A study on the interior environment of the traditional Huizhou patio house

Jia He

1. INTRODUCTION

1.1 Background

The traditional patio house in Huizhou, Anhui province as an important part of traditional Chinese vernacular dwellings with its own unique style, which shows an extremely high value and historic significance. There were 7,000 units of vernacular dwellings and over 100 ancient villages during the Ming and Qing Dynasties in this area. The various types of ancient living architectures in Huizhou are more than 15 forms in total. (Local chronicles of Huizhou). However, most of the traditional patio houses in Huizhou need to reconstruct in order to meet the people's living needs nowadays. This research objective is focused by more people and scholars. However, it is a difficult subject to combine with the modern architectural concepts and reserve the advantages of traditional patio house in Huizhou together at the same time.

1.2 Research purposes

Summary and discussion through the formation, development and influencing factors for the Huizhou traditional patio house, and took the tests and questionnaire on the interior environment conditions in summer and winter, which include the temperature, humidity, ventilation and the illuminance (only in summer), then by analysis the date of the tests, got the advantages and disadvantages in Huizhou traditional patio house and proposes the corresponding improvements, which provide some ideas and basis for the Huizhou traditional patio house innovation and development.

1.3 Research methodologies

1. Summarize the patio’s origins, influence factors, and categories, characteristics from the previous researches and historic documents.
2. The writer went to south Anhui in Yixian country and examination the local environment from August 15th to 22nd, and December 10th to 26th. Also, I compared documents and made a conformation from documents and data.
3. By comparison and selected a patio dwelling locating in the Pingshan village. Determination the thermal environment data in winter and summer. Do surveys of comfort satisfaction to the local residence.
4. Based on the data collection and considering from documents and references, summarize the advantages and disadvantages of patio that can provide the criteria for the conception of sustainable residence design.

2. THE ORIGIN OF PATIO

2.1 The combination of northern courtyard and southern stilt house

The ancient Huizhou people fused the northern courtyard to the southern stilt house [Fig2] together, then constantly changes, summing up experience, resulting in a residential which compound in the form of both northern construction and Huizhou characteristics also adapt to the natural environment in that area called Huizhou architecture.

Fig2. The northern courtyard and southern stilt house

Patio can be thought a deformation of the northern courtyard, but also has a lot of differences in the following points:

1. Different scales: Patio's scale is indoor scale, and surrounded by the construction of the indoor space, which is similar as people. While the courtyard's scale is the outdoor scale, enclosed by the walls and more like an open space, which give person a feeling in the sense of nature.
2. Structural: From the detailed point of view of structure, there are a series of structure for lighting, drainage, ventilation in patio. While courtyard is with floor coverings, potted and other outdoor structures dominated.
3. Different spatial form: Patio space form, the hall and the hall as a whole, which is a non-figurative interface, well-shaped pan class space, a gray space between indoor and outdoor community. However courtyard on the contrary, is part of the outdoor space, which encompasses artificial imitation of nature, embodies the idea that people love the landscape and natural.

2.2 The impact of the geographical environment and climate

2.2.1 Natural environmental overview of the research area

Geographical location of study area Huizhou, called Xinchen in ancient, since the Qin as a county, has more than 2200 years of history.

2.2.2 The topography and landscape overview of study area

Southern Anhui area belongs to the original ancient land on the geological structure, low hills and dominated by Zhongshan landform types, 1000 meters above the sea level, the relative height of 800 meters above the Zhongshan distributed in the
surrounding area of Huizhou, mainly Huangshan Mountains.

2.2.3 Climate overview of study area

Southern Anhui area belongs to subtropical monsoon climate, mild and humid climate, plenty of heat, rainfall, fertile land, with four distinct seasons in Huizhou, the climate presented "a small temperature difference, more rainy days, heavy clouds and humidity" features.

Huizhou region climate is humid and rainy. Patio is a unique catchment and drainage system, also play a role in regulating the indoor microenvironment.

2.3 Humanities and social impacts on the patio

Huizhou locals mainly by business for a living. Since most men went out for business, in order to prevent thieves, and protect the peace of the whole family. So almost all the vernacular Dwellings in Huizhou are tall walls and small windows. That make the indoor ventilation and lighting rely mainly on the patio, and use of indoor walls and houses, the inner courtyard be surrounded become to be an enclosed space, which in order to ensure the safety of living.

2.4 Sense of social level impacts on the patio

Huizhou patio and patriarchal system of ethics also has a close relationship.
1) Following the hierarchical order inferiority or superiority.
2) pay attention to etiquette norms
   The higher social status of person, the more spend on the patio in the construction.

