Frontiers of Architectural Research (2013) 2, 11–22

Available online at www.sciencedirect.com

SciVerse ScienceDirect

www.elsevier.com/locate/foar

Frontiers of Architectural Research

RESEARCH ARTICLE

Research on parametric design method for energy efficiency of green building in architectural scheme phase

Borong Lin*, Qiong Yu, Ziwei Li, Xiaoru Zhou

Department of Building Science, School of Architecture, Tsinghua University, Beijing 100084, China

Received 21 July 2012; received in revised form 18 October 2012; accepted 24 October 2012

KEYWORDS
Scheme phase;
Parameterization of energy efficiency;
Prediction model of energy consumption;
Genetic algorithm;
Human-computer interaction

Abstract
Based on a large number of researches and engineering practices both domestic and overseas, it is shown that the building parameters to be determined during scheme phase can exert a great effect on the building energy consumption. In this paper, through a combination of the popular design method of building parameterization at present and the design goal of energy saving during the scheme phase, the author carries out researches on the design methods and tool development which are applicable to parameterization of building energy saving in this stage. In connection with the characteristics of both modeling process of parameterization and energy saving design, and by means of steady calculation as well as simulation, this paper establishes an simplified model to calculate the overall energy consumption of air-conditioning, heating, lighting and equipments, and ultimately gives suggestions on design of scheme for energy saving by optimization with the genetic algorithm (GA). On the basis of the model, a software platform is developed by computer language QT and openGL interface and is oriented to the design users and sets up the MMI (human-computer interaction) software interface for parameterization of building energy saving, which achieves automatic modeling of parameterization and promotes research on practical design cases.

1. Introduction

The scheme design is not only the first step of the architectural design, but also a crucial decision-making phase that contains all the design requirements of the designer and mobilizes all the design elements (Xia, 2008). In this phase, it will basically determine the building shape, space, skin and other parameters which are expressive and concerned by the designers

*Corresponding author. Tel./fax: +86 10 62785691.
E-mail address: linbr@tsinghua.edu.cn (B. Lin).
Peer review under responsibility of Southeast University.

Production and hosting by Elsevier

2095-2635 © 2013. Higher Education Press Limited Company. Production and hosting by Elsevier B.V. Open access under CC BY-NC-ND license.
http://dx.doi.org/10.1016/j.foar.2012.10.005

on the one hand, and essential factors for the building energy consumption on the other hand. Many scholars have discussed the necessity of incorporating the energy saving into the scheme phase in their researches (de Wilde, 2004; Hong et al., 2000; Augenbroe, 2001). The research of Wilde, a Dutch scholar, shows that 57% of the energy-saving technical measures should be considered in the scheme phase (de Wilde, 2004). With the constant development in the design progress, the potential of energy saving becomes smaller and smaller, while the costs for the same energy-saving benefits become higher and higher, as shown in Fig. 1.

In addition, parametric design is widely popular. However, presently many programs focus on the diversity of body and skin unilaterally, while ignoring the function, energy-saving and environmental protection, which runs counter to the original intention of parametric design on the inherent rules and logics. Therefore, setting the lowest energy consumption principle as a design control law in the architectural design may unify parameterization design and energy-efficient purposes, and achieve the parametric design optimization of building form, skin, space, thus seeking a new direction for parameterization design of architectural style (Fig. 2).

Since the 1980s, scholars from various countries began to carry out the researches on thermal environment and control system simulation technology, sequentially followed by simulation in the field of CFD (Computational fluid dynamics), lighting, natural ventilation and other related researches—all of these have gradually begun to be widely applied in engineering since 2000 (DeST, 2006). However, the application of building performance simulation software in the scheme phase is still rare at current. The main reason is that there is few simulation aid tools designed specifically for the scheme phase in the preliminary design or detailed design stage, thus failing to provide the detailed building information required by most of the existing simulation tools. In addition, as some important parameters which can greatly impact the performance of the building itself, such as the shape, orientation, facade design, functional classification, etc., are mainly determined in the scheme phase, and the energy saving part in the preliminary design and detailed design phase mainly refer to node design, thermal insulation materials, glass options, as well as system design of mechanical and electrical equipment, there is only a little room left for the architectural design to promote energy efficiency improvement. Therefore, in the scheme design stage, the international academic community and engineering circle have realized the necessity and importance of combining simulation aiding tools and architectural design in the research and practice of building energy saving (Xia, 2008; de Wilde, 2004; Zhou, 2009; Yu, 2009). Besides, in recent years the architectural designers have never stopped the research on the design theory innovation by considering the complex and nonlinear characteristics of the architectural design process and production mode. Among which, the parametric design of building in scheme phase has drawn more and more attention, and has been widely applied in the practice (Huang and Xu, 2009; Xu et al., 2010; Zhou and Zhang, 2010; Di and Du, 2010).

How to closely link the technology and design during the design process and how to reflect the evaluation of building performance in the control rules of the scheme design—these are the important issues to combine the ecology, energy-saving design concepts and parameterization. Based on the most energy-efficient procedures, this paper establishes the procedures and technical system to generate energy-saving parameterization design in the scheme phase, builds the MMI

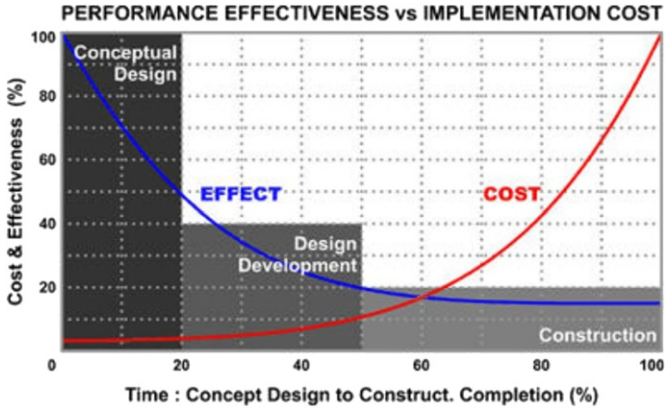

Fig. 1 Relationship between building performance and cost of implementation.
Source: Literature Survey (Autodesk).

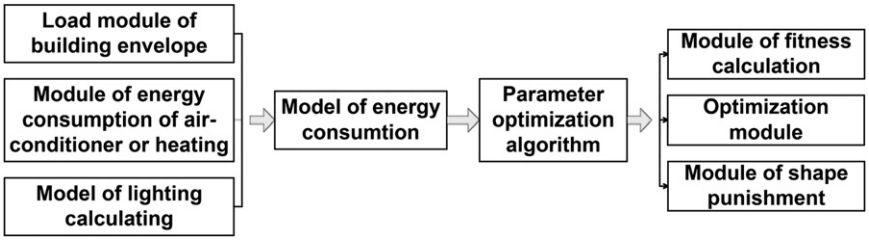

Fig. 2 Modules of energy-saving design algorithm.