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Energy-efficient management modeling towards interior thermal comfort: an architectural element manipulating case study on small detached houses in Bangkok

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Abstract

This paper investigates the thermal perceptual aspect from daily activities. The research uses the cases of small detached houses in Bangkok to examine the best manipulation of architectural elements to optimally provide thermal comfort in the Thai living context applying a multi-facet research methodology. Two aspects of design manipulation—the spatial arrangements and buildings feature—are examined towards the optimization modeling. The level of perceived comfort obtained from data analysis is used as input in the modeling program to be tested to obtain the model of comfort optimization strategy and to set the guideline of passive design for tropical climate.

Keywords: interior architecture, energy efficient, passive design.

1. Introduction

The current global energy crisis has alarmed and called for local actions involving energy consumption. The "think globally act locally" (Moberg, 2005) notion brought about awareness and cooperation from the design discipline, where energy-efficient design has become among the crucial design elements taken into consideration by architects and designers. In the past, architects had designed interior environment with respect to its local climate and social conditions. However, the Western designs and ideologies have recently created a huge influence on the interior design in order to meet the needs of residents in terms of use values and the way of life. As a result, most of the modern designs have tended to adopt the technological aspects from the West to maximize the living comfort and paid little attention to the use of interior environmental management in creating the thermal comfort from passive energy. The principles and techniques of interior designs from the East are greatly different from Western perspectives. In the West, the living comfort is induced by the design strategy to create warm and comfort living ambiance in a house. Meanwhile, the Tropical designs for comfort living environment have been created by

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decrease indoor temperature such as ventilation through the manipulation of architectural elements and the treatment of interior spatial arrangements.

Each of the remedial choices for energy-efficient design has its pros and cons and they interacted with each other when applied simultaneously. Applicability of combined remedial actions depends much upon the most efficient interaction effect providing the occupants an optimal living thermal comfort. Utilizing the small detached house in Bangkok as a case study, the research endeavors to examine the best manipulation of architectural elements which can optimally serve to provide a thermal comfort in the Thai living context. And finally, the study attempts to derive an interior environmental management model for the optimization of thermal comfort design.

2. Theoretical background

Derived from the literature review, theoretical basis as foundations of the research framework comprises principles of tropical architectural design, outdoor thermal conditions, physical requirement for passive design, human thermal perception and comfort zone, and spatial behavioral pattern of residential usage. Since to create effective energy consumption, architects and interior design should consider the energy saving concept, especially passive energy thought. The passive means of heating, cooling, and lighting are more closely tied to building form. The passive means are the most important energy uses in building and demonstrate a strong influence on form. Those effects should be know and taken into consideration in the design process (Brown, 1985). There are four lines of thought involving the study that focusing on effective passive-energy saving in term of cooling mean.

2.1 Tropical architectural design & Outdoor thermal conditions

Tropical architecture requires considering thermal conditions which is hot and humid climatic zone, especially in South-East Asian coastal regions. Traditional architecture in this region is influenced by the difficult with is high level of humidity, little movement of air in the interior, and constant high temperature both day and night. Thus the typology of the building is marked by adaptation to the climate revealed in the raising of the buildings to open the living space, and deep roof projection for countering to a most difficult climate (Lauber, 2005)

2.2 Physical requirement for passive design

Architectural elements influence ventilation. The pattern of air flow in room relevant into two factors – first, the pressure distribution around the building; second, the inertia of the moving air. It also involves with window orientation, window size, cross-ventilation, and location of windows, methods and positions of opening, sub-division of internal space. (Givoni, 1981)

2.3 Human thermal perception and comfort zone

Human comfort relates to a variety of variables. A major factor is getting rid of the heat requirement. it generates as a by-product of our metabolic system. Sensible heat is that we can 'sense' or feel. A physical basis for understanding thermal comfort they include: air temperature, air movement, ambient water vapor pressure, amount of clothing, and occupants' level of activity. (Randall, 2006) Furthermore, the amount of heat is also generated by people is a function of sex, age, and other factor. (Brown, 1985)

2.4 The complete forms of the building Bio-Climatic Charts

Architectural responses the produce thermal comfort in the climate by using the bioclimatic chart. The Bio-Climatic Charts shows the relationships of four major climate variables that determine human comfort. By plotting temperature and, relative humidity, wind, and shading. (Brown, 1985)

