SAFETY ENGINEERING OF ANTHROPOGENIC OBJECTS

A MAP OF KNOWLEDGE AND ITS IMPORTANCE IN THE LIFE CYCLE OF A CONSTRUCTION OBJECT

"Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?"
(T.S. Eliot, The Rock, Hardcover, 87 pages, Published by Faber, 1934)

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Abstract
In the modern world, knowledge is treated as another resource necessary for the development of civilization. An important element is information, thanks to which you can update knowledge and thus create a compendium of knowledge. Knowledge and its organization is particularly useful in construction. The article proposes a knowledge map, which is a record of domain knowledge. The fields were designated there, and the fields were assigned elements of importance in the life cycle of the building.
Key words: construction objects, construction life cycle, knowledge map

INTRODUCTION

The rapid intensification of globalization trends in world economies, political changes and the dynamic development of the Internet are phenomena full of data that make the role of knowledge very important and the information being its component becomes a necessary factor for efficient operation. The information society is being shaped, in which the creation, distribution and handling of information is the essence of economic activity and cultural.

In the modern world, the terms: data, knowledge and information, should be combined and based on feedback: on the one hand, analyze and select information from the data, then convert information into knowledge, with continuous updating, and on the other - adjust knowledge based on new information and new interpretation already possessed, thus creating a compendium of knowledge in a selected field. In any case, information will be the basis for building knowledge and one of the most important elements of decision making. Each type of knowledge is based on information. In this way, the need for information arises in the conduct

of business and information needs are formed. Information needs result from the information gap (Fig. 1).

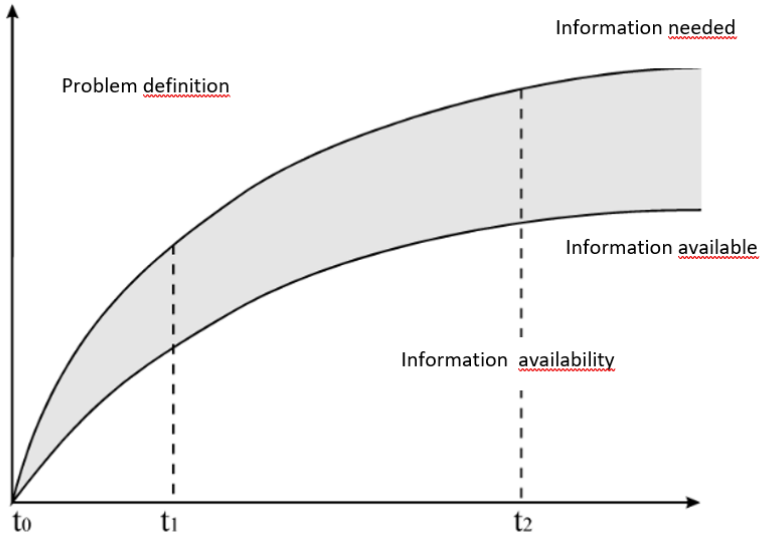

Fig.1. Information gap [Kemball 1973]

Transforming human knowledge into data that can increase people's knowledge in the future is a separate problem. It is a problem of representing knowledge in the form of data in such a way that many future recipients will be able to understand this data, interpret it correctly and use it as knowledge in making decisions. Knowledge and its organization is particularly useful in construction, in the life cycle of a building [Building Law].

Construction objects (buildings, structures, small architecture objects) are specific anthropogenic objects that meet the needs of human existence. They are technical objects with a long life cycle. The life cycle of a construction should be understood as all possible subsequent or related phases of its existence related to supplies, services or works, including research, development, design, production, transport, use, repair, modernization, changes in use, maintenance for the duration of its existence, logistics, training, wear, demolition or demolition [Obolewicz 2016, 2017, 2018].

The specificity of a construction object is mainly due to the conditions in which the implementation of projects in which objects are erected: buildings, structures, small architecture objects [Construction Law]. Specific features of the construction process include:

- the individual character of each undertaking,
- significant dispersion of ongoing construction facilities in the field,
- real estate construction works,
- dependence on atmospheric influences,
- getting the effects of building objects late;
- significant dimensions and large mass of building objects,
- long service life of construction works,
- the random nature of the duration of construction processes.

