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DESIGN CONCEPT OF BUILDING CONSTRUCTIONS, ENVIRONMENTAL ASSESSMENT AND MATERIAL SOLUTIONS

Designing a building requires an interplay of architecture and design parameters to create an artificial material environment. Each architectural and engineering design has direct impact on the indoor climate environment and is a key determinant of operational performance of buildings throughout their life. The following paper presents one important component of the process of reducing the operating energy performance of buildings within a designated period of their exploitation as packaging design of buildings and their physical and technical characteristics, which are intended design concept and building material solutions.

Keywords: **energy consumption, indoor climate environment, design concept and building material solutions**

INTRODUCTION

The construction industry has a significant impact on the environment, economy, and society. Buildings are one of the largest contributors to greenhouse gas emissions; they are responsible for 38% of all emissions of CO_2 (retrieved from *EIA*). Increased awareness of the enormous ecological footprint of the built environment has substantially increased importance and popularity of various green building initiatives as a possible solution to remedy the damages incurred on the planet. Many of these initiatives focus on enhancing biodiversity, improving air and water quality, reducing solid waste generation, and conserving natural resources of buildings. These initiatives are changing the construction industry and significantly increasing the share of green building market [1-3]. The assessment of environmental performances of construction materials and products is a complex issue which requires use of a set of comprehensive criteria [4]. The environmental impacts of these materials can be observed, in fact, at several levels: locally, if we look at the effects of activities such as quarrying or at specific impact of the manufacturing processes (e.g. dust emissions, noise); globally, as a result of greenhouse emissions linked to the energy consumption or released during the manufacturing process; also internally, considering the effects on the health of the building occupants [4, 5]. Therefore, a correct evaluation should adopt a life cycle perspective [6, 7], considering not only the impact of materials production stage (raw material supply, transport, manufacturing of products and all upstream processes from cradle to gate), but also their contribution in the building construction process (transport to the building site and building installation/construction), use phase (energy losses, maintenance, repair and replacement, refurbishment) and, finally, end-of-life (recycling and disposal, including transport). In the existing buildings, the impacts of the use phase are usually the dominant ones and are mainly due to the building energy demand for heating and cooling [2, 8, 9]. The impacts due to the construction products manufacturing on the overall lifetime impact of a building are smaller, but nevertheless significant [10, 11] and, as buildings become more energy efficient, they are expected to increase significantly [12]. In order to reduce the total energy use in buildings, it's extremely important that the design of new buildings will focus not only on reducing the required operational energy (obtained by burning fossil fuels or consuming electricity in lighting, heating and cooling systems), but also on the choice of building materials [3, 12].

1. THE CONSUMER MODEL

The assessment of the environmental performances of building materials and products is a complex issue which requires use of a set of comprehensive criteria [9]. Energy and environmental impact are two major concerns of today's new building design and construction [2, 8]. The aim of this paper is to present a concept of building structure design and environmental assessment for a consumer model of research in order to force the integration of renewable energy sources. In this paper there is presented an initial integration of the energy and environmental performance of the consumer model which will be confronted with measurement in situ. It is designed as a passive house with the specific heat energy demand for heating that is less than 15 kWh/m^2a. The specific total final demand of the consumer model is 40÷60 kWh/m^2a. Its total amount of primary energy is 100÷120 kWh/m^2a. It is equipped with a comfortable ventilation system with heat recuperations. The heat transmittance coefficient: envelope structures: $U < 0.10 \div 0.13$ W/m^2K; roof structures: $U < 0.10$ W/m^2K; floor on the ground: $U < 0.10 \div 0.15$ W/m^2K; windows: $U < 0.8$ W/m^2K. Built-up area is 55.2 m^2.

Consumer model is an experimental building that is a part of the research faculty. It is built in the laboratory hall and placed in climate chambers, where exterior temperatures are simulated. Parameters of peripheral structures correspond to the parameters of passive house. The paper presents systems to ensure the internal environment in rooms with the help of air conditioning and heating systems using renewable energy sources.

1.1. Concept of building structure design

The consumer model is a single-story building with one bedroom, one living room with kitchen, bathroom and toilet. In the figure (Fig. 1) there are shown its view and floor plan. The consumer model has been designed in two alternatives of thermal insulation. The alternative I has mineral insulation (Fig. 1 Details “B” of Exterior Roof Composition, Details ”C” of Exterior Wall Composition, Details “A” of Foundation Composition) and the alternative II has polystyrene insulation.

