Vibrations from blasting's. Annoyance reactions from residents in neighbouring areas.

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Summary

Blast activities near residential areas may cause fear, annoyance and residential and/or community complaints even when the vibrations are not strong enough to cause building damages. Ignoring the potential for adverse reactions in such situations, may generate unnecessary annoyance, complaints, delays in production, and time-consuming public relations management. To assess the strength of human reactions as a function of vibration velocity, a socio-vibrational study of people's annoyance responses was undertaken, and exposure-effect relationships developed. The study obtained answers to a postal questionnaire from 519 residents living in seven different study areas (3 quarries and 4 road/rail construction sites). Even when the vibrations were well below limit values, many residents express annoyance. A high proportion of the respondents worry about potential damages to their house, and to fixtures and fittings. About half of the respondents stated that they were worried about damages to their house due to the blasting activities. More than half of the respondents had experienced that the house vibrated, and 10 percent reported objects that moved or fell down from their original place because of blast activities. Residents who were satisfied with the information they received prior to the blasting, were less annoyed by the blast activities. To reduce the number of complaints and anxiety level among residents in the neighbourhood of blast activities, the information should cover a wider area than presently considered sufficient. Self-reported sensitivity to vibrations was not correlated with exposure to vibrations, but is associated with a significantly higher degree of annoyance. This is similar to noise annoyance.

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1. Introduction

In 2012-14 parts of the Norwegian Standard [1] NS 8141 – *Vibration and shock- Guideline limit values for construction work, open pit mining and traffic, Part 1,* was updated. The standard is designed to avoid damages to buildings during different types of construction work using blasting.

One of the aims was to include information of how residents in these areas are affected by the blasting activities and establish an exposure-response curve to be used by contractors. This will aid them in the planning phase of the construction work, making it easier to take preventive measurements and reduce delays due to protests from neighbours.

2. Method

2.1. The sample

The study was executed in 2010-2013 using a postal questionnaire. The questionnaires were sent to home owners in seven different study areas in Norway. Four of the study areas were close to road/rail construction sites, and three sites were close to quarries. The questionnaires were sent to home owners in all households that were presumed to notice the blasting activities. A total number of 519 persons answered the questionnaire, giving us a response rate of 43 percent. The response rate varied somewhat (33- 58%) in the selected areas, which may have several causes. In two of the areas, there were many rental properties. Empirically, the response rate is often lower in such areas.

The sample consisted of 52 percent women, and about 25 percent of the respondents were above 45 year.

Table I. The respondents age

	18-24	25-35	36-45	46-65	66-74	75 +
N=	2	33	95	238	85	66
%	0,4	6,4	18,3	45,9	16,4	12,7

2.2. **The questionnaire**

The questionnaires consisted of a number of questions, e.g. noise/vibration annoyance from different sources, worries concerning the blasting activities, quality of the received information, personal characteristics such as age, sex, education, sensitivity to vibration and noise and various questions concerning the residential environment.

The vibration annoyance question utilized in the exposure-effect curve was:

”*When thinking about the last 12 month, how annoyed are you by vibration from blasting activities when you are inside your own dwelling?* (five-point scale: Extremely annoyed, Very annoyed, Moderately annoyed, Slightly annoyed, Not annoyed. - Not relevant)”

2.3. **Calculations/measurements of vibration**

The vibration was measures using vibration sensors. These sensors were mounted at the foundation of the dwellings. About 50 percent of the respondents had a sensor mounted at their dwelling, in the other cases the vibration was calculated based on the nearest sensor.

All measurement data for the study were recorded as unweighted time series, and collected from the different contractors’ databases. For each dwelling, five time series with the highest registered unweighted peak vibration velocities were selected. The highest of the five frequency weighted peak vibration velocity value was chosen as the exposure measure for the dwelling. The Norwegian Geotechnical Institute were responsible for collecting and if needed calculating the data.

Table II give an overview of the collected exposure data. Average vibration velocity was at about 14 mm/s. Very few had experienced vibration velocity of above 50 mm/s.

