SHEAR WALLS SHEATHED WITH GLUED LAMINATED GUADUA BAMBOO PANELS SUBJECTED TO LATERAL LOADS

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ABSTRACT: In order to study the feasibility of using Glued Laminated Guadua (GLG) bamboo panels as an alternative sheathing, a study of their performance within shear walls was conducted at Universidad de los Andes Bogotá, Colombia. During the initial stages of the research, monotonic and cyclic lateral load tests were conducted on shear walls sheathed with GLG panels with aspect ratios of 1:1 and 2:1. Three different sheathing nail schedules were considered and the relative performance of the walls was evaluated based on parameters such as the peak shear strength and elastic shear modulus. Similar tests were conducted on shear walls sheathed with Oriented Strand Board (OSB) and Plywood for comparison purposes. The results of these tests showed a comparable strength and stiffness properties between GLG and wood-based sheathed walls but with low damage observed in the GLG panels. Once the shear wall with GLG panels were studied, a 2-story woodframe housing module was built to experimentally evaluate the performance of GLG panels within an actual structural system. A series of shake table tests were conducted to simulate earthquake loading conditions. The building module was subjected to a sequence of ground motions with increasing intensity that were representative to those expected on a high seismic hazard zone in Colombia. Whereas no substantial damage was observed on the tests of the bare woodframe structure, considerable cracking of exterior stucco and interior gypsum wallboard were observed when the structure was subjected to a 2% exceedance probability in 50 years event. In general, good behavior of lateral force resisting system of the test structure was observed in all test phases, and significant overstrength of the test structure was observed compared to that considering only the contribution of the structural shear walls.

KEYWORDS: Laminated Bamboo, Sheathing Material, Shear Wall, Bamboo Panels.

1 INTRODUCTION

Guadua Angustifolia kunt is a South American Bamboo species that not only exhibit suitable physical and mechanical properties for construction of structures, but also has fast growing rate since the mature age is reached between 3 to 4 years old [1]. In order to overcome the cross section limitation of the round bamboo, Glued Laminated Guadua (GLG) bamboo products have been developed. Preliminary research show that GLG has very good mechanical properties when compared to the best structural timbers in Colombia [2], which make GLG an alternative, renewable and sustainable material besides wood. A possible application of GLG in wood frame buildings could be in the form of structural sheathing used in the construction of shear walls, which are typically made of Oriented Strand Board (OSB) or plywood. Structural panels sheathing are the key elements in the lateral force resisting system of woodframe structures, since they provide the lateral stiffness and strength of Light-Frame Systems subjected to earthquake or wind forces. Wood Light-Frame Systems have been used extensively in North American and Europe, alternative materials like bamboo could be interested material to explore in order to reduce the pressure on the forest.

The Universidad de los Andes at Bogotá Colombia conducted a comprehensive study of the structural potential of Glued Laminated Guadua Angustifolia kunt Bamboo (GLG) as a construction material. As part of this research, monotonic and cyclic lateral load tests were conducted on shear walls sheathed with GLG panels with aspect ratios of 1:1 and 2:1 and three edge nail spacing of 152 mm (6 in), 76 mm (3in) and 51 mm (2in). In order to evaluate the performance of GLG panels within an actual structural system a series of shake table tests were conducted to simulate earthquake-
loading conditions on a 2-story woodframe housing module with shear wall with GLG panel.

2 TEST RESULTS

2.1 SHEAR WALLS TEST

Based on the envelope curve an idealized elasto-plastic model using equivalent energy method the lateral capacity ($V_{max}$), elastic stiffness ($K_e$) and ductility displacement capacity ($\mu$) were obtained. Figure 1 presents the average values of $V_{max}$ and $K_e$ and $\mu$ achieved from EEEP curve. Those values were normalized respect to the maximum nail spacing (6 in) and they are showed as a function of the inverse of the nail spacing. It was found that $V_{max}$ and $K_e$ increased as nail spacing decreased, whereas $\mu$ decreased as nail spacing decreased. In addition, the $V_{max}$, $K_e$ and $\mu$ were not affected by the aspect ratio which is the same behavior observed in previous research done in wood shear walls [3].

![Figure 1: Parameter variation with respect to nail spacing, normalized by the larger spacing](image)

Based on the experimental results, shear walls with GLG panels showed the same load-displacement behavior compare to shear walls with OSB and Plywood panels. Moreover, GLG panels has an equal or more lateral load capacity that Structural I type panels reported at International Building Code. Also, shear walls with GLG panels presented less damage compare to shear walls with OSB and Plywood panels.

2.2 SHAKE TABLE TEST

No substantial damage was observed on shear wall and bare woodframe structure, whereas considerable cracking of exterior stucco and interior gypsum wallboard were observed when the structure was subjected to a 2% exceedance probability in 50 years event. Most of the damages at the interior and exterior finishing were observed at the corners of the windows and at the joints between structural walls and non-structural walls as it can be seen in Figure 2.

The test structure exhibited a pinched global hysteretic behavior (base shear vs. roof relative displacement) in all test phases, similar to that observed for the isolated shear wall tests. In general, good behavior of lateral force resisting system of the test structure was observed in all test phases, and significant overstrength of the test structure was observed compared to that considering only the contribution of the structural shear walls.

![Figure 2: Observed damage](image)

3 CONCLUSIONS

1. Shear walls sheathing with GLG has similar load-displacement behaviour to shear walls sheathing with OSB and Plywood panels.

2. The stiffness and maximum load carrying capacity of the wall increases as edge nail spacing decreases whereas; the displacement ductility capacity decreases as edge nail spacing decreases. Stiffness, maximum load capacity, and ductility of the GLG sheathed shear walls are not affected by the aspect ratio of the wall.

3. Limited damage was observed on shear wall sheathing with GLG panels after a strong earthquake records simulated by shake table tests. Considerable but repairable cracking of exterior stucco and interior gypsum wallboard were observed after design earthquake with a PGA of 0.3g expected on a high seismic hazard zone in Colombia.

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REFERENCES

