Note that the significance coefficients of the criteria can be determined by the method of expert assessments of a group of quality specialists.

The interpretation of the values of the final criterion for the effectiveness of the quality management system is given in Table 7.

TABLE 7– SYSTEM PERFORMANCE ASSESSMENTS

The obtained quantitative assessment of the system's performance	The degree of effectiveness of the system
$R_{res} < 0,60$	invalid
$0,60 < R_{res} < 0,75$	acceptable
$0,75 < R_{рез} < 0,95$	sufficient
$R_{res} > 0,95$	high

Using the gradation of the degree of effectiveness of the product quality management system, a conclusion is made about the state of the product at the stages of the life cycle.

The application of the methodology allows you to monitor the quality level at the stages of development, production and operation, and take appropriate measures to prevent the appearance of product inconsistencies.

The developed method can be automated with the help of modern applied software tools [4-5], but this is the topic of the next article.

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GEOECOLOGICAL RISKS OF TECHNOGENIC NOISE AT LOW FREQUENCIES

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Abstract — The tasks of evaluation of geoecological risks related to transport vibrations in the ground and acoustic vibrations in the atmosphere generated by moving transport, such as railway, automobile, tracked transport are considered. The main ecologically harmful frequency areas on the basis of spectral and spectral–time analysis of the records of technogenic noises are identified. Estimates of vibro–acoustically conditioned risks in the allocated frequency bands are

calculated. Comparative analysis with critical norms and discussion of the obtained results were carried out.

Keywords — Technogenic noise, geoecological risks, numerical estimates, transport types, experimental records, critical norms, comparative analysis.

INTRODUCTION

The problem of estimation and prevention of harmful influence of technogenic noises generated by various kinds of transport and productions now becomes especially acute. The level of noise pollution is among the most important indicators characterizing comfort of living of people in an urban area [1]. The World Health Organization conducted research and gave estimations of noise levels to which inhabitants of European countries are exposed. According to this data during the daytime about 40% of European residents are exposed to noise levels exceeding 55 dB and 20% are exposed to noise levels exceeding 65 dB [2]. This is contributed by active development work, an increase in the number of cars, and various landfill and quarry explosions, etc [1]. Noises of a natural character are added to this (for example, noise of sea surf, hurricanes, sharp fluctuations of atmospheric pressure).

The problem of harmful effects on the environment increases sharply in the area of low and infra–low frequencies, the most ecologically dangerous for humans, as well as the most destructive for large structures (bridges, buildings, industrial premises, etc.). The latter is determined by the fact that in the area of infralow frequencies are natural frequencies of vibration of structures. This determines the relevance of the research.

PROBLEM STATEMENT

The acoustic impact of technogenic noises on the surrounding infrastructure and humans is related to the concept of geoecological risk, defined by the equation:

$$L_{Aeg} = 10\lg\frac{1}{T}\int_0^T\left(\frac{p_A(t)}{p_0}\right)^2 dt\,, \tag{1}$$

where L_{Aeg} is equivalent corrected noise level for a given period T, $p_A(t)$ is the current value of root mean square sound pressure, Pa; p_o is the reference sound pressure in the air, it is taken equal to $p_o = 2 \cdot 10^{-5}$ Pa; T is time of noise, hour [3].

Along with the negative impacts of the processes of acoustic transport noise in the atmosphere, it is also necessary to consider the impact of vibrations arising as a result of seismic vibration propagation in the ground. Of these vibrations are: transport, which occurs as a result of traffic on the roads; technological – occurs during the operation of machinery and equipment in the process of carrying out technological operations on the production sites. The environmental risk indicator attributed to vibrations is determined as follows:

$$L_v = 20\lg\left(\frac{v}{v_0}\right)\,, \tag{2}$$

where L_v is vibration velocity level; v is the root mean square value of vibration velocity, m/s; v_0 is the reference value of vibration velocity, taken as $5 \cdot 10^{-8}$ m/s [4].

Since noise exposure has a cumulative effect, a summary noise and vibration velocity level may be calculated for each mode of transport, taking into account the duration of exposure.

The summary noise level may be determined by the equation:

$$L_{Aegsum} = 10\lg\int_0^T\left(\frac{p_A(t)}{p_0}\right)^2 dt\,, \tag{3}$$

where $p_A(t)$ is the current value of the root mean square sound pressure, Pa; p_o is the reference sound pressure in the air, is taken to be $2 \cdot 10^{-5}$ Pa; T is the time of action of noise, hour.

The summary vibration velocity level can be determined by the equation:

$$L_{vsum} = 10 \lg \int_0^T \left(\frac{v(t)}{v_0} \right)^2 dt \,, \qquad (4)$$

where v is the current value of the root mean square value of vibration velocity, m/s; v_0 is the reference value of the vibration velocity, is taken to be $5 \cdot 10^{-8}$ m/s.

