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The Independent Control of Buildings and Structures Breakdowns Risk as a Way of Accidence Reducing

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Abstract

The article analyzes the risks and causes of breakdowns in construction. The procedure of a risk control is based on knowledge of the risk threshold, which mustn't be crossed. Such values are independent of the constructive type of a building and number of stories in it. The expert main working tool in controlling breakdowns risk of designed, constructed or used projects should be automated expert system that provides efficiency, reliability and objectivity of the results at the lowest cost of carrying out expert work.

Keywords: structural assessment, safety, technical condition, constructional project, buildings breakdowns.

1. Introduction

1.1 Facts Affecting the Damaged Buildings and Structures

Russia's experience and lessons learned from the cases of breakdowns of buildings and structures provide two facts which are significant for the safety problems of construction. The first fact is that, in most cases, the script of construction accident is the intersection of at least two negative events. One of them is the fact that a certain set of human errors took place during design, construction and operation of the project that led to an unacceptable value of the risk of an accident; another event is an off-design, natural and climate or manmade, impact on the project, provoked its breakdown. The second fact is that the severity and extent of the damage from an accident caused by an emergency on a given territory depend mainly on the degree of failure of buildings and structures, caught in the disaster area (Melchakov A.P., 2002). While the first fact explains the causes of buildings and structures breakdowns, the latter one gives reason to believe that structural safety is the basic and requiring close attention type of safety of construction projects, as it characterizes the degree of protection against failure of bearing structures in the off-design impact situations. An indicator of such safety is a value of a constructional project breakdown risk (Melchakov A. P., 2009).

Inspection of buildings and structures is carried out in order to:

1. Evaluate the technical condition of the object and the reliability of its structures;

2. Determine the amount of damages due to the breach, poor quality of work performed;

3. Determine compliance of capital investment, design and construction documents, the requirements of SNIP (construction norms and rules), SP (building regulations) to identify and eliminate the cause-effect relationships between actions, the design of the buildings and identified defects.

1.2 The Risk of Accidents

Risk of an accident - a vector quantity, which is adjustable component object risk generated by errors designers, suppliers, builders, inspectors, and others. Unregulated components of accident risk are the probability of beyond design basis external actions on the object, which differ in frequency and manifestations of power. Economic components of the risk of an accident is the cost of ensuring structural safety, accident and loss of benefit of reducing the risk of an accident the object. In many cases, the accident of buildings and structures are the result of the intersection of two independent negative events: events, consisting in an unexpected appearance of beyond design basis external impact, provoking an accident and the events is the fact that during the construction and operation of the facility allowed a certain set of human error, reduce the level of its structural safety. In an accident, an object the size of the damage depends on the magnitude of the internal (object) the risk of an accident. Forecast construction projects accident risk on the basis of the classical probabilistic approach is not possible for two reasons (International Building Code, 2000).

Firstly, the accident of buildings and structures are very rare events, and secondly, the unpredictability of human errors made in the design, construction and operation of the construction site, make a significant uncertainty in the response (behavior) of the carrier frame object to an external stimulus (Iverson J. K. and Hawkins N. M., 1994, pp. 38-55). Because the risk of accident and the degree of uncertainty of a technical condition of the carrier frame objects are closely related concepts, risk assessment of the accident should be based on logic and probabilistic approach, based on theorems of probability theory, methods of fuzzy set theory, fuzzy logic techniques and methods of decision-making under uncertainty. The magnitude of the actual risk of an accident, physical deterioration and secure life of buildings and structures are also interrelated (JCCE, 1997). To determine these quantities must be used the law of distribution of accident risk, which is an integral indicator of the level of structural safety of building object. If such a law is known, then the value of its most representative figure - information entropy can judge the degree of uncertainty of the technical condition of the supporting framework of the object (Korenkova, G.V. et al., 2012). From the change in the growth rate of the entropy can find such values risk of an accident in which the supporting frame building project goes into a qualitatively different state: for example, from a safe in an emergency, and of emergency in the Old-emergency (Kusumo-Rahardjo F. I., 1996).

