INTERNATIONAL MULTIDISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
SJIF 2019: 5.222 2020: 5.552 2021: 5.637 2022:5.479 2023:6.563 2024: 7,805
eISSN :2394-6334 https://www.ijmrd.in/index.php/imjrd Volume 12, issue 03 (2025)

STATISTICAL ANALYSIS OF RANDOM EXPLOSION PARAMETERS AT VARIOUS LEVELS OF DAMAGE TO STRUCTURES AND BUILDINGS

Tursunov Kadirjon Mukhammadjonovich
PhD in Technical Sciences, Professor, Head of the Department
Institute of Communications and Information Technologies, Ministry of Defense of the Republic of Uzbekistan
Makhmudov Nemadulla Akhmatovich
Candidate of Technical Sciences, Professor of the Department
Academy of the Armed Forces of the Republic of Uzbekistan
Mamatkulov Alisher Azamatovich
Researcher Institute of Communications and Information Technologies,
Ministry of Defense of the Republic of Uzbekistan
Ummatkulov Farrukh Murodjonovich
Doctoral student of the Armed Forces Academy of the Republic of Uzbekistan

Abstract: This article examines the issue of determining the resource capacity of structures and buildings using statistical methods. Based on experimental data, mathematical modeling was used to study the durability of objects and their condition under the influence of internal and external forces. The assessment of the degree of damage to buildings and structures under the impact of explosive substances was carried out using the Gaussian normal distribution. Statistical parameters such as the coefficient of variation, arithmetic mean, variance, and standard deviation were determined. The calculation results showed that the mathematical and statistical analysis of random explosion processes corresponds to the experimental data.
Keywords: statistical analysis, mathematical modeling, structural durability, Gaussian normal distribution, coefficient of variation, arithmetic mean, variance, standard deviation, explosive processes, building damage.

Using statistical methods, any experimental results can be mathematically modeled. The essence of mathematical statistics lies in determining all parameters of the probability distribution functions of random processes (phenomena). To find these parameters and their values, integral calculus and the solution of differential equations are usually required. Such problems are addressed within the field of mathematical analysis.

When determining the resource capacity of structures based on experimental data, the mathematical expectation $M(x)$, the arithmetic mean $\bar{x}$, and the behavior of structures and buildings under the influence of external and internal forces (earthquakes, explosions, loads, pressure, etc.) are analyzed. In particular, their oscillations or damages of varying degrees are considered, expressed through deviations from the center of gravity $D(x)$ variance and the standard deviation ( ).

The resource is an indicator that determines how long a structure (building) can be operated and how long it can continue functioning without interruption. The resource diagnosis is expressed through the function $e^{-\lambda t}$. The condition of structures damaged as a result of a random explosion has been proven to depend on the parameters of the explosive material. However, the degree of correlation between the constituent components of explosives and their statistical parameters ($\sigma(x)$, $\bar{x}$, V_6 z coefficients of variation) is not always precisely determinable. The coefficient of variation V_6, expressed as a percentage, represents the ratio of the standard deviation to the arithmetic mean and is determined by the formula:

$V_R = \frac{\sigma(x)}{\bar{x}}$.

If the mass of the explosive substance m_k increases and the distance between the charge and the object R becomes relatively smaller (closer), then the pressure variation coefficient will be higher.

In all statistical distributions (Gaussian, Rayleigh, Student's t-distribution, Fisher-Snedecor, Weibull-Gnedenko, etc.), three main parameters must be determined: the mathematical expectation $M(x) = a_m$, the variance of the random variable $D(x)$, and the standard deviation ( ). Among them, the Gaussian normal distribution stands out due to its high accuracy in diagnosing the degree of damage to structures and buildings, as well as in scientific research of their physical and mechanical properties [1-3]. In a series of studies, experiments were conducted in which pressure was recorded at various distances from the explosion epicenter. The impact of the explosion was analyzed using a numerical model and subjected to statistical analysis [4].