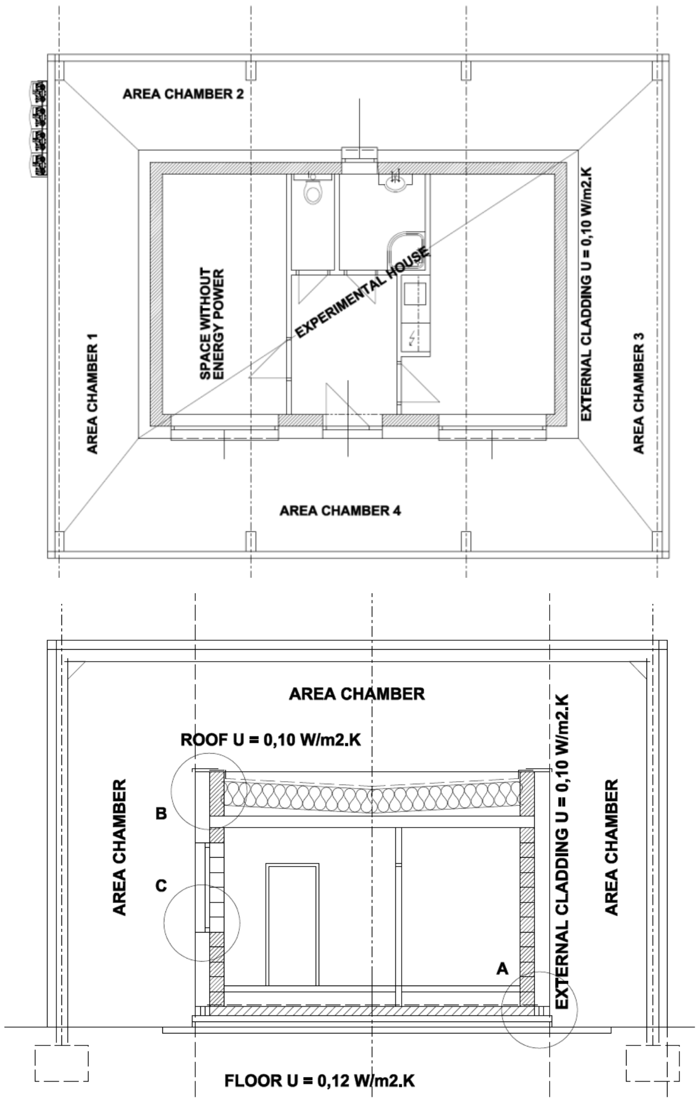

Fig. 1. The floor plan of the consumer model

2. ASSESSMENT OF BUILDING IN TERMS OF ENERGY NEED FOR HEATING

The annual energy consumption affects the amount of input parameters. When considering quantitative thermal variables of transparent and opaque building envelope design and the resulting average heat transfer coefficient U_{em} (primary variable describing the quality of the building envelope in terms of heat loss) the conditions of the building annual energy consumption must be satisfied [10].

3. ENVIRONMENTAL PERFORMANCE OF CONSUMER MODEL

The construction industry has a significant impact on the environment, economy, and society. Buildings are one of the largest contributors to greenhouse gas emissions; they are responsible for 38% of all emissions of CO_2 [11]. The environmental impact of the consumer modes has been computed using the information database Passivhaus Bauteilkatalog [12]. Building materials, components and structures of two alternatives of consumer model were evaluated according to amount of embodied energy, amount of CO_2 and SO_2 emissions. The present knowledge allows evaluating the part of life cycle from raw material exploitation to production of architectural elements. The values of primary energy for this part of the life cycle are determined by specialists. The consumer model was assessed from primary energy point of view derived from non-renewable energy. The value of total primary energy embodied in building materials and constructions is 198 352.94 MJ per year in alternative I and 295 164.81 MJ per year in alternative II (Fig. 2). The global warming potential is expressed as equivalent amount of CO_2, which significantly contributes to the greenhouse effect. The following figure (Fig. 3) shows the amount of CO_2 emissions related to building materials and structures used in the evaluated object.

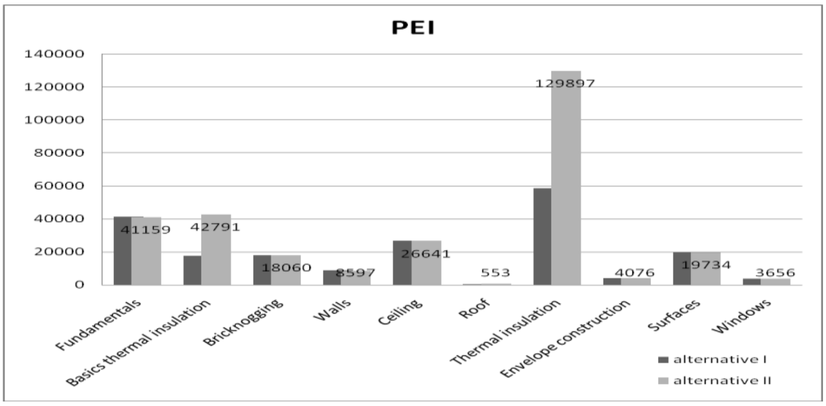

Fig. 2. PEI [MJ]

The total CO_2 emissions represent the value of 17 970.20 kg per year in alternative I and 97 522.4 kg per year in alternative II. The total area of building represents value of 55.2 m^2. The value of CO_2 emissions related to m^2 area of the building represents a value of 325.54 kg/m^2 per year in alternative I and 1766.7 kg/m^2 per year in alternative II. The acidification of environment produces sulfur dioxide, nitrogen oxides, ammonia and others. Sulfur dioxide has the most significant effect, therefore it is expressed as equivalent amount. The total amount of SO_2 emissions related to building materials and structures represents value of 65.52 kg per year for alternative I and 217.09 kg per year for alternative II (Fig. 1 Details "B" of Exterior Roof Composition, Details "C" of Exterior Wall Composition, Details "A" of Foundation Composition). The value of SO_2 emissions related to m^2 area of the building represents value of 1.18 kg/m^2 SO_2eq. per year for alternative I with mineral insulation and 3.93 kg/m^2 SO_2eq. per year for alternative II with polystyrene insulation.

