Seismic Optimization Simulation Analysis of Yi People’s Light Steel-Wood Plastic Residential Structure

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Abstract. Through the SAP2000 finite element software, the finite element calculation model of three steel frames for earthquake resistance, base isolation were established for the Xishuangbanna Dai light steel wood-plastic structure. The EI seismic wave was used to analyze the steel frame structure. The acceleration, displacement, natural vibration period and damping effect of the two structural forms under earthquake are compared and analyzed. The research results show that the isolation and shock absorption technology can effectively reduce the impact of earthquake on the structure. Under the comprehensive comparison, the isolation structure with additional Isolation bearing is better than that of the seismic structure.

Introduction

As people put forward higher requirements on the living environment, light steel structures have the advantages of lighter weight, less steel consumption and shorter construction period than steel structures. This form of residential system is developed on the basis of wooden houses, originated in Europe and the United States, developed in Japan, is a brand new building system [1]. Light steel structure refers to steel structure with thickness less than 10mm. It has the advantages of light weight, low cost, short construction period, good comprehensive economic benefit, good seismic performance, convenient disassembly and environmental protection. It has been widely used [2].

In recent years, due to the enhancement of global environmental awareness, there are fewer and fewer buildings of all-wood structure, and the housing of steel-wood structure system is developing rapidly. Especially in North America, light steel and timber-framed homes are very mature. In Yunnan, China, ethnic minority architecture has become a cultural feature of the region, but with the economic development, some architectural culture is dying, and timber-based buildings are difficult to continue to build. In order to preserve national characteristics and protect forest resources, wood-plastic composite materials have been developed to replace wood. Wood-plastic composite (WPC) is a composite material prepared by melt mixing of thermoplastic resin and biomass fiber and appropriate additives [3, 4].

The light steel-wood-plastic structure has better seismic performance than the concrete structure. However, due to the great harm of earthquakes, buildings are the main target of earthquakes. Earthquake-damaged building structures are still the most serious natural disasters that threaten human life. The traditional seismic resistance relies mainly on the ductility and plasticity of the structure itself, based on the “resistance”, which dissipates the energy input caused by the earthquake. From the current development point of view, this kind of earthquake resistance cannot meet the structural seismic requirements required by the society. In recent years, domestic and foreign scholars have proposed a large number of researches to propose building isolation and shock absorption technology, to control the seismic input of energy input to the building structure and the seismic response of the structure, which greatly increases the safety of the structure, which makes the structure realized by "resistance". Change to "control".

Through the SAP2000 finite element software, the finite element calculation model for seismic, foundation isolation and shock absorption of three steel frames of Xishuangbanna Dai light steel wood-plastic structure was established. Based on the EI seismic wave time-history analysis of steel
frame structure and three seismic design methods under seismic action, the self-vibration period, deformation, acceleration, displacement and damping effect of the structure are analyzed. It is especially important to establish and promote a safer seismic structure.

**Project Overview**

The project is located in the light steel-wood-plastic building of the Yi people's residence in Xishuangbanna, Yunnan Province. The floor plan is shown in Figure 1 below. It has 2 floors and a total construction area of 172.2m². The total height is 8m and the floor height is 2.8m. The engineering design life of the project is 50 years. The seismic fortification intensity of the project is 8 degrees, and the seismic acceleration design value is 0.30g. The site category is Class II and Group III, and the seismic design grade is Grade III. The design earthquake group is the first group with a characteristic period of 0.45. The damping ratio under multiple earthquakes is 0.04.

![Figure 1. Floor plan of the Yi people's residential buildings.](image)

The seismic wave of this paper uses EI seismic wave, and the time history of seismic load acceleration is shown in Fig. 2.

![Figure 2. Seismic load time history.](image)

**Establishment of Traditional Seismic Model**

The basic principle of traditional seismic structures is to resist earthquakes by enhancing the seismic strength and stiffness of the structure itself. That is to say, relying on the damage of the structure itself and the load-bearing members to store, convert and consume seismic energy [5]. In the traditional seismic structure, the increase of the section size or the increase of the number of steel bars is generally adopted to achieve the seismic requirements. The earthquake is consumed by the damage of the structure under the action of the earthquake. The structure does not have the active regulation function, and the traditional earthquake resistance is a passive and negative seismic measure.

**Establishment of Isolation and Shock Absorption Models**

The isolation of the building structure is mainly through the establishment of an isolation layer, which can be established between the foundation and the superstructure, or can be placed between the layers of the superstructure. The isolation system consists of a seismic isolation layer composed of flexible isolation devices, forming a “flexible structure” system with small horizontal stiffness [6]. When an earthquake occurs, the energy of the earthquake is transmitted to the flexible isolation
layer through the substructure, which consumes a large amount of seismic energy and reduces the seismic energy input to the superstructure.

Considering the practicality of the structure, the base isolation is used, and an isolation layer composed of a lead rubber bearing is arranged at the bottom of the house. The rubber bearing isolation system is simple in installation and convenient in construction, and is considered to be the system with the most excellent effect of the isolation technology to practical use [7].

Set 12 isolation bearings on the foundation and set the height of the isolation layer to 600mm to facilitate the inspection and maintenance of the isolation bearing. The sap2000 finite element software is used to simulate the 3D model of light steel-wood plastic isolation.

**Structural Analysis**

The above two structural models are used for nonlinear time-history analysis under multiple earthquakes. According to the requirements of the specification, the EI seismic wave suitable for the site type of the structure is selected. The maximum seismic acceleration is 390mm/s². Through time history analysis, period, top layer acceleration and displacement of the two structures are compared and analyzed.

**Modal Analysis Results**

The modal analysis was performed on the two structures to obtain the first, second and third order vibration periods of the two models, as shown in Table 1.

<table>
<thead>
<tr>
<th>structure</th>
<th>Mode shape 1 (X 向)</th>
<th>Mode shape 2 (Y 向)</th>
<th>Mode shape 3 (Reverse)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-isolated</td>
<td>0.653</td>
<td>0.336</td>
<td>0.301</td>
</tr>
<tr>
<td>Isolated</td>
<td>3.683</td>
<td>1.405</td>
<td>1.324</td>
</tr>
</tbody>
</table>

**Acceleration and Displacement Comparison Analysis**

Since the vertical displacement and acceleration of the structure are mainly caused by vertical earthquakes, The following figure are the vertical acceleration and displacement diagram of the bottom layer, the second layer and the top layer of the structure under earthquake action.
**Conclusion**

1) The isolated structure can significantly prolong the natural vibration period of the structure, avoiding the excellent period of the site, and can accurately control the earthquake transmitted to the structure, so that the structure does not resonate and cause serious damage.

2) From the acceleration comparison chart, the maximum acceleration of the isolated structure in the isolation layer indicates that the seismic isolation layer consumes a large amount of seismic energy, and the maximum acceleration limit is smaller than the maximum acceleration of the top layer of the seismic structure.

3) Where the structural deformation is greater, the displacement that occurs is greater. Under the action of earthquake, the earthquake-resistant structure has a large displacement of the top layer and the structure is easily destroyed.

In summary, this paper analyzes the traditional earthquake-resistant and seismic isolation of the Yi-light steel-wood-plastic residential structure. The analysis shows that the seismic isolation structure has obvious advantages in all aspects, and the two are compared with the isolation treatment. Relatively superior, it is an effective way to absorb shocks in rural buildings. It has broad application prospects and is worth promoting.

**References**


