можна досягти за рахунок додаткового утеплення огороджувальних конструкцій будівель до нормативних значень опорів теплопередачі.

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OPTIMIZATION OF DEPLOYMENT AUXILIARY STRUCTURES IN IMPLEMENTATION OF BUILDING THERMAL INSULATION

Показана графічно розроблена математична модель, що полегшує і прискорює процес прийняття рішень у виборі допоміжних споруд для ізоляції фасадів житлових будинків. Це дало змогу оптимізувати розміщення допоміжних споруд у специфічний процес ізоляції будівель, порівнюючи графічно чи генеруються значення ефективності розгортання ешафот.

Ключові слова: будівельні риштування, витрати, ефективність використання допоміжних споруд.

The paper presents graphically elaborated mathematical model which facilitates and accelerates decision making in the choice of auxiliary structures for insulation implementation of the residential home facades. It is possible to optimize deployment of the auxiliary structures in the specific process of building insulation, comparing graphically generated values of the deployment scaffold effectiveness.

Key words: scaffold, costs, effectiveness, auxiliary structures.

Introduction. At renovation of residential building with additional thermal insulation of facades the type of auxiliary structures in the bidding budget is indicated only approximately. The cost of auxiliary structures may be an important part of the budget. The support for cost estimates for auxiliary structures are often only experience from the same or similar buildings. Suitable model, allowing expression evaluation of the effectiveness of the deployment of auxiliary structures for the technical, technological, spatial conditions for carrying out the work on the facades of resident buildings, to constructor may be an effective tool to optimize the deployment of auxiliary structures.

Aim and methodology solution. The aim of this work was to establish a general mathematical model for evaluation of the effectiveness the deployment of auxiliary structures for process thermal insulation of facades for different residential buildings, with respect to the required implementation dates of the works. To facilitate the implementation of the mathematical model in the conditions of practice it was necessary to design suitable graphical form of model.

Methodology project solution Designed methodology for solution the task from the point of view methods used, can be divided into three fairly separate parts:

- Analytical part;
- The solution of partial tasks (calculation of the aggregate utility and determination the cost of the rent) the methods of value analysis and polycriterion optimization;
- Generalization of the results and mathematical modeling using graph theory.

Entering the solution task was the definition of size and spatial division of a representative sample of facades of residential buildings. Economic, technical and technological parameters of the implementation of thermal insulation system have been specified. Since the cost of the auxiliary structures, for specific process of thermal insulation, are functionally dependent on the time of deployment and amount of auxiliary structure, it was necessary for task solution to define schedule variants within the relevant time period.

In the analytical parts theoretical knowledge of the auxiliary structures in the building industry was processed. Except for standardized rules knowledge gained from the internet and consulting firms dealing with the hiring of auxiliary structures have been incorporated. As a source of information and the answers of respondents who were contacted in the process of solving task related to parts of polycriterion evaluation of utility on of alternative deployment of auxiliary structures were also used.

The scoring method with weights of criteria was chosen for utility evaluation of the deployment of the auxiliary structures. Costs of auxiliary structures were determined by calculation depending on the type, quantity and period of deployment of scaffold, suspended platforms and working platforms, as well as size of building facades. Theoretically, the calculation of the costs was verified with values obtained from the practice. For 80 variants of solutions (mutual combinations: 4 types of auxiliary structures, period of realization thermal insulation: 1, 2, 3 and 4 months and 5 representatives of the residential building) the value of the effectiveness of the deployment of auxiliary structures was determined by calculation.

Based on the results of mathematical modeling variants generalized mathematical model was designed. The graphical processing of the model provides express and conforming information for optimal decision to the contractor.

The effectiveness of the deployment of auxiliary structures for thermal insulation of buildings Selected reference residential buildings (Figure 1) vary by the number of floors, number of sections, bearing system and the construction of the cladding (Lipták, 1990) (Greško et al., 1998). Different size of façades was important in the choice the residential buildings.

