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Introducing Climate Consultant software in the education of building physics

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Abstract: This paper introduces a graphic-based computer program in teaching building physics. Based on this tool, students can easily understand the climate conditions of a specific location and passive design strategies can be derived from the analysis and be applied in building design. The advantage of using this tool over conventional methods in teaching is its friendly user interface and accurate passive design strategies can be easily obtained without using complex calculations or analysis.

Keywords: Building physics; Teaching; Computer program.

1. Introduction

Building energy saving is an important issue in reducing carbon emissions. Building physics is the application of the principles of physics to the built environment. Building physicists bring a fundamental understanding of physics to improving the design of building fabrics and surrounding spaces and energy performance of buildings [1-4]. It aims to provide a detailed knowledge of main scientific principles of heat, light and sound in the building engineering context. This course tries to help students understand and apply simple quantitative methods and engineering software in order to analyse an engineering problem, and finally help them use building physics related knowledge in building design. However, the current building education mainly focuses on design and art related skills and students just understand the basic ideas of green building and building energy. More detailed analysis on building energy related building design requires students to use complex calculations and a deep understanding of the mechanism of building physics. To help students understand these mechanisms of building physics, Ecotect was introduced in previous research [3]. However, this tool has now not been supported and maintained. Therefore, it is need to consider other tools to improve the teaching effects. Due to the limitations in existing building physics education in China. This paper tries to introduce a tool to help students understand the thermal related knowledge in building physics.

2. 2. Method

To help students better understand thermal related knowledge, a graphic-based computer program was introduced in teaching. This tool is called Climate Consultant (see Fig.1), which is a simple-to-use, graphic-based computer program that helps architects, builders, contractor, homeowners, and students understand their local climate. It uses annual hourly climate data that is made available at no cost by the Department of Energy for thousands of weather stations around the world. Climate Consultant translates this raw climate data into dozens of meaningful graphic displays. Therefore, this tool is used in teaching the impact of climate on building design and passive design strategies. Students was asked to download the weather file of their hometowns and analyze the climate conditions in their cities (includes air temperature, relative humidity, solar radiation, wind speed and direction, thermal comfort percentage). Furthermore, students are asked to use this tool to analyze suitable passive design strategies for the studied climate in their cities and possible application in building design.

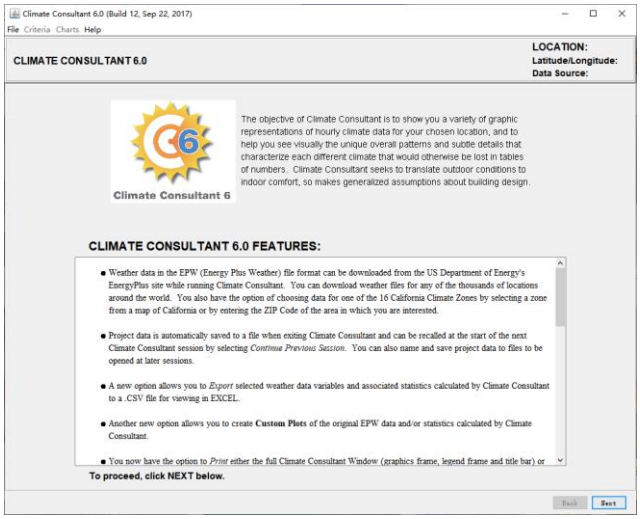
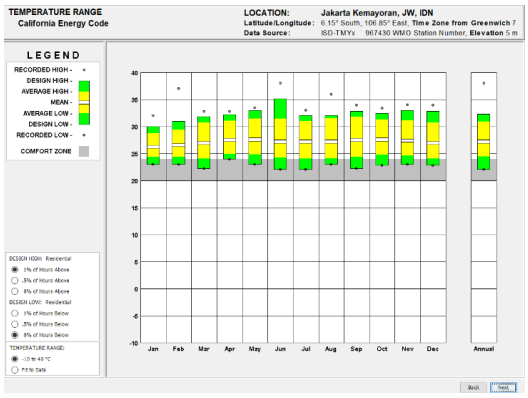


