Sustainable materials in Fujian vernacular residential architecture

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Abstract: Cases abound in Fujian province of applying sustainable materials in the construction of traditional residential buildings, which demonstrate the skills and creative techniques of local builders, reflecting their wisdom in molding and adapting to the environment. This paper probes into the utilization of locally available resources in Fujian traditional residential architecture from the perspective of the characteristics of “reduction, recycling and reuse” of sustainable materials, and puts forward the view that sustainability study of contemporary architecture should be approached from the relationship between man and environment and that inspiration can be drawn from the creative and innovative ideas of the folk residential builders.

Keywords: sustainability; Fujian province; vernacular architecture; 3R building materials; walls patterned with red bricks and stones

1 Introduction

Fujian province is located in the southeastern part of China, on the western side of the Taiwan Straits. Secluded by the north-south trending Wuyi Mountain range in the eastern part of the province, Fujian boasts a unique architectural style of its own, free from the cultural and historical influence of the inner lands. The locals in Fujian have developed a plain and simple vernacular dwelling style in adaptation to the landscape featuring mountains, forests and comparatively poor transportation network. In terms of their architectural materials, a rich variety of unique materials are utilized in addition to the usual bricks, stones and timber. Cases abound in Fujian vernacular architecture which addresses local residential needs and circumstances by using locally available resources. When observed from the perspective of sustainability, these traditional dwellings, in spite of their oblivion and seemingly crude appearance, demonstrate creativity in the use of building materials, the ease and quiet beauty as well as the regional characteristics of the architectural design that carry modern notions. Much can be drawn from traditional vernacular architecture that will benefit architects today, in terms of aesthetic value, the local style and the sustainable building materials particularly [1].

In the study of sustainable architectural materials, 3Rs (reduce, reuse and recycle) were used in the professional circles to define their characteristics which best sum up the notion of sustainability [2]. In modern architectural design, architects should strive to pioneer in the utilization of sustainable materials instead of waiting passively for the future development of new materials, exploiting their professional wisdom to design green buildings, which can be illustrated from the examples of outstanding works in modern architecture [1] (Fig. 1). In the studies of Fujian traditional residential architecture, many researchers focus on the settlement patterns, spatial layout efficiency, building modes, climatic adaptability, and
regional characteristics \cite{4}, and pay little attention on the sustainability of architectural materials. Therefore, the aim of this study is to probe into the sustainability of architectural materials from the perspective of 3Rs.

2 Reduce: use of energy-efficiency materials

Fujian is rich in bamboo materials. As a kind of gramineae, bamboo has great adaptability to the environment. Bamboos grow very rapidly and form natural ready-to-use building materials. A grove of bamboo can produce in its lifetime, usable bamboo poles that reach 15 km long with a diameter of 30 cm. It takes 60 a for a tree to grow to a height of 60 feet while it only takes 56 d for a bamboo to reach the same height. Bamboos are energy-efficiency materials, research results indicate that in constructing a building of the same size, using bamboo as material only takes 1/8 of the resources consumed by using concrete and 1/3 by using timber; compared with steel, bamboo consumes only 1/50 \cite{5} of the energy in the same process.

In Fujian province, bamboos are often used to build make-shift buildings. In Longyan, which is located in southwest Fujian, the locals use full-grown bamboo poles to set up buildings of large spans. Fig. 2 shows that bamboo is used in the workshop construction of an industrial enterprise.

The local architects tie 3 to 5 full-grown bamboo poles into a bunch. Several bunches are linked together at the ends, at the junctions of which, the thinner ends are inserted into the thicker ones, and the junctions are further strengthened by binding them together to prevent them from cracking. Then, exploiting the flexibility and elasticity of the bamboo poles, builders bend them into arches that serve as lagging jacks which are arranged horizontally with an interval of 4 m to 6 m to form a large space. The roofing is also made of bamboo purlins with water-proof tops. The architectural span reaches over 18 m and the length reaches more than 40 m. The construction is simple in technique and low in consumption. The workshop built with bamboo materials in Fig. 2 was constructed in 1999 at the price of RMB 19 Yuan/m² and it is still in use now. According to the workshop-owner, the lifespan of this bamboo building can reach 20 a and beyond, and it is very easy to demolish it or to reconstruct it.

3 Recycle: use of renewable materials

The well-known Fujian round-shaped earthen
buildings are constructed by drawing on local resources of rammed earth (Fig. 4).

Fig. 3 Retaining wall of tiles

Fig. 4 Construction of rammed-earth wall of earthen buildings [6]

The natural material of clay can be recycled. To consolidate the storied earthen buildings, bamboo or wooden plates are placed as tie pieces at vertical intervals. Rammed-earth buildings should be kept away from water and moisture, so for water resistance, cobble-stone masonry is laid at the base of the earthen buildings. No base mortar is required in masonry, instead the technique of jointing design is adopted by placing the big ends of the cobbles inwards and the smaller ends outwards (Fig. 5). From the modern perspective, this design saves mortar and avoids the pollution in mortar manufacturing and utilization process [7]. The cobbles can be readily reused as they are not bound by mortar. The methods of stock ramming and dry cobble walling are widely used in the construction of local dwellings in the western part of Fujian province.

