

Determination of the Influence of Gender on the Perception of Blast-Induced Vibration

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ABSTRACT: Nowadays, several excavation works with blasting are close to cities and towns. Daily blasting activities are felt by people living at a proximity of them. In such case, several complaints are inevitable. People can be uncomfortable by the blast-vibrations, even if particle velocities are within the permissible levels for structures according to regulations. The aim of the study was to determine the perception of blast vibration and to investigate the effect of gender on these perceived vibrations. For this purpose, blasting operations were followed in two different areas. Volunteers taken to the blast areas were surveyed about the vibrations exposure and perception, while blast-induced vibrations were being recorded. The questions were prepared according to 4-Point Likert scale in order to classify the vibration and to determine the perception level. Firstly, the reliability analysis of the survey was carried out to determine whether the items in this survey was related to each other and the scale was reliable. After that, the influence of the gender on human response to vibration was investigated. To that end, participants' answers were evaluated by independent t-test using SPSS software and it was analyzed whether there was a meaningful relationship between gender and vibration perception.

KEYWORDS: blast-induced vibration, human perception, survey studies, statistical analysis, SPSS.

I. INTRODUCTION

Mining and quarrying activities and excavation with blasting used for construction cause environmental vibrations due to the use of advanced production technologies applied to blasting operations. Several mines in Turkey are close to cities and towns because the cities have expanded into the rural areas. Also, excavation works with blasting are used commonly for foundation constructions which are located in cities. Thus, as a result, these activities are subject to several complaints. In order to prevent these complaints, regulations in Turkey related to blasting activities (Regulation of Environmental Noise Management) were developed only according to damage criteria of aboveground structures. Therefore, it does not include any assessment and damage limit values for human vibration perceptions at a proximity of these mining activities[1].

Daily blasting activities can be felt by people living at a proximity of these areas where explosives are used. People living in these areas can be uncomfortable by the blast-induced vibrations, even if the structures in these areas are within the permissible vibration levels according to the regulations. In the circumstances, the problem directly turns from a structural damage problem into people's complaints and lawsuits about these complaints.

When the literature was investigated, it can be seen that extensive research has been undertaken on the environmental effects of blast-induced vibrations, especially for structure damage levels. But there are few studies that focus on the human perception of blast-induced vibration in literature. The problem is to determine the response of people who are perceived and responded to blast-induced vibrations. To solving this problem, previous literature works related to the determination of human perception to vibration have been reviewed.

People react differently to vibrations. Vibrations that cause some people annoyance do not bother others. At the same time, there is a clear and systematic relationship between the percentage of people experiencing different effects and

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the vibration velocity. This relationship can be determined by a statistical analysis of people's responses and be illustrated as an exposure-effect relationship [2].

The survey conducted by Woodroof and Griffin [3] to investigate the human response to vibration is one of the pioneering work on surveying. In their study, annoyance by railway induced vibration was determined using a survey of people who lived in the buildings and vibrations were measured in those buildings.

Howard and Griffin [4], has developed a social survey questionnaire to obtain human responses to vibration in residential environments. They have expressed that statistical analyses of responses from the questionnaire can test the reliability of the responses and examine relationships between subjective responses and objective measures of vibration exposure. They have touched on some statistical analysis methods for evaluation of survey, such as; Spearman's rank correlation, Wilcoxon matched-pairs signed ranks test, the Friedman test.

According to results of their study, partial and multiple correlation analyses can be used for determination of the relationships between subjective responses and objective measures of vibration and noise. Simple logistic regression (univariate analysis) and multiple logistic regression (multivariate analysis) may be conducted to investigate relationships between single dependent variables and one or more independent variables.

To determine people reaction of blast-induced vibration, survey studies were conducted by Lusk (2006) in different neighborhoods close to quarry mines. He obtained five survey pools. The data conducted by surveys were analyzed using descriptive statistics. Firstly, the data was validated, in other words, the level of reliability of survey questions was determined using Cronbach's Alpha and Split-Half reliability coefficient. After that, average comfort values for each question in five survey pools were calculated. He compared the survey pools to each other using these average values. According to the results of that study, people with technical backgrounds tend to be more comfortable than other groups. He emphasized that positive relationships with neighbors are important in terms of quarry operations [2].

When the literature has been reviewed, it has been understood that usage of statistical analysis is necessary to analyze the results of the surveys and most researchers prefer quantitative data for analyzing the survey. For this reason, some methods for quantifying perception via surveys have been reviewed. Likert scale is commonly preferred for obtaining a quantitative value for a qualitative question especially for quantifying perception-type data. On a Likert scale question, respondents indicate their level of agreement or disagreement with a particular statement or question using an ordinal scale [5, 6].

