The economic and technological efciency of building producton in view of contemporary industrial building materials

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Abstract. Efficiency of construction production, economic category, expressing the achievement of construction and installation organizations the greatest result of production while minimizing the cost of material and labor resources. This publication examines the possibility of improving the efficiency of construction production through the use of innovative building materials and methods of their application. The methodological problem of the use of building materials, their choice depending on the long-term economic prospects. The questions of risk and uncertainty in the selection of effective building materials are considered.

1 Introduction

When planning, design, erection, servicing, and repair of completed structures, the requirements for building materials may often be quite controversial.

Such requirements may be satisfied depending on their composition and the technology the materials were produced with, and also on their resistance to exposure. The art of a civil engineer is to match the requirements to the object and the possibilities of building materials at minimal construction costs.

When objects under construction were relatively simple and the spectrum of building materials limited, it was relatively easy for the engineer to choose the right option. Then, their intuition and experiences were the only factors for making final decisions.

Nowadays, the complexity of objects under construction and the abundance of construction materials makes the engineer resort to science. Also, to achieve the desired, the civil engineer should be well aware of the basic principles of behavior of building materials. It is the only opportunity of the engineer to be aware of the continuous and fast-growing progress in the technology of building materials. The wall panel technology may serve as a good example of solving some most complex problems in the spectrum of construction materials that the modern engineer should face. Some of the key characteristics of such panels are the mechanical, thermal and soundproof features, esthetic appearance, and also the resistance to environment throughout the designed lifetime.

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There're certain relationships among these parameters depending on at which stage of design, calculations, construction, servicing and repair the engineer should make their choice. For example, mechanical characteristics at each stage may be influenced by the following:

a) choosing bay dimensions at design;
b) making design decisions about load distribution along the panel;
c) quality control during erection;
d) control over the actual environmental conditions during erection;
e) preventive and planned repairs.

Moreover, while controlling the building material characteristics, their mechanical properties are controlled by considering their type and composition, production and technology, response to the environment during the planned lifetime[1,2].

2 Goal, tasks, methods of study

The front-end engineering and construction of buildings which have direct and indirect impact on the environment, as well as during operation, abandonment and suspension of the building must be followed by the meeting of environment safety requirements, the nature protection activities development, rational use and the reproduction of natural resources, the improvement of the environment.

Nowadays the limitation of air pollution emissions from construction operations is regulated by a number of normative documents, but civil designers, unfortunately, do not always meet the regulation of emissions in full obedience in the construction operating for a number of reasons. For example, different operations can be carried out at different times; the technique cannot work simultaneously. The correct environmental impact assessment from construction is possible, taking into account the sequence and simultaneity of the operations. It is especially important for the construction taken place on the territory of cities.

The construction site works are carried out in two stages - pre-construction and main construction period.

There are 4 stages of the main construction period:

1. The substructure construction;
2. The superstructure construction;
3. The road construction works;
4. The landscaping and site finishing.

Two cases of air pollution emissions in Rostov-on-Don are considered during the landscaping works of the construction site. The first case is the air pollution of the 20-storeyed residential house construction site in Malinowski Street, 3 in close proximity to the busy highway and the second case is the 25-story apartment construction site in Magnitogorskaya Street 1, located near the owner-occupied dwellings area. The results of air pollution concentration are calculated in accordance with standard methods[12-14].

Figure 1 show the air contaminants emission rate diagrams at the landscaping and site finishing stage of both considered construction sites.

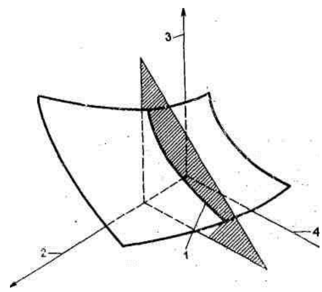

Fig.1. Diagram of pollutant emissions into the atmosphere at the stage of landscaping and finishing of both construction sites under consideration
1- servicing properties; 2-functionality; 3 - reliability; 4 - restorability

To boost the progress in building technology it should be useful to resort to achievements in space and defense spheres industries. Because space industry had to develop and urgently introduce some most complex systems, it became necessary to create a few highly-sophisticated methodological systems. Such a wide-rage approach included: target determination (task setting), wide optional analysis, choice of a most optimal variant, problem solving and evaluation of results. Being highly multifaceted and complicated, construction industry might also use this approach for better decision making. Some data obtained while solving space problems, may be easily applied to construction industry[15,17].

3 Results and discussion

In construction industry, there prevail two different points of view from the point of view of methodologies: the system approach to problem solution and construction systems. The term "system" is used in the classical meaning of the word, i.e. applying new methods to solving problems about the new methods of system analysis, model-based research in the period of servicing[18-20].

Setting targets is performed rather in terms of desired servicing parameters than about a particular technology or model that already exist. Special care is given to the bounds inside a system in question in order to specify the effect of available options on other relating solutions. Models are used to check alternatives. In turn, the term "construction system" means using norms, labor force, and energy for the desired ends.

The parameters of matching all of the components in the object constructed are determined. Then specific contractors are contracted to produce some separate components or sub-components to match the specifications. A specialized technical and legal team coordinates purchasing of reliable subsystems, checks their compatibility, accumulates a sufficiently large fund for attracting contractors at competitive costs. As an example of applying "construction systems", we could mention the development of the structural systems for high-rise buildings with the UNIAS system.