External thermal insulation composite system (ETICS) has been designed uniformly to all objects of residential buildings. The identity of thermal insulation system was important in the comparison of results. The basis for calculating the costs, as well as for determining the required number of auxiliary structures, was a detailed analysis of technological, spatial and temporal structure of the implementation process insulation.

Analysis of parameters of auxiliary structures. To solve task four types of auxiliary structures have been selected: tubular scaffold, frame scaffold, suspended platforms and working platforms that are used in most of our building thermal insulation now. Scaffolding frame system SPRINT (width 75cm) and tubular scaffold TRUSTA (width 105 cm) were selected. Platforms are products of firm STROS. For selected types of scaffolding, working platforms and suspended platforms the value of their technical, technological and economic parameters have been specified in detail (Krajňák, 2011).

Figure 1. Five variants of residential buildings
***Residential buildings: A) T 13 – 3 floors,** Place: Probstnerová cesta, Levoča; **B) T 06 B – 4 floors,** Place: Pri prameni, Levoča; **C) P 1.14 – 6 floors,** Place: ul. Jozefa Czauczika, Levoča; **D) T 06 B – 8 floors,** Place: Trieda 1. mája, Spiš. Nová Ves; **E) T 06 B – 12 floors,** Place: Kuzmányho, Košice.*

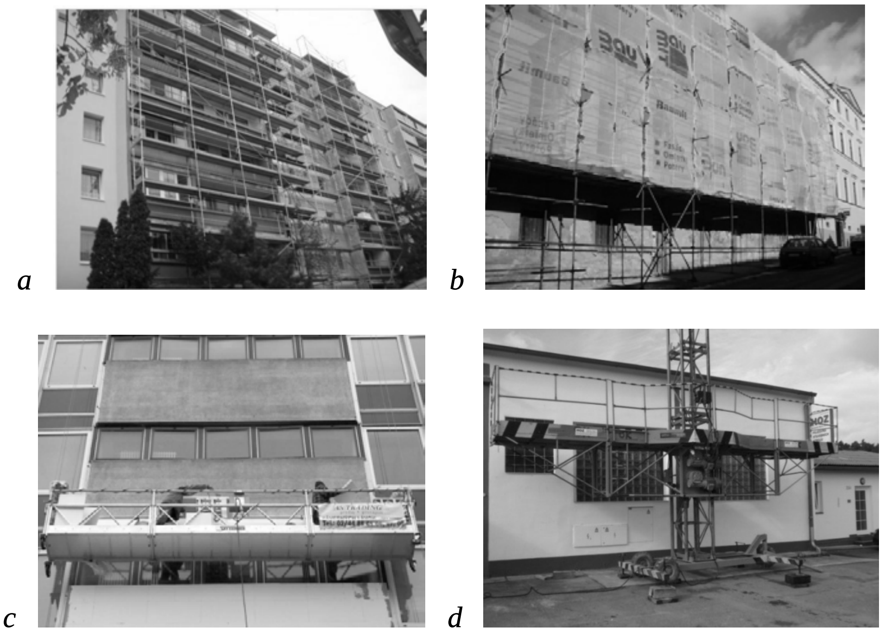

Figure 2. a – scaffolding system SPRINT; b – tubular scaffold TRUSTA; c – suspended platforms STROS 0; d – work platforms STROS WP 1000 0

The aggregate utility of auxiliary structures. The basis for determining the aggregate utility is a set of goals, so called evaluation criteria, which have to be achieved in solving the decision of problem. For each criterion it is necessary to determine and quantify the importance of values which will be expressed in terms of their utility for the evaluated variants (Repiský, 2005; Bašková, 2004).

To determine the aggregate utility of variants of the deployment auxiliary structures, a set of 14 decision-making criteria was specified from the technical, organizational, technological and environmental point of view (Figure 4). In determining the importance weights of criteria results from the research review were incorporated. The research review respondents were from the construction practice and educational environment.

