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# Risk Analysis of Rural Housing in yingshang County Anhui Province—For example Brick-Wood Structure

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**Abstract:** Through the observation and judgment of rural dilapidated houses in yingshang County, by inductive statistics and analysis of data, the criteria for identification of rural dilapidated buildings are used to define rural areas with qualitative and quantitative criteria. The housing is divided into hazard levels, and the structural damage form of the house is pointed out. According to above materials, professional treatment suggestions are given to provide reference and reference for the identification of rural dilapidated buildings in the future.

## 1. Introduction

Anhui has a large rural population, of which the rural population of Yingshang County accounts for 84.1% of the county as a whole. Therefore, the safety of rural houses is of particular importance to rural population and property security. Most of the rural houses in Yingshang County are mainly self-built by local construction workers according to owners' needs and economic conditions. The houses are simple in structure, similar in type, convenient in drawing materials, and low in cost. However, these houses are not built based on a comprehensive plan, corresponding geological survey, and seismic fortification design, leading to many security risks [1].

In August 2018, Anhui University of Architecture cooperated with Real Estate Administration of Yingshang County in conducting an extensive rural housing risk survey, focusing mainly on the structure and failure characteristics of rural houses. This paper selects part of those houses for a comprehensive appraisal and risk assessment. Relevant data selected is shown in Table 1.

Table 1. Statistics on the level of rural dilapidated houses in Yingshang County.

Region	Town	Village	Number of houses (based on danger level)			
			B	C	D	Total
Yingshang County	Jiangdian zi	Nongke	5	9	6	24
		Yangzhuang	8	5	12	30
		Yingcun	10	6	2	23
		Huangba	12	7	12	34
		Huangba Community	2	4	3	9

According to the survey, the structure of rural houses in Yingshang County is mainly brick-concrete structure and brick-wood structure (wooden trusses and brick walls are the main load-bearing structure of wooden frame girder masonry houses). Among them, brick-wood houses are



old houses while brick-concrete houses are those under construction or built in recent years. Since it takes a long time to build rural houses and they are not maintained, bearing capacity of the upper weight-bearing part of the brick-wood structure has been reduced; in addition, there are circumstances where people willfully rebuild the upper structure and add the number of floors, which affects the overall house safety. If timely measures are not taken, the house will be destroyed or even collapse. In order to prevent or reduce this kind of situation, it is necessary to spot potential hazards as soon as possible, and take corresponding measures so as to protect the lives and property in the rural area.

## 2. On-site investigation

Nongke Village, Jiangdianzi Town, Yingshang County, Anhui Province, with a population of 4,700, is located 0.4 kilometers south of Jiangdianyu Town. It has 24 dangerously identified houses, all of which are brick-wood ones. Due to the long-term disrepair, some of the beams are in a dangerous condition. There are obvious cracks on the inner and outer sides of the walls, which are prone to tilting and collapse. The houses have major safety risks and cannot be normally used.

## 3. Failure characteristics and risk identification of brick-wood structure houses

This paper takes a rural brick-wood structure house in Nongke Village, Jiangdian Town, Yingshang County, Anhui Province as an example to identify and analyze dangerous houses. This house was built in the 1980s with no repair or maintenance of the truss. After conducting on-site observation and inspection, taking photos and samples of the house, we observed four dangerous aspects in this rural house. See Figure 1.

The failure characteristics of the brick-wood structure are as follows:

- Figure 2 shows the front view of the house. On the outside, there is no obvious large crack.
- Figure 3 shows the obvious crack at the left side of the roof. The width of the crack is 20mm. It starts from the middle of the roof to the wall and spreads all the way to the ground.
- Figure 4 shows the internal wall, which is connected to the external wall. There are large cracks on the internal wall. Due to the insufficient strength of the condensed material, the masonry has fell and staggered. The staggered width is about 40 mm. There are also other slender cracks, penetrating from the root to the ground.(4) Because of weathering erosion and uncertain weather, the external wall has detached and the material of the wall has also detached. Thus, the masonry has been exposed on the surface and water seepage has occurred. The roof has been for long years out of repair, water seepage has also occurred

Due to the above structural and external damage, the brick-wood house is considered as an overall dangerous house.

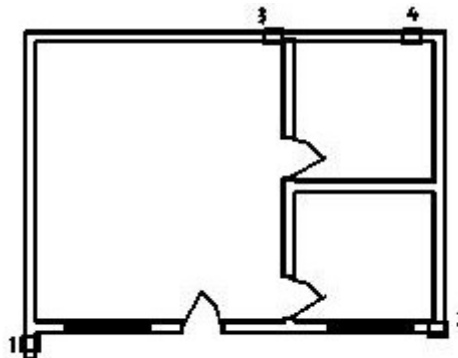


Figure 1. Construction Plan.

## 4. Risk identification

Comprehensive evaluation of brick-and-wood structure houses was carried out based on Criteria for Identification of Rural Dilapidated Houses JGJ/T363-2014.

#### 4.1. Qualitative identification

The bearing capacity of the load-bearing structure of the brick-wood structure meets the requirements, but since there are obvious large cracks, it cannot meet the requirements of normal use, so the house is in a dangerous condition. According to Section 4.2.4 in Criteria for Identification of Rural Dilapidated Houses JGJ/T363-2014, qualitative risk level of this house is D.