Table II. The Exposure data, distribution of the vibration velocity values

	Average	**Min**	**Max**	**Standard deviation**
v (mm/s)	**14.52**	0.68	128.55	13.29
v_f (mm/s)	**13.94**	1.52	170.45	14.02

The indicator used in the standard [1] is a peak value weighted using a filter that is designed for vibration frequencies that may cause building damages. The filtering for building damages amplify vibrations at low frequencies and attenuating those at higher frequencies (above 80 Hz).

2.4. **Modeling the exposure-effect relationship**

Ordinal logit models [2, 3] were used to estimate exposure-effect relationships between log-transformed vibration indicators and annoyance responses. Since there was little to be gained from choosing a different exposure indicator for human reactions and that used in the standard for building damage, we used the logarithmic transformation of the vibration indicator. Results are plotted on logarithmic x-axis as a function of the vibration indicator.

3. Results

We found no statistically significant correlation between the degree of vibration annoyance and age, gender and sensitivity to noise. People living near quarries rated their annoyance somewhat higher than those living near construction sites, but the difference was not statistically significant.

The quality of the information sent to the residents about the blasting was important. Respondents that rated the information as good reported less annoyance than those who were dissatisfied with the information they received.

There was a statistically significant correlation between being self-reported sensitivity to vibration and a respondent’s degree of annoyance. Respondents that reported being at home during daytime were somewhat more annoyed than those

Table III. Proportion of the respondents reporting being annoyed or worried by blasting's. Percentages,

	Yes	No	Not relevant
Had problems falling asleep, due to blasting's? N=464	9,7	81,3	9,1
Woke to early, due to blasting's? N=462	20,6	71,0	8,4
Was disturbed during resting, due to blasting's? N=466	36,5	57,5	6,0
Had problems concentrating, due to blasting's? N=461	15,4	78,5	6,1
Was worried about possible damages to dwelling? N=471	49,3	47,3	3,4
Worried about possible damages to fixtures/fittings? N=469	32,4	64,0	3,6
Was worried during the blasting's? N=465	23,9	72,5	3,7

who were away. The degree of annoyance diminished with the time elapsed since the last blasting activity. Respondents having experiences the blastings less than 3 month prior to answering the questionnaire were more annoyed than when it had been longer since the last blasting took place.

Approximately 60 % of the population report that they are more or less sensitive to noise and vibration. Of those who are either very sensitive to noise or vibration, less than one-fifth report that they are very sensitive to both noise and vibration.

Table III give an overview of different circumstances that had the residents worried/annoyed due to the blasting activity. Worry about possible damages to the dwellings is what worries most people, in our sample almost 50 percent worried about this. The respondents who were at home during the blasting's were also asked how they had noticed the blasting's. More than 50 percent had experienced that the house shaked/trembled, and almost 30 percent had experienced that the fixtures or fittings were trembling. In 10 percent of the houses, things moved or fell down from their usual place.

Figure 1 shows the exposure-effect relationships for the seven different study areas combined. Most of the respondents were exposed to vibration velocity of about 2- 50 mm/s, so outside this interval the exposure curves are quite uncertain. The curves indicate that even at very low levels of exposure, quite a few respondents' state high levels of annoyance.

4. Discussion

Due to limited number of respondents and a limited dispersion of the exposure data, the exposure-effect curves are uncertain. But within the normal range of vibration velocity from blasting activity in Norway, the curves will non the less give an indication of the level of annoyance expected to occur among the residents exposed to the blasting's.

This information are useful when deciding the areas around the construction site that are to be included in the information scheme. Information of good quality about the blasting activity can reduce the number of annoyed residents and the numbers of complaints and possible delays prior to and during the blasting activity.

In three of the seven study areas, the blasting activity took place in open-pit quarries. These quarries had all been in operation for years, while at the other four study sites the blasting only occurred in a limited (a couple of month) construction period. There was a tendency towards higher annoyance among residents living near quarry sites, but this difference was not statistical significant. The difference might have been significant if we had managed to get a higher sample of people living near active quarries (16 percent of our sample lived near quarries).

