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SIGURNOST GRAĐEVINSKIH KONSTRUKCIJA

Slavko Zdravković[1], Dragan Zlatkov[2], Biljana Mladenović[3], Dragana Turnić[4]

Rezime
U radu se sa tehničkog i funkcionalnog stanovišta definiše faktor sigurnosti (ili upotrebljivosti) (γ), građevinskih konstrukcija, kao odnos nosivosti konstrukcije S i projektnog opterećenja L i on (γ) uvek mora biti veći od 1. Iako je cilj rada da se definiše termin "faktor sigurnosti" date su dve definicije. Navedeni termin nema smisla sve dok se ne poveže sa odgovarajućom verovatnoćom. Svojstva otpornosti materijala i maksimalni uticaj opterećenja kojima su konstrukcije izložene promenljivi su, pa se koristi teorija verovatnoće i matematičke statistike. Radije se koristi i termin "efekat-opterećenje" nego "opterećenje", jer se ono menja tokom vremena. Vrši se selekcija termina verovatnoća u zavisnosti od više uslova, kao što je na primer vrednost ljudskog života ili cena koštanja i održavanja građevinske konstrukcije. Uveden je standard za upoređivanje kao neko verovatno odstupanje od Gauss-Laplass-ovog zakona normalne raspodele.

Ključne reči,: građevinska konstrukcija, faktor sigurnosti, statistika, nosivost, krive verovatnoće.

SAFETY OF CONSTRUCTION STRUCTURES

Slavko Zdravković, Dragan Zlatkov, Biljana Mladenović, Dragana Turnić

Abstract
In this paper we define a safety factor (or usability) (γ), from the technical and functional point of view of construction structures.It is ratio of load capacity S and design load L. It must always be greater than 1. Although the purpose of this work was to define the term "security factor", we gave two definitions. This term made no sense until it is related to the appropriate probability. The properties of the strength of material and the maximum load influence of which the structures are exposed are variable, so the theory of probability and mathematical statistics were used. The term "effect-load" is also used instead of "load" because it changes over time. Selection of probability terms depends on several conditions, such as, for example, the value of human life or the cost and maintaining the structure. A comparison standard has been introduced as a possible deviation from Gauss-Laplass's law of normal distribution.

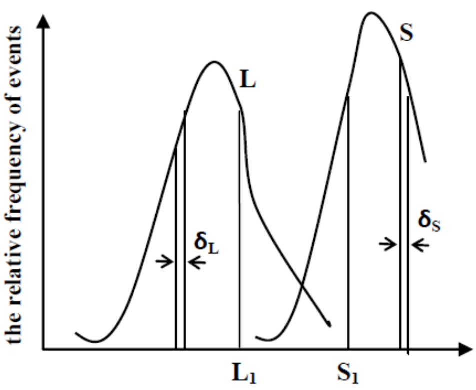
Key words: structure, safety factor, statistics, load capacity, probability curves.

[1] Prof. dr, član Srpske Kraljevske Akademije Inovacionih Nauka – SKAIN; ekspert bivšeg Saveznog ministarstva za nauku, tehnologiju i razvoj u oblasti: građevinsko inženjerstvo, aseizmičko građevinarstvo, stabilnost mostova; Građevinsko-arhitektonski fakultet Univerziteta u Nišu, e-mail: slavko.zdravkovic@gaf.ni.ac.rs.
[2] Doc. dr, Građevinsko - arhitektonski fakultet Univerziteta u Nišu, e-mail: dragan.zlatkov@gaf.ni.ac.rs.
[3] Doc. dr, Građevinsko - arhitektonski fakultet Univerziteta u Nišu, e-mail: biljana.mladenovic@gaf.ni.ac.rs.
[4] Doc. dr, Građevinsko - arhitektonski fakultet Univerziteta u Nišu, e-mail: dragana.turnic@gaf.ni.ac.rs.

1. INTRODUCTION

From a technical viewpoint, it is possible to build a building structure that is exposed to damage in the calculated boundaries because all factors are variable, although some of them can be accurately predicted. So, we can build a building structure with varying degrees of security. The adopted level of safety is largely depending on the amount of available financial assets, because with increasing safety the cost of construction increases too. In order to provide increased strength, the required dimensions are increased with increased foundations, or, more expensive materials. As a complement to the determination of technical safety there is also a social factor, that is an additional level of safety that protects owners, users and the general public of the consequences of the crash. Adjusting the safety factor does not define the probability of the load, which is indicated. On Fig.1 the load and resistance are precisely workable, and the possibility of damaging is small. At the Fig.1b is the reverse case. In Fig.1a is less probability of damage than that of the Fig.1b, although the both cases have the same safety factor.

