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Monitoring timber moisture content in timber-concrete hybrid construction: St Lukes Health Insurance mid-rise office building

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ABSTRACT: The St Lukes Health Insurance building in Launceston, Tasmania is one of Australia's latest mass timber buildings to be constructed. This seven-storey, 7000 m^2 building will be the largest office dwelling in Launceston, Tasmania. Constructed with European spruce post and beams, radiata pine CLT and local Tasmanian Eucalyptus nitens CLT, the speed of construction and natural beauty of this project is unprecedented. The research presented in this article is about the monitoring of the change in moisture content (MC) in the concrete capped CLT composite solution used on the level five ceiling to level six floor. This hybrid solution provided a platform for a garden terrace located on level six. The change in moisture content (MC) of the radiata pine CLT structure post concrete capping, was measured to the point of structural cure (28 days) and beyond to ensure the timber structure returned to an acceptable MC. Several months of data collection highlighted the initial peak in MC as a result of the concrete capping and the gradual decline in timber MC over 2023/24 period. This article acts as an exemplar study that future scholars and practitioners can adopt to monitor change in mass timber MC during construction and post hybridisation solutions.

KEYWORDS: CLT/concrete hybrid, Moisture content

1 – INTRODUCTION

Hybrid composite timber and concrete construction has been widely used across the world for many years. Yeoh et al. (2011) [1] highlighted, in recent years this type of construction has increased in bridges, new buildings and refurbishing existing timber floors. The advantages of this type of construction include greater structural capacity among other important factors such as seismic, acoustic, thermal, aesthetics, and in some circumstances off-site prefabrication. Both timber and concrete are hygroscopic and therefore absorb and release moisture according to atmospheric conditions and deliberate interventions. With respect to concrete capped mass timber, the change in MC in the timber component is a direct result of pouring the wet concrete onto the timber component that has equilibrated to its environment. According to Lukacevic et al. (2021) [2] timber MC can increase to as high as 84 % for unsealed, exposed end grain surfaces in construction systems. According to Australian standard, AS 4785.1 - 2002 [3] radiata pine should be within the range of 9-14 % and not more than 18 %. A report by Nolan et al. (2021) [4] noted as timber progresses through manufacturing, transport, construction and in service, its MC fluctuates according to the equilibrium moisture content (EMC) of its environment. In the report by Nolan et al., static radiata pine specimens stored on a construction site with a calculated EMC of 16.5 % in Launceston, Australia during the Winter season can reach a MC in excess of 16 %. In this research paper, the change in MC of the radiata pine CLT post concrete capping is recorded for over 12

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months to illustrate the impact that the deliberate intervention of this construction system and the atmospheric conditions had on the timber MC.

2 – PROJECT DESCRIPTION

The composite CLT/concrete hybrid was poured along the north, west and south facing perimeter facades. The area covered an approximate 420 m^2 as part of an exterior garden terrace on the sixth floor. Nine zones across the hybrid construction were identified as reference points for monitoring the change in MC (Fig. 1).

Prior to pouring the concrete the MC of each reference point was measured with a Delmhorst J-2000 moisture meter. The CLT was 7-layer radiata pine with a thickness of 290 mm. Each layer of the CLT was nominally 40 mm thick. The CLT and concrete hybrid system had no water membrane to separate the two construction materials. Post concrete pouring the top face of the CLT was no longer accessible to measure the uptake in moisture caused by the wet concrete. Therefor a semi-invasive design was developed to monitor the MC of the top CLT lamella surface (10 mm below the concrete) and the top of the second lamella layer (40 mm below the concrete). The design included silica-bronze insulated pins that were inserted at 280 mm and 250 mm depth into the CLT from level five which were used as contact extensions for the resistance moisture meter each time a reading was taken (Fig. 2). The MC readings were initially monitored weekly and site permitting during July 2023. This frequency continued to the critical milestone of day 28 (concrete cure) and thereafter less frequently by appointment to May 2024.

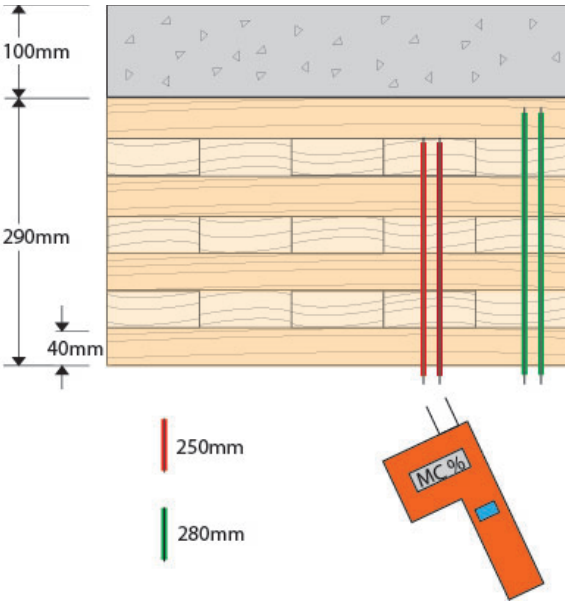

Figure 2. Semi-invasive design with extended silica-bronze insulated pins to measure MC in CLT lamellas.

The intent of the two depths was to monitor the top surface of the CLT which would obviously be affected by the concrete poured onto the CLT and the second layer of the CLT lamellas to monitor the ingress of moisture through the CLT.