1.3 Prediction and Evaluation of the Risk of Accidents

Prediction and assessment of risk of accident construction site are carried out on the basis of an expert system, which is a man-machine complex, combining mathematical methods and information technology with the experience, knowledge and intuition of the people who have mastered the profession of "expert". Within the framework of an expert system the main function of the expert is to provide formal information about the technical condition of the supporting framework of the object (Menegotto M., 1994). This feature requires an expert knowledge of methods of analysis of limit states, structural and method of decision-making under uncertainty. An important function of the expert is to assess the accuracy and reliability of the forecast results of accident risk, since the accuracy of the decision on the actual level of structural safety of the object and the value of its residual life has a direct economic impact. (Nakaki S. D., 2000). In a market expert function becomes more and informational support of the customer. For example, the customer, before you invest money in the implementation of technical solutions to reduce the risk of an accident, it is necessary to know how to increase the level of safety and service life of the object belonging to him as a result of the repair activities. In the case of an accident the object to the expert functions are to determine the causes of the accident and the terms of the persons who will bear responsibility for it. This feature requires an expert in-depth knowledge of the laws of jurisprudence (PCI, 1999).

In (Bolotin V.V., 1982) argues that by the end of the facility due to human error the actual probability of failure compared with the theoretical value increases several times. Human errors blur the distribution law of resistance of the object to external influences, which leads to an increase in the probability of an accident as compared with the theoretical value (Buhonova S. M., 2012).

2. Method

Practically from the expert at purpose of level of danger it is necessary to establish degree of structure in one of absolute limit states which include the following:

1) Local brittle fracture in a limited volume or cross-sectional structure.
2) Chrezmernoe deformation of the supporting structure, provoking turning it into plastic hinge.
3) Obschaya or local buckling of the type of deformation load-bearing structure.

Responsible stage diagnostics of technical state of structures bearing structure object is expertise base.

During survey of base it is necessary:

1) To compare data of the soil basis
2) To establish that causes in soil of a decompression and to measure the potential of the damaged layer.
3) To check the level of ground waters, land subsidence, to establish a zone of endurance and to measure moistening depth.
4) To make sampling of the soil for laboratory tests to obtain basic data for calculation base rainfall. The test

determines the soil deformation module density, a corner of internal friction, specific coupling and thickness of a layer.

The knowledge of real risk of accident can be referred to technical conditions of the bearing object framework to one of possible on safety, emergency and shabby (the Ministry of Emergency Situations, 1998).

To determine the actual average value of accident risk experts carried out a visual inspection tool carrier frame object. According to a survey of experts in each member of the supporting frame of the object group of similar designs seek out the most and the least defective design, for which special rules that determine the levels of danger, with their ranks, characterizing the degree of membership of the defective design of one of the absolute limit states (Grace N.F., et al., 1999). When assigning risk levels experts use factual information about the technical condition of defective structures, virtual information on the most dangerous structural defects, their experience, knowledge and engineering intuition. The decision was made experts confirm the calculations and testing of defective structures.

In the technique as a criterion for assessing the technical condition of buildings and structures are used:

- fixed the average values of accident risk, which include the normal risk of an accident, the maximum allowable risk of accidents and limiting the risk of accidents;

- standard levels of reliability groups supporting structures, which include the normal level of reliability and maximum permissible level.

3. Results

Risk and the causes of breakdowns of buildings analysis shows, that:

1. Accidents tend to occur with buildings and structures which haven't gone through a structural survey and assessment;

2. Structures accidents also occur if there is a failure to meet the term date of the next assessment;

3. Breakdowns may occur at any stage of the life cycle of the project;

4. Structural survey and assessment of the safety of buildings and structures must be periodic.

Due to operational occurrence during the period between the regular structural survey and assessment of the safety of buildings and structures, the condition of structures responsible for the carrying capacity of a building may cause a breakdown (Shin H-C., 2000).

All of this is compounded by the general difficulties and disadvantages of the current practices for the safety of buildings and structures, including:

1. Lack of a systematic approach in assessing the safety of buildings;

2. The lack or insufficiency of criteria and methods for determining the ratings of a technical condition of buildings at any time of operation;

3. Complexity and novelty of the technology developed and introduced a comprehensive condition monitoring of structural elements of buildings and structures.

Therefore, an opportunity of controlling the technical condition of buildings and structures in real time is of great importance at present time.

