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**MULTICRITERIAL MODEL OF CONSTRUCTION SELECTION**

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Abstract

One of the most important stages of construction is the initial survey and selection of the construction variant. One of the options for choosing a variant is to use only one evaluation criterion. Under the conditions of the quantitative nature of the criterion, it would then be sufficient to arrange the variants according to the values ​​of this criterion. The variant with the highest value would be the optimal variant. However, the use of multi-criteria decision-making results in a better outcome, including a more objective approach to the issue. The main part of the paper is to describe and process three types of models of multicriteria decision making. The Scoring method, the basic variant method and the discriminant method with Ivanovic deviation. At the end of the work, to verify the functionality of the models, a comparison of 3 variants of construction related to the issue of brownfields was processed, specifically construction at the brownfield site or other.

Keywords

Brownfield; multicriterial model; multicriteria analysis method.

Introduction

One of the most important parts of construction is the pre-investment phase. At this phase, it is decided where the construction will be carried out. If the initial survey for selection is poor, the entire construction can be unprofitable and inefficient. If we want to make a qualified selection of products, it is more appropriate to take into account more than one decision criterion. Just like in financial decision-making. For the right choice, it is ideal to use multicriterial selection models.

The current situation of brownfields in the Czech Republic

For the possibility of quantification of brownfields, the definition created by the author is given. "The term brownfield means real estate, as a land, object or complex. It is currently partially or completely unused and very often damaged in some way and contamination is possible. In the past, the property was used within an urbanized area or open landscape and lost its original function. At present, it degrades itself or its surroundings economically or physically. It cannot be used appropriately and effectively without a process of regeneration. "[1].

The issue of brownfields has been receiving attention in the Czech Republic since the late 1990s. Twenty years from the developed countries of the world. As a result of the transformation of the economy, abandoned industrial areas, military areas, agricultural areas, production halls, warehouses, transport areas, etc. At the same time, there is great development potential in the regeneration of these properties. However, it often does not do without the support of the state and the public sector.

In the period 2007-2014, it is estimated that up to 15% of brownfield areas were regenerated. Nevertheless, a large part of the originally estimated number of 10,000-12,000 brownfields remains unused and new brownfields are emerging again. At present, according to the CzechInvest Agency, 3,500 localities are registered in the national database. Other smaller databases and offers are managed by several regions and cities. [2] A qualified estimate of the number of brownfield sites is higher. This is based on the assumption that a group of potentially developing brownfields has been regenerated within the framework of market mechanisms. According to an expert study from 2008 [3], there are 5% brownfields in the Ústí nad Labem Region. 22% of brownfields are located in the South Moravian Region. An estimate that in 2007-2014, approximately 15% of the total brownfield could be regenerated. Information on the addition of new areas of brownfields is missing and an estimate is not possible.

Value engineering

Value engineering, which also includes value analysis, is a modern matter whose origins date back to the mid-20th century. There was a shortage of manpower and materials due to the war in Europe. Value analysis is a set of four separate but interconnected systems. Specifically, the needs that the company demands. An object that meets a need. And also, the object of analysis. Furthermore, they are tools of value analysis, which are to quantify the utility value of the object and the subject itself, ie. team of workers processing the analysis. [4]

Customer value can be defined as "the relationship between the satisfaction of a need and the resources used to achieve that satisfaction." At this point, it is also appropriate to define other terms from the definition. [5] Value is the relationship between the contribution of a function to the satisfaction of a need and the cost of the function. [6]

(1)

Methodology

The possibility of value analysis using 3 methods was created for the evaluation of offers. Specifically, it is a scoring method, a method of index coefficients and a discriminant method.

Scoring method

Determining the weights of evaluation criteria requires most methods of multi-criteria evaluation of variants. The weights numerically express the meaning of these criteria. The more important the criterion for the decisive, the higher its weight. In order to achieve comparability of weights of criteria determined by different methods, weights are usually standardized so that their sum is equal to one. If the result is a non-standard weight, they are normalized by determining the sum of the weights of all criteria in their set and the weights of the individual criteria are divided by their sum. [7]

Method of index coefficients

The basic variant method is used in this paper. The basic variant is a fictitious variant, which takes on predetermined values ​​for individual criteria. These values ​​can be determined, for example, by averaging all the specified variants or by selecting the best criteria values ​​from a set of variants. The essence is a comparison of the basic variant with partial variants. Again, revenue and cost criteria must be taken into account. For yield-type criteria, the partial valuation is determined as equation (2). [7]

(2)

where: h = partial evaluation of the j-th variant with respect to the i-th criterion;

x (ji) = value of the i-th criterion for the j-th variant;

x (bi) = value of the i-th criterion for the basic variant.