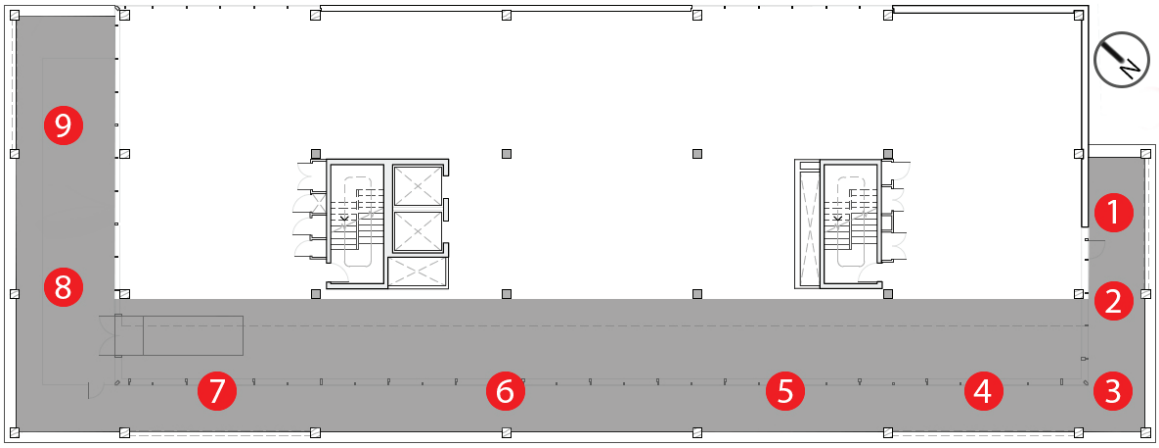

Figure 1. Plan view of the St Lukes Building level 6 (image courtesy of Terroir and modified by the author).

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3 – OUTCOME AND DISCUSSION

The wet concrete was poured on 6 July 2023. The MC of the CLT top lamella (10 mm below the concrete) post concrete capping reached a maximum of 33.6 % in the south-west location (zone 4). This highest reading was recorded 8 days after the concrete was poured. At the same time the highest MC measured in the second lamella layer (40 mm below the concrete) was 18 % at the northern end of the building (zone 8). On day 29, August 4th 2023, one day after the structural cure of the concrete, the average MC across the zones measured 22.1 % in the top lamella and 13.9 % in the second lamella layer. On day 158, December 11th 2023, the average MC across the zones measured 16.2 % in the top lamella and 14.4 % in the second lamella layer. The significance of this date is that it was the last time every zone was measured together and the approximate period when the building was enclosed. Following this date, access to each zone was compromised due to interior fit out. On day 327, May 28th 2024, the final average MC from the accessible zones across the building measured 14.6 % in the top lamella and 13.1 % in the second lamella layer.

The data collected in this research has provided confidence that the composite CLT/concrete hybrid construction has subsequently returned to an acceptable MC range of 9-14 % (Fig 3. and Fig. 4) and not more than 18 % as noted in AS 4785.1 - 2002 [3] for radiata pine.

4 – CONCLUSIONS AND RECOMMENDATIONS

The St Lukes Health Insurance building is a contemporary building with a variety of structural timber elements and different timber species that incorporates an established hybrid composite timber-concrete construction solution. This research presents the monitoring of the change in timber MC of radiata pine CLT post concrete capping during construction. The design of the monitoring system and the results of the change in MC during construction can act as a case study for future construction projects and provide confidence for others to utilise this construction hybridisation solution.

5 – ACKNOWLEDGEMENT

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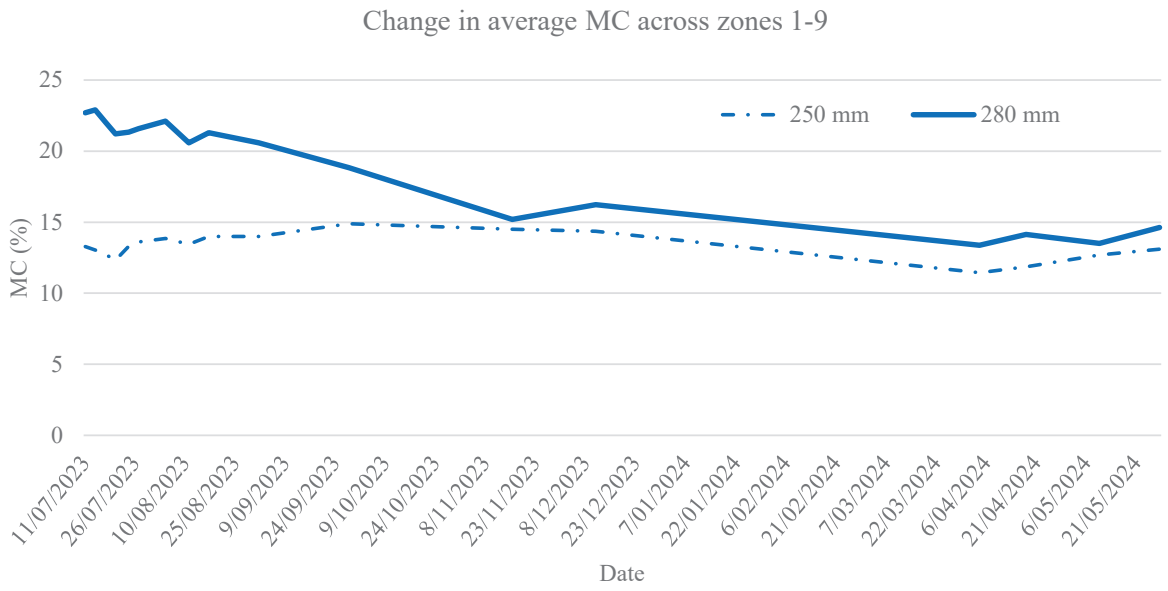

Figure 3. Change in average MC across zones 1-9 over 327 days.

6 – REFERENCES

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Figure 4. Change in MC for each zone 1-9 over 327 days.

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