International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 5, Issue 2 (February 2016), PP.01-11

Effects of Noise Barriers on Reducing Highway Traffic Noise

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Abstract:- Noise is an important type of environmental pollution that effects human hearing health and perception can ruin physiological and psychological balance and may impair work performance. Noise pollution has been taken into consideration all over the world and has become an area of concern in many countries. However, this issue has not been solved completely, even in developed countries, and day-by-day noise sources are spreading, bringing about an increase in their negative effects.
In recent years, the increasing number of vehicles parallel to the fast growing population, transportation and need for shipping has caused an increase in highway noise pollution.

In this study, highway noise resources and their effects have been determined, and two situations were compared by examining the situation before and after placing noise-reducing barriers. In this study, we chose the Atakum Ilbank facility and its public housing located in Samsun as the pilot study area. With the help of the Cadna A® simulation program, area noise maps for both normal conditions and after the placement of a barrier was produced and analyzed.

Keywords:- Noise; Highway Noise; Noise Map; Noise Barrier; Noise Level

I. INTRODUCTION

The word 'noise' is derived from the Latin word "Nausea," which means unwanted noise [1]. Noise, which rises proportionally with technological development and population growth, influences people both outside and inside a given structure at varying rates depending on the circumstances and conditions, and these influences sometimes result in serious problems. OECD (Organization for Economy Cooperation and Development) [2] scaled the intensity of noise pollution impact on human health in 1996. The effects of noise on human health and comfort can be grouped as follows [3]:

Physical Effects: Temporary or permanent hearing impairment.

Physiological Effects: Increase in blood pressure, circulatory disorders, acceleration in breathing, heart rate deceleration and sudden reflex.

Psychological Effects: Behavioral disorders, excessive nervousness and stress.

Effects on Performance: Declining business efficiency, impaired concentration and slowness of movement.

In addition, the negative effects of noise pollution on human health greatly reduce the productivity per capita. This decrease is detected as 30% in physical workers and 60% in white collar workers. Deafness caused by noise in the work place is also on the rise [4].

It is possible to divide noise types into two possible groups depending on the propagation path and position of the source and receivers; outdoor noise (transportation noise, industrial noise, construction noise, entertainment place noise) and indoor noise (electronic / mechanical systems within a given structure and all noise resulting caused by life activities) [5]. Road traffic is by far the largest of these and accounts for approximately 78% of noise annoyance Different noise sources in urban areas are shown in Figure 1[6].

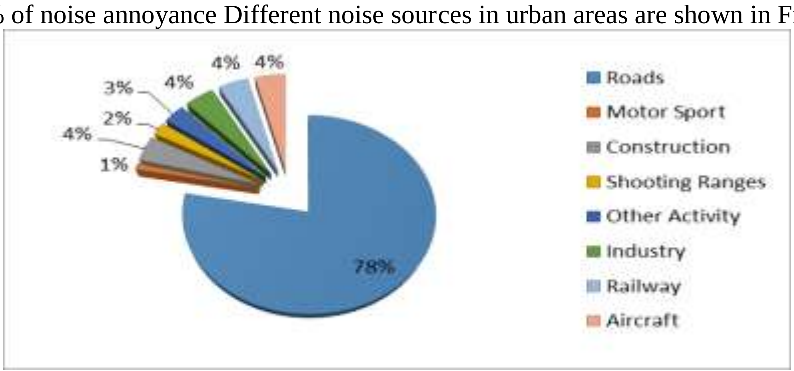


Figure 1. Different noise sources in urban areas

II. NOISE INDICATORS AND HIGHWAY NOISE

Different types of indicators are used to evaluate noise measurements and effects. These are used for determining the noise characteristics as well as the effects on humans. Recently, various types of studies have been conducted on transportation noise (motorways, airways, railways and waterways). However, transportation noise is the most extensively studied because it is the most common type of noise pollution [7].

According to Calixto (2003) [8] in Curibita, Brazil, 73% of the 850 participants responded that they were disturbed by traffic noise. This was followed by disturbance from the neighborhood with 38% and siren sounds with 30% [8].

The noise measurements in this database is in dBA and is expressed with standard European Lden indicators. For the dBA unit of measurement (Decibel with an A-weighted filter), the filter A scale corresponds to human natural hearing sensitivity recognition at different sound frequencies [9][10][11]

Day-Evening-Night level Lden, which is the noise indicator, is the description of the day-evening night levels in decibels A dBA by the formula given below (Road noise prediction, 2009).

$$L_{den} = 10 \log_{10} \frac{1}{24} \left[12 \times 10^{\frac{L_{day}}{10}} + 4 \times 10^{\frac{L_{evening}+5}{10}} + 8 \times 10^{\frac{L_{night}+10}{10}} \right]$$

L_{day}: As described in TS 9798 (ISO 1996-2), Lday is the A weighted long-term average volume level and is determined according to the entire period of the year. Daytime hours are taken as 07:00 to 19:00.

$L_{evening}$: As described in TS 9798 (ISO 1996-2), Levening is the A weighted long-term average volume level and is determined according to the entire period of the year. Evening is the range from 19:00 to 23:00.

L_{night}: As described in TS 9798 (ISO 1996-2), Lnight is the A weighted long-term average volume level and is determined according to the entire period of the year. Night hours are in the range of 23:00 to 07:00.

