

The Effects of Low-Frequency Noise and Vibration on People

Edited by Colin H. Hansen

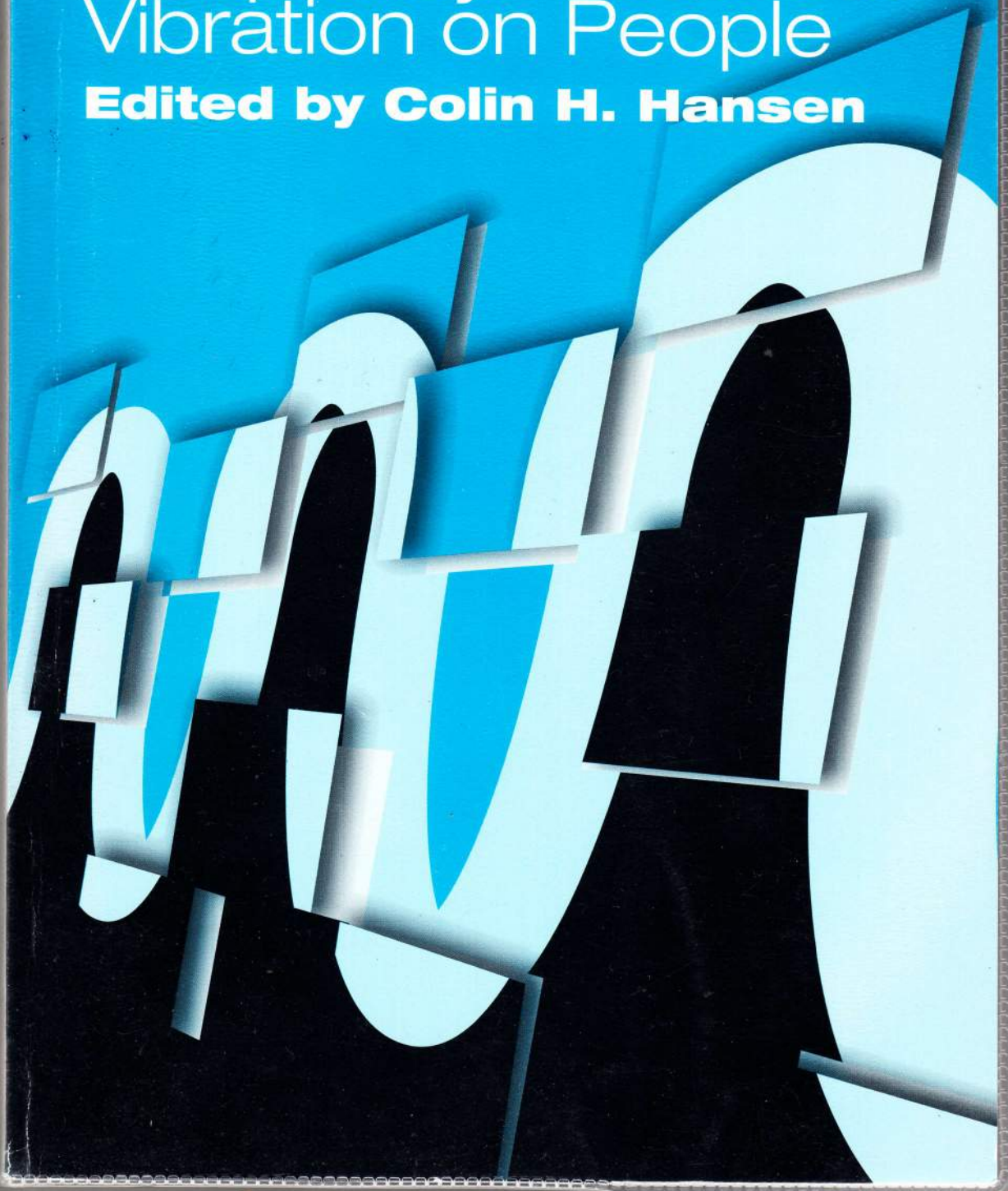


Table of Contents

INTRODUCTION

CHAPTER 1: PERCEPTION THRESHOLDS FOR LOW FREQUENCY NOISE

- 1.1. Unpleasantness and acceptable limits of low frequency sound
Yukio Inukai, Norio Nakamura and Hideto Taya..... 7
- 1.2. An investigation of the perception thresholds of band-limited low frequency noises: influence of bandwidth
Yasunao Matsumoto, Yukio Takahashi, Setsuo Maeda, Hiroki Yamaguchi, Kazuhiro Yamada and Jishnu K Subedi..... 15
- 1.3. Masked perception thresholds of low frequency tones under background noises and their estimation by loudness model
Jishnu K. Subedi, Hiroki Yamaguchi, Yasunao Matsumoto..... 27
- 1.4. Thresholds and acceptability of low frequency pure tones by sufferers
Yukio Inukai, Hideto Taya and Shinji Yamada..... 45

CHAPTER 2: EFFECT OF LOW FREQUENCY NOISE ON PEOPLE IN TERMS OF ANNOYANCE AND SLEEP DEPRIVATION

- 2.1. Unpleasantness and acceptable limits of low frequency sound
Yukio Inukai, Norio Nakamura and Hideto Taya..... 7
- 2.2. Low frequency noise and annoyance in classroom
Pär Axelsson, Kjell Holmberg and Ulf Landström..... 61
- 2.3. A Structured approach to LFS-complaints in the Rotterdam region of the Netherlands
Ing. Piet Sloven..... 71
- 2.4. Annoyance of low frequency noise and traffic noise
Frank Rysgaard Qistdorff and Torben Poulsen..... 87
- 2.5. Perceptions of the public of low frequency noise
D.M.J.P. Manley, P. Styles and J. Scott..... 93
- 2.6. A questionnaire survey of complaints of infrasound and low-frequency noise
Henrik Møller and Morten Lydolf..... 105

