EVALUATION METHOD REGARDING THE EFFECT OF BUILDING DESIGN IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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EXTENDED ABSTRACT

In this essay a method for the evaluation of building design is formed, which takes into consideration the crucial parameters of design and evaluates their environmental impact during the life-cycle of a building (construction, operation, and demolition). Buildings of similar geometrical characteristics, but constructed of different materials are being compared. According to this method, the parameters being evaluated are the energy consumed during the construction and operation of a building, as well as its toxic behavior and the different pollutants that appear in the various stages of its life-cycle. In addition, the assimilation of its materials and therefore of the building itself by the environment is being considered.

At first, the quantity of construction materials used is being measured out, in order to determine the embodied energy of the total structure. Secondly, with the use of proper software, the required energy for the heating and cooling of each residence is being calculated. As a result, an energy-time diagram is formed which indicates the long-term energy behavior of the residences, starting from their embodied energy. Following the above, a comparison of the different type of residences is being made regarding their assimilation by the environment, the evaluation of materials' toxic behavior and the presence of pollutants in the various stages of construction. Moreover, due to the fact that the lifetime of modern buildings can be exceptionally variable, each residence should be recycled or reused along with its materials.

Key words: material, ecology, evaluation, green building design

1. INTRODUCTION

The area of construction is considered to be an extremely polluting activity of modern production and therefore the introduction of more sustainable and environmentally friendly technologies may lead to short-term considerably positive results. In order to achieve a different approach in building design it is vital to provide engineers with the technical knowledge of sustainable solutions and also to raise awareness towards the advantages of these designing solutions. Bioclimatic architecture, green building design, a more rational management of domestic wastewater and solid waste, as well as the use of alternative forms of energy to name a few are the appropriate tools towards sustainable building design [1].

In this essay a method for the evaluation of building design is formed, which takes into consideration the crucial parameters of design and evaluates their environmental impact during the life-cycle of a building (construction, operation and demolition) [2,3]. Buildings of similar geometrical characteristics but constructed of different materials are being compared. According to this method, the parameters that are being evaluated are the energy consumed during the construction and the operation of a building, as well as its toxic behavior and the different pollutants that appear in the various stages of its life-cycle. In addition, the assimilation of materials and therefore of the building itself by the environment is being considered.

2. METHOD OF ANALYSIS

2.1 Parameters

Energy is one of the most critical aspects in sustainable development. That happens because the production of energy is connected with pollutant aspects. In this essay, there are two characteristic types of energy that we have to calculate.

Embodied energy is the energy consumed by all the processes associated with the production of a building, from the acquisition of natural resources to product delivery. This includes the mining and manufacturing of materials and equipment, the transport of the materials and the administrative functions. Embodied energy is a significant component of the lifecycle impact of a building [4, 5, 6,7].

The *energy of use* is the necessary energy loads to achieve thermal comfort.

Materials have toxic aspects in many stages of the construction. **Toxicity** is a measure of the degree to which something is toxic or poisonous. It is therefore necessary to describe and evaluate these aspects [8].

In order to make a building material, **raw materials** are being used. So it is necessary to calculate the waste of raw materials, and the possibility of **recycling** of building materials [9,10].

2.2 Analysis and models

As an application of this method, four different construction models (ground floor, 60,5m^2) with similar geometrical characteristics are being evaluated (Figure 1-4).
The first construction model represents a typical contemporary residence designed and built in a conventional way [11]. The second model represents a conventionally built residence, designed according to the principles of bioclimatic architecture. In this case,

conventional structural materials are being used, while at the same time the building orientation and the shading of its openings are being optimized. More bioclimatic techniques, such as the construction of a planted roof and the optimization of thermal behavior of building with suitable heat insulation, are also being applied [12,13,14,15]. The third constructional model represents a plinth construction. To create this model, existing plinth constructions in Greek agricultural areas were studied, while testimonies of users and constructors of such buildings were taken into consideration. Finally the fourth model represents a residence made of (natural) stone [16].

