AIRPORTS AND THEIR INFRASTRUCTURE

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VERBAL RELIABILITY OF BUILDING CONSTRUCTIONS

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Abstract

This article is devoted to the consideration of issues of reliability of building constructions in its qualitative terms from the point of view of a philosophical and organizational aspect. The argument of this problematic was carried out not through the prism of mathematical formulas, theorems and proofs, but through a set of verbal rules and their critical discussion. In particular, the basic verbal rules were formulated regarding the role of the design and reliability control services in the creation and testing of reliable structures. The meaning of verbal reliability of building constructions in the structure of the general theory of reliability is highlighted and the main components of this concept are given. Negative factors that have a direct impact on the reliability of constructions are considered, and the need for an independent monitoring and balancing policy regarding scientific and engineering activities related to ensuring the actual level of reliability at all stages of the building or structure life cycle are indicated. The role of the reliability control service as an independent structure is justified, and its responsibilities and functional environment are predetermined. In the study of conceptual problems, examples are given from the experience of designing real constructions of silo tanks for storing grain.

Keywords: theory of reliability; quality criterion; verbal rules; design service; reliability control service; storage capacity

1. Introduction

Historically, the formulation of the reliability problem was determined, first of all, by the technical sciences for characterizing the level of system security during the life cycle (design, manufacturing, operation) [1]. From the point of view of the theory of reliability of building constructions, this concept characterizes the ability of a construction to perform specified functions and to keep in time the values of its performance indicators within the specified limits, throughout the design life. This concept includes such characteristics as reliability, durability, maintainability and storability [1]. For different facilities and operating conditions, the values of these indicators have different significance. The value of the reliability parameter itself, in most cases, is a formal or conditional indicator of the probability of failure, which is used rather as a tool for creating project rules [2 - 4]. In the scientific community there is a whole direction of design for reliability of building constructions, which is essentially an applied mathematical discipline and uses the fundamental principles of probability theory, mathematical statistics and the theory of random functions. Traditionally, in this vein two groups of concepts are considered. The first (“design for reliability”) is associated with the problems of ensuring the design reliability of constructions, and the second - “maintainability” defines a set of operational indicators of durability, maintainability, storability, etc. [1].

At the same time, the theory of reliability is a global scientific discipline, which, like any professional science, is constantly being improved and developed. The formation and execution of modern building constructions are constantly becoming more complex, which entails the

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complication of reliability problems. The solution of these specific problems is based on an extensive methodological and mathematical basis and in fact requires the introduction of an alternative approach based on probabilistic analysis [1, 5]. However, the complexity of the design nature and the specificity of the calculation methods make it very difficult to directly use this approach in design practice. Thus, there is a logical need to create a special reliability control service, whose responsibilities will include checking and ensuring the design reliability of buildings and structures by using suitable design procedures based on a probabilistic approach to the problem, which for the above reasons cannot be assigned to the design service.

2. Analysis of the latest research

Already over a long period of time, the theory of reliability of building constructions is a hot topic for many famous scientists and researchers. The modern interpretation of the concept of reliability of buildings and structures was laid in the works of N.S. Streletskii, A.R. Rzhanitsin, V.V. Bolotin, V. Raizer, V.P. Chirkov, C.A. Cornell, E. Basler, P. Toft-Kristensen, M.I. Baker, O. Ditlevse, A.M. Hasofer, N.C. Lind [6-10].

Modern studies in the field of reliability in construction are presented by the authors J.D. Sorensen, M.H. Faber, J. Ferry Borges, J. Schneider, R. Rackwitz [11-15] as well as the well-known pleiad of Ukrainian scientists A.Y. Barashykov, Ye.V. Horokhov, V.N. Gordieiev, M.I. Kazakevych, A.I. Lantukh-Liashchenko, M.A. Mykytarenko, V.A. Pashynskyi, A.V. Perelmuter, S.F. Pichugin and others [1, 2, 5, 16-20].

3. Forming the aims of the article

In engineering, the informal postulate is widespread that only a quantitative assessment of a quantity, phenomenon, or process can serve as a consistent and “reliable” characteristic of the quantity, phenomenon, or process being evaluated. This article proposes to look at the problem of reliability not through the prism of mathematical formulas, theorems and proofs, but through a set of verbal rules and their critical discussion. Such consideration provides an opportunity to solve a number of conceptual problems that are not related to technical or mathematical aspects.

4. General method of solution of the problem

We formulate the main theses regarding the role of the design and reliability control services in the creation and testing of reliable constructions.