2.5 The traditional culture impacts

2.5.1 The traditional Chinese Feng Shui influence on patio

Feng Shui theory on the patio is reflected the following points:
1) The shape of the patio
2) Patio space form
3) The size of patio

2.5.2 Nature and human in harmony with the traditional ideological thinking impact on decoration in patio

The patio is not only the center for family activity, but also an important standard to identity the owner’s taste and the social status. The wood carving, brick carving and the stone carving play the most important roles in here.

3. THE CONSTRUCTION DETAILS OF PATIO

3.1 The structure of traditional patio house in Huizhou

Huizhou traditional patio house structure consists of the following components:
1. Floor coverings.
2. Interior wooden structure.

As the Fig3 and Fig4.

3.2 The patio coverings

The floor covering of Huizhou architecture has its own characteristics. Patio often used permeable pavement, which are trapezoidal bricks laying out the permeable rain gap.

3.3 Wall construction

Most of the ancient Huizhou dwellings used of very thick wall, which the mostly exterior walls are brick walls. While the interior walls are usually made of wood or is the transparent sliding door which in close proximity to the external walls.

3.4 Crescent beam

Due to the structure of Huizhou patio, in order to have a good lighting, the hall space are usually very large which the weighty at least 6m. So the long span needs a huge support beams. This kind of beam in Huizhou called crescent beam or melon beam.

4. THE TESTS AND INVESTIGATION ON INTERIOR THERMAL ENVIRONMENT IN THE HUIZHOU TRADITIONAL HOUSE

4.1 The tests location

Pingshan village is located in jinlong county Huang Qian Township, 34km far from Huangshan and 3.5km from Yixian, which is an ancient village. There are 275 ancient architecture of Ming and Qing dynasties. Now the population of village is 1175, and 342 households. The total area of the village is 452.62 hectares. There has been 1100 years history.

4.2 Tests object

Select a typical ancient dwelling called Youqingtang in Pingshan village as the object building. It located in the center of the pingshan village, and has 264 years history. This building is a typical three-bay wooden structure room which is considered two floors, but actually it is three floors building which the second floor is a mezzanine floor hidden on both seaside position, and not open for public. Through the measurement of high, the top of the patio is about 8.5m, and the lowest part is about 7m high. The façade, elevation, section plan and photos are shown as the Fig4.

The content tests include temperature, humidity, illuminance (only in summer), and the ventilation.

The summer test is from August 17th to 21th. and the winter test is from December 20th to 24th. All the test, the doors and windows in the state of natural ventilation without any heating or air condition equipment.

4.3 Temperature and humidity tests and analysis

4.3.1 The tests method

The tests used four auto recording instruments TR-74U1 and TR-73U. The test time from 6:00~18:15 continuous five days.

4.3.2 The result and analysis:
By analysis the temperature and humidity data of summer test, on the sunny day, the outdoor temperature amplitude is higher than the indoor from 5.8°C ~ 8°C; while in the rain day, the outdoor temperature amplitude is higher than indoor from 0.9°C ~ 5.3°C. The temperature in first floor is generally lower than the third floor, while the temperature in hotel as a control group change little and range between first and third floor. There is obvious sign of hysteresis for temperature rise in the indoor than that in the outdoor.

For the humidity, the average volatility of outdoor is 30% larger than that in the first floor indoor, but there is no significant in regularity. Additionally, sunny weather in the summer, the differences indoor temperature and humidity between outdoor are more significantly than that in rainy.

By analysis the temperature and humidity data of winter test, it can be summarized like that: The traditional Huizhou patio house indoor temperature and humidity have no significant improved by the building envelope. The indoor temperature and humidity are almost the same as that in the outdoor. Because there is no boundary between the indoor and outdoor in this case. So in the winter the thermal environment of the Huizhou patio house is very unsatisfactory.

4.4 Illumination tests and analysis

4.4.1 The tests method

The test was done only in summer from the August 17th to 21th. The measurement used four auto recording instruments TR-74Ui placed in hall in the first floor and the out beside the door. The results and analysis:

Although part of the patio can address the needs of indoor lighting, even on a sunny day, the best position still difficult to achieve standard indoor lighting. So Huizhou architecture, the lighting becomes a shortcomings urgent need to improve.

4.5 Ventilation tests

4.5.1 Ventilation introduction

There are two main ways for ventilation, one is wind-induced ventilation and another is stack ventilation.

4.5.2 The tests method

The summer test is from August 17th to 19th. The winter test is from December 21st to 23th. The test interval of 15 minutes-per-record the test, which is the 24 hours a day continuous test.