Determining the targets of an object under construction should include some newer servicing criteria that bear in mind the consumer's interests. To develop some possible approaches here it is necessary to express them quantitatively and keep the following factors in view:

- functionality, i.e. a measure based on the customer's evaluation (how well a properly constructed object performs its designed functions);

• reliability, meaning the chances that the functionality of the object under construction would not be lower than the permissible one throughout the whole operational period;

• restorability is described by the measures taken to support functionality at the required level as well as by the ability to restore the previous level in cases of functionality drops.

By attributing a functional form to the above characteristics, the designer may set up some optimal relations and also use some analytical means to evaluate alternative solutions.

Regarding building materials, serviceability should be determined by considering the properties that satisfy the needs of the completed object. For example, the term " serviceability" from the angle of structural concrete should span its mechanical and thermal insulation properties, and also shrinkage characteristics.

The "reliability" of materials is determined by how well the final product would correspond to the desired serviceability and how accurately one may predict any possible changes in the serviceability in time. Such "probabilities" are influenced by the rate of quality control as well as the factors of ignorance accepted at the state of design.

Since the objects, for which repairs are not initially provided, are quite rarely feasible economy- or technologywise, some specific expenses for repair works should be envisaged.

Therefore, the term "restorability" covers the estimate of optimal relations between the initial cost and the cost of repair. Moreover, it is critical to make use of random models to set up optimal relations between preventive and planned repairs.

Analytical models have been developed and practically introduced in space and defense industries for the purposes of setting up the relations among "functionality", "reliability", and "restorability". Some initial uses of this approach have already been made in construction industry. As an example, there is a current growing interest in quality control of objects under construction.

4 Development of the science of building materials

Before, when the process of developing new materials and improving old ones was quite slow, there was enough time both to watch how materials behaved during operation and to solve whatever problems of their quality and applicability. Now, however, the coming of new materials and improvements on existing ones is going on at a faster rate. This makes the engineer to decide about the choice of proper materials lacking any traditional data obtained through field tests in the real-life environment. To optimize decision making in view of the fast-growing system of building materials, the engineer must have enough fundamental knowledge of their behavior.

This knowledge enables the engineer to critically estimate new and improved materials basing on the limited amount of data or field-test experience results. For instance, high-strength low alloy steels with higher corrosion behavior have been developed in large quantities in a relatively short time. Consequently, the research in the process of forming a natural surface oxide film that has good adhesion to the metal enables the design engineer to make the right choice of materials without waiting for the results of perennial field tests. In the last few decades, a great amount of effort has been made trying to understand the mechanism that connects the properties of materials to their contents and microstructure. These key dependencies have been established at a few levels, starting with the atomic-level structure and, via the microstructure, to the microscopic-level structure. Like, at the atomic-level structure, the interatomic bonds and the positions of atoms, in particular where their normal position is dislocated, influence such properties as the modulus of elasticity, strength, and plasticity. The material engineer may change the properties of a certain material or may control them at the macrolevel by influencing at the level of microstructure. For instance, the yield point of construction steel is accurately controlled by applying age hardening, while resulting from fast tempering there comes a microstructure that brakes dislocation. Being aware of micromechanics, the designer knows that this way you may gain in strength but lose in plasticity. Therefore, the engineer may use this knowledge when making optimal decisions about choosing materials.

With the above ideas growing in popularity, there have come new directions of developing materials, and the design engineer has obtained a better freedom in determining the desired parameters of the building materials they use.

These new directions are shaped as follows: improving the properties of existing materials and creating absolutely new ones. As a good example of improving an existing materials, we may view the latest achievements in applying the portland cement concrete. Portland cements were originally developed considering their mechanical properties, looks, and rate of setting. In the market there are additives that may add or improve wear resistance, workability, and strength. Some latest improvements here include regulating the volume mass, creation of autostressing concrete, new techniques of laying the dry concrete mix.

New materials may be developed either to the requirements of contractors or for commercial application. Synthetic high-molecular polymers, alias plastics, may serve as an example of developing new materials in each of these two directions. Foam plastics are designed for highways and airports. They protect the surfaces from frost by blocking the capillary suction of ground water. Polyvinylchloride has been widely used for pipelines, thus making even a vaster market for this existing material.

Composites is another exciting approach in the field of developing new materials. Two or more materials are joined to produce sandwich panels, sheet or matrix systems, thus giving birth to a new material with the properties different from those of any of its components but jointly inheriting some separate properties of each of them. With appropriate design, we obtain composites with a variety of desired properties. As a rule, such materials as laminated plywood, fiberglass, and sandwich panels are only used in places where traditional monolith materials are too expensive to use. We may expect even a wider application of composites, since they may optimally satisfy any customers' demands in different properties.

5 Summary

The joint application of the method of system analysis and material sciences empowers the engineer with the optimal approach to solving their problems; this may bring about a creation of even more efficient and sophisticated engineering structures. The method of efficiency system analysis has been used for a few construction processes for some time. Material sciences facilitate a more detailed study of the existing construction materials and their control. This has already brought about a few most valuable innovations in the field of building materials.

In view of the above, with all the complexity and variety of contemporary building materials, the only way for the engineer, who wants to match the needs of constructions and the available opportunities at minimal costs, is to jointly apply system analysis and material sciences.

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