To quantify the fulfillment of partial criteria for different variants cardinal scale - scale with descriptors were chosen. Based on a detailed analysis of each criterion the appropriate number was assigned of points from 0 to 5 for certain interval values for utility criteria in the units, where the best rating it 5 points. In the resulting calculation was the point value of the resulting utility variations converted to % (5 points represents 100%).

Figure 3. Procedure for setting aggregate utility

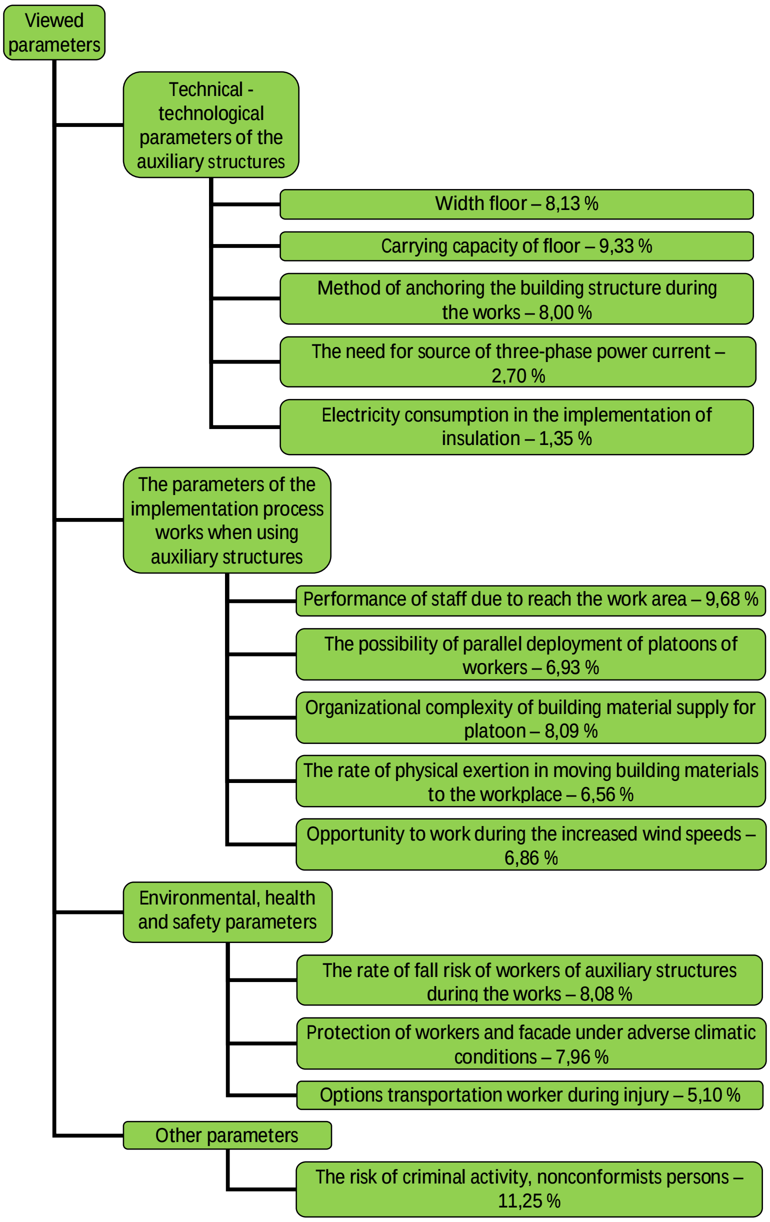

Figure 4. Tree of the evaluation criteria optimality of auxiliary structures

To determine the aggregate utility Uj of variants a scoring method with weights was used. The resulting utility of variants (Figure 5) was calculated according to the relation:

$$U_j = k\sum_{i=1}^{j} u_{ij}V_i \qquad [\%] \qquad (1);$$

where U_j – the aggregate utility of the jth variant; u_{ij} – the partial utility ith criterion of the jth variant is expressed in %; V_i – the resulting normalized weight of the ith criterion (relative number); k – the coefficient which takes into account the suitability of using an auxiliary structure, can take values: 0 and 1.

