Study on Adaptive Disaster Prevention Strategy of Tibetan Traditional Village -A Case Study of Shuzheng Village in Jiuzhaigou Valley, World Natural Heritage Site–

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The security and stability of villages have an important impact on the sustainable development of heritage sites in the World Natural Heritage Site. The spatial distribution relationship between geological disasters such as debris flow and landslide and village was sorted out through investigation and GIS simulation. The village's fire risk problem was analysed in combination with the construction materials and distribution of the village. Based on the risk identification, this paper systematically summarized the specific practices and experiences of village pre-disaster prevention, planning layout, engineering implementation and disaster management.

Keywords: *Jiuzhaigou Valley, Traditional Village, Disaster, Disaster prevention*

1.Research background

On August 8th,2017, a magnitude 7.0 earthquake occurred in Jiuzhaigou County, Sichuan Province, China (Fig.1). With the earthquake center located at 5 km Bimang Village (33.20°N,103.82°E) west of the core scenic spot of Jiuzhaigou Valley, the world natural heritage site. (The data of the China Seismic Network).The natural ecological environment and the infrastructure of Tibetan traditional villages were seriously damaged. Potential secondary disasters (e.g., landslides and debris flows) are more likely to occur and to cause harm to traditional villages than before earthquakes[1)]. Hongtao Liu, Xinliang Ye and Ning Yuan successfully made relevant studies on adaptive site selection, disaster monitoring and warning[2)], impact assessment of geological disaster[3)] and natural disaster risk assessment [4)] in Jiuzhaigou Valley. However, there is a lack of relevant research on the relationship between geological disasters around villages and the spatial distribution of villages, identifying village disaster risk and disaster response strategies. This study selected the most representative Shuzheng Village in Jiuzhaigou Valley as the research object(Fig.2), carried out detailed investigation and analysis, and systematically summarised a series of more mature response measures from pre-disaster to post-disaster reconstruction.

Fig.1 Location map of Jiuzhaigou Valley

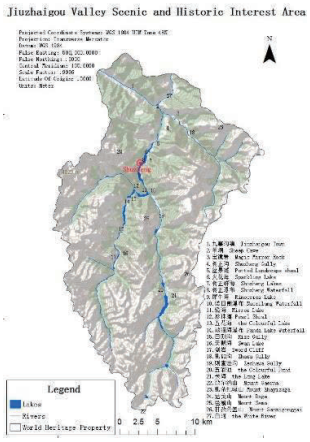

Fig.2 Jiuzhaigou Valley Scenic and Historic Interest Area[1)]

2.Overview of Shuzheng Village in Jiuzhaigou Valley

Shuzheng Village located between Heye Village and Zhawa Village, with landscape resources such as Shuzheng Lakes, Shuzheng Falls, Spark Sea, and Wolong Sea around it. Shuzheng Village and other villages in Jiuzhaigou Scenic Spot together form the "Jiuzhai", in the early stage of the formation of the "Jiuzhai", people have already lived. The village has been a mountainous and gentle slope village with relatively concentrated Tibetan villagers for hundreds of years[2)].As a whole, the buildings growed freely along the terrain, and half of them were built on slopes above 15%.

3.Investigation and analysis of village disaster risk

(1)Village terrain and disaster

The Shuzheng Valley, where the Shuzheng Village is located, originated from the Dago Mountain at a altitude of 4110m. The water flows from west to east into the Shuzheng Lakes under the Shuzheng Village, with a total length of 3.8km and a drainage area of 4.92km^2.The debris flow disaster in Shuzheng gully has a history of more than 100 years. A large number of sediment stones are accumulated in the valley, forming a stepped gully bed and fan-shaped ground with a width of 100 – 300m. Shuzheng village is established on the fan-shaped slope at the gully mouth(Fig.3).

The village buildings mainly distributed at the altitude of 2290 – 2310m in Shuzheng Village. The village is 300 m long in east and west, 260 m long in north and south, and the average slope within the village is 5%. The relative height difference between the mountain and the village on both sides of a-b is more than 80 m, and the slope along the tree trench in the c-d direction is more than 15%. Geological disaster have been focused on around villages that existed with disasters because of special geographical location, topography and geomorphology. The distribution of geological disasters around Shuzheng village is as follows(Fig.4).