4. Discussion

4.1 Normative Documents Affecting the Safety Design of Buildings and Structures

The most important areas to ensure buildings and structures safety are: normative and technical support for the safe operation of buildings and structures, RTN (Russian Technical Supervision Service) arrangements and managerial and engineering issues of monitoring structures and buildings condition (Semeikin A.Y. & Khomchenko Y.V., 2012, pp. 63-65).

World practice shows that only those documents, which are under development even after their publication ,which are upgraded and re-issued in the coming years by the same group of developers (organizations and specialists), take root and gain a solid status of documents, which must be applied. Thus, GOST and SNIP were developed and republished (every 3-5 years) in Soviet times. Another example is API (the American Petroleum Institute) which has been developing the regulations in the oil and gas industry for more than 80 years. Having status of recommendation, standards issued by the Institute, are actually recognized as a mandatory document in many countries around the world, aided by the position of the world's leading insurance companies (Slabinsky I.A., 2012).

The current domestic codes and standards on industrial safety of buildings and structures mainly concern its technical condition survey and are linked to the structural elements or to industrial buildings. However, the structural survey is only a part of the assessment.

The main objectives of the output of such legal documents are:

1. Improving industrial, environmental and energy safety of industrial buildings and structures, including the flue and vent pipes;

2. Reduction in the administrative burden on small and medium-sized businesses;

3. Staff training and competence of bodies responsible for assessment of safety conformance of the buildings and structures;

4. Ensuring that safety conformance methodical documents used by Rostehnadzor (RTN) are in line with scientific and technological progress;

5. Increasing the responsibility of the owners for the safety of their buildings and structures.

One of the most important issues is the quality of the safety assessment of constructions and structures. In a number of cases, the poor quality of the structure assessment is caused by the following:

1. Incompleteness or lack of design, executive and operational and technical documentation at the enterprise;

2. Extreme depreciation of buildings and structures, which have been paid less attention to than technical devices have;

3. Repair period is delayed, the repair are not done fully, saving for the repair of buildings and structures;

4. Attract of unskilled organizations offering their services at dumping prices, because not the quality but the cost of the structure assessment is considered to be the most important for the developer choosing a contractor for such a work;

5. Review and approval of safety assessment of industrial buildings and structures by the local administrations of RTN, which often do not have highly qualified personnel in the field of construction.

It seems appropriate that only specialists should review and approve safety assessments of buildings and structures, subject to declaration, projects with foreign investments, as well as buildings and structures with structural volume of more than 30,000 square metres.

4.2 Ancillary Analyses

There are a great number of unfair, unprofessional firms that replace highly qualified experts and specialists having and advanced diagnostic equipment at the market due to the dumping services prices which they get thanks to incomplete and poor quality of work. To improve the quality of industrial safety assessment such firms should be eliminated from the market of assessment services.

All this costs a lot of expenses. Currently available licensing and accreditation systems are not sufficient for becoming a barrier in the way of all the unscrupulous companies.

Off-design impact on the constructional project is almost under control. Therefore, first of all it is necessary to minimize the negative impact of human factors on the value of the breakdown risk during the design and construction of buildings and structures so as to reduce the number of accidents in the construction industry. However, building codes do not take into consideration human factor at all. Structural strength reserve, often laid in the design of the building (structure), does not compensate for it either. Therefore, tough and independent control of breakdown risk value in the process of design and construction of projects, and at the phase of their operation is the only but highly effective way of accidence reducing .These measures should be taken to the constructional projects which are rather complex in the engineering sense and are usually operated in mass gathering conditions (Wood S. L., et al., 2000, pp. 50-64). Control functions should be conducted by trained experts who are able to assign the maximum allowable risk of a breakdown for projects under construction. An expert can check the value of accident risk at the design and construction phases, as well as determine the current accident risk of existing sites and taking into account this risk assess their residual life.

It should be noted that the concept of breakdown risk includes not only a threat of the emergency failure of the structure due to the loss of stability of its load-bearing structures, but also the collapse severity level. In other words, accident risk combines both the probability of occurrence of the breakdown and the amount of the associated losses. This concept of risk is actualized, if the accident risk value is taken as a ratio of the actual probability of an accident to its theoretical value specified by the design standards and laid in the building or structure design by the default. In this case, the actual probability of the project failure is always higher than the theoretical probability as the complete elimination of defects in the implementation of investment construction project is virtually impossible. Put that way, the accident risk value can be determined.

