1. Introduction

More than 80% area within Shanghai territory is covered by agricultural lands°1. These countryside areas of Shanghai is usually forgotten as part of Shanghai, though it has much longer history before Shanghai city area come into being in the late colonial period. Some existing dwellings can track back to 1800s.

Shanghai - culture and the city itself (Figure 1, zone I) mainly formed by migrants in 1900s, from Jiangsu and Zhejiang province, and also foreigners in the late colonial era°2. But, Great Shanghai (Figure 1, zone III) has a different story. Although surrounding by Shanghai city and not far away, there are indigenous people originally live there lead a living by agricultural and fishing for hundreds of years far before the modern Shanghai come into being. Their culture was uninfluenced in the process of modernization of Shanghai, and they even kept their own accent till now (rather to say it’s another language) which totally different for Shanghainess and Jiangsu, Zhejiang resident’s accents. More than 11,000 micro-villages still there in the countryside of Shanghai°3. Although not many, there are still traditional residence housing are standing untouched. They are built by the people live there for generations and uninfluenced by foreign technology. Recently, we finished a field survey of all historical residential building in Feng Xian. What we’ve found how the local’s wisdom understands local climate condition, and how they utilize the climate to fit their housing, with proper passive designs.
2. Shanghai Climate Condition And Passive Design Strategy
Shanghai is a subtropical maritime monsoon climate. The main climatic characteristics are: warm spring, hot summer, cool autumn, cold winter, moderate rainfall throughout the year, and even seasonal distribution. Generally speaking, it is mild and moist, with four distinct seasons. The highest temperature in Shanghai was in July and August. In recent years, summer in Shanghai is getting hotter and hotter. Annual hot days above 35°C are usually more than 10 days. The coldest days from late January to early February usually during the Spring Festival [4] (Figure 2 left). Although the number of continues cold days is small (generally no more than 3 days), Officially, Shanghai is still in a no heating facilities zone. And with high humidity in winter, body sensation is uncomfortably cold in winter. Jun and Jul usually with a continuous raining season without limited sunshine.

According to the climate condition and through the psychrometric Chart (figure 2 right), seasonal temperature range is not extreme, but Shanghai is not in winter heating zone in China that means almost all buildings don’t provide heating in winter. Obviously on the psychrometric chart, moisture level very high throughout the year. High level of moisture in Shanghai made the winter feels much chillier than the dry bulb temperature tells. Much worse, usually entire winter covered with thick cloud all the time, and no efficient direct solar irradiation to provide enough energy and made passive solar design in winter extremely desperate. During a hot summer, wind is not generous to provide enough cross ventilation, and very high moisture (usual summer sunny days 70-90% moisture all the time) made it even worse for utilizes any evaporation cooling strategy effectively. This kind of climate condition is the typical characteristic along south bank of Yangtze River, covers many cities along the Yangtze River, and it is the most difficult area in China for passive design. It’s the architect’s worst nightmare for passive design in such climate condition.
3. Local Dwellings Aesthetic And What We Can Learn From Them

As far as the difficulty in passive design in Feng Xian, it’s surprised to discover the local dwellings have some wise ideas in passive design and as our stay and interviewing the residents our team experienced very good internal thermal comfort experience. Local residents were very proud of the thermal performance of their traditional buildings. They still love to stay in these houses, although have some complains about building material failure but not anyone complain about thermal comfort. Locals even complain the bad experience for them to move to new built resident apartments for bad thermal comfort. And all these design methodologies of how to adapt their housing to the environment and also formed the aesthetic of the local dwellings (figure 3).

