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EVALUATION OF COMPRESSIBILITY INDICATORS FOR HOUSING DENSITY

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Construction in an existing building usually increases the time required to organize and perform process operations. The paper analyzes the existing methods for evaluating compressibility for various regulatory documents and their relationship with the conditions of the construction site and surrounding buildings, shows the need to systematize approaches to compressibility evaluation and develop appropriate design recommendations.

Based on theoretical research, the author concludes that there is a need to formulate the terms "compact construction conditions" or "conditions of dense housing"; to compile a list of compressibility conditions and their classification, grouping in order to identify the impact of each group on the cost and duration of construction and installation works; to develop a general procedure for assessing the compressibility of work conditions (indicator) and the necessary measures depending on its quantitative value.

Key words: compressible conditions, dense housing, coefficient of compressibility of working conditions, internal compressibility, external compressibility, construction site.

Introduction

In today's construction environment, there is a tendency to increase the housing density of established areas. Developers are conducting new construction in such locations, for a number of reasons:

- low costs for the construction of external networks;
- use of the existing transportation and social infrastructure;
- high sale price of housing.

Construction in the conditions of existing buildings, as a rule, increases the time for organizing and performing process operations, and imposes significant restrictions on the conditions of work due to the presence of both internal and external obstacles to construction (Cherednichenko et al., 2018, Belchevskyi R. 2020). The presence of spatial obstacles on the construction site, as well as for the adjacent territory, causes limited construction conditions (limited construction site space in terms of width, length, height, depth of underground space, size of the working area of machinery, etc.) The construction site in the existing infrastructure will be limited by existing buildings and structures, underground utilities, amenities and the road and transport network (Schwabe K. et al., 2019, Zavari M. et al., 2022, Yi W. et al., 2018, Xu M. et al., 2022). The presence of these restrictions is called "compressibility" in accordance with DSTU B A.3.1-22:2013 or "dense housing" in accordance with DBN V.1.2-12-2008 (the regulatory documents do not provide a single wording of the concept of "restricted conditions").

In the compressed conditions of construction infrastructure and existing urban development (or the territory of an existing enterprise), there is a need to develop and justify rational and effective methods for the construction of buildings or houses (Znamenskyi et al., 2012, Chebanova S. et al., 2018), with the solution of the following issues related to the implementation of construction and installation works:

- the need to locate construction equipment and economic facilities on plots smaller than the standard ones;

- performing work near structures in operation;
- conditions for installing tower cranes according to the height of the surrounding building;
- work near existing utilities and green spaces to be preserved;
- the ability to bring only certain types of machines and equipment to the construction site (passability, insufficient load-bearing capacity of the road surface, etc.);
- compliance with environmental requirements (minimization of noise, air pollution and dust, and area contamination);
- the need to carry out measures to monitor the surrounding development during the construction process;
- development of special measures of safety conditions (development of protective screens, establishment of restriction zones, restriction of machine manipulations, etc.).

When developing process design package, in conditions of dense housing, it is necessary to adopt rational construction schemes (object-based) for the dimensions of a particular construction site, which are characterized by various constraints and obstacles (Gaido A., 2017). When making decisions, it should be borne in mind that the general procedure for developing such schemes is not provided in DBN A.3.1-5-2016, and in the practice of developing process design package (Mudryy et al., 2021, Dorosh, 2011), the degree of compressibility of both the construction site and the surrounding infrastructure is not assessed. The construction organization design is limited to assessing whether the existing construction conditions are compressed, and if so, a procedure for monitoring the impact of the work on the surrounding area and buildings is developed.

Accordingly, there is a need to study the influence of compressibility of the work conditions on making design decisions. To analyze the existing regulatory documents on the procedure for determining and quantifying the performance of construction works in dense development conditions.

Results and discussions

In accordance with DBN B.1.2-12-2008, dense construction conditions are considered to be conditions for which at least one of the factors is present:

– erection of a construction project close to existing buildings, structures, and utilities;

– the risk of negative man-made impact of construction on nearby buildings or landscaping objects, as a result of which there may be a threat to the life or health of people or causing material losses;

– the risk of negative impact of the construction facility or its construction works on the foundations, foundations and load-bearing structures of adjacent facilities or on utilities due to the creation of additional stresses in the core of their foundations, disruption of the structure of the foundation soils, changes in the established hydro-geological conditions in the adjacent territory and under existing buildings;

– providing transportation services for the construction site through intra-block (intra-plant) passages;

– risk of deterioration in the living environment of people who live, work or temporarily stay in the area affected by construction activities due to noise and night lighting that exceed the values permitted by the standards, air pollution, anomalies in thermal, electrical and other physical fields, radiation, restrictions on movement, etc.;

– construction of the next stage of the facility near the previous one when it is built in stages;

– Impossibility to locate production sites, construction equipment, sanitary and administrative facilities, passages for construction machinery and vehicles, fire breaks, etc. required for a particular stage of construction due to the limited size of the construction site and the conditions of the land allocated for construction.