It is known that design safety and design reliability are interrelated quantities. The design reliability of the project means its supporting structures ability to resist failure (strength), to maintain the shape when there are external forces on it (stiffness), returning to its original configuration when the external forces disappear (stability). So, to assess the accident risk, the expert should examine the physical state of load-bearing structures of the building, and then to assess its design reliability.

4.3 Automation Expert System

Accident risk control procedure of constructional project is based on knowledge of the thresholds of accident risk, which cannot cross. Such values are independent of the constructive type of a building and number of stories in it. For example, a reasonable design and construction accident risk limiting during a building process is the value of the natural risk of an accident on an unbounded set of new buildings and structures, as the people take the natural risk in stride. The critical risk of an accident for operating buildings and structures is a threshold value. After its attaining building safety is exhausted, and the project begins a gradual transition to the emergency state. Although the operation capacity of the project in an emergency condition still exists, it has almost no off-design impacts resistance and their sudden appearance may lead to a breakdown of the project. There is also a risk limit value at which the constructional project is considered to be a ramshackle building, and even if it continues to operate, the date of accident occurrence is already known.

The expert main working tool in controlling accident risk of the projects which are being designed, constructed or projects used, should be automated expert system that provides efficiency, reliability and objectivity of the results at the lowest cost to carry out expert work. Automated expert system is a man-machine complex that combines mathematical methods and information technologies with the experience, knowledge and engineering intuition of people who have mastered the profession of expert. Its main elements are the database and knowledge base.

The database includes a variety of information: general information about the project, knowledge of the participants of its construction, the structure information, geological characteristics of the site and information about the loads. Database must contain a list of common errors that can be admitted by participants in the process of making a design, constructing and operating of the project.

The knowledge base of an expert system consists of two independent units. The first is a block of expert information formalization and danger level determination for the design and construction errors detected by the expert. The function of the second block is to calculate the accident risk of a project and its safe-life. It contains a set of algorithms that allow to find the index of structural reliability of the project by using formalized expert information; this indicator helps to determine the value of accident risk and safe- life of the project, and a comparison of the actual accident risk with thresholds gives an opportunity to assess the technical condition of the project as safe, emergency or ramshackle.

Bearing structures "tree" is a mechanism for the proper transfer of the user's response and representing of different comments to the conformance and an explanation of its reasons. It can also serve as a control mechanism in the inspection of building or structure, diagnosis and assessment of the technical condition of the project. The "tree" gives the involved organizations an opportunity to get any information in the real-time relating to the quality of execution of certain types of survey, design, construction and installation works, including specific information about the contractor, the date of execution and the safety level of the final construction product. This information allows identifying "perpetrators" of unacceptable accident risk and gives the opportunity to introduce some mechanisms of personal responsibility, which are based on the financial and legal principles and insurance approaches.

5. Conclusion

In construction practice of developed countries, the risk-management works due to expert surveyor's institute. Surveyor is an agent of the insurer, carried out the inspection of the property to be insured, i.e. the same construction expert, but with in-depth knowledge of risk theory and the law. Thanks to the Institute of expert surveyors, there is an accident risk insurance which is the best way to control the risk. Unfortunately, such a scheme of insurance in the construction has not developed in our country yet due to the lack of specialists of risk management. So the training of expert surveyors is the most important task of the problem of preventing accidents in the construction industry. Self-regulatory organizations of designers and builders need such experts mainly for the procedures of controlling accident risk in the design and construction. They will also be in demand with insurance companies, for example, to insure construction projects against an accident. Such measures will help to change the situations for the better and stop the process of "our" money going to foreign insurance companies. Besides, it will make it possible to solve a more important problem which is accidence reducing in construction.

In my future researches the attention to complex inspection of technical condition of buildings and constructions, receiving a quantitative assessment of the actual indicators of quality of a design taking into account the changes happening in time for establishment of structure and amount of works on capital repairs or reconstruction will be paid.

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