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CROSS LAMINATED TIMBER (CLT) STRUCTURE: THE FIRST IN MALAYSIA

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Introduction

Not until recently, Cross Laminated Timber (CLT) has attracted the building industry and related agencies in Malaysia to use it as a building material. A pioneer work initiated by FRIM through an E-science project entitled the *Development of Cross Laminated Timber (CLT) using Pioneer Timber Species into Structural Panel for IBS Application* was approved by the Ministry of Science, Technology and Innovation (MOSTI) in July 2013 for a duration of 30 months. It introduces an architecture that embraces the green building concept. In Malaysia, the building industry is more comfortable working with reinforced concrete, clay or sand brick and steel as the main materials in building construction, but with public awareness and concern towards the environment an alternative green material is sought after. The solution is to use more engineered timber products that will definitely have more environmental benefits and economic advantages.

The pioneer species timber selected to be utilized in this project was sesenduk (*Endospermum diadenum*). The main criterion for selection of species for CLT is that the density of the timber must be light and within the range of 400-600 kg/m^3 aside from being readily available. CLT technology optimises the structural capabilities of the raw material by rearranging the direction of the force onto the fibre. Realizing the limitation of sesenduk as a non-durable timber, pretreatment is essential to prolong its life span. CLT has high structural strength because the load received by the panel will be spread to the laminas that are arranged in perpendicular manner. It can be used in the construction ranging from small scale structures to large multi-story buildings (Crespell & Cagnon 2010).

Prior to the construction of a building, CLT panel is produced in advance at a manufacturing plant according to the architectural drawings and intended specifications. Similar to other Industrialised Building System (IBS), precision is the essence of the product before being shipped to the construction site for installation. This method of construction merits ease and quick in construction with minimal labour that in total may be able to save construction costs (Sutton et al. 2011). A detailed description on the preparation and manufacturing process of the CLT panel is published in Timber Technology Bulletin (TTB) No 59: 2016 (Hamdan et al. 2016). Basically, it is made up of timber boards that have been glued together with structural adhesive and stacked in perpendicular orientation between laminates. The result is an engineered timber product with excellent thermal, acoustic and finish benefits that is also the primary building structure. In normal practice, the external façade of the CLT panel is layered with other material such as cement boards or other durable membranes.

Construction of the CLT structure in FRIM campus

Construction of the CLT structure in FRIM campus was based on the following sequence:

1 Labelling and in-situ preparation of the CLT panels

Preparation of a CLT structure required a complete design ahead of commencement on site to enable for offsite manufacture in the factory. The design was used as the basis for CLT panel preparation as well as labelling the respective panels. It required optimum coordination before any work could start whereby the openings for doors and windows were precut. Positioning of this opening was important too as it might affect the structural integrity of the panel. Further works such as routing, filling and pre-finishing were carried out in a workshop (Figure 1). On these CLT panels, jointing gaps between the laminates might occur that filling work was carried out to cover those gaps with similar wooden sticks with or without saw dust glued together. This was followed by sanding to regain the smooth surface prior to finishing.

Figure 1 Preparation of the CLT panels, (a) routing of CLT panel for connections, (b) routing work in progress, (c) wood filling and (d) sanding of CLT panel

2 Preparation of concrete platform

Upon clearing the site as well as the leveling job done, preparation for concrete footing and platform commenced (Figure 2). It required an accurately set out groundwork. A strong and stable base was important as it would support the load of the superstructure above. Reinforcement of the platform with the right diameter of bar reinforced concrete (BRC) was done. The platform was built at about 600mm high, and the soil was treated against termites. Once the concrete had cured and properly dried, the process of erecting the CLT panels started.

