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A preliminary study on the climate adaptive design of green rural houses in west China

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Abstract

This paper introduces a preliminary study on the climate adaptive design of green rural houses in the Qinling mountainous region of west China. Based on literature reviews and field investigations on the existing traditional and contemporary rural houses in the researched region, the folk wisdom implied in the traditional rural houses, the perceptions and expectations of local residents, and the inheritance of folk wisdom in contemporary rural houses, are identified and discussed. Suggestions for the climate adaptive design of new rural houses in the researched region are provided, further researches are also recommended.

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Keywords: Climate; adaptive design; green; rural house; China.

1. Background

Along with fast economic development and government promotion of New Village Construction, large amount of new rural houses have been constructed in China during the last 10-15 years. However, many of such houses, especially the self-constructed ones which simply copied the so-called “city styles”, are not adaptable to their local climate conditions and performed poor in terms of their indoor thermal environment and energy efficiency. Therefore, in year 2013, the China Ministry of Housing and Urban-Rural Construction (MHURC) together with the Ministry of Industry and Information Technology (MIIT) jointly issued a document for promotion of green rural houses in the country[1]. With this background, a series of researches have been conducted targeting rural houses in different regions of the country. This paper introduces one of such researches, which is also the preliminary study of

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a national demonstration project conducted in the Qinba mountainous region in west China. A brief conceptual framework of the project is shown in Fig.1. This paper mainly involves part B of the research.

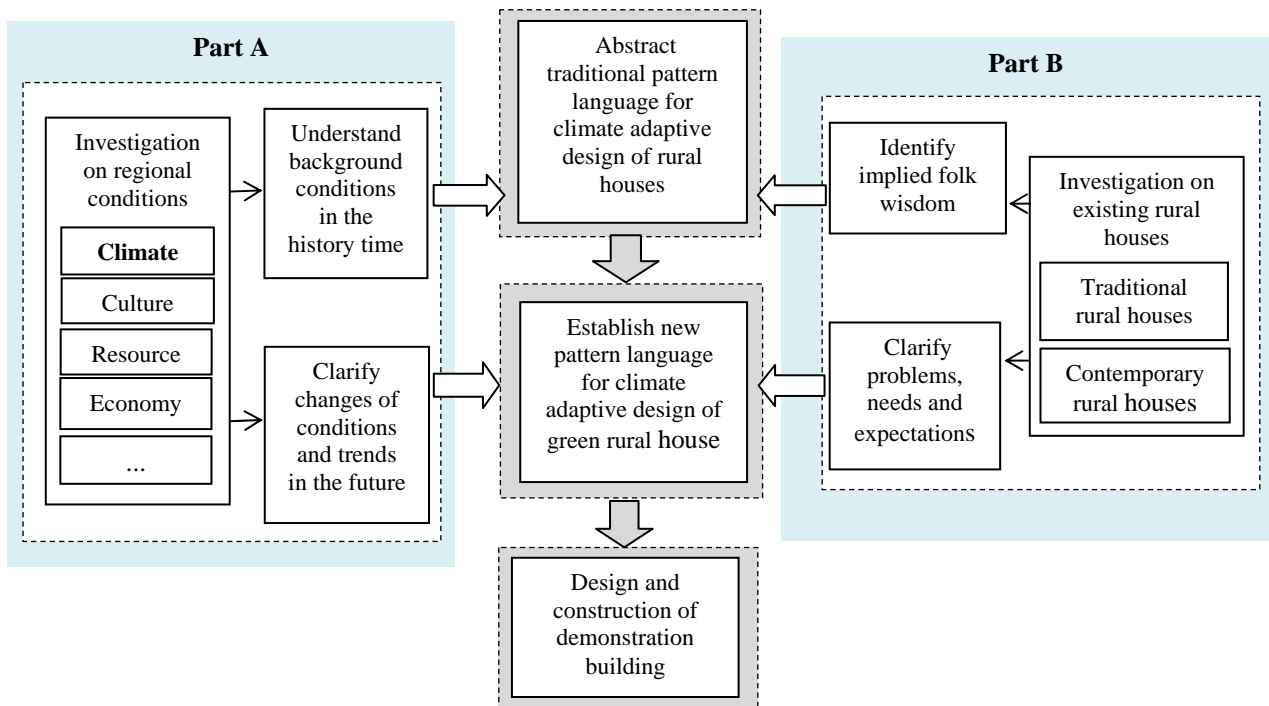


Fig. 1. Brief conceptual framework of the project

2. Climate conditions of the Qinba mountainous region in west China

The Qinba mountainous region locates at the “cold in winter and warm in summer” climate zone for building thermal design in China. Its precipitation is between 750-1000mm with rainfall mostly concentrated in the summertime. Hu et al.[2] and Feng and Dong [3] observed that, in the recent 40-50 years, while the average annual temperature is increasing, the amount of annual precipitation is decreasing, and the frequency of storms is also increasing, which potentially may course more natural disasters (like hill-creep, mud-rock flow, etc.), especially in the summertime.

