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# Cost management of building constructions and works through knowledge-based database

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**Abstract.** Civil engineering represents an important economical segment. Higher pressure on raising effectiveness, productivity and automation is perceived in society. An important factor that influence raise of effectiveness and productivity is cooperation support between participants of building sector. Individual participants are connected between each other and they are allowed to gain, collect, share, rate and use available information's in required quality and required time. For this purpose, a lot of supporting tools are created and these dispose with automation features, such as knowledge system or knowledge database. One of the most important processes in building's life-cycle is cost setting through the whole life-cycle. Correct cost setting is an important indicator in deciding about size, shape, equipment and also on building realization itself. In building's life-cycle, besides economical aspect that is represented by costs connected with individual life-cycle phases, it's also important to consider other parameters that greatly influence building method and using or disposal of the building. This article, based on mentioned facts, brings a proposal of methods and structure to create knowledge database, that brings user a tool that dispose with information's needed for deciding about construction solution of future building and allows to manage costs for building operations and building works.

## 1. Introduction

Raising demands for prompt and effective realization of individual processes is displayed also in building sector. During preparation, realization and using of buildings, automatized processes are enforced more and more. One of the ways for raising effectiveness, productivity and automation is creation of knowledge systems. Knowledge systems are used for sharing and managing knowledge's. This system supports acquisition, organization and collection of knowledge's. Knowledge systems are a tool for knowledge management, that includes a number of strategies and experiences focused mainly on discovering competitive benefits and improving organization's efficiency [1].

Knowledge database is created on the ground of setting the specific goal or setting the need. After setting of the goal, it's important to acquire information's, accustom acquired data's, set the style of presentation and database management and constantly update the data's [2].

Availability and recency of data's positively influences the pricing process of building production. Into the process of calculation and building cost setting, there enters a high number of factors, for example wrong setting of starting costs, unexpected technical problems, not specified changes, missing or wrong extensity definition and outer factors [3].

Building production pricing is an important process in building's life-cycle. Tools that supports building production pricing are on different level. There exists a lot of software applications that allows building production pricing. These applications works on a basis of allocating the price data's and information's to individual bill of quantities' items.



These limitations could be eliminated or reduced through knowledge system creation. In respect of current status in building production pricing, main goal of research was identified. The main goal of the research is method and structure design for creation of knowledge database that allows creation, identification, organization and sharing the information assets for support the building production pricing, and integration option of proposed solution into BIM environment. The goal was set in consideration of support of Slovak agency for research and development under the contract no. APVV-17-0549: "Research of knowledge-based and virtual technologies for intelligent designing and realization of building projects with emphasis on economic efficiency and sustainability. The main objective project is to develop the methodology for modelling the economic parameters in BIM environment. To propose the multidimensional structure of parametric interactions between intelligent construction element in the BIM model some on cost and economic parameters.

## 2. Cost estimating of construction production

Construction cost setting is one of the most important processes in building's life-cycle. Proper cost setting, construction price is important indicator in deciding about its 'size, shape, features and also realization itself. Cost is mostly set by price calculations. Success of each project depends on exact cost assessment.

Every building goes through life-cycle. This life-cycle is defined as a time lapse from first thought about building until its disposal. Based on this fact, life-cycle of a building is divided into four basic phases – pre-investment phase, investment phase, operational phase and disposal phase. In each of the life-cycle phases, cost demands are different [4].

Many factors enter the building cost calculation process. Most important reasons of cost raising are small starting cost assessment, unspecified changes, unpredictable technical problems, outside factors and missing or wrong range definition[3].

Result of calculation is the building estimate respectively building budget. Building budget is a form of setting the price in building works pricing. This budget represents priced bill of quantities, built-up according to technical documentation. Individual items are priced by relevant prices of construction items, itemized construction budget is created [5].

Building production pricing is noted for various specifications, which must be taken into account. Main factors are following: building production is custom-made and from bigger part the production is individual, long production cycle with many production processes, it's characterized by movable building production, character of used material, high amount of transport processes, building's place and character, imminent weather influence, performing activities on buyer's ground, investment severity and dependence on loans, transport, accommodation and catering pretence concurrence with building's occupation, realization time period, extent of equipment on project site, delivery character, reimbursement method, delivery and other conditions [6].

## 3. Knowledge database

Currently more emphasis is put on support the cooperation of institutions, processes, participants, etc. An important tool that supports cooperation is mutual connection of each part and an option to collect, share, rate and use available information's in required quality and required time. For this purpose, a lot of supporting tools are created, such as knowledge system respectively knowledge database. Knowledge database is so-called public library, or a database of relevant information's about particular subject[7].