Lden: (day-evening-night noise indicator): In EU Directive 2002/49/EC [32], Lden represents the A weighted long-term average volume level, and it was shown as the Lden (day-evening-night) indicator [12]

III. CAUSES OF HIGHWAY NOISE AND PREVENTION METHODS

Highway traffic noise consists of factors such as noise generated by vehicle operation and movements, engine, exhaust, horns, chassis and bodywork noises, noise made by the wheels touching the surfaces and aerodynamic noise caused by vehicles. These types of noises are connected to factors such as the distance to the road, the traffic volume, the road capacity, the coating type of the road, the angle of the road, the vehicle length and type, road construction and the vegetation on the side of the road [13]. While a significant portion of noise caused by small vehicles is generated in between the wheel and road interface, exhaust noise is more notable for large vehicles [14]

Some of the main sources that increase noise are shown in Table 1[15].

Table 1. The main sources of traffic noise

Vehicle Sources	Non-Vehicle Sources
Engine	**Traffic conditions**
Exhaust	**Road type and conditions**
Tire/road interaction	**Site condition**
Aerodynamic effects	**Other infrastructure**
Air intake and cooling fan	**Weather and climate**

"NMPB-Routes-2008 (SETRA-CERTU-LCPC-CSTB)" has been used as the calculating method of traffic noise in the by-law of the Assessment and Management of the Environmental Noise and noise maps are executed in three different time periods; day (Lday: 07.00-19.00), evening (Levening: 19.00-22.00) and night (Lnight: 22.00-07.00) [16].

In 2008, the French traffic noise prediction method (Nouvelle Me' thode de Prevision du Bruit des Routes-NMPB) was released and applied. NMPB is the method used for estimating highway traffic noise in the application of the Europe Directive on Environmental Noise 2002/49/CE [17]. The purpose of NMBP Routes-2008 is to calculate highway traffic noise levels by taking all of the effective factors of the physical environment, particularly the meteorological conditions, into consideration [18].

Ground effect

Ground types are typically characterized as acoustically hard or soft. Hard ground refers to any highly reflective surface in which the phase of the sound energy is essentially preserved upon reflection; examples include water, asphalt and concrete. Soft ground refers to any highly absorptive surface in which the phase of the sound energy is changed upon reflection; examples include terrain covered with dense vegetation or freshly fallen snow. An acoustically soft ground can cause a significant broadband attenuation (except at low frequencies).

A commonly used rule-of-thumb is that: (1) for propagation over hard ground, the ground effect is neglected; and (2) for propagation over acoustically soft ground, for each doubling of distance the soft ground effect attenuates the sound pressure level at the receiver by an additional 1.5 dB(A). This extra attenuation applies to only incident angles of 20 degrees or less. For greater angles, the ground becomes a good reflector and can be considered acoustically hard [18].

IV. NOISE BARRIERS ON HIGHWAYS

Noise pollution is studied in many developed countries and studies have been conducted for noise pollution management. It is a serious problem for which precautions must be taken [19].

Figure 2 is a simplified sketch showing what happens to road traffic noise when a noise barrier is placed between the source (vehicle) and receiver. The noise barrier now interrupts the original straight-line path from the source to the receiver. Depending on the noise barrier material and surface treatment, a portion of the original noise energy is reflected or scattered back towards the source. Other portions are absorbed by the material of the noise barrier, transmitted through the noise barrier or diffracted at the top edge of the noise barrier [20].

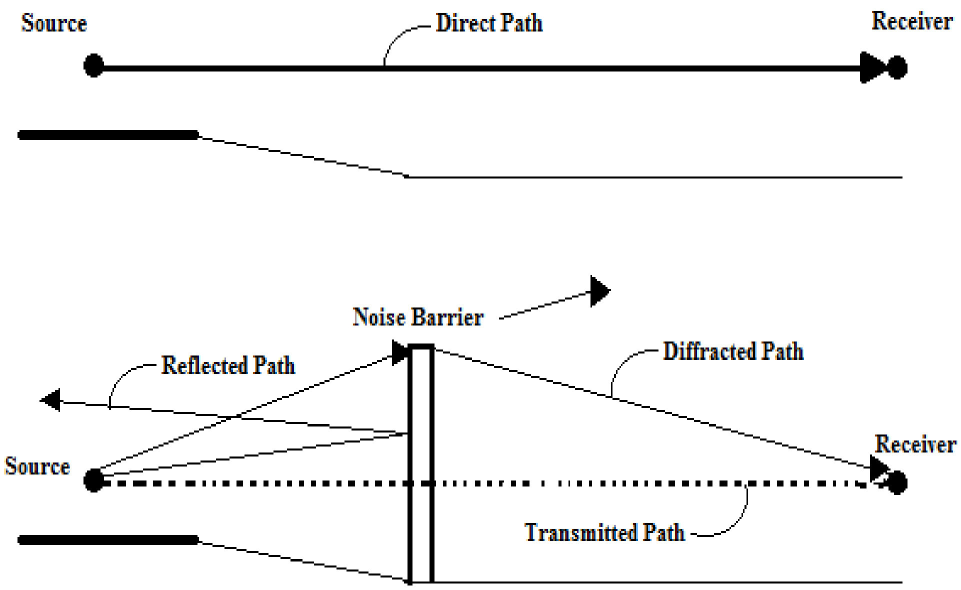


Figure 2: Alteration of Noise Paths by a Noise Barrier [19]

Many precautions that can be taken to reduce the harmful effects of highway traffic noise are listed below. These include the following:

a) Using suitable surface coatings on highways (silent roads)
b) Reducing noise by creating soil mounds on roadsides
c) Planting of roadsides
d) Building noise protection walls on roadsides (artificial noise barriers)
e) Precautions that can be taken on road sections (other barrier types)

The methods that are mostly used to reduce highway noise pollution are roadside vegetation (natural barriers) and artificial noise barriers [20].

