Environmental Assessment and Preservation for Fujian Hakka Villages

ISISS 2011 Xiamen University

Minoru Ueda
MU Design Inc. Japan
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Map Showing the Area of Nominated Property and Proposed Buffer Zone around Fujian Tulou – 3: Gaobei Tulou Cluster

Gaobei Tulou Cluster

高北土楼

Fujian

厦门

永定

龙岩

高头镇

#28 承啓楼 Chengqi Lou (1709)

(Ref: United Nations UNESCO World Heritage Centre)
Cheng Qi Lou  承啓樓
Cheng Qi Lou  承啓樓
Structure 建築

- Typical Hakka Toulu – one of the largest
- 4 Story South Facing  4層樓朝南
- Area  878 m² 面積平方米
- Diameter 62 m 直徑
- Height 15.8 m 建築高度
Cheng Qi Lou  承啓樓

• 150 km from Xiamen  150公里從廈門

• Altitude 515 m  高度

• Hot Summer/Mild Winter  炎熱的夏季/寒冷的冬季溫和

• Surrounding area agricultural  圍繞區域農業

• 40 Family 200people lives  四十家族 二百人
Local Climate 地域氣候
Gabei area 高北

- Temperature 溫度
- Humidity 潮濕
- Insolation 日射量
- Wind 風向・風力
- Rain 雨量

- Hot Summer/Mild Winter 炎熱的夏季/寒冷的冬季溫和

- 700 Heating Degree Days 700的采暖度日數
Evaluating Environmental Impact
評估對環境的影響
Key Factors 關鍵因素

- Energy Utilization 能源利用
- Comfortability Index

<table>
<thead>
<tr>
<th>Comfortability index</th>
<th>Temperature</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASHRE</td>
<td>20 – 27 ℃</td>
<td>0 - 80 %</td>
</tr>
<tr>
<td>Chinese Indoor</td>
<td>16 –24 ℃</td>
<td>30 - 60 %</td>
</tr>
</tbody>
</table>
Data Loggers Installed

4F Bed Room

2F Storage

1F Kitchen

Courtyard

Outside

Reference: Drawings by Katayama and Tokyo Art University
Data Loggers Installed
安裝數據採集器

Data Collected 夏季的數據收集
June 28 – July 6, 2009

Data Locations
數據的位置
Data Loggers - Cheng Qi Lou 2009

數據記錄儀 - 承啓樓

Monitoring Temperature and Humidity

監測溫度和濕度
Temperature Data 溫度數據

• External temp. variation 6.5°C 外部溫度變化
• 2 fl. temp. variation 1.7°C 溫度變化
• 1 fl. temp. variation <5.5°C 溫度變化

Cooler - vaporization effect 散熱器 - 汽化效應
Relative Humidity Data 對濕度數據

- 2 fl nearly constant at 76% (± 2%)
- 1 fl relatively constant in 85% range
- 4 fl similar to external temp. but 7% lower
Massive Rammed Earth Walls

Thermal Performance 熱性能

Mass 建築群

Internal Temperature and Humidity Fluctuation 在內部的溫度和濕度的波動
Massive Rammed Earth Walls
大規模的夯土土牆

- Cheng Qi Lou 承啟樓

Volume mass of earth - 3213 m³
地球的大批量
26% of total building area
總建築面積

Smaller Toulu - similar wall thickness
Total volume mass / total space is even greater

Significant Thermal Battery Potential
顯著的熱電池的潛力
Historic Rammed Earth Structures

• Defense / Security 國防/安全

Sustainable Architecture 可持續發展的建築

• Protection from climate 從氣候保護
• Storage preservation 儲藏保鮮
• Use local materials 使用當地材料
Natural Air Flow

Summer

Chimney Effect

Vapour

Wind

烟囪效應

風
Natural Air Flow

Winter - gate closed

Winter - 閘門關閉
Improve Winter Heating Performance
提高冬季供暖性能

Prevent Heat Loss 防止熱損失

• External Insulation 外牆保溫

• Building perimeter 建築外圍
Environmental Performance Assessment

- LEED (US)
- BREEAM (UK)
- CASBEE (Japan)

