CONCEPTUAL CONSIDERATIONS ON THE PERFORMANCE AND ENERGY EFFICIENCY OF BUILDINGS

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Lately, discussions about the quality of construction have been brought to a higher level, by using the concept of performance. The performance consists in an overall assessment of a series of indicators, which may define the functional and economic efficiency of a construction based on all the factors that take part in the design, execution, use and after-use of the latter.

All the definitions of the performance concept highlight a fundamental element: this type of approach is underlined not by ***"what a product represents"***, but ***"what it should offer, independently of the chosen solutions"***.

A more typical approach, through the prism of sustainable development, is underlined by "***what it should offer, independently of the solutions chosen and with maximal energy efficiency".***

The performance concept aims primarily at establishing the performance requirements for the constructions and components thereof, with a view to satisfying users' requirements throughout the entire lifecycle of the constructions, in line with the social and economic requirements.

The performance concept is based on a "*systemic approach*" of the entire process of design, execution, use and after-use of constructions, independently of the material assets and the solutions used, taking into account the users' activities and needs and focusing particularly on the behavior of constructions during their use.

Basically, the performance approach means thorough analysis and scientific methods in conducting operational research and in executing a construction and the components thereof, according to users' requirements. The quality of a construction may be assessed based on the extent to which such requirements are met when the building is commissioned. Certainly, such assessment may not be conclusive or unique, since it depends on social, economic and technical factors, which change over time.

Setting requirements is a fundamental need for the construction activity, without which it will not possible to have a proper designed, to improve some elements or to assess the obtained results. The list of performance requirements, the criteria and the information levels, materialized in technical specifications, serve for the design and execution, thus ensuring an appropriate quality level of constructions.

Within the current conditions, any element or construction may be design and executed in several versions, of which the best should be selected based on objective analyses, not on subjective or incomplete appreciations. This is a concern of the professionals in the field, who try to define methods based on the performance concept and the value analysis.

The performance is a technical and economic concept defining a process in a systemic approach, based on the needs and operation.

Specialized books offer various definitions for the performance:

- ✓ ***the performance of a product is a quantitative expression of its behavior within operation, in relation to its use;***
- ✓ ***performance expresses the actual value of a measurement that serves as a criteria, obtained after having tested a technical solution.***

A simple method of assessment of the quality of a building using the performance concept comprises two elements:

- the share of each performance requirement in the quality of the analyzed unit (i.e. building element, entire building);
- the extent to which the performance requirement was met in the case of the proposed solution.

The procedure is the following:

a) The fulfillment of performance requirements set in the technical specifications is established through performance assessment. Thus, the quality indicator in construction is p_i represents the quotient of the value of the required performance level *I* and the actually achieved value, based on the project solution. The value of $p_i = 1.00$ means that the respective requirement has been fulfilled. If p_i is above this value (1.00), it means the required performance level has been exceeded; if p_i is under the value of 1.00, the required level of performance has not been met.

By accepting this relatively simple method of assessing the quality of a project, one should know that the quality is not always proportional to the p_i ratio; it actually varies according to more complex rules. Several examples on this are shown below:

- The expansion of the thermal insulation capacity of an exterior closure element (i.e. exterior wall, roof) increases the comfort level and reduces energy consumption for heating. However, for specific values exceeding some levels of the thermal insulation capacity, the effect is slower, as there are other elements through which heat gets lost (i.e. the exterior carpentry).
- The expansion of the acoustic insulation capacity increases the level of comfort in dwellings. However, at a specific level of noise reduction, anxiety sensations might appear, due to the loss of the auditory contact with the environment. In such situation, a person may hear sounds of his/her own body (i.e. heartbeats), which engenders an atmosphere of worry, which is hard to bear, in addition, it is hard to detect certain dangerous situations (i.e. fire) and therefore the dwellers need to be altered, etc. Thus, a positive effect may turn into a negative one.

Therefore, it is not simple to establish the p_i values; this requires additional regulations.

b) In order to express the share of each performance requirement, the coefficient α_i is used, to suggest that certain performances are more important than others. Obviously, all coefficients are below 1.00 and

$$\Sigma\alpha_i = 1{,}00 \qquad (1)$$

c) The overall assessment of the project is done based on the following ratio:

$$N = \Sigma\ \alpha_i\ *\ p_i \qquad (2)$$

where *N* is the grade obtained within a design competition.

