Noise in Big Cities and Methods of Combating It

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Abstract.

One of the most widespread harmful factors of the urban environment is noise. Noise sources interfere with people's rest, causing dissatisfaction and irritation. When designing buildings and structures, architects must take into account the noise load on individual facilities as well as on the entire building complex. Noise protection can be implemented both at the source of noise generation and along its path of propagation. For the effective adoption of appropriate measures, it is necessary to know the noise characteristics of the sources. Noise maps make it possible to more rationally plan measures to combat noise of both urban-planning and administrative nature related to the organization of urban transport traffic. Transport, industrial, and domestic noise are considered as the main noise sources. The effectiveness of protecting buildings from sound waves increases with distance; moreover, the efficiency of protection is enhanced by greening the space located between the noise source and the receiver.

Satisfactory protection results can be achieved when the green zone extends over more than 100 m. The construction of buildings with enclosed courtyard layouts in developments strictly parallel to the street should be considered an effective measure; however, such an arrangement affects the architectural and planning solution of the building. The main methods used to limit noise propagation include appropriate external and internal spatial planning, the installation of adequate sound insulation for the enclosing structures of residential and public buildings, and related measures.

Keywords: Noise sources; noise load; transport noise; industrial noise; domestic noise; protection efficiency; sound insulation of enclosing structures.

Noise in big cities and methods of combating it.

Introduction: Noise is one of the most widespread harmful factors of the urban environment. In noise-control practice, this term refers to any sounds that disturb people. When designing buildings and structures, architects must take into account the noise load on individual facilities as well as on the entire building complex. Noise sources interfere with people's rest, causing dissatisfaction and irritation. The impact of noise on humans varies depending on its level, spectral composition, and duration of exposure:

- low-level noise, typical of auditoriums and assembly halls, generally hinders the perception of speech and music;

- medium-level noise, occurring for example in office and administrative spaces, leads to premature fatigue among employees;

- high-level noise in industrial premises causes rapid worker fatigue and negatively affects labor productivity.

For this reason, already at the initial stage of developing the planning structure of buildings, it is necessary to consider the sound insulation of building elements and to ensure that indoor sound levels do not exceed permissible sanitary standards by applying a комплекс set of measures to protect buildings from noise penetrating into interior spaces.

1.1 Methodology: Noise protection can be implemented either at the source of noise generation or along its path of propagation. To successfully select and apply appropriate measures, it is necessary to determine the noise characteristics of the sources.

Measures to reduce noise in urban development and buildings must be envisaged at all stages of design:

1. at the stage of regional planning, addressing the placement of airports and transport infrastructure;

2. at the stage of developing the city master plan, determining a planning structure that reduces the number of noise sources and limits the extent of their impact;

3. at the stage of designing residential districts, defining the spatial, volumetric, and planning composition of development and landscaping that effectively utilizes the noise-protective qualities of the urban environment.

In the process of forming the master plan, noise maps should be prepared for the arterial road network based on projected traffic flows.

Noise maps consist of contour lines plotted on the plan, illustrating the reduction of noise levels with increasing distance from major roads. Such maps enable a more rational planning of noise mitigation measures of both urban-planning and administrative nature related to the organization of urban transport traffic.

- In the design of cities and other settlements, it is necessary to ensure a clear functional zoning of the territory into residential, industrial, utility–warehouse, and external transport zones.

- In the design and assessment of external noise, consideration is given to building orientation, articulation, and form; the presence of windows and balconies; the construction of embankments and barriers; the organization of green and protective zones; access roads and traffic layouts; as well as the planning solutions of individual buildings.

- When locating industrial and utility–warehouse zones, compliance with permissible noise standards must be ensured.