The research primary inquires features interior design providing comfort internal environment. Basing on the principle inquiry, the study aims to examine comfort environmental factors, how to implement and how to apply in Thailand condition. To examine comfort conditions, the study utilizes the complete forms of the building Bio-Climatic Charts (Givoni, 1998) combining with macro and micro climate condition of Thailand, including outdoor ambient climate, level of solar radiation, and amount of green area, wind speed, and seasonal settings. To find out how-to, the study utilizes passive design combinations involving natural ventilation, shading, building orientation, interior spatial configuration, building mass, and building envelope. Final, the research explores comfort treatment model relating behavioral context in Thailand basing on temperature, humidity, ventilation, and occupant conditions. For occupant condition, it includes activity, duration, and clothing features.

3. Research framework

Derived from the literature review, the background presented in the previous section attempts to explain the relationship among variables which link interior environmental design elements and optimal degree of comfort (Figure 2). The research bases its framework on two lines of thoughts: theories regarding physical environment and theories of comfort zone (Givoni, 1981; 1998). The research initially hypothesized that the interior environment and management can be effectively designed to benefit energy conservation purposes and simultaneously serve to provide a thermal comfort living conditions.

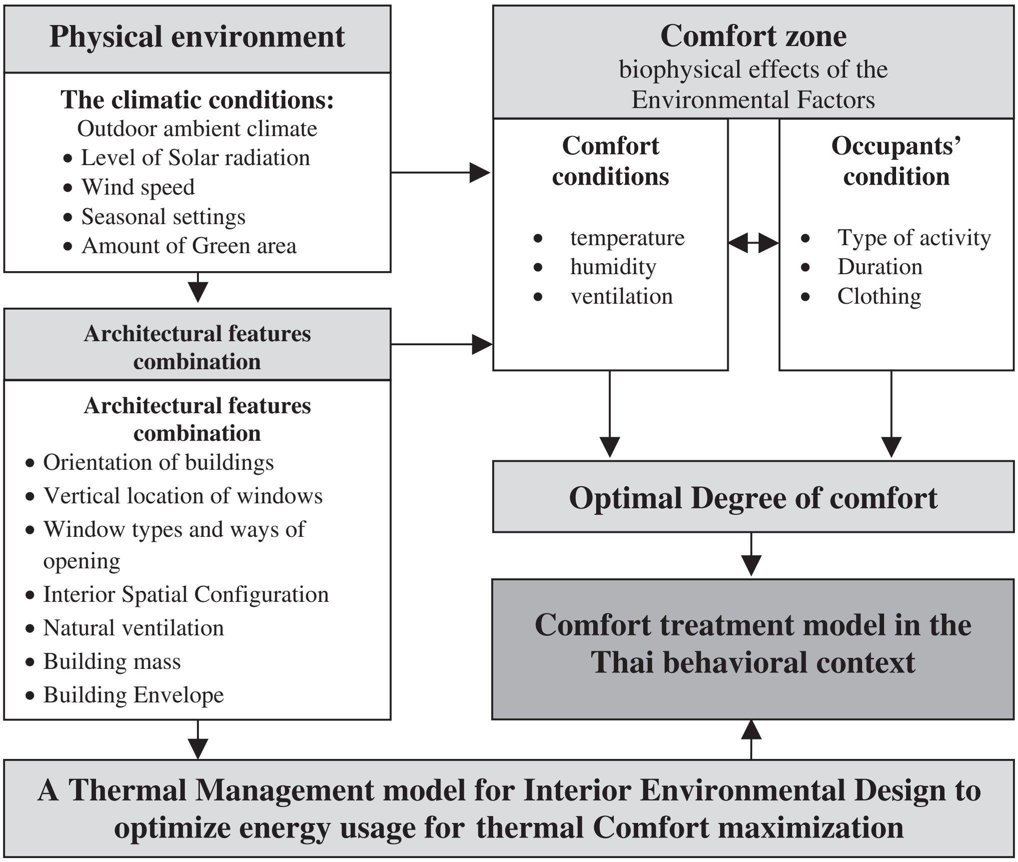

Figure 1 Conceptual Framework

4. Methodology

Applying a set of 150-200 square-meter detached houses in villa-estates of Bangkok Metropolis as testing models, the research investigates two interdependent aspects of design manipulation. First, it examines the treatment of interior spatial arrangements, which is usually a constraint to cross ventilations and air-conditioning.