- each created construction is characterized by a finite number of independent parameters that uniquely determine its design reliability;
- the engineering specialist creates the construction of the required level of reliability and is responsible at the design analysis stage for compliance with all parameters characterizing this level of reliability;
- design reliability of the construction can be achieved only in the case of its manufacture and installation in the working position in full compliance with the design documentation. However, it is rarely possible to fully implement design reliability, since the conditions of production, transportation, storage, installation and operation always differ from the design ones. As a result, the actual reliability of the construction is always less than the design one;
- the required level of design reliability of the construction must always take into account the reduced effect of the actual reliability, which is not amenable to rigorous mathematical evaluation;
- to achieve maximum reliability of constructions and structures as a whole, not only the design service should be involved, but also the reliability control service independent from it, which pursues an objective independent policy of control of the actual level of reliability. At the same time, responsibility for the design level of reliability remains with the structural designer;
- within the enterprise and the construction industry as a whole, control over the actual level of reliability should be independent of the benevolent or negative mood of the management. Moreover, the professional skills of services to control the actual level of reliability should not be limited to purely control, but should provoke an increased interest in the organization of research and development work leading to new design concepts.

Obviously, compliance with the above verbal rules is equally important as quantitative characteristics of reliability.

However, what exactly should be attributed to the concepts that form the verbal reliability of constructions. First of all, these are studies that are the basis of the scientific and engineering activities of an enterprise and are associated with the development of a new constructions or new and important methods of constructing existing structures. The following is the engineering activity of the enterprise for the implementation of the research idea, which we will call the development. Development can be successful and did not meet expectations. The first, continues with the design phase, being embodied in a design project or design development, the second is sent for additional refinement or complete oblivion.

At the design stage, the service of maintainability should have the most pragmatic approach to all design solutions, seeking from the design service maximum functional suitability, reliability, manufacturability, timeliness and competitiveness. It is assumed that the design service will apply generally accepted and approved design methods. In cases where constructive tasks cannot be solved by using approved and well-known constructive methods, the designer must apply his own methods, borrowed from other industries or using new modern materials and processes. As applied to grain storage capacities, it is, for example, optimization of the corrugation parameters of the frame sheets to increase the bending characteristics of the sheets while ensuring minimal metal consumption, transition to high-strength steels and shortening the installation time (this direction is the area of research by the authors [21, 22])

It should be noted that the work of designers in nature is creative, so it is often difficult for them to resist the desire to apply something new, despite the fact that there are proven methods that provide specified levels of reliability. Especially when their work is stimulated not only by project, but also by the financial component. It is no secret that among the manufacturers of silos there is a constant desire to further reduce the metal consumption of their products to ensure maximum competitiveness at tender. At the same time, the financial motivation of designers is sometimes so high that they deliberately offer non-working designs with “raw” design documentation without properly conducted research. There is, however, another side to the problem, when the designer from insufficient qualifications or fear of the subject of design, establishes unreasonably high requirements for the designed construction, seeking to increase reliability at the cost of deterioration of processability and increase in metal consumption. Therefore, one of the important responsibilities of the reliability control service is to identify such things and veto them against the wishes of the customer, the designer's fears and the persuasion of the management. The reliability control service must be constantly closely connected with the design service and at various points in time manifest itself as an assistant, as a “voice of conscience” or as an inspection.

In the design of constructions, tradeoff decisions should be developed in relation to various requirements. A designer who does not fully meet the requirements in terms of functional characteristics, development time, cost, technological and other parameters “pays for” this much faster and more clearly than if the reliability requirements are not fully met if there is no strong independent reliability service capable of attracting immediate and effective attention to any deficiencies in constructive measures to ensure reliability. In some exceptional cases, it may be necessary to sacrifice the requirement for reliability in order to obtain the desired functional qualities of the construction, but tradeoff decisions of this kind must be made reasonably, fully aware of the possible consequences. Very few designers would deliberately not want to provide for measures that provide the required reliability of constructions. The danger lies more in an oversight, lack of specialized knowledge and a complacent approach. Let’s consider these questions in more detail.

Inattention. In some cases, the designer ignores any of the countless details that are an integral part of the completed construction. For example, the designer, knowing that in a certain place of the structure the bolts of a higher strength class should be used, does not give any indication of this in the drawing. If this inattention is not detected in time, then there is a high probability that the construction may fail much earlier than the required service life.

Lack of specialized knowledge. No designer can be fully competent in all matters related to his construction. He does what he can, checks what he considers necessary, and calls experts on some highly specialized issues. The designer, for example, can choose the standard solution for a ladder of raising on a silo from an old series on design of tanks. Meanwhile, there are original new developments, with which he did not have time to get acquainted.

