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Sustainable Village Pattern of Post-earthquake Reconstruction and Rehabilitation

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ABSTRACT

The May Twelfth 2008 earthquake in China brought tremendous damages. Many villages in Sichuan province were destroyed. How to reconstruct a sustainable village with the limitation of rural area becomes a big challenge after the earthquake. This paper describes the project about reconstruct and rehabilitate Daping village, Pengzhou town of Sichuan province. The whole design of the project aims to get a sustainable village pattern through the sustainable design philosophy. The design takes on responsibility to produce an energy sufficient and affordable eco-house in regard to the local culture and living patterns. Sustainable design strategies are applied in the design process including site planning, sustainable building materials applying, passive solar space heating, natural ventilation and lighting. Also the water protecting system and local economy development with environment concerned are discussed. Much more, the project serves as a pioneer example for sustainable village pattern of post-earthquake rehabilitation in China.

***KEYWORDS*:** Sustainable Strategy, Traditional house, Reconstruction, Environment

1 Introduction

Daping village is located in Pengzhou county of Sichuan province, which is only 40 kilometers

from Wenchuan County, the epicenter of May twelfth earthquake 2008. Most of the buildings in Daping village were destroyed by the earthquake while the nature environment kept almost undamaged. According to the relative geological investigation the government decided to reconstruct the village in the original area.

Global Village of Beijing (NGO) organized the project. Liu Jiaping, professor from Xi'an University of Architecture & Technology led the designing team which included teachers and students from the architecture school. Architect Zhouwei also attended with some consulting engineers and planners. The survey and research commenced in June 2008 just after the May 12th earthquake took place in China. The construction began in the beginning of September 2008, and before July 2009 around 80 families have moved to their new houses.

In addition to the basic purpose of reconstructing the villager houses as soon as possible, the project extended its main purposes to:

(1) Improve the aspects of livelihoods, infrastructure, local economy and sanitation with strong consideration to the environment protection.
(2) Provide permanent, low cost and earthquake-resistant housing.
(3) To improve the indoor conditions and to meet high living requirements of the houses through better design ideas.
(4) To reduce the energy consumption and to protect the environment through general village layout, building design and construction.
(5) To develop rational house patterns corresponding to the local climate, local culture and living styles.

The following pages provide a brief introduction and overview of the village design under the term of sustainable strategies.

2 Site and local environment

The original settlement of Daping village was located in mountainous area with beautiful landscape, surrounded by four local famous mountains from the four sides. The altitude of settlement is around 1400 meters, where the relative mild climate provided both rich forest resources as well as fertile soil. The annual average temperature is around 13 centigrade. The highest and the lowest temperature are around 25 centigrade in July and 2.4 centigrade in January respectively. The climate is characterized as humid with a high rainfall average.

The reconstruction village layout based on the environmentally-responsive site planning. To respect the local culture, the reconstruction village layouts are well arranged according to the Chinese FengShui theory, the bible of Chinese planning and orientation, which reflects the harmonious rhythm between the

mother nature and human beings. The natural and social features of the original village site are preserved and protected (Fig. 1). The site of each house unit is considered with appropriate orientation and landscaping.

Fig. 1 view of the reconstruction village

3 Housing system

It is believed that traditional wisdom and lore in buildings may still offer wisely managed, economically effective and culturally appropriate solutions to the world's housing needs (Oliver, 1997). In the houses design, traditional skill is highly respected and upgraded. In the deadly earthquake, the brick houses that built in the village recent years are all collapsed, while a one-hundred-years traditional house remained undamaged, the fact that no traditional house collapsed for this two reasons: the lightweight and the flexible wood structure. The new houses design inherits the traditional style and features such as pitched roof. Pitched roofs with wide overhangs and verandas create shade, rain protection and inter-gradation space for local and daily activity.

3.1 Material and structure

Traditional cultural approaches to material specification are predicated on a sense of living with the earth, drawing on sustainable living traditions and practices which provide a vehicle for passing on local knowledge through deeply held beliefs and the teaching of skills (Ingold, 2000). Using the traditional natural material is an important approach to adapt the local climate and respect the cultural traditions. Based on the abundant forest resource, the main feature of the traditional house in Daping village is timber frame structure with pitched roof and wall of wattle and daub. In these traditional houses, the

lightweight structure can easily reduce the seismic load.