![Figure 3: the local dwellings in Feng Xian. Over a hundred of year these building still in working condition and provide good thermal performance. (photos by the authors)](image)

4. Building Materials

4.1. Roof

Roof is the most unique recognizable aesthetic parts of Chinese traditional buildings. In Feng Xian, As far as the typhoon is concerned, usually light weight roof such as straw roof, light weight panel roof is not common cause it cannot last a direct typhoon hit. A roof should be good at water resistant, anti-typhoon, also good thermal performance. Traditional local dwellings all had a robust and relatively heavy weight roof. Chinese style of grey tiles was most commonly used in this area for local dwellings. gray tile was made by clay in sintering process. In order to make an anti-typhoon roof in Feng Xian, the roof is local’s most concerned building part. From bottom to top, it’s constructed by rafter-purline-wood panle-lime-tile (figure 4). Alone east cost of China, we can find roof of local dwellings use more lime to connect tile together, and in the same time made the roof looks heavier than the roofs in inner part of China.

![Figure 4: typical roof pattern in Feng Xian(Left). (A) clay tile(cover); (B)clay tile(seated/reversed); (C)wood purline; (D)cover tile lime; (E)seat tile lime; (F)wood roof panel; (G) wood rafter; Difference of the roof and facade of south of the Yangtze River and Feng Xian dwellings (right) (photos taken by the Authors)](image)
Figure 5: A typical Feng Xian roof (heavier) than a typical roof of inner part of China (thinner) (all photos taken by the authors)

And local dwellings specially prepare thick layer of lime with chopped hemp rope, to add more weight and more cohesiveness to the tiles. Inner part of China without typhoon threat, use as less lime to connect tiles to construct a lighter roof [5], lime barely cover all the spaces under the tiles. But in Feng Xian, lime layer is much thicker and all space between tiles and the roof panel is covered. The structure of roof made the roof heavy enough, and no vacuum effect from heavy wind to blow/inhale the tiles to move under heavy wind load (Figure 5).

The local roof characteristic made Feng Xian dwellings looks very different from the outlook of traditional dwellings regions south of the Yangtze River to form an unique aesthetics, the roof is more curved and covers bigger area then other areas (figure 5). In the mean while, the heavier roof also act as a better thermal insulation material. As it’s thicker, it made the summer sun more difficult to reach internally. As shown on figure 5 top is a typical Feng Xian house, and bottom is a typical South of the Yangtze River village, most Feng Xian dwellings (figure 5 top) are single floor house, and most of South of the Yangtze River housing (figure 5 below) are usually 2-3 floors.

Most of South of the Yangtze River houses usually use top floor as a thermal damper, to cut off summer heat from the sun to transfer to lower floors [6]. Most of the traditional houses, the internal space of top floor usually never decorated and without furniture, only used as storage space and rarely used as guest rooms. It's a pretty low cost efficient solution for passive design, even that the residents still complain about over heating in summer for lower floors. But Feng Xian use their own wisdom to solve their problem much cost efficiently. With thicker roof, much robust to climate, much better thermal performance, and without the necessary to build another floor for thermal damper. Also their roofs last longer, require only minor maintenance around every 20 years compare to the south Yantze River houses to maintain every 10 years.

4.2. Walls

Figure 6: rowlock wall in Feng Xian is local’s choose for resident buildings even in today. (photos and illustrations by the authors)

Wall structure is another essential part to thermal performance. It’s a compromise to balance heat in/out, heat storage and cost to make a best solution. In Feng Xian, most local dwellings choose rowlock brick wall (figure 6) for envelope structure. Although it’s brick – a relatively heavy material – due to its space inside, it’s still light weighted. As the winter temperature is not very low in Shanghai, local residents consider thermal insulation on top of heat preservation. Rowlock wall with airspace in,
serves very good at thermal insulation to prevent external heat get into internal rooms. Also lighter walls reduced foundation cost. As in south Yangtze River region, no heating provided, people tent to accept a lower temperature comfort zone. Local people just put on more cloth to resist a humid/cold winter. And it’s still how local people get pass all the winters. Facade thermal performance in winter is less important around Shanghai than summer. Different from current building energy efficiency code, most resident house in Shanghai region including Nongtang (the narrow alleyways of old Shanghai) all use this kind of rowlock walls. And with our interview to the residents living in the dwellings, they all reported a cool summer and warm winter in stay in these houses, very satisfied with the internal thermal comfort performance.

