Environmentally friendly construction as a tool for ensuring the quality of construction products

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Abstract. In order for construction works in Russia to be carried out in the construction of objects and objects already built to be competitive on the world market, when implementing projects, it is necessary to take into account the requirements of not only the regulatory and technical documents governing construction and installation works in Russia, but also take into account the requirements of environmental standards imposed by certification systems such as LEED and BREEAM. At this stage of development of the domestic construction industry, there is no regulatory and technical framework governing the implementation of environmental standards on a mandatory basis. The construction market in Russia is highly competitive. When choosing a contractor, customers are guided by the shortest possible turnaround time and minimum cost. Often these two conditions are achieved by minimizing the costs of contractor's resources for work that are not provided for by the regulatory and technical base of the Russian Federation as mandatory. In order for the domestic construction industry to reach the World level, it is necessary to introduce foreign environmental certification systems that allow increasing the level of comfort for citizens.

1 Introduction

According to the statistical data of the Department of Environmental Management and Protection of the City of Moscow, in 2016–2017, the number of complaints against construction sites located in the proximity of residential buildings with regard to excessive noise level at night-time and a number of other impacts of construction operations went up by 21 percent as compared with the beginning of 2015.

In the Russian Federation, harmful effects of construction operations on the urban environment are not regulated by any environmental technical standards. These impacts deemed to be among the most destabilizing factors of construction and installation works

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are manifested unevenly during the whole course of construction. Rational use of appropriate technological solutions in construction operations makes it possible to offset major deviations of parameters of environmental impacts from the empiric optimum that ensures environmental safety and comfort for residents of the territories adjacent to the construction site. There is a concurrent need for a numeric evaluation of the aggregate deterministic counter-impact of these organizational and technological solutions on the anthropologic component of the integrated indicator of environmental pressure for determining the efficiency level of their introduction. Also, a positive effect can be achieved by regulating the use of any corresponding organizational and technological solutions in the form of binding certification criteria of an environmental program adapted for regional specific features of the Russian Federation.

Resource and energy saving solutions for construction of buildings and structures are becoming increasingly vital throughout the world. In response to the growing need of “green construction” — i.e. construction projects that meet the requirements of environmental safety and comfort of residents — a number of leading countries have developed “green standards” of certification of construction products with regard to conformity to environmental regulations (Table 1) [1-29].

Table 1. Main international rating systems of environmental certification

No.	Description of voluntary environmental certification system	Country that developed the system	Year of development	Number of certified projects in the world as of 2016
1.	BREEAM	Great Britain	1990	>110.000
2.	LEED	USA	1998	>4.400
3.	CASBEE	Japan	2001	>80
4.	GREEN STAR	Australia	2003	>237
5.	HK-BREAM	China	1996	>247

2 Materials and Methods

The USA and Great Britain have developed and widely use systems of environmental safety and comfort of construction projects. The programs of such certification rating systems (LEED and BREAM respectively) include both architectural planning and organizational and technological measures to offset harmful impacts on people affected by the new construction. They specify threshold values of impact indicators. as well as monitoring methods and frequency. Activities under these certification programs are regulated by regional legislation and ensure construction, commissioning and subsequent operations of environment-friendly projects. Drawing on international experience, we propose to minimize adverse human exposure of Russian construction sites using a number of similar organizational and technological activities described in the above mentioned certification programs (Table 2).

Table 2. A set of basic organizational and technological activities ensuring conformity with environmental safety requirements in accordance with the main certification systems

No.	***Organizational and technological activities***
1.	Drawing up and approval of a construction action plan
2.	Ground consolidation, ground covering, earth embankments
3.	Ban on construction operations at night-time
4.	Noise screens
5.	Noise-protective covers for machinery
6.	Geowebs, tree grills
7.	Wheel washing facilities
8.	Suspended particles catchers
9.	Removal and recycling of construction wastes
10.	Reduction of emissions of idling construction machinery and equipment with internal combustion engines
11.	Elimination of transmission of shock impact on the foundation soil

The Russian Federation has also introduced environmental safety certification of construction projects, but some developed programs (such as ECOPRO and others) are based on the principles and criteria of widely used international analogues that have been considerably simplified and reduced for adaptation to the conditions of Russia's economy and construction industry. Voluntary environmental certification practiced in leading foreign countries allows a systemic approach to environmental safety that is based on "green standards" and other regional legislation and consists of various interrelated essential stages at all phases of investment construction projects (Table 3).