The weighted average daily noise may be calculated by the formula:

$$L_{den} = \frac{\sum L_i \cdot p_i}{\sum p_i} \,, \qquad (5)$$

where L_i is equivalent corrected noise level for a given period, dB; p_i is the fraction of event time from day [3].

Estimation of ecological risks (1) – (5) represents a multifactorial problem, which solution depends on power of a noise source, their frequency range, conditions of distribution of noise fluctuations in the atmosphere, etc. [5].

The purpose of this work is related to the allocation of the most ecologically dangerous low frequencies of noises of various types of transport – railway, automobile, tracked, as well as industrial noise. The following stage is connected with obtaining of numerical assessments of risks (1) – (5) depending on noise frequencies, acoustic pressure levels and seismic vibrations.

NUMERICAL MODELING AND EXPERIMENTAL RESULTS

The approach to numerical modeling consists in determining the boundaries of emerging events (associated with the passage of one or another type of technique) by experimentally obtained records of traffic noise. This stage of the work is implemented with the application of the threshold algorithm according to the 3σ rule. The spectral-temporal functions (STF) are calculated on the selected parts of the recordings. This type of analysis is applied to the records of railway transport, heavy tracked and wheeled transport noises.

As a result of data processing, graphs were obtained, which allow tracing the dynamics of spectrum changes, determining characteristic frequencies of the types of transport under consideration. As an example, the STF graph of tracked transport noise, presented in Fig. 1a, is shown below. STF graph of KAMAZ noise is shown in Fig. 1b. It can be seen, that frequencies of about 1 – 100 Hz with predominance of frequencies in the range of about 10 – 50 Hz are typical for tracked transport. KAMAZ is characterized by frequencies about 1 – 90 Hz with the predominance of frequencies in the range of about 5–30 Hz, 50 – 65 Hz. The given data corresponds to a distance from the noise source of 20 m and an average speed of about 20 – 60 km/h.

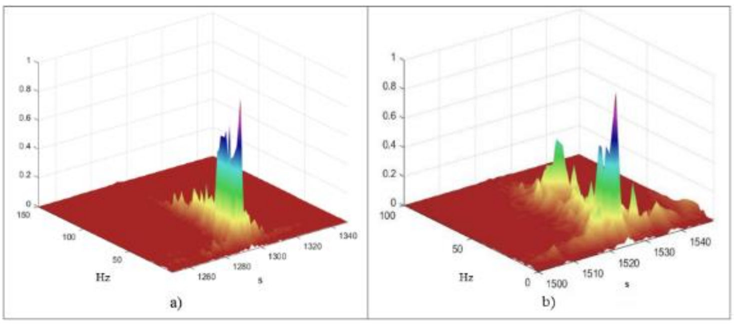


Fig. 1 Spectral–time functions (STF) of seismic noise: a) – tracked transport; b) – KAMAZ.

Acoustic and seismic noises of railway transport (passenger and freight trains) were recorded at a distance of 30 m from the railway track. For each type of railway transport were obtained STF graphs in the amplitude-frequency-time coordinates, as well as their projections on the "frequency-time" plane. The obtained graphs are presented below.

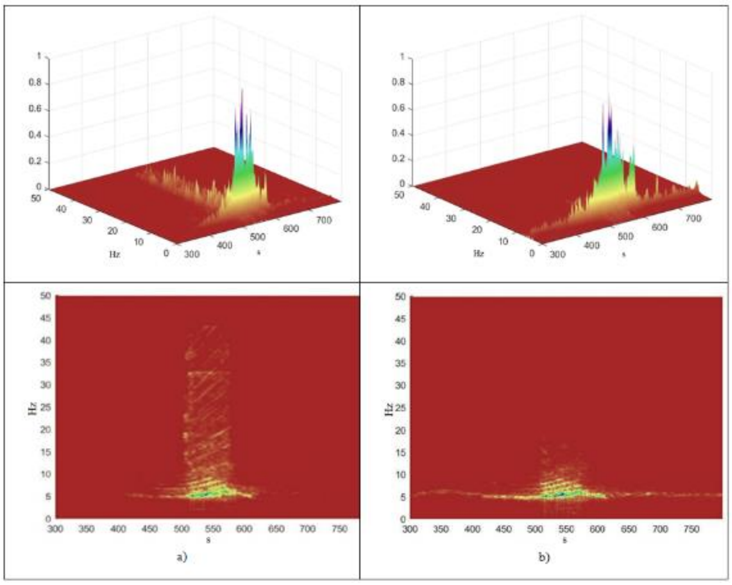


Fig.2 Spectral-time functions (STF) and their projections on the "frequency–time" plane for heavily loaded freight train noises a) –seismic; b) – acoustic

According to the STF analysis results, it was found that at a speed of 40 – 70 km/h, the predominant frequency range of seismic (Fig. 2a) and acoustic (Fig. 2b) noises of a freight train covers the frequency range of 4 – 10 Hz. At that, the main spectral mode lies in the area of 6 – 7 Hz.