Knowledge database is a database used for knowledge sharing and management. Database supports gathering, organization and acquisition of knowledge's. Knowledge database does not represent only a space for saving the data's, but through artificial intelligence tools, it supports intelligent determination. Determination is mediated by various knowledge presentation technologies, including frames and scripts. Two main types of knowledge database are known:

- **human readable knowledge bases** allow people to use knowledge's through saving information's, guides, information's about solving problems and saving the FAQ answers. This type of knowledge database can have interactive character, through which the database directly helps user with deciding. Database offers information's but the selection itself is performed by user.

- **machine readable knowledge bases** save knowledge's, but only in readable systems. Solutions are offered on the ground of automatically illative ideas and they are not so interactive because they rely on questions systems, that are included in sciential database basement, and thus the solution is constricted [7].

Knowledge database is an important tool of knowledge management. This management comprehends a number of strategies used in organization for creating, representing, analysing, distribution and accepting the experiences. It is focused mainly on competitive benefits and improving efficiency of organizations [1].

Knowledge database is created by knowledge engineer, that implement knowledge's into the database, based on real experiences from experts in this sphere. Database concept is created on the ground of "if-then" rules – if the condition is valid, then the conclusion is valid. During creation of the system, it's possible to use more rules. In this case, a rule-choosing conflict occurs, therefore is important to set the sequence of rules [8].

Knowledge databases are created in software applications for knowledge management. Software for knowledge management helps user to create, identify, organize and share informative assets. Software saves knowledge's, information's and manage policies, documents and databases thus all information's will be easily available, comprendious and continuously updated[9].

Knowledge databases can be created in many software's, such as: Sabio Knowledge Manage, Jira Service Desk, Dezide, Zoho Connect, Bitrix24, Freshdesk, Deskpro, Lighthouse Desktop, Enterprise Intelligence Platform and other [9].

#### **4. Proposal of methodology and structure of the knowledge database**

Knowledge database allows using, sharing and managing the knowledge's. Main purpose is to create a knowledge database of construction features like human readable knowledge bases, that allows users using the knowledge's included in knowledge system. Database will have an interactive character, that will help user in deciding with the system that offers options or information's and then it will offer user an option of particular pick. Database concept will be created on the ground of "if-then" rules - if the condition is valid, then the conclusion is valid. It's important to set the sequence of the rules, with which the conflict during rule choosing can be preceded.

Knowledge database structure will be chosen based on following aspects:

- allocation of an object into functional building parts,
- allowance of economical or financial aspect and time structure,
- allowance of object or feature durability
- allowance of environmental and sustainability aspect

##### *4.1. Description of proposed structure of knowledge database*

*4.1.1. Allocation of an object into functional building parts.* Building object is technically independent, spatially integrated part of a building, that subserves particular function. Functional building part is an integrated part of a building, that serves one or more particular, specified functions. During the building allocation into functional parts, it's important to take into account the building function, constructing method and project documentation structuring, and also in consideration of the connection to budgetary scale. Also important is to take into consideration the technological aspect. The technological aspect deals with the technology and parameters that will be used in each construction process. Technological structure of a construction process represents the object allocation into staging and fragmental construction processes. Based on these facts, an object will be divided into following functional construction parts:

- foundations construction and design of the substructure,
- hydroisolation,
- vertical load-bearing structures,
- partitions and partition walls,
- chimneys,

- ceiling constructions,
- stairways and communications,
- roof construction,
- roof drainage,
- isolations,
- surface modifications (interior, exterior),
- windows,
- doors (interior, exterior),
- floor,
- technical equipment of buildings (water supply, heating, electrical installation, ventilation, air and sanitary installations).

To every functional building all its types and kinds will be allocated. Every type and kind of a building is distinguished by different specific characteristics, therefore it's important to approach every type or kind individually and set particular specific characteristics, parameters and take into account f.e. production aspect, material aspect, technological aspect, financial aspect, option of burden diversity, object or feature durability, environmental aspect, etc. [4] [5].

*4.1.2. Economical (financial) aspect and time allowance.* Cost needed for the whole life-cycle of a building or a feature will be allocated to individual functional parts of knowledge database. Life-cycle of a building is divided into pre-investment and investment phase (acquisition costs), operating phase (costs for maintenance and operational costs) and disposal phase (disposal costs). Individual construction features will dispose with information's about costs needed in all life-cycle phases, thus costs connected with feature acquisition, maintenance costs, operational and disposal costs. Acquisition costs will be divided on the ground of calculation formula for direct material, direct wages, costs for machines and devices, other direct costs, production and administrative expenses, profit and risk. Besides cost parameters, each feature will include also time parameters, for example direct labour, technological breaks, etc.

*4.1.3. Durability of buildings and features.* Object ability to serve required functions until the reach of limiting state in maintenance system and reparation is expressed numerically by technical life, middle-technical life or a median use value[10].