2.7.	Assessments of low frequency noise complaints among the local Environmental Health Authorities and a follow-up study 14 years later <i>Johanna Bengtsson and Kerstin Persson Waye</i>	119
2.8.	Low Frequency Noise Annoyance: The Behavioural Challenge <i>Stephen Benton and Orna Abramsom-Yehuda</i>	131
2.9.	Comparison of objective methods for assessment of annoyance of low frequency noise with the results of a laboratory listening test <i>Torben Poulsen</i>	137
2.10.	Blast densification method: Sound propagation and estimation of psychological and physical effects <i>Hiroyuki Imaizumi, Yasumori Takahashi, Motoharu Jinguuji, and Sunao Kunimatsu</i>	157
2.11.	Annoyance of low frequency noise (LFN) in the laboratory assessed by LFN-sufferers and non-sufferers <i>Torben Poulsen</i>	177
2.12.	Psychological analysis of complainants on noise/low frequency noise and the relation between psychological response and brain structure <i>Toshiya Kitamura, Masaki Hasebe, and Shinji Yamada</i>	191
2.13.	Annoyance of low frequency tones and objective evaluation methods <i>Jishnu K. Subedi, Hiroki Yamaguchi*, Yasunao Matsumoto and Mitsutaka Ishihara</i>	199
2.14.	LFN and the A-weighting <i>Piet Sloven</i>	219
2.15.	Thresholds and acceptability of low frequency pure tones by sufferers <i>Yukio Inukai, Hideto Taya and Shinji Yamada</i>	45
2.16.	Low frequency noise annoyance and the negotiation challenge for environmental officers and sufferers <i>Stephen Benton</i>	227

CHAPTER 3. PHYSIOLOGICAL EFFECTS OF LOW FREQUENCY NOISE

3.1.	Some characteristics of human body surface vibration induced by low frequency noise <i>Yukio Takahashi, Kazuo Kanada and Yoshiharu Yonekawa</i>	249
------	--	-----

