The impact of ecology on labor productivity in the development of hard-to-reach areas

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Abstract. The structure of extreme factors in the pioneer development of hard-to-reach territories is considered. The activity of their influence on employees in the pre-production and production periods is assessed. The dynamics of the impact of factors of the pre-production period associated with the duration of the employee's move from permanent residence toplace of work and change of time zones and climatic zones. The influence of not only traditional factors during the production period - low temperatures, hurricane winds and atmospheric pressure drops, but also the impact on the body of the "polar night" and "magnetic storms" is described, indicating the correction factors for the rehabilitation time. The model of the most optimal type of workers for northern conditions and their psychophysiological characteristics are revealed. A favorable period of active work is indicated with rational indicators of overtime hours and average coefficients of decrease in labor productivity, as well as recommended cycles and modes of work and rest for the Arctic, Komi and the Tyumen region. The features of preparation for the pioneer development of the territory are highlighted, representing measures to maximize the return on labor based on the creation of future objects from aggregate-block units of full factory readiness, delivery of labor and material and technical resources only by flights, maintaining the continuity and pace of work.

Keywords: development of hard-to-reach areas, extreme factors, dynamics of labor productivity, rehabilitation time, work and rest regimes, workers' health.

1 Introduction

The Russian Federation is a northern country and almost 2/3 of its territory is located in the permafrost region with harsh climatic conditions, and the regions of the Far North and the Arctic are generally characterized by an extreme climate. Such natural and climatic conditions are a serious obstacle to the development of new territories [1].

The available knowledge of the natural and climatic conditions of the northern regions makes it possible to develop appropriate requirements and manufacture construction

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equipment in the northern version, including construction machinery and equipment, small-scale mechanization and standard sets of tools, special and general-purpose vehicles. In the development of new territories, new materials and innovative technologies for the construction of buildings and structures are widely used, including construction methods with the preservation of the frozen state of soils, effective metal frame systems with sandwich panels and energy-saving windows. Prefabricated (modular) buildings capable of withstanding the most difficult operational and climatic conditions are becoming more and more popular [2,3,4,5]

The development of new northern territories is carried out mainly by the forces of mobile construction units, the regions of activity of which are, as a rule, in other climatic zones and far enough from the places of their permanent base and residence of workers. Natural and climatic conditions, the length of stay on watch (on an expedition), the degree of labor intensity and other factors in the areas of pioneer development of territories significantly affect the production and physiological capabilities of workers. At the same time, without knowledge of the medical and biological limitations of labor activity, it is impossible to competently and objectively plan and manage the production and quality of work [6].

2 Materials and methods

Domestic and foreign practice of pioneering the development of territoriy with extreme natural and climatic conditions has accumulated a large amount of knowledge about the professional activities of workers in various construction specialties, functional changes in the body, and the dynamics of labor productivity.

The totality of factors affecting workers in extreme conditions should be divided into two groups. The first group includes the so-called factors of pre-production impact. The main ones are the duration of travel to the place of work from the place of permanent residence, the frequency of these moves, the change of climatic zones, the change of time zones, the comfort of the vehicles used for moving. The second group consists of factors affecting the employee during the production period such as the total duration of stay on the watch (on the expedition), natural and climatic conditions, the technological characteristics of the production process, the conditions of work, the degree of labor intensity, the duration of the work shift, the microclimate in the team, sanitary and housing and communal conditions.

Each of these extreme factors has an individual degree of activity, which provokes the development of a negative state of the employee (Table 1).

Table 1. The main extreme factors influencing workers

№ № p/n	Factor name	The degree of activity of the factor		
		High	Average	Low
1	2	3	4	5
I	**Group of factors of the pre-production period**			
1.1	Duration of travel to the place of work from the place of permanent residence	+		
1.2	Frequency of transfers to the place of work from the place of permanent residence	+		
1.3	Change of climatic zones			+
1.4	Jet lag	+		
1.5	Comfort of vehicles used for moving		+	

Continuation of table. 1

1	2	3	4	5
II	**Group of factors of the production period**			
2.1	Total duration of stay on watch (expedition)	+		
2.2	Natural and climatic conditions	+		
2.3	Technological characteristics of the performed workflow		+	
2.4	Conditions of work		+	
2.5	The degree of labor intensity	+		
2.6	Duration of the work shift	+		
2.7	Microclimate in the team			+
2.8	Sanitary and housing and communal conditions	+		

Studies show that the physiological discomfort of an employee begins long before his production activity as a result of exposure to factors of the pre-production period. For example, the factor of the duration of travel to the place of work from the place of permanent residence has a high degree of activity. This activity is due to the fact that the employee overcomes time zones in the latitudinal direction and climatic zones over long distances in the meridional direction. As a result, the employee has serious disorders of the physiological functions of the body, which are especially pronounced during diagonal moves. To return the employee's body to its original state, physiological adaptation is necessary, which can take a very long time (Table 2).