For random TNT (trinitrotoluene) charges with a mass of $m = 10, .. 30$ kg, the correspondence of building damage points to the Gaussian normal distribution is scientifically analyzed. During the calculations, the coefficient of variation was assumed to be $V_v = 0{,}2$ and was considered constant for a series of random explosions.

The density (differential) function of the normal distribution can be expressed in the following form:

$$f(m) = \frac{1}{\sigma(m)\sqrt{2\pi}} \cdot \exp - \frac{(m-a_m)^2}{2\sigma^2(m)} \qquad (1)$$

Here:

( ) — differential (density) function of the Gaussian distribution by mass;

$\sigma_m(x) = mV_m$ — standard deviation;

a_m — unknown mathematical expectation,

= 2.71... — base of the natural logarithm.

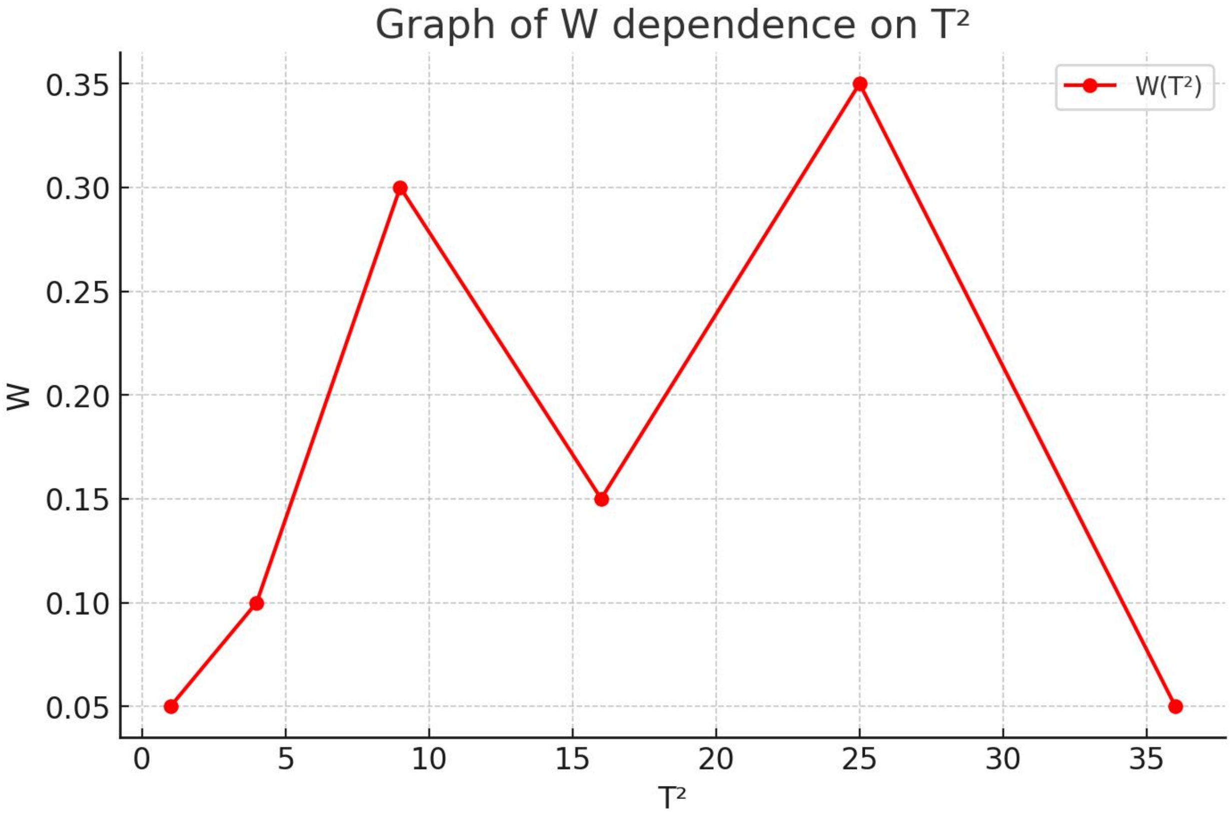
Table 1

№	Number of charges (n)	Charge mass m (кг)	Random probability W_i	$x = 4T + 16$ T_i	T_i^2	$M(t)$	$M(t^2)$	$M(x)$	$D(x)$	$\sigma(x)$
1.	1	20	0.05	1	1	3.80	16.10	21.20	26.56	5.2
2.	2	24	0.10	2	4					
3.	6	28	0.30	3	9					
4.	3	32	0.15	4	16					
5.	7	26	0.35	5	25					