Vegetation of Roadsides (Natural Barriers)

Vegetative barriers are chosen because they are economical, appealing to the eye, natural and help eliminate vehicle air pollutants in addition to the traffic noise (Figure 3) [21]. The relation between noise reduction and vegetative barriers determined in the OECD study is shown in Table 2 [22](Ünver 2008).

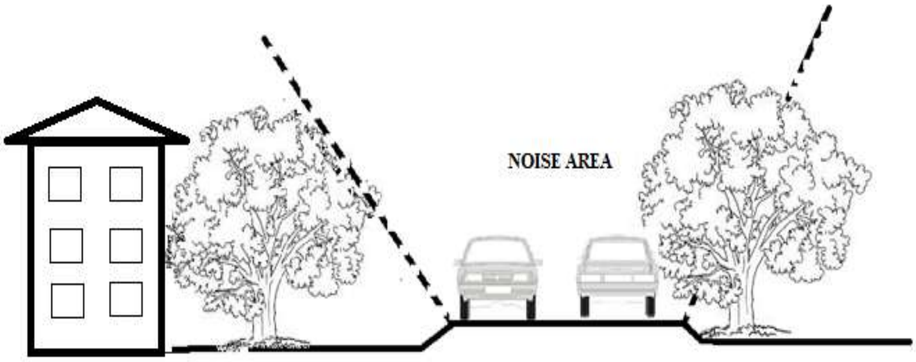


Figure 3. Example of natural barriers [21]

Table 2. The role of plantal barriers in noise reduction [22]

Type	**Dimensions**	**Acoustic Function**	**Noise reduction,dBA**	**(+): Advantages (-): Disadvantages**
Trees and shrubs	L: at least 10 H: 8-9	Absorptive	3-4	(+): Appealing to eye and is able to absorb exhaust gases (-): Provides a limited level of acoustic improvement.
Shrub over mound	L: 15-18 H: 3-4	Absorptive and reflective	15-16	(+):Pleasing to the eye and effective in terms of reducing acoustics (-): There is a need for large areas.
L: length in meters H: Height in meters				

Artificial Barriers

According to the criteria of OECD, the weight of a unit meter square of an artificial noise barrier must be at least 20 kg/m2, each meter unit of barrier height should succeed a 1.5 dBA reduction in noise level, and the length of the barrier must be at least four times the distance between the recipient and the barrier [22;23].

V. THE CHOICE OF NOISE BARRIER MATERIAL

A noise barrier significantly prevents the distribution of sound waves from the road to the receiver. By being split over the barrier, sound waves create an effective area behind the barrier. Different types of noise barriers must be suitable for each different condition [24].

Highway noise barriers can be divided into the following categories: Reflective type – transparent and non-transparent

- Absorptive type – sound absorbent materials and possible finishes of absorptive panels
- Earth landscaped mound and retaining structures
- Mixed type – a combination of the above types [24].

Mostly, materials and construction (design) reveals the main structure of a noise barrier. Materials used in making barriers are as follows:

a) Wooden noise barriers
b) Concrete noise barriers
c) Steel noise barriers
d) Aluminum sheet noise barriers

Transparent noise barriers are preferred in many cases both for receivers and sources to not restrict the field of vision of drivers and to be able to see natural environments [21]. Various noise barriers used on highways are shown in Figure 4 [25].

(a) (b)

(c) (d)

Figure 4. (a) Transparent noise barrier, (b) Metal noise barrier, (c) Concrete noise barrier, (d) Plastic, PVC and fiberglass noise barriers

VI. DATA AND METHODOLOGY

Study Area

Iller Bank Inc. Samsun Regional Directorate, located at the 8.4 km mark of Ataturk Boulevard on Samsun-Sinop road in Turkey, was chosen as the study area. The Iller Bank Atakum Service Branch and four public housing complexes are situated on the 27825 m2 of land owned by Ilbank. The total number of employees working in the facility between the hours of 08:00 to 17:00 during the week is 86 (Figure 5) [26]

Figure 5. Ilbank Inc. Samsun Regional Directorate Atakum Building

The purpose of this study is to investigate the extent to which employees in the institution and people living in the public houses are affected before and after the noise barriers are placed. Meteorological data and noise measurement values were used for the purpose of mapping the noise level. The noise level measurements are taken from these five locations; Atatürk Boulevard (Bafra direction- Samsun direction), 15th street, Nişantaşı Avenue and İsmet İnönü Boulevard. For two days, the number of vehicles, heavy vehicles and motorcycles were recorded at 15 min intervals throughout the day. The number of vehicles obtained in specific time intervals is shown in Tables 3 and 4.