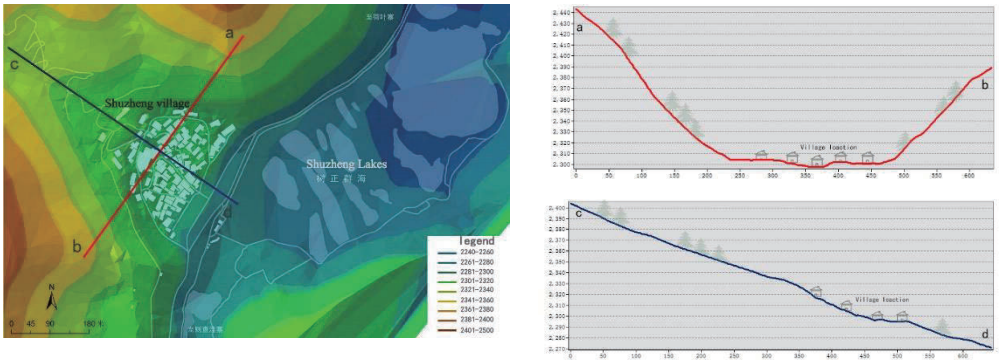

Fig.3 Elevation analysis diagram and a-b, c-d section diagrams of Shuzheng Valley

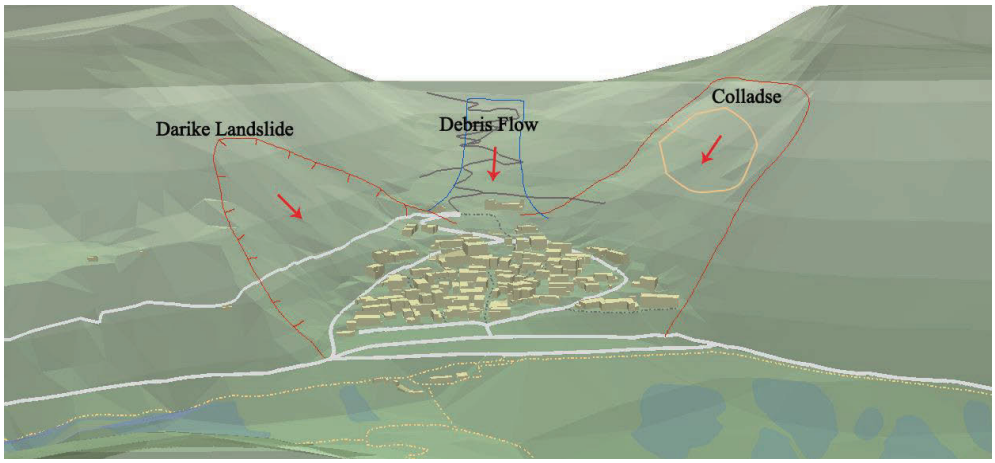

Fig.4 Distribution map of geological disasters in Shuzheng Valley

(2)Village Construction and Fire Protection

Shuzheng Village located the mountainous terrain. With the economic development, it has continuously adapted to the functional needs of scenic tourism and commerce. The residential buildings have undergone major changes in the use of indoor space, construction methods and materials. Due to the continuous enrichment of village internal construction, new requirements are put forward for disaster prevention such as fire safety and disaster evacuation.

a） Building and Firefighting

There are diversified types of architectural structures in Shuzheng Village. A total of 203 buildings were surveyed, including 151 brick and brick-concrete structures, with a construction area of 30,209.26m^2, accounting for 68.03% of the village's total construction area. There are 52 wooden, stone and brick buildings with a construction area of 14,198.10m^2, accounting for 31.97% of the village（Fig.5- Fig.6）. The distribution of the overall number of building layers in the village is scattered. Buildings on both sides of the central pedestrian evacuation passage are above two layers. In contrast, the non-street buildings slowly update; the number of layers is relatively low, forming the wrapping and enclosure of non-street buildings by street buildings, which has a negative impact on fire fighting (Fig.7- Fig.8).