6.	1	40	0.05	6	36					

If this statistical distribution is close to the mean value, the approximate equality $hf(x)$ holds. More precise criteria corresponding to empirical and theoretical distribution laws will be proposed in the future.

Table 2

T	1	2	3	4	5	6
W	0,05	0,10	0,30	0,15	0,35	0,05
T^2	1	4	9	16	25	36



Substituting the variable into the formula $X = 4T + 6$, we write the statistical distribution for T and T^2. Thus:

$M(T) = 0{,}05 + 2 \cdot 0{,}10 + 3 \cdot 0{,}30 + 4 \cdot 0{,}15 + 5 \cdot 0{,}35 + 6 \cdot 0{,}05 = 3{,}80$

$M(T^2) = 0{,}05 + 0{,}40 + 2{,}70 + 2{,}40 + 8{,}75 + 1{,}80 = 16{,}1$

$M(\bar{x}) = 4 \cdot M(T) + 6 = 4 \cdot 3{,}8 + 6 = 21{,}2$

$M(T^2) = \frac{x^2+12x+36}{16} = \frac{1}{16}M(x^2) - \frac{3}{4}M(x) + \frac{9}{8} = 16{,}1$

$M(x^2) - 12M(x) + 36 = 16{,}1 \cdot 16$

$M(x^2) = 257{,}6 + 12 \cdot 21{,}2 - 36 = 476$

$D(x) = M(x^2) + \left(M(\bar{x})\right)^2 = 476 - 449{,}44 = 26{,}56$

$\sigma(x) = 5{,}15 \approx 5{,}2$

From this, it follows that: $f(x) = \frac{1}{\sigma\sqrt{2\pi}} \cdot \exp\ -\frac{(x-M(x))^2}{2\sigma^2}$.