Table 3. The First Day of Car Count

1ST DAY ATATÜRK BOULEVARD, SAMSUN DIRECTION				1ST DAY ATATURK BOULEVARD, BAFRA DIRECTION			
Hours	Vehicle	Heavy Vehicle	Motorcycle	Hours	Vehicle	Heavy Vehicle	Motorcycle
06:45 - 07:00	95	31	1	06:45 - 07:00	29	6	0
08:00 - 08:15	186	33	1	08:00 - 08:15	83	15	5
09:00 - 09:15	187	31	5	09:00 - 09:15	67	4	1
12:00 - 12:15	205	18	6	12:00 - 12:15	68	6	5
17:15 - 17:30	230	38	1	17:15 - 17:30	86	5	1
19:00 - 19:15	169	35	6	19:00 - 19:15	78	8	6
22:45 - 23:00	121	13	1	22:45 - 23:00	28	3	1
23:00 - 23:15	-	-	-	23:00 - 23:15	-	-	-
TOTAL	1193	199	21	TOTAL	439	47	19
1ST DAY NISANTASI AVENUE				1ST DAY 15th STREET			
Hours	Vehicle	Heavy Vehicle	Motorcycle	Hours	Vehicle	Heavy Vehicle	Motorcycle
06:45 - 07:00	66	24	3	06:45 - 07:00	83	29	0
08:00 - 08:15	127	27	0	08:00 - 08:15	176	17	0
09:00 - 09:15	85	9	0	09:00 - 09:15	82	6	1
12:00 - 12:15	135	6	4	12:00 - 12:15	100	5	0
17:15 - 17:30	206	17	5	17:15 - 17:30	176	12	2
19:00 - 19:15	158	19	5	19:00 - 19:15	102	11	3
22:45 - 23:00	-	-	-	22:45 - 23:00	-	-	-
23:00 - 23:15	44	1	0	23:00 - 23:15	26	1	1
TOTAL	821	103	17	TOTAL	745	81	7
1ST DAY ISMET INONU BOULEVARD							
Hours	Vehicle	Heavy Vehicle	Motorcycle				
06:45 - 07:00	57	1	1				
08:00 - 08:15	138	2	0				
09:00 - 09:15	128	4	0				
12:00 - 12:15	98	8	0				
17:15 - 17:30	249	12	4				
19:00 - 19:15	273	6	4				
22:45 - 23:00	36	1	1				
23:00 - 23:15	-	-	-				
TOTAL	979	34	10				

In this study, the Cadna A® simulation program was used. The program was developed by the Datakustik Company in Munich, Germany. The program allows calculations to be made, according to various standards, to create noise maps in various application areas (Cadna A., 2000). After selection of the correct method for the given study purpose and depending on the time frames, data of transport density, % of heavy and light vehicles, average speed, traffic flow condition, road width, the height of buildings surrounding, land topography, meteorological data, demographic information are recorded in the program [27;28]

Table 4. The second day of Car Count

2ST DAY ATATÜRK BOULEVARD, SAMSUN DIRECTION				2ST DAY ATATURK BOULEVARD, BAFRA DIRECTION			
Hours	Vehicle	Heavy Vehicle	Motorcycle	Hours	Vehicle	Heavy Vehicle	Motorcycle
06:45 - 07:00	113	19	2	06:45 - 07:00	106	22	1
08:00 - 08:15	191	21	3	08:00 - 08:15	177	28	1
09:00 - 09:15	208	27	3	09:00 - 09:15	203	38	1
12:00 - 12:15	204	42	3	12:00 - 12:15	173	23	8
17:15 - 17:30	205	56	6	17:15 - 17:30	225	27	7
19:00 - 19:15	197	48	15	19:00 - 19:15	194	23	0
22:45 - 23:00	135	11	1	22:45 - 23:00	142	8	4
23:00 - 23:15	-	-	-	23:00 - 23:15	-	-	-
TOTAL	1253	224	33	TOTAL	1220	169	24
2ST DAY NISANTASI AVENUE				2ST DAY 15th STREET			
Hours	Vehicle	Heavy Vehicle	Motorcycle	Hours	Vehicle	Heavy Vehicle	Motorcycle
06:45 - 07:00	108	20	0	06:45 - 07:00	120	21	1
08:00 - 08:15	139	18	0	08:00 - 08:15	192	12	0
09:00 - 09:15	88	8	1	09:00 - 09:15	97	6	2
12:00 - 12:15	88	20	3	12:00 - 12:15	93	11	5
17:15 - 17:30	197	18	6	17:15 - 17:30	169	39	2
19:00 - 19:15	135	20	2	19:00 - 19:15	97	15	1
22:45 - 23:00	-	-	-	22:45 - 23:00	-	-	-
23:00 - 23:15	45	1	1	23:00 - 23:15	23	1	0
TOTAL	800	105	13	TOTAL	791	105	11
2ST DAY ISMET INONU BOULEVARD							
Hours	Vehicle	Heavy Vehicle	Motorcycle				
06:45 - 07:00	69	1	1				
08:00 - 08:15	121	7	1				
09:00 - 09:15	119	5	1				
12:00 - 12:15	71	5	3				
17:15 - 17:30	196	10	7				
19:00 - 19:15	143	3	2				
22:45 - 23:00	37	2	0				
23:00 - 23:15	-	-	-				
TOTAL	756	33	15				

Meteorological conditions play a strong role in the propagation of sound. Therefore, annual meteorological data of Samsun for the year 2013 was provided from the Meteorology Office on March 13, 2014. The obtained data are shown in Table 5. The average temperature in the year 2013 is 16.5°C and the average relative humidity is approximately %72 [28].