3. Investigation of existing rural houses

3.1. Target and method of the investigation

In the long period of self-evolution, traditional rural houses in different regions of China have accumulated abundant of climate adaptive wisdom, which could be good references for the contemporary building design and construction.

With this consideration in mind, a series of field investigations had been conducted to identify and abstract useful folk wisdom implied in the traditional rural houses, and to understand the perceptions and expectations of local residents in the researched region.

3.2. Content and method of the investigation

Content of the investigation included functional layout, material selection, construction details, indoor and

outdoor environmental conditions (including physical data and users' perceptions) of traditional and contemporary rural houses.

Methods of the investigation mainly involved in-house interview, on-site observing, group discussion, instrumental measurement, building survey and drawing.

3.3. Results of the investigation regarding traditional rural houses

(1) Basic conditions

Only a small number of traditional rural houses still exist in the researched region. They are mostly single level buildings with earth-wood structures (earth or clay walls, pitched wooden roofs), big overhanging eaves, and high indoor spaces beneath the pitched roofs. Their plans are usually arranged in simple “-”, “L” or “U” forms. (see Fig. 1.)

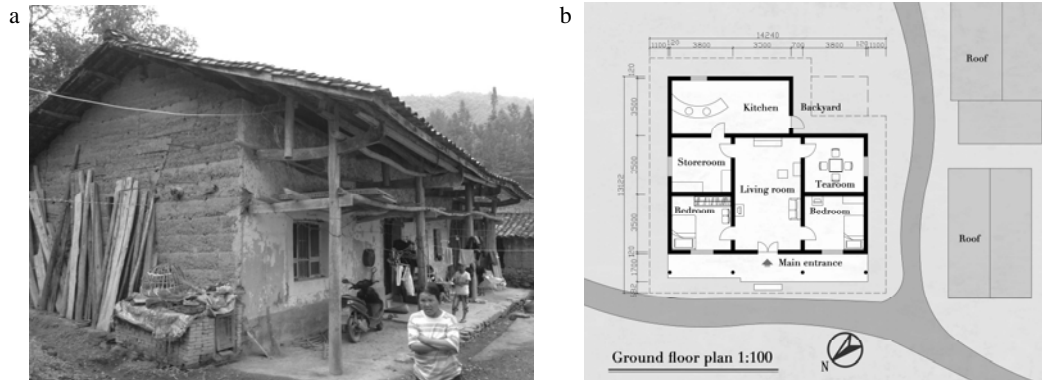


Fig. 1. A typical traditional rural house in the south Qinba mountainous region in west China
(a) front yard view; (b) ground floor plan

It was interesting to find out that, although the tradition style rural houses are only used temporarily or as supplementary spaces and not constructed anymore, their thermal environmental conditions, especially that in the summer time, are still highly praised by local residents.

(2) Implied folk wisdom

Analyzing results of investigation, following folk wisdom was identified and abstracted from the traditional rural houses in the researched region.

- Site selection

The sites of houses were usually selected on relatively high and flat place, close to river and away from potential natural disasters.

- Local natural materials

Local natural local materials applied in the building structures and envelops (e.g. wooden roof structures, earth or clay walls, stone steps and basements, wooden windows and doors, etc.) were low cost, easily available, recyclable and in harmony with their natural environment.

- Thermal insulation and thermal storage materials

Thermal insulation & thermal storage materials (such as earth, clay and stones) applied in the building envelops and floors helped in maintaining a relatively stable and comfortable indoor thermal environment all year round.

- Deep eaves

Deep eaves along the building envelops help in protecting the exterior walls & windows against rainwater and solar radiation.

- High floor to ceiling living rooms

Local residents used to burn charcoals for heating in the winter time. High floor to ceiling living rooms are good

not only for cooling indoor environment in the summertime, but also for extracting the polluted air out of indoor space in the wintertime.

- Under-ceiling and under-eave spaces

Under-ceiling (indoor) space and under-eave (outdoor) space can provide storage rooms for agricultural products, tools and chopping woods, etc. The under-eave spaces can also be used as secondary living rooms between the indoor and outdoor environment.

3.4. Results of the investigation regarding contemporary rural houses

(1) Basic conditions

The contemporary rural houses in the researched region are mostly one-two level brick-concrete structures with brick walls, concrete floors, and flat or pitched roof. (see Fig. 2.)