Figure 1. The interface of Climate Consultant

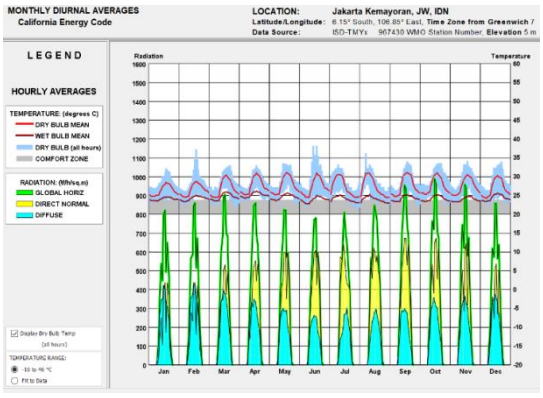
3. Results

One student from Jakarta Indonesian used this tool to analyze the local climate conditions and illustrated the research results. The geographical coordinates of Jakarta are -6.215 deg latitude, 106.845 deg longitude, 16 meters elevation. The topography within 2 miles of Jakarta contains only modest variations in elevation, with a maximum elevation change of 233 feet and an average elevation above sea level of 50 feet. Within 10 miles also contains only modest variations in elevation. Within 50 miles contains only modest variations in elevation. The area within 2 miles of Jakarta is covered by artificial surfaces (96%), within 10 miles by artificial surfaces (74%) and cropland (15%), and within 50 miles by water (42%) and cropland (23%). The following figure 2 shows the detailed results of the climate conditions in graphic format, including monthly variation of temperature, solar radiation, wind velocity, sky cover range and solar chart. It can be seen from these chart that Jakarta has a hot climate throughout the year and the strong solar radiation indicates that solar shading is required most of the time during the year.

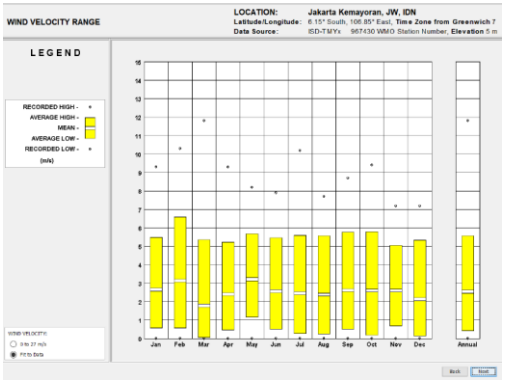
Therefore, the passive design strategies for this climate need to focus on how to lower indoor air temperature and reduce solar heat gain.



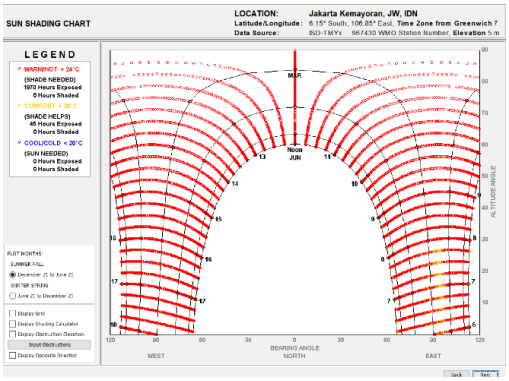
(a) Air temperature



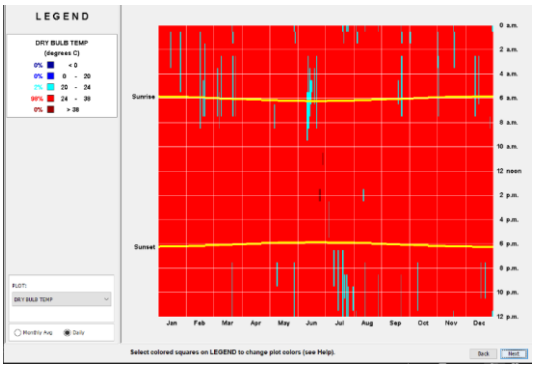
(b) Solar radiation



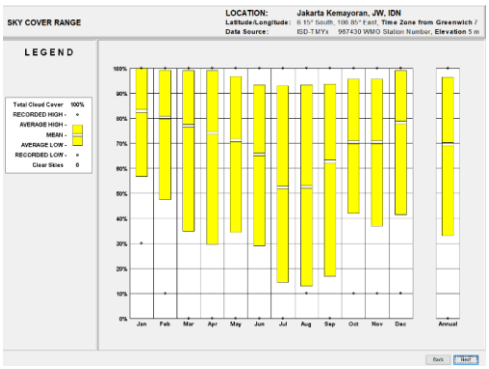
(c) Wind velocity



(d) Solar shading



(e) Dry bulb temperature



(f) Sky cover range

Figure 2. Results of climate analysis

In addition to the above environmental conditions illustrated, this tool also gives the thermal comfort conditions with and without passive measures (see Figure 3). It can be seen that most of the data points located in the right upper part of the psychrometric chart, outside the thermal comfort regions if passive measures were not considered. That means the thermal comfort percentage is 0%. The introducing solar shading of windows can improve thermal comfort conditions by 31.5% and natural ventilation measures can further improve thermal comfort by 5.6%. If more percentage of thermal comfort needs to be improved, active measures such as cooling systems need to be used. Therefore, solar shading and natural ventilation measures are the main passive measures for this climate region.

To better apply these two passive measures, this tool also gives some simple strategies (see Figure 4), and more detailed measures are proposed by students based on the tips provided by this tool.

Ways to reduce the incoming heat:

Reduce the surface area facing east and west. Protect walls with shading. Heat gain can also be reduced by minimizing heat absorption from the surface, especially for the roof surface. Use of bright colors. Light colors have less absorption of solar radiation than dark colors. Large heat absorption will cause the surface temperature to rise. So it will be much greater than the outside air temperature. This causes a large temperature difference between the two surfaces of the material, which will cause a large heat flow.