After reviewing the many articles using Likert-scaled data, analyzing individual Likert type items (%54) reported only descriptive statistics (e.g., means, standard deviations, frequencies/percentages by category). On the other hand, when investigated analyzing Paired Likert type items or sets of items, it was seen that they were compared using nonparametric statistical techniques (e.g., chi-square homogeneity tests, Mann-Whitney-Wilcoxon U tests, Kruskal-Wallis analysis of variance tests) in 12 (13%) of the articles. Means for paired Likert-type items were compared using parametric statistical procedures (e.g. t-tests or analysis of variance F-tests) in 32 (34%) of the articles [7].

For this study, in order to investigate the effect of gender on perceived blast induced vibration, vibrations were measured as a peak particle velocity in two different areas and survey study was chosen as a method of determination of human perception to blast-induced vibration. Before blasting operations, volunteer participants with an age ranging between 20 and 30 years were taken to the place at a distance between 95-580 m from blast areas. The reason why different distances were chosen is to obtain different peak particle velocities. Because the amount of explosive per delay was approximately 50kg/hole. These volunteers were surveyed about the vibrations exposure and perception, while blast-induced vibrations were being recorded for the blast. 124 surveys were obtained from the blast events. The results of these surveys were evaluated by statistical analysis method using SPSS Software to determine a relationship between gender and vibration perception.

II. WORKING AREAS DETAILS

Investigations were carried out two different areas in Izmir, Turkey. One of them was limestone quarry which is called Area-1 and second was an explosive-assisted excavation area for construction of Izmir-Bayrakli integrated health campus located in İzmir/ Turkey which is called Area-2. These areas are at a proximity of populated towns. Fig 1 shows the location of these areas and neighborhood close to these areas. The details of the field study are given in this chapter.

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Fig 1 Location of areas and Settlements (A) Explosive-assisted excavation area (B) Limestone quarry

Drilling and blasting operations were followed in these areas. 32 blast induced vibration measurements were taken at Area-1 from different distances using vibration measurement devise. The distances from blasting sources to the nearest measurement point of geophone are between 90 m and 100 m and the maximum distance is 322 m. The peak particle velocities are between 0.798 mm/sec and 17.4 mm/sec due to distance. Also, at Area-2, from different distances 14 blast induced vibration measurements were taken the measurement point distance from the blast area is between 250 m and 580 m. Measured peak particle velocities from blasting are between 0.85 mm/sec and 4.88 mm/sec. Measurement points were on a rock mass, between the blast areas and settlements.

III.SURVEY STUDIES

A survey was developed in order to determine the perception of blast-induced vibration and the effect of gender on perceived vibration. This survey was where conducted so as to exclude daily activities noise and vibrations, in other words, the survey was conducted at a geophone measurement points on a rock mass (Fig.2). So people's reactions can be objective when other environmental noise and vibration is much less.



Fig 2 Some of volunteers near geophone

The number of questions was kept limited so that the questionnaire was understandable and clear. A total of 8 questions were created to collect data which 5 of them were about demographic properties, these were sex, education status, date of birth, weight, and height. Three questions were used to collect to determine the perception of blast-induced vibration. Except for the question for measuring whether a person feels the blast-induced vibration, two questions were prepared according to 4-point Likert scale which is widely used in survey scaling technique in order to

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Vol. 7, Issue 10, October 2018

classify the vibration and determine the level of perception. These two questions given below were asked to obtain information to the question as to whether women and men give the equal response to the various particle velocities. Because people react differently to vibrations with different frequencies and/or different particle velocities. Questions with 4-point Likert scale used in this study are given below;

- Could you classify the severity of the vibration you felt?
None (1) Low (2) Moderate (3) High (4)
- How much did this vibration annoy or disturb you?
Not at all (1) Slightly (2) Moderately (3) Extremely (4)

Two questions should be answered to on a Likert scale of 1-4 in this survey, so a high score on a question indicates a high uncomfortableness and/or high level of vibration severity classification in perceived vibration value.