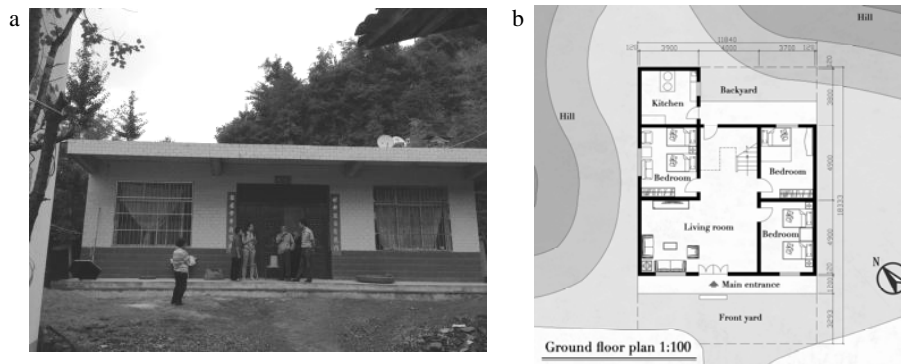


Fig. 2. A typical contemporary rural house in the south Qinba mountainous region in west China
(a) the front yard view; (b) the ground floor plan

(2) Differences between the traditional and contemporary rural houses

The contemporary rural houses are different from the traditional ones in the following ways: 1) **Building materials** Building materials are mainly brick and concrete; local natural materials in the traditional houses are seldom used any more. 2) **Height of spaces** The height of living rooms are smaller. 3) **Spacial layout** The simple layouts of traditional rural houses are replaced by the relatively more complex city apartment/unit styles. 3) **Depth of eaves** The depth of the overhanging eaves become smaller. 4) **Under-eave spaces** The under-eave spaces no longer exist. 5) **Features** The regionally specific features (forms, colors, textures, etc.) are replaced by more unified “city styles”, which are largely lack of regional identities.

(3) Perceptions and expectations of local residents

Most local residents in the rural areas of the researched region considered that, comparing to the traditional rural houses, the contemporary ones provided better lighting, ventilation and functional layouts. However, they were mostly lack of storage and drying spaces; their living spaces were not high enough. Local residents commonly expressed expectations for effective sun-shading and ventilation in summertime, good access to sunlight in wintertime. They also emphasized the needs of high quality waterproof roofs.

(4) The inheritance of folk wisdom

Although most of the traditional building materials, structures and styles are no longer used in the contemporary rural houses, some folk wisdom implied in the traditional houses have been inherited spontaneously.

Take contemporary rural houses in the Caobachang village of Ningqiang County as an example (see Fig.3.):



Fig. 3. A contemporary rural house in the Caobachang village of Ningqiang county
(a) front yard view; (b) ground floor plan; (c) second floor plan

- The sites of the houses were selected on a high and flat place, which were both close to river/road and away from potential hill creep and mud-rock flow.
- Traditional-style front yard and back yard were applied not only to provide private space for family activities, but also to enable cross ventilation in the summertime.
- Pitched roofs were applied to provide better water proof abilities, to act as thermal buffer zones, and to remove warm air in the upper space through ventilation in the summertime.
- The under-roof spaces were used as storage rooms, which also performed as thermal buffer zones.

4. Conclusions and suggestions

Results of the above preliminary study mainly shows that: the climate in the researched region is becoming hotter and dryer all year round with higher frequency of heavy storms in the summertime; traditional rural houses implied much folk wisdom, some of which have been inherited spontaneous in the contemporary rural houses; local residents' specific needs and expectations of houses should be considered in the future design and construction.

Based on the above results, following are some suggestions for the climate adaptive design of new rural houses in the researched region:

First, according to the general “hot in summer and cold in winter” climate features of the researched region, shading and ventilation in the summertime, accessibility to solar radiation, protection from cold wind in wintertime, and provision of thermal insulation in the building envelopes should be considered comprehensively and designed in integrated ways.

Second, considering the specific trend of climate change (increasing frequency of heavy storms) in the researched region, waterproof design should be strengthened not only in the selection of building materials, but also in the design of building forms and construction details.

Third, considering the specific life styles of local residents, front and back yards should be maintained and designed not only to facilitate the needs of house works and family activities, but also to help improving cross ventilation of buildings in the summertime .

Last but not least, further researches should be conducted to explore more effective ways for the intended inheritance of the folk wisdom, the integration of such wisdom with new materials and technologies in the design and construction of new rural houses, as well as the compatibility of new design with local residents' specific needs and expectations both at present and in the future.

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