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Assessment and relative sustainability of common types of roadside noise barriers

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ABSTRACT

There is increasing legislative and public pressure for the design and build of road infrastructure schemes to achieve better sustainability performance. Roadside noise barriers (RNBs) form a major part of the growing road infrastructure system in mitigating undesirable road noise to impacted communities. However, the relative sustainability of common RNBs is little understood in the research and industry literature. This makes it difficult for stakeholders to make informed decisions with regards to the sustainable design and procurement of RNBs. This paper presents nowel research carried out to assess and rank the relative sustainability of 13 RNB types using three multi criteria analysis (MCA) techniques, i.e. Simple Additive Weighting (SAW), Preference Ranking Organisation MeTHod for Enrichment Evaluations (PROMETHEE), and Elimination et Choice Translating Reality (ELECTRE III). The paper concludes that the presented sustainability rankings of the main RNB types from least sustainable to most sustainable will support the relevant stakeholders, involved in the planning, design, and procurement stages, to evaluate the sustainability of RNB options as either part of a large highways scheme or standalone project. The presented results will save significant analysis time and costs in cases whereby it is unfeasible to conduct MCAs. The presented sustainability asssessment methodology may also provide the basis for an industry sustainability certification sceheme and in turn support advancing the sustainability transport agenda.

1. Introduction

There is a growing need resulting from various legislative and public pressures for the design and build of road infrastructure schemes (and their supporting systems) to achieve better sustainability performance (Commission of the European Communities, 2001; 2011). Roadside noise barriers-RNBs (also referred to in the literature as Transport Noise Reducing Devices-NRDs, Sound Walls, Noise Walls, or Acoustical Barriers) form a major part of the developing road infrastructure system in mitigating undesirable road noise to impacted communities. The consideration of their sustainability in parity with traditional road schemes (e.g. the design and build of a single carriageway) is becoming increasingly difficult to ignore as RNB projects alone need to: meet key technical requirements, balance and address social and environmental impacts, incur high levels of expenditure which need to be justified, and involves a level of utilization of raw materials comparable to the road scheme itself. Indeed, in some cases the roadside noise barrier forms a major visual and functional component of the overall road scheme.

The need for the selection and design of a RNB system occurs in one of two scenarios: (1) when the acoustic model for a potential road scheme predicts the generation of surface road noise emissions to be at levels considered unsafe or of serious annoyance to the impacted community, or (2) the conditions of an existing track of road are or become such that transport noise emissions are at levels now consideredharmful or of serious annoyance to affected residents. In either case, several noise abatements options are available (e.g. quieter road surfacing, double glazing solutions to impacted properties, etc.), but the placement of RNBs are the most effective as they block the sound transmission path from the source to the receiver. Moreover, the need for RNBs is unlikely to decrease in the near future as surface transport noise is projected to increase over the next two decades beside traffic growth (e.g. Boer and Schroten, 2007; Organisation for Economic Co-operation and Development-OECD, 2008).

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Oltean-Dumbrava et al. (2012a,b) further details the significance of their impact as a typical installation of noise barriers in the UK may be as much as 2 km, or 4 km if both sides of the carriageway are treated. A typical height is 4 m which means that the total area of the erected noise barrier is 16,000 m^2. At an average installed cost of approximately £100/m^2 for a timber option (Watts et al., 2006) this amounts to a total resource cost of £1.6 m. Note that aluminium, wood cement and acrylic barriers would be approximately double this cost. If the barrier contains covers over the road then costs would be at least an order of magnitude higher. A public funded expenditure of this scale underlines the need for the sustainability of RNBs to be considered at all stages and, in particularly, during procurement where often the lowest installation cost has greatest weight in the decision process (Joynt and Kang, 2006). Fig. 1 highlights the complexity and typical scope of considering the sustainability of RNBs/NRDs. It shows the Sustainability Life Cycle Analysis (SLCA) system boundary developed by the authors of this paper for the purposes of conducting a whole life sustainability assessment of RNBs/NRDs projects that have as their main functionthe reduction of noise pollution.

The careful selection of justifiable noise abatement solutions will continue to be an important factor when it comes to sustainably developing, upgrading, and maintaining national road networks in the foreseeable future. Even so, there are many types of RNBs available for selection to the decision maker (DM) in either of the two previously described scenarios. However, there is at present a worldwide lack of decision support for the relevant stakeholders (e.g. engineering managers, local authorities, transport planners, consultants, contractors, etc.) tasked with selecting or designing a sustainable RNB for a given road scheme. Although approaches for assessing RNBs' sustainability have been established by Oltean-Dumbrava et al. (2016), there exists no relative and generic sustainability assessment and ranking of the main RNB types used around the world, and thereby forms the central axis and novelty of this paper. The paper, therefore, provides an account of the first research carried out to assess and rank the relative sustainability of 13 main RNB types via the application of Multi criteria analysis (MCA) techniques that assumes and demonstrates the criteria independence. It is apparent there are multiple and conflicting issues (as shown in Fig. 1) which need be integrated and objectively evaluated for relatively assessing and ranking the sustainability of the said RNB types. MCA techniques are able to solve such problems and so form the principle area of investigation in this paper for assessing and ranking the said RNB types. The presented research will thus support making more sustainable decisions for transport noise reduction which is consistent with advancing the overall transport sustainability agenda.