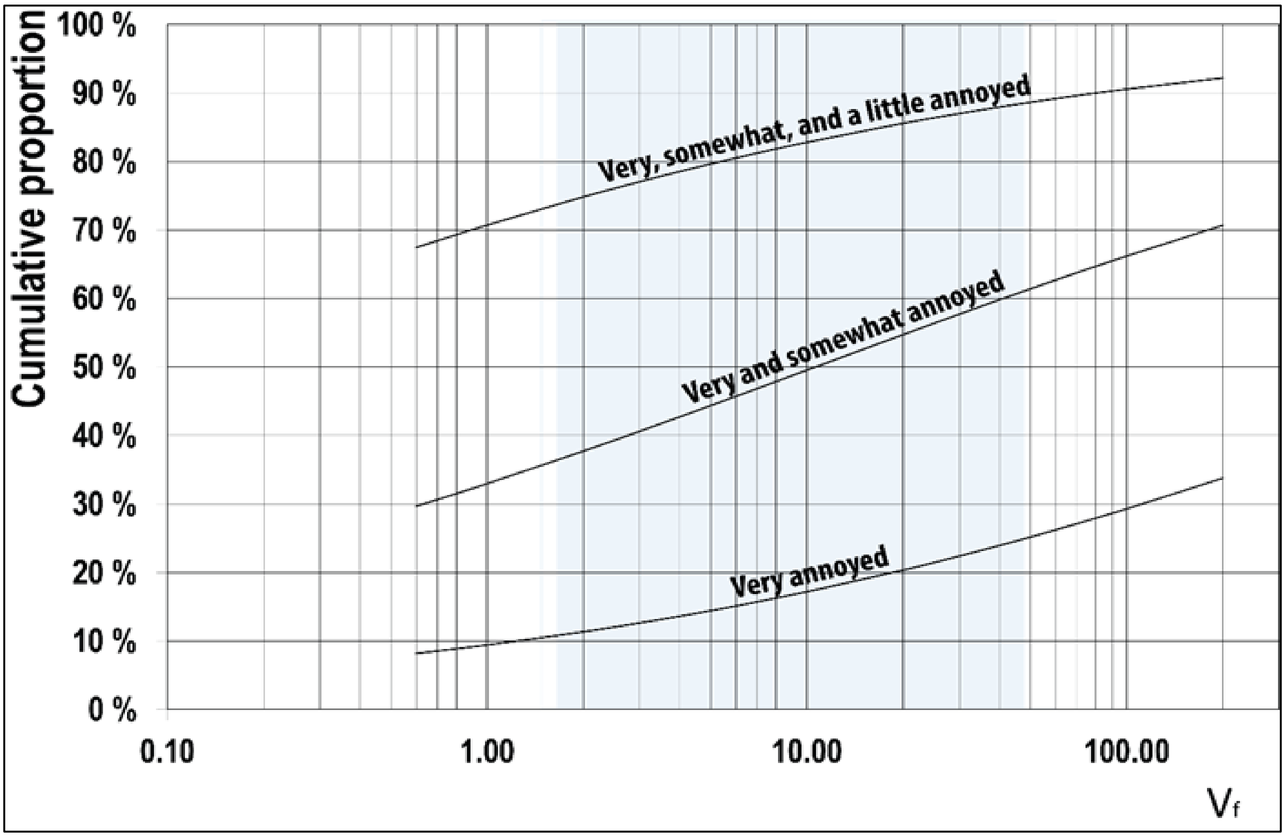

Figure 1. Exposure-effect curves for vf (mm/s). N= 468. The curves have been extrapolated outside the range of the study (light blue area covers 95% of the exposure levels).

The respondents who stated that they were sensitive to vibration reported higher amount of annoyance. Self-reported sensitivity to vibrations was not correlated with the vibration velocities. This is similar to what is found for noise sensitivity and residential noise exposure. This indicates that noise sensitivity can be regarded as a personal trait or property.

A high number or our respondents stated that they were annoyed by the vibration from the blasting's. The amount of annoyance may also have been influenced by the noise from the blasting's and from the construction site itself, and partly also from the increased air pollution in some of the areas. In the questionnaire, we had individual questions about noise from the blasting's, and air quality. The respondents reported higher amount of annoyance when asked about vibrations, than when asked about noise and air pollution.

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References

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