Applications of ECOTECT and HEED in building energy analysis - Case study: A typical tube house in Hanoi

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Abstract

Sustainable architecture generally describes environment-conscious design techniques in the field of architecture, which has a great potential in the future of architecture design as well as construction engineering. The idea of sustainability or ecological design is to ensure that our actions and decisions today do not inhibit the opportunities of the next generations. Energy efficiency over the entire life cycle of a building is the most important single goal of sustainable architecture. The objective of this study is to understand how to analyze building energy and recognize the factors which influence on building environment by software of HEED and ECOTECT trial version. A complete building design and environment analysis tool that covers the full range of simulation and analysis functions required to truly understand how a building design will operate and perform.

Keywords

Green building, Tube house, HEED, ECOTECT

1. Introduction

The building was built in Hanoi, Vietnam, with subtropical climate; that is determined
as a typical tube house in this South East Asian country. The land area is 5m width and 21m length while the architect left 30m$^2$ for the front yard and 6m$^2$ for the back garden. Designing an atrium in the middle of the house to create stack ventilation, improve daylighting level as well as bring the better environment into 2 rooms of different sides; equipping a roof floor with water tank to reduce solar energy absorption of the top floor. South is facing façade, as South and South East was well-known as the optimal orientation for general building in Vietnam.

![Fig. 1- Detail of the building](image)
(a) Second floor plan
(b) Section of the house

2. Weather data analysis with weather tool

Hanoi experiences the typical climate of northern Vietnam, where summers are hot and humid, and winters are relatively cool and dry. The summer months from May to September receive the majority of rainfall in the year (1,682 mm rainfall/year). The winter months from November to March are relatively dry, although spring often brings light rains. During the cooling season from April to October, the HVAC could be turned on to reduce heat, energy used in this period is much more than energy used during the heating season, it is caused mainly by people who do not use heating system in Vietnam. The minimum winter temperature in Hanoi can dip as low as 6–7°C not including the wind chill, while summer can get as hot as 38–40°C. The summer monsoon is from South East, while the winter monsoon is from North East. The optimal orientation, SOUTH EAST was suggested as shown in Fig.2.

The natural ventilation is the highest efficient passive strategy [1], which can improve the thermal comfort up to 40% in April, May, September and October, whereas the weather is probably hot and humid during cooling season as the distribution in Fig.3.
3. Preliminary analysis with HEED

**Table 1** - HEED set-up parameters

<table>
<thead>
<tr>
<th>Overhang width</th>
<th>None</th>
<th>300mm</th>
<th>600mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass type</td>
<td>Clear single pane 1/8” in window/vinyl frame</td>
<td>Clear double pane low E in window/vinyl frame</td>
<td>-</td>
</tr>
<tr>
<td>Insulation</td>
<td>Insulated attic and raised floor</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Walls</td>
<td>Stucco and face brick on 2x6 wood studs at 24”, with plaster board interior</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Roof</td>
<td>Brighter color shingles, fan ventilated attic, sloped roof</td>
<td>Clay on concrete tiles, natural ventilated attic, sloped roof</td>
<td>-</td>
</tr>
<tr>
<td>Floor</td>
<td>Slab on grade exposed or tiled, under first floor condition is earth</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Heating &amp; cooling</td>
<td>No any heating or cooling equipment</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Waste 60% of energy when compare with energy code</td>
<td>Save 70% of energy when compare with energy code</td>
<td>Save 70%</td>
</tr>
</tbody>
</table>
In Heed simulation, the overhang and different material significantly improve the building energy efficiency. The 300mm overhang is high efficient, when the result showed 70% energy efficient, with both 300mm and 600mm overhang. Furthermore, the double glaze - low E glass significantly enhances energy saving. ECOTECT is indeed a powerful tool to discover the detail of shading device and it will be applied for advanced study.

3. Analysis building energy with ECOTECT

3.1. Shading design

As the humidity has little impact on the shading line, it can be neglected [2]. The convenient maxim can be adopted in the subtropical region as every condition which is below 25°C belongs to “underheated” period, while temperature above it should be categorized as an “overheated” condition displayed in Fig. 5.

Fig. 4 – Results with HEED (a) Energy cost; (b) Energy efficient design

Fig. 5- (a) Yearly chart showing overheated and underheated periods, (b) Overheated period transferred to sun-path diagram, (c) shading device guideline, (d) Psychrometric chart.
In Fig. 6 sections of shading device are shown, which are used on south elevation. The shading system is a complex of horizontal and vertical shading device with the width of approximately 390mm and 200mm, respectively; bearing sun angle is 50° and 20°. Shading device eliminated solar heat gain during the cooling season from April to November. The shading efficiency increases from 2 to 10% during the whole year when the shading devices are added into the South façade as shown in Fig. 7.

Fig. 6- (a) Vertical shading device; (b) Horizontal shading device.

Fig. 7- Effective shading coefficient.

3.2. Gain Breakdown

Fig. 8- Gain breakdown with single and double glazed- low E Alum frame
Double glazed- low E window reduces solar heat gain during the whole cooling season; although it is slightly efficient, still recognizable, it is caused by the small area of window and door. The heat gain will be less if solar gain factor of double glazed- low E window is smaller.

3.3. Daylighting and Natural Ventilation

As a result, daylighting is not a problem for this house when the atrium helps to improve the daylighting illuminance in the middle zone up to 250lx at 12pm in December 21st, which is quite enough for daily activities. However, daylighting uniformity does not aim at 0.8 in the remote zone, hence with special visual task, the electric lights are necessary.

The stack ventilation which has a significant effect is caused by the atrium in the middle of the building.

(a) Daylighting simulation result; (b) CFD simulation and stack effect

4. Conclusion

There are several elements which influence the energy efficiency in a building such as material, type of window with glass, shading device, air conditioning and so on. The efficient horizontal lightshelf in Hanoi should be designed to neglect the direct solar energy with solar altitude up to 50°. The atrium was proved that it has high efficiency for natural ventilation with local design. However, the building energy research in Vietnam is still limited without high technology and practical researches.
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5. References


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