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The choice of variant technologies and materials supported by multicriteria methods and an assessment of variants with graphic profiles of criteria*

Elżbieta Szafranko[a]*

[a]*University of Warmia and Mazury in Olsztyn, Faculty of Geodesy, Geospatial and Civil Engineering, Institute of Building Engineering, ul.Heweliusza 4, 10-724 Olsztyn, Poland*

Abstract

On many occasions, while executing construction projects, we must solve dilemmas regarding the use of specific technologies and materials. Depending on the purpose and future functions of a building, as well as expectations of its occupants and users, different solutions might prove to be superior. Numerous factors influence the final decision, hence effective tools which support the decision-making process are needed. When many parameters must be taken into consideration, multi-criteria analysis methods appear to be the best choice.

Having analyzed many such cases, the author has developed her own approach, which includes a graphic template corresponding to the importance of criteria assigned to a planned building project, to which profiles of the variants submitted to an assessment are compared. The discussed case is the roof structure over a machine shop, in which – due to the intended production – harsh ambient conditions are expected. An analysis was made to evaluate three variants of the roof cover, i.e. based on timber, steel or prestressed ferroconcrete girders.

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Keywords: building materials, variants of a development project, multi-criteria methods, graphic method

* Corresponding author. Tel.: +48600964682.

E-mail address: elasz@uwm.edu.pl

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1. Introduction

For making an assessment of a building project, it is crucial to prepare and analyze several variants of its execution. These variants are reviewed with respect to technical and technological possibilities, economic aspects, conditions in which a planned structure will function and other project- or site-specific circumstances. While developing a plan of a new building, it is necessary to take into account the relevant standards and directives, regulations governing technical aspects of the building craft, work safety and hygiene, fire protection, and many other norms, regulations, technical approvals, technical documentation, administrative decisions, etc. All structural elements of buildings must be designed in compliance with the above regulations. The total costs of a building enterprise are composed of the site-specific costs of the construction, costs of transport, costs of hiring qualified employees and specialist equipment and others. The future maintenance expenses, on the other hand, can be affected by the necessary conservation works [1].

Making a decision about the shape of a construction project in such a complicated situation calls for an efficient decision-making support method, which will take into account all significant aspects and, on the other hand, which will allow the analyst to identify the variant that will ensure the best fulfillment of all important criteria. A great number of available methods and techniques serving for analysis of variant solutions make it difficult to choose the one that will guarantee the expected effect. When selecting a decision-making support method, one should pay attention to such features as the method's readability, quality and ability to provide verifiable results as well as the mathematical apparatus involved. Subjectivity of an assessment is another aspect that should be considered because many of the broadly used methods are based on opinions provided by experts and persons engaged in the performance of a given project. Hence, their assessment and the final evaluation can be burdened by some error, which should be kept in mind. Subjectivity is most often encountered in methods which deal with non-measurable quality factors [2].

2. Methodology of computational methods

An analysis of criteria carried out in order to evaluate variant solutions includes events and processes of diverse nature. They can belong to so-called measurable factors, the assessment of which according to a given criterion is quite obvious. In turn, two approaches can be taken to obtain an objective evaluation of non-measurable factors. One is a descriptive method, while the other one requires a numerical measurement scale. The two approaches can be included in any of a number of multi-criteria methods, e.g. MCE analysis, AHP, Indicator Methods. It is, however, difficult to determine to what extent the final outcome is laden with error. One can only assume that the final results are acceptable approximations, but they still need additional interpretation before a rational decision can be made. Each of the mentioned methods has unique characteristics, which have an impact on the final result [3, 4].

Let us see how computational methods are applied in practice, taking the simplest one, such as the MCE Analysis, as an example. The foundation for the MCE method is to determine weights and to assess the importance of criteria as well as the degree to which they said criteria are satisfied by subsequent variants of the project. These assessments are made based on field interviews as well as surveys completed by experts and persons engaged in the planning of a given project. Surveys must be designed in a way that allows one to order data and to determine a scale for the evaluated criteria [1, 2]. The MCE (Multi-Criterial Evaluation) analysis is applied to support a decision-making process when the number of analyzed criteria ranges from a few to over a dozen. The first step in any analysis is to define criteria which will lead to the achievement of the aim. The criteria occurring in the MCE analysis can be divided into two groups: hard criteria (so-called constraints, barriers, obstacles) and soft criteria (parameters, factors) [3, 5]. First, variants that do not fulfill the principal requirements (constraints) are discarded from our analysis, which therefore deals only with the criteria identified as having the character of factors. The suitability of the analyzed variants [2, 6] is derived from the following (1) formula:

$$S = \sum_{i=1}^{n} w_i x_i \tag{1}$$

where: S – suitability, w – weight of a criterion, x – value of a parameter, i – a criterion, n – number of criteria.
In the following section we will present an example of such calculations.