The values that are specific for the functional damage and failure varied. It is generally acceptable excess risk of functional damaged than the failure. Curve in Figure 1. S shows the variability of the size of a resistance for a large number of building structures which are designed and constructed according to the same requirements. L curve shows the different size loads.



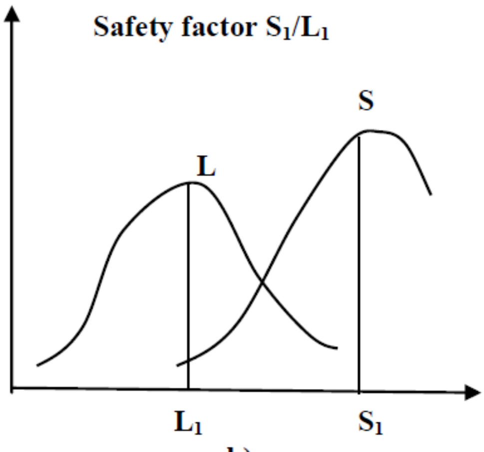


Fig.1. The size of the load and strength

Implementation of additional security, greater than those required by technical reasons which is provides social consequences of functional caused by damage or failure is determined by varying certain value. It is impossible to determine the numerical effect of social consequences of the failure of the probability or risk of failure. If any of of those values introduced in the cost of construction, deciding on the level of safety obtained engineering aspect. Reinforced concrete is tested constructive form and it is natural to introduce a stress factor in this field as a method of security. It is illogical to have different levels of security for the fracture of steel and concrete in reinforced concrete. That attitude is acceptable from an engineering viewpoint. However, due to social reasons there can be different variations in the level of security for one structure. Resistance of structure depends on its in exploitation life because fatigue, corrosion, creep (flow), wear, reduces load capacity, but the safety factor must always be $\gamma > 1$, defined as the ratio of load capacity of structures S_1 and design loads L_1, ie.

$$\gamma = \frac{S_1}{L_1} > 1 \text{ is safety factor.} \qquad (1)$$

Technical safety factor γ_1 is equals

$$i \cdot L_1 = \frac{S_1}{j}, \quad \gamma_1 = i \cdot j \qquad (2)$$

The final safety factor γ_2 is equal to

$$i \cdot L_1 = \frac{S_1}{j \cdot k}, \quad \gamma_2 = i \cdot j \cdot k \qquad (3)$$

Thus, the value for the S_1 and L_1 may vary in equation (1). This means that for a different episodes in the life-century structures can select different values for S1. It is certain only that there is a stationary load, but when the building structure, according to their purpose was put into use, is likely to act and moving loads, perhaps only occasionally. In the non-linear relations with the critical section, the value of the load factor γ_L and stress factor γ_S classified building constructions as "valuable" and "inferior", so in the valuable is $\gamma_L > \gamma_S$. If P_F is probability to break down and it is equal to the sum of the values of inside all of boundaries pP_L, and $p = z\delta s = f(s)\delta s = f(R)\delta R$, for all positive values of resistance and the load it will be

$$P_F = \sum_0^{\infty} P_L f(S)\delta s = \int_0^{\infty} P_L f(S)\delta s = \int_0^{\infty} P_R f(R)\delta R \quad (4)$$

wherein,

$$P_R = \gamma_L L_1 \int_0^{\infty} f(M\gamma_L L_1) dM \qquad (5)$$

and M is the apparent variable.

We can observe the safety factor with the failur as a factor in the equation (4). In the case of load

$$L_1 = L_M + \mu\delta_L \qquad (6)$$

where it is L_1-load value in the equation (1); L_M- the mean value of a strength; δ_L- the standard deviation and μ- the value which depends on the probability of a higher load than the L_1 that comes to mind. Criteria for reinforced concrete is a load or stress in the armature in relation to harmful cracks, or some adopted amount of elastic deformation of the non-linear ratio of stress and strain. If the designed lifetime is known, then it should provide greater dimensions. The problem can be solved by choosing the optimal dimensions which mean the most economical solution for the community.

2. FACTORS OF SAFETY IN TERMS OF BUILDING CONSTRUCTION

First of all, this paper aims to:

1) Defines the term "safety factor" and related terms which are used for building construction: bridges, buildings and similar;
2) To connect these terms with the appropriate probability;
3) To examine the situation in terms of applied existing factors and
4) To recommend the shape in order of these factors should be applied in the future.

