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The significance of using local predicted temperature for cooling load simulation in the tropics

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ABSTRACT

In building energy simulation, researchers commonly use weather data obtained from the software database or (meteorological) MET station. However, this method leads to disparity of urban-rural temperature condition, hence the input weather data do not characterize the on-site condition. This paper highlights the importance of generating and implementing the urbanized weather data, primarily on the ambient temperature. A parametric approach was used to create hundreds urban layouts of the hypothetical office block plan. An annual temperature profile was generated for each scenario using the Screening Tool for Estate Environment Evaluation (STEVE) tool. It was found that the local average temperature (T_{avg}) and peak afternoon period (T_{max}) from these scenarios could differ 1–2 °C and 1.2–3.5 °C respectively as compared to the MET station data. Using Integrated Environmental Solutions (IES) to simulate the thermal load performance, this temperature difference can lead to an approximately 8% difference in the predicted cooling load, 20% in external conduction gain, and 17% in fresh air intake gain. These numbers can be deemed substantial in simulating building performance, especially cooling load due to changes in the external condition. Furthermore, the comparison proves to be significant in term of enhancing the simulation result and representing the studied area.

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1. Introduction

The urban heat island (UHI) problems in cities have been widely discussed by many researchers, where the changing of natural landscape due to man-made structures have been accounted to be the main cause of the increasing temperature [1–8]. Some studies highlighted the temperature difference between urban and rural areas [9–11], as well as its implications on the building energy performance [5,12–14]. Several studies also addressed the larger impact of urban form on the daytime temperatures at the micro scale than that of the landscaping, as the local shading patterns were closely related to form and spatial arrangement of urban features [15–19]. Furthermore, due to the complexity of the microclimatic condition in the urban areas, some studies focus on the impact of urban form and spatial on the building energy performance, radiation absorption and wind [20–25]. In these studies, advanced computational modeling was widely used in the microclimate analysis, especially when it comes to simulate the heat island effect in the urban areas.

Various simulation software have provided advantages for researchers to simulate the heat island impact on the building performance at different levels. The accuracy of simulation results is determined by the quality of input data in the simulation software, such as EnergyPlus, ENVI-met, Ecotect, or IES. One of the required data input is the annual weather profile of the site where the studied building or precinct is located. These data consist of several weather variables, such as dry bulb temperature, relative humidity, dew point temperature, solar radiation, wind speed, direction, etc. Typically, the weather data have been provided by the respective building energy simulation software or obtained from MET station.

However, some issues are often encountered when using the software database or MET station data as simulation input. Firstly, the weather data might be outdated, making it obsolete to reflect the current condition. Secondly, MET stations are mostly located in the airports or rural areas, which do not resemble the urban areas of high density. Several studies have highlighted the signifi-

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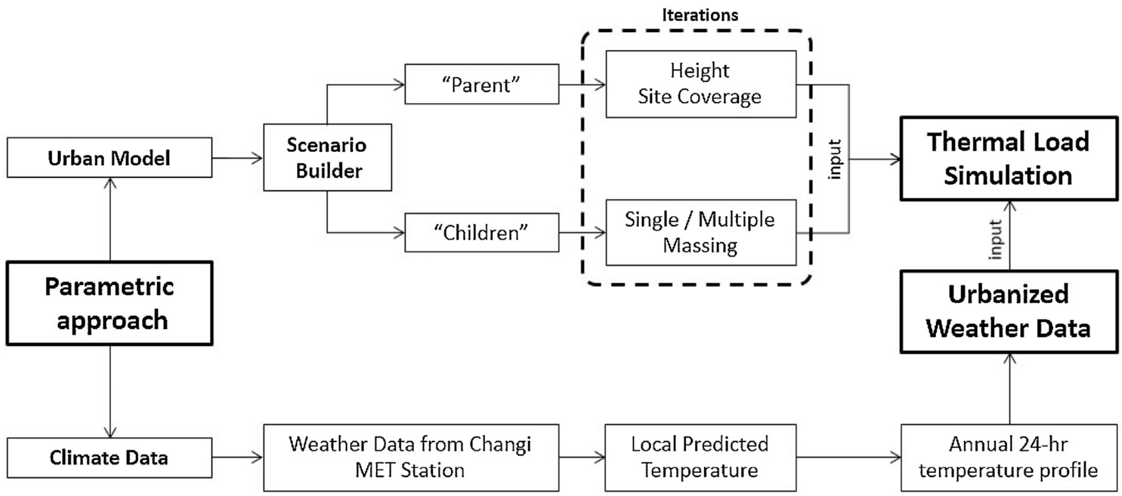