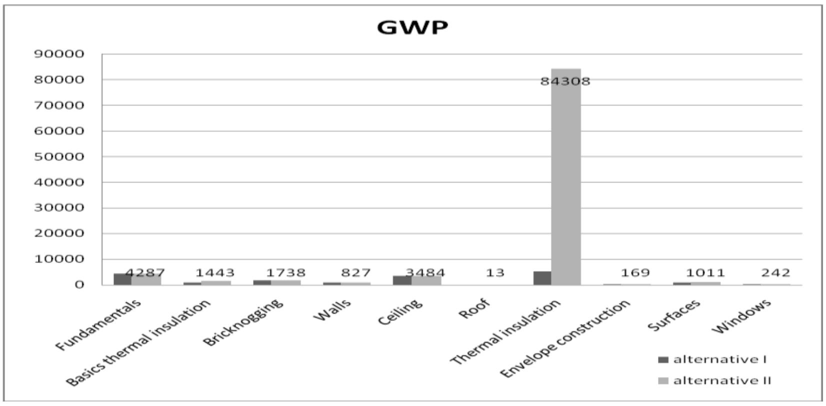

Fig. 3. GWP [kgCO_2eq.]

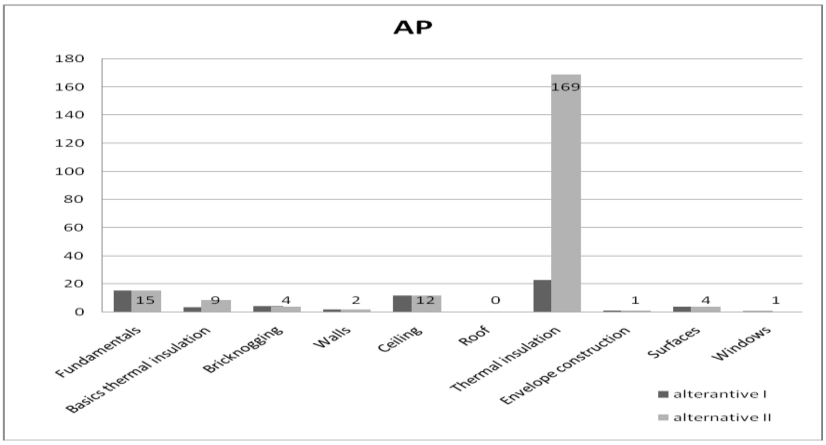

Fig. 4. AP [kg SO_2eq.]

CONCLUSION

In order to identify savings in energy and emissions from any type of bioenergy production and use, a thorough evaluation from "cradle to grave" must be carefully carried out [13] but our LCA analysis has been computed from „cradle to gate". Energy efficiency is a basic principle of the Passive House concept, but despite its importance, efficiency of household appliances is designated as an optional Passive House solution [4]. Energy efficiency is a basic principle of the Passive House concept, but despite its importance, efficiency of household appliances is designated as an optional Passive House solution. Therefore, the consumer model will be confronted with measurement in situ. Based on the results of measurements and after fine-tuning simulations of the experimental building it is to obtain relevant results applicable in practice for the design of passive buildings, in compliance with basic hygienic requirements in terms of structures, internal environment and in terms of design and use of heating or ventilation systems. The objective of this article was to present a concept of building structure design and environmental assessment for the consumer model of research in order to force the integration of renewable energy sources.

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KONCEPCJA PROJEKTOWA KONSTRUKCJI BUDYNKU, OCENY EKOLOGICZNEJ I ROZWIĄZAŃ MATERIAŁOWYCH

Projektowanie budynku wymaga współgrania rozwiązań architektonicznych z wymaganymi parametrami projektowymi w celu stworzenia optymalnego środowiska wnętrz. Każde architektoniczne i konstrukcyjne rozwiązanie ma bezpośredni wpływ na mikroklimat oraz kluczowe znaczenie dla kształtowania się parametrów eksploatacyjnych budynku w cyklu jego życia. Istotnym elementem w procesie redukcji zużycia energii w planowanym okresie eksploatacji jest wybór odpowiednich rozwiązań materiałowo-konstrukcyjnych.

Słowa kluczowe: **redukcja zużycia energii do ogrzewania, rozwiązania materiałowo-konstrukcyjne, mikroklimat wnętrz**