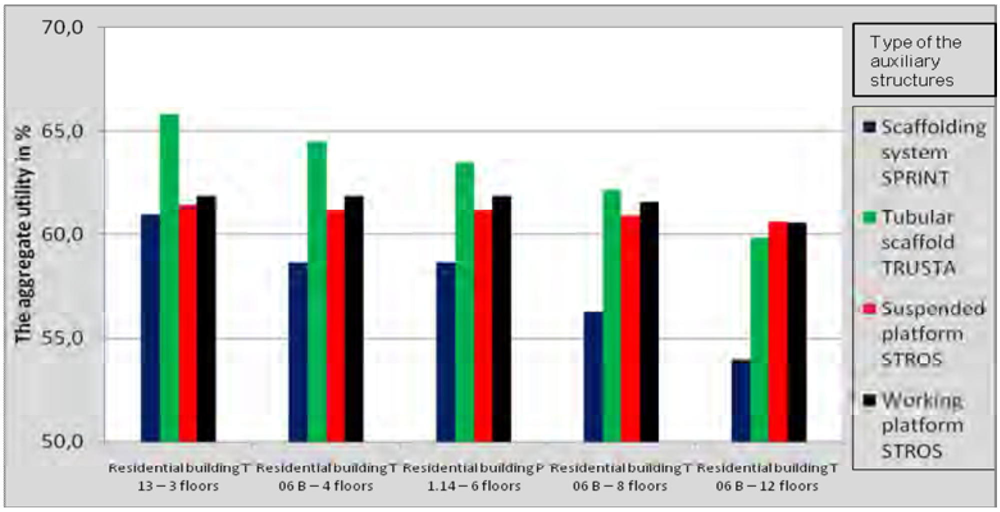

Figure 5. The resulting value of the aggregate utility the deployment of auxiliary structures

Determination of the cost for renting auxiliary structures. The cost of renting were determined on the basis of analysis of economic and time parameters of partial processes of thermal insulation and data from list prices for the given type and quantity of auxiliary structures. The basis for determining the amount auxiliary structures was prepared a detailed schedule for the progress of work for the selected variant construction period: 1, 2, 3 and 4 months. The analysis of necessary number (Figure 6) of suspended platforms and working platforms has been done.

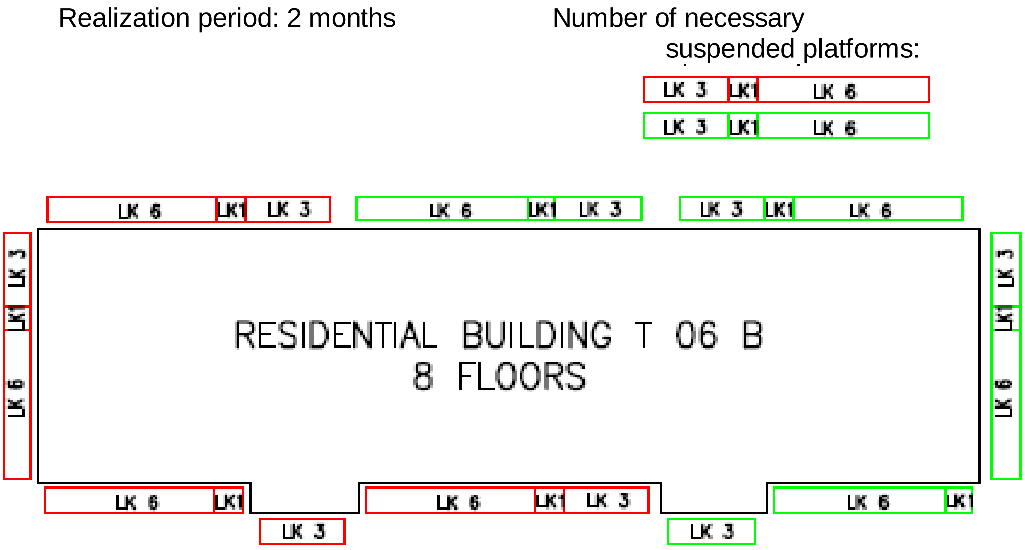

Figure 6. Analysis of the necessary number of suspended platforms at the time of realization: 2 months, on the object: Residential building T 06 B, 8 floors

For all objects has been considered using the scaffolding on the half of the building (1 face+1 shield), this condition resulted from the knowledge and recommendations of construction practices. Number of deployed suspended platforms and working platforms varied depending on the desired time work.