Fig.5 Layout of building structure

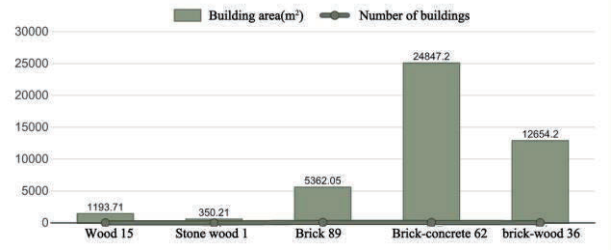

Fig.6 Layout of building structure

Fig.7 Distribution of Building Layers

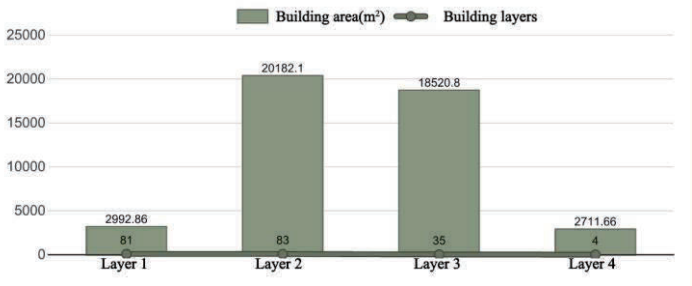

Fig.8 Statistical chart of building layers and area

With the careful consideration of strict control of forest materials by the government, convenient transportation of modern materials and cheap purchase, residential buildings have gradually used brick and concrete materials for house construction. Compared with traditional wooden buildings, the fire prevention performance of brick-concrete buildings have been greatly improved. However, the improvement of the fire prevention performance of buildings themselves has prompted residents to ignore fire prevention spacing between buildings to a certain extent. Therefore, mixing old and new buildings in the village is severe, resulting in built brick-concrete buildings wrap existing buildings, and new buildings occupy fire passages and other issues(Fig.9).

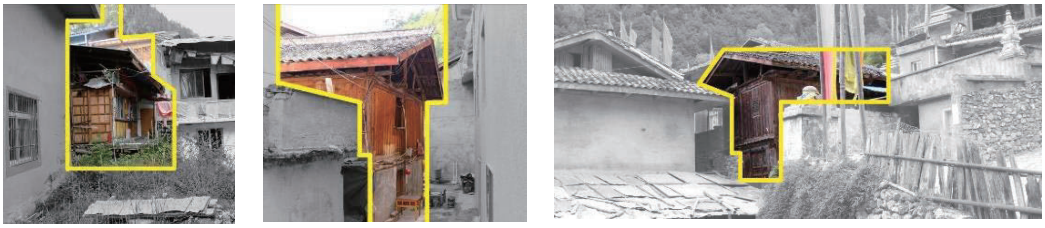

Fig.9 The current relationship between the new and old buildings

b) Street and Firefighting

There are many kinds of asphalt pavement, gravel pavement, soil road, cement road and slate pavement in the Shuzheng Valley roadway. According to preliminary statistics, the main walking streets and alleys are the east-west contact streets and alleys of the village, with a width of 1.5–3.5m and a length of about 700m. The asphalt pavement is mainly the main vehicle loop inside the village, with a width of 3.5-6m and a length of about 1200m. The cement road is mainly the newly built road on the southwest side of the village, with a width of 3.5m and a length of about 700m. The gravel and soil roads are mainly ascending roads along the direction of Shuzheng ditch, with the width of 2–3.5m and length of 1200m(Fig.10).

As the building heights, building materials, and ground materials on both sides of streets and lanes continue to change, the spatial scale and spatial activities of village streets and lanes also change. The investigation found that with the increase of commercial activities, the middle main street's width in Shuzheng Valley was broader than that of the living walking street on both sides, which met the primary demand for fire control. However, the pedestrian streets on both sides are relatively narrow, with the width about 2.0m and the narrowest place is only 1.2m , which cannot meet the traffic requirements of standard fire-fighting vehicles. In the narrow streets, there are still occupied phenomenon, such as the accumulation of wood and prayer flags that also exist fire risk. In addition, village walking roads have individual end roads or roads connected with stone steps, which have a certain impact on the convenience and safety of residents(Fig.11).