Fig. 5 Cobble masonry [6]

Fujian province is endowed with long stretches of costal shoals in its southeastern part, which offer rich natural resources. At the crossing between the river and the sea, oysters are farmed in large scale. Oyster shells are calcined into ashes, which can be used as adhesive materials in architecture, with excellent effects in bonding bricks, stones and earth. Larger oyster shells are used by the local fishermen as materials for exterior walls or adhered to building surfaces as decorations. Oyster shells are durable, heat-resistant and water-proof. Oyster walls, with their plain and natural appearance, generate excellent stereoscopic effect with strong coastal features. As excellent renewable resources, oyster shells are widely used by the local architects (Fig. 6).

4 Reuse: recycling waste materials and “walls patterned with red bricks and stones”

“Walls patterned with red bricks and stones” are so named because waste stones and bricks of different shapes are laid overlapping and crisscrossing each other in wall building. It is a unique walling art in southern Fujian province where red brick architecture is popular. Walls of this kind are warm in winter and
cool in summer, and beautiful in look. In addition, they are solid, durable, and theft-resistant. The walling technique is regarded as one of the unique civil building arts in China, which is popular mainly in Quanzhou and extends to such places as Zhangzhou, Xiamen, and Jinmen. In the old city of Quanzhou, large stretches of civil dwellings are built with this art (Fig. 7). It is generally believed that this walling art first appeared in the Wangli Period of the Ming Dynasty [4]. According to local records, the local residential area was completely ruined in a severe earthquake and then the reconstruction was difficult. Under such circumstances, the locals gave full play to their intelligence and wisdom, and made use of the bricks, gravels, and debris from the quake ruins as building materials for reconstruction. This approach is widely applied by later generations and has over the history formed a very distinctive feature of local residential construction style (Fig. 8).

Characterized by their plain and simple look, as well as distinctive vernacular features, “walls patterned with red bricks and stones” have given painters and photographers inspirations for their artistic creation. In terms of their aesthetic effects, they are unique in the following aspects: first of all, the contrast of the textures of the brick and the stone, the arrangement of the brick lines and the stone surface create a kind of rhythm for the entire wall (Fig. 9). Secondly, the colors of the white granite and the simple red bricks achieve a harmonious contrast which is foregrounded by the different shades of the brightness of the materials, as the stone used is of a white grayish color instead of being pure white which sets off the red color of the brick, generating a soothing effect. This technique best exemplifies the beauty of brick and stone walls. In addition, it generates the visual effect of the alternative red and white colors and the intrinsic rhythms of concavity-convexity patterns of the bricks and stones. When put into the background of green foliage, this effect is highlighted and creates a warm and homely atmosphere (Fig. 10). Thirdly, the method of plain brick wall pointed with cement mortar is widely used in the construction of residential buildings in southern Fujian. The regular brick lines and the irregular stone shapes form yet another contrast (Fig. 11). Although the art of “walls patterned with red bricks and stones” is simple, the selection of different stones and bricks, the varied arrangement of the patterns and the flexible handling of the details bring about a great difference in the design and creates great beauty. The arrangement of stone patterns alone boasts such different forms as regular patterns, irregular patterns, and random patterns. The novelty of the local building craftsmen...
is best demonstrated in their handling of the waste building materials.

Fig. 9 Walls: rhythms of beauty

Fig. 10 Warm and lively effect of “walls patterned with red bricks and stones”

Fig. 11 Details of brick arrangement

5 Conclusion

With the increasing awareness of environmental protection and the importance of sustainable development, the use of green materials has become one of the greatest concerns in modern architecture. For modern architects, much is to be learned from the folk experiences in the use of building materials. In fact, some techniques in vernacular architecture are great innovations based on the fundamental mode of “existence-region” adaptability, displaying in a direct way, the inter-dependent relationship between man and land[8]. “Land” represents not only the physical regions and territories, but also the social conditions of the times of architectural construction[9]. Therefore, the folk wisdom reflected in vernacular architecture goes far beyond the superficial level of the apparent forms. It is the underlying notions of the respect for nature and for the man and land relationship that throw light on modern architectural design[10]. But it is regrettable that in the ongoing large-scale residential building construction, we are heading in the opposite direction in terms of the notion of man-land relationship: thousands of tons of reinforced concrete are being wasted and architectural designs have been confined to showy displays of the so-called symbols application. In the area of Quanzhou, Fujian province, large capitals are currently invested on archaized buildings, and some rich locals have even covered the old brick walls with shiny and showy tiles. These practices have gone astray from the traditional architectural wisdom as displayed in the local building tradition of “walls patterned with red bricks and stones”. In learning from folk architects, we should go beyond the geometrical and physical calculations, notions of forms and symbols, but focus our concerns on the harmonious relationship between man and land, as well as the issues of environmental protection and sustainable development.

References