IV. ANALYSIS OF DATA

Before analyzing surveys to determine the influence of gender on the perception of blast-induced vibration, it is necessary to determine the consistency degree of two items in this survey. For this purpose, the pilot surveys were performed prior to main survey research and reliability analysis of this pilot surveys for two questions with Likert type scale was carried out to determine whether the items in this survey were related to each other and the scale was reliable. Cronbach's alpha was chosen for reliability and it was calculated using SPSS software. The Cronbach's alpha coefficient is a coefficient that reveals similarities and closeness of the questions. For this purpose, to determine the reliability coefficient, Pilot surveys were administered at Area-1. 23 pilot surveys from five blast events were obtained and reliability test was performed by selecting the 95% confidence interval for these pilot surveys. SPSS Statistics software produces many different tables for reliability analysis. Table 1 presents Reliability processing, Cronbach's Alpha coefficient output of SPSS and Items Statistics.

Table 1. Case processing summary and Cronbach's Alpha coefficient by SPSS.

Case	[N]	%	Cronbach's Alpha	Number of Items
Valid	23	100	0.785	2
Excluded	0	.0		
Total	23	100		

N means the number of items, in which 23 variables are used in this process. On the other words, this processing is based on all variables which mean 23 different surveys. When the results in table 2 have been evaluated, it is seen that the first question or item have a higher mean value than the second question. Meaning of this is that the degree of disturbance is lower than the level of classification of vibration severity according to people's answers of surveys.

Table 2. Item Statistics of 23 surveys

	Mean	SD	N
Could you classify the severity of the vibration you felt?	3.1739	0.5762	23
How much did this vibration annoy or disturb you?	2.000	1.2792	23

*SD: Standard Deviation

As seen in table 1, Cronbach's Alpha coefficient was found %78.5 which indicates a high level of internal consistency for the scale of this study in terms of two questions that are defined as items. Researchers suggest that a commonly accepted limit value for Cronbach's Alpha coefficient should be 0.7. This means that the values for these statistics should be equal to or higher than 0.7 in order that the survey can be reliable [1, 8, 9, 10, 11, 12, 13]. In light of this information, when Cronbach's Alpha of pilot surveys has evaluated, it is seen that the survey is reliable.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 10, October 2018

After it was concluded that the survey was reliable, the influence of the gender on human response to vibration could be investigated using this survey. To determine the influence of the gender, a survey was conducted for all blast events in two areas to capture the human perception, while blast-induced vibrations were being recorded for the blast. 124 surveys were obtained from the blast events. 48 of them were collected from Area-2 and others were obtained from Area-1. Volunteer participants were chosen with an age ranging between 20 and 30 years in this study. The women are %34.6 of volunteers. An informational note about the purpose of the survey was given to all participants. First of all, answers of “did you feel this vibration” have been evaluated according to gender. Table 3 shows the difference between women’ answers and men’s answers. As can be seen in table 3, 98.53% of the men, as compared with 73.21% of the women, said yes for a question about feeling the vibration.

Table 3. Answer percentage of “Did you feel this vibration”

		Area-1	Area-2	Overall
Women [%]	Yes	58.33	100	73.21
	No	41.67	---	26.78
Men [%]	Yes	97.5	100	98.53
	No	2.5	---	1.47

Participants who said yes to question which is “Did you feel this vibration” were asked to rate by perceived level on a four-point Likert type scale, as mentioned in Chapter three. The results of survey were analyzed using independent T-test which is one of recognized statistical methods. The answers they gave were evaluated to make comparison between groups by taking the averages of two questions. It was analyzed whether there was a meaningful relationship between gender and vibration perception. Two hypotheses have been proposed for this comparison. The first hypothesis (H0) is that there is no meaningful difference in blast-induced vibration perception of participants in terms of their genders. The second (H1) is opposite of first one. That is to say that there is a meaningful difference in blast-induced vibration perception of participants in terms of their genders. Independent T-test analyzes have been performed by SPSS software and their results are presented in Fig.3.

Independent Samples Test										
Area-1	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
Mean	2.258	.138	2.642	58	.011	.48718	.18437	.11813	.85623	
Equal variances assumed										
Equal variances not assumed			2.497	35.026	.017	.48718	.19510	.09112	.88324	

Independent Samples Test										
Area-2	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
Mean	.243	.625	2.221	46	.031	.33929	.15278	.03175	.64682	
Equal variances assumed										
Equal variances not assumed			2.143	35.423	.039	.33929	.15836	.01704	.66063	

Independent Samples Test										
Both of These Areas	Levene's Test for Equality of Variances		t-test for Equality of Means							
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
Mean	2.513	.116	3.408	106	.001	.41372	.12139	.17306	.65439	
Equal variances assumed										
Equal variances not assumed			3.264	73.393	.002	.41372	.12674	.16116	.66929	