Upon arrival at the location of the watch (expedition), the employee immediately falls under the aggressive influence of a group of factors of the production period. First of all, it is affected by natural and climatic conditions - low temperature (up to -50°C), hurricane winds (30-40 m / h), sudden changes in atmospheric pressure, high humidity, etc. But of particular concern is the impact on the body of electromagnetic fields, which are actively manifested in high-latitude regions, as well as penetrating powerful atmospheric radiation. In this regard, women and young men are not recommended for work in the Arctic.

Table 2. Dynamics of the impact of factors of the pre-production period (fragment)

Chaso-howl belt	Per climatic zone				Into three climatic zones			
	Distance move thousand km	Dynamics of labor productivity, %	Duration of adaptation, h	Duration of incapacity for work, h	Distance move thousand km	Dynamics of labor productivity, %	Duration of adaptation, h	Duration of incapacity for work, h
1	1,6	100	16	21	3,9	100	40	26
2	3,2	98	20	25	4,9	99	64	32
3	4,9	97	28	28	6,1	96	84	37
4	6,7	94	32	32	7,5	97	108	43
5	8,3	89	36	35	9,0	94	140	50
6	9,9	84	48	38	10,6	92	168	55
7	11,6	78	56	41	12,2	87	200	61
8	13,3	71	64	44	13,7	79	232	66
9	14,9	61	76	47	15,3	65	272	72
10	16,7	47	92	50	17	38	324	77
11	18,3	27	112	52	18,6	-	-	81

Foreign corporations of Canada, the USA, Germany, etc., in the formation of pioneer mobile expeditionary and rotational construction complexes, use the so-called rehabilitation coefficients, which take into account the influence of "magnetic storms" and "polar night" on workers during their air travel (Table 3).

Table 3. Rehabilitation time to overcome the factors of "magnetic storms" and "Polar Night" (fragment)

Travel time, min	Distance, thousand km	Rehabilitation time, min		
		standard conditions	Correction factors	
			Polar Night	Magnetic storms
Turbojets, design speed 1000 km/h			$K\ 1 = _{1.2}$	$K_2 = 1.3$
30	0,5	18	22	23
120	2,0	186	223	242
210	3,5	372	446	487
300	5,0	423	508	550
360	6,0	447	536	581
480	8	504	605	665
600	10	573	668	745
Helicopters, design speed 200 km/h			$K\ 1 = _{1.1}$	$K\ 2 = _{1.2}$
30	0,10	20	22	24
60	0,20	40	44	48
90	0,25	120	132	144
120	0,40	306	337	367

Among the natural and climatic factors, great harm is caused by the aggression of the midge, which significantly reduces labor productivity in the period June-October. For example, the dynamics of loss of labor productivity is for

concrete workers

- "absolutely healthy" – 3-11%;
- "healthy" – 8-31%
- installation workers
- "absolutely healthy" – 2-27%;
- "healthy" – 9-37%

At the same time, you have to work in mosquito nets and anti-encephalitis suits.

Some areas are not affected by midges due to the peculiarities of wind regimes.

3 Results and discussions

Domestic science considers three forms of rehabilitation of the human body - adaptation, acclimatization and disease, expressing the restructuring and adaptation of the body to extreme conditions. Constant study of practice in this area today allows us to develop requirements for the health of workers, develop rational modes of work and rest, apply effective forms and methods of organizing work. At the same time, the task of selecting not only an employee as a qualified and healthy specialist, but also the formation of units, teams, groups with a high level of mutual support in harsh extreme conditions from employees is becoming more and more urgent. In this regard, the approach of medical specialists in Canada and the United States, which, on the basis of comprehensive and long-term studies, have identified a two-pronged and conditionally optimal type of employee for work in extreme conditions, deserves to be studied and disseminated. According to their model, this is a man aged 28-50 years, whose health meets the standards of the Navy. The duality of the worker is characterized by the combination of an "absolutely healthy" person of the sanguine type with a "healthy" person of the choleric type in a percentage ratio of 40 to 60. The need to combine the hard-to-excitable with the delayed reactions of the employee with the excitable is explained by the following facts: the "healthy" employee is more purposeful and therefore he always finds the right solution, but at the same time the "absolutely healthy" employee more clearly organizes the task and brings the production process to completion with qualitiesOhm products in accordance with the standard. The second important fact indicates that "healthy" workers are very difficult to tolerate the influence of natural and climatic conditions, and especially in the spring and autumn periods, their labor productivity is significantly reduced. This is a natural psychophysiological feature of people of the choleric type. Over time, the performance of "healthy" workers is restored, but, as a rule, never reaches the maximum productivity of "absolutely healthy" workers who are distinguished by resilience and stable reactions [6].