It should clearly be understood that the terms such as the factor of safety, with no real sense until they are connected with the corresponding probabilities. The properties of the material strength and maximum impact of loads that the structures are exposed, are variable. The correlation Factor of security and factor of usability with probabilities durability and usability for each designed construction is impractical. However, it is practical to observe such a correlation in the creation of laws and regulations for the design. It is highly desirable that these laws and regulations are systematically determine appropriate factors and probability which are incorporated herein. For some cases, the probability having a lot more sense than factors. Engineers should receive:

a) The statistical basis of the relation to the strength of materials and structures, including the weather flow, dynamic load and fatigue;
b) A similar basis in relation to influence of the load;
c) It is necessary competence in the science of probability, which incorporates elements of statistical analysis, which for the engineering profession requires a great effort.

The question: What is "factor of safety"?, leads to many misunderstandings and wrong conclusions but gives two definitions, namely:

- Minimal required factor of safety, by which we ensures that data is not exceeded the probability of fracture structure P_F, is defined as the ratio (greater than unity), the average (arithmetic mean) the estimated strength R_o, according to failure, during the estimated life of a large number of structures designed as identical to the given structure, and the impact of medium load W0, which was used for the design of structures.
- Minimal required factor of usability, by which we ensures that the given probability has not been exceeded and the structure is ready for use during its envisaged service life, which is projected. It is defined as the ratio, but compared to usability instead of the failure.

These definitions are more operating with structure than with its individual parts, it is because it is not necessary that the strength of the structure affect its individual parts. For example, a construction that has excessive elements or connections will be safe and usable if some of the elements be removed or becomes unusable (statically undetermined systems). For the structures which are exposed to a pulsating load, as for instance: bridges, based machines, etc., first instance of the importance is phenomena of fatigue. For the resistance of an element or structure is only mandatory stress caused by fatigue, which is used for assessing the effect of the load, the ratio of the time and load, and the estimated lifetime of the structure, so they prefer to use the term "impact-load" rather than load or loads and time during application. Usually only one guaranteed when choosing much higher probability that a construction become unusable before failur (for example, during an earthquake), and the corresponding factor of usability sometimes is lower than the safety factor.

In these definitions are defined in terms related to the probabilities. If we make the selection of these probabilities can be allocated considering the following:

a) The type of release, whether it will be without prior warning, such as relaxation due to the tightening of materials such as concrete, or will warn the increase in deformation of the imminent danger;
b) The value of human lives that can be lost in the event of demolition;
c) The importance of the structure and its cost, including costs outside the construction itself, occurring during its exploitation;
d) Cost, including interest, maintenance of the construction in terms of usability;
e) Cost of demolition compensation;
f) Cost per construction, equal to the total invested price of demolition multiplied by the probability that it will occur.

Factor of safety and factor of usability can be considered as a "factor of load" by which we multiply the mean computational "load effect" to equalize with the mean calculated resistance. In some cases, this may correspond to be limited by a relatively small deformation that makes the construction unusable, while in other cases it can be almost as large as the marginal resistance. In accordance with each of these cases, as well as interfaces, there are boundary stresses that can not be exceeded. Assuming that suitable "interaction formulas" are permissible for cases such as axial stress bending, we can carry out the calculation and analysis in accordance with the concept of boundary resistance. In the second case, the account can be carried out with regard to deformations that can make the construction useless.

In order to assess the resistance of the structure in the stages of the calculation, we need to have statistical data on the relationship between the existing resistance, the lower point of flow, and the resilience to the fatigue of material similar to that to be used. These data will consist predominantly of the results of a large number of tests and should be in such a form that for each applied material the following sizes and charts can be determined and prepared: maximum and mean resistance, variation coefficient, lowest and highest test values, histogram and cumulative frequency nomogram that show the statistical distribution of test results.

3. CONCLUSION

It is known that we can build construction structures of different degrees of security. The adopted level of security depends on the available financial resources, as with the increase in security, the cost of construction increases. The images show the size of the load and resistance. Particular attention is paid to the degree of security for the breakdown of steel and reinforced concrete, since they are mostly applied in construction practice for significant facilities. The resistance of a construction depends on its lifetime of fatigue, corrosion, rupture (leakage), wear decreases load capacity, but it always has to be a safety factor $\gamma = \frac{S_1}{L_1} > 1$. We can observe the safety factor with factor demolitions as to the form of the formula given in the paper. The paper presents the safety factor from the aspect of construction structures as objects of the future. The term security factor is explained with the corresponding probabilities that constructors should get to include them in the design. Since this term leads to many misunderstandings and wrong conclusions, two broader definition definitions are given. Definitions work more with the construction than with its individual parts. Stress generated by fatigue which is used to estimate the load effects or the designated lifetime of the construction, also uses the term "effect-load" instead of the load and duration. The usability factor and the safety factor are considered in several points. The most important of them is the value of shell life that can be lost in case of demolition.

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