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DESIGN, CONSTRUCTION AND INSTRUMENTATION OF A SIX-STORY ENGINEERED MASS BAMBOO BUILDING

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ABSTRACT: This presentation reports the design, construction and instrumentation of the world first tall engineered mass bamboo building. The building has six story bamboo structure with a rooftop attic, reaching a total height of 20.3 meters and a total building area of approximately 800 square meters. The main structure of the building is composed of engineered mass bamboo frames, steel braces and shear walls. The dimensions of the structural components were designed referencing current timber design codes however with experimental data. The structural analysis confirmed that the structure meets the requirements of existing standards for seismic and wind design. The construction of the building combined the "frame" and "platform" procedures used in wooden building construction, ensuring installation efficiency. Instrumentations have been carried out to obtain the vibration modes and building behavior under strong wind load.

KEYWORDS: engineered mass bamboo, glubam, tall building, design, construction

1 – INTRODUCTION

Similar to timber, bamboo is a promising bio-based material that is fast grown and widely available, particularly in many developing countries. In recent years, engineered bamboo manufactured by lamination process has become available, which can integrate the geometrically non-uniform round bamboo into various shapes and sizes suitable for modern structure. Glubam (glued laminated bamboo) is a type of engineered bamboo developed by the author's team [1,2]. The glubam components can be made by a pressure lamination process using thin strip or thick strip laminae, similar to the process of manufacturing timber based glulam. In this paper, the design, construction of the world's first six story (seven story including attic) engineered mass bamboo building is reported, which is based on the authors' research for twenty years and references of timber structures.

2 – BACKGROUND

The six-story engineered mass bamboo building was planned as a demonstration project to assess the constructability of engineered mass bamboo for tall buildings and showcase its potential. The project was carried out after the accumulation of twenty years of research on bamboo materials and structures, admiring recent progress and trend in tall and high-rise timber building development. As the first and to date the tallest engineered mass bamboo building, it offers the authors and collaborators valuable opportunity to conduct various research, such as vibration assessment, control, durability, thermal and acoustic performance, etc.

3 – DESIGN AND ANALYSIS OF ENGINEERED BAMBOO STRUCTURE

The tall bamboo structure demonstration building (nicknamed as the Ninghai Bamboo Tower, shown in Figure 1) is completed in 2024. The building has 6 stories with a roof access attic, reaching a total height of 20.3m. The building foot area is about 130sqm, with a total floor area of about 800sqm, and Figure 1a shows its standard floor. The structural skeleton is exhibited in Figure 1b, which has engineered mass bamboo frames combined with braces and shear walls for lateral resistance. There are two types of floor slabs: cross-laminated bamboo and timber (CLBT) [3], and a lightweight floor with a flame-retardant veneer boards supported by glubam I-joist beams.

The vertical load is distributed to the floors which are supported by the glubam sub-beams or I-shape joists, to transfer the load to main frames. The lateral loads by wind or earthquake are transmitted to the foundation through the lateral resisting systems, which include the framed lightweight timber or bamboo shear walls in the long direction (X-direction), and the bamboo frame with steel or bamboo bracing in the narrow direction (Y-

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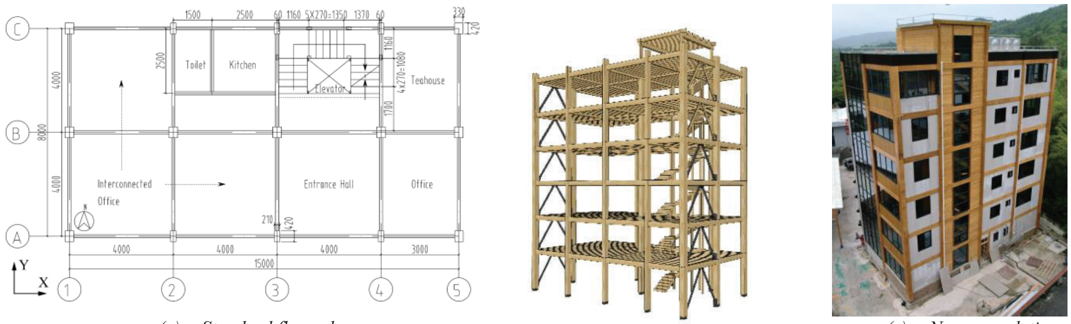
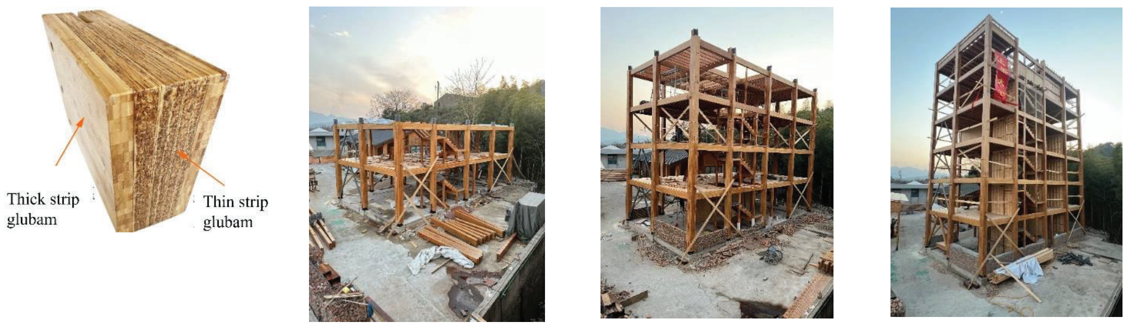
direction), as shown in Fig.1b. A finite element model in SAP2000 is established with the chosen structural systems and the dimensions of components to obtain the internal forces, for member design following methods similar to timber design [2]. The controlling load is wind load, and the maximum story drifts corresponding to code required load combinations are confirmed to satisfy the limit of 1/350 = 0.29%.



(a) Standard floor plan *on* *(c) Near completion*

Figure 1. Six plus one-story mass bamboo building.



(a) *(b)* *(c)* *(d)*

Figure 2. Mass bamboo manufacture and module unit construction: (a) glubam section; (b) first two-floor unit; (c) second two-floor unit; (d) third two-floor unit.

4 – CONSTRUCTION AND INITIAL INSTRUMENTATION

Manufacturing glubam involves planking, saw-sizing, gluing, and cold pressuring or direct nailing to form structural components based on design, followed by surface smoothing, drilling and cutting. An example of a glubam beam section is shown in Figure 2a. Selected components were sampled for non-destructive evaluations of elastic modulus MOE using static and dynamic methods, to verify that the actual MOE, of the elements is larger than that adopted in the analysis and design. The construction of the building combined the “frame” and “platform” procedures, effectively ensuring installation efficiency. Each of two stories is designed as an installation module involving bamboo frame columns and beams, followed by adding the joist beams and slab sheathing panels, lightweight timber or bamboo frame-shear walls, steel or bamboo braces. Figure 2(b~d) exhibits the installation process of the mass bamboo building. Accelerometers were employed to instrument the building vibration modes and deformations at each construction stages and after completion. The data verified the adequacy of the analytical models.

5 – CONCLUSION

An engineered mass bamboo building with six stories plus a roof attic with a total height of 20.3m is successfully designed and constructed. The initial vibration instrumentation of the building verified the adequacy of design and analytical models. Further structural and environmental studies will be carried out on the building.

6 – REFERENCES

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