Seismic noise of passenger trains at a speed of 50 – 80 km/h is characterized by the frequencies in the band of 5 – 44 Hz (Fig. 3a) with the location of the main spectral modes in the area of 8 – 9 Hz, 20 Hz. The frequency range of acoustic noises (Fig.3b) covers the band in the range of 3 – 15 Hz, and the main mode of noises lies in the region of 7 – 8 Hz.

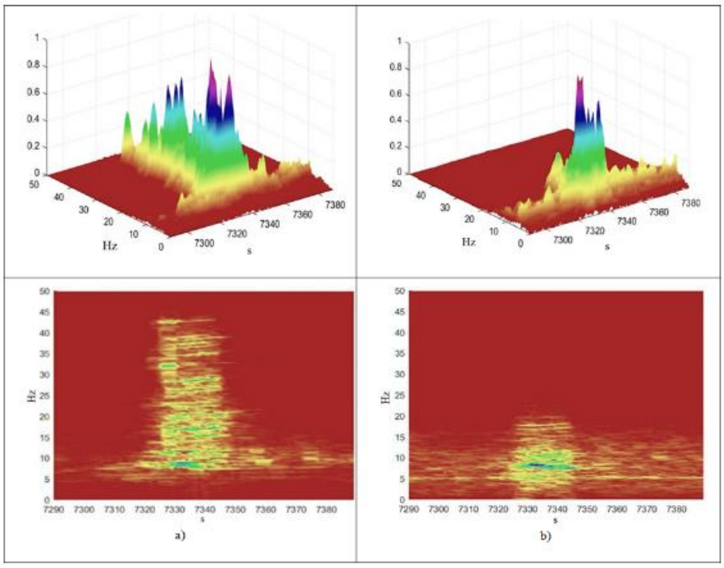


Fig.3 Spectral-time functions (STF) and their projections on the "frequency–time" plane for passenger train noises a) – seismic; b) – acoustic.

Seismic noises of electric trains moving at a speed of about 50 – 80 km/h are characterized by frequencies in the 5 – 44 Hz band with the location of the main spectral modes around 8 – 11 Hz, 33, 38 Hz. The frequency range of acoustic noise is in the range of 3 –15 Hz, and the main mode of noise lies around 7 – 8 Hz.

Acoustic noise level according to (1) and vibration velocity level according to (2) were calculated for the considered types of transport. For KAMAZ and tracked transport the vibration velocity level was calculated according to the data obtained by the transport moving from the seismic station at distances of 20 m to 500 m. Calculations were performed in frequency bands typical for the type of transport that was considered.

The results of calculations of the transport noise level with regard to the types of transport under consideration are presented in Table 1. Table 2 presents the results of calculations of the vibration velocity level.

TABLE I. NOISE LEVEL

№	Transport type	Frequency range, Hz	Distance, m	Averaging time, s	Noise level, dB	Summary noise level, dB
1	Freight train	4–10	30	190	64,0	106,8
		1–49	30	178	64,2	107
2	Electric train	1–49	30	30	51,2	86
		3–15	30	30	50,8	85,6
3	Passenger train	6–44	30	23	53,6	87,2
		1–49	30	23	54	87,7

TABLE II. VIBRATION VELOCITY LEVEL

№	Transport type	Frequency range, Hz	Distance, m	Averaging time, s	Vibration velocity level, dB	Summary vibration velocity level, dB
1	Freight train	4–10	30	190	59,1	101,6
		1–49	30	178	75,5	118,0
2	Electric train	6–44	30	30	50,7	85,4
		1–49	30	30	50,8	85,5
3	Passenger train	6–44	30	23	47,1	80,8
		1–49	30	23	47,2	80,9
4	KAMAZ	1–90	20–50	10	47,2	87,2
			50–100	7	38,9	77,4
			100–150	7	35,3	73,8
			150–200	13	31,2	72,4
			200–300	18	23,4	66,0
			300–400	14	20,0	61,5
			400–500	14	18,3	59,8
5	Tracked transport	1–100	20–50	9	63,2	102,7
			50–100	5	54,1	91,1
			100–150	5	44,9	81,9
			150–200	11	36,5	76,9
			200–300	13	34,0	75,1

			300–400	10	26,0	66,0
			400–500	11	21,2	61,6

Noise levels in the railroad area were calculated for each hour during the day. The data on the hourly dynamics of changes in the noise situation are shown in Fig. 4. It has been established that the average level of noise in the area of the railroad noise impact during the day at a distance of about 30 meters is about 53,7 dB. Average noise level during daytime (time interval 7 a.m. – 7 p.m.) is 57 dB. The average noise level at night (23 p.m – 7 a.m.) is around 51,8 dB. Average weighted daily noise level of railway transport is about 60 dB. Summary noise level during trains running during 24 hours was 117,4 dB (summary time of trains running during 24 hours was about 1 hour 9 minutes). Thus, if we take into account the influence of noise sources as separate events, the noise level is within the established norms (does not exceed 76-83 dB) [6]. At continuous action of sources, taking into account accumulation, the noise level can exceed norms.