Transport, industrial, and domestic noise are considered the main types of noise sources. Cities are characterized by numerous noise sources, which can be условно classified into two major groups: individual sources and composite sources consisting of multiple individual emitters. Individual noise sources include single vehicles, electrical transformers, intake or exhaust openings of ventilation systems, installations of industrial or power-generation facilities, and similar elements. Composite noise sources include traffic flows on streets and roads, train movements on railways, industrial enterprises with multiple noise-generating units, sports or playground facilities, and others. When developing master plans for new or реконструируемых cities, industrial zones should be located on the leeward side relative to residential areas, based on data on prevailing wind directions in different seasons of the year. The effectiveness of protecting buildings from sound waves increases with distance; moreover, the protective effect is enhanced when the space between the noise source and the receiver is landscaped. Satisfactory protection results can be achieved when the green zone extends over more than 100 m

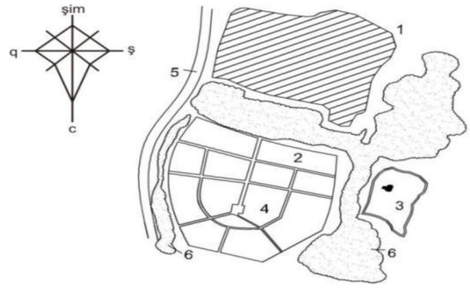

Fig. 1. Diagram of the city master plan

1 – industrial zone; 2 – green belt; 3 – recreational area; 4 – administrative and commercial center; 5 – main arterial road; 6 – protective zone. A number of methods have been developed for assessing various types of noise, many of which are widely applied in practice. In order to unify measurement and assessment methods for urban environmental noise, the international standard **ISO 1996-1 "Acoustics — Description, measurement and assessment of environmental noise.**

Part 1: Basic quantities and assessment procedures" was developed. According to this standard, the equivalent continuous sound level, expressed in **dBA**, should be used as the basic parameter for describing environmental noise conditions. An essential prerequisite for the correct evaluation of noise characteristics is the appropriate selection of the time interval over which the equivalent sound levels of noise sources are determined. The main cause of transport noise is street traffic. When designing street and road networks, terrain features should be utilized as natural barriers to noise propagation. Where it is necessary to route arterial streets and roads on embankments or elevated structures, the installation of noise barriers should be provided on the basis of acoustic calculations (Fig. 2). Artificial and natural terrain features (cuttings, embankments, hills, etc.) may also function as noise barriers. The reduction in sound level behind barriers is determined by the dimensions of the barrier, the distance between the barrier and the noise source, and other related factors. The effectiveness of screening walls or embankments should be verified through preliminary schematic design. In this approach, barriers are positioned close to the noise source in order to protect the open space located between the noise source and the receiver.

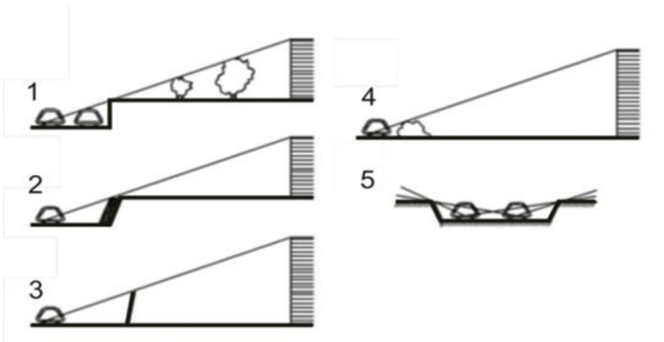

Fig. 2. Schemes of noise barrier placement for the reduction of transport noise:

1- wall;
2- inclined surface covered with sound-absorbing material;
3- noise-reducing screen;
4- mound/hill;
5- depressed roadway.