Figure 1: Model 1. Typical contemporary construction

Figure 2: Model 2. Bioclimatic construction

Figure 3: Model 3. Plinth construction

Figure 4: Model 4. Natural stone construction

2.3 Calculations and evaluation

In order to calculate the effect of building design in the context of sustainable development this method proposes the following calculation for each model construction (Figure 5).

At first, the quantity of construction materials used is being measured out, in order to determine the embodied energy of the total structure. Therefore the volume of used material must be calculated in order to determinate the weight. Using the proper tables and data the weight of each material is corresponded as energy (embodied energy) [5,6,8].

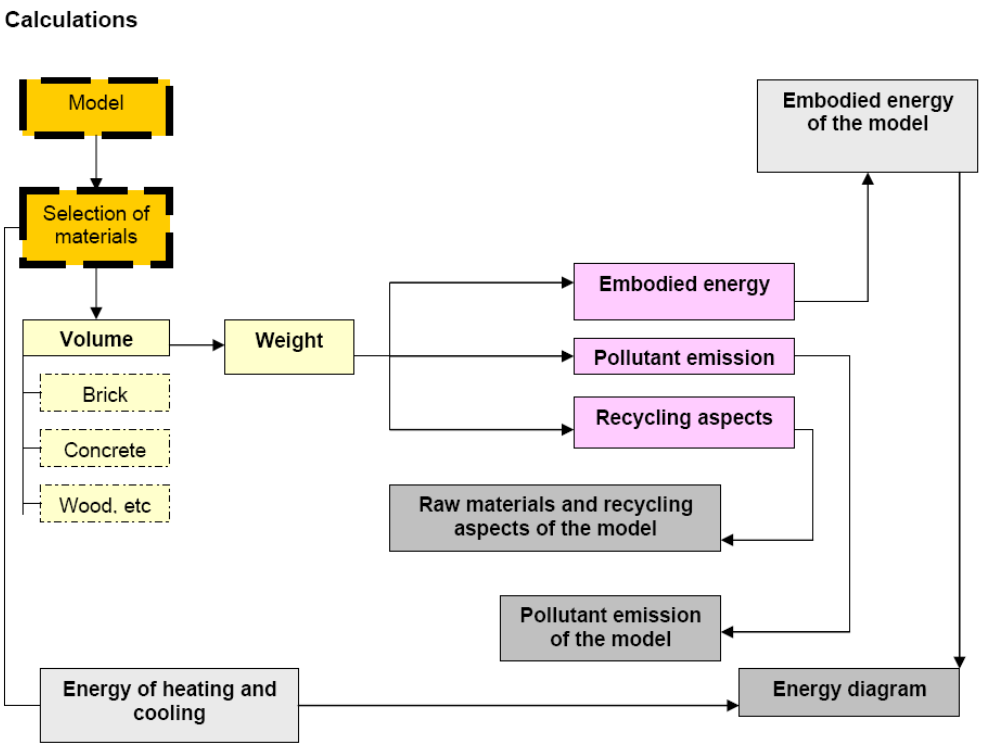

Figure 5: Calculations flowchart.

The embodied energy of each part of the construction (wood, concrete etc) is summarized and determines the embodied energy of each construction model (Figure 6).

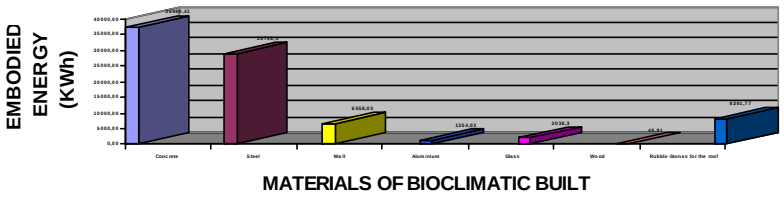

Figure 6: Embodied energy of each part of the construction (Model 2).

With the use of proper software, the required energy for the heating and cooling of each residence is being calculated [17,18]. As a result, an energy-time diagram is formed which indicates the long-term energy behavior of residences, starting from their embodied energy (Figure 8).