But DBN v. 1.2-12-2008 does not fully take into account all the factors of compressibility, since there are certain specific criteria and restrictions for each type of construction (for example, restrictions on the intersection of process flows during the reconstruction of existing enterprises), or forms of compressibility of work conditions. Types and forms of compressibility can be divided into two main groups (Sedov, 2010):

I. External compressibility:

– limiting the size of the working areas of construction machines outside the construction site;

– restrictions on the passage of construction machinery and vehicles;

– traffic intensity in the construction zone, direction and possibility of access to the construction site;

– the presence of residential development, for which it is necessary to ensure the operational properties of the facilities located in proximity to the development.

II. Internal compressibility:

– existing obstacles to the placement of storage areas or auxiliary equipment, movement of machinery, structures or materials (Mudryy et al., 2022);

– combining installation, dismantling, or reinforcement of structures and excavation within the same site (Ivaneyko, 2021);

– administrative requirements for limiting the noise level and operating mode (DBN A. 3.2-2-2009, 2012).

The presence of compressed work conditions will affect the estimated cost of construction. Thus, in the construction of utility systems and structures, as well as construction engineering facilities in the compressed conditions of the built-up part of the city, DSTU-N B D.2.2.-48:2012, Table. Г1 apply the appropriate increase factor k=1.1, and in the presence of particularly difficult conditions for organizing workplaces – k=1.15, or construction in compressed conditions on harsh terrain k=1.2. However, factors that take into account compressed conditions can be used in determining the estimated cost only if their presence is justified by the construction management design (Hryhorovskyi et al., 2010), and practical experience shows that such justification is often not carried out.

When developing process design package, as a rule, the internal compressibility of the conditions of work is taken into account, which is estimated by the compressibility factor of the construction site (F_c), and is determined by the dependence:

$$Fc = \frac{Sa}{Sr}, \tag{1}$$

where S_a is the actual area of the construction site, square meters; S_r is the required area of the construction site for the rational organization of work, square meters.

$$S_f = S - (Sb + Sp + Su + Sh), \tag{2}$$

where S is the area of the construction site within its fencing, square meters; S_b is the area occupied by existing structures and buildings, including buried structures, square meters; S_p is the area occupied by designed structures and buildings, square meters; S_u is the area of underground utilities, taking into account their security zones, square meters; S_h is the area located in hazardous areas and hindering the performance of work, square meters.

$$Sst = Sc.c. + Sm + Smh + S_{aux.}, \tag{3}$$

where S_{st} is the area required for storage of materials and structures, sq.m.; $S_{c.c.}$ is the area required for the construction camp, sq.m.; S_m is the area required for the construction machinery, sq.m.; $S_{m.h.}$ is the area that takes into account the hazardous areas during the operation of machinery, sq.m.; S_{aux} is the area required for the auxiliary processing areas, sq.m.

If the value of the factor of internal compressibility of the facility $F_c < 1$, the conditions of work are considered compressible, and if $F_c \rightarrow \min$, the conditions will be especially compressed. However, the list of unprofitable measures does not depend on the quantitative value of F_c and is decided by the designer independently. In fact, the factor of internal compressibility F_c only takes into account the size of the construction site and the area of the economic facilities elements and does not take into account other conditions that will determine compressibility (the presence of green spaces that cannot be removed, traffic intensity near the construction site, adjacency to existing structures, etc.) These conditions of internal compressibility are taken into account by DSTU B A.3.1-22:2013 with the factor F_{13}, which determines the degree of influence of the conditions of dense construction on the duration of work, the specific weight of the influence of factors in this factor:

– traffic and pedestrian intensity near the work site – 25 % (external compressibility parameter);

– network of existing utilities to be relocated – 15 %;

– buildings and natural plantations that preserved in the vicinity of the work site; compressed conditions for the storage of materials or the impossibility of their storage at the construction site for the normal provision of materials for workplaces, restrictions on the vertical movement of structures – 60 % (in various combinations).

Paragraphs 4.2.7. and 4.2.8. DSTU B A.3.1-22:2013 states that the F_{13} factor should be influenced by the parameters of utility systems, such as location and depth of installation; physical volume of systems; ratio of the construction site area occupied by underground facilities to the total site area; root systems of trees that cannot be removed, etc. However, these standards do not specify how to determine the proportion (or combination) of these parameters in the compressibility factor, and in practice, their values are accepted by engineers independently based on their own considerations and experience.