Fig 3 Independent t-test analyzes results from SPSS

Sig (2-tailed) value which is a part of t-test results is important to understand the relationship between perception and gender. This value is called the p-value in literature. The p-value is used as the indicator whether the null hypothesis is rejected or not. If the p-value is smaller than the chosen alpha level, a null hypothesis is rejected. The alpha level was used as 5% (0.05) in this study. Accordingly, the p values obtained from the test were 0.011 in Area-1, 0.031 in Area-2 and 0.001 in general, so H0 was rejected because the p values are less than 0.05 alpha levels. In other words, the H1

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Vol. 7, Issue 10, October 2018

hypothesis which is evidence that the gender differences influence the perception of blast-induced vibration was accepted according to test results.

There is a small p-values in test results then the test has another significant result that shows in Fig 4. If the other output of the t-test is checked, it will be seen that the mean of women is not equal to mean of men.

When the mean values of the group statistic are examined, it is seen that the mean values of the women are higher. While in area-1 women mean is 2.1167, in area-2 women mean is 2.000 and women mean is 2.0854 in general evaluation which means to test together values in both areas, men mean values are respectively 1.6795, 1.6607 and 1.6716. That is to say, women have been found to provide higher perceived intensity than men's.

As can be seen, the response/perception of the blast-induced vibration is not identical for men and women. The results of the statistical analysis presented thus far demonstrate that women participants are more heavily influenced by the blast-induced vibration than are men. In other words, the results seem to suggest that women participants have a higher perception level on blast-induced vibration than men.

→ T-Test

[DataSet0] C:\Users\user\Desktop\area-1.sav

Group Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
mean	woman	21	2.1667	.76376	.16667
	man	39	1.6795	.63336	.10142

[DataSet0] C:\Users\user\Desktop\area-2.sav

Group Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
mean	woman	20	2.0000	.58490	.13079
	man	28	1.6607	.47246	.08929

[DataSet0] C:\Users\user\Desktop\general-both areas.sav

Group Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
mean	woman	41	2.0854	.67918	.10607
	man	67	1.6716	.56777	.06936

Fig 4 Group statistics outputs of independent t-test

V. CONCLUSION

Mining and quarrying activities cause environmental vibrations due to the use of advanced production technologies applied to blasting operations. Thus, as a result, mining activities are subject to several complaints. In order to prevent these complaints, regulations related to blasting activities were developed in different countries, but almost all are only according to damage criteria of aboveground structures. When the literature reviewed, it can be seen that there is a few studies about assessment and damage limit values for human vibration perceptions at a proximity of these mining activities. Hence, there is a need for research on the perception of blast-induced vibration levels on human. For this

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Vol. 7, Issue 10, October 2018

reason, the effects of gender on the perception of blast-induced vibration were investigated in this scientific research. The obtained results of this research are summarized below.

First of all, a survey was developed in order to determine the perception of blast-induced vibration and the effect of gender on perceived vibration and the number of questions was kept limited because of understandable. Volunteer participants were surveyed about the vibrations exposure and perception using this survey, while blast-induced vibrations were being recorded for the blast in two different areas. Peak particle velocities obtained from measurement were between 0.8 mm/sec and 17.4 mm/sec. A total of 124 surveys were obtained from the blast events. %34.6 of surveys belongs to women. When the results of the survey are investigated, it is seen that 98.53% of the men, as compared with 73.21% of the women, said yes for a question about feeling the vibration. 26.25% of participants did not feel the blast-induced vibration.

The results of the survey of participants who felt the vibration were analyzed using SPSS software. Independent T-test was chosen to understand whether there was a meaningful relationship between gender and vibration perception. According to the results of independent T-test, p values are less than 0.05 alpha levels. It means that the gender differences influence the perception of blast-induced vibration.

The mean of women and men in Group statistics which is another output of the independent T-test are compared to each other. It is obtained that the mean values of the women are higher than men's. This means that women have a higher perceived intensity. In other word, women participants appear to be more sensitive to the blast-induced vibration. Effects of blast-induced vibration on human being should be paid attention by industry using blasting operations. People living close to mining/excavation areas must be comfortable with the blasting operation. In order to avoid issues with neighbors and complaints in the blasting industry, human perception of blast-induced vibration should be considered. Human response is subjective according to not only different conditions but also their gender. According to the outcome of this study, it is necessary to determine blast induced vibration effects on perception and compare them to gender, because the response/perception of the blast-induced vibration is not identical for men and women. The results of statistical analysis showed that women participants are more heavily influenced by the blast-induced vibration than are men.

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