3.2.	The relationship between vibratory sensation and body surface vibration induced by low-frequency noise <i>Yukio Takahashi, Kazuo Kanada and Yoshiharu Yonekawa</i>	265
3.3.	Measurement of human body surface vibrations induced by complex low-frequency noise composed of two pure tones <i>Yukio Takahashi and Setsuo Maeda</i>	283
3.4.	Blast densification method: Sound propagation and estimation of psychological and physical effects <i>Hiroyuki Imaizumi, Yasumori Takahashi, Motoharu Jinguuji, and Sunao Kunimatsu</i>	157
3.5.	An investigation on the physiological and psychological effects of infrasound on persons <i>Chen Yuan Huang Qibai and Hanmin Shi</i>	303
3.6.	Effects on spatial skills after exposure to low frequency noise <i>Jessica Ljungberg, Gregory Neely and Ronnie Lundström</i>	311
3.7.	Does low frequency noise at moderate levels influence human mental performance? <i>Malgorzata Pawlaczyk-Luszczynska, Adam Dudarewicz, Malgorzata Waszkowska, Wieslaw Szymczak, Maria Kamedula1, Mariola Sliwińska-Kowalska</i>	319

CHAPTER 4. PERCEPTION THRESHOLDS FOR LOW FREQUENCY VIBRATION AND THE EFFECT OF LOW FREQUENCY VIBRATION ON PEOPLE IN TERMS OF COMFORT AND ANNOYANCE

4.1.	Perception of low frequency vibrations by heavy vehicle drivers <i>Rayya Hassan and Kerry McManus</i>	349
4.2.	Vibration perception thresholds assessed by two different methods in healthy subjects <i>Ewa Zamysłowska-Szmytke, Wieslaw Szymczak and Mariola Sliwińska-Kowalska</i>	367

CHAPTER 5. PHYSIOLOGICAL AND HEALTH EFFECTS OF LOW FREQUENCY VIBRATION

5.1.	Occupational disease induced by hand transmitted vibration – The relationship between characteristics of case and kind of tool <i>Shin'ya Yamada and Hisataka Sakakibara</i>	387
------	---	-----

5.2.	The evaluation of horizontal whole-body vibration in the low frequency range <i>Masashi Uchikune</i>	399
5.3.	Study of the effects of whole-body vibration in the low frequency range <i>Masashi Uchikune</i>	409

Introduction

The effect of low frequency noise and vibration on people is an important issue for communities around many industrial facilities and on transportation systems, and there are a number of research groups throughout the world who have been actively researching these effects. However, up to the present time, there has been no attempt to bring together all the various papers into a unifying book. It is hoped that the current book will partly fill that gap by including and commenting on all papers on the effects of low frequency noise and vibration on people, which have been published in the *Journal of Low Frequency Noise Vibration and Active Control* from the beginning of the year 2000 up to and including 2005.

This book is divided into two sections containing a total of five chapters, section 1 with three chapters for low frequency noise and section 2 with two chapters for low frequency vibration. Each chapter is concerned with one particular topic and where a paper is concerned with more than one topic, it is referred to in later relevant chapters but only reproduced in the chapter where it is first referenced. At the beginning of each chapter, each relevant paper is listed and the listing is followed immediately by a short summary. Following the paper listing, the original and sometimes revised papers are reproduced in full in chronological order. Chapter 1 is concerned with perception thresholds and acceptability levels of low frequency noise, chapter 2 is concerned with annoyance and sleep disturbance as a result of low frequency noise and chapter 3 is concerned with studies on the physiological effects of low frequency noise. The final two chapters are concerned with low frequency vibration, with chapter 4 being concerned with perception thresholds, comfort levels and annoyance levels and the final chapter being concerned with physiological effects. The contents of each chapter are discussed in more detail in the following paragraphs.

