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DETERMINATION OF THE LIMITS OF THE APPLICATION OF THE STATISTICAL METHOD FOR EVALUATION INTEGRAL FIRE RISKS

Calculations of integral fire risks for the grouped regions of Ukraine and the city of Kiev are carried out. The possibility of using a statistical method for risk assessment is defined. In accordance with the statistical method, calculations were made of the minimum number of people that should live in the study area.

Keywords: integral fire risk, statistical method, number of observations, relative error.

Problem statement. The analysis of the array of accounting records for fires for 2010-2017 years indicates an increase in the number of fires, which is accompanied by an increase in the number of victims and those killed as a result of these dangerous phenomena. For example, in 2017 there were 12% more fires than in 2016, and the number of injured persons increased by 9,1%. As the number of fires increases, this increases the risk of being in a fire R_1 and die in a fire. R_3. The concept of risk management [1] indicates the need to implement the conceptual framework for managing the risks of emergencies caused by the presence of dangerous factors of anthropogenic and natural nature, including fires. Thus, the creation of a man-made and fire safety management system based on a risk-oriented approach and European standards for risk assessment is an actual scientific and applied problem. It should be noted that the application of the risk-based approach is based on a statistical evaluation of data, but the boundaries of the use of the corresponding statistical methods have not been determined at present.

Analysis of recent researches and publications. Modern methods for determining the integral risks of hazardous events are given, for example, in papers [2, 3]. However, they assume that statistical methods for calculating fire risks can be applied without restrictions. At the same time, the task [4] solves the problem of assessing the boundaries of applying existing approaches to the definition of occupational risk, whose results showed limited statistical approach. A similar situation occurs in works [5, 6], where the analysis of integrated fire risks on the territory of Ukraine was carried out and the grouping of administrative-territorial units in accordance with the levels of risks was carried out with the help of cluster analysis. In the United States, the FEMA agency deals with the assessment and management of fire

risk, with the results of its activities listed in [7, 8]. At the same time, these works do not include calculations for determining the boundaries of the use of the statistical method. A similar conclusion can be drawn in the analysis of risk assessment methods in different countries of the world, as outlined in the Global Concept for Building Fire Safety [9-11].

Statement of the problem and its solution. The purpose of this work is to determine the boundaries of the application of the statistical method for the investigation of integral fire risks R_1 and R_3, in particular, the risk for a person to be in a fire, as well as the risk of perishing during a fire per unit time.

In the determination of the boundaries of the application of the statistical method for estimating integral fire risks for the calculated clusters (the grouped regions of Ukraine, see Table 1 [6]), the approach outlined in [4] was used. This approach also made it possible to determine the accuracy of the statistical assessments of these risks.

First of all, it was calculated the magnitude of the risk of being in a fire and die from a fire per unit time using such expressions [12]:

$$R_1 = \frac{N_{fire}}{N_{people}}; \quad (1)$$

$$R_3 = \frac{N_{victims}}{N_{people}}, \quad (2)$$

where N_{fire} – number of fires per unit time (in our case, a year); N_{people} – the number of people living in the respective territory, $N_{victims}$ – number of fatal fires per calculated unit of time (year).

Having received groups of administrative and territorial units of Ukraine that are united into clusters, we will analyze the statistical data for these clusters and the city of Kyiv, namely, we will make calculations on the definition of risks and using the statistical information obtained during 2010-2016. The summarized data and the obtained results are shown in the table 1.

Tab. 1. The value of integral fire risks R_1 and R_3 for the four clusters and the city of Kyiv on the basis of statistical data over 7 years

Cluster	N_{fire}	$N_{victims}$	$N_{people} * 10^3$	$R_1 * 10^{-3}$	$R_3 * 10^{-5}$
1	11171	456	6249,8	1,79	7,3
2	27325	959	16431,7	1,66	5,84
3	9951	229	7904,4	1,26	2,9
4	7423	267	5697,7	1,3	4,69
c. Kyiv	4598	58	2831,1	1,63	2,01

To limit the maximum number of people living in the area, the following restriction was used [4]

$$N_{people} \geq \frac{Z_{\gamma}^2}{R \cdot \delta_{need}^2}, \quad (3)$$

where Z_γ – quantile of normal distribution of the level γ; $\delta_{R_{need}}$ – relative risk of error.

To implement the statistical method of estimating integral fire risk, it is necessary to determine the minimum number of observations (the number of persons residing in the studied territory). Let's calculate taking into account the relative error of measurements 10%, which corresponds to the confidence probability of 0.9 and quantile of normal distribution $Z_\gamma = 1{,}282$.

We find the minimum number of people who must live in the regions of regions that have fallen into the corresponding clusters to assess the risk of a person to be in a fire. The results of the calculation are shown in the table 2.

Tab. 2. The value of the minimum population to be resettled in the area under study for the assessment of the integral fire risk R_1

Cluster	$R_1 * 10^{-3}$	$N_{people}^{R_1} * 10^3$
1	1,79	92
2	1,66	99
3	1,26	130
4	1,3	126,4
Kyiv	1,63	100,7

The comparison of calculated population figures $N_{people}^{R_1}$ with statistical indicators N_{people} (see table 1) suggests that the use of the statistical method for the investigation of fire risk R_1 is correct both for the obtained clusters and for the city of Kyiv.

Find the minimum number of people to live in the investigated clusters and in the city of Kiev for the correct assessment of the risk of a person to die in a fire. The results of the calculation are shown in the table 3.

Tab. 3. The value of the minimum population to be resettled in the area under study for the assessment of the integral fire risk R_3

Cluster	$R_3 * 10^{-3}$	$N_{people}^{R_3} * 10^6$
1	7,3	2,26
2	5,84	2,2
3	2,9	5,67
4	4,69	3,5
Kyiv	2,01	8,18

From table 3 it follows that the use of the statistical method for determining the fire risk is correct only for clusters, since the value of the minimum required population in the city of Kiev should be more than 8 million people, and in fact, live less than 3 million.

Conclusions. In this paper, for four clusters (groups of oblasts of Ukraine), calculations of integrated fire risks were conducted, namely, the risk for a person to be in a fire (R_1) and the risk for a person to die during a fire per unit time (R_3). According to the statistical method with an error of 10%, calculations were made of the minimum population that should be inhabited in the study area. It was found that the use of the statistical method for calculating the fire risk is correct both for clusters and for the city of Kiev, and the calculation of fire risk is correct only for clusters. Thus, the use of statistical estimation to determine the integral fire risk for a person to perish during a fire per unit time is correct only for large areas with a population of more than 3 million people. Further research will be aimed at developing a method for managing integral fire risk, which is supposed to be applied for each group of regions (clusters).

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Визначення границь застосування статичного методу для оцінки інтегральних пожежних ризиків

Проведено розрахунки інтегральних пожежних ризиків для групованих областей України та міста Києва. Визначено можливість використання статистичного методу для оцінки ризиків. Відповідно до статистичного методу проведено розрахунки мінімальної кількості населення, що повинна проживати на досліджуваній території.

Ключові слова: інтегральний пожежний ризик, статистичний метод, кількість спостережень, відносна похибка.

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Определение границ применения статистического метода для оценки интегральных пожарных рисков

Проведены расчеты интегральных пожарных рисков для группированных областей Украины и города Киева. Определена возможность использования статистического метода для оценки рисков. В соответствии со статистическим методом проведены расчеты минимального количества населения, которое должно проживать на исследуемой территории.

Ключевые слова: интегральный пожарный риск, статистический метод, количество наблюдений, относительная погрешность.