After the construction works have been carried out, the phenomenon of "disappearance of knowledge" at the participants of the undertaking. It is recommended to gather this knowledge.

A knowledge map serving as a compendium for participants participating in the life of a construction object may be helpful in activities [Obolewicz 2020].

The life cycle of a construction object is defined differently in the literature. According to the standards [Standard ISO 15686-5: 2008], the life cycle of a building means subsequent interrelated periods of time between the selected state and the time until the end of use -"end of life". According to the results of the research on the Engineering of Construction Projects of the Committee of Civil and Water Engineering of the Polish Academy of Sciences, the life cycle of a building is called a certain finite process involving activities related to the phases of the implementation of a construction project involving the planning, execution and operation of a building until its demolition, in which the building is located in various states of existence [Kapliński 2008; Kasprowicz 2010; Kasprowicz et al. 2015]. Using the above-mentioned terms, the life cycle of a construction object can be represented as a model (Fig. 2).

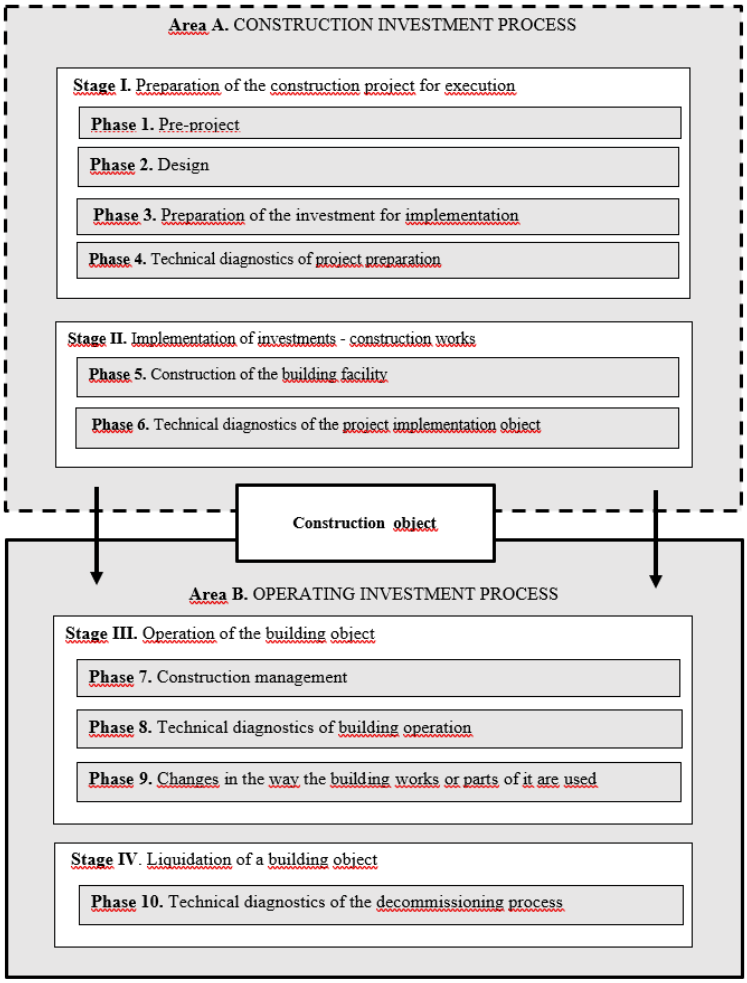

Fig.2. Life cycle model of construdtion object [Obolewicz 2020; Baryłka 2016, 2018, 2019]

The model consists of four stages and ten phases. After making the decision by the inwestor on the investment in the form of a construction project (Area A stage I) technical,

economic and analytical studies of the project's feasibility are carried out due to technical, economic and environmental impact (phase 1). They relate to the conditions for implementing the project on the construction site and the operation of the building. On this basis, the concept is prepared and the project implementation project is prepared, including the construction project (phase 2) and the project preparation for implementation (phase 3). In area A the building does not exist. Jet is a virtual object that during construction is transformed into a real building object (stage II, phase 5) and an operated object (stage III, phase 7) until the decision is made to change the use of all or part of it or the decision to liquidate the object (stage IV).