Table 3. Correspondence between the stages of an investment construction project and a certification program

No.	**Phase**	**Activities by participants**	**Environmental certification stages**
1.	Pre-design phase	Development of a design concept, a feasibility study for the project	Pre-design
2.	Design phase	Design development. Expert examination of the design	Design — A set of design actions and requirements specified in the design documentation
3.	Phase of construction of a building or a structure (project implementation)	Construction of a building or a structure. Obtaining a statement of conformity	Technological — organizational and technological activities for mitigating the impact of construction operations on the environment. Monitoring
4.	Commissioning of the building	Formation of a working commission for acceptance and commissioning of the project. Integrated testing of utility systems	Certification of completed construction products
5.	Operational phase	Technical operations of the building or structure, utility systems, adjacent territory	Analysis of solutions of technical operations of buildings and structures

The environmental certification process for a construction project consists of documentary confirmation of conformity to the required criteria of the selected rating system based on the findings of the expert certification group that functions throughout the whole term of the investment construction project. This group ensures contacts between participants in the construction operations and the parent certification authority, holds consultations, makes assessments, monitors the project being constructed, carries out the prescribed environmental tests and performs modelling (developing an energy model for the project, etc.).

The choice of a particular system is individual and depends on particular features of the construction project being certified, as well as on the current stage of the investment construction project, at which the certification program is planned for introduction. Strong and weak points of each system are described in a number of research works by foreign scientists and aggregated by the basic specified criteria (Table 4).

Table 4. Comparative assessment of the main environmental rating systems

Popular rating systems	Popularity and influence	Accessibility (working capacity)	Methodology (methodological substantiation level)	Applicability	Characteristics of the data collection process	Accuracy and verification ability	Expert-friendliness	Development	Clarity of results
BREEAM	10	7	11	13	7	8	8	8	3
LEED	10	7	10	13	7	7	10	8	3
CASBEE	6	7	13	11.5	6	9	6	7	4
GREEN STAR	5	8	9	10	9	5	8	8	3
HK-BREAM	5	8	11	9	8	5	8	8	4

3 Results and Discussion

According to the findings of this research (Table 4), the most efficient are the US certification system LEED and the British system BREEAM. In fact, they are also the most popular systems.

Due to the fact that the existing technical legal framework in the Russian Federation fails to provide any sufficient requirements for ensuring environmental safety and comfort of participants in the construction process and users of completed construction products, we propose to use these systems as an organizational and technological tool of environmental reliability. LEED or BREEAM certification (depending on the initial conditions) will ensure a set of world-level environmental safety measures from the design concept to the technical operations phase. This progressive international approach to “green construction” makes it possible to reduce operational maintenance costs of the project owing to resource-saving technologies, and to raise the level of comfort of residents and the working efficiency of administrative and industrial staff.

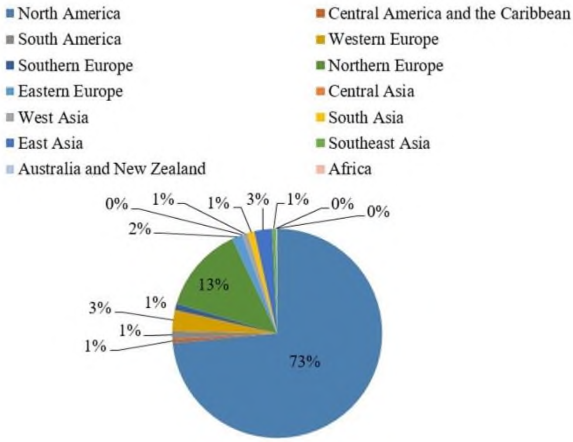

Fig. 1. Breakdown of LEED and BREEAM certified projects by regions of the world

The abundance of certified projects in foreign countries (Figure 1) is explained by the fact that compliance with the requirements of the said rating systems necessitates a number of organizational and technological solutions requiring some additional resources, an expenditure that Russian construction and installation companies often prefer to economize on. Russia’s construction market is highly competitive, and customers are guided by the shortest possible duration and minimum costs of works when selecting a contractor. As often as not, this is achieved by minimizing contractors’ expenses on works that are not stipulated by Russian technical standards as obligatory.

Let us review a quantitative evaluation of sufficiency of a number of obligatory and optional activities carried out on some construction sites in the course of construction and installation works, using the efficiency rating scale for organizational and technological solutions affecting the environmental situation developed by A. Yu. Berezhnoy. There are six criteria expertly evaluated in this scale as the most important indicators:

1) Atmospheric pollution: 0, 1, 2, 3 points (3 points — maximum possible activities are organized to minimize the impact of this factor on the existing environmental situation).
2) Noise: 0, 1, 2, 3 points (3 points — maximum possible activities are organized to minimize the impact of this factor on the existing environmental situation).
3) Construction waste: 0, 1, 2, 3 points (3 points — maximum possible activities are organized to minimize the impact of this factor on the existing environmental situation).
4) Soil contamination: 0, 1 point (1 point — maximum possible activities are organized to minimize the impact of this factor on the existing environmental situation).
5) Household waste: 0, 1, 2, 3 points (3 points — maximum possible activities are organized to minimize the impact of this factor on the existing environmental situation).
6) Sanitary protection zones — 0, 1, 2 points (2 points — maximum possible activities are organized to minimize the impact of this factor on the existing environmental situation).

