EFFICIENCY OF SINGLE-FAMILY HOUSES AND HARMONISATION OF THEIR LIFE CYCLE PARTICIPANTS' INTERESTS

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- THESIS REVIEW -

Topic of research. An efficient single-family house is the main purpose of the life cycle. It determines the necessity to evaluate various decisions of the life cycle of single-family houses and possibilities to satisfy objectives and requirements of the participants of that process. To design and achieve an effective process of the life cycle of a single-family house, it is necessary to take care of its efficiency starting from the determination of needs and objectives and ending with the usage of a building.

At each stage of the life cycle of a building, various interested parties are involved: clients, designers, contractors, manufacturers and suppliers of construction materials and products, users, public and municipal institutions, buildings supervisory and repair organisations, etc. During the design of the life cycle of a building and the decision-making, it is necessary to take into account the interests of these interested parties. The life cycle of a building depends on a variable external environment, as well as its stability. While making complex analyses, the efficiency of a single-family house depends on other parts of the system in a definite moment. Therefore, the life cycle of a single-family house has to be designed and implemented taking into consideration its stages, objectives and opportunities of interested parties involved in the process, having evaluated the external environment on the micro- and macro-level, simultaneously influencing the efficiency of a single-family house and the process of its life cycle. A variety of factors describing the efectiveness of single-family houses poses the question: how to evaluate decisions of the life cycle of a building in many aspects.

Seeking to solve strategic, economic, technical, social, qualitative and other goals, it is necessary to base them on quantitative and qualitative

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evaluation criteria describing objectives and opportunities, alternative decisions of interested parties, and the existing situation of the external environment. Seeking to define ground and reach these objectives, it is required to apply the methods of multiple criteria analysis that may be successfully implemented in the decision support systems.

The decision support system, in the settlement of various problems related to construction activities and the life cycle of a building, takes the shape of a modern and advanced tool. This tool helps participants (i.e. client, designer, contractor, supplier, user, etc.) of the building life cycle to successfully seek for their objectives and increase the efficiency of the life cycle. While applying the methods of the multiple criteria analysis in a decision support system, it is possible to settle the problem of optimisation of the intended objectives and sources required for their implementation: having made an analysis of possible variants of the life cycle of a single-family house, the most efficient combination of he intended objectives and the existing opportunities of the participants (interested parties) of this process.

Object of research are single-family houses and their life cycle. The research covers the whole complex of life cycle stages and the interested parties involved in the process, as well as seeking for their objectives and determining the influence of the external environment to the efficiency of single-family houses.

Main goal of research is a complex solving of problems associated with the single-family houses life cycle and the increasing of efficiency with the assistance of a decision support system, a model of a building life cycle analysis and the multiple criteria analysis methods. In order to reach the objective, the following problems are addressed:

- making an analysis of composition parts of single-family houses' life cycle (stages, participantd and the factors of the external environment influencing a building life cycle) and describing them by a set of criteria;
- making an anylsis of mathematical methods and models being used at present and applied in the settlement of problems of a building life cycle;
- developing a theoretical model of analysis of a single-family house life cycle, implementation of which, would allow the interested parties of a building life cycle to more efficiently implement their objectives and needs, in order to simultaneously increase the efficiency of the life cycle and the single-family houses;

- suggesting a criteria system describing the life cycle (decisions) of the single-family houses, which would describe the life cycle of a building, influencing factors and the parties involved in the process, both in a qualitative and a conceptual form;
- applying the methods of multiple criteria analysis to a model of single-family house life cycle;
- developing a decision support system of the single-family houses' life cycle, which would allow a complex analysis of such a process, as well as its multivariant design and evaluation.

Method of research of the single-family houses' life cycle is based on the analysis of Lithuanian and foreign scientific literature in the field of designing a building life cycle, theory of decision-making and information systems. While solving problems associated with the research, the following methods were applied: data collection through a questionnaire and interviews, statistical analysis, principles of analogy, comparative analysis and the methods of multiple criteria analysis.

