OLD AND GREEN

Environmental performance of traditional Chinese housing

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Abstract. Traditional Chinese housing, like vernacular housing everywhere, is under threat. Because such housing is considered wasteful in its use of land or energy, it is often demolished for more intensive and supposedly more energy-efficient housing, despite the resulting loss of embodied energy and urban amenity. Although the conservation movement has helped to preserve some traditional housing, the need for old buildings to meet modern standards of comfort and environmental performance remains a potential economic deterrent to conservation. For this reason, a team from the University of Technology Sydney (UTS) undertook in 2009-10 the first stage of a research project to study the environmental performance of traditional Chinese housing in Xiao He Zhi Jie, Hangzhou. The UTS team of Dr Grace Ding, Dr Janet Ge and Peter Phillips was assisted by staff and students from Zhejiang University and local members of ICOMOS China, and by a research grant from the Australia-China Council. Temperature and humidity monitors were installed in six local houses, and in a modern unit in a nearby multi-storey building as a control. Readings were made every hour and the data collected every fortnight for a full year. This paper reports on the project and its initial findings, including the surprisingly small difference in environmental performance between traditional and conventional modern construction.

1.Introduction

Traditional Chinese housing, like vernacular housing everywhere, is under threat. Much has already been demolished for urban renewal. There are claims that such houses are old-fashioned, need too much maintenance, and provide too little accommodation on scarce urban land. In energy-conscious times, demolition of old houses is also being advocated on the grounds that they do not meet modern standards for energy efficiency.

However, traditional housing can also create a level of urban amenity not usually provided by modern high-rise development. The design and construction of vernacular housing has evolved over centuries in response to its local climate, during times when the building itself was the only available means to moderate climatic extremes. When properly understood and used, traditional buildings may be less energy inefficient than supposed. Moreover, even if new buildings are more efficient, it may take many years of energy savings to recover the loss of the embodied energy resulting from demolition and rebuilding. As the American architect Carl Elefante has written (Elefante, 2007), the greenest building may well be the one that is already built.

Historic buildings are part of humanity's cultural capital. They are a physical record of historical evolution, scientific progress, cultural influences, and economic and social development. In response to the loss of many valuable heritage assets over the last decades, governments and the public have worked to conserve what remains. Nevertheless, the need for old buildings to meet modern standards of environmental comfort and performance remains a potential economic deterrent to conservation.

For this reason, in 2009 the Australia-China Council agreed to fund a research project to study the environmental performance of traditional Chinese housing, to compare its performance with that of modern housing and to see whether the historic housing could serve as a model for sustainable urban development in China and perhaps also in Australia, or what measures might be needed to improve its environmental performance. The research project was carried out by Peter Phillips, Dr Grace Ding and Dr Janet Ge of the School of the Built Environment within the University of Technology Sydney (UTS) Faculty of Design, Architecture and Building,

2.The study area

The location selected for the project was Xiao He Zhi Jie (Little River Street), a typical South China water town in the Gongshu district of Hangzhou. Hangzhou lies at the southern end of the Grand Canal which extends north to Beijing. Xiao He Zhi Jie is part of a former thriving port town at the junction of the canal with the Xiao He and Yuhang Tang Rivers (Figure 1). Most of the surrounding area has been redeveloped, but Little River Street has been conserved by the Hangzhou municipal government as part of an extensive conservation program which began in 2002 and was completed in 2007. Because some buildings were conserved while others were rebuilt in a traditional appearance using modern materials, this site provided an excellent opportunity to compare traditional and modern construction versions of the same building configuration.

Xiao He Zhi Jie has a long history, beginning as early as the Tang Dynasty at the end of the first millennium. The area gradually developed into a community during the late Qing Dynasty, during the 19th and early 20th centuries. It was an important port with integrated warehouse, transportation, retail and service businesses. In the modern Xiao He Zhi Jie there are about 120 households with 450 residents, half of whom are over 60 years old and most of whom have retired. The area now contains residential and retail businesses, and provides a setting for activities relating to traditional Chinese culture.

The style of the buildings is typical of the late Qing dynasty and reflects the living environment of relatively poor people (Figure 2). Most of the buildings were one or two storeys high, combined in terraces or around courtyards. The buildings originally had no

Figure 1. Location of Xiao He Zhi Je (base map © map-of-china.org shows location of Hangzhou; inset top left from Yuhang tourism map shows detail of Gongshu district; and inset bottom left from site plan shows the street itself)

bathrooms or kitchens, and little acoustic or thermal insulation. The spaces between the houses were very narrow and contained little or no landscaping.
Masonry (usually brickwork) coated with a weak stucco was used mainly for ground floor walls, although some common walls were built in masonry to two storeys. The main structure consisted of framing poles (often built into the masonry) with horizontal poles as beams. Many upper floor external walls were timber framed and boarded, even between adjoining houses, with the pole framing partly exposed.

