EVALUATION OF DESIGN

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Up-to-date design methods may yield several, nearly equivalent plans. Obviously, the choice between them cannot be left entirely to commonsense: right selection supposes the development of an unambiguously exact method.

Surveying the Hungarian and foreign industrial practice or even the public life the terms "economical" or "optimal" are often encountered in connection with technical solutions, with the operation of equipment or with investments. But these terms of economy are often used in relation to the planning and construction of buildings and structures as well.

Let us see here, what do these concepts mean for the designing engineer, rather than for the economist, and how they fit into the design process. For this purpose the entire design process has to be analyzed in detail. Even to sketch the course of this process requires the synthesis of the essentials of design: professional skill, reasonableness, lack of subjectivity. These elements must be expounded so that their peculiarities could be adapted by scientific design means. As a first statement, differences between architectural, engineering or even industrial design will be disregarded.

This consideration is based on the independence of the logic of design as a process of the kind of design itself. As a second statement, the evaluation of design cannot be deduced from the data of the designed object, the aim of the exposed method being to develop the best plan, to construct the best building. Thus, the best of the possible solutions has to be selected in the design stage, depending, in turn, on the availability of a scientific method. This method may be a decisive proof of the suggestion that purposeful design can produce a better building than the so-called intuitive planning.

The act of designing

Man generally appreciates his surrounding conditions. The classification given may vary from time to time, depending on both the features and the social position of the subject. If he realizes that his conditions are considerably inferior to his expectations, he will proceed to a change. The measures he will take aim at approaching his desires.

As for the model of design the expectation is reflected by a system of requirements. The aim is to satisfy these demands as much as possible. The activity displayed to attain this aim is designing.

Evaluation of the result of the designing process

The problem is essentially to what extent the design as result of the designing process satisfies the system of — often contradictory — requirements, i.e. the demands of man for better conditions of life.

The method to be adopted for this evaluation should be based on the purport of the above question, so a means for numerically measuring the efficiency has to be found.

The first step is to establish a limit between acceptable and inacceptable. Actually, there is no method available to allow numerical characterization, evaluation of a design. On the other hand, in case of building constructions, this method is not fit for the simultaneous evaluation of how the great many different requirements are met.

It has been mentioned above that the quality of a plan or a building depends on the degree of how it satisfies requirements. The different requirements are, however, not equally important: some of them are indispensable, while others are only regarded as more or less desirable qualities. It seems to be clear that the efficiency can be appreciated as weighted percentage. The question is how quality can be measured.

In order to evaluate the outcome of satisfying the system of requirements, it is necessary to know how to satisfy each of them. The demands to a design of a building, an element etc. — e.g. strength, thermal, economical, aesthetic conditions — are of different character.

Evaluation is facilitated by a system of co-ordinates (Fig. 1) representing the efficiency K as a function of the intensity t of the feature $K(t)$.

$K(t)$ is understood as meeting the following conditions (Fig. 2):

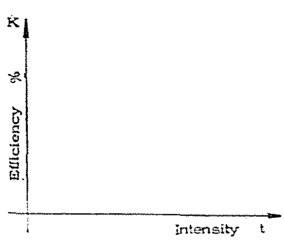

Fig. 1

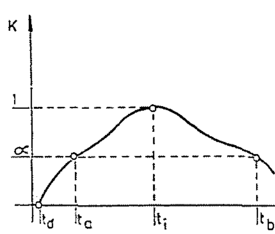

Fig. 2

1. be $0 \leqq K(t) \leqq 1$ ... $t \geqq 0$ continuous;
2. be $0 \leqq I \leqq 1$ ... arbitrary but fixed, of a value dependent on the economy standard of society,

in this case the bulk

$I = \{t \mid K(t) \geqq \alpha\}$ defines an interval.

Critical points of function $K(t)$ are defined as:

3. t_i — ideal intensity of the feature, i.e. $K(t) = 1$
4. t_a — minimum intensity of the feature at a level
5. t_b — maximum intensity of the feature at a level
6. t_0 — absolute inadmissibility $K(t)_0 = 0$

These definitions make the inequality:

$$t^0 \leqq t_r \leqq t_i \leqq t_j$$

self-intended.