4.3. Floor
Feng Xian traditional dwellings mostly use gray brick tiles or lime-earth-broken brick concrete as flooring material (figure 7). Without a basement, the floor is just directly lay on the top of rammed earth. This helps to reduce summer internal temperature. Groundwater level in Shanghai is very high, these porous materials can encourage moisture to reach it’s surface. In summer sunny days, moisture level can be as low as 60% in the hottest afternoon which can cut in some evaporation cooling effect to reduce internal temperature. These materials also in very low cost.

4.4. Building Layout
In Feng Xian, wind direction in summer is mostly SSE, and in winter, mostly is WWN. As our survey to more than 10 villages, all the dwelling is facing the same direction, facing south with around 5-10 deg offset to east. Most building has either a Kwan-Yin shape gable wall (figure 8 the left wave shaped wall) or a horse head gable wall (figure 8 the right wall).
High Gable wall (higher than roof) is a typical aesthetic characteristics in South Yangtze River zones [7]. As horse head type is very common, Kuan-Yin Dou is unique in Feng Xian, just to be differ from well known horse head type. This might because it was fishing villages before and the fisher man like more wave like shape. Any way both shape serves the same function: cause large amount of building material is timber, it’s necessary to keep fire hazard in a small region especially in a village or town while all the buildings attached to each other.

Besides the fire proof function, the gable wall also called “wind and fire wall”, that means it’s also functional as wind guard. According to our survey, locals tells their house usually good ventilated in summer, but also block winter west wind to penetrate to their room and yards. We find these gable walls may take part in the seasonal wind guide. As (figure 9 left) summer wind pattern shown, summer prevailing winds usually comes from east sea, mainly SSE direction. The building layout follows the direction, and these gable walls almost parallel to the wind guide sea wind through all the residential area. Even more, to encourage cross ventilation, lots of passageways are found facing south to open a gap for wind to pass (figure 9 right). To the contrary, winter cold wind usually comes in WWN directing from Russia and China main land, while in the winter seasons, cold wind is almost vertical to the gable walls, thus blocked the winter cold wind).

As figure 10 shows, most of local dwelling compound as shown in the same direction, we can find skylight on roof serves as what we do by light pipes. The extended roof provide sufficient shading in summer to the courtyard and the rooms, while in winter, tilted roof encourage sun light directly cast into rooms thanks for south facing layouts.

5. Conclusion & Further research recommendations.
Local dwelling was born in the passive design era, while resource, energy is not abundant, local architects, master builders have to study local climate and learn how to tame the environment. Local
wisdom is still we modern architects can learn from their abilities to encourage and respect passive
design principles. How to adapt the environment, and how to reduce resource use, it’s an appropriate
technology what ‘small is beautiful’ [8] still chasing.

Utilize passive design principle in Shanghai is difficult, but as our survey in Feng Xian, we can
find even it’s hard, Local citizen already tried their best to adapt the building to the environment and
even their later generations still benefit from their design wisdom. They can easily tell their old house
is almost zero energy consumption and still provide high level of thermal comfort throughout the year
than modern apartment buildings. In the case of building orientation, facade materials, they already
find out a best solution in low costs. i.e. the rowlock wall already functions very well in thermal
performance in local condition, in the mean while our new building code is still trying to add more
thermal insulation material to facade [9] while architects hundreds of years ago already find thermal
insulation don’t really functional.

Most of the thermal performance description of local dwellings based on interview the original
residents. More detailed internal environment monitoring should be carryout in the next step. Also a
test to how the building facade thermal performance also need to be lab tested and verified. Through
these study, passive design in hot high moisture summer and cold winter area is still viable and can
reach more practical detailed guild lines for new buildings.

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