The chart (Figure 7) shows the calculated cost of renting four types of auxiliary structures in their applications for five different residential buildings, taking into account the four different schedules of the implementation of thermal insulation system.

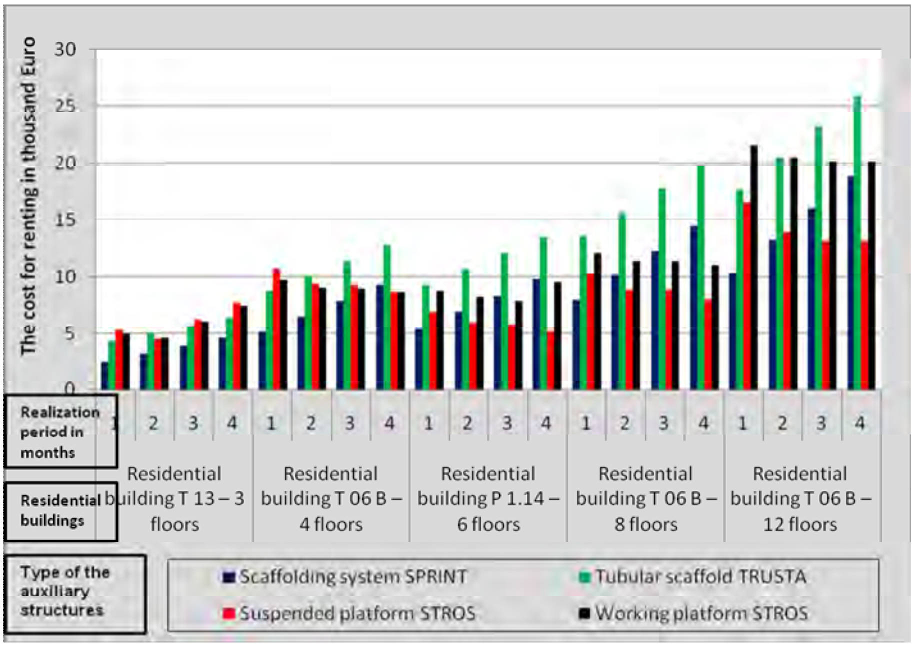

Figure 7. Costs for renting auxiliary structures; taking into account the type of residential building and construction period

For three variants was done the cost comparison for calculating the actual costs for renting auxiliary structures on the practical implementation of thermal insulation system (Figure 8).

The difference between the calculated and actual costs can be attributed to regional differences in the rates for renting or deviations in the calculation of costs. On the basis of small differences in calculated and actual costs can be noted that for calculating rental costs for different types of auxiliary structures was used appropriate methodology and calculated costs can be used to determine the effectiveness.

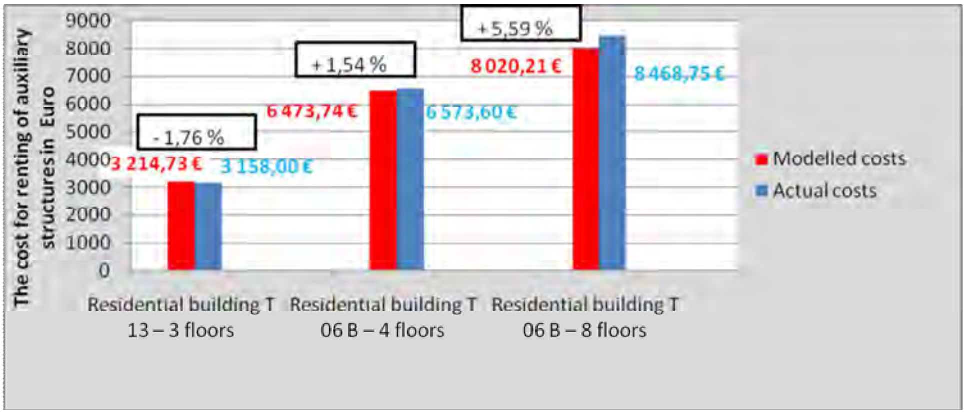

Figure 8. Comparison of the calculated costs and the actual costs for renting auxiliary constructions in their use of the three variants of residential buildings