Table 5. Monthly averages of the meteorological values in Samsun for 2013

	January	**Februar y**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Average**
Average temperature (^{C})	9.5	9.7	7.3	11.2	17.5	22.4	25.3	27.1	22.8	15.3	16	13.8	16.5
Relative Humidity	61.6	69	76.5	79.9	77.4	80.9	75.6	71.5	76.8	74.1	57	61	72
Average Wind Direction	SSW	SSW	N	NNE	SW	NNE	NNE	NNE	NNE	SW	SW	SW	SW
Average Wind Speed	2.1	1.7	1.1	1.3	2.3	1.3	1.4	1.5	1.3	1	1.5	2	1.5
The number of clear days	1		3	6	7	3	4	13	1	2	11	4	55
The number of cloudy days	25	13	16	17	23	26	23	18	21	13	18	17	226
The number of overcast days	10	14	11	7	1	1	5		8	16	1	10	84
Average Cloudiness (0-10)	7.1	7.4	6.7	5	4.2	5.6	5	2.5	5.7	7	3.4	6.5	5.5

Calculations of the map are expressed via color shading and to interpret the colors, a color scale is shown in Table 6. The color changes on the map are given in widths of 5 dBA bands as is required by strategic mapping protocol [29]. (Samsun Directorate of Meteorology 2013)

Table 6. Map Representation of Noise Levels Ranges in 5 dBA

NOISE VALUES (dBA)	THE POSSIBLE COLOR VALUE
< 35	
35-40	
40-45	
45-50	
50-55	
55-60	
60-65	
65-70	
70-75	
75-80	
80-85	
85 <	

Research Findings

Noise pollution information was obtained from the maps created and analyses were conducted before and after the placement of the barriers. Because the intensity of traffic was the highest during the day, which coincided with the employee work hours, Lday measurements were examined.

The Creation of Noise Maps Before The Installation of Noise Barriers

Measurements, which were made before the placement of the barrier, and derived A-weighted long-term average sound level of the daytime hours, are displayed in Figure 6a. Noise levels proportionally affect all of the plant's northern area (Figure 6b).

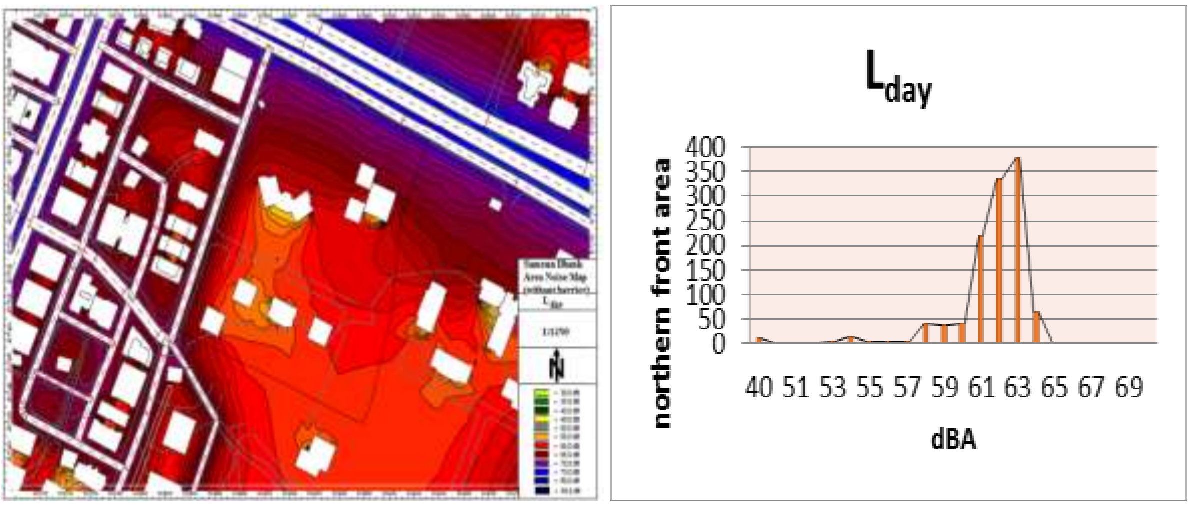
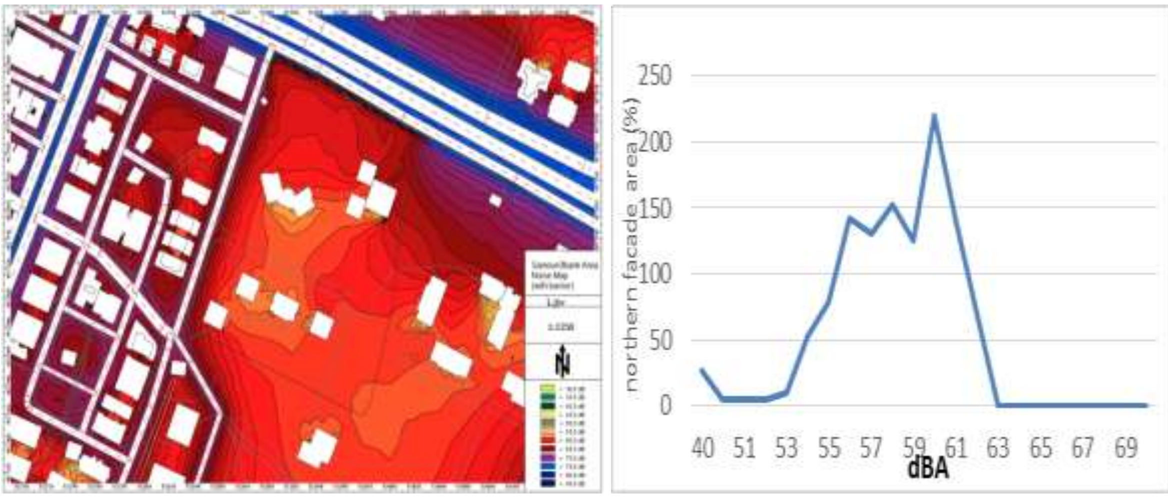