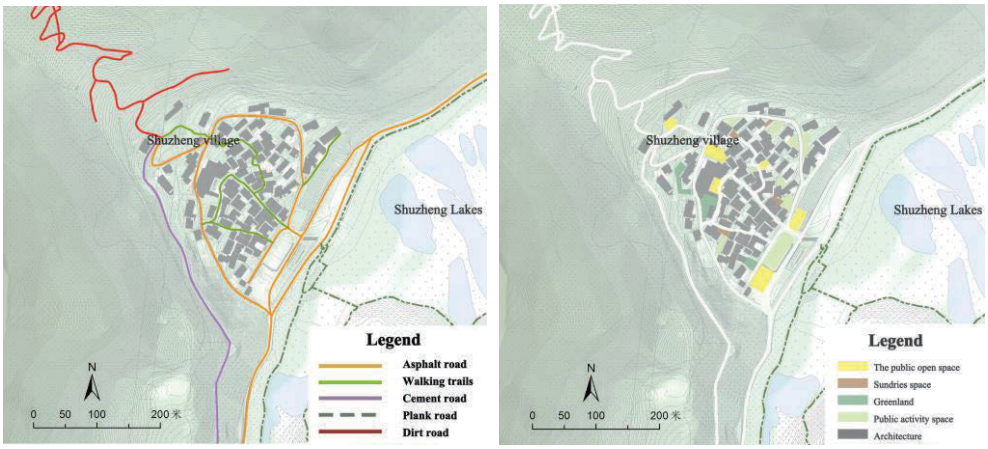

Fig.10 Current situation map of village roads and availabe spaces

Fig.11 Lane width and occupied passageway

4.Adaptive Disaster Prevention Strategy in Village

Compared with traditional disaster prevention strategies, adaptive disaster prevention strategies emphasized the concept of adaptive disaster prevention throughout process, which attaches importance to disaster resistance and emphasises disaster adaptation based on the principle of minimising disaster loss[5]. Through field investigation of village disaster risk, based on the mechanism of disaster action and the traditional village exposure, vulnerability analysis, from the pre-disaster prevention, planning response, engineering implementation, disaster prevention management four aspects of Tibetan traditional village adaptive disaster prevention strategies.

(1) Preventive Strategy

a) Installing risk monitoring equipment

Due to its unique geographical location, Shuzheng Village faced various disaster risks, such as fires, mudslides, landslides, collapses and other geological disasters. Combining the above analysis of disaster risk sources, the research team has installed environmental sensors, rainfall sensors, and wheel-type fixed oblique devices to monitor 58 devices at 4 points around Shuzheng Village.

b) Establishing a monitoring and warning platform

Use the Internet of Things technology to connect the monitoring equipment data to the network platform for real-time monitoring, mainly monitoring the village temperature, water content, vibration frequency, wind speed, rainfall and other indicators. The monitoring platform comprehensively sets first-level early warning, second-level early warning, and third-level early warning. When indicators of geological data disasters are higher than the safety threshold, the villagers can be notified in time to evacuate to minimise the villagers' losses (Fig.12).

Fig.12 Monitoring data computer and early warning platform [2)]

(2) Planning response strategy

The plan will use the current villagers' centralized storage space to clean up and form a disaster prevention system with an open flat space, public activity space, green space, and streets in the village to improve the village's disaster prevention and emergency response capabilities. From the village planning level, with the help of technical means to simulate disasters and possible routes. It is used in the reconstruction and new construction to make the village construction avoid the simulated routes of debris flow, landslide, rockfall so that the villagers can escape orderly according to the disaster prevention evacuation channels and reduce the possible losses caused by disasters(Fig.13).

