ABSTRACT

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Title of the dissertation: *Life Cycle Assessment (LCA) application in the design of single-family house architecture*

The subject of this dissertation is the application of Life Cycle Assessment (LCA) in the design of single-family house architecture.

The anthropocentric character of the natural environment's transformation results in an inclination to investigate of the impact of the life cycle of buildings from the their construction, to their use and demolition. This leads to an analysis of climate change and environmental impact control. Currently erected buildings feature a diverse array of construction techniques and technologies, and research methods enable the classification and analysis of their environmental impact.

The following hypothesis was formulated in the dissertation: The application of Life Cycle Analysis and Assessment methods throughout all stages of the design process significantly impacts the architecture of single-family houses and provides control over environmental impact.

The study of the impact of buildings on the natural environment across the entirety of their life cycle (construction, use, demolition) was intended to determine the impact of LCA on the architecture of single-family houses and the properties of their ecological features that belonged to the architectural form during the design process.

The objective of the dissertation was to verify how Life Cycle Assessment, applied over the different design phases, affected the architecture of single-family houses, their function, construction and materials, as well as form.

The following research objectives were defined:

- Human impact on the natural and built environment,
- The life cycle of materials used in single-family housing,
- The life cycle of structural systems used in single-family housing,
- The life cycle of a single-family house in connection with the stages of a family's life,
- Assessment of materials in terms of their life cycle in combination with the entire building's life cycle,
- Demonstrating the life cycle of the entire structure, along with renovations, demolition, recycling, neutralization, etc. in connection with the life cycle of residents (families),
- Investigation of whether the introduction of Life Cycle Assessment (LCA) in the design process can lead to achieving minimum building environmental impact without impacting the aesthetic character of the building's architectural form,
- The utility of introducing Life Cycle Assessment in architectural design as based on single-family houses.

The subject matter discussed in the dissertation is an attempt at presenting a new approach due to the fact that the LCA method was extended to include additional analyses that characterise the ecological properties of a single-family house's architecture.

For the purposes of the dissertation, Life Cycle Assessment was conducted and its results were analysed. To this end, research concerning the Life Cycle of construction materials used in the buildings' structure also covered the technology of building single-family houses.

To perform additional analyses, specialist software was used: Autodesk Ecotect Analysis, Autodesk REVIT, Autodesk Flow Design, Solidworks Flow Simulation. These tools enabled the analysis of the ecological properties of the building's architectural form in terms of:

- Analysing its orientation relative to the cardinal directions,
- Analysing the building's annual surface insolation and that of the entire urban area,
- Analysing the shadows cast by buildings,
- Analysing annual access to daylight in the building's indoor spaces,
- Analysing annual energy gains and losses via passive solar energy systems,
- Analysing energy demand over a period of 100 years,
- Analysing wind flow along the entire housing complex,
- Analysing the impact of pressure from wind load on the external structure of buildings.

The assessment was performed by comparing the results of Life Cycle Analyses. Afterwards, the ecological features of buildings were determined based on Life Cycle Assessment results subjected to Life Cycle Analyses.

The dissertation acknowledged that the problem under investigation is impacted by numerous factors that define its complex character. These include, among others, environmental factors that affect the form of the building and the properties of construction materials included in its structure. Difficulty in characterising the ecological dimension of a building via its physical properties in controlling impact on the natural environment was encountered. The investigation, which had the character of life cycle assessments and analyses, simultaneously define two dependencies: the impact of the environment on architecture (e.g., the sun and wind), and of architecture on the environment (e.g., resource consumption, CO_2 emissions). Both of these problems are inseparably subjected to assessment over the life cycle, giving the proper dimension to the ecological properties of a building's architecture. The study found that the selection of material, technical and technological solutions defines the impact of the building's entire structure on the natural and built environment over time. This applies to environmental, ecological and aesthetic considerations. Investigating a single-family house using LCA appears to be a rational and correct trajectory in the development of eco-friendly architectural design.

Based on the material collected over the course of the study and the analyses performed, it was concluded that applying LCA allows to identify the impact of this method on architecture (structure-function-form) of a single-family house. Extending LCA to include the impact of the building on the environment, and of the environment on the building, determine the design process in terms of the multi-aspect and multidimensional perception and design of the building. It is also indicated that these analyses affect architecture (structure-function-form) and minimise the negative impact on the environment via informed material selection, energy analysis and proper design of the architectural form. The hypothesis was proven, as indeed the application of Life Cycle Assessment and Analysis (LCA) across all stages of the design process has a considerable impact on the architecture of single-family houses and the control of their environmental impact.