Figure 6. The locations of the measuring points

Noise Barrier Design and the Creation of New Noise Maps

According to article 20/b of the by-law of the Assessment and Management of the Environmental Noise, taking a high volume of complaints about highway traffic noise into consideration, the maximum environmental noise level Lday exceeded 68 dBA for houses near highways not affected by the present roads. Taking into consideration noise screening techniques in accordance with the standards TSEN 1793-1, TSEN 1793-2 and TSEN 1793-3, effective and applicable precautions may be taken by the business organizations/institutions for the traffic flow, road coatings, etc., of highways and their environments [16].

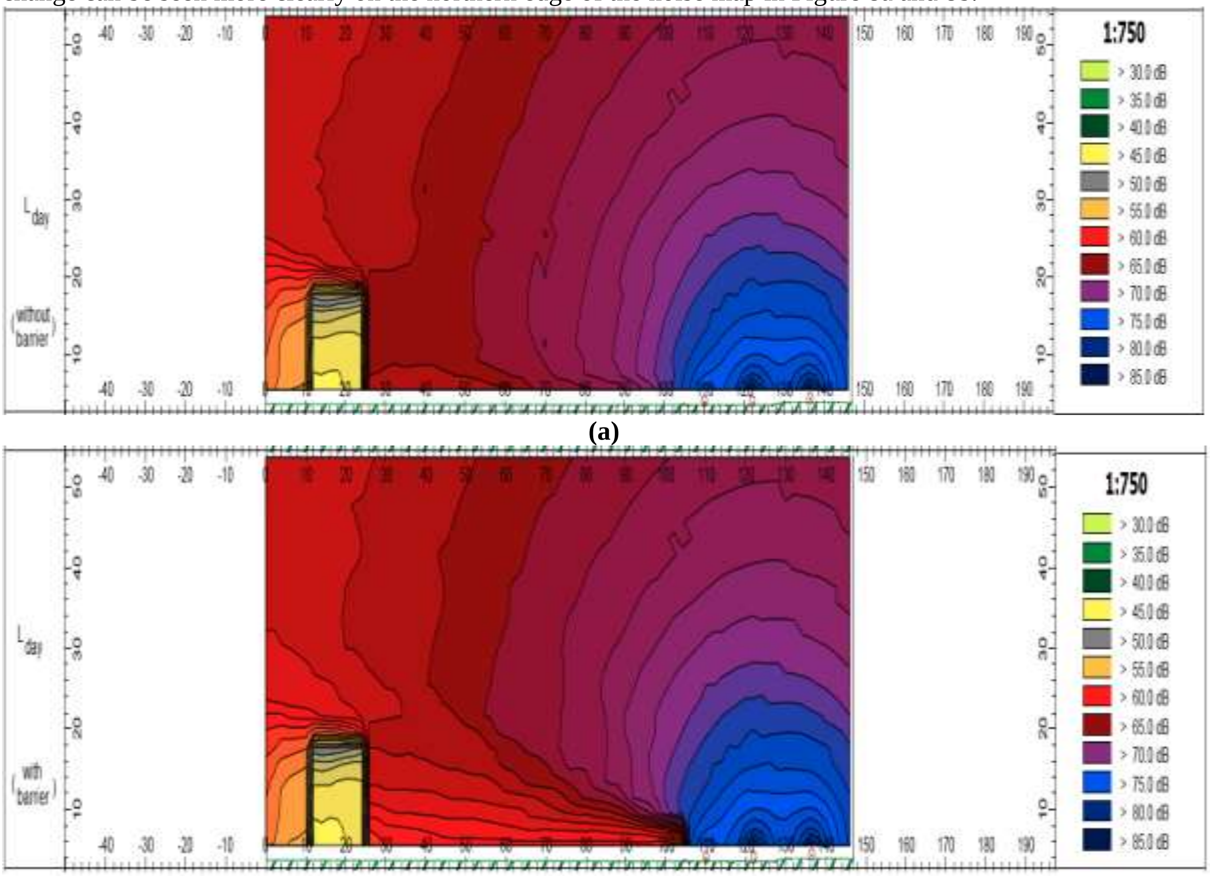
In this section, a vertical noise barrier 4 m in height and 25 cm in width is placed on the northern side of the facility and the effects of the noise have been mapped. This barrier acts as a shield between the source and recipient. By considering the sections that are mostly affected by the noise in the study area, noise barrier design is conducted, and afterwards, the obtained day-time hour noise map and north facades' proportional noise values are shown in Figure 7a and Figure 7b, respectively.