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<th>LEED</th>
<th>CASBEE</th>
<th>BREEAM</th>
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<td>Indoor Air Quality</td>
<td>MAX</td>
<td>MAX</td>
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<tr>
<td>Noise &amp; Acoustics</td>
<td></td>
<td>MAX</td>
<td>MANY</td>
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<tr>
<td>Service Ability</td>
<td>N/A</td>
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<tr>
<td>Energy</td>
<td>Simulations</td>
<td>Simulations</td>
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<tr>
<td>Rain Recycles</td>
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<td>MAX</td>
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<tr>
<td>Water Wastes</td>
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<td>N/A</td>
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<td>Nox, LCCO2</td>
<td>N/A</td>
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<tr>
<td>Heat Islands Effects</td>
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<tr>
<td>Flexibility</td>
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<td>Exist</td>
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<thead>
<tr>
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<th>LEED</th>
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<tbody>
<tr>
<td>Sustainable Sites</td>
<td>Q-3 Outdoor Environment on Site</td>
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<tr>
<td></td>
<td>LR-3 Off-site Environment</td>
<td></td>
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<tr>
<td>Water Efficiency</td>
<td>LR-1 Energy</td>
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<tr>
<td>Energy &amp; Atmosphere</td>
<td>LR-2 Resources &amp; Materials</td>
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<tr>
<td>Materials &amp; Resources</td>
<td>Q-1 Indoor environment</td>
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<tr>
<td>Indoor Environmental Quality</td>
<td>Q-2 Quality of Service</td>
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## CASBEE Criteria

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<th>Q-1 Indoor Environment</th>
<th>Q-2 Quality of Service</th>
<th>Q-3 Outdoor Environment on Site</th>
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<tbody>
<tr>
<td>Noise &amp; Acoustics</td>
<td>Provision of Space &amp; Storage</td>
<td>Biotopes</td>
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<td>Sound Insulation</td>
<td>IT Innovation</td>
<td>Townscape &amp; Landscape</td>
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<td>Sound Absorption</td>
<td>Barrier-free Planning</td>
<td>Local Characteristics &amp; Outdoor Amenity</td>
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<tr>
<td>Room Temperature Control</td>
<td>Perceived Spaciousness &amp; Access to View</td>
<td>Thermal Environment on Site</td>
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<tr>
<td>Humidity Control</td>
<td>Space for Refreshment</td>
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<td>Lighting &amp; Illumination</td>
<td>Décor Planning</td>
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<td>Air Quality</td>
<td>Durability &amp; Reliability</td>
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<td>Ventilation</td>
<td>Earthquake-resistance</td>
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<td>CO₂ Monitoring</td>
<td>Seismic Isolation &amp; Vibration Damping Systems</td>
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<td>Control of Smoking</td>
<td>Interval for Exterior Finishes</td>
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<td>Interval for Main Interior Finishes</td>
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<td>Interval for Plumbing &amp; Wiring Materials</td>
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<td>HVAC System</td>
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<td>Water Supply &amp; Drainage</td>
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<td>Electrical Equipment</td>
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<td>Support Method of Machines &amp; Ducts</td>
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<td>Communications &amp; IT equipment</td>
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<td>Story Height</td>
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<td>Floor Layout</td>
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<td>Floor Load Margin</td>
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<tr>
<td>LR-1 Energy</td>
<td>LR-2 Resources &amp; Materials</td>
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<tr>
<td>Building Thermal Load</td>
<td>Water Saving</td>
<td>Rainwater &amp; Gray Water</td>
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<td>Natural Energy Utilization</td>
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<td>Recycled Materials</td>
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<td>Renewable Energy</td>
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<td>Timber from Sustainable Forestry</td>
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<td>Efficiency in Building Service System</td>
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<td>Materials with Low Health Risks</td>
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<tr>
<td>ERM *</td>
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<td>Reuse of Existing Building Skeleton etc.</td>
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<td>CFCs &amp; Halons</td>
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<td>LR-3 Off-site Environment</td>
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<td>Air Pollution</td>
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<td>Noise, Vibration &amp; Odor</td>
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<td>Wind Damage &amp; Sunlight Obstruction</td>
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<td>Light Pollution</td>
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<td>Heat Island Effect</td>
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<td>Load on Local Infrastructure</td>
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\[
\text{ERR} = \frac{\text{Total amount of energy saved in the evaluated building}}{\text{Standard primary energy consumption for the evaluated building}}
\]
Building Environment Efficiency Calculation (BEE)
建築環境效率計算

Building Environmental Quality and Performance
建築環境負荷

\[
\text{BEE} = \frac{Q: \text{Building environmental quality and performance}}{L: \text{Building environmental loadings}} = \frac{25 \times (S_Q - 1)}{25 \times (5 - S_{LR})}
\]
Results

BEE = 2.7

Existing Building

BEE = 2.9

New Construction
Assessment of Chen Qi Lou
評估承啓樓

- Impressive Performance for a 383 year old building
- Efficacy of vernacular buildings 鄉土建築的療效觀察
Preserve

修葺 + Revitalize

1) total water management upgrade
2) small energy efficient heating system
3) increased use of natural energy sources
4) more emphasis on the biotope and improvement in the outdoor environment.
Double Skin Window

雙層窗
Perimeter Window Zone
周邊窗戶區
Conclusion 結論

- Research for preservation and sustainable retrofit
- Work with villagers to preserve and retrofit buildings
- Establish research and demonstration center