External compressibility, as a rule, is not assessed by indicators, except when it is necessary to justify the possibility of bringing large construction machinery to the facility through existing passages, then the external compressibility indicator (F_{ext}) is determined by dependence:

$$F_{ext} = \frac{S_{trans}}{S_{pas}}, \quad (4)$$

where $S_{trans.}$ is the required transport area in external dimensions for the delivery of the machinery, taking into account the required stock, square meters; S_{pas} is the actual passage area, square meters.

It should be noted that F_{ext} is an indicator of passability, the values of which can sometimes erroneously assess the adequacy of the passage area, since it actually assesses the ratio of areas, not the actual dimensions of the machine and the opening.

Thus, based on various current regulatory documents, the procedure for assessing (quantitative indicator) the compressibility conditions of construction will be different, and it should be carried out:

- based on the conditions for organizing the construction site and the procedure for performing work in accordance with DBN V.1.2-12-2008;
- based on the labor costs of workers according to DSTU-N B D.2.2.-48:2012;
- construction terms according to DSTU B A. 3.1-22:2013.

The existence of a number of separate regulatory approaches to assessing the compressibility of construction site conditions means that their determination can be based on various factors and at different stages of the development of process design package, in particular:

- based on the conditions of the construction site organization and the procedure for performing works – at the stage of developing the design of works, since only at this stage is the actual scope of works (respectively, the required areas of storage areas), the means of mechanization used by machine brands (actual areas for their placement or dimensions of access to structures); methods of performing certain types of works (areas of process sites);
- based on labor costs – when developing estimate documentation (given that this section is not mandatory for facilities constructed with private investment, such an assessment may not be carried out);
- based on construction terms – not at the stage of development of the construction management design for CC2 and CC3 consequence class facilities.

Existing studies of compressibility (Hryhorovskyi et al., 2010, Znamenskyi et al., 2012, Chebanova S. et al., 2018) consider influencing factors under different conditions, separately: construction site organization; labor costs; terms of construction. Accordingly, there is a need for a combined consideration of these parameters for the systematization of approaches to the assessment of compressibility conditions and the development of regulatory design recommendations.

Conclusions

The study of the conditions of compressed construction (dense development) revealed the need for:

– formulation of the terms themselves "compressed construction conditions" or "conditions of dense development", since the regulatory documents list such conditions but do not provide a generalized definition;

– compiling a complete list of such conditions and their classification, grouping in order to identify the impact of each group on the cost and duration of construction and installation works;

– creation of a general procedure for assessing the compressibility of work conditions (indicator) and the necessary measures to organize work depending on its quantitative value.

Further research is needed to create a general methodology for assessing compressibility conditions and developing a regulatory procedure for designing construction sites in conditions of compacted construction.

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ОЦІНКА ПОКАЗНИКІВ СТИСЛИВОСТІ ДЛЯ УМОВ УЩІЛЬНЕНОЇ ЗАБУДОВИ

Наявність окремих нормативних підходів до оцінки стисливості умов будівельного майданчика призводить до того, що їх визначення може виконуватися за різними чинниками та на різних етапах розробки проєктно-технологічної документації. Такий підхід до оцінки умов виконання робіт, як правило, дає різні кількісні значення показників стисливості будівельного майданчика та заходів, які потрібно організовувати під час зведення.

У практиці розробки проєктно-технологічної документації оцінка ступеня стисливості як будівельного майданчика, так і навколишньої інфраструктури не проводиться. У проєкті організації будівництва обмежуються оцінкою наявні стисливих умов будівництва, а у випадку наявності розробляється порядок моніторингу можливого впливу виконуваних робіт на навколишню територію та забудову. Діючі нормативні документи не враховують у повному обсязі всі фактори стисливості, оскільки існують певні специфічні чинники та обмеження для кожного виду будівництва та умов виконання робіт.

У статті було проведено аналіз існуючих методів оцінки стисливості для різних нормативних документі та їх зв'язок із умовами будівельного майданчика та навколишньою забудовою, показано необхідність у систематизації підходів до оцінки стисливості з розробкою відповідних проєктних рекомендацій. Аналіз включав розгляд діючих показників внутрішньої та зовнішньої стисливості.

На основі теоретичних досліджень зроблено висновок про необхідність формулювання термінів "стиснені умови будівництва" або "умови ущільненої забудови"; складання переліку умов стисливості та їх класифікації, групування з метою виявлення впливу кожної з груп на вартість та тривалість виконання будівельно-монтажних робіт; розробку загального порядку оцінки стисливості умов виконання робіт (показника) та необхідних заходів залежно від його кількісного значення.

Ключові слова: стисливі умови, ущільнена забудова, коефіцієнт стисливості умов виконання робіт, внутрішня стисливість, зовнішня стисливість, будівельний майданчик.