The effectiveness of using auxiliary structures. The effectiveness of using auxiliary structures was calculated on the relation:

$$E_j = \frac{U_j}{N_j} \qquad \left[\frac{\%}{thous.€}\right] \tag{2}$$

where E_j – effectiveness of the jth variant in % . thousand € $^{-1}$; U_j– the aggregate utility of the jth variant in %; N_j – the cost of the jth variant in the thousand €.

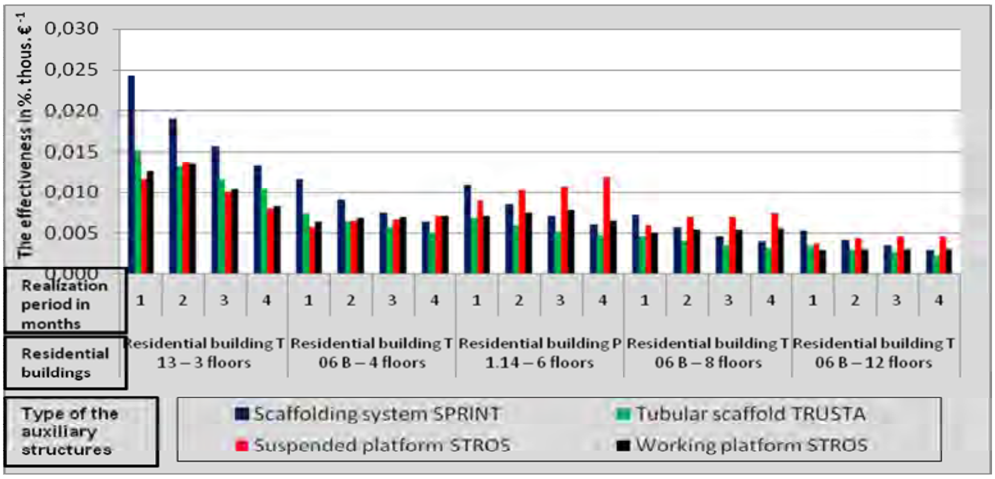

Figure 9. The values of the effectiveness of eighty variants auxiliary structures

The chart (Figure 9) gives resulting values of the effectiveness for 80 variants of deployment of auxiliary structures (4 types of auxiliary structures for five residential buildings with respect to different dates of implementation: 1, 2, 3 and 4 months).

Generalization of mathematical modeling results and conclusion Mathematical modeling of 80 variants of deployment of auxiliary structures provides sufficient grounds to generalize the results obtained. In designing the optimal auxiliary structure for the process of thermal insulation implementation can relate to the graphic design cost or effectiveness (Figure 7 and 9). Marked trend lines (Figure 10) shows the evolution of effectiveness at the time, suggesting convergence, respectively penetration effectiveness of auxiliary structures.