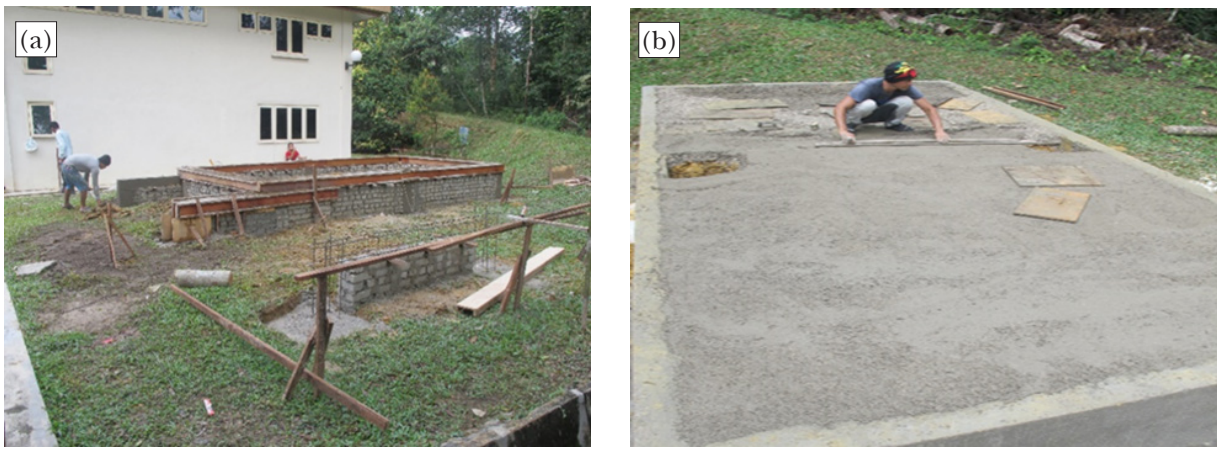

Figure 2 Preparation of concrete platform, (a) formwork for concreting and (b) concrete platform

3 Erecting CLT panels and connectors

Being a first for everyone involved in the construction of this CLT structure in Malaysia, project planning was very crucial. Coordinating between the drawings and transferring the labelling onto the panels were important. This would determine the sequence which panel would be handled first. In this project, it was decided that the panels to be erected first were at a corner in the back and perpendicular to each other. Each panel was lifted and temporary bracings were inserted to provide security and stability. After the adjacent panel was erected, clamps were used to steadily hold the connections before fasteners were screwed into (Figure 3). Once done, the two panels would give initial stability for the whole CLT panel system. The erection of the subsequent panels becomes much easier. For a build-up area of 6 meters by 3 meters, the CLT wall panel was erected manually in one day by 8 workers using simple tools. However, this procedure could be shorten if the right the tools and equipment were made available. Another important aspect was connecting the panels together steadily. A simple but appropriate jointing system was developed to secure all the adjacent panels. Steel plates, angle cleats, screws, bolts and nuts were used extensively in this structure and sourced locally.

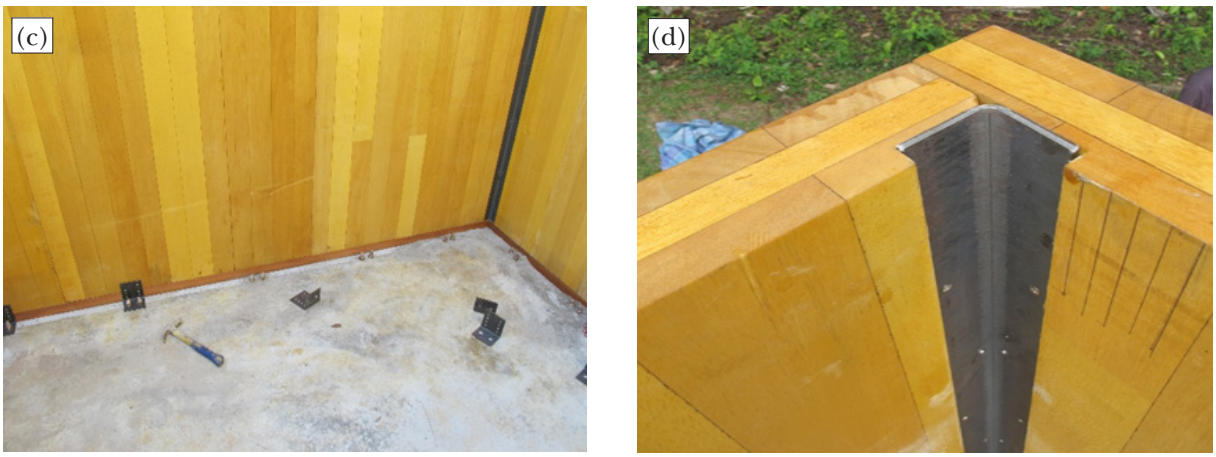

Figure 3 Erecting CLT panels with appropriate connectors, (a) first set of CLT panels erected, (b) erecting process of CLT panels, (c) angle cleats and raw bolts were used to hold the panels to the floor and (d) vertical angle bars were used to hold panels at each corner

4 Fabrication of the roofing system

The fabrication of the roof followed as soon after all the four side panels were erected (Figure 4). The mono-pitched roof followed the typical roofing design but slanted in a single direction. The advantage of a mono-pitched roof was that it could easily be constructed without much hassle within a very short span of time. The rafter refers to the sloping member that forms the pitch of this kind of roofing system. Its function was to support the roof material and also used to transfer the loads to the supporting walls. A chord at each rafter was used to tie the walls, and struts were provided to prevent the rafters from deflection. Another advantage of this design was it would be able to maximize the natural lighting in the area as it allowed maximum sunlight to enter through the vertical side opening.