The study of the complex of emerging anomalous phenomena and the degree of their influence on the body made it possible to substantiate the most favorable time period when stable labor productivity of workers is combined with the least losses in production and minimal costs for their arrangement and life support. Such a favorable period begins in May and lasts up to and including November and is seven months. It is during this period that the bulk of the work is carried out. In the remaining period from December to April inclusive, work is significantly slowed down, employees are provided with vacations, resources are redistributed, and various organizational and technical tasks are solved.

In practice, the duration of the working week on the watch (on the expedition) significantly exceeds 40 hours. Work is carried out, as a rule, very intensively and usually in one shift, which sometimes lasts up to 12, and in exceptional cases up to 15 hours a day. But such long shifts are provided under favorable conditions, when atmospheric radiation is not large, atmospheric pressure is stable and there is a relatively calm temperature regime. Overtime is taken into account by the existing system of categories, which is based on the conditions of maintaining the health of the employee. It is believed that the following indicators of overtime hours are the most rational:

- one-week watch - 21-28 hours;
- two-week watch - 36-49 hours;
- four-week watch - 80-86 hours.

According to experts, these indicators are quite effective for maintaining a high level of work. But at the same time, with an increase in the duration of the shift, as a rule, labor productivity decreases. To take this phenomenon into account, on the basis of domestic and foreign studies, averaged coefficients of decrease in labor productivity of shift workers are proposed:

- with a 9-hour work shift from 0.02 to 0.05;
- with a 10-hour work shift from 0.05 to 0.08;
- with an 11-hour work shift from 0.08 to 0.12;
- with a 12-hour work shift from 0.12 to 0.18.

At the same time, for almost every northern region, taking into account its natural and climatic features, the most rational cycles and modes of work and rest of workers have been developed. For example, for the Arctic, Komi and the Tyumen region, a double cycle is recommended, including two and a half months (October-December) of the expedition, three weeks of rest, then two and a half months of the expedition (January-March) and a month and a half of rest. At the same time, for example, with a 12-hour shift, the mode of work and rest can be in the form of a variant of the table. 4.

In general, any work in extreme conditions provides for the maximum return on labor per unit of time, since the arrangement of the employee, the delivery of material and technical resources, energy costs

Table 4. Modes of work and rest of shift workers with a 12-hour shift and different duration of rotational work

Days of the week	**Duration of rotational work**																		
	Week																		
	I	**II**	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**	**V**	**VI**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**
Monday	12	O(8)	12	12	O(8)	O(8)	12	12	12	O(8)	O(8)	O(8)	12	12	12	12	O(8)	O(8)	O(8)	O(8)
Tuesday	12	O(8)	12	12	O(8)	O(8)	12	12	12	O(8)	O(8)	O(8)	12	12	12	12	O(8)	O(8)	O(8)	
Wednesday	12	O(8)	12	12	O(8)	O(8)	12	12	12	O(8)	O(8)		12	12	12	12	O(8)	O(8)	O(8)	
Thursday	12	O(8)	12	12	O(8)		12	12	12	O(8)	O(8)		12	12	12	12	O(8)	O(8)	O(8)	
Friday	12		12	12	O(8)		12	12	12	O(8)	O(8)		12	12	12	12	O(8)	O(8)	O(8)	
Saturday	12		12	12	In		12	12	12	In	In		12	12	12	12	In	In	In	
Sunday	In		CENTURIES	In	In		CENTURIES	CENTURIES	In	In	In		CENTURIES	CENTURIES	CENTURIES	In	In	In	In	
Worked, hour.	**72**		**144**				**216**						**288**							
Recycled, hour.	**32**		**64**				**96**						**128**							

Legend:
B – day off;
BB - rotational day off;
O – day off

You and others are very expensive. And in this regard, a particularly thorough preparation of construction production is required. To this end, first of all, attention is paid to the industrial solutions of future facilities. This is the first and very important feature of

preparing for the development of hard-to-reach areas. As a rule, future objects are completely assembled at manufacturing plants from individual products in the form of aggregate-block units, the mass of which does not exceed 80 kg. As a result, the entire volume of loading and unloading, transport and assembly work can be carried out manually by two low-skilled workers using winches, wrenches and mounting ladders. This approach significantly reduces the cost of work in extreme conditions, since there is no need to use large construction machines and highly professional workers [7,8,9,10].

The second feature is the active use of flights for delivery to the areas of pioneer development of the territories of aggregate-block units, energy, technological and dispatching complexes and life support complexes from rear bases. It is believed that in the production of work in extreme conditions, the time factor is decisive.

The third feature is the maintenance of the continuity and pace of work, since downtime for any reason leads to the disruption of the work of the watch (expedition) due to the impossibility or inexpediency of redistributing labor and material and technical resources to other, unprepared objects [11,12,13,14,15]. Therefore, the organization of uninterrupted active activity of mobile formations at the facilities is the main task, for the solution of which all the necessary measures are developed and implemented both in preparation for the pioneer development of territories and in the process of work.