In the new houses design, the main building materials are wood and bamboo also, both are rich in the village. These natural materials are cheap, recycled and environment friendly. Some wood elements used in various aspects of the design have been recycled from the previous houses. Construction with these natural and local materials has an important economic advantage as could be afforded by most common villagers. Traditional housing techniques and principles are applied and upgraded to make the building seismically stable and to meet the seismic design code in the new designs. Most of the new buildings are traditional timber frame structure (Fig. 2) and traditional house style has been inherited (Fig. 3). Traditionally, the beam, sparrow brace and pillar are jointed by hidden mortise and tenon. To increase the seismic capacity critical joints and the plinth are designed to be reinforced by small steel accessories. In some buildings light steel structure is also used. The local builders are trained by engineers. All the houses, including public buildings have been building by the community through self-help and mutual-help progress, hence cutting the cost.

Fig. 2 traditional timber frame structure

Fig. 3 a new house with respecting the traditional style

3.2 Architecture plans

The core house and module idea used to give more flexible design to the houses, as it is the essential idea of the rural houses design, thus diverse houses plans can be obtained, altered, adjusted easily (Fig. 4). The core house in its basic module and according to the tradition plans and culture consist of a main living room in the center and two other rooms on both side as a wings. Functional and auxiliary rooms like kitchen, toilet, store room and other bedrooms can be added around the core house to meet different family number and economy condition. After the core house finished, areas can be added in coming future according to the further living requirements. The plan form of the house can be transformed from [−] to [L] to [U] shapes. For more environment integration and benefits, an

eco-sanitation toilet built for each house in the courtyard. The surrounding space of the house is also designed according to the local living patterns. As a result, the new houses inherited the traditional style, the features and enhanced the occupants' satisfaction by providing more attractive places. The local people involved in the design and construction process. All the design proposals are discussed with the villagers. The residents not only interact with designers in the design but also have the power to alter a design, or even to reject one.

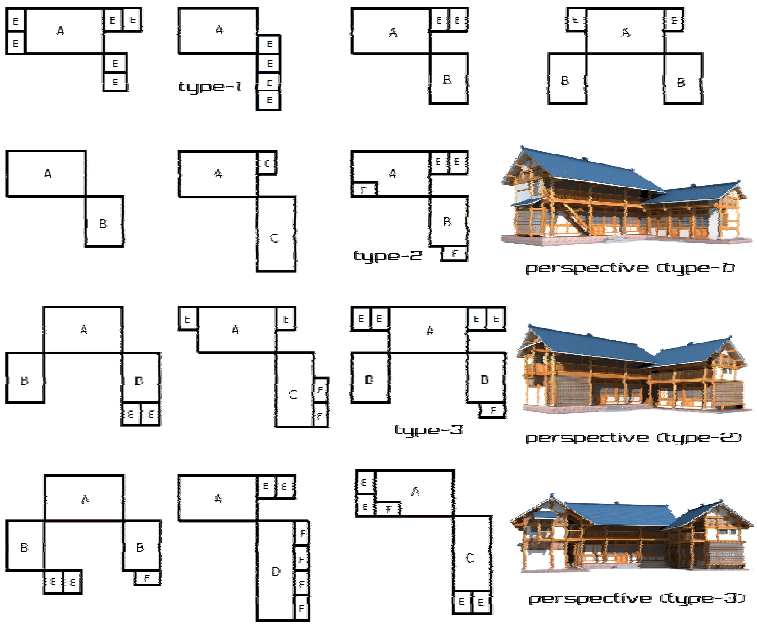

Fig. 4 design idea about core house and module (A-D: Core house and basic modules with different area, E-F: functional modules)

4 Indoor comfort and environment

The indoor environment of the old traditional houses is not that good based on the field measurements. In order to improve the indoor comfort in sustainable methods, the new designs are compatible with the local climate aspects; conserve energy naturally for heating, lighting and ventilation. Numerical analysis techniques such as DOE2.1E (York and Tucker, 1980), ECOTECT (Li and Yu, 2006) and AIRPAK (Ye, X. et al., 2006) are applied in the design process.

4.1 Thermal environment

Daping village weather generally characterized as cold winter and cool summer. Stoves are usually

used as a heating resource during winter for two months. The field measurements on the traditional house show that, the temperatures of indoor and outdoor are almost same in winter. More than 90% of the villagers feel cold during daytime and night without stove in winter while cool in summer without air conditioner, according to the questionnaire investigation. The envelope of the traditional house is poorly insulated: as the walls made of lath wood or wattle and daub, and the roof made of wood purline and tiles without any insulation material. Improving the thermal environment in winter is the keystone in the new design.