With the use of proper tables and data, the recycling aspects are determined (recycling weight of material and the recycling embodied energy of the material). The recycling aspects of each part of the construction (wood, concrete etc) are summarized and determine the recycling aspects of the whole of each construction model [9,19] (Figure 9, 10).

With the use of proper tables and data the weight of each material is corresponded as pollutant emission to the environment during the production. The pollutant emission of

each part of the construction (wood, concrete etc) is summarized and determines the pollutant emission of the whole of each construction model [11] (Figure 11).

Toxic aspects in the life time of the construction can not be measured. Therefore evaluation method refers the possibility of toxic aspects of the materials in the lifetime and these aspects are represented by quality comments in the model.

Following the above, a comparison of the different type of residences is being made regarding their assimilation by the environment, the evaluation of materials' toxic behavior and the presence of pollutants in the various stages of construction. Moreover, due to the fact that the lifetime of modern buildings can be exceptionally variable, each residence should be recycled or reused along with its materials [20,21] (Figure 7).

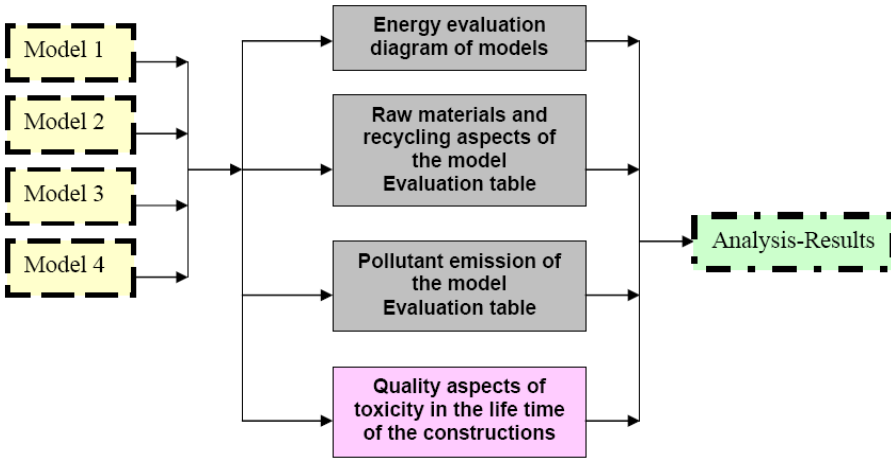

Figure 7: Evaluation flowchart.