Complacent approach. The designer is under pressure for lack of time. He sincerely believes that his construction will satisfy all requirements, including the requirements of reliability. However, for complete confidence, an additional series of calculations is needed, which he either has no time or no desire to carry out. The designer is easily tuned to the fact that in reality there is no particular need for carrying out these calculations. This practice of a complacent approach leads to an explanation of failed calculations when the result contradicts the logic of the construction: “this is just a modeling error”, “real environmental conditions will never be close to these hard conditions of the design scheme", "these minor elements have no special influence on work of facilities in general".

Requirements for reliability increase in cases where the consequences of reliability become dangerous, lead to a great investment of time and money, or threaten national security. In the case of ensuring high reliability, one cannot rely only on good intentions or chance. There must be an independent monitoring and balancing policy for each operation. It is necessary to constantly pay special attention to detail. No organization, no employee can be considered as ideal or omnipotent, so that you can refuse to analyze or study the results of their activities.

At the end, we note that most of the failures that occurred during the operation of the grain storage capacities were not caused by the malfunction of any "exotic" element, a fundamentally new constructive form. On the contrary, many failures were caused by a malfunction of the functional and structural elements of the previously tested construction. Sometimes the elements were made incorrectly, and in other cases there were errors in the work of the manufacturer, installers or service personnel. Examples include improper punching of holes in silo cladding sheets caused by a failure in machine positioning, the occurrence of non-design gaps between adjacent marks of bearing stiffeners of silos due to non-compliance of tolerances at previous stages of work or uneven loading (unloading) of silage capacity during operation. There is no such trifle that would be too insignificant in order not to be a possible cause of failure. High potential and achievable reliability is largely the result of deep and close attention to detail.

5. Conclusions of this study and prospects for further development in this provision

1. The basic verbal rules are formulated regarding the role of the design and reliability control services in the creation and testing of reliable constructions.

2. The meaning of verbal reliability of building constructions in the structure of the general theory of reliability is highlighted and the main components of this concept are argued.

3. Negative factors that have a direct impact on the reliability of constructions, as well as the need for an independent monitoring and balancing policy in relation to scientific and engineering activities related to ensuring the actual level of reliability at all stages of the life cycle of a building or structure are considered.

4. The role of the reliability control service as an independent structure is substantiated. Its responsibilities and functional environment are predetermined.

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Вербальна надійність будівельних конструкцій

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Розглянуті питання проблеми надійності будівельних конструкцій в її якісному вираженні з точки зору філософського і організаційного аспекту. Аргументація даної проблематики здійснювалась не через призму математичних формул, теорем і доказів, а через сукупність вербальних правил і їх критичне обговорення. Зокрема, були сформульовані основні вербальні позиції, щодо ролі конструкторської служби та служби контролю надійності в створенні та апробації надійних конструкцій. Виділено значення вербальної надійності будівельних конструкцій в структурі загальної теорії надійності і наведені основні складові даного поняття. Розглянуто негативні фактори, які мають прямий вплив на надійність конструкцій, а також зазначена необхідність проведення незалежної політики контролю і балансування, щодо наукової та інженерної діяльності, пов'язаної із забезпеченням фактичного рівня надійності на всіх етапах життєвого циклу будівлі або споруди. Обґрунтовано роль служби контролю надійності, як незалежної структури, а також зумовлені її обов'язки і функціональне середовище. При дослідженні концептуальних проблем наводяться приклади з досвіду проектування реальних конструкцій силосних ємностей для зберігання зерна.

Ключові слова: теорія надійності; критерій якості; вербальні правила; конструкторська служба; служба контролю надійності; ємності зберігання

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Вероятностный расчет стенки стальных вертикальных силосов

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Рассмотрены вопросы проблемы надежности строительных конструкций в ее качественном выражении с точки зрения философского и организационного аспекта. Аргументация данной проблематики осуществлялась не через призму математических формул, теорем и доказательств, а через совокупность вербальных правил и их критическое обсуждение. В частности, были сформулированы основные вербальные правила, касательно роли конструкторской службы и службы контроля надёжности в создании и апробации надёжных конструкций. Выделено значение вербальной надежности строительных конструкций в структуре общей теории надежности и приведены основные составляющие данного понятия. Рассмотрены негативные факторы, которые оказывают прямое влияние на надежность конструкций, а также указана необходимость проведения независимой политики контроля и балансирования в отношении научной и инженерной деятельности, связанной с обеспечением фактического уровня надежности на всех этапах жизненного цикла здания или сооружения. Обоснована роль службы контроля надежности, как независимой структуры, а также предопределены ее обязанности и функциональная среда. При исследовании концептуальных проблем приводятся примеры из опыта проектирования реальных конструкций силосных емкостей для хранения зерна.

Ключевые слова: теория надежности; критерий качества; вербальные правила; конструкторская служба; служба контроля надежности; емкости хранения

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