Technical diagnostics of the virtual object (phase 4, phase 6) and real object (phase 8, phase 10) is indicated at each stage of the life cycle of the building being constructed.

THE CONCEPT OF KNOWLEDGE MAP OF THE LIFE CYCLE OF A CONSTRUCTION OBJECT

In the literature on the subject, various varieties of the Knowledge Map are found. They are used in various fields and in the design of technical devices [Obolewicz 2018, 2020] and increasingly in the implementation of construction projects.

The classic concept of the knowledge map is modeled on cartographic maps in a three-dimensional system (Fig. 3).

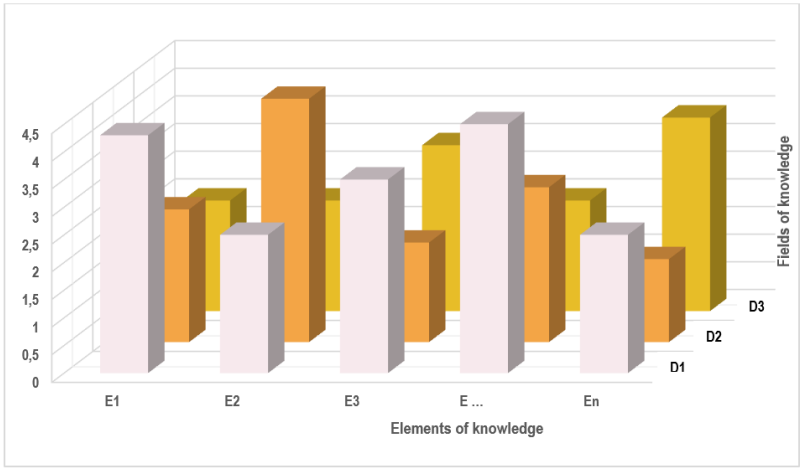

Figure 3. Universal Map of Knowledge [Obolewicz 2020]

The basis of the knowledge map is determined on the "x" axis of the domain (**D**) and on the "y" axis by the elements of knowledge (**E**), and on the "z" axis is the value of knowledge expressed in points, percentages, decimal numbers or other units. The presented situation illustrates the state of deficiencies of the required knowledge in specific elements, which means that knowledge should be supplemented within a specified time. The reason for the lack of knowledge may be faulty training or education and the aging of knowledge in the long term due to failure to keep up with changing legal regulations and technical progress.

The Life Cycle Knowledge Map is a record of domain knowledge. Three areas of knowledge were designated in it and marked with the symbol D_1 , D_2, D_3. Knowledge has been assigned elements of knowledge and marked with symbols E_i.

It is recommended that a preliminary review of the project should be carried out before starting the development of the Life Cycle Knowledge Map. It should include:

- identification of requirements arising from legal and other provisions in relation to the organization's activities in the areas, stages and phases of life of the building,
- assessment of the effects achieved during the implementation of the project in comparison with relevant regulations, norms, guidelines and internal criteria,
- analysis of cases of non-compliance with legal requirements, for example, ascertained by supervisory authorities,
- identification of hazards at workplaces and other hazards associated with the activities of participants of the building life cycle, products or services that can be supervised and which can be influenced,
- checking all the methods used to implement the construction project.

An example knowledge map of a construction project should cover the following areas:

D1 - Stage of preparation of the construction project for execution,

D2 - Stage of implementation of the construction project (construction contracting),

D3 - Stage of use (operation) of the building, combined with the stage of liquidation of the building,

and elements of knowledge assigned to each field - stage of the investment process, e.g.

E1 - Structure, responsibility and rights of participants and commitment of participants: investor, designer, construction manager, building manager

E2 - Provision of funds,

E3 - Communication,

E4 - Documentation of the project implementation stage,

E5 - Occupational risk,

E6 - Subcontracting,

E7 - Monitoring,

E8 - Reliability, corrective and preventive actions,

E9 - Inspections,

E10 - Improvement.

Fields of knowledge (**Dn)** are described with the help of (**En**) elements, which constitute the main components - particles of the whole life of a building object and contain the most important information about a given field, in accordance with the classic definition of an organization, treated as a whole consisting of parts of success which parts contribute and parts contribute to the success of the whole. At the same time, each building object (building, structure, small architecture object) in each phase of its life cycle has its subjective characteristics that should be identified and placed in the knowledge map.

