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ECOLOGICAL FEATURES OF PILE WORKS IN CONSTRUCTION

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Abstract
This article shows ecological features of pile works (provided with tables and figures) including pile works for driven piles. The most unfavorable features of pile works are noise and vibrations. Maximum permissible value of noise and vibrations are often exceeded during pile works. It causes growth of different illnesses, including neurological and mental. The article describes individual and collective ways to combat noise. It also shows noiseless and low noise types of pile works protected by patents of USSR and Republic of Belarus and utility models.

Keywords: pile works, features of works, noise, vibration, illnesses, maximum permissible values, individual and collective ways to combat noise, noiseless and low noise technologies, copyright certificates, patents, inventions and utility models.

ЭКОЛОГИЧЕСКИЕ ОСОБЕННОСТИ ПРОИЗВОДСТВА СВАЙНЫХ РАБОТ В СТРОИТЕЛЬСТВЕ

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Реферат
В статье описаны экологические особенности производства свайных работ (с таблицами и цифрами), в том числе забивными способами. Наиболее неблагоприятными и проблематичными из них являются шум и вибрация, величина которых превышает предельно допустимые нормы по шуму и вибрации более чем в 2 раза, и они постоянно растут из года в год, а это является причиной множества разнообразных заболеваний людей, в том числе психических и невралгических. В этой связи рекомендованы индивидуальные и коллективные способы борьбы с шумом, а также представлены бес – и малошумные методы производства свайных работ, защищенные а.с. СССР и патентами РБ на изобретения и полезные модели.

Ключевые слова: свайные работы, особенности производства, шум, вибрация, болезни, предельно допустимые нормы, коллективные и индивидуальные средства защиты, бесшумные и малошумные технологии, авторские свидетельства, патенты, изобретения и полезные модели.

Introduction

Protecting the environment and protecting the health of workers are two of the most important issues facing the world today. Noise and vibration control, among others, are an integral part of them. The level of noise in a workplace and in the home might reach 90-100 dB, i.e. 1.5 times the maximum allowable noise standards, and it grows continuously from year to year by 1.5-2 dB, which is the cause of many human illnesses, including neurological ones. The incidence of neurological diseases is almost 80 %.

Noise in industrial and residential construction is particularly damaging, as it usually occurs in densely populated areas, as shown in [1.2]. About 41 % of the complaints of the population are related to noise and vibrations caused by diesel hammers, 12 % – to vibration hammers, vibration divers and copers, 17 % – to jackhammers, 7 % – to compressors and 23 % to other construction machines (excavators, cranes, cars, etc.). Approximately half of the public complaints about noise and vibration arising from construction work are psychological causes – impediments to rest, sleep, work and training. About two thirds (65 %) of complaints from the public are brought before the courts for compensation for moral damage, damage to health, and another third for material damage caused to residential buildings and structures adjacent to construction sites where construction works are being carried out. This is mainly due not only to the noise but also to the vibrations that accompany the construction of pile foundations due to piling equipment action.

In many Western European countries, such as France and the United Kingdom, pile works, operated with impact methods, are prohibited by law because of high levels of vibration and sound pressure and also to protect and preserve historical monuments, buildings and structures, as well as human health. This prompted many construction companies to switch to other impactless and quiet pile works and types of piles - from driven piles to filling and drilled piles (Strauss, Benoto, Franki, vibrotam, delta pile, and others) and the companies producing hammers for driven piles and copra adapt to production of machines with improved technological and technical characteristics.

Main part

As numerous studies have shown, noise and vibration can, to a greater or lesser extent, temporarily activate or permanently suppress certain psychological processes in the human body and lead to various neurological diseases. Physiopathological effects can occur in the form of hearing impairment and other analysers, such as the vestibular apparatus coordinating the functions of the cerebral cortex, the nervous and digestive system, the circulatory system and the heart. In addition, noise affects carbon, fat and protein metabolism in the body.

Vibration, in turn, acts on the central nervous system, gastrointestinal tract, organs of balance (vestibular apparatus), causes dizziness, numbness of limbs, joint disease. Long-term exposure to vibration leads to occupational disease, a vibrational disease that can only be effectively treated in the early stages and recovery is very slow, and under certain conditions irreversible processes may occur in the body, accompanied by total disability and impending disability.

Noise and vibration problems

The highest level of noise and vibration, and these are the associated adverse human exposure factors in the construction industry, as shown by the analysis, are created by machines and mechanisms, equipment and instruments of impact action.

The most unfavourable thanks to level of noise, sound and vibration, the degree of exposure is pile-driving equipment, especially diesel hammers (both rod and tubular), copra of any type (rail, tractor, road, excavator, bridge type), followed by vibration hammers and vibratory pile driver, rolling stock of rail transport as well as buses, trucks, cars and special vehicles, excavators and other earth-moving equipment, concrete mixers, concrete laying and other construction equipment.