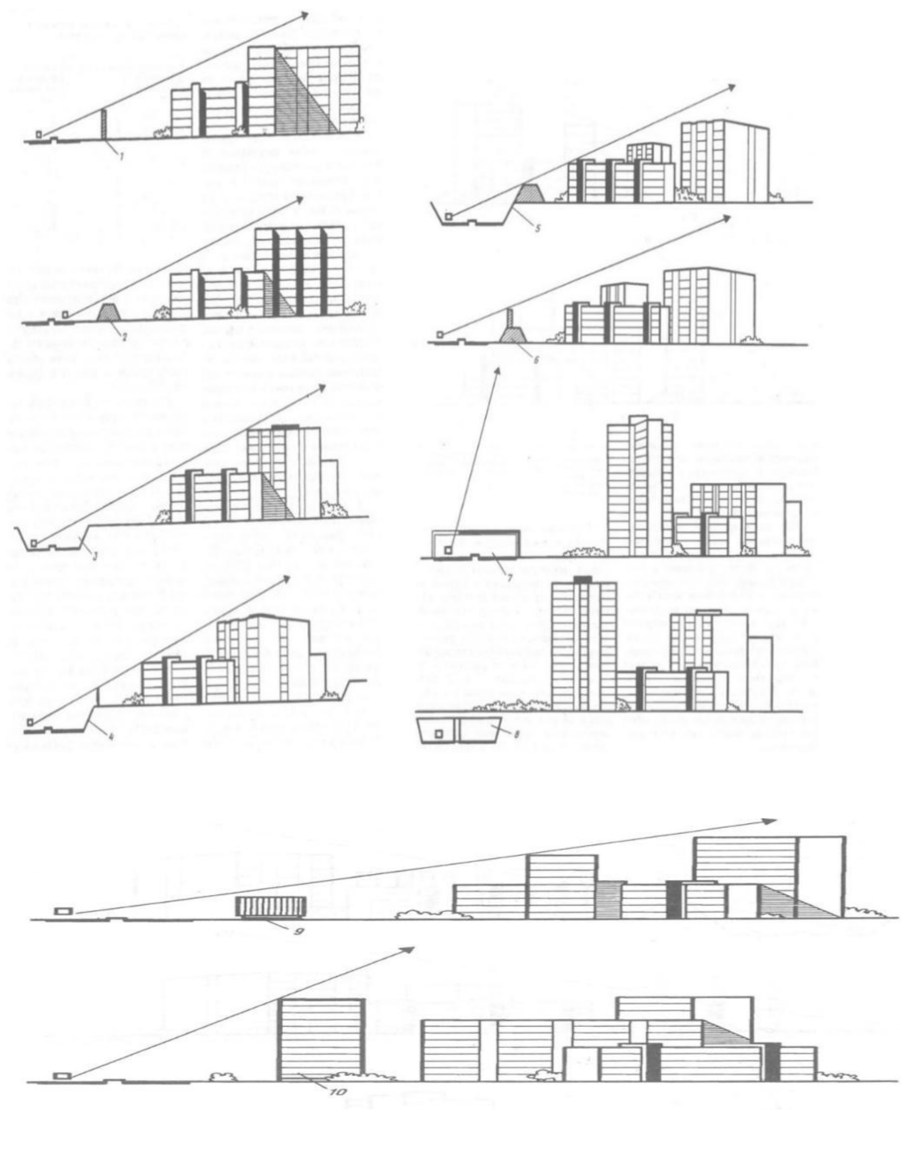

Fig. 3. Types of noise barriers:
1 – wall-type barrier; 2 – embankment barrier 3 – cutting (trench) barrier;
4 – terrace barrier; 5, 6 – combined barriers:
5 – cutting combined with an embankment or wall; 6 – embankment combined with a wall; 7 – gallery-type barrier; 8 – tunnel-type barrier; 9 – non-residential building used as a barrier 10 – noise-protective residential building.

Let us consider in more detail the means by which the above-mentioned noise reduction methods can be implemented. It is advisable to organize building layouts in such a way that all rooms associated with the generation of noise are concentrated in one area and located at a distance from working and residential spaces. Thus, in residential and public buildings, boiler rooms, elevator machine rooms, elevator shafts, refuse chutes, pumping stations, rooms housing fans, canteens, buffets, and similar facilities should not adjoin living or working areas. Kitchens, bathrooms, and sanitary facilities are recommended to be grouped into separate blocks adjoining stairwell walls or similar blocks of adjacent apartments. Living rooms in multi-storey residential buildings, dormitories, and hotels; workspaces in administrative buildings; wards in hospitals and sanatoriums; as well as classrooms and lecture halls in educational institutions should be separated from stairwells by auxiliary spaces (kitchens, bathrooms, corridors, etc.). Gymnasiums, workshops, and other noisy premises in educational buildings should not be located in close proximity to classrooms, lecture halls, or laboratories.