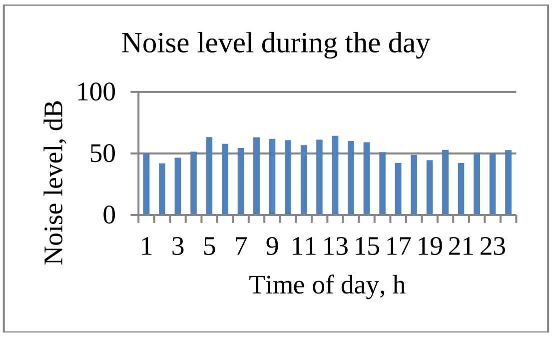
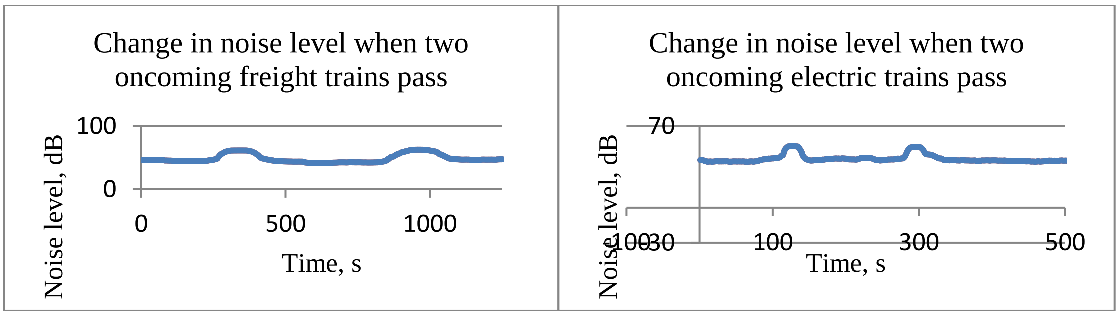


Fig. 4 Hourly dynamics of the noise situation in the city territory in the area of the railroad noise impact

Fig. 5 shows graphs of noise level changes at the simultaneous passage of two oncoming trains: Fig.5a – freight trains, Fig.5 b) – electric trains in the daytime.



a) b)

Fig. 5 Change of noise level when passing two oncoming trains: a) – freight trains, b) – electric trains

In the first case, the averaging window was 100 s, in the second – 20 s. The choice of the averaging window is determined by the duration of the passage of the train in the area of the recording sensors. From Fig. 5a shows that the noise level increases approximately 1,5 times when trains pass. In the second case, the noise level increases approximately 1,3 times.

CONCLUSION

The problem of the harmful effect of technogenic noises on the environment in the area of low and infra–low frequencies, the most ecologically dangerous for humans and destructive for large structures, is considered. Experimental records of seismic and acoustic noises of railway, heavy tracked and wheeled transport were analyzed using the method of spectral-time analysis. The frequency ranges most typical for each of the considered types of transport were identified. On the basis of the data processing it was determined that the prevailing levels of transport noise are in the range of ecologically dangerous frequencies. The levels of noise and vibration velocity, occurring during the movement of transport at different distances in the allocated frequency ranges were determined.

ACKNOWLEDGMENTS
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MULTIFUNCTIONAL MOBILE APPLICATION "MIEMAPP"

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Abstract—Mobile devices have large distribution across the world. Almost everyone has either a tablet or smartphone. Thus, applications for mobile operating systems are useful in solving a variety of problems. For instance, MIEM HSE has several online services, which can be accessed with applications. However, it is unnecessary to develop separate programs for each service, because it is uncomfortable for users to install a new application each time, they need a new service. This paper is being carried out as a comprehensive solution to develop a project based on client-server architecture. Goals of this work are designing a suitable client app "MIEMapp" and servers.

Keywords: client-server architecture; internet of things; mobile app; server application; REST API; python; modular application; Kurento.

INTRODUCTION

There are unique useful web services for teachers and students inside HSE MIEM with media and schedule features for convenient interaction with the growing community within the university. For example, LMS system is a website for marks and paperwork handling, MIEM