The uses of air flow or ventilation are:

To meet health needs, namely providing oxygen for respiration, bringing smoke and water vapor out of the room, reducing the concentration of gases and bacteria and eliminating odors. To meet the needs of thermal comfort, emit heat, help cool the inside of the building. Air flow occurs

because of the temperature difference between the air inside and outside the room and the height difference between the ventilation holes. Both of these forces can be best utilized to get the desired amount of airflow. The amount of air flow that can meet health needs is generally smaller than that required to meet thermal comfort. For the first one, it is better to use a fixed ventilation hole that is always open. To fulfil the second, it is better to use ventilation holes whose openings can be adjusted.

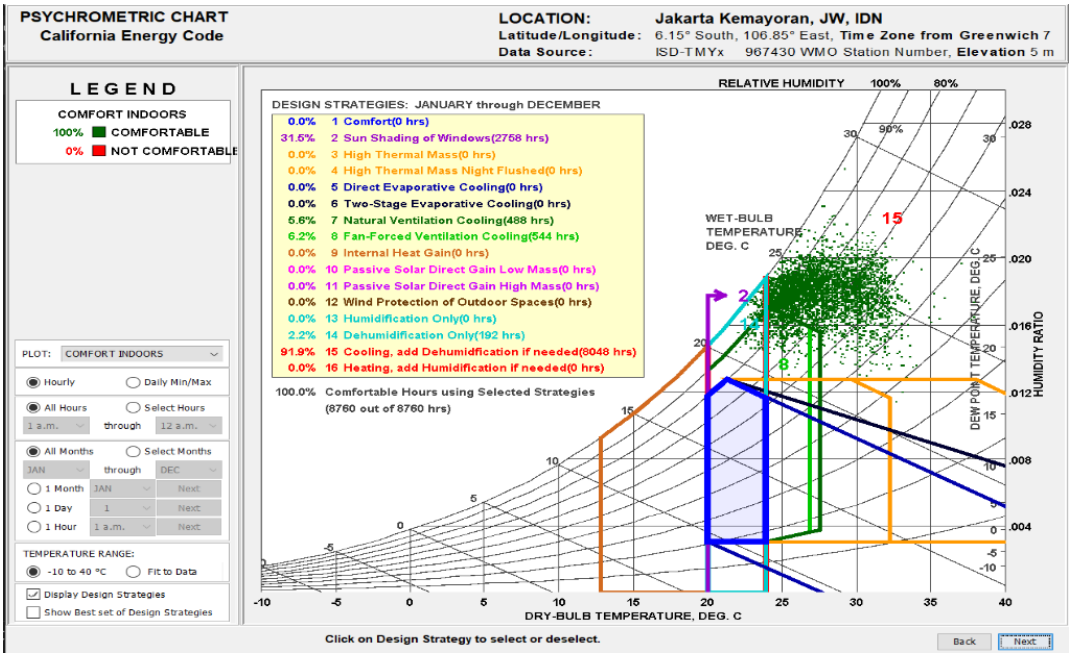


Figure 3. Psychrometric chart analysis

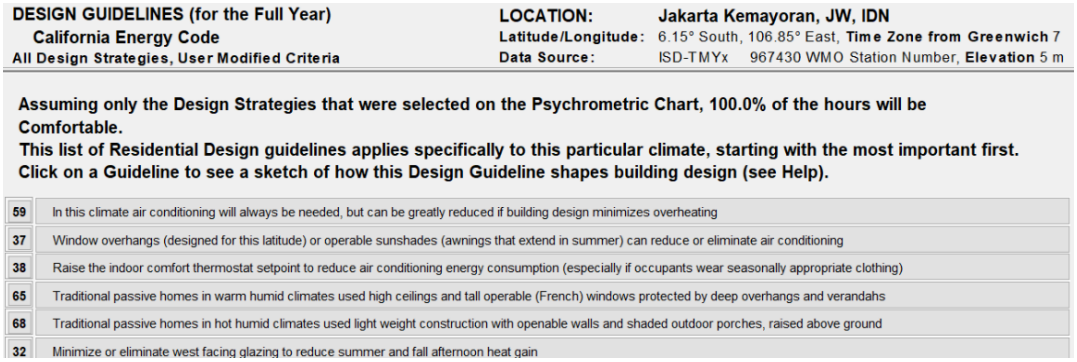


Figure 4. Passive measures recommended by the tool

4. Conclusions

This paper introduces a graphic-based computer program in teaching building physics. This tool has a simple-to-use interface which is suitable for students majoring architecture to learn and use. Based on this tool, students can easily understand the climate conditions (such as air temperature and solar radiation) of a specific location and passive design strategies can be derived from the analysis and be applied in building design. The advantage of using this tool over conventional methods in teaching is its friendly user interface and accurate passive design strategies can be easily obtained without using complex calculations or analysis. Students' feedback also shows that its welcomed in teaching.

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