4 Findings

Every year, the northern regions rich in natural resources are increasingly being developed, the territory of which is difficult to access and is characterized by harsh natural and climatic conditions - low temperatures, hurricane winds, sudden changes in atmospheric pressure, the effects of electromagnetic fields and atmospheric radiation.

The development of the northern regions is an extremely difficult task, for the solution of which new materials and innovative technologies for the construction of buildings and structures, construction machines and vehicles in a special northern version, a huge range of various life support resources are widely used. The entire cycle of work on the pioneer development of territories and the construction of buildings and structures on them is carried out, as a rule, by the forces of mobile formations operating in a rotational or expeditionary mode at a considerable distance from rear bases and places of permanent deployment.

The results of domestic and foreign studies allow us to assert that the strategic direction for the development of scientific and technological progress in the development of the northern regions is the aggregation of material and technical resources in the field of industrial production in the form of blocks and assemblies of full or high factory readiness with the transformation of the construction site into an assembly line for the construction of buildings and structures.

To date, science and practice have accumulated considerable knowledge on the effective development of the northern regions, which make it possible to develop requirements for the health of workers, develop rational work and rest regimes, use various forms of labor organization, create optimal and comfortable housing and communal complexes and life support complexes, effective sets of construction machinery and equipment. The accumulation of knowledge, of course, must continue. Especially the forms of rehabilitation of the organism need to be developed and detailed, depending on changes in the activity of natural and climatic factors and their combinations with factors of labor intensity, as well as requirements for the formation of micro-collectives - links and brigades.

References

1. Fedosenko, V.B. Features of construction production in the regions of the Far North and the Far East. Housing construction, 2003. - № 8
2. Prefabricated buildings and structures / A.N. Asaul, Y.N. Kazakov, V.Y. Bykov et al. - St. Petersburg: Humanistics, 2004
3. Zakharova M.V. Experience in the construction of buildings and structures using modular technology / M.V. Zakharova, A.B. Ponomarev // Bulletin of the Perm National Research Polytechnic University. Construction and architecture. – V. 8, No 1. – 2017. – P. 148-155
4. Production technologies in construction: modular systems / S.I. Zavrazhnov, D.S. Rachkov, M.A. Novikov, S.V. Yudin // Bulletin of MGSU. - № 3 – 2010. – P. 185-190.
5. Erofeev P.Y. On the study of the market of block-modular construction of prefabricated buildings and settlements / P.Y. Erofeev, M.M. Kalyuzhnyuk, E.V. Seko // Thematic collection of works. - St. Petersburg: Stroyizdat, 2003
6. 1.Oleinik P.P. Industrial-mobile methods of erection of enterprises, buildings and structures: Monograph. – M.: ASV Publishing House, 2021Shepeleva E.A., Shepelev A.L. Organization of construction of production facilities by the complete block method. - Arkhangelsk: IPC NArFU, 2013.
7. Competitive interaction between investing firms on dynamic market vbwith taxation / O.A. Malafeyev, I.V. Zaitseva, S.A. Sychev, G. Badin, A. Parfenov, A. Shulga // IC-NAAM 2019; (17th International Conference of Numerical Analysis and Applied Mathematics), September 23-28/ - Greece, 2019/
8. Nadim, W. Offsite production in the UK: The Way forward? A UK construction industry perspective /W. Nadim, J. S. Goulding // Construction Innovation: Information, Process, Management. – 2010. - # 19(2). – P. 181 – 202.
9. Sychev, S.A. Methods of forecasting progressive technology and technology of high-speed installation of modular construction / S.A. Sychev, G.M. Badin // Installation and special work in construction. – 2015. - № 10. – S. 22-25.
10. Oleynik P.P. Planning as the basis of strategic development of the conatruction organization. MATEC Web of Conferences, 164, 0030, (2020)
11. Oleynik P, Kuzmina T, Dzueva. Optimization of the duration of the pioneer construction period. XXIII International Scientific Conferense “Construction the Formation of living Environment” (FORM-2020) (23-26 September 2020, Hanoi, Vietnam, volume 869 Management and construction).
12. Knaack, U. Prefabricated systems: Principles of construction / U. Knaack, Sh. Chung-Klatte, R. Hasselbach. – Berlin: De Gruyter, 2012. – P. 133/
13. Sychev, S.A. Multifunctional optimization in the technology of high-speed modular construction / S.A. Sychev // Bulletin of Civil Engineers - 2016. - № 4(57). – P. 99-104
14. Analisis of the computational aspects of the applied optimization aigorithms / O.A. Malafeyev; WECONF-2019, June 3-7. – Saint-Petersburg, Russia, 2019.