The setout of the pole framing is typical of the combined chuandou and tailiang structural systems, with the eaves and ridge purlins supported directly on columns, and intermediate purlins supported on stub columns off main beams between the columns

Figure 2. Typical construction of houses in Xiao He Zhi Jie (Peter Phillips)

(Figure 3). Ground floors may have been stone flagged or of rammed earth, with timber used for upper floors and stairs. Roofs were clay tiled directly over timber boarded ceilings.

3.Previous conservation works

Old buildings in China are generally classified into one of three categories depending on their cultural significance. In descending order of significance these are:

- Heritage
- Intermediate
- Historic

For heritage buildings, conservation will be undertaken only with original materials, and the original function of the building will be conserved wherever possible. Intermediate buildings can be conserved

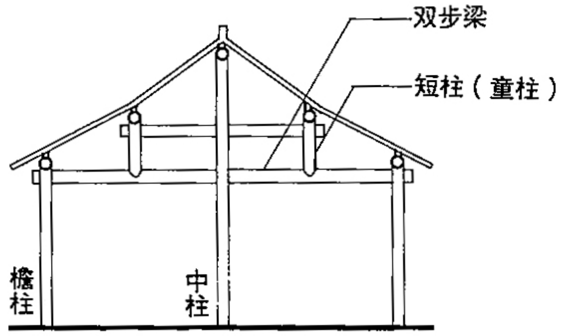


Figure 3. Typical structural system of houses in Xiao He Zhi Jie (Chang and Blaser, 1987)

for a different use from the original, although original materials will generally still be used in conservation works. The conservation of historic buildings can involve both a change of use and the introduction of new materials.

The buildings in Xiao He Zhi Jie were classified in the historic category. In the recent conservation works, the traditional external appearance of the buildings was restored or reconstructed. Where the original construction had survived it was retained, but some of the houses had to be rebuilt entirely, which was done using masonry walls throughout, with cement-rich mortar and stucco, sometimes with timber boarding overlaid externally. Almost all ground floors and some first floors were rebuilt in concrete. Externally, gutters and downpipes have been added (the buildings originally having none), and the streets and river banks have been paved with stone.

4.Research methodology

The houses selected for the study were a mix of reconstructed buildings (such as Buildings A and D) and old buildings that had been repaired (Building F). Even where the old structure was retained, the interiors of the houses were almost all modernised to some extent, with plasterboard wall and ceiling linings (often encasing the pole frame structure), and modern bathroom and kitchen facilities, usually located in a newly built extension.
Many houses have now had air-conditioning installed, and some of the rebuilt houses have secondary aluminium-framed windows constructed behind the traditional timber windows. The control building (Building E) was a modern two-bedroom apartment in a multi-storey building nearby. The locations of the

buildings are shown in Figure 4, and details of each dwelling are given in Table 1.

The main activity of the research project was to measure and record the temperature and humidity at different locations around the dwellings, over a full annual climate cycle. Each of the selected houses had up to seven monitors located on walls and ceilings

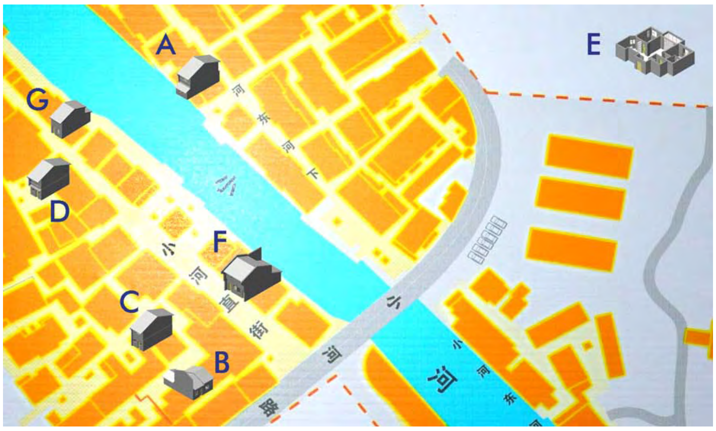


Figure 4. Location of the seven sample buildings within Xiao He Zhi Jie (base map adapted from original by Hangzhou municipal government)

upstairs, downstairs, inside and outside. The locations (shown in the drawings of each building) were chosen to cover a range of different orientations, positions within rooms, and locations relative to the river and streets. The monitors recorded the temperature and humidity in their vicinity every hour throughout the day and night. Occupants were also asked to keep a logbook of their activities that might affect the temperature and humidity, noting when they opened and closed windows or turned on heating or cooling equipment. All this information was collected every fortnight by a research student from Zhejiang University. The full research team visited the site three times throughout the monitoring period, to install the monitors and to measure up and document the buildings for future computer modelling.