Fig. 1. Research methodology flowchart.

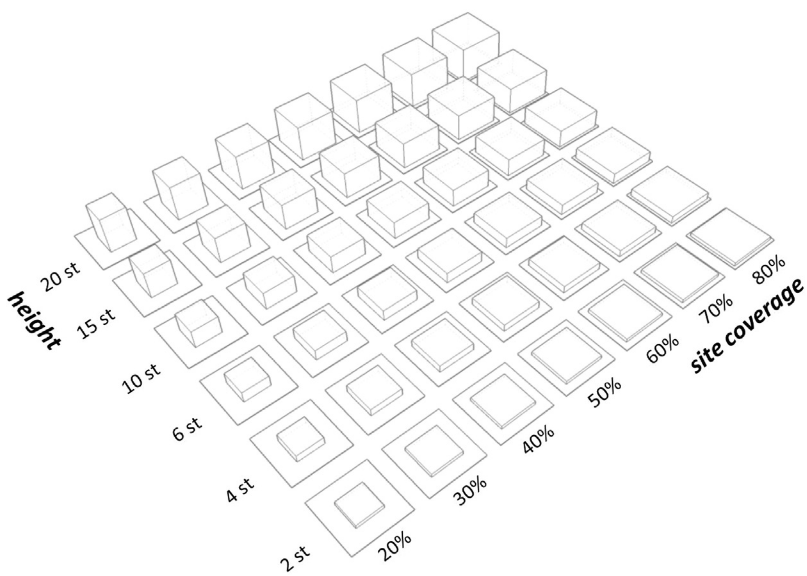

Fig. 2. Compilation of all 'parent' scenarios, with site coverage and height increments.

cance of this location issue, especially when the main issue of heat island study focuses on the disparity of urban-rural temperature condition [26–29]. Kolokotroni et al. highlighted the UHI intensity difference, and tested it out on energy simulation, where the weather data input was based on measurement data [28]. Meanwhile, Sun and Augenbroe investigated how UHI modifies the urban climate, looking at both cooling and heating degree days across 15 climate zones in the United States, and consecutively conducted a series of computational studies to highlight the UHI impact on energy use [29].

This paper aims to highlight the importance of generating and implementing the localized weather data, mainly on the ambient temperature, in predicting the thermal load performance, particularly due to the sensible cooling load as a direct result from the external condition. Case studies were conducted for a wide range of hypothetical urban layouts. The ambient temperature were simulated using a prediction tool developed for urban tropical condition, which takes into account the impacts of building density, form and its variation on the outdoor temperature.

2. Research methodology

Fig. 1 displays the overall research methodology flowchart, using the parametric approach to produce hypothetical urban scenarios, where a localized predicted temperature was generated for each of the scenario with regards of its urban morphological condition. The localized predicted temperature was derived from recorded data and utilizing the prediction model. The impact of this localized weather data was simulated to look at the difference on thermal load performance compared if using the recorded weather data.

The parametric study involved multiple urban texture scenarios with varying densities and forms. All scenarios options were assumed to be in the same district of six 100 m × 100 m plots, surrounded by a row of two-story buildings as buffer area in each orientation. The building plots were put together into a hypothetical district of an urban area, which resembles the grid pattern of Singapore new Central Business District (CBD) area in the master plan. This study did not limit itself by implementing a single square form, which was often adopted by other similar studies. Based on the literature review on urban indices [30,31], several variables

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