The construction of buildings with enclosed courtyard layouts in developments strictly parallel to the street should be regarded as an effective measure. However, such an arrangement influences the architectural and planning solution of the building. If buildings are constructed perpendicular to the street without additional screening measures, sound propagates freely, resulting in high noise levels around the building. When a residential building is used as a noise barrier, special measures are required to improve the acoustic environment within the building itself; such buildings are sometimes referred to as noise-protected buildings. Buildings may be designed with layouts in which the windows of all residential rooms face the courtyard façade, oriented toward the acoustic shadow behind the building. From the standpoint of noise protection, it is also advisable to locate commercial and service enterprises by attaching them to such building.

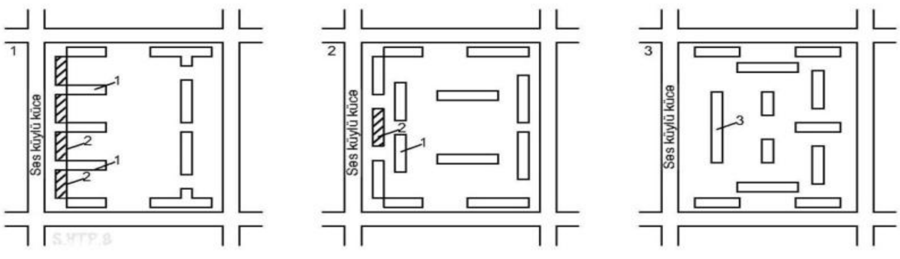

Fig. 4. Optimal placement of residential buildings in relation to a noisy arterial road:
1–residential buildings; 2-shopping centers and service buildings; 3 – sound-insulating barrier buildings.

One of the most effective ways to protect residential environments from transport noise is the construction of screening buildings (such as garages, business facilities, and commercial zones), as well as the development of barrier-type residential buildings with high sound-insulating performance along major transport corridors. Such buildings are sometimes referred to as **noise-protected buildings**.

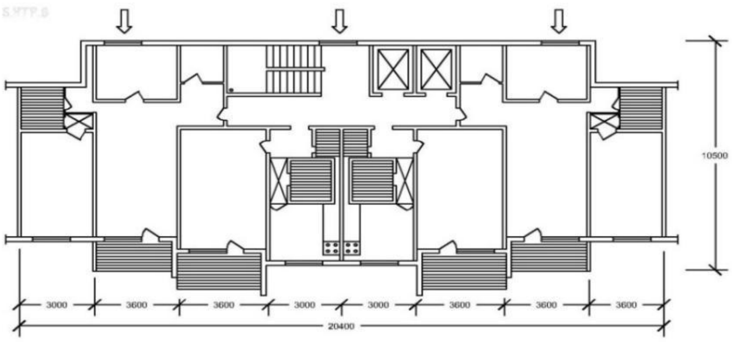

Fig. 5. Four-apartment section on the side of non-residential premises of apartments in a 9–12-storey barrier-type residential building *(plan of a residential building with high sound-insulating performance).*

In urban development, green spaces may also be used for noise mitigation (Fig. 5).

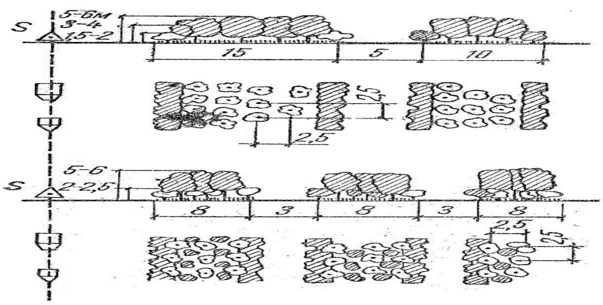

Fig.6 Sound insulation with the help of green spaces

Green spaces can be used to reduce noise in urban development**.**

In the noise environment of residential developments, so-called **intra-block noisesources** play a significant role. These include:

- sports and children's playgrounds within the courtyards of residential microdistricts;
- loading and unloading areas in service yards of shops, canteens, and other public catering and community service facilities;

- refuse collection vehicles, splash pools/fountains, garages, transformer substations, and similar facilities.

When organizing children's playgrounds within courtyards, in order to reduce sound reflection it is recommended to place them in the central part of the courtyard, where noise levels may be reduced by up to 3 dB.