Second, the manipulation of the building envelope will optimize the best thermal comfort in accordance with the Thai daily activities.

An integration of multi-facet research methodologies are applied towards the modeling of the optimization of comfort design. Firstly, information regarding microclimate of the Bangkok Metropolis is retrieved from the meteorology office to be compiled to derive the average outdoor ambient temperature and humidity as an input in the Bio-Climatic Chart. A perceptual Comfort zone in the Thai context is then derived by means of a questionnaire survey. The second stage involves the classification of physical settings vis-à-vis the level of perceived comfort to be used as input in the modeling computer programming. A number of architectural features are manipulated utilizing the trade-off approach (Robinson, 1987) and input into the computer program to test the responsive indoor ambient environment. The third stage tests the resultant of stage two—in terms of temperature, humidity, and air movement—to obtain the final model of comfort optimization strategy. The diagram in Figure 2 summarizes the detail of research procedure.

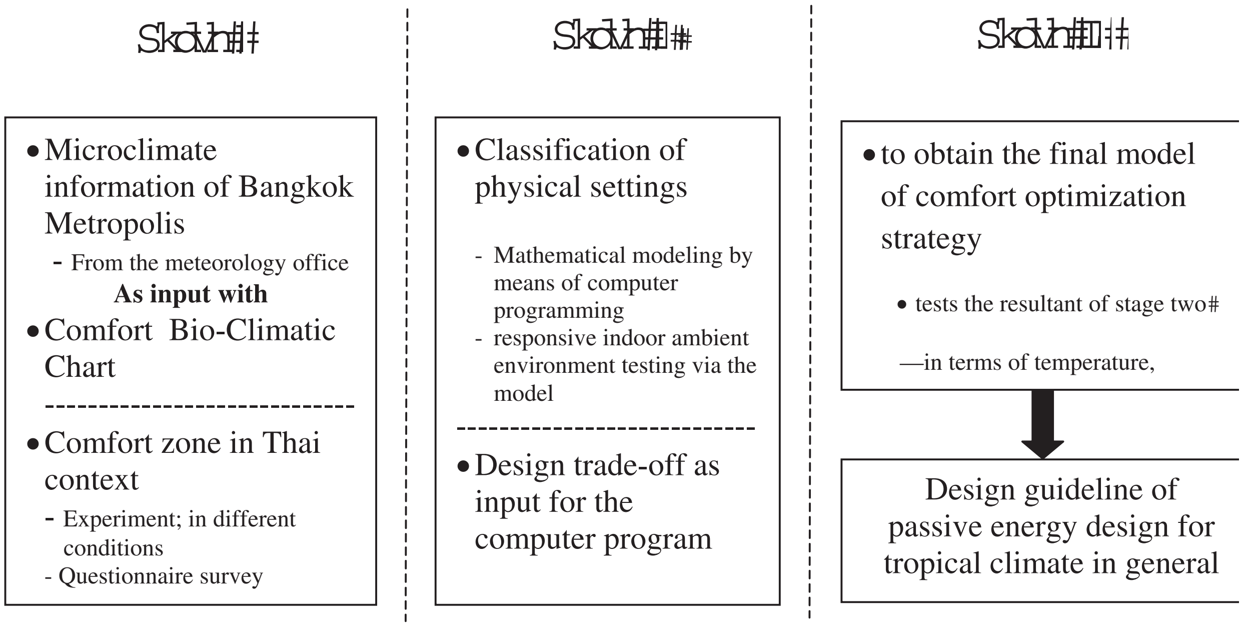

Figure 2 Research Procedure

5. Expectation of the research

The research procedure established for this study aims to acquire the set of key environmental features and local factors that determines optimal degree of comfort. The data regarding to the key parameters: temperature, humidity, and air movement will be imported into the computer simulation model and tested to derive the final model of comfort optimization strategy. The final modeling product is utilized as design guideline of passive energy design for cities in tropical climate in general and for Bangkok in particular.

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