As well as physiological effects, sleep disturbance effects and annoyance, it is of considerable interest to know the threshold levels of human perception of low frequency noise and how threshold levels may differ from annoyance levels for various groups of people. Chapter 1 and the four papers included therein report on investigations of threshold level determination and levels of acceptability of low frequency noise. The first paper is concerned with acceptability levels, the second with threshold levels for normal test subjects, the third with the effect of masking noise on threshold levels and the fourth with threshold levels for people identified as low frequency noise sufferers. For this latter group it was found that threshold levels were very close to acceptability levels, which is in contrast to studies of normal adult populations.

By far the most effort in the study of low frequency noise (LFN) and vibration has been concentrated in the area of annoyance and sleep disturbance and chapter 2 contains sixteen papers devoted to the topic. The first paper in chapter 2 is concerned with a comparison of the levels of unpleasantness with levels of detectability for low frequency tonal noise, with the interesting result for some test subjects that the two levels were very close together. Paper 15 reports on a similar study using different frequency tones and found that only for low frequency noise sufferers (previous complainants) were the levels of acceptability close to the levels of detectability, even though the levels of detectability were similar for sufferers of LFN and non-sufferers. Paper 4 also reports on the different levels of annoyance between sufferers and non-sufferers for a number of typical low frequency sounds including traffic noise. The authors indicate that sufferers are always more easily annoyed than non-sufferers. This conclusion is also supported by the results reported in paper 11. The smaller annoyance thresholds for LFN sufferers may be because sufferers have already been sensitized to low frequency noise as pointed out in paper 5, which also comments on the correlation between low frequency vibration and infrasound, indicating the although infrasound cannot be heard, it can sometimes be sensed as a result of vibrations it may generate.

In chapter 2, papers 2, 9, 13 and 14 are concerned with the objective measurement of low frequency noise and how this correlates with annoyance. Paper 2 is concerned with evaluating the annoyance of various low frequency sounds in classrooms and the authors conclude that the dB(C) minus dB(A) method to assess annoyance may not be valid for low level noise. A later paper (paper 15) suggests a more complex formula, based on the dB(A) and dB(C) weightings for evaluating the annoyance of music noise with a heavy beat. Papers 9 and 13 compare the effectiveness of a number of objective methods for determining the annoyance of low frequency noise and vibration and paper 14 proposes a new method for assessing annoyance of LFN.

A number of papers in chapter 2 are concerned with finding out reasons why people complain about LFN and ways of resolving the complaints. It is not unusual for LFN sufferers to continue complaining even after the noise source has been removed and for others to complain about LFN when no disturbance can be detected with instrumentation. Thus a number of studies have been devoted to trying to understand what makes people complain (papers 6, 8, 12 and 16) about LFN, what are the most common sources of LFN causing complaint (paper 7) and how best to resolve such complaints (papers 3, 8 and 16). Finally, paper 10 is concerned with the effects of low frequency noise generated by blasting at distances from 30 m to 1 km from the blast site.

The seven papers in Chapter 3 are concerned with physiological

effects of low frequency noise. The first three papers are concerned with the effects of LFN on vibration levels measured on the skin at various locations on the body. Paper 4 reports on oppressive feelings experienced by test subjects when closer than 50 m to a blast site; at larger distances the physiological effects were not experienced. Paper 5 is concerned with the effect of infrasound on blood pressure, heart rate and subjective feelings, while papers 6 and 7 are concerned with the effect of low frequency noise on spatial skills and brain function.

Chapter 4 is concerned with perception and comfort thresholds of low frequency vibration for articulated vehicle drivers (paper 1) and for laboratory test subjects experiencing a range of low frequency hand vibration environments (paper 2).

Chapter 5 is concerned with the physiological effects of low frequency vibration. The first paper reports on results of a study on vibration disease caused by excessive exposure to hand arm vibration and the second and third papers are concerned with the effect of low frequency vibration on the autonomic nervous system, heart rate, respiratory rate, salivation and subjective symptoms, with fairly inconclusive results.