For example, pile-driving machine equipped with a diesel hammer, at a distance of 15 m, the maximum sound pressure level reaches 100 Db or more, which has a detrimental effect on the health of the workers and surrounding peple, increases their fatigue and, consequently, reduces labour

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productivity. Levels of sound pressure for different ways of driving piles, measured by «Octave 101A» instrument, showed the following results:

Pile-driving with diesel hammers - 100 120 dB;

Vibration immersion of piles with vibratory pile driver - 80 100 dB;

Vibration with impact - 90 110 dB.

At the same time, the maximum allowable sound pressure levels, sound levels and equivalent sound levels for the most typical types of works are established by SanPiN 22.4/2.18.1032-2002 in the table. 1, almost 2.5 times lower than above mentioned. At the same time, the maximum allowable sound pressure levels (dB), sound levels (dBA) and equivalent sound levels (dBA) for the most typical types of works are given within octave bands with geometric mean frequencies of 31.5; 63; 125; 250; 500; 1000; 2000; 4000; 8000 Hz, because the human hearing system perceives sound oscillations in a frequency range of 16 to 20,000 Hz, and the area of the highest hearing sensitivity is in the region of 50,000 Hz, which is located in the octave band region. Oscillations up to 16 Hz (infrasound) and above 20,000 Hz (ultrasound) are not perceived by human ears. However, this does not mean that the effects of infrasound and ultrasound are not harmful to human beings.

In addition to the Republic's health standards for industrial noise GOST 12.1.003 also regulates sound and sound pressure levels in workplaces (tabl. 2).

Table 1 – Sound pressure limits, sound levels and sound equivalencies for the most typical occupations

Type of occupation	Sound pressure levels, dB, octave bands with geometric mean frequencies 31.5 - 8000 Hz	Sound levels and equivalent sound levels, dBA
Creative activity, management with increased requirements, design, study, teaching, medical activity, etc.	86-38	50
Focused, high-quality, administrative and managerial work	93-49	60
Operations and movement control	96-54	65
Focused and observational work	103-64	75
Work in permanent locations (except above)	107-69	80
Jobs in railway rolling stock	93/100 49/69	60/80
Jobs in buses, trucks and special vehicles	93/100 49/59	60/70

Note: Sound pressure levels, sound levels and equivalent sound levels for intermediate values in octave bands are between minimum 31.5 and maximum 8,000 Hz octave frequencies.

Table 2 – Allowable sound pressure levels, sound levels in workplaces, industrial premises and on the premises of enterprises

Workplaces	Sound pressure levels, dB, octave bands with geometric mean frequencies 63 - 8000 Hz	Sound levels, dBA
Design office facilities, experimental data processing laboratories	71 - 38	50
Control rooms, work rooms	79 - 49	60
Laboratory facilities for pilot work	94-70	80
Permanent workplaces and work zones in industrial premises and on the premises of enterprises	99-74	80

Note: see note to table. 1.

Noise abatement techniques

In general, human noise protection, including noise induced by pile works, is divided into personal and collective. Personal protective equipment:

- headphones that provide reasonable protection of the hearing. For example, VCNIOT headphones reduce the sound pressure level by 7÷38 dB in a frequency range of 125÷8000 Hz. Currently, the industry produces headphones of the Aria, Nautilus, Big, Traxon, etc.
- Noise-free inserts («Comfort-plus», MAX-1, Laser life, noise-free inserts (Byushi) etc.) inserted directly into the auditory canal of the outer ear. They are made of light rubber, elastic plastics, rubber, ebonite and ultrafine fibre. They lower the sound pressure level by 10÷15 dB.
- helmets are recommended for noise protection with a general level above 120 dBA. They hermetically cover the entire parotid region of the head and reduce the sound pressure level by 30 40 dB in the operating range of 125÷8000 Hz.

Means of collective protection:

- sound insulation - fences, panels, cabinets, screens, enclosures, fences and «green walls» preventing noise from one room to another or in the same room;
- sound absorption - the ability of a material or structure to absorb the energy of sound waves. These include linings, single-piece sound absorbers made of materials with sound absorption factor α>0.2. Sound-absorbing barriers are divided into 4 classes: fibrous-porous (felt, wool, acoustic plaster, ultra-thin glass or basalt fibre), membrane (PVC and other films, thin sheets of plywood or metal on trim), resonant (special structures based on the acoustic properties of the resonator), combined (devices using previous materials);
- silencers - adsorption, active, reactive, combined.

Collective protection measures such as:

- Removal or reduction of noise and vibration directly at the source, i.e. in piling equipment;
- Localization of noise and vibration sources in piling equipment;
- rational placement of piling equipment on the construction site;
- acoustic treatment of the auxiliary rooms for the staff servicing the installation;
- introduction of quiet and low-noise technological processes and equipment.

Mentioned in the last paragraph way, as the most promising and effective way to combat noise, must be discussed separately.

One of the most noiseless is the technology of pile works with predrilled large-diameter wells (larger than the diagonal of the cross-section of the pile), applied in dense and strong soils, where much noise is made during the process of drilling, followed by the filling of the grooves with a dirt mud. The method relates to drilling piles, is applicable and only possible in conditions of permafrost spread (Norilsk, Vorkuta, Yakutia and other regions) in the Far North of the Russian Federation and in areas of stable and rocky soils, including in Bashkortostan, in which piling is simply impossible.