The performance of a construction is characterised by the quality of the project. The initial performance level of a construction is closely related to its behaviour in time.

Among all civil constructions, residential buildings have the main role, as they are the most important assets built by people and have the longest term of use.

The function of civil constructions is to create a comfortable climate inside, regardless of the season. Therefore, the elements forming the building envelope have to be conceived in such a way as to ensure the corresponding conditions of *hygrothermal, acoustic, visual and light, and olfactory-respiratory comfort*. Comfort means creating an environment proper for a normal living.

Hygrothermal comfort means a level of temperature and humidity which are easy to support. This is achieved through energy consumption for heating the space (in winter) or for cooling it (in summer). Therefore, hygrothermal comfort of is directly linked to the energy efficiency of a building, in the sense that the goal usually to attain highest comfort with minimal energy consumption.

A building represents an ensemble of rooms, circulation areas and other common spaces, delimited by a series of surfaces that form the building envelope, through which heating is lost in most part.

A global approach to the building envelope is the key to a well-performing thermal insulation. For an efficient insulation of the envelope, all the components thereof have to be taken into account. However, in practice this is not so simple, since the components have to meet many diverse requirements (i.e. transparency, mobility, mechanic characteristics, etc.)

The control of the heat flow through the envelope is carried out using a thermal material, which insulates the building envelope in order to reduce the heat loss towards the outside. The still air is a good thermal conductor; therefore, it represents a relatively good insulator. However, in large spaces, such as the wall cavities, heat may still be lost through convection and radiation. The role of insulation is to divide the amount of air in sufficiently small parts as to hinder the formation of convection currents, while the air remains static. At the same time, the insulation material reduces the radiation from one surface to another of the air compartment.

Years ago, when insulation was extremely limited, the measurement of the efficiency of an insulation layer was its thickness. Nowadays insulations are chosen based on their *thermal resistance*, a feature that is defined as follows: (3):

$$Rt = \Delta T/Q \qquad [K/W], \qquad (3)$$

analogically to the electrical resistance of a conductor (4)

$$Re = \Delta V/i \qquad [V/A], \qquad (4)$$

The higher the thermal resistance, the lower the heat flows through the material. Insulation materials may have different thickness but if their thermal resistance is the same, they will be able to control heat loss equally.

A thermal insulation is efficient if it is installed properly in all the elements of the building envelope. Although the *installation technology* is relatively complex and depends on the place, I would like to make the following general recommendations:

❖ The insulation should cover the space entirely and uniformly. Any uncovered portions or corners allow convective heat transfers, which may totally destroy the insulation.

❖ Thermal bridges should be avoided wherever possible. As the name suggests, a thermal bridge is a portion of envelope with a lower thermal resistance, allowing heat to flow through that portion (for instance, a beam in the wall). When thermal insulation is applied over one of the thermal bridge's faces, it acts as a barrier by blocking the heat flow.

❖ The insulation should have a thickness allowed by the size of the space and when it consists of a soft and porous material, it should have a proper density in order to create the necessary thermal resistance.

The dimensions of the thermal insulation should be selected based on several factors:

✓ The standards of thermal rehabilitation of buildings should include specifications of the thickness of insulation to be added.

✓ The condition and thickness of the existing insulation impose the thickness and type of insulation to be added.

✓ The way of construction of the building, determines the thickness of the insulation layer, which should be necessarily established based on correct thermo-technical calculations.

✓ The conduct of other rehabilitation works may allow re-insulating the building at a higher level.

The abovementioned issues and solutions highlight the need to approach the building as an entire system, particularly when renovation and rehabilitation works are planned. A particular attention should be paid to the balance between the air flow and humidity flow, as well as to the effects of various interventions on the heating and the ventilation systems.

The energy efficiency of buildings is a major priority, given the poor quality of most of the existing buildings, both old and new but cheap. On the other hand, the costs for the thermal rehabilitation of a building are lower than the costs for securing additional quantities of energy for heating. In Moldova, the energy consumption for the population accounts for 46.8% of the total energy consumption of the country; this share is valid for almost all countries in the world.

The concept of sustainable development through energy efficiency includes minimizing the costs for use and maintenance and maximizing the economic profit so that "the needs of the present could be met without compromising the ability of future generations to meet their own needs."

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