Novelty of work can be assessed through the following features of the thesis:

- Various criteria systems describing the efficiency of a single-family house life cycle and methods of their constructing are analysed. On the basis of such an analysis, the complex criteria systems are suggested, describing the life cycle of a single-family house;
- The life cycle of a single-family house is being evaluated in a complex manner, including evaluation of the whole complex of different stages, interested parties and external environment. Influence of various quantitative and qualitative factors on the efficiency of a building life cycle is examined;
- A model for analysis of a single-family house life cycle is developed and the key stages of a building life cycle, interested parties, factors of the macro- and micro-level influencing the efficiency of a building life cycle, including their mutual dependency, are described;
- Methods of multiple criteria multivariant design and multiple criteria analysis are applied to making and evaluating variants of a single-family house life cycle;
- A decision support system of the life cycle of a single-family house is developed, application of which would allow the interested parties to implement their objectives and needs more efficiently, as well as increase the efficiency of a building and its life cycle;

- A complex approach into the efficiency of the single-family houses is realised by using the research methodology and the decision support system. By following such a system, it is possible to evaluate the life cycle of a building in a economic, technical, qualitative, ecological and similar aspects.

Practical benefit of work reflects in the following:

- The decision support system og a single-family house life cycle is developed, application of which would allow the interested parties of a building life cycle to solve the problem of optimisation of intended objectives and sources for their implementation. Having made an analysis of the possible variants of a building life cycle, the most efficient combination of the intended objectives and available possibilities is determined;
- Broad material describing the stages if a single-family house life cycle, interested parties and external environment is summarised. The complex systems of qualitative and quantitative criteria characterising the life cycle of a building are suggested;
- The main results of the work, conclusions ans suggestions may be useful for further research in the settlement of problems of efficiency of single-family houses.

Verification of the results obtained. The main data obtained in the research were discussed at the scientific conferences and seminars held in Aachen, Minsk, Kaunas and Vilnius. The basic results of the research are published in nine articles.

Structure of the research. The research comprises an introduction, four chapters, conclusions and suggestions, references to 147 items of source literature, references to the author's publications and nine appendixes. The work consists of 158 pages.

Chapter 1 reviews the research works of scientists from Lithuania, UK, Denmark, Sweden, USA, and Russia, whose works include settlement of various issues on the building life cycle, the theoretical fundamentals of decision-making and the building life cycle decision evaluation and the opportunities to use information systems in the life cycle of a building. Having summarised the problems regarding the settlement in research works in the field of the building life cycle, a classification of researches is made. The submitted

classification shows a concept of the efficiency of a building, its nature, relation with the life cycle, and opportunities to use information technologies.

Chapter 2 includes an analysis of the efficiency of the single-family houses and their life cycle, its dependency on different stages (decisions) of a building life cycle and its whole complex, the level of external micro- and macro-level environment and the level in which the interested parties fulfill their objectives. It also presents criteria systems describing the life cycle and the prerequisites for development of a database. A theoretical model developed for the complex analysis of the efficiency of single-family houses and their life cycle is under detailed examination, in which various factors and circumstances are described by a set of criteria. Following that model, the interested parties involved in the design and realisation of a project are able to design alternative variants of a single-family house life cycle (various decisions), to evaluate them and determine the most efficient, i.e. to find an efficient decision for the existing situation. A variety of decisions allows a more exact and efficient evaluation of the life cycle of a building in economic, qualitative, legal, technological and other aspects, as well as the fulfillment of interests of the various parties, efficient satisfying of the client's requirements and the needs of other interested parties involved in a project.

Chapter 3 presents an analysis of mathematical methods used in the dissertation and prerequisites for the application of the methods in the evaluation of the single-family houses' life cycle, which include:

- opportunities for use of multiple criteria analysis in the single-family houses' life cycle,
- methods of determination of the values and the significances of the criteria,
- method of multiple criteria complex proportional evaluation of the projects,
- method of defining the utility degree and the
- method of multiple criteria multivariant design of a building life cycle.

