition, surface waves are prevented from propagating over the berm crest.***

8. ***Optimal berm/wall performance was observed when the wall comprised less than half the total barrier height***. For example, a 3 m high, 3:1 sloped berm with a 1 m wall on top gave the largest noise reduction (10.2 dBA) of any <u>normally sound absorpive</u> berm or berm/wall configuration tested.

9. ***Berm/walls then tend to perform better than pure berms of normal softness and similar to, or in some cases better than, pure walls.*** While it may be possible to "tune" berm/walls so as to achieve optimum sound cancellation at the barrier top and hence maximum noise reduction, this would require detailed analysis of site geometry, wall and berm height and berm slope and surface nature.

10. When a 1 m wall was added to the top of a 3 m high berm having a <u>highly sound absorptive</u> surface, the overall barrier performance was reduced slightly from 10.4 to 9.9 dBA - in spite of the total berm/wall height being 1 m greater than the pure berm. ***This indicates that the substantial benefit of applying a very soft surface to a berm is largely duplicated by the placement of a wall on top of a berm so that unfortunately the two effects do not appear to be directly additive.***

11. The presence of vegetation on the face of an earth berm or wall can have minor beneficial effects due to the absorption and scattering of traffic noise, however, on a plantable scale, vegetation does not provide an effective noise barrier. ***However if vegetation is allowed to overtop the crest of a noise barrier, it will cause sound to be scattered down in behind the barrier, thereby reducing its performance, particularly at higher frequencies where the barrier itself is most effective.***

1. Introduction

Background

Since 1989, the Ministry of Transportation & Highways of B.C. (MoTH) has had a noise impact mitigation policy (the revised 1993 version is summarized in Appendix A) which applies to all new or upgraded freeway and expressway projects. It is intended to prevent excessive noise impacts at residences and educational facilities and requires that mitigation measures to be considered wherever project-related noise increases are predicted to exceed certain limits. ***Where such mitigation measures are warranted, cost-effective and widely supported by the directly affected community, they are to be carried out.***

Figure 1.1: Noise Barrier Wall at Victoria's McKenzie Avenue Interchange

Highway project noise impacts can be avoided or minimized through thoughtful alignment selection. Active mitigation measures however, for impacted residences are effectively limited under the policy to the construction of noise barriers within MoTH right-of-way (<u>note</u>; the use of open-graded asphalt, or quiet pavement, is being considered for some projects).

Noise barriers have three basic forms: a wall, earth berm or berm/wall combination. For aesthetic and cost reasons, the policy limits wall heights to 3 m but no such limit exists for earth berms. Given their natural appearance and potentially low costs (where sufficient right-of-way is available), earth berms have often been the preferred form of mitigation.

The three basic types of noise barriers have varying capital costs, maintenance and right-of-way requirements and aesthetic implications, but these factors are readily ascertainable. Their relative acoustic (noise reduction) performance, however, has not been clearly established and some questionable "rules of thumb" have persisted for many years. Since the MoTH policy requires all mitigation measures to provide a minimum traffic noise reduction of 5 A-weighted decibels (dBA) - corresponding to about a 40% reduction in loudness - ***such uncertainty has been the source of some concern.***

To gain a clearer understanding of earth berm performance, the ***Highway Environment Branch of MoTH*** contracted with the ***U.B.C. Department of Mechanical Engineering and Wakefield Acoustics Ltd.*** to conduct a joint research effort. In 1994, the ministry entered a Professional Partnership arrangement with M.A.Sc. candidate Todd Busch to conduct, under the supervision of Dr. Murray Hodgson, acoustic scale-modelling of the traffic noise reduction performance of walls, earth berms and berm/wall combinations. Wakefield Acoustics Ltd. has provided direction and review of the lab research effort, conducted field assessments of existing earth berms and prepared these guidelines.

Intent of the Guidelines

These guidelines are intended for use by project managers, environmental management and roadside development staff, and other MoTH personnel ***who must integrate noise control concerns with the many other highway project design issues.*** They will hopefully be of assistance in:

- appreciating the acoustical strengths and limitations of noise barriers - earth berms in particular - and how these can be exploited to maximize noise reduction performance,

- constructing earth berms and berm/walls which optimize noise reductions while minimizing negative aspects such as capital costs, right-of-way, maintenance and aesthetic impacts.