#### 4.2. Quantitative identification

- By identifying above-mentioned structural failure dangerous based on aspects of key building components and evaluating according to Section 4.2.4 in Criteria for Identification of Rural Dilapidated Houses JGJ/T363-2014, we come to conclusion that the percentage of foundation-based dangerous components is  $P_{fdm} = n_d/n \times 100\% = 0$ ; the percentage of dangerous components of the upper load-bearing structure is  $P_{sdm} = \{2.4n_{dc} + 2.4n_{dw} + 1.9(n_{dmb} + n_{drt}) + 1.4n_{dsb}\} / \{2.4n_c + 2.4n_w + 1.9(n_{mb} + n_{rt}) + 1.4n_{sb} + n_s\} \times 100\% = 64.2\%$ ; the percentage of hazardous components of the building envelope is  $P_{esdm} = n_d/n \times 100\% = 0$
- Assessment of the risk level of housing component

Table 2. Data calculation and result

Level of housing component	Foundation	Topside structure	Building envelope
a	$\mu_{af}=1$	$\mu_{as}=0$	$\mu_{aes}=1$
b	$\mu_{bf}=1$	$\mu_{bs}=0$	$\mu_{bes}=1$
c	$\mu_{cf}=0$	$\mu_{cs}=0.44$	$\mu_{ces}=0$
d	$\mu_{df}=0$	$\mu_{ds}=0.49$	$\mu_{des}=0$

According to quantitative evaluation method of rural dangerous houses in Section 5.9.8 of Criteria for Identification of Rural Dilapidated Houses JGJ/T363-2014,  $\mu_A=0.3$ ,  $\mu_B=0.3$ ,  $\mu_C=0.44$ ,  $\mu_D=0.49$ ,  $\max\{\mu_A, \mu_B, \mu_C, \mu_D\} = \mu_D=0.49$ , so the comprehensive result is D (whole house).



Figure 2. Front view of the house.



Figure 3. Structure damage near the left wooden beam



Figure 4. Damage on the top of the right wall

### 5. Finite element analysis

Conduct finite element stimulation of the brick-wood structure house using the ABAQUS software. Apply seismic action (6 degree fortification, 0.05g gravity acceleration) and vertical load (mainly snow load), observe the strain of the house so as to determine the maximum position of the strain, which is called the weak link. By strengthening the weak link, we can reduce the damage of brick-wood structure houses and extend their service life.

The brick and wood structure is a wooden beam brick masonry house. Its upper wooden roof truss directly rests on the vertical and horizontal walls in a connection form of sliding overlapping, which basically does not provide horizontal support. Therefore, this paper replaces the sloping roof panel with a flat roof panel, in which horizontal stiffness is zero and red brick and the mixed mortar are used between the vertical and horizontal walls; the upper roof load-bearing structure is a wooden truss and purlin with tile laid on the roof and purlin placed between wooden beams.

Under earthquake and vertical load, the strain of the model is shown in Figure 5. The wall is close to the foundation, the inner wall is close to the roof and the foundation position, and the strain of upper and lower positions of window is large, indicating it is a weak link in the structure. In the case of insufficient knot material, cracks are likely to occur, leading to large damages, thus a dangerous house. The maximum position of the simulated strain is close to the actual position of the gap.

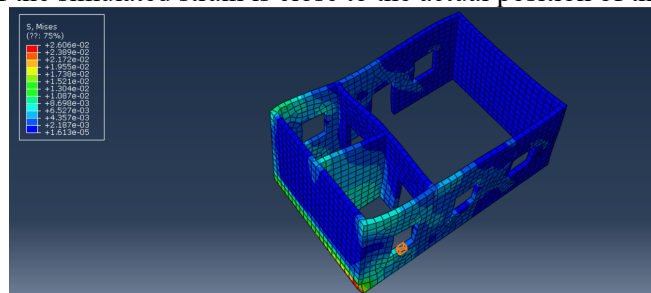


Figure 5. Strain of brick-wood housing

### 6. Conclusion and suggestions

This paper takes a rural house of wooden beam masonry in Nongke Village, Jiangdianyu Town, Yingshang County, Anhui Province as an example to analyze its risk level from both qualitative and quantitative perspectives and the failure characteristics of the house. This paper can offer some suggestions to future rural house construction by determining the weak link of brick-wood structure

houses using finite element simulation:

(1) Level C and D houses with safety risks and cannot be reinforced should be dismantled as soon as possible to avoid collapse. For level A houses without safety risks or level B houses that can be repaired, structural measures should also be taken to improve the brick-wood structure to make the house more resistant to shock.

(2) Under earthquake and vertical load, the weak points are located at the foundation, the upper and lower parts of the window, the corner of the wall and the internal partition wall.

(3) Reinforce the weak link through finite element simulation of the brick-wood structure. More attention should be paid to the weak link of level A, B, and C houses. Level A and B houses should be strengthened, and the level C houses should be reinforced to avoid further damage.

(4) It is recommended that the relevant departments put forward requirements for newly built rural houses and offer professional suggestions on geological conditions, housing design and construction so as to improve the quality of newly built houses in rural areas and provide a safe living environment for rural population.

(5) This appraisal offers me more insights and helps me to improve my professional skills and abilities. My understanding of harm of the identification oType the title of your paper hen strengthened.

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