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Database of building information models - identification and design of parameter structure

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Abstract. Evolution in the construction industry is constantly progressing. Many applications are currently being developed to track the building's life cycle. Increasing emphasis is placed on managing the entire life cycle of buildings. New technologies are evolving, for example building information modelling. The output of this technology is a building information model. Building information model processes digital content related to the whole life cycle of a building. Developers create information models. These models are then archived to mass repositories such as databases and libraries. The databases contain models that contain graphical information and selected non-graphical information. The main aim of the article is to design and identify the structure of a database, that will be containing graphic models with selected non-graphical information based on the acquired knowledge.

1. Introduction

Lifestyle change in modern society is reflected in increased levels of flexibility, productivity and technological development. The construction industry supports process automation. Automation in construction industry brings achieve the following advantages:

- uniform quality with higher accuracy,
- replacing of human labor in tasks involving heavy physical work or monotonous work,
- replacement of human work in dangerous environments,
- making tasks that are beyond human capabilities easier.
- increasing productivity and efficiency of work at reduced costs,
- economic improvement,
- improvement of working environment [1].

Automation in the building industry is manifested, for example, by the use of drones, the automation of prefabricated construction of houses, the application of robotics, the application of information modelling technology and support autonomous equipment for example stiles machinery, hundegger, Trimble, 3D printing concrete and other [2].

2. Building information models

Construction of buildings is a time-consuming and costly process. The following steps are important to improve the construction and use management process:

- improve cooperation between information suppliers and users,
- provide more accurate background information to support decision-making,
- provide a standard way to store information,
- integrate data collection and information retention into business processes [3].

To improve the construction process, has been developed building information modelling technology. Building information modelling is an important technology in the building industry. BIM is a process



that involves generating and managing physical and functional project information. The output of the process is building information models. Building information models are digital files that describe every aspect of a project and support decision making throughout the project cycle [4].

Objects are also defined as parameters and relations to other objects, so that if there are changes in a related object, dependent or adjacent ones will automatically change or adjust, as well [4].

Building Information Modelling is a digital representation of the physical and functional characteristics of an element. The model represents a shared source of knowledge that forms a reliable basis for decision making during the life cycle of an element [3].

The traditional building design relied heavily on two-dimensional technical drawings. BIM extends traditional technical drawings to 3D dimension. 3D models to give primary spatial dimensions (width, height, and depth). In addition to the three-dimensional model, BIM also provides additional information such as for example the fourth dimension - time parameter, the fifth dimension - cost parameters, the sixth dimension - environmental and sustainability analysis of buildings and the seventh dimension taking into account facility management across the life cycle [5][6][7][8].

The use of information models goes beyond the planning and design phase of a project to its use and demolition. Within the building lifecycle, it includes cost management, construction management, project management and operations management processes.

3. Database design

The database is an organized collection of data. The data is stored and accessed electronically from a computer system. The database is usually managed by a database management system (DBMS). The database management system consists of an integrated set of computer software that allows the user to interact with one or more databases and provides access to all the data contained in the database [9].

The created database provides four main functional groups:

- data definition –create, change, delete definitions that define,
- update –input, change and delete actual data,
- retrieval–providing information - directly applicable or suitable for further processing by other applications,
- administration– user registration and monitoring, data security, performance monitoring, data integrity maintenance, concurrency control and information retrieval [10][11][12].

Data within the most common types of databases in operation today is typically modelled in rows and columns in a series of tables to make processing and data querying efficient. The data can then be easily accessed, managed, modified, updated, controlled, and organized. Most databases use structured query language (SQL) for writing and querying data [9].

