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Teaching innovation of building energy and environmental course: a case study of shading devices

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Abstract: Solar shading design is an important skill for architects and thus it is an essential course in teaching of building energy and environmental course. Conventional teaching method only tells students the main principle of designing overhang shading and they can not identify an optimal overhang depth. This paper uses computer technologies to aid students in designing overhang. The advantage of this teaching innovation is significant compared to the conventional one. This teaching innovation can help students understand the inter-relationship between overhang depth and building energy consumption and can be widely used to enhance students' skill of designing a better building.

Keywords: Building energy efficiency, Solar shading, Teaching innovation.

1. Introduction

Building energy consumption is growing significantly in China in recent years due to urbanization and improved living standards. Reducing the energy demand for buildings requires a lot of active and passive energy saving measures. The passive measures for building envelopes, due to their relatively low costs, are widely used and evaluated by researchers [1-3]. Among them, solar shading devices play an important role in both reducing energy consumption but also daylight performance (visual comfort). Overhang is one of the simplest shading devices and thus is introduced in building energy and environmental course teaching in China. When teaching overhang design, teachers always use a chart as shown in Fig.1 to illustrate how to determine the optimal depth: reduce unwanted solar radiation in summer to lower cooling loads but admit it in winter to warm indoor space. However, this only tells students the main principle of designing an overhang and they can not identify an optimal overhang depth because the manual calculation process is extremely complex and manual based calculation only considers sun positions at a specific time but not the whole year, which may lead to a deviation of optimal overhang depth. To address this need, this paper uses computer technologies to aid students in designing overhang.

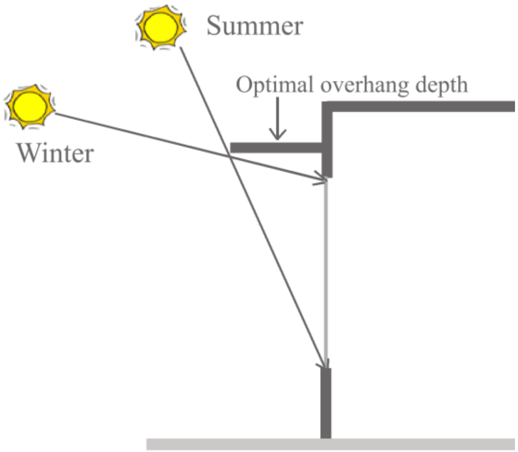

Fig. 1 An optimal overhang depth

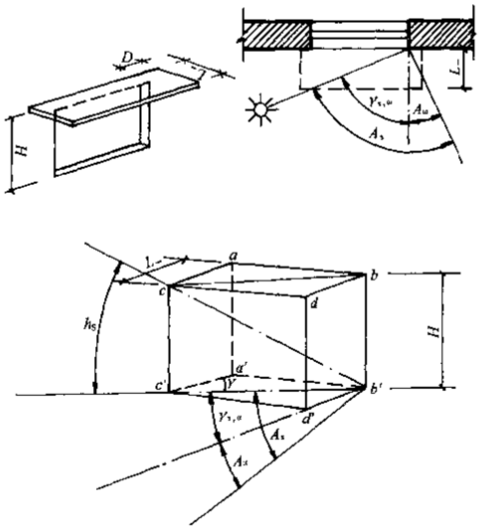

Fig.2 Determination of optimal overhang depth

2. Conventional Teaching Method

For the conventional teaching method, the determination of the optimal overhang depth is usually illustrated as shown in Fig.2. The optimal overhang depth L can be calculated as:

$$L = H \cdot \cot h_s \cdot \cos \gamma_{s,\omega} \quad (1)$$

Where H——the distance between the bottom of window and overhang (m);

h_s——solar altitude angle (deg);

$\gamma_{s,\omega}$ ——the angle between solar azimuth and surface azimuth (deg), which can be calculated as:

$$\gamma_{s,\omega} = A_s - A_\omega \quad (2)$$

A_s——solar azimuth (deg);

A_ω——surface azimuth (deg).

To calculate the solar altitude and azimuth angle, we need to know local solar time, time correction factor, declination etc for each time in a day. Moreover, these factors vary in the whole year. Thus it is very difficult to do a manual calculation to determine the optimal overhang depth. Consequently, students will be hard to identify an optimal depth.