Once the data had been collected, the first task was to review it for consistency. Temperature and humidity readings from external monitors in comparable locations were checked against one another and

TABLE 1. The dwellings in the study sample

Dwelling	Type	Construction	Monitors
Building A	Two-storey terrace house, reconstructed; two upstairs bedrooms	Concrete floors (first overlaid with timber), masonry lower and common walls, timber upper walls, timber windows and shutters, tiled roof	A1: bedroom external wall A2: bedroom internal wall A3: bedroom common wall A4: living room external wall A5: living room common wall A6: living room suspended A7: exterior lower rear
Building B	Two-storey terrace house, reconstructed; two upstairs bedrooms	Concrete floors (first overlaid with timber), masonry lower walls, timber upper/common walls, timber outer and aluminium inner windows, tiled roof	B1: bedroom external wall B2: bedroom internal wall B3: bedroom external wall B4: stair hall common wall B5: living room external wall B6: living room suspended B7: exterior lower rear
Building C	Single storey courtyard house, reconstructed; one bedroom	Concrete floor, rendered masonry walls, timber outer and aluminium inner windows, tiled roof	C1: bedroom external wall C2: bedroom common wall C3: bedroom internal wall C4: living room external wall C5: living room internal wall C6: living room suspended C7: exterior courtyard
Building D	Two-storey terrace house, conserved and altered; two upstairs bedrooms	Concrete ground floor, timber first floor, masonry lower walls, timber upper/common walls, timber outer and aluminium inner win-dows, tiled roof	D1: bedroom external wall D2: bedroom external wall D3: bedroom external wall D4: living room external wall D5: living room common wall D6: living room suspended D7: exterior upper rear
Building E	Single storey apartment in new 12-storey buil-ding; two bedrooms	Concrete floor and cei-ling, rendered masonry walls, double glazed alu-minium framed windows	E1: bedroom external wall E2: bedroom internal wall E3: dining room internal wall E4: wardrobe suspended E5: exterior enclosed balcony
Building F	Two-storey double width terrace house conserved and altered; two upstairs bedrooms	Concrete ground floor, timber first floor, masonry lower/ common walls, timber upper walls, aluminium windows, timber shutters, tiled roof	F1: exterior lower front F2: living room external wall F3: bedroom external wall F4: bedroom suspended F5: bedroom ceiling

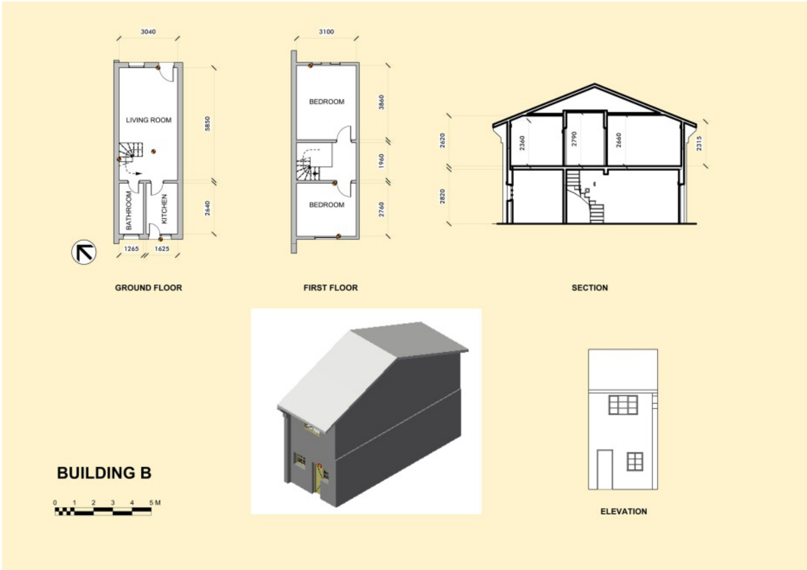


Figure 5. Typical building documentation, showing dimensioned building plans with monitor locations, section, elevation and axonometric view (Peter Phillips)

