Human response to vibration in residential environments: A seven year journey to establish exposure-response relationships

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INTRODUCTION

The project "Human Response to vibration in residential environments" is the culmination of seven years of research funded by the Department for Environment, Food and Rural Affairs (Defra) UK. The aim of the research was to investigate the relationship between human response in residential areas, primarily in terms of annoyance, and combined effects from exposure to vibration and noise. The project steering group for the project consisted of technical staff appointed by the Department for Environment, Food & Rural Affairs (Defra), and representatives of the British Standards Institution working group for BS6472 (Guide to evaluation of human exposure to vibration in buildings), and the UK Association of Noise Consultants (ANC) vibration working group.

This paper presents an insight into the role of the project steering group, the technical considerations made during the progress of the project, the interface with the three contractors who delivered the scoping stage, the pilot stage and the main study respectively, and a review of the results of the main study delivered by the University of Salford, and what they may mean for future technical and policy development on vibration.

PROJECT INCEPTION

Following written representations from the ANC in 2002 to Defra, a working group was appointed to explore the possibility of determining a dose-response relationship between vibration and human response in a residential environment. Defra agreed that the project was worthy of funding through the Noise and Nuisance Research Program, and appointed Richard Perkins of Parsons Brinckerhoff Ltd to manage the project, and to lead the steering group.

The first actions for the steering group were to consider the nature of the project, and the various technical requirements required of the appointed contractor. Following a series of technical workshops, during which the mechanics of vibration measurement and social survey techniques were debated at length, the steering group arrived at a final specification of work. The work would involve the development of a methodology to measure the vibration dose, a social survey questionnaire, and a methodology to undertake both in a field trial.

SCOPING STUDY

The Scoping study was let through a competitive tender to a consortium led by David Trevor-Jones & Associates in 2004. They developed a hypothesis to enable further consideration of the methodology for the study to be undertaken. The location and method of acquiring the vibration data was of particular relevance, and how to deal with extraneous data was debated. The various types of measuring equipment were analysed, and evaluated for their various merits for a study of this kind. The scoping study resolved a number of technical issues, such as whether measurements should be internal or external, and how to develop a robust method for analysing the data.

On the social survey side, questionnaires were trialled to test the various words used to describe vibration – whilst noise questionnaires are well established, little work had been done previously on the human response to vibration, so these had to be developed during the project.

PILOT STUDY

The Pilot Study was again let through a competitive tender to a consortium of Arup Acoustics, Temple Group, Transport and Research Laboratories & the Institute of Sound and Vibration Research in 2005. The results from the Scoping Study were reviewed and developed, leading in the summer of 2006 to the finalisation of a measurement methodology and social survey questionnaire that was ready to be trialled in the field.

Before the field trials were approved, a number of workshops were held between the contractor and the Defra steering group, with both methodologies given a thorough examination and critique from both the steering group members and a number of external reviewers.

The steering group were generally in agreement on most topics, but some differences of opinion were found in some areas, particularly on whether vibration could be treated independent of its source. It therefore followed that a consensus approval was given to proceed to the field trials.

The field trials were completed in the autumn of 2006, and a final report ((March 2007) Human Response to Vibration in Residential Environments) delivered to Defra in January 2007. Presentations of the results of the Pilot Study were made to the Institute of Acoustics "Rumble in the Jungle" seminar in March 2007. The final report was then published on the Defra website.

The Pilot Study demonstrated that the measurement methodology and social survey protocol developed had been successfully trialled in the field, and an ordinal relationship could be derived from correlation of the subjective responses to the vibration input for a railway source.

MAIN STUDY

An internal review followed the publication of the pilot study report, and the steering group met a couple of times to discuss the results, and to draft the specification for the main study. The membership of the steering group was boosted with the addition of Henk Miedema and Sabine Janssen of TNO to assist with the social survey side of the project.

The project was let to the University of Salford in January 2008 for a three year study into the human response to vibration in residential environments.

Their work began with a review of the pilot study findings, and the production of a list of other issues that required further consideration by both the contractor and the steering group before the field studies could be commenced. This work took a full year, but included an international peer review of the social survey methodology before submittal to Defra.

The measurement protocol, social survey questionnaire and field protocol were completed and again a consensus approval was given by the Defra steering group to commence the field studies in the summer of 2009. Railway sources were targeted in the first case studies.

Field studies continued until late autumn, at which point the weather and available daylight hours prevented further progress until the spring of 2010. The winter months were spent processing and analysing the data, and preparing a modified set of protocols for other vibration sources such as construction and internal sources.

The summer of 2010 was spent getting the last field studies, whilst at the same time data analysis was underway. A draft final report was delivered to Defra in January 2011, and a final report submitted for Defra's review in April 2011. Publication of the final report is due soon.

A number of Oral presentations and Poster sessions are being presented to the ICBEN 2011 conference related to the project, and I will not steal their thunder, except to say that a dose response relation does appear to exist, and the dataset appears to be robust.

NEXT STEPS

The submittal of the final report now presents Defra with a significant wealth of technical evidence to show the relationship between vibration and human response to vibration exposure in residential environments on which future policy development can be based. It is further hoped that the evidence can assist with future updates of British Standard BS6472.

ACKNOWLEDGEMENTS

I would like to take this opportunity to publically acknowledge all of the people involved with the project and the countless hours put into making this project the success that it undoubtedly is. This includes the aforementioned contractors who did all of the hard work, the main steering group of Colin Grimwood, Colin Stanworth, Rupert Thornely-Taylor, and in the early days Stephen Turner of Defra (formerly Bureau Veritas). Thanks also go to the various people who assisted in peer reviews and proof reading of the contractor reports from the ANC vibration working group, and my Parsons Brinckerhoff colleagues on the Defra research support team of Ian Sherlock, Richard Jackett and Rebecca Hutt.

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The final paper was not available at deadline.

Assessment of annoyance caused by different types of construction noises

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ABSTRACT

In the present study, annoyance caused by diverse construction noises was evaluated through surveys and laboratory experiments. A survey with a total of 100 construction workers was carried out to investigate annoyance from construction noises at different construction phases. Then, a number of noises from machinery that were evaluated in the survey as highly annoying were recorded from construction sites in Korea. Recorded construction noises were classified into four groups: stationary, fluctuating, intermittent, and impulsive, according to the temporal, psychoacoustical and spectral characteristics of the noises. A laboratory auditory experiment was then performed in order to quantify the total annoyance caused by individual construction noise and multiple construction noises. From the experiment, synthesis curves were derived for the relationship between noise levels and the percentage of highly-annoyed (%HA) and the percentage of annoyed (%A) for the combined noise sources.