4.5.3 The result and analysis:

In summer, the average wind speed in the first floor is about 0.2m/s the indoor ventilation is not obvious during the daytime. At the noon, the sun light can direct go through the patio, and reach into the indoor causing the water under the patio floor be evaporated, which result in 0.5m/s ventilation after the noon. And at night, the outdoor temperature is below than the temperature indoor, that resulting in a stack 0.4m/s ventilation. Interior ventilation in winter is unsatisfactory, and because there is no heating equipment at all which make the indoor living environment is unbearable in the cold day. The average of wind speed in first floor only 0.13m/s, and almost all the data shows that all the time the wind speed in the first floor are less than
0.2m/s. The average of wind speed in third floor higher than the first floor reached in 0.22m/s. So how to improve the ventilation in winter is must be considered.

![Image](https://via.placeholder.com/150)

4.6 Questionnaire

4.6.1 Survey object:
In the Hongcun village and Pingshan village, each village to select 20 households represented. The villagers surveyed in each age between 20-35 years Survey result:
In the survey of residential households, residents of the highest residential bedroom natural lighting and natural ventilation of dissatisfaction, both are up 100%, halls of natural lighting and natural ventilation of dissatisfaction, both of the highest residential bedroom natural lighting and natural ventilation of dissatisfaction, the extent of the hall is not damp satisfaction reached 75%.

<table>
<thead>
<tr>
<th>objects</th>
<th>Satisfied</th>
<th>General</th>
<th>Dissatisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer 8:00 indoor temperature</td>
<td>32people 80%</td>
<td>6people 15%</td>
<td>2people 5%</td>
</tr>
<tr>
<td>Summer 12:00 indoor temperature</td>
<td>12people 30%</td>
<td>20people 50%</td>
<td>8people 20%</td>
</tr>
<tr>
<td>Summer 18:00 indoor temperature</td>
<td>20people 50%</td>
<td>16people 40%</td>
<td>4people 10%</td>
</tr>
<tr>
<td>Winter 8:00 indoor temperature</td>
<td>2people 5%</td>
<td>16people 40%</td>
<td>4people 10%</td>
</tr>
<tr>
<td>Winter 12:00 indoor temperature</td>
<td>6people 15%</td>
<td>8people 20%</td>
<td>26people 65%</td>
</tr>
<tr>
<td>Winter 18:00 indoor temperature</td>
<td>0people 0%</td>
<td>4people 10%</td>
<td>36people 90%</td>
</tr>
<tr>
<td>Ventilation in hall</td>
<td>8people 20%</td>
<td>12people 30%</td>
<td>20people 50%</td>
</tr>
<tr>
<td>Ventilation in rooms</td>
<td>0people 0%</td>
<td>0people 0%</td>
<td>40people 100%</td>
</tr>
<tr>
<td>Humidity in hall</td>
<td>4people 10%</td>
<td>6people 15%</td>
<td>30people 75%</td>
</tr>
</tbody>
</table>

4.7 Summary
From the above analysis that there is an obvious defect in the indoor natural ventilation, natural lighting, humidity in the Huizhou patio house. The satisfaction of summer indoor thermal environment is high, while the satisfaction in the winter is low.

5. HUIZHOU TRADITIONAL PATIO HOUSE INTERIOR ENVIRONMENTAL IMPROVEMENTS

5.1 The improvement on the exterior walls
By repeatedly comparing on the actual situation, choose the intermediate insulation to improve the performance of the thermal environment is a better choice. Fig.5

5.2 The improvement on windows
In order to get more lighting and improve the ventilation of the house, the house must have windows.

5.3 The improvement on patio
Making the sun shading layer under the glass roof so that can adapt both the summer and winter. In summer the glass roof must be able to open or partially open. In winter, the glass roof is closed to avoid the heat loss in the house.

6. CONCLUSIONS
By analysis and summary of interior environment tests get some shortcomings of the Huizhou traditional patio house on the interior environment. Based on the results of the data and the local situation, make some suggestions on improvement measures in Huizhou traditional patio house, which can provide some ideas and basis for the Huizhou traditional patio house innovation and development in the future.

References
1. Xiaonkui Li, Chinese courtyard houses the spirit, Chinese traditional houses and culture, China Construction Industry Press
2. Qijun Wang, Chinese dwelling, China Electric Power Press
3. Fan Yan Bing, China Huizhou architecture, China Building Industry Press, 2002
8. Jia Ping Liu, Liu Yang, indoor thermal environment design, Mechanical Industry Press, 2005
11. L.Song, R Lin and Y Zhu, simulation study on the summer thermal performance of a typical chinese traditional residential building anhui resident Dept. of Building Science, Tsinghua University, Beijing, P.R.China