1.2 Noise sources in residential, public, and industrial buildings. Noise occurring in residential and public buildings can be classified into:

- **domestic noise**, associated with human activity;
- **mechanical noise**, related to the operation of engineering and sanitary equipment (elevators, fans, pumps, etc.).

Domestic noise is generated by residents or occupants of a building. Loud conversations, singing, playing musical instruments, children's shouting and crying, and especially the operation of televisions, radios, record players, and tape recorders are sources of airborne noise.

During walking, dancing, and the movement of furniture, sound vibrations arise in the building envelope; these vibrations are transmitted to floor slabs, walls, and partitions and propagate over long distances throughout the building in the form of structure-borne noise. This occurs due to the very low attenuation of sound energy in the materials commonly used for building structures.

Elevators installed in multi-story buildings are sources of significant noise, which propagates not only through the air within the shaft and stairwell, but primarily through the building structures as a result of the rigid attachment of the elevator shaft to walls and floor slab (Fig.7).

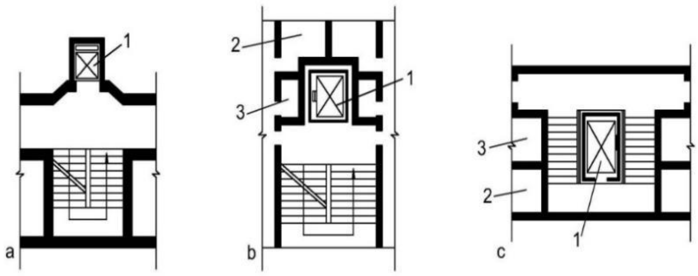

Fig. 7. Optimal options for the placement of an elevator shaft within a stairwell:

- the elevator shaft is located outside the stairwell;
- the elevator shaft is located within the building;
- the elevator shaft is positioned between the stair flights and the landing;

1 – elevator shaft;
2 – kitchen;
3 – sanitary unit.

Fans, pumps, elevator winches, and other mechanical equipment in buildings are sources of both airborne and structure-borne noise. Ventilation systems, in particular, generate intense airborne noise which, if appropriate measures are not taken, propagates along with the air flow through ventilation ducts and penetrates rooms through air grilles. Depending on the type of noise, different mitigation measures are adopted to reduce its propagation. The main methods used to limit noise transmission include appropriate external and internal spatial planning, the provision of adequate sound insulation for the enclosing structures of residential and public buildings, and related measures. propagation. The main methods used to limit noise transmission include appropriate external and internal spatial planning, the provision of adequate sound insulation for the enclosing structures of residential and public buildings, and related measures. propagation. The main methods used to limit noise transmission include appropriate external and internal spatial planning, the provision of adequate sound insulation for the enclosing structures of residential and public buildings, and related measures. Especially high noise levels may occur in rooms located directly beneath installed propagation. The main methods used to limit noise transmission include appropriate external and internal spatial planning, the provision of adequate sound insulation for the enclosing structures of residential and public buildings, and related measures. Fans, due to vibration, generate highly intense sound vibrations in floors and walls, which propagate easily as structure-borne noise throughout the building and are radiated into rooms, even those located far from the noise source (Fig. 8).

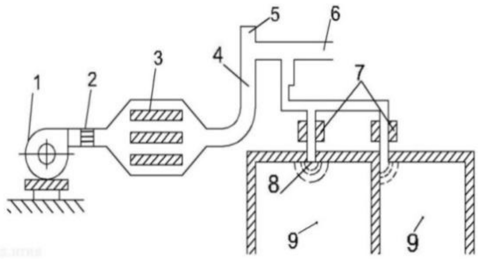

Fig. 8. Noise control in ventilation systems:

1 – fan or motor mounted on a vibration-isolation layer; 2 – rubber-covered canvas gasket; 3 – primary sound absorber; 4 – air duct; 5 – air mass; 6 – duct branch; 7 – additional sound absorber; 8 – ceiling panel; 9 – ventilated room.

Fans, due to vibration, generate highly intense sound vibrations in floors and walls, which propagate easily as structure-borne noise throughout the building and are radiated into rooms, even those located far from the noise source (Fig. 7). Ventilation systems and pumps are often located in basement rooms. In such cases, barriers are installed close to the noise source to protect the open space located between the source and the receiver.