3.1. Types of Databases

Since its establishment in the early 1960s, databases have been constantly evolving. One of the primary types of databases was the creation of navigation databases as a system of hierarchic database (tree model- one relationship between items) and network database (more flexible model that allowed multiple relationships between items). These systems were characterized by simplicity but were inflexible. The development of database types is constantly evolving. We know the following types:

- relational databases – the items are organized as a group of tables with columns and rows. Relational database technology provides the most efficient and flexible way to access structured information,
- object-oriented databases – information is represented in the form of objects,
- distributed databases – a database consists of two or more files located at different sites; the database can be stored on multiple computers,
- data warehouses – central data archive, a type of database that is specially designed for fast search and analysis,
- NoSQL database or a non-relational database allows the storage and manipulation of unstructured and semi-structured data (as opposed to a relational database that defines how all data entered in the database must be stored),

- graph databases – store data in terms of entities and relationships between entities,
- OLTP databases – a fast, analytical database designed for a large number of multi-user transactions [9].

In addition to these types of databases, specific scientific, financial and other functions are complementary and adapted to the development and automation effects. The latest databases include:

- Open source databases – database system with open source,
- Cloud databases – a set of structured or unstructured data on a private, public or hybrid cloud computing platform. There are two types of cloud databases: traditional and cloud-based databases with database services (DBaaS) - also include administrative and maintenance services,
- Multimodel database – combined different types of database models into one integrated system,
- Document / JSON database – the database is designed to save, retrieve and manage information focused on documents representing a modern way of storing data in JSON format instead of rows and columns,
- Self-driving databases – the latest and most innovative type of self-managed database (automated management) is cloud systems that uses machine learning to automate database tuning, security, backup, updates, and other routine management tasks traditionally performed by database administrators [9].

3.2. Database structure

The main aim is to design a database of elements respectively information models, which will be contain graphical and non-graphical information. It is important to design in the database individual links between elements, apply machine learning to optimize building solutions, support multi-criteria evaluation in the selection of elements and support the possibility of combining elements based on user-entered values.

3.3. Database output – building information model

The database structure was created on the basis of a secondary survey. The survey showed that there is a lack of a united environment on the market that has elements containing graphical, technical, economic and other selected parameters. The elements in the database are divided based on the functional parts of the building. The individual functional parts or elements of the structure will contain, besides graphic and technical parameters, economic and time information, durability parameters and environmental parameters.

3.3.1. Division of the construction into functional parts. When dividing the construction into functional parts, it was important to take into account the function of the element, the way of making and taking into account the project documentation in terms of the calculation formula. In addition to the division into functional parts, it was important to take into account the technological aspect. The technological aspect of the construction process represents the division of the object, element into phase and partial processes. Individual function components are divided into types and kinds. Each type and kind of construction work will have specific information for material, technical and technological aspect and so on, see the example in figure 1.

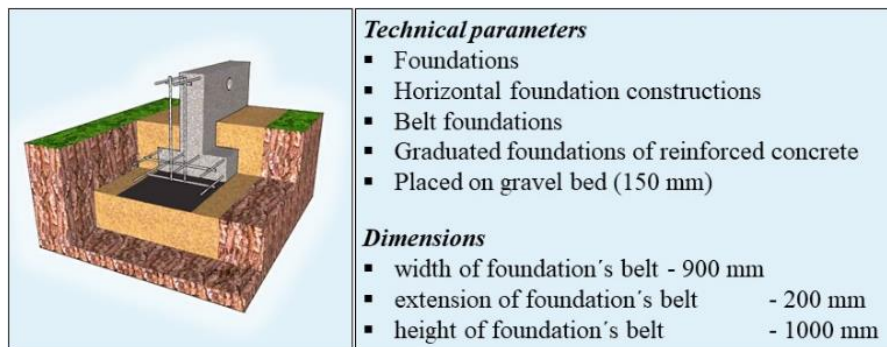


Figure 1. Example of a structural element - Belt foundation - description and specification.

3.3.2. Economic and time aspect. Individual construction elements disposable cost information across the building's life cycle. Procurement costs will be divided according to the calculation formula into direct material, direct wages, machinery and equipment costs, other direct costs, production and administrative overheads, profit and risk. In addition to the above economic parameters, the element will also have information about time, ie unit labor, total labor, technological breaks and the like (see figure 2).

