Project on
“Study of Energy Consumption and Indoor Environment Problems of Residential Buildings in China”
by
Research Committee of Architectural Institute of Japan
Committee Members

Chairman  : Toshiyuki Watanabe (Kyushu Univ.)
Secretaries  : Hiroshi Yoshino (Tohoku Univ.),
              Hiroyuki Kitahara (Total System Lab.)

The number of the members
Japanese : 13        Chinese : 12

Purposes of This Project

1. Data compilation of residential energy consumption and indoor environment based on literature survey, field investigation and numerical simulation.

2. Proposing and promoting technologies for energy conservation and sustainable environment creation with improving the living standard.
Contents of Three Years Project

- **The First Year (April, 2002 ~ March, 2003)**
  - Literature survey and field investigation on energy consumption and indoor environment of residential buildings
  - Compilation of weather data for building design based on observed data in China

- **The Second Year (April, 2003 ~ March, 2004)**
  - Literature survey and field investigation on energy consumption and indoor environment of residential buildings
  - Estimation and verification of effect of various environmental symbiosis technologies

- **The Last Year (April, 2004 ~ March, 2005)**
  - Proposal of residential energy conservation technologies with taking account of regional characteristics
  - Proposal of design guideline of residential buildings based on sustainable environmental technologies
### Basic Data of China

- **Total Land Area**: 9,600,000 km²
- **Population**: 1,265,830,000 persons
- **GDP**: 1,230,000 million dollar
- **GDP/person**: 911 dollar / person

<table>
<thead>
<tr>
<th>Category</th>
<th>China</th>
<th>Japan</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Land Area</td>
<td>26</td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td>Population</td>
<td>10</td>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>GDP</td>
<td>1</td>
<td>3.4</td>
<td>8.5</td>
</tr>
<tr>
<td>GDP/person</td>
<td>1</td>
<td>36</td>
<td>37</td>
</tr>
</tbody>
</table>

The Ministry of Foreign Affairs of Japan
http://www.mofa.go.jp/index.html
Outline of Activities in the First Year (1/3)

- Literature survey on energy consumption of residential buildings in China
- Literature survey on the regulations of residential buildings design in China
- Investigation on indoor environment and energy consumption of residential buildings in urban area
- Compilation of weather data for simulation of heating and cooling load
- Retrofitting of residential buildings in terms of thermal comfort and energy conservation in rural area
Outline of Activities in the First Year (2/3)

- The 2\textsuperscript{nd} International Workshop “Energy and Environment of Residential Buildings in China” at Tongji University in Shanghai (October, 2002)

  - The number of papers: 50
  - The number of participants: 85
    (from Japan, the U.S., the Republic of Korea and People’s Republic of China)

The 3\textsuperscript{rd} International Workshop is held in Xi’an, China next year.
Outline of Activities in the First Year (3/3)

- Lecture “Traditional Dwellings in China and Regenerations” by Jiaping Liu (Xi’an University of Architecture and Technology) in Tokyo (March, 2003)
Energy consumption of residential buildings in China (1/2)

Fig. 6 Relationship between Energy Consumption and Degree-days

\[
y = 0.028x + 32.18 \\
y = 0.0274x + 19.31 \\
y = 0.0148x + 16.52 \\
y = 0.0063x + 6.195
\]

Heating Degree-days
Energy Consumption (GJ/Household/year)

USA
Canada
Japan
China

Chongqing
Hong Kong
Xi’an
Beijing
Energy consumption of residential buildings in China (2/2)

- Urban (China)
- Rural (China)
- Japan

- Coal
- District heating
- Natural gas
- LPG
- Petroleum product
- Others
- Lighting, home electric appliances
- Kitchen
- Hot-water supply
- Cooling
- Heating

Graphs showing energy consumption in GJ/household/year for different regions and uses.
The regulations of residential buildings design in China (1/2)

GB 50176-93 Standard of climate regionalization for architecture

- Very Cold Zone
- Cold Zone
- Moderate Zone
- Hot Summer & Cold Winter
- Hot Summer & Warm Winter
The regulations of residential buildings design in China (2/2)

- Design code for heating, ventilation and air conditioning (GBJ19-87)
- Thermal design code for civil building (GB50176-93)
- Energy conservation design standard for new heating residential buildings (JGJ26-95)

<table>
<thead>
<tr>
<th></th>
<th>Heat Transmission (W/m²K)</th>
<th>China (external surface area / dwelling unit volume ÷ 0.3)</th>
<th>Japan (reinforced concrete buildings, external insulation method)</th>
<th>Heat Transmission (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>External Wall</td>
<td>Roof</td>
<td>Window</td>
</tr>
<tr>
<td>Very Cold Zone (Harbin)</td>
<td></td>
<td>0.52</td>
<td>0.50</td>
<td>2.50</td>
</tr>
<tr>
<td>Cold Zone (Beijing, Xi'an)</td>
<td></td>
<td>0.90</td>
<td>0.80</td>
<td>4.70</td>
</tr>
<tr>
<td>Hot Summer and Cold Winter Zone (Shanghai, Chongqing)</td>
<td></td>
<td>1.16</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td>Moderate Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Summer and Warm Winter Zone</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Investigation on indoor environment and energy consumption of residential buildings (1/2)

Fig. Ratio of heating equipped in families.

Contents of the questionnaire survey
1) Housing Equipments
2) Life Style
3) Building Characteristic
4) Residential Characteristic
5) Satisfaction ratings
6) Energy Consumption
7) Indoor Thermal Environment

Fig. Ratio of use of heating system in winter months.

Fig. Average temperature of living room (L) and bedroom (B), in seven cities.
Investigation on indoor environment and energy consumption of residential buildings (2/2)

Temperature and humidity (Field measurement)

<table>
<thead>
<tr>
<th>Location</th>
<th>Temperature (°C)</th>
<th>Humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harbin</td>
<td>-20</td>
<td>100</td>
</tr>
<tr>
<td>Beijing</td>
<td>-10</td>
<td>80</td>
</tr>
<tr>
<td>Xi’an</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Shanghai</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Changsha</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Chongqing</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>35</td>
<td>10</td>
</tr>
</tbody>
</table>

The charts illustrate the temperature and humidity levels in various locations, with Harbin, Beijing, Xi’an, Shanghai, Changsha, Chongqing, and Hong Kong being the sites measured. The graphs show the temperature fluctuations in living rooms and bedrooms, as well as outdoor conditions, with humidity levels indicated for each location.
Compilation of weather data for simulation of heating and cooling load (1/2)

Solar radiation

Heating load
Compilation of weather data for simulation of heating and cooling load (2/2)
Residential improvement in rural area (1/2)
Residential improvement in rural area (2/2)

Section Plan of the village

New Yao Dong (built up type)

Renovation of Cave Dwelling