APPLICATION OF PREDICTABLE ACOUSTIC SOFTWARE FOR TRAM NOISE MODELING IN URBAN ENVIRONMENTS

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Introduction. Scientific and technological progress in all industries and in transport is accompanied by the development and widespread introduction of various equipment, machines and vehicles. The growth of capacities of modern equipment, machines, household appliances, and the rapid development of all modes of transport have led to the fact that people at work and in everyday life are constantly exposed to high-intensity noise. The harmful effects of noise can be the result of occupational diseases, increased overall morbidity, reduced efficiency, increased risk of injuries and accidents associated with impaired perception of warning signals, impaired auditory control of technological equipment, and reduced productivity. The whole complex of changes that occur in the human body during prolonged exposure to noise should be considered as a "noise disease".

Aim. Current work led us to measure the noise levels of trams in urban areas. The harmful effects of noise on humans are now widely recognized and manifested in a variety of effects from subjective irritation to objective pathological changes in the central nervous and cardiovascular systems. The main goal is to use predictable acoustic software to model tram noise in an urban environment.

Problem and solution. Traffic flow significantly exacerbates the environmental problems of cities. One of the most negative factors is the growing acoustic load. Noise pollution is currently becoming one of the most important environmental stressors. The noise level depends on the intensity, speed, nature of traffic, type and quality of coverage, spatial planning (longitudinal and transverse profile of streets, building architecture, traffic lights) and the availability of greenery. Noise leads to an imbalance of auditory adaptation, regulatory processes of the central nervous system, gastrointestinal tract, hemodynamic disorders, and the development of noise sickness. Prolonged exposure disrupts the mechanisms of reflex and neurohumoral reactions, there is a nervous pathology, reduced attention by (12-16)%. Physiological and biochemical adaptation of a person to noise is impossible, in addition, noise has an inherent consuming effect. Acoustic load has a negative
impact on flora and fauna. The main ones are reduced adaptability and reproductive capacity, changes in trophic networks, increased risk of predation, growth retardation, accelerated transpiration, death of leaves and flowers. This problem is most acute for urban ecosystems, as urbanization is one of the main factors in reducing biodiversity due to the loss of natural habitats, their fragmentation or drastic change. In the conditions of the city many anthropogenic (industrial, noise of transport) is added to natural noise that essentially changes an acoustic background. Currently, the noise load in megacities has increased by (12-15) dB, and the volume by three to four times. ln cities with heavy traffic, the noise level is approaching 80 dB.

The graphical representation of the noise map is based on the color scale of the noise level symbols, based on the types of zoning by the exaggeration factor, and the size of the point icons to indicate the control points on the ground may be related to their sound levels.

There are many approaches [1] to assess the environmental quality of the urban environment or its components, as well as to characterize the environmental conditions in cities. They are generally based on a methodological approach based on the relationship between the sources of anthropogenic impact, often perceived as negative consequences, and the response of components of the urban environment, including derivatives such as public health. The differences between the individual methods are:

- in the choice of indicators that characterize the types and intensity of impact;
- in the choice of indicators that characterize the reaction and changes in the components of the urban environment;
- in the mathematical apparatus used to calculate the integrated quality indicators of the urban environment or individual components, score or numerical quality characteristics, the level of impact.

The assessments performed within the framework of this methodology can be effectively used in the field of social and economic decision-making, which regulate the current economic activity in the city. With their help, you can also plan the stages and technological solutions of the planned construction. But they do not allow the introduction of environmental factors in urban planning. Based on them, it is impossible to assess and recommend the configuration of the urban space structure, both in planning and functional aspects, because to build an integrated urban structure it is necessary to work with the primary natural structure and socio-economic structure created by the city. The approaches mentioned above only allow to assess the consequences of the functioning of the already formed as a result of construction of the urban structure, and work only as tools in making specific economic and social decisions in managing the functioning of already established urban structures. The problem of acoustic safety, in our opinion, is to ignore or ignore the objective laws of noise control in the form of a complex dynamic system that is evolving, with its research methodology [2; 3], a set of rules, principles and axioms. Let's try to close this annoying gap.

The following factors should be taken into account when modeling noise propagation: the dependence of sound propagation processes on frequency, different characteristics of the atmosphere as a medium for noise propagation, and so on. To take into account most of these factors, we need to solve a series of
differential and integral equations that describe the process of sound wave propagation. Another difficulty in using this approach is that it is quite sensitive to the accuracy of the computer model of the area where the simulation is performed. Taking into account the nature of the underlying surface, the nature of landscaping, the presence of shielding structures also requires additional computing resources.

Despite some difficulties in using direct simulation of the propagation of sound waves on a computer, there are a number of software implementations. One of the first was the BRUIT model modeling system, introduced in the 80s of the twentieth century. Despite the fact that a number of simplifications were made in this calculation system and a schematic model of the area was used, it allowed to effectively model the process of noise in the main area [1].