On the basis of described methods, a model of analysis of a single-family house life cycle, developed in Chapter 2 of the dissertation, is being realised: the whole complex of the life cycle, participating interested parties and the external environment influencing the project are described in quantitative and qualitative forms. A complex database is also developed, alternatives of an actual life cycle of a single-family house are designed, different variants (plots of land, the single-family houses, contractors and maintenance process variants) are selected for analysis, and the efficient variant is selected.

Chapter 4 presents the original decision support system developed in this research. In this chapter, its structure and the main functions of its components are shown.

Using the information gathered in the decision support system database and following the models of the model base, various interested parties involved in the process of the single-family houses' life cycle are able to make efficient decisions. Methods of multiple criteria multivariant design and analysis being applied in the developed decision support system allow the establishment of the efficient life cycle (its decisions) of the single-family houses, in quantitative and qualitative terms, as well as the level of project utility. Use of the methods of multiple criteria analysis in the decision support system enables various interested parties (clients, designers, contractors, users, etc.) to reach their objectives and satisfy their needs.

Conclusions and suggestions are the following:

- The suggested criteria system describing the life cycle of the single-family houses allows the evaluation of economic, architectural, technical, technological, comfort and other decisions in terms of needs and opportunities of the clients, designers, contractors, users and other participants of this process;
- An evaluation model of analysis of the life cycle of the single-family houses is developed. The analysis showed that the efficiency of a building life cycle depends on the adjustment of efficient stage decisions and interests of interested parties involved in the process, implementation of objectives and the external environment influencing the project. Implementation of the developed model of complex analysis would allow the interested parties of a building life cycle to more efficiently meet their needs and objectives and to evaluate all the expenses relative to the implementation of the project;
- The conceptual and quantitative description of the single-family houses' life cycle and the different alternatives of its decisions are proposed, which allow to evaluate, in detail, the life cycle of a building. Following the conceptual and quantitative information, which describes the life cycle of a building, the interested parties (taking into account their priorities and the existing situation) are able to rationalise decisions made;
- Methods of multiple criteria analysis (method of complex determination of the significances of the criteria, method of multiple criteria complex proportional evaluation of the projects, method of defining the utility degree) are applied to complex analysis of the single-family houses' life cycle, as well as to evaluation of decisions;

- The method of multiple criteria multivariant design is applied for designing variants of the single-family houses' life cycle. On the standpoint of long-term prospects, the multivariant design and multiple criteria evaluation of a building life cycle allows interested parties to make efficient decisions on the ground of quantitative and qualitative variants analysis;
- The proposed methodology allows evaluation of the single-family houses' life cycle as a whole complex, i.e. to take into account the different stages of a building life cycle, the whole of interested parties involved in the process and factors of the external environment;
- Following the performed analysis of the used information, expert and decision support systems, described in the dissertation by the key principles and methods of multiple criteria analysis, an original decision support system of the single-family houses' life cycle has been developed, as well as the required data structures as well. The system allows a complex analysis of the life cycle of a building, its compound parts, interested parties involved in the process and factors of the external environment influencing this project;
- Methods of multiple criteria multivariant design and analysis being applied in the developed decision support system assist to establish, in quantitative and qualitative terms, the efficient life cycle of the single-family houses (decisions thereof), as well as to determine the level of utility of projects. Use of the methods of multiple criteria analysis in the decision support system enables implemention of objectives of various interested parties (clients, designers, contractors, user, etc.) and guarantees a satisfaction of their needs;
- Complex databases of the single-family houses life cycle and its compounds are developed, in which the alternatives are being described in economic, technical, technological, architectural, infrastructural, quantitative, legal and other aspects. Use of these complex databases in the decision support system creates conditions for the complex analysis of a building life cycle in quantitative and conceptual forms;
- Having applied information gathered in the database of a decision support system, following the models of the model base, various interested parties of a building life cycle are able to make efficient decisions. The system provides the user with all the necessary support that is required to argue upon the decisions taken: in information terms – receipt of quantitative and conceptual information describing a building life cycle, including their collection and use; in terms of selection of efficient variants – management and processing of such information by applying the methods of multiple criteria analysis.