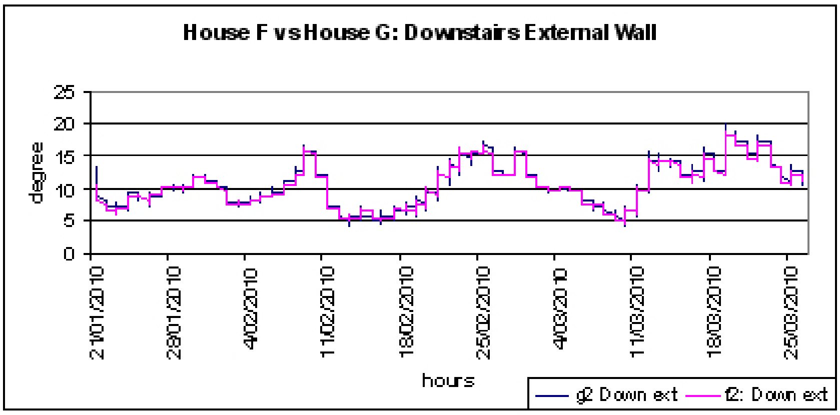
compared with official climatic data for the area. Then the data from internal monitors was compared with that from external monitors nearby, or with internal monitors in the same or different houses. Apparent variations from the normal daily cycle were also checked against the logbooks to investigate possible reasons for the disparity. The site measurements were converted into CAD drawings for later use in computer modelling (Figure 5).

5.Research results

Although the analysis of the data is not yet finalised, investigation so far has revealed good correlation between official climate data and the monitor readings, and good consistency between predicted and actual results. At the same time, comparisons of readings from different types of construction, house orientation and monitor location have yielded interesting and less predictable outcomes.
Results for individual houses during winter months indicate that:

- indoor temperature fluctuates less than outdoor temperature
- wall temperature inside is generally higher than outside, even without any heating
- external wall temperature on the water side of the house is generally lower than that on the street side
- external wall temperature is lower on a downstairs wall than on an upstairs wall

When data from different houses is compared, the research has shown surprisingly little difference between the temperature and humidity readings in the conserved old buildings and those in the houses that have been rebuilt using modern materials (Figure 6). These findings were reasonably consistent for all of the buildings in the study. This indicates that, at least for the construction types encountered in the study, buildings of conventional modern construction may perform little better than historic buildings.



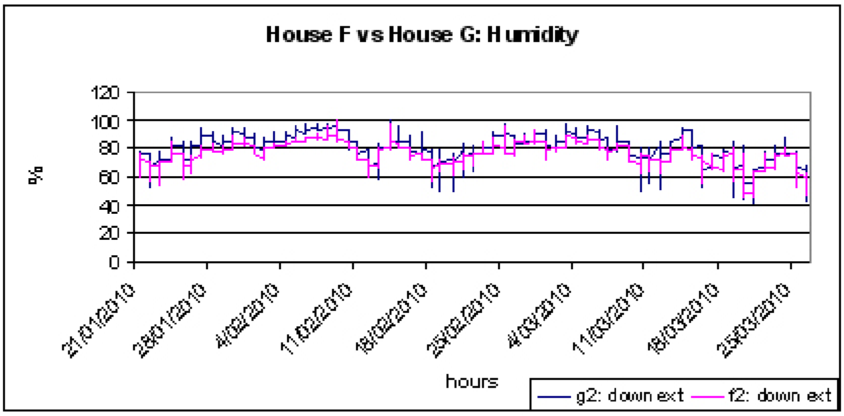


Figure 6. Graphs comparing temperature (above) and humidity (below) readings from monitors located on the inside of external ground floor walls in Buildings F and G (Janet Ge)

6.Conclusions and further research

This study was always envisaged as the first stage of a more extensive research project. The initial results have demonstrated that the methodology is generally sound and can generate verifiable and useful results. The local architects from the Ancient Architecture Design Institute of Zhejiang Province, who assisted the research team with the project, were keen to extend it in the future through comparable studies of the performance of unrenovated buildings, and also buildings where less intervention has taken place. As conservation work is continuing on other similar sites near Hangzhou, there are also opportunities to incorporate and assess the performance of different upgrading measures as the building works proceed. It is hoped that these further stages of the project can be undertaken once funding becomes available.

Interestingly, at a seminar held at Zhejiang University Department of Architecture during the research project, Chinese colleagues suggested that conservation of traditional housing such as that in Xiao He Zhi Jie faces other challenges. Although governments can do much to influence conservation practice and undertake model projects, there is still a need for the completed buildings to have a viable future use for private occupants, and for conservation and reuse in general to be attractive to the private sector. The past associations of areas such as Xiao He Zhi Jie with people of lower class and little wealth may however be a more powerful disincentive for their future conservation and continued use than any real or perceived lack of environmental performance. The Western concept of gentrification, in which humble buildings of the past are conserved, upgraded and occupied by the wealthier citizens of the present, may not be compatible with current Chinese cultural perceptions. This suggests that there is scope for more research on cultural attitudes to traditional housing, as well as its environmental performance.

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