Let us compare the sufficiency of organizational and technological solutions focused on minimization of adverse impacts of construction and installation works using the efficiency rating scale for projects certified by environmental rating systems and projects implemented in accordance with the requirements of Russian technical standards (Table 5).

Table 5. Assessment of efficiency of project works in the Russian Federation

No	**Description of a certified / noncertified project**	**Conformity to requirements**	**Location**	**Assessment of the impact of hazardous production factors (score)**					
				Atmospheric pollution	**Noise**	**Construction waste**	**Soil contamination**	**Household waste**	**Sanitary protection zones**
1	Duckat Place III business center	BREEAM	Moscow	3	3	3	1	3	2
2	Hamilton Standard — Nauka production facilities	LEED	Kimry	3	3	3	1	3	2
3	R shopping center	NTB RF	Saint-Peters-burg	0	1	3	0	3	2
4	N residential complex	NTB RF	Moscow	1	1	3	0	2	2
5	M sports complex	NTB RF	Moscow	1	1	3	1	3	2

4 Conclusion

In spite of the fact that these criteria have been identified by a group of experts as producing the most adverse impact on the environmental situation, the activities of minimizing that impact have been undertaken in full measure only in compliance with the certification requirements of environmental rating systems. Environmental requirements to the projects implemented solely in accordance with Russian technical standards have not been fully met due to lack of strict regulations. It should be noted that, according to domestic construction organizations, the above-mentioned criteria are the most important and produce the maximum adverse impact on the environment. An assessment of efficiency of organizational and technological solutions in construction operations in confined areas should also take into account the following major anthropologic factors:
- Vibration on the territories adjacent to construction sites;
- Visual pollution at night-time.

These criteria are important for residents of dwellings in immediate proximity to construction sites and taken into account by such rating systems as BREEAM and LEED.

So, the heuristic approach to the organizational and technological problems of the environmental safety of construction sites in the Russian Federation is largely attributed to the absence of an obligatory regulatory and technical framework that regulates these issues. In the Russian Federation, Federal Law No. 184-FZ of December 27, 2002 "On Technical Regulation" divides the terms “technical regulations” and “standard”, therefore, all the above-mentioned normative documents became non-mandatory and are applied on a voluntary basis.

On the other hand, systems for the voluntary certification of environmental safety and comfort of construction facilities have been developed and are widely used both in the United States and the U.K. The programs of such certification rating systems (LEED and BREAM, for example) include both architectural and planning, and organizational and technological measures allowing neutralizing the impact of factors harmful to a person in the zone of impact of new construction. So, on the basis of foreign experience, the authors suggest that harmful effects on people at Russian construction sites be minimized by taking a number of similar organizational and technological measures indicated in the widespread certification programs (Table 6).

Table 6. Set of basic organizational and technological measures ensuring the environmental safety requirements in accordance with the main certification systems

No.	Organizational and technological measures	Variable
12.	Drawing up and approval of the plan for construction activities	t_1^A
13.	Creation of fortifications for the earth, shelter of the earth, earth embankment	t_2^A
14.	Restrictions of construction works at night	t_3^A
15.	Anti-noise shields	t_4^A
16.	Noise protection covers for machinery	t_5^A
17.	Construction of geogrids, tree grills	t_6^A
18.	Deployment of wheel wash-down stations	t_7^A
19.	Creation of traps to capture solid particles	t_8^A
20.	Measures for construction waste removal and treatment	t_9^A
21.	Reducing emissions from idle construction machinery and equipment with internal combustion engines	t_{10}^A
22.	Prevention of the impact force from being transmitted to the ground	t_{11}^A

A particular indicator of the ecological load (anthropological component) can be expressed by a matrix of dimensions 3x1 (formula 1).

$$A = \begin{bmatrix} q_1^A \\ q_2^A \\ q_3^A \end{bmatrix} \quad (1)$$

The integrated indicator of organizational and technological measures reducing the value of a particular environmental load (impact on a person in the zone affected by a construction site) can also be expressed by a matrix (formula 2).

$$B = \begin{bmatrix} t_1^A & t_2^A & t_3^A \\ t_4^A & t_5^A & t_6^A \\ t_7^A & t_8^A & t_9^A \\ t_{10}^A & t_{11}^A & t_n^A \end{bmatrix} \quad (2)$$

It is assumed that organization the necessary and sufficient complex of organizational and technological measures bring matrices to the form B→A.

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