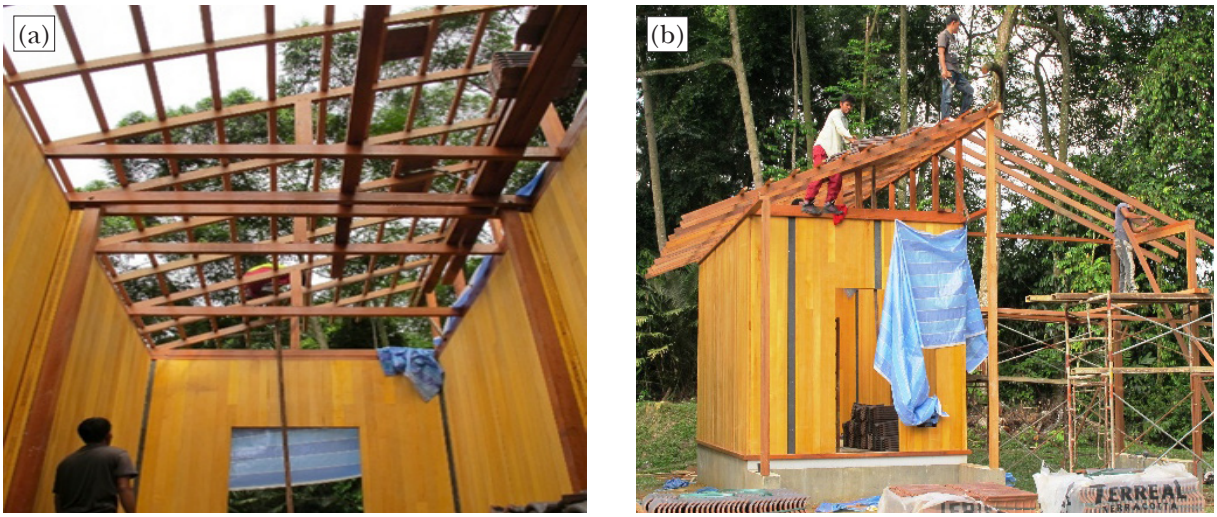

Figure 4 Fabrication of the roofing system, (a) the installation of mono-pitched roof, (b) roof tiles installation in progress, (c) rear view of the CLT structure during construction and (d) semi finished CLT structure

5 Finishing

Finishing work was the final step in the CLT construction that gave the CLT panel surfaces desirable characteristics, including enhanced appearance and increased resistance to moisture and other environmental agents (Figure 5). Finishing would also enable timber to be cleaned easily, and it can also enhance low quality timber with luxurious appearance. High moisture content of the timber will encourage staining. Changes in moisture content can result in shrinkage and swelling of timber that will cause stress and crack to the wood. In this project, the CLT panels were coated with a layer of coating prior to installation. After all the installation work of the CLT, another two layers of coating were applied. As a preventive measure, insecticide and fungicide were also added in the coating.

Figure 5 Finishing of CLT structure, (a) applying of coating onto the CLT panel and (b) final coating of the CLT panel at the balcony area

Conclusion

The construction of the CLT structure, the first of its kind in Malaysia, was completed in December 2016. It took less than three weeks to complete. The biggest challenge to this construction method was that it required proper planning and rethinking an otherwise standard timber building construction. During panel preparation, the assembly line in the factory must be planned appropriately to take into account the modularity aspect. While during construction the erection of the panels have to take into account the domino effect if failure was to occur.

The panels once fabricated would be easy to move by ship or truck, and could be installed quickly with the right tools which would reduce construction time and expensive labour costs. The completed structure is as shown in Figure 6. Another challenge in this project was to retain the strength and durability of the sesenduk CLT panel to endure the vigor of climatic changes and pest attack. While certain measures such as chemical treatment and layers of finishing were applied onto the panels, it would be a continual task to monitor the in-service performance of the CLT structure as a whole.

Figure 6 The first known CLT structure in Malaysia, (a) front view and (b) rear view

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