Low noise method is the way in which piles are filled into small diameter wells (leading wells) pre-drilled in the ground, the diameter of which is equal to or less than 5 cm on the side of the square section of the pile. The conditions for the use of the method are the same as those for the noiseless ones, but the sound pressure level is reduced by half compared to the driven piles.

The low- and noiseless techniques used to immerse piles also include hydraulic submersion of the soil under the piles, as well as submersion of piles with sleeves and in thixotropic (clay) shirts. In these techniques, the dive force is reduced by 50-70%, which also reduces noise and vibration. In the development of these methods, the authors from BSTU proposed a number of technical developments of effective structures of driven piles and ways of their submersion by hydraulic and other methods protected by USSR patents (779507, 779508, 881201, 887725, 891840, 947278, 962447, 962454, 1004539, 1032102, 1135843, 1153010, 1157164, 1458500) RB patents on inventions (6032, 10518) and useful models (1682, 3603, 5228, 6882) and published in [3, 4]

The water-washing of a soil under high-pressure pumps or self-flow is used to facilitate immersion of hollow-shell piles, especially of large dimensions (cross-section and length) in unconnected (sand) and poorly connected (loamy and clay) soil, as well as for the high depth immersion and insufficient immersion capacity of the pile-driving equipment. This method is applicable if it doesn't cause slump of neighbouring buildings and structures.

The inventive method consists in washing the ground under the pile end. A water is suppled to the end of pile with a help tubes fixed on sides of a pile. As a result under the action of own weight and the weight of the hammer mounted thereon it immerses to the soil. At the last metre of immersion, the pile is stopped and the piling is finished in the usual way. Friction piles should be immersed with care, as the adhesion of the side surface of the pile to the ground is impaired. The effect of hydro-sweeping is that, under water pressure, the frontal resistance of the soil is reduced by erosion. In addition, the flow of water rises along the side surface of the pile, washing the soil and weighing its particles. As a result, ground resistance is reduced and the required pile loading is reduced too.

It is known that the fraction of resistance under the pile head is more than half the total immersion resistance, the rest (about 50%) is the friction on the side surface of the pile. Their ratio depends on the length and size of the cross-section of the pile (the longer the pile, the smaller the proportion of frontal resistance of the ground, and vice versa), the physical-mechanical properties of the soil and other parameters. In order to reduce friction (adhesion) of the pile against the ground, it is advisable to apply the coating of the side surface of the pile with materials having high antifriction properties and low friction coefficient. Such materials include clay (thixotropic) solutions and pastes, carbamide, furfurfurolanil, polyacrylamide and epoxy resins and coatings, and water as lubricant. The department of TSP has created a number of progressive inventions (RB patents on useful models 7573, 8601, 9781 and etc)

Several fairly simple and efficient hydraulic and self-lubricating structures of such piles are represented in figure 1, in which the reduction of the frontal and lateral resistance of the pile during immersion is due to the forced supply of water or the moulding into the friction zone and the destruction of the ground.

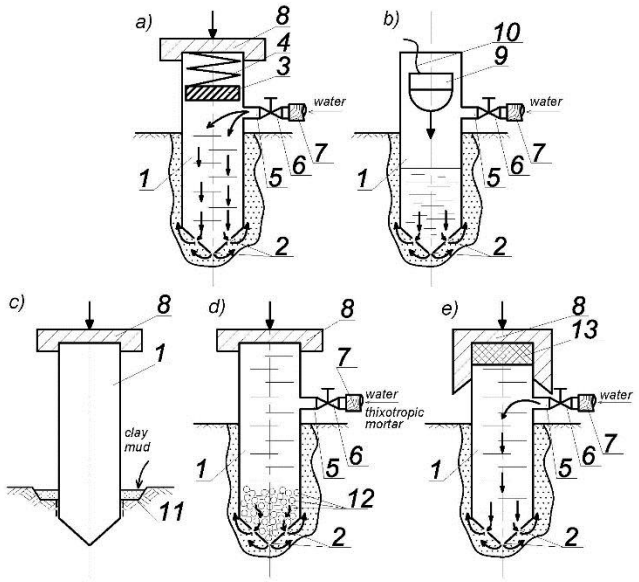

Figure 1. Efficient hydraulic washing (a, b, d, e) and self-lubricating piles (d, c): a) with spring-loaded disc; b) with floating cargo; c) with thixotropic moulding; d) - large-scale additions; e) with a resilient tie pad; 1 - pile; 2 - through holes; 3 - solid disc; 4 - compression spring; 5 - pipe; 6 - valve; 7 - hose; 8 - hose tip 9 - suspended weight; 10 - flexible thrust; 11- dibhole with thixotropic mortar; 12 - large-area rounded inclusions (boulders, pebbles); 13 - a resilient rubber pad.

Conclusion

Usage of individual and collective means of protection against noise and vibration, as well as noiseless and low-noise methods of pile works, washing the ground under the pile's, as well as coating of pile's lateral surfaces with anti-friction materials and lubricants makes it possible to reduce the noise level during the immersion of driven piles to permissible limit values, and also reduces the risk of occupational diseases at work.

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