Examples of the elements of knowledge of stages: preparation of a construction project for execution, implementation of a construction project (construction performance) and use (operation) of a building object are presented in Table 1.

The process of preparing the investment for implementation is very complex because it covers a number of different disciplines of knowledge that must be applied and used to identify market needs, develop technological and technical assumptions and solutions, acquire and properly spend financial resources, perform a number of different surveys, studies and documentation and conducting administrative procedures that will result in various types of administrative permits and decisions.

Table 1. Example elements of knowledge domains **D1**, **D2**, **D3**

Number	Field of knowledge	Elements of knowledge
1	D1 - Stage of preparation of the construction project for execution	E1. Project formulation in terms of market needs. E2. Characteristics and functional and material parameters. E3. Organizational and financial assumptions. E4. Legal conditions conditioning the enterprise. E5. Location infrastructure and technical conditions. E6. Type, scope and procedures for preparation of program documentation. E7. Program documents and technical documentation. E8. Applications, studies, permits and decisions. E9. Administrative procedures in the investment preparation cycle.
2	D2 - Stage of implementation of the construction project (construction contracting)	E1. Preparation of the construction site. E2. Organizing hygiene and sanitary facilities. E3. Construction documentation. E4. Warehousing and storage of building materials. E5. Collective protection measures. E6. Machines and technical devices. E7. Construction media. E8. Construction works technology. E9. Employee qualifications and training. E10. Organization of work places on the construction site. [Obolewicz 2016, 2017, 2018, 2020]
3	D3 - Stage of operation of the building, combined with the stage of its liquidation	E1. Technical and aesthetic condition of the building. E2. Technical requirements to be met by building objects in the process of their operation. E3. Forms of building object wear in the process of its operation. E4. Identification of damage to building structures in the process of their operation and the reasons for their occurrence. E5. The process of changing the technical condition of a building. E6. Technical diagnostics of building objects in the process of their operation. E7. Periodic inspections of building objects in the process of their operation.

		E8. Renovation works at construction works in the process of their operation. E9. Works related to the adaptation of construction works to new technical and functional requirements. E10. Legal conditions for the implementation of works related to renovation, reconstruction (extension, superstructure) and demolition of building objects .. E11. Changes in the use of buildings or parts of buildings. E12. Obligations of entities responsible for the operation of buildings. E13. Problems of construction accidents and disasters in the process of operating construction works [Baryłka 2016, 2018, 2019; Baryłka A, and Baryłka J. 2016].

The investment preparation process includes certain stages such as forecasting, programming and plan creation. Forecasting is based on predicting future phenomena and processes, while programming is based on the final definition of the goal and means of its implementation. The plan includes specific technological, technical, organizational, legal and financial solutions. The plan's effectiveness can only be assessed at the end of the investment cycle by analyzing the process, time, costs and final effects.

Preparation of an investment project requires a good knowledge of legal and administrative, technical, technological and organizational issues, and in large undertakings, also logistics and professionally conducted coordination, supported by modern management tools.

Before making a decision on the implementation of an investment project, it is necessary to recognize the local market and related markets, to understand the economic and economic conditions of the planned production environment. Market recognition can indicate niches for specific goods or services, the ability to seamlessly integrate into an existing market, or to join a cooperative structure. At this stage of production preparation, knowledge is needed to recognize current processes and economic phenomena as well as forecast trends of market changes.

Knowing the needs and absorptive power of the market, you can start programming the project. At this stage of the preparatory work, technical knowledge is needed to determine the type of planned activity, technology and detailed technical solutions for the project. Knowledge derived from market recognition must be directly translated into determining the volume of production, quality and modernity of products. Technologies and technical solutions must be selected for these boundary conditions. The entire process of preparation, production and distribution of finished products must be detailed in necessary objects, structures and technical devices. A detailed list of equipment and material needs creates the basis for preparing an estimated cost estimate for the project.

Knowing the estimated cost of the planned undertaking, actions should be taken to specify the sources and terms of financing the undertaking. Large projects mean that the financing comes not from one, but more payment sources, financing specific tasks or parts of the investment process, imposing different conditions for granting the loan. In this section of preparatory work, a lot of knowledge is needed regarding the possibilities of obtaining funds

from various sources and in the field of banking, planning and settlement of financial resources depending on the conditions of the loan granted.