The paper begins by asserting the scope and limitations of the study and the 13 RNBs inferred as being the most commonly used around the world and hence selected for assessment and ranking. Then, the definition of sustainability for RNBs is stated and discussed in order to clearly state the aim of the MCA for assessing and ranking the said RNB types. The paper then proceeds to present the overall methodology adopted and stages carried out to assess and rank the sustainability of RNBs. The next section after that implements the described methods using generic sustainability data and three MCA tools (SAW, PROMETHEE, and ELECTRE 3) to assess and generate relative rankings of the main RNB types from the point of view of their overall sustainability performance, and overall performance per sustainability factor (i.e. social, technical, environmental, and economic performance). The section thereafter contains a discussion on the study's results, and the final section draws some conclusions on the research presented and its implications for improving the sustainable procurement and design of RNB projects for the industry.

1.1. Noise barriers selected and scope of the study

The primary function of a noise barrier is to reduce or shield impacted communities from undesirable or harmful surface transport noise generated by road traffic. Noise barriers are comparatively unique in comparison to similar scale projects as there is a significant scope for maximising their sustainability primarily through material selection. This is realised specifically

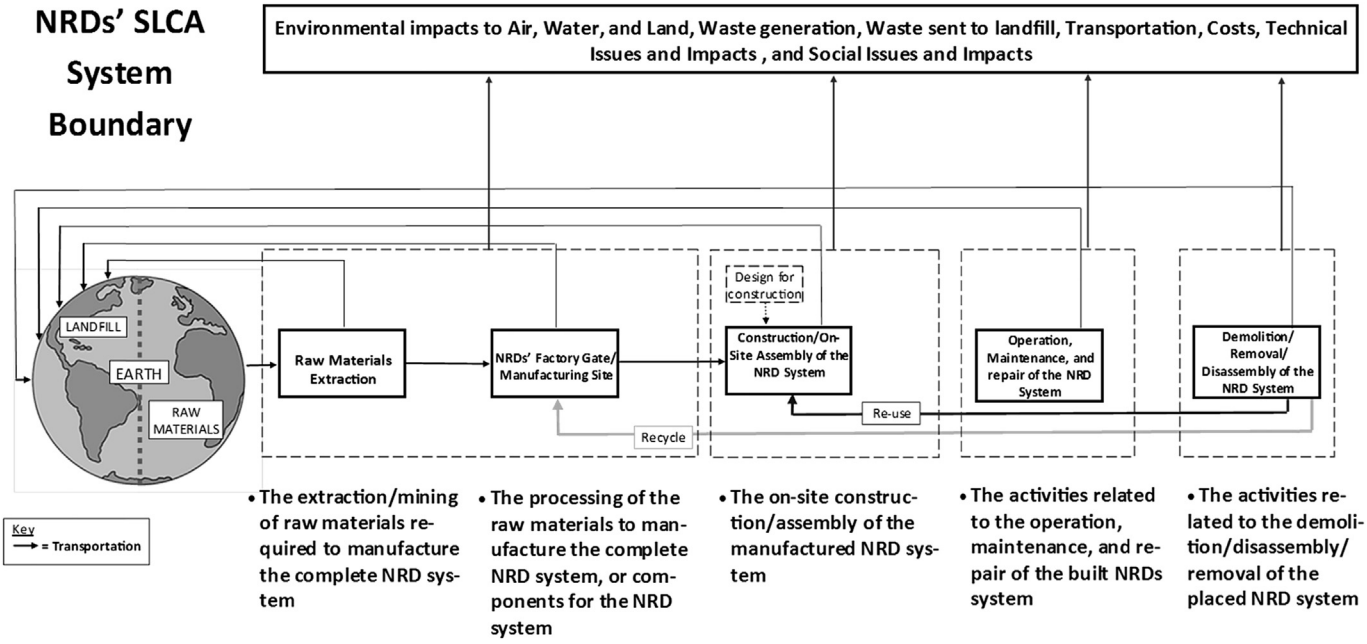

Fig. 1. The NRDs' sustainability life cycle assessment (SLCA) system boundary.
(Source: Oltean-Dumbrava et al., 2016).