Durability of an object is influenced directly from the start of an object predesign. Durability is influenced by quality of the materials, that undergo monitored check-ups and corresponds with required class, building feature realization method or object – technological methods, building standards and regular maintenance of a feature or an object.

Feature durability can be divided into two groups:

- technical durability – period from creation of building feature until its expiration. Technical durability is a period, when the mentioned feature serves its function, meet basic safety requirements and does not endanger building users. In this durability type, emphasis is put mainly on a material structure, that is divided into long-life durability features (bearing construction structures – basement, masonry, etc.) and short-life durability features (all other features - roofing, plumbing structures, windows and doors, floors, insulation, furnishings, etc.),
- economical durability – period from creation of building feature, object until the time when it's profitable to operate the building or a feature. After this time, the building become uneconomical, that means costs are higher than the profit. In this case, it's necessary to change the purpose of a feature, building or to dispose it and substitute it for new one. Economical durability is significantly shorter than technical durability [11].

*4.1.4. Environmental aspects – feature sustainability.* A care about the environment is an important activity about socio-economic significance. A healthy environment is the basis for the preservation of human existence, healthy development and influences the factors of the living standard of the population significantly [12][13].

Construction activity influences the quality of the environment greatly and requires enormous consumption of natural resources and energy. A huge amount of waste and pollution is generated. The negative consequences of construction work led to redundant pumping of natural sources, pollution, ecosystem disruptions, but also to negative socio-cultural impacts and changes in the environment [14].

Every building, every construction feature influences its surroundings. Influence of a building or construction feature on surrounding environment can have various displays, from this point of view it's possible to evaluate for example. spending resources, environmental pollution, inner environment quality but also functional, aesthetical and social context of a building or a feature. Based on mentioned facts, environmental effects can be integrated into following categories:

- PEE - total amount of primary energy,
- GWP- Global Warming Potential,
- ODP – Ozone Depletion Potential,
- AP – Acidification Potential,
- POCP –potential for photooxidant formation,
- NP – potential for eutrophication of soil and water [15].

An important factor that influences knowledge database's structure are environmental aspects. The term "sustainability" certainly belong between environmental aspects. The definition of "sustainability" is the study of how natural systems function, remain diverse and produce everything it needs for the ecology to remain in balance. Human civilization takes resources to sustain our modern way of life [16][17].

Sustainability consists of three basic pillars economic development, social development and environmental protection:

- to mitigate the effect of climate change, pollution and other environmental factors that can harm and do harm people's health, livelihoods and lives,
- increase health of the land, air and sea,
- sustainable economic growth while promoting jobs and stronger economies and other[18].

Currently, there exists several certification systems and standards, that helps to set the level of concordance of the buildings with sustainable construction principles. The impulse for their creation was the need to set, how are buildings beneficial and the need to evaluate the influence of creation and operation of the buildings on environment. Every building has different ratio of consumption places allocation, therefore evaluating systems were created for the purpose of calculation individual influences on an environment and possible mutual comparison. In Central Europe, four main certification systems are used BREEAM (1990, United Kingdom), LEED (1993, United States of America), DGNB – Deutsche Gessellschaft für Nachhaltiges Bauen (2007, Germany), SBToolCz – Sustainable Building Tool CZ (2010, Czech Republic)[19].

The priority is to take into account and incorporate mentioned environmental aspects and certification systems into proposed knowledge system.

*4.2. Possibility integrating the proposed knowledge database into building information modelling.*

Created knowledge database offers user a deciding tool that implements acquired knowledge's. User can choose correspondent construction feature type from functional, technological, economic and environmental point of view, or a sustainability view. Every feature will carry graphic and non-graphic information's. Graphic information's will be visualized through 3D model. Non-graphic information's of construction feature will represent information's about material, costs (wages, material costs, machine and device costs, other direct costs and operational costs) and information's about feature durability and its' environmental influence or sustainability. So-defined feature will carry similar information's and data's as are features created in BIM environment. Based on this fact, there will be an ambition to integrate proposed solution into BIM environment.

## 5. Conclusion

Raising requirements for prompt and effective realization of individual processes are displayed also in building sector. Automated processes are used more and more in preparation, realization and using of the buildings. One of the ways for raising effectivity, productivity and automation is creation of knowledge systems. This article brings a proposal for method and structure of knowledge database, that will allow cost management for building constructions and works and helps with deciding about construction solution for future building. The result of compliance mentioned method and structure of knowledge database will be an evaluation tool that allows user to choose construction feature with consideration of functional, technological, economic and environmental aspect. In the database, user can visualize chosen construction feature, its' graphic and non-graphic parameters. Information's will be provided to user through 3D model that dispose with information's about material, costs, feature durability and environmental influence or sustainability.

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