(a) (b)

Comparison

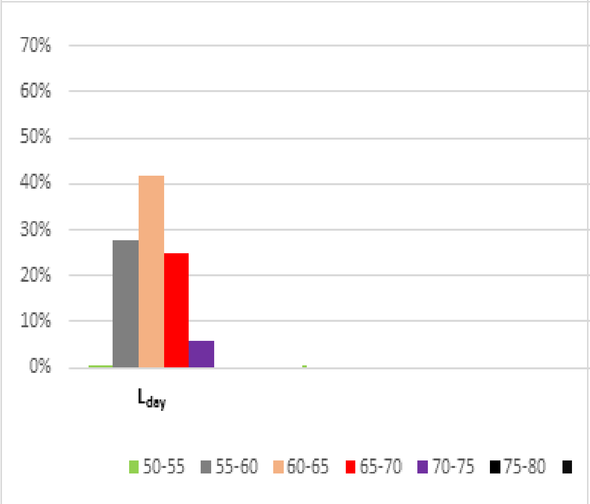
When the noise maps created before and after the barriers are examined, the Lday value in the public facilities reached approximately 65-70 dBA, but after the barriers were installed, this value decreased to approximately 50-55 dBA. In accordance with the law, the dB value should be 65 dBA for working sites and rebuilt roads and 70 dBA for present roads. Therefore, the designed barrier is acceptable for this purpose. This change can be seen more clearly on the northern edge of the noise map in Figure 8a and 8b.



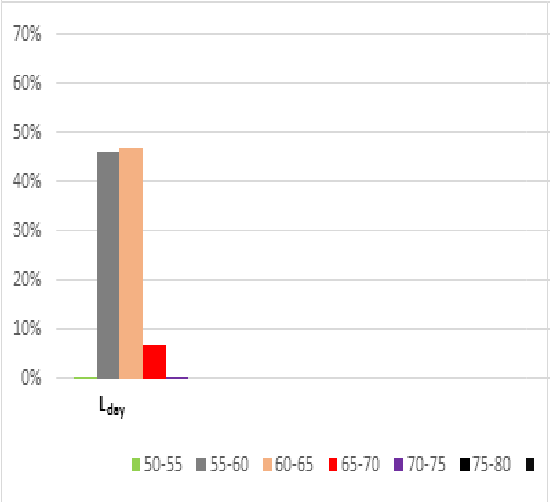
(b)

Figure 8. Vertical direction noise map (Lday) of Facilities' (a) without barrier (b) with barrier.

Under normal circumstances, 6% of the land is exposed to 70-75 dBA and 25% is exposed to 65-70 dBA in the facilities (Figure 9a). However, after the installation of the barriers, these values decreased to 0% and 7%, respectively (Figure 9b).



(a)



(b)

(b)

In this study, during working hours (Lday), 50 workers were exposed to a disturbing noise level of 60-65 dBA under normal conditions, but after the barrier was added, the number of people exposed to such a noise level dropped to 24. In addition, the number of employees exposed to a normal noise level of 50-55 dBA increased from two to six (Table 7).

Table 7: At Daytime Hours, Number of Employees Working at Lday Level

	Barrier-Free	Barrier
50-55	2	6
55-60	34	56
60-65	50	24
65-70	-	-
70-75	-	-
75-	-	-

V. CONCLUSIONS

In our country, necessary consideration has not been given to the subject of noise pollution in regard to decisions related to urban, regional and construction planning. As a result, the majority of people have been affected negatively from noise pollution.

Conditions set to provide acoustic comfort are detailed in various national and international standards and regulations. These standards and regulations classify the regions where structures with various functions can be located at the urban level with their noise level limits and determine the noise levels that must not be exceeded in the structures.

In this study, a public institution located next to the highway, which was exposed to high noise levels that were modeled with the help of Cadna A® programs, was investigated before and after the installment of noise barriers.

It is important for employees to work in a quiet environment. Acceptable exterior noise limits were exceeded (75 dBA) during the day and employees work performances showed that they were quite effected by these noise levels. After installation of the barriers, the noise levels were within the limits specified in the standards (55 dBA).

Observations and calculations performed during this study suggest that institutions, among which are research and development centers such as Techno parks, hospitals and educational facilities, should be located in areas that have low levels of traffic noise to provide a comfortable work environment, or these noises should be reduced to minimum with natural or artificial barriers. Additionally, the Ministry of Labor and Social Security in our country should take these types of precautions for the comfort of workers, which will enable them to work more effectively.

REFERENCES

[1]. Chauhan, A., Pawar, M., Kumar, D., Kumar, N., Kumar R. (2010). Assessment of Noise Sound Level Status in Different Areas of Moradabad City, Report and Opinion, 2(5), pp 59-6

[2]. OECD Road Transport Research (1995). Road Infrastructure Rehabiliation and Safety Strategies in Central and Eastern European Countries. OECD Document (also available in Russian), Paris.