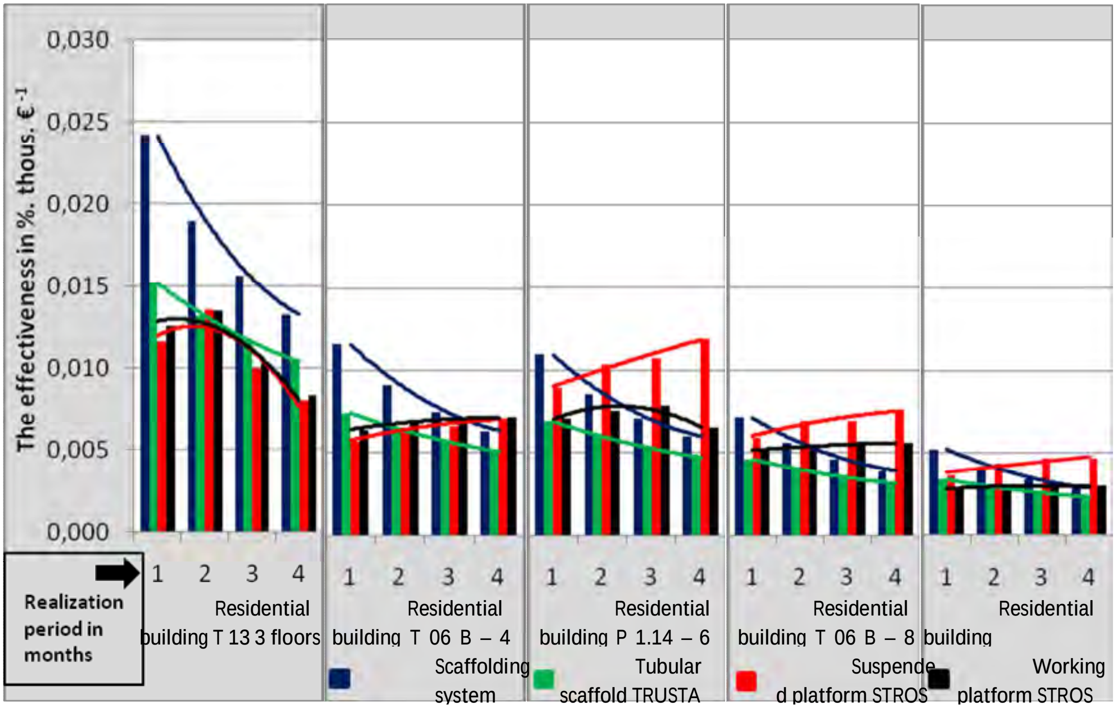

Figure 10. Analysis of the effectiveness of the deployment of auxiliary structures

An alternative way of graphic processing of results modeling is the nomogram (Figure 11). The values of effectiveness in this case derived from the size of the façades.

Procedure readings of each parameter in the nomogram:

Input information:

- Determining the size of facade surface residential building (including surfaces of windows and protruding parts of the building - according to the principles of report and assessment of scaffolding), its value is displayed on the axis x.