(3) Engineering Implementation Strategy

a) Geological disaster protection

Aiming at the threat of debris flow in the Shuzheng Village ditch, debris flow prevention embankments have been built in the Shuzheng Valley ditch successively. Siltation in front of the dam has been removed regularly. After the Jiuzhaigou earthquake in 2017, in response to the collapse and landslide disasters on the left and right sides of the village, wall protection and other projects began. The length of the protective network in the village was 440 m, and the wall protection was 570 m, effectively preventing the threat of geological disasters to the village(Fig.14).

b) Firefighting of Village

In order to strengthen the fire safety of the village, the village god-supply house is used as the village fire-fighting house, the village committee is used as the temporary fire command center, and the large parking lot at the village entrance is selected as a large temporary evacuation site. At the same time,fire hydrants are installed in the main street position and public space of the village, fire extinguishers are configured in places that are easy to find and clear, and fire alarm devices are installed in public buildings and residential buildings(Fig.15).

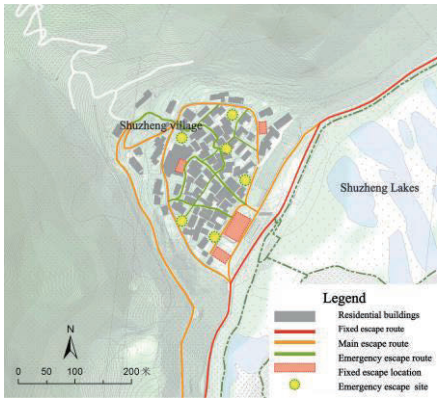

Fig.13 Evacuation space planning for disaster prevention and shelter

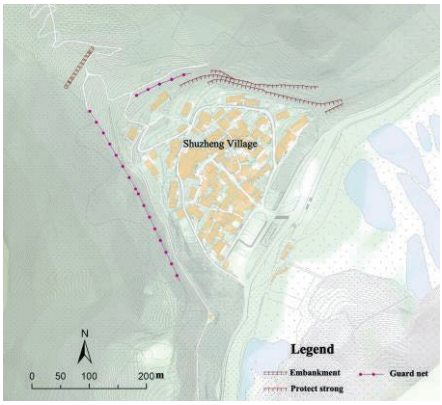

Fig.14 Distribution diagram of engineering protection facilities

Fig.15 Location of Fire Rooms in Village

(4) Disaster prevention management

a)Strengthen the construction of emergency management system and give full play to the positive role of villages

Relying on village staff and integrating existing disaster risk monitors and other types of personnel, establish grass-roots full-time (part-time) emergency information staff team, At the same time, strengthen training to improve the timeliness and quality of information submission. Give full play to the role of village information officers. Combining traditional methods such as gongs, whistleblowing, and village broadcasts to reduce information coverage blind spots, which effectively solved the bottleneck problem of early warning information release ' last kilometer '.

b)Strengthen publicity and education, improve villagers' awareness of disaster prevention and mitigation

While using various new medias such as radio, television and the internet for publicity and education , it is possible to strengthen on-site disaster prevention and mitigation publicity and education in the village. For example, specific explanations, disaster prevention exercises, and other forms of publicity and education activities are carried out at the village site to raise awareness of disaster prevention and disaster reduction among rural residents.

5.Conclusions

Since the Jiuzhaigou earthquake in 2017, a series of disasters caused a serious threat to the habitat security of traditional villages. The Shuzheng Village of Jiuzhaigou is built on the fan-shaped ground at the mouth of the debris flow. Through disaster investigation and analysis, it is found that the debris flow disasters are relatively stable, but the geological disasters such as collapses and landslides are still severe. The village buildings conform to the topographical layout, the old and new buildings integrated. Although the fire resistance of modern building material has been improved, the short distance from traditional buildings is not conducive to fire fighting. Moreover, the distance between the pedestrian roads in the village is narrow, and some road sections are piled up with debris, which makes it difficult to form a smooth escape route for disaster prevention.

Based on these situations, the research systematically summarized some adaptive disaster prevention strategies for traditional villages. Firstly, monitoring the occurrence threshold of various disaster risks by installing monitoring equipment. Secondly, using the remaining space in the village to open up blocked roads, establishing a fire-fighting evacuation and disaster prevention and refuge space system to resist preventable disasters. Besides, according to the village's terrain, the establishment of dams, protective nets, walls and other engineering measures adapt to frequent disasters. Finally, it is proposed to strengthen the construction of emergency management system as well as simple and easy to understand publicity and education, which will help enhance the villagers' awareness of disaster prevention and reduction to prevent the occurrence of irresistible disasters.

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