[3]. Tekalan, Ş.A. (1991), Effects of noise to audition and other systems, Ecology and environment journal (in Turkish), 1, İzmir , 2-l l.

[4]. Turkey Environment and Urbanization Ministry (in Turkish), http://gurultu.cevreorman.gov.tr/gurultu/AnaSayfa/gurultu/sagliketkileri.aspx?sflang=tr, 2011

[5]. Ollerhead JB: Noise as a Public Healty Problem. OSHA Report, ICBEN 1980

[6]. Amundsen AH., Kleaboe R: A Nordic perspective on noise reduction at the source. Institute of Transport Economics, TØI Report 806, Oslo, 2005

[7]. Maraş, EE: Productıon Of Noise Maps In Context With European Union Requirements With The Support Of Geographic Information System: Samsun Province Example. Yıldız Teknik University, Graduate of Science, , İstanbul, 2011, 179 (in Turkish).

[8]. Calixto A, Diniz FB and Zannin PHT: The Statistical Modeling of Road Traffic Noise in an Urban Setting. Cities, 2003, p: 23-29

[9]. Jones K: Environmental noise and health: a review. In Book Environmental noise and health: a review. City: UK Civil Aviation Authority, 2010:56. 56.

[10]. Maynard R, Berry B, Flindell I: Environmental Noise and Health in the UK - A report published by the Health Protection Agency on behalf of the ad hoc Expert Group on the Effects of Environmental Noise on Health. In Book Environmental Noise and Health in the UK - A report published by the Health Protection Agency on behalf of the ad hoc Expert Group on the Effects of Environmental Noise on Health. City: Health Protection Agency; 2010:110.

[11]. Méline J, Huls A, Thomas F, Karusisi N, Chaix B: Transportation noise and annoyance related to road traffic in the French RECORD study. Internatıonal Journal Of Health Geographıcs, 2013, 12:44, p:1-13

[12]. Instructions for Assesment and Management of Environmental Noise, http://www.mevzuat.gov.tr, 18.04.2014 (in Turkish).

[13]. Erdoğan S, Doğan M, Yılmaz İ, Güllü M, Baybura T, Ulu M., Şişe Ö: Preparetion of The Traffic Noise Map In The City of Afyonkarahisar. Afyon Kocatepe University, Journal of Science, 2007, 7 (2), 137-152 (in Turkish).

[14]. Baaj, M.H., El-Fadel, M., Shazbak, S.M., Saliby, E. (2001). “Modeling noise at elevated highways in urban areas: a practical application”, Journal of Urban Planning and Development, 169.

[15]. Farcaş, F. (2008). Road Traffic Noise: A study of Skåne region, Sweden, Master Thesis, Linköping University, ISRN: LIU-IDA/FFK-UP-A--08/015—SE, http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-17786.

[16]. Road noise prediction, 2:NMPB 2008- Noise propagation computation method including

[17]. Lang, J. (2001). Calculation method for road traffic noise, Ar-Interim-Cm (Contract: B4-3040/2001/329750/Mar/C1), Adaptation And Revision Of The Interim Noise Computation Methods For The Purpose Of Strategic Noise Mapping, WP 3.1.1: Road traffic noise - Description of the calculation method.

[18]. Dutilleux, G., Defrance, J., Gauvreau, B. and Besnard, F. (2008). The revision of the French method for road traffic noise prediction, Acustics 08 Paris, June 29-July 04 2008, www.acoustics08-paris.org

[19]. Harvey S. Knauer, Soren Pedersen, Cynthia s.y. Lee, Gregg G. Fleming (2000). Federal Highway Administration Highway Noise Barrier Design Handbook, Final Report, U.S. Department of Transportation, Cambridge.

[20]. The Highways Agency (2003). Guidelines on Design of Noise Barrier, Environmental Protection Department, Highway Department, Government of the Hong Kong SAR Second Issue, January 2003.

[21]. Ataoğlu, E. (2014). Landscape Desıgn In Noise Barriers, Graduate School of Natural and Applied Sciences Urban Systems and Transportation Management, Bahçeşehir University, İstanbul 2014, 88 Pages (in Turkish).

[22]. Ünver, E. (2008). Determinatıon of Noise Pollution Due to Traffic and Recreation: A Case Study Of Çorlu, Namık Kemal University, Graduate of Science, Tekirdağ, 90 Pages (in Turkish).

[23]. OECD Road Transport Research (1995). Road Infrastructure Rehabiliation and Safety Strategies in Central and Eastern European Countries. OECD Document (also available in Russian), Paris.

[24]. Nelson P. M. ve Piner R. (1997). "Classifying Road Vehicles for the Prediction of Road Traffic Noise".

[25]. Maraş, E.E. (2013). Photo Albums.

[26]. View of Ilbank Samsun Regional Directorate Atakum Building from Google Map, https://www.google.com/maps/search/samsun+ilbank 20.05.2014

[27]. Cadna, A. (2000). Computer Aided Noise Analisis Software for Environmental Engineering, Munich, Germany

[28]. Maraş E., Maraş H., Maraş S., Alkış, Z. (2011). Analysis of the Prediction Method Used in Environmental Noise Mapping from GIS Data, Survey Journal, 145, (ISSN 1300-5790) (in Turkish).

[29]. Samsun Directorate of Meteorology (2013). Meteorologic Status Report (in Turkish).