

A knowledge-aid approach for designing high-performance buildings

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Abstract

Today, global warming and the sustained increase in energy prices have led to a quest for energy-efficient buildings among designers and users alike. This has been accompanied by increasingly strict thermal and energy regulations for buildings. In addition to such changes on the energy front, building regulations have also been created or reinforced in other areas, including accessibility, fire safety and seismic risk, alongside the demands of users. The combined effects of these two factors have made building design much more complex. Thus, designers are constantly in search of tools and information that can provide them with ways of designing high-performance buildings for their projects. In response to these needs, we propose an optimization-based, knowledge-aid approach for designing high-performance buildings. This approach is aimed at providing architects and design offices with clear knowledge of their project's potential (exploration of various options) that will allow them to design the best possible high-performance buildings (in this version of the approach only energy needs and construction cost are assessed). This potential is evaluated by means of the external and internal geometric parameters as well as the energy characteristics of buildings. In this paper, the approach will be applied to an office building in Lyon, France.

Keywords

high-performance building design, bioclimatic architecture, multicriteria optimization, genetic algorithms, energy efficiency

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1 Introduction

The current situation of ever-increasing energy prices and increasing greenhouse effect, which is expected to persist over the long term, has led to a demand for less energy-consuming among designers and users alike. This has been accompanied by reinforcements in thermal and energy regulations.

The desire among users and designers for improved housing quality does not only concern energy aspects but also includes other areas such as acoustics, fire safety and mechanical performance. These aspirations have been accompanied by improvements in regulations in these fields. The combined effects of these factors are making it increasingly hard to design buildings.

Furthermore, clients' requests to keep design costs in check constitute yet another constraint. Thanks to dynamic simulation, designers already possess high-performance tools for assessing design solutions, especially in terms of thermal and lighting aspects.

However, if designers wish to have a comprehensive overview of all the solutions that meet their design needs, especially non-intuitive solutions, they cannot rely on these tools alone as too many cases would have to be simulated, thereby rendering the process extremely time-consuming (e.g. a million of years for the test case presented in this paper). Besides, such tools cannot be used early on in the design phase because many parameter values that are required for the simulations are unknown at this stage.

Hence the needs for an efficient way of scanning the entire solution space that will limit computation times and also provide a comprehensive and reliable view of all the possible high-performance solutions. Furthermore, users should be able to explore these options as they wish in order to obtain as much information as possible on the various ways of designing a high-performance building for their project. The selected approach should also allow users to compare the various solutions being considered, even during the early design phase.

In this paper, we will present an approach that address