Among the modern systems of this class is the FHWA Traffic Noise Model, developed by order of the Federal Highway Administration (a division of the US Department of Transportation). Features of this software package include modeling of five different types of vehicles, calculation for continuous and intermittent traffic flow. This software package also analyzes different road profiles and noise barriers.

Among the software products that use statistical estimates to model noise pollution are the products of Integral (St. Petersburg) and Citis (Ekaterinburg) [1;4;6].

The Integral Noise Calculation software module is a typical example. This calculation module, designed to calculate the noise characteristics of motorways, takes into account the following modes of transport:

- cars and trucks;
- trams;
- railway trains.

This software considers the highway as one or more linear noise sources, the characteristics of which are calculated based on the intensity and speed of each mode of transport. The SNiП-regulated approach is used as a calculation algorithm in combination with empirical algorithms that simplify the modeling process [1].

The basic principles of the noise propagation model recommended by the current legislation are described in a collective monograph edited by GL Osipov and Ye. Yudin [4].

Using the mathematical apparatus of the monograph, it is possible to estimate the level of noise in the main area and determine the limits of maximum permissible noise levels, which are set by the regulatory framework.

A specific feature of software implementations of various methods of solving EIA problems is that if all calculations are mainly performed on an accurate vector model, the end result is still more appropriate to depict on a raster model. This is due to the fact that the ultimate goal of such tasks is to find areas with a certain value of the indicator. At the same time, high accuracy of the task of such an area is often not required.

The shape of the cell, optimal from the standpoint of the ratio of accuracy/speed for calculations with EIA, is usually chosen square with sides of 1 m or more. The exact size depends on the type of EIA calculation and the scale of the problem.

Thus, it is logical to use vector (to set the source data) and raster (to represent the results of calculations) data models when solving a single problem.

In the process of performing various calculations on the raster model, it is often
necessary to move from the cells of the raster model to the original vector objects. Such capabilities are provided by standard raster GIS tools.

Experience in recent decades has shown that the development of conventional sound insulation devices from the point of view of material selection, shaping and location relative to the axis of sound radiation has become more advanced and significantly affects the acoustics.

New parameters of noise radiation, and hence the effectiveness of measures taken to reduce its level determine, as already evidenced, based on profitability and growing environmental requirements.

The calculation of the model for used or planned noise protection projects on the ÖBB network gave the following results: by reducing the noise level in the entire fleet by 8 dB (A), costs could be reduced by more than a third (43%), which would be required for noise protection infrastructure measures.

By equipping all types of rolling stock with modern noise protection equipment (disc brakes, composite brake pads) can reduce by about two thirds (66%) the cost of infrastructure measures and construction of noise barriers and installation of soundproof windows in nearby buildings [1; 5].

Today, the most promising is modeling based on geographic information (GIS) systems.

The main advantage of noise maps is the ability to import and process data for an object of any area, including the state as a whole.

In addition to vibroacoustic parameters, it is necessary to assess and control the vibroacoustic comfort of cars outside the rolling stock in order to ensure the comfort of passengers.

Vibroacoustic comfort inside cars is closely related to two factors:
- vibration characteristics of the structure (structural rigidity of the body);
- change of vibration and acoustic characteristics of internal coverings and equipment.

To reduce vibration and noise, Talgo is developing vibroacoustic models that take both factors into account, which, thanks to simulation contrast methods (finite and boundary element methods, statistical energy analysis) and experimental analysis of real trains, allow:
- predict the noise level inside the cars;
- take into account the criterion of maximum noise reduction in the process of designing new products;
- to optimize the characteristics of trains on the market that are being converted.

The vibroacoustic characteristics of a vehicle depend to a large extent on the different loads it undergoes and on the complex resulting interactions between the many components and joints. Therefore, it would be correct to approach the design with noise and vibration in the form of optimization of the vehicle as a general system, starting from the earliest stages of concept development.

The purpose of acoustics modeling is:
- assessment of the level of vibroacoustic interference at the study point without significant time, resource and money costs required for instrumental measurements;
- providing the ability to analyze different vibroacoustic scenarios;
- Ability to estimate vibroacoustic parameters for the projected object or potential noise source.

Vibroacoustic simulation software calculates railway noise in accordance with national and international directives or current methods and procedures such as Schall 03 (D), NMPB-Fer (Fr), DIN 18005 (D), CRN (UK), SRM II Interim method for EU), ÖNorm S 5011 (A), Semibel (CH) [1; 5; 7].

Conclusions. Thus, the intensity of traffic noise depends on the condition and width of roads, and the distance of residential buildings from the axis of the roadway. Depending on the capacity of roads, the presence of intersections varies the acoustic load. Reduction of urban traffic noise is associated with absorbing, reflecting, shielding and insulating acoustic ability. Optimization of noise protection of the urban ecosystem depends on a set of architectural and planning solutions. When introducing technical and economic characteristics of noise protection measures, it is necessary to take into account their features (practical limitations and opportunities).

References: