Solution to increase the strength when the large wind, the storm for the type of rural houses in mountainous areas of Thai Nguyen province in Vietnam

Nguyen Tien Duc

Abstract— Strengthening resilience to strong winds and storms for rural houses in mountainous areas of Thai Nguyen province in Vietnam is an urgent requirement in the current global climate change conditions. The paper identifies the possibilities to enhance resilience to wind and storms of rural areas in Thai Nguyen province in Vietnam. Then select three reinforcement options suitable to economic and social conditions and practical local techniques. Thereby modeling three structural options selected by Etabs software, comparing the internal forces of each plan to choose the best option for rural mountainous areas in Thai Nguyen province in Vietnam.

Index Terms— Rural houses in mountainous areas, Enhance wind resistance capacity, Enhance the bearing capacity.

I. INTRODUCTION

With the current global climate change conditions, abnormal wind storm events are likely to occur [1]. For rural and mountainous areas with particularly difficult economic and technical conditions, it is necessary to find a plan to improve and enhance the resilience of houses for unusual wind and storm phenomena. Several solutions have been proposed to enhance the resilience of housing as mentioned in [2] but still not suitable for local economic, cultural, social and technical conditions. The article goes to research to find solutions to strengthen resilience for rural mountainous areas in Thai Nguyen province, Vietnam.

II. SUBJECTS AND METHODS OF RESEARCH

A. Objects

The study area consists of Dai Tu, Dinh Hoa, Dong Hy and Vo Nhai districts of Vietnam (Figure 1), which features topography that is flat land in the valley, the climate is cold in winter. Rural housing types in this area include: stilt houses, brick houses, half-floor houses and half-brick houses. Rural houses are often made up of villages gathered together.

The campus is fenced, planted with fruit trees and vegetables. The house has three rooms with two wings, four roofs.

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The interior space is divided horizontally into two parts, the outside is the place of ancestor worship, common activities, reception of guests, the inside is the kitchen, the upper part is guarded so that rice corn and supplies need to be preserved. Typical house type is shown in Figure 2.
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B. Solutions to strengthen resistance to high wind and storm in accordance with local economic and technical conditions

In order to enhance the bearing capacity of the structure, we can reinforce the components: Roof, column, beam, floor. Specific solutions are shown in Table 1.

<table>
<thead>
<tr>
<th>STRUCTURE SYSTEM</th>
<th>SOLUTIONS TO INCREASE THE RESISTANCE ABILITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>Steel truss roof</td>
</tr>
<tr>
<td></td>
<td>Cement tile roof</td>
</tr>
<tr>
<td>Linking roof with column girder system</td>
<td>Tied off bamboo Bolts Bamboo latches Rivets</td>
</tr>
<tr>
<td>Roof bracing system</td>
<td>Horizontal bracing system Vertical bracing system Cross bracing system</td>
</tr>
<tr>
<td>Link between roof beams</td>
<td>Additional link bolts</td>
</tr>
<tr>
<td>Floor</td>
<td>Replace steel floor</td>
</tr>
<tr>
<td>Column</td>
<td>Increase the number of columns</td>
</tr>
<tr>
<td>Build more walls</td>
<td>Build horizontal walls Build vertical walls Addition of the whole wall Build half-house walls</td>
</tr>
<tr>
<td>Bracing columns with beams</td>
<td>1st floor: cross bracing, horizontal bracing, vertical bracing 2nd floor: cross bracing, horizontal bracing, vertical bracing 1st &amp; 2nd floor: cross bracing, horizontal bracing, vertical bracing</td>
</tr>
</tbody>
</table>

Due to the characteristics of rural mountainous areas, Thai Nguyen province has difficult economic conditions and construction techniques are not developed. Through actual surveys and proposed architectural solutions suitable to the function and culture and the needs of the people [5], it is possible to identify three options to enhance resilience when there are high winds and storms: building walls bearing along the structural frame, adding braces for the frame system, building walls to increase the hardness of the corner for houses in rural mountainous areas of Thai Nguyen province as shown in Table 2.

<table>
<thead>
<tr>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction of load-bearing walls along the structural frame</td>
<td>Add a tie for the frame system</td>
<td>Build walls to increase the hardness of the corner</td>
</tr>
</tbody>
</table>

Table 2. Solutions to strengthen resistance to high winds and storms for rural housing types in Thai Nguyen province in Vietnam

C. Method

In the modeling process for research related to materials, bonding and practical interactions, in this paper, it is limited to compare the bearing model of the construction by simulation in Etabs software. First modeling the structure of the house for the current conditions defining the internal forces of the structural frame (torque, shear force). Then build structural models with the case of building walls in the horizontal direction of the house, adding slant bars along the house, building reinforced walls on both sides of the column to determine the internal force results of the alternatives. From the internal force calculation results compare the largest internal forces of the options to choose the best option for rural housing in mountainous areas of Thai Nguyen province in Vietnam.

III. RESULTS AND DISCUSSION

Modeling and calculating structural by Etabs software are internal force in beams, column of wall construction in horizontal direction shown in Figure 3, adding anti-slant bars shown in Figure 4, built Reinforced wall two sides of the column shown in Figure 5.
The comparison of the above results shows that case 1 is most suitable to increase the bearing capacity of houses in rural mountainous areas of Thai Nguyen province. Because when considering the damage of high winds and storms, the floor principle will be transferred to the sub-beam, from the secondary beam to the main girder, the main beam will be transferred to the column. In which the column has the largest role, so in the three options choose the option of both the internal force of the column and the small main beam, so option 1 is the best.

IV. CONCLUSION

To increase the resilience of rural houses in mountainous areas of Thai Nguyen province, Vietnam. The article has identified three options: building vertical walls across the house, adding slant struts along the house, building reinforced walls on both sides of the column. Then modeling the structural system of the alternatives shows that the case of building vertical walls across the house is the most optimal for bearing in the first and second column of the second floor beam. Then determine the best improvement solution to enhance the resilience to wind and storms of rural areas in Thai Nguyen province in Vietnam.

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