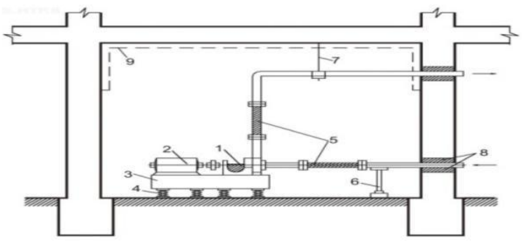

Fig. 9. Sound insulation of a pump installation:

1 – pump unit;
2 – motor;
3 – reinforced concrete base;
4 – vibration isolator;
5 – rubber covering;
6 – support;
7 – suspension;
8 – pipe vibration isolation;
9 – sound-absorbing material.

Conclusions: The primary means of protecting the interiors of residential and public buildings from noise is the proper sound insulation of enclosing structures, which must ensure compliance with regulatory requirements for soundproofing. In many rooms of public buildings, the installation of sound-absorbing wall finishes is advisable, for example in elongated spaces such as corridors in schools, hospitals, and hotels, as this prevents noise propagation along these spaces. To reduce noise in typing rooms, accounting offices, computing centers, administrative offices, restaurants, railway and airport waiting halls, shops, canteens, and similar facilities, sound-absorbing finishes for walls and ceilings should be provided. In most ventilation systems of public buildings, the use of **noise silencers** is necessary (Fig. 10).

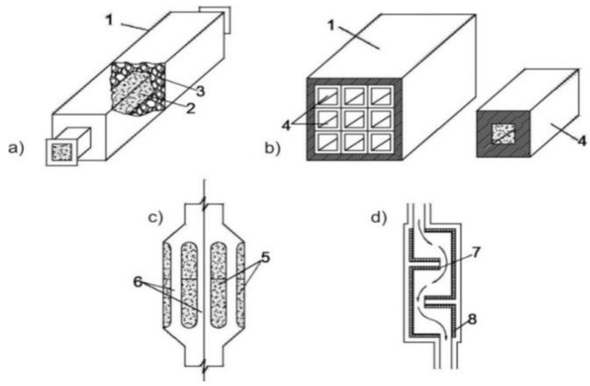

Fig. 10. Schemes of noise silencers:

a – tubular; b – cellular; c – plate or slit-type; d – chamber-type.

1 – outer shell; 2 – porous duct; 3 – sound-absorbing material;
4 – sound-absorbing cells; 5 – panels made of sound-absorbing material;
6 – duct; 7 – transverse partitions; 8 – sound-absorbing material.

Industrial noise differs from other types of noise in terms of its high level and spectral composition. The effectiveness of isolation depends on the noise spectrum, the technological process, and the equipment used. In production workshops with noisy equipment, isolation is required through special acoustic screens, partitions, ceiling structures, and similar constructions. These may include U- and L-shaped acoustic screens or freestanding panels.

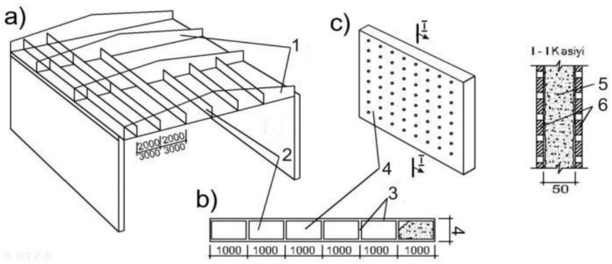

Fig. 11. Arrangement and construction of a sound-absorbing beam:

a – beam placement schemes; b – general view; c – sound-absorbing element.

1 – beam; 2 – sound-absorbing beam; 3 – beam frame; 4 – filler; 5 – mineral wool mats; 6 – porous metal element.

In the planning of industrial buildings, noisy rooms should be grouped into a single unit, reliably isolated from quiet areas by solid walls or auxiliary spaces (cloakrooms, sanitary facilities, airlock corridors, etc.). To reduce noise, technical solutions such as those shown in Fig. 11are applied. Technological processes in very noisy rooms are often carried out from **sound-insulated booths**

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