Securing financial resources, opens the next stage of preparatory work, concerning the outline of the administrative procedure path, determining the required studies, documents, projects, technical documentation and obtaining the necessary administrative arrangements, permits and decisions. This stretch of work requires different preparation and specialist knowledge. At this stage, there are also detailed legal regulations conditioning technical, organizational, planning, environmental solutions and a number of other depending on the specifics of the planned undertaking.

Legal requirements make it necessary to adapt the necessary documentation and technical and organizational solutions to the requirements in order to obtain the necessary permits and administrative decisions. Preparation of documentation that meets the imposed conditions as well as conducting administrative procedures, obtaining arrangements and decisions requires separate specialist knowledge.

Investment preparation is a very complex process and takes a relatively long time. In the course of these works, various market conditions, legal requirements, quality standards, requirements, financial conditions and a number of others may change. A shorter investment cycle, especially the investment preparation stage, facilitates the planning process and contributes to improving the accuracy of decisions made. The implementation of individual sections (stages) of the preparation process gives an overview of the progress and advancement of works and is commonly referred to as the investment process meter. However, this is not a permanent concept, clearly defined in terms of the content of the works, which fit into the distinguished sections.

The process of preparing investments in the budgetary sphere is even more complex compared to the investment process carried out in private enterprises. The differences occur mainly in the documentation and detail of the proceedings regarding the determination of project costs, obtaining funds for implementation, procedures related to the selection of contractors, kept documentation of project implementation and settlement of financial resources.

There are also differences resulting from the specifics of the facilities being built, consisting in the need to draw up additional documentation, obtain arrangements and additional administrative decisions

ANALYSIS OF AVAILABLE KNOWLEDGE

The content of Table 1, although exemplary, aptly reflects both the complexity of the project, including the preparation, implementation and operation of building objects and conditioned by multidimensional impacts of the environment, as well as the requirements for knowledge resources necessary for proper organization and implementation of the life cycle of building objects. This complexity means that situations arise during the implementation of the project that require decisions on potentially far-reaching - multidimensional - effects. Therefore, making the right decision requires skilful processing of information resulting from

observing the environment, while using available knowledge resources. The well-thought-out organization as well as their completeness and timeliness contribute to the efficient use of knowledge resources. Knowledge resources should therefore be treated as a living system of potentially interrelated, constantly updating components. A necessary condition for efficient management is the proper modeling of relationships between its components. To this end, various tools can be used.

Such mature tools include cognitive maps [Tolman 1948] and decision maps [Tzeng et al 2008]. Their use is favored by the possibility of modeling them using commonly available, universal methods. In this context, DEcision MAking Trial and Evaluation Laboratory (DEMATEL) can be particularly recommended [Fontela and Gabus 1976]. The practical usefulness of, among others, the choice of this method to identify the causes of failures [Dytczak and Ginda 2010] and key success factors [Dytczak and Ginda 2009] and the correlations between risk factors in construction [Ginda and Maślak 2012]. An important advantage of this method is also the possibility of taking into account imperfect information and expanding its potential due to diverse joint applications with other tools [Dytczak and Ginda 2012].

CONLUSION

Construction objects are anthropogenic objects with a long life span and they require the organization of knowledge in particular. In any case, they should be designed, built and operated in a way that is safe for human health and life.

The proposed Knowledge Map is a compendium of knowledge that uses information from the guidelines of the International Labor Organization, European Union directives and national (Polish) legal regulations regarding the implementation of construction projects as well as the experience of participants involved in the implementation of construction projects that can be used in the implementation of future construction projects . The process of preparing an investment project requires special attention. In this process you need to have a good knowledge of legal, administrative, technical, technological as well as organizational, logistic and management issues. The investment preparation process is characterized by stages of action determining the stage of completion of the preparatory works, such as forecasting, programming and creating a plan. Forecasting is based on predicting future phenomena and processes, while programming is based on the final definition of the goal and means of its implementation. The plan includes specific technological, technical, organizational, legal and financial solutions. The quality of preparatory work can be assessed only at the end of the investment cycle, analyzing the process, time, costs and the final result achieved.

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