The basic method is used mainly for a set of criteria, where quantitative criteria predominate. From the mentioned relations it can be deduced that the utility functions for the revenue and cost criteria will have a different form. It is linear for yield criteria. This means that the same benefit growth is expected with the same increments of criterion values. In contrast, for cost criteria, the function has the shape of a hyperbola and a degressive decrease in benefit is expected with the same increments of criterion values. [7]

Discriminant method

Discriminant analysis belongs to the group of methods of multidimensional statistical analysis. They examine the interrelationships of variables, especially for complex investment projects such as buildings. The evaluation of a variant of an investment project consists of a set of dependent and independent functionally conditioned properties. The set of criteria for technical evaluation are usually indicators, such as qualitative characteristics of certain properties. To determine the functional level, these are functions that can also be quantified using some parameters or by scoring. When using the method with Ivanovič deviation, emphasis is placed on the use of criteria that can be expressed by exactly measurable quantities. So as to guarantee the objectivity of the results obtained by mathematical and statistical operations. A mathematical procedure called the author was developed for the evaluation of objects and is given by the relation [8]:

(3)

where: x (f1) = value of the fictitious variant of the i-th criterion;

X (j1) = value of the i-th criterion of the j-th variant;

σi = standard deviation;

rki = correlation coefficient between indicators;

n = number of criteria.

The calculated I. deviation of the given variant of the implementation of the investment project then expresses the fulfillment of its overall usefulness. The overall efficiency of the variants is then expressed by the share of the I. deviation and the costs of the variant. The efficiency relationship is then simply expressed as [9]:

(4)

where: Ei - efficiency of the i-th variant;

Di - Ivanovič deviation of the i-th variant;

Ni - the cost of the i-th variant.

Results

The first basic point of decision is to specify the investment plan. For this case, one of the most frequently used plans is chosen, the construction of an apartment building in Prague. Furthermore, the differences in the acquisition costs of the investor during the construction on a different plot of land are addressed.

The paper used the freely available documentation of the Na Hodinářce building in Přelouč from K2 Invest s.r.o.It is an apartment building with a total of 28 residential units and 10 parking spaces, with a total built-up area of ​​411 m2 and a built-up area of ​​8,800 m3. [*10*]

Obsah obrázku strom, exteriér, budova, obloha

Popis byl vytvořen automaticky

Fig. 1: Visualization of an apartment building, source [10]

Option A: new construction (greenfield alternative)

For more information about the land, the land advertisement is interpreted. This is a sale of a building plot with an area of ​​671 m2, for the construction of an apartment building in the locality of Prague 10 - Strašnice. The land is overgrown with greenery, adjacent to an apartment building and a panel house, which is intended for the construction of an apartment building. According to the price map, the prices of land in this district range between CZK 8,000 - 9,000 / m2, which corresponds approximately to the offered price. This check can be used to verify the price of the offered parcel. [11]



Fig. 2: Photo of the offered land in Prague - Strašnice. [11]

**Option B: brownfield area without development**

The same construction on an undeveloped area is considered. The distance of connection to engineering networks is considered the same. It can be stated that the basic budget costs will have exactly the same cost value. A suitable locality for the exhibition at the brownfield locality is considered to be the locality Prague - Letňany. These have become a brownfield since the final metro station and countless vacant unused areas were created in Letňany. These areas are a suitable plot for such construction. The issue of this part has been addressed for several years and is still unresolved.

Obsah obrázku snímek obrazovky

Popis byl vytvořen automaticky

Fig. 3: Possibility of construction in Letňany. Source: www.mapy.cz

**Option C: brownfield area, including development**

It is a brownfield of an unused hall, which was built in the village of Záryby. The previous use of the hall was industrial. It is no longer used today. The area of ​​the building is 1,497 m2. All utilities are on the boundary of the plot.