	Economic parameters		
	Process	Unit of measure (UM)	Unit price (UM/€)
Economic parameters	Gravel bed under belt foundation with compacting from gravel 0-32 mm fraction	m3	49,078
	Concreting of reinforced concrete belt foundation (reinforcement 10505)	m3	123,485
	Formwork of foundation strips - components - performance	m2	11,548
	Formwork of foundation strips - components - removal	m2	2,475
	Total price		172,563
	Time parameters		
	Process	Unit of measure (UM)	Unit elaboratenes (Nh)
Time parameters	Placement of gravel bed with compacting from gravel 0-32 mm fraction	m3	1,60
	Reinforcement process of foundation strips - reinforcement 10505	100 kg	1,16
	Concreting of reinforced concrete belt foundation	m3	1,27
	Formwork of foundation strips - components - performance	m2	0,23
	Formwork of foundation strips - components - removal	m2	0,12
	Total elaboratenes- hour		4,38
	Total elaboratenes - days		1
	Technological breaks -days		2
	Total elaboratenes (work+breaks) - days		3

Figure 2. Example of a structural element – Belt foundation – economic and time parameters.

3.3.3. Element durability. The lifetime of an element is the period of time from the actuation of the element to the state when the desired properties fall below an acceptable minimum.

There are two types of durability:

- technical durability – the period during which the construction element performs its function, meets the essential safety requirements and does not endanger the occupants of the building,
- economic durability – time from the beginning of use of the building to its economic disappearance - time of replacement of the original element with a new one. After this time, the construction element becomes unprofitable, so the cost exceeds profit. The economic durability is shorter than the technical durability [13].

Individual building elements have information about the technical and economic durability of the element. Construction elements dispends information also about possible failures, their causes and ways of eliminating the resulting failures. An example of the information included in the information model is shown in figure 3.

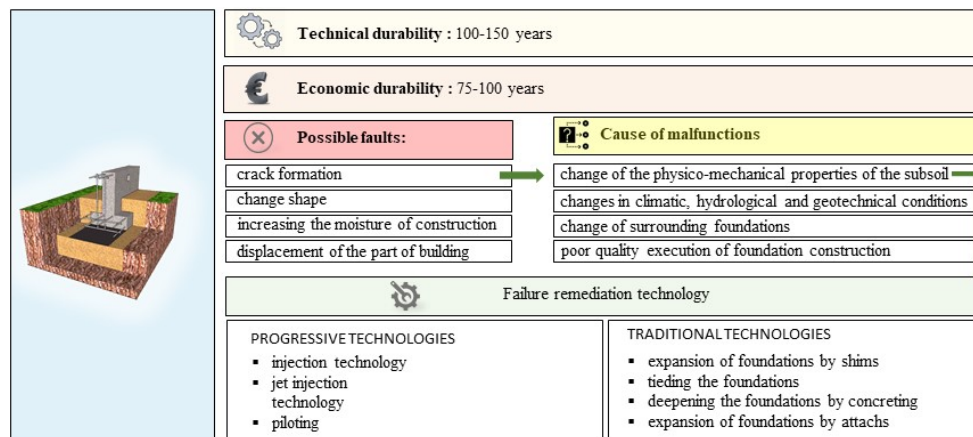


Figure 3. Example of a structural element – Belt foundation – information of durability.

3.3.4. Environmental aspect, concrete sustainability feature. The priority of the created database is to consider and integrate selected environmental aspects of individual elements. Construction elements can have different impacts on the environment, so it is important to consider, for example, resource use, environmental pollution [13][13], the quality of the indoor environment and the functional, aesthetic and social context of the element.

4. Conclusion

Many of the challenges faced by the industry stem from the working environment, which is often unstructured and faces unpredictable and uncontrollable elements. Individual industries are ahead of the construction industry in terms of technological development. Building production is a costly and demanding process. When managing construction production, it is important to have a many of information that will help you manage effectively process. Many innovative technologies and methodologies are used for this purpose. The article deals with database design and identification of parameter structure of information models of individual construction elements. The individual models in the database contain, in addition to the graphical information - 3D model of the element, also information about acquisition costs, information taking into account the time demands realization of the selected structural element and information on the service life of the element and its environmental burden.

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