Determination of critical values and functional relationships of the design requirements for buildings or building structures permits to distinguish between the following types:

For the majority of requirements a linear relationship exists between intensity and efficiency of the feature (Fig. 3). This applies, e.g. to the requirement of façade cladding, as a thicker layer of a given material will obviously better comply with the requirement of shock resistance.

The same is true for the requirement of thermal insulation, since a thicker layer of a given heat-insulating material will give a better thermal protection.

In these examples the α value is standardized, a so-called threshold value. The function and its diagram yielding also the critical points are seen in Fig. 3.

For certain requirements, efficiency and intensity of the feature are exponentially related (Fig. 4). Such are general requirements for the structural design, e.g. the airtightness of joints. By improving both materials and technol-

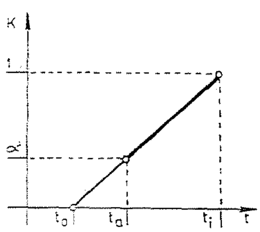

Fig. 3

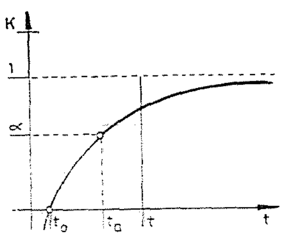

Fig. 4

ogy, airtightness can be increased, but never to perfection. Also in these cases there is a fixed threshold value α depending, however, on the available choice of materials and technologies. The function and its curve yielding the critical points are represented in Fig. 4.

Some of the design requirements for external walls, such as economy, illumination intensity etc., have functions with extreme values (Fig. 5).

The same phenomenon is encountered in the complex examination of two requirements as well (e.g. heat insulation and heating). In this case the determination of the α value is subject to different considerations: e.g. the requirement of lighting involves the standard threshold value, that of economy is based on the economic possibilities of the society or possibly, on a value approaching the optimum point inside the so-called optimum zone. The function and its curve yielding the critical points are seen in Fig. 5.

There are, essentially, three ways of determining the function of efficiency.

In some of the cases the relationship is self-intended (e.g. linear). Another possibility is by statistical analysis of efficiency (working hypothesis).

The third method — adopted largely in the field of sociological analysis — is based on theoretical considerations. The following example may allow the complex examination of several correlated requirements. The hypothesis is the following: The rate of meeting the requirements is proportional to the degree of dissatisfaction (Fig. 6):

$$K(t) = \gamma(1 - K) .$$

Availability of a method of examining the complex requirements related to different goals — even if each requirement is met at a different degree — permits to establish a practical method for evaluating the design of a building or a structure. Certain kinds of quality requirements for the building — functional or aesthetic — are inaccessible to numerical evaluation. The question is whether the requirements described more or less exactly and those suiting subjective estimation alone are comparable at all. Although there are certain — mostly sociological — methods to examine the preferences of populations or communities, and the evaluation by these mathematical methods, the

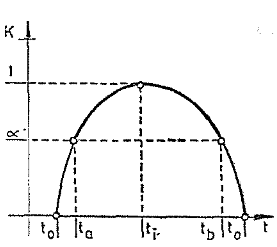

Fig. 5

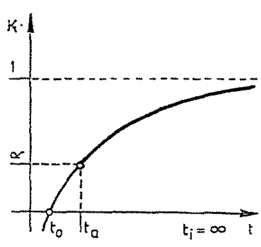

Fig. 6

"sequence" may be confronted with the former one, it would be premature to suggest their application.

In engineering practice, actually different economy indices are applied to rate buildings, but they offer a rough estimation of the engineering quality of the different constructions, although this economy rating completed by technical evaluation may be expedient.

Summary

Architectural planning, and in general, design raises the question to what degree design data and requirements are met by the building in the design stage. Possibility of objectively answering this paramount question is examined. Means to satisfy design data, specifications are analyzed and a mathematical evaluation method established.

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