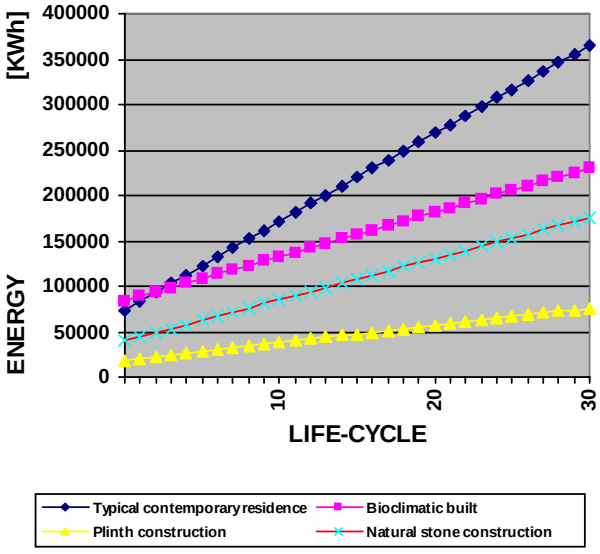

Figure 8: Energy evaluation diagram

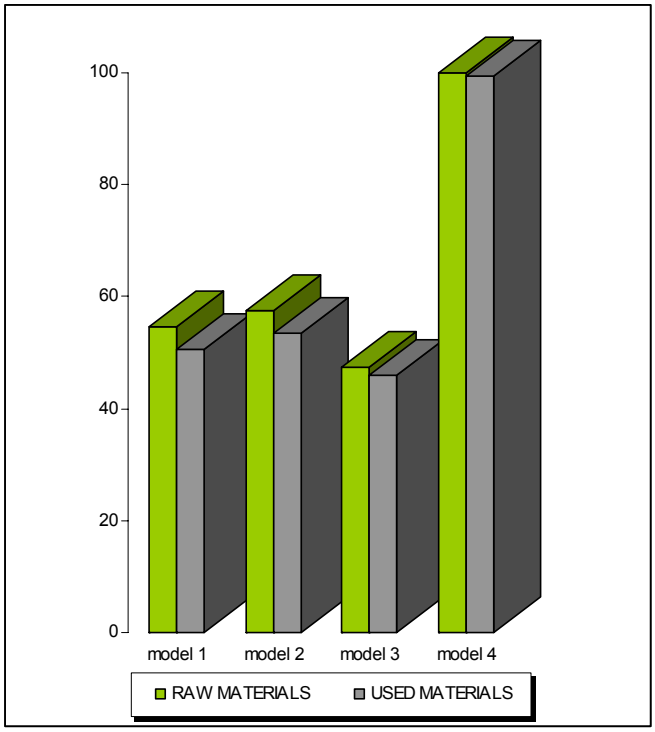

Figure 9: Evaluation. Raw materials-used materials (%)

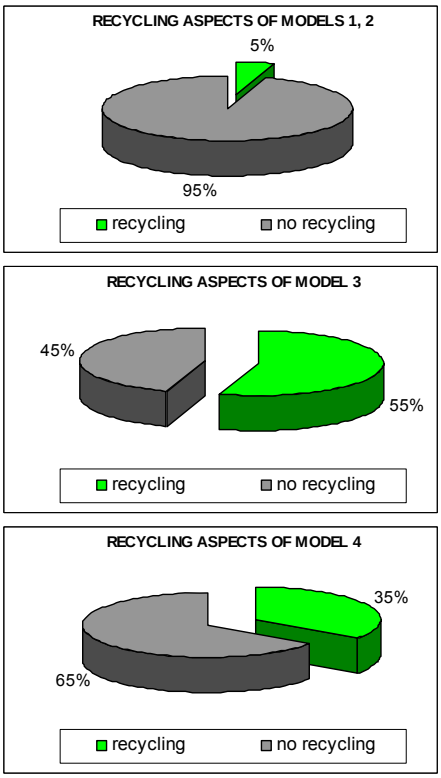

Figure 10: Evaluation. Recycling aspects (%)

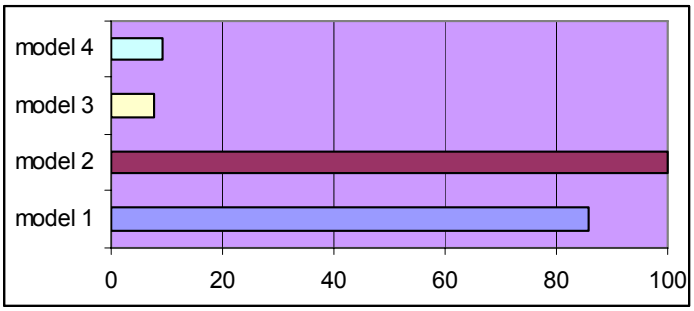

Figure 11: Evaluation. Pollutant emission during materials production (%)

Industrial production of modern materials (model 1, 2) uses complex methods of production and diffuses pollutant emission on the environment. The use and demolition of modern materials is possible to have toxic aspects. On the other hand, production, use and demolition of traditional building materials (model 3, 4) guarantee no toxic aspects of the used materials [15].

3. CONCLUSIONS

The application of the method described above on these four construction models gives a useful comparison of four critical environmental aspects during their life.

Moreover, it led to the conclusion that the residence made of plinths is a construction with exceptionally low embodied energy and a very good long-term thermal behavior. At the same time its capacity of recycling is very high. Moreover a plinth construction has no toxic behavior at any stage of its life-cycle. Therefore the extent use of plinth in a building envelope, can lead to energy saving, a rather important issue of sustainable development, resulting at the same time in more acceptable environmental construction solutions for contemporary societies.

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