3. Computer Aided Teaching Innovation

Computer technologies allow to do building simulation for energy prediction by using well-known tools such as DeST, TRNSYS, DOE-2 and Energyplus [4]. This is an efficient solution for determining overhang depth, taking into account the variation of climate conditions and sun positions in the sky. Students can be easily taught to practice on any other building design. The following shows an illustration of using Energyplus, a powerful tool developed by Lawrence Berkeley Laboratory, to design the fixed overhang.

Firstly, we need to model a simple room in Energyplus for students for further analysis. A number of tools are available to create EnergyPlus input files (IDF file). Here the IDF Editor was used to model this room and the IDF file is illustrated in Fig. 3. This room model can be changed according to the desire by modifying the text-based IDF file if a different room dimension is required.

Secondly, students can change the window dimension for different design purposes as shown in Fig.3. Then they suppose an overhang depth by setting the vertices values (see Fig. 3: overhang dimension) and select a weather file (provided by Energyplus as shown in Fig.4) to run building simulation.

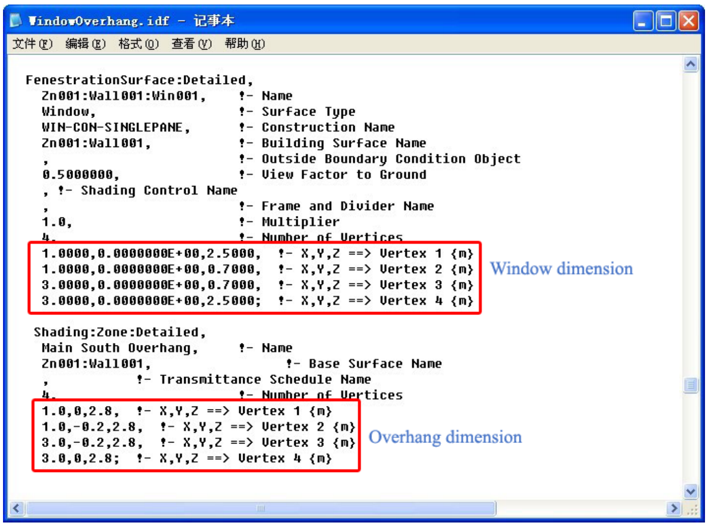

Fig.3 Energyplus IDF file

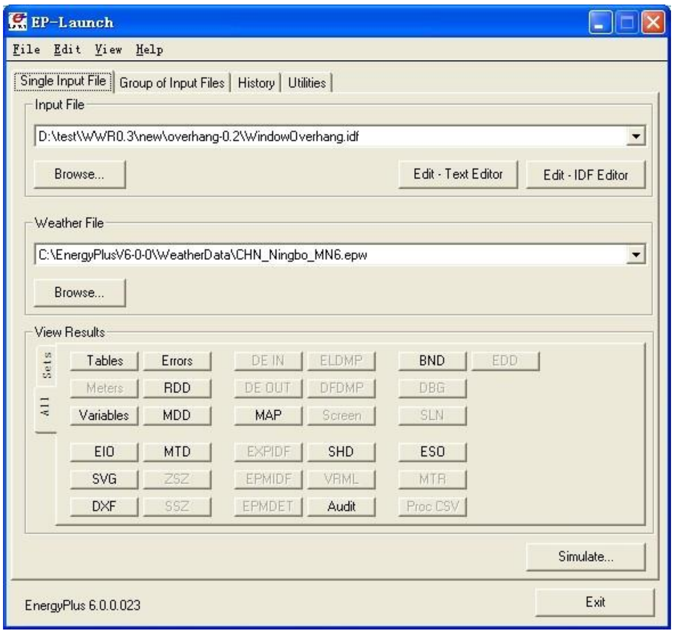

Fig.4 Energyplus simulation program interface

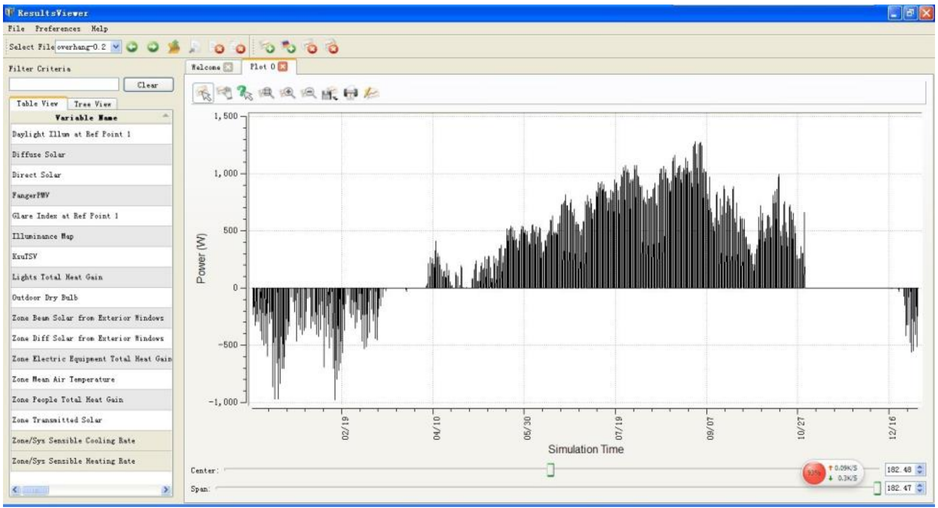

Fig.5 Annual energy performance

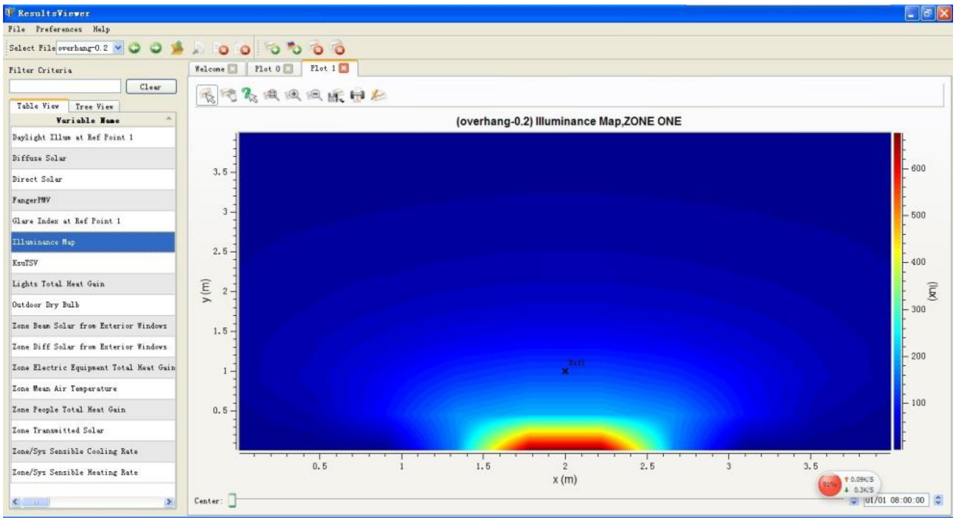

Fig.6 Daylight illuminance map

Thirdly, the energy performance (see Fig. 5) as well as daylighting map (see Fig. 6) for the indoor space can be obtained after building simulation. Using these charts, students can easily determine the energy peak time, total energy performance and daylight availability and check whether the overhang depth is too long. If the result is not acceptable, then students can change the overhang depth as shown in Fig.3 and repeat the building simulation until the performance reaches the desire levels.

Through the above procedure, students will gradually understand the relationship between overhang depth and building energy consumption and the optimal overhang depth can be easily obtained. The advantage of this teaching innovation is significant. At least 90% of students have used this method to improve shading design and the best energy and daylighting performance was achieved in design practice. Thus this innovation teaching method can be widely used to enhance students' skill of designing a better building.

4. Conclusion

Overhang design is a main part in teaching building energy and environmental course. Conventional teaching method only tells students the main principle of designing an overhang and they can not identify an optimal overhang depth due to complex manual calculation. This paper uses computer technologies to aid students in designing overhang. The advantage of this teaching innovation is significant compared to the conventional one. This method can help students understand the inter-relationship between overhang depth and building energy consumption and can be widely used to enhance students' skill of designing a better building.

Acknowledgements

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