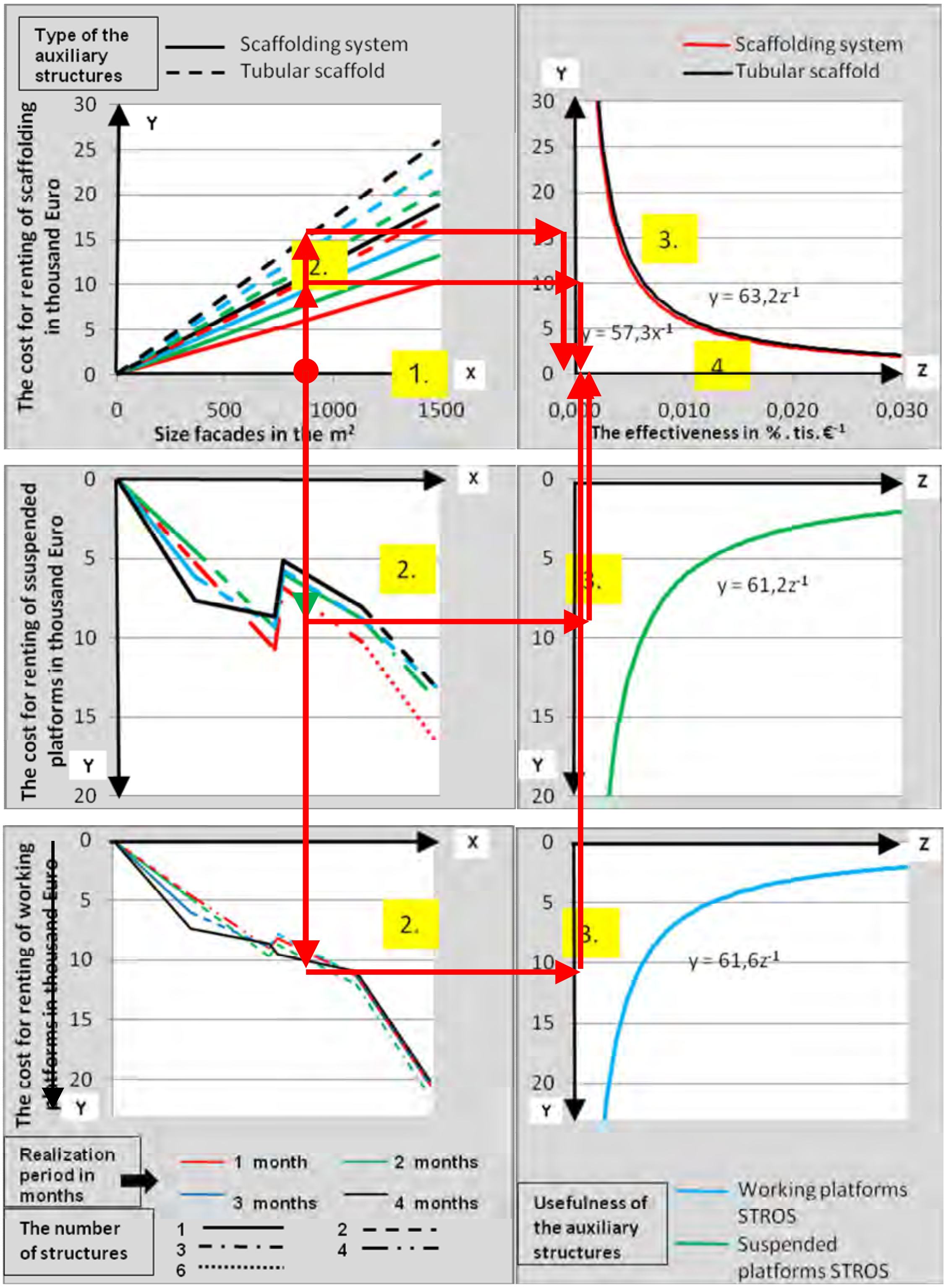

Figure 11. Nomogram effectiveness of the deployment of auxiliary constructions

Costs of auxiliary structures are among the most expensive items in the facade work. In this context it should be understood optimization as a basic tool of cost reduction in the use of auxiliary structures, resulting in increased competitiveness building companies and ultimately reducing the price offer.

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IMPACT OF SHAPE OF BUILDINGS ON ENERGY CONSUMPTION

Наведено аналіз форми будівель (план фундаменту і вертикальний розподіл) і їх вплив на коефіцієнт форми / аеродинамічний коефіцієнт/ FT будівель. Для деяких будівель запроваджений параметричний аналіз, отриманий з вичерпного відтворення енергетичних потоків цілої будівлі. Параметричний аналіз стосується орієнтації будівлі і пропорційно процентності скління конкретної стіни.

Ключові слова: форма будівель. Коеффіцієнт форми (аеродинамічний коеффіцієнт), орієнтація, процентність скління.

This paper provides analysis of buildings shape (ground plan and vertical division) and their impact of shape factor – FT of buildings. For some shape is provide a parametric analysis obtained from a comprehensive whole building energy simulation. Parametric analysis regards orientation of buildings and ratio % glazing to the wall.

Key words: shape of buildings, shape factor, orientation, % of glazing.

Introduction. Designing a building requires the interplay of architecture and design parameters to create an artificial material environment. Each architectural and engineering design has a direct impact on the indoor climate environment and a key determinant of operational performance of buildings throughout the life of the building. One important component of the process of reducing the operating energy performance of buildings within a designated period of their exploitation as packaging design of buildings and their physical and technical characteristics, which are intended design concept and building material solutions.