New wall technology is created and applied in the new houses design, which is easy to construct using bamboo or wood and improving the indoor comfort in winter. The house envelope is improved with insulation of polystyrene foam or straw earth interlining between the double wall boards, whilst respecting the necessary acoustical separation requirement. Both of the outside and inside wall boards are made of bamboo or wood, applying great landscape adaptation (Fig. 5 and Fig. 6). With adding cheap insulation material inside walls and roofs the indoor temperature can rise much higher comparing to the traditional house. Analysis result shows the indoor average temperature in bedroom and sitting room is 10.8℃ when the house is kept closed in the coldest month January without extra heating, while 9.46kwh/m2 per annum heating energy will be required to reach the comfortable temperature (the heating temperature is set to 18℃). Without using any active heating such as stove, 60% villagers feel acceptable and not cold in winter basing on the questionnaire investigation about 44 families living in new houses after the first phase of the project finished.

Fig. 5 wall made of bamboo

Fig. 6 wall made of wood lath

The designs also include passive solar spaces regarding to the original house style. South-face sunrooms can be built as part of new buildings or can be added to existing ones to maximize the amount of solar heat and light. Because, the sunroom will increase the cost, the building time is according to the

owners' economic condition.

4.2 Natural ventilation & lighting

By using a combination of vents, operable windows and reducing the depth and width of the rooms, both natural ventilation and lighting of the new house are improved compared to the traditional house. Taking the analysis of a U shape house design for example, the AIRPAK model analysis result showed in summer with windows opening the indoor wind speed of the rooms is between 0.125~0.625m/s and the mean age of air is less than 230s, when the outdoor wind speed is 1.30m/s. The basic ventilation can meet the indoor air quality requirements. ECOTECT program is applied in the design to evaluate the daylight and visual comfort. The results under overcast sky conditions show the daylight factors of the living room and bedrooms in original traditional house are less than 1% and more than 6% in the new house, the average daylight factors and illumination of the traditional house are about 21% and 915 lux respectively, 40% and 1620 lux of the new house.

The questionnaire survey of the feedback shows 90% and 73% villagers are satisfied with the natural lighting and ventilation respectively.

5 Other environmental strategies

The mountainous area and the village itself are plentiful of springs and fresh water resources. And in order to protect the water environment, a simple water treatment system also applied in the project based on the relevant design used in another project (Liu et al., 2010). The sewage can be collected and filtered through this system, the pollution then be reduced and the grey water can be used for irrigation after the process.

Future plans and ideas are about how to improve the livelihoods and develop the local economy with considering environment protection. Handicrafts industry and planting industry are planned to generate further income in the future. An embroidery workshop has established. The local people make living by planting Chinese traditional medicine, thus a village clinic and Chinese traditional health preserving center is being built.

All the villagers are responsible for the ongoing management and maintenance of the buildings and environment.

6 Conclusions

This paper describes the design layouts of a village of post-earthquake reconstruction project, which is to create an ecological village pattern according to the principles and the idea of sustainability.

Sustainability concepts are carried out in the strategies during the phases of site planning, building design, construction and operation of the project. To address long-term issues, the project also includes the plan about developing local green planting ecological industry and carrying on village environmental management. Close collaboration between designers and the villagers are required to achieve all the requirements of the project.

The authors believe to learn from the traditional houses and upgrade their living quality such as safety and indoor comfort is the key and an optimal way to create a sustainable village pattern.

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震後村落重建與恢復之永續發展

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摘 要

2008 年 5 月 20 日，中國面臨地震災害所帶來的巨大災難。四川省許多村落都遭毀滅。因此，如何將資源有限的農村村落重建爲永續發展的村落，便成爲災後的重要挑戰。本研究將介紹四川省彭州鎮大平村的重建與恢復工程。研究目的爲透過永續設計的理念，來建造永續發展的村落模式。研究任務爲設計一個能源自給自足，同時能融入當地文化與生活模式之生態屋。永續設計的策略可應用於土地規劃、永續發展建築之材料、被動式太陽能發熱、自然通風與照明等設計。此外，本研究亦討論水資源保護系統以及當地生態保育發展。甚者，本研究可作爲中國震後重建永續發展村落之參考模式。

關鍵字: 永續發展策略，傳統房屋，重建，環境