.Obsah obrázku obloha, exteriér, silnice, tráva

Popis byl vytvořen automaticky

Fig. 4: Brownfield: Záryby Hall.

It would first be necessary to demolish the existing building, from which it would be possible to use the foundations. This could shorten the construction time of the new building and possibly save costs. However, everything depends on the quality and type of original construction.

For the calculation of the financial indicator of the estimated acquisition costs for construction, the calculation is the most advantageous in the initial considerations. From it is possible to find out the approximate costs of construction, including important elements that will be part of the construction. Using the classical calculation and selection of suitable land, a recapitulation of construction costs was created.

Tab. 1: Recapitulation of the comparison of the calculation of construction variants

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option A | Option B | Option C |
| Building objects | 40 284 800 CZK | 40 284 800 CZK | 44 656 759 CZK |
| Design and research work | 3 393 994 CZK | 3 393 994 CZK | 3 762 332 CZK |
| Construction site costs | 1 208 544 CZK | 1 208 544 CZK | 1 339 703 CZK |
| Reserve | 2 920 648 CZK | 2 819 936 CZK | 3 125 973 CZK |
| Other investments | 6 490 000 CZK | 2 684 000 CZK | 0 CZK |
| Other costs | 1 409 968 CZK | 1 409 968 CZK | 1 562 987 CZK |
| Operating costs for the preparation and implementation of construction | 664 699 CZK | 664 699 CZK | 736 837 CZK |
| Total costs without VAT | **56 372 654 CZK** | **52 465 942 CZK** | **55 184 589 CZK** |

**Comparison of multicriteria decision models**

In order to be able to compare the variants, the following criteria were selected (Tab. 4). For the purposes of the paper, the weightings of the individual criteria were considered identical.

Tab. 2: List of criteria



Subsequently, models were created in Excel for a maximum of 5 variants with a maximum of 10 criteria. These models were used to evaluate the subject specified for this work. The final evaluation is shown in the following tables (Tab. 5, Tab. 6, Tab. 7).

Tab. 3: Multicriteria decision making in the form of a discriminatory method

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option | | |
| A | B | C |
| U (Benefit) | 4,487034237 | 2,449489743 | 8,874151798 |
| C (Cost) | 56372654 | 52465942 | 55184589 |
| E=U/C | 7,95959E-08 | 4,66872E-08 | 1,60809E-07 |
| Order of options | 2 | 1 | 3 |

Tab. 4: Multicriteria decision making in the form of a basic variant

|  |  |  |
| --- | --- | --- |
|  | Ranking | Order of options |
| Option A | 1,77391E-08 | 3 |
| Option B | 2,16991E-08 | 1 |
| Option C | 1,79733E-08 | 2 |

Tab. 5: Multicriteria decision making in the form of a scoring method

|  |  |  |  |
| --- | --- | --- | --- |
|  | Option A | Option B | Option C |
| Prize | 56 372 654 Kč | 52 465 942 Kč | 55 184 589 Kč |
| Benefit | 80,326 | 90,000 | 60,435 |
| Calculated Value | 1,42491E-06 | 1,7154E-06 | 1,09514E-06 |
| Order of options | **2** | **1** | **3** |

Conclusion

Within value engineering, it is possible to assess issues from various fields. The most common sectors are engineering, and manufacturing in general. Construction can be qualified as demanding and complicated, especially due to a number of factors that affect the project and their prediction is not fixed in advance.

The basic goal of the work was to develop models of multicriteria decision making designed for the selection of options. Specifically, three models were created, each of which applies a different evaluation method. The first model was used for the basic scoring method. The second model is devoted to the basic variant. And the last model is determined using the discriminant method with Ivanovic deviation. The model was then used to compare three construction variants, namely at the site to be built, a brownfield with existing buildings, and a brownfield without existing buildings.

The results of all variants are not identical due to relatively similar parameters for variants 1 and 3. The main factor was the price. The most advantageous variant is B. The functionality of the models was verified using an example. All models are still in the beginning of development and it is possible to subsequently optimize and use other more complex modifications taking into account, for example, possible risks.

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