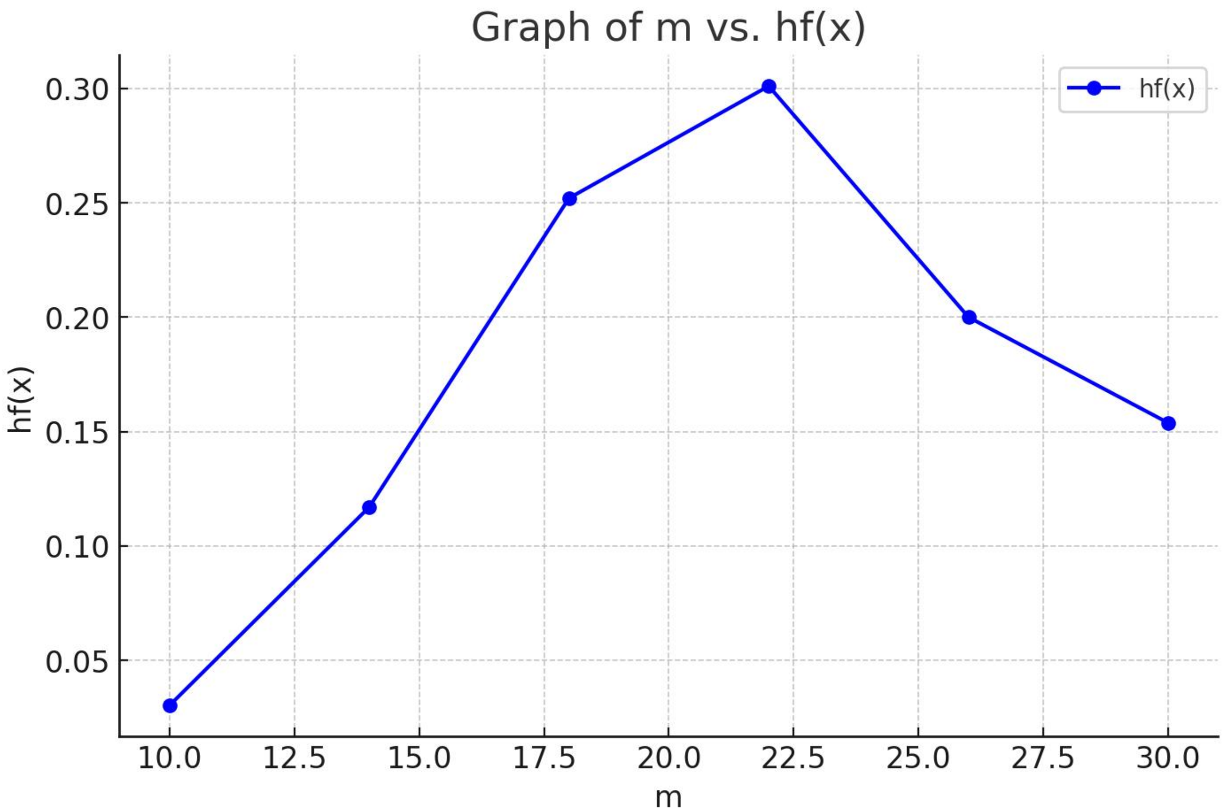
If $\frac{(x-31{,}2)}{5{,}15} = U$, то $f(x) = \frac{1}{5{,}15\sqrt{2\pi}} \cdot e^{-\frac{n^2}{2}} = 0{,}19z_n$ where $z_n = \frac{1}{\sqrt{2\pi}} \cdot e^{-\frac{U^2}{2}}$

The values of the function z_n – are provided in the second table. Using these values, we construct the third table.

Table 3

№	x	U	z_n	$f(x)$	$hf(x)$
1.	10	-2,15	0,039	0,0075	0,0303
2.	14	-1,38	0,154	0,029	0,117
3.	18	-0,62	0,331	0,063	0,252

4.	22	0,15	0,396	0,075	0,301
5.	26	0,92	0,262	0,050	0,200
6.	30	1,69	0,096	0,038	0,1538



Conclusion

The degree of damage to buildings and structures was analyzed using mathematical and statistical methods. A diagram was constructed to show the relationship between the mass of explosive substances in the range of [10...30] kg and their quantity (frequency). The analysis demonstrated that in the case of random explosions with a charge mass ranging from 10 to 30 kg and a number of 1 to 7, the points of destruction of buildings and structures follow the normal Gaussian distribution. The results of the mathematical and statistical analysis confirmed the correspondence between the experimental data and theoretical models.

References:

1. Mamatkulov A.A., Kodirov A.A., Makhmudov N.A., Kurbanbaev M.Sh., Tursunov K.M. Mathematical modeling of strength levels and probability analysis of structural element damage in buildings under random explosions. *Journal of Mechanics*, No. 3. Tashkent, 2024. pp. 114–119.
2. Belov N.N. et al. Calculation of reinforced concrete structures under explosive and impact loads. *Northampton – Tomsk*, 2004. 465 p.
3. Belov N.N., Yugov N.T. et al. Calculation of the strength of steel-concrete columns under explosive and impact loads. *Bulletin of TASU*, No. 2, 2007. pp. 132–138.
4. Mkrtichev O.V. Reliability of multi-element rod systems in engineering structures. Doctoral dissertation in technical sciences. *Moscow State University of Civil Engineering*. Moscow, 2000. 324 p.