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A new simplified thermal design tool for architects

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Abstract

Architects form an integral link in the design of efficient buildings. Energy-efficient design strategies therefore, require architects and engineers to work closely together in optimising the building shell. However, this is not always practical. Architects must therefore, be able to perform a preliminary thermal analysis if energy efficient design strategies are to succeed. Existing tools do not cater for them or fit their design methodology. A need therefore exists for a simplified thermal design tool for architects. This article discusses the development of a tool to fulfil this requirement. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

It has long been known that the building envelope has a considerable impact on thermal comfort and HVAC system size [1–4]. Hens [5] in fact states that the HVAC system and building shell are inseparable, like Siamese twins. In most cases architects design the building shell. These designs are then passed on to HVAC engineers. They perform a thermal analysis and design the necessary systems to achieve the required comfort level [6].

According to Holm [7], the thermal analysis is done at a stage when major design decisions have already been made. It is then difficult for the architect to change his design based on the thermal analysis results. This sequential design can potentially lead to buildings that are energy inefficient and require large HVAC systems. It is therefore, essential that architects are able to evaluate their designs before important building characteristics are frozen.

Building thermal simulation tools have a tremendous potential for aiding designers in evaluating and optimising the building envelope design. Unfortunately, existing tools do not accommodate architects nor fit into the current design process. These tools tend to be complicated and time consuming to use. Furthermore, they often require detailed information of the building construction. Existing tools have thus so far failed to be incorporated into the general design practice [8]. A need for a simplified thermal design tool for architects therefore still exists.

A new thermal design tool was developed to fulfil the above requirement by addressing the needs identified by the design community in Lausanne [9]. The tool was simplified by reducing the number of input parameters and defining them in terms that architects can relate to. The output of the program further enables designers to quickly evaluate their design without the need for detailed processing of the analysis results. These properties make the design tool ideal for use early in the design process.

2. Importance of initial design stages

Building designers typically follow a top–down design procedure when designing new buildings [7,10,11]. It consists of initially starting with the building as a whole and then working down to smaller detail, such as colour and wall finishes. This process is divided into several design stages [12,13]. The definition and detail of the various design stages may vary for different designers, but the basic idea remains same.

The initial design stages form the foundation of all new building designs. During these stages the general size, orientation and construction of the building are defined. All subsequent decisions and design calculations are based on

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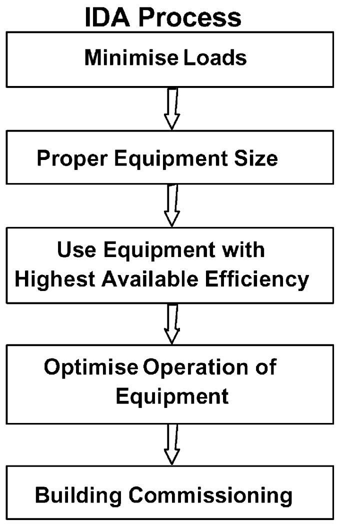

Fig. 1. Integrated building design approach.

these characteristics. It therefore, becomes more difficult and costly to alter the design as it progresses. Decisions made without careful consideration or knowledge of their consequences can thus have a dire effect.

This top–down design practice has evolved over a long period of time. It is therefore, unlikely that it will change radically in the foreseeable future. Energy-efficient design strategies need to take this into consideration. If a strategy alters the design process too much, it will most likely not be used extensively [14].

3. The need for a thermal design tool for architects

The Integrated Design Approach (IDA), shown in Fig. 1, is suggested as a simple inexpensive means of achieving energy efficient and comfortable buildings [15]. Minimising the building load is the first step in this approach. This load is mainly affected by the building shape, form and thermal characteristics of the building [3,4]. Architectural design decisions consequently, have a significant effect on the building load and thus thermal efficiency.

Building thermal efficiency is only one of many items to be considered by the architect. According to Holm [7], it is often given little or no thought at all during the design of the building. He further states that this can be attributed to the fact that many architects and building owners have not been exposed to the realities of life-cycle energy cost, nor its social and environmental impact. Initial cost of the building and its aesthetic value are therefore, frequently still used as basis for evaluating the design.

Furthermore, thermal design would require the architect to allocate more of his time and resources to considering the thermal impact of his design decisions. Holm [7] states that "*the architect doing thermal design does so at considerable additional cost to himself, putting himself at risk while the building owner enjoys the long-term benefit, often without paying for it*". There is thus little incentive for architects to perform thermal load analysis.

Currently engineers usually perform building thermal load analysis in order to determine the required heating and cooling system size. It is consequently, only done after most of the design has been finalised. The critical initial design stages have thus already been completed making it difficult and expensive to change the design. New energy-efficient design strategies therefore require architects and engineers to work closely together in minimising the building load.

Ideally the above design professionals need to be appointed at the same time. This however does not fit into the current design practice and is consequently not always practical. If energy efficient building design strategies, such as the IDB approach, are to succeed, it is essential that architects are able to perform some elementary thermal analysis when designing the building shell.

Building simulation is seen as an ideal tool for aiding designers with the thermal analysis [1]. Using a simulation tool it is possible to determine what effect various design decisions will have on the building load. Changes can thus be made before major design decisions are fixed. There are a host of simulation tools available for use by designers. To date, these tools have however largely failed to be applied in the building design process.

Various speakers discussed this lack of use during the 1997 International Building Performance Simulation Association (IBPSA) conference held in Prague. Complexity and the time required to use these tools are frequently cited as reasons for this. The users further require knowledge of thermal and numerical analysis [16]. Architects, in general, are not well versed in these areas.

Detail required to generate a thermal model of the building is also a major limitation. Most of the information needed for simulation is not yet available during the preliminary design stages when analysis is most needed [7,17]. According to Holm [7], the thermal simulation process is diametrically in the opposite direction of the architectural design approach.

Another trend in new software development is towards total building energy estimation. These tools therefore incorporate elementary lighting and HVAC system simulation. Although beneficial during subsequent design stages, these features tend to cloud the impact of architectural design decisions by a host of other data. Existing simulation tools consequently do not cater for architects or aid them in designing the building thermal shell.

These above obstacles must be addressed if architects are to be encouraged to perform preliminary thermal analysis. A need therefore exits for a simplified thermal design tool for architects.